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CAPCOM

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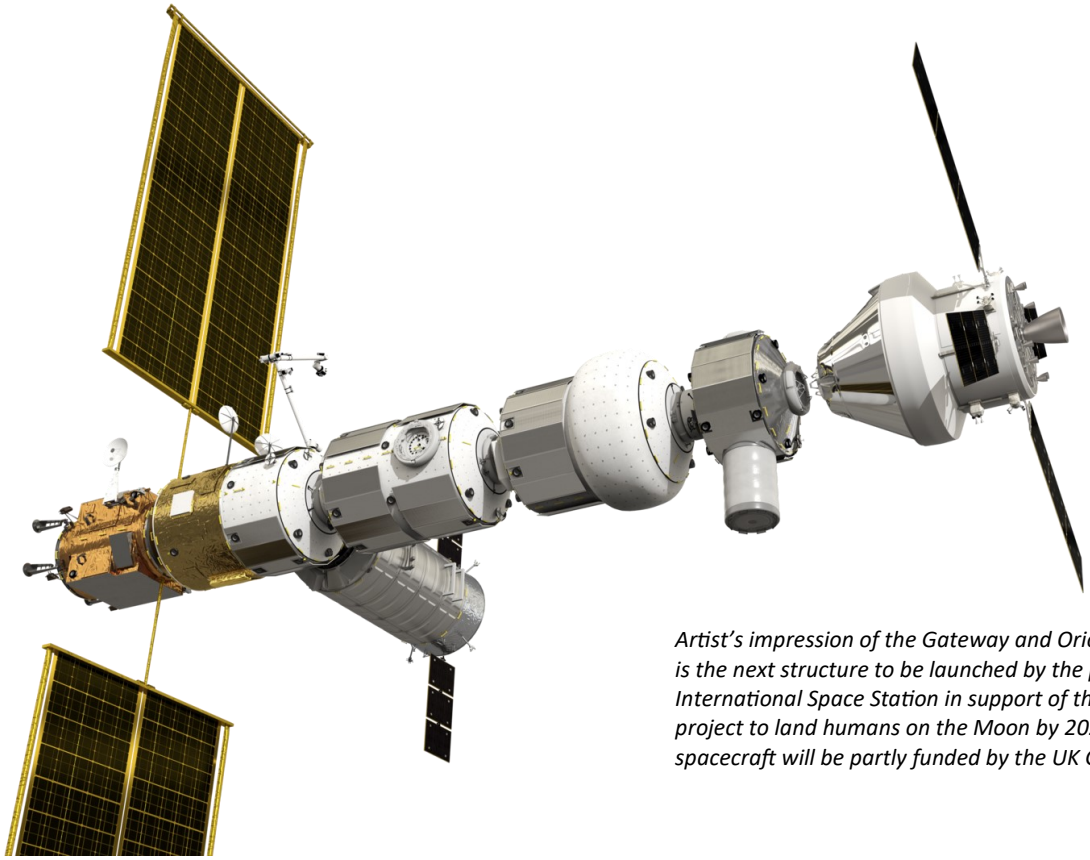
UK Government Invests in European Space Agency Programmes

The UK Space Agency has announced it will invest £374 million per year with the European Space Agency (ESA)

Cover Story



Artist's impression of the Gateway and Orion. The Gateway is the next structure to be launched by the partners of the International Space Station in support of the NASA Artemis project to land humans on the Moon by 2024. These spacecraft will be partly funded by the UK Government.

ESA
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CAPCOM is Produced by Go Space Watch for Midlands Spaceflight Society

www.gospacewatch.co.uk | www.midspace.org.uk

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Global Space News

The UK Space Agency has today (28 November) announced it will invest £374 million per year with the European Space Agency (ESA) to deliver international space programmes over the next 5 years.

The UK is one of the founding members of ESA, an inter-governmental organisation established in 1975 to promote cooperation in space research, technology and applications development. ESA is independent of the EU, bringing together countries across Europe and around the world.

Membership enables the UK to collaborate with space agencies across the world on projects like the International Space Station and the ExoMars programme to send a UK-built rover to search for signs of life on Mars.

The funding, confirmed today at the 2019 ESA Ministerial Council in Seville, Spain, is in line with the Space Innovation and Growth Strategy agreed between government and the UK space sector in 2010, to increase investment in ESA.

This investment will secure UK involvement in international space missions and the development of new technologies, including:

- building the Lunar Gateway, a new space station orbiting the moon
- returning the first samples from Mars
- new satellites to help us understand climate change
- an early warning system for solar storms
- research in space technology to deliver high-speed mobile technology such as 5G and satellite broadband services around the world
- removing space junk to prevent collisions in space

Business Secretary Andrea Leadsom said:

We are delighted to be making this investment in ESA today. From improving communication and connectivity, to helping us monitor the impact of climate change and protect our power grid, our membership of this international organisation will further our position as a space, innovation and climate superpower.

The UK joined all ESA member states in supporting a 10% rise to the overall space science budget (UK share around £600 million) to increase the number and ambition of space science missions. These include missions to use gravitational waves to study black holes and to intercept and study a comet in our solar system.

The combined international investment will fund the following international programmes (funding is committed in euros so all figures are subject to future foreign exchange rates (GBP/Euro):

£250 million for ESA's telecommunications programme, which could enable faster 5G connectivity through the development of new satellites

£180 million on the global exploration programme to bring back the first samples from Mars and support the US ambition to have a sustainable presence on the Moon through the Lunar Gateway and the lunar communications programme to support astronauts and robots on the moon

£80 million on space safety and security for a mission in partnership with the US to protect infrastructure in space and on Earth from space weather and to help remove space debris

In Seville, the UK also committed over £200 million investment in Earth Observation, including a UK-led TRUTHS mission to help tackle climate change and the ESA Copernicus Space Component, which runs to 2028.

Following investment from the UK and other member states, ESA has re-confirmed that all astronauts from the class of 2009, including Tim Peake, will return to the International Space Station before 2024. The timings will be confirmed by ESA in due course.

Additional investments include over £16 million on satellite navigation innovation, £12 million to support commercial spaceflight and over £30 million to support space technology, including help for small businesses to take advantage of the space sector.

The UK is now spending an average of almost £95 million per year to support telecommunications research and £80 million per year to support Earth observation and climate science projects.

European Space Agency (ESA)
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Tim Peake on his return from the ISS in 2016. This report confirms his revisit as a UK ESA astronaut to the station by 2024.

Ariane 5's Fourth Launch of 2019

On 26 November an Ariane 5, operated by Arianespace, delivered the TIBA-1 and Inmarsat-GX5 telecom satellites into their planned orbits.

Liftoff was announced at 21:23 GMT (22:23 CET, 18:23 local time) this evening from Europe's Spaceport in Kourou, French Guiana. The mission lasted about 34 minutes.

TIBA-1 with a launch mass of 5600 kg, was the first to be released after about 27 minutes. The 4007 kg Inmarsat-GX5 was released 7 minutes later.

TIBA-1 for broadband communications is owned and operated by the Government of Egypt. It has a design life of more than 15 years.GX5, owned and operated by Inmarsat, enhances mobile broadband services particularly for aviation passenger wifi and commercial maritime services in Europe and the Middle East. This satellite has a design life of more than 16 years.

The performance requested for this launch was about 10 495 kg. The satellites totalled about 9607 kg, with payload adapters and carrying structures making up the rest.

Flight VA250 was the 106th Ariane 5 mission.

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Go Space Watch

space exploration and astronomy for everyone

Honouring the Past… Prospects for the Future

Four lectures, four prominent Speakers.

We honour the 50th Anniversary of Apollo 13 and the 30th Anniversary of the launch of the Hubble Space Telescope.

A Public Space Lecture Event by Go Space Watch

Saving Apollo 13 by Dave Eagle FRAS;
The Legacy of the Hubble Space Telescope by Dr Steve Barrett (University of Liverpool);
Return to the Moon—A New Era by Dr James Carpenter (European Space Agency)
Science with the James Webb Space Telescope by Naomi Rowe-Gurney (University of Leicester)

Saturday 4th April 2020 from 10:00 am until 5:00 pm

at Sutton Arts Theatre, South Parade, Sutton Coldfield. B72 1QY.

Tickets (all day) at £10.00 per person from https://gsw4april.eventbrite.co.uk

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CAPCOM and MSS: The Future

Midlands Spaceflight Society — Go Space Watch

Midlands Spaceflight Society (MSS) will close in August 2020 after 30 years of continued operation.
How times have changed. It is time for a new chapter to begin.
Since its creation in the early 1990's MSS's Newsletter CAPCOM has communicated to its subscribers the latest news and information, including original articles and other contributions, about Space Exploration.
Beginning in the days long before the wonderful Internet came to be the valuable resource it is today, CAPCOM has been continually Edited and Produced by Michael Bryce, with Proof-Reading by Dave Evetts. This will continue with new plans to further develop the magazine content and appeal. Michael Bryce has set up a new Company "Go Space Watch" in order to carry on this venture and bring CAPCOM into the 21st Century.
Current subscribers through MSS will continue to receive CAPCOM Magazine until the end of this subscription on 31st August.
From 1st September 2020 the MSS Facebook group will become a Go Space Watch group.
New CAPCOM subscribers can sign up now through the Go Space Watch web site below.
CAPCOM will then be available as a printed document as it is currently or securely downloadable from the Internet after purchasing a subscription online.

Contribution Opportunity

Go Space Watch is looking for contributors for CAPCOM Magazine. Original Articles on all aspects of Space Exploration and Astronomy will be considered. Content ideas are also welcome. At present this would be on a voluntary basis but as CAPCOM is being made available world wide and could nurture future possibilities.

Public Speaking

Go Space Watch hold public lecture meetings around the West Midlands to further engage the general public of all ages in Space Exploration and Astronomy. Interested participants, either as Speakers or Attendees, should contact Go Space Watch at the email address or telephone number below. Go Space Watch is looking for low cost, good value meeting venues for these events.

Go Space Watch can be contacted at: **michael@gospacewatch.co.uk or 07821 896 304**

www.gospacewatch.co.uk

MSS Facebook Group: https://www.facebook.com/groups/midspace/
Go Space Watch Facebook Page: https://www.facebook.com/gospacewatch/

NASA's Newest Astronauts Ready for Space Station, Moon, and Mars Missions

NASA welcomed 11 new astronauts to its ranks Friday, increasing the number of those eligible for spaceflight assignments that will expand humanity's horizons in space for generations to come. The new astronauts successfully completed more than two years of required basic training and are the first to graduate since the agency announced its Artemis program.

The new graduates may be assigned to missions destined for the International Space Station, the Moon, and ultimately, Mars. With a goal of sustainable lunar exploration later this decade, NASA will send the first woman and next man to the surface on the Moon by 2024. Additional lunar missions are planned once a year thereafter and human exploration of Mars is targeted for the mid-2030s.

"These individuals represent the best of America, and what an incredible time for them to join our astronaut corps," said NASA Administrator Jim Bridenstine at the agency's Johnson Space Center in Houston where the graduation ceremony took place. "2020 will mark the return of launching American astronauts on American rockets from American soil, and will be an important year of progress for our Artemis program and missions to the Moon and beyond."

During Friday's ceremony, each new astronaut received a silver pin, a tradition dating back to the Mercury 7 astronauts, who were selected in 1959. They will receive a gold pin once they complete their first spaceflights.

This was the first public graduation ceremony for astronauts the agency has ever hosted, and Sens. John Cornyn and Ted Cruz of Texas were among the speakers at the event.

"For generations, the United States has been the world leader in space exploration, and Johnson Space Center will always be both the heart and home of human spaceflight activity," said Cornyn. "I have no doubt the newly minted astronauts will add to that history and accomplish incredible things."

Selected for training in 2017, the NASA astronaut candidates were chosen from a record-setting pool of more than 18,000 applicants.

"I congratulate these exceptional men and women on being the first graduating class of the Artemis program," Cruz said. "They are the pioneers of the final frontier whose work will help fortify America's leadership in space for generations to come. I am excited for the opportunities ahead of them, including landing the first woman ever on the surface of the Moon, and having the first boots to step on Mars."

Including the current class, NASA now has 48 active astronauts in its corps. NASA is also considering plans to open the application process this spring for the next class of astronaut candidates.

Training alongside the NASA astronaut candidates for the past two years were two Canadian Space Agency (CSA) astronauts who also participated in the graduation ceremony.

NASA's newest astronauts are:

Kayla Barron, a US Navy lieutenant, originally is from Richland, Washington. She graduated from the US Naval Academy with a bachelor's degree in systems engineering. A Gates Cambridge Scholar, Barron earned a master's degree in nuclear engineering from the University of Cambridge in the United Kingdom. As a submarine warfare officer, Barron served aboard the USS Maine (SSBN 741), completing three strategic deterrent patrols. She came to NASA from the US Naval Academy, where she was serving as the flag aide to the superintendent.

Zena Cardman calls Williamsburg, Virginia, home. She completed a bachelor's degree in biology and a master's degree in marine sciences at The University of North Carolina, Chapel Hill. Cardman was a National Science Foundation Graduate Research Fellow, working at The Pennsylvania State University. Her research focused on microorganisms in subsurface environments, ranging from caves to deep sea sediments. Her field experience includes multiple Antarctic expeditions, work aboard research vessels as both a scientist and crew member, and NASA analog missions in British Columbia, Idaho and Hawaii.

Raja Chari, a US Air Force colonel, hails from Cedar Falls, Iowa. He graduated from the US Air Force Academy with bachelor's degrees in astronautical engineering and engineering science. He continued on to earn a master's degree in aeronautics and astronautics from Massachusetts Institute of Technology (MIT) and graduated from the US Naval Test Pilot School in Patuxent River, Maryland. Chari served as the commander of the 461st Flight Test Squadron and the director of the F-35 Integrated Test Force at Edwards Air Force Base (AFB) in California.

Matthew Dominick, a US Navy lieutenant commander, was born and grew up in Wheat Ridge, Colorado. He earned a bachelor's degree in electrical engineering from the University of San Diego and a master's degree in

systems engineering from the Naval Postgraduate School in Monterey, California. He also graduated from the US Naval Test Pilot School. Dominick served on the USS Ronald Reagan as department head for Strike Fighter Squadron 115.

Bob Hines, a US Air Force lieutenant colonel, attended high school in Mountaintop, Pennsylvania, but considers Harrisburg, Pennsylvania, his hometown. He has a bachelor's degree in aerospace engineering from Boston University and a master's degree in flight test engineering from the US Air Force Test Pilot School at Edwards AFB. Hines served as a developmental test pilot on all models of the F-15 while earning a master's in aerospace engineering from the University of Alabama. He has deployed in support of Operations Enduring Freedom and Iraqi Freedom. Prior to being selected as an astronaut, he was a Federal Aviation Administration flight test pilot and a NASA research pilot at Johnson.

Warren Hoburg originally is from Pittsburgh. He earned a bachelor's degree in aeronautics and astronautics from MIT, and a doctorate in electrical engineering and computer science from the University of California, Berkeley. He is a commercial pilot, and spent several seasons serving on the Bay Area Mountain Rescue Unit and Yosemite Search and Rescue. Hoburg came to NASA from MIT, where he led a research group as an assistant professor of aeronautics and astronautics.

Dr. Jonny Kim, a US Navy lieutenant, was born and grew up in Los Angeles. He enlisted in the US Navy, then trained and operated as a Navy SEAL, completing more than 100 combat operations and earning a Silver Star and Bronze Star with Combat V. Afterward, he went on to complete a degree in mathematics at the University of San Diego and a doctorate of medicine at Harvard Medical School. Kim was a resident physician in emergency medicine at Massachusetts General Hospital in Boston.

Jasmin Moghbeli, a US Marine Corps major, considers Baldwin, New York, her hometown. She earned a bachelor's degree in aerospace engineering with information technology at MIT and a master's degree in aerospace engineering from the Naval Postgraduate School. She also is a distinguished graduate of the US Naval Test Pilot School. Moghbeli came to NASA from Yuma, Arizona, where she tested H-1 helicopters and served as the quality assurance and avionics officer for Marine Operational Test and Evaluation Squadron 1.

Loral O'Hara was born in Houston. She earned a bachelor's degree in Aerospace Engineering at the University of Kansas and a master's degree in Aeronautics and Astronautics from Purdue University. Prior to joining NASA, O'Hara was a Research Engineer at Woods Hole Oceanographic Institution in Woods Hole, Massachusetts, where she worked on the engineering, test, and operations of deep-ocean research submersibles and robots.

Dr. Francisco "Frank" Rubio, a US Army lieutenant colonel, originally is from Miami. He earned a bachelor's degree in international relations at the US Military Academy at West Point, New York, and a doctorate of medicine from the Uniformed Services University of the Health Sciences in Bethesda, Maryland. Rubio has accumulated more than 1,100 hours as a Blackhawk helicopter pilot, including 600 hours of combat and imminent danger time. He was serving as a surgeon for the 3rd Battalion of the Army's 10th Special Forces Group at Fort Carson, Colorado, before coming to NASA.

Jessica Watkins hails from Lafayette, Colorado. She graduated from Stanford University in Palo Alto, California, with a bachelor's degree in geological and environmental sciences, then went on to earn a doctorate in geology from the University of California, Los Angeles. Watkins has worked at NASA's Ames Research Center in Silicon Valley, California, and Jet Propulsion Laboratory in Pasadena, California, and was a postdoctoral fellow at the California Institute of Technology, where she collaborated on NASA's Mars Science Laboratory rover, Curiosity.

Canadian Spae Agency's newest astronauts are:

Joshua Kutryk, a Royal Canadian Air Force lieutenant colonel, is from Beauvallon, Alberta. He has a bachelor's degree in mechanical engineering, as well as master's degrees in space studies, flight test engineering, and defense studies. Prior to joining CSA, Kutryk worked as an experimental test pilot and a fighter pilot in Cold Lake, Alberta, where he led the unit responsible for the operational flight-testing of fighter aircraft in Canada.

Jennifer Sidey-Gibbons hails from Calgary, Alberta. She holds an honors bachelor's degree in mechanical engineering from McGill University in Montreal and a doctorate in engineering from the University of Cambridge. While at McGill, she conducted research on flame propagation in microgravity, in collaboration with CSA and the National Research Council Flight Research Laboratory. Prior to joining CSA, Sidey-Gibbons worked as an assistant professor in combustion in the Department of Engineering at Cambridge.

Astronaut candidate training for the new graduates included instruction, practice, and testing in spacewalking, robotics, International Space Station systems, T-38 jet proficiency, and Russian language. As astronauts, they will help develop spacecraft, support the teams currently in space and ultimately join the ranks of only about 500 people who have had the honor of going into space. NASA continues its work aboard the space station, which, in November, will celebrate 20 consecutive years of human occupation. The agency also is on the verge of launching astronauts again from American soil aboard American commercial spacecraft, and is preparing to send humans to the Moon as part of the Artemis program.

NASA
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First Artemis Rocket Stage Moved onto NASA Barge Ahead of Green Run

The first Artemis rocket stage is guided toward NASA's Pegasus barge on 8 January ahead of its forthcoming journey to NASA's Stennis Space Center near Bay St. Louis, Mississippi. Teams rolled out, or moved, the completed core stage for NASA's Space Launch System (SLS) rocket from NASA's Michoud Assembly Facility in New Orleans to the barge in preparation for the core stage Green Run test series. Pegasus, which was modified to ferry SLS rocket hardware, will transport the core stage more than 40 miles from Michoud to Stennis for the comprehensive core stage Green Run test series. Green Run, named for its testing of new, or green, hardware progressively, is the final test campaign ahead of the first Artemis launch.

NASA
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Rosetta's ongoing science

On 12 November 2014 Philae became the first spacecraft to land on a comet as part of the successful Rosetta mission to study Comet 67P/ Churyumov-Gerasimenko. Five years later, and after the mission's official end in 2016, Rosetta is continuing to provide insights into the origins of our Solar System.

Rosetta's instruments have already discovered that the comet contained oxygen, organic molecules, noble gases and 'heavy' or deuterated water different to that found on Earth. As scientists continue to analyse data from Rosetta's instruments, including the ionised gas or plasma, the results are improving our understanding of comets. Mission data is also being delivered to an archive as a future resource.

Rosetta orbits the Sun every 6.5 years and will pass the Earth again, visible from ground-based telescopes, in 2021. ESA's future Comet Interceptor mission will build on Rosetta's success when it performs a flyby of a comet. But, unlike Rosetta, the comet will be new to our Solar System.

The European Space Agency have produced a new film about its ongoing science. The film contains interviews with Charlotte Goetz, Research Fellow, ESA; Kathrin Altwegg, ROSINA instrument principal investigator, Rosetta/ University of Bern; Colin Snodgrass, Comet Interceptor deputy principal investigator/University of Edinburgh

The short 5-minute film is available on YouTube at the following address:

https://www.youtube.com/watch?v=KinazVWZ3Ag

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Record Funding for European Space Investments in Seville

In a world where change is the only constant, leadership is more important than ever. European ministers have strongly endorsed ESA to take this lead, increase its organisational agility, effectiveness and efficiency, and reinforce its relationship with the European Union.

"We have looked at the future of our activities solely from the point of view of benefits we can bring to society, industry, governments and all Europe's people," says ESA Director General Jan Wörner.

"We tried to explain these benefits to European citizens, scientists, company leaders, the politicians and our international partners. With the support of our member States we created the Space19+ proposal, which was not only looking nice on big screens. European Ministers funded everything proposed with 14.4 billion Euro, the highest subscription in the history of ESA. This is a full success, a collective success!".

Inspiration, competitiveness and responsibility

Modern societies heavily depend on services enabled by space technology. Without being aware we permanently use satellite-based navigation devices to find our way, rely on satellites to check the weather forecast, watch television brought to us by satellites and try to understand the consequences of climate change – collecting data via satellites.

European citizens expect ESA to make their lives better – reaping the benefits of space technology in day-to-day activities. This is a challenging responsibility. To fulfil it, ESA needs to excel in the global competition with inspiring space programmes in all domains of space.

Inspiration

"At Space19+, ministers decided on a boost of space science in Europe for the first time after 25 years," says Prof. Günther Hasinger, ESA Director of Science. "This enables Europe to embark on some of the biggest upcoming scientific opportunities. Observing supermassive black holes mergers, analysing at the same time the light as well as the gravitational waves, will tell us how these gargantuan monsters alter time and space. This is absolutely essential to understand how our Universe works."

The 10% increase for Science allows also for more small but fast-developed missions in close cooperation with ESA Member States like Cheops and Comet Interceptor.

"The holy grail in astronomy today is to find a second Earth," says Prof. Hasinger. "Everybody is intrigued by the question whether there is life out there. I am very much looking forward to the launch of our first exoplanet mission Cheops, on 17 December this year. It is the first mission in a series of three dedicated to the search for life elsewhere than Earth."

European astronauts enjoy a huge popularity in their home countries and beyond. Their missions to the International Space Station capture the imagination of citizens and inspire the younger generations in Europe.

"Humankind has been living and working permanently in space on the International Space Station for nearly two decades," says David Parker, ESA Director of Human and Robotic Exploration.

"Now it is time to expand our presence to the Moon and one day Mars. The one-third growth in Europe's space exploration programme will make our dreams a reality. While we fully explore the Moon and its resources in preparation for going further, we will also bring pristine samples back from Mars to understand why the Red Planet is hostile to life today although long ago it was similar to our Earth."

With the funding provided at Space19+, ESA will be able to issue a call for a new generation of European astronauts, send them to the International Space Station and also to the Moon aboard the Orion spacecraft. ESA will strengthen its partnership with NASA by contributing vital transportation, technology and habitation for the Gateway, the first lunar spaceport. As part of the most ambitious robotic exploration programme ever attempted, ESA will build the first spacecraft to return pristine samples from the surface of Mars, transforming our knowledge of the Red Planet.

Competitiveness

Autonomous access to space is of strategic political importance for Europe to realise its own ambitions. The entry into service of Europe's new family of launch vehicles, Ariane 6 and Vega-C and the investment in the future of space transportation will reinforce Europe's independent access to space, transport in and return from space for both commercial customers and critical government users.

"The demand for space transportation services is growing fast while competition is fiercer than ever," says Daniel Neuenschwander, ESA Director of Space Transportation. "Europe is ready to play a strong role in all segments from heavy to small launchers and even in support to commercial micro launchers. Space Rider, ESA's small shuttle for fast turnaround such as science experiments in microgravity, complements our portfolio. It's time to embrace the private sector and we are ready for it. Space19+ demonstrates Europe's determination to maintain its 40-year legacy of autonomous access to space."

The cooperation between the EU and ESA in Galileo and EGNOS is a success with more than a Billion users for one of the most, if not the most accurate system in the world. It provides European companies and citizens with independent access to satellite positioning, navigation and timing services crucial to day-to-day life.

"Europe's space ministers have given a clear vote of confidence to the Navigation and Innovation Support Programme, by subscribing to its next phase with a significantly enhanced yearly budget," says Paul Verhoef, ESA Director of Navigation.

"The programme looks to the future of 'positioning, navigation and timing' by supporting commercial R&D projects, efforts to sharpen European competitiveness and long-term R&D including navigation beyond Earth. Its flexible, agile nature makes it a very suitable partner for ESA Member States and companies, including small-medium enterprises and the New Space ecosystem."

Fast-paced digitalisation and miniaturisation have disrupted the telecommunication market forcing everyone to change.

"European ministers responsible for space have increased our budget by 35%," says Magali Vaissière, ESA Director of Telecommunications and Integrated Applications, "Allowing us to implement all three strategic lines of our ARTES 4.0 programme."

"In partnership with the satellite communication industry, we will drive Europe's competitiveness in the global market in particular by developing the first fully flexible satellite systems to be integrated with 5G networks, space systems for safety and security including SAGA as part of the European Quantum Communication Infrastructure as well as the next-generation optical technology for a fibre-like 'network in the sky'."

The past success of Europe in space depends fully on the competitiveness of its industry and of the cutting-edge basic R&D and world-class facilities of ESA. All domains of space technology, including innovative propulsion, digital design and new production methods, first flight of specialised microprocessors dedicated to artificial intelligence tasks and cyber-resilience both in terms of enabling technologies for a wide range of applications and resilience of space systems will benefit from the increase of funding at Space19+.

"Member States have recognised the key role of investment in basic technology research and the associated laboratories," says Franco Ongaro, ESA Director of Technology, Engineering and Quality.

"Once the technology is mature the private sector is ready to use it. Europe's ministers responsible for space understand that better than anybody else. They have substantially upgraded the funding for developing ideas, by increasing the basic activities by 10%, and by strongly supporting the generic support technology programme; converting ideas into working prototypes and for readying leading-edge technology for spaceflight and open markets. I am very grateful for this strong endorsement of R&D programmes at ESA. Now our challenge is to keep our technology target

promise: to increase innovation sustainability and efficiency' and to reduce the development time of our systems."

"Substantial funds will be devoted to the mission operations infrastructure over the next three years," adds Rolf Densing, ESA Director of Operations.

"This infrastructure is essential for mission success. We will deliver advanced new capabilities as well as increased efficiency, notably a 'multi-mission operations infrastructure as a service', the deployment of new software to control satellites, dubbed 'European Ground Systems Common Core' and a new deep space antenna. Major investments have also been decided to make ESA a fully cyber-resilient agency. These efforts will all boost European industrial competitiveness on the global market."

"Now, we need to quickly transform this fantastic success into jobs and economic growth in all ESA Member States" said Eric Morel de Westgaver, ESA Director for Industry, Procurement and Legal Services. "Ministers have clearly recognised the industrial policy as a key challenge for the future of ESA. We will therefore work to further increase responsiveness and flexibility to adapt to all industrial actors, in particular SME who have a key role to play in this new space eco-system."

Responsibility

Reflecting one of the major concerns of European citizens, European ministers responsible for space have made the greatest funding increase in Earth Observation. This will allow for a suite of eleven Earth Observation satellites to monitor climate change and the global carbon cycle to meet the Green Deal goal of a carbon-free Europe by 2050.

"Europe further enhances its role as global leader in Earth observation with clear targets to play an active role in supporting solutions to global issues related to Climate, Arctic and Africa," says Josef Aschbacher, ESA Director of Earth Observation.

"The Copernicus space component programme, co-funded with the EU, has received a record over-subscription of nearly one third, to develop six new Sentinel missions and the related ground segment. This is a clear endorsement for the continuation of a successful EU-ESA cooperation in space."

"We will also initiate the Digital Twin Earth project combining high-performance computing, artificial intelligence and cloud-based processing to push the frontier of science and technology to better understand and model the Earth system with the most advanced technologies" adds Aschbacher.

The sky has so far not been falling on our heads – However, dinosaurs did not have a space agency, which explains why European Ministers established now firmly Space Safety as a new programme.

"Compared to its precursor, Space Situational Awareness, Space Safety is more than four times bigger in volume" says Rolf Densing, ESA Director of Operations.

"We will be able to build three new missions: Lagrange, the first satellite to warn us of extreme space weather from an orbit simultaneously viewing both the Sun and Earth, Hera to demonstrate for the first time Asteroid deflection together with NASA and ADRIOS to demonstrate for the first time active debris removal."

United space in Europe

Recognising ESA's vital role in guaranteeing Europe's place in space, Ministers have expressed their full support to the Director giving him a clear mandate to reinforce both ESA's relationship with the European Union and to increase its own organisational agility, effectiveness and efficiency.

"Taken by the European ministers at Space19+ in Seville, these far-sighted decisions allow ESA to look with confidence and fresh commitment towards the opportunities of the next decade and beyond. I am proud to be the Director General of a stronger European Space Agency, leading a united space in Europe, cooperating where possible and competing where necessary, but uniting Europe in and through space" says Jan Wörner.

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Arianespace and ESA announce the Euclid satellite's launch contract for dark energy exploration

Arianespace and ESA announced, on 7th January 2020, the signature of a launch services contract for the Euclid satellite – with the mission's timeframe for liftoff starting in mid-2022 from the Guiana Space Centre, Europe's Spaceport in French Guiana.

Euclid is a medium-class astronomy and astrophysics space mission in ESA's Cosmic Vision 2015–2025 scientific programme to investigate the history of the expansion of our Universe over the past 10 billion years, looking into the current acceleration of cosmic expansion fueled by a mysterious component referred to as dark energy, and the growth of cosmic structures driven by the presence of dark matter. To this aim, Euclid will survey galaxies at a variety of distances from Earth in visible and near infrared wavelengths, over an area of the sky covering more than 35% of the celestial sphere.

According to Albert Einstein's general theory of relativity, gravity – the fundamental force that rules the Universe on its largest scales – is intimately linked to the geometry of spacetime, hence the mission concept was called Euclid, honouring the Greek mathematician Euclid of Alexandria who is considered as the father of geometry.

The Euclid mission will use either a Soyuz or an Ariane 62 launch vehicle from Europe's Spaceport in French Guiana, with a launch timeframe starting in mid-2022.

The satellite will have a mass at liftoff of approximately 2160 kg and will orbit around the Sun at an average distance of 1.5 million km beyond Earth's orbit. This special location, known as the L2 Lagrangian point, keeps pace with Earth as it orbits the Sun. Euclid's planned mission lifetime is six years.

To accomplish the Euclid mission, ESA has selected Thales Alenia Space as the prime contractor, as well as for the construction of its Service Module (SVM). Airbus Defence and Space is providing the Payload Module (PLM), including the telescope.

Nearly 1000 scientists from 100 institutes form the Euclid Consortium that is building the instruments and will participate in the mission's harvest of scientific data. The Euclid Consortium comprises scientists from 13 European countries: Austria, Denmark, France, Finland, Germany, Italy, Netherlands, Norway, Spain, Switzerland, Portugal, Romania and the UK. also includes a team of scientists from NASA.

Following the contract signature, Günther Hasinger, ESA's Director of Science, said: "Euclid will scrutinise the very nature of our Universe, shedding light on its dark side – the mysterious dark matter and dark energy – and building up on the great progresses made in cosmology over the past decades, which were recently recognised with a share in this year's Physics Nobel Prize. We're thrilled to confirm Euclid has a ticket to ride on a launcher operated by Arianespace, and we are delighted to continue working with our responsible and reliable partner to fulfil the ambitious goals of our space science programme."

Stéphane Israël, Chief Executive Officer of Arianespace, added: "Six months after being awarded the Juice (Jupiter Icy moons Explorer) mission, Arianespace is proud to start 2020 by announcing a new iconic scientific launch for ESA. With the goal of better understanding our Universe, launching this mission aboard an Ariane 62 or Soyuz is further proof of Arianespace's ability to offer independent access to space for Europe's ambitions."

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Solar Orbiter launch campaign begins

ESA's mission to the Sun has been unpacked following its arrival in Florida, ready to begin pre-launch testing and checks.

The mission is currently scheduled to lift off from Cape Canaveral launch complex late in the evening of 5 February US time (early morning 6 February central European time) on an unprecedented mission to study our star up-close.

An Antonov cargo plane transported the spacecraft and essential ground support equipment from Munich, Germany, to Florida, landing at the Shuttle Landing Facility at Kennedy Space Centre on 1 November. From there the satellite and equipment travelled by road to the AstroTech Space Operations facility. The first weeks were dedicated to setting up the equipment that will be needed to perform the upcoming checks and tests on the spacecraft. This will include repeated simplified tests of the spacecraft and science instruments so that the functioning of the various systems is confirmed as it was before the long flight, and checking of the propellant pressurisation system pressure before eventually fueling the spacecraft.

ESA
www.esa.int

Trees planted grown from seeds that went into space

Tim Peake and Andrea Leadsom plant trees at the home of Isaac Newton that were grown from apple seeds taken to space.

Saplings grown from apple pips from Isaac Newton's tree and taken into space by astronaut Tim Peake have today (Monday 13 January) been given homes to inspire the next generation.

The 8 young trees were grown from seeds taken from the 'Flower of Kent' tree at Woolsthorpe Manor, National Trust, in Lincolnshire, the home of iconic scientist Sir Isaac Newton who drew out the principles of gravity after seeing an apple fall.

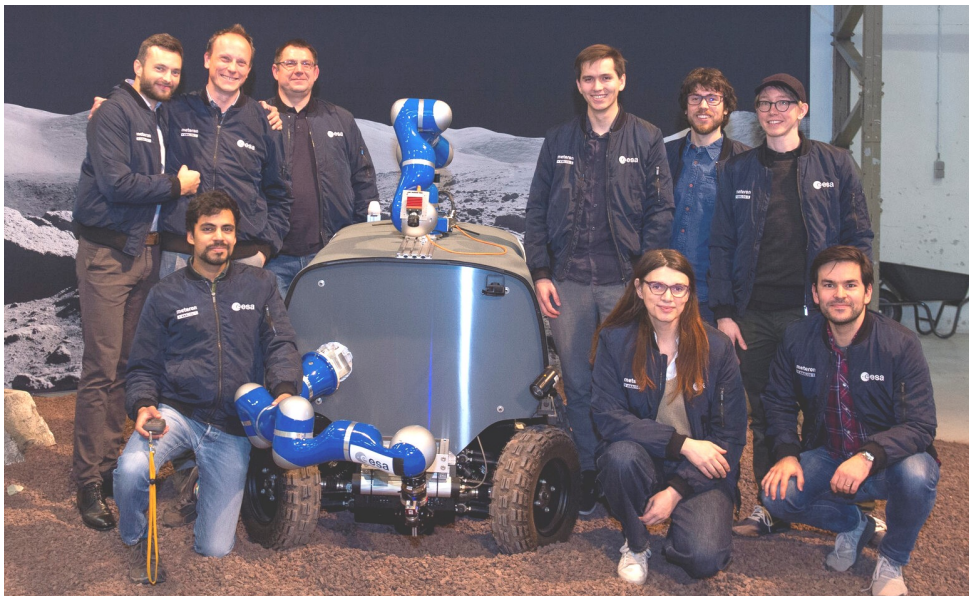
Tim Peake took the seeds with him when he went to the International Space Station on the British European Space Agency (ESA) astronaut's Principia mission in 2015.

The seeds spent 6 months floating in microgravity as part of the 'Pips in Space' project and then landed back on Earth in 2016 to be nurtured into young trees. The UK Space Agency, the National Trust and the Royal Botanic Gardens, Kew, worked together on the project.

UK Government
www.gov.uk

Happy Rovers

The team behind ESA's Interact Centaur rover are all smiles after ESA astronaut Luca Parmitano successfully maneuvres the rover in the Netherlands from space.



A dry-run of the Analog-1 experiment, in which Luca completed a "proficiency run" to test the system, set the stage for another flawless performance on 25 November.

Taking command of the rover (centre in this picture) located in a hangar in the Netherlands, Luca expertly drove it to three sites and used its robotic arm to collect rock samples, all while circling our planet at 28 800 km/h on the International Space Station.

Which samples to collect and save for further analysis was decided by a science team based at ESA's Astronaut Centre in Cologne, Germany in conversation with Luca.

The Human Robot Interaction Lab provided the rover and test infrastructure and is located at ESA's technical heart in the Netherlands.

The team finds novel ways for humans and robots to work together, furthering ESA's exploration strategy that foresees astronauts controlling robots from orbit around the Moon or Mars or from inside a planetary base.

The Analog-1 rover, for example, is equipped with force feedback so astronauts can feel what the robot feels and adjust their grip accordingly using a joystick that allows for six degrees of motion.

The robot also sports "spot turn" wheels, allowing it to get out of tight places.

Both contributed to a successful sampling excursion, despite the 800-millisecond communication delay between Luca in space and the ground teams on Earth.

Acing this test proves the technology that ESA has developed to operate rovers from afar.

Analog-1 is the latest in a series of human-robot test campaigns that make use of the International Space Station. Called the Multi-purpose End-to-End Robotic Operation Network or Meteron, the project is developing the communication networks, robot interfaces and hardware to operate robots from a distance in space.

The Analog-1 experiment demonstrates the value of human-robotic cooperation in space and the technology that will be used as the basis for many of ESA's exploration projects. Ministers from ESA's Member States will convene later this month at the Space19+ in Seville, Spain, to decide on the Agency's future course.

ESA
www.esa.int

Two [NASA] Rovers to Roll on Mars Again: Curiosity and Mars 2020

Curiosity won't be NASA's only active Mars rover for much longer. Next summer, Mars 2020 will be headed for the Red Planet. While the newest rover borrows from Curiosity's design, they aren't twins: Built and managed by NASA's Jet Propulsion Laboratory in Pasadena, California, each has its own role in the ongoing exploration of Mars and the search for ancient life. Here's a closer look at what sets the siblings apart.

The Missions

Landing in 2004 to "follow the water," the twin rovers Spirit and Opportunity discovered evidence that the planet once hosted running water before becoming a frozen desert. But when did this happen and why?

NASA launched the supersized Curiosity rover to learn more. Since landing in 2012, Curiosity has been roaming Gale Crater, which, it discovered, contained a lake billions of years ago and an environment that could have supported microbial life. The rover is still hunting for clues related to this environment as it ascends the 3-mile-tall (5-kilometer-tall) Mount Sharp, which sits within Gale Crater and was partially formed by water.

Some 3,760 miles (6,050 kilometers) away, Mars 2020 will also explore a landscape shaped by water: Jezero Crater, the site of an ancient delta. But 2020 will take the next scientific step: It will look for actual signs of past life, or biosignatures, capturing samples of rocks and soil that could be retrieved by future missions and returned to Earth for in-depth study.

The Tools

Mars 2020's chassis, or body, is about five inches longer than Curiosity's. It's also heavier, checking in at 2,260 pounds (1,025 kilograms), compared with Curiosity's 1,982 pounds (899 kilograms). The weight difference has to do with the tools each carries.

Start with the robotic arms: Curiosity's extends 7 feet (2.2 meters) and wields a rotating 65-pound (30-kilogram) turret equipped with a scientific camera, chemical analyzer and drill. The roving science lab pulverizes rock samples and pours the powder into its chassis, where two laboratories can determine the rocks' chemical and mineral makeup.

Mars 2020's arm has the same reach as Curiosity's, but its turret weighs more - 99 pounds (45 kilograms) - because it carries larger instruments and a larger drill for coring. The drill will cut intact rock cores, rather than pulverizing them, and they'll be placed in sample tubes via a complex storage system.

The Eyes and Ears

All of NASA's Mars missions have allowed the public to ride along as scientists and engineers explore the planet. Curiosity has been doing that with 17 cameras on its Mast, or head, and body; four of them are color cameras.

Mars 2020 has 23 cameras, most of them color. The new rover also includes "ears" - two microphones to capture not only the first sounds of a Mars landing, but also Martian wind and the rover's chemical-analyzing laser zaps. Mastcam-Z, an improved version of Curiosity's Mast Camera, has a zoom capability and will take high-definition video and panoramas.

The Wheels

Curiosity has prepared Mars 2020's team for "off-roading" on the Red Planet. When holes began appearing in the veteran rover's aluminum wheels, engineers realised that sharp rocks cemented on the Martian surface exert more pressure on the wheels than expected. Careful drive planning, along with a software upgrade, will keep them in shape for the rest of Curiosity's journey up Mount Sharp.

While Mars 2020's wheels are made from the same materials, they're slightly bigger and narrower, with skins that are almost a millimeter thicker. Instead of Curiosity's chevron-pattern treads, or grousers, Mars 2020 has straighter ones and twice as many per wheel (48 versus 24). Extensive testing in JPL's Mars Yard has shown these treads better withstand the pressure from sharp rocks but work just as well on sand.

The Brains

Mars rovers don't drive themselves. Teams of scientists and engineers beam meticulously programmed task lists to them at the beginning of each Mars day, or sol. Rover drivers on Earth then wait for the vehicle to report back before planning the next drive. The more a rover can do on its own, the more time drivers have to program new commands.

After Curiosity landed, it took an average of 19 hours for the rover's team to analyze a day's data, build and test commands, then send those commands back to the rover. Years of honing operations shrunk the time it takes to develop each day's plan to seven hours, and a limited degree of auto-navigation has enabled Curiosity to take some cautious steps on its own.

But Mars 2020 has even more self-driving smarts, allowing it to calculate a path five times faster than Curiosity can. That self-driving will be key to condensing the amount of time it takes for the 2020 team to plan each day's operations. The new mission intends to eventually condense daily operations to just five hours. The faster pace will allow it to cover more ground and gather more samples over the course of its prime mission. Mars 2020 won't move faster than its older sibling, but more automation means that it can potentially drive farther and collect more science without having to wait for engineers back on Earth.

The Landing

Curiosity transformed Mars landings with the seemingly radical "sky crane maneuver." Mars 2020 will rely on the same process but also features an important new technology: Terrain Relative Navigation. An onboard computer matches surface images from a camera to a map to keep the spacecraft on target. Meanwhile, the Range Trigger lets the rover get miles closer to an ideal site before firing a parachute.

The Humans to Come

NASA's Artemis program aims to return astronauts to the Moon by 2024, preparing for future exploration of Mars. Helping pave the way for humans, Curiosity carries instruments that study the Martian environment, like surface radiation and weather.

Besides studying the weather, Mars 2020 will carry spacesuit samples, allowing scientists to study how they degrade. An oxygen generator will test technology for astronauts to make their own rocket fuel from the Martian atmosphere. A subsurface radar like the one on the rover could someday be used to find buried water ice.

For more information about Curiosity and Mars 2020, visit:
https://mars.nasa.gov/msl/home/
https://mars.nasa.gov/mars2020/

Boeing CST-100 Starliner Update:

NASA and Boeing are in the process of establishing a joint, independent investigation team to examine the primary issues associated with the company's uncrewed Orbital Flight Test.

The independent team will inform NASA and Boeing on the root cause of the mission elapsed timer anomaly and any other software issues and provide corrective actions needed before flying crew to the International Space Station for the agency's Commercial Crew Program. The team will review the primary anomalies experienced during the December 2019 flight test, any potential contributing factors and provide recommendations to ensure a robust design for future missions. Once underway, the investigation is targeted to last about two months before the team delivers its final assessment.

In parallel, NASA is evaluating the data received during the mission to determine if another uncrewed demonstration is required. This decision is not expected for several weeks as teams take the necessary time for this review. NASA's approach will be to determine if NASA and Boeing received enough data to validate the system's overall performance, including launch, on-orbit operations, guidance, navigation and control, docking/undocking to the space station, reentry and landing. Although data from the un-crewed test is important for certification, it may not be the only way that Boeing is able to demonstrate its system's full capabilities.

The uncrewed flight test was proposed by Boeing as a way to meet NASA's mission and safety requirements for certification and as a way to validate that the system can protect astronauts in space before flying crew. The un-crewed mission, including docking to the space station, became a part of the company's contract with NASA. Although docking was planned, it may not have to be accomplished prior to the crew demonstration. Boeing would need NASA's approval to proceed with a flight test with astronauts onboard.

Starliner currently is being transported from the landing location near the US Army's White Sands Missile Range to the company's Commercial Crew and Cargo Processing Facility in Florida. Since landing, teams have safed the spacecraft for transport, downloaded data from the spacecraft's onboard systems for analysis and completed initial inspections of the interior and exterior of Starliner. A more detailed analysis will be conducted after the spacecraft arrives at its processing facility.

Boeing's Orbital Flight test launched on Friday, 20 December 2019, on United Launch Alliance Atlas V rocket from Space Launch Complex 41 at Cape Canaveral Air Force Station in Florida. The mission successfully landed two days later on Sunday, 22 December, completing an abbreviated test that performed several mission objectives before returning to Earth as the first orbital land touchdown of a human-rated capsule in US history.

NASA
www.nasa.gov

Virgin Galactic Milestone

Virgin Galactic has announced that it has reached the "Weight on Wheels" milestone in the build of its second commercial spaceship. In this milestone, all major structural elements of the vehicle were assembled, and the vehicle deployed its main landing gear and carried its own weight for the first time. The milestone signals strong progress in the manufacture of Virgin Galactic's space vehicle fleet by The Spaceship Company, VGH's wholly-owned aerospace development subsidiary.

This Weight on Wheels milestone has been reached considerably faster than it took to get to this stage with the first spaceship in the Virgin Galactic fleet, *VSS Unity*, which is currently in flight test. This pace has been achieved through a more efficient, modular assembly process, as well as experience curve benefits.

With the spaceship now capable of bearing its own weight, the assembly team is hard at work connecting the vehicle's integrated systems, including the flight control systems from fuselage to tail booms, as well as completing the final structural closeouts.

As this work is completed, the spaceship will be positioned in the hangar for the start of integrated vehicle ground testing, which will verify the integrity of all systems. This step is a precursor to the start of its flight test program.

Virgin Galactic
www.virgingalactic.vom

New Shepard Mission Success

New Shepard had a wholly successful mission on 11 December 2019. This mission was another step towards verifying New Shepard for human spaceflight as we continue to mature the safety and reliability of the vehicle.

This was the 6th flight for this particular New Shepard vehicle. Blue Origin has so far reused two boosters five times each consecutively, this mission marks a record with this booster completing its 6th flight to space and back.

This particular rocket has been an operational payload vehicle for several flights, meaning there are no more updates to the system.

This was also the 9th commercial payload mission for New Shepard, and we are proud to be have flown our 100th customer on board.

Blue Origin
www.blueorigin.com

Remembering the Fallen

The months of January and February are always tinged with sadness in the NASA space flight community. In these two months alone over the years NASA lost seventeen Astronauts.

Apollo 1: On 27 January 1967, a fire broke out in the Command Module at the Apollo 1 launchpad, killing Astronauts Gus Grissom, Ed White, and Roger Chaffee.

STS 51-L: The crew of the space shuttle *Challenger* were lost in on 28 January 1986 during a catastrophic launch failure, killing Astronauts Ellison S Onizuka, Michael J Smith, Christa McAuliffe, Francis R Scobee, Gregory B Jarvis, Judith A Resnik, and Ronald E McNair.

STS-107: On 1 February 2003, the space shuttle *Columbia* broke apart on re-entry, killing all seven crewmembers: David M Brown, Commander Rick D Husband, Laurel Blair Salton Clark, Kalpana Chawla, Michael P Anderson, Pilot William C McCool, and Ilan Ramon.

mages credit: NASA
www.naa.gov

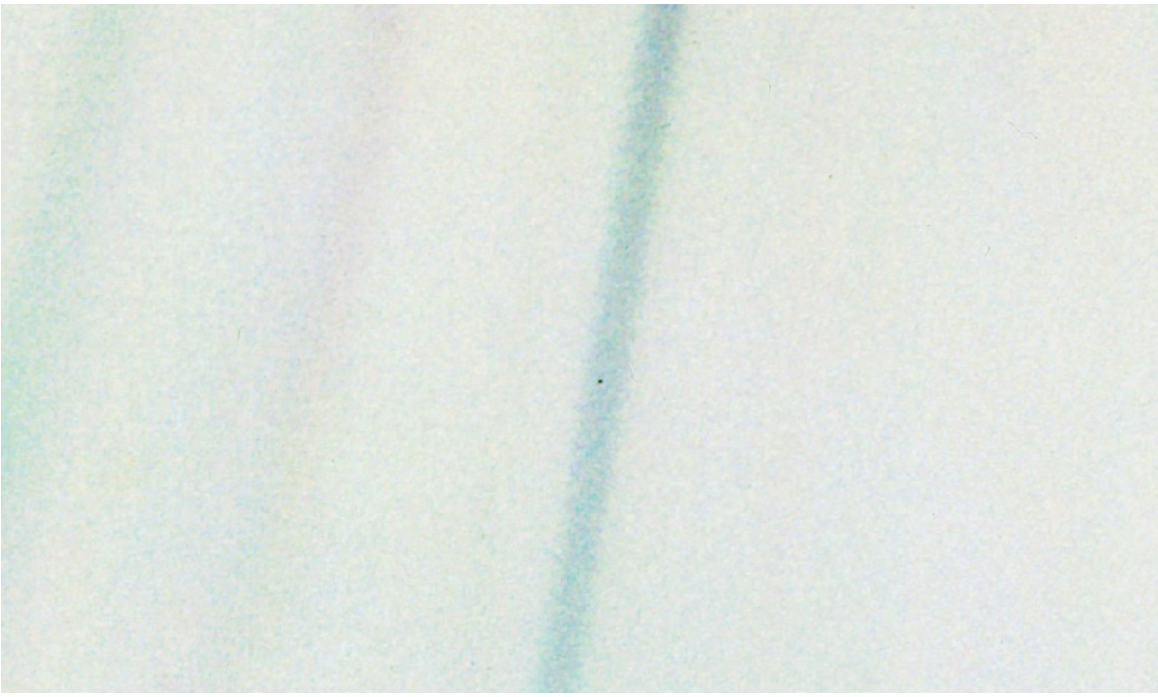
Sergei Korolev

We also remember rocket engineer and spacecraft designer Sergei Korolev (or Korolyov) born on 12 January 1907 (30 Dec 1906 old calendar). The Chief Designer of OKB-1 and the driving force of the early Soviet space programme until his death on 14 January 1966 just 2 days after his 59th birthday.

Astro Info Service via Twitter
www.astroinfoservice.co.uk

Voyager 1's Pale Blue Dot

***Image Right**:*
Voyager 1 took this image of Earth on 14 February 1990. We have reproduced it here in a negative form to give better resolution to the printed version of CAPCOM.



Thirty years ago, on 14 February 1990, Voyager One was commanded to train its cameras to it home planet. This narrow-angle colour image of the Earth, dubbed 'Pale Blue Dot', is a part of the first ever 'portrait' of the solar system taken by Voyager 1. The spacecraft acquired a total of 60 frames for a mosaic of the solar system from a distance of more than 4 billion miles (6.4 billion kilometers) from Earth and about 32 degrees above the ecliptic.

Namesake

This image inspired the title of Sagan's 1994 book, "Pale Blue Dot: A Vision of the Human Future in Space." "Look again at that dot," Sagan wrote in his book "Pale Blue Dot." "That's here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives. The aggregate of our joy and suffering, thousands of confident religions, ideologies, and economic doctrines, every hunter and forager, every hero and coward, every creator and destroyer of civilization, every king and peasant, every young couple in love, every mother and father, hopeful child, inventor and explorer, every teacher of morals, every corrupt politician, every 'superstar,' every 'supreme leader,' every saint and sinner in the history of our species lived there -- on a mote of dust suspended in a sunbeam."

— Carl Sagan, "Pale Blue Dot," 1994

Original Text and full composite mosaic of the Solar System can be found at: NASA
https://solarsystem.nasa.gov/resources/536/voyager-1s-pale-blue-dot/

"At Its Best":

Remembering the Record-Breaking Mission of STS-32, Thirty Years On

By Ben Evans

Thirty years ago, in January 1990, the Space Shuttle turned a corner. Long touted as a vehicle capable of regular sorties into low-Earth orbit and having captured and repaired satellites to the delight and astonishment of the world, its career was forever dented by the tragic loss of Challenger and the painful years of introspection which followed. Yet having triumphantly returned to flight in September 1988, the shuttle had conducted several highly successful missions and had begun to re-cement its credentials. And when STS-32 Commander Dan Brandenstein and his crew roared to orbit on 9 January 1990, their 11-day flight would achieve satellite deployment, rendezvous and retrieval and a new empirical record for the longest shuttle mission to date. As the Capcom remarked when Columbia returned safely to Earth after 11 days, STS-32 "showed the shuttle at its best".

The major objective was retrieval of the 12-sided Long Duration Exposure Facility (LDEF), a bus-sized spacecraft launched by another shuttle crew in April 1984 to house experiments and samples for long-term exposure to the harsh environment of low-Earth orbit. Original plans called for LDEF to be retrieved in February 1985, but it was repeatedly delayed and by the time of the Challenger disaster it had been rescheduled for no sooner than September 1986. The loss of Challenger and her 51L crew added several more years onto LDEF's tally of time in orbit and by the end of 1989 the aging satellite was in a precarious state. Trajectory specialists estimated that it would naturally re-enter the atmosphere by March 1990 at the latest, with the loss of a tremendous amount of data. And since LDEF's materials samples promised valuable data for the construction of Space Station Freedom, it was imperative that a shuttle crew bring it home.

In November 1988, NASA assigned Chief Astronaut Dan Brandenstein to command STS-32; a veteran of two previous shuttle missions, he had already trained for the LDEF retrieval and had come within weeks of flying it in early 1985. Mission specialist Bonnie Dunbar, who had flown once before, had also been assigned to the September 1986 incarnation of the LDEF retrieval, and so brought added expertise to this complex task. Rounding out the STS-32 crew were three "rookies": Jim Wetherbee in the pilot's seat and two more mission specialists, Marsha Ivins and David Low.

Nor was the recovery of LDEF the only task on the flight, for Low would deploy the powerful Syncom 4-5 communications satellite for the US Navy. It was the fifth and final member of this drum-shaped satellite network and would be deployed like a frisbee out of Columbia's payload bay on the second day of STS-32. Although four previous Syncoms had been launched in 1984-1985, one had did not reach its intended orbit and was successfully revisited by a shuttle crew, whilst another suffered a catastrophic failure of its UHF electronics and was declared lost. The arrival of Syncom 4-5, therefore, would complete a 'minimum' required constellation of at least four operational satellites.

***Image left**: The crew of STS-32 aboard Columbia*

Image Credit: NASA, via Joachim Becker/SpaceFacts.de

***Image right**: Deployment of the Syncom 4-5 communications satellite*

Image Credit: NASA, via Joachim Becker/SpaceFacts.de.

Launch of STS-32 was initially scheduled for 18 December 1989 and its ten-day planned length promised to make this the first-ever shuttle mission to spend Christmas in space. Brandenstein organised a mock crew portrait of the five of them in Santa suits, hats and dark glasses, but unfortunately problems with getting Pad 39A at the Kennedy Space Center ready for its first shuttle launch in four years meant that the launch was postponed until no earlier than 8 January 1990.

By that time, NASA had successfully flown seven shuttle missions since the return to flight after Challenger, but STS-32 was to be a totally different beast. Scheduled for nine days and 21 hours, it would be almost twice as long in duration and was expected to come close to breaking the record for the longest-ever shuttle mission at that time. Although the Syncom 4-5 deployment and LDEF retrieval only required three days, NASA was keen to stretch the shuttle's capabilities, because plans were already afoot to modify Columbia for missions lasting over 16 days. Even before that could happen, the ten days of STS-32 required the oldest shuttle in the fleet to have several major upgrades, including an extra set of oxygen and hydrogen tanks under her payload bay floor.

Unfortunately, launch on 8 January was threatened by clouds and rain showers, although the crew boarded Columbia without incident and the countdown proceeded with a few hiccups to T-5 minutes. A troublesome electronics component on Pad 39A reared its head, but eventually the weather again closed in and STS-32 was rescheduled for the 9th. Columbia roared aloft at 7:35 EST that morning, right on the opening of an hour-long "launch window", to kick off a three-day chase of LDEF. During their first day in space, the astronauts checked out the shuttle's Canadian-built Remote Manipulator System (RMS) robotic arm, which would used for the capture of the satellite, and getting Syncom 4-5 ready to go. At 8:18 a.m. EST on 10 January, about 25 hours into the flight, Syncom was sent spinning out of Columbia's payload bay, and eventually boosted itself into geosynchronous orbit. It went on to support military communications during Operations Desert Storm and Desert Shield in Iraq and was finally retired in 2015.

When the STS-32 crew reached orbit, they trailed LDEF by 1,700 miles, but their lower altitude caused them to close on their quarry by about 45 miles during each 90-minute circuit of Earth. Brandenstein and Wetherbee performed three engine firings during the chase to reduce this distance and by the morning of 12 January the astronauts were awakened to music from Mission Control: the tune of *Let It Snow*, albeit with revised lyrics of *Bring It Home*. It was imperative that they approached LDEF carefully, with relatively few engine firings, to avoid contaminating the satellite's experiments. Brandenstein gingerly guided Columbia 'below', then 'ahead' of LDEF, before pitching the shuttle's nose to achieve a holding point directly 'above' it. After six years in space, the satellite had travelled 800 million miles and orbited Earth 32,000 times. And during that time, it had suffered some damage: a small solar cell had somehow dislodged itself and was flying in formation with LDEF and a number of micrometeoroid 'holes' were also apparent.

At 10:16 a.m. EST, high above the Atlantic Ocean, near Brazil, Dunbar grappled the satellite with the robotic arm.

"Houston, Columbia," radioed Brandenstein, "we have LDEF!"

"You've made many scientists very happy that their LDEF experiments are finally coming home," replied Capcom Tammy Jernigan, with applause in the background. Over the next five hours, Ivins extensively photographed the satellite, before Dunbar finally lowered it into the payload bay and latched it into place at 3:49 p.m. EST.

The successful retrieval had clearly reinvigorated many spirits at NASA. Although seven missions had flown since the return to flight after Challenger, all of them had been relatively vanilla satellite deployments. STS -32, on the other hand, had finally begun to press the shuttle's other capabilities back into action. On the morning of 13 January, Brandenstein's crew sent Mission Control a tongue-in-cheek picture of LDEF, seemingly overgrown with tomato seeds. It was a joke based on the 12 million tomato seeds flown on the satellite as part of student experiments. "We saw something strange," grinned Brandenstein, "so we got it on the video recorder and thought we would show it to you!"

The following week was spent on science, including fluid physics, protein crystal growth and work with an off-the-shelf ultrasound monitor known as the American Flight Echocardiograph. Although several shuttle commanders had objected to flying medical experiments, Brandenstein considered it part of the job, so long as they were of value. "I was very demanding on the experiments that they do have real merit," he told the NASA oral historian, "and be well-organised and have a test plan, not a willy-nilly type of experiment." His enthusiasm, though, was pushed a little far by fellow astronaut Sonny Carter, a physician, who talked the STS-32 crew into what Brandenstein called "the granddaddy of all experiments": a muscle biopsy. Surprisingly, the crew were game and willfully volunteered to have hunks of muscle pulled from their legs both before and after the mission.

Despite its success, STS-32 suffered its share of problems, including water oozing from a leaking dehumidifier into the middeck. Then one of Columbia's inertial measurement units—a critical navigational tool—began to exhibit signs of trouble, potentially threatening an early landing. This possibility was not helped by the fact that overcast skies and even snow was

***Image left**: NASA's Long Duration Exposure Facility as seen during a photographic survey after it's retrieval by Columbia on mission STS-32. visible is the bay and town of Lüderitz in the top left corner.*

Image Credit: NASA via Wikipedia
www.nasa.gov

expected at Edwards Air Force Base in California as early as 17 January. As events transpired, a shorter-than-intended mission did not prove necessary, although mission managers kept a cautious eye on the Edwards weather. Columbia had to land on concrete Runway 22, as having LDEF aboard would push the shuttle's landing weight to almost 228,000 pounds. And the satellite's presence in the payload bay also shifted the centre-of-gravity 'forward', requiring deft handling by Brandenstein on the runway to ensure that the landing gear did not 'slap' prematurely down.

Hopes of returning home on 19 January evaporated, when a dusting of snow left water on the Edwards runway, along with unacceptable foggy conditions. A 24-hour delay meant that STS-32 would seize the record for the longest-ever shuttle mission at that time, eclipsing the ten days and seven hours spent aloft by STS-9 in late 1983. In fact, consumables aboard Columbia were so good that she could have remained in orbit until 22 January if required, a full 13 days. As well as breaking this record, Brandenstein celebrated his birthday in space and joked that he hoped flying at Mach 25 might slow his aging process.

The first attempt to land on 20 January was called off when a switch on one of the shuttle's computers failed, but Brandenstein and Wetherbee fired Columbia's engines on the second opportunity to bring STS-32 home. The shuttle alighted in darkness on Runway 22 at Edwards at 1:35 a.m. PST (4:35 a.m. EST), wrapping up a mission of ten days, 21 hours, one minute and 39 seconds. It was a new shuttle program record that would endure for the next 2.5 years. And for Columbia—sadly no longer with us—it cemented her credentials as the long-duration heavyweight of the shuttle fleet. Of the ten longest missions in shuttle history, six of them were flown by Columbia. But for the astronauts of STS-32, breaking records was not their goal. "Records are there to be broken," Dunbar remarked, "but we were just glad to get another day in space."

Long Duration Exposure Facility (LDEF)

The Long Duration Exposure Facility was placed in low-Earth orbit (LEO) by the space shuttle Challenger in April, 1984, and retrieved by the space shuttle Columbia in January, 1990. LDEF was a 14-faced (i.e., a 12-sided cylinder and two ends), gravity-stabilized spacecraft that was host to 57 individual scientific experiments. Several of these experiments were designed to characterize various aspects of the meteoroid and orbital-debris environment during the nominal nine month mission. However, as a result of LDEF's unexpectedly long exposure time (5.7 years) and the heightened awareness of the man-made debris collisional threat, it was decided to utilize the entire spacecraft as a meteoroid and orbital-debris detector. The Meteoroid and Debris Special Interest Group (M&D SIG) was organized to achieve this end.

As a result of the gravity-gradient stabilized orbital nature of LDEF (i.e., the same general surface pointed into the velocity vector during the entire mission), the large exposed surface area (~130 square meters) of LDEF provided a unique source of information concerning the LEO particulate environment and associated directionality effects for both natural and man-made particles.

STS-32 Mission Log

Mission:	Deploy SYNCOM IV-F5 satellite; Retrieve LDEF
Space Shuttle:	Columbia
Launch Pad:	39A
Launch Weight:	255,994 pounds
Launched:	9 January 1990, 7:35:00 am EST
Landing Site:	Edwards Air Force Base, California
Landing:	20 January 1990, 1:35:36 am PST
Landing Weight:	228,335 pounds
Runway:	22
Rollout Distance:	10,096 feet
Rollout Time:	62 seconds
Revolution:	172
Mission Duration:	10 days, 21 hours, 0 minutes, 36 seconds
Orbit Altitude:	178 nautical miles
Orbit Inclination:	28.5 degrees
Miles Travelled:	4.5 million

***Image right**: STS-32 Mission Insignia The STS-32 patch, designed by the five crewmembers for the January, 1990 space mission, depicts the Space Shuttle orbiter rendezvousing with the Long Duration Exposure Facility (LDEF) satellite from above and the Syncom satellite successfully deployed and on its way to geosynchronous orbit. Five stars represent the mission number with three on one side of the orbiter and two on the other. The seven major rays of the sun are in remembrance of the crewmembers for STS 51-L. In preparation for the first Extended Duration Orbiter (EDO) missions, STS-32 conducted a number of medical and middeck scientific experiments. The caduceus on the left represents the medical experiments, and the crystalline structure on the right represents the materials science. The crew is comprised of Astronauts Daniel C. Brandenstein, James D. Wetherbee, Bonnie Dunbar, Marsha S. Ivins, and G. David Low.*

Image Credit: NASA via Wikipedia
www.nasa.gov

Image above: Space Shuttle *Columbia*, returning to Kennedy Space Center (KSC) after the successful STS-32 mission, flies past the Vehicle Assembly Building at KSC, secured atop the Shuttle Carrier Aircraft.

Image Credit: NASA via Wikipedia

Ben Evans

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Carolian Astronomy Society

The Martin Humphries Memorial Lecture

"Reaction Engines: Unlocking the future of space access and hypersonic flight"

By Robin Davies (Head of Systems and Control) Reaction Engines Ltd
Venue: King Charles 1 Lower School, Borrington Road, Kidderminster DY10 3ED

7:30 pm, Wednesday 11th March 2020

Everyone Welcome, entrance is free

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Midlands Spaceflight Society

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The Editor welcomes contributions for CapCom. Articles on any aspect of space exploration are considered. Articles in Word format or text files should be sent by email to

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Copy Deadline

All contributions intended for the March—April 2020 issue should be emailed to the editor by **Friday 14 February 2020**