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bulletin

→ space for europe

esa

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 Launcher Development Organisation (ELDO). The Member States are Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, 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, cooperation 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:

- 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;
- by elaborating and implementing activities and programmes in the space field;
- by coordinating 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;
- 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:

ESTEC, Noordwijk, Netherlands.

ESOC, Darmstadt, Germany.

ESRIN, Frascati, Italy.

ESAC, Madrid, Spain.

Chairman of the Council: M. Lucena

Director General: J.-J. Dordain

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ESA's six astronaut candidates took part in ESA's 52nd parabolic flight campaign and flew aboard the Novespace Airbus A300 Zero-G aircraft on 7 May 2010. In between training and performing science experiments, the trainees could enjoy the weightlessness.

bulletin

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Editor
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One of the major disasters that stands out in Charter activations was the December 2004 tsunami that caused immense devastation in coastal regions of India and Southeast Asia. A wide range of crisis-mapping products were supplied via the Charter to support the international humanitarian response (Royal Society Publishing)

→ IN ACTION AROUND THE WORLD

The International Charter 'Space and Major Disasters'

Philippe Bally, François Boubila, Monique Viel*, Simon Jutz, Simonetta Cheli, Stephen Briggs
Directorate of Earth Observation, ESRIN, Frascati, Italy (*Argans Ltd)

Operating since November 2000, the International Charter 'Space and Major Disasters' has continued to demonstrate the importance of space in helping relief organisations that deal with major natural and technological hazards around the world.

Initiated by ESA and the French space agency CNES after the Unispace III conference held in Austria in 1999, the Charter officially came into operation after the Canadian Space Agency signed up to the charter on 20 October 2000.

These agencies initially called on data from ERS, Envisat, SPOT and Radarsat, but now a much broader range of sensors from various national, international and private organisations operating Earth observation missions can be accessed to support disaster management authorities in the event of disasters.

The following agencies subsequently joined the Charter as members: the Indian Space Research Organization (ISRO) and the US National Oceanic and Atmospheric Administration (NOAA) in September 2001, the Argentine Space Agency (CONAE) in 2003, the Japan Aerospace Exploration Agency (JAXA), the US Geological Survey (USGS) and the UK Space Agency/Disaster Monitoring Constellation (DMCii) in 2005, and the China National Space Administration (CNSA) in 2007.

The Charter in operation today

The Charter is an international collaboration to provide space-based services for immediate response to major natural or man-made disasters. Its functions are simple: to task satellites in response to a major disaster and to provide fast access to satellite data to support disaster response. Space agencies play a key role because they are able to ensure that a range of very different satellites is programmed according to a unified plan and their data are disseminated rapidly.

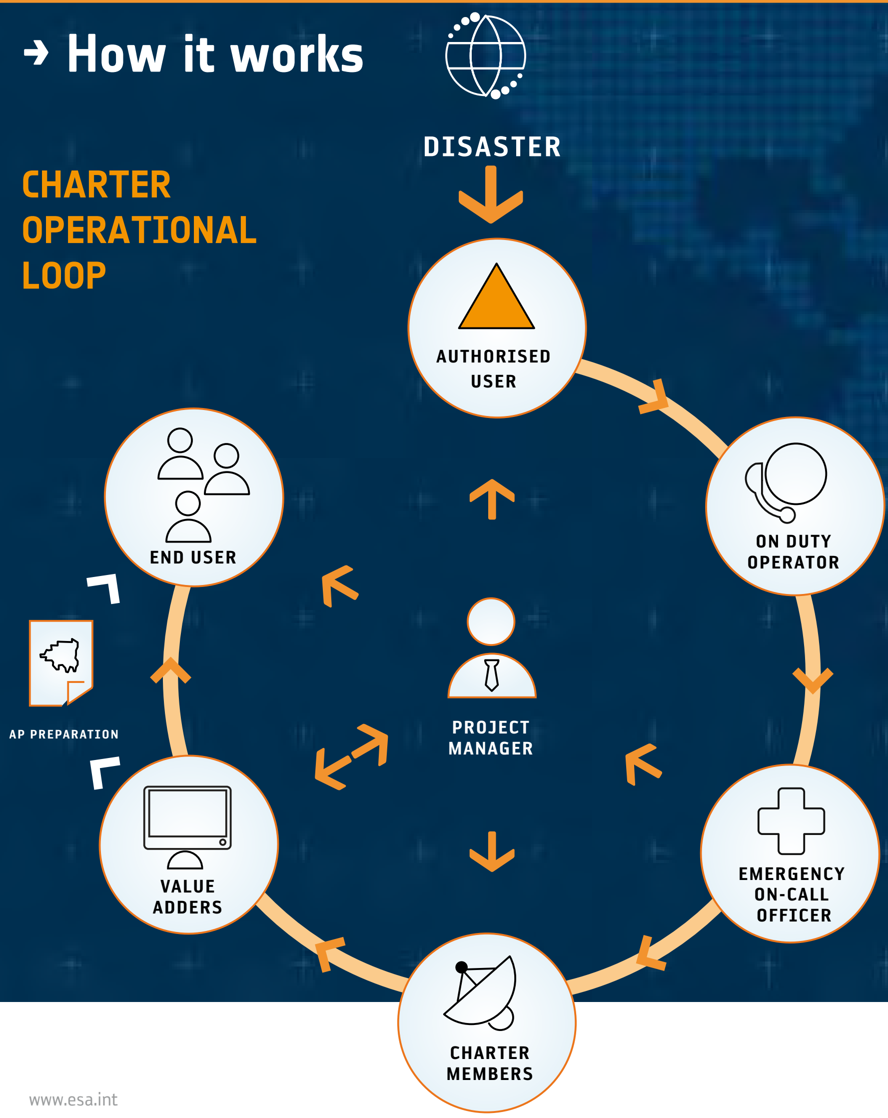
The Charter focuses on major disasters, addressing a portion of the 200–400 catastrophes that occur yearly around the world. It is not designed to address the natural hazard emergencies recorded each year – over 800 according to reports from the insurance sector – nor is it used for other parts of the risk management cycle, such as rehabilitation, reconstruction, prevention or preparedness.

Within its mandate, the Charter is available globally for a predefined list of appointed users, the 'authorised users' who are granted a direct access for triggering the system. Today, there are 10 national and international space agency members of the Charter, representing over 40 countries; each of these countries designates authorised users who primarily are national disaster management authorities such as civil protection, rescue or security bodies.

Each Charter member commits to provide access to Earth observation mission data for disaster response following

→ How it works

CHARTER OPERATIONAL LOOP



Operators are at readiness 24 hours a day at ESRIN to deal with requests for assistance from civil protection authorities. On receiving a request, they check the identity of the caller and verify that the information needed to respond to the emergency is specified correctly.

This information is then passed to an on-call officer who analyses the request and the scope of the disaster with the user to establish how to use the satellites that can provide data to the Charter to their best abilities.

The final step is to prepare an acquisition and processing plan using the available space resources. Data acquisition and delivery take place on an emergency basis, and a project manager, qualified in data ordering, handling and application, assists the user throughout the process.

the procedures of Charter activation – a simple process to supply crisis data in rush mode following a request from an authorised user. The management of the Charter works on a rotation, with a member agency leading the Board and Executive Secretariat on a six-month basis. Following the Indian space agency ISRO, ESA became the lead agency in April 2010.

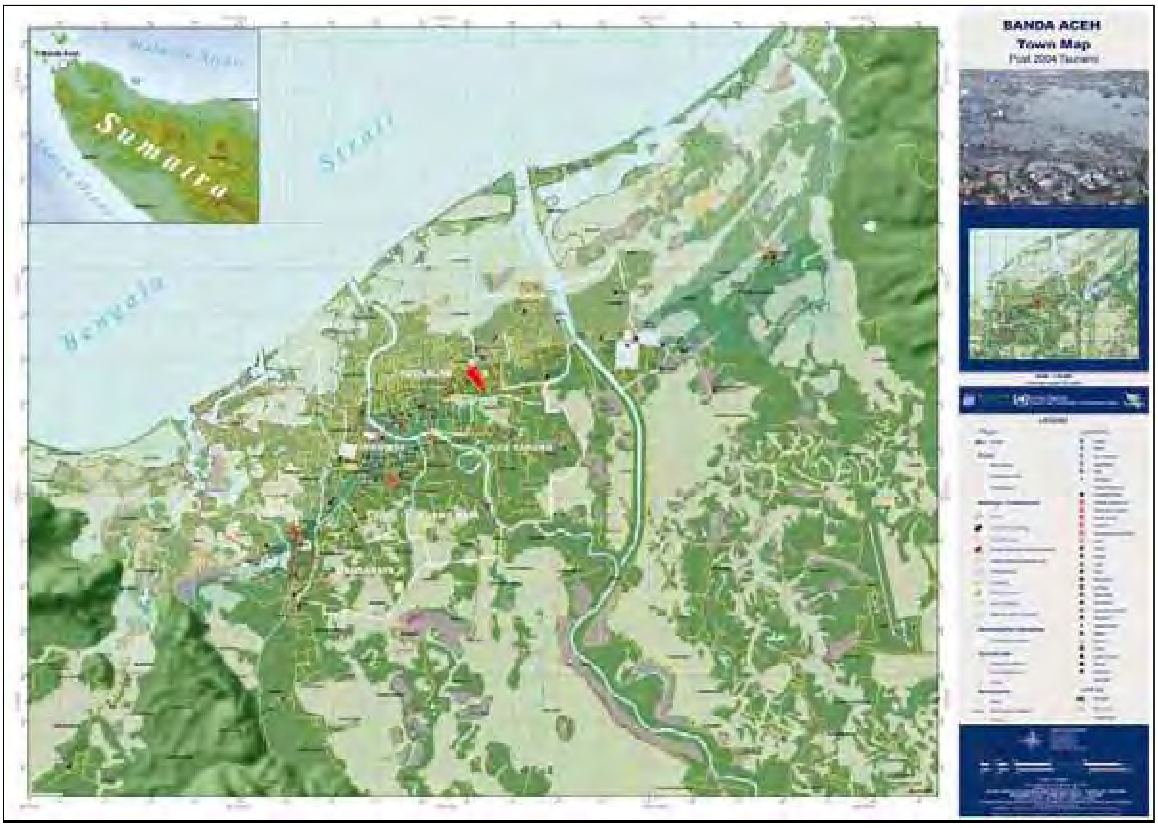
Ten years of Charter operations

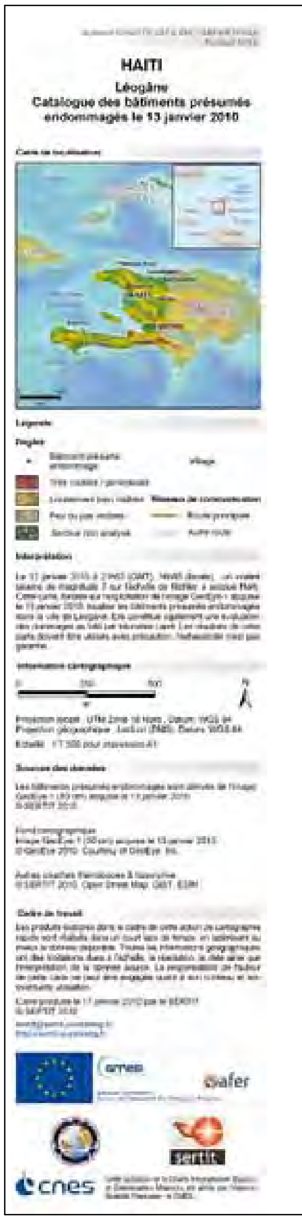
First activated for landslides in Slovenia in November 2000, the Charter has brought space assets into action on many occasions, for disasters such as flooding, hurricanes, tsunamis, earthquakes, forest fires, volcanic eruptions and oil spills.

Looking at the types of hazard for which the Charter has most frequently been requested, hydro-meteorological events appear in the first position: between 2000 and 2010, the system was activated for more than 120 major floods worldwide and 37 hurricanes, making a substantial part of the more than 260 activations in over 90 countries.

There are many major disasters that are milestones in the last 10 years' records of the Charter. On 26 December 2004, the coastal regions of India, Sri Lanka, Thailand, Indonesia, Maldives, Malaysia and Myanmar were all severely affected by an earthquake and a consequent tsunami that caused immense devastation. A wide range of crisis-mapping products was elaborated using data supplied via the Charter to support relief teams and the international humanitarian community engaged with disaster response.

→ A tsunami survivor in the rubble of Banda Aceh, Indonesia, January 2005 (Alertnet/Reuters/Y. Ahmand)





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Satellite-derived street maps of post-tsunami Banda Aceh, Indonesia, were used by more than 400 relief groups operating in the city (Respond/Keyobs)

→

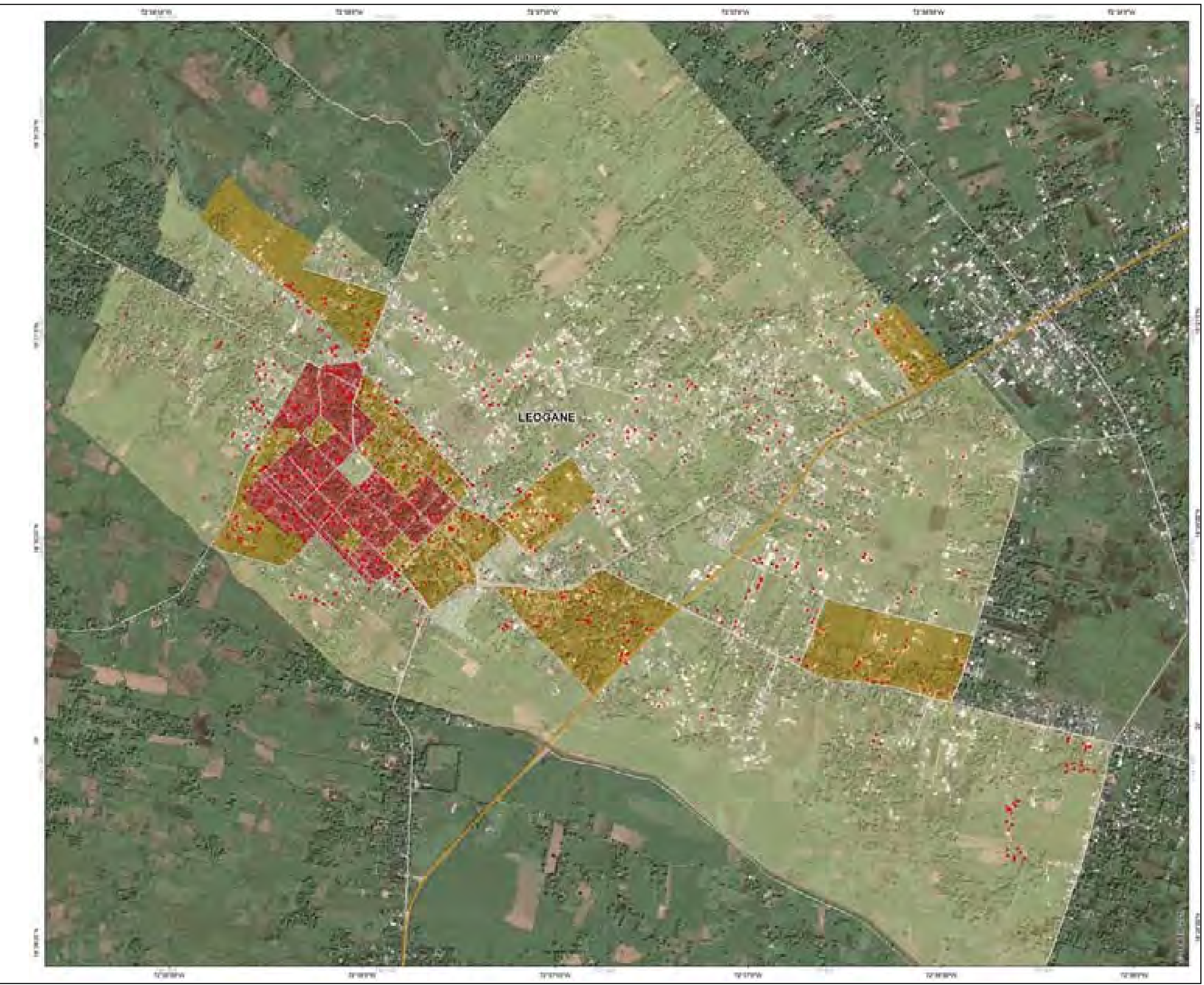
Example of a value-adding map supplied by SERTIT (FR) for GMES SAFER project. SAFER provided added-value support following the Charter activation for the earthquake in Haiti on 12 January 2010. The Charter was triggered by the French civil protection authorities, the UN Stabilisation Mission in Haiti, Public Safety of Canada and the US Geological Survey. The map is a 1:7500 scale rapid damage assessment product over Léogâne, Haïti, using a GeoEye-1 image from 13 January as background.

In October 2005, an earthquake of magnitude 7.6 struck on the India/Pakistan border in the Kashmir region. As of 8 November, the Pakistan government official death toll was 79 000. Again, to assist disaster response, the 'virtual constellation' of Earth observation missions that the Charter operates was activated to acquire imagery and generate damage assessment maps to users in the field. Beyond this, during a donor conference in Geneva, hardcopy maps produced using Charter data were delivered to UN Secretary General Kofi Annan, UN Humanitarian Coordinator Jan Egeland and the Director of the Office for the Coordination of Humanitarian Affairs in Geneva, Yvette Stevens.

Similarly, the Charter was activated in response to other major earthquakes, such as the magnitude 7.8 event in eastern Sichuan, China, on 12 May 2008, the magnitude 7 event destroying the capital city of Haiti, Port-au-Prince, on 12 January 2010 and the magnitude 8.3 event hitting Chile on 27 February 2010.

Sometimes the 'immediate emergency response' phase is longer than the standard four-week crisis window time of the Charter and the service is supplied over an extended period; this is the case with the Charter activation to monitor the oil slick following the collapse of the *Deepwater Horizon* drilling rig on 20 April in the Gulf of Mexico. NOAA and the US Coast Guard indicated that Earth observation imagery might be useful at least for a few months after the oil slick started to expand in the sea.

Earth observation data are key because they provide objective and synoptic information. However, even with



a multi-sensor system using different satellites, the main issue is timeliness because most users request fresh information on a daily or even hourly basis. The capacity of the Earth observation missions that the Charter provides today is still not at the level most disaster management centres would expect.

However, this is improving every year and currently, for a given target anywhere around the globe, the average time to task one of the satellites and perform the first acquisition is less than two days. The average time to produce an Earth observation data product after data downlink is between a fraction of an hour and half a day.

The average time to analyse data products and produce the first crisis/damage assessment product is better than half a day. This latter component is generally performed by external value-adding organisations collaborating with the Charter and working on a 24-hour basis.

Just looking at ESA mission data, more than 1350 products have been provided since 2000; they are primarily based on ERS Synthetic Aperture Radar (SAR) and Envisat Advanced SAR. All-weather SAR imagery is often requested and is the main data source for floods and hurricanes. Out of the national Earth observation missions from European members of the Charter, SPOT and DMC are used very often and for a broad range of hazard types. Evidently, to meet timeliness requirements from the users, many sensors are activated as the activation starts: Earth observation missions from all 10 Charter member agencies are used.

↑ A high-resolution image of central Port-au-Prince, Haiti, showing extensive damage and debris-covered streets, taken by the US GeoEye-1 satellite in January, as part of the worldwide satellite observation campaign activated by the International Charter 'Space and Major Disasters' (GeoEye)

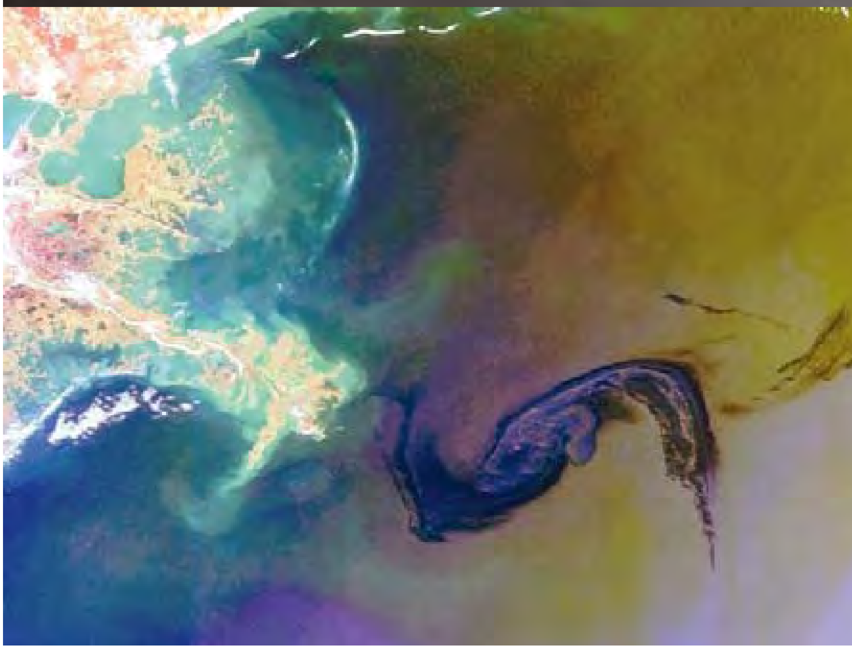
The expansion of the Charter

New space agencies regularly contact the Charter to take part, such as the Russian Federal Space Agency Roscosmos, the Brazilian National Institute for Space Research (INPE), the Korea Aerospace Research Institute (KARI) and the Taiwanese National Space Organization (NSPO), who has provided access to data from their Formosat Earth observation satellite for several years.

As far as users are concerned, the number of organisations asking to be able to access the system is increasing every day. There are several mechanisms to access and activate the Charter. The first is directly from one of the authorised users (AUs). The second is from a country without an AU via a 'sponsor AU', that is an AU who requests the Charter to assist a disaster management user from another country.

The Charter has defined arrangements with the UN Office of Outer Space Affairs (OOSA), in Vienna, and the Operational Satellite Applications Programme of the UN Institute for Training and Research (UNITAR/UNOSAT), in Geneva, to provide support to UN agencies. UN OOSA and UNITAR/UNOSAT may submit requests on behalf of users from the UN to assist the international humanitarian community.

With these mechanisms, over the last few years, the Charter has been able to provide data for more than one activation per week on average. However, this is not enough and it is intended to increase Charter access with a primary focus on users from regions exposed to major disasters without direct access to the system. With this in mind the Charter Board adopted the principle of 'universal access' in 2008, with the aim of improving Charter access worldwide.



Example of imagery supplied by ESA in response to an activation of the Charter, Call 308 on 22 April 2010, for the oil slick following the explosion of the Deepwater Horizon oil platform in the Gulf of Mexico. These images represent how repeat Envisat observations are supplied to NOAA and the Charter requester, the US Coast Guard. Above, an Envisat ASAR image from 26 April, left, a MERIS Full Resolution image from 29 April, prepared by Alessandro Burini, Rheagroup SA, with ESA. Since the first day of this incident, continuous Envisat observations were provided in near-real time (two hours after downlink) with observations from other Earth observation missions associated with the Charter

In this spirit, and following a formal request from the intergovernmental Group on Earth Observations (GEO) Secretariat in 2007, several initiatives were implemented in 2009 and 2010 to make request submission possible for more users from GEO member states. A collaboration with GEO was put in place by ESA with priority on the 44 out of 81 member states of GEO that do not have direct access to the Charter.

Improving access for the Asia–Pacific region

In April 2009, the Charter decided to establish an interface between the Charter and Sentinel Asia, a regional Earth observation capacity for emergency response. By allowing improved Charter access to the national users from member states of Sentinel Asia, significant progress was achieved concerning the Asia–Pacific region.

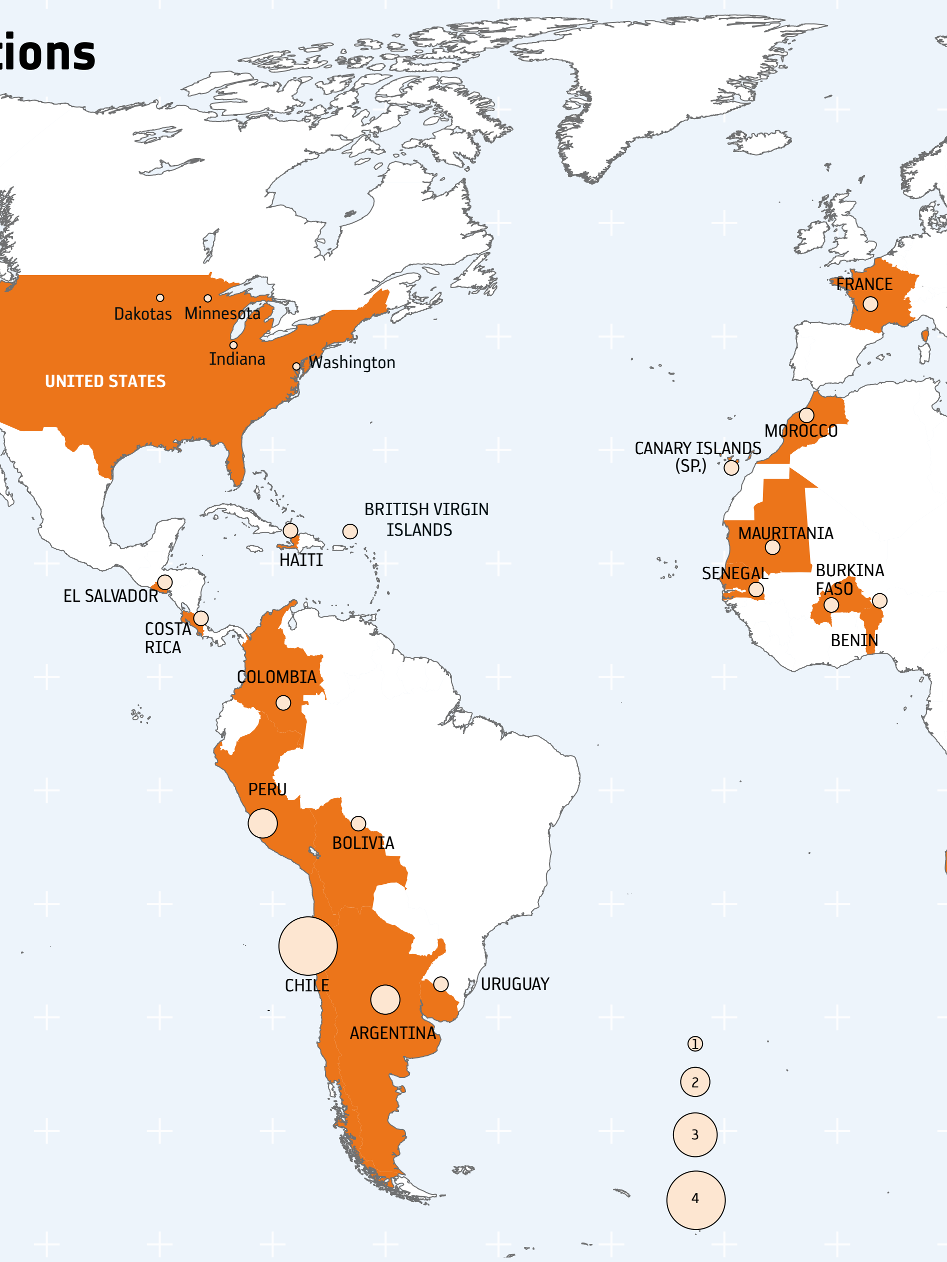
In October 2009, the Asian Disaster Reduction Centre (ADRC) was granted the status of Charter Cooperating Body with the prerogative to trigger the Charter on the basis of the activation mechanism of Sentinel Asia. This agreement concerns 31 countries of the region – 28 of which did not have direct access to the Charter before and 15 of which are GEO member states. Just looking at the GEO requests, after one year of collaboration, from those 44 countries worldwide without direct Charter access, now 12 GEO member states from Asia–Pacific can trigger the system.

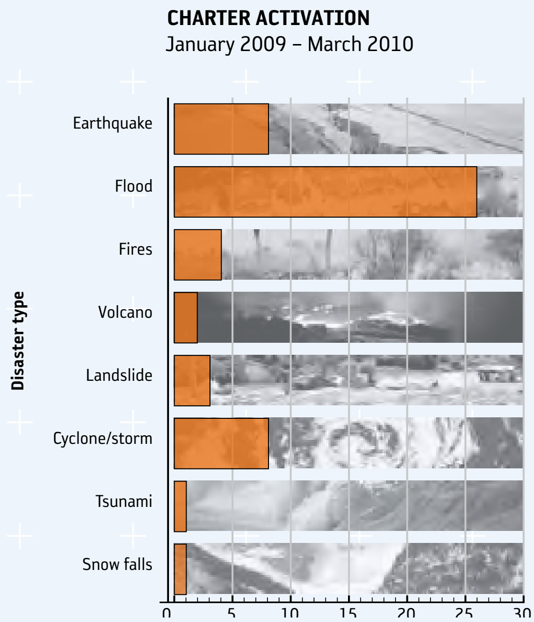
Improving access for the Africa region

In close collaboration with the GEO Secretariat and with support from the network of local GEO principals, ESA has organised a first 'formal user consultation' in Africa,

→ Recent Charter activations

Between January 2009 and March 2010, the Charter was activated 55 times, for 45 countries. Twenty-four activations responded to UN humanitarian organisations requests and 29 responded to national civil protection authority requests. Flooding is the most common type of major hazard.



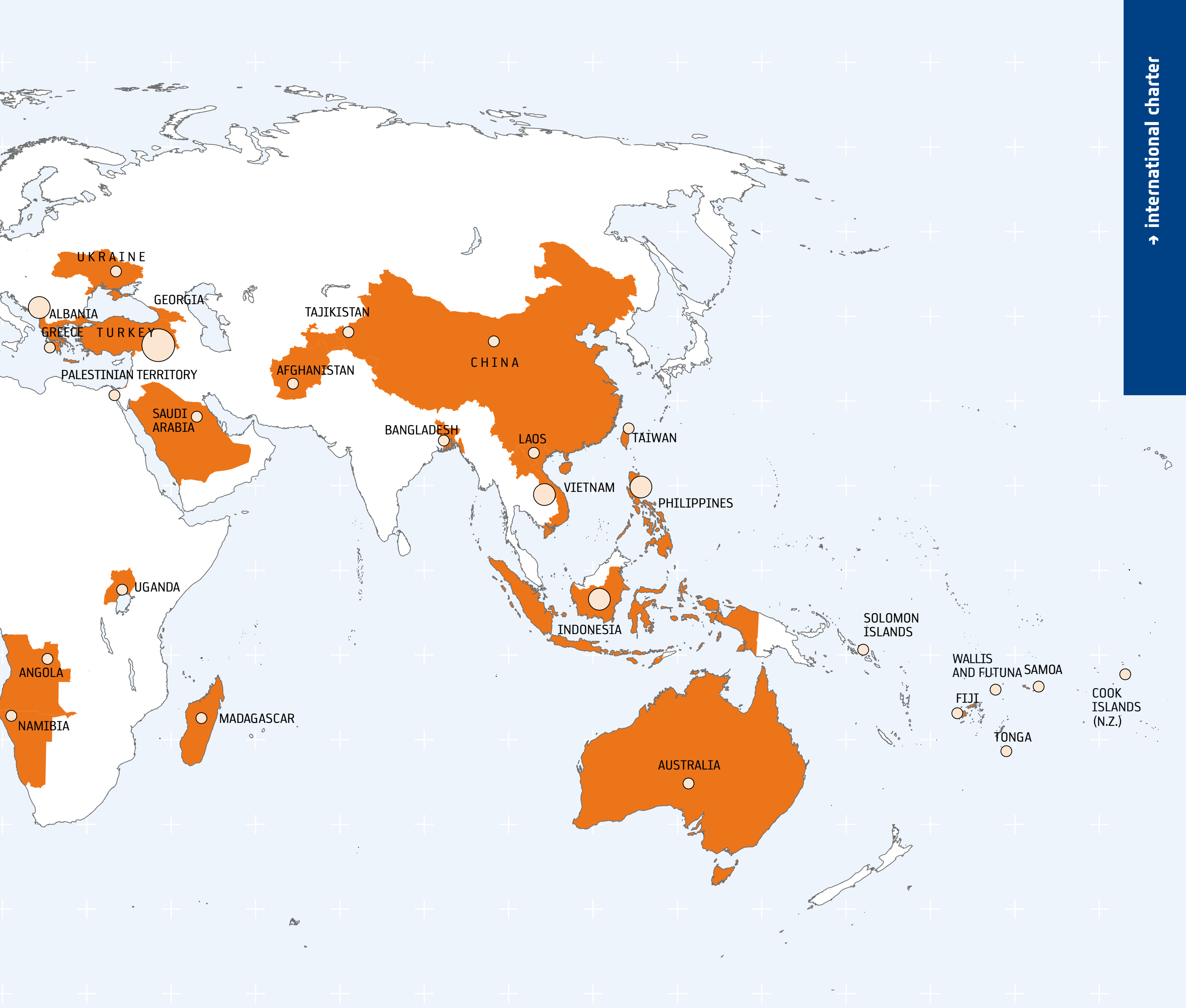


focusing on national users with the aim to gather and analyse their viewpoints concerning how EO can be accessed and used for disaster response. This two-year programme is accompanied with dedicated actions to raise awareness, explain and promote the Charter and provide training support.

Priority has been put on 17 African countries, the most affected by natural disasters: Angola, Cote d'Ivoire, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Madagascar, Mali, Morocco, Mozambique, Namibia, Niger, Senegal, South Africa, Tanzania, Uganda and Zambia. Consultation with national authorities of Ethiopia, Mali, Mozambique, Niger, South Africa and Uganda took place between September 2009 and May 2010.

So far feedback from national users is showing a strong interest in the contribution that the Charter can bring by providing rapid, objective and free information to monitor an emergency and its impact. For the majority, the national disaster centres consulted were generally not aware of the Charter. The Charter and GEO are working together to evaluate the current access mechanisms, methods to improve it and the potential role that national, regional and international organisations could play to use the data and information that the Charter provides.

Beyond the fundamental subject of triggering the system, the way the Charter service is provided and exploited generally requires collaboration and local organisations can play a key role because they are close to the theatre of operations. Once an activation is triggered, the Charter designates a Project Manager – not necessarily from a country of a Charter member – who plans for the appropriate Earth observation acquisitions and manages their dissemination and exploitation. This aspect is also under investigation for the many countries not yet closely linked to the Charter.



Global Monitoring for Environment and Security (GMES)

GMES is a joint initiative of the EC and ESA aimed at achieving an autonomous and operational Earth observation capacity. It has a major component concerning Emergency Response. In this context, a collaboration has been initiated between European members of the Charter (UK Space Agency, CNES and ESA) and the GMES SAFER project.

This involves the interpretation and added value of Earth observation data provided through the Charter when activated by authorised users. Accessing support from SAFER for Charter activations is particularly relevant for Charter users concerning requests on emergencies in Europe and emergencies outside the European sphere that are priorities in the policy sectors of Europe.

The collaboration with GMES SAFER was activated for several Charter activations in 2009 (for example, tropical cyclone Aila in Bangladesh in May, fires in Greece in August, tropical storms in Philippines in September) and recently in 2010 (the major earthquake in Haiti in January and the volcanic eruption in Iceland in April). With its capacity, SAFER also brings access to other extremely useful data sources, such as the very high resolution SARs on the German TerraSAR-X and Italian COSMO-SkyMed satellites.

Celebrating ten years of the Charter

To celebrate the 10 anniversary of the Charter, with the support of the other agencies, ESA has developed a new brochure and prepared a short movie illustrating the Charter and its achievements. This material is available on a revised Charter website (www.disasterscharter.org), in five languages: French, Spanish, English, Japanese and Chinese. To watch the Charter movie, click on the ‘News’ link. ■

→ HOME IMPROVEMENT

Enhancements for reducing ISS operations costs

Johannes Witt, Philippe Deloo & Daniele Laurini
Directorate of Human Spaceflight, ESTEC, Noordwijk, The Netherlands

With the International Space Station (ISS) partner agencies exploring the possibility of extending ISS operations beyond 2015, ESA is considering enhancements that will reduce the cost of ISS operations.

↑ Water is a precious commodity on the ISS: ESA astronaut Pedro Duque experiments with a water droplet

The ISS is almost complete and has been a home to a permanent crew of six since May 2009, allowing the start of mature operations in support of the utilisation objectives of the ISS partner agencies. The partners are now exploring an extension of ISS operations beyond 2015, at least up to 2020, with a decision on this by the end of 2010.

Since commissioning the Columbus laboratory, ESA is fully entitled to exploitation rights of the ISS but is also responsible for the payment of its share of the ISS Common System Operations Costs (CSOCs). Various items contribute to the CSOCs, but the main ones are the common costs associated with the ground operations of the ISS and the costs required for the logistics support of common systems on the ISS, including crew supplies.

As part of the arrangements with NASA, ESA offsets the CSOC obligation by providing propulsion services and cargo transportation to the ISS with the launches of a number of Automated Transfer Vehicles (ATVs). This is more beneficial to Europe and its space industry than providing NASA with cash payments.

As part of the decision on the extension of ISS operations, ESA is looking at different ways to make cost reductions, and is considering some enhancements that will help achieve this.

The first enhancement, the Advanced Closed Loop System (ACLS), is a system that will be installed in the Columbus laboratory and is meant to reduce the amount of water taken up to the ISS. In this way, a direct reduction of the ESA CSOC obligation is achieved. The second enhancement is an improved design of the ATV. By increasing the number of physical accommodation areas inside for cargo, the vehicle is used more efficiently. This would reduce the overall number of ATVs required to offset the ESA CSOC during the ISS lifetime.

These enhancements will allow additional objectives to be met, such as rebalancing the ratio of development to operational costs of the ISS programme, and developing European capabilities in critical industry sectors. The ACLS development is also beneficial to other future programmes related to the human exploration of space, with also very interesting applications on Earth.

Regenerative systems on the ISS

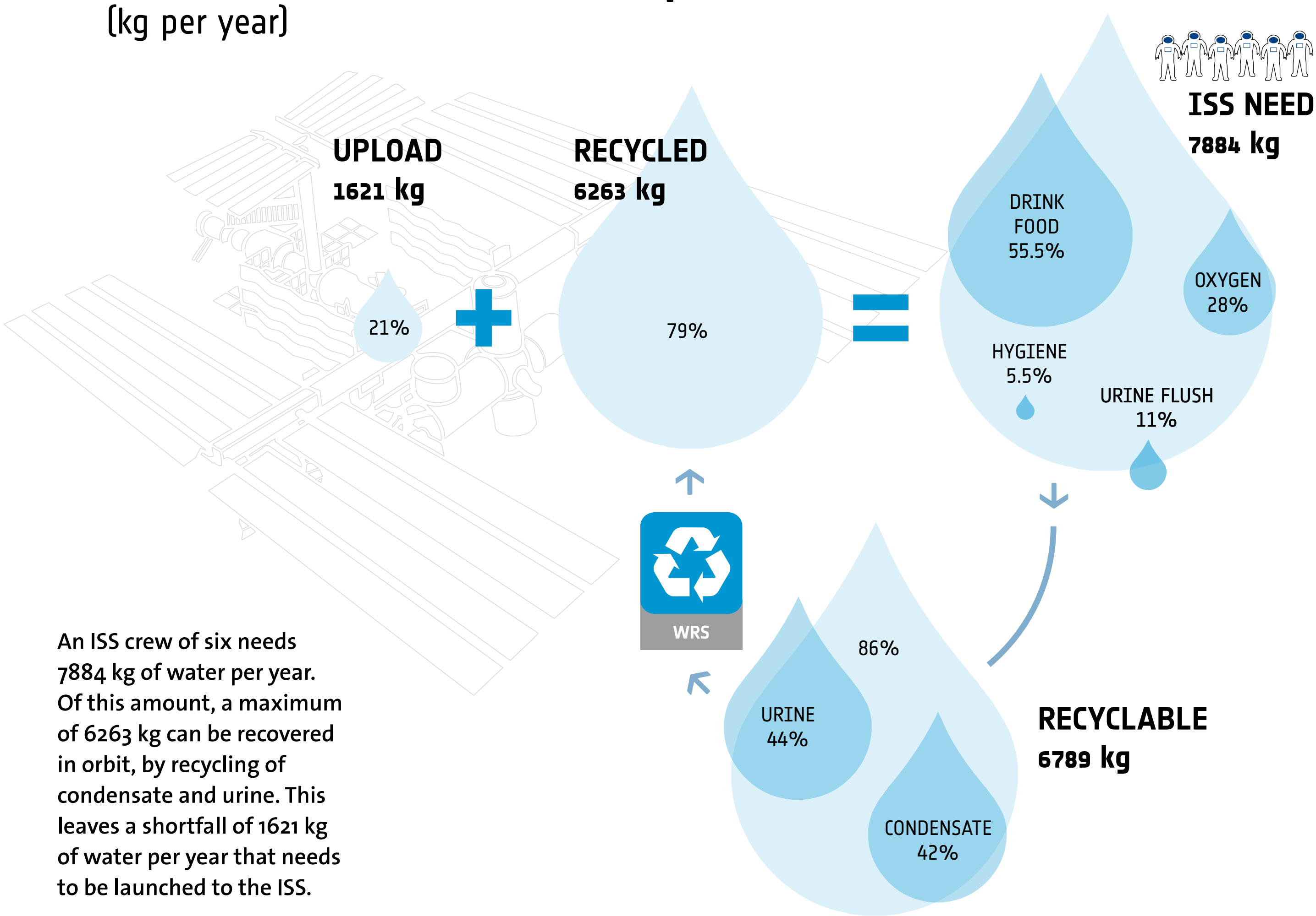
Astronauts require air, food and water for living and working in space. During the early years of manned spaceflight, all resources were carried with the crew in their spacecraft. However, the first long-duration missions, such as Skylab, Salyut and Mir space stations, saw the development and implementation of life-support systems that required less consumables, called 'regenerative' systems.

The ISS features regenerative systems on both the American and Russian sides. Carbon dioxide is removed from the cabin atmosphere with the US Carbon Dioxide Removal Assembly (CDRA) and the Russian 'Vozdukh' unit, without using expendable adsorbents. Condensate from the cabin atmosphere is recycled into potable water by the SRV-K system on the Russian side and the Water Recycling System (WRS) on the US side. Furthermore, the WRS can also recycle urine.

These systems together achieve a very important reduction of the water upload to the ISS, now that a crew of six is on board and with the expected reduction in logistics availability due to the retirement of the Shuttle at the end of 2010. The remaining need for water supply to the ISS from the ground is still very high, mainly for the production of oxygen.

An additional on-orbit recycling possibility exists by reclaiming oxygen from the carbon dioxide exhaled by the astronauts. Until now, carbon dioxide could only be vented into space by the CDRA and Vozdukh systems. This was therefore lost from the ISS, together with the oxygen contained in it. A carbon dioxide recycling system, as proposed for the ACLS and based on the Sabatier principle, would be able to produce water from the reaction of carbon dioxide and hydrogen; hydrogen is a by-product of the oxygen production system through water electrolysis.

→ ISS crew water needs and production
(kg per year)



An ISS crew of six needs 7884 kg of water per year. Of this amount, a maximum of 6263 kg can be recovered in orbit, by recycling of condensate and urine. This leaves a shortfall of 1621 kg of water per year that needs to be launched to the ISS.

The Advanced Closed Loop System (ACLS)

Early system studies had identified the need for closing the ISS air revitalisation loop, and since then ESA has been developing regenerative technologies in this area, working towards a possible implementation on the ISS.

The ACLS can produce water from carbon dioxide exhaled by astronauts inside a spacecraft. This water then is used to produce oxygen for the crew. The ACLS has three major functions:

1. The Carbon dioxide Concentration Assembly (CCA) concentrates the carbon dioxide from the cabin and thus keeps the amount of carbon dioxide within acceptable levels.

2. The Oxygen Generation Assembly (OGA) is an electrolyser that separates water into its constituents: oxygen and hydrogen.

3. The actual recycling step takes place in the Carbon dioxide Reprocessing Assembly (CRA) or 'Sabatier reactor'. Hydrogen, coming from the OGA, and carbon dioxide react over a catalyst to form water and methane.

The water is condensed and separated from the product gas stream and fed back to the electrolyser. Methane is vented overboard together with excess carbon dioxide.

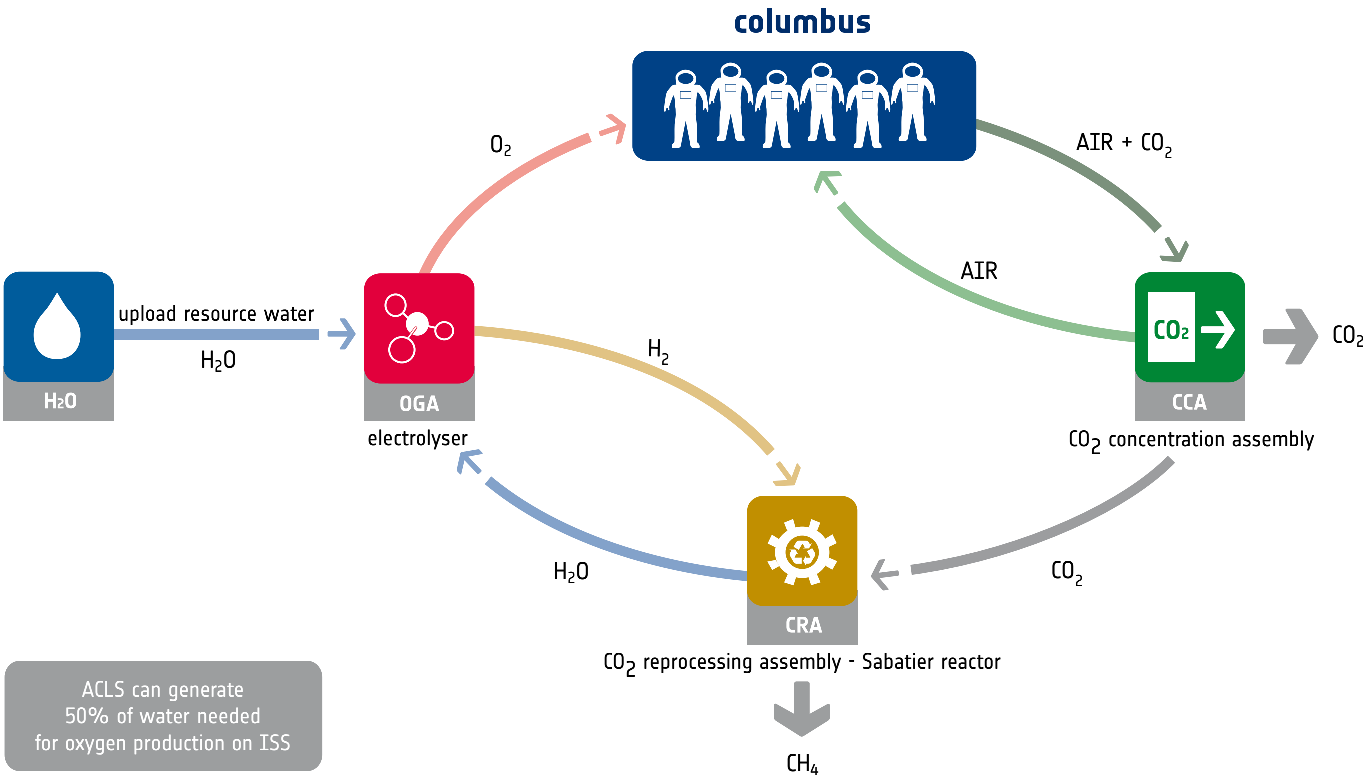
The ACLS system also includes the necessary equipment for internal water processing, ventilation, thermal control, power supply and data handling. The ACLS can generate about 50% of the water needed for oxygen production on the ISS, reducing the logistics demand for this consumable item. Sized for a crew of three, ACLS can save about 450 kg of water upload per year for the ISS.

ACLS has been designed as an integrated system from the beginning; its performance is very competitive when compared to other existing and planned air revitalisation systems.

ACLS will be accommodated in an International Standard Payload Rack (ISPR) that contains all ACLS assemblies. This ISPR will be located in an active rack position inside Columbus.

A few modifications to Columbus will be required for the operation of ACLS: a new interface to the condensate line would be needed for water supply and return.

→ Principle of the Advanced Closed Loop System ACLS



For continued operations, a dedicated vent line may become necessary in order to avoid interference with experiment operations; the feasibility of these changes has been confirmed by industrial analysis.

ACLS is designed for on-orbit maintenance, so that limited-life items or failed units can be exchanged in space. In this way, its operational life can be extended according to the needs of the ISS programme, also beyond 2020. It is likely that ACLS would be launched as an integrated payload rack on the Japanese HII Transfer Vehicle (HTV).

The installation of ACLS in Columbus does pose some challenges, especially because Columbus does not have access to the potable water supply lines of the ISS and its vacuum vent lines are dedicated to payload operations. Supply of water in bags is not a viable option for an operational system; therefore the possibility of using condensate water has been assessed with promising results. Access to the Columbus condensate line can be established, and an initial test with an electrolyser cell indicated sufficient tolerance towards the use of condensate as feedwater. Possibilities for installing an additional vent line for ACLS's product gases (methane and carbon dioxide) have been identified.

← ACLS accommodation in ISPR Rack

ACLS on the ISS

The ISS already is equipped with water regeneration systems for condensate and urine. Recently NASA added a Sabatier-based system for the US segment, but at the time of writing it was not yet operational. A similar capability for the air revitalisation system of the Russian segment is not planned so, for the Station as a whole, the air revitalisation loop is not closed, which leaves room for a system such as the ACLS. The ACLS will also be able to better support increases in numbers of ISS crew, for example during crew change-over periods, and it will add robustness to the ISS by acting as a back-up system when other ELCS systems might not be working.

A Technical Memorandum of Understanding was signed recently by NASA and ESA on the launch and accommodation of the ACLS on the ISS. The ACLS is categorised as 'systems hardware' and its launch and operations will be accounted as ESA system resources already agreed with NASA. The savings resulting from operation of ACLS owing to the reduced upload of water will result in credits to ESA's contribution to the ISS CSOC. The operation of ACLS will be coordinated between ESA and NASA, taking into account the overall operational scenario of the ISS. The Technical MoU also allows ESA to acquire one of the NASA active rack locations inside Columbus to accommodate the ACLS rack, together with the associated resources (power, cooling, data, crew time) required for its nominal operations.

ACLS in support to exploration

Regenerative ECLS are an essential, enabling capability for all future manned missions like extended missions in LEO, lunar outposts or a mission to Mars. ACLS technologies are important building blocks for such future systems that will require an even higher degree of environmental loop closure. The development and operation of ACLS on the ISS will provide essential experience for the development of future life support systems. Part of ACLS technologies can also be applied to shorter missions, like a manned Advance Return Vehicle (ARV), which is currently being studied by ESA.

The demonstration and extended operations of ACLS at the ISS will allow ESA and European Industry to demonstrate achieved technological maturity in a highly visible way. It will increase Europe's footprint not only on the ISS but in human spaceflight in general. It will be an important step towards increased European autonomy in human long-duration missions, which is essential for ESA's cooperation in exploration programmes at international level.

ACLS status and next steps

ACLS is currently in a preliminary design phase. Most of its hardware has been developed to the level of 'Elegant Breadboard' and extensive subsystem testing has been carried out to further optimise the design. An integrated system test of the Elegant Breadboard has confirmed that all systems work together.

Life testing has been finalised on the electrolyser and the carbon dioxide adsorber material and recently a life test of the steam generator started.

Further development activities will cover the detailed design of the water management system, a reduced-size Sabatier reactor, the pressure control for the vent line and the power supply and data management subsystems. For the avionics, a decentralised system with remote data acquisition units is being considered. Such a system may simplify the system harness, and also the integration and test of the ACLS rack.

A further ACLS project bridging phase (phase C2) is under preparation which will cover the establishment of a full industrial consortium and a Preliminary Design Review in 2011. This will allow the ACLS project to move swiftly into the full development and implementation phase once ESA's ISS Programme for period 2011–20 is approved. The full development of the ACLS will be part of the proposal to be presented to ESA's Member States at the end of 2010 to cover for the extension of the ISS operations. According to the present planning ACLS will be ready for launch towards the ISS in early 2015.

Enhancements of ATV

ESA and NASA agreed that payments of CSOC costs (and ESA's own transportation requirements) will be met by providing propulsive services and cargo launches to the ISS with ATVs. Up to 2015, ESA will provide five ATVs (ATV-1 to ATV-5) for a cumulative total equivalent 'up-mass' cargo capability to the ISS of 27 697 kg

On 29 September 2008, ESA's first ATV vehicle, *Jules Verne*, completed its mission and demonstrated ESA's capability to reliably provide such logistic services to the ISS.

The most important ATV mission objectives are: propulsive support of the ISS for reboost, attitude control, Control Moment Gyro (CMG) desaturation and debris avoidance; delivery of dry cargo, water and gases (air, oxygen, nitrogen); refuelling of ISS with Russian propellant; and waste disposal of solid and fluids

→ Comparison in size of ESA's ATV with the Russian Progress spacecraft

The capability of the current ATV design allows a maximum of 7700 kg to be carried up to the ISS, in any combination of the following items, augmented by the mass of the structures necessary to accommodate the dry cargo:

- 1500–5500 kg of dry pressurised cargo for crew supply, experiments and logistics;
- up to 855 kg of water, in tanks of 260 kg each;
- up to 100 kg of one gas type, or up to 67 kg of one gas type plus up to 33 kg of another gas (either air, oxygen or nitrogen)
- up to 860 kg of propellant, comprising 306 kg of fuel (UDMH) and 554 kg of oxidiser (nitrogen tetroxide) for ISS refuelling (Russian propellant)
- 1821–4000 kg of propellant for propulsive support (European propellant)

The ATV is able to take away from the ISS for disposal 1500–5500 kg of waste cargo in pressurised environment, and up to 840 kg of liquid waste in the water tanks.

Increased ATV cargo capability

The implementation of enhancements currently under consideration would allow for a significant increase of the dry cargo that can be accommodated and launched on the future ATVs, given their currently advertised manifests. For ATV-3, the additional cargo could be up to 500 kg, and for ATV-4 or ATV-5 up to 1150 kg each. This increase in mass performance would cover part of ESA's obligation in the common cost of the ISS exploitation beyond 2015 for a relatively small investment.

Enhancements in detail

After the formal approval of ATV development at the ESA Ministerial Council in 1995, assumptions had to be made during its design to define the cargo combination configuration that the vehicle had to be able to provide. The result is the current ATV vehicle.

However, the ISS needs in terms of logistic supply have evolved over the years, driven by variations in the orbital environment (solar activity cycles affecting propellant needs), changes in logistic capabilities of the partners (Shuttle retirement, Commercial Resupply System development completion, etc.) or ISS hardware maintenance needs.

All in all, for the period up to 2015, NASA prefers the resupply of dry cargo and gases, with less emphasis on propellant resupply or propulsive support.

This was realised soon, but only limited enhancements could be achieved in time for the second ATV, *Johannes Kepler*, which was already well advanced in its production and could therefore benefit only from two changes: the increase of Ariane 5 launch capability from 19 700 to 20 050 kg; and the use of Integrated Light Racks, which are about 50 kg lighter than the original racks.

Now with the ISS logistic supply phase in full swing, and with more time to implement changes, further enhancements have been identified to optimise ATV use to suit the more important logistic needs of the ISS. Indeed, the NASA future cargo manifests of ATV-3, -4 and -5 are not the same as the cargo assumptions that ATV development was based on, resulting in a non-optimal use of the ATV capabilities.

The assumptions that are not in line with current ATV loading manifests relate to the dry cargo average mass density, the minimum propulsive propellant needed, and the need for refuelling propellant and water.

Dry cargo average mass density
While the ATV was being designed, it was assumed the dry cargo density for the design of the racks was 500 kg/m3. Experience gained from the resupply of the ISS with Jules Verne, but also with other logistics vehicles, such as the Multipurpose Logistics Module (MPLM) and Progress, show that the average density of the dry cargo bags is around of 200–250 kg/m3.

This lower cargo density has two negative impacts on the performance of the ATV. First, it means that the racks are over-designed, and hence overweight – ATV could have otherwise carried this weight as cargo. The lower density also results in a much larger volume of bags for a given weight of cargo, for which the current ATV design cannot provide enough accommodation locations. To address both problems, new secondary structures to replace or complement existing ones are under investigation.

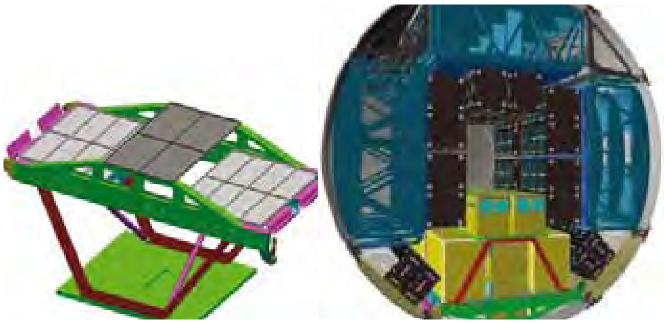
In the current ATV baseline design, dry cargo bags can only be accommodated inside ILR racks and on adaptor plates attached to the front of the ILR racks. With a cargo density of 250 kg/m3, the maximum cargo weight that can be accommodated in ATV is of the order of 3200 kg, well below the maximum capability of 5500 kg.

This is achieved with a vehicle outfitted with eight ILR racks incorporating adaptor plates to attach the maximum number of bags front-mounted to the racks. To improve the situation, the following improvements to the internal structures of the pressurised section (the Integrated Cargo Carrier, ICC) are proposed. They consist mainly of an increase of the locations where dry cargo can be attached.

One area that is available to accommodate additional dry cargo is the aft cone of the pressurised section. It is proposed to develop a platform (Aft Cargo Plate) that could accommodate up to 338 kg of dry cargo.

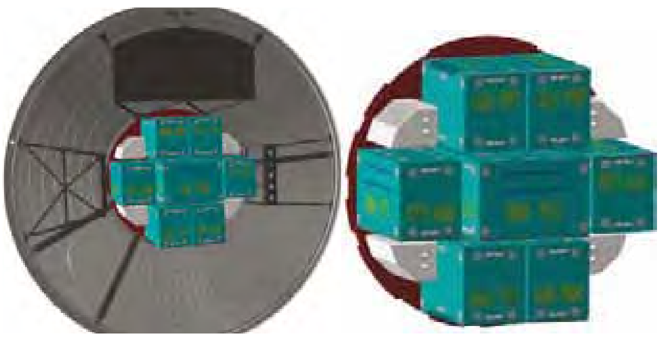
Another type of stowage platform is the Enhanced Integrated Stowage Platform (EISP). In 2008, NASA requested ESA to develop hardware to launch up to 900 kg of cargo in the empty racks bays of Node-3. For that purpose, Thales Alenia Space Italy developed the Integrated Stowage Platform (ISP). This attached to the rack interface of a pressurised element and was able to carry dry cargo bags fixed in place with straps. The EISP, now being considered for future ATVs, is an evolution of the ISP, providing equivalent dry cargo accommodation capabilities to that of an ILR.

With the introduction of the EISP, the volume in the lower 'standoff' area becomes accessible when the EISP is unloaded in orbit and can be used to accommodate more bags. Such access is not possible with ILR racks. Standoff Support Frames, able to hold 67 kg of dry cargo are proposed as further enhancements.

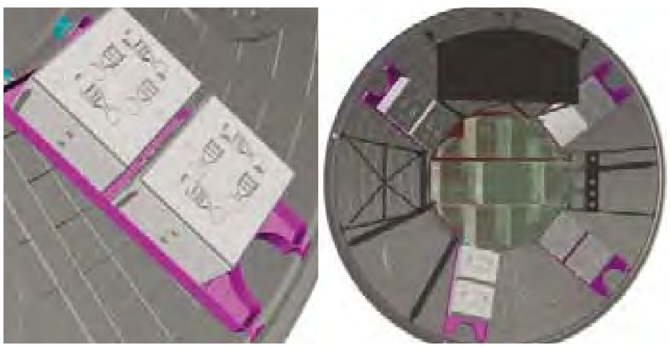


Left, Enhanced Integrated Stowage Platform (EISP), right, EISP loaded with dry cargo bags in bottom bay and with ILR in the top, left and right bays, both having adaptor plates for front mounted bags

A maximum of four frames can be installed on the deck side of the pressurised ICC, since the overhead standoff areas are already occupied by the standoff secondary structures supporting air diffusers, power harnesses and lighting equipment that can not be blocked.



Left, ACP installed in Aft Cone of ATV pressurised section, right, ACP loaded with dry cargo bags



Left, Aft Cargo Frame (ACF) for accommodation of dry cargo bags, right, layout of four ACFs on aft cone

Still more space can be found in the aft cone area to accommodate additional bags. Aft Cargo Frames (ACFs) are being proposed to accommodate 26 kg of dry cargo, with room for up to four frames.

Minimum propulsion support

ATV-4 and ATV-5 will fly in a period of low solar activity, during which the ISS requires less propulsive support. The NASA propulsive support analysis shows that the ISS will need less than 1500 kg of propellant in that period, but some technical constraints of the ATV design mean that a minimum of 1821 kg has to be loaded. Hence, at least 321 kg of propellant that is not needed has to be flown instead of useful cargo.

This can be solved by fitting of bubble traps in the lower tanks of the vehicle and requalifying the Guidance, Navigation and Control (GNC) system of the spacecraft (for changes in its centre of gravity and inertia properties that now fall outside the qualified performance envelope). While the first item is not a big issue, the second is more delicate. Indeed, the saved propellant mass will be replaced by fluid or dry cargo located on the other side of the vehicle.

Considering the risk related to the GNC qualification and the fact that it might not be possible to use the saving in mass for additional dry cargo because of limited accommodation volume, it was decided not to proceed with this at this time.

Refuelling propellant

Similarly to the propulsive support, no refuelling propellant is expected to be required for ATV-4 and ATV-5. The Refuel Propellant System (RFS) is a standalone system, and therefore it should be possible not to install it and save the 420 kg mass of this system in addition of the 860 kg of refuelling propellant mass.

Preliminary investigations showed that the removal of the RFS from the ATV baseline is feasible with acceptable impacts. However, for the ATV-4 and ATV-5 cargo manifests, the benefit of this modification is limited by the capability to accommodate the additional volume of dry cargo. In addition, given the resulting marginal benefit in terms of dry cargo increase and the fact that the capability to load refuelling propellant would be lost if a last-minute change of the cargo manifest occurred, it was decided, in consultation with NASA, to keep the RFS hardware in the baseline design of ATV-4 and ATV-5 even though there is currently no plan to use it.

↓ ESA astronaut Jean-François Clervoy inside ATV *Jules Verne*'s pressurised section, showing the cargo racks and part of the aft cone where more cargo can be stored

↗ From left, Expedition 17 crewmembers Oleg Kononenko and Sergei Volkov practice unloading cargo during the 'ATV Vehicle Familiarisation' training at EAC, Germany; the ATV Cargo Bench Review held in Turin, Italy, in 2007, is that last chance to check the 180 kg of European dry cargo

Water
The cargo manifest of ATV-2 does not include water and, assuming the ISS water regeneration systems work properly, the water request for the remaining ATVs is expected to be low. However, the manifest of a flight is not known at the time when the water system is integrated on the spacecraft. The ability to install or remove the water system so late in the ATV production flow, when the manifest is known, is in the current design, although it would allow 100 kg to be saved in case the manifest does not include water. The modifications to allow for a late installation or removal of one or all of the three water tanks consist of:

- making a cut-out in the platform on which the tanks are accommodated;
- introducing Quick Disconnects in the fluid lines for easier connection/disconnections;
- rerouting of piping to all access points for integration activities.

Such modifications are fairly simple, but the benefit of introducing them is still to be weighed against the impacts, even if these are not considered to be significant.

Micrometeoroid and Debris Protection System (MDPS)
In addition to modifications driven by the evolution of the cargo manifest, improvements in the vehicle's performance are also under consideration. A more-accurate characterisation of the micrometeoroid and debris environment, together with the availability of more-sophisticated analytical tools to predict penetration risk, allows a lighter protection system to be considered for the vehicle. With a lower vehicle mass, we can increase of the cargo mass capability.

↓ ESA astronaut Jean-François Clervoy, senior advisor to the ATV programme, performs a Late Cargo Access test at ESA's research and technology centre, ESTEC, in Noordwijk

↗ From left, technicians loading dry cargo bags at Europe's Spaceport, Kourou, just before launch of ATV *Jules Verne*, December 2009; Kononenko and Volkov unpack cargo for real during Expedition 17 in 2008

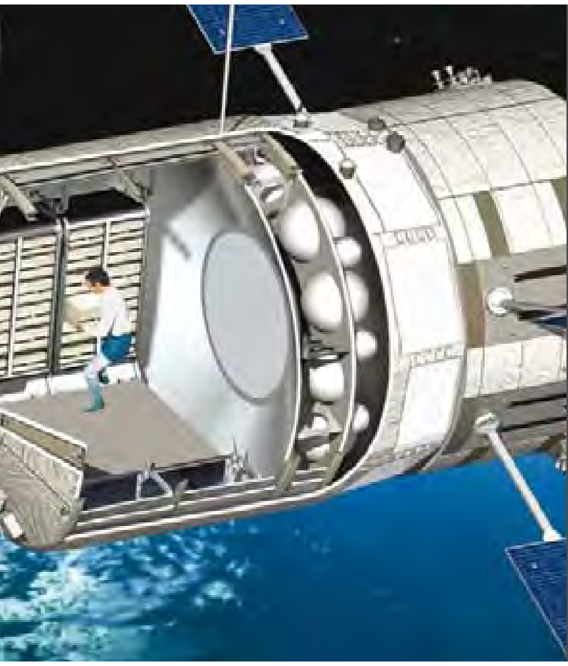
The ATV MDPS consists of one sheet of aluminium, 1.6 mm thick, and a blanket made of multiple Kevlar and Nextel layers. The thickness of the aluminium sheet can be reduced to 1.2 mm and save a mass of around 60 kg.

Recent analyses made with the latest debris environment and analytical tools have shown that results from the verification of the ATV were too conservative and there is room for optimisation of this sub-system.

Late Cargo Access (LCA)

The design of ATV requires that most of the dry cargo is loaded into the ICC, the pressurised section, before the final assembly of the vehicle (i.e., fitting the ICC to the Service Module). This is performed before the assembled vehicle itself is installed on the Ariane 5 rocket, which means that nearly all of the dry cargo bags need to be available for integration well in advance of the launch date.

Only a limited number of bags can be installed while the full ATV is on top of the Ariane 5. This is called the Late Cargo Access (LCA) and is essential for obvious logistical reasons. However, the proposed enhancements to accommodate more dry cargo in the ICC are not compatible with the existing LCA Mechanical Ground Support Equipment. The LCA hardware and processes have to be revised to preserve and improve the capability, a result which would be very much welcomed by NASA to meet the operational needs of the ISS, which often require loading of cargo late in the resupply process.



← For a modest investment, a more-efficient use of the ATV volume can be achieved

Conclusion

As part of the decision to extend operations of the ISS beyond 2015 and up to 2020, ESA Member States are asking to reduce the costs of operating the ISS and to rebalance the ratio of development to operational costs of the ISS programme. The two enhancements presented here address these requests in different ways.

The ACLS is a life-support system that will be installed in the Columbus laboratory and is meant to reduce the amount of water taken to the ISS. Apart from reducing ESA's CSOC obligation, ACLS is a development project with a high technological content, which fosters European industry in a critical sector that is also essential to future human space exploration programmes, as well as applications on Earth.

Design improvements of the ATV ICC will increase the number of places where cargo can be stored, resulting in a more-efficient use of the ATV volume. For a modest investment, the additional cargo that can be launched on future ATVs will establish a CSOC credit for ESA to be used in the new period of ISS operations starting in 2016. ■

↓

ESA astronaut Hans Schlegel outside the European Columbus laboratory during its installation on the ISS in 2008

→ MISSION 'POSSIBLE'

Creating a real operational outpost in space

Bob Chesson, Alberto Novelli & F. Castel
Directorate of Operations and Infrastructure, ESTEC, Noordwijk, The Netherlands

Helmut Luttmann
EADS Astrium Space Transportation, Bremen, Germany

The task of supporting the European part of International Space Station (ISS) operations seemed at times to be a 'Mission Impossible'. But, with streamlined processes and a change in mindset from development to continuous operations, European teams report a successful first two and a half years.

The huge ISS programme, which represents the largest scientific cooperative endeavour in history, brings together five space agencies representing the United States, Russia, Canada, Japan and 10 European countries.

In switching from an on-orbit construction project to an operational programme, the ISS has had to overcome some difficult challenges. Not only did the task require running both phases simultaneously for almost a decade, but also the construction itself had a history of delays, making the job even more difficult for all the partners. After more than a decade of development and numerous frustrating postponements, such as the delay in launching first Russian module in 1998 and the Columbia tragedy of 2003, the Columbus laboratory was launched in February 2008.

↑ The launch of Columbus on board Space Shuttle *Atlantis* STS-122 in February 2008

Background to Columbus operations

In 1996, ESA awarded Astrium the development contract for the Columbus module, Europe's main contribution to the ISS infrastructure. When Europe's ISS exploitation programme was approved at the Ministerial Council in Brussels in 1999, this utilisation programme adopted a new approach, to outsource the operations activities to industry. This strategic choice addressed three objectives: to reduce costs by procuring commercial services, with performance-based incentives and penalties; to continue the task of industry after the end of ISS development and to retain the know-how of the teams that had developed ISS operations systems over a lengthy period of time. These objectives marked a major change of philosophy and carried with them many unknown factors.

> **"Columbus operations can be compared to an iceberg, only a small part of their huge structure visible to the outside world."**

↑ ESA astronaut Léopold Eyharts flew with Hans Schlegel on STS-122, participating in the installation and configuration of Columbus. He remained on the ISS as the second ESA astronaut to join a resident ISS crew, Expedition 16, and devoted a large part of his time to activation and checking of Columbus and its racks to start up actual science experiments

After a dozen years of effort by 41 companies in 14 European countries, under the prime contractor EADS Astrium Space Transportation, the challenge was to sustain – immediately after the delivery of Columbus to the ISS in orbit – continuous operations of one of the most complex labs ever launched into space. The learning curve was steep; after all, the ISS was still in the assembly phase with only a three-man crew mainly dedicated to the assembly and maintenance process.

The initial operations proved to be difficult because, although the Columbus systems performed exceptionally well, the start of payload operations in Columbus was hampered by numerous anomalies with both the payload facilities and the experiments, as well as a shortage of available crew time.

However, within two years of Columbus's launch, crew time dedicated to science and technology research with ESA experiments has improved from 6% in 2008 to 49% in December 2009 without a single interruption in the operations of Columbus or and the ground segment.

"This is a considerable achievement when you consider the enormity of the operations involved. Most of this operation is done behind the scenes. Columbus operations can be compared to an iceberg, only a small part of their huge structure visible to the outside world," says Bob Chesson, Head of the Human Spaceflight Operations Department in ESA's Operations and Infrastructure directorate.

↑ Home of the Columbus Control Centre, at DLR's Oberpfaffenhoffen site near Munich (DLR)

The complexity of the task

The support of the Columbus operations programme is not confined merely to the flight module. It also includes a large and complex ground infrastructure, consisting of a Columbus Control Centre (COL-CC) at Oberpfaffenhofen, near Munich, connected to three partner control centres, three engineering centres and nine User Support and Operations Centres (USOCs), plus the training centres at the European Astronaut Centre in Cologne and Johnson Space Center in Houston, and the ATV Control Centre during ATV missions.

"We have to take care of the maintenance and operations of the hardware at 20 locations or so, from Houston to Huntsville, to Moscow and the nine USOCs dotted all over Europe," said Hiltrud Pieterek, ESA's Head of ISS Operations Support Division.

In order to ensure a round-the-clock operation, more than 70 operators and engineers of the Industrial Operator Team (IOT) are on duty in COL-CC. They prepare and execute the complex operations required to run Columbus and its payloads. This means hundreds of thousands of working hours invested on Earth to support a platform for experiments in weightless conditions and a safe and efficient working environment for the astronauts.

To provide a robust organisation for ISS operations support, EADS Astrium organised its effort as a number of operations services with the following tasks and locations:

- Mission and increment integration in Bremen, Germany, and Leiden, The Netherlands
- Engineering and operations integration for the Columbus systems and payloads in Bremen and Friedrichshafen in Germany and Turin, Italy
- Astronaut training at the European Astronaut Centre in Cologne, Johnson Space Center in Houston and Star City in Moscow
- Mission operations and planning at COL-CC
- Ground segment operations at COL-CC and in Bremen
- Product support in Turin and Bremen

The overall IOT consortium, which includes EADS Astrium prime and subcontractors, involves about 600 people. The EADS Astrium prime and overall programme management is based in Bremen.

This amazing feat can be compared to 20 groups of musicians located in various parts of the world with different responsibilities playing as one orchestra, each playing its part in time and without hitting wrong notes. A wrong note would impact the science carried out in Columbus.

The orchestration of engineering and logistics services presents its own challenges, considering that the hardware of the various ISS partners must be launched in timely manner from four different spaceports by four different launch vehicles, each with its own constraints and process peculiarities.

"Our role with the IOT team is like a 'garage and a truck transporter'. We make sure that all the hardware needed is ready and properly configured; for some complicated equipment we also provide a manual like you have for a new car," says Hiltrud Pieterek, whose team supervises the relevant services provided by the IOT.

↑ Left to right: Jesús Jiménez, Head of ESA ISS In-orbit Infrastructure Maintenance and Operations, Hiltrud Pieterek, Head of ISS Operations Support Division, Bob Chesson, Head of the Human Spaceflight Operations Department in ESA's Operations and Infrastructure directorate, and Alberto Novelli, ISS Operations Manager, during a teleconference with the ISS partners

Each ISS increment crew starts training on the specific tasks to be performed more than a year before their launch. This means that crews train with different hardware in USA, Canada, Russia, Europe and Japan. When big delays occur in the preparation of programmes of different space agencies, it requires heavy and costly logistical reshuffles that create 'snowball' effects for the schedule.

To handle such complex task as supporting the whole Columbus operations programme on the long term has been a challenge that ESA has never faced before. With the innovative IOT concept, ESA remains in control of the programme, setting and updating the objectives as well as taking care of the interfaces to the international partners, while IOT does the detailed implementation and provides the service.

> **This constant search for excellence remains a driving force in the ISS operations programme that never stops, 24 hours a day, 365 days a year.**

"IOT was a first for ESA and it was a first for EADS Astrium. Even if the road has been sometimes hard, we are pleased with what has been achieved. IOT gives a certain stability to the programme. It is an end-to-end responsibility that has worked well for both sides," says Alberto Novelli.

An amazing learning curve

"The ambitious objective for Europe was to start Columbus with four internal payload facilities and two external. We had to transition from normal working days to continuous operations. We had to do some integration at the same time as we were starting the facility operations," says Helmut Luttmann, EADS Astrium's ISS Exploitation Programme Manager.

Another difficulty was in 'real-time' engineering: meaning how to solve problems and at the same time find immediate ways to work around them to continue operations safely and without impacting on the crew's busy timeline that required split-minute timing. When, for example, European Technology Exposure Facility failed, it took three weeks to find a time slot to do some troubleshooting because of the crew availability and the priority of other tasks on board the Station.

"At the beginning of Columbus operations and utilisation, it was hectic because the teams were overloaded with failures and bugs. Even if they were prepared for most, they did not expect so many at the same time. During the first six months of operations, we learned about 300 lessons and new ways to improve our processes," says Luttmann.

↑ Frank De Winne works with the 'Investigating the Structure of Paramagnetic Aggregates from Colloidal Emulsions' (InSPACE) experiment in the Microgravity Science Glovebox in Columbus during his OasISS mission in 2009

A new efficient ESA/industry partnership

The experience gained so far with Columbus has also made it possible to shape the cooperation between the different ground teams in a more efficient way, and to develop concepts for future improvements. These are Flight Control Team (FCT), the Ground Control Team (GCT), the European Planning Team (EPT) and the Engineering Support Team (EST). This increased efficiency was essential for handling the intensified payload operations on board Columbus that began when ESA astronaut Frank De Winne joined the crew in May 2009 for his OasISS mission.

Increasing efficiency in engineering integration and operations was built into the contract between ESA and IOT negotiated in early 2008. The negotiated annual price for the contract was steadily reduced from 2008 to 2010 and most of this reduction had to be found in the engineering teams. "We were able to achieve a 20% reduction in the size of the engineering teams from 2008 to 2009 and then a 10% cut from 2009 to 2010, but this is the limit," says Helmut Luttmann.

Feedback from astronauts, scientists and user centres has been valuable. After each increment, a comprehensive 'lessons learnt' exercise was conducted and, consequently, reviews of the integration and operations processes were conducted to sustain a continuous improvement. For Frank De Winne, debriefings and postflight tour visits are essential because they allow constant improvements of spaceflights and support operations.

"There is always room for improvement. Our feedback will serve support teams as well as future crews. This synergy is necessary if we want to keep running this state-of-the-art laboratory in a smart way for 10 or 15 years or more. Now, if we want in the long-term to increase the utilisation of the ISS and at the same time to reduce significantly the costs, we really have to look for new ideas," says De Winne.

"There is always room for improvement. Our feedback will serve support teams as well as future crews."

↑ The crew of Soyuz TMA-15 visits ESA's Columbus Control Centre. From left: Thomas Uhlig, DLR Flight Director; Bob Thirsk; Roman Romanenko; Sergi Ginebrera, Columbus Flight Controller; Frank De Winne and Katja Leuoth, Columbus Operations Coordinator

"This constant search for excellence remains a driving force in the ISS operations programme that never stops, 24 hours a day, 365 days a year," says Alberto Novelli, ESA's ISS Operations Manager and in charge of the IOT contract at Human Spaceflight Operations.

Jean-Christophe Grenouilleau, one of the ESA Mission Directors in charge of Frank De Winne's mission, says: "With combined efforts from an ESA/industry team, we have quickly built up some new methods and ways of working which are very efficient. We are very proud of the results and we could even think about exporting this model to other fields."

"After the six-month flight of our astronaut Frank De Winne, we have gained a lot of experience. Frank's feedback has improved even more our ISS operations, and we'll get smarter in terms of processes and efficiency," said Bernardo Patti, ESA's ISS Programme Manager.

A small step for a crew, a giant leap for operations

"In May 2009, when I arrived with my crew, the ISS resident crew doubled in size from three to six astronauts. This allows astronauts more time to operate the experiments, an increase from about 30 to about 100 hours of astronaut work hours per increment for ESA experiments," said astronaut Frank De Winne.

This in turn meant that more work would be required to prepare the additional experiments and more ground-based support would be required during their operation. De Winne's presence on board the ISS also brought about a substantial increase in the Columbus Control Centre's workload, since it has a major role in supporting European astronauts.

No more Space Shuttle

After another two scheduled missions, the Space Shuttle fleet will be retired. This will have a significant impact on the ISS programme. For example, download capacity will be severely affected, and failed hardware units will not be able to be brought back to Earth for repair then returned, as has been the practice until now.

"There is a race against time to launch as many spare parts as possible. However, without any dedicated storage room on ISS, all the ISS modules are getting full of large stowage bags which sometimes fill working areas," said Jesús Jiménez, ESA's Head of the ISS In-orbit Infrastructure Maintenance and Operations.

"The good news is that logistics will be easier to schedule without the frequent delays in the launches of Shuttle flights. Soyuz and Progress vehicles are normally launched on time because Soyuz rocket launches are not sensitive to weather conditions, owing to the requirements imposed in their former application as ballistic missiles!" said Reinhold Ewald, Head of the Flight Operations Division at the Columbus Control Centre.

A cultural shift

Even with all the obstacles encountered at the beginning of Columbus operations and despite the limits of a tight budget, the ISS operations have never stopped or been severely disrupted. On the contrary, the learning curve accommodated all the operations tasks and requirements. Against the odds, the IOT contract succeeded in providing an efficient end-to-end service for the preparation of the various flights and increments.

↑ Former ESA astronaut Reinhold Ewald, now Head of the Flight Operations Division within ESA's ISS Operations department at the Columbus Control Centre. He directs a team of ESA Mission Directors who managed the Columbus delivery flight in 2008 and subsequent Columbus activities

"The next challenge is to transition to long-term operations and to learn to be cost-efficient for the best use of this unique orbital research facility."

The measure of the service performance is one of the major new features of the IOT concept. ESA and EADS Astrium agreed to conduct three performance reviews per year. ESA assesses the quality of the service and the payments are made accordingly, with a possibility for ESA to retain 10% in case of poor performance.

"We are improving work efficiency and getting a better feeling for the team size required. This was the result of our three-year contract requiring us to make a 10% reduction in the annual cost of the contract after the first year, and then a further 5% after the second year," says Helmut Luttmann.

But even with constant improvement and new methods, some limitations remain. "In working with NASA, we tried to simplify the processes and the amount of paperwork required. But still, sometimes we have five Astrium individuals interfacing with sometimes 50 NASA people on the other side of the Atlantic and, although this works most of the time, we are sometimes overloaded because of the 1:10 ratio," says Helmut Luttmann.

"NASA has a way of working which is highly manpower intensive and it is not always easy to match such a team size," says Bob Chesson.

Even under budget constraints, the ESA/industry partnership was already able to achieve a substantial result by reducing the annual operations between 2007 and the end of the decade. More reductions might be possible, but they become increasingly difficult. ESA and EADS Astrium managers agree: "There is a point where, if you cut too much on operations, you take a high risk in not fully supporting the science programme, and this is one of the main purposes for which ISS was built," says Alberto Novelli. With such state-of-the-art technology, technical failures are inevitable, and that requires intensive maintenance work to avoid them.

↑ The Columbus Flight Control Team consists of several engineers working under the on-shift Columbus Flight Director (COL FLIGHT). With the callsign 'Munich', they are in direct contact with the flight directors at the other ISS Mission Control Centres in Houston and Moscow. The Flight Director is also in contact with the Ground Operations and Engineering teams at Col-CC, ESA Operations Management and the Crew Medical Support Office at the European Astronaut Centre (EAC), Cologne, Germany. EAC also provides the 'Eurocom' mission controllers to the Flight Control Team, who maintain voice contact with the ISS crew and communicate all necessary information prepared by the FCT

Next challenges

In decade-long programmes such as the ISS, with an inevitable turnover of personnel, there is a continuous need to transfer the know-how of the early developers to successive generations of operators.
Finding a cost-effective solution to this classic 'knowledge management' problem will be one of the key challenges of the coming years. To cope with this problem, in addition to their internal measures to provide solutions, the IOT team employs expert consultants to help the know-how transfer.

To meet the budget pressure put on Operations by programme management, the next phase of the IOT contract, covering the period 2011–13 will need to perform more cost-reduction measures. Providing an adequate service to the users while respecting the safety requirements of a human spaceflight programme is the biggest challenge that the programme has faced in its long history.

ESA has already asked Astrium to submit a proposal for this next phase, and it will be negotiated in the fall with a possibility for extension until 2020.

'Now with the completion of the ISS and the programme stabilised until at least 2020 or 2025, the next challenge is to transition to long-term operations and to learn to be cost-efficient for the best use of this unique orbital research facility," said Bob Chesson.

In reflecting on ESA's participation in the ISS programme, Bob Chesson compares it to having children. "Preparing for ISS operations was a bit like preparing to have a family. We attended all the pre-natal classes, but nothing prepared us for what it would be like. The birth was exciting, emotional and hectic. Now with the kids, Columbus and ATV, to take care of on a continuous basis, our lives have changed forever. But it was an experience that none of us involved would have missed for the world, and we still have lots of exciting things to look forward to." ■


RISK
MANAGEMENT

→ EXPECTING THE UNEXPECTED

Agency-level risk management in ESA's strategic and long-term planning

Maria-Gabriella Sarah & Andrea Vena
Strategic Planning and Control Office
Director General's Policy Office, ESA Headquarters, Paris, France

Space programmes face risks, not only from technical challenges or extreme environments, but also from many unexpected situations on Earth, such as project delays, cost overruns or even from legal barriers between countries.

Running any kind of business can be a dangerous occupation with many different types of risk. Some of these potential hazards can destroy a business, while others can cause serious damage that can be costly and time-consuming to repair. Despite the risks implicit in doing business, chief executives and risk managers – no matter what the size of the business, from small to corporate giant – can prepare for them, if they know what they are.

That's why risk management is a major component of ESA's management activity. Its purpose is to systematically identify and assess future events, situations or circumstances that may occur, and which could adversely affect the achievement of our objectives. Then we can plan and implement, in a cost-effective way, appropriate arrangements to prevent those 'risks' from arising, to prevent their consequences and to ensure the necessary reporting to allow overall supervision.

The Director General's Policy Office, following the Risk Management Policy, is implementing Agency-level risk management in support of strategic planning and decision-making processes to guarantee ESA's capabilities and preparedness to set objectives and pursue their success.

The Risk Management framework

Risk Management is in place at ESA at each management level. The Risk Management Policy, in force since May 2007, defines principles for ensuring that this is done in a consistent way across ESA, in a reliable and properly documented process. It therefore sets out ESA's approach to risks, for example risk criteria, roles and responsibilities, as well as reporting requirements.

Risk management is organised and carried out either at the level of programmes, projects and major activities, or at the level of functions and departments, depending on the project or the nature of the activity. For function-based activities, risk management takes into account the risks to their own function objectives, such as for planning, resource management, responsiveness, cost efficiency, reporting, information dissemination and ability to control the processes. Risk management is also performed directly under the Director General and Directors' responsibilities for their strategic activities.

In particular, the Director General is provided with visibility of all relevant risks. He takes risk management decisions regarding the critical risks. He refers risks to the ESA Council as necessary, among others the preparation of strategic and programmatic objectives and planning assumptions for the ESA Long-Term Plan.

↑ To manage risks associated with agency-level strategic or multi-Directorate objectives, ESA's Director General Jean-Jacques Dordain required a risk management framework to be in place as the tool for an early identification and treatment of those risks

To manage risks associated with agency-level strategic or multi-Directorate objectives, the Director General required a risk management framework, consolidated at agency-level, to be in place as the tool for an early identification and treatment of risks to ESA's strategic objectives. This framework will provide the Director General and Member States with supporting elements for long-term planning.

The agency-wide assessment of risks potentially impacting the long-term objectives and linked to programmatic and corporate activities will be included in the ESA Long-Term Plan. This will support the strategic planning process and Member State decision-making by granting a full picture of all risks inherent to the long-term vision of ESA.

In accordance with the Risk Management Policy, an agency-level Risk Management Plan was defined according to the European Cooperation for Space Standardization (ECSS) standard (ECSS-M-80) for the purpose of identifying requirements and setting up the appropriate framework for agency-level risk management.

To refine requirements and verify their adequacy to the Director General's and Member State expectations, a pilot phase was initiated in the summer of 2009. The pilot phase assessed the overall risk exposure of ESA, considering not only those risks induced by its main programmatic activities, but also those inherent to its external environment (for example, interactions with other organisations within or outside the space sector) or those relating to its governing framework. The pilot project also supports the ISO 9000 certification process, which requires a suitable risk management framework to be in place in the organisation.

Agency-level Risk Management Framework

Building a Long-Term Plan for the ESA's programmes and activities may be effectively supported by having in place a risk management framework allowing a global vision of risks with a long-term perspective. Risk management is therefore a valuable tool in support of decisions to be taken in the long run, providing an additional means to the achievement of the long-term strategic objectives.

The primary objectives of having a risk management framework are to:

- allow consolidation, at agency level, of risks identified and managed at Directorate level;
- assess the resulting risk scenarios to consolidate strategies and policies, and support mid- and long-term planning;
- enhance the risk visibility for Member States in the context of the preparation and the endorsement of the ESA Long-Term Plan;

- provide the Director General with an aid to the decision-making process regarding the implementation of agency-level mitigations actions relevant to critical risks; and to
- foster effective communication on risks at the relevant levels in ESA, enhancing transparency and sharing lessons learned among the different Directorates.

The agency-level risk assessment includes an initial step of identification of potential areas of concern for ESA, for example the 'sources' of risks, as well as the 'domains' impacted by the potential materialisation of these risks. A risk can have multiple sources and impact on multiple domains.

Sources of risks

Programmes/activities
All issues related to an individual programme/activity with impact on the whole agency;

Managerial
All issues related to the management of ESA programmes e.g. ESA strategy, policy and regulations, ESA's procedural and human resources aspects, as well as internal communication within ESA and all ESA infrastructure management;

Governance
All issues related to the decision-making process within ESA, related to the industrial procurement policy of ESA, geographic return issues, funding issues;

ESA's environment
All issues related to other key space players outside ESA, i.e. Member States, third parties, other space agencies, European industry, the EU and the general public.

Domains of impact (may be affected by risks)

Financial capacity
ESA's budgetary requirements, projected income, contingencies

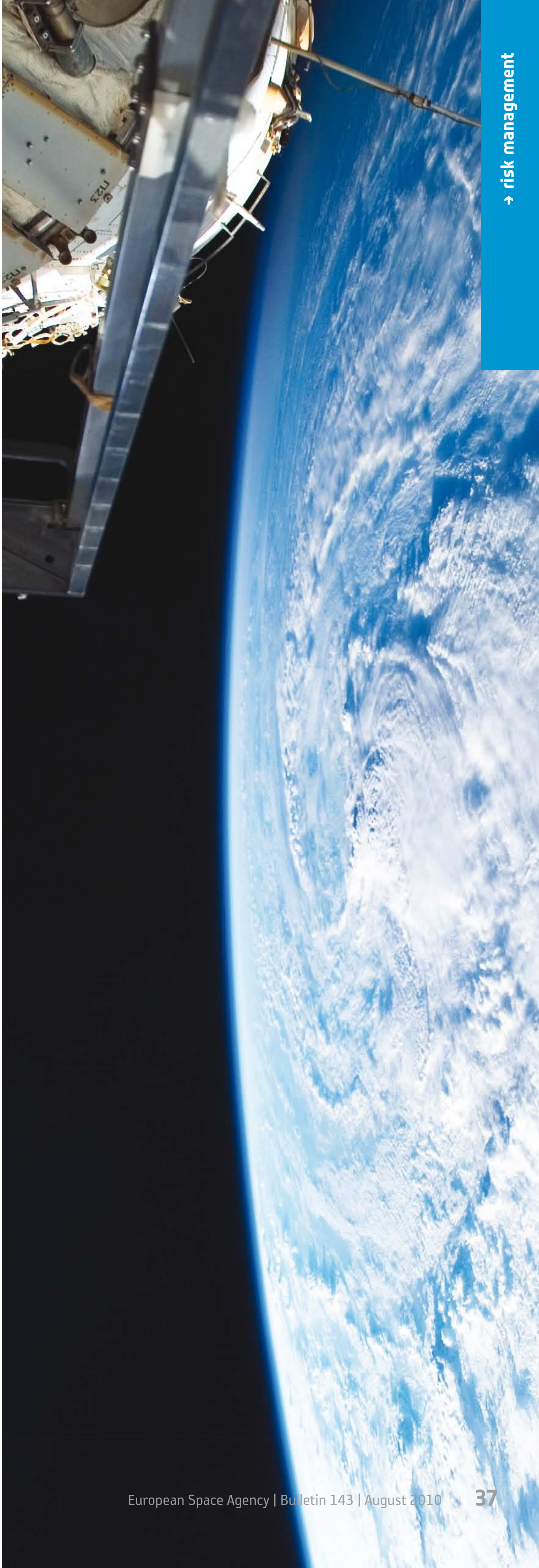
Schedule
Planning of ESA's programmes /activities

Performance
ESA's primary technical, organisational, operational performance

ESA's image
ESA's credibility and trustworthiness among Member States, other space agencies, EU, industry and the general public

These classifications have allowed the areas of concern to be identified by showing the distributions of risks in the respective sources and impacted domains.

CONTINUED ON PAGE 40



→ AGENCY LEVEL RISK REGISTER

Severity of consequence scoring scheme

Minor impact, i.e. which can be contained within ESA's available resources, requiring monitoring as preventive measures

Minor delay i.e. which can be contained in the activity/programme contingency

Minor impact on the ESA's global performance

Event which has a minor impact on ESA's image

Significant impact, i.e. which can be contained within the level of ESA's available resources, but with significant changes to ESA's programmes/ activities.

Significant delay i.e. that can be recovered via some replanning of an activity/ programme

Significant impact affecting ESA's operational objectives

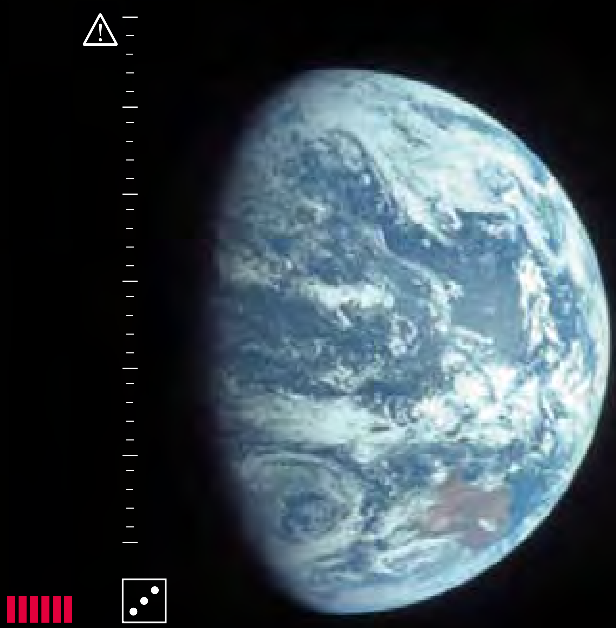
Event such as Director General needs to intervene on a diplomatic level with Member States, other space agencies, third parties, etc.

Likelihood of occurrence scoring scheme

Score	Likelihood	Likelihood of occurrence
C		Highly likely
B		Likely
A		Unlikely

Risk Index Scheme

Severity \ Likelihood	A	B	C
3	3A	3B	3C
2	2A	2B	2C
1	1A	1B	1C



Critical impact, i.e. which cannot be contained within ESA's currently available resources, and requiring Member States to reconsider contribution before next Council

Critical delay affecting the launch or whole planning of an activity/programme and requiring Member States decision to go forward

Critical impact impeding the achievement of ESA's strategic objectives.

esa: Event which damages Member State's or any stakeholder's confidence in ESA, sufficiently to impact its future activities

KEY

- Financial
- Schedule
- Performance
- esa ESA's image
- SCORE

RISK INDEX
- CRITICAL
- MAJOR
- SIGNIFICANT

SEVERITY
- High
- Medium
- Low

RISK REGISTER TEMPLATE

Directorate: ....

Interviewer: ....

Interviewee: ....

Organisation: ....

Controlled by: ....

Supported by: ....

Source: ....

Objective impacted: ....

Date: ....

Issue: ....

Risk scenario and magnitude

No.: ....

RISK SCENARIO TITLE: ....

CAUSE AND CONSEQUENCE: ....

....

....

Severity (S)
Low **1** - Medium **2** - High **3**

Risk Index (*) ☐ ☐ ☐

Likelihood (L)
Low **A** - Medium **B** - High **C**

Risk impact domain (s)(**)

Risk decision and action

Accept Risk: ....

Reduce Risk: ....

Risk reduction measurement: ....

Verification means: ....

Expected risk reduction: (severity, likelihood, risk index): ....

PROPOSED MITIGATION ACTION: ....

STATUS TO DATE: ....

Agreed by Director: ....

Risk Rank: ....

Name, signature and date

NOTES
(*) Mark box as appropriate for the value of 'R' (risk index)
(**) Indicate risk impact domain,
e.g. Performance - Financial - Schedule - ESA's image
R = Likelihood (L) x Severity of consequences (S)

The Agency-level Risk Register: above, the template for the register, and left, the scoring schemes used for assessing the severity and likelihoods. The product of the severity and likelihood gives the Risk Index, which helps to rank the risk according to a magnitude (red=critical, yellow=major and green=significant)

FROM PAGE 37

The risk assessment then proceeds to a second step, consolidating at agency-level the risks identified by the various Directorates and stemming from their programmes/activities and managerial procedures. Their combined impact on the achievement of ESA's long-term objectives with corporate risks stemming from ESA's environment and governing rules is also assessed.

The outcome of this exercise led to an 'Agency-level Risk Register'. The identified risks have been further scrutinised by the Director General, who selected those requiring a special level of attention from Member States because of their potentially high impact on the achievement of the ESA's strategic long-term objectives. Their assessment in support of the strategic planning will be then included in the draft ESA Long-Term Plan 2011–20.

Pilot phase

The pilot phase followed the process given in the ECSS standard on Risk Management. It was composed of various face-to-face interviews, and several risk management workshops involving the Directorate Risk Coordinators and the agency-level Risk Coordinator. The Risk Coordinators were nominated by Directors to conduct risk assessments in their Directorates and to be the interface with the agency Risk Coordinator.

The outcome was a complete Agency-level Risk Register including all risks impacting the ESA's strategic objectives, rated high, medium and low. This Register presents the risk scenario and its related source(s) and domain(s) of impact. A field is devoted to the strategic objectives which might be impacted if the risk materialises; other fields explain in detail the causes and potential consequences; then relevant mitigation actions are identified. The mitigation actions are intended to reduce either the probability of occurrence of the identified risk, or its severity of consequence, should the risk materialise.

Mitigation actions identified at this stage are intended to be strategic orientations. They result in further elaboration, specific proposal or action definition and when required, approval by the normal decision-making bodies of ESA. Traceability of the specific actions to the Risk Register will be maintained to ensure visibility of the overall rationale, whenever approval by Member States will be required.

Agency-level risks requiring Member State attention

From the Risk Register, the Director General has identified a number of risks concerning the achievement of ESA strategic objectives and which deserve the Member States' attention.

ESA's objectives, as stated in the ESA Long-Term Plan 2010–19 (ESA/C(2009)127, rev.1) are in line with the priorities identified by Member States of ESA and EU in the implementation of the European Space Policy.

EUROPEAN SPACE POLICY PRIORITIES

ESP 1
To develop and exploit space applications serving Europe's public policy objectives and the needs of European enterprises and citizens, including in the field of environment, development and global climate change

ESP 2
To meet Europe's security and defence needs as regards space

ESP 3
To ensure a strong and competitive space industry which fosters innovation, growth and the development and delivery of sustainable, high quality, cost-effective services

ESP 4
To contribute to the knowledge-based society by investing strongly in space-based science, and playing a significant role in the international exploration endeavour which fosters innovation, growth and the development and delivery of sustainable, high quality, cost-effective services

ESP 5
To secure unrestricted access to new and critical technologies, systems and capabilities in order to ensure independent European space applications

In that framework, ESA has the following objectives, to:

1. continue to position itself as a global space agency for the benefit of Europe by contributing to the successful and efficient implementation of ESP and coordinating the European space programme;

2. pursue the dialogue on security matters as appropriate with Member States, EC EDA and EU Council, EUSC;

3. further advance on the implementation of the 'Earth System' and contribute to climate change monitoring and science;

4. carry out and coordinate studies on different scenarios to support the debate for a long-term global vision on exploration; and

5. prepare data necessary for Member States participating to the ISS Exploitation programme to take decisions by 2010 together with the other ISS partners about the possible continuation of ISS operations beyond 2015.

Analysis of pilot phase results

Main sources impacted

The distribution per source of risks shows that most of ESA's risks in the long-term stem from its environment (40%) and its governance (30%). Indeed, in pursuing its objective of becoming a global space player, ESA is cooperating more and more on many programmes and activities with other space agencies or third parties, such as the EU and private partners. There are therefore some inevitable risks, which are inherent in some partners' different legislative practices or security rules.

The same applies for risks stemming from the ESA governance: if ESA is not able to react to an evolving environment and adapt its own internal rules according to future scenarios, its capability to make decisions and therefore implement programmes in a timely and effective manner would be in serious danger.

Another point of concern is linked to the implementation of the Financial Management Reform, which involves all the financial processes of ESA and went live in January 2010. To mitigate the risk associated with such a delicate transition, a whole range of measures was put in place and the project is continuously monitored.

Lastly, programmatic risks are not treated by programme in ESA's overall risk exposure. ESA has tried to consolidate most of the risks stemming from different programmes and see how they could lead to a more-generic risk endangering its strategic objectives. For example, the risk related to cost overruns and delays on ESA's programmes illustrates the fact, that ESA's management is aware that many times, it could face (and has faced) bad estimations in Phase-A/B1 or industrial underbidding. This is not specific to one programme, but can occur across the whole agency.

Main domains impacted

The distribution per domain shows that the domain most impacted by the 'high' risks is its performance (31%). This is understandable, since an underlying strategic objective of ESA is to use Member States' resources to their utmost in order to achieve the best performance on its programmes/activities.

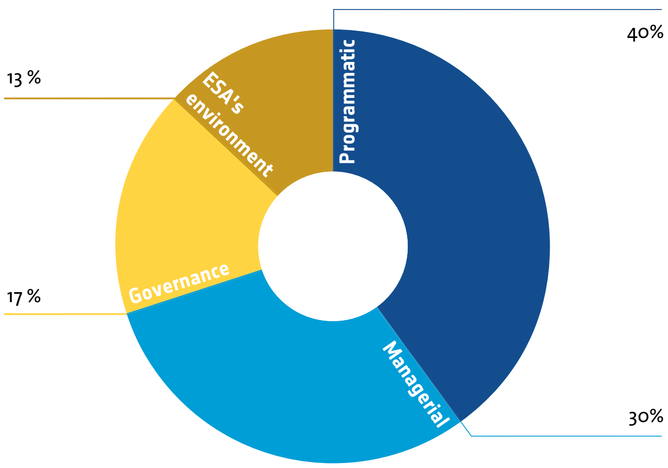
One major concern affecting the performance of ESA is the transfer of critical technologies between Member States. It is possible that if legal barriers impede the transfer of necessary technologies between Member States, some programmes might be blocked.

This risk has materialised in the past and so ESA proposed to build on lessons learned to prevent this happening again. ESA is working on behalf of Member states, so it would be a waste of resources to deal with such situations, which will incur delays and costs overruns.

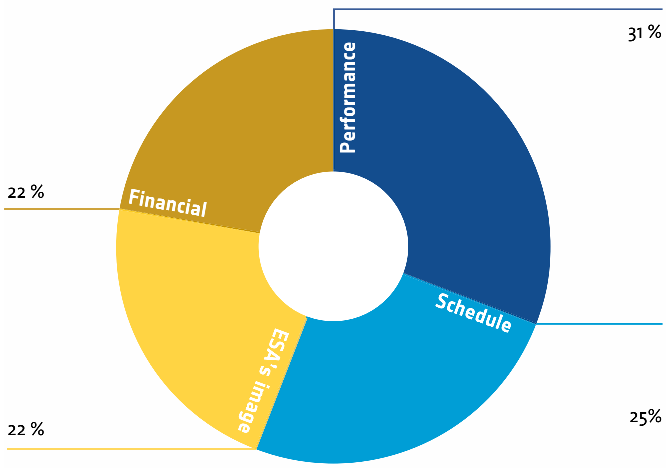
All four domains are interlinked and affected at strategic level: having an impact on performance means often that there is a delay on an activity, which leads to cost overruns. This is expressed through the distribution of domains impacted: schedule, finance and ESA's image are all three slightly above 20%.

One of the major issues related to schedule is linked to the Member States' reduced affordability, which could hinder ESA implementing programmes as planned. This could affect the whole planning of ESA's activities and, at the same time, imply reduction of the industrial workload. Due to the recent financial crisis, ESA needs to find the appropriate balance of activities to guarantee a viable European industry.

Distribution per source of risks



Distribution per domain of impact



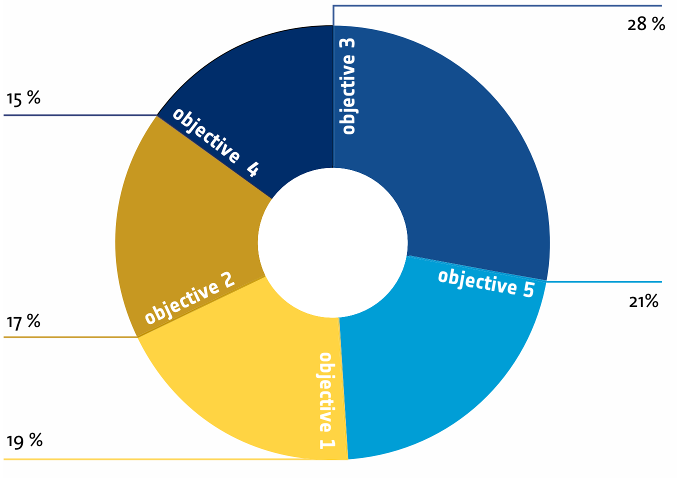
↑ One major risk having a direct financial impact is linked to the unexpected increase in cost of launch services

One major issue having a direct financial impact is linked to the unexpected increase in cost of launch services. The existing agreements with launch service providers do not guarantee process up to the contract signature.

Therefore ESA's management is in favour of encouraging the refinement of the Launch Service Policy, which could allow a framework of prices linked more to the evolution of the cost of the launcher, rather than evolution of the market prices.

Last but not least, ESA is highly involved in promoting a positive image to its stakeholders and the outside world in general, as 'the space agency for Europe'. Therefore ESA management believes that issues affecting its image (among other things), such as the continued dependency for critical technology – for which ESA has been entrusted to find a solution – or the degradation of ESA technical facilities, are of relevance for Member States. Here, these examples need appropriate action, such as programmatic measures to enable ESA enhance European technological independence, or decisions on the added value of refurbishment of a facility to prevent accidents and possible legal consequences for the agency.

Distribution per ESA objective impacted



The way forward

This pilot phase represents the first attempt to implement an agency-level risk management process and is planned to pave the way for a systematic process to be carried out, according to the policy in force, on a regular basis.

It has allowed ESA to refine procedures and internal requirements, to properly identify risks and assess their impacts on ESA strategic objectives, consolidate them at agency level with other external and internal factors, and finally identify appropriate mitigation actions.

With the compliance to international standards, such as ISO 9000, the recommendations of the decision-making process working group, and the Financial Management Reform, all these imply a systematic risk management process is in place in ESA with best managerial practices are adopted. In particular, a Risk Management Procedure, compliant with ISO 9000, is being drafted to guide the operational implementation of the process in ESA.

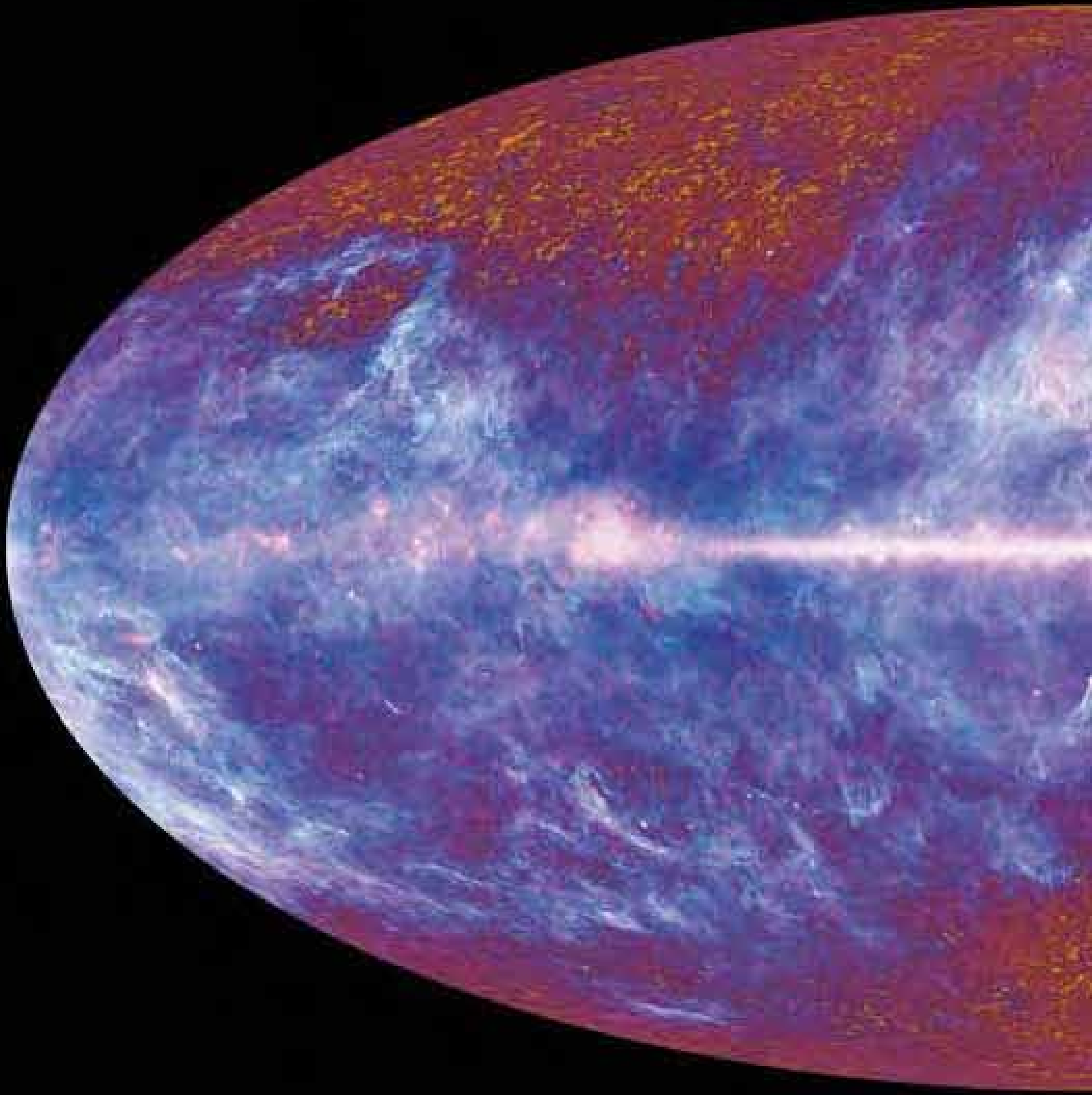
Consultation with ESA Council in June 2010 was essential to complete the pilot phase and assure the Director General that the risk management policy at ESA is in line with Member State expectations and requirements.

Today, a procedure following the ISO 9000 is being produced by the Risk Coordinators and will pave the way to the operational phase. A systematic 'agency-level risk assessment review' will be carried out each year, and its outcome included in the annual update of ESA's Long-Term Plan.

→ NEWS IN BRIEF

This false-colour Envisat image shows a unique cloud formation, created by 'Von Karman vortices', south of the Canary Islands, about 95 km from the northwest coast of Africa (top) in the Atlantic Ocean. North is to the left. The clockwise and counterclockwise spirals in this image were created by these vortices when wind blowing from the north over the Atlantic was disturbed by the islands.

PLANCK'S IMPRESSIVE FIRST VIEW



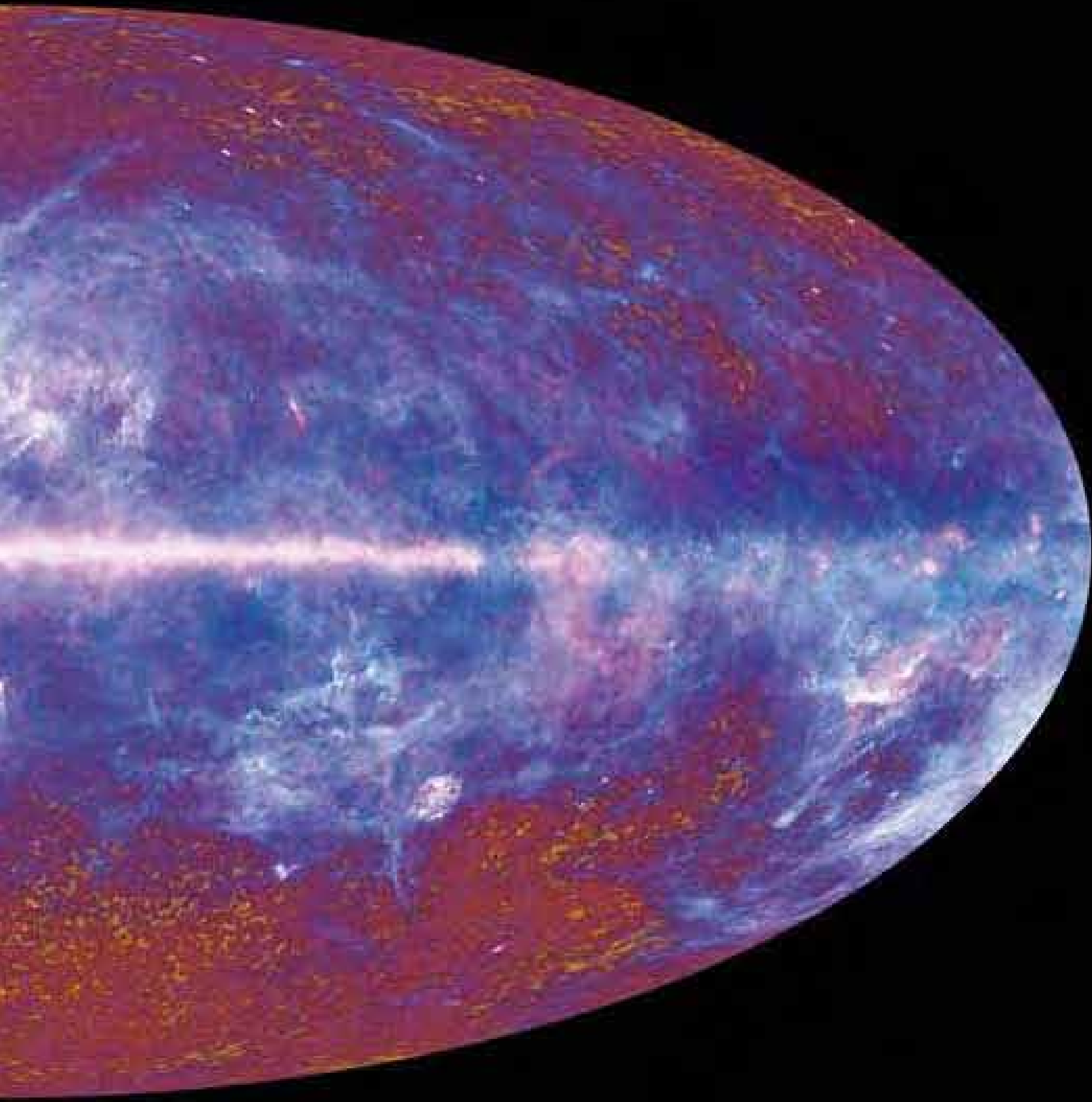
ESA's Planck mission has delivered its first all-sky image, which not only provides new insight into the way stars and galaxies form, but also how the Universe itself came to life after the Big Bang.

The main disc of our Milky Way galaxy runs across the centre of the image. Immediately striking are the streamers of cold dust reaching above and below the Milky Way. This galactic web is where new stars are being formed, and Planck has found many locations where individual stars are edging toward birth or just beginning their cycle of development.

Less spectacular but perhaps more intriguing is the mottled backdrop at the top and bottom. This is the 'Cosmic Microwave Background' radiation (CMB), or the oldest light in the Universe, the remains of the fireball from which our Universe sprang into existence 13.7 billion years ago.

While the Milky Way shows us what the local Universe looks like now, those microwaves show us what the Universe looked like close to its time of creation, before there were stars or galaxies. This is the heart of Planck's mission, to decode what happened in that primordial Universe from the pattern of the mottled backdrop.

The microwave pattern is the cosmic blueprint from which today's clusters and superclusters



of galaxies were built. The different colours represent minute differences in the temperature and density of matter across the sky. Somehow these small irregularities evolved into denser regions that became the galaxies of today.

The CMB covers the entire sky but most of it is hidden in this image by the Milky Way's emission, which must be digitally removed from the final data in order to see the microwave background in its entirety. When this work is completed, Planck will show us the most precise picture of the microwave background ever obtained. The big question will be whether the data will reveal the cosmic signature of the primordial period called inflation. This era is thought to have taken place just after the Big Bang and resulted in the Universe expanding enormously in size over an extremely short period.

By the end of its mission in 2012, Planck will have completed four all-sky scans. The first full data release of the CMB is planned for 2012. Before then, the catalogue containing individual objects in our galaxy and whole distant galaxies will be released in January 2011.

"This image is just a glimpse of what Planck will ultimately see," says Jan Tauber, ESA's Planck Project Scientist.

Asteroid encounter

ESA's Rosetta mission returned the first close-up images of the asteroid Lutetia, showing that it is most probably a primitive survivor from the violent birth of the Solar System.

Rosetta raced past the asteroid at a speed of 15 km/s and a distance of 3162 km, making its closest approach at 18:10 CEST on 10 July. Its cameras and other instruments had been working for hours, and in some cases days beforehand, and continued afterwards. At closest approach, details down to a scale of 60 m could be seen over the entire surface of Lutetia.

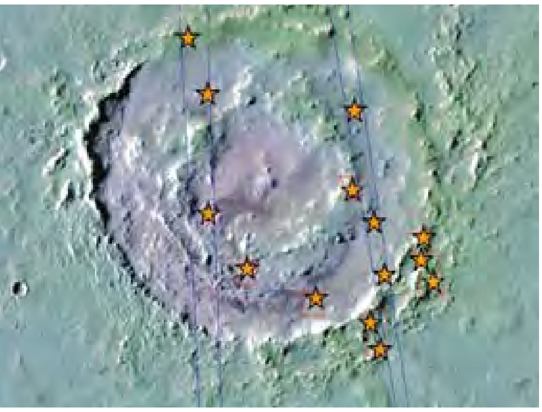
The images showed that the asteroid is heavily cratered, having suffered many impacts during its 4.5 billion years of existence. As Rosetta drew close, a giant bowl-shaped depression stretching across much of the asteroid rotated into view. The images confirm that Lutetia is an elongated body, about 130 km across at its widest.

Lutetia has been a mystery for many years. Ground-based telescopes have shown that it presents confusing characteristics. In some respects it resembles a 'C-type' asteroid, a primitive body left over from the formation of the Solar System. In others, it looks like an 'M-type'. These have been associated with iron meteorites, are usually reddish and thought to be fragments of the cores of much larger objects.

The new images will help to decide along with more compositional information from Rosetta's other instruments. Rosetta's full suite of sensors were operating during the encounter, and together they looked for evidence of a highly tenuous atmosphere, magnetic effects, and studied the surface composition as well as the asteroid's density. They also attempted to catch any dust grains that may have been floating in space near the asteroid for onboard analysis.

The flyby marks the achievement of one of Rosetta's main scientific objectives. The spacecraft continues towards its 2014 rendezvous with its primary target, Comet 67P/Churyumov-Gerasimenko.

Wet era on early Mars was global



The whole martian surface was shaped by liquid water around four billion years ago, and conditions favourable to life may once have existed all over Mars.

Signs of liquid water had been seen on southern Mars, but the latest findings reveal similar signals in craters in the north of the Red Planet.

↑ Lyot Crater, one of the impact craters studied, showing locations of the hydrated minerals (NASA/ESA/JPL/APL/IAS)

Scientists made their discovery by examining data ESA's Mars Express and NASA's Mars Reconnaissance Orbiter. The spacecraft have previously discovered thousands of small outcrops in the southern hemisphere where rocky minerals have been altered by water. Many of these exist in the form of hydrated clay minerals known as 'phyllosilicates', indicating that the planet's southern hemisphere was once much warmer and wetter than it is today.

However, until now, no such evidence had been found in the northern lowlands, where thick blankets of lava and sediments up to several kilometres thick hamper efforts to probe the underlying bedrock.

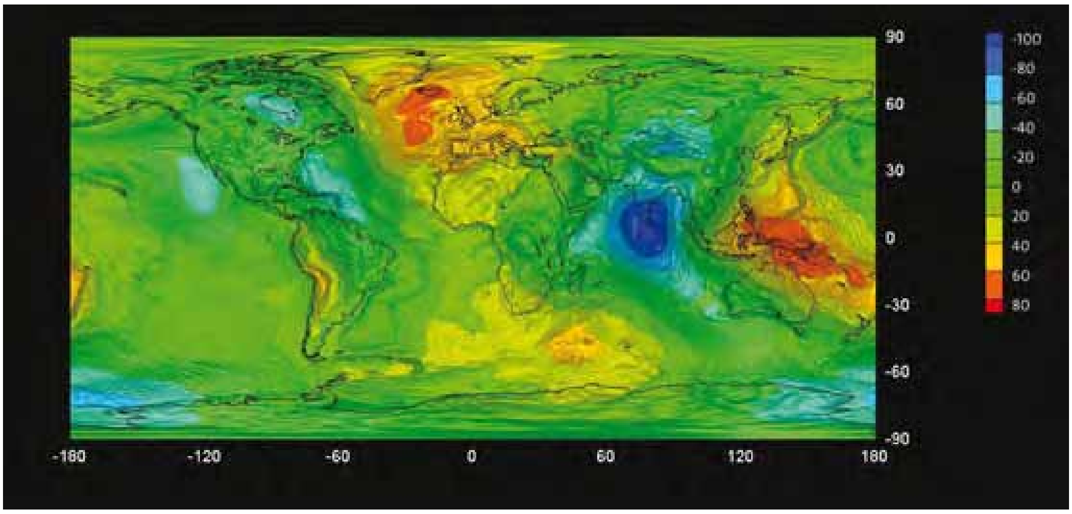
The first hints that there may be hydrated silicates beneath the northern plains were provided by ESA's Mars Express OMEGA sensor. However, the outcrops were small and more detailed observations were required to confirm their presence. The OMEGA team sifted higher resolution data from a sensor on NASA's orbiter. Their search concentrated on several large impact craters, where incoming meteorites had punched down several kilometres, exposing ancient rocks. At least nine craters were found to contain phyllosilicates or other hydrated silicates. These minerals, which formed in wet environments on the surface or underground, were identical to those found in the southern hemisphere. "We can now say that the planet was altered on a global scale by liquid water more than four billion years ago," says John Carter, University of Paris.

"They are rich in iron and magnesium, but less in aluminium. Together with the close proximity of the mineral olivine, which is easily modified by water, this indicates that the exposure to water lasted only tens to hundreds of millions of years," says Jean-Pierre Bibring, the OMEGA Principal Investigator from the University of Paris.

Evidence for water flowing during the early history of Mars means that conditions may have been favourable for the evolution of primitive life. Potential martian habitability may not have lasted long, but its record is still preserved in these phyllosilicate-rich spots, which could be good sites for future landers.

↑ Rosetta's view of asteroid Lutetia on 10 July, 2010

GOCE's new insights into Earth's gravity



← The first global gravity model based on GOCE satellite data showing tiny variations in Earth's gravity field

The first global gravity model based on GOCE satellite data has been released. ESA launched GOCE in March 2009 to map Earth's gravity with unprecedented accuracy and resolution.

The model, based on only two months of data, from November and December 2009, shows the excellent capability of the satellite to map tiny variations in Earth's gravity.

"GOCE is delivering where it promised: in the fine spatial scales. We have already been able to identify significant improvements in the high-resolution 'geoid', and the gravity model will improve as more data become available," said GOCE Mission Manager Rune Floberghagen.

The geoid is the shape of an imaginary global ocean dictated by gravity in the absence of tides and currents. It is a crucial reference for accurately measuring ocean circulation, sea-level change and ice dynamics – all affected by climate change.

Was Venus once a habitable planet?

ESA's Venus Express is helping planetary scientists investigate whether Venus once had oceans. If it did, it may even have begun its existence as a habitable planet similar to Earth.

These days, Earth and Venus seem completely different. Earth is a lush, clement world teeming with life, while Venus is roasting, with surface temperatures higher than those of a kitchen oven.

Thanks to ESA's Venus Express, planetary scientists are now seeing more similarities too. "The basic composition of Venus and Earth is very similar," says Håkan Svedhem, ESA Venus Express Project Scientist. But one big difference stands out: Venus has very little water.

If the contents of Earth's oceans were spread evenly across the world, they would create a layer 3 km deep. The amount of water vapour in Venus's atmosphere would create a global puddle just 3 cm deep.

Billions of years ago, Venus probably had much more water. Venus Express has confirmed that the planet has lost a large quantity of water into space, the process for which is caused by ultraviolet radiation from the Sun breaking up the water molecules in Venus's atmosphere into atoms that then escape to space.

Venus Express has measured the rate of this escape and confirmed that roughly twice as much hydrogen is escaping as oxygen. Because water molecules are made up of two hydrogen atoms and one oxygen, it is likely that water is the source of these escaping ions.

"Everything points to there being large amounts of water on Venus in the past," says Colin Wilson, University of Oxford, UK. But that does not necessarily mean there were oceans on the planet's surface.

Eric Chassefière, Université Paris-Sud, France, has developed a computer model that suggests the water was

Living Planet showcases ESA missions

More than 1200 scientists from around the world gathered in Bergen, Norway, to present their latest findings on Earth's environment and climate using data from Earth observation satellites.

The Living Planet Symposium in June was one of ESA's largest scientific symposia, organised with the help of the Norwegian Space Centre and Norway's Nansen Environmental and Remote Sensing Center.

Prof. Volker Liebig, ESA's Director of Earth Observation, opened the symposium and stressed the importance of Earth observation, saying that ESA satellite archives, dating back to 1991, have delivered valuable data about our planet, increased our knowledge of Earth and improved our confidence in climate change predictions.

Prof. Liebig commended the scientists at the symposium for using these data to identify and analyse long-term climatic trends and changes. He also emphasised ESA's continued commitment to meeting the growing demand for observation data as decision-makers are faced with responding to environmental change, natural disasters and civil security issues, and managing sustainable development.

"ESA is responding to the ever-growing demand for Earth observation data with new missions and simplified access to our data archives,' said Prof. Liebig. In this context, he announced that the new ESA Data Policy now guarantees free and open access to the majority of data from ESA's missions.

One of the main highlights was the unveiling of new datasets from ESA's recently launched Earth Explorer satellites – GOCE, SMOS and CryoSat – but the continuing achievements of ESA's ERS and, in particular, Envisat satellites were also praised.

↑ Prof. Volker Liebig, ESA's Director of Earth Observation, opens the symposium in June

Dr Johnny Johannessen of the Nansen Environmental and Remote Sensing Center said, "Twenty years of regular monitoring with ERS-1, ERS-2 and Envisat have provided an excellent and powerful satellite database for multidisciplinary studies of the Earth system, including the ocean, cryosphere, atmosphere, land, biosphere and the solid Earth."

↑ Artist's impression of the surface of Venus long ago, suggesting the possibility of lightning in the atmosphere (J.Whatmore)

largely atmospheric and existed only during the very earliest times, when the surface of the planet was completely molten.

As the water molecules escaped into space, the subsequent drop in temperature probably triggered the solidification of the surface. In other words: no oceans.

Although it is difficult to test this theory, it is a key question. If Venus ever did possess surface water, the planet may have had an early habitable phase. Even if true, Chassefière's model does not mean that additional water could not have been brought to Venus in other ways, such as by colliding comets, after the surface solidified, and these created bodies of standing water in which life may have been able to form.

"Much more extensive modelling of the magma ocean–atmosphere system and of its evolution is required to better understand the evolution of the young Venus," says Chassefière.

THIS WAY UP ↑

ESA's new astronauts enjoyed a taste of space during a special flight of a modified Airbus A300, getting a glimpse of their future working conditions.

Aircraft flying on special parabolic paths can simulate weightlessness for research and astronaut training. Up to 22 seconds of microgravity can be created at a time and, by repeating the manoeuvres, the total time of weightlessness during one flight can be up to 12 minutes.

Operated from Bordeaux, France, the Novespace 'Zero-G' Airbus A300 is the biggest and most advanced aircraft in the world for these flights. This faithful workhorse has flown 52 ESA parabolic flight campaigns, offering weightless conditions not only to Europe's astronauts, but also to scientists conducting microgravity experiments.

↑ One of the main goals of the flight was to teach the astronauts how to move and work in weightlessness. Luca Parmitano demonstrates the handling of large and bulky objects

↗ Alexander Gerst running on a new treadmill, installed at 90° to the aircraft floor. In zero gravity, angle has no meaning but for testing this position gives more accurate results

→ Thomas Pesquet and ESA astronaut instructor Herve Stevenin in a more relaxed moment of the flight

Photography by Anneke Le Floc'h/ESA

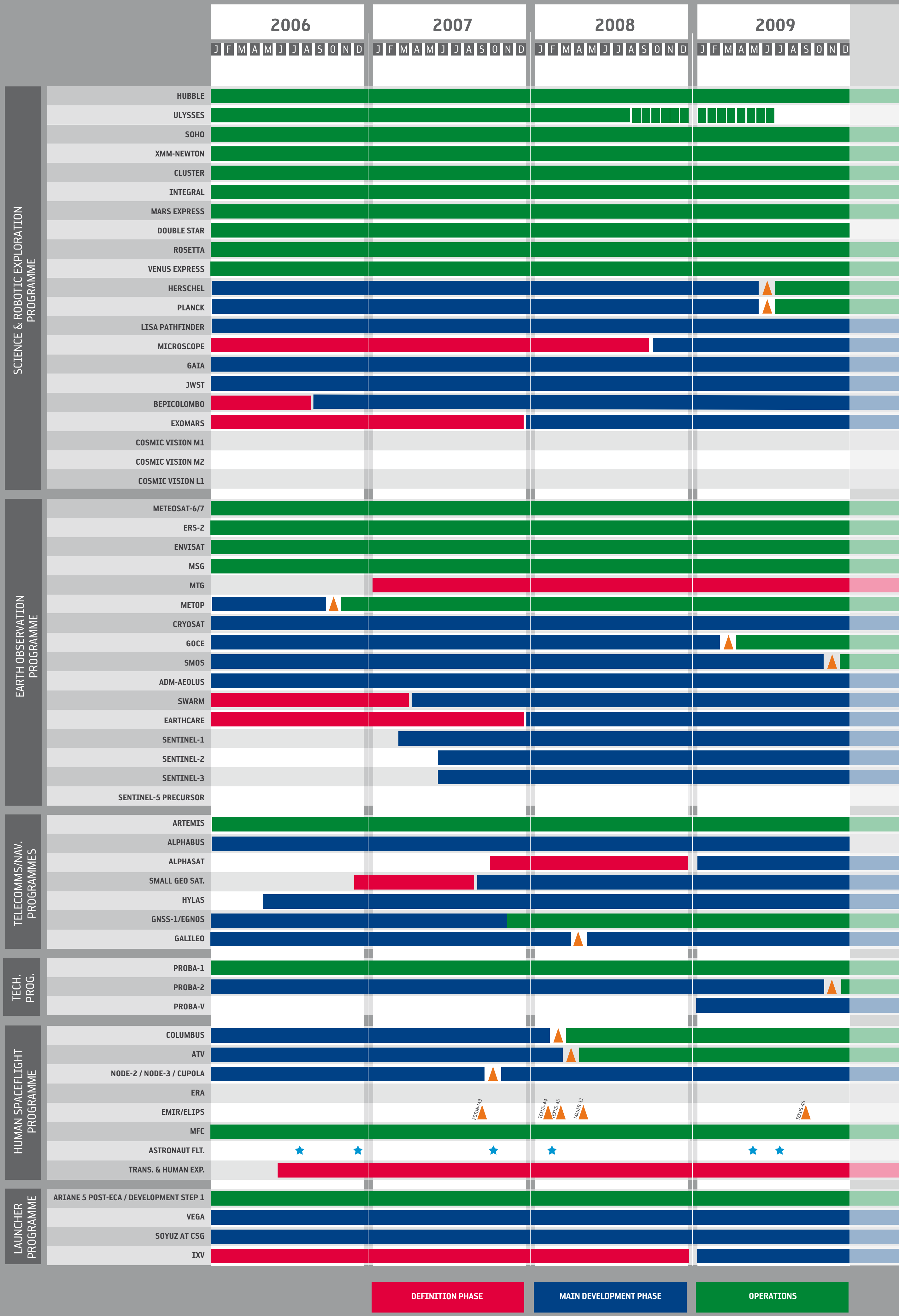
↑ Practicing spacewalk techniques, Thomas Pesquet moves along a handrail wearing spacesuit safety tethers and gloves

↗ Luca Parmitano and Tim Peake share a joke as they start to float

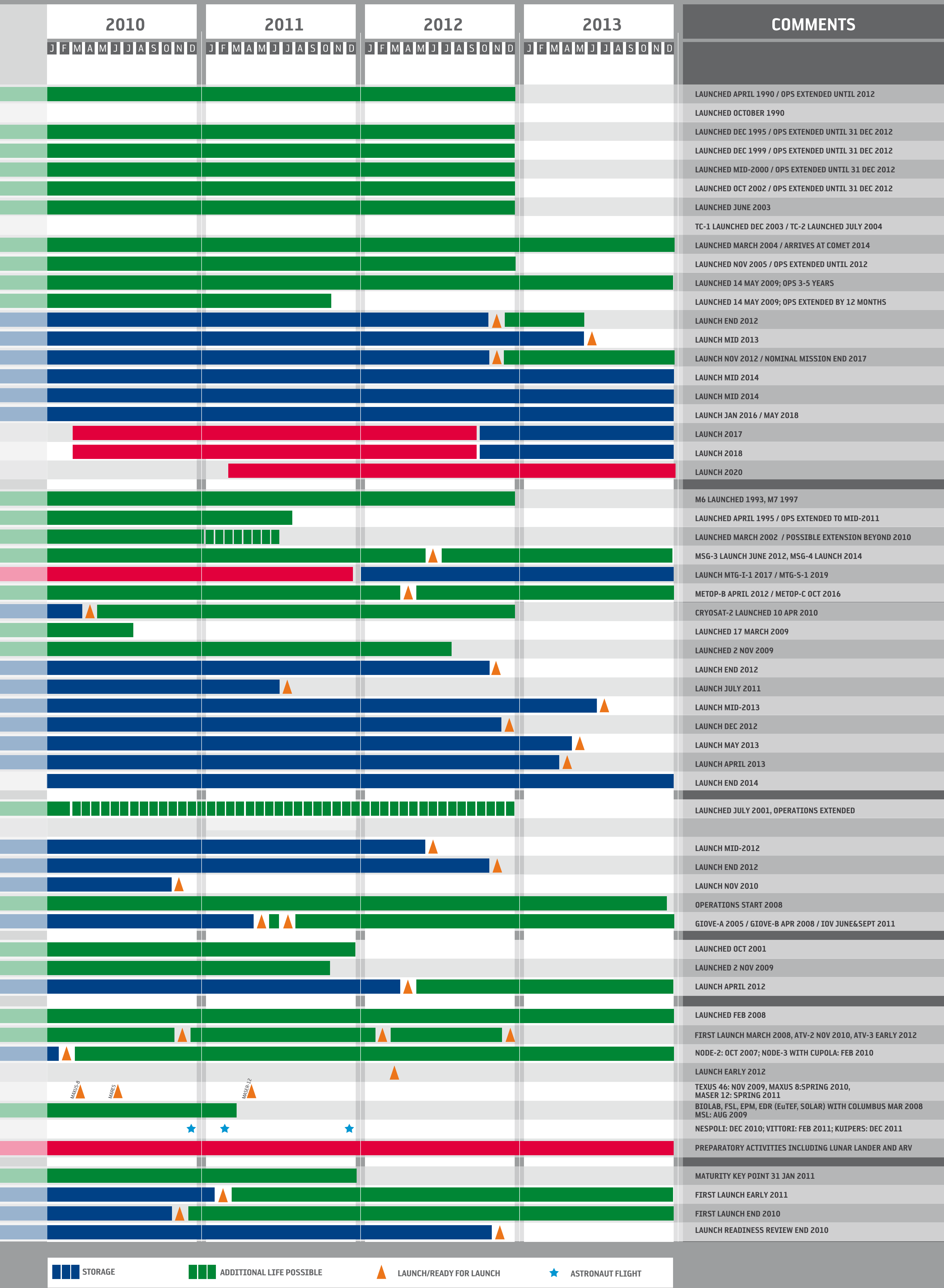
↘ The flight was not all work – in between training exercises and performing science experiments, Samantha Cristoforetti enjoys the weightlessness

→ PROGRAMMES IN PROGRESS

Status at July 2010



2006
2007
2008
2009
J F M A M J J A S O N D
SCIENCE & ROBOTIC EXPLORATION PROGRAMME
HUBBLE
ULYSSES
SOHO
XMM-NEWTON
CLUSTER
INTEGRAL
MARS EXPRESS
DOUBLE STAR
ROSETTA
VENUS EXPRESS
HERSCHEL
PLANCK
LISA PATHFINDER
MICROSCOPE
GAIA
JWST
BEPICOLOMBO
EXOMARS
COSMIC VISION M1
COSMIC VISION M2
COSMIC VISION L1
EARTH OBSERVATION PROGRAMME
METEOSAT-6/7
ERS-2
ENVISAT
MSG
MTG
METOP
CRYOSAT
GOCE
SMOS
ADM-AEOLUS
SWARM
EARTHCARE
SENTINEL-1
SENTINEL-2
SENTINEL-3
SENTINEL-5 PRECURSOR
TELECOMMS/NAV. PROGRAMMES
ARTEMIS
ALPHABUS
ALPHASAT
SMALL GEO SAT.
HYLAS
GNSS-1/EGNOS
GALILEO
TECH. PROG.
PROBA-1
PROBA-2
PROBA-V
HUMAN SPACEFLIGHT PROGRAMME
COLUMBUS
ATV
NODE-2 / NODE-3 / CUPOLA
ERA
EMIR/ELIPS
FOTON-M3
TEXUS-44
TEXUS-45
MASER-11
TEXUS-46
MFC
ASTRONAUT FLT.
TRANS. & HUMAN EXP.
LAUNCHER PROGRAMME
ARIANE 5 POST-ECA / DEVELOPMENT STEP 1
VEGA
SOYUZ AT CSG
IXV
DEFINITION PHASE
MAIN DEVELOPMENT PHASE
OPERATIONS


2010
2011
2012
2013
COMMENTS
J F M A M J J A S O N D
LAUNCHED APRIL 1990 / OPS EXTENDED UNTIL 2012
LAUNCHED OCTOBER 1990
LAUNCHED DEC 1995 / OPS EXTENDED UNTIL 31 DEC 2012
LAUNCHED DEC 1999 / OPS EXTENDED UNTIL 31 DEC 2012
LAUNCHED MID-2000 / OPS EXTENDED UNTIL 31 DEC 2012
LAUNCHED OCT 2002 / OPS EXTENDED UNTIL 31 DEC 2012
LAUNCHED JUNE 2003
TC-1 LAUNCHED DEC 2003 / TC-2 LAUNCHED JULY 2004
LAUNCHED MARCH 2004 / ARRIVES AT COMET 2014
LAUNCHED NOV 2005 / OPS EXTENDED UNTIL 2012
LAUNCHED 14 MAY 2009; OPS 3-5 YEARS
LAUNCHED 14 MAY 2009; OPS EXTENDED BY 12 MONTHS
LAUNCH END 2012
LAUNCH MID 2013
LAUNCH NOV 2012 / NOMINAL MISSION END 2017
LAUNCH MID 2014
LAUNCH MID 2014
LAUNCH JAN 2016 / MAY 2018
LAUNCH 2017
LAUNCH 2018
LAUNCH 2020
M6 LAUNCHED 1993, M7 1997
LAUNCHED APRIL 1995 / OPS EXTENDED TO MID-2011
LAUNCHED MARCH 2002 / POSSIBLE EXTENSION BEYOND 2010
MSG-3 LAUNCH JUNE 2012, MSG-4 LAUNCH 2014
LAUNCH MTG-I-1 2017 / MTG-S-1 2019
METOP-B APRIL 2012 / METOP-C OCT 2016
CRYOSAT-2 LAUNCHED 10 APR 2010
LAUNCHED 17 MARCH 2009
LAUNCHED 2 NOV 2009
LAUNCH END 2012
LAUNCH JULY 2011
LAUNCH MID-2013
LAUNCH DEC 2012
LAUNCH MAY 2013
LAUNCH APRIL 2013
LAUNCH END 2014
LAUNCHED JULY 2001, OPERATIONS EXTENDED
LAUNCH MID-2012
LAUNCH END 2012
LAUNCH NOV 2010
OPERATIONS START 2008
GIOVE-A 2005 / GIOVE-B APR 2008 / IOV JUNE&SEPT 2011
LAUNCHED OCT 2001
LAUNCHED 2 NOV 2009
LAUNCH APRIL 2012
LAUNCHED FEB 2008
FIRST LAUNCH MARCH 2008, ATV-2 NOV 2010, ATV-3 EARLY 2012
NODE-2: OCT 2007; NODE-3 WITH CUPOLA: FEB 2010
LAUNCH EARLY 2012
MAXUS-8
MARES
MASER-12
TEXUS 46: NOV 2009, MAXUS 8:SPRING 2010,
MASER 12: SPRING 2011
BIOLAB, FSL, EPM, EDR (EuTEF, SOLAR) WITH COLUMBUS MAR 2008
MSL: AUG 2009
NESPOLI: DEC 2010; VITTORI: FEB 2011; KUIPERS: DEC 2011
PREPARATORY ACTIVITIES INCLUDING LUNAR LANDER AND ARV
MATURITY KEY POINT 31 JAN 2011
FIRST LAUNCH EARLY 2011
FIRST LAUNCH END 2010
LAUNCH READINESS REVIEW END 2010
STORAGE
ADDITIONAL LIFE POSSIBLE
LAUNCH/READY FOR LAUNCH
ASTRONAUT FLIGHT

KEY TO ACRONYMS

AM	Avionics Model	ITT	Invitation to Tender
AO	Announcement of Opportunity	MoU	Memorandum of Understanding
AU	Astronomical Unit	PDR	Preliminary Design Review
CDR	Critical Design Review	QM	Qualification Model
CSG	Centre Spatial Guyanais	SM	Structural Model
ELM	Electrical Model	SRR	System Requirement Review
EM	Engineering Model	STM	Structural/Thermal Model
EQM	Electrical Qualification Model	TM	Thermal Model
FAR	Flight Acceptance Review		
FM	Flight Model		

→ SOHO

A 12-year series of Michelson Doppler Imager (MDI) data has been used to make the first homogeneous, highly precise, complete solar-cycle measurement of the Sun's radius variability. The solar radius was found to be constant to a high degree: any intrinsic radius changes that are synchronous with the sunspot cycle are smaller than 16.5 km peak-to-peak, and the average solar radius is not changing by more than 0.86 km per year. These results are inconsistent with previous ground-based measurements, which have led to claims of much larger apparent radius changes. The effects of long-term changes in the terrestrial atmosphere through which the Sun is observed from the ground must be corrected for in order to reconcile the ground- and space-based measurements.

→ XMM-NEWTON

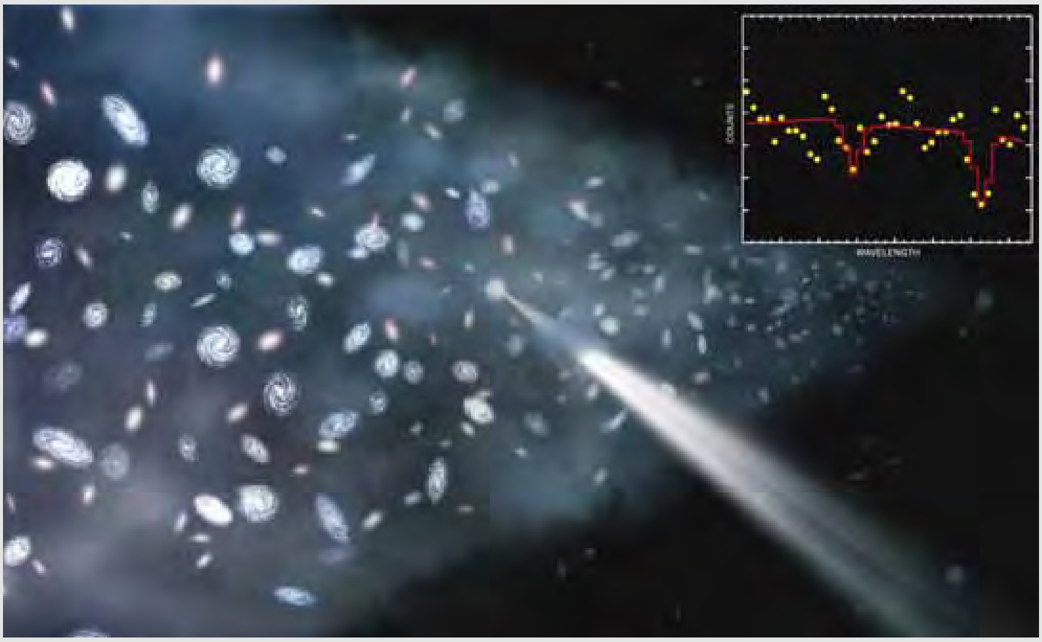
ESA's XMM-Newton and NASA's Chandra X-ray observatories have been used to detect a vast reservoir of gas lying along a wall-shaped structure of galaxies about 400 million light years from Earth. This discovery is the strongest evidence yet that the 'missing matter' in the nearby Universe is located in an enormous web of hot, diffuse gas called the Warm-Hot Intergalactic Medium (WHIM).

Previous studies have provided a good estimate of the amount of normal 'baryonic' matter (i.e. protons, neutrons, electrons, etc.) present when the Universe was only a few thousand million years old, and yet inventories of the nearby Universe have turned up only about half as much baryonic matter, an embarrassingly large shortfall. However, by studying absorption of X-ray light from a bright background source by the WHIM in the so-called 'Sculptor Wall', the new study supports predictions that the WHIM holds a very substantial additional reservoir of baryonic material in the local Universe.

→ CLUSTER

During the first five months of 2010, the Cluster spacecraft endured a total of 71 orbits containing eclipses, but they have all now returned to perpetual sunlight with no casualties, following excellent work by the ESOC operations team. The spacecraft are now moving round to the tail region of the magnetosphere, where their science operations will focus on the inner magnetosphere.

The Cluster science output continues, recently passing 1200 refereed publications. One recent result was about high-speed plasma jets that formed downstream of Earth's bow shock. These unexplained phenomena have been observed for more than a decade, but recent multipoint



Artist's impression of the 'Sculptor Wall', showing spiral and elliptical galaxies in the wall along with the newly detected intergalactic gas, part of the Warm-Hot Intergalactic Medium (WHIM) shown in blue. The inset shows an X-ray spectrum where the dip in the data plot at the right of the spectrum is due to absorption by oxygen atoms in the WHIM (CXC/M. Weiss) measurements with Cluster have revealed how, under certain conditions, ripples can form along the bow shock. These ripples change the way the shock interface acts on the solar wind and in some places affects minimal change in the speed of the plasma as it passes through the shock. It is in these regions where the jets are found. A secondary shock downstream of the bow shock has also been observed.

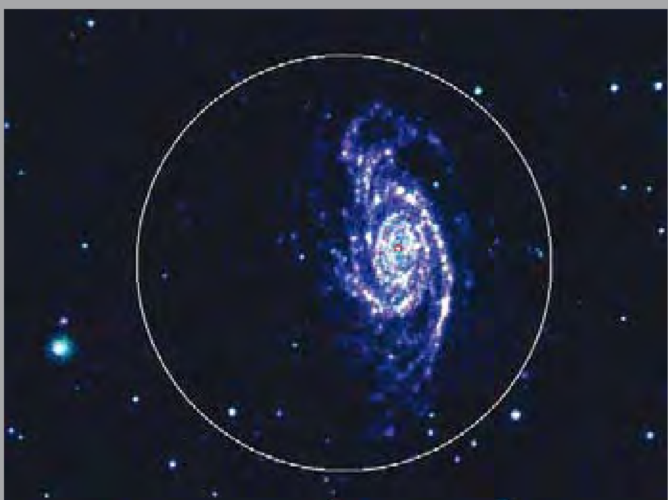
In an astrophysical context, such jets can act as seeds for magnetic field amplification and particle acceleration on the downstream side of supernova blast waves. Some of these blast waves are triggered by the death of massive stars, which end their lifetime as neutron stars.

→ INTEGRAL

Integral operations continue smoothly. On 27 May, another SPI spectrometer detector failed for reasons which are yet unknown, leaving 15 of 19 detectors active. Besides the loss of a few percent in active area, there is no further impact on operations or scientific performance. In all other aspects, the instruments and spacecraft continue to perform normally.

In response to the Eighth Announcement of Opportunity, 64 observing proposals were received. From these, 41 proposals were at least partially accepted, including 21 target-of-opportunity follow-up observations and three gamma-ray burst observations, for a total of about 25 Ms of observing time.

Integral has discovered hundreds of new sources in the hard X-ray range (>20 keV). Most of these sources have an unknown nature, and multi-wavelength studies are necessary to try to classify them. One such source, IGR J13042–1020, and multi-wavelength follow-up observations with the Swift satellite allowed the X-ray, UV and optical counterparts to be identified. The UV/optical counterpart is the nucleus of the galaxy NGC 4939 which permits easy identification of IGR J13042–1020 as an active galactic nucleus (AGN) at about 140 million light-years away. AGNs are powered by accretion of large amounts of material onto a central supermassive black hole, and one of their key characteristics is the high absorption that can shield a significant amount of the soft X-rays, thus hindering or preventing their discovery. By observing at higher energies unaffected by absorption, Integral has discovered dozens of such systems.



One example of a source discovered in hard X-rays by Integral, IGR J13042–1020 (large white circle). The small red circle shows the coincident nucleus of the galaxy NGC 4939 (J. Rodriguez et al., *Astronomy & Astrophysics*)

→ MARS EXPRESS

In May, ESOC mission controllers commanded the Visual Monitoring Camera (VMC) on Mars Express to acquire an image of Mars every minute during one complete orbit of the planet. The VMC was originally used to confirm separation of the Beagle 2 probe in December 2003, but has since been used for a number of experiments monitoring Mars from orbit. The images resulting from this new time series have been combined to create a movie as the spacecraft moves around Mars, the first of its kind ever generated from a satellite orbiting the Red Planet. See www.esa.int/SPECIALS/Operations/SEMOR15XT9G_0.html.

→ ROSETTA

On 10 July, Rosetta performed a close flyby of the main-belt asteroid (21) Lutetia, the second and main asteroid target in Rosetta's 11.5-year mission. Closest approach occurred at 18:10 CEST, when the spacecraft passed the asteroid with a relative velocity of 15 km/s and at a distance of 3162 km, only 2 km more than the minimum distance required for Rosetta to be able to track the asteroid continuously during the flyby. At the time of encounter, Lutetia was 2.72 Astronomical Units (AU) away from the Sun and 3.05 AU away from Earth, leading to a signal travel time of some 20 minutes. The flyby strategy allowed continuous observations of the asteroid before, during and 30 minutes after closest approach, after which the spacecraft had to turn away from Lutetia.

Seventeen instruments were switched on during the flyby, obtaining spatially-resolved imaging and spectral observations covering ultraviolet to radio wavelengths, as well as *in situ* measurements of the asteroid and its direct environment. The images show Lutetia as a heavily cratered, elongated body with a maximum width of around 130 km. During the flyby, a giant bowl-shaped depression stretching across much of the asteroid rotated

Asteroid (21) Lutetia imaged by Rosetta from a distance of 36 000 km. The OSIRIS Narrow Angle Camera took this image catching the planet Saturn in the distant background (ESA/MPS/UPD/LAM/IAA/RSSD/INTA/UPM/DASP/IDA)

A final glance of Lutetia as Rosetta moves away from the asteroid's illuminated side (ESA/MPS/UPD/LAM/IAA/RSSD/INTA/UPM/DASP/IDA)

into view. Detailed analysis of the data obtained during the event is under way and soon we will know much more about Lutetia, particularly about its overall density and surface composition, adding to the understanding of the different types of asteroids and to solving the puzzle of how the Solar System formed and evolved.

→ VENUS EXPRESS

Venus Express continues to operate smoothly and is approaching its third inferior conjunction, when Venus will pass between the Sun and Earth. This event, which occurs in late October, also means that the spacecraft is at its closest distance to Earth.

Using the radio link between the spacecraft and the New Norcia ground station, more than 350 thermal profiles of the atmosphere at various latitudes and longitudes have been measured via radio occultations. These data make it possible for thermal and density structures in the altitude range 40–95 km to be mapped in unprecedented detail. Complementary nadir observations by the VIRTIS instrument and by solar and stellar occultations with the SpicaV/SOIR instruments extend the measurements up to 140 km altitude, providing a comprehensive picture of the atmospheric structure as required by a large variety of atmospheric phenomena studies.

These and many other new results were discussed at a major international scientific workshop about Venus held in Aussois, France, in June. A wide range of topics were covered, from modelling of the deep interior, through surface physics and chemistry, several aspects of the atmosphere, the plasma environment, atmospheric escape, the solar wind, comparative planetology, planetary evolution and future missions.

→ HERSCHEL

Herschel is now routinely performing science observations with all its three instruments, PACS, SPIRE and HIFI. Roughly one third of the observations comprising the 42 'Key Programmes' selected before launch have now been executed. The first Herschel In-Orbit Performance Review was held at ESOC in June, concluding that Herschel is operating well within specifications, and that no major anomalies are currently open.

In May, more than 400 astronomers attended ESLAB 2010, the 'Herschel First Results' symposium at ESTEC. Herschel has also prominently featured in plenary presentations at two other major meetings (American Astronomical Society and SPIE Astronomical Telescopes). In July, a special issue of *Astronomy & Astrophysics* was published featuring 152 papers based on Herschel observations. Another 50 papers featuring observations by the HIFI instrument, which became available for science later than PACS and SPIRE, will appear in the same journal in the autumn.

The first in-flight 'Announcement of Opportunity' for observing proposals was issued in May with a deadline of July.

→ PLANCK

The Planck satellite, payload and ground segment operations continue to work routinely, providing excellent and uninterrupted data. By this July, the whole sky has been surveyed at least once, and about half of the sky has been covered twice. Planck is scheduled to image the sky until the end of November 2011, by which time four sky surveys should have been completed.

The first Planck all-sky image of the microwave sky was released in July, derived from data collected over 12 months of observations. It has been synthesised using data spanning the full frequency range of Planck, which covers the electromagnetic spectrum from 30–857 GHz.

→ COROT

The CNES/ESA COROT mission continues to operate nominally after more than 1300 days in space. With almost three years left of its ongoing mission, COROT is currently searching for exoplanet companions to more than 5500 dwarf stars, while simultaneously carrying out an in-depth study of a number of interesting variable stars in the same field.

In addition to the continuing stream of exciting exoplanet discoveries, COROT continues to make detailed asteroseismological studies of bright stars. Among recent results, the detection of gravity modes in the massive B3V-type star HD 50230 has made it possible to determine that this star has exhausted about 60% of the hydrogen initially available in its core. Stellar structure models can now put realistic estimates for the remaining lifetime of this object, which is particularly interesting in this case because HD 50230 lies on the borderline between stars that will end their lives as white dwarf stars or as core-collapse supernovae.

→ LISA PATHFINDER

The Transfer Orbit Thermal Balance Test of the LISA Pathfinder launch composite, consisting of the Science Module (SCM) STM and the Propulsion Module (PRM) FM, was completed in the Solar Simulation Vacuum Chamber at IABG, Ottobrunn, near Munich. This test served as a proto-flight qualification test for the PRM and as a thermal design qualification test of the SCM. It included Launch and Early Operations Phase and Transfer Orbit thermal cases, and characterised the thermal noise to the instrument interfaces. The test ran very smoothly and the preliminary results indicate that the PRM FM can be stored and the SCM thermal design will be qualified.

The SCM FM is in Stevenage waiting for a number of units to return from scheduled refurbishment or completion of acceptance tests. The functional verification of the spacecraft is progressing, both at Real-time Test Bench and Software Verification Facility level, with the start of the preparation for the first Integration System Test, which will take place around November.

The micro-propulsion system is progressing with the final acceptance test of the Power Control Unit and the Neutraliser unit to be delivered between July and October. The FEEP thruster will start the second lifetime test by the end of July, which will confirm the performance obtained in the first lifetime test of two years ago. Work is being done to reduce the total impulse demand of the mission from the micro-propulsion and to gain sufficient margins in this respect. At the same time, a set of characterisation tests are being performed in order to improve the lifetime capability of the thruster in view of the needs for the LISA mission.

LISA Pathfinder in launch configuration after the Transfer Orbit Thermal Balance Test held at IABG. The Propulsion Module is the Flight Model, while the Science Module is partially made of Flight Models and thermal/structural dummies

The US Disturbance Reduction System payload flight hardware was previously integrated on the SCM. All suppliers of the electronics units of the European LISA Technology Package (LTP) have completed the testing of the flight equipment, and most have been accepted and electrically integrated at instrument level by Astrium GmbH; furthermore, the qualification model of the Caging Mechanism Assembly has been delivered to Carlo Gavazzi Space. The test campaign of the Optical Metrology Subsystem FM started in early July and will last until October.

The Mission CDR was completed, noting the criticality of the LTP and FEEP development still present and of the relevant impact on the launch date, which will not take place before the end of 2012.

GAIA

The Gaia 'torus' (optical bench) is now standing on its three bipods. The folding optics structure, which will later accommodate part of the optics, will be glued in July. Four FM mirrors have been delivered and the other two are expected in July. Almost all flight CCDs have been delivered and the coupling tests with their front-end electronics are ongoing.

One of the major risks of the project, the production and test of a huge amount of silicon carbide pieces, has now disappeared. All FM elements have been delivered by Boostec Industries.

A major achievement was the recent delivery of the Phased Array Antenna EM. An important test is planned in July to verify that, when the antenna is coupled with the transponder, the spurious emissions in the deep-space band are within specification.

At Astrium Ltd, Stevenage, UK, integration of the chemical propulsion and micro-propulsion tanks on the Service Module FM was completed last month. The Service Module will be shipped in July to Astrium SAS, Toulouse, where integration of the electrical units will continue.

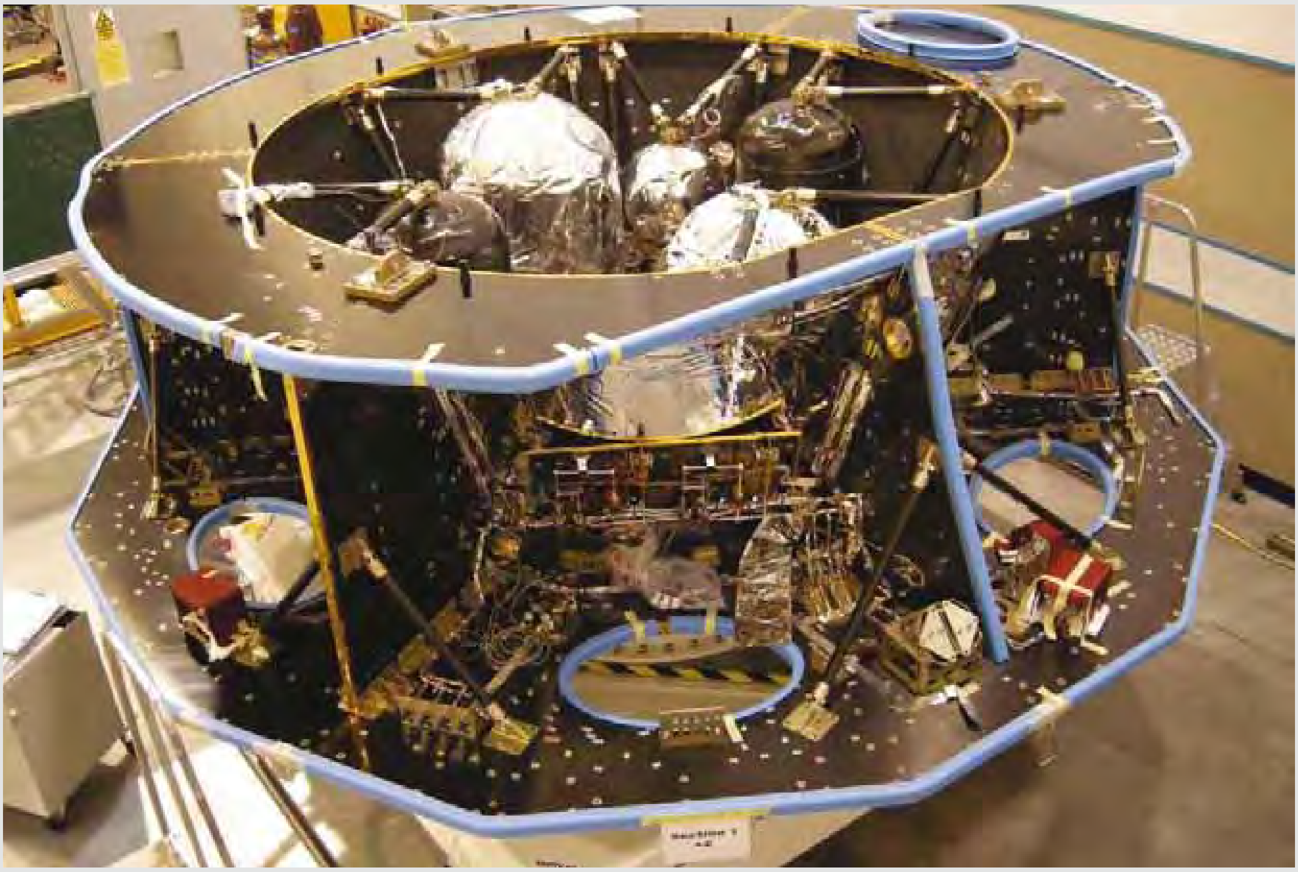
A major decision was taken on the Deployable Sun Shield: the baseline design has been changed to an active system with two motors and the relevant drive electronics. An assessment of the system-level implications is being carried out.

The Spacecraft CDR began on 1 July, and will run through the summer period and the CDR is planned for 15 October.

MICROSCOPE

The integration of the T-SAGE instrument QM continues at ONERA; the internal cylinder, proof mass and grounding gold thread are now mounted. Procurement of the FM components has started. The instrument front-end electronics FMs are being tested at ONERA. Preparation for the second droptower test at ZARM, University of Bremen, is ongoing.

A proportional cold-gas thruster system configuration is now the baseline design and the distribution of responsibilities between ESA and CNES was agreed. The system is based on the one developed for Gaia. The overall phase-B/C/D contract is being prepared for work to start in November.



The Gaia Service Module Flight Model under integration in the cleanroom at Astrium Ltd, Stevenage, UK (Astrium)

→ JAMES WEBB SPACE TELESCOPE

The NASA JWST project is facing major challenges to remain within the allocated cost profile while keeping pace with the schedule. NASA recently delivered the detector system and microshutter system FMs for the NIRSpec instrument to ESA.

Integration of the NIRSpec instrument FM is nearing completion. The Grating Wheel Assembly is the only subassembly not yet delivered and is under final cryogenic verification testing. All the electrical and optical ground support systems have been upgraded and are ready to support the instrument acceptance test campaign starting in September.

Integration of the MIRI FM, developed by a European consortium of scientific institutes, is also nearing completion. The detector system provided by JPL is the only subassembly yet to be delivered. The detector modules have been ready for some time, but problems of data loss from the electronics have hindered the timely delivery of the full detector system.

Activities on the launcher are progressing, with final agreement reached for the qualification activities for the launcher adaptor. The Final Coupled Load Analysis is ongoing and should confirm the load environment for JWST.

→ BEPICOLOMBO

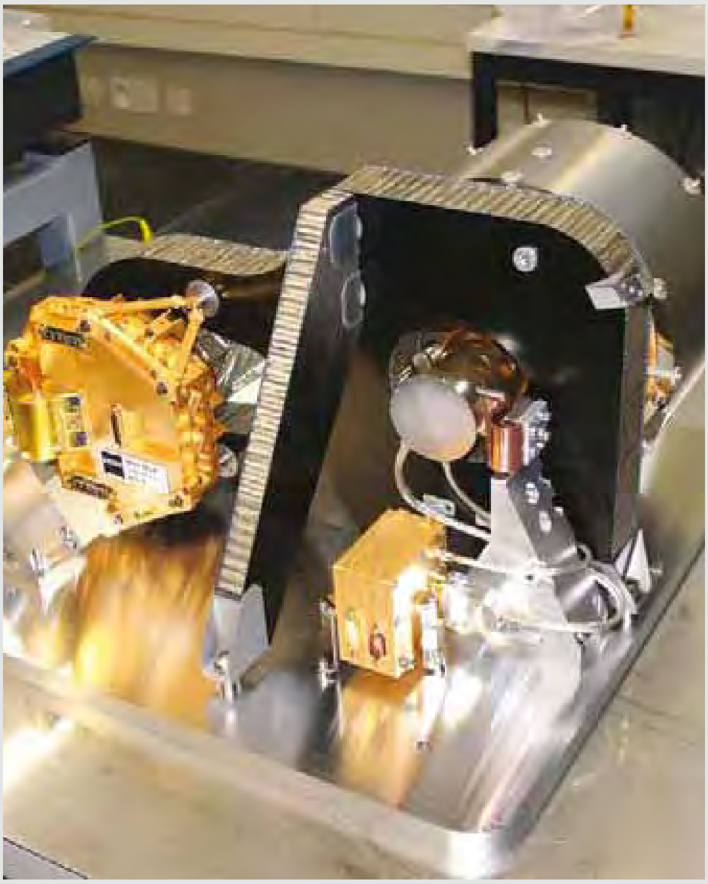
The Structural/Thermal and Electrical Qualification Models (STMs/EQMs) are being manufactured. More than 80% of the spacecraft items of equipment have passed their PDRs. Manufacturing problems with large panels of the MPO (European Orbiter) structure have been solved, but caused a delay in integration. All large structural elements have now completed manufacturing and the MPO structure is in its final assembly phase. Qualification tests of the 22 N thrusters used for the final descent to Mercury orbit were completed, mitigating one risk on reaching the nominal orbit.

A detailed thermal analysis showed that a number of experiment temperatures are up to 10°C above limits in the perihelion phase. Options are under investigation with the payload teams. A vibration failure of the ion thruster occurred but is now fully resolved, however the work on the Electric Propulsion System has slipped because some complex parts had to be remade. In addition, the neutraliser appears to operate with a high noise level.

Investigations and tests necessary to decide on a solution are being carried out. The first version of the central software was released and the validation campaign is ongoing.

NIRSpec Flight Model Microshutter Assembly (NASA/GSFC)

NIRSpec Flight Model Detector Assembly (NASA/GSFC)



BepiColombo's BELA Laser Altimeter Structural/Thermal Model

BepiColombo's MIXS X-ray telescope and collimator Structural/Thermal Model

The Acceptance Reviews for the STMs of the MPO payload are complete for five of the 11 instruments and the corresponding hardware is ready for delivery. Owing to a number of test failures experienced by instruments with a high-fidelity STM build standard, the remaining acceptance needs more time for solutions and additional tests. Nevertheless, these results allowed early identification of problems and provided valuable feedback for the subsequent instrument qualification programme. In parallel, work on the Engineering Models is also nearing completion, with deliveries at the end of 2010. In total, 60 physical instrument units for STMs and EMs have to be manufactured, integrated and tested by the science engineering teams and industry this year.

The MMO (Japanese Orbiter) payload electromagnetic compatibility (EMC) tests on the EM were completed and Proto-Flight Model (PFM) manufacturing is going as planned. EMC tests on spacecraft equipment EMs were completed as a prerequisite to begin PFM manufacturing. The MMO TM is ready for shipment to the ESTEC Large Space Simulator and will arrive in September for the 10 solar constant test.

The Ariane 5 launcher coupled-loads analysis was completed and the proposed notching profiles are acceptable. Launch is planned for the Mercury launch opportunity in mid 2014.

→ EXOMARS

ExoMars entered the second extension of Phase B2 (named Phase B2X2) on 1 April 2010. This phase will run until 31 March 2011 and will develop the system designs with a System PDR planned for October/December. An intensive effort has been made to distribute the new baseline design documentation to sub-contractors and negotiate their detailed work packages for Phase B2X2. Completion of negotiations is expected in the summer, which will allow industry to concentrate their efforts on the design activities for the baseline and prepare for the PDR. Some advance procurements necessary to secure the launch schedules have also been initiated and new industrial team members will be joining shortly.

The ExoMars Trace Gas Orbiter instruments Announcement of Opportunity, which was issued in January 2010, has been well received by the scientific community. The evaluation of large number of proposals took place with participation of ESA staff and European scientists, including an intensive accommodation study of various instrument combinations on the ESA-provided Orbiter. The final announcement of the selected instruments is expected later this summer.

Some of the ESA ExoMars team with the ExoMars 2018 Rover Module as reproduced using locally-grown flowers and entered in the 'Bloemencorso' flower parade competition in Noordwijk, The Netherlands, in April

The accommodation of the Rover Module, which will fly in 2018 on the NASA-provided spacecraft, was discussed with NASA/JPL at a workshop earlier this year. A preliminary requirements document for the interfaces was provided by NASA/JPL as a basis for the PDR design. Accommodation of two new instruments in the Rover Module, the LMC and CLUPI, has been completed. A major interruption of work on the NASA-provided part of the MOMA instrument in the Rover Module occurred, owing to responsibility for the design and construction of the NASA-provided part of MOMA moving from Johns Hopkins University to Goddard Space Flight Center. The full impact of this change is under assessment but significant replanning and a schedule change are expected.

→ CRYOSAT

Following launch on 8 April, CryoSat's six-month Commissioning Phase started with the main payload instrument, SIRAL, being switched on. The early results looked extremely promising at the level of raw data, but the ground processing system proved to have a number of bugs. During the first three months of the mission, these bugs were removed from the operational processors such that distribution of data to the calibration and validation teams could start in July. Initially, only data at Level 1b were distributed, since the bugs in the Level 1b processor had prevented any assessment of Level 2 products. Assuming these do not show any major deficiencies, they will also be released to the Calibration and Validation community soon after the Level 1b products.

The SIRAL radar is designed to operate in a specific range of heights, associated with a so-called 'frozen orbit'. Here, some of the orbital elements (eccentricity and argument of perigee) are selected so that the eccentricity vector remains static. The actual orbit achieved had a very low eccentricity, so that the orbit was not frozen. The resulting oscillation of the eccentricity vector would lead to exceeding the design height range in just over a month. Therefore, during May and early June, two measures were taken: a series of orbital manoeuvres were performed to partially freeze the orbit, reducing the height range, and some changes were made to the radar timing (implemented in an on-board database) which broadened the operating height range.

Data are being collected by both the prime and redundant SIRAL instruments, in successive periods of 15 days, to allow cross-calibration. As a result of the orbit and timing changes, the first of these 15-day periods did not occur until the second half of June. Between the 15-day data-takes, a series of roll manoeuvres were performed to gain additional information about the interferometer performance. Data have also been acquired while passing over a dedicated transponder at the Svalbard ground station, which also provided valuable calibration results.

→ ADM-AEOLUS

The Aeolus satellite platform is in storage and will be reactivated in September for reaction wheel maintenance, loading of qualified software and an integrated system test at avionics level. The In-orbit Cleaning Subsystem, providing the required oxygen flow for 'cleaning' the high-intensity laser optics, has passed its PDR; the associated equipment suppliers are being selected and the development model is under integration. The activities also involve partial sealing of the laser and transmitter optics.

Aeolus telescope Flight Model during testing at the Centre Spatiale de Liege, Belgium (Astrium SAS)

Swarm Flight Models 1 and 2 during integration at Astrium GmbH, Friedrichshafen

The full telescope FM has been tested in vacuum at the Centre Spatiale de Liege, Belgium, to characterise the laser-induced contamination effects on the optical elements that cannot be protected by the oxygen gas flow.

Master oscillator testing in vacuum of the first FM of the ALADIN laser transmitter is being conducted by Selex Galileo, Florence. Recent EM testing has further increased the insight into the causes of slow energy losses observed under vacuum conditions. Several parallel activities are taking place to safeguard scientific performance at system level.

Stable and complete versions of the end-to-end simulator and ground payload data processing software are available and releases of refined versions are planned on a six-monthly basis.

→ SWARM

Flight Model structures of the first, second and third Swarm satellites have been delivered, equipped with the cold-gas propulsion sub-system. Meanwhile integration of the first and second satellites with the avionics is taking place, if somewhat slowed by late delivery of some instruments. Investigations into the failure of the Absolute Scalar Magnetometer (ASM) FM during thermal vacuum testing are under way at CNES/Laboratoire d'Electronique et de Technologie de l'Information (LETI).

A third characterisation/calibration campaign was organised at the Calar Alto Observatory, Spain, for the fine characterisation of the Euler angles from the vector magnetometer as mounted on the optical bench of the second satellite. The preliminary results from the first and second campaign were excellent.

A launcher requirement review was completed in June with Eurockot and Khrunichev.

→ EARTHCARE

The ATLID Instrument PDR took place in May. The instrument concept was changed last summer to a bistatic configuration to mitigate the potential risk of laser-induced contamination (LIC). Instrument design and associated changes have been reviewed together with instrument performance budgets, feasibility aspects and spacecraft interfaces. The IPDR Board concluded on the feasibility of the proposed bistatic implementation but recorded the need to demonstrate robustness to LIC, the need to confirm the transmitter performance and the design of the new sub-systems of the bistatic instrument.

In parallel with above instrument redesign, the system documentation update for the System PDR was prepared, taking into account earlier action items as well as the increased ATLID accommodation and resource demands by modification of the satellite design.

The System PDR took place at the end of June and recorded that all issues were properly addressed. Although there were some reservations about the maturity of the ATLID bistatic configuration and the overall project schedule has to be revised as a result of the instrument redesign, significant progress was achieved and the PDR objectives were met pending the remaining action items and satisfactory implementation of PDR recommendations.

Following thermal vacuum testing by JAXA, the Cloud Profiling Radar EM is undergoing antenna pattern testing. Meanwhile, the instrument interface control document has been updated by industry and reviewed by JAXA and ESA teams.

Equipment procurement continued during the last quarter with about 60% of the procurement now initiated; procurement of the structure and solar array remains on hold until full confidence is achieved regarding the ATLID sizing.

→ MTG

The contract proposal was submitted to the Industrial Policy Committee (IPC) at the end of June. More detailed negotiations are now under way with the selected consortium, which comprises Thales Alenia Space France, OHB Systems and Kayser Threde. A positive outcome from the IPC will allow Phase-B2 to begin later this year.

→ METEOSAT

Meteosat-8/MSG-1

The satellite is in good health with instruments performing normally. It continues to provide the Rapid Scan Service (RSS), complementing the full-disc mission of the operational Meteosat-9.

Meteosat-9/MSG-2

Meteosat-9 is Eumetsat's nominal operational satellite at 0º longitude, performing the full-disc mission (one image every 15 minutes on 12 spectral channels), with Meteosat-8 serving as its back-up. Satellite and instrument performance are excellent.

MSG-3

MSG-3 is in long-term storage in Thales Alenia Space Cannes. The change request to industry concerning all satellite activities, starting with leaving storage in 2011 up to return to Europe after the launch campaign, is under negotiation. MSG-3 launch is planned for June 2012.

MSG-4

Assembly of the new SEVIRI Drive Unit (DU) is completed and testing has started. Once the qualified DU is available, dismounting activities on the satellite will start. After reintegration of the DU, the satellite will be submitted to mechanical, acoustic and reference testing. MSG-4 launch is planned for January 2014.

→ METOP

MetOp-A satellite, launched on 19 October 2006, is in very good health. All instruments continue to perform excellently in orbit.

MetOp-B and MetOp-C

The industrial team is preparing MetOp-B for launch (April 2012) and also preparing MetOp-C to be available as back-up. Following finalisation of the integration activities on the Payload Module (PLM-1) for MetOp-B, it was placed in ESTEC's Large Space Simulator ready for the thermal/vacuum test to verify the instrument performances.
The Service Module (SVM-1) for MetOp-B completed the reference tests and will go back into storage while waiting for its thermal/vacuum test in July 2011.

PLM-3 was taken out of storage in April and the High Rate Picture Transmission (HRPT) system was integrated and tested. In September, the MHS and AMSU-1 instruments will be also available for integration and the PLM-3 will go to functional testing. The SVM-3 was taken out of storage and is being prepared for tests. The satellite assembly and integration activities (PLM-3 and SVM-3) will start at the end

MetOp-B Payload Module being moved into the Large Space Simulator at ESTEC, Noordwijk of 2010 ready for the MetOp-C mechanical tests in early 2011. MetOp-C is planned for launch in October 2016.

→ SENTINEL-1

The Sentinel-1 project is currently going through the System CDR, to be completed on 14 July. In preparation for the System CDR, the CDRs of the SAR payload and the critical platform equipment took also place during the spring.

The Waveguide Radiator (Astrium GmbH) manufacturing process is under control with a reported yield of the critical plating process of about 80% for the QM units. The SAR Antenna Electronic Front-end module (Thales Alenia Space Italy) manufacturing continues with the production of the EQM models and the dedicated Tile Amplifiers. The test campaigns for the mini-Tile STM and the Tile STM are currently in place to verify the SAR antenna thermo-mechanical design and life test.

The consolidation of the Optical Communication Payload (OCP) interfaces is progressing with the review of the OCP ICD by ESA, DLR and TESAT, as OCP provider, in order to have this ICD signed by all parties in July.

Following approval by the Industrial Policy Committee, a new ITT for the procurement of the Sentinel-1A launch services will be issued, open also to non-European launch service providers.

→ SENTINEL-2

Following instrument and equipment-level CDRs, a multispectral payload instrument EM including detectors, optical filters, front-end electronics and video and compression unit has been integrated and is under test. At platform level, all equipment underwent PDR. Some equipment CDRs are also being conducted, with the delivery of the first EMs due for integration within the Engineering Functional Model by the end of 2010.

The first onboard software delivery for assembly, integration and testing is expected in October. The payload instrument and satellite CDRs are scheduled for September and December. The Optical Communication Payload underwent an Interface Requirement Review in June, allowing the start of the production.

On the launcher side, the ITT for the selection of the Sentinel-2 launch services provider was issued. The evaluation of the offers and the selection of the contractor should be finalised by the end of this year.

The Sentinel-2 Ground Segment PDR began and should be completed in September.

→ SENTINEL-3

Sentinel-3 Phase-C/D detailed design activities are proceeding, with more than 50% of the equipment CDRs completed and the remainder to be completed in the summer. Instrument and satellite-level CDRs will follow in late 2010 and early 2011. The Sentinel-3 Ground Segment PDR has been completed and the Ground Segment implementation phase started. At Space Segment level, the industrial consortium is almost finalised, with only three subcontracts remaining to be placed out of 120.

At system level, the activities focused on the Spacecraft Characterisation database definition. The first release of the Ocean Land Colour Instrument (OLCI) CCDB was delivered for simulation tool development (O-GPP and O-SPS). The Sea Land Surface Temperature Radiometer (SLSTR) CCDB definition was improved and delivery of the first release is expected soon. In parallel, the Ground Processor Simulator development was consolidated based on these new inputs, leading to availability around March 2011 for the optical simulators and December 2010 for topography.

Manufacturing and testing activities at unit level are taking place, with delivery of several STMs and EMs. The delivery of the SMU (On-Board Computer) EM is expected at the beginning of July, allowing the set-up of the Virtual EM test bed at satellite level, where all satellite avionics will be integrated and validated together with the flight software, before starting the assembly, integration and testing of the Proto Flight Model (PFM).

For the SLSTR, several breadboarding activities were performed by Selex Galileo and demonstrate very good results for the front-end Electronics, with very stable performance over the operational temperature range. For the Microwave Radiometer, the SM test campaign was completed and test review held in May. EM/EQM activities are ongoing for the Radio Frequency Front End (RFFE) and the Radiometer Processing Module. Some delays are faced on the RFFE due to manufacturing problems. Synthetic Aperture Radar Altimeter development is ongoing and a modification to the instrument antenna fixture on the satellite has solved a critical issue.

On the launcher side, the ITT for the selection of the Sentinel-3 launch services provider has been issued. Evaluation of the offers and selection of the contractor should be finalised by the end of this year.

→ SENTINEL-5 PRECURSOR

Two parallel Sentinel-5 Precursor System and Spacecraft Phase-A/B1 studies with Astrium Ltd and OHB Systems were initiated in June for one year.

Procurement of the TROPOMI equipment by the prime contractor Dutch Space is progressing with competitive ITTs issued and evaluations almost complete. The TROPOMI instrument, provided by the Netherlands as a national contribution to the Sentinel-5 Precursor project, completed a design-to-cost exercise that has resulted in rationalisation of the overall payload design. The Phase-B design process should be complete by the end of the year.

→ ALPHABUS/ALPHASAT

System and launch

The Alphasat CDR was concluded on 18 June at Inmarsat. The review covered all aspects of the mission, from payload to service module and declared that all elements are in a state of maturity appropriate for this phase of the programme. The next review, the Alphabus Qualification Review, is planned in the autumn to confirm the qualification of the Service Module as a generic product line item. Launch of Alphasat on an Ariane 5 is scheduled for mid-2012.

Service Module

The 'shogun' test to characterise the launcher-induced shock levels at the spacecraft/launcher interface and within the spacecraft took place at Intespace, under the leadership of Arianespace. The test article was the Service Module FM, complete with harness, piping and thermal control but with potentially sensitive flight electronics replaced by dummies or structural models. Data acquired during the test is being processed and final results for all spacecraft units will be available in September.

Preparation of Alphabus 'shogun' shock test at Intespace, Toulouse

The gas control part of the xenon propulsion system is being assembled at Thales Alenia Space Cannes for delivery to Astrium for integration on the Service Module and completion of fluid tests in the summer.

Repeater Module

Both North and South Half Repeater Module structures are being fitted out at Astrium Ltd, Portsmouth, UK. Harness and piping have been fitted and the Multiport Amplifiers are being fitted in preparation for alignment and test. A significant proportion of the various payload equipment items are undergoing integration.

Payload

The Inmarsat extended L-band payload will support advanced geomobile communications and augment Inmarsat's Broadband Global Area Network (BGAN) service with its coverage centred over Africa, providing additional coverage to Europe, the Middle-East and parts of Asia.

Development of the Inmarsat operational payload equipment is ongoing. For most of the equipment targeted for the payload, qualification model testing is complete and Proto-Flight Models or FMs are being shipped to Portsmouth for integration. The state-of the-art integrated processor is being tested, which remains a priority in the programme due to its pivotal role in the payload performance. The similarly important Frequency Generator Unit and Payload Calibration Unit tests are both nearing completion. More than half of the 135 Solid State Power Amplifiers are now delivered and testing on the first Multi-Port Amplifier is continuing. The Payload Test bench is under assembly, with the MDPA Payload Processor available for test in Portsmouth following refurbishment.

The Payload Repeater Module is on track to be shipped to Astrium Toulouse at the end of 2010.

Technology Demonstration Payloads

TDP qualification hardware is being manufactured. All TDPs have passed a test campaign on the Alphabus Avionics Test Bed hence confirming their compatibility with the satellite avionics. The operational concept for the TDP commissioning and routine operations is being established.

A new activity related to the ground segment of TDP5 is under preparation with Joanneum Research (Austria) in coordination with ASI (Italy), responsible for the TDP ground operations. It consists of the definition, selection, installation and operation of a high-performance Q/V-band ground station with tracking antenna on a fixed location in Graz.

Alphabus extension

The Alphabus extension will increase the platform's power, mass and thermal rejection capabilities. The workplan includes the development of key enabling technologies such as a deployable panel radiator for increased heat dissipation and an ultra-stable antenna module for future complex Alphabus satellites. The request for proposal for the corresponding full scope programme has been issued to the Alphabus industrial co-contractors Astrium and Thales Alenia Space in June, and it is planned to place the industrial contract before the end of the year.

Alphasat Ground and User Segment and applications

The workplan for the Ground and User Segment and Applications programme contains a set of activities defined together with Inmarsat for the exploitation of Alphasat as well as the global Inmarsat 4 satellite constellation. Activities started in 2010 with Inmarsat, including general Alphasat service and system requirement definition, preliminary design activities and the development of core functionalities for safety and emergency communication services for maritime, aeronautical and land-vehicular environments.

A further activity is in preparation with Thrane & Thrane (Denmark) for the development of a generic BGAN user terminal platform supporting the upgraded capabilities of the BGAN system using Alphasat.

→ HYLAS

Hylas (derived from 'Highly Adaptable Satellite') is the first satellite project specifically initiated to provide broadband data services (i.e. internet access) to under-served regions of Europe. It will provide capacity to serve hundreds of thousands of internet users and broadcast up to 30 standard or 15 high-definition TV channels. The project is funded via a Public Private Partnership (PPP) between ESA and Avanti Communications, a UK-based satellite operator, set up in 2006. Astrium was awarded the Hylas 1 satellite development contract directly by Avanti.

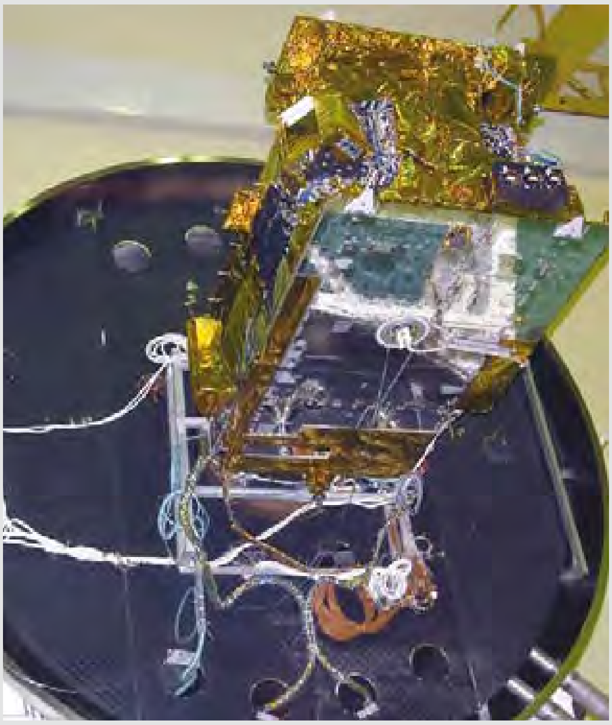
Hylas 1 will include a high-performance communications payload based on the Generic Flexible Payload (GFP) concept developed by EADS Astrium. The GFP architecture uses advanced analogue technologies to enable satellite resources to be continuously adapted to match evolving market demands throughout a satellite's lifetime.

The Ku and Ka band payloads will be integrated onto an Indian Space Research Organisation (ISRO) I2K platform, provided through a commercial partnership between Astrium and Antrix Corporation, ISRO's commercial arm. The spacecraft lift-off mass will be 2600 kg and its mission lifetime will be 15 years in geostationary orbit. Hylas 1 will be launched by Arianespace from Europe's Spaceport, Kourou, French Guiana.

As part of the PPP agreement, Avanti also procured the services and hardware elements necessary to operate the satellite and provide communication services (e.g. gateway stations, user terminals and network infrastructure).

Satellite development activities formally began in April 2006. The GFP comprises flight equipment developed by Astrium, as well as by other European and Canadian manufacturers. GFP qualification activities were completed in October 2009 in Portsmouth and included the first end-to-end measurements of the flight Ka and Ku band payloads, already installed on the spacecraft panels. The panels were then shipped to ISRO facilities in Bangalore for integration on the spacecraft and the start of the ground test programme.

The spacecraft test campaign progressed swiftly, with thermal vacuum testing completed in May, launch vehicle interface checks in June and vibration and acoustic tests completed in July.



Hylas 1 leaving the thermal vacuum chamber, Bangalore, India

→ ARIANE 5 POST-ECA

The Launch System Concept Review (LSCR), the first major review of the project, began and will be completed by the end of July.

→ VEGA/P80

The main achievements are the successful Zefiro 9A Verta 2 firing test on 25 May, completion of the Payload Adaptor qualification review, delivery of Vega Electrical Simulator to Kourou and finalisation of the P80 SRM qualification review.

The first part of the Launch System Ground qualification review started in March and will be completed as planned in July.

Qualification of the Roll Attitude Control System thrusters is ongoing, with additional tests to consolidate the test database, to be completed in July. All other Vega subsystems have been qualified or have finished qualification testing.

The qualification tests at system level of the avionics and software are continuing. For the ground segment, the Mobile Gantry installation is complete and the first integrated tests will be complete by mid-July.

Tests at Kourou, for qualification of the launcher/ground interfaces, will start in June, combined with the electrical and software test campaigns.

→ SOYUZ AT CSG

The Russian delivery to the Soyuz launch site is complete and activities are now focused on equipment and system site acceptance tests.

The Mobile Gantry structures were fully integrated in May and delivered to the European side in June, allowing the 'Corps d'Etats Complémentaires' implementation to start. Other activities, such as on the Ancillaries Control Bench, and adaptations to the Payload Preparation Complex, are all proceeding on schedule, with a first launch planned for late 2010.

On integration activities, the second launcher storage metallic structure and roofing are now completed, and the second launcher kerosene storage is nearing completion. Installation of the Russian systems is almost complete. Cleaning of the liquid oxygen/liquid nitrogen (LOX-LIN) system (storage area and pipelines between storage and launch zone) and pipelines and vacuum pumping of the pipeline double envelopes is ongoing.

The Soyuz Consultation Committee, comprising representatives of ESA, CNES, the Russian space agency Roscosmos and Arianespace, met on 11 May in French Guiana to confirm the inaugural Soyuz launch (ESA/CNES/Arianespace Optique Video CSG/P. Baudon)

Integration of the first and second stages is complete for the first Soyuz to be launched from Europe's Spaceport in French Guiana ((ESA/CNES/Arianespace Optique Video CSG/P. Baudon)

The Russian autonomous tests on all systems are taking place and the preparation for the acceptance review is ongoing. The Infrastructure S3B qualification tests started in May with a mock-up filling campaign.

Maintenance of the first launcher in the assembly and testing building (MIK) was completed in May. The Soyuz launcher is now fully integrated and stored in the MIK building.

→ FUTURE LAUNCHERS PREPARATORY PROGRAMME

Intermediate eXperimental Vehicle (IXV)

Phase-C Key Point was reached, with consolidation of the improved design. In addition, activities on technology development for the Ceramic Thermal Protection System started. The Request for Quotation for the Phase-D activities was issued to industry. Detailed design activities are progressing towards the sub-system level CDRs. Completion of Phase-C is expected at the end of the year with the System CDR.

Next Generation Launcher (NGL)

Negotiation of system activities for the NGL concepts has been completed. Industrial system activities for the NGL concepts were initiated and are progressing towards the first key point at the end of 2010.

Propulsion

In Main Stage Propulsion, after completion of the Preliminary Requirements Review of the High Thrust Engine (HTE) Demonstrator, the Architecture Key Point was held, dealing with the thermodynamic cycle and mechanical architecture of the demonstrator. The HTE Demo SRR is being prepared, with industrial partners preparing a proposal for continuation of the activities leading to HTE Demo PDR.

Activities are progressing towards PRR/SRR for the storable propulsion demonstrator. Pressure Oscillation Demonstrator activities are being resumed. Several activities have been initiated in technology development for optimised structures. The development of several enabling technologies for a reignitable Cryogenic Upper Stage is also progressing.

→ HUMAN SPACEFLIGHT

Senior representatives from the five ISS cooperating agencies met for the ISS Multilateral Coordination Board (MCB) in the USA on 24 June. They unanimously reaffirmed their determination to maximise the benefits from utilisation of the ISS while also trying to reduce operations costs. The benefits to future exploration beyond low Earth orbit through enhanced ISS research, technology development and broad utilisation opportunities were also noted.

The MCB was pleased to learn that the Japanese Space Activities Committee on ISS Extension has completed its final report and recommended to the government of Japan the continuation of ISS operations to 2020. The government of the Russian Federation has similarly given its initial approval. The Canadian Space Agency is

The International Space Exploration Coordination Group: senior staff representing space agencies of Canada, China, Europe, Japan, Korea, Russia, Ukraine and USA met in June

also in discussion with government authorities. All the ISS partners expect to secure, by the end of 2010, final authorisation from their governments to continue ISS operations to 2020.

Looking to the future, the MCB reviewed efforts under way to increase efficiency and further enhance the use of the ISS and future exploration through standardisation of interfaces (such as docking and berthing mechanisms), definition of common transportation requirements, and cost reduction strategies. The MCB is also working together to develop mechanisms to increase outreach to non-traditional users to fully exploit the ISS for science, engineering, technology development and education. In support of this effort, the MCB were favourable to ESA's request to extend the utilisation of its Columbus laboratory to all member countries of the European Union.

Meanwhile, the major international space agencies of the International Space Exploration Coordination Group (ISECG) met on 23 June to review work carried out in the last three years. The meeting was opened by NASA Deputy Administrator Lori Garver and ESA Director of Human Spaceflight Simonetta Di Pippo, the outgoing ISECG Chair. The lunar human exploration reference architecture was endorsed, and foundations were laid for further work on a Global Exploration Roadmap, which will include destinations other than the Moon as the natural extension of the Global Exploration Strategy, of which ISECG is the implementing group. Future work may also include a technology assessment exercise in support of the Roadmap. The group also agreed on the need to intensify their dialogue to seize cooperation opportunities to strengthen activities in the near future.

Ten past and present ESA astronauts and the Director of Human Spaceflight attended a workshop dedicated to 'Spaceflight: Yesterday–Today–Tomorrow' at the ILA international aerospace show in Berlin on 11 June.

The full 520-day simulated mission to Mars began on 3 June, when ESA prime crew members Romain Charles (FR) and Diego Urbina (IT/Colombia) together with one Chinese and three Russian participants closed the hatch to their 'spacecraft' at the Institute of Biomedical Problems in Moscow. The simulated human mission to Mars will have a planetary phase in February 2011 and runs until November next year.

The Mars500 crew give a thumbs-up before they are locked in the Mars mission modules that will be their home for next 18 months. Left to right, Alexander Smoleevski, Romain Charles, Alexei Sitev, Sukhrob Kamolov, Diego Urbina and Wang Yue, face a mission that is as close as possible to a real space voyage (ESA/IBMP/O. Voloshin)

The European Robotic Arm spare elbow unit, before being covered under a thermal blanket, attached to Russian Mini Research Module 1 (MRM-1) for launch on the Space Shuttle *Atlantis* in May

The European Robotic Arm (ERA) flight spare elbow unit, attached to Russia's Mini Research Module 1 (MRM-1), was launched to the ISS on 14 May inside the cargo bay of Space Shuttle *Atlantis*. The MRM-1 module with the ERA spare has since been installed on the Russian segment of the ISS. With regards to ERA, Roscosmos has resumed activities for the Multipurpose Laboratory Module, targeting a launch in March 2012. The Joint Project Plan, announced on 2 March, was signed in Tokyo by the ESA and Roscosmos Directors of Human Spaceflight on 10 March.

ESA's 52nd A300 Parabolic Flight Campaign was carried out in May with 12 experiments (six in Life Sciences and six in Physical Sciences). The next campaign is planned for the end October 2010.

With respect to the 'Call for Ideas for Climate Change studies from the ISS', issued at the end of October 2009, the internal scientific evaluation of the 45 proposals received and preliminary feasibility assessment has been made and there are a number of promising proposals with high scientific relevance. The release of a dedicated AO is planned for autumn 2010.

The evaluation and resulting selections for the three ELIPS research solicitations (AO-2009/ILSRA-2009/BR-2009) were approved on 26 May. With the new experiments in the research pool, ESA's ISS resources will be fully utilised beyond 2015 and include a lot of internal scientific cooperation with ISS partners.

By the closing date of 12 April, 12 proposals had been received in response to the latest Concordia AO. The peer review and feasibility assessment has been completed and a dedicated results and selection proposal has been submitted for endorsement.

→ SPACE INFRASTRUCTURE DEVELOPMENT/ISS EXPLOITATION

The ATV *Johannes Kepler* (ATV-2) launch campaign is now well under way following the shipment from Bremen on 12 May and its unloading in Kourou on 25 May. The 'ready for launch' date has been moved to 18 December, owing to late availability of the CSG integration facilities related to a recent Ariane 5 launch delay. This date is still compatible with a docking before closure of the 'window' on 7 January 2011. The precise launch date will be determined before 31 July depending on the launch campaign status and vehicle traffic to the ISS. Meanwhile, the NASA ATV-2 review board highly appreciated the status of the ATV-2 mission.

The ATV *Edoardo Amaldi* (ATV-3) launch readiness date has also slipped to the end February 2012 because of the thermal vacuum testing of the Equipped Avionics Bay, with this new date still under ESA assessment. The ATV-4 system integration started at the end of June.

ATV *Johannes Kepler* being shipped from Bremen at night on 10 May 2010 (Astrium GmbH)

ATV *Johannes Kepler*'s Integrated Cargo Carrier Pressurised Module at CSG, Kourou

→ UTILISATION

Implementation of the Increment 23 experiment programme concluded and Increment 24 will continue until September 2010. However, because of the delay of the STS-134/ULF-6 launch and some KUBIK and Biolab anomalies, some impact on the Increment 24 and 25/26 experiment programmes is expected with some replanning required.

External payloads

The SOLAR platform was in Sun-pointing mode and acquiring data until 13 June, when the Sun observation window closed. Earlier Sun observation cycles were completed in April and May. The SOLAR science team contributes to an international data pool and is now envisaging continuing science operations beyond 2013.

The Expose-R facility with nine exobiology experiments continues to function well and acquire scientific data. A tentative return date for the sample trays is late 2010, which allows for a scientifically beneficial extension of the open space exposure period by 50%.

Following commissioning of the Automatic Identification System (AIS) in June, the system is continuing to acquire data and is tracking about 90 000 vessels. AIS is testing the means to track global maritime traffic from space.

Life sciences

The next ESA experiment to take place in the European Modular Cultivation System (EMCS) in July, Genara-A, was transported to the ISS on the Space Shuttle *Atlantis* STS-132 in May. Genara-A will study plant (*Arabidopsis*) growth in weightlessness at a molecular level.

In Biolab, all runs of the second part of the Waving and Coiling of *Arabidopsis* Roots (WAICO) experiment were performed. The four experiment containers were returned to Earth on 26 May with STS-132 and are undergoing analysis at the science team's laboratory.

The European Physiology Modules (EPM) facility in Columbus has been repeatedly activated in support of several sessions of the DOSIS (Dose Distribution inside the ISS) and PASSAGES experiments. The PASSAGES experiment is designed to test how astronauts interpret visual information in weightlessness. The DOSIS experiment is progressing well with the instrument acquiring data using the active DOSTEL detector in the EPM following removal and return of the passive dosimeters on STS-132. The passive detectors are now undergoing detailed scientific analyses. Files for the DOSIS experiment were transmitted via the EPM facility on 30 June.

The Portable Pulmonary Function System is continuing to support ESA's ThermoLab and EKE experiments in combination with NASA's VO2Max experiment. The Muscle Atrophy Resistive Exercise System (MARES) was launched on STS-131/19A in collaboration with NASA and uses the last remaining rack space in Columbus. Commissioning will be done during Increment 24.

ESA is carrying out its new Vessel Imaging experiment in conjunction with NASA's Integrated Cardiovascular Experiment. The first sessions of both experiments were carried out by ISS Flight Engineer Shannon Walker (US), assisted by Doug Wheelock (US), in June. ESA's experiment evaluates the changes in central and peripheral blood vessel wall properties and cross-sectional areas of long-duration ISS crewmembers during and after long-term exposure to weightlessness.

The Matroshka radiation 'phantom' has been equipped with a set of new dosimeters and is now accommodated in Japan's Kibo lab until early 2011 under an international cooperation agreement including Russia and Japan.

Materials and fluids research

The CETSOL and MICAST experiments were carried out in the Material Science Laboratory, with 12 sample cartridges processed, meanwhile processed samples are being analysed by the relevant science teams on the ground. CETSOL and MICAST are two complementary material science projects that carry out research into the formation of microstructures during the solidification of metallic alloys. US scientists have joined the European science teams and are performing joint experiments.

In addition to the completed SODI-IVIDIL experiment, the next SODI experiments are Diffusion and Soret Coefficient Measurements for Improvement of Oil Recovery (DSC) and Crystallisation of Advanced Photonic Devices (Colloid). The Colloid experiment cell assembly will be uploaded to the ISS on the Progress flight 39P in early September together with the refurbished SODI control unit.

Technology research

On 9 June the European Drawer Rack was activated during the commissioning activities for the Erasmus Recording Binocular (ERB-2). ERB-2 is a high definition 3D video camera that takes advantage of high-definition optics and advanced electronics to provide a vastly improved 3D video effect for mapping the ISS.

Non-ISS Missions

The winter-over isolation campaign is running at the Concordia station in Antarctica until November. Operated jointly by French and Italian scientists, Concordia is the third permanent research station on the Antarctic Plateau beside the Russian Vostok and US Amundsen-Scott Stations.

Two bedrest studies are taking place, one at DLR in Germany and the other at the MEDES Space Clinic, Toulouse. The first has a focus on nutrition, and the latter on artificial gravity.

→ ASTRONAUTS

ESA astronaut Christer Fuglesang (SE) was presented with NASA's Exceptional Service Medal at a ceremony in June in

Left to right, the Soyuz TMA-21 crew, Catherine Coleman (US) Dmitri Kondratyev (RU) and ESA astronaut Paolo Nespoli (IT) will fly to the ISS in December 2010, joining Expeditions 26 and 27 and staying on the station until May 2011 (GCTC)

Houston, Texas. The medal is awarded for 'significant and sustained performance, characterised by unusual initiative or creative ability that clearly demonstrates substantial improvements or contributions in engineering, aeronautics, spaceflight, administration, support or space-related endeavours that contribute to NASA's mission'.

ESA astronaut Frank De Winne (BE) and his Soyuz TMA-15 crewmates Roman Romanenko (RU) and Bob Thirsk (CA), visited ESA's Columbus Control Centre near Munich, Germany, in April. They also met with ESA Director General Jean-Jacques Dordain and Antonio Tajani, Vice-President of the EC in charge of Industry and Entrepreneurship, in Brussels on 3 May.

Crew training for ISS Expeditions 25 to 30 is on schedule. Astronauts Paolo Nespoli (IT) and Roberto Vittori (IT) are training for their planned missions in December 2010 and February 2011 respectively. André Kuipers (NL) continues his mission training for the ESA ISS Increment 30/31 starting at the end of 2011.

During basic training, the new astronaut candidates enjoyed a taste of space during a special parabolic flight in Bordeaux, France, in May. Then they headed to Sardinia for their survival training in June. The candidates are now having special skills training, such as Extravehicular Activity (EVA) pre-familiarisation training and Generic Robotics Training (GRT). Basic training will be completed this November.

The Multilateral Crew Operational Panel took place in Montreal in June to discuss the ISS Crew Rotation Plan, the status of the Soyuz/Progress planning manifest, the status of HTV and ATV launches and the assignment of crews for Expeditions 34 and 35.

→ CREW TRANSPORTATION AND HUMAN EXPLORATION

Advanced Reentry Vehicle (ARV)

ARV Phase A has progressed with the delivery of the PRR data package. In the meantime, Requests for Quotations and ITTs have been released or are under preparation to include other subcontractors, following Best Practices procedures.

Further interactions have taken place with the ISS partners for a more detailed assessment of the ISS needs for 2016–20, to establish a Common Transportation Policy.

International Berthing Docking Mechanism (IBDM)

A Request for Quotation for advanced tasks in the development of the IBDM Enhanced Engineering Development Unit has been issued to Qinetiq (BE) and MDA (CA). These tasks will enable further closed-loop testing of the 'soft capture' system, the definition of the requirements and a first system-level design for an Enhanced Engineering Development Unit in line with international standards and its application to the ARV.

The International Docking System Standard Working Group is working on the detailed configuration for the new docking standard. The 5th Technical Interchange Meeting was hosted by ESA at ESRIN in June. Progress was made for all the technical aspects of the docking standard interface with the final definition to be finalised at the next meeting in October or November.

Expert

Phase-D of the test bed development is ongoing. Vehicle integration has started at Thales Alenia Space Italy, Turin, to be ready for system tests in October. The schedule for the delivery of the parachute is being negotiated with the Russian supplier. Sufficient margin must be maintained for a launch in spring/summer 2011. Discussions with Russian authorities have secured a launch from a Russian submarine on a Volna rocket.

Lunar Lander activities

An Information Day on the Lunar Lander mission was held in April at ESTEC. Presented as a human exploration precursor mission, it attracted a large audience with a strong interest on the mission technology and scientific payload. Industrial proposals for the Lunar Lander Phase-B1 contract were received and the Tender Evaluation Board completed their evaluation. Negotiations with the recommended bidder are in progress.

Human exploration technology

The Tender Evaluation Board for the MELiSSA Food Characterisation Phase 2 activity is in progress. Meanwhile, the MELiSSA Pilot Plant in Barcelona is running to plan. In response to the ITT for Energy Provision and Management, proposals have been evaluated and a report has been finalised with a recommendation.

International Architecture Development and Scenario Studies

Negotiations for the Exploration Scenario Studies have been held with EADS Astrium GmbH and Thales Alenia Space Italy and the two parallel studies have subsequently been initiated.

Outreach

ESA issued a Call to Teachers in May, launching a new fitness initiative, 'Mission X: Train like an astronaut', using the example of space explorers to promote exercise and healthy nutrition to young people. This worldwide initiative is supported by ESA and the national space agencies of Austria, France, Germany, Italy, the Netherlands, Spain, UK and USA. The initiative starts in January 2011 and runs for six weeks.

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