number 154 | May 2013

bulletin

→ space for europe

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:

ESTEC, Noordwijk, Netherlands.

ESOC, Darmstadt, Germany.

ESRIN, Frascati, Italy.

ESAC, Madrid, Spain.

Chairman of the Council:
D. Williams (to Dec 2012)

Director General: J.-J. Dordain

←

ESA astronaut Luca Parmitano, wearing the full spacesuit he will use for working outside the International Space Station during his six-month Volare mission (NASA/ESA)

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Tel: +31 71 565 3408

Email: contactesa@esa.int

Editor
Carl Walker

Designer
Emiliana Colucci

Organisation
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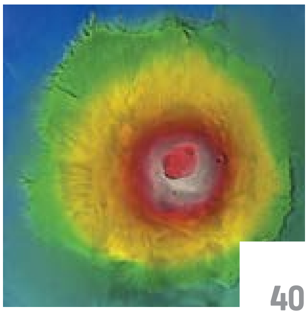
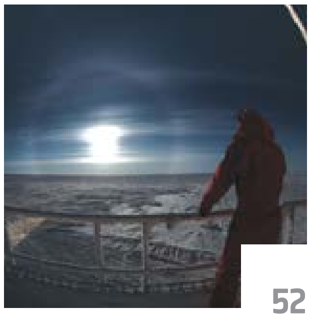
→ contents





Valentina Tereshkova

→ THE FLIGHT OF THE SEAGULL

Fifty years of women in space

Carl Walker
Communication Department, ESTEC, Noordwijk, the Netherlands

On 16 June 1963, Valentina Tereshkova became the first woman to fly in space. As an 'ordinary' cotton mill worker, she roared into orbit on Vostok 6 and accomplished the 'extraordinary'.

This June we celebrate another anniversary: 20 years after Tereshkova, almost to the day, on 18 June 1983, Sally Ride became the third (and first US) woman in space on the Space Shuttle *Challenger* (STS-7). Even though separated by two decades, the flights of Tereshkova and Ride made it possible for millions of young women around the world to dream of space, to succeed in science and engineering careers, and eventually for some, to make their own space history.

Valentina Tereshkova was born in Maslennikovo, near Yaroslavl, in Russia on 6 March 1937. Her father was a tractor driver and her mother worked in a textile factory. Interested in parachuting from a young age, Tereshkova trained in skydiving at a local flying club, making her first jump at age 22 in May 1959. At the time of her selection as a cosmonaut, she was also employed as a textile worker in a local factory.

After the flight of Yuri Gagarin, the selection of female cosmonaut trainees was authorised by the Soviet government, with the aim of ensuring that the first woman in space was a Soviet citizen.

Sally Ride (NASA)

On 16 February 1962, out of more than 400 applicants, five women were selected to join the cosmonaut corps: Tatyana Kuznetsova, Irina Solovyova, Zhanna Yorkina, Valentina Ponomaryova and Valentina Tereshkova. The group spent several months in training, which included weightless flights, isolation tests, centrifuge tests, 120 parachute jumps and pilot training in jet aircraft. Four candidates passed the final examinations in November 1962, after which they were commissioned as lieutenants in the Soviet air force (meaning Tereshkova also became the first civilian to fly in space, since technically these were only honorary ranks).

Originally a joint mission was being planned that would see two women launched into space, on solo Vostok flights on consecutive days in March or April 1963. Tereshkova, Solovyova and Ponomaryova were the leading candidates. It was intended that Tereshkova would launch first in Vostok 5, with Ponomaryova following her in Vostok 6.

However, this flight plan was changed in March 1963. Vostok 5 would carry a male cosmonaut, Valeri Bykovsky, flying the mission with a woman in Vostok 6 in June 1963.

← Valentina Tereshkova in training for her flight (spacefacts.de)

The Russian space authorities nominated Tereshkova to make the joint flight.

↓ Celebrating their flights, Valeri Bykovsky and Tereshkova landed within hours of each other on 19 June 1963 (RIAN)

Flight of the 'Seagull'

After watching the launch of Vostok 5 at Baikonur Cosmodrome on 14 June 1963, Tereshkova completed preparations for her own flight. On the morning of 16 June, Tereshkova and her backup Solovyova both dressed in spacesuits and were taken to the launch pad by bus. After completing checks of communication and life support systems, she was sealed inside her Vostok spacecraft.

After a two-hour countdown, Vostok 6 lifted off without fault and, within hours, she was in communication with Bykovsky in Vostok 5, marking the second time that two manned spacecraft were in space at the same time. With the radio call sign 'Chaika' (meaning seagull), Tereshkova had become the first woman in space. She was 26.

Tereshkova's televised image was broadcast throughout the Soviet Union and she spoke to Khrushchev by radio. She maintained a flight log and performed various tests to collect data on her body's reaction to spaceflight. Her photographs of Earth and the horizon were later used to identify aerosol layers within the atmosphere.

Her mission lasted just under three days (two days, 23 hours, and 12 minutes). With a single flight, she had logged more flight time than all the US Mercury astronauts who had flown to that date combined. Both Tereshkova and Bykovsky were record-holders. Bykovsky had spent nearly five days in orbit and even today he retains the record for having spent the longest period of time in space alone.

→ 'The Mercury 13'

In 1960–61, 13 US female pilots took part in an early effort to test the ability of women to be astronauts. This small group, later called the 'Mercury 13', went through the same medical tests as the Mercury astronauts, and scored very well on them – in fact, better than some of the male astronauts. Despite the fact that several of the women had been employed as civilian test pilots, and many had considerably more flying time than the male astronaut candidates, the testing project was cancelled and it was never taken up as a NASA initiative.

→

Jerrie Cobb, the first woman to undergo the same selection tests as the Mercury astronauts. Passing the tests, Jerrie helped to recruit 25 more women pilots with the support of record-breaking female aviator Jacqueline Cochran. Twelve passed the tests and together they became known as the 'Mercury 13' (NASA)

"I want test pilots."

Premier Nikita Khrushchev saw Tereshkova's flight as a triumph for the Soviet Union. However, no more Soviet women would enter space for another two decades. It was not until 1982 that cosmonaut Svetlana Savitskaya became the second woman in space, and America would have to wait until the following year for Sally Ride to become the third woman fly in space. But why did it take so long for other women to fly in space after Tereshkova?

There are several reasons, and maybe the question should be, why weren't female pilots selected in the first US astronaut groups? One of the reasons was the process that NASA decided to use in 1958 when recruiting its Mercury astronauts. At first, NASA thought that the best candidates to be selected as astronauts would most likely be pilots, submarine crews or members of expeditions to the Arctic or Antarctica, or people with experience in parachuting, climbing, deep-sea diving or scuba diving. NASA soon realised that many people were likely to apply, and that processing all the applications would be expensive and take time. President Eisenhower believed that military test pilots would make the best astronauts and, as a result, the selection requirements were altered, greatly simplifying the selection procedure.

So it was decided: all NASA astronauts must be graduates of military jet test pilot schools and have engineering degrees. The criteria were relaxed as later groups of astronauts were recruited, but the choice of military test pilots as the first astronauts had set the trend.

→ PIONEERING WOMEN OF AVIATION AND SPACE

1910
Raymonde De Laroche (FR)
First woman to gain a pilot license

1911
Harriet Quimby
First American female licensed pilot

1914
Russian Princess Eugenie Shakhovskaya
First woman to become a military pilot

1930
Amy Johnson (UK)
First female pilot to fly solo from England to Australia

1932
Ruth Nichols (US)
First female pilot to fly a commercial airliner

1932
Amelia Earhart (US)
First female pilot to fly solo across the Atlantic Ocean

1910 1920 1930

The problem was that, in the early 1960s, women were barred from US military flight training. Therefore, no American women could become military jet pilots and therefore gain the test piloting experience necessary. In fact, women had been excluded from military flying since the end of the Women's Airforce Service Pilots in 1944.

It was only in 1973 that the US Navy allowed women into flight training. The US Army soon followed and trained female helicopter pilots, with the US Air Force catching up in 1976. The US Air Force had accepted women into its Test Pilot School at Edwards Air Force Base in 1974, but only as engineers.

It would be 14 more years until the first female test pilot graduated there. In 1989, only a year later, Major Eileen Collins was the second female pilot to graduate from the Test Pilot School. She joined NASA in 1990, and was the first female Shuttle pilot and the first female Shuttle commander in 1999.


Eileen Collins, the first female Shuttle pilot (*Discovery* in 1995) and first female Shuttle commander (*Columbia*, 1999) (NASA/A. Leibowitz)

Equal opportunities

In the 1960s, the US aerospace industry and NASA were working hard to achieve President Kennedy's goal of landing a man on the Moon by the end of the decade. Although the space programme employed thousands of people across the US, the aerospace field at that time was mostly composed of white males, with very few women and minorities. Few female and minority employees worked as engineers or scientists or held management positions and, even though four women had applied for NASA's 1965 science astronaut class, none were selected as astronauts.

Signs of change appeared when the US government began addressing many of the inequalities faced by women and minorities in the workplace (the Equal Pay Act of 1963, the Civil Rights Act of 1964 and the Equal Employment Opportunity Act of 1972).

When the Act of 1972 came into force, NASA had already been recruiting female and minority applicants since 1966, when NASA administrator James Webb called for equal opportunities regardless of sex, going above the federal mandates of the time.

However, it wasn't until the late 1970s that public perceptions about women in space really began to change. When NASA's 1978 astronaut class was selected, it was notable for many reasons, including having the first African-American and first Asian-American astronauts. And it was the first to include women.

The Space Shuttle era

The US Space Shuttle was an entirely new human spaceflight programme that became a watershed for cultural diversity, especially within NASA. The Shuttle had created the opportunity to broaden the selection of astronaut candidates to include skills other than jet flying. A new type of astronaut was introduced: the mission specialists, who were researchers with advanced scientific or technical degrees.

1943
Hanna Reitsch (DE)
First female pilot to fly a rocket plane, the Messerschmitt 163

1944
Hanna Reitsch (DE)
First female pilot to fly a jet aircraft, the Messerschmitt 262

1944
Ann Baumgartner
First American woman to fly a jet aircraft, Bell YB-59

1953
Jacqueline Cochran (US)
First female pilot to break the sound barrier, flying an F-86 Sabre

1960
Jerrie Cobb (US)
First female pilot to pass all phases of US Mercury astronaut testing

1940 1950 1960

← Kathryn Sullivan, the first American woman to walk in space on Shuttle mission STS-41G, seen here during the STS-131 Hubble deployment mission (NASA)

↑ Svetlana Savitskaya, second woman in space and first female spacewalker (spacefacts.de)

By the end of the 1970s, it was possible to select the first American women astronauts because the applicant pool now included a greater proportion of women with research degrees (PhDs or MDs) than had previously existed.

Of the 1978 class, Kathryn Sullivan became the first American woman to walk in space on STS-41G; Shannon Lucid was the first mother to be selected as an astronaut and the first American woman to work on the Mir space station. Sullivan and Sally Ride became the first women to fly together on a mission when they flew on STS-41G in 1984.

The Shuttle programme also had substantial cultural impact outside the world of spaceflight. The new women astronauts drew a lot of attention from the media and the public but, as Sullivan explained, “We didn’t want to become ‘the girl astronauts,’ distinct and separate from the guys. All of us had been interested in places that were not highly female, and just wanted to succeed in the environment, at the tasks, and at all the other dimensions of the challenge.”

Yet NASA and those pioneering women astronauts still faced many challenges, not least from mind-sets slow to adapt to the changing roles of women. The six women sometimes faced embarrassing situations by being NASA ‘firsts’. Ride related one such story: “The engineers at NASA, in their infinite wisdom, decided that women astronauts would want makeup – so they designed a makeup kit. A makeup kit brought to you by NASA engineers. You can just imagine the discussions amongst the predominantly male engineers about what should go in a makeup kit.”

The story was similar on the other side of the Iron Curtain. Though the Soviet Union had sent the first two women into space, only three of all the women in space have been Russian or Soviet. Much like NASA’s transformation was a consequence of social changes from the 1960s onwards, in the fifteen years since the selection of the first Soviet female cosmonauts, the Russian space programme had also changed. The 1970s in Russia had also seen a rise in the number of women with qualifications in science and engineering.

By the time the next group of female cosmonauts was being selected in 1979, a specialisation in a technical field was a requirement. This group included Svetlana Savitskaya, an aeronautical engineer and civilian test pilot.

1962 · 1970 · 1980 · 1990

1963 Valentina Tereshkova (USSR)
First woman in space

1982 Svetlana Savitskaya (USSR)
Second woman in space

1983 Sally Ride
First American woman and third woman in space

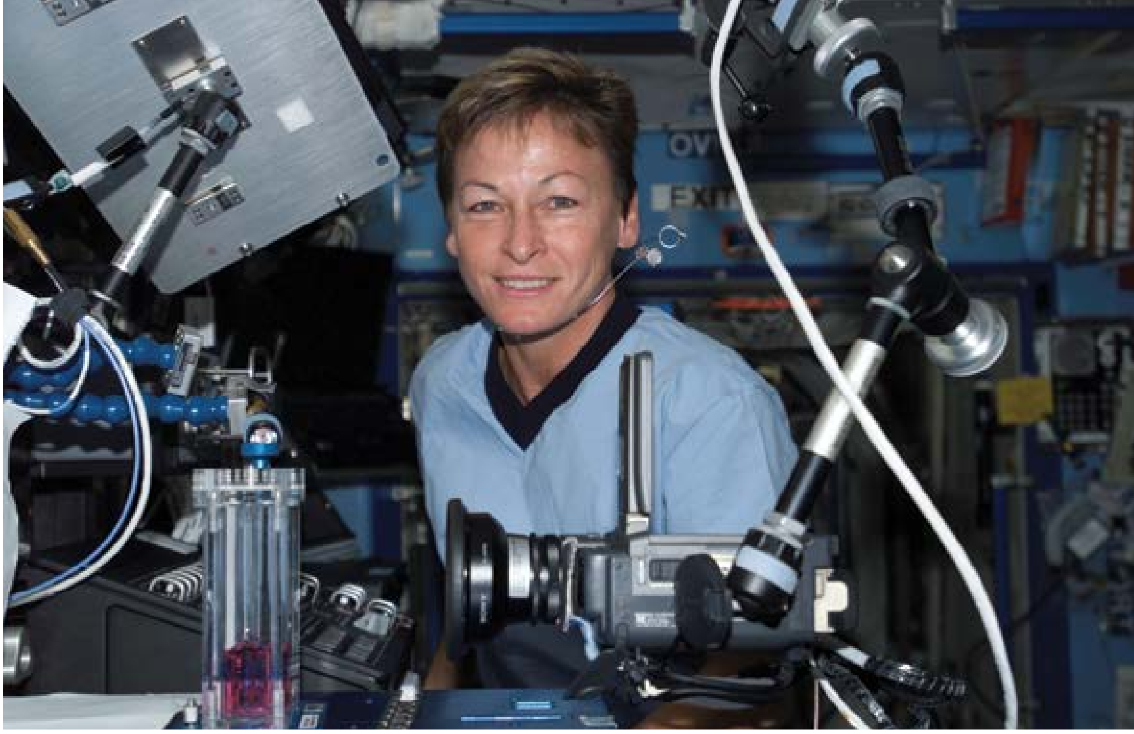
1984 Svetlana Savitskaya (USSR)
First woman to walk in space and first woman to go into space twice

1984 Kathryn Sullivan
First American woman to walk in space

1986 Christa McAuliffe (US)
Chosen to be first teacher in space died in the Space Shuttle *Challenger* disaster

1991 Helen Sharman
First British astronaut and first European woman in space

1992 Roberta Bondar
First Canadian woman in space



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Peggy Whitson, the first female ISS commander (NASA)

Today's women in space

The assignment of women to space missions is no longer regarded in the same 'historic' way that it was in years gone by. In 2012, NASA's Sunita Williams was only the second woman in history to command an ISS Expedition and this was barely mentioned in the media.

Men and women work alongside each other in space as members of expert teams on the ISS. There is no difference between the training given to male or female astronauts, or in the responsibilities given in space missions. It is commonplace for female astronauts to fly several times in space.

Susan Helms jointly holds the record for the longest spacewalk, while Peggy Whitson (first female ISS commander) has spent more than a year of her life off the planet. Whitson and South Korean astronaut Soyeon Yi flew the first spacecraft reentry in which women outnumbered men on a crew.

NASA astronaut Karen Nyberg, flying with ESA's Luca Parmitano on Expedition 36/37 this May, will be working on the ISS on the anniversary of Valentina Tereshkova's pioneering flight.

Nyberg said, "I grew up in an age where it was OK to do what you wanted to do as a girl, but I know that before this, it was not necessarily so. A lot of the scientists, engineers and astronaut females who came before me, set the stage for me. It's incredible what some of those women probably had to go through to make it no question for me."

Inspiring future explorers

On 16 June 2012, exactly 49 years after Tereshkova, Liu Yang became the first female Chinese astronaut ('taikonaut') to fly into space when she participated in a 13-day mission to dock with China's prototype space station.

Today, there are 15 active women astronauts at NASA. Russia's current cosmonaut group includes two women. One of them, Yelena Serova, is preparing for a spaceflight in September 2014 as part of Expedition 41/42. The second, Anna Kikina, is still in training.

As of 2013, there have been 525 space travellers. When ESA's Samantha Cristoforetti launches into space in November 2014, she will be the 57th woman and the second ESA female astronaut in space. A captain in the Italian air force,

1994 Chiaki Mukai
First Japanese woman in space

1995 Eileen Collins (US)
First female pilot of a Space Shuttle

1996 Shannon Lucid
First American woman to stay on Mir space station, sets endurance record for women and US space endurance record

1999 Eileen Collins (US)
First female Space Shuttle Commander

2000

2001 Susan Helms (US)
First female member of an ISS Expedition, sets world record for single longest spacewalk, 8 hours, 56 minutes

2001 Claudie Haigneré
First French woman in space, first European woman to visit the ISS

2006 Anousheh Ansari
First Iranian-born woman in space

2007 Sunita Williams (US)
Sets record for longest spaceflight by a woman, 195 days

2007 Peggy Whitson
First female ISS Expedition commander

2010

2012 Sunita Williams (US)
Sets record cumulative spacewalk time by a female astronaut

2012 Liu Yang
First Chinese woman in space

→ European women in space

The first call for Shuttle Payload Specialists came in 1977, in Europe and the US, for one place on board the first Spacelab mission. Each of ESA's 12 Member States conducted a national selection process. There were several female candidates, but none were selected as the final four European astronauts.

After the success of Spacelab-1 in 1983 and Spacelab D1 in 1985, the German space agency (DLR) began another selection process for the upcoming flight of the German Spacelab D2. This group included two women, Renate Brummer and Heike Walpot, who served in back-up roles for this flight.

By 1989, ESA was ready for another selection and wanted to expand its astronaut corps for flights on the planned Hermes spaceplane. Member States were again invited to submit candidates, and 60 applicants were screened. Some were members of national astronauts teams, such as Claudie Haigneré (nee Deshays) of CNES, and some had already flown in space, such as the UK's Helen Sharman. Sharman was the first European woman in space on Soyuz TM-12 in 1991, and Haigneré would later become the first French woman in space in 1993 and ESA's first female astronaut in 2001.

↑ The German 1987 group with ESA astronaut Ulf Merbold. Left to right, Ulrich Walter, Gerhard Thiele, Merbold, Renate Brummer, Hans Schlegel and Heike Walpot (DLR)

↑ ESA's Samantha Cristoforetti during underwater spacewalk training (NASA)

Cristoforetti has logged more than 500 hours of flying time on six types of military aircraft. She completed basic training in 2010 and will be part of the Expedition 42/43 long-duration mission to the International Space Station.

Whether they see themselves as heroes or not, Cristoforetti and her colleagues will be inspiring a whole new generation of youngsters, both boys and girls, to reach for the stars. ■

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↑ ESA's 1992 group, Christer Fuglesang, Maurizio Cheli, Thomas Reiter, Marianne Merchez, Pedro Duque and Jean-François Clervoy

In 1992, ESA named its six astronauts, and they included Marianne Merchez from Belgium. Merchez trained in the ESA astronaut corps for two years, but resigned for personal reasons.

Helen Sharman, UK, the first European woman in space

Claudie Haigneré, the first French woman in space and ESA's first female astronaut

↑ In April 2010, STS-131 docked with the ISS and allowed Mission Specialists Dorothy Metcalf-Lindenburger, Naoko Yamazaki (JAXA) and Stephanie Wilson to join Expedition 23 Flight Engineer Tracy Caldwell-Dyson (NASA)

ESA astronaut Luca Parmitano, Expedition 36/37 flight engineer, suited in a NASA Extravehicular Mobility Unit spacesuit, prepares for underwater training for his upcoming spacewalks at Johnson Space Center, Houston (NASA)

→ SKY WALKER

Luca Parmitano's Volare mission

Nadjejda Vicente
Directorate of Human Spaceflight and Operations, ESTEC, Noordwijk, the Netherlands

Carl Walker
Communications Department, ESTEC, Noordwijk, the Netherlands

Luca Parmitano has always wanted to fly. On his mission, called Volare (meaning 'to fly' in Italian), he will not only be the first of his astronaut group to fly in space, but he will also become the first Italian spacewalker.

Luca was born in Paternò, Italy, in 1976. Now, at the age of 36, he is where he longed to be – living his dream of being an astronaut. He has always been interested in science fiction and, in particular, he is a Star Wars fan. "I always wanted to be an astronaut, all my classmates knew that," he admits.

Pursuing his passion to fly, he joined the Italian air force and began training in top flying schools around the world. Becoming a jet fighter pilot was his way of chasing the dream, a trampoline to something even higher. In six years as a fighter pilot, he has logged more than 2000 flying hours on more than 20 types of military aircraft and helicopters, and has flown over 40 types of aircraft in total.

Just as he was selected to be a helicopter test pilot in 2009, Luca applied for ESA's astronaut selection that was taking place around the same time. More than 8000 people from all over Europe applied. The process narrowed

↑ 2009: ESA's new astronauts are are selected: left to right, Tim Peake, Samantha Cristoforetti, Andreas Mogensen, Alex Gerst, Thomas Pesquet and Luca

down the numbers of qualified candidates but, after each stage, Luca found himself still in the running.

"I have very sharp memories of the selection tests. The whole process was very emotional. I would check my email obsessively for results," said Luca. When he received the call that he was selected as ESA astronaut, he broke down in tears. They were tears of joy.

After qualifying as a European astronaut in 2009, Italy's ASI space agency proposed him for the mission. "It has been amazing, time has flown by. What a ride!" he recalls.

In the four years since then, he has gone from newly selected astronaut candidate to Soyuz flight engineer and robotic arm operator on the International Space Station.

→

Expedition 36/37 winter survival training in Russia; Luca is trained for an emergency splashdown, also in Russia; Luca and Karen in the Space Vehicle Mock-up Facility, Houston; Luca during robotics training with ATV instructor Richard Moss at EAC

In less than three years, he has travelled between all five international partners' training sites, gaining the knowledge and skills required for his mission. His tailored training has taken him to Houston in Texas, Star City near Moscow, Tsukuba in Japan, Montreal in Canada and the European Astronaut Centre at Cologne, Germany. "I've been able to enjoy every single day of my training. It has been one of the most exciting and exhilarating periods of my life," he said.

Living the dream

The moment he has been preparing for has finally arrived. The Italian astronaut will be part of Expeditions 36 and 37, and will be launched from the Baikonur Cosmodrome in Kazakhstan in May on Soyuz TMA-09M with Russian cosmonaut Fyodor Yurchikhin and NASA astronaut Karen Nyberg.

Yurchikhin, 54, is a very experienced cosmonaut, already having logged over 370 days in space on three previous spaceflights, which included five spacewalks. A mechanical engineer specialised in aeronautics, he worked in the mission control centre in Russia before becoming a cosmonaut in his forties. Luca says of his commander, "I can only learn from him. He is always ready to help and to pass on his experience to me."

Nyberg, 43, became the 50th woman to travel in space, in 2008. On Space Shuttle mission STS-124, she led the robotic arm operations to attach Japan's Kibo laboratory to the Station. This made her the first astronaut ever to operate all three robotic arms (the Shuttle's, the Station's and the Japanese Kibo arm). "Karen is like a big sister to me. She is a very friendly, optimistic person," says Luca.

Luca will be the first of ESA's new generation of astronauts to go into space, living and working on the fully operational International Space Station for almost half a year. He doesn't mind being a rookie on the Station, or in the Soyuz spacecraft. He is eager to learn, representing the values of his young class of astronauts for the human spaceflight endeavour: professionalism, hard work and team spirit.

Luca considers being able to fly to the Space Station and to live such an incredible experience to be a real privilege. "I promise to not read any books or watch any movies in my spare time. I would rather look out the window and enjoy the unique sights from the Space Station," he says.

His ESA colleagues describe him as a very focused and straightforward person, always able to give prompt feedback and show strong leadership. "It doesn't really matter to be the best one, just try to be the best you can be," says Luca, aware that his personal motto may sound clichéd. However, he doesn't hesitate when saying that this guiding maxim has been key in his path to become an astronaut.

I've been able to enjoy every single day of my training. It has been one of the most exciting and exhilarating periods of my life.

Volare

During the 166-day mission, Luca will have many duties on the orbital outpost: "We have different roles according to the tasks of the day – we are the plumbers, the engineers, the scientists, the cooks and the pilots on board."

He will take part in around 20 ESA experiments, covering a range of disciplines: human physiology, fluid physics, materials science, biology, radiation and solar research, as well as technology demonstrations. His research activities will include subjects ranging from understanding how our 'biological clock' ticks to casting lightweight metals.

He will perform experiments not only for ESA, but also more than 20 experiments for the US, Canadian and Japanese space agencies that require using almost 30 research facilities in space.

I, robot

Robotics operations are a highlight of Luca's mission, including participating in the docking and cargo operations of visiting spacecraft. In quick succession, he will have to capture the free-flying vehicles with robotic arms and move them into place to attach them to the Station.

> **"I think ATV is a great spacecraft, a miracle of technology that works wonderfully."**

Commanding the Station's principal robotic arm, he will participate in docking Japan's fourth HTV. He will also support the complex berthing operations of the next Space-X Dragon and the Cygnus (Orbital Sciences) cargo vehicles as part of NASA's commercial resupply programme.

Luca will be welcoming Europe's cargo ferry, ATV *Albert Einstein*, currently the largest servicing vehicle for the Station. Even though it is fully automated, the docking

↑ The Soyuz TMA-09M crew, Karen Nyberg, Fyodor Yurchikhin and Luca Parmitano (NASA) still requires supervision by the astronauts. "Imagine that you have a spacecraft of the size of a double-decker bus flying fast towards you! We have to give the green light from the Station as the last line of safety."

Once the docking is complete, Luca will configure the spacecraft to be another module of the Station. Apart from delivering more than six tonnes of essential cargo, ATV will regularly reboost the orbital outpost and perform attitude control manoeuvres. "I think ATV is a great spacecraft, a miracle of technology that works wonderfully."

Luca will also bring a universe of educational activities down to Earth. From primary school pupils to university students, the astronaut will encourage the study of science, technology, engineering and mathematics among the next generation of scientists. Building a robot to help him fetch items in the Station, talking to pupils via radio and taking part in an international challenge to be as fit as an astronaut are part of his mission.

A mission of firsts

As well as being the first new ESA astronaut to fly on a long-duration mission, Luca will be the first European to fly on Soyuz fast-track flight to the Station in the post-Shuttle era.

↑ Lasagna for space, developed by Italian company Argotec, is freeze-dried, has a shelf-life of 36 months, is salt-free and organic. Choosing the right food to keep energy and morale high is very important for space missions

↑ Luca uses virtual reality hardware in the Space Vehicle Mock-up Facility at NASA's Johnson Space Center to rehearse some of his operations on the ISS (NASA)

He will reach the Station in record time – his Soyuz docking after just four orbits in less than six hours, eight times faster than a standard Soyuz approach.

The 'Optimal Propellant Manoeuvre' allows the Soyuz to execute a same-day rendezvous and docking, gaining two working days on the Station. Adjusting to weightlessness for two days in the cramped conditions of the Soyuz spacecraft is also not ideal, and, as Luca puts it, "The quicker, the better. We become more efficient."

Keen on jogging, keeping fit and eating healthily, it is also especially fitting for Luca to be the first Italian astronaut to enjoy the most complete menu of Italian home-cooked cuisine in space, including lasagne and pesto risotto, with tiramisu for dessert!

'Luca Skywalker'

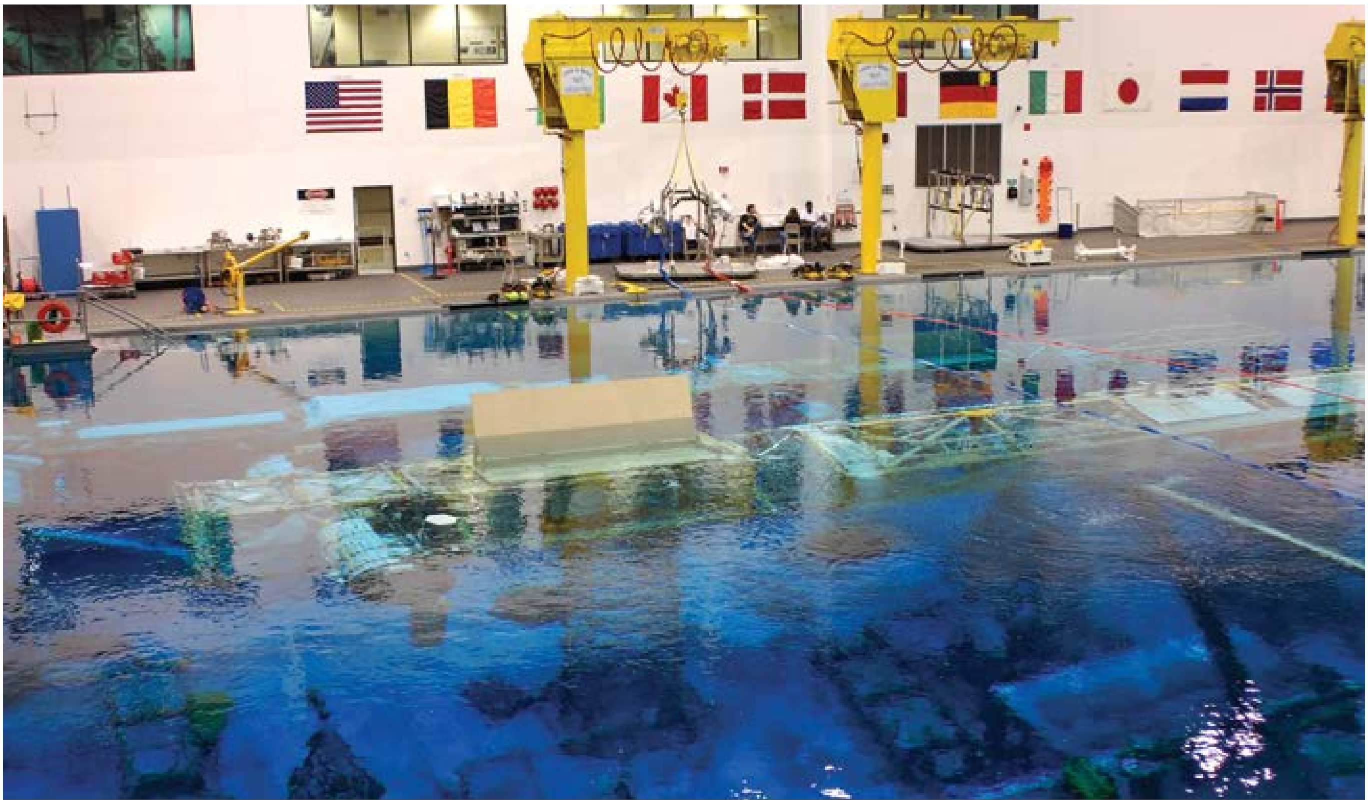
The highlight of any astronaut's career is a spacewalk, or 'Extravehicular Activity' (EVA) in space jargon. Luca will be the first Italian astronaut to perform a spacewalk. In fact, he will venture outside twice in early July. Working outside the Station for typically about seven hours per EVA, Luca will have the best views of our planet, when he is not focused on retrieving science payloads, replacing a camera and preparing the Station for the arrival of the new Russian Multipurpose Laboratory Module.

Floating in space with just a few centimetres of protection against the vacuum and extreme heat and cold is extremely challenging. Luca trained at NASA's Neutral Buoyancy Laboratory in Houston, Texas, which has one of the largest 'swimming pools' in the world for diving on realistic mock-ups of the Space Station modules.

Aware of how daunting a first look at the Station's exterior surfaces could be, Luca trained his sense of direction and had to learn every metre of the orbital complex, literally inside and out. Underwater, he became acquainted with the pressurised suit and a simulated lack of gravity.

The spacesuit is a small vehicle in its right. It has electronics systems, a life-support system and a set of tools. "I was very excited the first time I put it on, but it is also physically and mentally very demanding," says Luca.

Today, Luca is ready for his next destination: outer space. Set to soar higher than ever before, he is excited but remains calm, saying, "I'm not planning anything specific, I will let the Station and the incredible space environment surprise me."



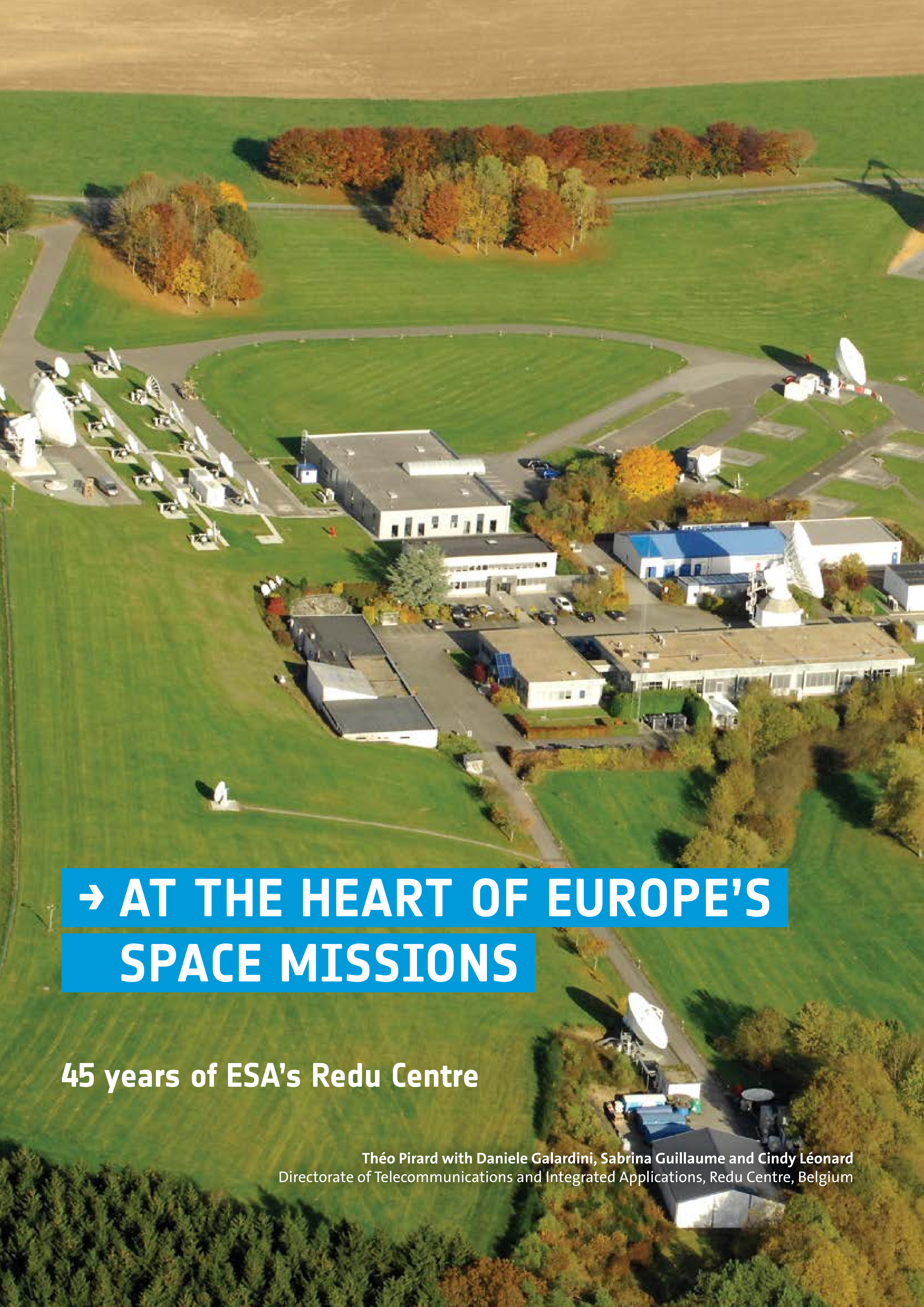
↑ The Neutral Buoyancy Laboratory pool in Houston, 62 m in length, 31 m wide and 12 m deep. It contains 23.5 million litres of water kept at between 27°C and 31°C to reduce risk of hypothermia for the safety divers (NASA)

→ The Volare logo

A competition was opened for Italian residents to suggest a mission name and logo. Norberto Cioffi, 32, from Milan, sent in the winning mission name 'Volare', which means 'to fly' in Italian. The name symbolises the search for new frontiers and opportunities for discovery.

The winning logo was designed by Ilaria Sardella, 28, from Taranto. This logo contains many elements of Luca's mission: the Soyuz spacecraft that will fly him to the orbital outpost, the Station itself and the colours of the Italian flag. The orbits represent the human desire to travel beyond Earth and the Sun as well as our curiosity for knowledge.

↑ Luca gets suited up in a training version of his Extravehicular Mobility Unit (EMU) spacesuit, preparing for spacewalk training session (NASA)



→ AT THE HEART OF EUROPE'S SPACE MISSIONS

45 years of ESA's Redu Centre

Théo Pirard with Daniele Galardini, Sabrina Guillaume and Cindy Léonard
Directorate of Telecommunications and Integrated Applications, Redu Centre, Belgium

Aerial view of ESA's Redu Centre, Belgium (JLB Photo)

↑ Looking towards the village of Redu from the ESA site

In space, the Belgian province of Luxembourg is a force to be reckoned with – a position it owes to ESA. The Redu station, ESA's centre in the Belgian Ardennes, plays a discreet but essential role in Europe's space effort.

Close to half a century ago, the picturesque village of Redu first came to the attention of Europe's then fledgling space community. It was planned to locate a European satellite tracking station a mere stone's throw from the village church and main square, bringing the tranquil Ardennes countryside to the forefront of the conquest of space.

Almost five decades after the site was chosen, ESA's Redu station in the municipality of Libin has grown to cover over 20 hectares with around 50 dishes mostly pointing at geostationary satellites. Some of its antennas are used to control the Proba microsatellites and conduct in-orbit testing of telecommunications and navigation satellites. The site also houses the backup control centre for major Luxembourg-based satellite operator, SES.

↓ Aerial view of Redu station during construction in 1966

1968–78: science comes calling

In February 1965, with the agreement of the European Space Research Organisation (ESRO), the Belgian government chose Redu, located 380 m above sea level, as a tracking station for its first satellites. Situated in a natural basin amid pasture and woodland, the site offers excellent protection from radio and electrical interference. No detail was overlooked in making sure that the station's interferometer and antennas, entering service in 1968, were not affected by radio interference. Even the local farmers were required to play their part.

At that time there was no security fence marking the outer limits of the station. Instead, at the entrance to the site, there was some truly extraordinary signage. Motorists were met with a stop sign, a red light and a sign saying: 'Stop when red light shows and turn off engine. Satellites passing overhead. Approximate duration: ten minutes.' Warned against causing interference with their tractor engines, Redu farmers found themselves unwitting participants in Europe's great space adventure.

Since 1968, Redu has been part of Estrack, formerly ESRO's and now ESA's satellite tracking and control network. It has participated in many European science missions, relaying signals from ESRO's scientific satellites in orbit to the European Space Operations Centre (ESOC) in Darmstadt, Germany. These included: ESRO-2B (launched in May 1968), HEOS-A1 (December 1968), ESRO-1B (October 1969), HEOS-A2 (January 1972), TD-1A (March 1972), ESRO-4 (November 1972), ANS (the Netherlands' first satellite, August 1974) and Cos-B (August 1975) – all European satellites and all launched by NASA.

↖↑ Views of the control room for the ECS European communications satellite in the 1980s

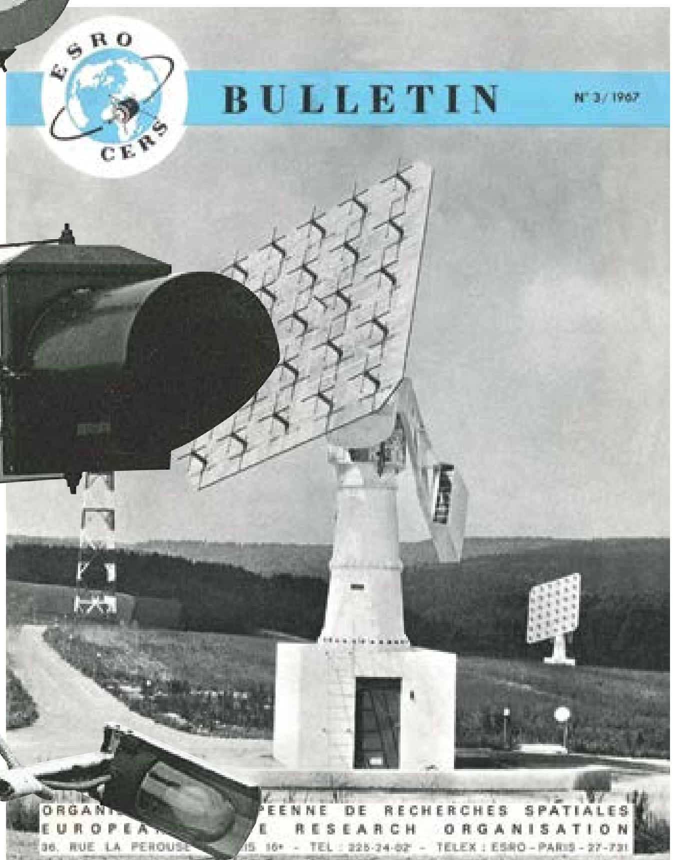
1978–2000: control centre status

In 1975, ESA was formed by the merger of ESRO and the European Launcher Development Organisation, the latter having been tasked with designing and producing a launcher system. With the advent of geostationary satellites, Redu's role grew in importance. Along with ESOC and the other stations in the ESA network (Kourou, Malindi, Perth and Villafranca), the Ardennes station participated in the launch and orbit insertion phases of several missions to geostationary orbit.

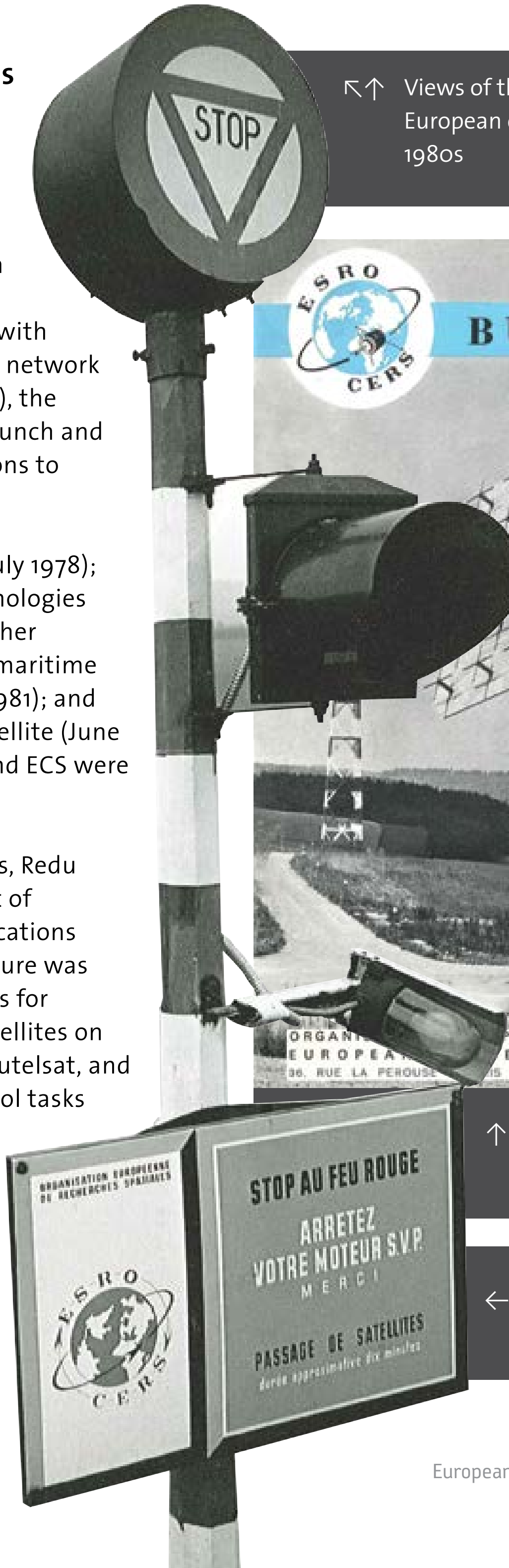
These included: GEOS-2 (launched in July 1978); OTS, testing telecommunications technologies in orbit (May 1978); the Meteosat weather satellite (November 1977); the Marecs maritime communications satellite (December 1981); and the ECS European communications satellite (June 1983). It is worth noting that Marecs and ECS were placed in orbit by Ariane launchers.

On its elevation to control centre status, Redu assumed a key role in the development of space-based systems for telecommunications and television in Europe. Its infrastructure was extended to include parabolic antennas for monitoring and controlling the ECS satellites on behalf of European satellite operator Eutelsat, and of Marecs, leased to Inmarsat. Its control tasks have included orbit determination, stationkeeping by correction manoeuvres, the processing of telemetry data and the sending of telecommands.

Thanks to its receiving antennas and processing capability, the station also



↑ Redu in the cover of the ESRO *Bulletin* in 1967



← Traffic control light at Redu's entrance

↑↓ The site keeps a rural flavour, with Redu's antennas forming a quiet backdrop to agricultural activities (JLB Photo)

started to perform in-orbit commissioning and measured the performance of the telecommunications transponders on the second- and third-generation ECS and Eutelsat satellites employed for commercial purposes. Between 1989 and 1993, Redu was also involved in operating the high-powered Olympus geostationary direct television broadcasting satellite. Operating on behalf of Eutelsat, Redu developed expertise in in-orbit testing, an activity that it has carried out on numerous communications satellites and is currently being performed on Galileo navigation satellites.

Dishes of varying sizes sprung up in the natural 'amphitheatre' of Redu to connect with S-band, C-band, K-band and Ka-band satellites. In the control rooms in Redu's main building, banks of sophisticated computers and measuring equipment are manned by an experienced staff of around 50 engineers and specialised technicians.

The science missions of ESA's orbital astrophysical observatories are also supported from Redu. One such mission is Integral, in orbit since October 2002, which uses a 15 m-diameter parabolic tracking antenna. Today, Redu hosts the Space Weather Data Centre of ESA's Space Situational Awareness programme. The station is manned around the clock and has a state-of-the-art power facililty, as well as five generators to make sure it can be kept running 24 hours a day, seven days a week.

2000–08: intersatellite communication

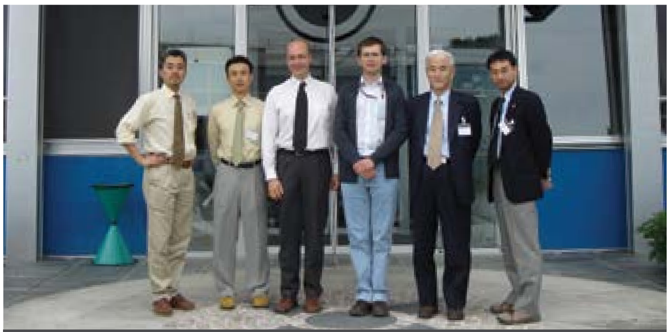
Redu's facilities were upgraded in preparation for ESA's Artemis (Advanced Relay and Technology Mission) programme. Tasked with the satellite's exploitation, the station had to carry out the in-orbit commissioning of Artemis that, after launch in July 2001, was unable to reach its intended transfer orbit. With the help of its electric propulsion system and after conducting a series of complex manoeuvres in space lasting a year and a half, the satellite arrived at its correct geostationary position in January 2003.

In addition to having a role in the salvaging of the Artemis mission, Redu now plays a key role in ensuring the proper communication with the satellite, which is continuing to accomplish its mission.

↑ Tranquil view of Redu station during the summer of 1994

Using the infrastructure deployed at Redu, Artemis has proved itself capable of relaying the high data rates transmitted by low-orbiting satellites such as Spot-4 (already in orbit), ESA's Envisat and Japan's Oicets and Adeos. This it has achieved in both S- and Ka-band and in optical mode (by laser beam with onboard Silex hardware). For Artemis, the station is responsible for payload testing as well as for scheduling of the services provided by the satellite to its different users.

Fresh from this startling success, the station will take part in the service deployment of the European Data Relay System, Europe's future information superhighway in space.



↑ Japanese engineers working on the JAXA Oicets mission welcomed at Redu in 2005

↑ View of Redu on a sunny winter's day, 2011

↑ Opened in 1991, the Euro Space Center museum nearby at Transinne features scale models of spacecraft and launchers, including an actual Europa II rocket

Redu is also responsible for controlling the Project for On-Board Autonomy (Proba) missions, built around Belgian-made ESA microsatellites. Two Proba technology demonstration satellites are exploited from Redu: Proba-1 (launched October 2001), capturing Earth observation imagery, and Proba-2 (November 2009), carrying out solar observations.

These satellites will be joined in May 2013 by Proba-V, which will perform global monitoring of food and forestry resources. The Proba demonstrators have shown the effectiveness of small satellites when it comes to performing specific missions in space. With a mass of around 100 kg, the Proba satellites are built by Verhaert Space (now QinetiQ Space) in Kruibeke, near Antwerp.

2008 to date: both European and Luxembourgish

As time has gone by, and one ESA mission has given way to another, Redu's team of engineers and technicians has witnessed the installation of a steadily growing number of dishes whose job it is to maintain contact with the satellites overhead.

Today, ESA's Redu Centre is unique in Europe, with its three 'pillars'. Pillar One is to provide support to 'ESA missions and particularly to telecommunication missions, associated applications, and to Proba missions that will be controlled by Redu'. Pillar Two is the Galileo navigation system with a constellation of tens of satellites whose functional status will be validated and monitored from Redu.

Pillar Three is the security aspect of governmental space activities. This includes Galileo Public Regulated Service, an encrypted governmental service; the Space Situational Awareness database; future strategic missions to be executed under security constraints. Redu's isolated location makes it a good choice in terms of infrastructure and expertise for processing protected information under secure conditions.

For the EU's flagship programme in space, the Galileo civil satellite navigation system developed by ESA on behalf of the European Commission, Redu has the essential role of conducting the in-orbit testing (IOT) campaign for each of the satellites of the constellation. With precursors GIOVE-A (launched in 2005) and GIOVE-B (2008), Redu has proved itself capable of evaluating the proper functioning of the Galileo satellites, using a 20 m dish for each satellite's IOT campaign.

The 15 m Redu-1 S-band antenna was recently upgraded to provide the telemetry and telecommand functions required for the Galileo constellation during the test phase, and Redu hosts a Galileo sensor station which is the key element of the Galileo system.

In addition, EGNOS, the precursor navigation service to Galileo, makes use of the Artemis satellite exploited from Redu. In 2012 and 2013, two satellites in the SES fleet were fitted with additional L-band EGNOS payloads. On behalf of the European Commission, SES controls the relay of EGNOS signals from Betzdorf (LU) and Redu, while for its geostationary satellite fleet for telecommunications and television, it runs its backup control centre with close to 21 antennas from Redu. The commercial activities complement the institutional work and will be reinforced in the future to assure the growth of Redu Centre.

Space zone extends to Libin

The ESA presence close to the village of Redu eventually led to the Libin municipality being caught up in exciting space activities. The municipality sits alongside the E411 motorway running from Brussels to Luxembourg. Not far from the ESA centre, just off the motorway, the Euro Space Center permanent visitor and educational complex was set up.

More recently, a modern solar-powered modular infrastructure has sprung up nearby to house the Galaxia business park, with a focus on integrated

Mayor of Redu, Léon Magin, views the Redu site in 1990, over 20 years after its opening

space applications such as Galileo, mobile uplinks and geomanagement. The ESA Redu Business Incubation Centre is now located there.

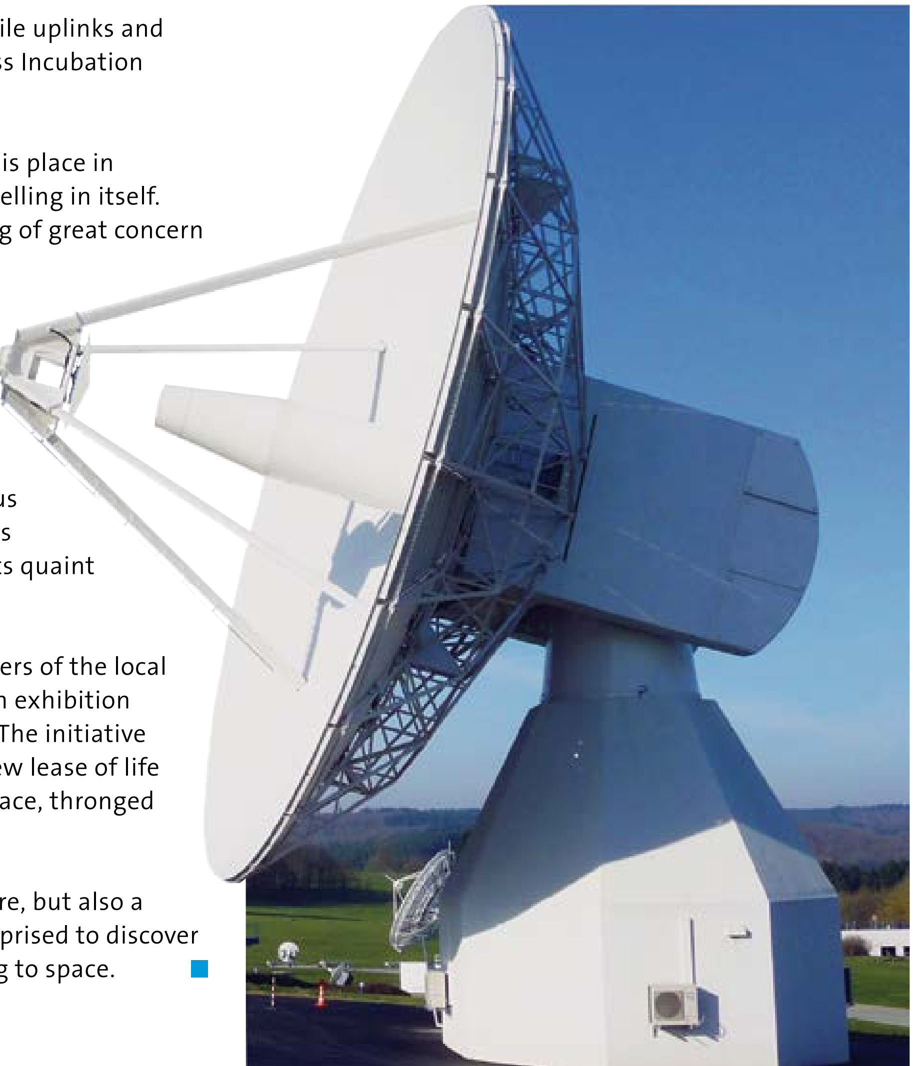
Just how the Redu area came to have this place in Europe's space history is a story worth telling in itself. Back in 1972, this process was something of great concern to then mayor Léon Magin.

When it chose Redu as the site for its tracking station, ESA gave an international dimension to a rural site in Belgium's largest province. Yet at the time, this remote location was being severely affected by an exodus from the countryside. Redu's inhabitants were leaving for jobs in the cities, and its quaint traditional houses were out of fashion.

Mayor Magin rallied able-bodied members of the local population to assist him in mounting an exhibition on the subject of Europe's space effort. The initiative proved a great success, giving Redu a new lease of life as visitors, keen to know more about space, thronged to the village.

Today, Redu is not only a high-tech centre, but also a tourist attraction for visitors always surprised to discover the high-tech view of antennas pointing to space.

Théo Pirard is an external writer for ESA



The Galileo L-band antenna

→ CLEANING UP

Guaranteeing the future of space activities by protecting the environment

Luisa Innocenti and Jessica Delaval
Directorate of Policies, Planning and Control, ESA Headquarters, Paris, France

Andrew Pickering
Directorate of Technical and Quality Management, ESTEC, Noordwijk, the Netherlands

Sean Blair
Communications Department, ESTEC, Noordwijk, the Netherlands

A debris field orbiting Earth, as depicted in the IMAX movie 'Space Junk 3D', would pose a great danger to any spacecraft travelling through it (Spacejunk3D, LLC)

Space has been an extremely successful instrument for monitoring and safeguarding our environment on Earth. But space itself is a vulnerable environment and has to be preserved. ESA's Clean Space initiative responds to this need and supports a sustainable space environment as well as a more sustainable space industry.

← Clean Space is a major objective of Agenda 2015

Space and the environment have long been intertwined. Early images of Earth seen from space helped to inspire the green movement, starting from the very first Earth Day in 1970. Since then, satellite-based monitoring has become an indispensable element of sustainable development and environmental protection.

But reaching for the stars can also leave footprints on the ground. What price is paid by our environment for the exploration and exploitation of space, and how can these environmental impacts be reduced in the future?

Through its efforts in establishing Sustainable Development practices, ESA has for some time been committed to maintaining the highest environmental and social standards. The Clean Space initiative seeks to expand ESA's knowledge of its own environmental impacts, as a way of minimising these in future.

While the space industry produces a much smaller amount of products when compared to other Earth industries, it is necessary to study the environmental effects since very specific materials and processes are used. Some space activities can have a wide reach: for example, rocket launches are the only human activity that crosses all segments of the atmosphere.

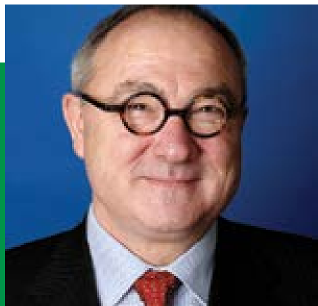
New legislative demands and regulations burden the space industry by imposing potential limitations on currently essential materials. While it may seem tempting to adhere to the lowest environmental standards for as long as possible, it is smarter to comply with the most stringent rules, and do so before they are enforced.

By pioneering an eco-friendly approach, Europe can develop new processes and technologies and be well positioned to help shape and comply with future regulations in these areas. The process of ensuring the ESA's compliance with current and upcoming regulations marks a first step in making its activities more sustainable.

In orbit too, the requirement for sustainability is clear. Half a century of space exploration has created a shroud of junk

→ A top priority

ESA Director General Jean-Jacques Dordain emphasises that implementing Clean Space is a major objective of Agenda 2015, ESA's upcoming action plan:



↑ Jean-Jacques Dordain

"Our belief in space and its significance has three consequences: if there is economic and societal value in space infrastructures, then we must protect them. We must protect them from natural threats (space weather) and man-made threats (debris). Threats to our space infrastructure are increasing; we regularly have to perform avoidance manoeuvres to avert collisions with debris.

"If space infrastructure is essential for understanding the climate and the environment, then the least we can do is ensure that this infrastructure is not itself a threat to climate and environment. If we are convinced that space infrastructure will become more essential, then we must pass on the space environment to future generations as we found it, that is, pristine.

"But we have duties and must be consistent. Thus, the three objectives of Clean Space are to protect space infrastructure, to be environmentally friendly and to keep space clean. We can say that Clean Space is not a new programme, but instead a new way of designing all of ESA's programmes."

→ Redesigning the way industry operates

Previously from ESA's Directorate of Launchers, Luisa Innocenti has led ESA's Clean Space initiative since the start of 2012, building on a long-term interest in environmental issues:

"Clean Space was born in response to our Director General's request for input to Agenda 2015 – his plan for the future course of ESA. The underlying idea, after more than 50 years of space exploration is to redesign the way the industry operates, to ensure it operates in a sustainable way over the really long term, safeguarding both the terrestrial and space environments. Not only is it the right thing to do – the space industry shares the same planet as everyone else – but also it should lead to significant advantages for European industry."

↑ Luisa Innocenti

"The idea, after more than 50 years of space exploration, is to redesign the way the industry operates."

around Earth. If debris populations grow at their current rate then key orbits will become unusable. Europe is far from the biggest space polluter – but the problem affects everyone.

Clean Space has been introduced as a theme cutting across ESA's Technology programme, with four branches:

- Eco-design
- Green technologies
- Space debris mitigation
- Technology for space debris remediation

These activities aim to make ESA an exemplary space agency within the area of terrestrial and space environmental protection. This will in turn provide European industry with a new source of competitive advantage – working more cleanly typically means working more efficiently too.

Branch 1: Eco-design

How can the space industry quantify its environmental impacts on an ongoing basis? This branch of Clean Space

→ Looking for alternatives

Monica Politano heads the Planning and Implementation section of ESA's Basic Technology Research Programme – ESA's main 'ideas factory'. She took part in initial sustainability studies leading to Clean Space.:

"Europe is subject to a growing number of environmental regulations. ESA and the space business can, to a certain extent, cope with this thanks to regulatory waivers. With Clean Space, the aim is to tackle this subject in a more critical, proactive way, and apply a technological point of view that might actually open up some promising opportunities.

"It's not really a fancy idea, but a down-to-Earth one. For instance, in the area of materials, lead for soldering is being phased out. However, the space industry could still require it, because tin solder without lead can grow harmful 'whiskers' in space conditions. So we could get a waiver and be allowed to continue working in this way.

"But we would no longer be able to source such a material on the open market. Supporting such a specific solution would be very costly for what is, in the end, a relatively small industrial sector. And, in general, waivers won't last forever. So there are solid reasons we should look for less harmful and potentially better-performing alternatives."

↑ Monica Politano

is developing a harmonised framework of information tools and measuring systems to consider environmental issues properly when designing satellites, including dedicated databases for space activities:

Existing terrestrial management tools such as Life Cycle Assessment (LCA) analysis are being adapted. An LCA quantifies the emissions, resources consumed and pressures on human health and the environment that can be attributed to different goods and services throughout their life cycle. It attempts to quantify all physical exchanges with the environment, sometimes termed the 'cradle to grave' method.

In addition, eco-design involves evaluating environmental laws and regulations – these are currently among the fastest growing areas of law, particularly within the EU. The aim is to avoid potential disruptions to its supply chain of qualified materials and processes. As prime examples, the EU directive on Restriction of Hazardous Substances

→ Vertical learning curve

Neil Murray of ESA's Aerothermodynamics section is overseeing a Clean Space study in ESA's General Studies Programme, applying advanced computer modelling to study the environmental effect of a launcher's rise to orbit:

"We want to find out if the rocket combustion process has a distinct environmental impact. We're using computational fluid dynamics to simulate the entire launcher, including the combustion process and subsequent evolution of the plume in the atmosphere. This includes the Vega and Soyuz-ST plumes and the two rocket plumes of the Ariane 5's solid rocket boosters and its liquid-propellant central stage and their subsequent interaction together, up to 500 m downstream.

"We're also using a far larger-scale chemical transport model to assess each launch's impact on the atmosphere in terms of chemical effects and climate forcing. This requires the modelling of thousands of discrete boxes, each up to 200 km in size, representing a significant portion of the wider atmosphere.

"Launcher simulations and climate models have been done many times before, but here we face an interesting problem: we have to somehow bridge the gap between the very small scales of the plume and the very large scales of the climate model. The chemical and climate effects typically behave in a non-linear way, so this bridge has to be very accurate – and also innovative."

↑ Neil Murray

→ Plume of an Ariane 5 launched at night (ESA/CNES/Arianespace–Service Optique CSG) in Electrical and Electronic Equipment (RoHs) – adopted in 2003 and brought into force in 2006 – and the EU regulation on the Registration, Evaluation, Authorisation and Restriction of Chemical substances (REACH) – entering into force in 2007 – have considerable implications for European space activities.

↑ Matthew Smith

Branch 2: Green technologies

Characterising the environmental impacts of current activities is one side of the coin; the other is to develop new, green technologies as a means of mitigating these impacts and complying with environmental legislation.

'Green' means different things to different people, but ESA has a solid definition: green technologies should allow for the reduction of energy consumed during the life cycle of a space mission; enable the use of resources in a more sustainable way; limit and control the use of harmful substances for human health and biodiversity; adopt a proactive approach towards environmental legislation and manage the residual waste and polluting substances resulting from space activities.

Green technologies identified to date include green propulsion, aimed at reducing the toxicity of spacecraft propellants. Hydrazine, for instance, has been included on REACH's list of 'Substances of Very High Concern', and other toxic liquid propellants may yet be added.

This risk has driven research into green propulsion, which has been part of ESA's Technology Harmonisation roadmap since 2002. Some 38 European companies or universities are working on the subject, with some success in developing ammonium dinitramide (ADN) and hydrogen peroxide alternatives.

Other materials and processes under study include additive layer manufacturing, thermoplastics and energy efficient solid-state welding processes such as friction stir welding. Less toxic replacements are being sought across a variety of areas including green electronics and components – addressed within the ESA's European Component Initiative.

→ Route to greener propellants

Matthew Smith of ESA's Propulsion Engineering section became involved in Clean Space through ESA's green propulsion harmonisation activity:

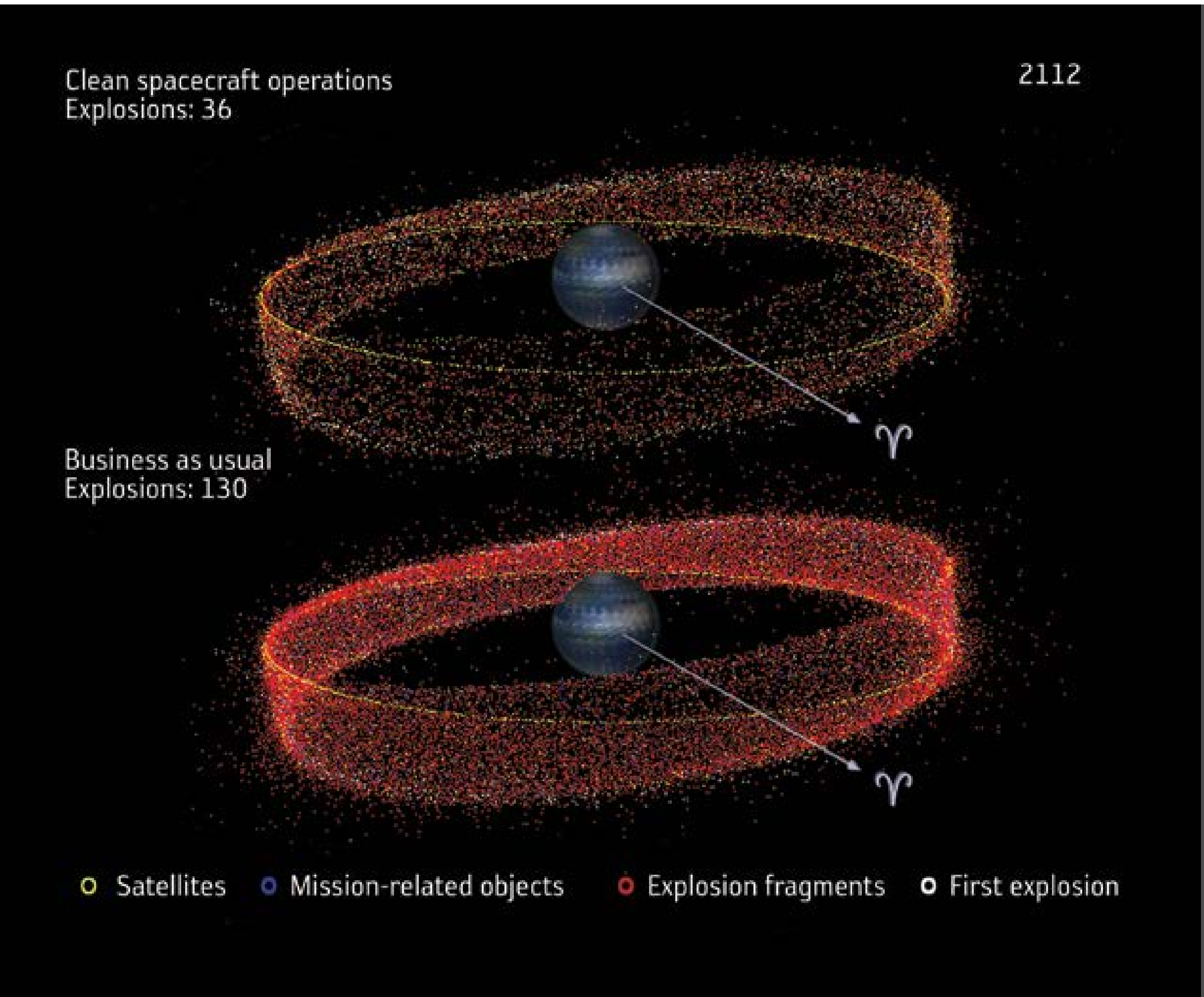
"Our general definition of a 'green' propellant is one with reduced toxicity for the environment or personnel that may come into contact with it. We're looking to replace higher toxicity propellants that demand special measures – such as SCAPE suit operations – to reduce the risks to the personnel involved. We are targeting hydrazine first; we are also interested in replacing higher toxicity bipropellants and possibly solids.

"A one-newton thruster using ADN-based monopropellant has been demonstrated on one of Sweden's Prisma satellites. We are now approaching generic qualification of this thruster for ESA use. Testing and analysis has also been performed with green bipropellants, hybrids and solids.

"Does a greener propellant mean sacrificing mission performance? Some monopropellants such as those based on ADN have slightly higher specific impulse than hydrazine, while others such as hydrogen peroxide have lower specific impulse. However, both have higher density than hydrazine. This allows a smaller tank size for a given mass of propellant. For spacecraft where the propellant tank is a key factor in sizing, this offers the potential for smaller, lighter satellites."

→ Technicians wearing SCAPE (Self Contained Atmospheric Personnel Equipment) suits for MSG-2 filling operations

↑ The 'beehive': a representation of the cloud of satellites and objects currently surrounding Earth (objects not to scale)



← Simulation of the geostationary orbit environment in 2112 with and without mitigation measures (objects not to scale)

→ Finding replacements, maintaining performance

↑ Tommaso Ghidini

Heading ESA's Materials Technology section, Tommaso Ghidini discusses the manufacturing process, the 'birth of a mission'. The cleaner it can be done, the cleaner the rest of the mission life cycle to follow:

"Some of the materials, processes and coatings we work with are environmentally dirty and hazardous for health and safety. The challenge is to find green replacements that have the same performance as the nasty ones.

> **The challenge is to find green replacements that have the same performance as the nasty ones.**

"Take chromate-based coatings used to protect against corrosion – they're ideal for corrosion protection, but chromates are also carcinogenic. We are testing various cleaner candidates in the hope of finding a complete replacement. We are also considering tailoring operating requirements to minimise their use: for instance, the exterior of a launcher exposed to coastal elements could have more stringent corrosion protection requirements than something kept in a controlled, protected environment.

"On the process side, solid-state welding is an example of a greener alternative to current welding techniques. It does not reach the material's melting point – making it greener by definition – while also reducing spatter, fumes, ultraviolet light and associated health hazards, with a reduced need for chemical cleaning agents and related disposal costs. The lower temperature welding also delivers improved mechanical strength and performance, meaning it can be lighter.

"It's an example of how changes that may cost money in the short term will pay back significantly further down the line, while also producing better products and making our industry more competitive.

"Additive layer manufacturing (ALM) is another promising game changer, reducing manufacturing waste. While classical manufacturing starts from a block, from which material is removed to leave a final shape, with ALM – also known as 3D printing – we do the opposite: adding material, to use exactly what is need, nothing more. The amount of material waste is lessened by more than 50%, even up to 95%."

← An alloy antenna support produced in a 3D printing process

Branch 3: Space debris mitigation

Today there more than 12 000 objects larger than 10 cm being tracked by the US Space Surveillance Network in Earth orbit. These items – the legacy of more than 4800 launches during half a century – represent a clear danger to active space missions. Moving at speeds of many kilometres per second, an object of just 1 cm in diameter (too small to be monitored using current techniques) can release the equivalent energy of an exploding hand grenade if it hits a satellite.

Europe has a good record in this area, having produced only about 6% of the world's space debris, and is implementing strong regulations on debris mitigation. But space debris is a global problem. Mitigation measures such as the passivation of spacecraft and the reduction of orbital lifetimes are two essential recommendations made by

→ Capturing non-cooperative objects

↑ Guillermo Ortega Hernando

Heading ESA's Guidance, Navigation and Control (GNC) section, Guillermo Ortega Hernando is supporting Clean Space's debris mitigation as well as the remediation branches. His involvement reflects a long-term interest in environmental issues, stemming from safety analyses performed early in the new century for the reentry of ESA launcher stages and the Automated Transfer Vehicle:

"Unlike cooperative rendezvous, docking or capture in the case of servicing missions, non-cooperative targets can have any position and rotational rates. In GNC, our objective is to adapt and upgrade existing control systems for cooperative targets to be used for non-cooperative ones.

"The handling of an uncooperative, potentially tumbling target and the physical interaction during capture and the subsequent control of the coupled system for deorbiting will require innovative test sequences and test benches upgrades. The Clean Space initiative will push GNC systems to an unprecedented degree of innovation, accuracy, complexity and sophistication."

international experts in 2002, now standard for major spacefaring nations.

This branch covers the development of technologies required to manage the end-of-life of space assets to minimise their space environment impact. This can include new methods of deorbiting or reorbiting satellites. Low-orbit satellites should reenter within 25 years of launch, but this has to occur safely. 'Design for demise' technologies will ensure they burn up entirely without endangering populations on the ground. Another key requirement is a way of accurately gauging a propellant tank's contents in weightlessness, to better estimate a satellite's remaining lifetime.

Branch 4: Technologies for space debris remediation

Reducing the amount of debris produced by future missions is not enough. In fact, even if all launches worldwide ended tomorrow, the total level of space debris is bound to go on increasing.

→ Right response at the right time

↑ Holger Krag

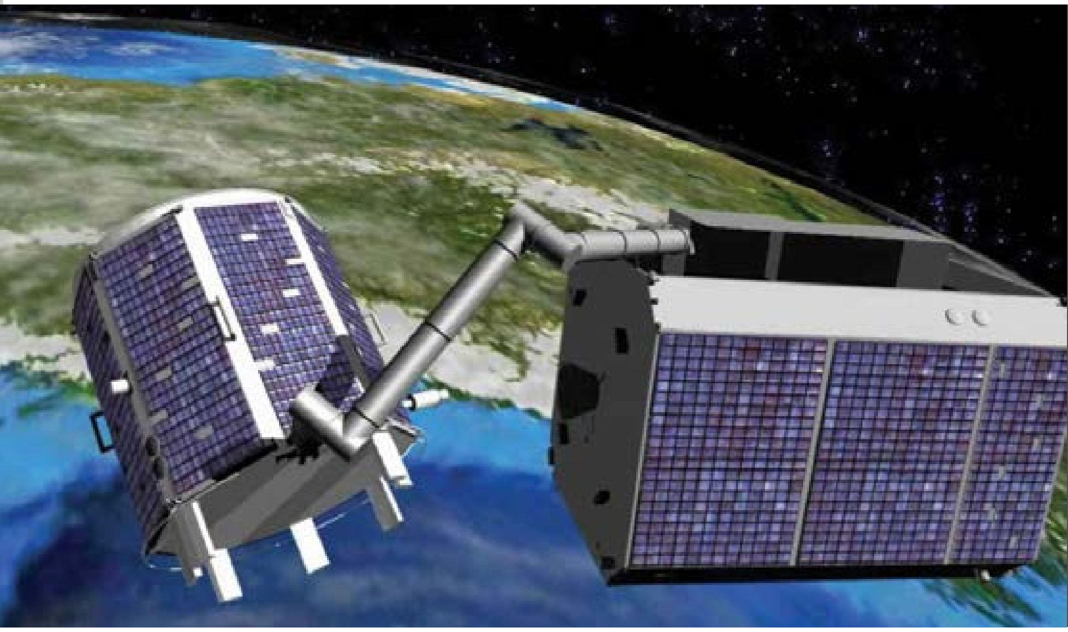
Holger Krag, of ESA's Space Debris Office, is advising Clean Space in two branches of the initiative, space debris mitigation and remediation:

"The passivation of spacecraft, in practice, means venting all residual fuel or other pressurised materials and the discharge of batteries and other remnant chemical or mechanical energy. About 250 on-orbit break-ups have been counted, being the major source of space debris.

"Quantifying spacecraft impact risks and the effectiveness of mitigation and remediation measures requires reliable space environment status and prediction models. My role is to support Clean Space with activities covering precisely these areas.

"The Clean Space initiative is the right response at the right time: our environment in space is continuously degrading."

"Space debris will gradually increase the costs of spaceflight, but relatively small investments – in terms of mitigation options – can contribute to overcoming this problem."



← The proposed German 'Deutsche Orbital Servicing' (DEOS) twin-satellite mission to demonstrate new technologies for the maintenance and disposal of satellites (DLR)

Four decades ago, NASA space debris expert Don Kessler correctly predicted that, once past a certain critical mass of debris, collisions between debris would lead to more collisions in a chain reaction. A 2009 joint study of the current space debris environment by all major space agencies bore out his prediction, now called the 'Kessler Effect'.

The most severe collision in low-Earth orbit to date involved the Iridium-33 and defunct Cosmos-2251 satellites in February 2009. Occurring with a relative speed of 36 000 km/h, the collision left more than 3000 trackable fragments. The density of large, massive objects in low orbits – mostly intact, for now – needs to be reduced to prevent future collisions. The only solution to preserve these key orbits in a usable state is the active removal of some of these objects.

This branch of Clean Space is studying and developing technologies to do just this. The automated capture and deorbit of an uncooperative object has never been performed before, and will require advances in several technology domains such as capture mechanisms, guidance and navigation, sensors and image recognition.

→ Weighing trade-offs for mission design

↑ Robin Biesbroek

Robin Biesbroek leads activities related to Active Debris Removal (ADR) mission design. He led the 'e.Deorbit' study in ESA's Concurrent Design Facility and is now the study manager for several system activities related to ADR:

"An ADR mission can be short and simple from a mission profile point of view. However capturing a satellite with another satellite has never been done before, and it will be a challenge to design a capturing method and guide two joined satellites back towards Earth's atmosphere.

"We're looking at different platform designs to fit on a small launcher, but the major issue will be the trade-off and selection of the capturing method.

We know that there are many factors influencing this choice, such as the size and shape of the target, its orbit, our knowledge of the positions of its antennas or other appendages and its attitude after it stopped functioning. Our strategy for capture and deorbit also needs to be able to deal with any contingencies that arise.

"The target selection is a trade-off in itself, involving many aspects such as in-orbit collision and on-ground risk as well as legal aspects."

↑ Debris impacts on side panel of the Hubble Space Telescope

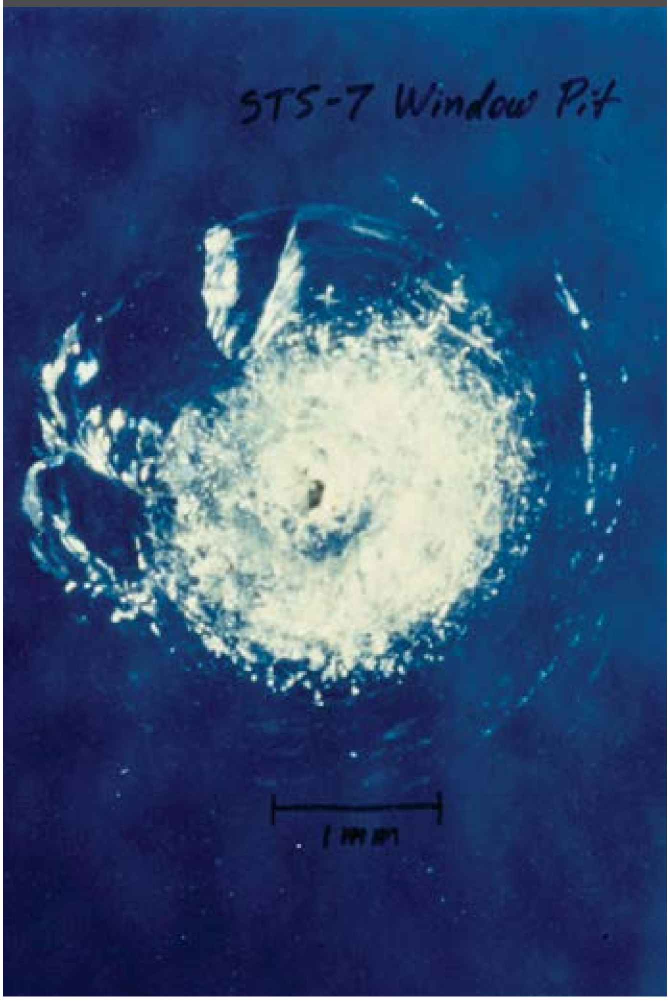
↑ Hole made by a piece of orbiting debris in a panel of NASA's Solar Max satellite (NASA)

For active removal, the dynamic characteristics of various potential targets need to be analysed. In an approach consisting of measurements and modelling, the attitude motion of large decommissioned space systems needs to be characterised and understood.

Clean Space will build on existing research by ESA and its national space agency partners, such as ESA's Robotic Geostationary orbit Restorer (ROGER) study for a roving debris-removal robot or the DLR Deutsche Orbital Servicing mission (DEOS) twin-satellite mission to investigate capture and control techniques. ESA's Automated Transfer Vehicle can perform docking and controlled reentry with unprecedented precision, giving European industry valuable heritage to begin tackling this problem. ■

Sean Blair is an EJR-Quartz writer for ESA

↑↓ A reentered Delta 2 rocket fuel tank found in Texas; a 1 mm impact pit in the window of the Space Shuttle *Challenger* that occurred during the STS-7 mission (NASA)



→ Eyes on the future

Tiago Soares is one of the initiators and the main system engineer of the overall Clean Space initiative, helping to define, streamline and implement the four Clean Space branches. He helped put together the proposal that led to the initiative becoming part of Agenda 2015:

↑ Tiago Soares

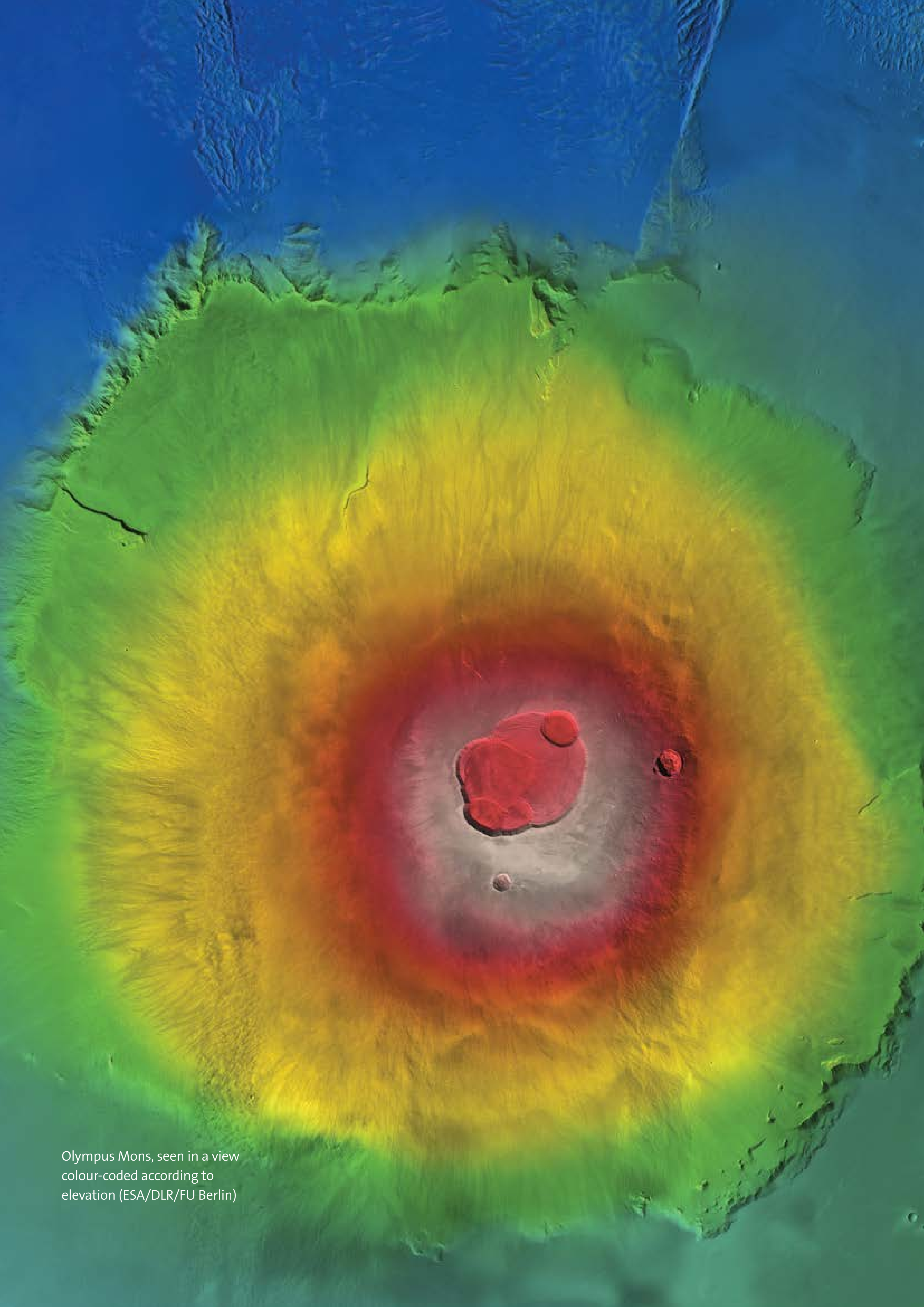
"An Active Debris Removal mission is a huge technical challenge from end-to-end. The capture of the target is not the only difficulty but is indeed one of the phases where the least is known so far, and that will drive the whole design. Capturing an uncooperative object of this scale in orbit is something that has never been done before by a robotic mission and raises all sorts of questions.

"Contactless methods – like the Ion Beam Shepherd – are elegant, minimising the risk of collision or target break-up, but cannot be used to deorbit the heaviest targets – two tonnes or more – that pose the greatest risk.

"These objects will have to be deorbited through controlled reentry to minimise risks of on-ground damage. The two concepts we've studied at ESA's CDF so far – a net and clamping mechanism – both look very promising but there are others. Clean Space activities will help us decide which is the most suitable.

"There is a long way to go before mounting an ADR mission, but Clean Space is making a start. The first objective is to streamline and further develop the key technologies needed for such a mission. After these steps, the decision on when and how ESA can mount such a mission will be much clearer.

"Associated legal issues also require further study. For instance, the definition of space debris does not even exist in space law so far, but is now being actively discussed in international forums. I see Clean Space as a great challenge: I am very happy and proud with what we have achieved so far, but also aware we are just at the start."



Olympus Mons, seen in a view colour-coded according to elevation (ESA/DLR/FU Berlin)

→ MARS EXPRESS

Ten years of European Mars exploration

Olivier Witasse, Fred Jansen and Agustin Chicarro
Directorate of Science and Robotic Exploration, ESTEC, Noordwijk, the Netherlands

Patrick Martin
Directorate of Science and Robotic Exploration, ESAC, Villanueva de la Cañada, Madrid, Spain

Michel Denis and Vicente Companys
Directorate of Human Spaceflight and Operations, ESOC, Darmstadt, Germany

Mars Express is the first European mission to another planet and, ten years after launch, it is still operating, making ESA a key player in Mars exploration and, excitingly, demonstrating that Mars once had an environment that may have been favourable to life.

Since it arrived at Mars in December 2003, Mars Express has been monitoring all aspects of the martian environment, from the subsurface to the upper atmosphere, at all local times, seasons, latitudes and longitudes, and has recorded unique data on the martian moons. The mission has provided an in-depth analysis of the history of the Red Planet, in particular of the role that liquid water played in its early history.

Mars is a fascinating planet that has long been the focus of Solar System exploration. Since the first successful mission to Mars by the US Mariner 4 in 1964, over 20 missions that followed have been building up our knowledge of the Red Planet in great detail.

Mars, our most Earth-like neighbouring planet, has undergone spectacular climatic and geological changes. Today, Mars looks like a dry cold desert. However, features on the surface argue for past fluvial and glacial activity, and the presence of large volcanoes indicates that in its early history Mars was active geologically.

In the late 1990s, the main questions concerning Mars were: how did Mars reach its present state? Could Mars have harboured life and, if yes, did life ever evolve?

→ Mars Express integration at Intespace facilities

Mars Express was launched on 2 June 2003 on a Soyuz rocket from Baikonur in Kazakhstan and injected into a Mars transfer orbit. Having escaped Earth's pull, Mars Express cruised at a velocity of 10 800 km/h for about seven months, on course for the Red Planet.

The UK-built Beagle 2 descent capsule was ejected five days before arrival at Mars, while the orbiter was on a collision course with the planet; Mars Express was then retargeted for orbit insertion. From its hyperbolic trajectory, Beagle 2 entered and descended through the atmosphere in about five minutes, however contact was not regained after the descent. The exact reason for its failure to land successfully remains unknown. Despite several searches from orbit, the location of Beagle 2 on the surface has never been identified.

The Mars Express project began in 1997, just after the failure of the Russian Mars-96 mission and when the popularity of Mars exploration had been boosted by NASA's Pathfinder and its Sojourner rover. Mars Express was designed to address the fundamental questions by studying Mars from a global perspective. Thus the two major themes of the mission, based on an orbiter and a lander, were defined: water and life.

Mars orbit insertion took place on 25 December, and the spacecraft was placed in an elliptical orbit around Mars. Following completion of spacecraft commissioning in mid-January 2004, the orbiter experiments began their own commissioning processes and started acquiring scientific data from Mars and its environment.

→ MARS EXPRESS INSTRUMENTS

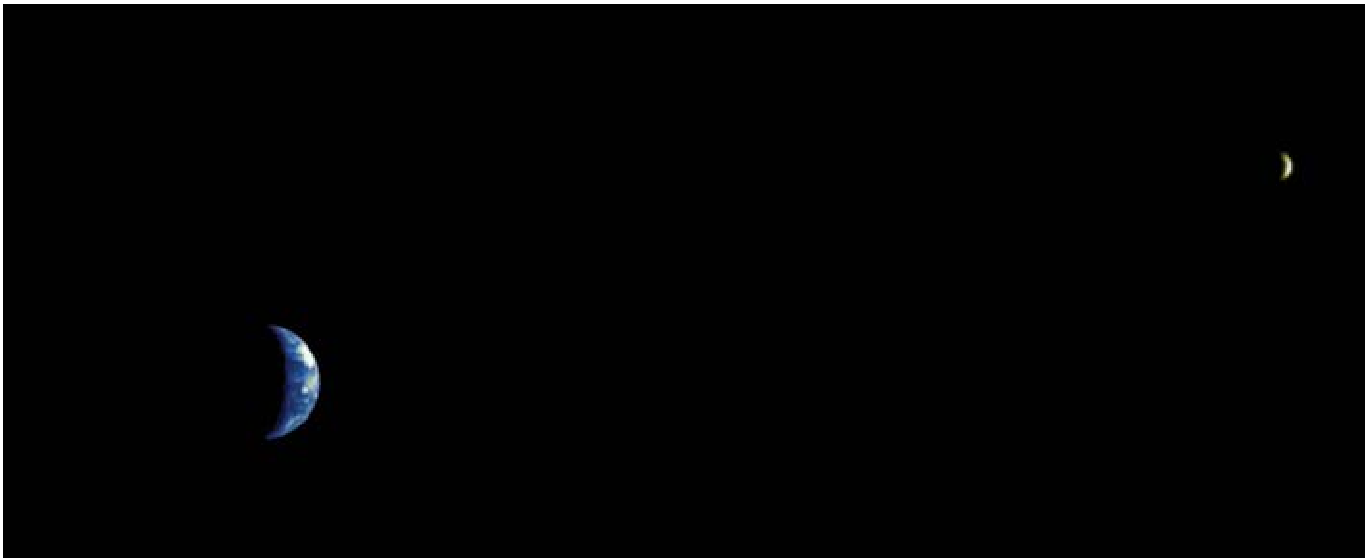
Instrument		Principal investigators
HRSC	High-resolution Stereo Camera *Freie Universität Berlin, Germany*	G. Neukum
OMEGA	Visible and Near infrared hyperspectral imager *Institut d'Astrophysique Spatiale, Orsay, France*	J.-P. Bibring
PFS	Planetary Fourier Spectrometer *Istituto Fisica Spazio Interplanetario, Rome, Italy*	M. Giuranna
ASPERA	Analyser of space plasmas and energetic neutral atoms *Swedish Institute of Space Physics, Kiruna, Sweden*	S. Barabash
MaRS	Radio-Science Experiment *Köln University, Germany*	M. Pätzold
SPICAM	Ultraviolet and infrared dual spectrometer *Lab. Atmosphères, Milieux, Observations Spatiales, Guyancourt, France*	F. Montmessin
MARSIS	Radar for subsurface and ionospheric sounding *Universita di Roma 'La Sapienza', Rome, Italy/NASA JPL, Pasadena, USA*	G. Picardi, J. Plaut, R. Orosei

↑ Beagle 2 lander in the clean room

↑ Mars Express launch on 2 June 2003 from the Baikonur Cosmodrome in Kazakhstan (ESA/Starsem)

On the orbiter, the optical instruments began their routine operational phase after the Commissioning Review in June 2004. It was planned to deploy the radar antenna last in order to maximise early daylight operations of the other instruments, before the natural pericentre drift to the southern latitudes. The deployment of the radar antennas was delayed for safety reasons and successfully carried out in 2005.

The planned orbiter mission lifetime was one martian year (687 days), following Mars orbit insertion and about seven months' cruise. These expectations have been greatly exceeded and the mission is now in its fourth extension and the seven original platform-mounted experiments continue to provide excellent scientific return today.



↑ Leaving Earth, Mars Express took this farewell picture of Earth and the Moon (ESA/DLR/FU Berlin)

↑ In orbit around Mars

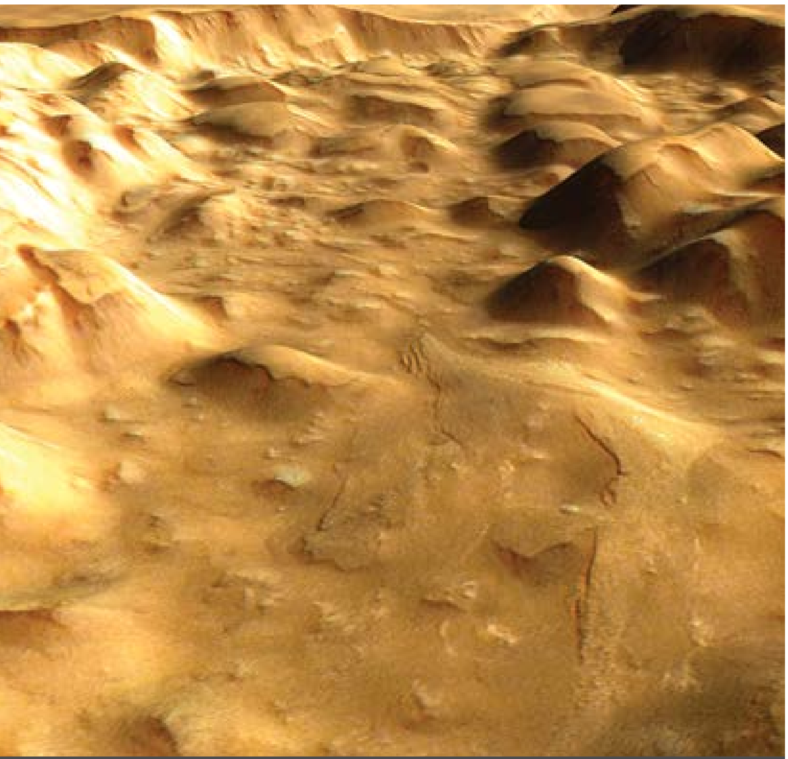
3D images

To the general public, Mars Express is best known thanks to its breathtaking images of Mars, at high resolution (better than 20 m per pixel), in colour and in stereo, allowing 3D images to be made. Besides their aesthetic appeal, some remarkable scientific results have been derived from these pictures, sometimes in combination with other datasets.

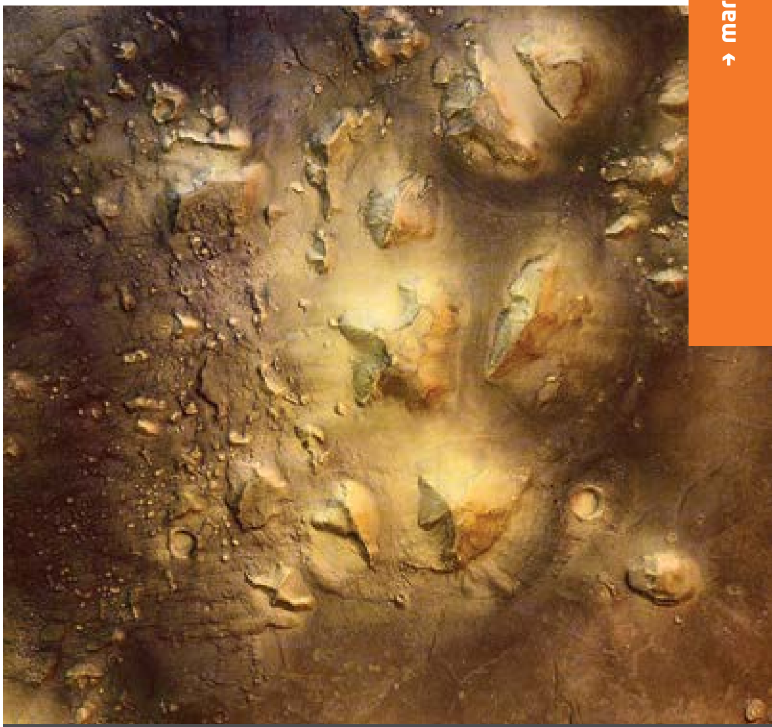
Their analysis has shown that the major martian volcanoes were active during the last quarter of Mars' history, with phases of activity as recent as two million years ago. It is even possible that some volcanoes are even still active today.

Around Olympus Mons, the largest volcano in the Solar System, there is evidence for glacial activity about four million years ago. Tropical to mid-latitude glacial features have been identified, and are interpreted as evidence for geologically recent and recurring glacial activity during periods when the planet's spin-axis was more oblique. This caused polar ice to be mobilised and redeposited at lower latitudes. Mars, like Earth, has thus undergone episodic volcanic eruptions and climate changes.

The caldera of the largest volcano in the Solar System, Olympus Mons (ESA/DLR/FU Berlin)

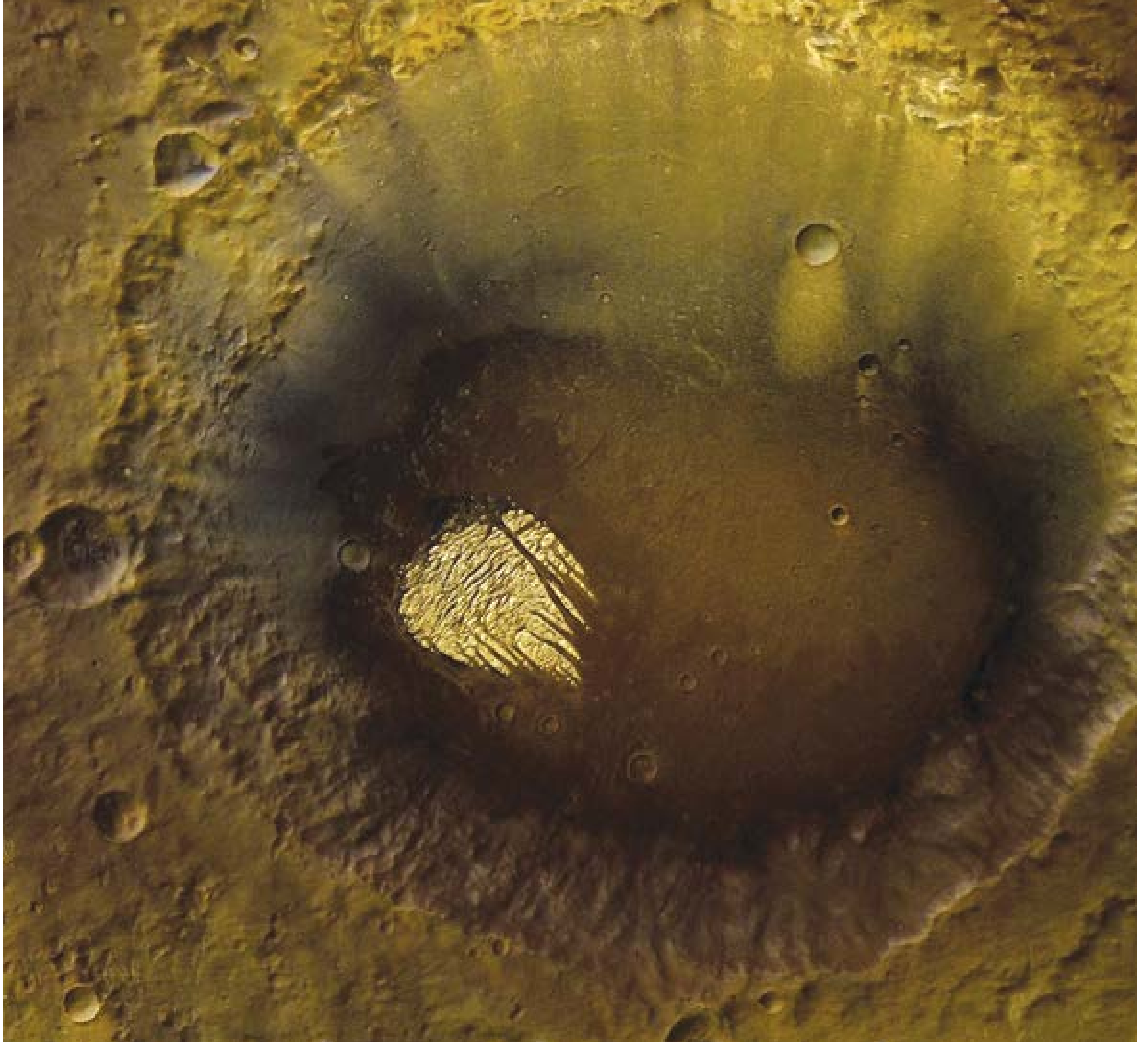


↑ The Aureum Chaos region (ESA/DLR/FU Berlin)



↑ The Cydonia region with the so-called 'face on Mars' (ESA/DLR/FU Berlin)

View of Candor Chasma, part of Valles Marineris, the largest canyon in the Solar System (ESA/DLR/FU Berlin)



←

Pollack crater on Mars, taken on 25 December 2004. The bright feature in the crater is called 'White Rock' (ESA/DLR/FU Berlin)

Water on Mars

Mars Express helped to rewrite the history books when it comes to water on Mars, based on mineralogical information provided by the OMEGA instrument. A special family of minerals called phyllosilicates have been detected for the first time at the surface of Mars, associated with the oldest terrains. To form, they need liquid water, so there must have been liquid water present on the martian surface in ancient times. Meanwhile, sulphates, which formed in an acidic environment, have been detected in younger terrains, while anhydrous ferric oxides were identified in even younger areas. These results suggest that liquid water played a major role very early in the planet's history, harbouring environmental conditions favourable for potential habitability, but that the planet has remained essentially dry over the last 3.5 billion years.

The study of the polar caps, an important element in current and past climates, is a major objective for the mission. The northern and southern polar caps have been observed in great detail by the OMEGA imaging spectrometer. Seasonal frost on the poles consists mostly of carbon dioxide (CO_2) ice, while the bulk of layered material is mainly water ice, mixed with dust.

The MARSIS radar has added the third dimension to this view, by probing through all icy layers to the subsurface. The amount of water trapped in frozen layers over the south polar region is equivalent to a liquid layer about 11 m deep if it were to cover the entire planet. The lower boundary of the polar caps can be as deep as 3.7 km at the south pole, and about 2 km at the north pole.

Mysterious methane

One of Mars Express's most intriguing discoveries was made in 2004 with the PFS instrument, with the detection of methane (CH_4). A globally averaged mixing ratio of 10 ppb (parts per billion) was derived, with a maximum of 30 ppb, which indicates that the concentration of this molecule is spatially variable. Seasonal maps of the methane abundance are now available, showing an increase of CH_4 concentration over the northern polar cap during the summer, suggesting a possible methane reservoir associated with the polar cap. The detection of methane has led to an intense debate in the scientific community, concerning its source: could it be from active biological processes or from geological processes?

Martian climate

Another discovery in the field of atmospheric science is the identification of carbon dioxide (CO_2) ice clouds at high altitude (about 80 km). The detection was first hinted at in 2006 by the PFS and SPICAM instruments, with an

↑ Unnamed impact crater located on Vastitas Borealis taken by Mars Express in 2005. The circular patch of bright material at the centre of the crater is residual water ice (ESA/DLR/FU Berlin)

unambiguous detection made by OMEGA one year later, and complemented by HRSC observations – a true team effort. The CO_2 clouds are detected around the equator and at two particular seasons, northern spring and summer.

Study of these clouds is important because they could have had a key role in the past climate of Mars. They offer a unique possibility to understand the processes involved in cloud formation, both on Mars and on Earth.

In 2011, the SPICAM spectrometer revealed for the first time that the martian atmosphere is supersaturated with water vapour, also demonstrating that important discoveries can still be made well into a mission's lifetime.

High levels of supersaturation were found, up to ten times greater than those found on Earth. Clearly, there is much more water vapour in the martian atmosphere than previously thought. This discovery has major implications for understanding the martian water cycle and the historical evolution of the atmosphere.

Mars Express is currently the only orbiter making measurements in the upper martian atmosphere, where the thin air strongly interacts with the solar wind as well as the highly energetic solar flux. While the presence of an ionosphere around Mars was discovered long ago, Mars Express has clearly identified – with the MARSIS radar and the radio-science MaRS experiment – its lower and upper boundaries, respectively called the meteoritic layer and the ionopause.

The positions of these frontiers were predicted, and Mars Express was able to detect them thanks to the very high sensitivity of these instruments. In addition, the SPICAM ultraviolet spectrometer has detected auroras located above regions characterised by strong crustal magnetic anomalies, shedding new light on how the solar wind interplays with the planet. These auroras, much fainter than Earth's Northern Lights, are caused by charged and energetic particles, in this case electrons originating from the Sun, channelled by the magnetic field lines and colliding with CO_2 molecules in the martian atmosphere.

The ASPERA suite of sensors measures how the atmosphere of Mars escapes. This is important to understand the climate and evolution of Mars. ASPERA has enabled a unique global analysis of the mass composition and escape rates of planetary ions into space.

The escape of hydrogen and oxygen ions (i.e. water) dominates, with relatively low amounts of CO_2 escaping. ASPERA found that the ion escape rate is highly variable, depending strongly on the solar wind and ultraviolet fluxes.

↑ Martian moon Phobos seen by Mars Express (ESA/DLR/FU Berlin)

> **This constitutes the first interplanetary and inter-agency relay network.**
>
> Michel Denis, Spacecraft Operations Manager

Exploration of the martian moons

Thanks to its elliptical and near-polar orbit with a slowly rotating major axis, Mars Express is able to contribute greatly to the exploration of the two martian moons, in particular the innermost, Phobos. A total of 46 flybys closer than 1000 km have been carried out between 2004 and 2012. The closest approach was a controlled one at a distance of 77 km from the centre of the moon on 3 March 2010.

Mars Express acquired the sharpest ever images of Phobos, improved the knowledge of the positions of the moons along their orbit, and provided more precise values on their mass, gravity field, shape, dimensions and density. The age of Phobos has been proposed as older than 3.5 billion years, based on crater counting. New geological interpretations for the grooves – long linear features covering the surface of Phobos – have been suggested; they could be chains of secondary impact craters from earlier impacts on Mars. While the question of the origin of the martian moons is still open, Mars Express data favour the scenario of a giant impact on Mars that would have ejected a disc of debris around the Red Planet, from which the two moons were born.

A strategic role

Mars Express is equipped with the MELACOM communication system that allows the satellite to communicate with a surface asset such as a lander or a rover, and was designed for use with Beagle 2. The Mars Express team is regularly requested by NASA to support the operations of their surface missions. Regular contact events have taken place with the Spirit and Opportunity rovers, and Mars Express monitored the Phoenix lander and the Curiosity rover during their entry, descent and landing (EDL) phases in May 2008 and August 2012, respectively.

For the Phoenix lander arrival, Mars Express PFS data of atmospheric temperature profiles were used to support the EDL phase. Specific data were acquired before the event and immediately sent to NASA for analysis. Mars Express relayed scientific data from Curiosity for the first time in October 2012. It is likely to continue to relay the NASA rover data from time to time, or in case of emergency.

↑ A self-portrait of the NASA MSL/Curiosity rover on the martian surface. ESA's Mars Express monitored its entry, descent and landing phases in August 2012 (NASA/JPL/Malin Space Science Systems)

→ The Mass Memory problem

In 2011, an anomaly affecting the Solid State Mass Memory (SSMM) subsystem caused the satellite to enter a 'safe mode'. Despite switching to the redundant memory controller, the problem persisted. After entering two more safe modes, it was decided to suspend science observations as a precaution, and to explore the flexibility of onboard software for increasing the robustness of the system.

An elegant solution for commanding the satellite was found: the so-called 'short Mission Timeline', instead of the regular Mission Timeline – meaning that Mars Express was now controlled with only 117 commands, compared with a few thousand commands needed previously. This complete redesign required a huge effort from the teams at ESOC and ESAC and, in particular, from the Flight Controllers.

When the Mission Control team first proposed this daring scheme, to operate Mars Express with so few commands, ESA's Head of Solar and Planetary Mission Operations Paolo Ferri asked, "You mean: for a test?" Systems engineer Daniel Lakey bravely replied, "No, for routine and forever."

The whole team had to work hard to solve the problem, but it took only three weeks until some science operations were restarted. There was a progressive return to 100% performance within three months.

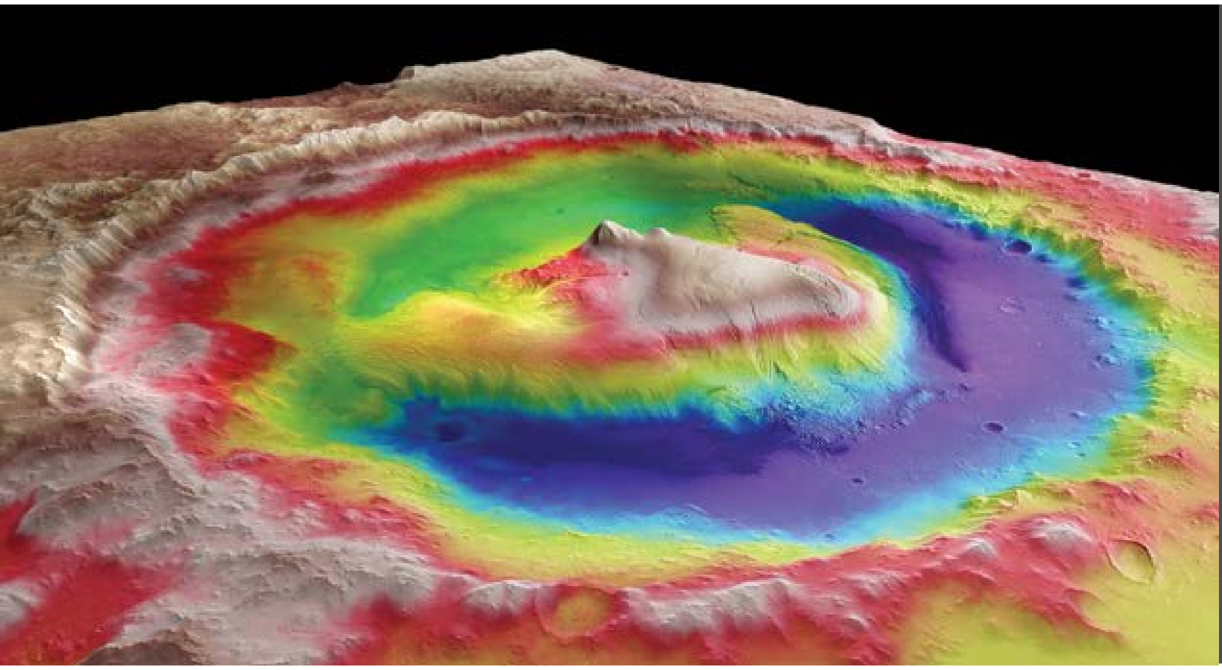
But that will not be the last time Mars Express will be used for such purposes. In October 2016, ESA's Exomars EDL Demonstrator Module is scheduled to land on Mars, and Mars Express will most likely be listening to its signal, or even relaying its data from the surface.

Landing sites of past and future missions

Data from Mars Express helped scientists choose a landing site for NASA's Mars Science Laboratory (MSL). The mineralogical data from OMEGA were also used to identify the most interesting sites that satisfied the scientific requirements of the MSL mission. The primary landing site of ExoMars 2016, a plain known as Meridiani Planum, has been characterised in detail thanks to HRSC data. The selection of the landing ellipse of the ExoMars 2018 rover will almost certainly be based on Mars Express data. In addition, the NASA Insight mission, a geophysical lander due to arrive on the martian surface in September 2016, has requested Mars Express to take several images of 16 potential landing sites.

An ordinary camera in an extraordinary place

The original role of the Visual Monitoring Camera (VMC) on Mars Express was to image the Beagle 2 lander after



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Gale Crater, landing site of the MSL/ Curiosity rover on Mars. This HRSC image is colour-coded based on a digital terrain model derived from stereo image data and according to elevation (ESA/DLR/FU Berlin)

Images from the Visual Monitoring Camera are used for increasing public awareness as well as scientific purposes

release from the spacecraft in 2003. It did not operate again until 2007, when the Flight Control Team at ESOC recommissioned the device as the 'Mars webcam'. Since then, the camera has been taking images of Mars that are immediately posted on the ESA VMC blog. These images are picked up frequently by space enthusiasts who apply more visual enhancement as needed.

While the primary goal of the camera is to increase public awareness, the data can be used for scientific purposes, thanks to a wide field of view and relatively good frequency of observations. The images can be used to study martian atmospheric features such as clouds and polar vortices.

The future

Mars Express operations are scheduled until the end of 2014, and a further extension for the period 2015–16 is under evaluation. The coming years should be very exciting, as new data will complete the global picture of the Red Planet. The evolution of Mars Express's orbit will soon benefit the remote sensing instruments and, in particular, the coverage by the HRSC will increase substantially.

The closest ever Phobos flyby, at a distance of 58 km from the centre of the moon, will take place on 29 December, during which a gravity experiment will be conducted.

→ MARS EXPRESS KEY EVENTS

2003
- 2 June:Launch from Baikonur
- 25 December: Mars orbit insertion

2004
- Identification of water and CO_2 ices at the south pole
- Detection of methane
- Recent and episodic volcanic and glacial activity

2005
- Detection and mapping of phyllosilicates and sulphates
- Identification of gypsum in north polar regions
- Identification of tropical to mid-latitude glaciers
- Discovery of auroras over magnetic anomalies
- Detection of NO molecule in the atmosphere
- Discovery of meteoritic layer in the ionosphere
- MARSIS radar deployment

2006
- September: Survival Mode with ultra-low power consumption during long eclipses
- Generation of ozone profiles
- Detection of CO_2 ice clouds

2007
- Subsurface radar sounding of south polar layered deposits
- Low ion escape rate, implications for the escape history

2008
- 26 May: Tracking Phoenix EDL arrival and relaying data
- Sharpest images of Phobos acquired

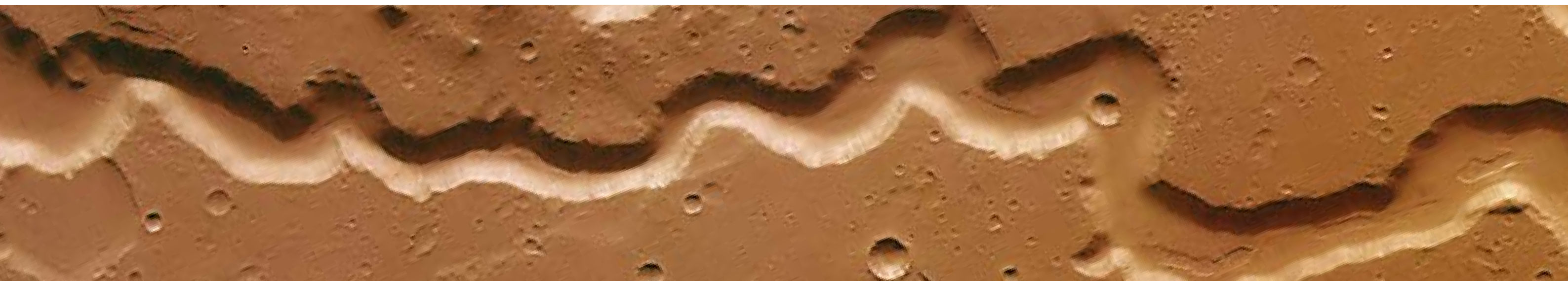
←

Mars Express data are paving the way for the expected detailed atmospheric survey by the ExoMars Trace Gas Orbiter

The current mission extension will make it possible to complete the data set to cover a full solar cycle (about 11 years). This is very important to further our understanding of how the solar wind and flux interact with the atmosphere and make it escaping to space. This has strong implications for understanding climate changes on Mars. Also, the NASA MAVEN spacecraft is due to arrive at Mars in September 2014 and coordinated measurements with both satellites will allow the space environment of Mars to be studied in great detail.

On 19 October 2014, a comet originating from the distant Oort cloud will approach Mars within 110 000 km, with even a low risk of impact. Mars Express will witness this rare encounter. Last but not least, the continuous observations of the atmospheric composition and variability will prepare for the expected detailed atmospheric survey by the ExoMars Trace Gas Orbiter.

Mars Express is paving the way for missions under development and under study (Mars Network, Phobos Sample Return) as well as the long-term goal of Mars Sample Return, and provides to all European partners – ESA, national agencies, industry and the scientific community – the capabilities and skills to plan the next steps of Mars exploration and to face new challenges. ■



2009
- Detection of the top of the ionosphere

2010
- 3 March: closest Phobos flyby yet, 77 km
- Backscattered solar wind protons by Phobos
- Atmospheric escape under varying solar conditions
- Most precise mass determination of Phobos
- Topographic atlas of Phobos
- Reflectivity map/Implications for the current inventory of subsurface water
- Near-tropical subsurface ice
- Detection of hydrated silicates in the Northern Plains
- Quantitative contributions to martian geology from Three-Dimensional Mapping

2011
- North polar regions campaign, orbit 10 000
- Supersaturation of water vapour in the atmosphere
- Multi-instrument survey of water vapour
- Seasonal map of methane
- Support of landing site characterisation for MSL and ExoMars

2012
- January: new concept for operating Mars Express
- 6 August: European assistance for NASA MSL Curiosity
- October: Relay MSL science data
- First detection of molecular oxygen nightglow

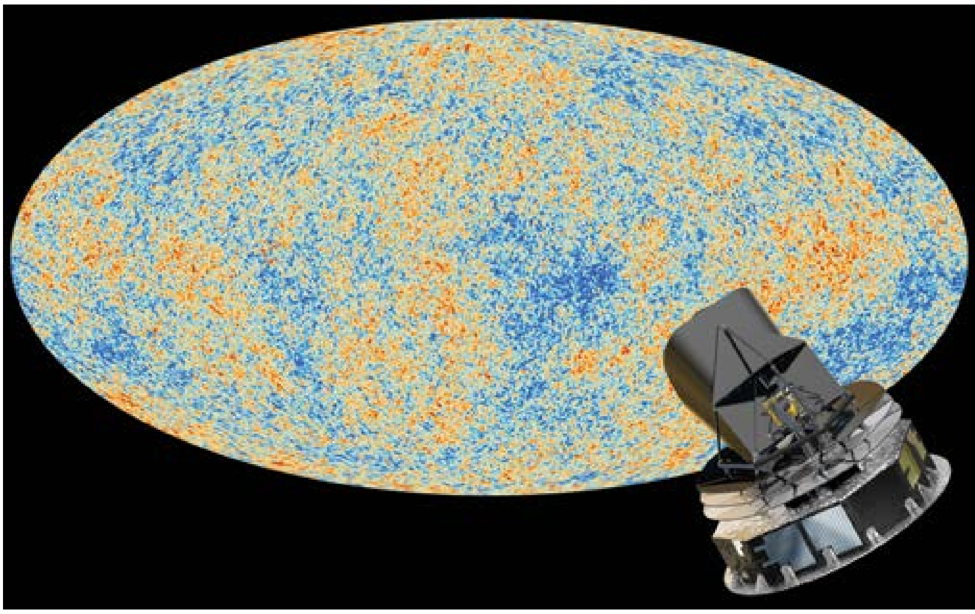
2013
- Global mineralogical maps
- 29 December: closest Phobos flyby 58 km

2014

→ NEWS IN BRIEF

Darkness is coming: Concordia research base in Antarctica, where the Sun will not rise above the horizon for the next four months, leaving the base in permanent darkness, and temperatures drop to –80°C in the polar winter (ESA/IPEV/PNRA - A. Salam)

Planck reveals almost perfect universe



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Planck's first all-sky picture of the oldest light in our Universe, showing anisotropies of the Cosmic Microwave Background (ESA/Planck collaboration)

The most detailed map ever created of the Cosmic Microwave Background – the relic radiation from the Big Bang as seen by ESA's Planck space telescope – was released in March.

The image is based on the initial 15.5 months of data from Planck and is the mission's first all-sky picture of the oldest light in our Universe, imprinted on the sky when it was just 380 000 years old. It reveals the existence of features that challenge the foundations of our current understanding of the Universe.

Overall, the information extracted from Planck's new map provides an excellent confirmation of the standard model of cosmology at an unprecedented accuracy, setting a new benchmark in our manifest of the contents of the Universe. But because precision of Planck's map is so high, it also made it possible to reveal some peculiar unexplained features that may well require new physics to be understood.

One of the most surprising findings is that the fluctuations in the CMB temperatures at large angular scales do not match those predicted by the standard model – their signals are not as strong as expected from the smaller scale structure revealed by Planck.

Another is an asymmetry in the average temperatures on opposite hemispheres of the sky. This runs counter to the prediction made by the standard model that the Universe should be broadly similar in any direction we look. Furthermore, a cold spot extends over a patch of sky that is much larger than expected. The asymmetry and the cold spot had already been hinted at with Planck's predecessor, NASA's WMAP mission, but were largely ignored because of lingering doubts about their cosmic origin.

One way to explain the anomalies is to propose that the Universe is in fact not the same in all directions on a larger scale than we can observe. In this scenario, the light rays from the CMB may have taken a more complicated route through the Universe than previously understood, resulting in some of the unusual patterns observed today.

Beyond the anomalies, however, the Planck data conform spectacularly well to the expectations of a rather simple model of the Universe, allowing scientists to extract the most refined values yet for its ingredients.

Normal matter that makes up stars and galaxies contributes just 4.9% of the mass/energy density of the Universe. 'Dark matter', which has so far only been detected indirectly by its gravitational influence, makes up 26.8%, nearly a fifth more than the previous estimate. Conversely, 'dark energy', a mysterious force thought to be responsible for accelerating the expansion of the Universe, accounts for less than previously thought.

Finally, the Planck data also set a new value for the rate at which the Universe is expanding today, known as the Hubble constant. At 67.15 km per second per megaparsec, this is significantly less than the current standard value in astronomy. The data imply that the age of the Universe is 13.82 billion years.

"With the most accurate and detailed maps of the microwave sky ever made, Planck is painting a new picture of the Universe that is pushing us to the limits of understanding current cosmological theories," says Jan Tauber, ESA's Planck Project Scientist.

New space weather centre

← ESA's Thomas Reiter (right), is joined by Philippe Mettens, Chairman of the Belgian Science Policy Office, for the centre inauguration (ROB)

ESA opened a new Space Weather Coordination Centre to gather up-to-date information on our Sun. It is the first such data coordination centre opened under the ESA's Space Situational Awareness (SSA) Programme.

Located at the Royal Observatory of Belgium, Brussels, the new SSA Space Weather Coordination Centre was formally inaugurated on 3 April by Philippe Mettens, Chairman of the Belgian Science Policy Office, and Thomas Reiter, ESA Director of Human Spaceflight and Operations.

The centre will serve as the central access point to a portfolio of European space-weather expertise for customers, including satellite operators, industrial sectors including telecommunications and navigation, and government agencies and research institutes.

Erik Quistgaard (1921–2013)

Erik Quistgaard passed away on 11 February, aged 91. Mr Quistgaard was the second Director General of ESA, served from 1980 until 1984.

Born on 3 June 1921, Mr Quistgaard gained a MS degree in mechanical engineering from the Technical University of Copenhagen, Denmark. Before joining ESA, Erik Quistgaard was managing director of the Danish shipbuilding company OLS. He had earlier served as general manager and director of Volvo in Sweden, before that spent three years with the Chrysler Corporation in the USA.

André Lebeau (1932–2013)

André Lebeau passed away on 26 February, aged 80. Mr Lebeau was the Deputy Director General of ESA and Director of Planning and Future Programmes between 1975 and 1980.

Born in 1932, Mr Lebeau entered the Ecole Normale Supérieure in 1952 where he studied physics and was awarded a PhD in 1965. After participating in a French expedition to Antarctica, he joined France's national research council, CNRS, in 1961 and then French space agency CNES in 1965. In 1975, with the founding of ESA, he joined as Deputy Director General under Roy Gibson. He left ESA in 1980. Between 1986 and 1995, Mr Lebeau was Director General of the French meteorological service Météo-France and then President of CNES. He also served as Head of the French Delegation to ESA, President of the Eumetsat Council and Vice-President of the World Meteorological Organization. More recently, he chaired the Advisory Committee for ESA's Directorate of Telecommunications and Integrated Applications and was a member of the Advisory Council of the European Space Policy Institute.

Galileo fixes position in history

Europe's new age of satellite navigation has passed a historic milestone – the very first determination of a ground location using the four Galileo satellites currently in orbit together with their ground facilities.

This fundamental step confirms the Galileo system works as planned. A minimum of four satellites is required to make a position fix in three dimensions.

The first two were launched in 2011, with two more a year later.

This first position fix of longitude, latitude and altitude took place at the Navigation Laboratory at ESA's ESTEC facility in Noordwijk, the Netherlands, on 12 March, with an accuracy between 10 and 15 m – which is expected taking into account the limited infrastructure deployed so far.

With only four satellites for the time being, the present Galileo constellation is visible at the same time for a maximum two to three hours daily.

This frequency will increase as more satellites join them, along with extra ground stations coming online, for Galileo's early services to start at the end of 2014.

Lift-off of Vega VV02

↑ ESA's latest launcher made its second flight from Europe's Spaceport in Kourou, French Guiana on 7 May. Two Earth observation satellites, ESA's Proba-V and Vietnam's VNREDSat-1A, were released into different orbits, demonstrating the Vega's versatility. Estonia's first satellite, the ESTCube-1 technology demonstrator, was also released into orbit.

Telecom anniversaries

↑ ECS-1 lifts off from Europe's Spaceport in Kourou, French Guiana, on an Ariane 1, on 16 June 1983

The first European operational communications satellite, OTS-2, was launched 35 years ago this month. Launched on 12 May 1978, OTS-2 became one of the first geostationary communications satellites to carry six Ku-band transponders and was capable of handling 7200 telephone circuits.

ESA's Orbital Test Satellite (OTS) project demonstrated technologies and techniques for a new generation of telecommunications satellites, leading directly to the ECS and Marecs designs. The OTS/ECS satellites were the first European-developed operational communications satellites, after groundwork laid by two experimental French/German Symphonie satellites in the 1970s. British Aerospace was the prime contractor from the European consortium that developed the OTS vehicle. The highly successful OTS-2 was retired from geostationary orbit in 1991.

Thirty years ago this June, ECS-1 lifted off from Europe's Spaceport in Kourou, French Guiana, the first telecommunications satellite to cover the whole European continent.

After in-orbit testing, ECS-1 was handed over to its operator, Eutelsat, by ESA on 12 October 1983. It was retired from service in 1996, having been in service for almost twice its design lifetime of seven years.
ESA developed and launched five European Communications Satellites (ECS) between 1983 and 1988 for use by Eutelsat. The ECS system anticipated the need for digital transmission techniques for telephony, allowing high-speed data traffic. Each ECS enabled coverage of the whole European continent for cable television, telephone communications, specialised services and Eurovision transmissions.

← OTS-2

They were the first telecom satellites for Europe before Eutelsat launched their own satellites. Eutelsat was created in 1977 as an intergovernmental organisation but reformed as a private company in 2001, and is today one of the world's leading satellite operators.

ESA's next Earth Explorer satellite

ESA has selected 'Biomass' to become its seventh Earth Explorer mission. This innovative satellite will map and monitor one of Earth's most precious resources, our plants and trees.

The satellite will be designed to provide, for the first time from space, P-band radar measurements that are optimised to determine the amount of biomass and carbon stored in the world's forests with greater accuracy than ever before.

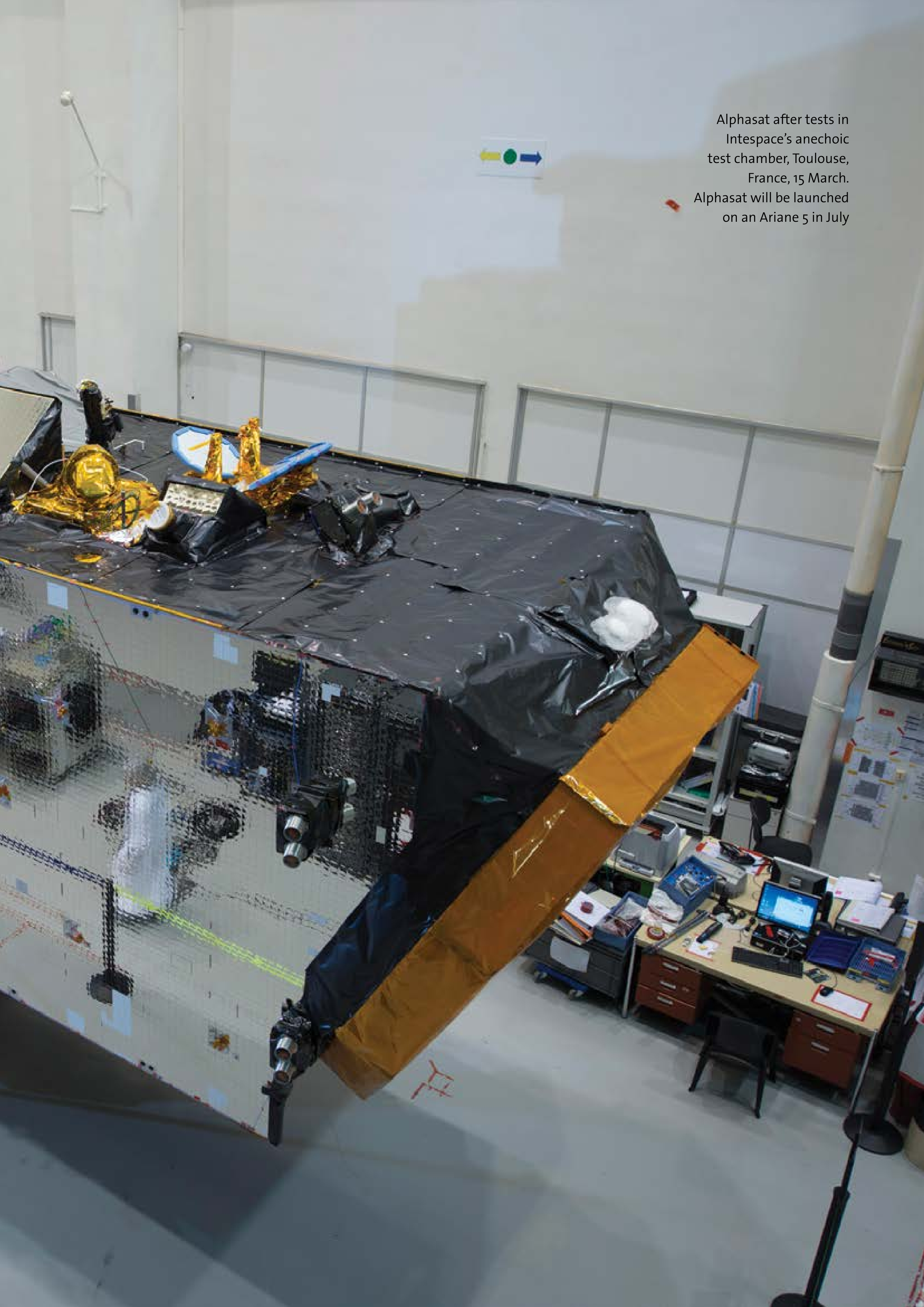
This information, which is poorly known in the tropics, is essential to our understanding of the role of forests in Earth's carbon cycle and in climate change. Reliable knowledge of tropical forest biomass also underpins the implementation of international efforts to reduce carbon emissions from deforestation and land degradation in developing countries.

Measurements made by Biomass also offer the opportunity to map the elevation of Earth's terrain under dense vegetation, yielding information on subsurface geology and allowing the estimation of glacier and ice-sheet velocities, critical to our understanding of ice-sheet mass loss in a warming Earth.

Biomass also has the potential to evolve into an operational system, providing long-term monitoring of forests – one of Earth's most important natural resources. Launch of the mission is planned for 2020.

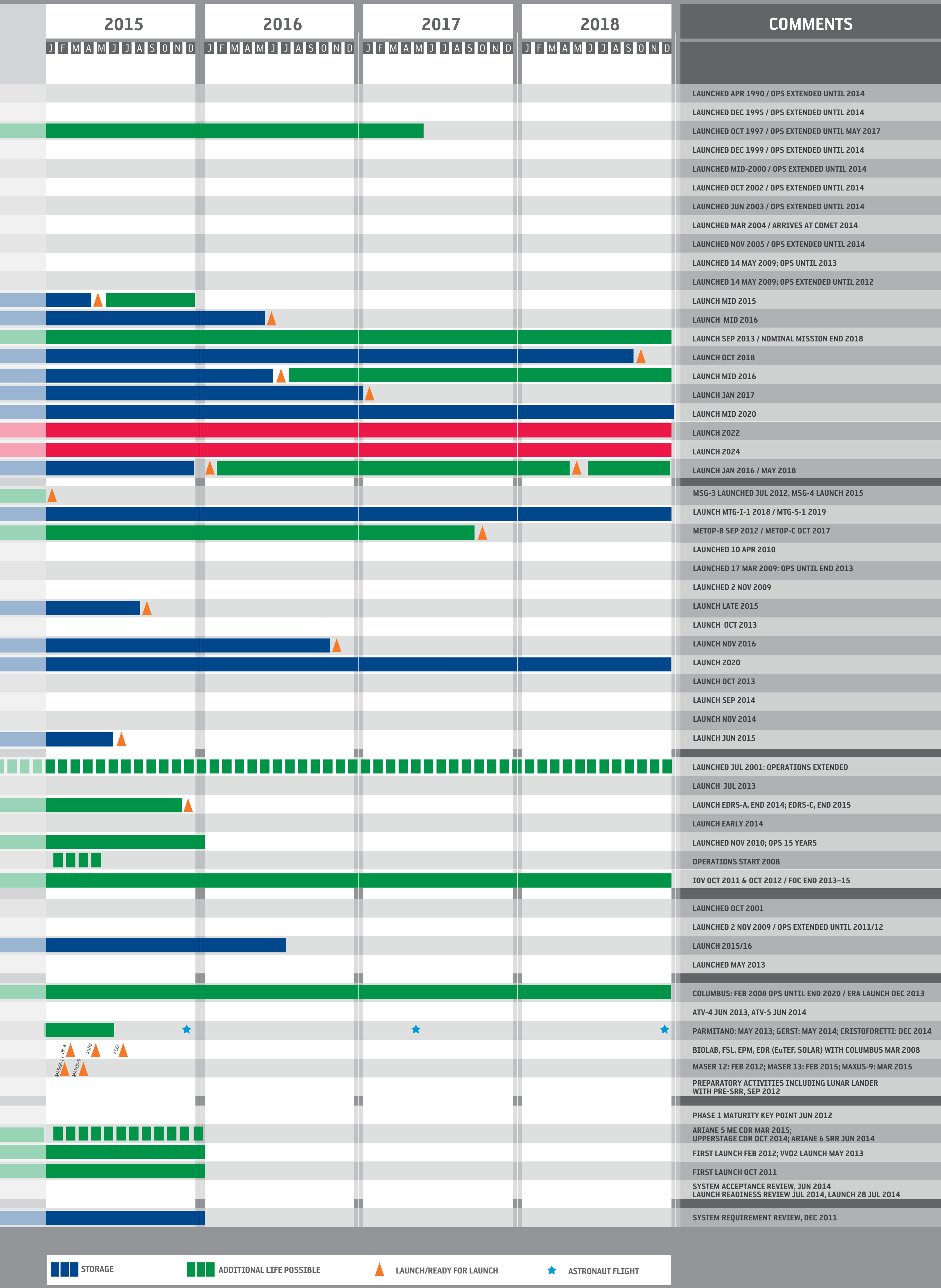
→ PROGRAMMES IN PROGRESS

Status at end April 2013



Alphasat after tests in Intespace's anechoic test chamber, Toulouse, France, 15 March. Alphasat will be launched on an Ariane 5 in July

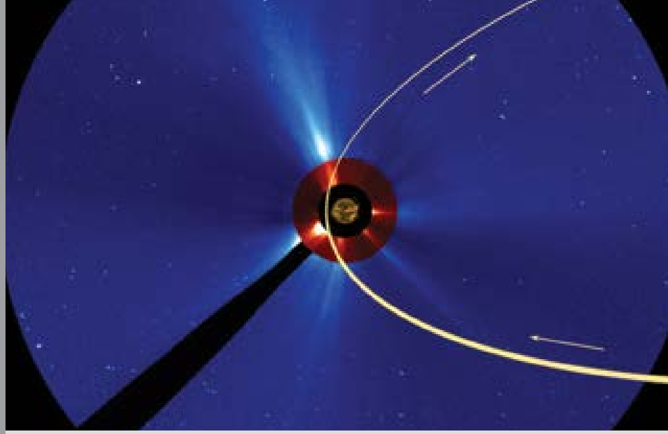

2011
2012
2013
2014
J F M A M J J A S O N D
SCIENCE & ROBOTIC EXPLORATION PROGRAMME
HUBBLE
SOHO
CASSINI-HUYGENS
XMM-NEWTON
CLUSTER
INTEGRAL
MARS EXPRESS
ROSETTA
VENUS EXPRESS
HERSCHEL
PLANCK
LISA PATHFINDER
MICROSCOPE
GAIA
JWST
BEPICOLOMBO
SOLAR ORBITER (M1)
EUCLID (M2)
JUICE (L1)
COSMIC VISION M3
EXOMARS
EARTH OBSERVATION PROGRAMME
MSG
MTG
METOP
CRYOSAT
GOCE
SMOS
AEOLUS
SWARM
EARTHCARE
BIOMASS
SENTINEL-1
SENTINEL-2
SENTINEL-3
SENTINEL-5 PRECURSOR
TELECOMMS/NAVIGATION PROGRAMMES
ARTEMIS
ALPHASAT
EDRS
SMALLGEO
HYLAS
GNSS-1/EGNOS
GALILEO
TECHNOLOGY PROGRAMME
PROBA-1
PROBA-2
PROBA-3
PROBA-V
HUMAN SPACEFLIGHT PROGRAMME
COLUMBUS / NODE-2 / NODE-3 / CUPOLA / ERA
ATV
ASTRONAUT FLIGHTS
VITTORI
KUIPERS
PARMITANO
GERST
CRISTOFORETTI
ELIPS ISS UTILISATION
FASTER
EML
FASES
TRIPLELUX A
TRIPLELUX B
CYTOSKEL
ELIPS NON-ISS PAYLOADS
MASER-12
TRANSPORTATION & HUMAN EXPLORATION
LAUNCHER PROGRAMME
ARIANE 5 POST-ECA
ARIANE 5 ME & ARIANE 6
VEGA
SOYUZ AT CSG
IXV
SSA
PREPARATORY PROGRAMME
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 2014
LAUNCHED DEC 1995 / OPS EXTENDED UNTIL 2014
LAUNCHED OCT 1997 / OPS EXTENDED UNTIL MAY 2017
LAUNCHED DEC 1999 / OPS EXTENDED UNTIL 2014
LAUNCHED MID-2000 / OPS EXTENDED UNTIL 2014
LAUNCHED OCT 2002 / OPS EXTENDED UNTIL 2014
LAUNCHED JUN 2003 / OPS EXTENDED UNTIL 2014
LAUNCHED MAR 2004 / ARRIVES AT COMET 2014
LAUNCHED NOV 2005 / OPS EXTENDED UNTIL 2014
LAUNCHED 14 MAY 2009; OPS UNTIL 2013
LAUNCHED 14 MAY 2009; OPS EXTENDED UNTIL 2012
LAUNCH MID 2015
LAUNCH MID 2016
LAUNCH SEP 2013 / NOMINAL MISSION END 2018
LAUNCH OCT 2018
LAUNCH MID 2016
LAUNCH JAN 2017
LAUNCH MID 2020
LAUNCH 2022
LAUNCH 2024
LAUNCH JAN 2016 / MAY 2018
MSG-3 LAUNCHED JUL 2012, MSG-4 LAUNCH 2015
LAUNCH MTG-I-1 2018 / MTG-S-1 2019
METOP-B SEP 2012 / METOP-C OCT 2017
LAUNCHED 10 APR 2010
LAUNCHED 17 MAR 2009: OPS UNTIL END 2013
LAUNCHED 2 NOV 2009
LAUNCH LATE 2015
LAUNCH OCT 2013
LAUNCH NOV 2016
LAUNCH 2020
LAUNCH OCT 2013
LAUNCH SEP 2014
LAUNCH NOV 2014
LAUNCH JUN 2015
LAUNCHED JUL 2001: OPERATIONS EXTENDED
LAUNCH JUL 2013
LAUNCH EDRS-A, END 2014; EDRS-C, END 2015
LAUNCH EARLY 2014
LAUNCHED NOV 2010; OPS 15 YEARS
OPERATIONS START 2008
IOV OCT 2011 & OCT 2012 / FOC END 2013–15
LAUNCHED OCT 2001
LAUNCHED 2 NOV 2009 / OPS EXTENDED UNTIL 2011/12
LAUNCH 2015/16
LAUNCHED MAY 2013
COLUMBUS: FEB 2008 OPS UNTIL END 2020 / ERA LAUNCH DEC 2013
ATV-4 JUN 2013, ATV-5 JUN 2014
PARMITANO: MAY 2013; GERST: MAY 2014; CRISTOFORETTI: DEC 2014
BIOLAB, FSL, EPM, EDR (EuTEF, SOLAR) WITH COLUMBUS MAR 2008
MASER 12: FEB 2012; MASER 13: FEB 2015; MAXUS-9: MAR 2015
PREPARATORY ACTIVITIES INCLUDING LUNAR LANDER
WITH PRE-SRR, SEP 2012
PHASE 1 MATURITY KEY POINT JUN 2012
ARIANE 5 ME CDR MAR 2015;
UPPERSTAGE CDR OCT 2014; ARIANE 6 SRR JUN 2014
FIRST LAUNCH FEB 2012; VV02 LAUNCH MAY 2013
FIRST LAUNCH OCT 2011
SYSTEM ACCEPTANCE REVIEW, JUN 2014
LAUNCH READINESS REVIEW JUL 2014, LAUNCH 28 JUL 2014
SYSTEM REQUIREMENT REVIEW, DEC 2011
STORAGE
ADDITIONAL LIFE POSSIBLE
LAUNCH/READY FOR LAUNCH
ASTRONAUT FLIGHT

KEY TO ACRONYMS

AM:	Avionics Model	LEOP:	Launch and Early Orbit Phase
AO:	Announcement of Opportunity	MoU:	Memorandum of Understanding
AIT:	Assembly, integration and test	PDR:	Preliminary Design Review
AU:	Astronomical Unit	PFM:	Proto-flight Model
CDR:	Critical Design Review	PLM:	Payload Module
CSG:	Centre Spatial Guyanais	PRR:	Preliminary Requirement Review
EFM:	Engineering Functional Model	QM:	Qualification Model
ELM:	Electrical Model	SM:	Structural Model
EM:	Engineering Model	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
ITT:	Invitation to Tender		



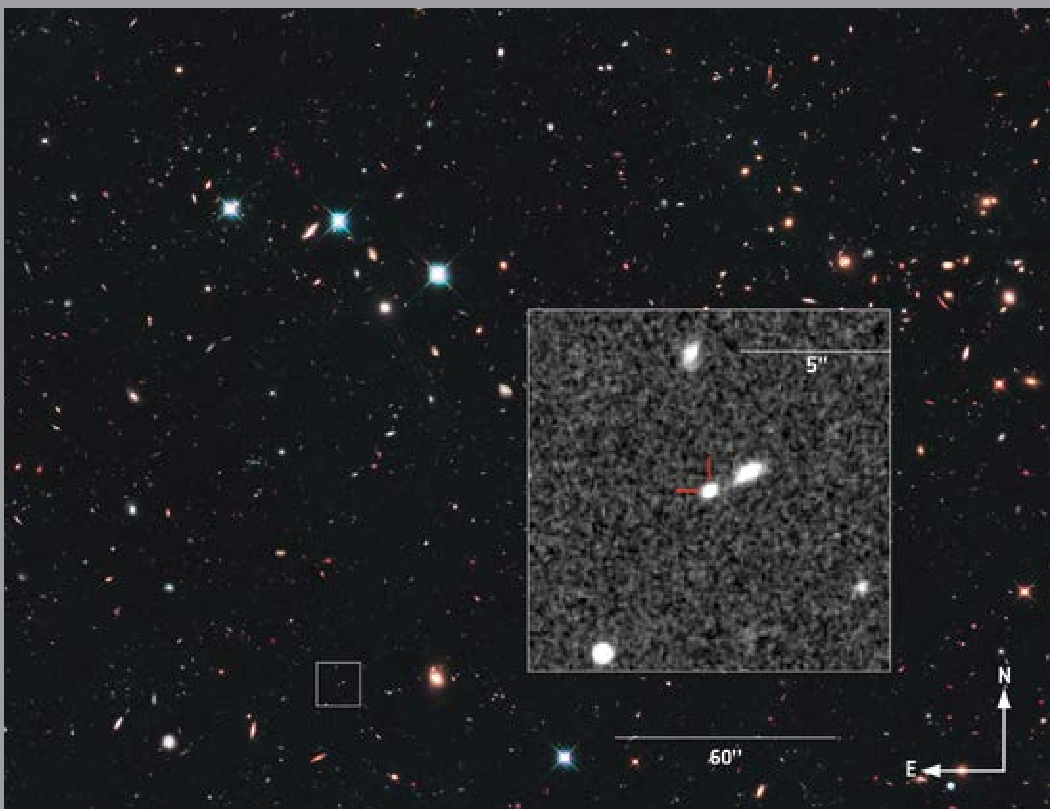
SOHO's LASCO C2 and C3 coronagraphs are expected to have a view of Comet ISON as it passes through their fields of view. From SOHO's viewpoint, the comet enters from the lower right early on 27 November and exits towards the top near the end of November

→ HUBBLE SPACE TELESCOPE

Hubble has found the farthest known supernova. This supernova exploded more than 10 billion years ago, at a time the Universe was in its early formative years and stars were being born at a rapid rate. The supernova, designated SN UDS10Wil, belongs to a special class of exploding stars known as Type Ia supernovas. These bright beacons can be used as yardsticks for measuring cosmic distances, thereby yielding clues to the nature of 'dark energy', the force accelerating the rate of expansion of the Universe. Knowing what triggers Type Ia supernovas will also show how quickly the Universe enriched itself with heavier elements, such as iron. These exploding stars produce about half of the iron in the Universe, the raw material for building planets, and life.

→ SOHO

Comet C/2012 S1 was discovered in 2012 by Russian astronomers Vitali Nevski and Artyom Novichonok using data from the International Scientific Optical Network (for that reason, it is also known as Comet ISON). This comet is on course for a close encounter with the Sun on 28 November, when it will pass at a distance of only 2.7 solar radii from the centre of the Sun. Since Comet ISON was discovered so far out, beyond the orbit of Jupiter, and will pass so close to the Sun, many think that this could turn out to be a major event and it may become visible even during daylight. An observing campaign involving a number of solar missions, including SOHO, is being planned to watch the comet as it passes by the Sun.



The supernova SN UDS10Wil in Hubble's Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey (CANDELS) field. The box pinpoints the supernova's host galaxy in the CANDELS survey (NASA/ESA/STScI/JHU)

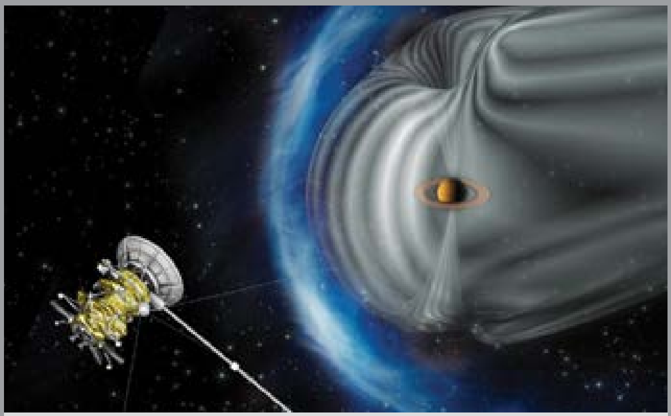
→ XMM-NEWTON

In December, one of the CCDs in one of the two EPIC MOS cameras suffered from what appears to be a repeat of an earlier event in 2005, which disabled CCD #6 in the same camera. This time, an event was registered in the focal plane of the EPIC MOS1 instrument, in the form of a bright flash of light. This event appears to have damaged CCD #3 in a similar way to the 2005 event, which was interpreted as a micrometeoroid impact. A number of new hot pixels and columns have also developed on some of the other detectors. There is no scientific impact for on-axis sources and a very limited impact for off-axis sources.

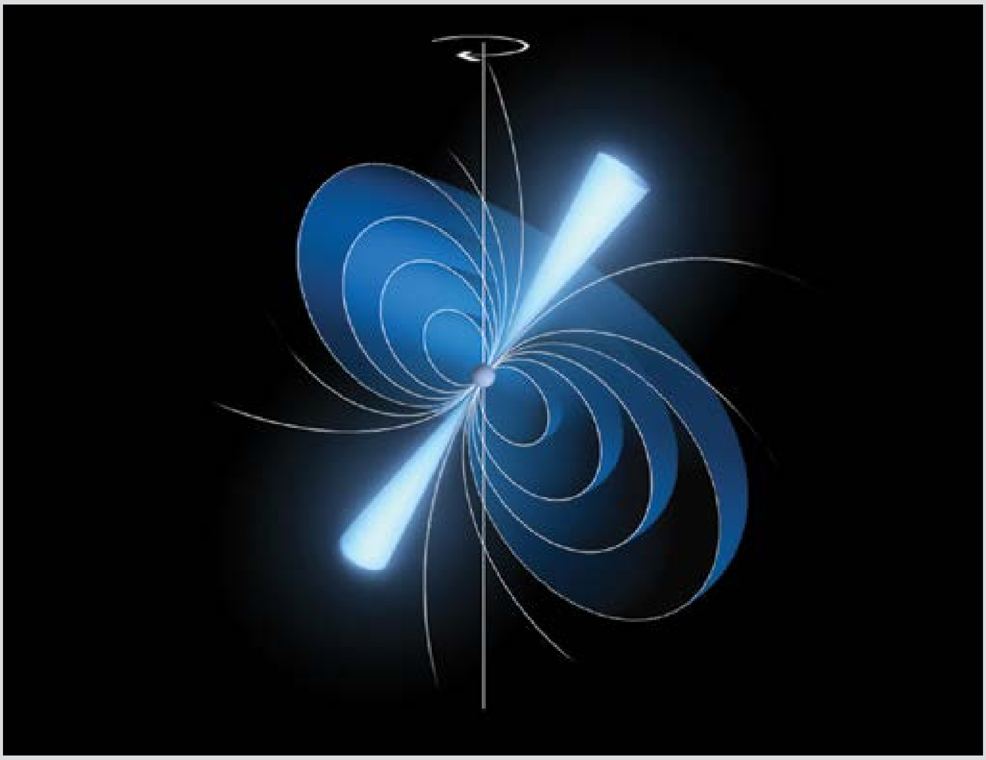
XMM-Newton has made observations of a pulsar, which were meant to help understand how these objects produce radio and X-ray emission, but have done exactly the opposite. Pulsars are rapidly spinning neutron stars that produce beamed emissions that 'pulse', like the beam of a lighthouse. The pulsar, called PSR B0943+10, was observed simultaneously in X-rays by XMM-Newton and in radio waves revealing that this source, whose radio emission is known to 'switch on and off' irregularly, exhibits the same behaviour in X-rays, but in reverse. This means that when the pulsar is bright in X-rays, it is faint in radio waves and vice versa. This is the first time that such behaviour has been detected from a pulsar. None of the current models for pulsar emission are able to explain this switching behaviour, which occurs within only a few seconds and so these observations have reopened the debate about the physical mechanisms powering the emission from pulsars.

→ CASSINI–HUYGENS

While crossing the bow shock (the transition region between the magnetosphere of Saturn and the interplanetary medium) on 3 February 2007, Cassini recorded a particularly strong shock under a 'quasi-parallel' magnetic field configuration, during which significant electron acceleration was detected for the first time. The findings provide significant new insight into particle acceleration and processes suspected at the shocks surrounding the remnants of supernova explosions.



Cassini exploring the magnetic environment of Saturn. Saturn's magnetosphere is shown in grey, the complex bow shock region is in blue



A pulsar with glowing cones of radiation stemming from its magnetic poles: a state referred to as 'radio-bright' mode (ESA/ATG Medialab)

→ CLUSTER

Last autumn, the spacecraft were separated into the widest configuration so far in the mission, around 36 000 km at the magnetopause, as part of a Cluster Guest Investigator (GI) special operation to investigate large-scale wave generation. First results reveal unique data describing the interaction of an interplanetary coronal mass ejection with the magnetosphere and its impact on the structure of the magnetopause. Inner magnetosphere observations were also made during this period in support of the newly launched NASA Van Allen probes mission. Cluster is now configured to investigate the nose of the magnetopause for another set of GI observations, the auroral regions before summer and, in September, two of the Cluster spacecraft will reach their closest separation since launch, about 5 km. Science and operations planning continue in anticipation of the launch of ESA's Swarm mission. Cluster and Swarm will make unparalleled combined measurements of the complex coupling between Earth's magnetosphere and inner core magnetic field.

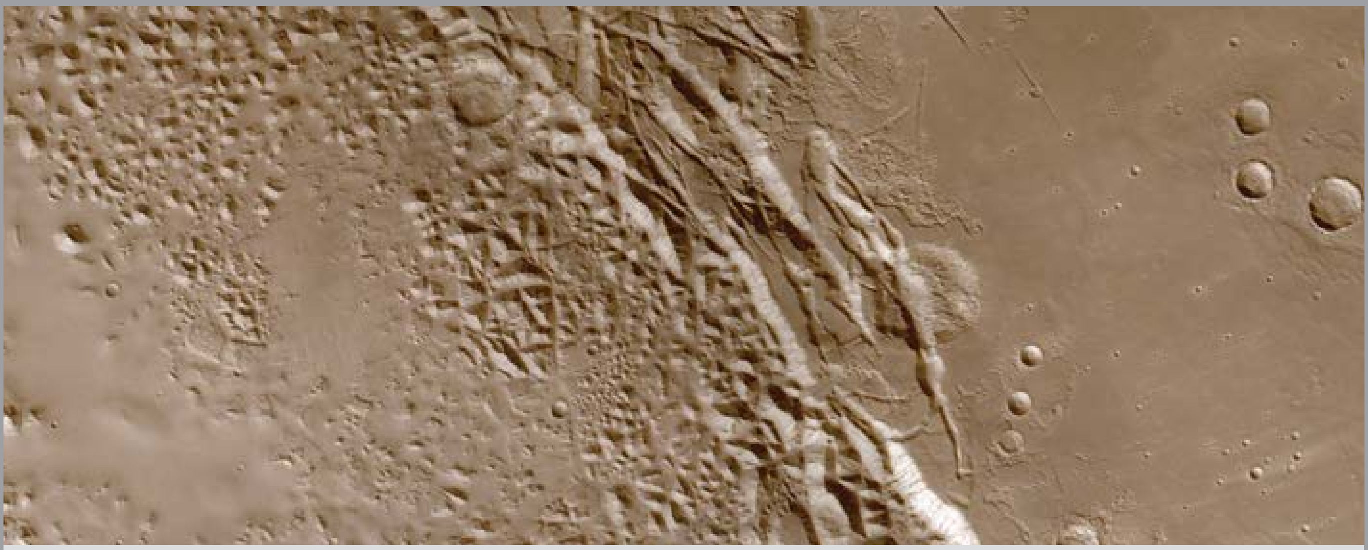
→ INTEGRAL

Integral observed a bright X-ray flare coming from NGC 4845 (47 million light-years away), a galaxy never before detected at high energies. By analysing the characteristics of the flare, it was determined that the emission came from a halo of material around the galaxy's 300 000 solar-mass central black hole as it tore apart and fed on an object of 14–30 Jupiter masses. The latter mass range corresponds to 'brown dwarfs', substellar objects that are not massive enough to fuse hydrogen in their core and ignite as stars. However, it could have had an even lower mass, just a few times that of Jupiter, placing it in the range of gas-giant planets. Recent studies have suggested that free-floating planetary-mass objects of this kind may occur in large numbers in galaxies, ejected from their parent solar systems by gravitational interactions. Note that only its external layers were consumed by the black hole, amounting to about 10% of the object's total mass, and that a denser core has been left orbiting the black hole. This is the first time that astronomers have seen the disruption of a substellar object by a black hole. The flaring event in NGC 4845 can be seen as a warm-up act for a similar event expected in the supermassive black hole at the centre of our own Milky Way, perhaps even this year. In this case, a compact cloud of gas amounting to just a few Earth masses has been seen spiralling towards the black hole and is predicted to meet its fate soon.

→ MARS EXPRESS

The spacecraft is in solar conjunction from 28 March until 2 May. During this period behind the Sun, there are no instrument operations except for the radio science solar corona measurements that are monitoring coronal mass ejections. The team at ESOC have put in a lot of effort to be able to bridge this five-week period with full spacecraft autonomy in fewer than 117 commands to the spacecraft, another challenge for Mars Express.

The recommissioning of the Super Resolution Channel (SRC) of the camera has been completed with the confirmation that science data can be returned as before. The SRC can be used again for science observations, in particular for astrometric observations of Phobos planned at the end of the year.



Taken by Mars Express in 2012, from an altitude of about 500 km, an image of the boundary between the plateau south of the Valles Marineris canyon system and Aurorae Chaos (ESA/DLR/FU Berlin)

→ VENUS EXPRESS

Since early in the mission, data from Venus Express have shown a large variability in several independent phenomena throughout the atmosphere of Venus. Now one additional variable parameter has been identified, this time with a long-term variability, derived from data from the SpicaV ultraviolet spectrometer. The amount of sulphur dioxide (SO_2) above the cloud layer (about 70 km altitude) has been found to vary by up to a factor of ten during the mission so far.

After having had a fairly low value of about 0.2 parts per million (ppm) at time of arrival of Venus Express, it quickly rose to more than 0.4 ppm in just about a year, after which a monotonic decay was observed over a six-year period to drop below 0.05 ppm. This resembles to some extent the debated observations by Pioneer Venus during the years 1978 to 1994. An obvious source for this large change could be an episodic injection by one (or several) major volcanic eruptions.

Even though Venus has a very thick atmosphere, models have shown that a large eruption would create a hot buoyant gas plume that could float up to high altitudes and so significantly change the abundances of the specific species that are typical in a volcanic eruption, like SO_2, water vapour and CO_2, in a fairly short time. This process is more likely than a direct injection by the force of the plume itself, which would not be strong enough to push through the dense atmosphere to a significant height.

An alternative explanation could be a periodic change in the dynamics of atmospheric circulation causing air from lower altitudes, where the SO_2 concentration is higher, to mix with air at higher altitudes. There are however no indications that this happens and the possible processes initiating such a change are also not clear.

Active volcanism has long been assumed to exist on Venus but direct observations have so far not been made. Strong indications of very recent volcanoes have been found in data from the VIRTIS instrument. Some surface areas appear to be very young, and these coincide with geological structures that resemble volcanoes, plus gravity measurements have shown anomalies matching that expected from active volcanoes.

→ ROSETTA

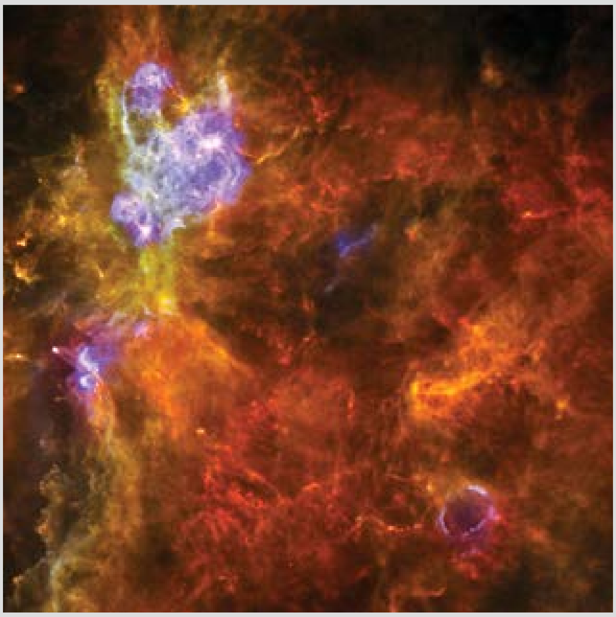
The spacecraft is set to wake up on 20 January 2014, when it will be 5.39 AU away from Earth and 4.49 AU away from the Sun. Science and operations teams are preparing the details for the rendezvous, the landing on the comet surface and the comet escort phase.

→ HERSCHEL

Spacecraft and ground segment continue to perform well, now operating in 'bonus time' beyond the predicted end-of-helium dates. As was always the plan, science observing will continue until Herschel actually runs out of its superfluid helium coolant, which is now expected to happen at any moment.

The activities for the post-helium phase have been defined. The spacecraft will eventually be injected into a well-defined heliocentric orbit, where it will remain indefinitely, with a campaign of three separate velocity change manoeuvres. The initial 'departure manoeuvre' from L2 took place in March. The 'disposal manoeuvre' and the final 'draining manoeuvre' are scheduled for May, after which the spacecraft will be turned off.

Herschel continues to produce spectacular science results, a situation which will continue for years after end of observing. A recent example is imaging of an area in the giant molecular cloud W3, providing new clues to how high-mass stars form. W3 is a giant molecular cloud spanning almost 200 light-years, containing an enormous stellar nursery, some 6200 light-years away in the Perseus Arm, one of our Milky Way galaxy's main spiral arms. For a long time, the formation of massive stars (with eight solar masses or more) has presented a conundrum. As they form, their own radiation pressure makes mass accretion gradually more difficult, eventually stopping further growth. Now these Herschel observations hint of a way around the problem,



Herschel view of part of the W3 giant molecular cloud where massive star formation is taking place. Dense, bright blue knots of hot dust marking massive star formation dominate the upper left of the composite image (ESA/PACS/SPIRE/HOBYS) given that the formation takes place in specific favourable surroundings, the problem can be alleviated, which is suggested to happen in W3.

→ PLANCK

The Low Frequency Instrument (LFI) continues to gather observations and its eighth sky survey is under way. The sorption cooler (required to keep the LFI detectors at a low temperature) is performing so well that it is no longer planned to regenerate it (an operation that extends its lifetime) since it is expected to be able to cool the LFI until end of operations in August.

Planck data were released to the public on 21 March, including all-sky maps at each of Planck's frequencies and of the major physical components of emission. Among these, the most important is the all-sky map of the Cosmic Microwave Background. At the same time, 28 scientific papers based on this data were made public by the Planck Collaboration. The 47th ESLAB conference took place at ESTEC in April to showcase Planck's scientific results in both cosmology and astrophysics. See the conference website **http://www.congrexprojects.com/13a11**

→ PROBA-2

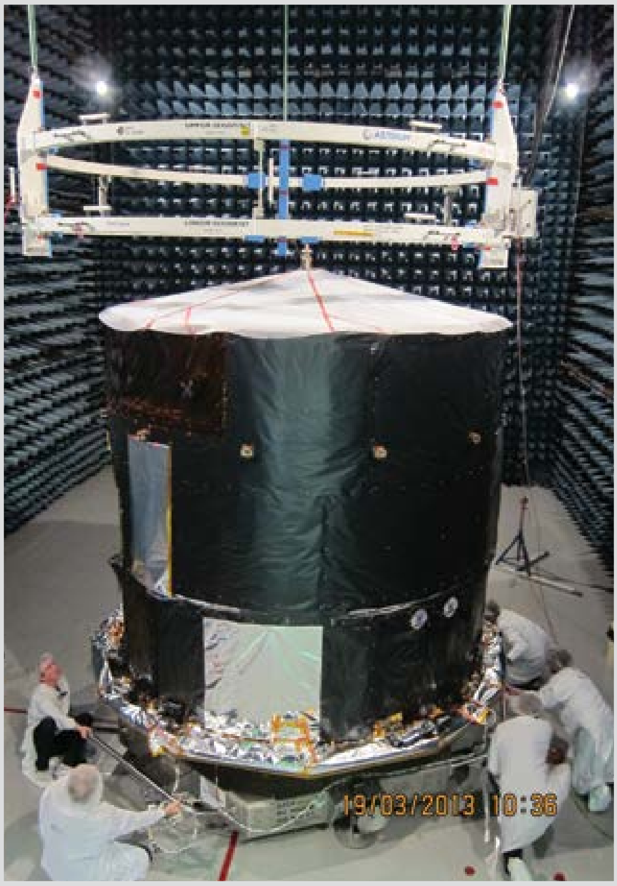
Images of the solar disc were acquired in the extreme-ultraviolet every two minutes by the SWAP instrument, and LYRA made 20 samples per second of solar irradiation at several wavelengths. Engineering, fully calibrated data and movies are available several hours after acquisition. The new long-coverage movies show the solar disc evolution over one solar rotation – the Carrington Rotation.

Educational booklet ready-to-use for teachers and students

Besides technology demonstration and scientific investigations on solar data, some educational activities have been initiated. One of the activities, the Junior College, is supported by the Proba-2 instrument team members, in collaboration with the Royal Observatory of Belgium, Brussels, and Leuven University in Belgium. In the Junior College activity, pupils at secondary level and their teachers are offered ready-to-use school material that integrates smoothly into the official curriculum. Parts of the mathematics and physics curricula are covered on a theoretical and practical basis using data from the SWAP imager, including example calculations to correct for detector artefacts, satellite rotations, distances to the Sun, and more.

→ GAIA

All activities on the SVM and PLM were completed. The two modules were mated on 31 January. In March, the integrated spacecraft was transferred to Intespace for the final environmental acceptance tests. All planned fuel tank pressurisation and leak checks, acoustic and sine vibration tests and electromagnetic compatibility tests were



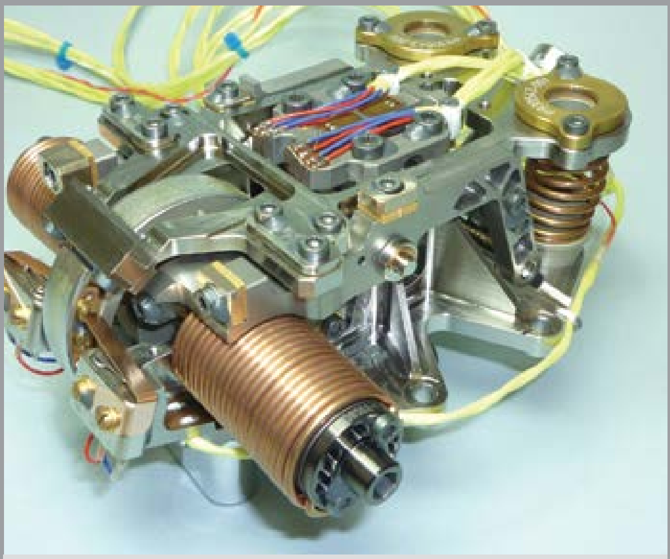
Gaia Flight Model in the electromagnetic compatibility test chamber at Intespace in Toulouse (Astrium) performed. The power control and distribution box was replaced after an anomaly identified during the thermal vacuum test of the SVM. The AIT campaign is proceeding and the schedule margins allocated for the PLM thermal tests and spacecraft mechanical acceptance were not used. Launch is now set for 19 September.

The first slot of the System Validation Test campaign on the FM was completed in January. The development/test of the software modules necessary for the scientific part of the in-orbit commissioning is on track. The Ground Segment Readiness Review began in March. Activities with Arianespace progressed and the Final Mission Analysis Review with the launcher authorities began in January.

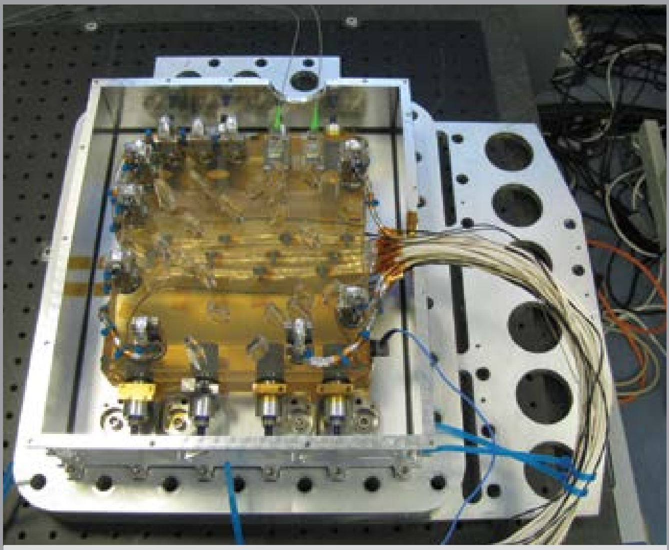
→ LISA PATHFINDER

The Propulsion Module and the Science Module remain in storage after system environmental tests and the Qualification Review Part 1. The detailed design review of the latest software that operates with the new cold-gas micropropulsion system took place in April. Cold-gas micropropulsion engineering and procurement activities proceed and qualification status reviews for all equipment have been completed. Shipment of the completed launch lock mechanism FM is planned for May.

The complete Inertial Sensor Head QM is readying for environmental testing. One of the key technology flight items, the set of interferometers achieving picometre metrology and mounted on an ultra-stable bench, has been delivered. Launch will be on the third Vega VERTA launch, with Rockot as the back-up launch vehicle.



LISA Pathfinder launch lock mechanism actuator developed by RUAG Space (RUAG)



Mounted on its vibration adaptor, the LISA Pathfinder optical bench flight model developed by the Universities of Glasgow and Birmingham and Mullard Space Science Laboratory (UK)

→ BEPICOLOMBO

The Mercury Planetary Orbiter (MPO) FM was sent to Turin for electrical harness integration. The thermal balance test of Mercury Transfer Module (MTM) STM at 10 Solar Constants was completed. Observed temperatures are within predictions. This positive result removes one of the major remaining risks for the MTM. The STM environmental test campaign is complete and efforts now concentrate on the spacecraft FM development.

Two more important achievements were the completion of the mission life test in a hot environment of the actuator for the Antenna Pointing Mechanism and the selection of the solar cell flight baseline. The spacecraft CDR identified several issues that will be closed during a CDR later in 2013.

Instrument FMs are being finalised and acceptance testing is ongoing for most payloads. Payload deliveries will contain four QMs for initial integration on the MPO. These models will be exchanged with the instrument FMs after completion of the thermal/vacuum test. Mercury Magnetospheric Orbiter flight unit integration is complete and functional verification is ongoing.

Work on launch vehicle interfaces concentrated on the outstanding structural issues, such as the unexpected high shock levels propagating into the spacecraft. In ground segment development, the second delivery of the mission control system took place. Compatibility tests with the FM transponder and the spacecraft Engineering Test Bench are ongoing. Launch readiness will be achieved in mid 2016.

→ MICROSCOPE

The procurement of the ESA-provided cold-gas micropropulsion system is progressing, and the software PDR of this system took place in March.

→ EXOMARS

The cooperation agreement between ESA and Roscosmos was signed in Paris on 14 March. This is now the governing document for the two ExoMars missions in 2016 and 2018, and provides a framework for future cooperation between the partners.

The SM mechanical test campaign for the 2016 Trace Gas Orbiter (TGO) Entry, Descent and Landing Demonstrator Module (EDM) was completed at ESTEC and Thales Alenia Space Italy. The SM will now be used to prove planetary protection procedures. The main structural elements of the TGO FM have been built and tested by CASA, and delivered to OHB for the next level of assembly with the propulsion system and secondary structures. For both modules the Avionics Test Benches have started and the first version of software merged with the first computer models. The four TGO payloads are in development and the two Russian instruments have completed their PDRs.

The Phase-B study for the 2018 mission is proceeding with teams from ESA, Roscosmos, Lavochkin and Thales working on requirements and architectural concepts. An avionics architectural review was held in March in Moscow to finalise responsibilities for computer, parachute and separation mechanism contributions. ESA will provide the computer to manage all operations except surface platform operations. The surface platform, being a Russian responsibility, will be operated using a Russian-supplied computer. The Rover will also feature an ESA-provided computer dedicated to Rover operations.

The Rover 2 m Drill and Sample Preparation and Distribution System elements started Mars environment test campaigns. A Science Working Team meeting was held at ESTEC for all scientific participants including the Russian partners. Procurement has started for the ground segment mission control system to be used for the Trace Gas Orbiter (also for operations in the 2018 mission).

→ SOLAR ORBITER

Most subsystem PDRs, several unit PDRs and Equipment Qualification Status Reviews have been completed. The first spacecraft subsystem CDR is ongoing. Manufacturing of several structural elements for the spacecraft STM has started (where not dependent on CDR).

The On-Board Computer EM was delivered for testing by the prime contractor. This is a milestone, marking the start of hardware build-up of the On-Board Computer Test Bench that will lead into the spacecraft Engineering Test Bench, one of the three hardware spacecraft models.

ExoMars Entry, Descent and Landing System Demonstrator Module Structural Model bioseal test

Solar Orbiter SoloHI instrument Baffle Assembly Qualification Model

More tests of surface-treated materials at ESTEC under simultaneous high temperature and high ultraviolet flux have been completed. Further tests will verify their behaviour under electron and proton fluxes, to investigate their suitability for high-temperature multilayer insulation for the back of the antennas, heatshield and feed-through coatings.

The METIS coronagraph instrument has been reconfigured and its development has been reinitiated. The EPD-STEIN sensor was also reconfigured (renamed EPD-STEP) and moved from instrument boom to spacecraft body. Instrument STMs are being readied for shipment to the prime contractor in summer and autumn 2013. Ground segment reviews and documentation are on schedule.

Two supplementary launch opportunities (July 2017 and October 2018) have been added to the baseline opportunities in January and March 2017 and the back-up opportunity in August 2018. NASA issued the Request for Launch Services Provision and confirmed its contribution to Solar Orbiter on 28 March.

→ JAMES WEBB SPACE TELESCOPE

The first flight instrument, the Fine Guidance Sensor from the Canadian Space Agency, has been integrated. Preparation for integrating the second flight instrument (MIRI) has been completed. The cryogenic functional and performance test of the NIRSpec flight instrument has been completed.

NASA has completed the manufacturing of two 'fast track' microshutter arrays with slightly adjusted geometry to mitigate the observed high number of 'failed closed' shutters in the present FM. The new array samples have been acoustically tested using the NIRSpec EM, and no stuck shutters were observed. New FM microshutter arrays are being manufactured.

MIRI thermal shield during thermal balance test (NASA)

The thermal balance test of the MIRI thermal shield was completed and measured performance is exceeding specification. The plan for the MIRI coolers made by JPL has been revised to accommodate a longer development time.

→ EUCLID

The Phase-B2 PLM activities began in December with Astrium SAS. Activities such as the definition of the interfaces with the instruments and the early procurement of long lead items, such as telescope silicon carbide structures and the dichroic plate element, are progressing. The ITT for the prime contractor was issued in December. Offers are presently under evaluation by ESA.

The procurement of the Near Infrared Spectro-Photometer (NISP) detectors is proceeding. The contract with Teledyne Imaging Sensors (USA) is proceeding. EMs have been produced and are under test. Procurement of the CCD detectors for the Visible Imager (VIS) has also started. A contract was signed with e2v (UK) in February; activities have started because this development is on the critical path for the VIS instrument and the entire project. Phase-B2 activities have also started on two scientific instruments (VIS and NISP) and the Science Ground Segment developed by the Euclid Consortium, actively monitored by ESA and PLM contractor.

→ SMOS

The RFI situation keeps improving in particular over Europe and North America, which has greatly improved the sea-surface salinity data over the northern hemisphere above 60° latitude. A joint workshop with NASA's Aquarius mission (observing sea-surface salinity) brought both science teams together at IFREMER, Brest (FR), to discuss common science activities and how to best exploit these complementary missions.

→ GOCE

Release 4 of gravity field models, based on about 27 months of GOCE data, is now publicly available. These models confirm that the objectives of the mission were met with the data acquired to the end of 2012. Meanwhile, in its fifth year of operations, GOCE continues to deliver top-class data in the form of gravity gradients and satellite-to-satellite tracking data, as well as gravity field models and derived quantities. The health of the satellite is excellent, while running on the redundant main onboard computer.

The mission team has executed its plan for lowering the satellite orbit by 20 km to significantly improve the spatial resolution of the gravity field data. A further lowering is under consideration for the very final phase of the mission. It is predicted that the mission will come to a natural end in late 2013. In an orbit as low as GOCE's, this will be followed swiftly by reentry into Earth's atmosphere.

→ CRYOSAT

New results on the decrease of sea-ice volume in the Arctic were published, showing that between the ICESat and CryoSat-2 periods (2009–12) the autumn ice volume has declined more than that foreseen by current models like PIOMAS. The CryoSat user community held a workshop in Dresden (DE) to discuss topics related to data quality.

→ ADM-AEOLUS

The laser transmitter FM has been used to screen the newly procured optics. In this set up, it has operated for three consecutive weeks with stable laser performance of 115 mJ, producing over 90 million laser shots. The reproducibility of the behaviour and the stability of operation are seen as very positive signs in this long development. The qualification of the Aladin optical bench was completed. The micro-vibration emission test for the Laser Chopper Mechanism has demonstrated very low emissions, providing assurances that the laser frequency stability will not be disturbed by this mechanism in flight.

The ADM-Aeolus laser integration team during the air test preparation (Selex ES)

The scientific impact study led by European Centre for Medium-range Weather Forecasts has confirmed that the estimated instrument performances (random and bias wind observation errors) will have a significant impact on numerical weather predictions.

→ SWARM

While waiting for a Rockot launch slot, the time has been used to investigate possibilities of reducing further the magnetic stray field seen by the Absolute Scalar Magnetometers and, in this way, improve the quality of the satellites' accuracy in measuring Earth's magnetic field. The launch date has been delayed to October while investigations are carried out on the Rockot launcher upper stage to correct an anomaly that occurred during a launch in January.

→ EARTHCARE

An important platform milestone was the delivery of the PFM structure by RUAG (CH) to Astrium. This was followed by the integration fit-check of the Cloud Profiling Radar SM. EM activities are also progressing with the delivery and test of integration software, Mass Memory and Formatting Unit and instrument ICUs.

The Multi Spectral Imager Engineering Confidence Model (ECM) thermal vacuum tests concluded and the ECM is being prepared for mechanical testing. The detailed design of the ATLID instrument subsystems is progressing and pre-CDR analysis and tests are being run to confirm the design of these complex sub-assemblies.

In Japan, JAXA completed the mechanical qualification of the Cloud Profiling Radar and began the CDR process with the radar prime contractor.

→ METEOSAT

MSG

Meteosat-8/MSG-1

Meteosat-8 has been repositioned at 3.9°E longitude and operations are normal. Meteosat-8 is now the operational back-up for Meteosat-9 and 10.

Meteosat-9/MSG-2

The satellite is in good health and performance is excellent. Meteosat-9 has been relocated at 9.5°E longitude and 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 now Eumetsat's operational satellite located at 0° longitude, 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

A new Mirror Scan Drive Unit for the SEVIRI instrument was delivered to Astrium GmbH, Friedrichshafen, in March after testing in Thales Alenia Space in Cannes. The repaired SEVIRI instrument should be back at Thales in September for reintegration on MSG-4. Launch is planned for the beginning of 2015.

MTG

The PDR Board for MTG-I will be reconvened in April to close the review. PDRs relating to the satellite and associated main elements (platform and instruments) will be completed by mid-2013. At subsystem and equipment level, PDRs are under way. The Lightning Imager instrument SRR is progressing with collocation planned for April. Best Practice Procurement activities are almost complete with selection of 95% of preferred suppliers complete.

→ METOP

MetOp-A

All instruments continue to perform excellently in orbit. MetOp-A completed its planned six years of life in October and its extended operation is confirmed, at least, up to the MetOp-B end of commissioning in 2013.

MetOp-B

System validation is complete, also for the ground segment, for Level 1 and 2 products, including the progressive data dissemination and as well the full characterisation of the services to end users. Most Level 1 and 2 products will be operational in Spring 2013.

MetOp-C

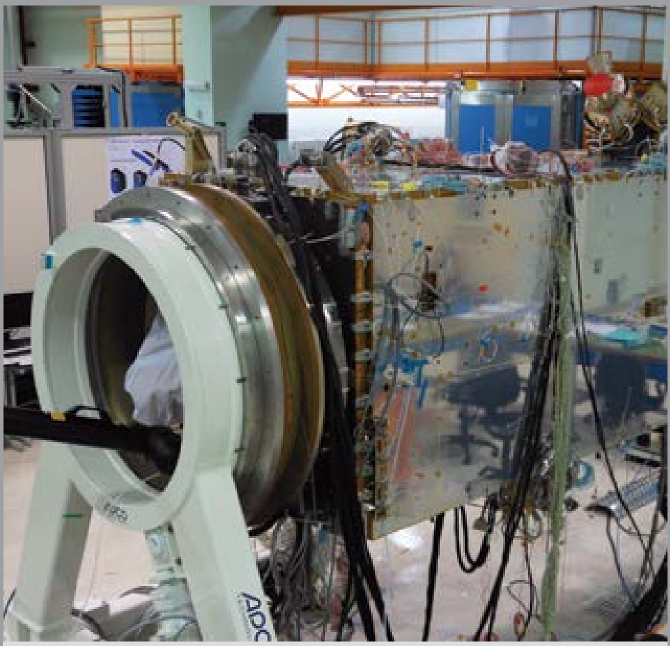
The satellite is stored as three separate modules (platform, payload, solar array). Annual reactivations and tests are planned for the modules to guarantee their healthy status when needed for launch. The open issues on instruments and platform will be closed in 2013 to allow a complete test during reactivation in 2014. MetOp-C will be launched on a Soyuz-Fregat from French Guiana; the launch window starts in October 2017. If needed, the satellite can be readied in a short time, between 12 and 18 months after request.

→ SENTINEL-1

AIT for Sentinel-1A is progressing at Thales Alenia Space Italy, Rome, with all equipment integrated on the platform. The thermal vacuum/thermal balance tests begin in April, followed by the integration of the large Synthetic Aperture Radar (SAR) antenna and solar array wings.

After delivery of the SAR payload for Sentinel-1A, the payload prime contractor Astrium GmbH focused on integration and test of the Sentinel-1B SAR payload. The Optical Communication Payload is already integrated on Sentinel-1A.

Definition of the launch campaign, the Launch and Early Operations Phase and the commissioning phase is progressing well, the latter with the preparation of the tools and ground equipment (including the Calibration and Performance Analysis Facility, the Calibration Transponder and Prototype SAR Processor). The Final Mission Analysis Review of the Sentinel-1A Soyuz launch vehicle is progressing, for a launch from Kourou in October.



Fully integrated Sentinel-1A platform in Rome (Thales Alenia Space Italy)

→ SENTINEL-2

The payload instrument PFM of the Visible and Near-Infrared focal plane has been fully characterised with excellent performance for radiometry and geometry. The Short Wave Infrared (SWIR) focal plane was also characterised for radiometry with good performance. A new problem of severe contamination of the PFM SWIR focal plane is under analysis. The telescope PFM is integrated and ready to host the two focal planes.

Image quality activities are progressing with the qualification review of the Ground Prototype Processor. An airborne calibration campaign over a deciduous forest is scheduled for mid-2013. A simplified level-2 prototype processor is being developed to analyse the feasibility of several geophysical products and prepare for the exploitation of the Sentinel-2 mission.

→ SENTINEL-3

Integration of the different satellite element FMs continued. The Sentinel-3A Platform was delivered to the prime contractor facilities in February. The SRAL (SAR Radar Altimeter) PFM testing is almost complete and should be delivered by the end of June. Testing of the PFM camera for OLCI (Ocean and Land Colour Instrument) is nearly complete.

Assembly of the SLSTR (Sea and Land Surface Temperature Radiometer) is proceeding. Validation of satellite avionics is progressing in the Functional Chain Validation (FCV) at satellite EM level. FCV-2, dealing with the instruments, is nearly completed.

A call for collaborative validation support was extremely successful, with 80 proposals submitted from 20 countries, confirming the very high interest in the Sentinel-3 mission.

Sentinel-3A platform arriving at prime contractor facilities in France (Thales)

→ SENTINEL-4

Industry focused on the completion of actions from the PDR. The Best Practice Procurement process continues with more than 90% (by value) of anticipated ITTs and Requests for Quotations being released in March in EMITS (and CORDIS for the FP7 co-funded activities). The remainder of the Best Practice Procurement is almost essentially non-flight hardware.

→ SENTINEL-5 PRECURSOR

Progress was made with FM equipment on the EADS/Astrium platform. The Platform CDR is being prepared for June. Dutch Space concluded the payload-level CDR on the TROPOspheric Monitoring Instrument (TROPOMI). Hardware deliveries include the EM Instrument Control Unit (ICU) and EGSE. A compatibility test was performed between the EM platform Payload Data Handling Unit and the EM Instrument Control Unit. The Short Wave Infrared (SWIR) EFM detector mounting was completed, allowing assembly to be completed for the start of characterisation testing in April.

Level-0/1b processors are developed by KNMI under a frame contract funded by the Netherlands Space Office (NSO) that also includes TROPOMI Calibration Requirements definition and Operations support. Level-2 Processors SRR/PDR was concluded in January feeding into the overall ground segment PDR. Launcher studies of Vega and Rockot are ongoing.

→ PROBA-V

The satellite is at Europe's Spaceport in Kourou, French Guiana, ready for the Vega VV02 launch. The spacecraft was fully retested after arrival in Kourou and then integrated on the Vespa multi-passenger adaptor before being installed on Vega. Final readiness tests were performed on the ground segment at Redu (BE) and the ground station network.

→ EDRS

A public–private partnership contract for development and launch was signed between ESA and Astrium in October. The EDRS-A Payload – comprising a Laser Communication Terminal (LCT) and a Ka-band inter-satellite link – will be carried on Eutelsat's EB9B satellite, built by Astrium and positioned in geostationary orbit at 9°E. This first of the two EDRS nodes will be launched in 2014.

The second EDRS node, carrying the EDRS-C Payload which includes a second LCT, will be launched into its geostationary slot at 31°E at the end of 2015 on a dedicated satellite built by OHB based on the SmallGEO platform; it will also embark Avanti's Hylas-3 as a 'hosted payload'.

Proba-V on the Vespa payload adaptor, with Vega fairing in background

The PDR was passed in October and early production of hardware for EDRS-A began. The CDR cycle started with the EDRS-A Payload CDR in April, to be followed by the EDRS-C space segment CDR in May.

→ SMALLGEO AG1

Integration of the Repeater Module, Core Platform Module and Propulsion Module are progressing at Tesat, OHB and Avio respectively. The latter two elements will be mated later this year, this being the key step in AG1 platform integration depending on the Qualification and Acceptance Readiness review. OHB is continuing the Platform EM test campaign with Electrical Propulsion System and Telecommand and Telemetry System tests.

→ SMALLGEO PRODUCT LINE

The assessment of the Baseline Design Review data package for the chemical propulsion configuration is ongoing and the final review will take place later in the year. OHB is defining a full electrical propulsion configuration (FLEX). A mid-term review, identifying key trade-offs for future payload accommodation, took place at OHB. The final review for the FLEX configuration will take place this summer.

Alphasat being prepared by the Astrium integration team for 'workmanship' acoustic test

→ ALPHASAT

After thermal vacuum testing, the satellite was submitted to a 'workmanship' acoustic test. The final System Functional Test campaign is now under way. This includes testing the Inmarsat payload, the four ESA Technology Demonstration Payloads and the platform. Launch is planned for July. Preparations for operations of the satellite, in the Launch and Early Orbit Phase as well as In-Orbit Testing, are ongoing.

→ ALPHABUS PRODUCT LINE

The Alphabus Extension programme is extending the Alphabus product range up to 22 kW. Several unit CDRs are being held. The preliminary design stage of the Deployable Panel Radiator, which is a major feature to improve overall heat rejection capability, is complete.

→ ADAPTED ARIANE 5 ME & ARIANE 6

Following the 2012 Ministerial Level, and the subscription to Adapted Ariane 5 ME (Mid-life Evolution) and Ariane 6 activities, a new organisation was implemented for the three projects: Adapted Ariane 5 ME, Upper Stage and Commonalities and Ariane 6.

Adapted Ariane 5 ME

Authorisation to proceed has been given for the specific Adapted Ariane 5 ME activities. A frame contract is under preparation for Adapted Ariane 5 ME activities, Upper Stage and Commonalities and Ariane 6. Industrial activities are ongoing, in particular on the fairing. The HSS3+ fairing separation system compatibility assessment was performed and showed that HSS3+ is compatible with Ariane 5 ME loads and that no design changes are required.

Upper Stage and Commonalities

Authorisations to proceed for the Ariane 5 ME/Ariane 6 Commonalities Assessment and the Common Upper Stage were placed in January. The first Key Point for the Commonalities Assessment was closed in March, during which the work plan on potential common subsystems and study topics was agreed. The second Key Point is on 30 April. The following areas were confirmed for commonalities: studies and impact studies on the Vinci engine, fluid control equipment, engine thrust frames, thrust control equipment, propellant tanks and attitude control systems.

Ariane 6

Phase-A/B1 began in February. The Request for Quotation was sent out and industrial proposals are expected in April. For launcher configuration selection, a first important technical milestone was the screening of the concepts, down-selecting those for the first trade-off phase. A second workshop in March agreed a short-list of concepts (all three stages to orbit, with cryogenic liquid oxygen and hydrogen upper stages but with different lower composites). Procurement activities for avionics and lower composite demonstrators and the ground segment are also ongoing.

→ VEGA

Activities focused on the launcher Vehicle Development contract, with the close-out of the subcontracts of the prime contractor. The launch vehicle qualification certificate was revised.

Technical development activities are close to completion, in particular with the Ground Qualification Review (CSI Qualification Review), the Vega Secondary Payload Adapter Qualification Review and the Flight Programme Software Qualification Review. On the ground segment, final transfer of property to ESA is scheduled to take place in May. In the meantime, a temporary provision was granted to Arianespace for the VV02 launch campaign.

After transfer of the VV02 first stage to the Mobile Gantry, the second stage was integrated on 20 February and the third stage on 2 March. On 9 March, the AVUM was integrated, completing mechanical integration of the launcher. Following the secondary payload fuelling, the Combined Operations Campaign (POC) of VV02 (VERTA 1) began on 27 March with the integration of the secondary payloads on the launcher.

The Vega VV02 first stage installed on the Mobile Gantry

→ IXV

In Phase-D/E1, all subsystems are in manufacturing and qualification, to begin vehicle assembly by mid-2013 and for delivery of the flight and ground segments by mid-2014. The preliminary mission analysis review for the Vega launcher started, including the safety submission process to CNES relevant authorities. Meanwhile, ESA has issued the Request for Quotation for Phase-E2/F (the flight into space), and the industrial proposals should be received by June. Efforts are being made to implement the Vega/IXV flight by the third quarter of 2014.

→ FUTURE LAUNCHERS PREPARATORY PROGRAMME

The SCORE-D (Stage COmbustion Rocket Engine Demonstrator) Engine PDR was completed in January; follow-on activities will be significantly adapted to support upper-stage cryogenic engine upgrades as well as generic cryogenic technologies.

Pressure Oscillation Demonstrator (POD-X) activities are progressing with the delivery of the three segments (loaded motor case). The demonstrator segment integration is confirmed for July, and a first hot firing test is planned in October at the CAEPE test centre, France.

Industrial activities are progressing in different Cryogenic Upper Stage Technologies topics, such as the Gas Port Phase Separator, the Jettisonable Fluid Ground Connector and the Liquid Hydrogen Propellant Management concept (LH2 PMD) with real fluid on a sounding rocket. Materials & Structures activities are progressing on several subjects such as the metallic/composite Interstage Structure. Implementation of the Integrated Solid Rocket Motor composite casing activity began.

→ HUMAN SPACEFLIGHT

February heralded a significant anniversary for European research activities, with the Columbus laboratory celebrating

The STS-122 crew, including ESA astronauts (from left) Hans Schlegel and Léopold Eyharts (NASA)

five years in orbit. Europe's permanent ISS laboratory was launched on STS-122 aboard Space Shuttle *Atlantis* on 7 February 2008 and was attached to the European-built Node 2 four days later. This mission included ESA astronauts Hans Schlegel and Léopold Eyharts, who undertook the first steps in commissioning Columbus.

→ ISS TRANSPORTATION

ATV *Albert Einstein*
A launch date of 5 June for ATV-4 has been confirmed by Arianespace. The Integrated Cargo Carrier was mated to the spacecraft in Kourou. The launch delay has been used to anticipate the loading of 509 kg of late cargo items (including the Columbus Water Pump Assembly spare), reducing the late cargo volume to be loaded to 620 kg.

ATV *Georges LeMaître*
All subsystems of ATV-5 have been integrated and readied for more activity at system level. The Integrated Cargo Carrier and spacecraft integration is proceeding at Astrium GmBH, Bremen, although at a slower pace because of the ATV-4 delay.

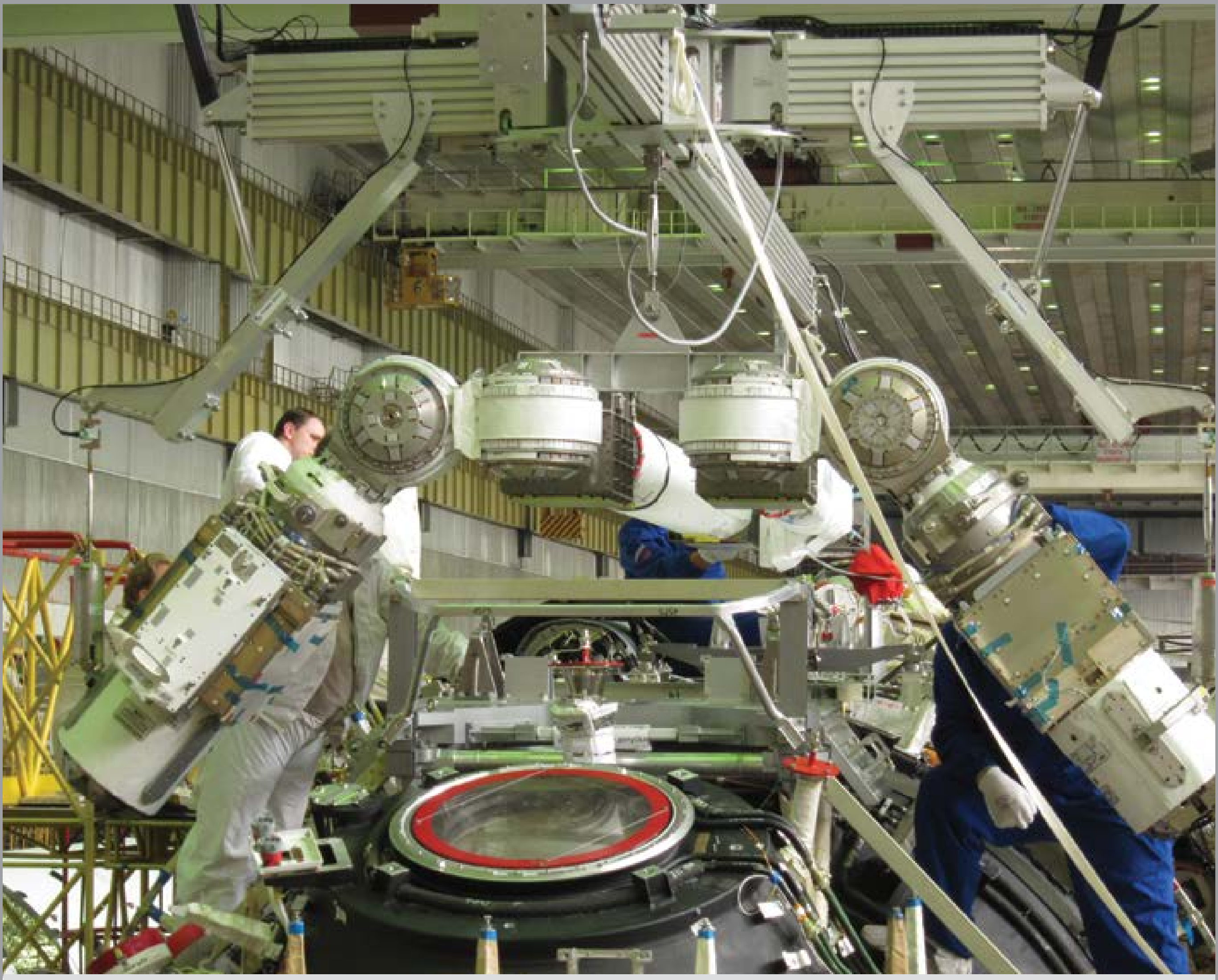
Multi-Purpose Crew Vehicle (MPCV)
The procurement proposal for the full MPCV European Service Module development was approved on 9 January. Progress has been made in consolidation of ESA/NASA bilateral documents, which will become the contractual baseline for the Phase-C/D Request For Quotation. Major challenges are still the mass requirement and the schedule.

→ ISS DEVELOPMENT/EXPLOITATION

The Erasmus User Support & Operations Centre (USOC) will stop activities at ESTEC. Erasmus activities will ramp down until the end of May and the European Drawer Rack facility is being moved to the Microgravity User Support Centre (MUSC) in EAC. Preparation for transfer of the remaining responsibilities to other USOCs is under way.

The Biolab microscope has been repaired. Final acceptance of the Biolab EM was finalised and the hardware shipped for launch on ATV-4. The Advanced Closed Loop System Delta Phase 1 Flight Safety Review was concluded on 1 March with a NASA Safety Review Panel supported by the ESA Payload Safety Review Panel.

An engineer checks the hinges on ATV-5's flight model solar panels at Dutch Space in the Netherlands (Dutch Space)



The European Robotic Arm being installed on the Russian Multipurpose Laboratory Module (Khrunichev)

European Robotic Arm (ERA)

Development of the ERA control centre in ESTEC is progressing. The telemetry data flow test with the Mission Control Centre Moscow was completed. The repair of the underwater training model in Star City (Russia) was completed in time for astronaut training. Discussions about ESA astronaut Alexander Gerst's involvement in ERA extravehicular activities and operations began. Launch is planned for 11 December. Sustaining engineering activities for ERA's 10 years on-orbit life are being discussed with Roscosmos.

Multipurpose End-To-End Robotic Operation Network (Meteron)

The Eurobot was delivered to ESTEC in March after upgrade for use in Meteron. Preparations continue for the next flight experiments of the Meteron suite: a standalone test of a single exoskeleton joint and tele-operation of Eurobot at ESTEC from ISS. Cooperation on telerobotics is being discussed with NASA and Roscosmos.

→ ISS UTILISATION

Human research

Expedition 34 Flight Engineers Chris Hadfield and Tom Marshburn continued as subjects of ESA's Reversible Figures experiment while Expedition 34 Commander Kevin Ford completed his fourth and final session before returning to Earth. This neuroscience experiment is investigating the adaptive nature of the human neuro-vestibular system in the processing of gravitational information related to 3D visual perception.

Neuroscience research continued with the conclusion of all on-orbit activities for Neurospat, which is investigating how crew members' three-dimensional perception is affected by long-duration stays in weightlessness. Hadfield, who is the fifth of five subjects, completed his second and final session of the experiment in February. Data were downlinked in March.

Sessions of ESA's Immuno experiment were continued by the Russian Flight Engineers Oleg Novitskiy, Evgeny Tarelkin (in January and March) and Roman Romanenko (in March). The aim of the Immuno experiment, which is performed under a bilateral cooperation agreement with Roscosmos, is to determine changes in stress and immune responses, during and after a stay on the ISS. The results will help in developing pharmacological tools to counter unwanted immunological side-effects during long-duration missions in space.

By 20 February, Marshburn and Hadfield had completed three sessions each of ESA's Circadian Rhythms experiment. The main objective of the experiment is to get a better basic understanding of any alterations in circadian rhythms in humans during long-duration spaceflight. On 22 February, the crew took the opportunity to explain the experiment during a public affairs event that was live-streamed on YouTube.

Kevin Ford completed all weekly questionnaires for the 'Space Headaches' experiment prior to his return to Earth in March. Hadfield and Marshburn also continued as test subjects. The questionnaires are being analysed on ground to help determine the incidence and characteristics of headaches occurring within astronauts in orbit that can be a common complaint.

Tom Marshburn started his 11-day session of the Energy experiment in March. The experiment features dietary monitoring and uses the ESA/NASA Pulmonary Function System to make cardiopulmonary measurements, and involves water and urine analysis in order to generate data for determining the energy requirements of astronauts. This will be used for future (exploration) missions in order to launch sufficient (but not excessive) crew supplies.

NASA astronaut Tom Marshburn wearing a sensor on his forehead used for the ESA Circadian Rhythms Experiment (NASA)

Biology research

The Seedling Growth experiment, which is a new joint ESA/NASA biology experiment, completed its first run in the European Microgravity Cultivation System at the end of March. The Seedling Growth experiment builds on previous space experiments with *Arabidopsis thaliana* seeds and studies the effects of various gravity levels on the growth responses of plant seedlings (roots and shoots; wild and genetically modified). The research will provide insight into the cultivation of plants on long-duration missions.

Fluids research

Multiple science runs for the additional Geoflow-2b experiment inside the Fluid Science Laboratory continued. Geoflow-2b is investigating the flow of an incompressible viscous fluid held between two concentric spheres rotating about a common axis as a representation of a planet.

Materials research

Following furnace repair activities, the Materials Science Laboratory (MSL) operations were resumed with the processing of a sample cartridge for each of the MICAST, CETSOL and SETA projects in the facility's Solidification and Quenching Furnace. The Batch 2a experiments are all studying different aspects of the solidification process in metal alloys that will help to optimise industrial casting processes.

In addition to MSL activities, preparations have started in Columbus for the arrival of the Electro Magnetic Levitator on ATV-5. This will perform containerless materials processing in the European Drawer Rack, involving melting and solidification of electrically conductive, spherical samples, under ultra-high vacuum and/or high gas purity conditions for the determination of high-precision thermophysical properties – important for casting models in industry.

Radiation research

The DOSIS 3D experiment uses both active radiation detectors located in the European Physiology Modules facility and passive radiation detectors in different locations around Columbus. The passive detectors that have been in Columbus since October were returned to Earth in March for scientific analysis on Soyuz TMA-06. A new set of passive detectors will be sent to the ISS on Soyuz TMA-08M. The Tri-Axis Telescope (TriTel) experiment has acquired 99 days of data to 31 March using its active cosmic radiation detector hardware and passive detectors inside Columbus.

The Spheres Zero-Robotics Competition was supported from ESTEC, with European school teams present for the live-link competition event with astronauts Kevin Ford (left) and Tom Marshburn on the ISS. The algorithms used to control the free-floating satellites on the ISS during this session were written by competing students from 18 European teams and 27 US teams (NASA)

Solar research
On 15 February, the SOLAR facility celebrated its fifth year in orbit since its installation on Columbus.

Technology research
Two ISS astronauts completed the first two sessions of ESA's new CRUISE (Crew User Interface System Enhancement) experiment. CRUISE is a technology demonstration testing voice-guided procedure execution with real-time command and telemetry elements included. It aims to significantly improve crew operations and performance, for example, shortening task-to-completion time while reducing the occurrence of system/human error.

Non-ISS research
The latest Concordia winter-over season started in February, which includes a campaign of eight ESA experiments. The 15 crewmembers will be isolated at the Concordia base for the next nine months.

As part of the Drop Tower Utilisation programme carried out at the ZARM facilities in Bremen, 16 drops/catapult shots were carried out in February. The campaign was for the SlugBoiling Experiment, studying the physics of bubbly turbulent flows in weightlessness.

Seed cassettes for mounting in ESA's European Modular Cultivation System (NASA)


ESA-sponsored medical doctor Vangelis Kaimakamis begins the winter-over season at Concordia Base in Antarctica (ESA/IPEV/PNRA/E. Kaimakamis)

New advanced materials research projects with the European Commission (Accelerated Metallurgy, ThermoMag, ExoMet, COLTS, AMAZE) are progressing. The AMAZE project began in January. Close links with ELIPS projects are exploited in terms of science team members and flight experiments.

→ ASTRONAUTS

Luca Parmitano is undergoing final preparations for Expedition 36/37. He completed ATV training, passed ESA ATV rendezvous and docking final exams and continued payload training. Astronaut Alexander Gerst

Luca Parmitano undergoes Soyuz exams in the centrifuge at the Gagarin Cosmonaut Training Centre in Moscow (Reuters/S. Remezov)

Alexander Gerst and Samantha Cristoforetti during training on the Russian Orlan spacesuit in Moscow (GCTC)

(Expeditions 40/41) is undergoing medical tests for his mission along with the prime and back-up crews. Astronaut Samantha Cristoforetti (Expedition 42/43) carried out Columbus operator and payload training at EAC in March and trained together with Gerst on the Orlan spacesuit and the European Robotic Arm in Moscow. Astronauts Andreas Mogensen and Thomas Pesquet carried out EVA Pre-familiarisation Training at the Neutral Buoyancy Facility at EAC. Including international astronauts, 12 ISS crew members have been training at EAC since January. They completed ESA training on European ISS elements such as ATV, Columbus and ESA payloads.

→ TRANSPORTATION/EXPLORATION

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

Open actions from the IBDM and the IDSS Evolved Engineering Development Unit PRR have been closed. The IBDM Soft Docking System procurement is complete, to be followed by that of the Soft Docking System development, manufacturing and testing. Testing of the first demonstration unit of the IBDM Linear Electro-Mechanical Actuators has started. The IBDM separator mechanism design was updated and the new locking concept agreed. The breadboard for this mechanism is being manufactured. The breadboard for the lock down mechanism is also in production after the redesign to achieve reduced mass and power budgets.

The ISS Multilateral Coordination Board approved IDSS Revision B. This revision retains both mechanical and magnetic capture systems that are compatible with the docking standard and includes the previously agreed reduced docking loads.

Operations Avionic Subsystem (OAS)

The industrial activities for Phase-2 of the OAS are ongoing and Phase 3 mock-up development is starting.

Expert

Investigation continues for launch alternatives to Volna. The vehicle prime contractor is working with Orbital Sciences (USA) to determine the feasibility of launching Expert on a suborbital trajectory using two different launch systems (Minotaur and Pegasus Light). Talks also continue with NASA and the US Army for the possible use of SWORDS, a new rapid response system, as an option. The updated Athena small launcher family from Lockheed Martin was considered, but may be too costly for Expert objectives. As an alternative, Lockheed has proposed a solid two-stage launch system with hydrazine upper stage that could perform the mission for a lower price, being dropped from a C-17 carrier aircraft. Another possibility could be based on a sounding rocket. Lockheed has also proposed air recovery by helicopter as a way to simplify the choice of the launch site location.

→ LUNAR EXPLORATION ACTIVITIES

Lunar Lander Phase-B1

Preliminary SRR actions are being completed by the industrial consortium. The last Mission and System Study tasks are progressing (for example, Monte Carlo campaigns using the Eagle-based Guidance, Navigation & Control simulator). These will ensure a consolidated technical close-out of activities (April 2013), and a good basis for moving forward with work on key technologies. The Lidar breadboarding was completed in February: a design concept is available and was tested at component level.

Lunar Exploration New Strategy

The Moon remains one of ESA's three exploration destinations. Following the negative outcome for the Lunar Lander proposal at 2012 Ministerial Council, a new approach is being developed in cooperation with Russia on a sequence of missions: Luna-Resurs lander (critical European contributions to be adapted to the Russian platform, such as drill and landing technologies) and Lunar Polar Sample Return (a full-scale cooperation at mission-element level). Exchanges have started with Roscosmos, based on discussions held in 2012. To prepare for the 2014 Ministerial Council, development activities for Luna-Resurs under ESA's General Support Technology Programme funding are being proposed.

Exploration

An International Space Exploration Coordination Group (ISECG) meeting at senior agency management level took place in Montreal in April with representatives of 11 agencies. Agency managers discussed the draft ISECG white paper on the Benefits of Exploration and the second iteration of the Global Exploration Roadmap.

→ SPACE SITUATIONAL AWARENESS (SSA)

SSA Architectural Design

The first SSA Architectural Design contract passed the Mid-Term Review (MTR). The second Architectural Design contract passed the Space Surveillance and Tracking (SST) and Near-Earth Objects (NEO) segments Requirements Review. The MTR will start in April.

SSA/SST

The new Conjunction Prediction System and the Reentry Prediction System are being tested. In addition to ensuring the compliance of the delivered system, enhancements will be made to reflect the inputs received from the user community. In parallel, validation of the new system was performed with reference to the work of the project team to develop a new Conjunction Data Message (CDM) together with the Consultative Committee for Space Data Systems. The new ESA SST system is now able to generate fully compliant CDM messages.

The Space Surveillance and Tracking Centre is now receiving data from the first coordinated surveillance campaign, which uses multiple optical telescopes to generate and maintain a representative independent catalogue. The results will be used to enhance the development of coordination and data exchange procedures for future expert centres. Work has also finished on the evaluation of the Croce del Nord radar in Italy and its potential to perform space object detection.

SSA/SWE

The SSA Space Weather Coordination Centre (SSCC) was inaugurated in April in Brussels, the first such coordination centre opened under ESA's SSA Programme. The new centre will make sure that space weather precursor services are available for end users at **http://swe.ssa.esa.int/**

The centre also includes the first European space weather helpdesk providing information on space weather or SSA space weather services. Contact the helpdesk by email (**helpdesk.swe@ssa.esa.int**) or phone (**+32 2 790391**).

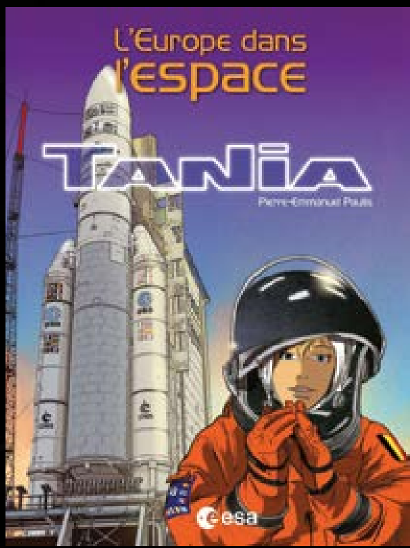
SSA/NEO

The close flyby of asteroid 2012 DA14 on 15 February and the unrelated impact on the same day of an asteroid (17 m diameter) in Chelyabinsk, Russia, triggered a lot of public attention and increased awareness of NEOs. Contract preparation has started for NEO activities during SSA Period 2. The ESA 1 m-diameter telescope detected its fifth near-Earth asteroid. A workshop on NEO impact effects and mitigation measures was prepared in May. Industry days were held with the new SSA Participating States: Poland, Romania and Czech Republic.

SSA Ground Segment Engineering

The preliminary test and validation of the monostatic breadboard radar are progressing in order to prepare for the radar final acceptance. Final integration of the radar at the site of Santorcaz, near Madrid, is nearly complete. Procurement began of the components for the bistatic breadboard radar assembly following completion of the Final Design Review.

→ TANIA: L'EUROPE DANS L'ESPACE



A new 'graphic novel' about Tania, the fictional European astronaut, has been published by Joker Editions of Belgium. It includes three cartoon stories: Tania, terreur sur le Cap, Tania, les diamants de l'espace and Tania, les oubliés de la Lune ('Tania, terror at the Cape', 'Tania, the diamonds of Space' and 'Tania, the forgotten of the Moon').

The author, Pierre-Emmanuel Paulis, is a space fan and a friend of ESA, known by all the ESA astronauts. He attaches a particular importance to making sure that his drawings are accurate and the technical details are correct. The book contains a foreword signed by ESA astronauts, and includes chapters about ESA and the US Apollo programme. It is available now on Amazon and in libraries, as well as from the publisher.

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Contact Joker Editions
11, Avenue De Visé – 1170 Bruxelles
Tel: +32 26 72 23 18
Fax: +32 26 75 17 97
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SP-705 // CD
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