SpaceFlight
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Rival rockets

Worldwide launcher numbers grow

New NASA astronauts

Artemis II February launch

SpaceX Starship V2 last flight

International Astronautical Congress

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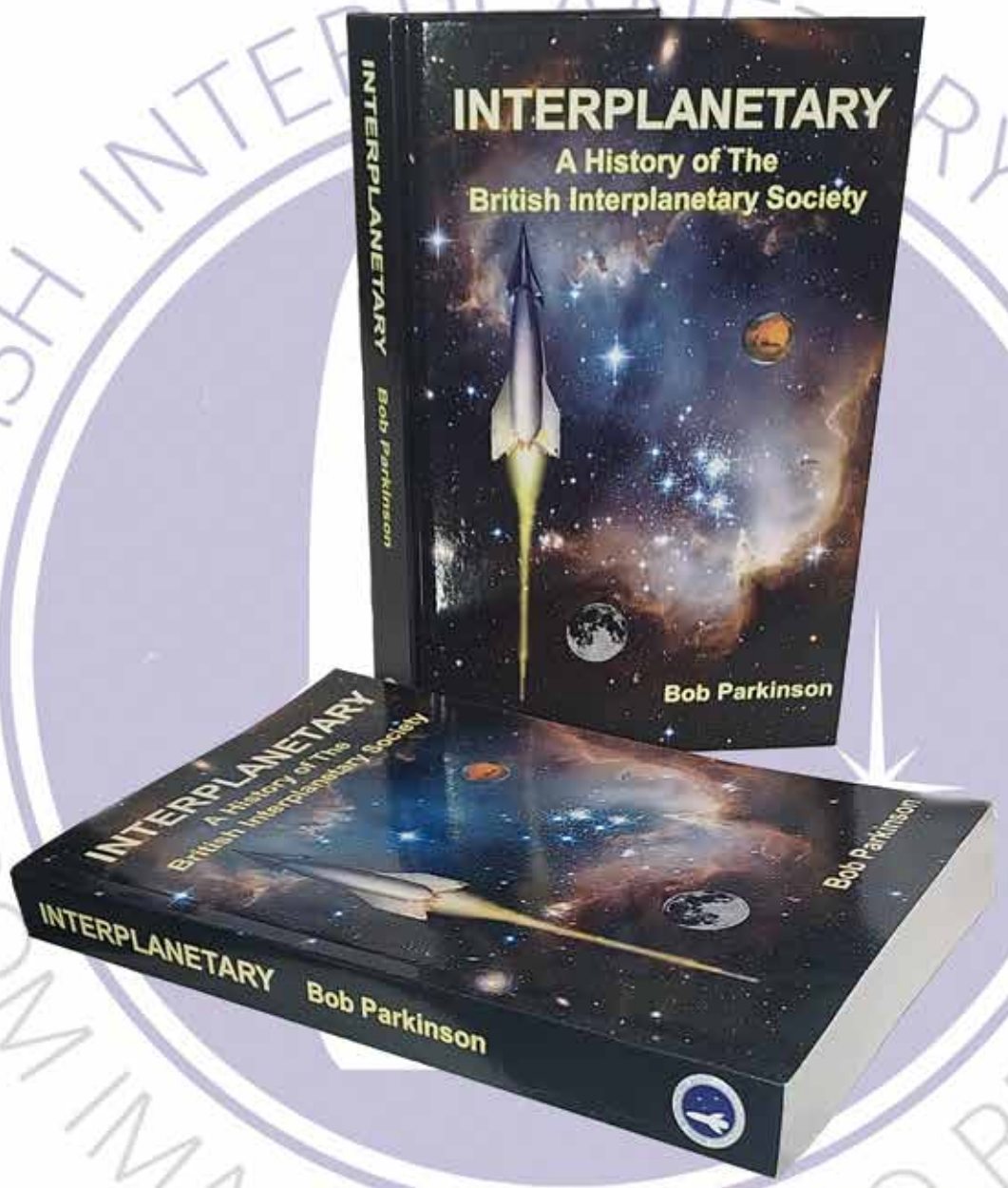
The comprehensive history of the **British Interplanetary Society** is now revised and updated.



Interplanetary was originally published in 2008 for the Society's 75th Anniversary. It has now been revised for the 90th Anniversary, with additional material in many of the chapters and a new chapter bringing the history up to 2020.

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Letter from the Editor

The levels of financing now for rocket companies point to a significant change. The 21st century has seen rockets, once top secret missiles, become just like aircraft, one more form of transport whose development the financiers can fund. For centuries, governments, and eventually commerce, paid for sailing ships. The 19th century saw the railway become the next big transport system. The 20th century was the age of the car. The iconic year of 2001 saw the first space tourist. The last few years have seen Blue Origin's New Shepard tourist flights, three private orbital flights and four commercial International Space Station missions. Most rockets in development are for satellites but four are for people. Russia's Angara-A5M is for the Orel capsule, India's HLVM3 is for the Gaganyaan crew module, China's Long March-10A is for the Mengzhou crew capsule and SpaceX's Starship is for Artemis' lunar lander. Ariane 6, which has made four flights since it entered service in 2024, has been proposed as a future crew capsule launcher. SpaceX's Falcon 9 has only launched crew since 2020 and NASA's Space Launch System is to launch crew in February at the earliest. These are only the beginning. The demand for human spaceflight is there and today it is a market that is akin to aviation in the early 1900s. Ad Astra

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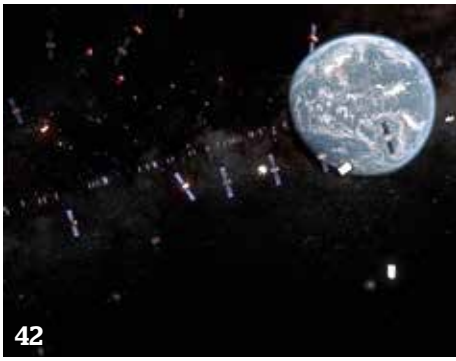
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OUR MISSION STATEMENT

The British Interplanetary Society promotes the exploration and use of space for the benefit of humanity, connecting people to create, educate and inspire, and advance knowledge in all aspects of astronautics.

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Final flight

PHOTO: SPACEX

The successful eleventh SpaceX Starship test flight on 13 October was the last launch of the version two of the two-stage fully reusable launch vehicle with version three (V3) being prepared.

All of the objectives for the eleventh test flight were accomplished but they were a repeat of the tenth test flight, which was the first success in four flights. The first time SpaceX specifically stated the version two Starship was being flown was for flight 10. Websites make claims about earlier flights but they cannot be substantiated. SpaceX has made incremental changes during the previous nine flights and Elon Musk has talked about a version 1.5. The difference between the version two and the first Starship design that flew from April 2023 is the upper stage foreplanes are in a different position, the first stage booster is slightly taller with a larger propellant volume and both stages' thrust is greater.

The test flight 11 booster was not a version two though it was the booster flown on test flight eight. That makes it the second booster to have flown twice. The first flew on tests seven and nine. Test flight 11 saw the booster conduct a landing in the same way the V3 will with 15 engines firing for the landing burn sequence that then shuts down 10 for five and finally three engines complete the burn. The next booster to fly on test 12 will be a V3 booster and the hot staging ring, which have been ejected after staging previously, will now be a permanent part of the first stage. Another change to the booster is the fuel transfer tube that channels propellant to the 33 engines. It is now larger and the same size as a Falcon 9 first-stage.

Once on its suborbital trajectory the upper stage, serial number S38, deployed eight Starlink satellite dummies. They were the size, shape and mass of a version three Starlink satellite that will have a much higher data bandwidth. The S38 spacecraft also relit a centre engine. This test had been accomplished on tests 10 and six. Eventually such a relight will be used to deorbit a spacecraft that is on an orbital trajectory. The S38's descent included banking turns and an aggressive turn right to simulate its Starbase return to launch tower trajectory. The upper stage's surface had some tiles removed and other alterations to test the heat shield. SpaceX has also fitted a material called Vulcan felt, or crunch wrap, that wraps around tiles and protects potential gaps between tiles from re-entry plasma.

The eleventh flight was also the last for the time being from Starbase's first launch tower. SpaceX has been building its second launch tower at Starbase this year, and another at NASA Kennedy Space Center in Florida. Test 12 will launch from Starbase's new tower, and it will be the first version three mission. The V3 is said by SpaceX to be the Starship that will go to Mars and the company was in the process of building multiple vehicles. During the eleventh test flight, a SpaceX webcast presenter said the second tower would be operational "very soon".

"We've learned from all these flight tests to make a vehicle that we're looking to mass produce. Starting with the Starship upper stage, which is going to look pretty similar on the outside, but it's getting pretty much a complete overhaul under the hood. We're getting major design changes to its propulsion system that's going to accommodate that new version of Raptor, which puts out higher thrust," SpaceX communications manager, Dan Huot, explained during the webcast. "We're also getting an energy storage upgrade, tons of avionics changes, a lot of things that will enable longer duration missions. One notable thing you'll start seeing on the outside are these new docking adapters, which we'll use when we bring two Starships together for propellant transfer. That's a core capability of Starship that we're going to demonstrate next year."

A comment by Huot's fellow webcast presenter, SpaceX Raptor lead propulsion engineer, Jake Burkowitz, may shed light on why NASA Acting Administrator Sean Duffy announced on 20 October he was reopening the Artemis III crew lunar landing contract which had been won by SpaceX. Burkowitz said: "Starship cargo flights to the surface of the Moon for research, development, and exploratory missions will start in 2028," but Artemis III is planned for 2027. SF

ABOVE
SpaceX's Starship upper stage spacecraft S38 ship re-enters the Earth's atmosphere during the 11th test flight of the Starship super heavy launch vehicle.

PHOTO: SPACEX

SpaceX to lose Artemis III?

On 20 October, NASA's Acting Administrator Sean Duffy announced in a television interview that he would reopen the contract for the 2027 Artemis III lunar landing which had been SpaceX's.

NASA awarded SpaceX the Artemis III crew landing contract in April 2021. Under the contract SpaceX was to complete a demonstration lunar landing mission before the Artemis III mission. The SpaceX lander, which NASA calls a human landing system (HLS), is derived from the spacecraft upper stage of SpaceX's Starship fully reusable rocket. Before the demonstration can occur SpaceX has to demonstrate orbital refilling of its lander by a spacecraft upper stage tanker and SpaceX founder Elon Musk has said this will be done in 2026. Under NASA HLS contracts SpaceX is providing three landers, the pre-Artemis III demonstration, the second is for Artemis III and the third is for the Artemis IV landing. Duffy has not said the Artemis IV landing contract is cancelled.

"The problem is they're [SpaceX] behind. They've pushed their timelines out and we're in a race against China. The President and I want to get to the Moon in the President's term. So, I'm going to open up the [Artemis III] contract," Duffy told the news channel MSNBC, announcing the contract cancellation on the channel on 20 October. "I'll let other space companies compete with SpaceX, like Blue Origin and whatever one can get us there first, to the Moon, we're going to take. And if SpaceX is behind, and if Blue Origin can do it before them, good on Blue Origin, we might have two companies that can get us back to the Moon in 2028." Duffy posted a video of his MSNBC comments and some additional written comment on his social media platform X account on 20 October. He wrote: "We are in a race against China so we need the best companies to operate at a speed that gets us to the Moon FIRST. SpaceX has the contract to build the HLS which will get U.S. astronauts there on Artemis III. But, competition and innovation are the keys to our dominance in space so @NASA is opening up HLS production to Blue Origin and other great American companies."

Musk responded on his X account by making personal attacks against Duffy. Beyond the public test flights of the Starship launcher, only some testing of the SpaceX HLS airlock and elevator mock-ups have been publicised. Another important element of the mission timetable is the Axiom Space spacesuits and what state of readiness that design has achieved. Very little is known about the progress of Blue Origin's Blue Moon lander that would land the astronauts. The Blue Moon MK1 lander, which is a cargo version, is to launch by the end of this year to deliver scientific instruments for NASA under the agency's commercial lunar payload services programme. In September, NASA also awarded Blue Origin an order worth $190 million for the 2027 delivery of a robot lunar rover that will look for ice.

In September and October, Duffy made public comments about the importance of returning American astronauts to the Moon before China lands there for the first time (*SpaceFlight* Vol 67 No.11 November pp 2-3). China's timetable for landing its taikonauts, as they call astronauts, on the Moon is around about 2030. Chinese authorities have not used language about a race with regards to their human lunar exploration plans. In May 2023, NASA awarded the Artemis V HLS contract to Blue Origin. During President Donald Trump's first term of 2016 to 2020 NASA's goal was to land on the Moon in 2024. President Joe Biden took office in January 2021 and in January 2024 NASA announced new dates for the Artemis programme. The first crewed mission, Artemis II, would take place in September 2025, but this is now February 2026 (see pages 40-41) and Artemis III was moved from September 2026 and it is now mid-2027. The date for Artemis IV, the first Gateway lunar space station mission, which includes a crew landing, has not changed. It had been 2028 and remains so now. Artemis V is scheduled for 2029. SF

LEFT
Pictured in March 2024, NASA astronaut Doug Wheelock and Axiom Space astronaut Peggy Whitson were testing SpaceX's Starship human landing system's airlock mockup in analog space suits.

European super heavy is viable says ESA

PHOTO: ESA - D. DUCROS

ABOVE
An artist's impression of a potential European very heavy-lift reusable rocket capable of carrying 60 t to space.

The European Space Agency has concluded that a European super heavy fully reusable launch vehicle would be economically viable from the 2030s.

The European Space Agency has been conducting what it calls "pathfinder activities" to come to decisions about whether its member states should fund a European version of SpaceX's Starship. The Agency's analysis has found that the development of a 60 to low Earth orbit (LEO) European super heavy reusable launch system faces considerable challenges in terms of risks, costs and uncertain demands. But it also found that it represents an opportunity in the 2030s for European countries to secure strategic autonomy in the medium to long-term and capture emerging markets. The next step for ESA's work on this is to complete a business plan for such a launch system.

"Therefore, the industrial development of a Super Heavy Reusable Launch System will strengthen Europe's strategic resilience with the necessary capabilities in terms of cadence, payload performance and costs to compete on the global stage and support the necessary autonomy for the future exploitation of space," was the conclusion of the European super heavy reusable launch system pathfinder activities status paper presented by ESA space transportation directorate personnel at the International Astronautical Federation's 76th International Astronautical Congress (IAC) in Sydney, Australia from 29 September to 3 October. The paper, and ESA's website, have a concept graphic for the Super Heavy Reusable Launch System. It has a very tall first stage that has grid fins for descent guidance and landing legs and a bullet shaped upper stage that has base fins for its aerodynamic descent control.

The missions and services enabled by the Super Heavy Reusable Launch System are stated to include LEO cargo and crew for space stations, beyond LEO cargo and crew exploration missions, mega constellation deployment and "large space infrastructure" missions. The timeframe for the Super Heavy Reusable Launch System is from the early 2030s, but ESA's analysts decided the first few years of its operation would not involve reusability. The analysis assumes all launches "prior to 2037 will be expendable". The ESA analysis baseline scenario assumes a maiden launch in 2034 and a slow increase in the annual cadence to a target of 24 launches in 2045, according to the market's needs. From 2037, reusable versions would be introduced. The year 2037 was selected based on industry benchmarking which pointed to when the reusable technology would be ready. The analysis was aided by European companies including Arianegroup, Italy's Avio, Spain's Sener, Thales Alenia Space, reusable propulsion developer Pangea, reusable cargo and crew spacecraft developer The Exploration Company.

Spanish rocket developer PLD Space was selected by ESA for its European Launcher Challenge for the firm's Miura 5 rocket. But PLD Space also has a Super Heavy Reusable Launch System-like concept it calls Miura Next Super Heavy. PLD Space plans to have a Falcon 9 first stage-like Miura Next rocket or "core stage". The Miura Next Super Heavy has a Miura Next core stage and four more Miura Next stacked around as side boosters. The Miura Next Super Heavy will be able to launch 53 t with its five reusable core stages landing on sea barges and it could loft 60 t when fully expendable.

The timeline for the Super Heavy Reusable Launch System set out in the IAC paper means that the ESA triennial budget setting meeting that was to take place last month, in November, would have had to have approved funding. The ESA analysis assumes a public, private partnership for the rocket's funding. To achieve a 2034 start of operations, funding would have to begin in 2026 according to the analysis. Internationally, only China and Blue Origin are working on huge rockets which have Starship-like payload capacities. But there are many ongoing rockets being developed to compete with SpaceX's Falcon 9 for satellites of various sizes (see pages 16-29). SF

PHOTO: JAXA

HTV-X1 success

LEFT
This illustration shows the HTV-X approaching the International Space Station.

The Japan Aerospace Exploration Agency's (JAXA) new cargo ship, H3 Transfer Vehicle (HTV)-X, arrived at the International Space Station (ISS) on 29 October after launching on the seventh fight of JAXA's H3 rocket on 26 October.

The HTV-X1 was launched at 0900hrs 15secs local time on 26 October from Japan's Tanegashima Space Center. After almost four days of being on-orbit, the HTV-X1, the first HTV-X, was captured by the Station's robotic arm, Canadarm2. The HTV-X resupply ship is 4.4 m wide, 8 m long, has a mass of 16 t and will deliver 4 t of cargo (*SpaceFlight* Vo 67 No. 9 September pp 22-25). The HTV-X1 was captured by the robotic arm, Canadarm2, at 0058hrs on 30 September Japan Standard Time (1558hrs 29 October universal coordinated time (UTC)).

"Following this [Canadarm2 capture], HTV-X1 was successfully berthed to the ISS at 20:10 on October 30 (JST) [1110hrs UTC]," JAXA stated in its press release.

As it is the first HTV-X, the HTV-X1 will spend 18 months in orbit after its six-month stay at the International Space Station. The HTV-X is designed to stay berthed to the ISS for six months. The delivery of supplies to the Station is how JAXA pays in-kind for its astronauts to participate in ISS Expeditions. The European Space Agency has been providing service modules for NASA's Orion crew spacecraft for its ISS participation. In the past ESA also sent an ISS resupply ship.

The HTV-X is capable of transporting refrigerators and experimental samples that must be kept at low temperatures. It can also provide a power supply to onboard experiments during their transportation. The HTV-X will also be able to carry external payloads. It has been designed so these payloads can be mounted on the top. This is called the "exposed cargo mount support system" and this means the full volume of the H3 fairing will be utilised. The H3 has two types of fairings on offer. Internally, HTV-X has a rack structure in its pressurised cabin and it is able to transport more pressurised cargo than its predecessor, the H-IIB Transfer Vehicle (HTV). The last time a Japanese cargo ship served ISS was May to August 2020 with the H-IIB Transfer Vehicle 9, the final HTV. The HTV was also called Kounotori which is Japanese for Stork. The Kounotori did not have the capability to transport refrigerators and experimental samples that must be kept at low temperatures. Nine HTVs were sent to the ISS from 2009 to 2020 and all nine of the Mitsubishi Heavy Industries H-IIB rocket launches for those HTVs were successful. The H-IIB was an evolution of the H-IIA and the B only launched the HTV, it had no other mission. The H3 launches from Tanegashima Space Center's Yoshinobu launch complex, the same complex the H-IIB used. The HTV-X is to be the basis for a future JAXA resupply vessel that will serve NASA's Gateway lunar space station that could be operational from 2028. Japan is also providing a pressurised lunar rover for astronauts. With these contributions to NASA's lunar plans, Japan will be the first non-North American country to see an astronaut fly to the Moon onboard NASA's Lockheed Martin Orion crew spacecraft.

The H3 is JAXA's latest rocket, and it has been operational since February last year with its second launch. The H3 first stage uses two or three LE-9 expander bleed cycle main engines, with none or two or four solid rocket boosters. The expander bleed cycle engine type is a Japanese creation. The first H3 launch in 2023 failed and the flight termination system had to be used. That first flight was carrying the Advanced Land Observing Satellite-3. The second flight was successful, and it carried the Vehicle Evaluation Payload-4 and two smaller payloads.

The fifth H3 rocket orbited the Quasi-Zenith Satellite System Michibiki No. 6 satellite on 2 February this year. Last July, JAXA conducted engine test firings with the sixth H3 rocket which has not been launched. The eighth H3 rocket is to be launched on 7 December to orbit the latest Michibiki satellite for the Quasi-Zenith Satellite System, a navigation constellation. SF

Contrarian comet

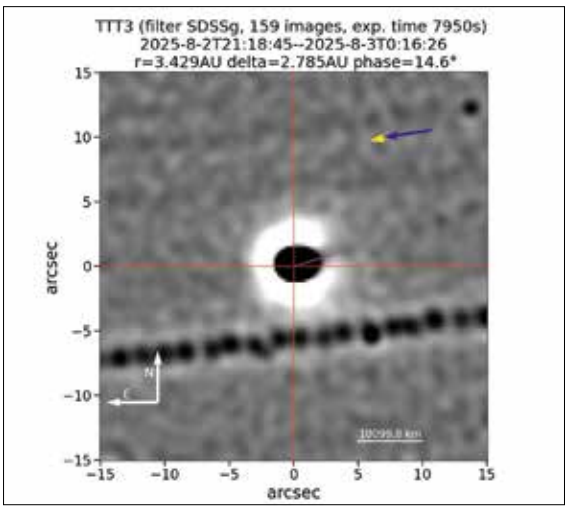


PHOTO: TWO-METER TWIN TELESCOPE (M. SERRA-RICART)

ABOVE
This image is based on observations made in the Two-meter Twin Telescope sited at the Teide Observatory of the Instituto de Astrofísica de Canarias, that Light Bridges operates in Tenerife.

While the object 3 Interstellar Asteroid Terrestrial-impact Last Alert System (ATLAS) was behind the Sun during October, analysis of observations from July to September continued to show a contrary object.

The 'tail' that 3I/ATLAS had pointing towards the Sun for much of its voyage through the Solar System after being detected on 1 July had been surpassed by a more conventional rearward tail by November. A 19 October paper from the University of California Los Angeles Department of Earth, Planetary and Space Sciences and the University of Oslo's Centre for Planetary Habitability stated: "The morphology of the comet changes from a Sun-facing dust fan in the early 2025 July observations, to one dominated by an antisolar dust tail at later dates." An image published on 15 October but taken on 2 August by the Two-meter Twin Telescope at the Teide Observatory of the Instituto de Astrofísica de Canarias on Tenerife shows a broad, sunward-directed plume. The Light Bridges Two-meter Twin Telescope scientific director, Miguel Serra-Ricart, told *SpaceFlight*: "3I/ATLAS is a natural object similar to the comets of our Solar System. It shows structures commonly observed in other comets, such as jets pointing toward the Sun. An anti-tail has also been detected by ground-based telescopes. During the next two months, we will have the opportunity to improve our knowledge about 3I[/ATLAS]."

By early December, 3I/ATLAS would be beyond the orbit of Mars again and making its way towards Jupiter. When it passes Jupiter it will be 53.8 million km from the gas giant. While in November the object became observable again after passing behind the Sun, during October it had been hidden by the star and its bright light. But scientists continued to analyse the data from observations in the preceding months.

Spacecraft from NASA, the European Space Agency (ESA) and the Russian Federal Space Agency (Roscosmos), China National Space Administration (CNSA) and the United Arab Emirates (UAE) Space Agency were in a position to image 3I/ATLAS as it flew past Mars at a distance of about 30 million kilometres around 3 October. The CNSA and UAE agency have not published any images. The Roscosmos, ESA joint Trace Gas Orbiter spacecraft's image shows a bright object but the camera has limited capabilities.

NASA's Mars Perseverance rover Navcam camera took images but with its extreme distance and the camera's own limited capability, a smeared blur that looked cylindrical was the outcome. NASA said its Curiosity rover on Mars would observe 3I/ATLAS but no data has been publicised. NASA also has its Mars Reconaissance Orbiter circling the red planet but its images, if it took any, have not been published. This maybe because the United States Congress failed to pass a government budget before the deadline of 1 October suspending all non-essential staff until a budget is passed.

The object was closer to the Sun, at its perihelion, on 29 October. The European Space Agency's Jupiter Icy Moons Explorer (JUICE) spacecraft was able to image 3I/ATLAS from 2 to 25 November. But due to the JUICE spacecraft's limited capabilities, the images will not be available until February next year, ESA has said in posts on its JUICE social media platform X account. NASA has stated that its spacecraft for its missions, Europa Clipper, Swift, Lucy, Psyche, Parker Solar Probe, Polarimeter to Unify the Corona and Heliosphere and its Solar and Heliospheric Observatory would all be used to observe the object. Data from all these spacecraft was yet to be publicised at the end of October.

Harvard University's Frank B. Baird, Jr. professor of Science and physicist, Abraham Loeb, is still the only prominent scientist proposing that 3I/ATLAS could be extraterrestrial technology, but he agrees it is more likely a comet. Astronomers and astrophysicists state 3I/ATLAS will be a comet, but words like unusual, paradoxical, unique and significantly different, have been used to describe its characteristics compared to Solar System comets. Southern Astrophysical Research Telescope researchers, in an 8 August paper, found the coma "paradoxical" with no "evidence of sublimation". Vera C. Rubin Observatory researchers described its sunward pointing tail as "unusual". The way light was reflected off of 3I/ATLAS, its polarisation of light, is "significantly different from all known comets," according to the 8 September paper, *Extreme Negative Polarisation of New Interstellar Comet 3I/ATLAS*. And the trajectory is "unique," according to researchers at the University of Maryland, NASA Goddard Space Flight Center and NASA Ames Research Center, because it has been through the ecliptic plane; the plane around which the planets orbit the Sun. SF

Final flight?

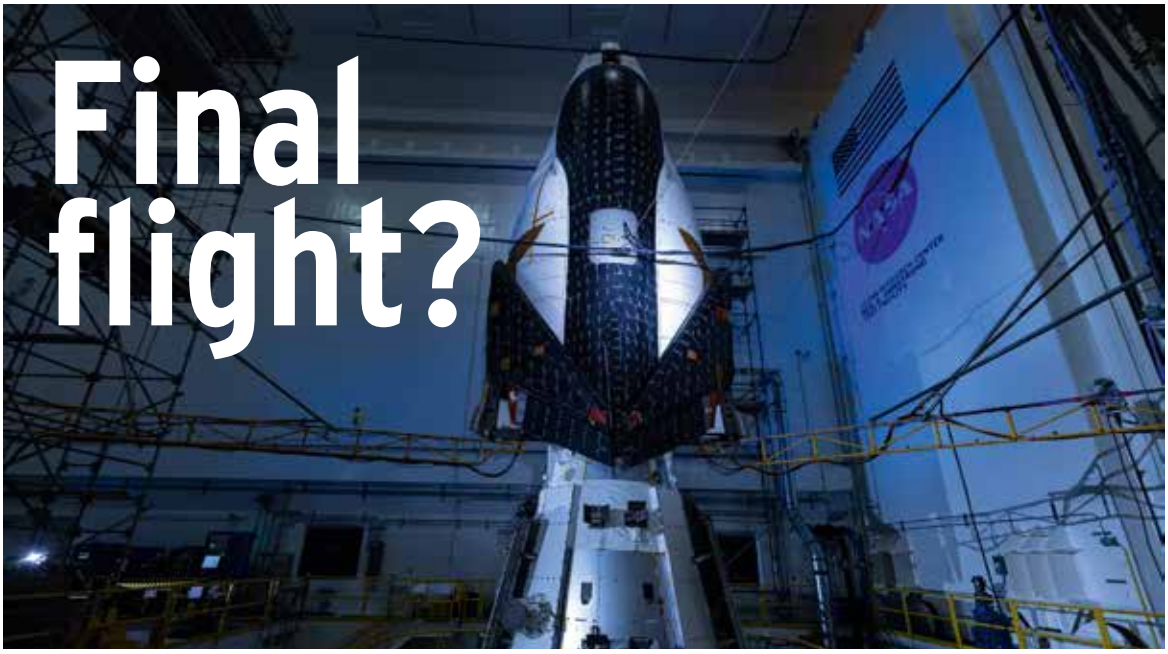


PHOTO: NASA

LEFT
The Sierra Space Dream Chaser is stacked atop its Shooting Star module on the vibration table at the NASA Armstrong Test Facility in Sandusky, Ohio for testing to simulate launch and re-entry conditions.

The maiden voyage of Sierra Space's Dream Chaser spaceplane will no longer be to the International Space Station (ISS) and instead it will fly free in orbit in late 2026.

Dream Chaser was envisaged to ferry crew and cargo to and from the ISS. On 14 January 2016, NASA awarded a commercial resupply services (CRS) 2 contract to Sierra Space's origin company Sierra Nevada for a minimum of six cargo delivery flights. In NASA's 25 September 2025 announcement about its ISS visit decision, the agency states it may order Dream Chaser Station resupply flights if the 2026 flight is successful. But the agency is no longer obligated to a specific number of resupply missions. Dream Chaser is years late and was to have launched in 2024 and that was delayed to 2025. In the third quarter of 2025, the very first Dream Chaser, *Tenacity*, had been in pre-flight processing at NASA Kennedy Space Center.

"This transition provides unique capabilities to meet the needs of diverse mission profiles, including emerging and existential threats and national security priorities that align with our acceleration into the defense tech market," said Sierra Space executive chair, Fatih Ozmen. "Together with NASA, we are seeking to preserve the exceptional potential of Dream Chaser as a national asset."

The comments by NASA's ISS programme manager, Dana Weigel, in the agency's statement suggest that the remaining six to seven years left for ISS meant Dream Chaser could not fulfil those six flights. "Development of new space transportation systems is difficult and can take longer than what's originally planned … As NASA and its partners look toward space station deorbit in 2030, this mutually agreed to decision enables testing and verification to continue on Dream Chaser," Weigel said. With NASA supporting the development of private space stations and Sierra Space being a partner in Blue Origin's station, Dream Chaser could possibly serve that outpost.

Originally to have launched on the United Launch Alliance (ULA) Atlas V, Dream Chaser was delayed for so many years ULA launched its new Vulcan Centaur rocket in the meantime. It launched in January 2024, and Dream Chaser is now to fly on that. The availability of the ULA Vulcan Centaur may be why *Tenacity*'s flight date is so far away as Sierra Space states that the date of "late 2026" is "to align with expected launch vehicle availability". Sierra Space's statement on NASA's decision also describes the Dream Chaser as a "national asset available for future national security and defense demonstrations". The United States Space Force operates the Boeing X-37B spaceplane which is used as a free-flying orbital laboratory. The Dream Chaser could carry out that role and it is a larger spacecraft with more volume for experiments and technology demonstrations.

When NASA awarded an ISS cargo resupply contract to the company that spun Sierra Space out, Sierra Nevada, in January 2016, the agency had already awarded CRS contracts to SpaceX and Orbital Sciences in 2008. Orbital Sciences flew its first CRS mission with its Cygnus spacecraft in 2014 and SpaceX in 2012 with its Dragon capsule. When it was awarded the 2016 contract, Dream Chaser had previously been under development for NASA's commercial crew programme since 2010. In February 2010, NASA awarded $20 million for the development of a reusable seven passenger Dream Chaser spaceplane. Dream Chaser began many years before that as a project by the Californian firm SpaceDev, but the Sierra Nevada Corporation acquired the company in October 2008. It was in November 2005 that SpaceDev announced it had opted for the 1980s NASA Langley Research Center's lifting body type HL-20 vehicle as the basis for its Dream Chaser. The HL-20 informed Dream Chaser design was unveiled in June 2006 and that year the spaceplane was proposed for NASA's commercial orbital transportation services programme, but it was not selected. SF

ACTION PLANS?

PHOTO: ESA/BIS/BNSC

ABOVE
On 23 March 2010, the new UK Space Agency was announced in London by, left to right, then European Space Agency Director General Jean-Jacques Dordain, the UK's then Minister for Science and Innovation, Lord Drayson, and the chief executive officer of the software firm Logica which was bought out two years later.

THE UK SPACE Agency's (UKSA) Corporate Plan 2025-2026 has provided some insights into the Agency's future actions including when it becomes a unit of the Department for Science, Innovation and Technology (DSIT).

The Corporate Plan 2025-2026 has a series of forecast dates for milestones, for example, one is 31 March 2026 for the first launch from SaxaVord Spaceport in Scotland. It names the German rocket developer Rocket Factory Augsburg as the customer. The 31 March is also the date by when a series of programmes and projects have to be completed. They are the Climate Service Funding programme, the Unlocking Space for Business projects, Unlocking Space for Government projects, the UK Space Agency Accelerator programme and the International Bilateral Fund projects. Various plans, processes publications and strategies are also to be completed by 31 March.

Two actions by the 31 March where money is given are the Connectivity in Low Earth Orbit funds tranche and the award of the phase three contract for the Agency's Active Debris Removal mission. The plan states that for 2025 to 2026 these tranches and contracts related budgets have been £4 million for in-orbit servicing, assembly and manufacturing and for telecommunications, £128 million, which is the second largest after space science. The plan states that the total budget for 2025 to 2026 has been £681 million and £73 million went to exploration, while the largest share went to space science at £166 million.

The Plan gives two examples of activities that will occur beyond 1 April 2026. They are an eight-week summer internship programme and improving the European Centre for Space Applications and Telecommunications (ECSAT) in Harwell, Oxfordshire. The UKSA will "improve the offering made by the ESA ECSAT centre in Harwell for all ESA Member States," with "full business proposals" for 2026 and beyond to be submitted to the European Space Agency at the triennial budget meeting that was held in November.

It was on 20 August that the UK government announced that UKSA would lose its status as an executive agency. It would become a "unit" within DSIT as part of the Department's space directorate from 1 April 2026. According to the Plan, UKSA established a "new operating model" in 2024 which was "developed recognising the Agency's position relative to cross-governmental thinking, such as the National Space Strategy's Outcomes for Space, and the eight categories within the Space Industrial Plan." The Plan states that UKSA expects the alignment of the operating model with "these outcomes" will be "centralised and reinforced in the new DSIT-led space strategy document expected in early 2026," which could mean the first quarter.

Under UKSA's exploration activities, the UK is providing propulsion subsystems and the descent engine for ESA's Argonaut lunar lander. The UK is also funding research for radioisotope heating units to heat and power future lunar and deep space missions.

Under exploration, the plan also states, "stage two of astronaut reserve training for astronauts Meganne Christian and John McFall" was to be completed by 31 October this year. The plan makes no mention of a mission for Christian, McFall or the UK born ESA career astronaut Rosemary Coogan.

The UKSA had signed a memorandum of understanding (MOU) with human spaceflight specialist Axiom Space in October 2023 that included the consideration of a commercially funded all-British mission. The MOU was renewed with a signing on 3 October this year at the Agency's exhibit at the 76th International Astronautical Congress held in Sydney, Australia.

When UKSA was created on 1 April 2010 it brought together under one organisation budgets that had been with different departments. The Natural Environment Research Council, the Science and Technology Facilities Council and the Technology Strategy Board contributions to ESA became UKSA's. The UK's financial interest in the European Union's Satellite Centre, which was the responsibility of the Ministry of Defence, also became an Agency responsibility. The UKSA was also responsible for the UK's involvement in the Global Monitoring for Environment and Security programme and the Galileo satellite navigation system, also EU programmes. When the UK left the EU its involvement in such programmes ended. SF

New frontier

PHOTO: SPACEX

THE UK SPACE biotech company Frontier Space announced on 9 October its self-contained laboratory Spacelab Mark 1 had performed successfully following its 21 April SpaceX Falcon 9 rocket launch.

Frontier is a startup founded by researchers from Cranfield University and they describe Spacelab Mark 1 as a self-contained space laboratory designed to conduct microgravity research. The company's goal is to provide orbiting laboratories for pharmaceutical research and development and biomanufacturing. Spacelab Mark 1's goal was to validate the systems needed for future self-contained laboratories in orbit. Spacelab Mark 1 was hosted inside European space logistics startup Atmos Space Cargo's Phoenix 1 re-entry capsule. Spacelab Mark 1 and Phoenix 1 were launched on SpaceX's Bandwagon-3 flight which was also the first orbital test flight of a Phoenix capsule.

"This mission gave us the confirmation we needed that our baseline systems work in orbit. We're already incorporating lessons from this flight into the next generation of our platform, and we're excited for what comes next," said Frontier Space chief executive officer, Aqeel Shamsul. Frontier has been supported by the European Space Agency Business Incubation Centre at Space Park Leicester.

Frontier refers to its self-contained space laboratories as "platform technologies" and it has two, the aforementioned Spacelab and a bioreactor design it calls XSB which is for biomanufacturing. In a cubesat format, Spacelab has a 2U cubesat sized payload bay with a sensor suite, a microfluidic subsystem and a multi-chamber disk rotating platform. The Spacelab also contains electronics with a data handling bus. The mission's primary objective was to validate the power supply, computing, imaging and communications, which it did. One of the Spacelab Mark 1's payloads took image data and it was transmitted back to Earth.

The Spacelab Mark 1 also contained other experiments. One aimed to test the space-readiness of freeze-dried biological samples. This was a joint experiment with Imperial College London's Bezos Centre for Sustainable Protein director, Professor Rodrigo Ledesma-Amaro. In-orbit performance data of the biological material confirmed it worked, according to Frontier. But as the Atmos capsule was also a test and was not going to be recovered, the biological samples were lost. And the Phoenix 1 capsule also transmitted data through limited downlink windows.

Another experiment was a Frontier microfluidics platform, a transparent, miniature device with internal fluidic channels used in cell culture labs on Earth but adapted for space. Unfortunately, "full in-space performance metrics were not recovered," the firm said in its announcement, due to that limited downlink capability caused in part by an altered trajectory for Phoenix 1. Frontier decided that the microfluidics platform was proven to be viable through its ground testing. The company stated: "An improved version of the system is already under development."

The Bandwagon-3 mission Falcon 9 upper stage was injected into a 45° inclination orbit and completed one full orbit before its own planned de-orbit burn placed Phoenix 1 on its own return trajectory. The capsule performed the initial inflation of its heat shield before entering Earth's atmosphere south-east of the Brazilian coast. It sent back some data and splashed down about 2,000 km off the American coast and was not recovered (*SpaceFlight* Vol 67 No.7 July p 9). A problem for Atmos was that data from the final stage of its descent could not be retrieved. According to Atmos, the test flight's three objectives were achieved. They were collecting in-flight data from the capsule and its sub-components while it was in orbit, gathering customer payload data and deploying the inflatable heat shield before re-entry. Phoenix 1 was carrying technology demonstrators and biological experiments for customers as well as Frontier Space. The other customers were the German Aerospace Center and Japanese on-orbit experiment specialist IDDK. The development of its next test capsule Phoenix 2 is underway, and its test flight is planned for 2026. SF

> This mission gave us the confirmation we needed that our baseline systems work in orbit. We're already incorporating lessons from this flight into the next generation of our platform, and we're excited for what comes next

ABOVE
On 21 April, a SpaceX Falcon 9 rocket launches the firm's Bandwagon-3 mission that orbited Frontier Space's payload.

ISS Report

12 September - 30 September 2025

A new Cygnus XL resupply ship arrived, but Dragon aborted reboosting the Station

Photographs courtesy NASA

Expedition 73 was in its sixth month, with its commander Russian Federal Space Agency (Roscosmos) cosmonaut Sergey Ryzhikov in his second month as International Space Station (ISS) commander. His crew of flight engineers were his fellow cosmonauts Alexey Zubritsky and Oleg Platonov, Japan Aerospace Exploration Agency (JAXA) astronaut Kimiya Yui and NASA astronauts Jonny Kim, Zena Cardman and Mike Fincke.

On 13 September, the Roscosmos Progress 93 cargo spacecraft was to dock with the aft port of the Station's Zvezda module delivering about three tonnes of food, fuel and supplies. The Progress had launched at 2154hrs local time on 11 September on a Soyuz rocket from the Baikonur cosmodrome in Kazakhstan. The Progress 93 arrived at ISS at 1723hrs universal coordinated time (UTC) and will be docked for about six months.

The following day another cargo spacecraft launched for the ISS. Northrop Grumman's first Cygnus XL spacecraft was orbited for the company's commercial resupply services (CRS) 23 mission. At 1811hrs local time, the Cygnus XL was launched by a SpaceX Falcon 9 rocket from Cape Canaveral Space Force Station's space launch complex 40. The Cygnus XL is a larger version of the Cygnus, which was originally developed by Orbital Sciences, a company that Northrop acquired. The Cygnus XL can carry more than 4,989.5 kg (11,000 lb), 33% more than the previous Cygnus variant. This first Cygnus XL is named *S.S. William "Willie" C. McCool*, in honour of the NASA astronaut who perished in 2003 in the Space Shuttle Orbiter *Columbia* accident. On ISS, Station commander Ryzhikov opened the Progress' hatch on 14 September and entered the spacecraft with Ovchinin to begin unpacking the new gear.

On 15 September at the start of their shift, Kim and Cardman collected blood pressure measurements and ultrasound artery scans. Kim, who is a physician, led the study operating the biomedical gear and examining Cardman with assistance from doctors on the ground. Cardman also wore electrodes measuring her cardiac activity for the portion of NASA's human research investigation programme that studies the heart, brain and eye function in microgravity. Later, Kim worked with Yui to study how liver tissue with blood vessels, which had been bioprinted on Earth, reacted to weightlessness.

> A big congratulations to the NASA and Cygnus teams for a successful Cygnus launch, rendezvous, and capture. Adapting and overcoming unforeseen challenges is something we do at NASA and I'm very proud to be a part of this team

RIGHT
On 14 September, the Roscomos Soyuz MS-27 spacecraft is pictured docked to the International Space Station's Prichal module as the outpost soared 259 miles (416 km) above the northern coast of Madagascar.

Cardman ended her shift treating bone stem cell samples in the Japan Aerospace Exploration Agency's Kibo laboratory module's Life Science Glovebox for preservation in a science freezer and later analysis. Researchers are exploring how microgravity affects bone tissue to safeguard a crew member's skeletal system and possibly treat aging conditions and bone diseases on Earth. Fincke worked inside the Harmony module exploring ways to produce vitamins and nutrients in microgravity to help supply adequate nutrition for long-term space missions. He treated yeast, yogurt, and fermented milk samples then stowed them in a research incubator for the Bionutrients-3 investigation.

Ryzhikov and Zubritsky spent the day configuring the new Progress 93 for its six months of docked operations. The duo began checking a docking mechanism inside of the Zvezda service module's aft port where Progress is docked. Ryzhikov and Zubritsky then spent the rest of their shift transferring water and unpacking cargo from inside the Progress. Their fellow cosmonaut Platonov focused on science, photographing landmarks in South America for analysis and maintaining physics research hardware.

Kim spent 16 September studying rendezvous procedures and practising Canadarm2 robotic arm manoeuvres that would be used when the Cygnus reaches a point about 10 m away from the orbital outpost. Kim will be in the cupola commanding Canadarm2 with Cardman backing him up and monitoring the activities. At the beginning of the day, Kim and Cardman joined Fincke and Yui and reviewed Cygnus' mission profile and the cargo it is delivering. Ryzhikov and Zubritsky spent the day »


СОЮЗ

« unpacking Progress and transferring fluids to and from the resupply ship. The Station commander and his flight engineer continued configuring Progress 93 for six months of cargo transfers and docked operations. Platonov worked on a pair of different science experiments. He set up some physics research hardware to observe complex plasmas for future spacecraft designs and industrial processes on Earth. His second experiment was photographing glaciers and mountains throughout South America and Africa to analyse natural and man-made conditions on Earth. On 16 September, NASA and Northrop Grumman announced that the planned arrival of the Cygnus on 17 September would be delayed.

The Cygnus delay was caused by an earlier than expected engine shutdown on 16 September, but all the other Cygnus XL systems were performing normally. The engine had stopped earlier than planned during two of five engine firings that were designed to raise the cargo ship's orbit for its rendezvous with the Station. The two burns that shutdown earlier were engine firings three and five. The engine shutdowns meant the Cygnus XL would have to conduct a series of further burns to ensure the spacecraft reached the Station for its robotic capture and installation.

Despite its early engine shutdowns, the *S.S. William "Willie" C. McCool* was at a safe distance behind the ISS. The NASA and Northrop Grumman engineers found that an early warning system initiated a shutdown command and ended the main engine burn because of a conservative safeguard in the software settings. The new arrival date and time was decided to be 1118hrs UTC on 18 September. Kim's job would still be to capture the Cygnus XL using the Station's Canadarm2 robotic arm. The *S.S. William "Willie" C. McCool* is staying at the Station attached to the Unity module's Earth-facing port until March 2026. "A big congratulations to the NASA and Cygnus teams for a successful Cygnus launch, rendezvous, and capture. Adapting and overcoming unforeseen challenges is something we do at NASA and I'm very proud to be a part of this team," said Kim in a NASA statement. On 18 September, it was at 1124hrs UTC that Kim, with assistance from Cardman, captured the Cygnus XL spacecraft with the Canadarm2. During 19 September, the Expedition 73 crew were unpacking the spares, food and supplies delivered by the CRS-23 Cygnus XL ship.

ABOVE

On 25 September, Northrop Grumman's first Cygnus XL cargo craft is installed to the Unity module's Earth-facing port as the International Space Station orbited 262 miles (422 km) above the Atlantic Ocean off the coast of South Africa.

OPPOSITE

Pictured on 18 September inside the Northrop Grumman Cygnus XL cargo craft are (clockwise from left) NASA astronauts and flight engineers Zena Cardman, Mike Fincke, and Jonny Kim and Japan Aerospace Exploration Agency astronaut and Expedition 73 flight engineer Kimiya Yui. Highlighted at center, is a poster of William "Willie" McCool, in honour of the NASA astronaut who perished in 2003 during the space shuttle *Columbia* accident and for whom the Cygnus spacecraft is named.

Unloading new science experiments delivered by the Cygnus XL cargo craft was ongoing on 22 September. Fincke, Kim and Cardman were removing cargo from the supply ship. A pair of portable science freezers containing research samples were removed from Cygnus and installed in an Express science rack for future experiments. Cardman also installed new cloud computing hardware in the United States segment Destiny laboratory module then relocated air monitors from Destiny to the US Tranquility module. Yui also spent his shift installing new computer networking gear inside the Kibo module. These ethernet hub upgrades are to transmit data quicker and more efficiently throughout the orbital outpost. Zubritsky and Platonov worked together unloading some of the cargo delivered by the Progress 93 cargo craft. Ryzhikov worked on an Orlan spacesuit in the Roscosmos segment's Poisk module ahead of spacewalks planned for later this year.

Fincke and Kim worked in the European Space Agency's Columbus laboratory module. Fincke scanned Kim's chest with the Ultrasound 2 device to identify signs of microgravity induced plaque buildup or accelerated aging-like symptoms in the arteries. Kim also wore sensors that measured his cardiac activity during the scans. Doctors collect the health

data from astronauts before, during, and after a spaceflight and compare it to data collected from other astronauts to gain clearer insights into crew health.

On 23 September, the crew were transferring emergency gear into the SpaceX Dragon crew spacecraft, *Endeavour*, maintained life support equipment and continued unpacking the Progress resupply ship. Cardman spent two hours exercising, working out on the Advanced Resistive Exercise Device (ARED) and pedalling on the Station's exercise cycle to counteract the accelerated muscle and bone loss caused by the lack of gravity. The exercise also forms part of NASA's investigation into human health in microgravity. After her workout, Cardman wore a sensor-packed bio-monitor headband and vest from the Canadian Space Agency for a 48-hour session measuring her health data. Fincke led an eye exam and operated medical imaging gear on Yui while personnel on the ground monitored in real-time. Doctors are studying how microgravity affects the eye structure including the lens, retina and optic nerve.

Kim and Cardman spent their 24 September shift exercising while wearing sensors and breathing gear to help scientists understand how the human body adapts to weightlessness. Kim began his day pedalling on the Destiny module's exercise cycle as biomedical hardware measured his heart and breathing rate. Cardman worked out in the Tranquility module jogging on the treadmill then doing deadlifts, curls, bench presses and other exercises on the ARED. Fincke would later replace components on the ARED in Tranquility. Fincke then spent half-an-hour checking and replacing hatch seal segments in Destiny. Kim and Cardman joined in the hatch work at the end of their shift inspecting hatch seals in the Destiny and Unity modules. Yui worked in Kibo on cubesat hardware.

This Cygnus XL is named the S.S. William "Willie" C. McCool, in honour of the NASA astronaut who perished in 2003 during the Space Shuttle Orbiter Columbia accident

Ryzhikov and Zubritskyspent the first half of their shift inside the Nauka science module routing cables for an experiment studying semiconductor manufacturing in space. Platonov kicked off his shift in the Zvezda service module working on ventilation system maintenance. He also collected radiation measurements from sensors throughout the Station's Roscosmos segment. The cosmonaut also tested remote control communications between the European robotic arm and mission controllers in Moscow.

On 25 September, Yui wore a specialised thigh cuff as part of the ongoing study, which began in September 2023, into preventing the flow of fluids headward. The fluid shift causes eye and vision changes on long-term space missions. This is a condition known as Spaceflight Associated Neuro-ocular Syndrome, or SANS. He wore the thigh cuff while in the Columbus module and Kim was helping Yui. He took Yui's blood pressure measurements, scanned his veins with the Ultrasound 2 device and imaged the inside of his eyes to evaluate the effectiveness of the thigh cuff.

Ryzhikov and Zubritsky joined each other after their breakfast to scan their bellies with an ultrasound device. Results from the long-running gastrointestinal study will help doctors understand how a crew member's digestion, metabolism and nutrient delivery adapt to weightlessness. During the day, Platonov filled the Elektron oxygen generator in the Zvezda service module and serviced orbital »

« plumbing gear in the Nauka science module. Afterwards, Platonov collected air samples throughout the Station's Roscosmos segment to analyse the quality of the outpost's breathing environment. Cardman wrapped up her 48-hour session wearing the sensor-packed bio-monitor headband and vest for NASA's human research investigation. She removed the biomedical gear and downloaded her health data for review by doctors on Earth. The data will also be compared to wellness metrics collected from other astronauts before, during and after a spaceflight.

Fincke worked in the Tranquility module and opened up the Nanoracks Bishop airlock ahead of scientific payload operations. Bishop can be used to transfer cargo inside and outside of the Station. The airlock can even be detached from Tranquility using Canadarm2 for experiment operations, satellite deployments or trash disposal.The 25th also saw the SpaceX CRS-33 Dragon cargo spacecraft conduct a reboost of the ISS using the Draco thrusters that were installed inside the Dragon's trunk. The firing was manually aborted about 3mins, 45secs into the planned 19mins, 22secs burn. Ground controllers at SpaceX, in close coordination with NASA's Mission Control Center at the agency's Johnson Space Center in Houston, commanded the abort when operators noticed a swap of the Draco thruster fuel tanks did not occur as planned.

The following day the Draco firing was completed with an engine burn lasting 15 minutes. This reboosted the International Space Station's orbit, the third such reboost in September. The reboost manoeuvres lifted the orbital outpost's altitude to prepare for a Soyuz crew swap operation later this year. During the day, Cardman and Kim were in Columbus to use a virtual reality headset to explore what happens to the structure of the vestibular system that detects movement. Kim was wearing the virtual reality headset as doctors on the ground monitored his responses. Later that day, Platonov wore another pair of virtual reality goggles for a sensory system study that took place in the Nauka science module.

Fincke and Yui worked together to unload new science and supplies delivered by the Cygnus XL cargo craft. Earlier that day, Fincke installed a cubesat on the Nanoracks external platform that was to be placed outside the Station. Yui downloaded station air quality data collected from atmospheric monitors in the Destiny module.

Ryzhikov and Zubritsky continued their gastrointestinal study scanning each other's bellies with an ultrasound device after breakfast. The two then split up to work on a variety of life support maintenance tasks throughout the Station's Roscosmos segment. For Fincke and Kim, 29 September began in Columbus installing foam coarsening samples inside the Fluid Science Laboratory. Fincke then moved to Tranquility and installed the Voyager Flytrap inside the Nanoracks Bishop airlock. Flytrap will test an inflatable capture bag that could be used to capture orbital debris or sample containers returning from Moon and Mars missions. The bag was to deploy, inflate and secure space objects while remaining airtight in microgravity.

Kim took over the Nanoracks airlock operations with Cardman and readied Bishop for the Flytrap

FROM ABOVE

Japan Aerospace Exploration Agency astronaut and Expedition 73 flight engineer Kimiya Yui takes notes while installing new computer networking gear inside the Kibo laboratory module on 22 September.

Expedition 73 flight engineers and NASA astronauts Zena Cardman and Mike Fincke pose for a portrait on 26 September inside the International Space Station's Kibo laboratory module during science hardware maintenance in Kibo's airlock.

experiment. Cardman then closed Bishop's hatch and depressurised the airlock. Earlier in her shift, Cardman checked the seating inside *Endeavour* as part of standard emergency preparations.

During Yui's shift, he began in Kibo configuring cables and swapping sample hardware inside the Electrostatic Levitation Furnace (ELF). He then moved to Harmony and installed a power supply for a spacecraft humidity removal investigation. He spent the rest of his day helping to unpack science and supplies in the Cygnus. Ryzhikov and Zubritsky took turns wearing specialised cuffs and measuring how blood circulates through an arm, wrist and fingers for a Roscosmos circulatory system investigation. Ryzhikov also inspected docking module hatch seals and cleaned vent fans. Zubritsky joined Platonov and installed a docking mechanism on the Poisk module where the Progress 92 resupply ship is docked. Platonov later took a fitness test on Zvezda's treadmill then worked on ventilation maintenance in Nauka.

On 30 September, Ryzhikov wrapped up his day jogging on the Zvezda service module's treadmill for a regularly scheduled space fitness test. Zubritsky serviced the Elektron oxygen generator in Zvezda and conducted the yearly Roscosmos segment inspection for moisture, corrosion, or damage. Platonov explored how blood circulates using blood pressure cuffs and electrodes. Spacecraft humidity removal technology was a focus for Kim and Yui, installing and activating a new technology demonstration in the Harmony module. This technology is for testing the removal of moisture from a spacecraft's environment for recycling. The technology will be useful for future regenerative life support systems for Moon and Mars missions. Yui also worked in the Kibo module on the ELF, processing samples inside the experimental device. The ELF uses lasers to heat materials to ultra-high temperatures and cameras measure the properties difficult to obtain in Earth's gravity.

The 25th also saw the SpaceX CRS-33 Dragon cargo spacecraft conduct a reboost of the ISS using the Draco thrusters that were installed inside the Dragon's trunk

Fincke spent the day installing the new heat transfer host fluid physics experiment hardware inside the Columbus module. The experiment is to investigate how a gas turns to liquid to help improve the design of crew spacecraft thermal systems for deep space missions. At the beginning of her shift, Cardman swapped sample cassettes for an experiment investigating how to manufacture pharmaceuticals in microgravity. But during the day, Cardman worked primarily on life support maintenance, first transferring fluids inside the Destiny module. Afterwards, she collected airflow measurements and inspected ventilation systems throughout the Station's US segment with assistance from Kim. She ended her day inspecting cables and insulation for signs of corrosion and degradation in the Unity and Harmony modules.

Due to the US government shutdown, NASA has not updated its ISS reports and so this edition of *SpaceFlight*'s ISS Report is truncated to 30 September. The 1 October is the first day of the new US government financial year and that is why the NASA information stops with 30 September. *SpaceFlight* will run an extended version of ISS Report in the January 2026 edition if NASA updates its reports for 1 to 11 October when the shutdown ends. That January edition will also have a history of ISS as 2 November will have marked 25 years since Expedition 1. SF

Rival rockets

Dozens of rockets, some expendable, some reusable, are under development worldwide

More than a dozen nations worldwide have one or more orbital rockets operational or in development and a few more starting with sounding rockets. Once coveted intercontinental ballistic missile technology, the 21st century has seen governments hand the development of rockets to the private sector. While historically, government sponsored rockets have operated from government owned spaceports, the new companies often offer not only launch services but manufacture satellites and some operate their own spaceports. Some launch vehicle operators even launch from barges or ships out at sea.

Australia

Gilmour Space Technologies' first Eris rocket on its launch pad at the firm's Bowen Orbital Spaceport in North Queensland.

PHOTO: GILMOUR SPACE TECHNOLOGIES

With a space launch history that includes the UK's one and only satellite launch, the Prospero mission launched by a Black Arrow rocket from Woomera in 1971, Australia is working towards a domestic satellite and launch capability. It is also becoming a location for landing payloads of in-orbit manufactured products in the firm Southern Launch's Koonibba Test Range in South Australia. The United States firm Varda Space Industries has now landed two of its capsules in the range. Private industry's leading role in the sector's development is reflected in the choice for the latest leader of the Australian Space Agency, the former Virgin Galactic chief operating officer, Enrico Palermo.

Gilmour Space Technologies

The company's first launch attempt for its Eris rocket took place on 30 July at Gilmour's Bowen Orbital Spaceport at Abbot Point in North Queensland. The rocket failed a few seconds after lift-off bringing the mission the company called Test Flight 1 to a rapid end. Gilmour Space Technologies' next attempt is in 2026. The Eris rocket is designed to put 305 kg into a low Earth orbit of 500 km. The 25 m tall rocket has three stages and a 1.5 m fairing. Gilmour calls this version of Eris its Block 1. The company's first satellite was successfully launched on a SpaceX's Transporter-14 rideshare mission last June.

Canada

Canada's first satellite, Alouette-I, was launched by an American rocket on 29 September 1962. Sixty-seven years later two Canadian startup companies, Nordspace and Reaction Dynamics, are aiming to provide a launch service for small satellites. Reaction Dynamics is to operate from Spaceport Nova Scotia which is operated by the company Maritime Launch Services.

Nordspace

The Ontario company's Tundra rocket is to deliver to 500 kg to low Earth orbit. Tundra's first stage is designed to be recovered from the water and refurbished and reused. The company has a 5,000 kg to low Earth orbit rocket in development called Titan. Nordspace plans to launch from its own spaceport, the Atlantic Spaceport Complex near St. Lawrence town in the Canadian province of Newfoundland and Labrador. The firm was going to launch its sub-orbital Taiga rocket in September, but the launch was cancelled.

Reaction Dynamics

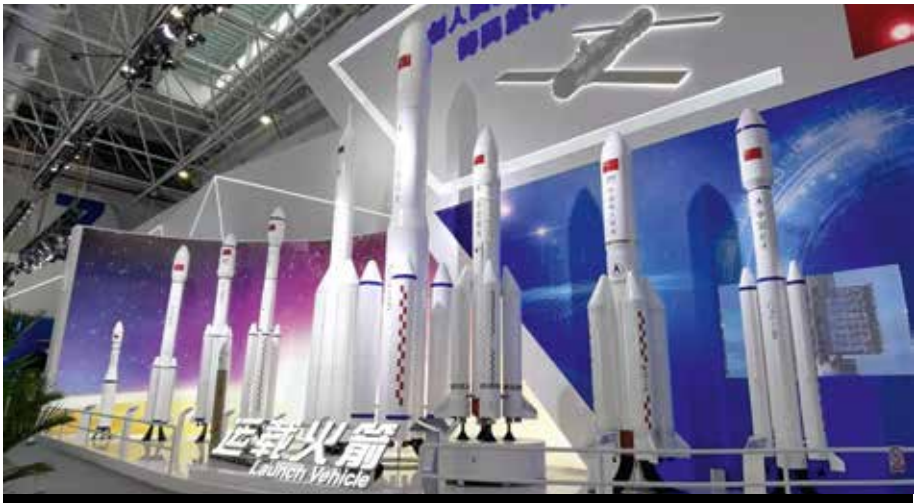
The firm's expendable Aurora rocket has two stages and can place 200 kg into low Earth orbit with a 1.3 m fairing. The rocket uses hybrid propulsion, which is the combination of solid fuel with a liquid propellant which for Aurora is hydrogen peroxide. This Quebec company wants to be able to launch weekly. Reaction Dynamics was to have its first launch in late 2024. The company has planned to launch from Spaceport Nova Scotia which is located near Canso in Nova Scotia and its construction began in 2022.

Maritime Launch Services

This Nova Scotia company is developing the Spaceport Nova Scotia and a rocket, with the help of Ukrainian aerospace companies Yuzhnoye and Yuzhmash. The Cyclone-4M rocket is being developed from flight proven Ukrainian made rockets.

China

China's first satellite, the Dongfanghong-1, was launched by a Long March-1 rocket on 24 April 1970. China's government developed rockets are still called Long March, named after a key historical event, a long march made by Chairman Mao's army in China's civil war that the communists eventually won. China's rocket development has seen its government's launchers slowly move from the highly toxic storable fuels to the cryogenic propellants of oxygen, hydrogen and more recently methane. China's commercial rocket companies have been founded since 2015. This new market has seen a mix of liquid oxygen and kerosene fuelled rockets and those that use solid fuel motors.



China Aerospace Science and Technology Corporation's launch vehicle models exhibition shows the range of Chinese government developed rockets including the Long March-8, the Long March-9, Long March-7 and Long March-2F that launches the Shenzhou crew spacecraft.

China Academy of Launch Vehicle Technology

A subsidiary of the state-owned China Aerospace Science and Technology Corporation, China Academy of Launch Vehicle Technology develops many of the Chinese government's rockets. It has two launchers in development, the Long March 9 and the Long March 10, and the 10A version. The Long March 9 will be 10.6 m wide, have three stages and be about 110 m tall. It will use liquid oxygen and methane. It is to launch spacecraft up to about 50 t for transfer trajectories for Moon and Mars missions. The Long March-10 is a three-stage rocket with two boosters. It has a diameter of 5 m and is 92.5 m tall. It will launch lunar mission spacecraft but with lesser masses of up to 27 t. The 10A is a two-stage launcher that is 67 m tall and 5 m wide with a reusable first stage. It will launch China's new crew craft, the Mengzhou, and the operational Tianzhou cargo ship. This year, an improved version of the Long March-8, the 8A, lifted-off on 11 February. The 50 m tall 8A can launch 7,000 kg into a 700 km Sun-synchronous orbit. The 8A launched from Hainan International Commercial Aerospace Launch Center in Wenchang, Hainan province. This is one of what the Chinese government is more recently referring to as commercial spaceports. The Long March-8 launched from Wenchang for the first time in 2020.

A Long March-8A launching in October this year from Hainan International Commercial Aerospace Launch Center.

PHOTOS: CNSA

China Rocket Co. Ltd.

Spun out of the Chinese government's China Academy of Launch Vehicle Technology firm in 2016, the China »

« Rocket company's solid fuel vehicle is called Smart Dragon (SD) and there are different versions of it. The SD-1 has a total length of 19.5 m, a diameter of 1.2 m and a gross lift-off weight of about 23.1 t. It is capable of sending more than 150 kg payloads to a 700 km Sun-synchronous orbit. China Rocket's Smart Dragon-3 is a larger four-stage solid fuel rocket that has been launched from the sea. The SD-3 was launching satellites in 2024.

Deep Blue Aerospace

Founded about five years ago and also known as Jiangsu Shenlan Aerospace Co. Ltd., the company is developing a rocket with a reusable first stage. Its rocket is called Nebula and there are different versions. The first two are Nebula-1 and Nebula-2. The Nebula-1 has two stages and a diameter of 3.35 m and it can launch 2,000 kg. Its engines use liquid oxygen and kerosene to power the first stage. There is an improved Nebula-1 able to put 2,000 kg into a Sun-synchronous orbit. Nebula-2 is a substantially larger vehicle with a 5 m diameter which is designed to place 25 t into low Earth orbit.

Expace Technology

Spun out of the Chinese government's China Aerospace Science and Industry Corporation in 2016, Expace has developed an expendable solid fuel rocket, the Kuaizhou which is designed for microsatellite and small satellite launches. There are various versions and one has a capacity of 1 t. Expace's rockets have launched from China's Jiuquan Satellite Launch Center in northwest China. The improved Kuaizhou-11 version's first launch was in 2022. By April 2024, the Kuaizhou-1 had completed 26 missions for 56 micro and small satellites.

Galactic Energy

The second private Chinese rocket company to launch a payload into space, its first successful launch of its Ceres-1 rocket was on 7 November 2020. Galactic Energy has three rockets, its flight proven solid fuel three-stage Ceres-1, which can place 450 kg into low Earth orbit, its Ceres-2 and the firm's in-development Pallas-1 which has a reusable first stage. The Ceres-1 can be launched from the sea from a modified barge and did so in September 2023 placing four satellites into an 800 km orbit. Galactic had planned to launch this year its Ceres-2 rocket that can loft 1,600 kg to a 500 km low Earth orbit. The Pallas-1 is a two-stage, 3.8 m diameter, 42 m tall, liquid oxygen, kerosene fuelled rocket that can place 8,000 kg into low Earth orbit.

I-Space

The Beijing company's first rocket was a solid fuel booster called Shuang Quxian (SQX) 1 that reached space in July 2019 from Jiuquan Satellite Launch Center. It was the first private Chinese rocket to do so. Shuang Quxian means hyperbola. The three-stage, 21 m tall SQX 1 has a diameter of 1.4 m and can place 100 kg into a Sun-synchronous orbit. The next three launches were failures, but the SQX 1 successfully returned to flight on 7 April 2023. During these years, I-Space was developing its liquid propellant SQX-2 which in 2019 was said to be a future reusable launcher. But by 2023, the company was focused on its SQX-3, a SpaceX Falcon 9-like rocket. Six months after the April 2023 SQX 1 launch on 2 November, I-Space completed a vertical take-off and landing flight test of its SQX-2Y first-stage. This month, the liquid oxygen, methane fuelled SQX 3 was to launch for the first time. Its second flight, using the same first-stage is planned for June 2026.

Landspace Technology

In December 2023, Landspace's rocket, the 49.5 m tall, 3.35 m diameter ZhueQue (ZQ) 2, or Rosefinch 2, launched on its first flight at 0900hrs local time from the Jiuquan Satellite Launch Center. The ZQ 2's engine is the TQ-12A which uses liquid oxygen and methane. The company claims a world first for a methane fuelled rocket to reach space with the December 2023 launch. The ZQ 2 can place a 4,000 kg payload into a 500 km Sun-synchronous orbit. In October, Landspace was preparing for its SpaceX Falcon 9-like ZQ 3's maiden flight.

Linkspace Aerospace Technology

Developing a vertical take-off, vertical landing rocket that uses liquid oxygen and methane, the company's website no longer works and its last social media post was in 2023.

Onespace Technology

Located in the city of Chongqing in central China, Onespace Technology launched China's first private rocket, the suborbital solid fuel Chongqing Liangjiang Star in May 2018 from a test site in the country's northwest. It was still launching a suborbital rocket in 2021. On 5 February, the company launched its truck mounted OS-X6B suborbital rocket from a launch site in China's northwest. The company's website shows a family of rockets from a short launcher to a taller version and one with two or more side mounted boosters and a fifth much taller launch vehicle.

Orienspace Technology (Shandong)

Launched from the back of a large ship, the 30 m tall Gravity-1 rocket is a solid fuel launch vehicle capable of putting up to 6,500 kg into a low Earth orbit. Founded in 2020, Orienspace is developing two more rockets, Gravity-2 and -3. Gravity-1 has a core booster and three side mounted boosters and made its first flight on 1 November 2024. Gravity-2 is 70 m tall, a 4.2 m diameter core stage that is reusable and liquid fuelled. It has two solid rocket boosters. It is designed to place 21.5 t in low Earth orbit. The Gravity-3 is like the SpaceX Falcon Heavy, it has three core boosters in series with an expendable upper stage. Gravity-3 will be able to put 61 t into low Earth orbit.

Space Pioneer

Launching from Jiuquan Satellite Launch Center in northwestern China, Space Pioneer, also known as Beijing Tianbing Technology, has developed its Tianlong (which means Sky Dragon) 2 and Tianlong 3. It is working towards its Tianlong-3Heavy, with three first stages in series, and the Tianlong-3M which has a crewed shuttle. The liquid fuel Tianlong 2 is an expendable 32.8 m tall, 3.35 m wide vehicle that can launch 1,500 kg payloads into a 500 km Sun-synchronous orbit. It became the first liquid fuelled privately developed Chinese rocket to reach orbit in April 2023. In 2024, Space Pioneers attempted to launch its Tianlong 3, which has a reusable first-stage, but the launch failed. Tianlong 3 is 72 m tall and can place up to 22 t into low Earth orbit.

France

France launched its first satellite, named Asterix, in 1965 from the Hammaguir launch base in Algeria on 26 November. The French Diamant rocket launched the satellite. The French company ArianeGroup has been the prime contractor for the European Space Agency's rockets for decades. Today, ArianeGroup has competitors with Latitude and Hyprspace.

ArianeGroup

A partially reusable rocket is being developed by ArianeGroup subsidiary MaiaSpace. The ArianeGroup has already been involved in reusability with the contract for the European Space Agency's Themis reusable first stage project which also has a European Union funded twin programme, Salto, which is an abbreviation of reusable strategic space launcher technologies & operations. MaiaSpace is developing its Maia rocket which will be a two-stage mini-launcher which has expendable and reusable versions. The reusable version's first-stage is to land on an offshore barge. Planned to launch in 2026, Maia can place payloads of up to 500 kg into a Sun-synchronous orbit. The 50 m tall Maia is 3.5 m wide and has a 3.5 m fairing. Maia is fuelled with biomethane and liquid oxygen with three engines on the first stage and one on the second stage. ArianeGroup developed the expendable Ariane 6 which had its first flight in July 2024. That rocket is operated by Arianespace.

This photo shows a fully assembled test model of the Ariane 6 standing on its launch pad at Europe's Spaceport in French Guiana in 2022.

Latitude

Based in the city of Reims and founded in 2019, Latitude's Zephyr rocket has two-stages, is 19 m tall 1.5 m wide with a 2.3 m long fairing. It is designed to be able to place 200 kg into a low Earth orbit. Its Navier engines use liquid oxygen and kerosene. The first stage has seven Navier engines and its upper stage one. The company is aiming to make its first launch in 2026.

A render of the Latitude Zephyr rocket ascending.

Hyprspace

The company announced in June that its 10 m tall Baguette-One single-stage suborbital rocket will fly from a French government site on mainland France in 2026. It will be capable of carrying up to 300 kg of payload. Its longer-term plans are for a low cost launch vehicle that uses a pressure fed hybrid propulsion system using a combination of solid fuel and liquid propellant.

PHOTOS: ARIANEGROUP / LATITUDE

Germany

The home of the very first rocket to reach space, an Aggregat 4 missile, also known as Vergeltungswaffe 2 (V2), which flew above 100 km on 20 June 1944, Germany has some of the most famous names in rocketry from Wehner von Braun to Herman Oberth. It was a German firm, Isar Aerospace, that attempted the first launch of a commercially developed rocket from continental Europe, when its Spectrum launcher lifted off from Norway's Andøya Spaceport last March.

Isar Aerospace

Founded in 2018 and located in the state of Bavaria, Isar Aerospace's expendable Spectrum two-stage rocket failed 30 seconds after lift-off on 30 March this year. Spectrum is 28 m tall, 2 m wide and designed to place 700 kg into a Sun-synchronous orbit or 1,000 kg into a low Earth orbit. The first stage has nine engines and the upper stage one engine. The rocket is fuelled with propane and liquid oxygen. The »

The Isar Aerospace Spectrum rocket lifts off from Andøya Spaceport seconds before it failed.

PHOTO: ISAR AEROSPACE

This illustration shows Rocket Factory Augsburg's One launcher ascending.

PHOTO: ROCKET FACTORY AUGSBURG

« company stated it would make its second attempt as soon as possible and its second and third rockets were in production last March.

Rocket Factory Augsburg

Aiming to launch from Scotland's SaxaVord Spaceport, Rocket Factory Augsburg's (RFA) One launcher is a three-stage expendable liquid fuelled vehicle for small satellites. It is designed to put a 1,300 kg payload into a 500 km Sun-synchronous orbit. Using the firm's Helix engine the liquid oxygen, kerosene rocket's structure is a mix of stainless steel and composite. Based in Augsburg, Germany, the firm was established in 2018, a spin out from the German companies OHB and MT Aerospace. The former European Space Agency's Director General, Jean-Jacques Dordain, is RFA's chairman.

India

The government space agency, Indian Space Research Organisation (ISRO), is still in the lead for rocket development as the country works towards human spaceflight and a space station. ISRO is human rating a flight proven rocket and developing a small satellite launcher. India has also seen in recent years the arrival of commercial rocket companies.

Indian Space Research Organisation

From the top down this shows the Gaganyaan capsule's launch abort tower, the crew capsule, the cryogenic upper stage and the liquid fuelled first stage with two solid rocket boosters.

India has three orbital rockets in operation, the Polar Satellite Launch Vehicle, the Geosynchronous Satellite Launch Vehicle and the Geosynchronous Satellite Launch Vehicle Mark III (LVM3). It also operates sounding rockets. Under development are the Human Rated Launch Vehicle (HRLV) version of the LVM3 and the Reusable Launch Vehicle, which is like the United States X-37B spaceplane. The most recent rocket to enter service is ISRO's Small Satellite Launch Vehicle (SSLV).

Human Rated Launch Vehicle

The LVM3 is the basis for the HRLV. All the systems of the LVM3, solid stage, liquid stage and cryogenic stage, have been improved to meet human rating requirements. The HLVM3 differs in that it has a crew escape system, known elsewhere as a launch abort system. The HRLV is also known as the Human Rated LVM3 or HLVM3. The HLVM3 will be capable of launching the Gaganyaan programme's crew Orbital Module to a low Earth orbit of 400 km.

Small Satellite Launch Vehicle

The Small Satellite Launch Vehicle (SSLV) is a 34 m tall, 2 m diameter, three solid fuel stage launch vehicle. It can launch 500 kg of payloads into a 500 km orbit. The SSLV has a fourth "Velocity Trimming Module," which uses a bi-propellant engine using monomethylhydrazine and mixed oxides of nitrogen. The SSLV is designed to be low cost and have a quicker turn-around time. Its first launch was on 7 August 2022 and it had two more launches in February 2023 and August 2024.

Skyroot Aerospace

Founded in 2018 in Hyderabad city in southern India, Skyroot is developing its Vikram-I rocket powered by the company's own cryogenic engine. In November 2022, the company launched a small solid fuel rocket, the Vikram-S. Skyroot has successfully test fired its Kalam-250 stage. The company plans to launch its expendable Vikram-I rocket from the Indian Space Research Organisation's Satish Dhawan Space Centre in Sriharikota, India before the end of 2025.

EtherealX

The company's goal is a fully reusable two-stage launch vehicle, the Razor Crest Mark-1, which can place 24.8 t into low Earth orbit. The company's engine is the Stallion and it produces 925 kN of thrust which is about 10% more than a SpaceX Falcon 9 first stage Merlin engine. The Stallion is fuelled with kerosene and liquid

PHOTO: ISRO

PHOTO: ISRO

An Indian Space Research Organisation Geosynchronous Satellite Launch Vehicle Mark III launches.

oxygen, and the first stage has nine Stallions. EtherealX aims to recover the second stage.

Agnikul Cosmos

Located in Chennai city on India's southeastern coast, Agnikul Cosmos is developing a liquid fuelled sounding rocket class vehicle, its Agnibaan launch vehicle. On 30 May 2024, Agnikul launched its Agnibaan rocket on its Sorted-01 mission from Satish Dhawan Space Centre in Sriharikota, India. The mission was a controlled ascent, it did not reach space. The firm had its own mission control. The company states its launchpad is its own, so it is India's first private launchpad launch. The small rocket had a single-piece 3D printed first-stage engine fuelled with kerosene and liquid oxygen. The rocket's avionics use an Ethernet architecture and Linux.

Italy

The third largest contributor to the European Space Agency budget, Italy's space industry has a variety of capabilities, notably in pressure vessels, but the nation has also led the development of a solid fuel rocket, Vega. The Italian company that is the prime contractor for Vega is Avio.

Avio

In 2025 Vega's operator, Arianespace, agreed that Avio would offer Vega launch services. Vega is an acronym for Vettore Europeo di Generazione Avanzata, which means European Advanced Generation Rocket. Arianespace has been the Vega operator since 2012 and it has been launched from France's Guiana spaceport. The Vega rocket has undergone various improvements during its operational life, and the C and E versions will see more. The original Vega's typical mission is 1,500 kg to a circular polar orbit at an altitude of 700 km. This Vega has a P80 Motor for its first stage, the Zefiro 23 for its second stage and the Zefiro 9 for its third stage and they are all solid fuel. There is a fourth stage, the Attitude Vernier Upper Module, or AVUM, which is liquid fuelled and takes the payload to its destination orbit. The maiden flight of the new Vega C took place on 13 July 2022. Its first stage is now the P120C, its second stage is the Zefiro 40, the third stage is the same Zefiro 9 while the AVUM has been improved and is now the AVUM+. The Vega C, C for consolidation, can put up to 2,300 kg into low Earth orbit. The E version, E for evolution, is under development and it will have three stages. It will retain the P120C and Z40 stages, but its third stage is a liquid oxygen and liquid methane fuelled stage called the MR10. »

PHOTO: ESA-JACKY HUART, 2017

This illustration shows the Avio Vega-C rocket on its French Guiana launch pad. The Vega-C is an evolution of the Vega and it increases the launch vehicle's performance by at least 300 kg.

Japan

This illustration shows the Interstellar Technologies Zero rocket ascending.

PHOTOS: INTERSTELLAR TECHNOLOGIES / HONDA / JAXA

« The Japan Aerospace Exploration Agency, previously the National Space Development Agency of Japan (NASDA) before 2003, oversaw the development of the N series and then the H series rockets and the latest is the H3. The Japanese government's industrial partner has always been Mitsubishi Heavy Industries for the rockets. The first H3 launch was in February 2024 and the seventh and eighth launches were planned for Q4 this year.

This is the 2 February 2025 launch of the fifth H3 launch vehicle carrying the Quasi-Zenith Satellite System satellite.

Interstellar Technologies

Founded in 2013 and about a 20 minute drive from Hokkaido Spaceport, Interstellar Technologies has been developing its Zero and Deca rockets. The company has launched to space three times with its 10.1 m tall, 0.5 m diameter Momo sounding rocket. The 32 m tall, 2.3 m diameter Zero will be a microsatellite launch vehicle with a goal of carrying up to 800 kg to low Earth orbit. It is fuelled with liquefied biomethane and liquid oxygen. The Deca will be a SpaceX Falcon 9 scale launcher with a reusable first stage and is planned to fly in the 2030s.

Honda

The famous car company has been developing reusable rocket technology. Honda successfully conducted a launch and landing test of its 6.3 m tall 0.85 m diameter 1,312 kg experimental reusable rocket reaching an altitude of nearly 300 m on 17 June. Honda started engine combustion tests and hovering tests for the Experimental Reusable Rocket last year at its Hokkaido island facility. Launching at 1615hrs local time at the Honda facility in Taiki Town in Hokkaido Prefecture, Japan, the flight lasted 56.6secs. Honda announced in 2021 it would develop technologies for space. Honda's plan is to work towards a sub-orbital test flight in 2029, but the company has made no decision on whether it intends to commercialise its rocket technology.

Honda's Experimental Reusable Rocket flying on 17 June this year.

Korea

PHOTO: KOREA AEROSPACE RESEARCH INSTITUTE

The third launch of a Korea Small Launch Vehicle II rocket, also called Nuri, from Naro Space Center that is on Korea's southern coast.

The Republic of Korea created the Korea Aerospace Administration (KASA) in 2024 because of the growing importance of space to the economy. The first Administrator of KASA is Yoon Youngbin. The fifth launch of the Korean government's Nuri rocket, also known as the Korea Space Launch Vehicle (KSLV) II, was to take place on 27 November. Its payload was the Next-Generation Medium Satellite-3. The first generation KSLV was called the Naro. On 25 July this year, KASA signed a technology transfer agreement for the Nuri KSLV-II launch vehicle to the private sector. The aerospace agency has a KSLV "Enhancement" programme. One of KASA's policies is the development of a reusable launch vehicle system able to send a 500 kg satellite to a low Earth orbit.

Hanwha Aerospace

The company has existed since 1952 and has been the lead industrial partner for the Korean government and its Korea Aerospace Research Institute (KARI) for the development of Korean launchers. Hanwha was involved with the development of the Korean Sounding Rocket-III in 1999 and in the Korea Space Launch Vehicle II, also known as Nuri. In 2022, Hanwha was selected for KSLV improvements. In 2024, the Korean government selected Hanwha as the system integrator for KSLV-III, the enhanced KSLV. Hanwha works with KARI on KSLV operations. They worked on the fourth KSLV-II launch and Hanwha is planning one launch per year in 2026 and 2027. A goal for the KSLV-III programme is to launch a lunar lander by 2032.

Innospace

The firm was founded in 2017 and its headquarters is in Sejong city. It is developing three launch vehicles, Hanbit Nano, Hanbit-Micro and Hanbit-Mini. The first launch of the first Hanbit Nano could take place this year from Brazil. The firm's Hanbit test launch vehicle was launched with its hybrid rocket engine in March 2023 from Brazil's Alcántara Space Center. The firm's launch vehicles use hybrid propulsion, a mix of solid fuel and liquid propellant. In September, Innospace announced it had completed the first stage certification test of its first Hanbit-Nano launcher at the firm's Goheung Integrated Test Center. The Hanbit-Nano is a 1.4 m diameter, two-stage rocket about 21.7 m tall and the upper stage uses methane. It would place its 90 kg payload into a 500 km Sun-synchronous orbit. Innospace is to launch Hanbit-Nano from Alcántara by the end of this year. It has been waiting for Brazilian Space Agency approval. Innospace also plans to launch from Australia and Norway.

Una Stella

The latin name means one star and this startup is developing a launch vehicle that can carry up to six people and reach an altitude of more than 100 km. Founded in February 2022, the company's graphics of its first launch system look like Blue Origin's New Shepard. The website states the company is being helped by the »

A Korea Small Launch Vehicle I rocket, also called Naro, launches from Naro Space Center on Korea's southern coast.

PHOTO: KOREA AEROSPACE RESEARCH INSTITUTE

« German Aerospace Center. Una Stella's plans are to develop a low Earth orbit human spaceflight service and be involved in the exploration of the Moon and Mars. In late May this year, the firm launched its small launch vehicle, Una Express-I from its own launch site in Bongrae-myeon, Goheung-gun, Jeollanam-do. The company claimed that it was the first successful rocket launch by a private company within South Korea's territory. The Una Express-I was a kerosene and liquid oxygen fuelled 9.45 m launch vehicle that travelled 10 km and landed in the Goheung County maritime safety zone.

New Zealand

A Rocket Lab Electron rocket ascends above New Zealand.

PHOTO: ROCKETLAB

The New Zealand space industry contributed NZ$1.26 billion directly to the country's gross domestic product in the financial year 2024, according to the April 2025 report by professional services firm Deloitte for the New Zealand Ministry of Business, Innovation and Employment. The country has a space agency, called the New Zealand Space Agency, and it regulates orbital launches, launch facilities, high-altitude vehicles and payloads and other activities. One launch provider operates in New Zealand, the firm Rocket Lab. The New Zealand spaceplane developer Dawn Aerospace is working towards being able to launch payloads into orbit but it is many years away from doing so.

Rocket Lab

Preparing to launch its fully reusable rocket Neutron, perhaps as soon as early 2026, Rocket Lab was founded in 2006 and Lockheed Martin was involved early in the company's development. Its founder, Dr Sir Peter Beck is from New Zealand, but the firm's headquarters are in Long Beach, California. Rocket Lab operates facilities, including factories and mission operation centres, in Virginia, New Mexico, Colorado, Maryland, Toronto and New Zealand. Its first launch site was its Launch Complex 1 in Mahia, New Zealand. The company's Electron rocket made its first launch in 2017. Electron is an 18m tall, two stage vehicle that uses nine of Rocket Lab's Rutherford engines on its first stage and one on its second stage. In 2019, Launch Complex 2 was built on Wallops Island in Virginia, USA and the first launch occurred there in 2023. In 2023, the firm recovered its first Electron first stage which had descended by parachute after staging. Rocket Lab's Neutron reusable rocket will launch 8,000 kg to low Earth orbit and land back at its launch site. It can launch 13 t to a low orbit but it would have to land downrange. It can also launch as much as 15 t but the entire vehicle would be expended.

Norway

Since 1962, Norway has launched rockets of some description from the Andøya peninsula that juts out into the Norwegian Sea as part of the country's northern coastline. Andøya Space operated Norway's first civilian suborbital research rocket and in 2018 the first fully Norwegian sounding rocket, called Nucleus, was launched. It was in October 2021 that the Norwegian government approved the proposal for orbital launches from Andøya with the country's first commercial satellite launching facility. The new launch facility would be located about 30 km south of the existing rocket range that served sounding rockets to research atmospheric phenomena for all those years. The plan had been for orbital launches from 2023. The Norwegian Space Agency coordinates the nation's space policy and works with the industry to develop the space sector.

Nammo

Nucleus is being developed and built by the Norwegian company Nammo in partnership with the Norwegian Space Agency and the European Space Agency's future launchers preparatory programme. The new 9 m long, 800 kg hybrid rocket reached an altitude of 107.4 km in 2018, splashing down in the Norwegian Sea, 180 km off the coast of northern Norway. The rocket's hybrid propulsion system uses liquid hydrogen peroxide and a synthetic rubber-like solid fuel. Since that 2018 launch, work has gone on to improve Nucleus with a larger motor to increase thrust, extend the burn time and to reduce its weight and cost. The goal is to develop Nucleus into a hybrid launch system for small satellites. Nammo also has UK offices in Cheltenham and at the Westcott Venture Park in Buckinghamshire.

The Andøya Spaceport orbital facility sits along the water's edge.

A sounding rocket launches from its launch rail at Norway's Andøya Space Center. »

PHOTOS: ANDOYA SPACEPORT

Russian Federation

The slow development of Russia's new family of Angara rockets has mirrored the pace of construction for the country's newest cosmodrome in its far east, Vostochny cosmodrome. The spaceport is far inland in Russia's most eastern territory and about 100 km east from the nearest Chinese border. While other countries have seen the transfer of government rocket technology to private enterprise, in the last 25 years the Russian government has taken ownership of its space industry with what it calls "joint stock corporations" under its space agency. The Angara family of rockets have been in development for more than 25 years and were created to replace the Khrunichev State Research and Production Space Center Proton launcher and the Rokot launch vehicles. The Rokot was a modified SS-19 ballistic missile. After the Cold War, Russia took missiles that were to be disposed of due to arms treaties and used them as launch vehicles to offer on the international market.

Khrunichev's latest Proton, the M, is a version of the Center's original four-stage liquid fuelled Proton, a launch vehicle that was first developed in the Soviet Union in the 1960s. Its first stage has six engines. Russia has its Plesetsk cosmodrome in northern Russia, where Proton, and Zenit rockets, launched from, and the country leases territory for the Baikonur cosmodrome in Kazakhstan from that country. Zenit rockets were Ukrainian and Russia phased their use out by 2018, four »

The Soyuz launcher for the Andromède mission at launch pad N°1 at Baikonur on 19 October 2001.

« years after Russia occupied Crimea. Russia's Soyuz rockets launch from Baikonur orbiting the Soyuz crew craft and Progress cargo ships. To potentially replace Baikonur, Russia began preparing for its Vostochny cosmodrome more than 20 years ago. The first launch from Vostochny was a Soyuz 2 rocket in 2016. By 2018, an Angara-1.2 had launched only once in July 2014 and an Angara-A5, also once, in December of that year and they both flew from Plesetsk. These are the two basic versions of the Angara family, the 1.2 "light" rocket and the A5 "heavy" rocket, with more variants to be developed. The Angara-1.2 is designed to place 2,500 kg into a 500 km orbit while the Angara-A5 is to have a payload capacity of up to 24.5 t for a low Earth orbit. A second Angara-A5 launch was made in December 2021 and the first mission, and second flight, for Angara 1.2 was in April 2022 and it flew its third mission in September 2024. Russian authorities had expected Angara to replace Proton in 2024, but this December a Proton-M launch is planned for a Russian meteorological satellite. However, work on Angara-A5 variants continues. In November 2023, the Angara-A5M design was approved and it has a larger payload capacity. The A5M is to launch the modules for Russia's post-International Space Station orbital outpost called Russian Orbital Station or ROS. Russia's ROS plan is to launch its power module at the end of 2027 and other modules from 2028 to 2030. Today, all the Angara rockets are expendable, but Russia has plans for recoverable Angara first and second stages. It is the Angara-A5V that will have the recoverable first and second stages and a hydrogen fuelled third stage.

European Space Agency payloads are launched on a Soyuz-M rocket from Vostochny cosmodrome on 5 July 2019.

PHOTOS: ESA/CNES / ESA-STEPHANE CORVAJA / ROSCOSMOS

Spain

Spain is not a country strongly associated with having an aerospace industry capable of producing a rocket developer, but Spanish firm PLD Space has already launched a sub-orbital test vehicle. The company has also unveiled ambitious plans that include a crewed spacecraft. The Spanish space agency, the Agencia Espacial Española, comes under Spain's Ministry of Science, Innovation and Universities. The agency has national programmes for space situational awareness and Earth observation satellites. Through the European Space Agency, Agencia Espacial Española has been involved with exoplanet and satellite navigation programmes. Space situational awareness, Earth observation and satellite navigation have also been activities Spain has participated in as part of the European Union's space programme.

PLD Space

Founded in 2011, PLD Space launched its Miura 1 technology demonstrator on 7 October 2023. This year it was selected along with four other companies for the European Space Agency's European Launcher Challenge. The Challenge's goal is for a successful orbital launch to be demonstrated by 2027. PLD Space's rocket for this Challenge is its Miura 5. This 35.7 m tall 2 m wide two-stage launcher uses bio-kerosene and liquid oxygen. The first Miura 5 version is not reusable but the company plans to make the first stage reusable for its Miura 5 Block 1.2 version. The firm aims to launch Miura 5 in 2026 and the firm's goal is 30 Miura 5 launches a year using three spaceports. PLD Space's ambitious plans include a larger reusable launcher. Miura Next is 58 m tall, has a 3.5 m diameter and is able to launch more than 13 t into low Earth orbit. PLD Space also has planned its Miura Next Heavy and Miura Next Super Heavy. Using the Miura Next as a core stage, the Miura Next Heavy is like the SpaceX Falcon Heavy with three cores attached in series with a single upper stage. The Miura Next Super Heavy has a Miura Next core stage and four more Miura Next boosters attached like solid rocket boosters. Its core's upper stage is expendable. The Miura Next Super Heavy will be able to launch 53 t with its five reusable stages landing on sea barges and it can also loft 60 t when fully expendable.

An illustration of PLD Space's Miura 5 rocket on its launch pad at France's French Guiana spaceport.

PHOTO: PLD SPACE

South Africa

This year saw the creation of the African Space agency and South Africa was a founding member. In 2024, South Africa launched two sounding rockets, the Phoenix-1D on 2 December and the Phoenix-1E on 4 December. They were launched from a new gantry at the Denel Overberg Test Range facility in Arniston on South Africa's southern coast. The rockets reached altitudes of 16.6 km and 11.9 km, respectively. The facility is equipped for rocket testing, propulsion system development and flight testing new technologies. The gantry's development was funded by the Department of Science, Technology and Innovation and implemented by the Aerospace Systems Research Institute at the University of KwaZulu-Natal. This involved the South African National Space Agency (SANSA) that was established in 2011. The agency focuses on Earth observation, space science, space engineering and space operations. The new rocket gantry was inaugurated on 3 December 2024 by South Africa's Deputy Minister of Science, Technology and Innovation, Nomalungelo Gina.

United States

SpaceX has dominated the news about rocket development in the United States for years (See page 2), but NASA has developed, with Boeing as its prime contractor, the Space Launch System, and a number of firms are working towards competing with SpaceX including the US launch industry legacy firms United Launch Alliance (ULA) and Northrop Grumman. The new firms are Blue Origin, Firefly Aerospace, Phantom Space and Stoke Space. Funding for these rockets has been a mix of NASA, US military and private investors.

New Glenn on the launch pad at launch complex 36 on 27 December 2024.

Blue Origin

Owned by famous Amazon retailer entrepreneur Jeff Bezos, Blue Origin's second New Glenn rocket was erected on its launch pad on 29 October. It was planned to launch NASA's Escape and Plasma Acceleration and Dynamics Explorers mission. The 98 m tall New Glenn launched for the first time on 16 January this year at 0203hrs local time from Cape Canaveral Space Force Station launch complex 36 (LC-36) which is New Glenn's launch pad. Both stages were expended for the test flight whose payload was described as a Blue Ring Pathfinder. Blue Ring is Blue Origin's in-development hybrid solar electric and chemical propelled space tug. New Glenn has a 7 m fairing for large payloads. New Glenn's first stage is designed to be reusable with minimal maintenance for a minimum of 25 flights. At the top of the first stage there are four actuated aerodynamic control surfaces, fins, for attitude adjustment during the first stage's descent and landing. At the bottom of the stage there are wing-like strakes to provide lift and cross-range for the reusable first stage during its descent. The first stage has seven Blue Origin liquid oxygen, liquefied natural gas fuelled staged combustion BE-4 engines with deep-throttle capability. Each produce 550,000 lbf (2,450 kN) thrust at sea level. The first stage's aft module houses six hydraulically actuated legs for a landing on a moving platform, such as a sea barge. The first stage will autonomously descend to a landing platform that will be located about 620 miles (1,000 km) downrange. New Glenn can launch 45 t to low Earth orbit and more than 13 t to a geostationary transfer orbit. The upper stage has two Blue Origin BE-3U engines that generate 175,000 lbf (778 kN) of thrust in vacuum. These engines are also able to restart on-orbit for mission versatility. Launch complex 36 is located nine miles (14 km) from the New Glenn factory. Since the first launch, Blue Origin has stated that it has plans to evolve the upper stage to make it reusable.

Firefly Aerospace's Alpha rocket ascends on its fourth flight.

Firefly Aerospace

Texas company Firefly Aerospace is developing vehicles to provide a logistics train from the Earth to the Moon with launchers, cislunar spacecraft and lunar landers. While Firefly is the first company to successfully land a lander on the Moon, its rocket progress has been mixed. Its first launcher is the Alpha which has had seven missions. It is also developing the larger Eclipse rocket. The Alpha rocket is a two-stage 29 m tall 2.2 m diameter vehicle with a 5 m long fairing. Its two stages use liquid oxygen and »

PHOTO: BLUE ORIGIN / FIREFLY AEROSPACE

SpaceX's Starship version three's key external design differences can be seen in this official illustration showing the exposed Raptor engines, the three, instead of four, grid fins on the first stage Super Heavy booster, and the fixed hot staging adaptor.

« kerosene. The first stage uses four of Firefly's Reaver engines and the upper stage, one Reaver. Alpha is designed to place about 1,000 kg into a 300 km low Earth orbit or 630 kg into a Sun- synchronous orbit. Alpha's seventh mission saw an explosive first stage failure on 29 September at space launch complex 2 at Vandenberg Space Force Base in California. The explosion follows the failure of the sixth mission during the ascent. The first Alpha rocket did not reach orbit on 2 September 2021 either, but the second flight on 1 October 2022 successfully launched three payloads. The third flight was a success on 14 September 2023. The fourth flight on 22 December 2023 failed to achieve the correct orbit for the payload. The fifth flight on 3 July 2024 was successful. Of the seven missions, the Alpha has only been successful three times. The Eclipse is 59 m tall, and the fairing is wider than the rocket at 5.4 m. The first stage has seven Firefly Miranda engines that produce 7,161 kN in vacuum. The second stage uses one Firefly Vira engine capable of 890 kN in vacuum. Both engines use liquid oxygen and kerosene. Eclipse will be able to put 16.3 t into a 200 km low Earth orbit.

Northrop Grumman

With a history that goes back to the Apollo programme, Northrop Grumman bought the company Orbital Sciences which developed the Antares rocket and the Cygnus cargo ship it launched. Operating from the Mid-Atlantic Regional Spaceport at NASA's Wallops Flight Facility in Virginia, the original Antares 230 was improved to make it the 230+ but its first stage used Russian Energomash RD-181 engines. With future supply issues arising for the RD-181, the decision was made to redesign the 230+ first stage. It would now use seven of Firefly Aerospace's liquid oxygen, kerosene fuelled Miranda engines. The new version is called the Antares 330 which keeps the 230+ upper stage. The previous Antares 230+ rocket took its last flight in August 2023. The 230+ rocket used Northrop Grumman Castor 30 XL solid rocket motors for its second stage, and the Castor 30 XL will be used for the 330. The new 330 first stage will be used for Northrop Grumman and Firefly Aerospace's jointly developed 59 m tall Eclipse launch vehicle. The Eclipse will use Firefly Aerospace's new second stage Vira engine and be able to place 16 t in a 200 km low Earth orbit. According to Northrop Grumman, the Antares 330 will launch up to three times with the improved Cygnus XL cargo ship to re-supply the International Space Station.

SpaceX

The first landing in 2015 of a Falcon 9 rocket first stage was the turning point for reusability in space access. While the Falcon 9 is only partially reusable, its upper stage being expendable, the company had achieved more than 500 first stage landings by November. The reduction in the cost per kilogramme for payloads is opening up new orbital markets like pharma manufacturing. The Falcon 9 will eventually be replaced by the super heavy fully reusable Starship. SpaceX's twelfth Starship launch was to be the rocket's version three which has a number of design differences (see page 2).

Phantom Space Corporation

Founded five years ago, the Arizona firm Phantom Space develops satellites as well as a rocket. The Daytona rocket is 20.3 m tall with a fairing and second stage diameter of 1.5m and the first stage is only 35 cm wider. It is designed to launch more than 600 kg to low Earth orbit. Daytona's first flight is planned for 2027. The firm was preparing for the Daytona launch vehicle's test campaign in late 2025.

Stoke Space

Founded in 2019, Stoke Space's Nova rocket will be about 30.02 m (100 ft) in height in total including its 5 m fairing and have a diameter of 3.04 m (10 ft), although the upper stage will be wider than 3.04 m at its widest point. The second stage, with the payload fairing, will be about 7.62 metres (25 ft) tall and the first stage booster about 22.4 m (75 ft). The first stage, which has seven Stoke Space Zenith engines, and the upper stage are assembled at the company's Moses Lake test facility in Washington state. Zenith is designed to produce more than 100,000 lbf (445 kN) of thrust at full power. It is fuelled with liquid natural gas and liquid oxygen. The upper stage uses liquid oxygen and liquid hydrogen. Nova will be able to launch 4.5 t to low Earth orbit and Stoke claims to have payloads for the first orbital launch it still plans to achieve this year, and future missions. Stoke started building its first orbital test flight Nova in 2024. The company's launch site is Cape Canaveral Space Force Station's launch complex 14. By October, Stoke had raised about $900 million in private financing.

This illustration shows Phantom Space's Daytona launch vehicle ascending.

PHOTOS: SPACEX / PHANTOM SPACE

United Kingdom

A nation that has shunned launch vehicles for much of the Space Age, the UK government began taking an interest more than 15 years ago with studies for potential spaceports on the island of Great Britain. Since then, the government, directly, and through the European Space Agency, has funded various launch technologies including expendable small satellite launchers and spaceport development. The German company Rocket Factory Augsburg is likely to make the first launch from a UK spaceport, namely SaxaVord Spaceport. The two UK companies working towards operational launchers are Orbex and Skyrora.

This photo shows a Prime test vehicle on its launch pad at what is Orbex's test site in Scotland.

Orbex

Founded in 2015, Orbital Express, or Orbex, has been developing its own spaceport and its Prime rocket and it has a larger Proxima launch vehicle planned. In early September this year, Orbex successfully simulated the launch of its Prime vehicle for the first time. The company wants to launch it in 2026 from SaxaVord Spaceport on Scotland's isle of Unst. In December 2024, Orbex announced it was moving to SaxaVord Spaceport from its own Spaceport Sutherland which is on Scotland's A'Mhoine peninsular. Prime is a 19 m tall two-stage rocket designed to launch satellites with a mass of up to 180 kg into low Earth orbit. The company was selected for the European Space Agency's European Launcher Challenge. Early in 2025, the UK government announced a £20 million investment in Orbex. When Orbex announced last December, its spaceport move it also announced a new larger rocket, Proxima, which it described as a "medium sized rocket". It is 61 m tall, has a 4 m diameter and two stages. The engines will use liquid oxygen and bio-methane. The rocket's fairing is wider than Prime's at 5.2 m. Proxima will not launch from Scotland, it will likely launch from France's Kourou, French Guiana spaceport, which is equatorial.

The Skyrora XL rocket at the company's test facility.

PHOTOS FROM TOP: ORBEX / SKYRORA

Skyrora

Like Orbex, Skyrora is to launch its Skyrora XL rocket from SaxaVord Spaceport. The launcher is 22.7 m tall, 2.2 m wide and one of its engines produces 70 kN thrust. Skyrora XL is to be able to place 315 kg into a polar orbit with its three stages, using its kerosene-equivalent fuel made from recycled plastic, called Ecosene, and its oxidiser, high-test hydrogen peroxide. During a launch, the Skyrora XL second stage will ignite at an altitude of about 62 km before the third stage is fired at around 190 km to achieve an orbital velocity of 28,000 kph. The firm, whose head office is in Edinburgh, applied for an XL launch licence from the Civil Aviation Authority in August 2022. Skyrora has also applied to launch from Iceland. By 2030, Skyrora wants to produce 16 of its XL rockets a year. The company also has its 11.65 m long, 0.7 m diameter Skylark L sounding rocket it is developing. Its maximum altitude is 102 km with a 50 kg payload. It also uses Ecosene and high-test hydrogen peroxide. This year the UK Civil Aviation Authority granted the company a license to launch and operate its Skylark L from SaxaVord. Skyrora wants to launch as many as 16 times per year by 2030. SF

A new era in space sustainability

The International Astronautical Federation's 76th International Astronautical Congress was held in Sydney, Australia, from 29 September to 3 October

The 76th International Astronautical Congress, held in Sydney, Australia, began on 29 September.

PHOTOS: INTERNATIONAL ASTRONAUTICAL FEDERATION

Performances by Aboriginal and Torres Strait Islander artists welcomed the delegates to the International Astronautical Federation's 76th International Astronautical Congress (IAC 2026) on its first day on 29 September. The performances highlighted indigenous connection to Land, Sea and Sky, as the world's oldest astronomers. The week would see close to 8,000 delegates from 99 countries attend this year's Congress. The opening ceremony of IAC 2025 profiled key moments in Australia's modern space history. The Governor General of Australia, Her Excellency the Honourable Sam Mostyn AC and New South Wales Government Premier Chris Minns also addressed the audience as part of the welcome ceremony. Australian astronaut, Katherine Bennell-Pegg, also spoke at the opening ceremony. The 76th International Astronautical Congress took place at the International Convention Centre Sydney, New South Wales bringing the world's biggest space event back to Australia after an eight-year absence. Previously it was held in the city of Adelaide in South Australia in 2017.

Organised by the International Astronautical Federation in 2025, as in 2017, the Congress was hosted by the Space Industry Association of Australia (SIAA), and this time co-hosted by the Australian Space Agency and the NSW Government. The Congress explored a wide spectrum of critical topics such as sustainable space activities, space applications for climate resilience, disaster management, and the long-term viability of human presence beyond Earth. The IAC 2025 had a powerhouse programme featuring high-level plenaries along with the second edition of the IAF Global Space Leaders Summit. This edition united 40 heads of space agencies worldwide, becoming the largest gathering of space agencies leaders ever to take place in Australia.

The week featured an extraordinary line-up of more than 3,500 speakers across over 40 plenary and IAF GNF sessions, alongside 200 technical sessions and a bustling exhibition with over 450 exhibitors from around the globe who showcased their skills and innovation across 19,000 square metres of the venue's trade show floor. The week also saw more than 1000 Interactive Presentations (IP), all competing for the IAF IP Award. Numerous dignitaries also attended the 15th IAF International Meeting for Ministers and Members of Parliaments (MMoP) welcomed over 40 top-level policymakers, including nine Ministers.

The IAC 2025 celebrated outstanding achievements with the prestigious IAF World Space Award, bestowed to Jeff Bezos of Blue Origin and the Chang'e 6 Mission (team category). The IAF Excellence in International Cooperation Award was presented to Pascale Ehrenfreund, President of COSPAR and Research Professor of Space Policy and International Affairs at George Washington University. Under the Congress' theme of "Sustainable Space: Resilient Earth," there were six key thematic pillars.

The pillars were, bringing together a diverse ecosystem of industries, sectors, and stakeholders, creating strong networking opportunities for global participants, highlighting innovation from the dynamic Asia-Pacific region, showcasing cutting-edge technologies and partnerships through a major international exhibition, empowering the next-generation space workforce through targeted engagement and opportunities and fostering public awareness of space and its societal impact through the

The opening ceremony of the 76th International Astronautical Congress included aboriginal dance.

dedicated Public Day. Every day of the Congress there was one or more Plenary Programme sessions.

The first day, Monday 29 September, had the Heads of Agencies One-to-One session and the Host Nation plenary. The Host Nation plenary was titled "Beyond integration: Building Earth-Sky Knowledge Infrastructure for Co-discovery in Space and Sustainability." It was co-developed by five Indigenous Australian leaders with the Australian, Canadian and New Zealand space agencies. The plenary explored how Indigenous perspectives can inform sustainable space practices and foster co-discovery between Indigenous knowledge systems and Western science. The Head of the Australian Space Agency Enrico Palermo participated in the Heads of Agencies plenary, as well as a plenary on sustainability alongside European Space Agency Director General Josef Aschbacher. Palermo also led the second ever Global Space Leaders' Summit with close to 50 other heads of agencies from around the world.

On Tuesday 30 September, the IAC saw the Circular Economy in Space tackling how circular frameworks can unlock innovation and commercial value. In the afternoon, Living on Another World: Humanity's Return to the Moon explored future lunar missions. The Wednesday had the Plenary session, Designing the Future of Human Spaceflight, a forward-looking session focused on the design principles, technologies, and policies shaping the next phase of human space exploration. Thursday's Plenary session was Space Sustainability: Regional Priorities, Global Responsibility, a discussion on how regional priorities align with global responsibility in sustainability and resource management.

At IAC 2025, the Australian Government announced negotiations on a Cooperative Agreement with the European Space Agency. The Agreement will establish a formal mechanism for new and exciting opportunities between Europe and Australia's space sectors. A treaty-level Space Framework Agreement between Australia and the United States was also signed. This opened the door to new opportunities for collaboration on joint projects with NASA and other American partners. An updated UK-Australia Space Bridge Arrangement was signed, as well as several other agreements with a range of international partners. The IAC 2025 Public Day set new records, drawing more than 11,000 space enthusiasts of all ages, including 1,500

Australian astronaut, trained by the European Space Agency, Katherine Bennell-Pegg, spoke at the 76th International Astronautical Congress opening ceremony.

students. The highlights of the Public Day were the numerous events with astronauts which were part of the fourth edition of the IAF International Astronauts Chapter at an IAC. This inspiring event gathered more than 30 international astronauts. The IAC 2025 also saw a landmark leadership transition with, Gabriella Arrigo, Director of International Affairs at the Italian Space Agency (ASI), appointed as the new IAF President for a three-year term. On the last day, it was announced that Samarkand in Uzbekistan was the winning city for the International Astronautical Federation's 79th International Astronautical Congress being held in 2028. Poznań in Poland will hold the IAC in 2027.

But now all eyes are turned to Antalya, Turkey and the 77th International Astronautical Congress from 5-9 October in 2026. At the Closing Ceremony, the IAF flag was ceremonially handed to the delegation of the Turkish Space Agency, led by its Chairman of The Board and President Yusuf Kıraç, host of IAC 2026 in Antalya, Türkiye! ■

To the Moon and, perhaps, even to Mars?

Ten astronaut candidates were selected from more than 8,000 applicants across the United States as the 24th NASA group

By Nick Spall | Photographs courtesy NASA

At a time of increasing excitement ahead of the forthcoming 2026 Artemis II lunar free-return flyby mission aboard the Lockheed Martin Orion crew spacecraft *Integrity*, on 22 September this year NASA announced a new astronaut intake. Their ages range from 34 to 43 years old and it is the first occasion where women outnumbered men in a new NASA intake, six to four. With a possible 20-year career ahead of them, some should stand a good chance of travelling to the Moon or even possibly going beyond to Mars. Until they are qualified to fly into space as fully trained astronauts in about two years' time, the "Class of 2025" group will be known by NASA as "astronaut candidates" or "ascans".

Held roughly every two to four years, regular new astronaut intakes are needed to refresh the corps and provide new skills and backgrounds to suit forthcoming mission plans. NASA are anticipating the retirement of the International Space Station (ISS) by 2031 and so it may well be that none of the ten new astronauts will ever get to visit that orbiting station. However, they will most likely have the chance of working on one of the new private low Earth orbit (LEO) commercial facilities funded by NASA. The competitors are Axiom Space's Axiom Station, Blue Origin's Orbital Reef or Starlab Space's Starlab (*SpaceFlight* Vol 67 No.11 November p 5). The real prize for the six women and four men from the new 2025 NASA intake will be the chance of journeying to the Moon, either to land on a post Artemis II flight or to spend time on the Gateway lunar space station.

As the 24th group to be selected since NASA recruitment began with the Mercury 7 back in 1959, they are boosting the currently active US astronaut cadre of forty-one (*SpaceFlight* Vol 67 No.11 November p 3). An expanded team of 51 sounds impressive, but in the heyday of the Space Shuttle years of the early 2000s, NASA had an astronaut listing of some 149 men and women in active service. By contrast, Russia now has only 24 operational cosmonauts. To date, China has flown 26 of its astronauts into orbit, but the actual number of those currently "active" has not been publicly released.

Like the Apollo programme, the full 2025 intake selection is a mix of military test pilots, engineers and scientists. The Class of 2025 were introduced at NASA Johnson Space Centre (JSC) by NASA Flight Operations deputy director, former astronaut Kjell Lindgreen, together with SpaceX Crew 10 astronaut Nicole Ayers and forthcoming Soyuz NS-28 Expedition 74 astronaut Christopher Wiliams. Ben Bailey is an Army test pilot and there are two United

States Air Force (USAF) pilots and three Navy test pilots. The two USAF pilots are Cameron Jones and Adam Fuhrmann. Erin Overcash is a current Navy test pilot while Rebecca Lawler and Katherine Spies are former Navy test pilots. Lawler has been working as a civil airline pilot. There is one more former Navy officer, Imelda Muller, who was a medical officer and is now a civil anaesthetist. The engineers and scientists are lunar geologist Lauren Edgar, biomedical engineer and SpaceX employee Anna Menon and a former SpaceX launch director, Yuri Kubo, who is an engineer.

Bailey has flown more than 2,000 flight hours in more than 30 different rotary and fixed-wing aircraft. Fuhrmann has accumulated more than 2,100 flight hours in 27 aircraft, including the F-16 and F-35 and deployed in support of Operations Freedom's Sentinel and Resolute Support, logging 400 combat hours. Jones has more than 1,600 flight hours in more than 30 different aircraft, including 150 combat hours. Lawler is a former Navy P-3 pilot and experimental test pilot with more than 2,800 flight hours in more than 45 aircraft. Spies is a former Marine Corps AH-1 attack helicopter pilot and experimental test pilot, with more than 2,000 flight hours in more than 30 different aircraft. Muller's experience includes providing medical support during Navy operational diving training at NASA's Neutral Buoyancy Laboratory.

Before her Polaris Dawn mission, Menon worked in the Mission Control Center at NASA JSC supporting medical hardware and software aboard the International Space Station. Kubo spent 12 years working across various teams at SpaceX, including as launch director for Falcon 9 rocket launches, director of avionics for the Starshield program, and director of Ground Segment. Edgar has served as the deputy principal investigator for the Artemis III Geology Team. With the Class' six women, NASA now has twenty-one active women astronauts out of the expanded total corps strength of 51.

Of the new 2025 intake, only Menon has already flown into space, being a mission specialist aboard a SpaceX Dragon crew spacecraft on the privately financed Polaris Dawn mission in September 2024. This mission flew higher than any other since the Apollo 17 moon flight of 1972. Menon's husband, Anil Menon, is an astronaut from the Class of 2021 intake. He is to launch to the ISS for Expedition 75 in 2026. Interestingly, people have been into space as payload specialists on the Space Shuttle before, before they went on to be selected as NASA astronauts. NASA's Space Shuttle era astronaut Joe Engle was a USAF X-15 programme pilot and flew above 50 miles, which the USAF deems the beginning of space, before he became an astronaut.

The lunar flight prospects for the new and relatively young Class of 2025 looks hopeful with Artemis III in just two years' time, according to NASA's official timetable. Artemis IV and V and beyond that will also see crewed lunar landings and Moonwalking opportunities for the Class of 2025. Beyond the Moon, NASA is instructed to prepare for future crewed flights to Mars. In Trump's January 2025 inaugural address, he vowed that America would be the first nation to put boot prints on Mars. NASA's Acting Administrator, Sean Duffy, has talked up the agency's determination to win any future space race with China. Writing in a social media X platform post in September: "We'll win today's space race against China, and we will always win tomorrow's space race".

CLOCKWISE FROM OPPOSITE LEFT

Taking on 17 September, this photo shows the 2025 Astronaut Candidate Class announced on 22 September. The 10 candidates, pictured here at NASA Johnson Space Center are: Ben Bailey, Cameron Jones, Katherine Spies, Anna Menon, Erin Overcash, Adam Fuhrmann, Dr Lauren Edgar, Yuri Kubo, Rebecca Lawler, and Dr Imelda Muller.

Yuri Kubo, selected by NASA to join the 2025 astronaut candidate class, spent 12 years working at SpaceX with roles including Falcon 9 launch director, the Starshield programme avionics director and Ground Segment director.

Former SpaceX employee, Anna Menon was selected by NASA to join the 2025 astronaut candidate class. She has already gone to space on a private SpaceX Dragon flight for the Polaris Dawn mission.

The new 2025 "ascans" will spend two years being trained in a variety of spaceflight areas. These include robotics, land and water survival, geology (lunar in particular), foreign languages, space medicine and psychology and extra-vehicular activity simulations at the JSC Neutral Buoyancy Laboratory in Houston. Those who will become astronaut-pilots will have NASA Northrop T-38 Talon fast jet flying. Beyond that, once they are selected for a mission it would be at least two years of mission-specific training before they launch. In accordance with NASA astronaut intake tradition, on graduation in two years' time, the 2025 grouping will be named by their predecessor group. In this case it will be the 2023 astronaut group, now known as the "Flies".

Formerly civilian astronauts working at NASA remain in the corps for at least five years, with the military origin/serving astronauts being given specific "tours" by their parent military authority. Since 1959, of the previous 360 NASA astronaut selectees, 299 have been male, with 61 women. The military has provided the majority of the intake at 212 astronauts, with 148 civilians chosen. Only two NASA astronauts are understood to have been dismissed from service, William Oefelin and Lisa Nowak in 2007. The new astronauts have much to be inspired by. Two days after their 2025 NASA astronaut intake press conference, in the same room at the Houston JSC it was the turn of Artemis II NASA astronauts Reid Wiseman, Victor Glover and Christina Koch, plus Canadian astronaut Jeremy Hansen, to present to the press and to the world their thoughts on their forthcoming lunar flight. They named their Orion spacecraft, *Integrity* (see pages 44-45). If all goes well in early 2026, for the first time there will be astronauts onboard the ISS in LEO sending greetings to a deep-space mission crew heading out on its Moon journey, the first humans to fly to the Moon since Apollo 17 in 1972. SF

Mission Watch

Mission Watch is SpaceFlight's regular listing of significant global space missions using the latest data from the world's space agencies

Compiled by Rob Coppinger

NASA's ESCAPADE spacecraft being inspected in 2024. / *NASA/Kim Shiflett*

ESCAPADE

LAUNCH: 2025
MISSION: Investigate Mars' magnetosphere

STATUS: NASA's Escape and Plasma Acceleration and Dynamics Explorers (ESCAPADE) mission was to be launched by a Blue Origin New Glenn rocket before the end of 2025. ESCAPADE is two identical spacecraft that will study Mars' magnetosphere. The mission was to be launched on Blue Origin's New Glenn rocket in 2024 but delays for the rocket postponed the launch.

This illustration shows Jupiter icy moons explorer's flyby of Venus. / *ESA*

Jupiter icy moons explorer

LAUNCH: 14 April 2023
MISSION: To study the Jovian system

STATUS: In November, the European Space Agency's Jupiter icy moons explorer (JUICE) mission spacecraft was to observe the interstellar object 3 Interstellar Asteroid Terrestrial-impact Last Alert System. The JUICE spacecraft will flyby Earth in September 2026 and later make flybys of Venus to reach Jupiter in July 2031.

Copernicus Sentinel-6B at Astrotech's Space Operations facility. / *USSF 30th Space Wing*

Copernicus Sentinel-6B

LAUNCH: November 2025
MISSION: Sea surface data

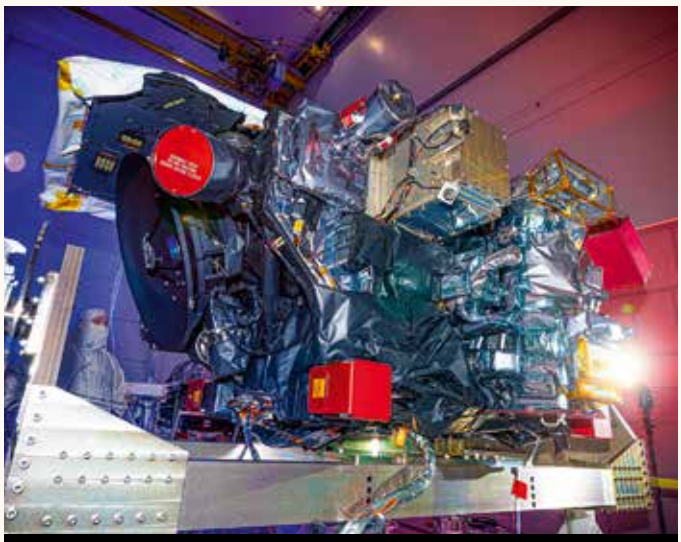
STATUS: The Copernicus Sentinel-6B arrived at in Vandenberg Space Force Base in September. The satellite was to be launched from California in November. Its mission is delivering precise sea-surface height data. Sentinel-6B is the product of international cooperation with the European Commission, European Space Agency, NASA, Eumetsat and the French space agency CNES.

Korean Aerospace Research Institute satellite KOMPSAT-7 is prepared for launch. / *CNES*

KOMPSAT-7

LAUNCH: November 2025
MISSION: Earth observation

STATUS: The KOMPSAT-7 satellite was developed by the Korean Aerospace Research Institute (KARI) and arrived at the Guiana Space Centre in Kourou, French Guiana in October to be prepared for its November launch aboard an Arianespace Vega-C rocket. The satellite system, bus and payload were all developed in the Republic of Korea.



Technicians inspect the observatory in July ahead of its launch. / *BAE Systems*

Space weather follow on L1 mission

LAUNCH: 23 September 2025
MISSION: Monitor space weather

STATUS: The National Oceanic and Atmospheric Administration's (NOAA) space weather follow on L1 mission (SWFO-L1) spacecraft is NOAA's first satellite dedicated to space weather observations. It was launched on 24 September by a SpaceX Falcon 9 rocket. Its objective is to orbit the Sun at the Lagrange Point 1 about 1.5 million km from Earth and collect data. The SWFO-L1 spacecraft has a suite of instruments to measure the solar wind, thermal plasma and the magnetic field. It will also have a compact coronagraph instrument to detect coronal mass ejections.

Carruthers Geocorona Observatory awaits its encapsulation. / *NASA/Kim Shiflett*

Carruthers Geocorona Observatory

LAUNCH: 23 September 2025
MISSION: Studying the Earth's exosphere

STATUS: The Carruthers Geocorona Observatory was launched on 24 September by a SpaceX Falcon 9 rocket from launch complex 39A at NASA Kennedy Space Center (KSC) in Florida. The Observatory is a small satellite that will operate at Lagrange Point 1, an orbit between the Earth and Sun about one million miles (1.6 million km) away. It will study the Earth's exosphere, the outermost part of the atmosphere. On 20 July, technicians offloaded the Carruthers Geocorona Observatory at Astrotech Space Operations near KSC.

Copernicus Sentinel-1D in the cleanroom at France's Guiana Spaceport in Kourou. / *ESA/CNES/Arianespace/Optique vidéo du CSG-S. Martin*

Copernicus Sentinel-1D

LAUNCH: December 2025
MISSION: Earth observation

STATUS: The fourth satellite of the Copernicus Sentinel-1 mission, the Sentinel-1D was to be launched on 4 November by an Arianespace Ariane 6 rocket. Equipped with a powerful radar instrument, the Sentinel-1D satellite will join the Sentinel-1 constellation to capture high-resolution imagery of Earth's surface in all weather and day-and-night. The Copernicus Sentinel-1 mission is based on a constellation of two identical satellites flying in the same orbit but 180° apart to optimise global coverage and data delivery.

The Interstellar Mapping and Acceleration Probe observatory being encapsulated inside its fairing ahead of its launch. / *NASA/Kim Shiflett*

Interstellar Mapping and Acceleration Probe

LAUNCH: 23 September 2025
MISSION: Studying heliophysics

STATUS: The Interstellar Mapping and Acceleration Probe (IMAP) observatory was launched on 24 September on a SpaceX Falcon 9 rocket from launch complex 39A at NASA Kennedy Space Center. The IMAP will operate at the Earth-Sun Lagrange Point 1. It has 10 instruments and its mission is to study the heliosphere, the Sun's magnetic bubble that shields the Solar System, to better understand this protective boundary. The IMAP's two-panel solar arrays were installed at Astrotech Space Operations in July. »

An H3 rocket on the launch pad for a previous Michibiki launch / JAXA

Michibiki

LAUNCH: December 2025
MISSION: Satellite navigation

STATUS: The latest Michibiki satellite for Japan's Quasi-Zenith Satellite System is to be launched this month by a Mitsubishi Heavy Industries H3 launch vehicle. The Quasi-Zenith Satellite System has been operated as a four-satellite constellation since November 2018. Three of its satellites are visible at all times from locations in the Asia-Oceania region to provide a positioning service for its users for navigation. The satellites' navigation signals are compatible with the United States' Navstar system's signals.

A Proton rocket on its launch pad at the Baikonur cosmodrome. / *ESA*

Electro-L

LAUNCH: December 2025
MISSION: Meteorology

STATUS: A Russian government meteorological satellite is to be launched this month by a Khrunichev State Research and Production Space Center Proton rocket from Baikonur cosmodrome in Kazakhstan. It is the fifth Electro-L meteorological satellite to be launched. The Electro-L satellites operate in geostationary orbit to monitor a huge swathe of the Earth's surface. The Proton was supposed to be replaced by Khrunichev's new Angara family of rockets in 2024 but the improved 60 year old Proton design continues to be operated.

The Metop-SG A1 is lowered down to the Ariane 6 adapter. / *ESA - M. Pédoussaut*

Metop-Second Generation A1

LAUNCH: 13 August 2025
MISSION: Earth observation

STATUS: The Metop Second Generation A1 (Metop-SG A1) satellite's Infrared Atmospheric Sounding Interferometer-New Generation instrument sent back its first data in October. The satellite has been undergoing a complex commissioning process. The Metop-SG A1 was launched by an Arianespace Ariane 6 rocket on 13 August this year from the European Space Agency's spaceport in Kourou, French Guiana.

A Korean Small Launch Vehicle II, Nuri, launches. / *KASA*

Compact Advanced Satellite 500-3

LAUNCH: November 2025
MISSION: Atmospheric science

STATUS: The fourth mission for the Republic of Korea's Korean Small Launch Vehicle II, Nuri, rocket, the launch of the Compact Advanced Satellite (CAS) 500-3 was scheduled for November. The CAS500-3 satellite was the primary payload with secondary payloads included. The CAS500-3 satellite was to have been launched in 2024. The CAS500-3 satellite's instruments are for studying the Earth's atmosphere.

HydroGNSS is one of ESA's new Scout missions being developed within the Earth Observation FutureEO programme. / *ESA/Mlabspace*

Hydro Global Navigation Satellite System

LAUNCH: 2025
MISSION: Hydrological climate

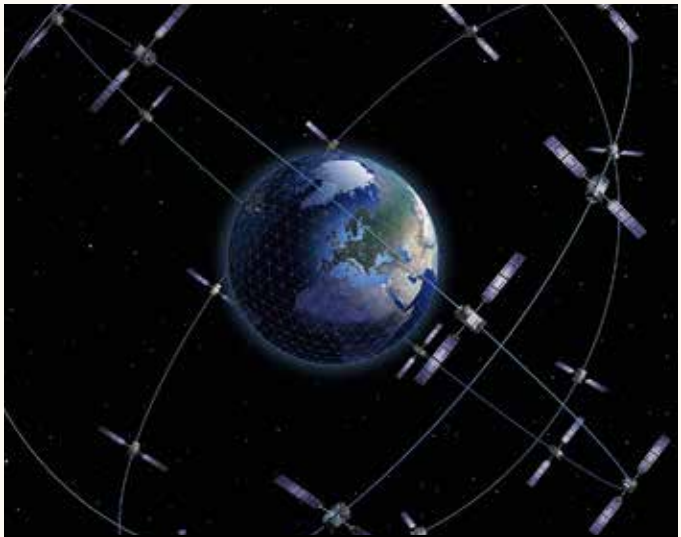
STATUS: The European Space Agency's (ESA) Hydro Global Navigation Satellite System (GNSS) spacecraft arrived in California by 2 October to be launched before the end of the year. The HydroGNSS mission comprises two satellites and it is one of ESA's new Scout missions being developed within the Agency's Earth observation 'FutureEO' programme. The two-satellite mission uses a technique called global navigation satellite system reflectometry to measure hydrological climate variables, including soil moisture, freeze-thaw state over permafrost, inundation and wetlands, and biomass.

A picture of the Gaganyaan launch abort test flight crew module. / *ISRO*

Gaganyaan

LAUNCH: December 2025
MISSION: Uncrewed crew capsule test flight

STATUS: The Indian Space Research Organisation (ISRO) has been planning to launch its crew module for its Gaganyaan human spaceflight programme this month. The test flight this month will be an uncrewed crew module with a crewed flight expected in 2026. The rocket for the Gaganyaan crew missions is a human rated version of the flight proven ISRO rocket, the Geostationary Satellite Launch Vehicle III (GSLV III) launcher. The GSLV III consists of a solid stage, a liquid stage and a cryogenic stage. The rocket is capable of launching the crew module to a 400 km altitude low Earth orbit.



This illustration is a representation of the Galileo constellation. / *ESA - P. Carril*

Galileo

LAUNCH: December 2025
MISSION: Satellite navigation

STATUS: The European Union's full operational capability Galileo satellite navigation system flight models 28 and 31 spacecraft are to be launched this month on Arianespace's fourth Ariane 6 flight of 2025, VA266. The Ariane 6-2 version of the rocket with its two solid rocket boosters will launch the navigation satellites. A constellation of 28 satellites orbiting in three orbital planes, Galileo serves more than three billion users around the world. The European Space Agency is the Galileo design authority and system development prime.

SaxaVord Spaceport's Fredo launch pad can be seen here. / *SaxaVord Spaceport*

One

LAUNCH: December 2025
MISSION: One rocket test flight

STATUS: The German launcher developer Rocket Factory Augsburg (RFA) is planning to test fly its One rocket this month from SaxaVord Spaceport's Fredo launch pad which RFA has a contract for the exclusive use of. The One is a three-stage expendable liquid fuelled vehicle for small satellites. It is designed to put a 1,300 kg payload into a 500 km Sun-synchronous orbit. Using the firm's Helix engine, the liquid oxygen, kerosene fuelled rocket's structure is a mix of stainless steel and composite.

From here to asteroid 2016 HO3

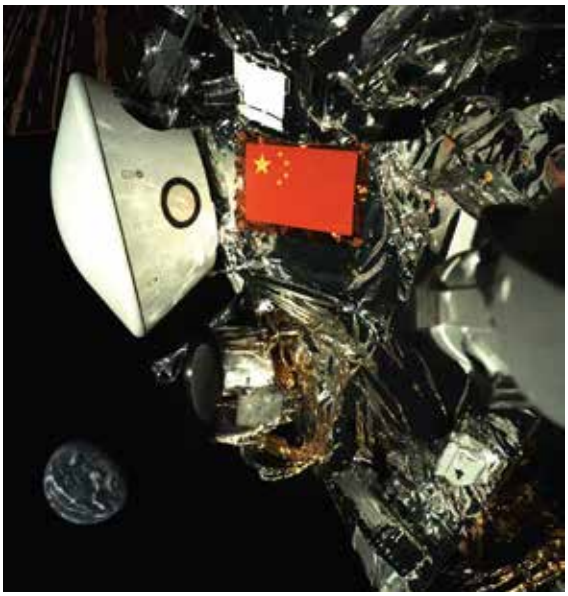


PHOTO: CNSA

ABOVE
China's National Space Administration first in-space image of its Tianwen-2 probe going to the asteroid 2016 HO3.

CHINA'S NATIONAL SPACE Administration (CNSA) released its first in-space image of its Tianwen-2 probe that will sample the asteroid 2016 HO3 and provided updates on the ongoing research on its Tiangong space station.

On 1 October, the CNSA released the Tianwen-2 probe image that the spacecraft took with a surveillance camera on its robotic arm, showing part of itself with Earth in the background. At the time, it was about 43 million km away from Earth and about 45 million km from asteroid 2016 HO3. Launched on 28 May, when it was pictured, it had been in Earth orbit for 125 days conducting tests such as deploying its sampling device. The white return capsule for the samples to be taken from asteroid 2016 HO3 is clearly visible. As well as sampling the asteroid, Tianwen-2 will explore the main-belt comet 311P whose orbit is beyond Mars.

In late September, the CNSA reported on the progress of the Shenzhou-20 crew onboard the Tiangong China Space Station. The Shenzhou-20 commander is SrCol Chen Dong and his crewmates are Col Chen Zhongrui and Col Wang Jie. Dong is on his third space mission. The crew had launched, and arrived at the Station, on 24 April. After about five months, with only a month to go until they leave, spacewalks, aerospace medicine experiments, microgravity physics, microbial monitoring, crew health examinations and the arrival of a cargo ship, had all been accomplished. One spacewalk saw the crew bring back into the cabin the material extravehicular exposure experiment device and store the experiment's third batch of samples.

The Shenzhou-20 crew had conducted four spacewalks by the beginning of October. Zhongrui and Jie carried out their extravehicular activity (EVA) for about six hours and finished at 0135hrs on 26 September Beijing time. They were assisted by the Station's robotic arm, ground-based researchers and Dong, who monitored their progress from within the Station. The two spacewalkers completed the installation of space debris protection devices and inspected external equipment. Zhongrui and Jie are the first of China's third batch of taikonauts, China's word for astronauts, to jointly carry out an EVA. Four spacewalks also makes Shenzhou-20 one of only two crews that have conducted the most EVAs. The spacewalk was the 24th carried out by Chinese astronauts. Shenzhou-20 is China's fifteenth crewed spaceflight and the crew is the ninth group of Tiangong residents.

Inside the Station, microgravity combustion science experiments have been undertaken. The Station has a combustion chamber, and it is used for experiments using various fuels, including gas, liquid and solid fuels. The potential for fire on a station or a spacecraft has meant that this is one reason why such experiments are carried out. The normal environment of a station is also studied, and microbial life is of interest. The Shenzhou-20 crew are regularly sampling microorganisms in different media such as gases, on surfaces and in water to detect bacterial species. Their growth needs to be evaluated for controlling the microbial population on any station.

Like the International Space Station (ISS) crews, taikonaut health is also studied by Tiangong teams and Shenzhou-20 has conducted cardiac and vascular ultrasound examinations. They have also used neuromuscular stimulators to prevent muscle atrophy to counteract the physiological effects of weightlessness. Astronauts' fine motor control has also been a topic of study. The Shenzhou-20 crew conducted tests to study the changing patterns of their fine motor control under microgravity conditions.

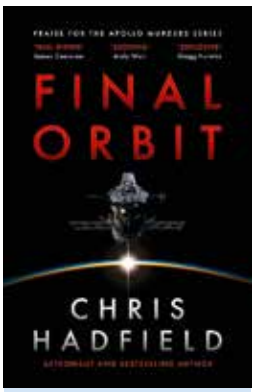
Like the ISS, Tiangong also sees the mundane tasks. The Shenzhou-20 crew completed the transfer and sorting of cargo bags and extravehicular clothing in the Station's Wentian module and its Mengtian laboratory module. They have also had to inventory medicines and carry out other material management work.

On 1 October, the Shenzhou-20 crew commemorated the 76th anniversary of the founding of the People's Republic of China. They wore red festive sweatshirts adorned with heart prints in Chinese language characters and spoke in a video for the Chinese people. The above information has been compiled from Chinese state media and government online sources including the China National Space Administration and China Manned Space Agency websites. SF

BOOK

Reinvent SETI

John Gertz redirects the search for extraterrestrial intelligence (SETI), examining its past missteps and proposing a new approach, one surprisingly closer to home. A businessman from the Californian world of entertainment, Gertz is no scientist but he is an amateur astronomer and has been heavily involved in the United States in the SETI Institute and Breakthrough Listen initiative, holding senior positions for many years. The foreword to his book is by the well known SETI researcher Dr Seth Shostak. In his preface, Gertz references the *Journal of the British Interplanetary Society* (JBIS) as the publication which has published most of his own SETI papers. The Journal is referenced in footnotes throughout the book and Gertz explains that the book is an "outgrowth" of his JBIS papers. While Gertz has written technical papers, as a businessman in the film and television industry his book is written in an accessible style, avoiding scientific jargon. He pulls no punches setting out straight away the thankless task that is the search for ET and its negative impact on people's careers. He also emphasises the historical lack of funds and the resulting retardation of the discipline. The needle in the infinite haystack challenge that is the job of finding aliens is also not lost on the reader. Gertz does not have a good word about the famous Drake equation either, which attempts to calculate the number of civilisatons. It is a fool's errand for Gertz. He also questions the viability of listening for signals at all and he is against sending them. Like some scientists, he fears the imperialist alien that seeks to neutralise its inferior neighbours before they can be a threat. What could be a dry tome of scientific endeavour is lightened by Gertz's approach of explaining SETI's work, challenges and pitfalls with the use of a fictional Proxima Centauri civilisation. So, why read *Reinventing SETI New directions in the search for extraterrestrial intelligence*? Because it does a good job of pulling apart the challenge, and the failings, of the discipline, proposes new directions, and it is from someone who has been in a position to see it all. While Gertz is explaining what is wrong with SETI he is also giving a good history of what has been done for decades. The new direction that Gertz opts for is perhaps perfectly, and fortuitously, timed for now. With speculation that the first interstellar object found travelling through the Solar System, 'Oumumua, was an alien probe, and this year's interstellar interloper, 3I/ATLAS (See page 6) possibly being another, is it time to point the observatories inward to the Solar System for the answers?



FINAL ORBIT
By Chris Hadfield
Published by: Quercus
ISBN: 978-1529435955
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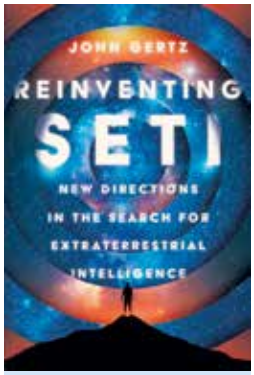
Fiction
416 pages



REINVENTING SETI
New directions in the search for extraterrestrial intelligence
By John Gertz
Published by: Oxford University Press
ISBN: 978-0197800416
£22.99 Hardcover
Non-fiction
240 pages

BOOK

Final orbit?

Astronaut Chris Hadfield's third book in his Apollo Murders series reimagines the events of the Apollo-Soyuz project, gives the then abandoned NASA Skylab space station a major role and changes history again with a 1975 crewed Chinese spaceflight when China would actually launch its first astronaut thirty years later in 2005. In the first Apollo Murders series book, Hadfield had another historical 'what-if,' the cancelled Apollo 18 flew its mission but this time it has a secret agenda. This mission is briefly referenced in this third book. That first book in the Apollo Murders series introduced Hadfield's one-eyed hero, the NASA flight controller Kaz Zemeckis, and that book is called *The Apollo Murders*. The second book is *The Defector*. In this third book, Zemeckis begins his journey in the prologue visiting the Great Wall of China, as a participant in the then United States' President Richard Nixon's famous trip there to change the relations with the communist country. And China is the central antagonist of the third book's story. Hadfield's knowledge of NASA facilities and spaceflight operations comes clearly through in the text and his two pages of acknowledgements thank the many experts that helped him. Included is *SpaceFlight* contributor Bart Hendrickx. The book is also endorsed by film maker James Cameron and science fiction writer Andy Weir. The quality of the writing is adequate with the text peppered with data and descriptions that are more text book-like than anything with an artistic flair. But as the author is an experienced astronaut the descriptions feel realistic. Along with Hadfield's fictional characters, real-life astronauts, and cosmonauts, are a key part of the story, notably the Apollo-Soyuz crews but with a twist. The first chapter starts with the Apollo-Soyuz crews practising their mission. In the back of the book, a seven page long *Editor's Note* details the 27 real people and the organisations Hadfield includes in his story. Hadfield also has a fictional female cosmonaut, Svetlana Gromova, who is a member of the Soviet Soyuz crew for Apollo-Soyuz. Alexi Leonov and Valery Kubasov are still part of the crew, Hadfield expands their number to three. By page 60 all the astronauts, cosmonauts and a taikonaut, as the Chinese call their astronauts, are in orbit and they stay there for almost all of the book. While the 'what-if' history plot and a realistic portrayal of space operations may appeal to many space enthusiasts, Hadfield's plot choices at the end may be unwelcome for many.

19,407 DAYS AND COUNTING

In September, NASA announced its tenth crew to go to the Moon could launch on 5 February 2026

By Rob Coppinger | Photographs courtesy NASA

NASA has a target of launching its second Artemis mission, and tenth crewed flight to go to the Moon, no later than April next year, but during briefings last September the agency explained that the launch windows for Artemis II will open from 5 February. On 23 September, NASA held two press conferences, one that was a mission overview, and the other was about Artemis II's science and technology. On 24 September, the space agency held its Artemis II crew press conference. The conferences were held at NASA Johnson Space Center (JSC) in Houston, Texas. That week, the mission's rocket and spacecraft were still being assembled. In the NASA Kennedy Space Center (KSC) Vehicle Assembly Building (VAB) the Boeing Space Launch System (SLS) rocket was having its Artemis II Orion stage adapter integrated. The adapter connects the rocket's Interim Cryogenic Propulsion Stage (ICPS) upper stage to the Lockheed Martin Orion crew spacecraft which was in the KSC Launch Abort System (LAS) Facility at the time. In the Launch Abort System Facility, as the name suggests, the Orion was having its LAS fitted.

During September, the Artemis II crew were continuing their training and had visited KSC. The crew's commander is Reid Wiseman, its pilot is Victor Glover and the two mission specialists are Christina Koch and Jeremy Hansen, who is a Canadian Space Agency astronaut. The other three are all NASA astronauts. Artemis II will be Hansen's first flight in space while his NASA colleagues have all had long-term missions on the International Space Station (ISS) as Expedition crew. On 17 October, their Orion crew spacecraft, named *Integrity*, was rolled from KSC's Launch Abort System Facility to the VAB to be stacked on top of the SLS. The name for the Artemis II spacecraft, *Integrity*, was announced by Wiseman during the crew's 24 September news conference.

> This is something we have experienced before, if you recall, in your history, we did that on Apollo 8 and Apollo 13

The day before, NASA Headquarters' acting deputy associate administrator, Lakiesha Hawkins, KSC Artemis launch director, Charlie Blackwell-Thompson, KSC exploration ground systems' test director, Daniel Florez, and JSC lead Artemis II ascent flight director, Judd Frieling, lead Artemis II flight director, Jeff Radigan and lead Artemis II entry flight director, Rick Henfling, gave the mission overview. The mission's duration has not changed and is still planned to be for 10 days (*SpaceFlight* Vol 65 No.7 July pp24-25). In the mission overview and the crew's conference, the test flight status of Artemis II was emphasised.

The mission is to see 24 hours of testing of the

Orion spacecraft prior to its trans-lunar injection burn to go to the Moon. The tests will also include proximity operations with the Space Launch System's ICPS which put Orion into its Earth orbit. The mission will reach the Moon on the sixth day, and the crew will go further beyond the Moon than any Apollo mission. The closest Artemis II will get to the Moon is about 5,000 miles (8,000 km) and the crew is planned to observe it for three hours.

Hawkins said that the mission will see new capabilities demonstrated including Orion's life support systems, its display capabilities and software. She explained that Orion will be on a free return trajectory with the course set when the trans-lunar injection burn occurs on the second day. The lunar and Earth gravity would return the crew without the need for what Hawkins called "major course corrections propulsion burns". Referring to the Apollo programme, Hawkins said: "This is something we have experienced before, if you recall, in your history, we did that on Apollo 8 and Apollo 13."

It was Hawkins that gave the earliest launch date. She said: "That [launch] window could open as early as the fifth of February. Depending on how we progress, of course, there will be more work in order to be able to nail that [launch date] down." If the mission launches on 5 February, it would have been 19,407 days since the 19 December 1972 landing in the Pacific Ocean of the Apollo 17 crew capsule. Hawkins also explained that the launch window opportunities are four to eight days in each month. She added that closer to February, NASA will say when those launch window opportunities will be.

In the crew press conference Wiseman was sanguine about the outcome of Artemis II. "I know this week NASA has said that we're going to open the launch window in early February and we just do not anchor on dates. We're going to launch when this vehicle is ready, when this team is ready. And we're going to go execute this mission to the best of our abilities. When we get off the planet, we might come right back home, we might spend three or four days around Earth. We might go to the Moon, that's where we want to go, but it is a test mission."

Shortly after reaching Earth orbit the crew will begin to organise their capsule's interior for the ten-day stay. Koch and Hansen have the job of setting up the toilet and the water dispenser. In the conference, Glover gave details on the proximity operation. "Right after that apogee raise burn on the interim cryogenic propulsion stage, we're going to disconnect from the upper stage, then turn around and fly and approach to it and we're going to fly it by hand and we are going to make sure that the flying qualities of the Orion spacecraft are suitable for the more complex missions where we're going to dock to a lander or to the Gateway, the [Moon] orbiting space station."

The ten day journey will be filled with science for the crew to carry out. Koch said: "[For] human research, science that we are participating in ourselves, there's four major experiments on the mission and we're excited to be part of all of them. One we call Archer. That one is basically something where we are learning how humans, how we, really get through these tough deep space exploration

CLOCKWISE FROM OPPOSITE LEFT

NASA's Artemis II Space Launch System rocket inside NASA Kennedy Space Center's Vehicle Assembly Building Florida on 24 July 2025.

The Artemis II crew, from bottom left clockwise, Christina Koch, Victor Glover, Reid Wiseman and Jeremy Hansen play a board game inside the NASA Kennedy Space Center's Neil A. Armstrong Operations and Checkout Building on 11 August during a launch day practice. NASA flight crews have a tradition of playing a board or card game before leaving the crew quarters ahead of their launch.

The four solar array wings for the Artemis II Orion spacecraft were installed inside the Operations and Checkout Building at NASA's Kennedy Space Center in Florida on 7 March 2025.

missions." In the 23 September Artemis II science and technology news conference, NASA headquarters science mission directorate's acting deputy associate administrator, UK born Mark Clampin, said: "Now there are three themes that we see in this mission, as it pertains to science. The first is the nature of deep space." Although the closest the crew will get to the Moon is about 8,000 km, lunar geology is still part of the science missions. Clampin said, mistakenly referring to three astronauts and not four: "Having three astronauts on the mission also means that we have eyes on the Moon and they will be able to, probably, see parts of the far side that were not seen during the Apollos, so this gives us a lot of opportunity for additional geological work and they'll be equipped with cameras and taking images that we can then use to basically follow up geologically and also potentially look for new landing sites."

When Wiseman announced what the Orion's name would be, he explained its origin saying: "A couple months ago … we [the four crew and their back ups Andre Douglas and Jenni Gibbons] went to the quarantine facility here, we locked ourselves in there until we came up with a name … we are bringing together an amazing workforce and they are bringing together an amazing vehicle ... [and] created magic. So, we're going to fly around the Moon in the spacecraft, *Integrity*. Thank you." SF

PHOTOS CLOCKWISE FROM LEFT: ESA/ID&SENSE/ONIRIXEL / ESA / ESA

No time to waste

Accelerating progress on the deployment of debris mitigation measures is now a policymaker's priority

By Tatiana Quercia

The international regulatory framework for debris is relatively new, having been adopted in 2005, and not legally binding and this is making space operators reluctant to adopt it. However, since 2000, the clearance of low Earth orbit (LEO) has slowly improved for commercial missions, with the share of compliance to the 25 years rule increasing from below 20% to above 80% which was achieved in 2015. The so-called "25 years rule" regulates end of life (EOL) design for LEO space objects requiring their disposal in this orbit within 25 years of their mission ending. The European Space Agency (ESA) states that about 70% of all catalogued objects are in low Earth orbit which extends to 2,000 km above the Earth's surface.

Despite the good news about 2015, extrapolations of the space community's behaviour, based on launch traffic, explosion rates and disposal success rates, show a net growth in the number of objects and their debris. The year 2014 was the year when launches of small satellites became significant. These results were from a study by ESA that used Monte Carlo simulations to examine the impact on the LEO environment of all the objects launched and the compliance and non-compliance by operators over a 200 year period with different scenarios.

The upstream's segment privatisation in recent years has also led to an increasing number of launches, bringing payloads, astronauts and tourists to LEO. This has rapidly raised awareness in the scientific community about the risks of collision with a multitude of on-orbit inactive objects, also known as space debris, and their safety and environmental implications. The phenomenon is being studied statistically, for example by ESA space debris office, to collect relevant data in support of more effective policy making. According to ESA's space debris environment model, Meteoroid and Space Debris Terrestrial Environment Reference, at the most recent reference epoch, 1 November 2016, the estimated number of debris objects in orbit was on the order of 10,000 for objects greater than 10 cm. There are also one million objects between 1 cm and 10 cm and 100 million for anything smaller than 1 cm.

> The highest number of conjunction events is estimated to be in Sun-synchronous orbits with an altitude of 500 km and inclination of 97.4° for constellations and small satellites

Within the LEO and geostationary orbit (GEO) regions, debris distribution is concentrated in narrow bands. For example, in LEO the highest traffic is generated between 450 km and 650 km by commercial telecommunication satellites. Their payload mass is between 100 kg and 1,000 kg. The industry is seeing an increase in the number of launches carrying one to five or 10 to 25 payloads to LEO at a time. For example, SpaceX's rideshare Transporter missions that launch many times a year. Half of the objects are identified within two months from their launch. When part of a constellation, their estimated lifetime is up to two years, but

unfortunately their re-entry is uncontrolled.The European Space Agency's collision risk assessment software can be used to study potential conjunctions, meaning a geometric close approach between two objects, that trigger the need for an operator's analysis.

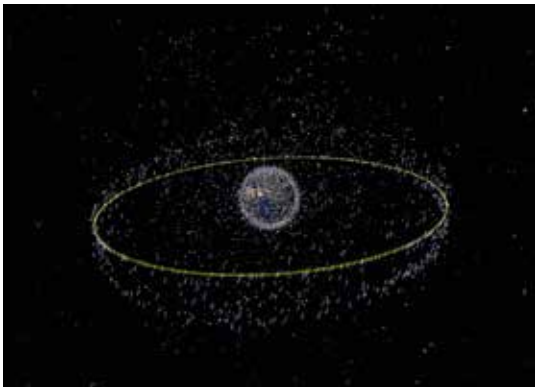
Conjunctions are categorised as "events" according to the primary and secondary objects' characteristics and Time of Close Approach (TCA). The highest number of conjunction events is estimated to be in Sun-synchronous orbits with an altitude of 500 km and inclination of 97.4° for constellations and small satellites. The leading international technical body in the field of space debris is the Inter-Agency Space Debris Coordination Committee (IADC). Founded in 1993, it is composed of ESA and twelve national space agencies from around the world. For payloads in the IADC-defined LEO, collision avoidance monitoring is activated when the probability equals 10^{-6} within three days of a TCA. Fragmentation events can be consulted in the ESA fragmentation database. The most frequent causes for fragmentation events are due to non-passivated propulsion-related subsystems' explosions or breakages, overcharging and explosion of batteries and collisions. The explosion probability due to non-systematic design flaws is considered to extinguish only after 18 years from launch.

To calculate the risk, an environmental index, or debris index, is used to measure the likelihood of a fragmentation during a mission and over 100 years. This is, in part, calculated as the probability of a catastrophic collision, multiplied by the severity of the impact on the operational spacecraft. NASA has a breakup model to simulate the outcome of severe impact events. The NASA model has found that 97% of the risk is carried by inactive objects, mostly rocket bodies. The enaction of EOL rules for a spacecraft begin one year after its operator's orbit control actions have stopped, unless a controlled re-entry is performed.

For payloads with a mass below 10 kg, more than 5% of spacecraft have complied with EOL rules since 1990. Since that year, a level of compliance that was about more than 30% for spacecraft between 10 kg and 100 kg has been achieved but two thirds of that compliance has been since 2015. Since 1990, the compliance rate has been more than about 30% for spacecraft whose mass is between 100 kg and 1,000 kg. But for spacecraft larger than 1,000 kg, since 1990 the compliance share has decreased by about 10%.

There was a more positive outcome for more than 7% of those 1,000 kg plus sized spacecraft, where the original design was not compliant, thanks to a successful disposal action. The EOL operations in GEO are regulated to ensure payloads' disposal at a graveyard orbit with minimal interference. Rocket bodies can avoid interference delivering orbit control capacity payloads below GEO and letting them reach target orbit, activating their propulsion system. In 2002, the IADC released its space debris mitigation guidelines. This is a baseline regulatory framework focused on limiting debris released during normal operations. It sets out how to minimise the potential for on-orbit break-ups and ensure post-mission disposal to clear LEO and GEO and prevent on-orbit collisions. Based on that, in 2007 the United Nations' Committee on the Peaceful Uses of Outer Space (COPUOS) released its space debris mitigation guidelines. These are for the long-term sustainability of outer space activities, taking into consideration the United Nations' treaties and principles on outer space. The combination of the IADC and UNCOPUOS space debris mitigation guidelines constitute a comprehensive non-binding international regulatory framework. This is slowly, and reluctantly, being adopted as a reference by space actors in the global market after continuous research dissemination efforts and warnings made by the scientific community.

Sadly, studies continue to show an increase in debris over time, justifying broader implementation of the debris mitigation measures defined by the guidelines and other studies in the field. More information on the studies' simulations, as well as on all the models and statistical data previously mentioned, can be found in ESA's *Space Environment Report 2024*. The report also says that more satellites were launched in 2023 than in any year before. The non-binding nature of debris mitigation guidelines and the worrying results of the phenomenon's statistical models partially explain only modest achievements in the reduction of space debris since the early 2000s. Accelerating progress on the development and deployment of mitigation measures has to become a priority in policymakers' agenda or the finite resource of LEO and GEO will be gone. SF



CLOCKWISE FROM OPPOSITE LEFT

Debris and defunct launcher stages in the Geostationary ring. Aging satellites are known to release debris and explosions can occur due to residual energy sources.

About 70% of all catalogued objects are in low Earth orbit which extends to 2,000 km above the Earth's surface.

The geostationary ring, at an altitude of about 36,000 km. This orbit is heavily used by telecommunication satellites.

PHOTOS: BIS

World Space Week 2025: Living in Space

World Space Week returned for its annual celebration from 4-10 October 2025, bringing together space enthusiasts, educators, and professionals

This year's compelling theme, Living in Space, explored humanity's journey towards making space a habitat, examining the innovative technologies, challenges, and collaborative efforts necessary for humans to thrive beyond Earth. Established by the United Nations in 1999, World Space Week has grown into the largest annual space event on Earth with over 14,647 events registered across the globe this year. For 2025, the UK events from Derry (Londonderry) to Dorset saw a diverse array of activities designed to inspire and educate. The week saw 38 UK events registered on the global calendar, with many more being featured (unregistered) on social media.

The Space Artwork Mosaic illuminated London's Piccadilly Lights on 8 October, displaying artwork from global participants reflecting the Living in Space theme. The British Interplanetary Society (BIS), serving as the UK's National Coordinating Body for World Space Week, supported and encouraged educational opportunities across the nation.

The Society's own event on 10 October had a group of panellists to discuss the theme. They were student Otilia Dogaru, lawyer Professor Emma Edhem, space exploration communicator Jerry Stone, physical training expert John Kennett, financier Per Wimmer, recruitment and training specialist Rudi Page. The BIS also hosted a special World Space Week edition of the Society's monthly online social Space Rendezvous. There was also a special World Space Week BIS Evening Lecture by Jerry Stone (See page 45).

Elsewhere in London, the Royal Society Lates presented 2075: A Space Odyssey and the Science Museum celebrated space exploration. The Canary Wharf Space Innovation Hub showcased space innovation in its recently opened Space Gallery.

The UK registered an impressive array of events for 2025, showcasing the country's strong engagement with space education and outreach. The University of Portsmouth hosted Heaven's Above: Explore the Night Sky. This was jointly held with the Hampshire Astronomical Group and included telescope observations, meteorite handling and panel discussions including one on gravitational waves and celebrating ten years of discoveries. The Gosport Digital Trail had a rocket design competition with local schools.

Other regional celebrations were also taking place. From Birmingham's GEC Space City consultancy, to Keele University in Staffordshire, Guildford High Street, Newcastle Upon Tyne's planetarium shows, and Glasgow's AntryXSpace which is online space education and astrophysics courses for children. More educational outreach included the Moon Landing Coding Adventure for ages 5-8 that was available nationwide. In

ABOVE
The Week in Space panellists and WSW event participants group photo.

FROM FAR LEFT
The Week in Space panellists (L-R) Otilia Dogaru, Professor Emma Edhem, Jerry Stone, John Kennett, Per Wimmer, Rudi Page.

Week in Space panellists (L-R) Otilia Dogaru, Professor Emma Edhem.

Leicester, there was the National Space Centre's One Step Beyond planetarium display along with modules on the space economy. The town of Prescot in Lancashire ran sessions about keeping astronauts healthy in space and in Bristol there was a range of activities including planetarium displays as part of the Out of this World October programme.

World Space Week 2025 arrived at a pivotal moment for humanity's spacefaring future. The technologies developed today will determine whether future generations can establish permanent settlements on the Moon, Mars, and beyond. This year's World Space Week served as both a celebration of how far we've come and an inspiration for the next generation of scientists, engineers, and explorers who will make living in space a reality. Join the Celebration and start planning for WSW2026 now!

See our guidance at: **bis-space.com/wsw**

Vix Southgate

Island Zero

A first step in producing large-scale space habitats with Jerry Stone

For the British Interplanetary Society (BIS) World Space Week activities, a Special Evening Lecture about living in space was given on 6 October by Jerry Stone.

Stone lectured on the history and future of orbital habitats, specifically focusing on the new Island Zero concept. But first, this author, gave a short prelude on the historical development of the space station idea. The prelude began by charting the origins of space stations, with the fictional Brick Moon of 1869 and Konstantin Tsiolkovski's early scientific speculation on rotating, artificial gravity structures.

The term space station was first used by Herman Oberth in 1930. Wernher von Braun would later have his space wheel concept which established the wheel image of a space station in the public's mind. This all led to real-world projects like the United States Air Force's cancelled Manned Orbiting Laboratory, NASA's Skylab, the Soviet Union's Almaz, Soyuz and Mir, and finally the International Space Station (ISS).

Stone then introduced the Island Zero project, based on physicist Gerard O'Neill's 1970s High Frontier concepts. O'Neill challenged his students to determine whether a planetary surface, such as that of the Moon or Mars are the best place for a technological civilisation. The students concluded that such surfaces are unsuitable for permanent mass settlements due to the medical effects of low gravity and power loss during long dark periods. The ideal solution is to build rotating habitats at the stable Lagrange Points L4 and L5 using lunar material delivered by electromagnetic mass drivers.

Island Zero is presented as a crucial, low-cost prototype designed to answer the most critical unknown factor for large-scale colonisation, the minimum level of simulated gravity required for human health. Stone emphasised that zero-gravity causes severe issues like heart weakening, fluid shifting, and osteoporosis, requiring ISS astronauts to perform two hours of exercise daily. Island Zero's design uses rotating, 100 m radius inflatable modules that rotate at three rotations per minute to produce 1 g. It is uniquely configured to simultaneously test different gravity levels from 0.7 g, for example, to 0.9 g, by placing research modules at various radii.

Beyond medical research, Island Zero could serve as an acclimatisation vehicle for Mars crews and house workers engaged in microgravity manufacturing in its central hub or elsewhere doing assembly work. Stone concluded by reiterating O'Neill's belief that expanding into space is the path to solving major global crises, including environmental overload, energy shortages and warfare, providing a vast new frontier for humanity.

Griffith Ingram

PHOTO: BIS ITALIA

BIS at European Researchers Night 2025

The Italian branch BIS Italia volunteered in the European Researchers Night annual public Outreach event

The European Researchers Night annual public outreach event at the European Space Agency's European Space Research Institute (ESRIN) campus in Rome in September saw some 19 Italian branch, BIS Italia, members volunteer.

The European Researchers Night typically takes place on the last Friday in September. It is an opportunity for many scientific institutions across Europe, as the name suggests, to open their doors to the general public to showcase their work.

The BIS Italia's volunteer activities, mostly located in ESRIN's Big Hall, enjoyed a constant flow of visitors. There were queues of people who were very keen to try out BIS Italia's ever-popular Lunar Lander Simulator and the 1:6 scale Vega launcher model to explain a launcher's avionics systems. There was also a stand about model rocketry. BIS Italia member Francesco Di Matteo answered questions about how rockets work and his specialty is rocket propulsion.

In the grounds outside, BIS Italia members thrilled the multitudes with frequent launches of their model rockets. After launching said rockets, retrieving them as they parachute down is enough of a challenge in broad daylight, but doing so in the dark of night was another matter altogether! Fortunately, all of the rockets were successfully recovered. BIS Italia member Mario Benincasa was sensibly helping the FELX/FLORIS remote sensing instrument activity, managed by ESA personnel, in a room adjoining the Grand Hall. And there was a constant line of visitors for this.

During this event, BIS Vice President Fabrizio Bernardini, and BIS Vice President Steve Salmon, took the opportunity to gift a hardback copy of the *Interplanetary* revised edition to Roberta Cristofanelli as a token of friendship and cooperation between the BIS and ESA. She is responsible for ESA public relations at ESRIN. In a return gesture of appreciation for BIS Italia's consistent support of ESRIN's outreach activities over some 12 years, Cristofanelli very kindly presented Bernardini and Salmon with an impressive double-volume book set about ESA's Cryosat mission. This will be available soon to view and enjoy in the BIS HQ Library. Being able to participate as partners with ESA in this kind of high-visibility events, on a continuous basis, is a major, and unique, achievement of the Society. Special thanks are due to all the members that make this possible every time. The ESA video is here: **www.youtube.com/watch?v=LsXO1kIFIpU** or search "ESA Open Day 2025: an unforgettable day inside ESRIN" on YouTube.

Steve Salmon

ABOVE FROM LEFT
(L-R) Steve Salmon, Roberta Cristofanelli, Fabrizio Bernardini.

Enthusiastic young participants with the lunar lander simulator.

ESA mascot PAXI with some of the BIS Italia crew.

Flying to a potentially hazardous object – a mission of gravity

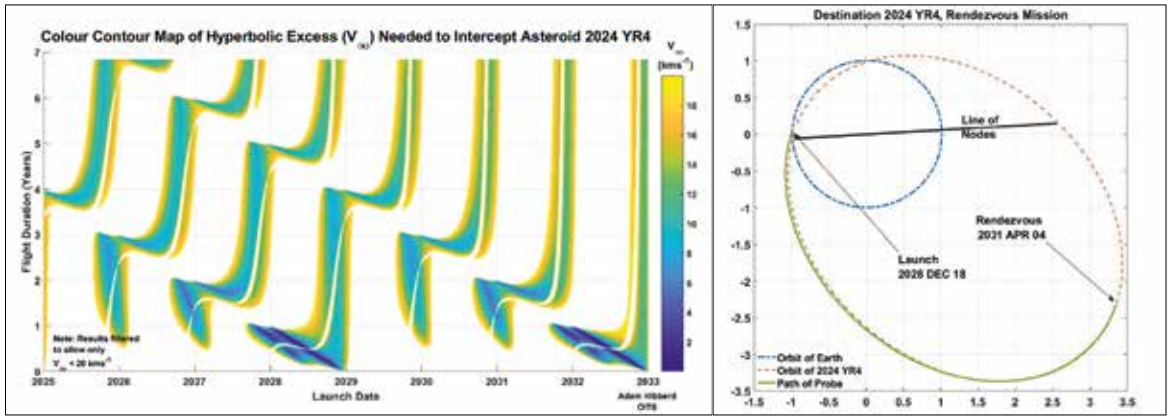


PHOTO: ADAM HIBBERD

The BIS West Midlands branch heard about the astrodynamics of a mission to the near-Earth asteroid 2024 YR4

This presentation, organised by the West Midlands branch of the British Interplanetary Society (BIS), offered an intriguing insight into the astrodynamics of a spacecraft mission to a particular Near-Earth Asteroid, namely 2024 YR4, and the potential havoc it could wreak should a collision of the Earth or the Moon really follow.

As explained by Marshall Eubanks of the United States company Space Initiatives, although this object is strictly speaking not a potentially hazardous object, as the term is normally applied, and indeed will not hit the Earth any time soon, 2024 YR4 is still an object worthy of some concern, if not alarm, should it impact the Moon, as it still has an estimated 4% chance of doing so.

The author, Adam Hibberd, is a member of the UK non-profit the Initiative for Interstellar Studies (i4is), which has a history of promotion and education in the field of interstellar travel, such as Project Lyra, discussed the orbital mechanics of how a mission to 2024 YR4 might be realised. His own software application, Optimum Interplanetary Trajectory Software (OITS), can be, and was, used to solve some of the problems. He researched (a) flyby missions, (b) rendezvous missions where the spacecraft matches velocity with the target upon arrival, and (c) sample return missions.

All three of these different mission scenarios lie easily within a domain of feasibility. For example, the rendezvous option is achievable by a New Horizons-type probe. As a reminder, New Horizons is a NASA mission which successfully flew past the dwarf planet Pluto and provides a handy existence proof should a mission to 2024 YR4 be required, as it may. Eubanks then pointed out the consequences for cislunar space and, for that matter humanity, should the object collide with the Moon in December 2032, as is entirely possible. Large quantities of debris would be thrown up, most of which would return to the Moon and pose an existential hazard for any astronauts or technology, such as rovers or landers, on the Moon at that time.

A fair fraction of that debris would be lifted beyond the Moon's escape velocity and there is a particular region on the Moon where, should the object impact it, debris would be thrown up and head directly for Earth. This area is within the current envelope of uncertainty. This lunar escape velocity debris would naturally follow a power-law type pattern such that the smaller particles would be more common, and the larger more dangerous particles would be less common. However, there would potentially be a density of debris with sufficient mass to knock out Earth's artificial satellites.

A mission to this object would therefore be hugely important. Should an impact probability increase significantly then a mission could be realised with relatively low required launch vehicle performance. Such a mission would provide the opportunity for an impactor to knock the asteroid off its catastrophic collision course.

Adam Hibberd

FROM FAR LEFT

A 'pork-chop' plot showing colour contours of feasibility assuming direct missions to 2024 YR4, with deep blue colours indicating regions of feasibility and bright yellow/blank areas indicating no feasibility. Observe two deep blue diagonal lines for launches in 2028 and a 2032, an indication of the relative ease of executing a flyby mission (with flight duration less than 1 year) for both of these windows of opportunity. This plot was generated by OITS.

A rendezvous mission to 2024 YR4 shown in plan view from above the Solar System. Optimal launch is on 2028 December 18th and one can observe a closeness between the orbit of 2024 YR4 (red dashed line) and the transfer orbit followed by the putative spacecraft (green solid line). This close alignment allows for as small a rendezvous ΔV as possible from the spacecraft to match heliocentric orbit with the target. Plot generated by OITS.

BIS LECTURES & MEETINGS

BIS ONLINE RENDEZVOUS
The second Thursday of each month
Thursday 13 November 2025, 1900BST
VENUE: Zoom
Join this online get-together to discuss all things space. Register through the BIS website: **www.bis-space.com**

THE LEROS 4 – A HIGH THRUST SPACECRAFT ENGINE FOR INTERPLANETARY APPLICATIONS
Saturday 8 November 2025, 1400GMT
VENUE: BIS West Midlands, Online via Zoom
A British rocket engine, LEROS-4, was used by the Firefly Aerospace Blue Ghost lunar lander to touch down on the Moon. This talk provides an overview of the LEROS 4 high thrust apogee engine used, and charts its design and development. Register through the BIS website: **www.bis-space.com**

BEYOND THE MOON
Wednesday 29 November 2025, 1000 to 1700GMT
VENUE: BIS London
This one-day Symposium examines the most critical challenges and opportunities facing humanity as it seeks to expand beyond lunar bases and into the wider Solar System. The call for papers closed on 30 September. Register through the BIS website: **www.bis-space.com**

CHRISTMAS GET TOGETHER
Friday 12 December 2025, 1900GMT
VENUE: The BIS London
All Members and Fellows are invited to the BIS Christmas Get together. This is always a popular event and numbers are limited, so please register online as soon as possible. Register in due course through the BIS website: **www.bis-space.com**

MARINER 2 - MAN'S JOURNEY TO VENUS
Wednesday 14 January 2026, 1900GMT
VENUE: The BIS London
BIS Member Harrison West will talk about this, the world's first successful mission to another planet, which, in 1962, paved the way for future space exploration. Register in due course through the BIS website: **www.bis-space.com**

CO-OPERATION OR COMPETITION? – THE SPACE WORLD OF TODAY
Saturday 10 January 2026, 1400GMT
VENUE: BIS West Midlands, Online via Zoom
Our speaker Brian Harvey is a space writer, author and broadcaster who lives in Ireland. He has written books about the space programmes of China, India and Japan. Register through the BIS website: **www.bis-space.com**

WORCESTER COMIC CON
Sunday 15 February 2026
VENUE: University of Worcester Arena
The BIS West Midlands branch will have a presence at the Worcester Comic Con to promote BIS. **www.facebook.com/WorcesterComicCon**

SPACE-COMM EUROPE
Wednesday-Thursday 4-5 March 2026
VENUE: Excel Centre, London
The BIS will have a stand with the simulator and books and merchandise to sell at the space industry conference and exhibition and promote BIS. **www.space-comm.co.uk**

PETS IN SPACE
Saturday 7 March 2026, 1400GMT
VENUE: BIS West Midlands, Online via Zoom
Alan Marlow will talk about the prospects for space tourists to take their pets with them. Register through the BIS website: **www.bis-space.com/event/bis-west-midlands-branch-pets-in-space**

ARMCHAIR ASTRONAUT
Saturday 7 March 2026, 1200GMT
VENUE: Cranfield
An Armchair Astronaut Space Social event with SpaceX Inspiration4 astronaut Chris Sembroski. The BIS is present promoting itself. Buy tickets: **www.armchair-astronaut.co.uk**

WESTCOTT 80TH ANNIVERSARY
Saturday, 17 or 25 April 2026
VENUE: BIS West Midlands
A celebration of 80 years of Westcott's involvement in British rocketry. Register in due course through the BIS website: **www.bis-space.com**

WORLD SPACE WEEK
October 2026
VENUE: Various
The BIS will again be participating in and coordinating UK events and activities for the United Nations' World Space Week. **www.worldspaceweek.org**

77TH INTERNATIONAL ASTRONAUTICAL CONGRESS
Monday-Friday 5-9 October 2026
VENUE: Nest Congress & Exhibition Center, Antalya
The International Astronautical Federation's 77th International Astronautical Congress is taking place in the Turkish city of Antalya. **www.iac2026.org**

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(25.8 x 22.5 x 0.82 cm)

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