number 160 | November 2014

bulletin

→ space for europe

1964–2014

→ SERVING EUROPEAN COOPERATION AND INNOVATION

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, Poland, Portugal, Romania, 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:

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ESOC, Darmstadt, Germany.

ESRIN, Frascati, Italy.

ESAC, Madrid, Spain.

EAC, Cologne, Germany.

ECSAT, Harwell, United Kingdom.

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Harald Posch

Vice-Chairs:
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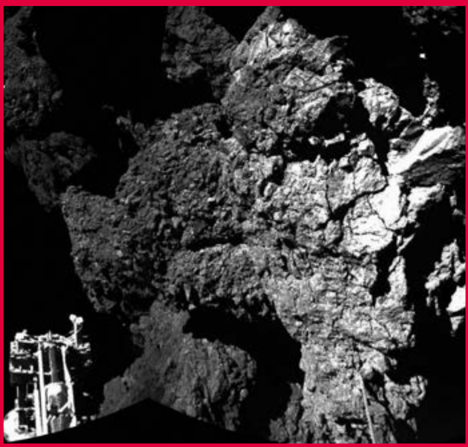
Director General:
Jean-Jacques Dordain



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On cover:
Welcome to a comet: the first set of images ever returned from the surface of a comet. The image is a two-image mosaic that was returned from Philae after arrival at its final landing site on 12 November. One of the lander's feet can be seen in the foreground (ESA/Rosetta/Philae/CIVA)

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Email: contactesa@esa.int

Editor
Carl Walker

Design
Emiliana Colucci
Giada Gasperoni (Taua)

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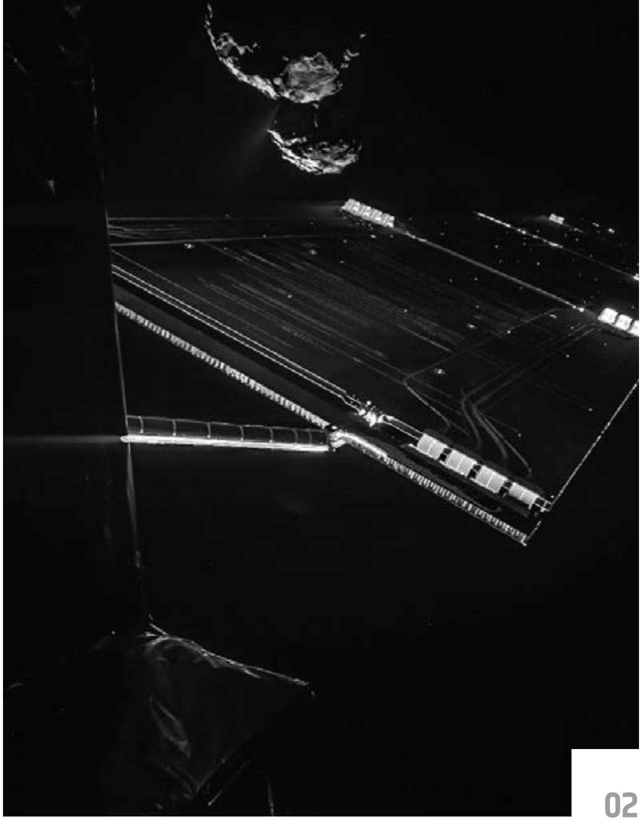
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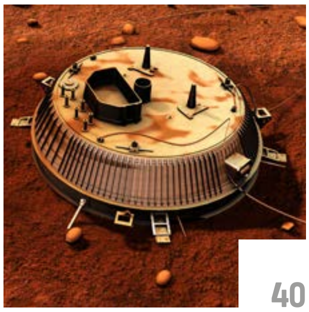
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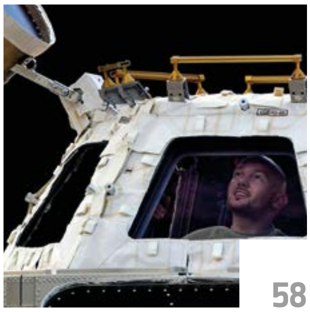
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Just before separation, Philae took this wonderful image looking across one of Rosetta's solar wings and onto the active comet, with streams of dust and gas extending away from the 'neck' region. The image was taken on 7 September from a distance of just 16 km (ESA/Rosetta/Philae/CIVA)

→ LIVING WITH A COMET

Rosetta in pictures, August–November 2014

Emily Baldwin and Carl Walker
Communication Department, ESTEC, Noordwijk, The Netherlands

The world now knows Rosetta, the first mission in history to rendezvous with a comet, escort it as it orbits the Sun, and deploy a lander to its surface.

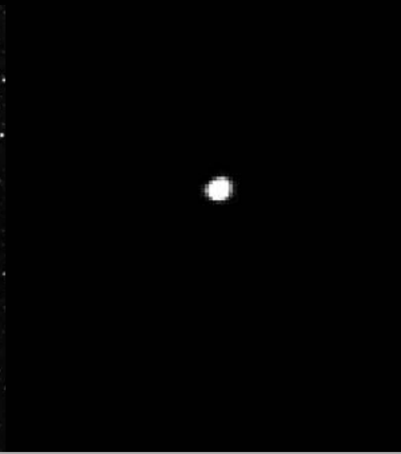
ESA's Rosetta spacecraft was launched in 2004 and arrived at Comet 67P/Churyumov-Gerasimenko on 6 August 2014. On 12 November, the spacecraft delivered its Philae lander to the surface of the comet for a dramatic touchdown, watched by millions of people around the world.

The lander's planned mission ended after about 64 hours when its batteries ran out, but not before it delivered a full set of results that are now being analysed by scientists across Europe.

With Philae's mission complete, Rosetta will now continue its own extraordinary exploration, orbiting Comet 67P/Churyumov-Gerasimenko during the coming year as the enigmatic body arcs ever closer to our Sun.

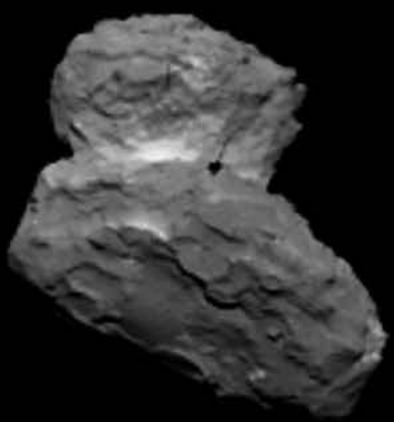
→ Closer and closer...

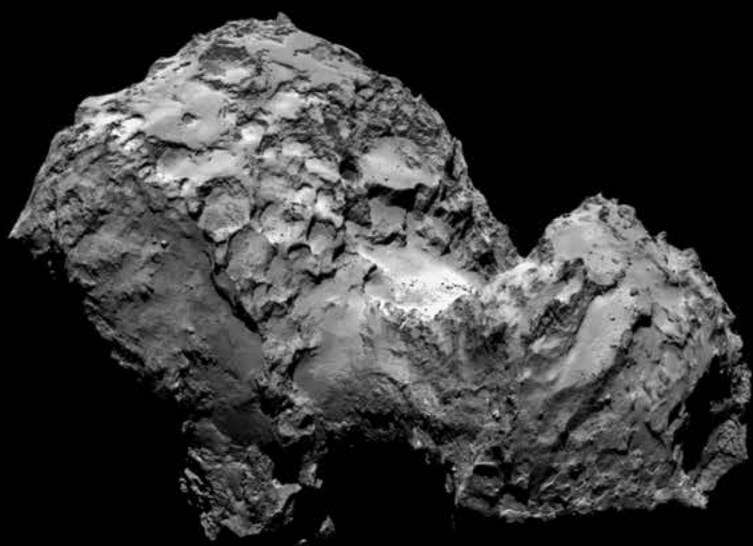
This sequence of OSIRIS narrow-angle camera images records the approach of Rosetta to its target comet, 67P/Churyumov-Gerasimenko, between March and August 2014 (ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA)



↑ Rosetta's first sighting of its target, taken on in 21 March, with about 5 million km still to go. The comet is indicated by the small circle next to the bright globular star cluster M107.

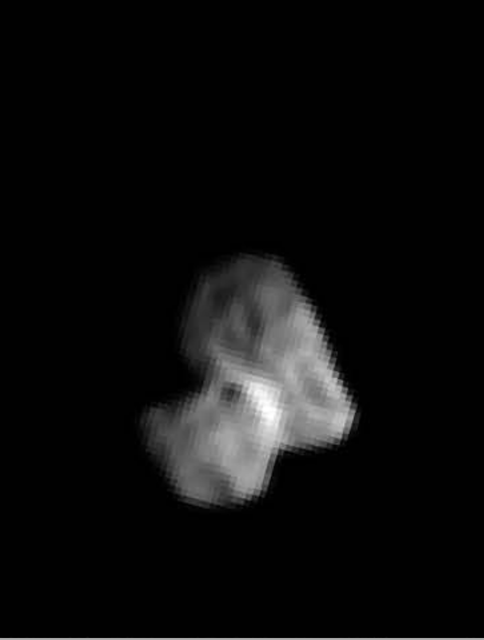
↑ With 86 000 km to go on 28 June, the comet appears as just a few pixels across.

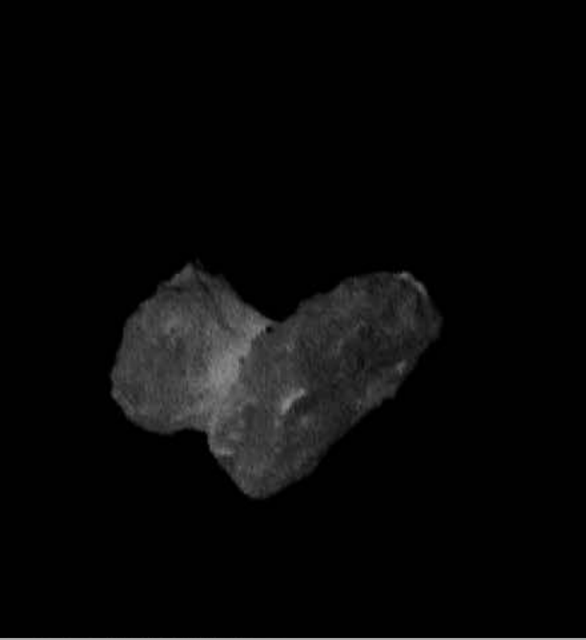




↑ Structure on the surface of the comet comes into view with this image taken on 1 August, and with a separation of just 1000 km (the dark spot is an image artifact).

↑ Spectacular detail is revealed in this 3 August image, taken from a distance of 285 km. The image resolution is 5.3 m/pixel.

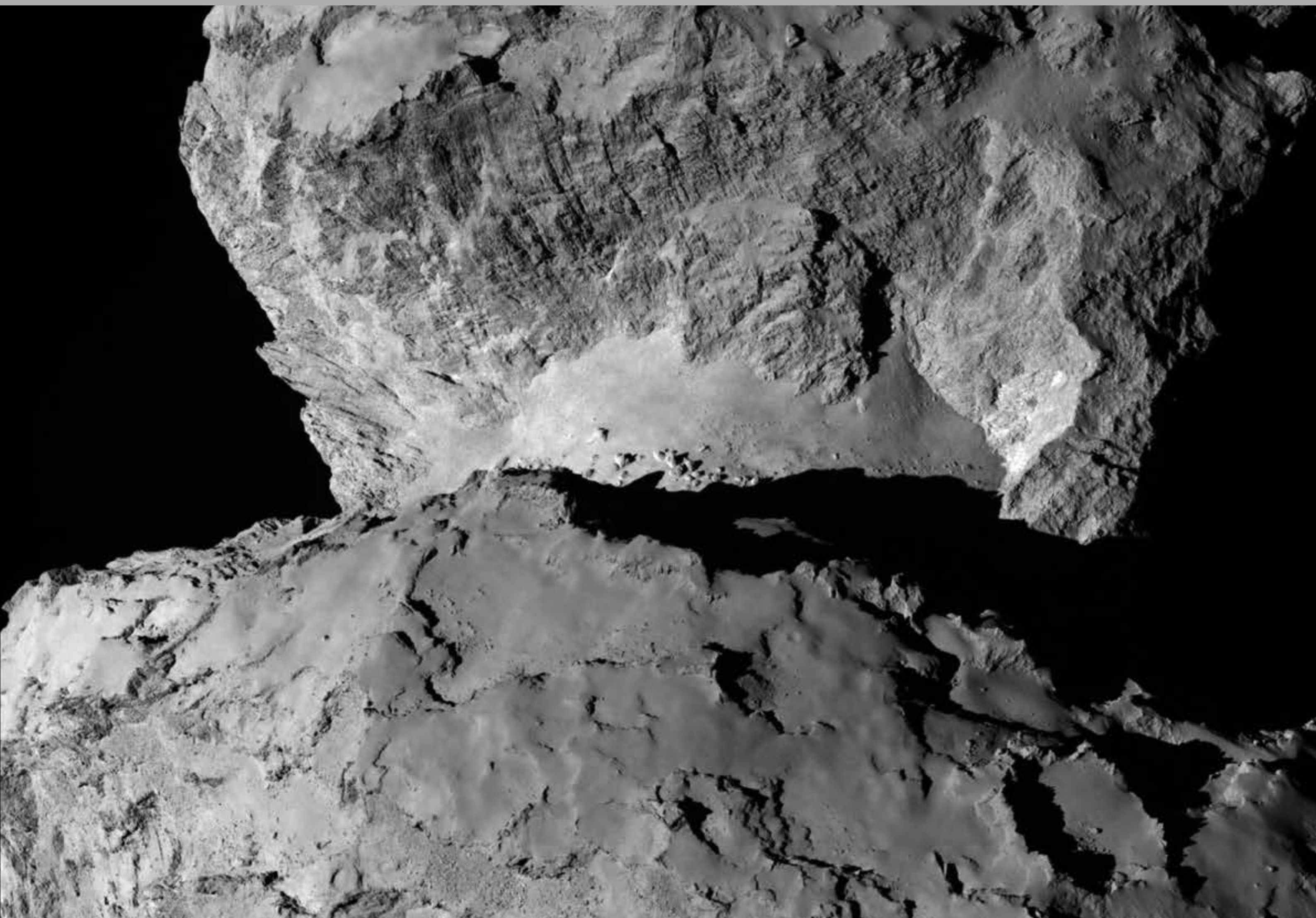




↑ By 14 July, with 12 000 km to go, the images start to suggest that the comet may consist of two parts: one segment seems to be rather elongated, while the other appears more bulbous.

↑ By 20 July, from a distance of about 5500 km, the 'bi-lobal' structure of the comet becomes clearer.

↑ With a distance of 1950 km on 29 July, and a resolution of 37 m per pixel, the bright neck between the two lobes of the nucleus becomes more distinct.



↑ After arriving at the comet on 6 August at a distance of about 100 km, Rosetta returned this image – the comet now over-filling the narrow-angle camera field of view. The image looks onto the smaller lobe of the comet in the top half of the image, revealing parallel linear features connecting with a smooth 'neck' scattered with boulders. The comet's larger lobe occupies the lower half of the image. The dimensions of the comet have since been measured as 2.5 x 2.5 x 2.0 km for the small lobe, and 4.1 x 3.2 x 1.3 km for the larger lobe.

→ Comet up close

These ‘beauty’ shots of the comet were taken by Rosetta’s navigation camera NAVCAM from a distance of less than 10 km (ESA/Rosetta/NAVCAM – CC BY-SA IGO 3.0)

→ This scene presents a dramatic view across the horizon of the body of the large lobe of the comet. The image includes a layered and fractured wall in the background, with several large angular blocks in the foreground. In the background, a faint stream of gas and dust can be seen, showing that an active region is nearby. This single-frame NAVCAM image measures 1024 x 1024 pixels and was captured from a distance of about 7.8 km from the surface on 26 October. The image resolution is 83.7 cm/pixel and the size of the image is 857 x 857 m.

→ This single frame 1024 x 1024 pixel NAVCAM view focuses on the boulder-strewn neck region of the comet, with the smaller lobe on the left and the larger lobe on the right. Much of the comet’s activity originates from the neck. The scene also shows the contrast between the rugged material in the cliff walls rising up to the smaller lobe and the soft, more ‘textured’ material that characterises the neck and that is also coating the larger lobe in this region. The image was captured from a distance of about 7.7 km on 28 October from the surface and has an image resolution is 82.4 cm/pixel; the size of the image is 844 x 844 m.

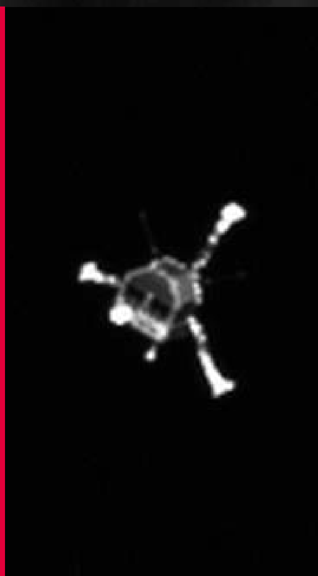
← Four-image mosaic comprising images taken by Rosetta's NAVCAM from a distance of about 7.8 km from the surface on 26 October. The image scale is about 66 cm/pixel. The scene features the boulder named Cheops, the largest and brightest boulder just above centre of the image. It measures about 45 m across and 25 m high. Cheops and the surrounding cluster of boulders reminded scientists of the famous pyramids at Giza near Cairo in Egypt, and so it was named for the largest of those pyramids. The boulders sit on a smooth, dusty material, with the rougher terrain at the periphery of this scene appearing to be exposed beneath it.

← This view highlights the distinctive flat feature set atop a raised plateau on the larger lobe of Comet 67P/Churyumov-Gerasimenko. In several locations close to the base of this feature, there are patches of brighter material, perhaps recently exposed by erosion. The image is a single-frame NAVCAM view taken from a distance of 7.8 km from the surface on 24 October. The image resolution is 83.3 cm/pixel and the size of the image is 854 x 854 m.

← Philae took this parting shot of its Rosetta mothership shortly after separation, after more than ten years travelling through space together. The image was taken with the lander's CIVA-P imaging system and captures one of Rosetta's 14 m solar arrays (ESA/Rosetta/Philae/CIVA)

→ Incoming!

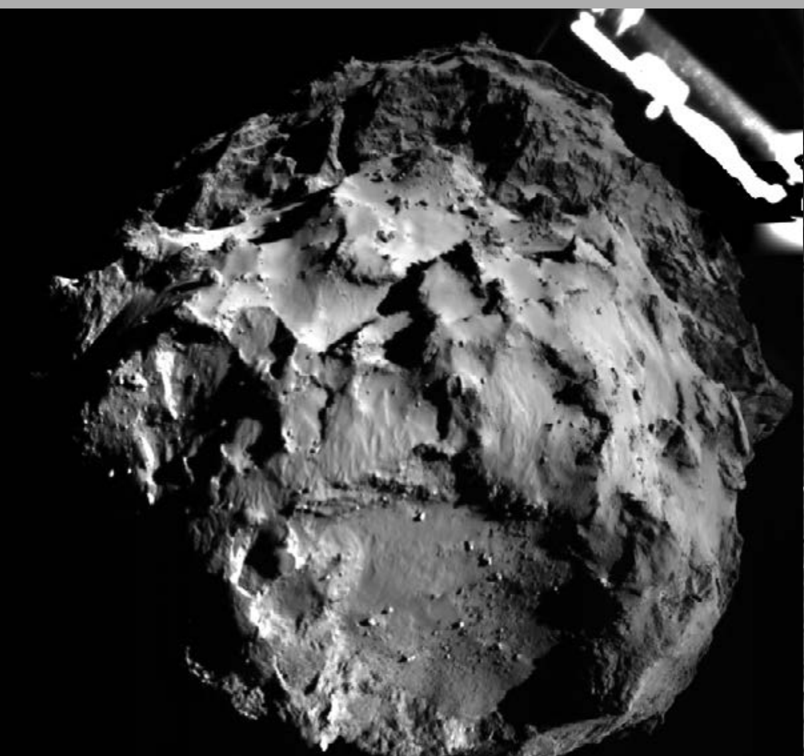
Rosetta's lander Philae became the first probe to land on the surface of Comet 67P/Churyumov-Gerasimenko on 12 November. Separation from the main spacecraft occurred at 08:35 GMT (09:35 CET), with the confirmation signal arriving on Earth at 09:03 GMT (10:03 CET). The signal confirming landing arrived on Earth at 16:03 GMT (17:03 CET). After the first touchdown, it unexpectedly rebounded from the surface, and made an additional touchdown almost two hours later, before bouncing to its final landing place on a different part of the comet. These images document the seven-hour descent, from separation to arrival at the comet.



← This image, taken by the OSIRIS narrow-angle camera, shows the lander falling away from Rosetta nearly two hours after separation, at 10:23 GMT (onboard spacecraft time). The image shows details of the lander, including the deployment of the three legs and of the antennas (ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/ID)

↓ The view of the first landing site from Philae's down-looking camera ROLIS, with 3 km to go. The comet is imaged with a resolution of about 3 m per pixel (ESA/Rosetta/Philae/ROLIS/DLR)

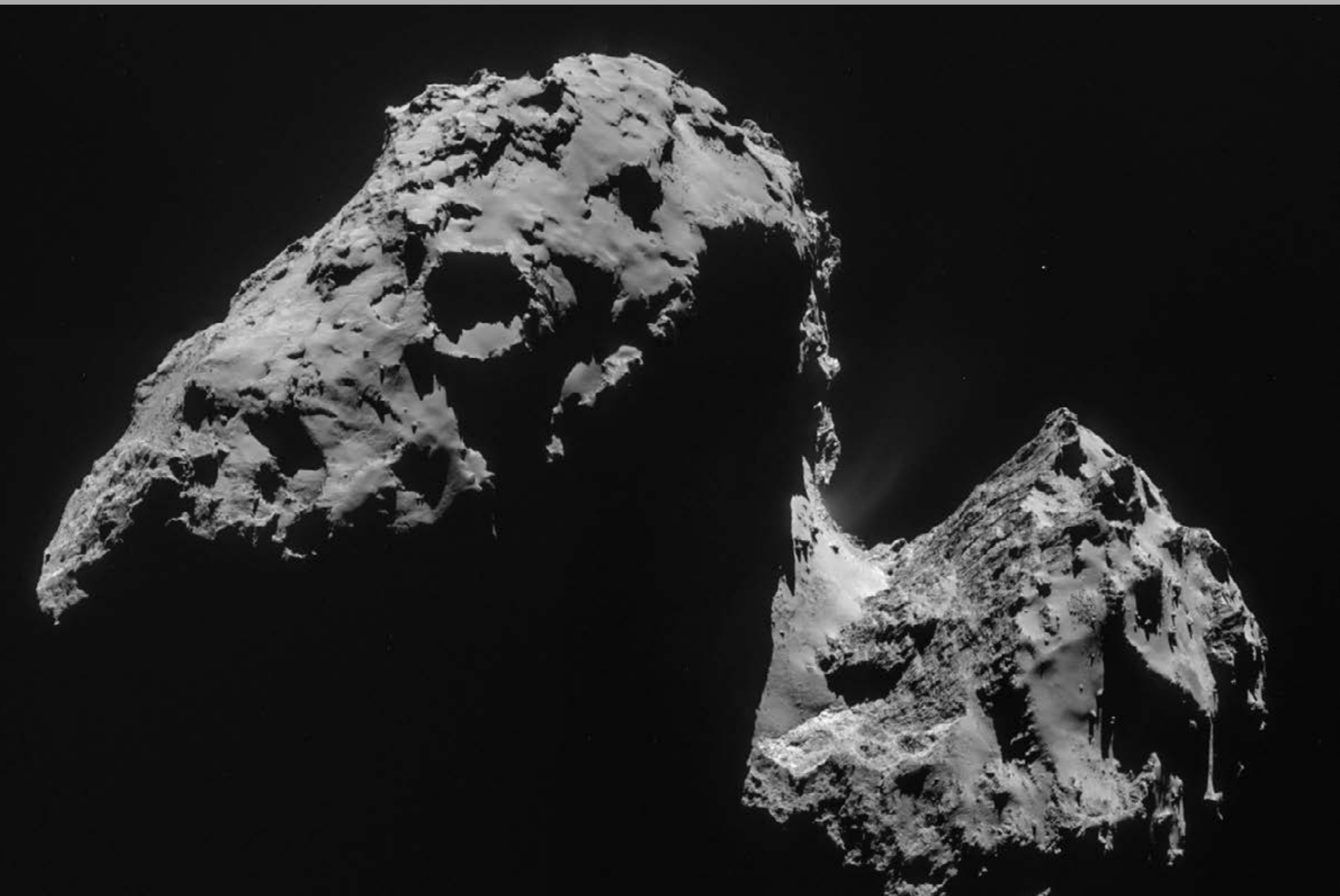
↘ This stunning image of the first landing site was taken just 40 m above the surface by Philae's down-looking ROLIS imager. It shows that the surface of the comet is covered by dust and debris ranging from mm to metre sizes. The large block in the top right corner is 5 m in size. In the same corner the structure of the Philae landing gear is visible (ESA/Rosetta/Philae/ROLIS/DLR)



Welcome to a comet: the first set of images ever returned from the surface of a comet. The image is a two-image mosaic that was returned from Philae after arrival at its final landing site on 12 November. One of the lander's feet can be seen in the foreground (ESA/Rosetta/Philae/CIVA)

↑ This mosaic comprises four individual NAVCAM images taken from 31.8 km from the centre of Comet 67P/Churyumov-Gerasimenko on 4 November. The image resolution is 2.7 m/pixel and the mosaic measures roughly 4.6 x 3.8 km (ESA/Rosetta/NAVCAM – CC BY-SA IGO 3.0)

↓ This mosaic comprises four individual NAVCAM images taken from 42 km from the centre of the comet on 17 November. The image resolution is 3.6 m/pixel and the mosaic measures roughly 5.0 x 4.1 km (ESA/Rosetta/NAVCAM – CC BY-SA IGO 3.0)



This mosaic comprises four individual NAVCAM images taken from 30.8 km from the centre of Comet 67P/Churyumov-Gerasimenko on 20 November. The image resolution is 2.6 m/pixel and the mosaic measures roughly 4.2 x 5.0 km (ESA/Rosetta/NAVCAM – CC BY-SA IGO 3.0)

→ CometWatch continues

Rosetta continues to watch the comet as it gets ever nearer to the Sun along its orbit. Closest approach to the Sun – perihelion – occurs on 13 August 2015, when the comet and Rosetta will be about 186 million km from the Sun, roughly between the orbits of Earth and Mars. As it gets closer, the comet's surface will warm and its ices and frozen gases will sublimate, contributing to the characteristic coma and tail. But this process is already under way, as recent images show.
Keep following with us one of Europe's greatest space adventures!

Emily Baldwin is an EJR-Quartz writer for ESA

→ ESA'S ROSETTA LANDING MISSION CONTROL TEAM

European Space Operations Centre, 12 November 2014

1964-2014
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Launch of Ariane L01,
24 December 1979

→ THIRTY-FIVE YEARS OF ARIANE

Flight L01, 24 December 1979

Nathalie Tinjod
ESA History Project, Records Management Office, ESA Headquarters, Paris, France

Pierre Kirchner
European Centre for Space Records, ESRIN, Frascati, Italy

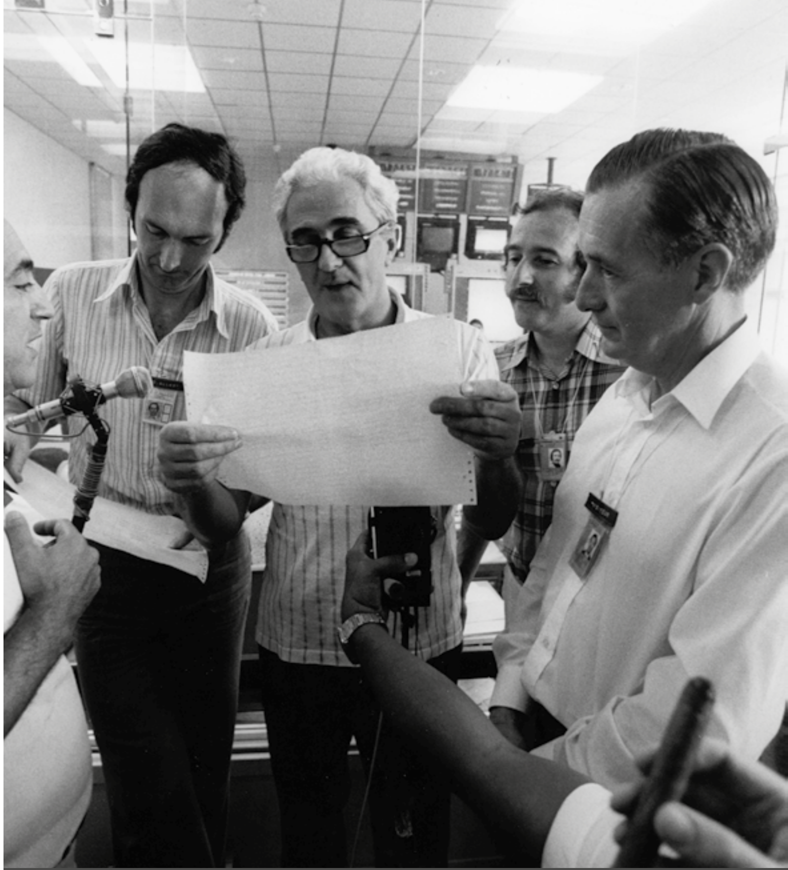
As a new and crucial chapter is being written in the extraordinary Ariane saga, the space community is celebrating the 35th anniversary of the first Ariane flight, on 24 December 1979, which made the ambition of European access to space a reality.

After the misfortune encountered by Ariane's forerunner, Europa, and the difficulties experienced by the European Launcher Development Organisation (ELDO) in defining a sustainable scenario for the design and production of a European launcher, this triumph was just reward for the combined efforts of the institutional and industrial actors – local, national and intergovernmental alike. For nearly four decades, this adventure has symbolised the successful pooling of the capabilities of the Member States of Europe's space organisations.

Europa: the precursor

Between 1964 and 1971, ELDO, composed of six Member States, performed 11 launches, seven of which were partial. Europa I was formed by combining a British Blue Streak first stage, a French Coralie second stage and a German Astris third stage. These three stages were tested together for the first time on 29 November 1968. The next two launch attempts, from the Woomera test range in Australia, like the previous, ended in disappointment.

Following the failed launch from Kourou of Europa II with its additional fourth (P068) stage on 5 November 1971, the fate of the organisation was effectively sealed. US President Nixon's announcement in January 1972, that, as of 1978, the Space Shuttle would begin carrying out weekly flights at an unbeatably low price, ended the hopes invested in Europa III. However, the Europeans were not about to stop there, and began fighting back in March of that year when French space agency CNES formed a working group with the task of designing a substitute launcher.



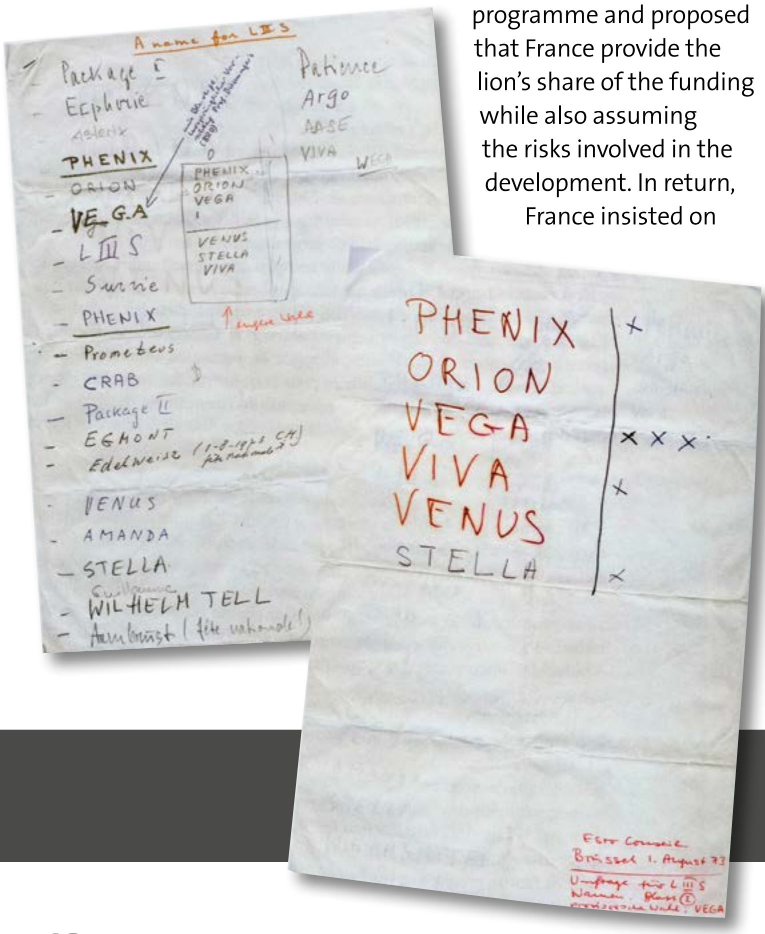
↑ Albert Vienne reads the final report indicating a perfect launch with CNES Director of Launchers Frederic d'Allest (left) and ESA's Director General Roy Gibson (ESA/Nogues-Sygma)

LIIIS: the third generation

It was only a matter of months before a configuration for the third-generation launcher had been defined. The proposal was presented at the sixth European Space Conference (ESC) in Brussels on 20 December 1972. Minister Jean Charbonnel reminded those present of France's very strong attachment to a launcher programme and proposed that France provide the lion's share of the funding while also assuming the risks involved in the development. In return, France insisted on fulfilling the prime contractor role and asked its partners to bear 40% of the cost. The ministers concluded an agreement in principle: on the one hand they would abandon the Europa III programme to focus instead on the new launcher, and on the other, they would form a single, unified European space agency. With ELDO having been dissolved, ESRO was temporarily entrusted with managing the 'special project'.

An optimised configuration called L140-L33-H8 (LIIIS) was presented on 10 May 1973. It consisted of a first stage carrying 140 tonnes of liquid propellant, a second stage of 33 tonnes, and a third stage with 8 tonnes of cryogenic propellant. Though the industry reaction was mixed, nonetheless, by the eve of the seventh ESC, on 31 July 1973, the project was already 27% subscribed.

The Belgian Minister Charles Hanin went to great lengths, employing the 'confessional' method, to ensure the nine other ministers were signed up to the second 'Package Deal' (which included the agreement on a European space agency, LIIIS, the Spacelab module and the MAROTS satellite). The decisions were finally voted on as dawn broke the next day.



← The original list of names for the new launcher from the ESRO Council in Brussels, August 1973

↑ After the successful launch of Ariane L01, a launch party was held in Kourou with Roy Gibson, ESA Director General, Peter Creola, Swiss delegate, Philippe d'Allest, CNES Director of Launchers, and Raymond Orye, Head of ESA Ariane Programme (ESA/Nogues-Sygma)

↑ ESA Director General Roy Gibson gives a speech to congratulate all staff, contractors and their families on 24 December 1979, Kourou, French Guiana (ESA/Nogues-Sygma)

The launcher was scheduled to be available as of 1980, as set out in the *Dossier de synthèse* of 15 April 1973 referenced in the agenda. In its agreement, the ESC specified that the programme would be managed within a common European framework. Contracts were allocated to firms from the participating states in proportion to their contribution to the amount of the works.

France, which took a 62.5% share, was represented by SNIAS, SEP, Air Liquide, Matra and by CNES, whose Launchers Directorate was then headed by Yves Sillard, later to be succeeded by Frédéric d'Allest and Roger Vignelles. The Federal Republic of Germany, with 20.12%, was allocated 11 contracts for MAN, Dornier, ERNO, DFVLR and MBB. Eighteen contracts were awarded to the Belgian firms SABCA, ETCA, FN and BTMC. Denmark obtained six contracts for its firms Rovsing and Terma, Spain had seven for CASA and SENER, Italy had four contracts for Laben, Aeritalia and SNIA-Viscosa, while the Netherlands had five for NLR, Fokker and PTI. Sweden, with Volvo and SAAB, won four contracts and Switzerland two for Contraves and CIR. Finally, the United Kingdom, with Marconi, AVICA, HSD and Ferranti, obtained nine contracts.

Finding a name for LIIIS

What would the new European launcher be called? According to the French delegate André Lebeau, the decision fell to the French Minister. He said, "At the Brussels Conference (ESRO Council), during the long break in the meeting, the idea came to me to write at the top of a blank sheet of paper the words 'a name for L3S' and to pass it round the immense table in the Orange Room of the Palais d'Egmont. When it came back a variety of suggestions had been scrawled all over it.

"Initially the preferred option, discussed at length within European circles, was Vega. However, after some time, the Minister Jean Charbonnel discovered that Vega was also the name of a make of beer. He came to the conclusion, quite rightly in my view, that that would be somewhat inappropriate, and decided that the launcher would be called Ariane. This did not go down well, resulting in moans and groans right across Europe, but was eventually accepted. Why Ariane exactly? Well, that's a point of history that has never been officially explained."

Swiss delegate Peter Creola described the situation, "How could European public opinion be swayed by something known as 'LIIIS'? Some jokers suggested 'William Tell'. A moraliser suggested 'Patience' and a classicist 'Prometheus'. Only one name, 'Vega', picked up three votes."

Ariane was formally 'christened' at the 93rd meeting of ESRO's Administrative and Finance Committee (AFC) in Bern on 27–28 September 1973. Peter Creola continued, "In September, at the AFC meeting in Bern, the French delegate lodged a formal objection. Paris, however, agreed to take part in negotiations about the names 'Phoenix', 'Penelope' and 'Ariane'. A whole continent was embroiled in a row between competing interpretations of classical mythology. Germany vetoed Phoenix, because the ashes of Europa and ELDO were still too hot. Penelope also got the thumbs down. People didn't fancy waiting 20 years like Odysseus's wife.

"Only Ariane was left. She had used her ball of string to help Theseus escape from the labyrinth. There were sceptics, both male and female, who thought the overtly male shape of the European launcher didn't suit a woman's name. Finally, they threw in the towel. Ariane quickly became a popular name. From 1977 onwards, it was also known on the far side of the Atlantic."

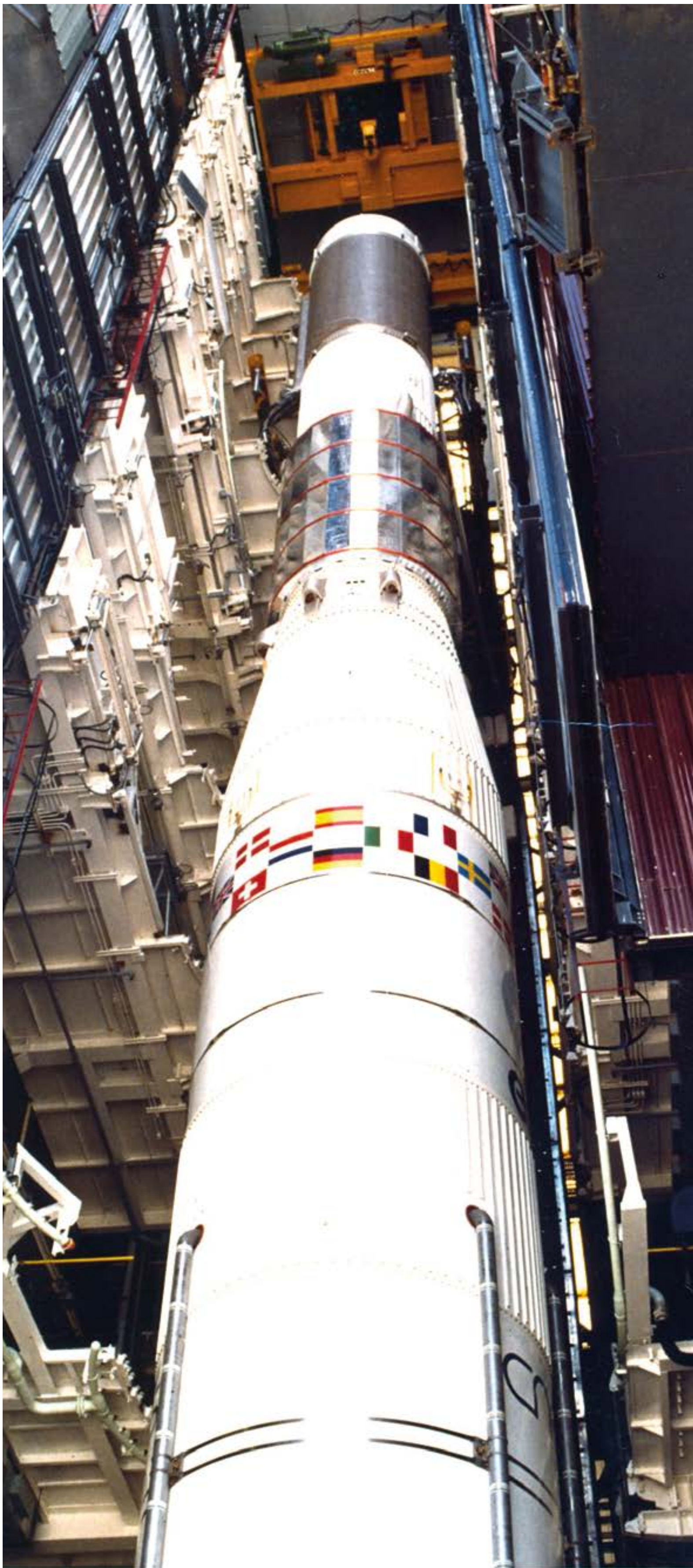
L01: the final countdown

The first of 11 Ariane 1 launches (between 1979 and 1986) took place at the end of the allocated launch window. Roger Vignelles of CNES recalls, "On 15 December 1979, we reached the end of the countdown and the engines ignited, but Ariane remained firmly rooted to the ground! It was what we refer to as 'an aborted launch'. A situation we had considered highly unlikely to occur, but which, by luck or intuition, we had prepared for, even going so far as to rehearse overhaul operations in the final stage tests in Europe. We had also chosen the teams to provide backup in the event of such an outcome.

"There then followed a full week's work. On 22 December, we were finished with a few hours to spare. On 23 December, a combination of weather conditions and some technical problems forced us to postpone the launch. The night of the 23rd to 24th was very difficult. The teams were really tired but at the same time driven by an immense desire to succeed. We knew this really was our last chance, [otherwise] we would have had to dismantle the launcher and overhaul it back in Europe!

"The first countdown was stopped at H–2 minutes 41 seconds, because a valve had failed to send information that it was working to the computers, which were in sole control in the final six minutes. The decision was then taken to override the computer. The countdown was able to resume. This time it worked, and Ariane launcher L01 lifted off at 17.14 UTC with only a 90-minute supply of liquid hydrogen left!"

Raymond Orye, then in charge of ESA's Ariane Programme, has very fond memories of those moments: "The atmosphere after the launch was just incredible, a mixture of joy and emotion. I remember the drink laid on after the launch for all the teams and their families in the old Europa II assembly building at the Centre Spatial Guyanais (CSG). The CSG firemen were waiting with their hoses



↑ Ariane L02 being prepared for launch in May 1980 for us to arrive and gave everyone, with no exceptions, a proper soaking, but it was all very good-natured. Professor Curien (then President of CNES) and Mr Gibson (the ESA Director General) managed to deliver speeches from a raised platform before launching into a duet of 'Auprès de ma blonde', which was promptly taken up by the assembled crowd. Everyone was in exceptionally high spirits, but none more so than the Ariane operational teams. What a Christmas that was for all concerned!"

The Ariane family

At the time, the market for application satellites was organised around two US families of launchers: Delta class, with a lift capability in 1978 of up to 1200 kg into geostationary transfer orbit, and Atlas-Centaur class, which could carry close to 1800 kg. With the exception of Intelsat satellites, every other satellite was in the Delta class, in which Ariane could not claim to compete. Hence came the need to adapt the launcher so that it could carry two satellites at once, thus increasing performance to twice 1200 kg plus the mass of the decoupling structure, bringing it to 2500 kg. The European launcher was also intended to remain competitive with Atlas-Centaur.

Despite the setback of the flight L02 launch failure in May 1980, this evolution was approved in July of that year. The investigations taking place from 1976 into increasing the performance of Ariane 1 resulted in the necessary modifications being identified and their feasibility being tested.

Many of these modifications were carried over into the Ariane 3 programme, notably reducing development-related risks (11 flights, 1984–89). Finally, the addition of two solid-fuel boosters made the launcher competitive on two fronts: Ariane 3 could be used for satellites of 1200 kg, of which it could carry two at a time, and Ariane 2, without solid boosters, for satellites of up to 2000 kg (six flights, 1986–89). The industrial organisation of the Ariane 1 programme was kept in place and booster production entrusted to Italian firm BPD.

From 1984, launches were carried out under the responsibility of Arianespace. The market share of this operator, founded in 1980, for satellite launches to geostationary orbit would soon approach and eventually even surpass 50%.

In January 1982, ESA adopted the Ariane 4 development programme (116 flights, 1988–2003). The Ministerial Council in Rome in January 1985 initiated the phase of preparatory work for the Ariane 5 programme, which had its first successful launch in 1998. To date, 220 Ariane flights have carried close to 400 payloads into space. Though the name Vega had not been chosen back in 1973, it was subsequently revived for the programme adopted in 1998, which got off to an exceptional start with three consecutive successful launches, beginning in 2011.

By paving the way for autonomous access to space, Ariane L01 enabled Europe to free itself from the constraints imposed by the bigger space powers, to move on from being merely experimental in the space applications domain. ESA became so much more than a reliable partner: it became a serious competitor in its own right. ■

Further reading

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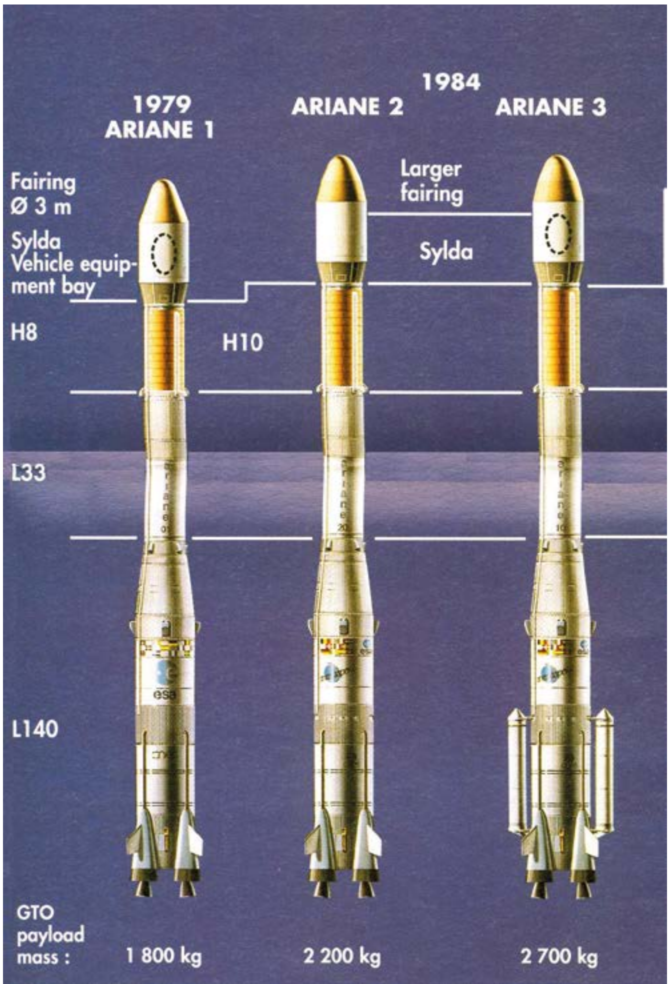
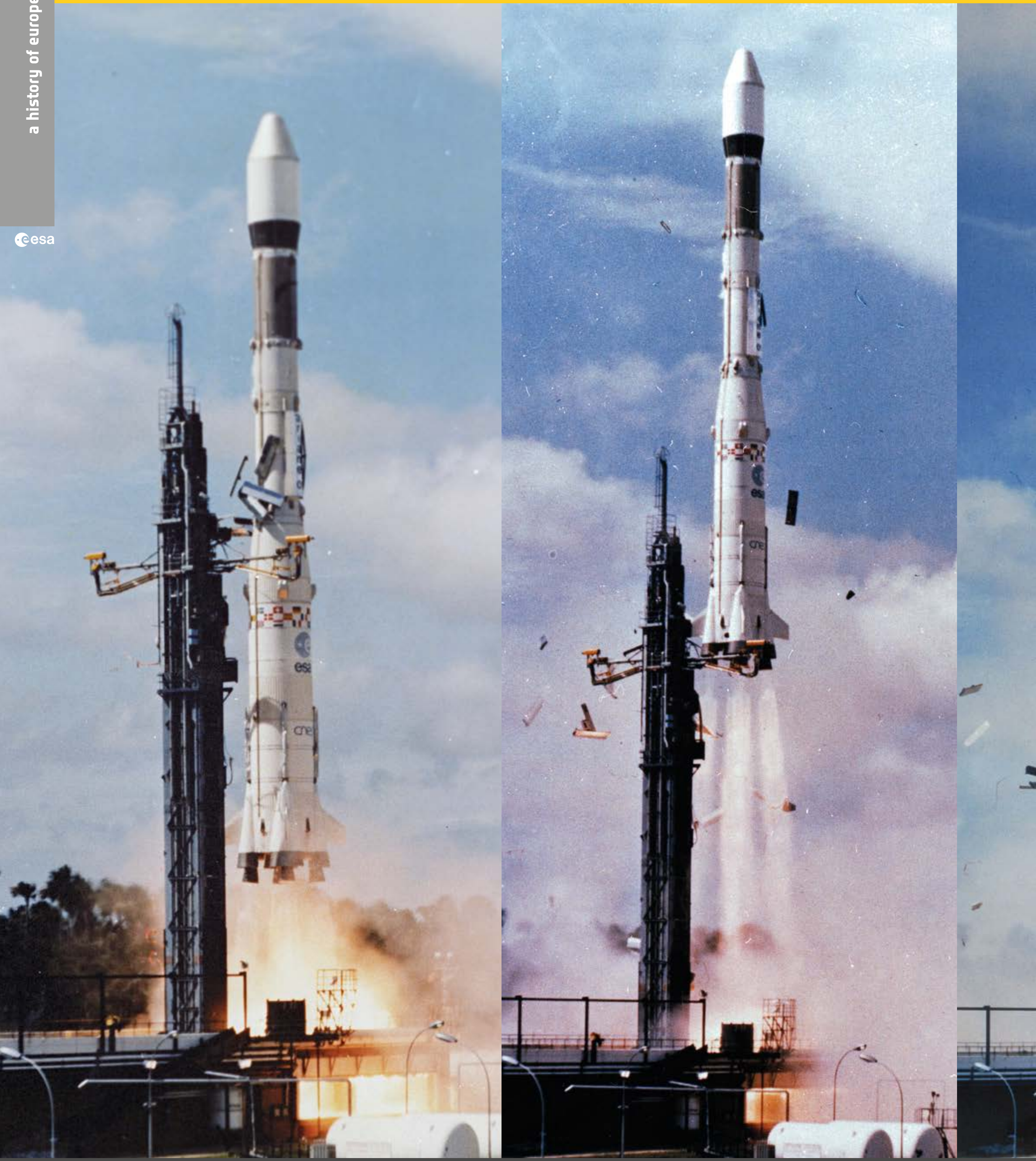
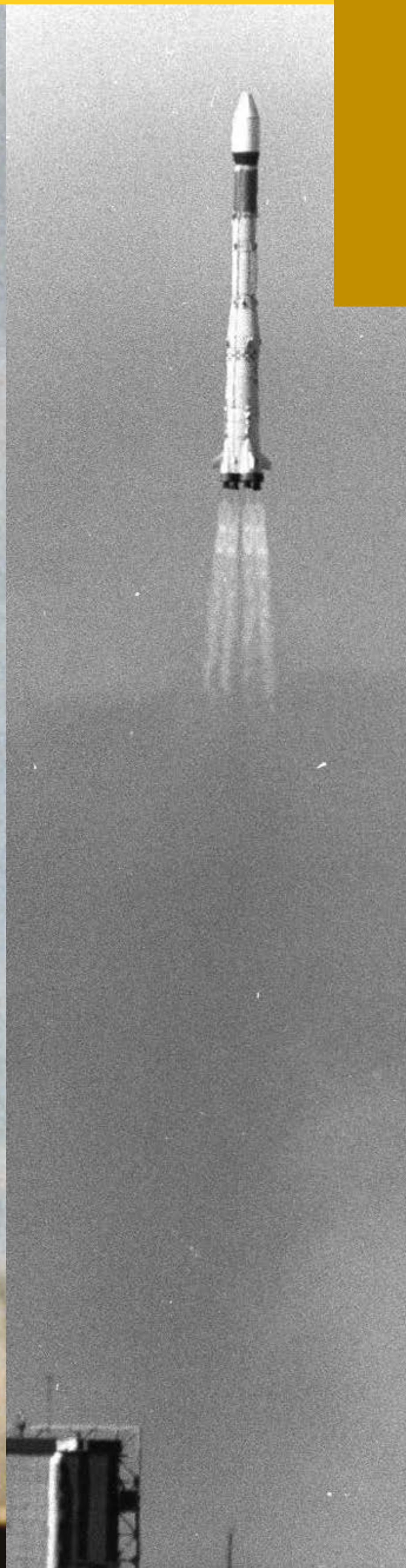
- R. Vignelles, *Les Lanceurs Ariane de 1973 à 2000*, CD-ROM
- J. Krige, *Fifty years of European cooperation in space: Building on its past, ESA shapes the future, Les Editions Beauchesne*, 2014
- Oral History of Europe in Space, ESA/EUI (http://apps.eui.eu/HAEU/OralHistory/EN/ESAOH.asp)



↑ Ariane 1, 2 and 3 comparison, 1980



↑ Photos in sequence showing the first few seconds of flight of the first Ariane rocket, flight L01



→ THE SCIENCE OF GRAVITY

A new era of ESA experiments on parabolic flights

Vladimir Pletser
Directorate of Human Spaceflight and Operations, ESTEC, Noordwijk, the Netherlands

Julien Harrod
Communication Department, ESTEC, Noordwijk, the Netherlands

The Novespace Airbus A300 'Zero-G', the European workhorse for microgravity research in parabolic flights (Novespace)

↑ Out with the old, in with new: the new Airbus A310 and the retiring A300 together on the apron at Bordeaux airport (Novespace)

ESA has been carrying out microgravity research in parabolic flights for 30 years, 17 of them in the Novespace Airbus A300 'Zero-G', which retires this year. The flights continue, as we introduce the new Airbus A310 'Zero-G'.

After 17 years of loyal service, the European workhorse for microgravity research in parabolic flights, the Airbus A300 'Zero-G' operated by Novespace of France, is retiring this year. Its successor, the Airbus A310 'Zero-G', is already being prepared for the first campaign in April 2015.

ESA has organised parabolic flights since 1984 and flown experiments on six different aircraft in over 60 campaigns. The A300 aircraft was used from 1997 for over half of ESA's microgravity campaigns. It was also used for two collaborations offering reduced-gravity flights with French space agency CNES and the German Aerospace Center (DLR) and seven ESA student campaigns.

From 1984 until 1996, ESA used five aircraft to conduct its first 23 parabolic flight campaigns: two NASA KC-135s, the CNES Caravelle, the Russian Ilyushin IL-76 MDK and the Dutch Cessna Citation II. In 1997, ESA began working with French company Novespace, a subsidiary of CNES, to organise all of its weightlessness campaigns on their Airbus A300.

The Airbus A300 was the largest airplane in the world used for gravity research. The success of this aircraft is evident in the long list of customers including ESA, CNES, DLR, the Japanese space agency JAXA, industrial customers and private commercial flights, offering hundreds of international researchers access to weightlessness and reduced-gravity for experiments and investigations in simulated lunar and martian gravity.

Next weightless steps

Even though the Airbus A300 was working well, maintenance costs were rising and finding spare parts was becoming difficult. Built in 1978, it was the third aircraft of its type, the A300B2. Novespace purchased an Airbus A310 from the German air force in June 2014.

The Airbus A310 has roughly the same dimensions as the A300, only about 5 m shorter. The interior of the aircraft will be designed differently so the cabin area and experiment volume will remain the same, about 20 m long by 5 m wide and 2.2 m high.

In summer 2014, the A310 flew its qualification flights from Bordeaux-Mérignac airport. It was modified by Lufthansa Technik and will undergo final certification in March 2015 with the European Aviation Safety Agency and the French Civil Aviation Authority.

The first scientific campaign is planned for next April in another collaboration between ESA, CNES and DLR, marking the beginning of a new era in microgravity and reduced-gravity research. Twelve experiments have already been selected by the three agencies for a mixed payload of physical and life sciences. After this flying start, 2015 also sees two more ESA microgravity campaigns in June and November.

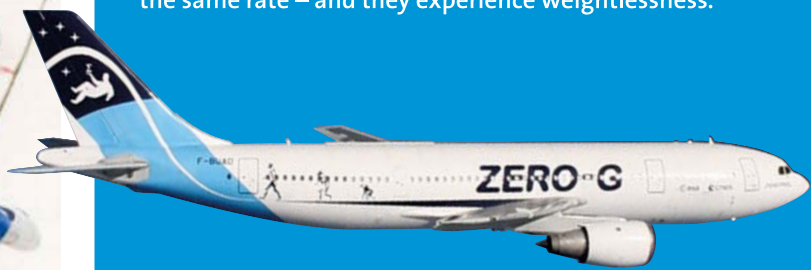
Vladimir Pletser, ESA's parabolic flight campaign manager, during one of the final flights with the Novespace 'Zero-G' Airbus A300

→ Changing gravity

'Weightlessness' is created in parabolic flights when the occupants and their experiments enter 'freefall', meaning the sum of all forces acting on them, other than gravity, is reduced to almost nothing.

To create this weightless environment, the aircraft flies in a long arc, first climbing, then entering a powered dive. During the arc, the propulsion and steering of the aircraft are controlled such that the 'drag' (air resistance) on the aircraft is cancelled out, leaving it to behave as it would if it were freefalling in a vacuum.

For a brief 20-second period, the aircraft enters a 'sweet spot' where its passengers are effectively not supported by the aircraft and are falling to Earth at the same rate – and they experience weightlessness.



Flying in parabolas

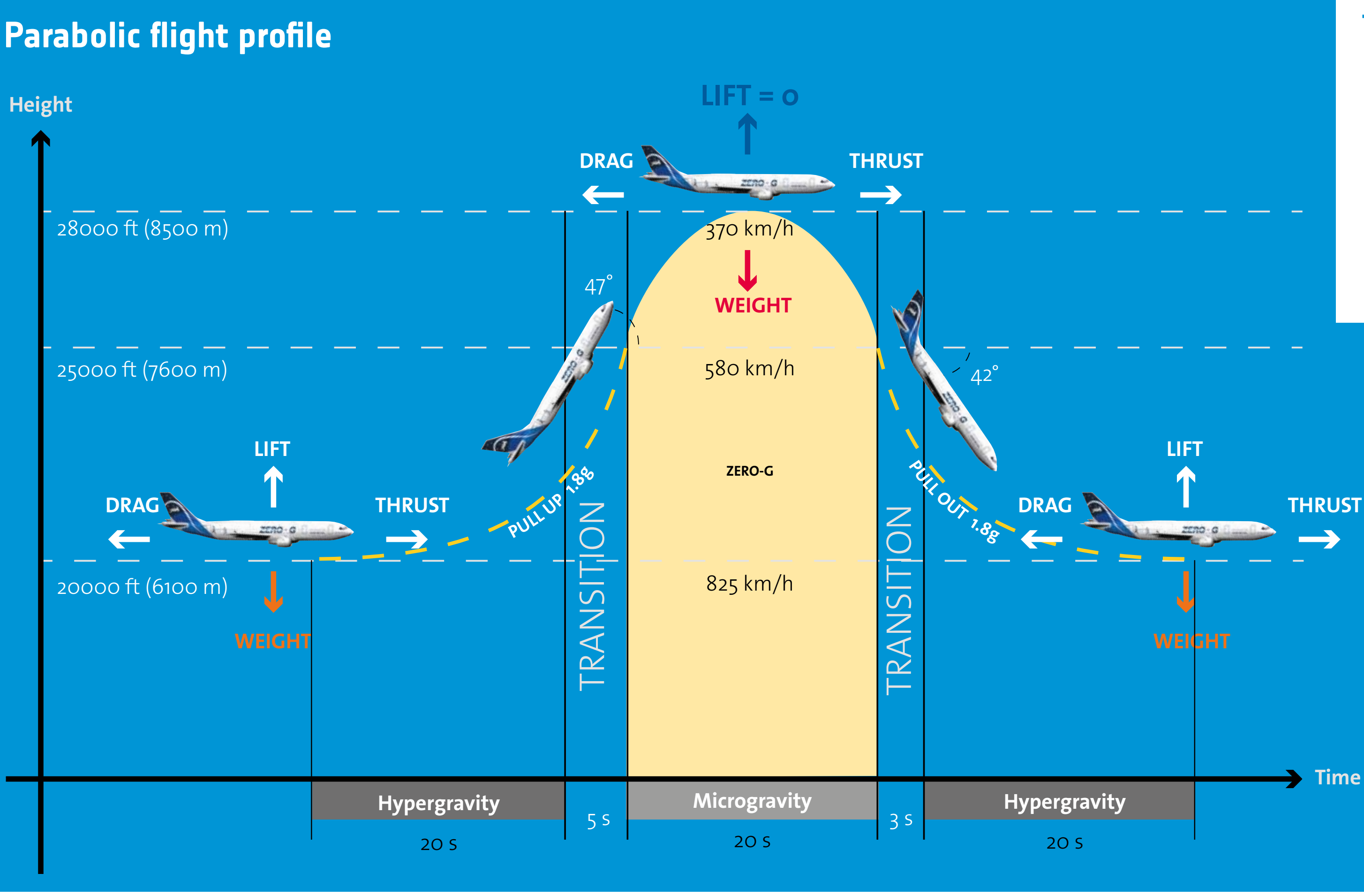
Experiments in microgravity can be conducted on Earth or in orbit, but achieving weightlessness on Earth has practical constraints, such as duration and cost. Depending on their initial velocity, freefall trajectories are either linear (drop facilities), parabolic (aircraft flights and sounding rockets) or circular and elliptical (orbital platforms, such as the International Space Station).

ESA provides a mix of gravity-altering platforms, such as drop towers, sounding rockets and centrifuges, but parabolic aircraft flights are the only way to include humans in the experiments without actually going into space.

An aircraft on a parabolic flight provides researchers with a laboratory for scientific experimentation where gravity levels are changed repeatedly, giving periods of about 20 seconds of microgravity preceded and followed by periods of about 20 seconds of 1.8 times the gravity we feel on Earth. For this reason, research on parabolic flights focuses on physical and life sciences, and for testing technology to be used in spaceflights as well as training astronauts.

Parabolic flights are a useful tool for performing short-duration scientific experiments and technology demonstrations in reduced gravity. The main value of these flights is in verifying equipment and experiments before they go into space to improve quality and success rate. After a space mission, parabolic flights can be used to confirm or invalidate results from space experiments.

Although not as glamorous as going into space, parabolic flights offer many advantages for microgravity research, including a short time from experiment proposal to



flight, low cost, and flexibility. They offer a hands-on approach, since investigators can monitor and modify their experiments directly during flights.

Parabolic flights also allow partial gravity levels to be created. Depending on how the pilots initiate a manoeuvre, they can create anything between 0 and 1g, including lunar and martian levels. No other research platform can accurately achieve these levels. This is considered to be a major advantage of parabolic flights for investigations by scientists in many disciplines.

Why fly?

ESA has several objectives for running experiments on parabolic flights. From a scientific point of view, the following objectives can be achieved:

- to perform short-duration qualitative experiments of the 'look and see' type. Using laboratory equipment, researchers can observe and record phenomena in microgravity;
- to repeat experiments that measure phenomena in microgravity over short time periods to get quantitative data and exploitable results;
- to allow researchers to perform their own experiments in microgravity and intervene directly while the experiment is in progress;
- to study phenomena that occur during the transition from high-to-low and low-to-high gravity levels (this research is very important for testing components that return to Earth and need to work in a variety of gravity levels).

In addition to scientific experiments, parabolic flights offer testing and validation of experiments that fly in space, including:

- assessing preliminary results for new experiments to improve the final design of the experiment hardware;
- testing critical phases of experiments before spaceflight;
- running human physiology experiments on a wider group of test subjects other than astronauts;
- repeating experiments shortly after a space mission that were not fully satisfactory or that gave conflicting results.

From a technical point of view, parabolic flights can help in preparing hardware for spaceflight by:

- initial testing of equipment hardware in microgravity;
- assessing the safety aspects of an instrument operation in real-life conditions;
- training of astronauts in experiment procedures or instrument operation.

Going for a ride

Creating weightlessness on an A300 parabolic flight is not a simple process. It requires a team of pilots working in unison to monitor thrust, attitude, altitude and other instruments. No less than two qualified pilots and two flight engineers sit in the cramped cockpit.

The Novespace A300 'Zero-G' flies from Bordeaux-Mérignac airport in France and heads to protected airspace over the Gulf of Biscay or the Mediterranean Sea. From a steady horizontal flight, the pilots alert the passengers over the speaker system and then initiate a steep 47° climb by increasing thrust for about 20 seconds with the aircraft and its contents feeling up to 2g.

After 20 seconds the aircraft engines are throttled back, with just enough thrust to compensate for air drag and for up to 25 seconds the aircraft enters freefall. The aircraft goes over the top of the arc and into a 42° dive. After this, the pilots pull out of the dive, accelerating for another 20 seconds to achieve up to 2g levels again before returning to a steady horizontal flight.

No two parabolas are the same. The pilots need to adapt to many factors, such as windspeed, direction and the weight of the aircraft while they control the parabolic trajectory with great accuracy. Releasing too quickly the stick controlling the pitch angle during the parabola can send the researchers heading towards the ceiling, with their experiments experiencing negative gravity; pull out of the dive too hard, and they increase hypergravity levels, putting unnecessary strain on the aircraft and the passengers.

The pilots and engineers work together, each concentrating on a particular aircraft operation. Just outside the cockpit, a sixth crewmember continuously monitors the aircraft's other systems. As the A300 goes through the weightless phase, its fuel indicators go haywire as the kerosene sloshes around in microgravity. Horizon indicators and stall warnings, normally active for safety reasons, are actively monitored while triggered during these extreme manoeuvres.

During the reduced-gravity period, the residual accelerations sensed by experiments attached to the aircraft floor are typically in the order of 10^{-2}g, while an experiment left to float freely in gravity levels can be improved to 10^{-3}g.

Researchers have generally two minutes to prepare for the next parabola, but extra time can be given if agreed in advanced. After the short break, the whole process is repeated another 30 or so times. The whole flight lasts over two hours and is only cut short for emergencies, there are no toilets on board or early exits.

↓ The Novespace crew work in unison to monitor thrust, attitude, altitude and other instruments during the parabolas

→ Spectacular view of the A300 on the dive part of the parabola off the coast of Bordeaux (Novespace)

Microgravity research campaigns

Many of the experiments for ESA's microgravity research campaigns are chosen via the International Announcement of Opportunities issued by ESA and selected by peer review. Proposals can be submitted at any time and sent to selected external experts for scientific review. If a proposal passes the scientific assessment, ESA looks at the technical feasibility and adds it to the manifests for a flight campaign. ESA offers the opportunity to fly free of charge after selection but does not cover costs of travel or preparing the experiment, additional insurance, medical examinations and so on.

All aircraft parabolic flights are considered to be test flights, so precautions are taken to ensure all operations during the flights are safe and that participants are prepared for the repeated gravity shifts. ESA and Novespace provide advice and support for the design of experiment equipment regarding related safety aspects.

All equipment and experiments embarked on the aircraft are reviewed by experts several months before a campaign, for structural, mechanical, electrical and operational integrity. Visits are made to the experimenters' institutions to review equipment. A safety review is held one month before the campaign, when the integration of all equipment is discussed and every safety aspect is assessed.

A campaign takes place over two weeks. The first week is devoted to experiment preparation and loading hardware into the aircraft. During the second week, a safety visit usually takes place on the Monday to make sure all safety recommendations have been implemented. A flight briefing is organised by the crew in the afternoon to present manoeuvres, emergency procedures and medical recommendations, and for the researchers to share details of their experiments.

A campaign consists of one flight per day, each of 30 parabolas, on Tuesday, Wednesday and Thursday of the second week. Each flight is followed by a debriefing where special needs and requests can be reviewed and discussed for the next day's flight. In the case of bad weather or technical problems, a flight can be postponed from the morning to the afternoon or to another day with the Friday as a spare day.

All experimenters flying on an ESA campaign must pass a medical examination. Safety personnel supervise and support in-flight experiment operations. A flight surgeon

> **"Imagine sitting in the world's largest rollercoaster, a ride that lasts for three hours without any possibility of getting off before the end."**

participates on each flight to assist participants, in case of motion sickness for example. Medication is available for participants in the form of an injection of scopolamine.

All experiments run on ESA's parabolic flights are documented in the Erasmus Experiment Archive database and researchers are encouraged to present results at microgravity research symposia.

> **"In the two-kilometre climbs and descents, you experience alternately 20 seconds of weighing twice as much as on Earth, then 20 seconds of weightlessness. Thirty times."**

ESA's campaigns on the Airbus A300

ESA conducted its 24th to 61st campaigns with the Airbus A300 Zero-G from 1997 to 2014. After just two years of working with the aircraft, ESA agreed with CNES and DLR to collaborate scheduling of parabolic flights and host each other's experiments. This more-flexible approach allowed urgent experiments to be flown and experiments to be flown on repeated campaigns over short periods of time. For example, the Advanced Respiratory Monitoring System instrument was tested and used extensively during three successive campaigns to prepare physiology experiments before its first spaceflight on NASA's *Columbia* Space Shuttle.

ESA organised seven campaigns for students from 2000 to involve future scientists in microgravity research. In 2008, a new programme called 'Fly Your Thesis' was launched for European doctoral students who are invited to submit experiment proposals for their PhD research.

Because of a large demand from the European scientific community, two partial gravity campaigns were organised in collaboration with CNES and DLR in 2011 and 2012 for experiments in lunar and martian gravity levels.

Julien Harrod is an EJR-Quartz writer for ESA

→ Parabolic record holder

The last campaign on the A300 with ESA also set a new record for the plane. ESA photographer Anneke Le Floc'h became the new European female record holder for parabolas flown, after logging over 3745 parabolas in the last 15 years.

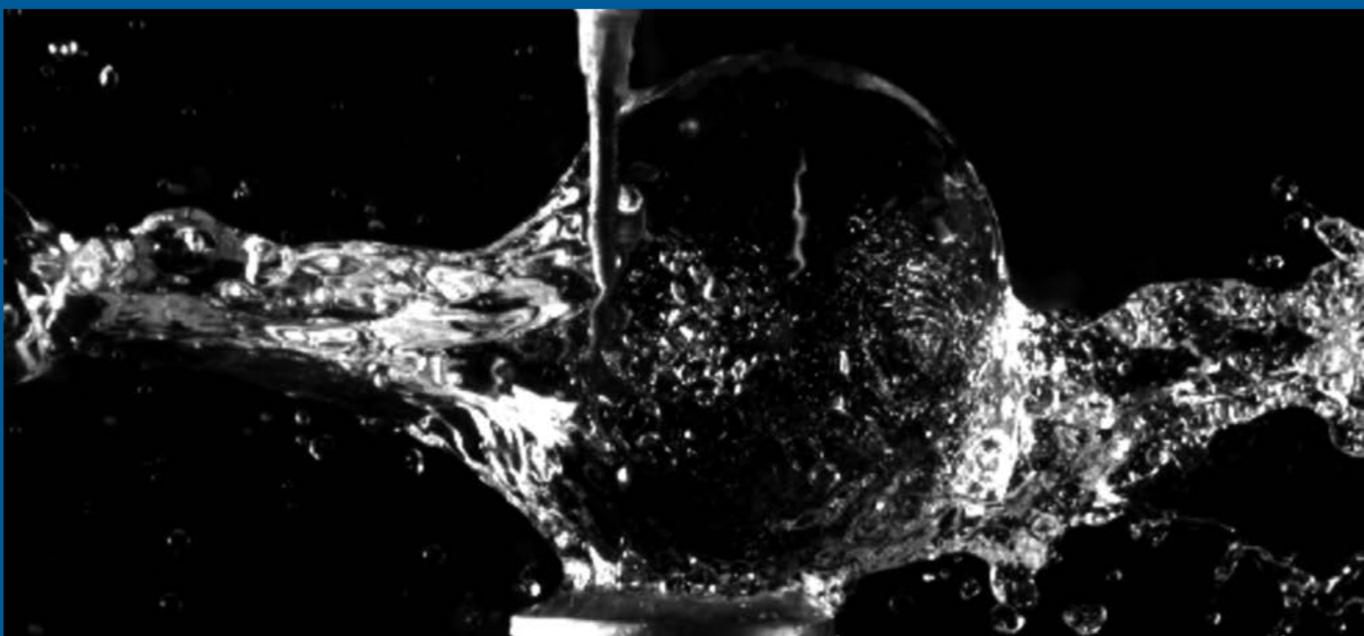
↓ Anneke Le Floc'h

→ What science do we do?

How will we walk on Mars?

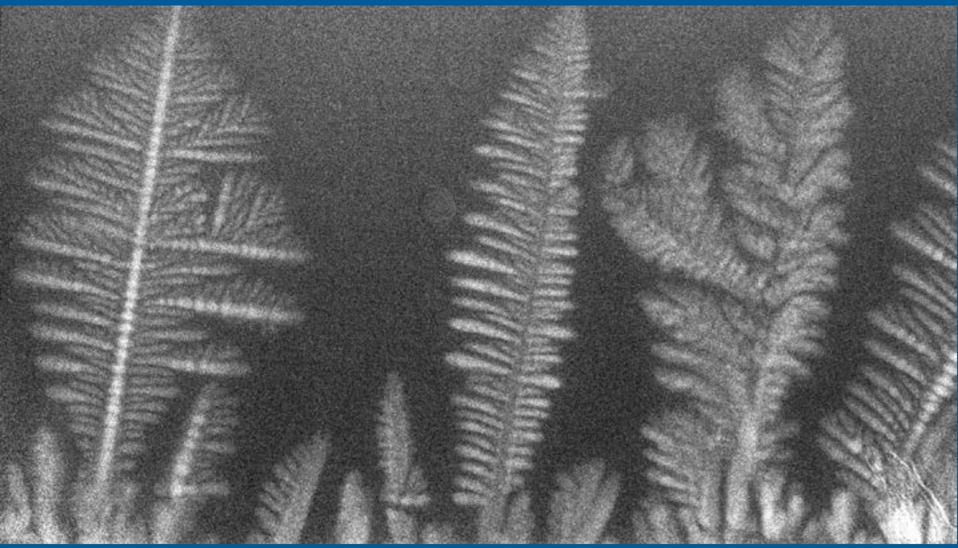
On Earth we use gravity to walk, falling forwards on every step we take, converting it into forward speed in an up-and-down motion, much like a pendulum. But how will astronauts walk on Mars, where the gravity is a third of Earth's?

On parabolic flights, volunteers walk on force-monitoring platforms while the aircraft flies to simulate martian gravity. The results show that the ideal walking speed on Mars will be only a little more than half of the terrestrial average. Although martian explorers will walk more slowly than they would on Earth, they will expend only half as much energy to move an object. These statistics are vital to mission designers preparing a mission to the Red Planet.



Flash and splash

Observing large but perfectly shaped bubbles in weightlessness sounds fun. But recording them with a high-speed camera can reveal some interesting properties. Shining lasers on pure water creates vapour bubbles that collapse violently – for an instant they shine brighter than the Sun, like miniature supernovae. All this energy needs to escape somehow and the water bubbles eject high-speed water jets. Hydraulic equipment on Earth suffers from the effects of such, jets so learning more about how these bubbles work will help in designing better machines. Harnessing the heat from imploding bubbles offers promise in medical applications, where precise bursts of energy and heat need to be delivered. This experiment started as a student proposal and evolved into a fully fledged scientific investigation. (image: EPFL)



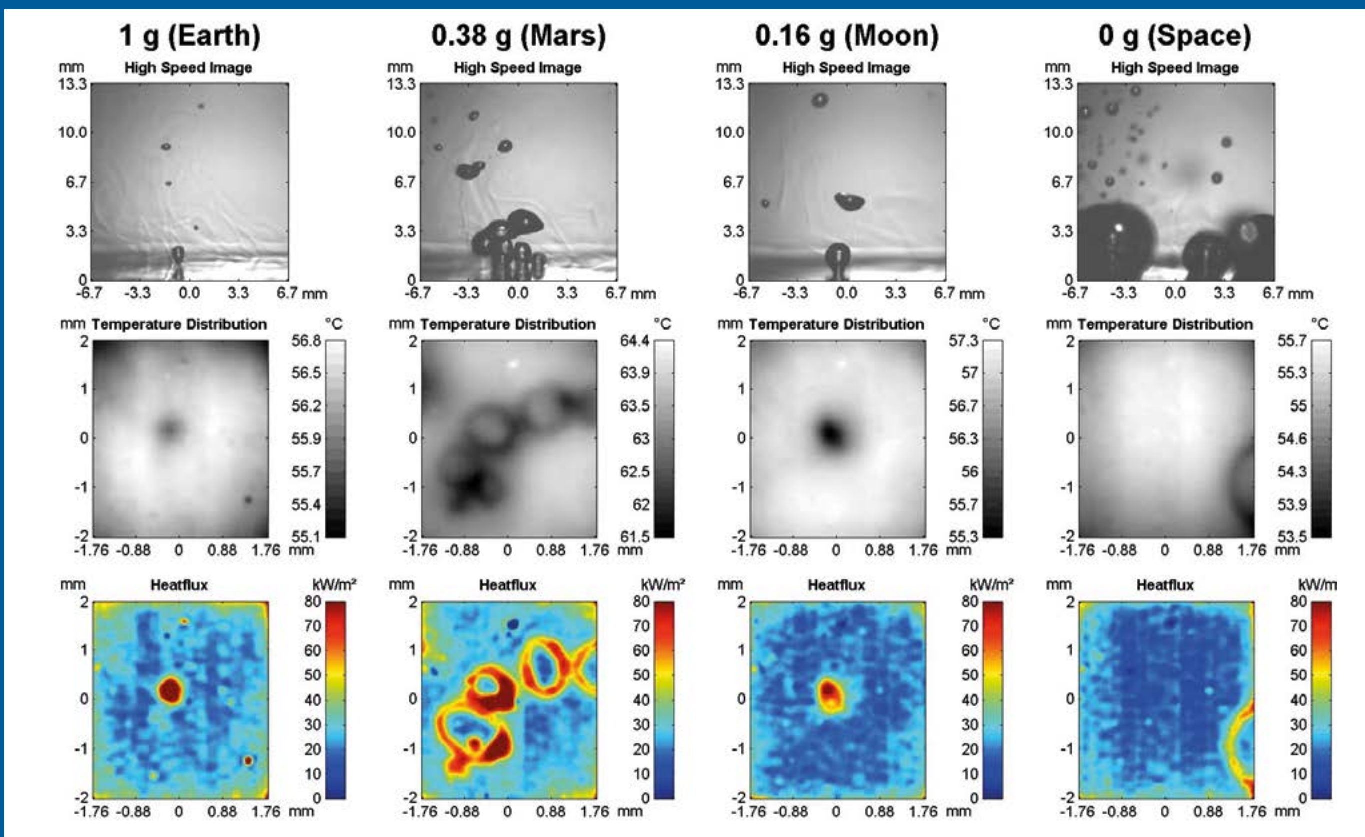
Zero-g metal X-ray

Casting metal alloys in weightlessness while capturing it on X-ray video helps researchers to understand the finer points of the process without gravity complicating the observations. Back on the ground, these experiments have helped to create space-age metals that are already being used in cars and aircraft for improved safety and fuel efficiency.

Keep it cool

Making sure equipment stays at the right temperature is a headache for engineers and designers. Cooling the semiconductors that power our electronic devices is becoming harder as chips get hotter. An efficient way of getting rid of excess heat is by boiling it away. Liquids evaporate from their surfaces, and bubbles can carry heat from deep down, but the process is complex and not yet fully understood by physicists.

Experiments on parabolic flights have shown that vapour bubbles behave very differently on other planets or in space. In weightlessness, the bubbles don't detach from a heat source but stick to it and form a large heat-transferring cavity, offering the potential to help space engineers keep their satellites cool. (image: TU Darmstadt)



The Tempus Pro system recording patient vital signs in emergency situations (RDT)

→ SPACE FOR HEALTH

Satcoms supporting remote medical monitoring

Arnaud Runge
Directorate of Technical and Quality Management, ESTEC, Noordwijk, the Netherlands

Francesco Feliciani
Directorate of Telecommunications and Integrated Applications, ESTEC, Noordwijk, the Netherlands

A portable device for monitoring the body's vital signs and providing communications for medics is offering a lifeline, even in the remotest areas on Earth – and it was developed with the support of ESA.

The Tempus Pro system combines the diagnostic facilities found in standard hospital vital-sign monitors with extensive two-way communications, packaged in a compact, robust and highly portable unit that can be tailored to user needs.

Developed by the Amazon project, led by Remote Diagnostic Technologies (RDT) in the UK and sponsored by ESA's Integrated Applications Promotion (IAP) programme, the system is at the leading edge of medical monitoring technology and is a shining example of how space can be utilised to enable value-added services.

↑ Telemedicine with Tempus IC on board an aircraft (RDT)

Over the years, ESA has gained a lot of experience and expertise in the field of health, through more than 170 related projects, ranging from medical instrumentation for astronauts to fully operational telemedicine services for the benefit of citizens in Europe and all over the world.

The success story of the collaboration between ESA and RDT started with the development of Tempus IC, a vital-sign monitor with telemedicine service capability for non-expert users in the commercial aviation market.

Today, several airline companies such as Etihad, Emirates, Qatar and Virgin have already equipped their long-haul and ultra-long-haul aircraft fleets with the ground-breaking Tempus IC medical device. In one year, more than 3600 calls had been performed using this device, which contributed to passenger safety and avoiding a number of 'false' flight diversions.

Based on this success (some 1000 units have been sold), it became clear to RDT that there was a need for a fully featured pre-hospital vital signs monitor with telemedicine capability for the professional market.

Teaming up with International SOS, a leading company for medical and travel assistance services, RDT began the Amazon project with funding from ESA's Advanced Research in Telecommunications Systems (ARTES) 20 IAP programme. Feedback from various user groups, including International SOS, military services and a number of large oil and gas companies, has shown that there is a need for telemedicine support in the various remote locations in which they operate.

However, users in many of these remote sites also have a strong requirement for a traditional vital-sign monitor. They have expressed a desire for a true dual-use system, able to fulfil the role of a traditional monitor as well as to provide additional telemedicine functions.

The new system, Tempus Pro, developed in the Amazon project, provides all the integrated features and capabilities expected in a market-leading vital-sign monitor with unmatched durability: daylight readable display, long battery life, intuitive interface and a glove-friendly touchscreen that is easy to use by both advanced and basic life-support paramedics and emergency practitioners.

In addition, the system can document and securely share all patient data electronically between medical professionals easily, ensuring that all care-givers have accurate information on patient injuries, therapies, trended vital signs, drugs and fluids, for example. These data can be sent ahead to hospitals or other treatment centres via telemedicine systems.

> **ESA is highly active in health and life sciences, supporting over 170 projects in the last 10 years, half of which have been telemedicine applications.**

↑ Ultrasound patient monitoring using Tempus Pro (RDT)

In order to assess the sustainability of the Amazon end-to-end service, including the adoption of the system by users, a pre-operational campaign lasting several weeks was performed in conjunction with International SOS. The campaign involved four sites in total, one clinic and one remote site in both Algeria and Nigeria.

The function of receiving data had been installed at the International SOS Paris alarm centre and at each of the clinics. This has allowed all four sites to connect to the alarm centre, but it has also provided the opportunity for the remote sites to connect to their in-country clinics when they did not need to escalate as far as Paris.

Not only was sharing the medical data via satellite with the assistance centre or clinic useful (to get a second opinion of the patient condition and to help ascertain if medical evacuation was required or not), but also it provided a second pair of eyes, both literally via the digital camera and also generally via the medical data and trends overview.

This was especially important for the remote sites that had very little on-site support (often only one doctor and one nurse). For example during one connection, the Paris alarm centre was able to highlight (using a photo) the incorrect positioning of a 12-lead electrocardiogram machine and how to rectify it in order to get a correct reading.

The Tempus Pro system has been very well received during the Amazon project trials by both the International SOS clinic and remote site staff and also their customers who have had the chance to see the device and associated services.

Now ESA is promoting the Tempus Pro device and its service capacity in its other telemedicine projects and

↓ Touchscreen interface records injury locations (RDT)

it has so far received a warm welcome from the project teams. The device has proven to be a game changer in this environment. It has succeeded at being both a valuable telemedicine device, as well as a market-leading, fully featured pre-hospital transport vital-sign monitor.

Tempus Pro is an unsurpassed lightweight, compact and robust package, perfectly balanced to be at home either in a remote extreme environment or in a well-equipped, modern clinic. It has GSM (3G), GPS, wifi, bluetooth and ethernet connectivity, and can use available VSAT facilities to exchange voice, video, medical data and GPS positioning. Various external devices can be connected such as a digital stethoscope, video laryngoscope, contact temperature sensors and electrocardiogram leads and USB ultrasound probe.

While several hundreds of units of the Tempus Pro monitor have been sold already, ESA and RDT are about to begin a third phase of the project, which should lead in 2017 to a fully certified portable system for triple use: medical monitoring, therapeutic cardiac intervention via an Automatic External Defibrillator module and able to support full-scale telemedicine services using satellite, terrestrial and hybrid mobile communication links.

These enhancements to the capabilities of the Amazon service and the associated Tempus Pro system will make it possible to address new areas, such as the civilian pre-hospital care market. ■

> **What made the Amazon project remarkable was that it didn't concern just the development of a prototype – Tempus Pro is a fully certified medical device, validated with end-to-end operational service.**

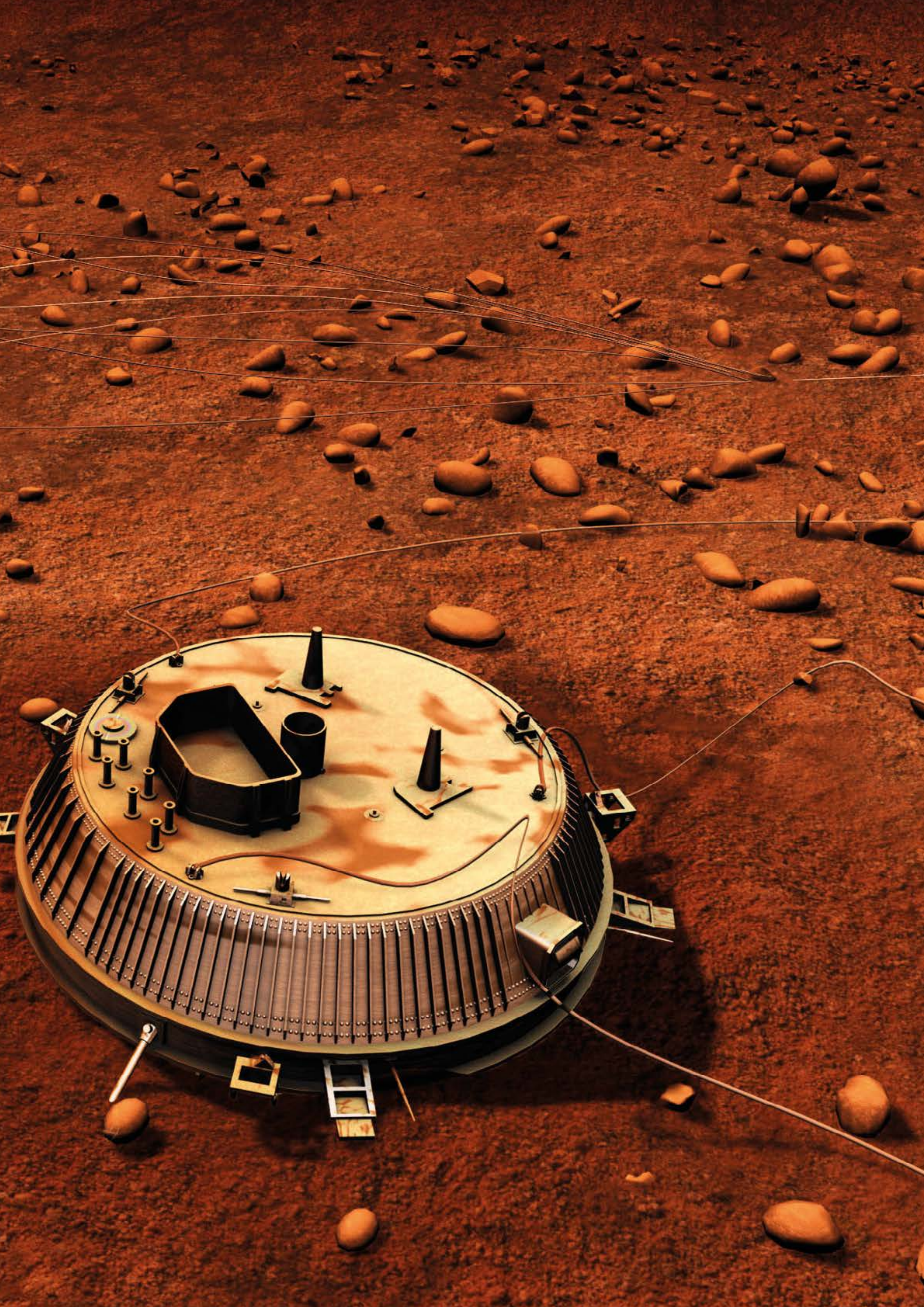
Tempus Pro is a tool for medical professionals who need telemedicine capability (RDT)

→ A DATE TO REMEMBER

Huygens on Titan: 14 January 2005

Carl Walker
Communication Department, ESTEC, Noordwijk, the Netherlands

Ten years ago this January, before the success of Rosetta, another European probe touched down on a different distant world. Huygens landed on a moon of Saturn – still the farthest landing of any man-made object.



The Huygens mission has been an outstanding engineering and scientific success, one of the most complex and scientifically rewarding space missions to date. As part of the joint NASA/ESA/ASI Cassini-Huygens mission to Saturn and its moons, the probe was deployed from the Cassini spacecraft to explore Titan, Saturn's largest moon.

Huygens arrived at Titan following a seven-year voyage. It then spent two hours and 28 minutes descending by parachute through Titan's atmosphere, blasted by winds of up to 430 km/h.

During its descent and landing, it beamed back to the Cassini spacecraft around four hours' worth of invaluable scientific data, revealing Titan to be a world with both striking similarities to and alien differences from Earth.

At 13:34 CET on 14 January 2005, Huygens made the most distant landing of any manmade object in our Solar System. Once it touched down, Huygens spent another 70 minutes transmitting more data before the Cassini spacecraft moved out of range. The Huygens signal then continued to be received for another two hours by a network of radio telescopes on Earth.

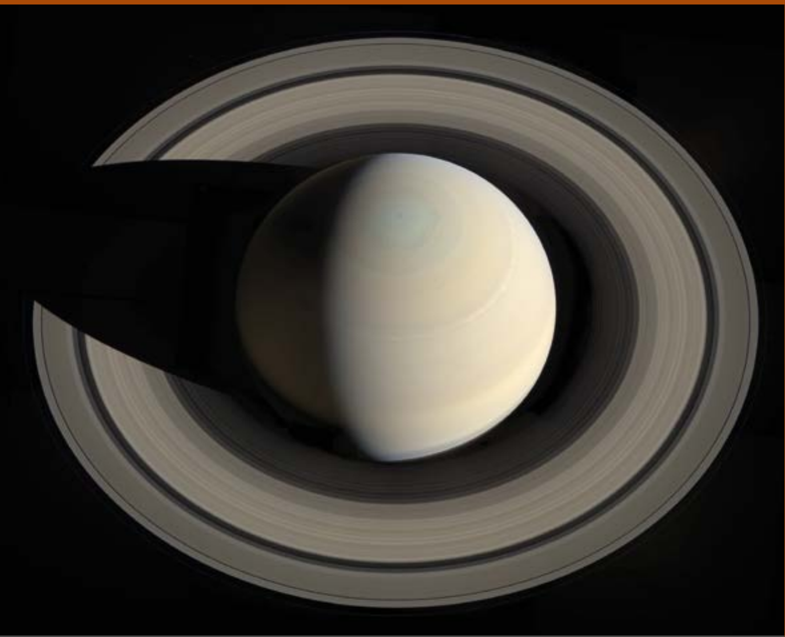
Titan had intrigued planetary scientists for decades. It is the only moon in the Solar System with a thick nitrogen atmosphere. Hidden beneath thick haze, its surface had never been seen before in such detail.

On that day, clear images of the surface of Titan were obtained below 40 km altitude – revealing an extraordinary world and a remarkably Earth-like landscape of hills, valleys and drainage channels. The images showed strong evidence for erosion due to liquid flows, possibly methane.

Titan's organic chemistry is thought to be like that of the primitive Earth around 4000 million years ago, and may hold clues about how life began on our planet. Huygens enabled studies of the atmosphere and surface, including the first *in situ* sampling of the organic chemistry and the aerosols below 150 km.

Its measurements have provided planetary scientists with a rich library of measurements from which to extract information, in conjunction with the wealth of data acquired by Cassini in subsequent flybys of Titan. These results confirmed the presence of a complex organic chemistry, which reinforces the idea that Titan is a promising place to observe the molecules that may have been the precursors of the building blocks of life on Earth.

← First image from the surface of Titan (ESA/NASA/JPL/Univ. Arizona)



↑ Spectacular view of Saturn seen by Cassini in 2013 (NASA/JPL/SSI)

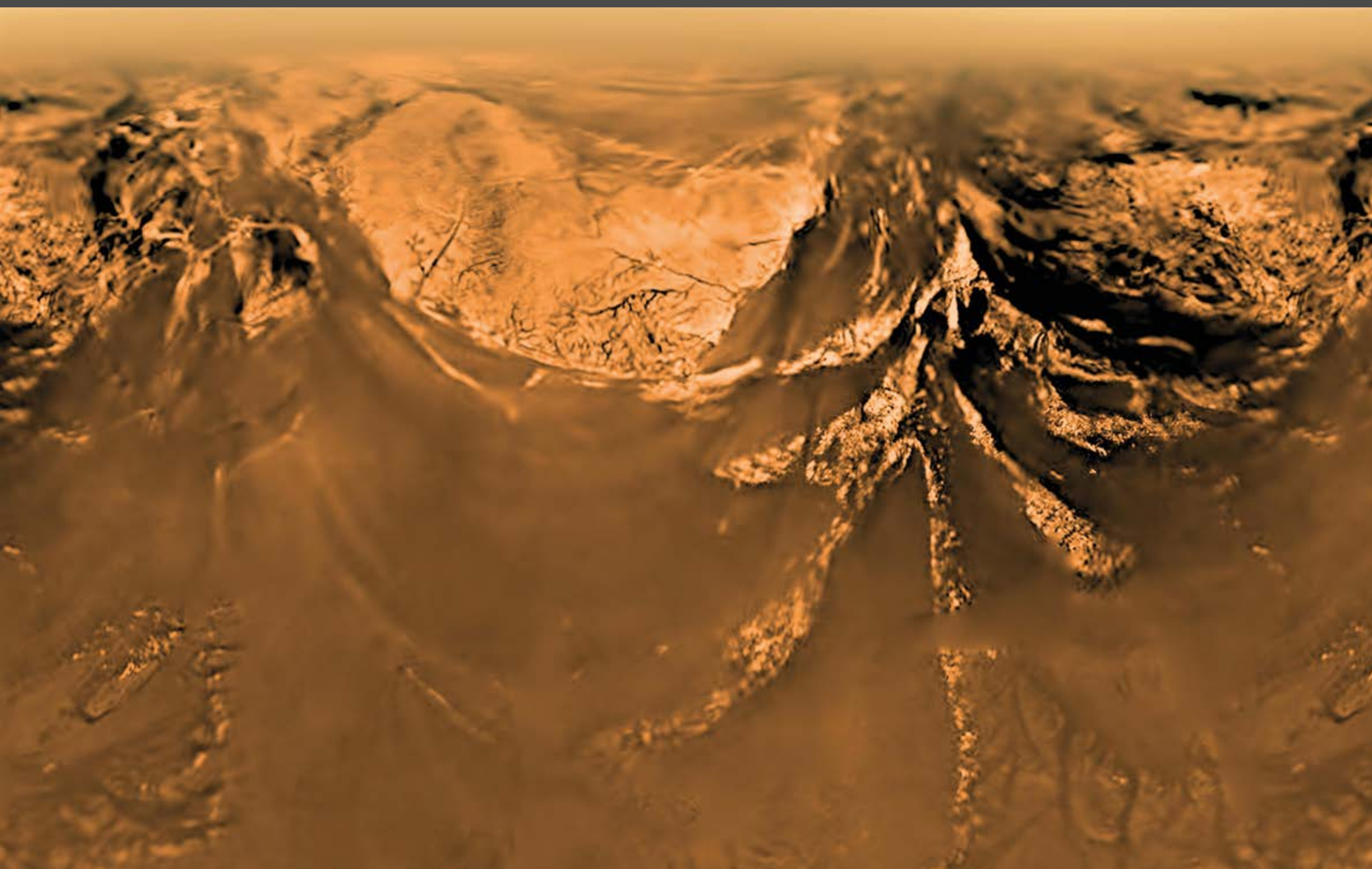
Today, Huygens' mothership Cassini is still orbiting Saturn, returning amazing pictures and taking measurements of Saturn and its moons, rings and magnetosphere.

The Cassini-Huygens mission is one of the largest and most advanced planetary exploration missions ever launched. Around 260 scientists and up to 10 000 engineers and other professionals from 19 countries worked together to achieve this astonishing cooperation.

ESA's former Huygens project scientist and mission manager, Jean-Pierre Lebreton said, "This mission took two decades to accomplish and pushed the limits of our capabilities, whether scientific, technological or organisational. But the scientists and engineers used their skills and intelligence to overcome technical, political and celestial barriers to their goals.

"In the end, they triumphed spectacularly and, apart from the amazing scientific return, the mission should be an inspiration and a lesson for organisations of all kinds, in all sectors, of how people can work together." ■

↓ Aerial view of the Huygens landing site from around 10 km altitude (ESA/NASA/JPL/Univ. Arizona)



→ NEWS IN BRIEF

At the European Space Operations Centre in Germany, 12 November: a very tired Rosetta flight director Andrea Accomazzo makes a call just after Philae's touchdown on the comet, with Elsa Montagnon, Paolo Ferri and Manfred Warhaut (ESA/J. Mai)

@ESA_rosetta #CometLanding

After achieving touchdown on a comet for the first time in history, European scientists and engineers working on the Rosetta mission are busy analysing this new world and the nature of the landing.

Touchdown of the Rosetta mission's Philae lander was confirmed at ESA's European Space Operations Centre (ESOC) in Darmstadt, Germany, at 17:03 CET on 12 November.

Since then, scientists, flight dynamics specialists and engineers from ESA, the Lander Control Centre in Cologne, Germany, and the Philae Science, Operations and Navigation Centre in Toulouse, France, have been studying the data returned from the lander.

These soon revealed the astonishing conclusion that the lander did not just touch down on Comet 67P/Churyumov–Gerasimenko once, but three times. The lander's harpoons did not fire and Philae appeared to be rotating after the first touchdown, which indicated that it had lifted from the surface again.

The information was provided by several of the scientific instruments, including the ROMAP magnetic field analyser, the MUPUS thermal mapper, and the sensors in the landing gear that were pushed in on the first impact.

The first touchdown was inside the predicted landing ellipse, confirmed using the lander's downwards-looking ROLIS descent camera in combination with the orbiter's OSIRIS images to match features. But then the lander lifted from the surface again – for 1 hour 50 minutes.

During that time, it travelled about 1 km at a speed of 38 cm/s. It then made a smaller second hop, travelling at about 3 cm/s, and landing in its final resting place seven minutes later.

The touchdown signal generated on first touchdown induced the instruments to 'think' that Philae had landed, triggering the next sequence of experiments. Now those data are being used to interpret the bounces.

Preliminary data from the CONSERT experiment suggest that Philae could have travelled closer to the large depression known as Site B, perhaps sitting on its rim. High-resolution orbiter images, some of which are still stored on Rosetta, have yet to confirm the location.

The lander remained unanchored to the surface but its science instruments were running and delivering images and data, helping the team to learn more about the final landing site.

The descent camera revealed that the surface is covered by dust and debris ranging from millimetre to metre sizes. Meanwhile, Philae's CIVA camera returned a panoramic image that on first impressions suggests the lander was close to a rocky wall, and perhaps had one of its three feet in open space.

By 15 November, Philae had completed its primary science mission after nearly 57 hours on the comet. After being out of communication visibility with the lander on 13 November, Rosetta regained contact with Philae late on 14 November. The signal was initially intermittent, but quickly stabilised and remained very good until early on 15 November.

In that time, the lander returned all of its housekeeping data, as well as science data from the targeted instruments, including ROLIS, COSAC, Ptolemy, SD2 and CONSERT. This completed the measurements planned for the final block of experiments on the surface.

In addition, the lander's body was lifted by about 4 cm and rotated about 35° in an attempt to receive more solar energy. But as the last science data fed back to Earth, Philae's power rapidly depleted and it fell silent.

→ The Rosetta flight control team as Philae touchdown is confirmed (ESA/J. Mai)

The search for Philae's final landing site continues, with high-resolution images from the orbiter being closely scrutinised. From now on, no contact will be possible with the lander unless sufficient sunlight falls on the solar panels to generate enough power to wake it up.

Meanwhile, the Rosetta orbiter was moved back into a 30 km orbit around the comet. It returned to a 20 km orbit on 6 December and continues its mission to study the body in great detail as the comet becomes more active, en route to its closest encounter with the Sun on 13 August next year.

Over the coming months, Rosetta will start to fly in more distant 'unbound' orbits, while performing a series of daring flybys past the comet, some within just 8 km of its centre.

Data collected by the orbiter will allow scientists to watch the short- and long-term changes that take place on the comet, helping to answer some of the biggest and most important questions regarding the history of our Solar System. How did it form and evolve? What role did comets play in the evolution of the planets, of water on the Earth, and perhaps even of life on our home world?

“The data collected by Philae and Rosetta is set to make this mission a game-changer in cometary science,” said Matt Taylor, ESA’s Rosetta project scientist.

Fred Jansen, ESA’s Rosetta mission manager, said, “At the end of this amazing rollercoaster week, we look back on a successful first-ever soft-landing on a comet. This was a truly historic moment for ESA and its partners. We now look forward to many more months of exciting Rosetta science and possibly a return of Philae from hibernation at some point in time.”

‘iriss’ mission logo

ESA astronaut Andreas Mogensen’s iriss mission patch was unveiled in October.

Andreas will be launched on a Soyuz rocket from Kazakhstan in September 2015. His short two-week mission offers excellent opportunities to test new technologies and return samples and results to scientists quickly. A competition to design the mission logo in Andreas’s native Denmark attracted 500 entrants. The winner for the mission logo, Poul Rasmussen, was inspired by the Greek goddess Iris, who is often depicted with wings. The wings in the design also represent a Viking ship as used to explore the world and seek unknown horizons.

↑ iriss mission logo

Principia mission logo

ESA astronaut Tim Peake's Principia mission patch was unveiled in November.

Each ESA astronaut has a mission name and patch, often chosen in a competition held in the astronaut's home country. For British ESA astronaut Tim Peake's Principia mission to the ISS in 2015, the BBC's Blue Peter programme asked schoolchildren to design a mission patch.

Out of more than 3000 entries, the winner was 13-year-old Troy, who explains: "Principia refers to Isaac Newton's principal laws of gravity and motion so I drew an apple because that is how he discovered gravity. Plus Tim Peake is promoting healthy eating as part of his mission and apples are healthy." Fittingly, a stylised Space Station glints in the apple.

↑ Blue Peter TV presenter Lindsey Russell, competition winner Troy and Tim Peake (ESA/M. Alexander)

Gerst returns from space

↑ Alexander Gerst after his landing in November

Landing on the Kazakh steppe in the same Soyuz TMA-13M spacecraft that flew them to the International Space Station on 28 May, Alexander then was flown straight to the European Astronaut Centre in Cologne, Germany, the home base of ESA astronauts. ESA's medical team monitored how he readapted to gravity after spending more than five months in weightlessness.

Alexander performed over 50 experiments during his Blue Dot mission on the ISS as orbited the planet at an altitude on 400 km. Highlights of his mission included installing ESA's Electromagnetic Levitator experiment, a spacewalk carry out maintenance on the Space Station and overseeing the docking of Europe's last Automated Transfer Vehicle.

Welcome to the Futura

The Soyuz TMA-15M spacecraft carrying ESA astronaut Samantha Cristoforetti, Russian cosmonaut Anton Shkaplerov and NASA astronaut Terry Virts to the ISS lifted off on 23 November.

The Soyuz spacecraft was launched from Baikonur cosmodrome in Kazakhstan and reached orbit nine minutes later. As is now standard with Soyuz, the astronauts reached their destination just under six hours after liftoff and four orbits around the planet. Their spacecraft docked as planned and the hatch to their new home in space was opened a few hours later.

Samantha and her crewmates were welcomed aboard the ISS by NASA astronaut Barry Wilmore and Roscosmos cosmonauts Yelena Serova and Alexander Samokutyaev. Together with her Expedition 42/43 colleagues, Samantha will live and work on the Station for five months.

Samantha's mission is named 'Futura' to highlight the science and technology research she will conduct in space to help shape our future. She is flying as an ESA astronaut for Italy's space agency ASI under a special agreement between ASI and NASA.

→

Samantha Cristoforetti, Terry Virts and Anton Shkaplerov board their Soyuz spacecraft on 23 November

First Copernicus satellite operational

The Sentinel-1A was declared operational in September, delivering radar coverage for an array of applications in the areas of oceans, ice, changing land and emergency response.

Launched on 3 April, Sentinel-1A completed commissioning on 23 September – an important process that ensures the satellite, instruments, data acquisition and data processing procedures are working well. Control of the satellite was transferred to the team in charge of its exploitation, with Project Manager Ramón Torres, who led the development team, formally handing over the satellite to the Mission Manager Pierre Potin.

The satellite will now begin delivering radar scans for an array of operational services and scientific research. The satellite will continue to be monitored, operated and controlled from the European Space Operations Centre in Darmstadt, Germany.

The Sentinels are a new fleet of ESA satellite poised to deliver the wealth of data and imagery that are central to Europe's Copernicus programme. By offering a set of key information services for a broad range of applications, this global monitoring programme is a step change in the way we manage our environment, understand and tackle the effects of climate change, and safeguard everyday lives.

Signifying the beginning of Sentinel-1A operations, Project Manager Ramón Torres (left) hands over to Mission Manager Pierre Potin, with ESA's Director of Earth Observation Volker Liebig

Sentinel-1 – a two-satellite constellation – is the first in the series and carries an advanced radar to provide an all-weather, day-and-night supply of imagery of Earth's surface. Even during commissioning, Sentinel-1A demonstrated its potential in the various applications domains. Just days after launch, its results were included in maps of the floods that hit Namibia, as well as those in the Balkans the following month. This information was then used by authorities involved in flood response. Radar images were also used to map the rupture caused by the 24 August earthquake that shook northern California – the biggest the area has seen in 25 years.

The towing of the *Costa Concordia* cruise ship off the west coast of Italy was captured by the radar, demonstrating Sentinel-1's ability to survey the marine environment.

This and many other services will now start benefiting from Sentinel-1A's operational status. These include services related to monitoring Arctic sea-ice extent, routine sea-ice mapping, surveillance of the marine environment, monitoring land-surface for motion risks, mapping for forest, water and soil management and mapping to support humanitarian aid and crisis situations.

The mission's contributions will further improve once the satellite's identical twin, Sentinel-1B, is launched in 2016.

Ministerial Council 2014

↑ ESA Council at Ministerial Level, Luxembourg, on 2 December 2014

Ministers in charge of space activities within the 20 ESA Member States and Canada met in December to make key decisions on ESA's activities and future perspectives.

The resolutions adopted were on Europe's launcher programmes, European participation in the ISS Exploitation Programme, the future European strategy for exploration and the evolution of ESA.

On of the most important decisions taken was the green light to develop a new generation of European launchers: Ariane 6, which will replace Ariane 5 from 2020, and an upgrade to the small launcher, Vega-C. Both launchers will allow Europe to maintain an independent access to space.

Ministers also confirmed ESA's involvement in ExoMars programme, with the implementation of two missions to Mars – one in 2016, the other in 2018. Other programmes approved at the meeting included the next phase of Sentinel-6, a future satellite for the EU to monitor the oceans; and 'AnySat', a concept for small, adaptable telecommunications satellites.

The Ariane 6, four-booster configuration

Europe secures new generation of weather satellites

Contracts were signed in October to build three pairs of MetOp Second Generation satellites, ensuring the continuity of essential information for global weather forecasting and climate monitoring for decades to come.

The contracts to build the MetOp Second Generation satellites were signed by Eric Béranger, Head of Space Systems Programmes at Airbus Defence & Space, and Volker Liebig, ESA's Director of Earth Observation, at ESA Headquarters, Paris, on 16 October

MetOp-SG is a cooperative undertaking between ESA and Eumetsat, the European organisation for the exploitation of meteorological satellites. These new satellites offer enhanced continuity of the current MetOp series, today's main source of global weather data.

Comprising six satellites in total, the mission is based on a pair of satellites that carry different packages to deliver complementary meteorological information. The A series of satellites will be equipped with atmospheric sounders as well as optical and infrared imagers, while the B series focuses on microwave sensors.

Airbus Defence & Space France now takes up the role as prime contractor for the A satellites and Airbus Defence & Space Germany for the B series.

Although the different satellites will be developed and built in Toulouse, France, and Friedrichshafen, Germany, respectively, a large industrial consortium of many European companies will be involved under the leadership of Airbus Defence & Space.

As a cooperative effort, ESA funds the development of the first satellites and procures the repeat satellites on behalf of Eumetsat. Eumetsat then funds the duplicate satellites, develops the ground segment, operates the satellites and carries out the data processing.

As with the first generation, the satellites will provide users with crucial information on atmospheric temperature and water profiles, cloud detection and analysis, and sea-surface temperature and winds, extending to aerosols, trace gases and air quality. New instruments observing extended spectral and frequency ranges will allow new environmental measurements to be made.

The MetOp-SG satellites will orbit Earth at an average altitude of 831 km in a polar orbit to provide global coverage, with the first A satellite being launched in 2021, followed by the first B satellite in 2022.

ESAC: 50 years of Europe in space

A celebration marking 50 years of European cooperation in space was attended by ESA VIPs and Spanish dignitaries, at ESAC, ESA's European Space Astronomy Centre near Madrid.

The President of the Spanish Government, Mr Mariano Rajoy, was welcomed to ESAC on 6 November by ESA Director General Jean-Jaques Dordain on a visit marking 50 years of European cooperation in space. President Rajoy stressed Spain's status as one of founders of this cooperation.

In 1964, two unique organisations came into being: ESRO was dedicated to space research, while ELDO focused on launchers. A decade later, they merged to form ESA – and Spain was a founding member of both ESRO and ESA. The country continues to be a strong supporter of ESA, as the fifth-largest Member State in terms of funding.

↑

Front row, from left: Carmen Vela, Secretary of State for Research, Development and Innovation; Alvaro Giménez, ESA Director of Science and Robotic Exploration and Head of ESAC; Pedro Duque, ESA astronaut; Jean-Jaques Dordain, ESA Director General; Mariano Rajoy, President of the Government of Spain; José Manuel Soria, Minister for Industry, Energy and Tourism; Luis Partida, Mayor of Villanueva de la Cañada; Jorge Moragas, Director of the Cabinet for the Governmental Presidency; Pedro Argüelles, Secretary of State for Defence. Back row, from left: Antón Cuadrado, Director General of Airbus Space Systems España; María Luisa Poncela, Secretary General of Science, Technology and Innovation; Begoña Cristeto, Secretary General of Industry and SMEs; Adolfo Menéndez, President of the Spanish Industry Association; Andrés Sendagorta, Vice-President of SENER.

ESRIN: 50 years of Europe in space

ESRIN, ESA's centre for Earth Observation welcomed high-ranking representatives of the Italian government, European institutions and industry on 26 November in an event to mark the 50th anniversary of European cooperation in space. Among the guests were Stefania Giannini, the Italian Minister of Education, Universities and Research, and Roberto Battiston, Head of the Italian space agency ASI. From left: ESA astronaut Luca Parmitano, Roberto Battiston, Head of the Italian Space Agency (ASI), Minister Giannini and ESA Director General Jean-Jacques Dordain.

Dawn of Orion

The flight and splashdown of NASA's first Orion spacecraft on 6 December paved the way for future human exploration beyond low orbit powered by ESA's European Service Module.

↑

Launch of NASA's Orion Exploration Flight Test-1 (NASA/ULA)

Orion is NASA's new spacecraft built to carry humans and designed for journeys to destinations never before visited by astronauts, including asteroids and Mars.

Lifting on a Delta IV heavy rocket from Cape Canaveral, Florida, the Orion capsule splashed down in the Pacific Ocean about 966 km off the coast of Baja California two orbits and about 4.5 hours later.

During Orion's Exploration Flight Test-1, systems critical for crew safety were tested, such as the parachutes, avionics and attitude control, and major events such as jettison of the launch abort system and separation of the service module and fairing were demonstrated.

Future Orion spacecraft will be equipped with a European Service Module, the first time that Europe has provided a system-critical element for a US crewed vehicle. For this first flight, Orion used only an engineering structural model – ESA's full service module is scheduled for the next uncrewed test.

The service module will be the powerhouse that fuels and propels the Orion spacecraft in space. It will provide essential functions such as propulsion, power, thermal control and life-support consumables storage and distribution.

Located directly below the Orion crew module, it will carry the propulsion capability for orbital transfer, attitude control and high-altitude ascent aborts. It will also generate power using solar wings and store it, and provide thermal control, water, oxygen and nitrogen for the astronauts until just before their return to Earth, when it will separate from the crew module.

On 17 November, ESA signed the contract with Airbus Defence & Space to develop and build the service module as part of Europe's contributions to the ISS. The design passed its Preliminary Design Review earlier this year. The next major milestone is the Critical Design Review, set for the end of 2015. Funding to complete development was agreed at the Ministerial Council in December.

ESA and Omega continue a space legacy

Swiss watchmaker Omega has announced a new version of its historic space watch, tested and qualified with ESA's help and drawing on an invention of ESA astronaut Jean-François Clervoy.

↑ The Omega Speedmaster Skywalker X-33 (Omega)

Jean-François flew in space three times in the 1990s and began thinking how to improve the wristwatches he wore on his missions. ESA filed a patent based on his ideas for a timepiece that helps astronauts to track their mission events.

One of the new functions allows the wearer to set a date in the past or future down to the second and have the watch calculate how much time has elapsed or is left. Other features useful for astronauts include flexible programming of multiple alarms with different ring tones.

The Omega company, with its strong links to spaceflight since the Gemini and Apollo flights in the 1960s, was interested in improving its line of Speedmaster Professional watches, and called on ESA's patent for the new Speedmaster Skywalker X-33.

The Skywalker watches have passed rigorous testing at ESA's technical centre ESTEC, in Noordwijk, the Netherlands, where many ESA satellites are put through their paces before launch. The timepiece proved itself capable of surviving anything an astronaut might experience – and more.

↑ ESA astronaut Jean-François Clervoy

President of Omega, Stephen Urquhart, said, "We are delighted that our friends at ESA have tested and qualified the Speedmaster Skywalker X-33 for all its piloted missions, which is a natural extension of our long relationship with NASA and its space programme. ESA's abilities and ambitions are extraordinary, as demonstrated by their recent high-profile successes with Rosetta and Philae, and we are proud that their name and endorsement grace the back of this iconic chronograph."

Jean-François Clervoy added, "I am excited and proud to see my invention implemented in a high-precision wristwatch. Having Omega in this partnership with ESA, based on our patent, will allow all ESA astronauts to benefit from its innovative functions."

This invention, owned and protected by ESA, is one of 135 available for commercialisation by non-space industry.

Europe's 3D printer set for Space Station

Europe's very first 3D printer in space is scheduled for installation aboard the ISS next year.

Designed and built in Italy, it will be put to the test as part as ESA astronaut Samantha Cristoforetti's Futura mission, and is set to reach orbit in the first half of next year. Samantha herself was launched on her six-month Space Station mission on 23 November.

"The POP3D Portable On-Board Printer is a small 3D printer that requires very limited power and crew involvement to operate," explained Luca Enrietti of Altran, prime contractor for the compact printer.

The unit is a cube with 25 cm sides and prints with biodegradable and harmless plastic using a heat-based process. "Part of the challenge of designing a 3D printer for the Station was to ensure its operation does not affect the crew environment," added Giorgio Musso of Thales Alenia Space Italy, principal investigator for the project.

Funded by Italian space agency ASI, POP3D should take about half an hour to produce a single plastic part, which will eventually be returned to Earth for detailed testing, including comparison with an otherwise identical part printed on the ground.

Laser link makes a space first

Marking a first in space, Sentinel-1A and Alphasat have linked up by laser stretching almost 36 000 km across space to deliver images of Earth just moments after they were captured.

This important step demonstrates the potential of Europe's new space data highway to relay large volumes of data very quickly so that information from Earth-observing missions can be even more readily available.

Having timely access to imagery from the Sentinel-1 mission, for example, is essential for numerous applications such as maritime safety and helping to respond to natural disasters.

↑ This image of Berlin, Germany, captured by Sentinel-1A is one of the first images delivered via the precursor European Data Relay System (EDRS) carried on Alphasat (Copernicus data/ESA)

Orbiting from pole to pole about 700 km up, Sentinel-1A transmits data to Earth routinely, but only when it passes over its ground stations in Europe. However, geostationary satellites, hovering 36 000 km above Earth, have their ground stations in permanent view so they can stream data to Earth all the time.

This takes a great deal of coordination between the different teams working intensively. Later on, in routine operations, this will be fully automated.

Creating a link between the two kinds of satellites means that more information can be streamed to Earth, and almost continuously. Engineers have turned to laser to accomplish this.

Funded by ESA and the DLR German Aerospace Center, Tesat has developed a laser communications terminal and downlink system that is carried on the geostationary Alphasat, Europe's largest telecommunications satellite. This novel unit's counterpart is flying on Sentinel-1A.

New Director General announced

In December it was announced that Mr Johann-Dietrich Woerner will be the next Director General of ESA, for a period of four years starting on 1 July 2015.

Prof. Dr.-Ing. Johann-Dietrich Wörner (DLR, CC-BY)

He will succeed Jean-Jacques Dordain, whose term of office ends on 30 June 2015. Mr Woerner is currently Chairman of the Executive Board of DLR, the German Aerospace Center.

Mr Woerner was born in Kassel in 1954. He studied civil engineering at the Technische Universität Berlin and the Technische Hochschule Darmstadt, from where he graduated in 1985. In 1982, as part of his studies, he spent two years in Japan, investigating earthquake safety. Until 1990, Mr Woerner worked for the consulting civil engineers König und Heunisch. In 1990 he returned to Darmstadt University, where he was appointed to a professorship in Civil Engineering and took over as Head of the Testing and Research Institute. Before being elected President of the Technische Universität Darmstadt in 1995, he held the position of Dean of the Civil Engineering Faculty.

Business incubator opens in Portugal

ESA's latest Business Incubation Centre has opened in Portugal, ready to help entrepreneurs and start-up companies take space technology and services into non-space areas such as health, transport and energy.

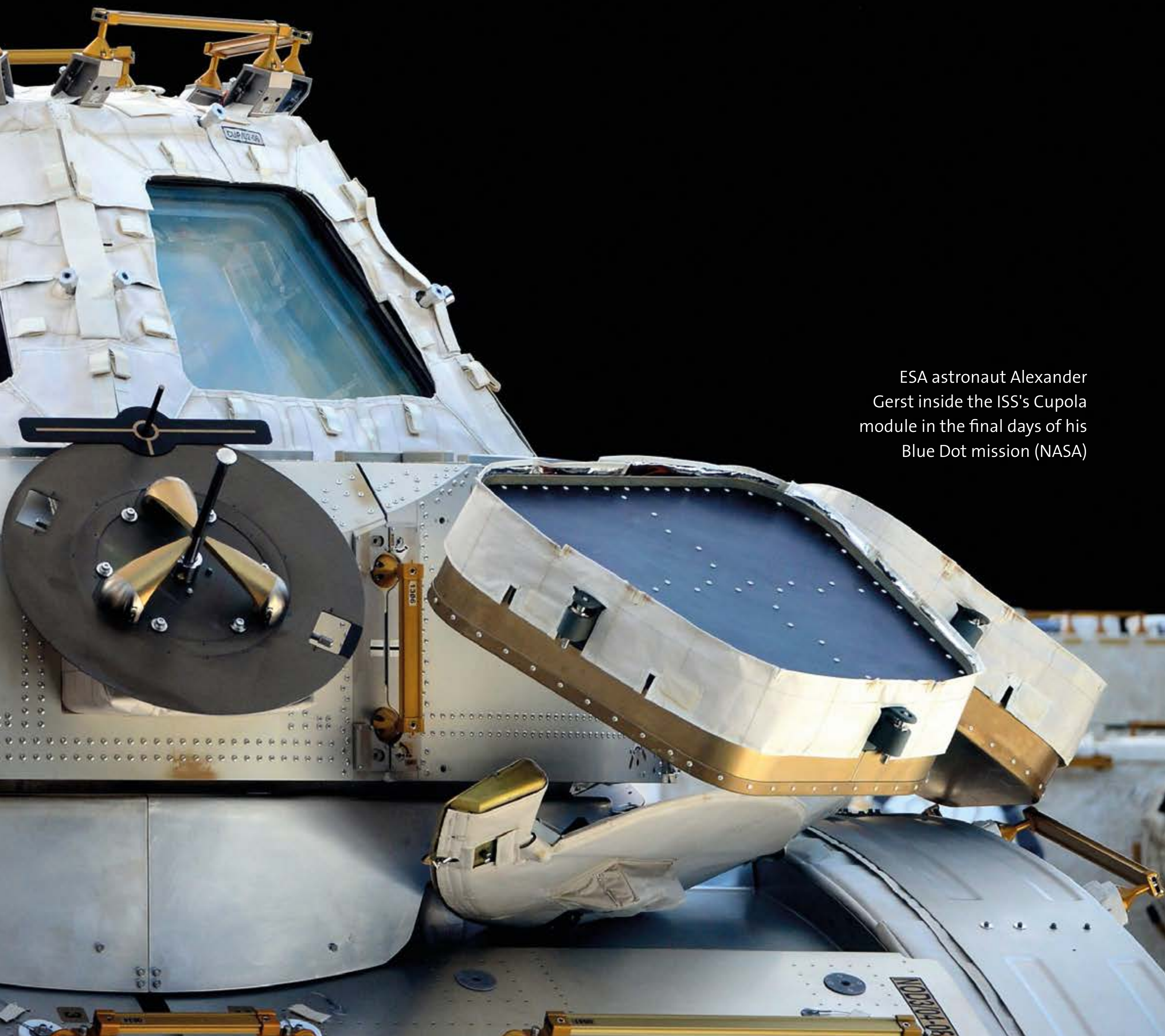
Portugal's Business Incubation Centre joins the network of BICs around Europe

Over the coming five years, the centre will help 30 Portuguese start-up companies to get their businesses going, creating at least 120 local high-tech jobs. The companies will receive €1.5 million as seed incentive and be able to tap into an additional €7 million. The new incubator is managed by the University of Coimbra's Instituto Pedro Nunes (IPN) in collaboration with Science and Technology Park at University of Porto and DNA Cascais, a non-profit organisation that fosters entrepreneurship in Cascais and the greater Lisbon region. With 18 years' experience in business incubation, the institute has supported more than 200 technology and innovation projects.

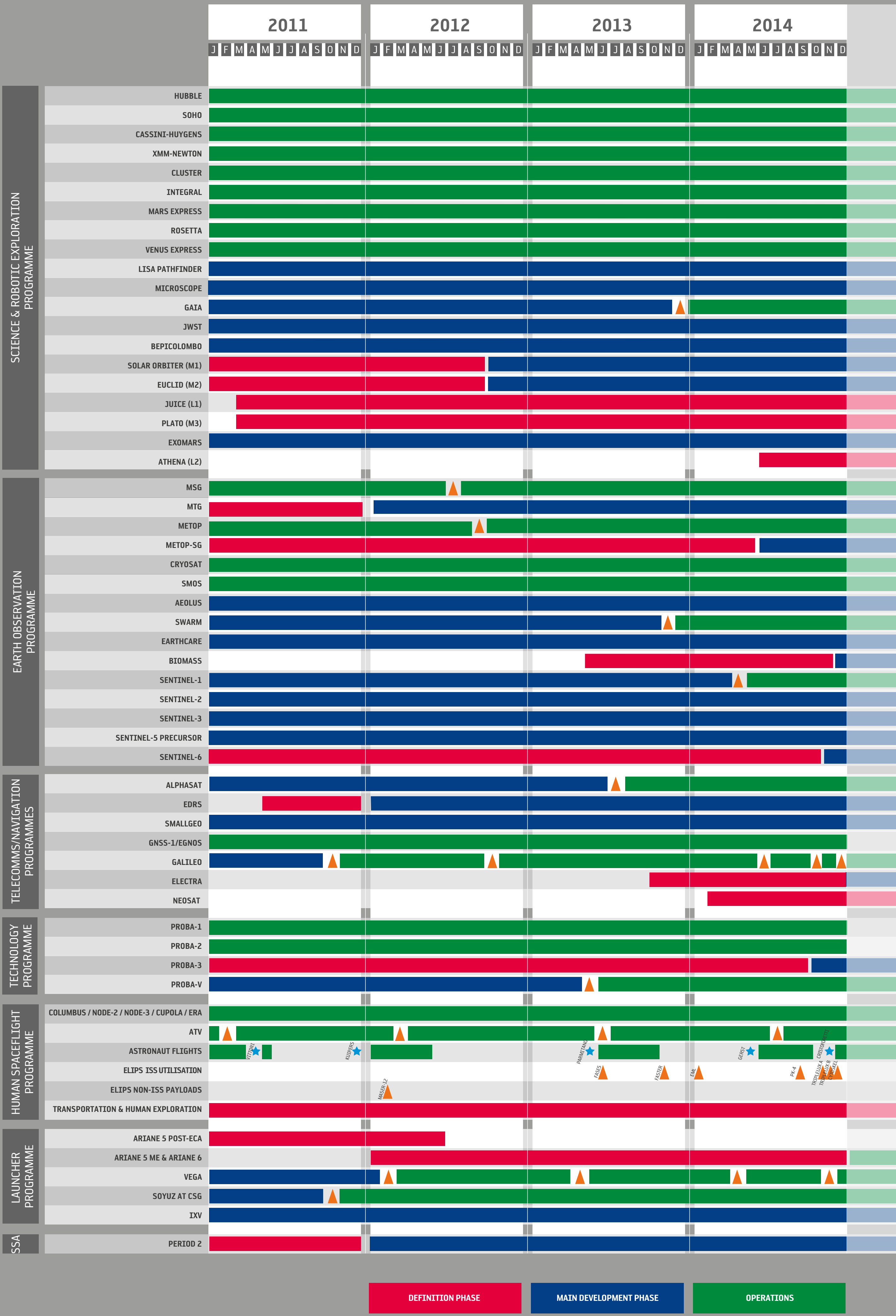

SHUTTER PNL (CUP) - 1007
CUP/02-05
CUP/01-04
SHUTTER PNL (CUP) - 1004

→ PROGRAMMES IN PROGRESS

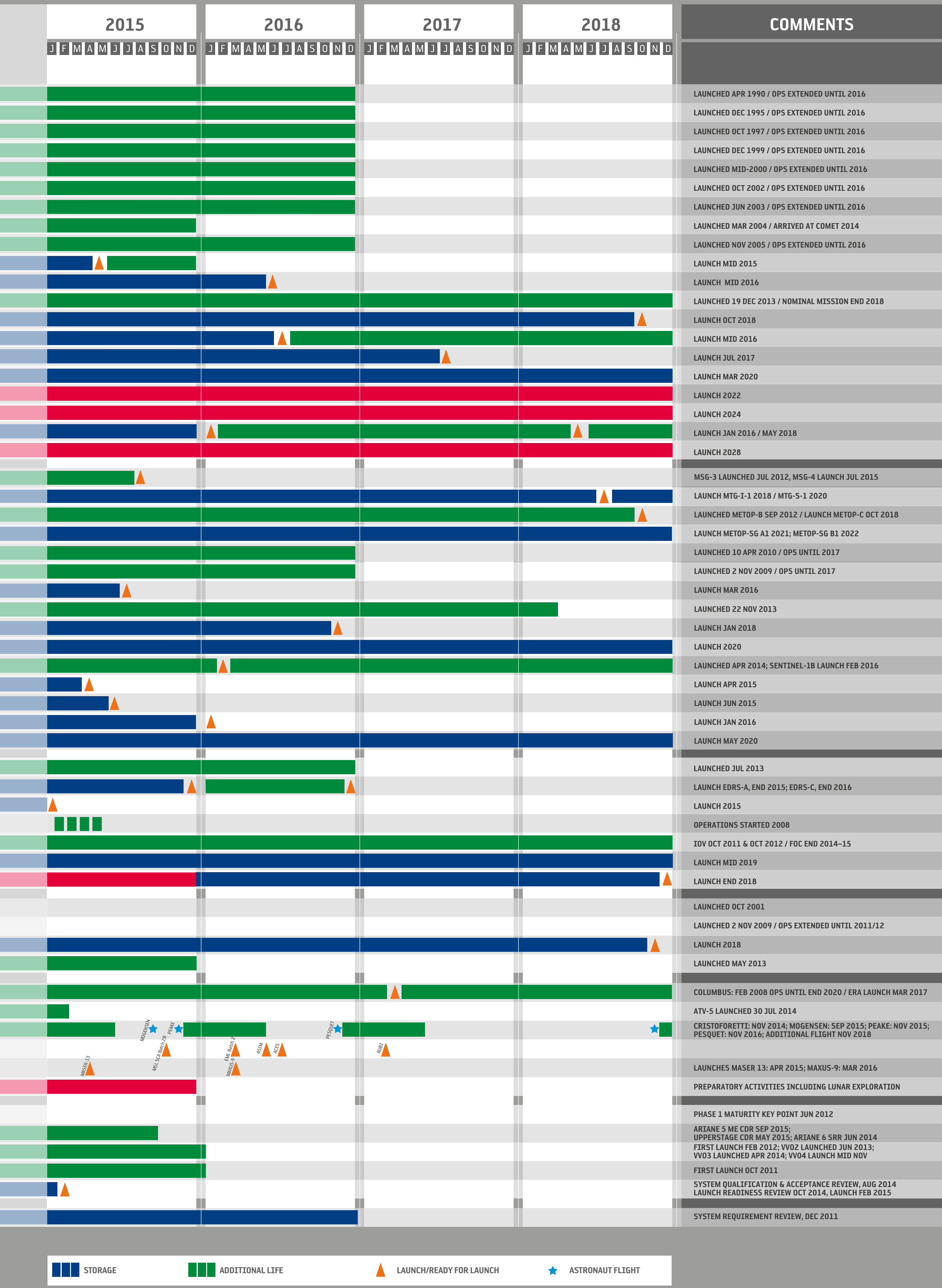
Status at end October 2014



ESA astronaut Alexander Gerst inside the ISS's Cupola module in the final days of his Blue Dot mission (NASA)



2011
2012
2013
2014
J F M A M J J A S O N D
SCIENCE & ROBOTIC EXPLORATION PROGRAMME
HUBBLE
SOHO
CASSINI-HUYGENS
XMM-NEWTON
CLUSTER
INTEGRAL
MARS EXPRESS
ROSETTA
VENUS EXPRESS
LISA PATHFINDER
MICROSCOPE
GAIA
JWST
BEPICOLOMBO
SOLAR ORBITER (M1)
EUCLID (M2)
JUICE (L1)
PLATO (M3)
EXOMARS
ATHENA (L2)
EARTH OBSERVATION PROGRAMME
MSG
MTG
METOP
METOP-SG
CRYOSAT
SMOS
AEOLUS
SWARM
EARTHCARE
BIOMASS
SENTINEL-1
SENTINEL-2
SENTINEL-3
SENTINEL-5 PRECURSOR
SENTINEL-6
TELECOMMS/NAVIGATION PROGRAMMES
ALPHASAT
EDRS
SMALLGEO
GNSS-1/EGNOS
GALILEO
ELECTRA
NEOSAT
TECHNOLOGY PROGRAMME
PROBA-1
PROBA-2
PROBA-3
PROBA-V
HUMAN SPACEFLIGHT PROGRAMME
COLUMBUS / NODE-2 / NODE-3 / CUPOLA / ERA
ATV
ASTRONAUT FLIGHTS
ELIPS ISS UTILISATION
ELIPS NON-ISS PAYLOADS
TRANSPORTATION & HUMAN EXPLORATION
VITTORI
KUIPERS
PARMITANO
GERST
CRISTOFORETTI
FASES
FASTER
EML
PK-4
MASER-12
LAUNCHER PROGRAMME
ARIANE 5 POST-ECA
ARIANE 5 ME & ARIANE 6
VEGA
SOYUZ AT CSG
IXV
SSA
PERIOD 2
DEFINITION PHASE
MAIN DEVELOPMENT PHASE
OPERATIONS


2015
2016
2017
2018
J F M A M J J A S O N D
COMMENTS
LAUNCHED APR 1990 / OPS EXTENDED UNTIL 2016
LAUNCHED DEC 1995 / OPS EXTENDED UNTIL 2016
LAUNCHED OCT 1997 / OPS EXTENDED UNTIL 2016
LAUNCHED DEC 1999 / OPS EXTENDED UNTIL 2016
LAUNCHED MID-2000 / OPS EXTENDED UNTIL 2016
LAUNCHED OCT 2002 / OPS EXTENDED UNTIL 2016
LAUNCHED JUN 2003 / OPS EXTENDED UNTIL 2016
LAUNCHED MAR 2004 / ARRIVED AT COMET 2014
LAUNCHED NOV 2005 / OPS EXTENDED UNTIL 2016
LAUNCH MID 2015
LAUNCH MID 2016
LAUNCHED 19 DEC 2013 / NOMINAL MISSION END 2018
LAUNCH OCT 2018
LAUNCH MID 2016
LAUNCH JUL 2017
LAUNCH MAR 2020
LAUNCH 2022
LAUNCH 2024
LAUNCH JAN 2016 / MAY 2018
LAUNCH 2028
MSG-3 LAUNCHED JUL 2012, MSG-4 LAUNCH JUL 2015
LAUNCH MTG-I-1 2018 / MTG-S-1 2020
LAUNCHED METOP-B SEP 2012 / LAUNCH METOP-C OCT 2018
LAUNCH METOP-SG A1 2021; METOP-SG B1 2022
LAUNCHED 10 APR 2010 / OPS UNTIL 2017
LAUNCHED 2 NOV 2009 / OPS UNTIL 2017
LAUNCH MAR 2016
LAUNCHED 22 NOV 2013
LAUNCH JAN 2018
LAUNCH 2020
LAUNCHED APR 2014; SENTINEL-1B LAUNCH FEB 2016
LAUNCH APR 2015
LAUNCH JUN 2015
LAUNCH JAN 2016
LAUNCH MAY 2020
LAUNCHED JUL 2013
LAUNCH EDRS-A, END 2015; EDRS-C, END 2016
LAUNCH 2015
OPERATIONS STARTED 2008
IOV OCT 2011 & OCT 2012 / FOC END 2014–15
LAUNCH MID 2019
LAUNCH END 2018
LAUNCHED OCT 2001
LAUNCHED 2 NOV 2009 / OPS EXTENDED UNTIL 2011/12
LAUNCH 2018
LAUNCHED MAY 2013
COLUMBUS: FEB 2008 OPS UNTIL END 2020 / ERA LAUNCH MAR 2017
ATV-5 LAUNCHED 30 JUL 2014
MOGENSEN
PEAKE
PESQUET
CRISTOFORETTI: NOV 2014; MOGENSEN: SEP 2015; PEAKE: NOV 2015; PESQUET: NOV 2016; ADDITIONAL FLIGHT NOV 2018
MSL SCA Batch 2B
EML Batch 2
ASIM
ACES
RUBI
MASER-13
MAXUS-9
LAUNCHES MASER 13: APR 2015; MAXUS-9: MAR 2016
PREPARATORY ACTIVITIES INCLUDING LUNAR EXPLORATION
PHASE 1 MATURITY KEY POINT JUN 2012
ARIANE 5 ME CDR SEP 2015; UPPERSTAGE CDR MAY 2015; ARIANE 6 SRR JUN 2014
FIRST LAUNCH FEB 2012; VV02 LAUNCHED JUN 2013; VV03 LAUNCHED APR 2014; VV04 LAUNCH MID NOV
FIRST LAUNCH OCT 2011
SYSTEM QUALIFICATION & ACCEPTANCE REVIEW, AUG 2014 LAUNCH READINESS REVIEW OCT 2014, LAUNCH FEB 2015
SYSTEM REQUIREMENT REVIEW, DEC 2011
STORAGE
ADDITIONAL LIFE
LAUNCH/READY FOR LAUNCH
ASTRONAUT FLIGHT

KEY TO ACRONYMS

AM - Avionics Model	ITT - Invitation to Tender
AO - Announcement of Opportunity	LEOP- Launch and Early Orbit Phase
AIT - Assembly, integration and test	MoU- Memorandum of Understanding
AU - Astronomical Unit	PDR - Preliminary Design Review
CDR - Critical Design Review	PFM- Proto-flight Model
CSG - Centre Spatial Guyanais	PLM- Payload Module
EFM - Engineering Functional Model	PRR - Preliminary Requirement Review
ELM - Electrical Model	QM - Qualification Model
EM - Engineering Model	SM - Structural Model
EMC - Electromagnetic compatibility	SRR - System Requirement Review
EQM- Electrical Qualification Model	STM- Structural/Thermal Model
FAR - Flight Acceptance Review	SVM- Service Module
FM - Flight Model	TM - Thermal Model

→ HUBBLE SPACE TELESCOPE

New observations of the ultracompact dwarf galaxy M60-UCD1 have revealed a supermassive black hole at its centre, making this tiny galaxy the smallest ever found to host a supermassive black hole. This suggests that there may be many more supermassive black holes that we have missed, and tells us more about the formation of these incredibly dense galaxies.

This particular one makes up 15% of the galaxy's total mass, and weighs five times that of the black hole at the centre of the Milky Way. That is interesting given that the Milky Way is 500 times larger and more than 1000 times heavier than M60-UCD1. In fact, even though the black hole at the centre of our galaxy has the mass of 4 x 10^6 solar masses, it is still less than 0.01 % of the Milky Way's total mass.

The team discovered the supermassive black hole by observing M60-UCD1 with both Hubble and the Gemini North 8-m optical and infrared telescope on Mauna Kea.

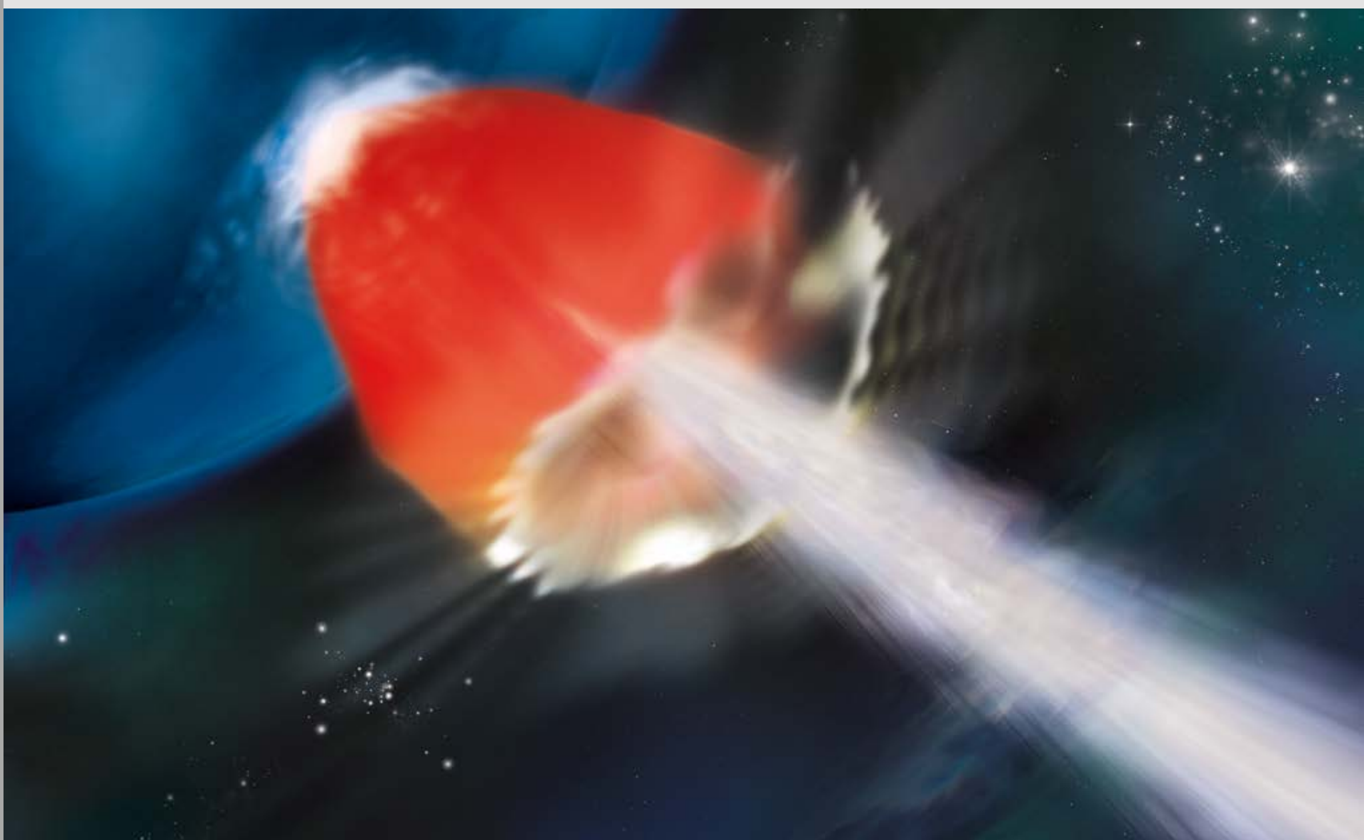
The Hubble images provided information about the galaxy's diameter and stellar density, while Gemini was used to measure the movement of stars in the galaxy as they were affected by the black hole's gravitational pull. These data were then used to calculate the mass of the black hole.

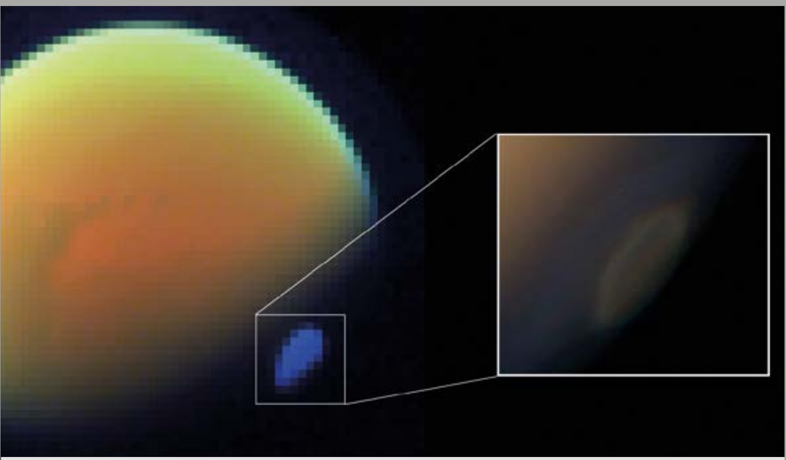
→ XMM-NEWTON

The observatory has helped to uncover how the Universe's first stars ended their lives in giant explosions.

Astronomers studied the gamma-ray burst GRB130925A, a flash of very energetic radiation streaming from a star in a distant galaxy 5.6 billion light-years from Earth, using space- and ground-based observatories. They found the culprit producing the burst to be a massive star, known as a 'blue supergiant'. These huge stars are rare in the nearby Universe where GRB130925A is located, but are thought to have been very common in the early Universe, with almost all of the very first stars having evolved into them over the course of their short lives. But unlike other blue supergiants we see nearby, GRB130925A's progenitor star contained very little of elements heavier than hydrogen and helium. The same was true for the first stars to form in the Universe, making GRB130925A a remarkable analogue for similar explosions that occurred just a few hundred million years after the Big Bang.

An exploding blue supergiant star (NASA/Swift/A. Simonnet, Sonoma State Univ.)





A map of Titan, the largest moon of Saturn, obtained with the Cassini Visual and Infrared Mapping Spectrometer (VIMS). The insert shows a Cassini natural-colour view of the southern polar vortex, a huge swirling cloud that was first observed in 2012 (R. de Kok/Leiden Obs./SRON)

→ CASSINI

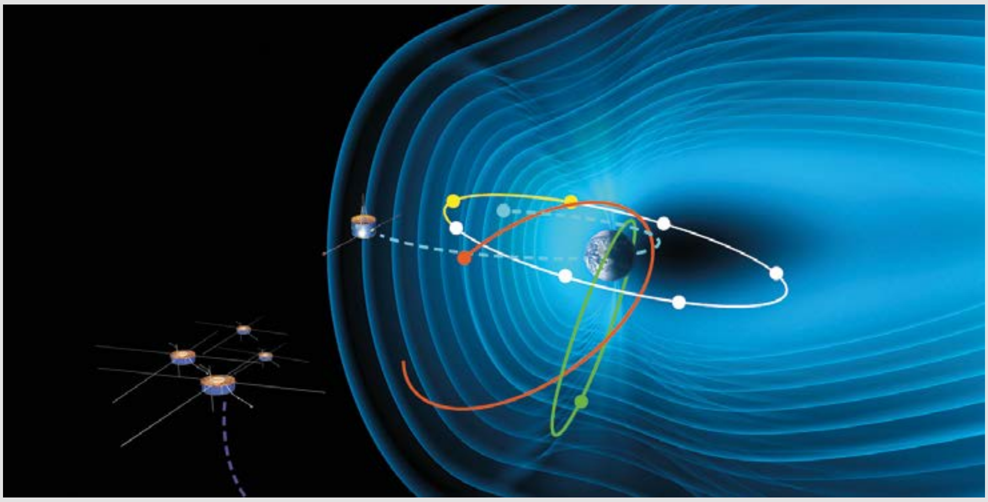
Titan's middle atmosphere is currently experiencing a rapid change of season after northern spring arrived in 2009. A large cloud was observed for the first time above Titan's southern pole in May 2012, at an altitude of 300 km. A temperature maximum was previously observed there, and condensation was not expected for any of Titan's atmospheric gases. We can report that this cloud is composed of micrometre-sized particles of frozen hydrogen cyanide (HCN) ice. The presence of HCN particles at this altitude, together with temperature determinations from mid-infrared observations, indicate a dramatic cooling of Titan's atmosphere inside the winter polar vortex in early 2012. Such cooling is in contrast to previously measured high-altitude warming in the polar vortex, and temperatures are a hundred degrees colder than predicted by circulation models. These results show that post-equinox cooling at the winter pole of Titan is much more efficient than previously thought.

→ CLUSTER

The Sun is a variable star, experiencing 11-year-long cycles of activity that impact our planet and near-Earth space. Forecasting the changing space weather and the effects it will have on Earth remains a challenge, as illustrated by an unusual magnetic storm that was observed by ESA's Cluster quartet and one of the Chinese/ESA Double Star spacecraft.

On 20 January 2005, the ESA/NASA SOHO spacecraft detected an explosion on the Sun that ejected a huge cloud of plasma (electrically charged gas) into space. Subsequent observations indicated that this was one of the fastest coronal mass ejections (CMEs) during solar cycle 23, with a velocity that peaked at perhaps 3000 km/s at a distance of between 3 and 50 solar radii, before slowing to 1000 km/s as it approached Earth. The typical speed of particles in the solar wind is 400–700 km/s.

By the time it reached Earth's vicinity, the CME exhibited two extremely unusual features. First, it was observed to contain a large amount of solar filament material. Filaments are ribbons of dense plasma that are driven upward into the



An unusual magnetic storm was studied using measurements from 12 spacecraft operating in Earth's magnetosphere on 21–22 January. The spacecraft were: ESA's four Cluster satellites (purple) in the solar wind directly upstream of Earth; Chinese/ESA Double Star TC-1 (blue) passing from the outer region of the planet's magnetic field and entering the magnetosphere; the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) satellite (green), GOES (yellow), and five geosynchronous satellites from Los Alamos National Laboratory (white) in complementary regions. SOHO and the Advanced Composition Explorer (ACE) were at the Sun–Earth L1 Lagrange point and are not shown. The orbit of the Polar spacecraft (orange) is included for completeness although the data were not used in this study (ESA/ATG medialab)

Sun's outer atmosphere – the corona – by strong magnetic fields emerging from active regions. However, despite observations indicating that more than 70% of active region eruptions involve solar filaments, these structures are rarely identifiable in CMEs arriving at Earth.

What happened next was observed by a flotilla of Earth-orbiting scientific satellites, including ESA's Cluster quartet, the Chinese/ESA Double Star TC-1 spacecraft, and various US spacecraft, as well as the ground-based SuperDARN radar network. They provided a unique opportunity to study the impact and merger of the CME material with the magnetosphere – the invisible magnetic bubble which surrounds our planet.

The magnetic storm that resulted from the CME impact on 21 January was moderate in intensity, since the interplanetary magnetic field was mainly northward.

The data show that the dense filament material following immediately behind the sheath in the CME was directly or indirectly responsible for most of the unusual features in the geomagnetic storm which resulted. Within one hour of the impact, a cold, dense plasma sheet had formed out of the filament material and high density material continued to move through the magnetosphere for the entire six hours of the filament's passage. Simulated and observed plasma sheet densities exceeded tens of particles per cubic centimetre along the flanks – high enough to inflate the magnetotail under northward magnetic field conditions, despite the cool temperatures.

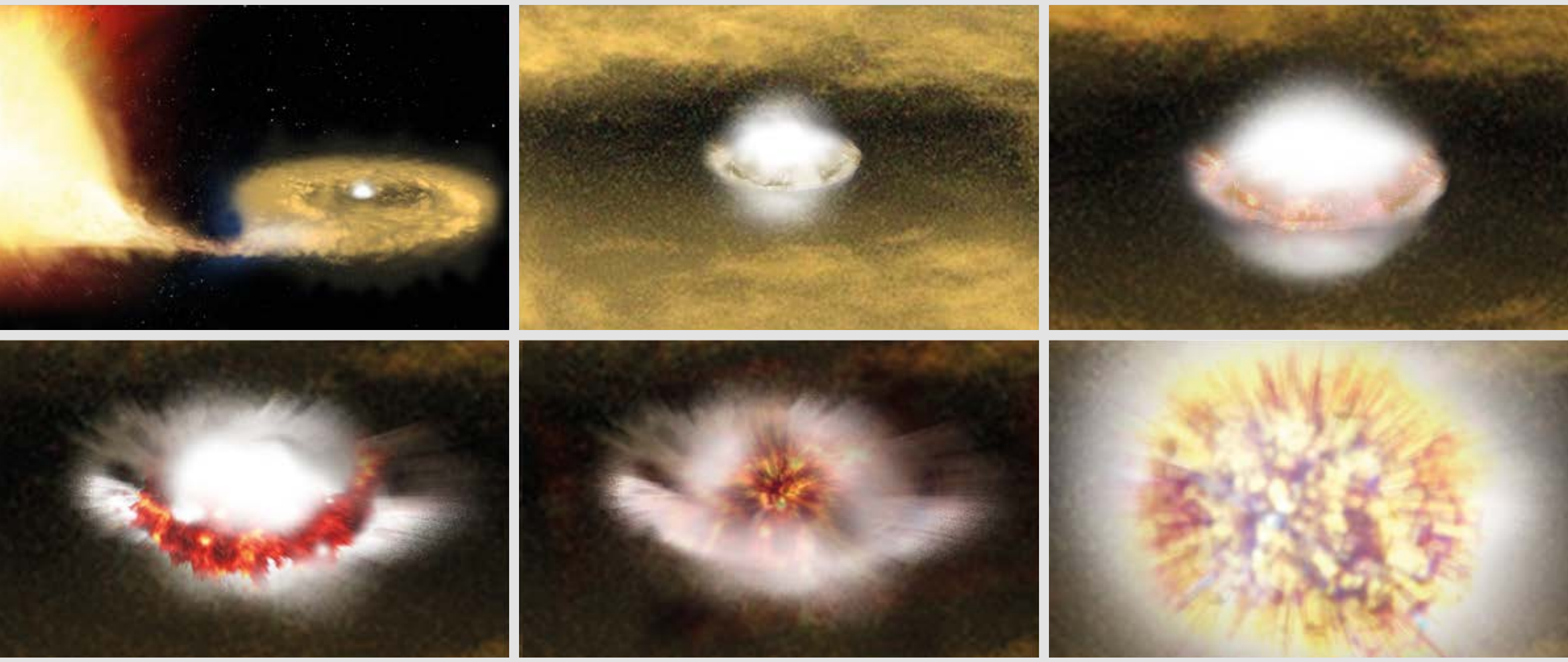
Predicting the impact of the Sun's activity on Earth is one of the major goals of space weather research. However, we are not there yet. It is well known that similar solar observations and solar wind conditions can lead to totally different consequences on Earth's magnetic environment. Coordinated observations and modelling of unusual events by multiple spacecraft orbiting near Earth are essential if we are to improve our understanding of the Sun–Earth connection.

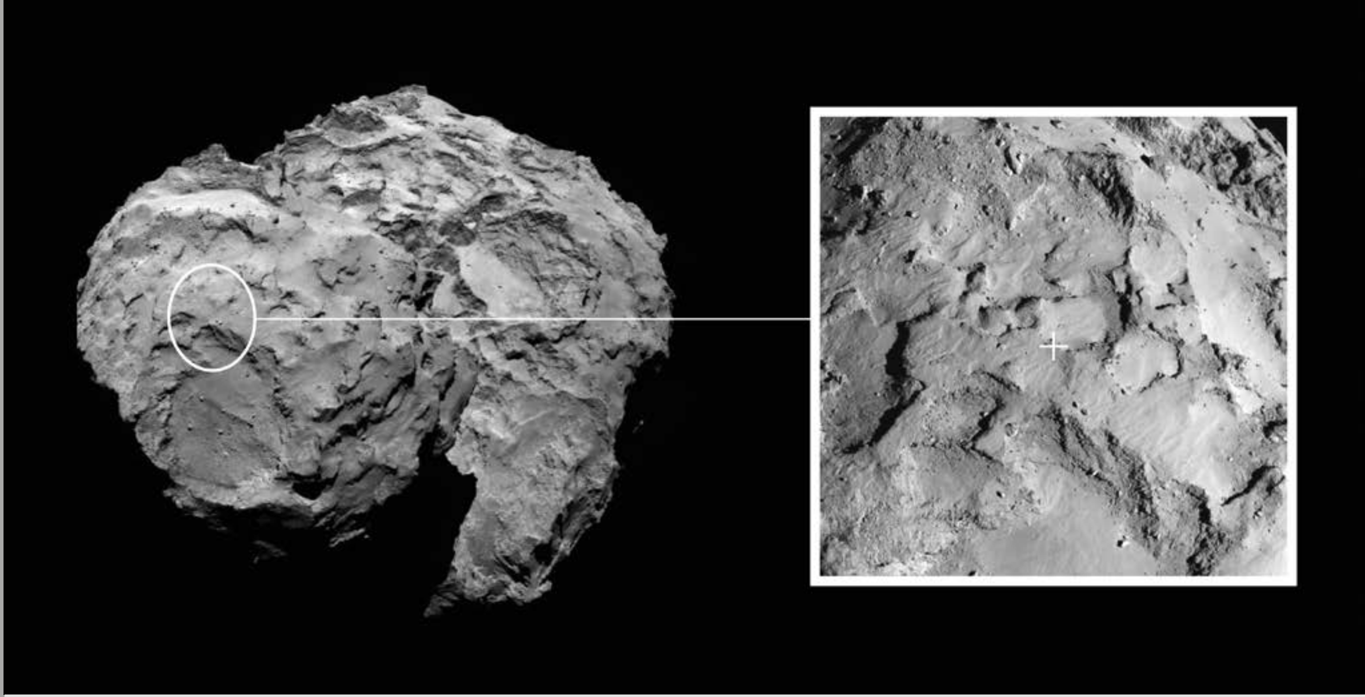
→ INTEGRAL

Supernovae of type Ia are used as 'standard candles' in cosmology. A physical understanding of this type of explosion is not yet obtained. Several models have been discussed for type-Ia, all involving white dwarf stars. In all cases, nuclear fusion of carbon to heavy nuclei create a large mass of radioactive ^{56}Ni. The decay of these radioactive nuclei creates the energy that makes the supernova shine for many months. The nuclear decay also produces gamma-ray lines, from the ^{56}Ni decay chain through ^{56}Co to ^{56}Fe.

A new supernova was detected in M82, the Cigar Galaxy, on 21 January. It was identified as a type Ia and is referred to as

A white dwarf, a star that contains up to 1.4 times the mass of the Sun squeezed into a volume about the same size as Earth, leeches matter from a companion star. Integral measurements suggest that a belt of gas from the companion star builds up around the equator of the white dwarf. This belt detonates and triggers the internal explosion that becomes the supernova. Material from the explosion expands and eventually becomes transparent to gamma rays





The primary landing site for Rosetta's lander Philae

SN2014J. At the distance of about 3.5 Mpc, this is the closest type-Ia discovered in the past four decades. Because of its proximity, it is a unique event. Integral, the only observatory currently capable of doing high-resolution gamma-ray spectroscopy, observed this supernova almost exclusively from end of January to end of June, i.e. during the whole bright supernova phase.

For the first time, Integral detected the ^{56}Ni decay lines at 158 and 812 keV, some two weeks after the explosion. The early appearance of these gamma-ray lines has interesting implications for the early explosion stages. Also for the first time, the ^{56}Co decay gamma-ray lines at 847 and 1238 keV were seen.

Integral thus confirms by direct measurement of the primary gamma-ray lines the ^{56}Ni origins of supernova light. This provides a unique opportunity to compare the direct gamma rays from the supernova's energy source with other more-indirect measurements. This will help astrophysicists to refine their models on how in fact these explosions do occur, because the explosion details affect how much new nuclei are created, and how they move and interact with the remainder of the exploding star. These observations constitute a reference in supernova type-Ia science, and thus an important scientific legacy for years to come.

→ ROSETTA

Rosetta rendezvoused with comet 67P/Churyumov-Gerasimenko on 6 August and in September entered orbit around the body. Mission and instrument operations focused on gaining experience in operating near the comet, as well as scouring the surface for a viable landing site for the Philae lander.

In late August, five candidate landing sites were selected and in September the prime landing site, 'J', was chosen. This site is on the upper lobe (the 'head' if thinking of the comet as 'duck shaped').

Ground-based observations of the comet reveal the outer atmosphere of the comet, its coma, stretching into a tail over 20 000 km in extent. *In situ* instruments have started to 'sniff' and 'taste' this coma. The GIADA and COSIMA instruments have detected and begun to characterise the dust environment of the comet, examining the velocity and size distribution, as well as the composition of individual grains of dust.

The ROSINA instrument has observed 'diurnal' variations of gas density, the variation of the coma over a comet day. The main species within the coma, as expected, are water, carbon monoxide and carbon dioxide but ROSINA has also revealed some interesting variations in the ratio of these species as well as minor species, such as ammonia, methane and methanol. ROSINA is also busy looking at hydrogen isotopes to compare the make-up of the comet's water to that of Earth's, a key investigation linked to Solar System evolution. The RPC instruments have begun to probe the plasma environment of the comet and how the Sun's outer atmosphere, the solar wind, interacts with the coma.

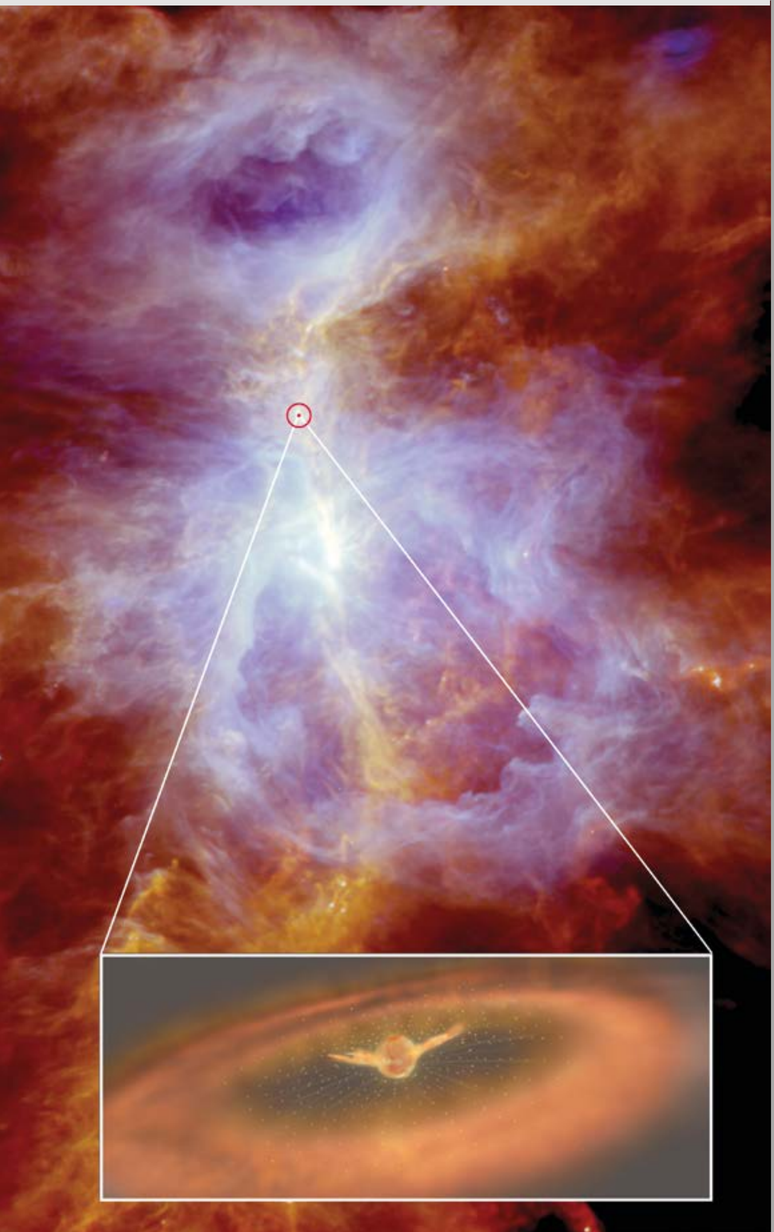
Remote sensing instruments have been busy mapping the nucleus, based on visible wavelength (OSIRIS) geographical and morphological analysis, revealing a very alien landscape. Infrared observations (VIRTIS) have revealed a variation of surface temperatures and have begun to reveal its chemical make-up, with hints of carbon-bearing compounds. A dark and dusty nucleus laden with complex chemistry is being uncovered. The MIRO instrument has been monitoring the production of water, revealing an increase from 0.3 to between 1 and 5 litres per second from June to August.

→ HERSCHEL

The post-operations phase is supporting the astronomical community exploiting Herschel data to do science, and continuously improving the Herschel archive functionality, data processing software and data products, as well as calibration and documentation. In addition, access to Herschel data products directly through astronomical 'tools of the trade' widely in use by the astronomical community (such as ADS, VizieR, SIMBAD) is being pioneered, enhancing the visibility and value of Herschel and its data products.

Herschel observations of enhanced abundances of particular molecular ions in the stellar nursery OMC-2 FIR4 in 'Orion's Sword' indicate energetic particles collide with the material in the protostellar envelope in at least one of the embryonic stars forming here. When the energetic particles hit the surrounding material, they may collide with atoms that are present in the star's environment, break them apart and produce new elements. Our Sun likely gusted a similar wind of particles in its early days; this could explain the origin of a puzzling short-lived isotope of beryllium, whose traces are found in meteorites.

Orion A, a star-forming nebula about 1500 light-years from Earth, as viewed by Herschel. OMC-2 FIR4 (red circle) is in the 'sword of Orion' – below the three main stars that form the belt of the Orion constellation (ESA/Herschel/Gould Belt Survey Key Programme/ATG medialab)



→ PLANCK

Now in post-operational phase, the next project milestone will be on 1 December with the release of all of data acquired by Planck to the public, including maps of the polarised sky. The data release will take place through a new web-based interface to the Planck Legacy Archive. The first scientific results derived from this data will be presented at a conference in Ferrara, Italy (Planck 2014: the microwave sky in temperature and polarisation).

A recent paper by the Planck Collaboration in September describes polarised dust emission at high galactic latitudes. One of the conclusions of this paper is that the whole sky is subject to significant emission from polarised dust originating from the Milky Way. Contamination by dust emission is a key issue for ground-based Cosmic Microwave Background (CMB) experiments, which seek to measure the primordial polarised CMB through the local sources of emission. In particular, the paper estimates the level of dust in the region previously observed by the Bicep2 experiment, and confirms suspicions that dust contamination is larger than assumed by the Bicep2 team.

→ VENUS EXPRESS

After completing the aerobraking in July and subsequently lifting the pericentre to above 460 km, the spacecraft is now in a stable and safe orbit configuration and science operations activities are now back to normal.

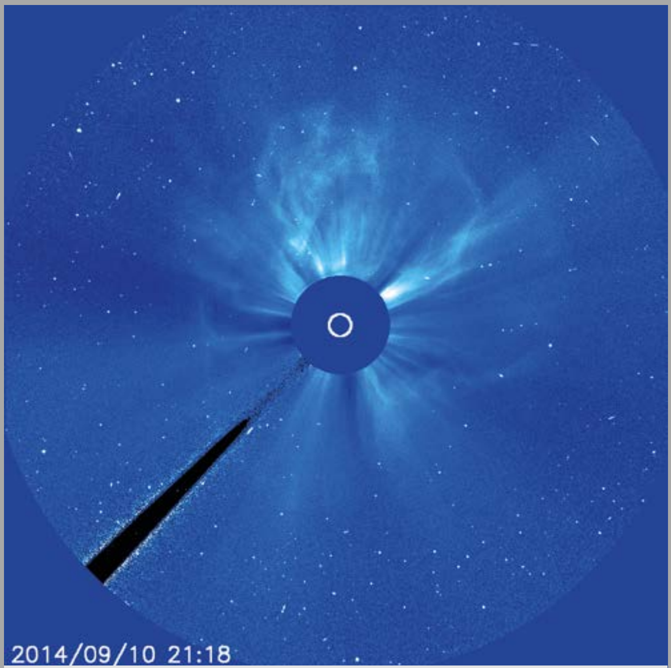
During the last weeks of October, Venus will pass behind the Sun and no communication will be possible for a period of three weeks. In late November, another set of pericentre rising manoeuvres will be executed to allow the spacecraft to operate at a sufficiently high altitude until February/ March next year. These regular orbit control manoeuvres are necessary to compensate for the strong influence of the solar gravity on the orbit of Venus Express.

→ MARS EXPRESS

Work has focused on preparations for the Comet Siding Spring Mars encounter on 19 October. All indications show that the dust flux at Mars will be very small and that the risk is well below what would require special measures. It was therefore decided to go ahead with a full set of scientific observations of this unique event.

The chance to make close-up images of an Oort cloud comet is absolutely unique. This comet has most likely never been in the vicinity of the Sun and therefore it represents the most pristine material in the Solar System. The distance will still not allow the nucleus to be resolved by the cameras but a lot of important information on the structure and the composition of the coma will be collected. At a relative velocity of 56 km/s, even very small particles have a substantial energy and we will study the effect of the interaction of the cometary dust and gas with the upper atmosphere of Mars, and derive what importance such events can have on the escape of atmospheric material over the lifetime of the planet.

Joint operations with NASA's Maven spacecraft are planned to start at the end of the year, following Maven's arrival at Mars on 21 September and subsequent orbit insertion.



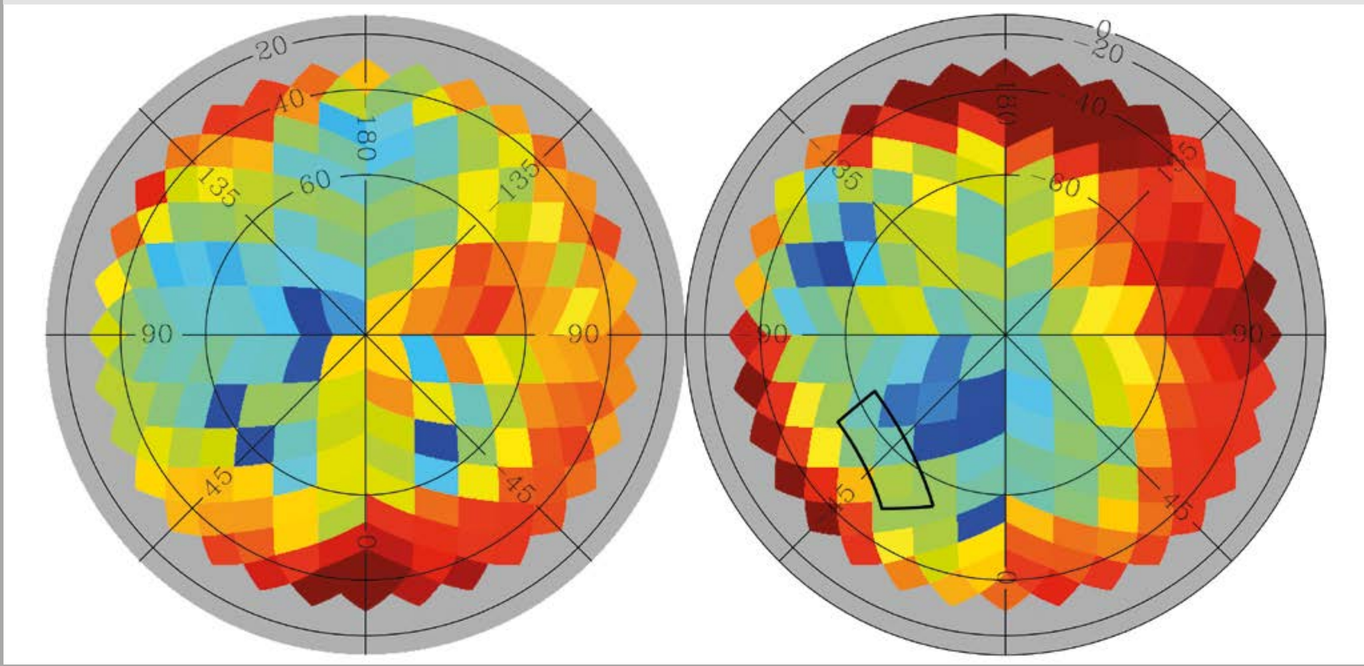
SOHO/LASCO image of the large Earth-directed coronal mass ejection of 10 September

→ SOHO

Active Region 12158 was just about squarely facing Earth when it erupted with an X 1.6-class flare and a major coronal mass ejection (CME) on 10 September. Based on LASCO observations of the CME, space weather forecasters predicted the arrival of the CME at Earth on 12 September.

A significant interplanetary shock was detected by SOHO/CELIAS and ACE on 12 September, only about $1\frac{3}{4}$ hours after the predicted arrival time. The total travel time of the CME from the Sun to Earth was 46 hours. The shock caused a strong magnetospheric compression and the

Planck: Orthographic projection of north (left) and south (right) hemispheres of the sky, with colours showing the level of polarised 'B-mode' emission due to galactic dust (red/high, blue/low). The southern Bicep2 field is in black. Blue regions are prime targets for searches of primordial CMB B-modes by high-sensitivity experiments



strongest geomagnetic storm of the year. The geomagnetic index Kp reached the level 7. At the peak of the storm on 12/13 September, bright aurorae ringed the Arctic Circle and observers in Scandinavia witnessed stunning coronas. Hints of aurorae were even seen as far south as Arizona, USA.

→ GAIA

Routine operations started immediately after the commissioning period. At the beginning the Ecliptic Pole Scanning Law (EPSL) was used, for 28 days, to guide the mapping of the sky. In this mode every scan crossed both the North and the South Ecliptic Pole. The advantage was that the stellar fields at the poles were studied in detail before the Gaia launch and could therefore be used for calibration. During the second routine operations month, Gaia was commanded to follow the Nominal Scanning Law (NSL). The transition from EPSL to NSL was done in a continuous fashion to transfer the calibration over to the nominal mode. At the end of September, Gaia's spin axis orientation was optimised to catch a bright star close to the limb of Jupiter later in the mission for a light deflection experiment.

Gaia is collecting huge amounts of data every day. The ground segment is receiving and processing the telemetry as it arrives. The numbers of elementary astrometric, photometric and spectroscopic measurements of stars all count already in billions. The data release scenario has been updated to match the in-orbit performance of Gaia leading to the first intermediate data release in summer 2016. In the meantime, the Science Alerts processing is being fine-tuned to extract from the datastream objects warranting quick ground-based follow-up. The first Science Alert was already announced with a new supernova found in another galaxy.

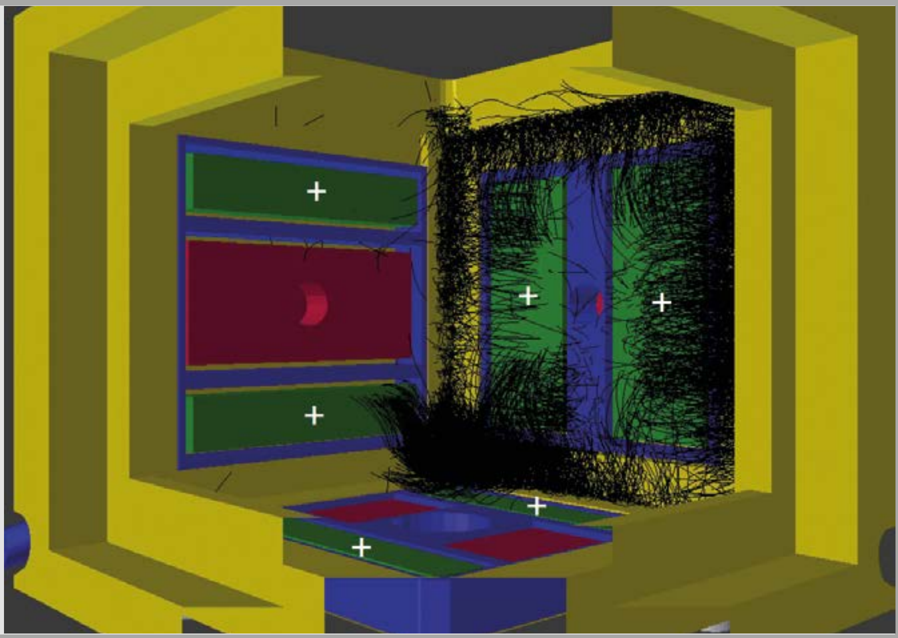
→ LISA PATHFINDER

The Science Module was retrofitted with three new side-panels onto which the cold-gas micro-propulsion equipment had been integrated. Functional verification of the spacecraft is progressing as planned, with the completed version of the flight software and using the FM micro-thrusters driving electronics. LISA Pathfinder carries two sets of six cold-gas thrusters; the first set is in acceptance testing, whereas the second redundant set is being manufactured. Both the micro-Newton thrust force and the sub-micro-Newton thrust force noise have been confirmed in a dedicated facility by Onera (FR).

Acceptance testing of the two FM Inertial Sensor Heads (ISH) has been completed. The testing campaign included bi-polar discharge of the test mass by means of ultraviolet light, contacting, photoelectric effect. In orbit, though, the discharge process will be without physical contact between the test mass and its surrounding electrodes. Thus, the ground verification requires novel modelling techniques. The ISH FMs will now be integrated on the LISA Pathfinder Core Assembly (LCA). The LCA includes an optical interferometry ultra-stable bench on its support frame, the two ISH, diagnostics equipment and support equipment. The LCA integration has advanced to the point where the next step is the integration of the ISH.

The launch vehicle will be Vega, on one of the VERTA launches. The lessons learnt from the first Vega launches are being closely monitored to confirm the compatibility with the mission and spacecraft. Considering the approaching launch date, activities by the launcher authority, ESAC and ESOC are running at full pace.

A novel computer simulation shows the cross section of the electrode housing that surrounds the test mass (not shown). The sensing (green) and actuation (red) electrodes are shown. Ultraviolet light is shone onto the test mass or onto the electrode housing, electrons are emitted via the photo-electric effect which travel to different surfaces with trajectories (black) (Airbus D&S)



BepiColombo Mercury Planetary Orbiter Flight Model spacecraft in final preparation for thermal test at ESTEC

→ BEPICOLOMBO

Preparation of the Mercury Planetary Orbiter (MPO) FM spacecraft for the thermal system test continued as planned. The test configuration is complete and a final dress rehearsal test was conducted. Installation of the outer skin progressed on the spacecraft; loading in the test chamber occurred on 24 October. The Mercury Transfer Module (MTM) had also been delivered to ESTEC in the summer. The thruster floor with pre-integrated thruster pointing mechanisms was delivered and verified with the high-pressure regulator and electronics unit.

Currently the MTM is waiting for the complex integration of the solar electric propulsion subsystem in preparation of the thermal test to be conducted mid-2015. All FM/QM payloads supporting the MPO spacecraft thermal vacuum test were integrated and verified.

→ MICROSCOPE

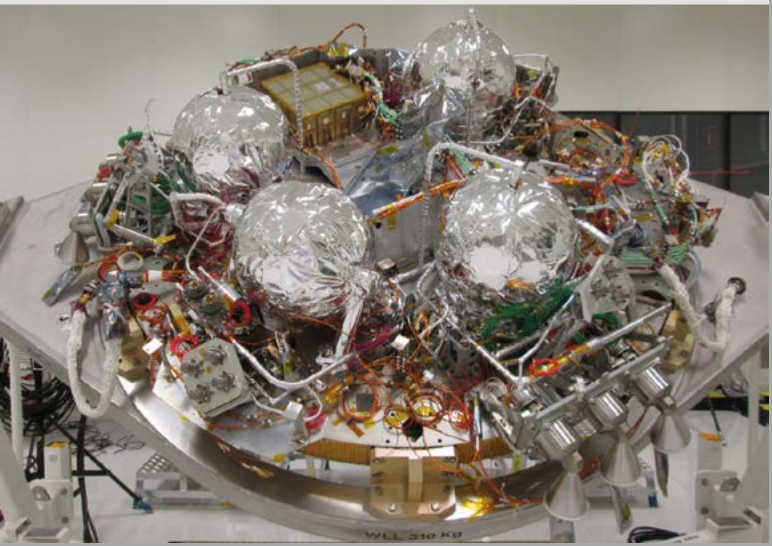
Integrated testing at Selex ES (IT) of the cold-gas micro-propulsion system electronic unit QM with two micro-thruster QMs is complete and the hardware was delivered to CNES. Tests at system level are running at CNES. The CDR of the micro-propulsion system took place in October. Production of FM hardware is ongoing for thrusters and electronic units.

→ EXOMARS

System-level AIT activities for the 2016 Mission Trace Gas Orbiter (TGO) and the Schiaparelli Mars entry and landing vehicle continue to progress at Thales Alenia Space France and Italy respectively. The TGO propulsion system is now integrated and the avionics and harness are nearing completion. Initial system tests with ESOC have been completed and the TGO flight software version is under development and testing. The Schiaparelli propulsion system is integrated and the avionics are being integrated along with the harness. Bench testing of the software has verified the core software and basic communications with the TGO.

The system PDR for the 2018 mission took place on 12 September and activities of the Russian-led Descent Module Design Review are proceeding. The Rover Analytical Design Laboratory (ALD) Sample Preparation and Distribution Sub-system (SPDS) EQM assembly is underway. Instrument EQMs are also being prepared to build the ALD EQM. Rover procurement activities are almost complete and the remaining procurements for the Carrier Module and European contributions to the Russian Descent Module are under way.

Schiaparelli Lander Platform and Trace Gas Orbiter spacecraft integration



The 2016 Ground Segment Implementation Review began in September. The 2016 Science Ground Segment (SGS) Requirements/Design Review was completed in September authorising full development of the Science Ground Segment. The Russian partners are fully involved for a parallel science archive in Moscow. An ESA/Roscosmos Working Group has confirmed the feasibility of adding a Russian 64-m antenna to the ESTRACK system to augment the science return on the 2016 TGO mission.

The 2016 mission spacecraft will be accommodated on a Proton rocket for a launch on 7 January 2016.

→ SOLAR ORBITER

Spacecraft STM assembly is proceeding at prime contractor facilities in Stevenage, UK, with the integration of platform and instrument units represented either by an STM of their own or a simpler Mass and Thermal Dummy.

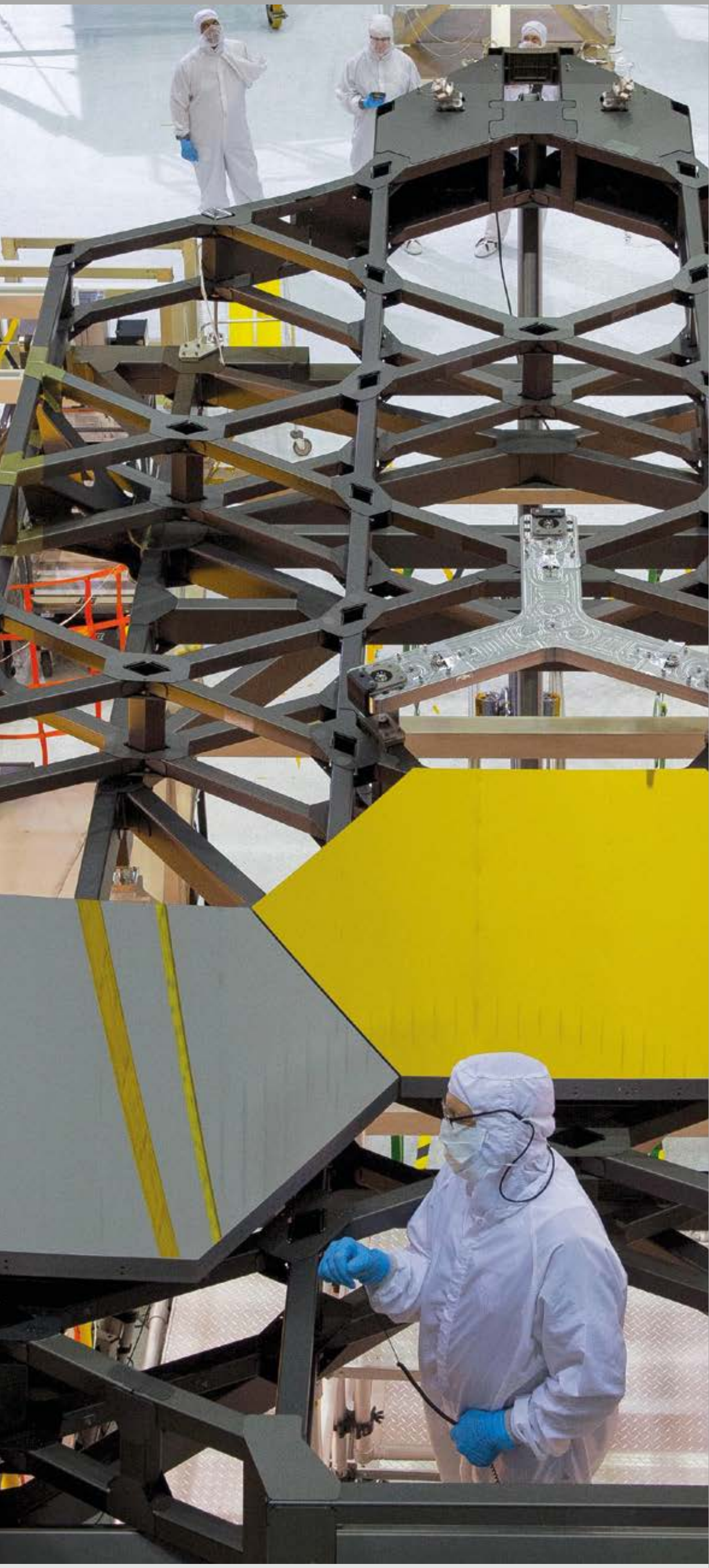
Spacecraft Engineering Test Bench integration and testing activities are continuing normally, with the integration of EMs or representative simulators as applicable.

The spacecraft FM units are being manufactured, including primary structure, on-board computer, inertial measurement units and battery. After successful delivery of the first version 1.0 and 2.0 of the Central Software, version 2.1 passed its PDR. After thermal balance tests, the heat shield STM is being upgraded for the vibration test and is expected to be available again in January 2015 for spacecraft STM assembly. The system CDR started in December.

Two alternative suppliers of reaction wheels have been set to work in order to address the serious EMC problem identified earlier on the baseline reaction wheels. The design and breadboard manufacturing of a magnetic shield for the reaction wheels are proceeding. Instrument boom EMC characterisation tests were conducted in Berlin.

Following application of the specially qualified Solar Black surface treatment to the titanium sheets that form the front layer of the heat shield, the facility has been enlarged to enable the use of this surface treatment on other spacecraft surfaces, including the antennas. This will help improve considerably the thermal performance of the spacecraft, while moderating undesirable stray light bouncing back towards instrument apertures. In parallel, testing is continuing on samples of the Solar White coating.

Six instruments have passed CDRs: SoloHI, MAG, SPICE, EUI, PHI and EPD. The STIX and SWA CDRs were performed and awaiting outcome. Two CDRs (RPW, METIS) will follow. Various instrument STM items have been delivered to prime contractor facilities and integrated on the STM spacecraft.



Integration of James Webb Space Telescope primary mirror segments onto the pathfinder telescope's back plane structure (NASA/GSFC)

Mission Operations Centre (MOC) and Science Operations Centre (SOC) development design progress is nominal. The Science Ground Segment Design Review (SGSDR) began in September. After completion of the SGSDR, SOC and MOC teams will study what extra ground passes (either ESTRACK only or ESTRACK plus NASA DSN) would be useful to improve the science data return.

Work on the Atlas V-411 launch vehicle is progressing, with a planned launch date of July 2017. The backup launch date is October 2018.

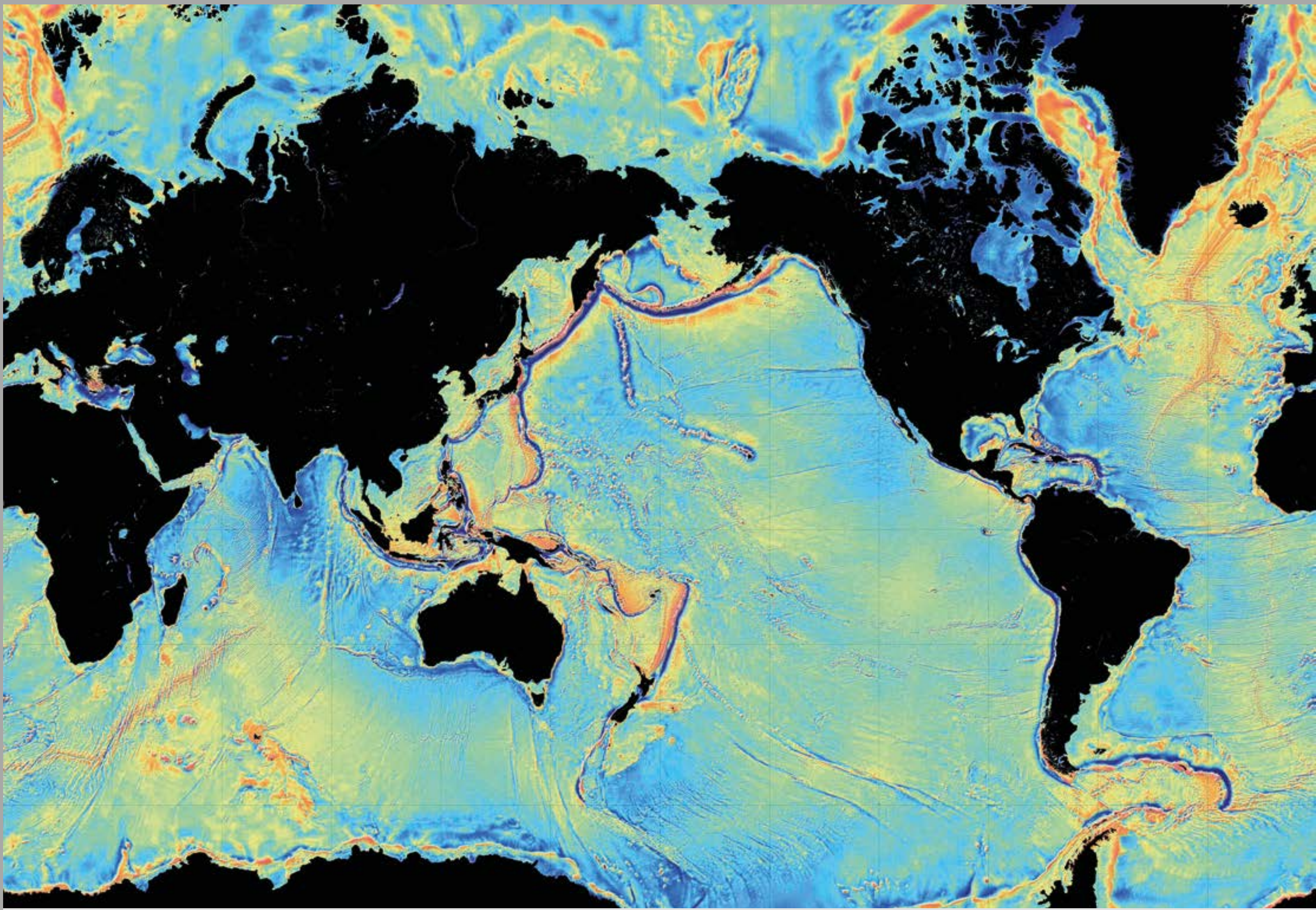
→ JAMES WEBB SPACE TELESCOPE

Progress is steady towards the planned launch in October 2018. The second cryo-test of the complete Integrated Science Instrument Module (ISIM) FM was concluded in early October. Trial integration of the Primary Mirror Segments onto the telescope pathfinder back plane structure is ongoing. The telescope pathfinder will later be tested at NASA Johnson Space Center as a precursor for the FM Telescope/ISIM optical and functional end-to-end test. A full-scale deployment test of the Development Model Sun Shield system has been performed. All the FM Sun Shield layers are being manufactured.

NASA has completed the acceptance test campaign of the new Micro-Shutter Assembly (MSA) for the ESA-developed NIRSpec instrument. NASA has also completed the acceptance test campaign of a new NIRSpec FM detector. They both meet all specifications. The exchange of the MSA and the detector is planned for early 2015 at Goddard Space Flight Center. This will take place before the ISIM vibration test and final cryo-performance test.

→ EUCLID

Prime contractor Thales Alenia Space, Turin, is finalising the activities of Phase-B2, while the Payload Module (PLM) contractor Airbus Defence & Space, Toulouse, is proceeding in Phase-C/D after completing the CDR. Both companies are completing the definition of the subsystem requirements, system design and subsystem and units procurement. Selection of all subsystems and units for the PLM is nearly complete. In addition to the long lead items, such as the SiC structures and mirrors whose detailed design is being finalised at Boostec and the dichroic plate element, many contracts for units like the secondary mirror mechanism, the mirror polishing, the external baffle, the OGSEs and the engineering support have been awarded. On the Service Module (SVM), procurement activities are proceeding with the aim to complete the subsystem procurement by the end of the year. ITTs have been issued according to Best Practices, proposals have been received and some subsystems have been already selected (Thermal and Structure, CPPA and



Scientists from Scripps Institute of Oceanography at University California San Diego used altimetry measurements from ESA's CryoSat mission and from the CNES/NASA Jason-1 satellite to create a new marine gravity map – twice as accurate as the previous version produced nearly 20 years ago (Scripps Inst.)

TT&C), while others are at various procurement stages (CDMS, Reaction Control, Micro-propulsion, Sun Shield, AOCS, SW, Harness, PCDU and EGSEs). In parallel, some critical activity (e.g. the Reaction Wheels parallel testing) has been completed and the subcontractor for the Fine Guidance Sensor, Selex Galileo (IT) is already preparing the SRR.

Procurement of the Near Infrared Spectro-Photometer (NISP) detectors is proceeding. Teledyne Imaging Sensors (US) has manufactured all the necessary detectors for the Evaluation and Qualification phase, showing very good performance. The proximity electronic unit mechanical design has been adapted to overcome a problem discovered earlier this year. Additional tests have also been performed to qualify the reliability of the data transmission from this unit to the NISP acquisition warm electronics.

The procurement of the detectors (CCDs) of the Visible Imager (VIS) is also proceeding with the company e2v (UK). Many STM devices have been delivered and the QM/FM production of the various parts is proceeding according to schedule. The first EM devices have completed testing.

The two scientific instruments (VIS and NISP) developed by the Euclid Consortium have completed their Phase-B2 activities, regularly monitored by meetings and workshops with ESA and industry. Both VIS development team led by the Mullard Space Science Laboratory and the NISP development team led by CNES and the Laboratoire d'Astrophysique de Marseille have completed their PDR at instrument level and are now reviewing the design of the various units. The Science Ground Segment team continues working on the preparation of the SRR. Launch is expected to take place in the first quarter of 2020.

→ SMOS

The mission continues to operate beyond its normal lifetime. Following a joint extension review with CNES, operating the platform, mission operations have been extended to 2017.

All data have been available to the science community since 2010. The RFI situation keeps improving, in particular over Europe. A second reprocessing of the entire SMOS data set is presently ongoing and reprocessed data will be available by spring 2015. The second SMOS science conference is planned for 25–29 May 2015 at ESA's ESAC, near Madrid (www.smos.info).

→ CRYOSAT

The mission continues to operate flawlessly, acquiring and generating science data to measure the variation of sea-ice mass floating in the Arctic and trend of land-ice volume over Greenland and Antarctica. The mission has been recently extended until the end of 2016.

The mission requirements for sea-ice over the Arctic basin have been verified by a group of scientists from the Alfred Wagner Institute (DE) and DTU (DK) and published in *The Cryosphere*.

CryoSat data are proving useful for a number of applications beyond its mission design and objectives, such as revealing a new gravity map, exposing thousands of previously unchartered 'seamounts', ridges and deep ocean structures. This has recently led to the discovery of new mountains at the bottom of the oceans. The research was carried out by a US/European research team and published in *Science*.

→ SWARM

The three-satellite constellation continues to acquire excellent quality science data from the seven identical instruments on board. Over the summer, early mission data were reprocessed in order to support the development of candidate solutions for the 2015 International Geomagnetic Reference Field (IGRF) model, for which the delivery date was 1 October. Such candidate models have been produced by various members of the Swarm science team, using data from both classes of magnetometers. The IGRF is a main field model that (by convention) is updated every five years, and which is used by practically all applications communities and services in need of geomagnetic data.

In terms of external fields and geospace measurements, Swarm instruments continue to demonstrate their feasibility to detect current systems and ionospheric features, thereby also demonstrating the high quality of the mission data. This holds for both elements of the electric field instruments, the Langmuir probe and the thermal ion imager.

Meanwhile, the mission calibration/validation effort continues, with particular emphasis on the detailed assessment of the instrument data quality. A third post-launch cal/val meeting will be held in Potsdam in December.

→ ADM-AEOLUS

Integration of the Aladin instrument is advancing by Airbus Defence & Space in Toulouse. High fluence endurance tests of the Optical Bench Assembly with the FM Laser Transmitter have demonstrated adequate quality of the optical coatings. The redundant FM Laser Transmitter has been assembled at Selex ES. An optical element had to be replaced due to a laser-induced contamination event, and a delta-acceptance test campaign is now under way. Work on the Payload Data Ground Segment has been resumed with the Aeolus Processing Facility.

ADM-Aeolus alignment for Optical Bench Assembly Fluence Test in Toulouse (Airbus Defence & Space)

→ EARTHCARE

The vacuum bake-out campaign of the spacecraft PFM Base Platform, including most avionics and electrical equipment, has been performed at Intespace and the Base Platform has been returned to Airbus Defence & Space GmbH.

Testing of the satellite EFM is progressing. Delivery of platform sub-systems and units is nearing completion and the large Solar Array Delivery PFM Review Board took place.

All ATLID sub-systems CDRs have taken place, with outcomes taken into account for preparation of the ATLID CDR. Integration of the first two laser transmitter heads began at Selex IT. The Broadband Radiometer PFM production is ongoing in Thales Alenia Space UK and RAL (UK). The Multi-Spectral Imager VNS PFM camera integration is complete at TNO (NL) and its environmental test campaign has started.

The Cloud Profiling Radar interface CDR continues to be progressed by JAXA and their contractor NTS. In parallel, the delivery of the CPR PFM subsystems is well advanced and the integration of the CPR instrument at NTS can proceed.

→ BIOMASS

Two parallel and competitive mission definition studies have being conducted with consortia led by ADS and OHB/Thales, respectively. The results of these studies are currently being reviewed with the aim to determine whether the satellites proposed by industry for the Biomass mission will allow the mission objectives to be achieved within the available budget and the required schedule. The two consortia will eventually compete to build the Biomass satellite.

→ METEOSAT

Meteosat-8/MSG-1

Meteosat-8 operations are normal. Meteosat-8 is now the operational back-up for Meteosat-9 and 10.

Meteosat-9/MSG-2

Meteosat-9 provides the Rapid Scan Service (one picture every five minutes of the northernmost third of Earth in 12 spectral channels), complementing the full-disc mission of the operational Meteosat-10.

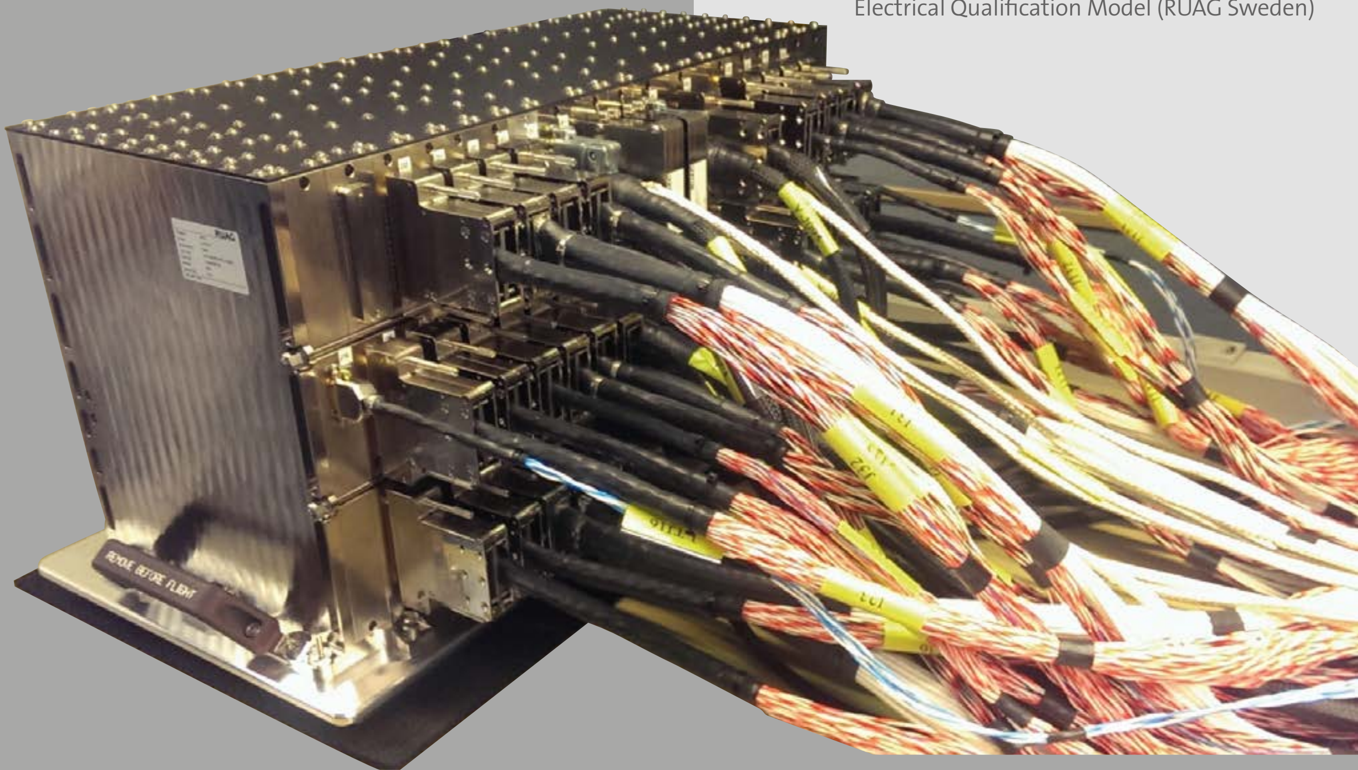
Meteosat-10/MSG-3

Meteosat-10 is performing the full-disc mission (one image every 15 minutes in 12 spectral channels), as well as the data collection, data distribution and search and rescue missions.

MSG-4

The optical vacuum test was performed in July and integration/testing activities in preparation for the launch campaign are proceeding. MSG-4 will be ready for launch beginning of July 2015. However, a launch date is yet to be agreed between Eumetsat and Arianespace.

Meteosat Third Generation: Satellite Monitoring Unit Electrical Qualification Model (RUAG Sweden)



→ MTG

An optimisation of satellite development logic and associated model philosophy has been agreed. This will allow the decoupling of mechanical verification activities from the avionics qualification, reducing the dependency of satellite activities with respect to payload developments. The result is an improvement of the robustness of the overall schedule.

The overall compliance status of the satellites has been revisited and agreed with industry. Regarding the satellite mass, the status for both satellites is now stable and consistent with the Eumetsat needs.

For the FCI and IRS instruments, good progress has been made. In particular, the attention was focused on the Structural and Thermal Design and on the Scan Assembly development.

For the LI, an agreement has been reached with the supplier to implement modifications to the detector chain electronics to overcome a predicted instrument sensitivity to dynamic disturbances (microvibration) which may lead to occasional instrument saturation and data loss.

Preparation for the satellite STM and EM campaigns are progressing and many lower level subcontractors are well advanced with respect to the detailed definition and manufacturing of development hardware, including the Platform STM Central Tube and SMU EQM to be used for the satellite EM.

The FAR for MTG-I-1 has remained stable (July 2018), while the FAR for MTG-S-1 has been brought forward (July 2020).

→ METOP

MetOp-A
The satellite will operate in parallel with MetOp-B until the commissioning of MetOp-C.

MetOp-B
Eumetsat's primary operational polar-orbiting satellite.

MetOp-C
The satellite annual reactivation confirmed the good health of the hardware kept in storage. The readiness for launch on Soyuz from French Guiana is planned for October 2018.

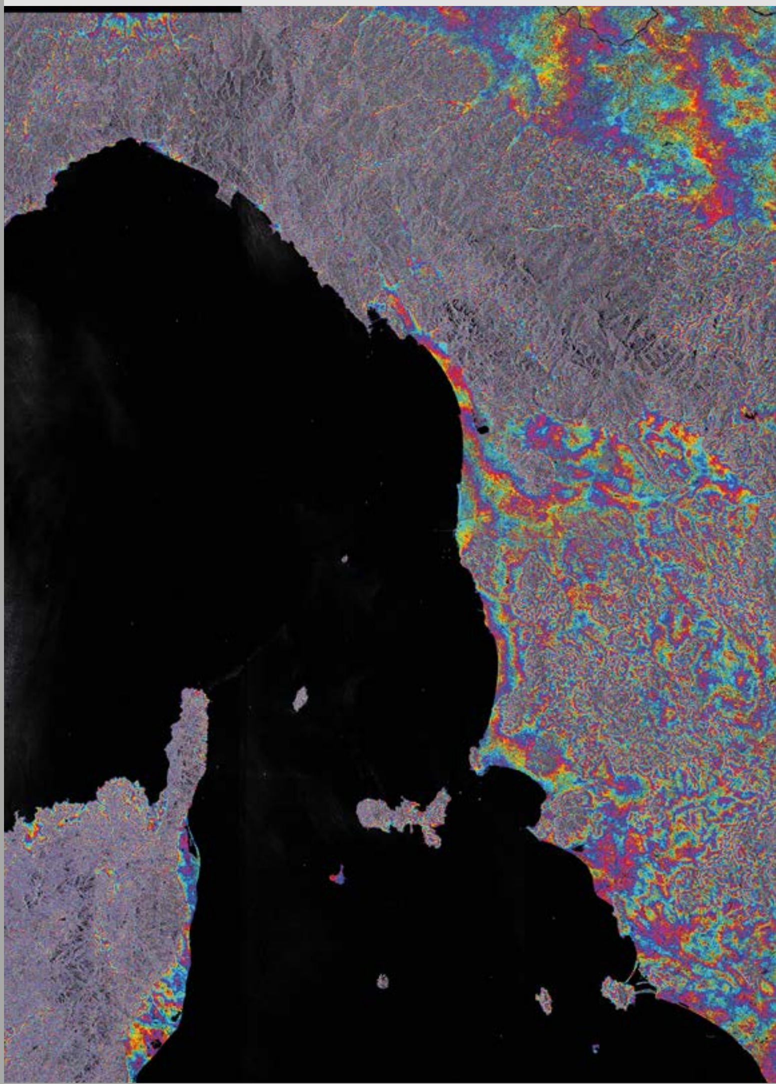
MetOp Second Generation
MetOp-SG consists of two series of satellites (Satellite A and Satellite B) and will provide the operational meteorological observations from polar orbit from 2021 to the mid-2040s. MetOp-SG development contracts began in May, with Airbus Defence & Space (FR) as prime contractor for Satellite A and Airbus Defence & Space (DE) as the prime contractor for Satellite B. The SRR is in progress.

→ SENTINEL-1

The In-Orbit Commissioning Phase was completed with the In-Orbit Commissioning Phase Review on 23 September, where Sentinel-1A's excellent performance was confirmed. The radar's unprecedented stability and the very high sensitivity make Sentinel-1A a leap forward from previous ESA missions, such as ERS and Envisat, and will ensure that all users' needs are fully met.

In parallel, Sentinel-1A sample datasets products have been made available on-line to users at senthub.esa.int, for familiarisation and support of preparatory user activities.

First Sentinel-1A interferogram (Copernicus/ESA/DLR Remote Sensing Technology Institute)



Sentinel-2A solar array deployment test at IABG (Airbus Defence & Space)

In particular, Sentinel-1A's unique interferometric capabilities were revealed to users in August. The Sentinel-1 satellites will provide continuous information on land motion in the order of millimetres over 250 km swaths, independent of weather, day and night, that will allow the monitoring of surface deformation caused by, for example, mining, earthquakes, volcanic activity, melting permafrost and glacial flow.

The AIT campaign of Sentinel-1B continues for launch in early 2016.

→ SENTINEL-2

Sentinel-2A completed its functional test campaign at Airbus Defence & Space (DE) and was shipped to IABG in August to undergo its environmental test campaign.

The Optical Communication Payload (that will be used to recover mission data through EDRS) will be delivered, integrated and tested in December prior to the final EMC radiated qualification test campaign. By the end of the EMC tests in February 2015, and pending confirmation from the Sentinel-2A Qualification and Acceptance Review Board scheduled in March 2015, Sentinel-2A will be ready for shipment to Europe's Spaceport. On this basis, the Sentinel-2A launch is planned for early 2015.

In-orbit commissioning preparations are conducted concurrently with the involvement of all the teams involved for operating, calibrating, validating and exploiting the Sentinel-2 mission. In the meantime, the functional testing of the second FM satellite is ongoing at Airbus Defence & Space (DE) and the delivery of the second payload instrument FM by Airbus Defence & Space (FR) is expected in July 2015. The good development status is consistent with a Sentinel-2B launch readiness in Spring 2016.

→ SENTINEL-3

Sentinel-3A is integrated. The last instrument to be delivered, the Ocean and Land Colour Instrument (OLCI), was mounted on the satellite in July and it has passed all post-integration tests. The environmental test campaign has started.

At system level, the Intermediate Satellite Qualification Review (ISQR) was completed, allowing the release of all testing at satellite level. The Integrated System Test 1a was conducted in July. For the first time, both ESOC and

Eumetsat Flight Operation Systems commanded remotely Sentinel-3A for a full week of testing. In parallel, preparation of the Sentinel-3A Commissioning Phase is proceeding, with a checkpoint of documentation readiness planned toward the end of the year.

In parallel to Sentinel-3A activities, Sentinel-3B satellite Manufacture, Assembly, Integration and Test started in August with the integration of the antennas of the Topographic Payload. Future activities on this model will continue in the coming months interleaved to the Sentinel-3A activities, optimising the use of the AIT teams.

→ SENTINEL-4

All 42 Best Practice procurement activities have begun. The telescope EM has been manufactured. The Manufacturing Readiness Review (MRR) for procurement of all lens materials of PFM of the Combined Optical Assemblies (COA) subsystem was completed in July. The sub-system PDRs have been completed. The Phase-C/D Price Conversion Proposal was delivered in July.

The Sentinel-4 telescope Engineering Model (Jena Optronik)

→ SENTINEL-5

The SRR was concluded in July. Some additional engineering work is required to complete the flow-down of requirements to all sub-systems. The baseline designs for all spectrometers have been completed. The Short-Wave Infrared (SWIR) and CCD detector development contracts have begun and respective Requirements Reviews are ongoing. Optical characterisations and heavy ion tests are now planned for the SWIR detector breadboards. The configuration solutions for the focal plane assemblies have been chosen, based on the need to minimise the risk of contamination of sensitive optical surfaces.

→ SENTINEL-5 PRECURSOR

During System Validation Testing (SVT-1) of the platform, an anomaly with the spacecraft was detected which was traced to a malfunctioning of the Remote Interface Unit (RIU). The unit was removed and returned to the contractor for investigation. As a consequence, the Thermal Vacuum/ Thermal Balance testing of the platform planned for October at Intespace had to be rescheduled.

Testing of the TROPOMI payload at CSL Liege is progressing well with completion of pre-environmental testing in vacuum, sine vibration and ongoing Thermal Vacuum and Thermal Balance tests. Acoustic tests in conjunction with the Radiant Cooler on a flight-representative platform top-floor are planned for November at IABG.

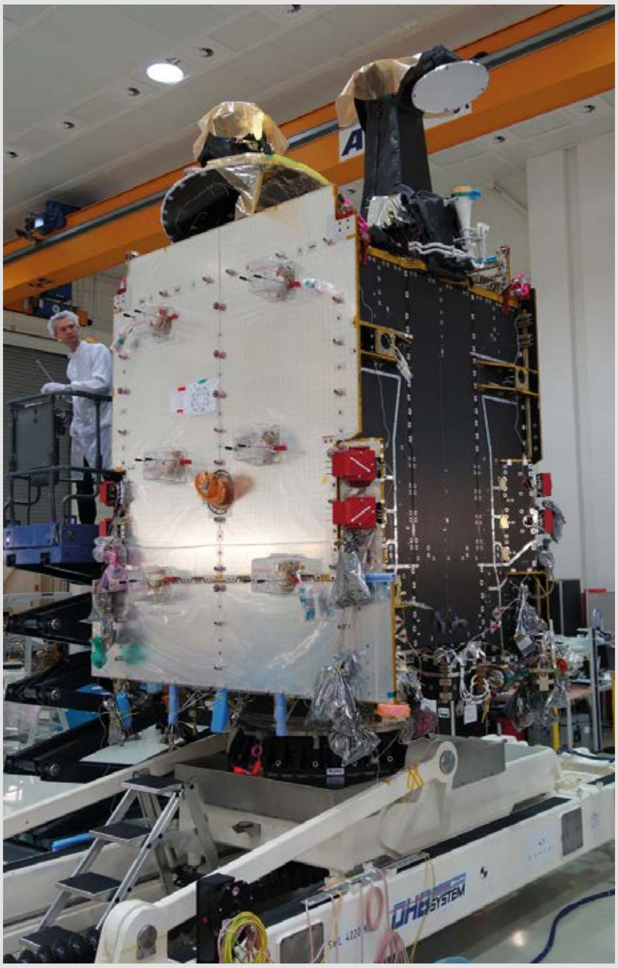
For the overall Ground Segment, Level-1b and Level-2 algorithm development work is progressing.

→ SENTINEL-6/JASON-CS

The approval process is progressing, with the Agreement between ESA and the European Commission to be ratified in mid-October. For Eumetsat elements of the programme, a proposal will be presented to the Eumetsat Council in November, with an expected entry into force of the programme in mid-2015. For the US elements, the steps necessary to include Jason-CS funding into the Financial Year 2016 Federal Budget are under way.

The Request for Quotation for the main development phase was issued in July. This phase is split into an initial Phase-C0 lasting six months, followed by the full start-up of Phase-C/D. In this phase, two satellites will be procured, subject to agreement of the partners Eumetsat and the European Union, who will fund the second satellite. The proposal was delivered in late September and it makes extensive reference, for the technical part, to the data package of the PDR, which began in September. This process of using a major review to examine the technical proposal has been used before, for Sentinel-5 Precursor.

Payload work progressed, particularly in the case of the Poseidon-4 radar altimeter, where breadboarding has neared completion and a new set of development breadboards, to prototype further electronic functions, are about to start. For the platform, the first batch of procurements, according to Best Practices selection of subcontractors, has started.



Hispasat AG1

→ SMALLGEO

Following the transfer of the Repeater Module at OHB Systems in 2013, preparations for the mating of Payload and Platform Modules occupied the industrial team in the first part of the year. This activity was concluded in July with the mating of Hispasat AG1. OHB and its industrial partners have completed the integration of the last equipment on the spacecraft. The preparation of the functional and environmental test campaign is the next milestone. The campaign started at the end of 2014 at IABG, Ottobrunn. In September, the Joint Communication Board delegates visited the OHB facilities in Bremen to see the PFM spacecraft.

→ EDRS

The PDR was held as a single review in October 2012, while the CDRs are being held separately for EDRS-A and EDRS-C missions because of their different development schedules and launch dates.

The EDRS-A payload features an Optical Intersatellite Link (OISL) via TESAT's Laser Communication Terminal (LCT), as well as a Ka-band ISL. It will be embarked on Eutelsat's EB9B commercial satellite, launched in early 2015.

All EDRS-A payload flight equipment – including the LCT – has been integrated with the EB9B satellite. All initial functional and performance testing has been finished, and the environmental testing campaign was completed.

Joint Communication Board delegates visit the OHB facilities in Bremen

The two satellites of Proba-3 will fly in formation, with one satellite eclipsing the Sun

The satellite is undergoing its final post-environmental functional and performance tests, and all onground AIT activities will be completed in December. The FAR – covering acceptance of the EDRS-A payload – will take place in December and will be followed by Eutelsat's FM Completion Review covering acceptance of the full EB9B satellite.

The EDRS-C satellite CDR was initiated in mid-2014, and identified the need for a further consolidation of the design in a number of specific technical areas. The EDRS-C satellite CDR will be followed by the mission CDR in 2015, ensuring the consistency of the EDRS-C satellite with the Ground Segment, thereby verifying the overall performance of the EDRS-C mission.

The first System Validation Test ensuring operability of the EDRS-A mission through the Ground Segment was carried out in summer as part of the EB9B Satellite AIT campaign. Further validation tests followed before the end of 2014.

The Mission Operation Centre, in Ottobrunn (DE), is being integrated and its functionality and interfaces to the EDRS Ground Segment, as well as to the anchor customer Copernicus Sentinel, will be tested in early 2015.

→ NEOSAT

The Phase-B contract was signed on 20 February with Airbus Defence & Space and Thales Alenia Space. System PDRs for the platform product lines are planned for the end of this year. The supplier selection process for the development of the Neosat building blocks and procurement of their first flight sets is ongoing.

→ ELECTRA

After completing the SRR, the satellite prime contractor OHB-System GmbH has consolidated their system concept and selected their list of baseline suppliers for the Platform Product Line as well as for the payload. This is the basis of the PDR and the proposal for Phase-B2/C/D/E1, which are being prepared by SES in cooperation with the satellite prime contractor. The platform PDR will be held before the end of 2014 and the evaluation of the proposal for Phase-B2/C/D/E1 will follow.

→ PROBA-3

Proba-3 is dedicated to the demonstration of technologies and techniques for high-precision formation flying, in preparation of future formation flying. The project will demonstrate high-precision formation flying in the context of a large-scale instrument. The paired satellites will form together a 150-m long solar coronagraph to study the Sun's faint corona closer to the solar rim than has ever been achieved before. They will fly together maintaining a fixed configuration as a 'large rigid structure' in space.

ESA astronaut Alexander Gerst spent six hours and 13 minutes outside the International Space Station with NASA astronaut Reid Wiseman on 7 October (ESA/NASA)

The mission and coronagraph proposals for Phase-C/D/E1 were evaluated in 2013. The Phase-C/D/E1 contract proposal was approved in April and the contract with the prime contractor SENER (ES) was signed in July.

The coronagraph payload Phase-C/D/E1 activities began in July with the coronagraph payload prime contractor, Centre Spatial de Liege (CSL, BE). The Principal Investigator for the coronagraph instrument is from Royal Observatory of Belgium. The first Science Working Team meeting was held in July with the international solar science community.

→ ADAPTED ARIANE 5 ME & ARIANE 6

Adapted Ariane 5 ME and Upper Stage and Commonalities

The creation of a 50/50 'joint-venture' between Airbus and Safran was announced on 16 June, and a joint proposal on an alternative Ariane 6 concept (PHH) was delivered. Following an informal meeting held by the Ministers for space matters on 8 July in Geneva, two working groups were set up, one dealing with scenarios for launchers development (Vega and its evolution, Ariane 5ME, Ariane 6) and the other dealing with governance.

Industry and ESA, supported by national agencies, have been working on a joint proposal for launchers development programmes to be decided at the 2014 Ministerial Council, and have developed principles for a new governance approach for the launchers sector, now under discussion.

The Bremen tank facility was opened in August, in the presence of the German government coordinator for aerospace. In September, the first stone of the cryogenic integrated test bench P5.2 was laid at Lampoldshausen.

The final decision on the Hot Gas Reaction System (HGRS) accommodation on the Upper Stage system was taken in July. The HGRS pulsing mode is suppressed and the tank and thrusters will be installed on the Engine Thrust Frame area.

On the Upper Part composite, the fairing industrialisation process is demonstrating its robustness as the manufacturing of the cylinder panel demonstrator, as well as the ogival element, were performed with the new process.

In the Vinci M5 test campaign, tests restarted on 26 June and ended after a total of 17 firings. The Test Review Board took place on 30 September. The total Vinci M5 campaign testing time is 6000 seconds. To date, 21 030 firing seconds have been accumulated.

The formal Bare Tank CDR Documentation Key Point was held in August and the review was confirmed for November.

Ariane 6

Considering the industrial position on the initial Ariane 6 concept, some programme activities are currently being reoriented. As a first step, also considering that the technical activities of the second Design Analysis Cycle are complete, it was agreed which documents would be completed, thus allowing the saving of a limited amount of the contract, which can then be used for reorienting activities.

→ IXV & PRIDE

The IXV mission preparation is on hold until further investigation on the Vega trajectory is performed.

With the objective to maximise the return on the technology investments performed within the ongoing IXV development and flight experience, together with the additional relevant flight experiences available in Europe in similar technologies, the PRIDE programme objectives have been reassessed with potential participants and a revised programme proposal has been submitted.

→ FUTURE LAUNCHERS PREPARATORY PROGRAMME

Implementation of Period-3 is now well advanced with more than 92% of the Ministerial Council 2012 subscriptions contracted or under formal contract negotiation with industry.

The deployment of the integrated requirements downflow within FLPP is running with the complete set of System Requirements Documents, consistent and iterated with development programmes for the integrated demonstrators such as Cryotank, Expander Cycle Technology, POD-X, SRM composite casing, Engine Thrust Frame and Opto Pyro systems.

For what concerns storable propulsion, the Demonstrator hot-firing test on the test bench in Lampoldshausen started and 24 successful firing tests were performed up to now. This engine is the precursor of the Europeanised AVUM for Vega-C Launcher. With the POD-X testing in April, this is the second FLPP hot-firing test campaign this year for a totally new engine.

In Technologies, the implementation of integrated demonstrators is progressing, with the Equipped Insulated Cryogenic Tank (CRONUS) Manufacturing Readiness Review performed. The frame contract on Upper Stage technologies is now in place and the first and second Work Orders on Avionic and cryogenic technology have been signed.

→ VEGA

The VECEP Phase-0/A activities, based on the P-CV SRM as first stage, are completed and relevant documentation provided. Signature of the full contract for Phase-B/C/D is still on hold, pending definition of first-stage nozzle export control issues and possible motors commonalities with Ariane 6.

→ HUMAN SPACEFLIGHT

The Blue Dot mission of ESA astronaut Alexander Gerst (DE) approaches completion on 10 November. In addition to his full programme of research, education and public relations

Suited for their return, ESA's Alexander Gerst, cosmonaut Max Surayev amd NASA's Reid Wiseman with fellow Expedition 41 crewmates Serova, Samokutyayev and Wilmore (NASA/ESA) activities for ESA, Alexander was actively involved with the docking of both the Cygnus and Dragon spacecraft. In September, three ISS crewmembers were exchanged with the transition from Expedition 40 to Expedition 41.

From July to September, the Orbital Sciences' Cygnus spacecraft was launched, docked and undocked on its second flight to the ISS, and the SpaceX Dragon spacecraft was launched on its fourth flight to the ISS. Cygnus and Dragon are NASA's commercial ISS resupply spacecraft. This period also saw the launch and docking of Progress 56P.

→ ISS

The training of ESA astronaut Samantha Cristoforetti (IT) was completed in preparation for her launch to the ISS at the end of November. She will be a Flight Engineer for Expeditions 42/43.

Astronaut Timothy Peake (GB) will fly to the ISS at the end of 2015 as a member of the Expedition 46/47 crew. He undertook Columbus and Payload training at EAC in July, together with astronauts Andreas Mogensen (DK) and Thomas Pesquet (FR). Andreas is set to fly on a Soyuz 'sortie' mission to the ISS in 2015, and Thomas is assigned to a long-duration ISS mission in 2016.

Andreas Mogensen participated in NEEMO 19 from 7–13 September with ESA payloads. NEEMO (NASA Extreme Environment Mission Operations) is a NASA programme for studying human survival in the Aquarius underwater laboratory off the coast of Florida, in preparation for future space exploration.

ATV *Georges Lemaître*

ATV-5 was launched from Kourou on 29 July, after a five-day delay. For the second time (after ATV-4), the docking was performed perfectly to an accuracy of a few millimetres on 12 August. Alexander and cosmonaut Sasha Skvortsov

The four 'aquanauts' of the 19th NASA Extreme Environment Mission Operations (NEEMO 19) from left: Canadian astronaut Jeremy Hansen, ESA trainer Hervé Stevenin, ESA astronaut Andreas Mogensen and NASA astronaut Randy Bresnik (NASA)

An unusual occurrence: four ESA astronauts in the same training venue at the same time. Andreas, Samantha, Thomas and Tim at the Gagarin Cosmonaut Training Centre, Russia, on 17 October (GCTC) monitored the docking. ATV-5 delivered 6602 kg of freight, including 2695 kg of dry cargo and 3907 kg of water, propellants and gases. The Laser Infrared Imaging Sensors (LIRIS) operated during fly-under and docking, and recorded data (76.5 Gb). Alexander dismounted the experiment recorders on 29 August and packed them for download via Soyuz.

The ATV-5 mission is running normally (a very smooth ATV mission so far with only one anomaly before docking, which was recovered and fixed by a software patch). By the end of September, about 43% of the dry cargo and all oxygen had been unloaded. All refuelling propellant has been transferred, and ATV-5 has already performed three reboost manoeuvres of the ISS. The undocking and reentry is scheduled for February 2015, when ATV-5 will perform this time what is called a 'shallow reentry' in order to collect crucial data for the ISS reentry analysis.

European Robotic Arm (ERA)

Roscosmos confirmed their commitment to launch the Multipurpose Laboratory Module (MLM) together with ERA. The anticipated launch date is March 2017. Because of contractual procedures in Russia, a formal schedule will be sent to ESA only when contracts are placed.

→ RESEARCH

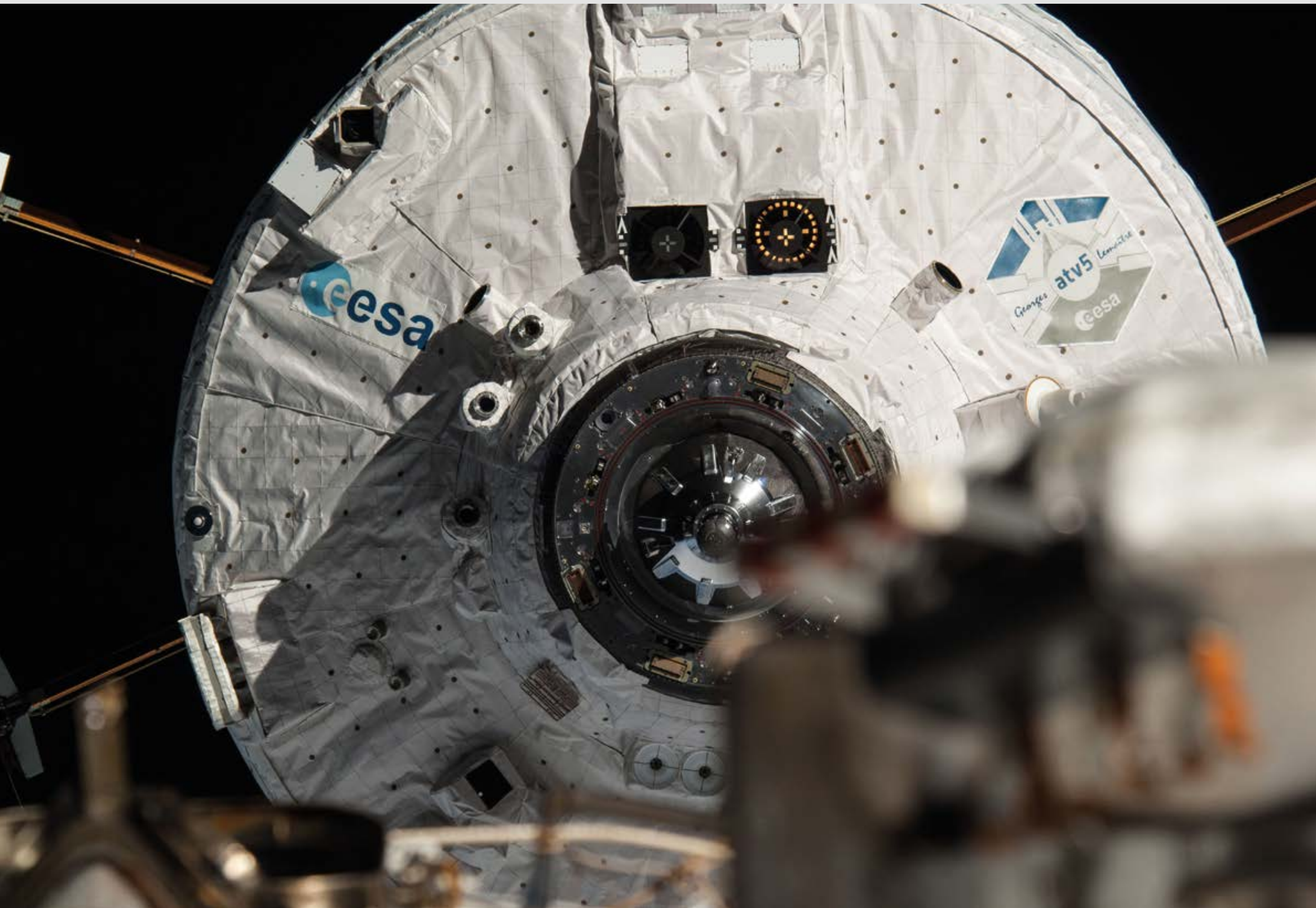
European research on the ISS

The European ISS utilisation programme has been continuing successfully with the assistance of the Expedition 40/41 crew members on orbit. Highlights of the three months until 30 September are as follows:

Prior to his return to Earth, NASA astronaut Steve Swanson completed all his sessions as a test subject for ESA's Space Headaches and Skin-B experiments. These experiments are studying the incidence and occurrence of headaches in astronauts, and helping to develop a mathematical model of aging skin (and other tissues in the body) to improve our understanding of skin-aging mechanisms, which are accelerated in weightlessness.

Alexander Gerst and NASA astronaut Reid Wiseman were subjects of ESA investigations including sessions of the Energy experiment, which aims at determining the energy requirements of astronauts during long-term spaceflight. This will allow for optimal planning when considering upload of food supplies.

ESA's fifth and final Automated Transfer Vehicle, ATV *Georges Lemaître* seen from the International Space Station as it approaches for docking in August (ESA/NASA/Roscosmos/O. Artemyev)



The Expose-R2 facility was installed outside the Russian Service Module of the ISS during a Russian spacewalk on 18 August. The payload includes new sample trays with three ESA experiments (BIOMEX, BOSS and PSS) and one from IBMP in Moscow. These experiments could help understand how life originated on Earth and what is the survivability of samples under 'space conditions', such as Mars, the Moon or other environments.

The Electromagnetic Levitator (EML) and a first batch of samples were transported to the ISS on ATV-5 and installed inside the European Drawer Rack by Alexander Gerst. The EML will perform containerless materials processing involving melting and solidification of electrically conductive, spherical samples, under ultra-high vacuum and/or high gas purity conditions.

ESA's new MagVector experiment has been installed inside the European Drawer Rack in the Columbus laboratory. The MagVector experiment investigates from a quantitative standpoint the interaction between a moving magnetic field (of Earth origin) and an electrical conductor. Using extremely sensitive magnetic sensors placed around and above the conductor, researchers will gain insight into how the magnetic field influences how conductors work. This is of interest for technical applications as well as for astrophysical research.

Non-ISS research in ELIPS

The 61st ESA Parabolic Flight Campaign was conducted in September with 11 experiments, five in Physical Sciences, five in Life Sciences and one exploration technology test. The first test flights of the Airbus A310, which will replace the current A300 aircraft, showed excellent performance and a good microgravity quality. The first joint flight campaign with CNES and DLR is planned for April 2015.

A campaign of the 'Slug Boiling' experiment took place at the end of July with ten drops at the Centre of Applied Space Technology and Microgravity (ZARM) at the University of Bremen. The experiment is studying the physics of bubbly turbulent flows in weightlessness.

→ EXPLORATION

Multi-Purpose Crew Vehicle - European Service Module

The system PDR for the MPCV-ESM was closed. Authorisation to negotiate the Phase-C/D contract was granted after the

Alexander Gerst prepares for a session of the Energy Requirements for Long-Term Spaceflight (Energy) experiment in Columbus in September (NASA)

Alexander Gerst working on the Electromagnetic Levitator experiment (NASA)

third Tender Evaluation Board on 25 August. Phase-C/D contract negotiation is almost complete, with agreement found on all major issues. NASA agreed to the ESM delivery date of 29 January 2017.

International Berthing Docking Mechanism (IBDM) and International Docking Standard System (IDSS)

An updated model of the IBDM, compatible with the new version of the International Docking Standard (IDS) and using improved linear actuators, was tested in Leuven (BE). In place of the original magnetic capture, it features mechanical capture, as specified by the latest version of the IDSS.

A joint ESA/NASA activity for the demonstration of an Exploration Docking System prototype is being finalised. The activity is aimed at demonstrating the compatibility of the IBDM with the new US docking ports and the NASA docking system.

Operation Avionics Subsystem (OAS)

A cockpit mock-up collecting all Operational Avionics Subsystem developments is being completed at SAS (BE). In the context of OAS options for extending participation, cooperation with the NASA Johnson Space Center Crew Office is being studied.

Transportation systems for exploration

Exchanges with NASA continued for the identification of a potential European role in future. The option of developing an orbital stage for the Space Launch System (SLS) based on the Orion MPCV-ESM, by addition of the navigation avionics, has been evaluated in ESA's Concurrent Design Facility.

Meteron

The OPSCOM-2 experiment was carried out on 7–8 August, when Alexander Gerst controlled the Eurobot rover located in ESTEC from the ISS. The communication chain involved ESTEC, ESOC, B-USOC and NASA. This experiment was the second in a series of Meteron experiments.

Lunar exploration

Technical and programmatic discussions with Russian partners are ongoing and a cooperation scheme is being consolidated for a progressive ESA participation on their sequence of Luna missions.

Several activities in industry and institutes across Europe have now been initiated to start developing the ESA Lunar Exploration products. These are PILOT (Precise and Intelligent Landing using On board Technology), PROSPECT (Package for Resource Observation and in-situ Prospecting for

Exploration, Commercial Exploitation and Transportation) and SPECTRUM (Space Exploration Communications Technology for Robustness and Usability between Missions), for a first flight opportunity on the Russian Luna-Resource Lander mission.

International Exploration Framework

The International Space Exploration Coordination Group (ISECG) Workshop took place in Tokyo in July. The ESA Space Exploration Strategy was subsequently presented at the JAXA Space Exploration Symposium on 31 July.

A Senior Agency Managers meeting was held in Toronto during the International Astronautical Congress (September–October). The status and forward work of the space exploration road-mapping process was reviewed, as well as the engagement of the global science community in human/robotic partnerships in space exploration. ESA took over the chair of ISECG from CSA.

→ SPACE SITUATIONAL AWARENESS (SSA)

System Engineering

Architectural Design Reviews (ADRs), involving representatives of the various user communities, were undertaken in September. Architectural design studies of the Space Weather segment of the SSA system, led respectively by Airbus Defence & Space and Kayser-Threde, were completed and the ADR began September.

Space Surveillance & Tracking (SST)

An augmented system for front-end SSA product dissemination has been developed and accepted. New features include reentry predictions and fragmentation detection in addition to improved conjunction predictions.

Space Weather (SWE)

A new contract to continue the SSA SWE Coordination Centre (SSCC) has been placed, allowing the continuation of the testing and validation of the space weather precursor services and providing space weather bulletins to the Rosetta and Venus Express missions.

In parallel, the SSA space weather Expert Service Centre network and new services are being enhanced. A contract was started with the Research Centre for Astronomy and Applied Mathematics (RCAAM) of the Academy of Athens to implement a fully automated solar flare forecasting utility called A-EFFort.

Two hosted payload missions are currently under preparation: for the NGRM mission on the EDRS-C satellite (the EM is undergoing testing). For the second mission, the SOSMAG magnetometer has been accepted as part of a space weather hosted-payload instrument package on a South Korean satellite, GEO-KOMPSAT2A. The SOSMAG magnetometer is being prototyped in ESA's General Support Technology Programme, but the SOSMAG FM would be developed in the framework of the ESA SSA Programme.

Near Earth Objects (NEO)

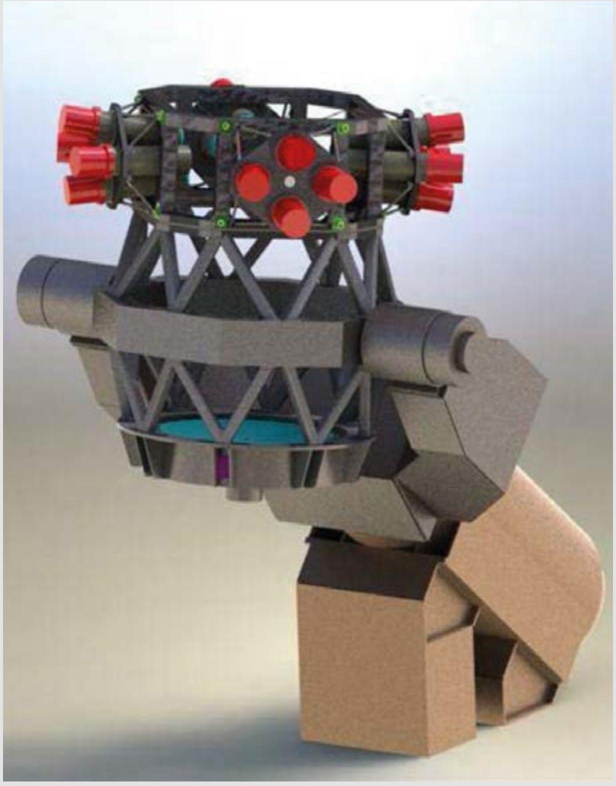
The contract to continue the operations of the NEO Coordination Centre at ESA/ESRIN has been signed. Observational activities have expanded to include a number of cooperating telescopes in Europe. Discussions on the information distribution policy in case of a real impact threat have started with national civil protection authorities.

Radars and telescopes

The test and validation campaigns using the monostatic breadboard radar, deployed in Spain, are continuing. More than 300 different objects have been detected to date, with a total of more than 1000 observations carried out. The bistatic breadboard radar, located in France, has passed the preliminary tests for both the transmitting and receiving subsystems.

The project to develop the first prototype of the NEO Survey Telescope using fly-eye technology has started, with the detailed design launched in July.

Model of NEO Survey Telescope showing fly-eye sensors (ESA/Compagnia Generale dello Spazio CGS)



→ ESA PUBLICATIONS

Brochures

Galileo: The Future Becomes Reality (August 2014)
BR-320 // 8 pp
E-book online

Sentinels: Space for Copernicus (July 2014)
BR-319 // 8 pp
E-book online

Rosetta: Rendezvous with a Comet (May/September 2014)
BR-318 EN/FR // 18 pp
E-book online

ARTES Competitiveness (May 2014)
BR-317 // 22 pp
E-book online

Technologies for European Launchers (June 2014)
BR-316 // 38 pp
E-book online

Sentinel-1: Radar Vision for Copernicus (April 2014)
BR-313 // 8 pp
E-book online

The ESA Effect (April 2014)
BR-306 (2nd ed.) // 303 pp
E-book online

The ESA ARTES Programme (April 2014)
BR-305 (2nd ed.) // 8 pp
E-book online

Looking for Bright Minds (October 2014)
BR-304 (2nd ed.) // 16 pp
E-book online

Das Zuhause der Europaischen Astronauten (November 2014)
BR-286 DE // 10 pp
E-book online

Special Publications

ESA's Report to the 40th COSPAR Meeting (June 2014)
SP-1328 // 402 pp
Price: €40

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