your window to space

CAPCOM

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First All Female Spacewalk

The first spacewalk performed entirely by women took place on Friday 18th October 2019 by NASA astronauts Jessica Meir (at left above) and Christina Koch (at right above). It was the first spacewalk for Meir; who became the 15th woman overall and 14th US woman to carry out a spacewalk.

Credit: NASA (www.nasa.gov)

Alexei Leonov: 1934—2019

First space walk

Russian Cosmonaut Alexei Leonov, (left) the first man to walk in space, sadly passed away on 11th October 2019. On 18 March 1965, he became the first human to conduct a spacewalk, exiting the Voskhod 2 capsule, for 12 minutes and 9 seconds.

Credit: Wikipedia (www.wikipedia.org)

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Global Space News

Alexei Leonov, the first spacewalker, passes away

Russian cosmonaut Alexei Leonov, the first person to conduct a spacewalk, passed away on 11 October, aged 85.

On 18 March 1965, Alexei Leonov became the first person to float freely outside a spacecraft in Earth orbit, when he ventured from Voskhod 2. Famously, Alexei displayed nerves of steel when his spacesuit expanded in the vacuum of space so much that he was unable to squeeze back into the spacecraft. Taking a hair-raising decision, he opened a valve on the suit to let enough air escape for him to enter the airlock. His spacewalk lasted only 12 minutes but proved that astronauts could work outside a spacecraft.

News of his passing came as two astronauts – Andrew Morgan and Christina Koch – conducted the latest spacewalk from the International Space Station. ESA Director General Jan Wörner paid tribute saying, “I’m sorry to hear of the passing of Alexei Leonov. With his first ever spacewalk, he led the way for many astronauts. He was also an outstanding ambassador for international cooperation. I send my condolences to his family, friends and colleagues."

French ESA astronaut Thomas Pesquet said, “Sad to hear a legend like Leonov, first ever spacewalker, passed away. Strangely fitting though, that I was watching astronauts venture outside the Space Station live today as I heard the news. He opened the way for many of us!” British ESA astronaut Tim Peake said, ”A hero to so many, Alexei was pioneer of spacewalking and always full of wisdom and humour.”

One of ESA's most experienced spacewalkers, Swedish ESA astronaut Christer Fuglesang, said, “One of the greatest icons of space travel, not only was he a true astronaut pioneer with, among other things, the first ever spacewalk, but also he was a lifelong passionate supporter of space and for collaboration there. Quiet, sympathetic, wonderful.”

Alexei was a member of the first group of Soviet cosmonauts, selected in 1960 along with Yuri Gagarin, first human to fly in space. He was born on 30 May 1934 in the small town of Listvyanka, in Siberia. The eighth of a family of nine, he soon showed his skill in mechanics by building himself a bicycle from spare parts.

His career as a cosmonaut started when he joined the Chuguyev Air Force School in Kharkov, Ukraine, to qualify as a parachute instructor in the Soviet Air Force.

Full Story at ESA
www.esa.int

NASA Astronauts Wrap Up Historic All-Female Spacewalk

At 19:55 BST, Expedition 61 Flight Engineers Christina Koch and Jessica Meir of NASA concluded their spacewalk, the first with only women. During the 7-hour, 17-minute spacewalk, the two NASA astronauts completed the replacement a failed power charging component, also known as a battery charge-discharge unit (BCDU). The BCDU regulates the charge to the batteries that collect and distribute solar power to the orbiting lab’s systems. Mission control activated the newly installed BCDU and reported it is operating properly.

The astronauts were also able to accomplish some get-ahead tasks including installation of a stanchion on the Columbus module for support of a new external ESA (European Space Agency) payload platform called Bartolomeo scheduled for launch to the station in 2020.

Commander Luca Parmitano of ESA and NASA Flight Engineer Andrew Morgan assisted the spacewalkers. Parmitano operated the Canadarm2 robotics arm and Morgan provided airlock and spacesuit support.

It was the eighth spacewalk outside the station this year. Space station crew members have now conducted 221 spacewalks in support of assembly and maintenance of the orbiting laboratory. Spacewalkers have spent a total of 57 days, 20 hours, and 29 minutes working outside the station.

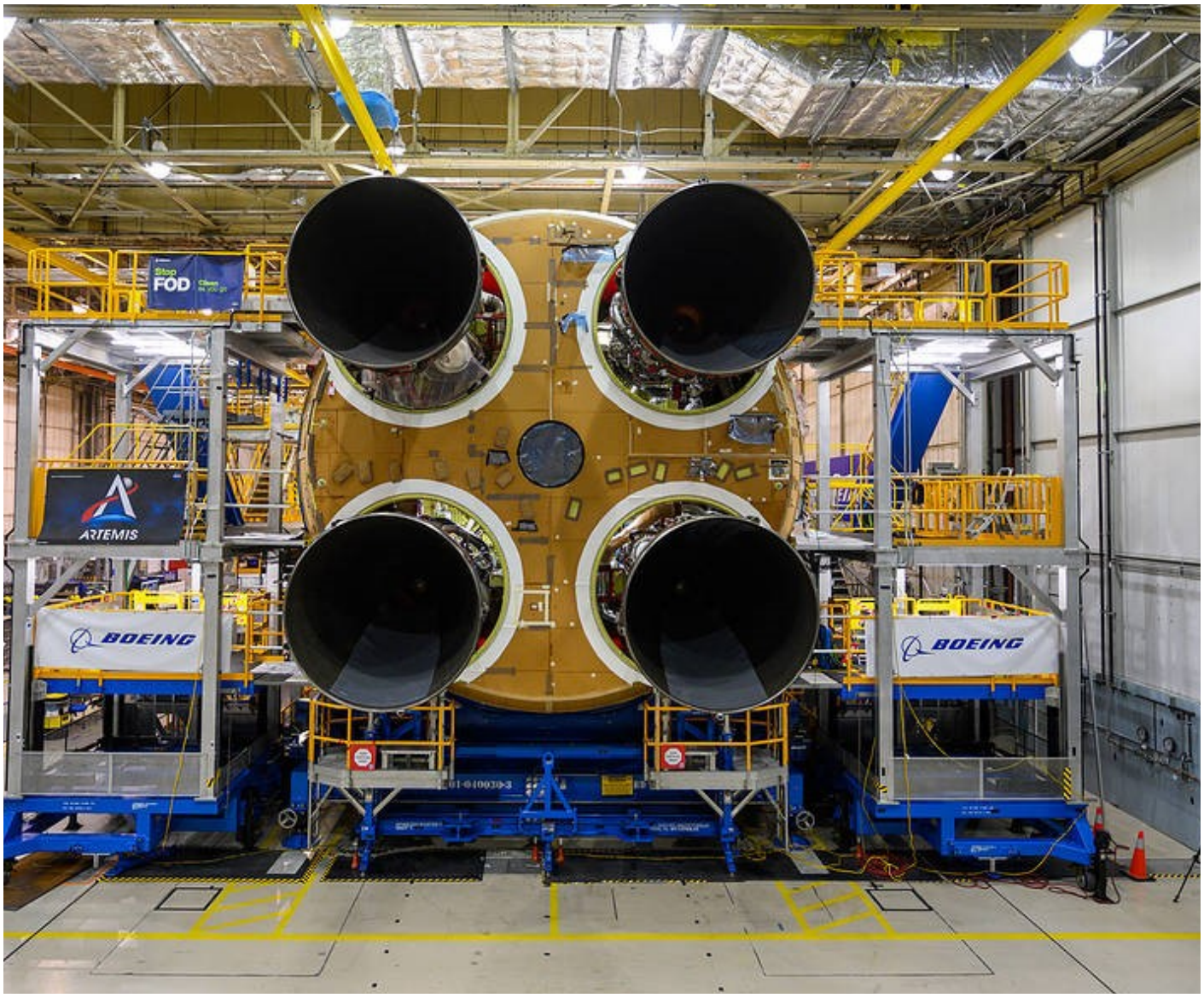
It was the first spacewalk for Meir and the fourth for Koch, who now has spent a total of 27 hours and 48 minutes spacewalking. It is the first spaceflight for both women, who were selected in the 2013 astronaut class that had equal numbers of women and men. Koch arrived to the orbiting laboratory in March 2019 and will remain in space for an extended duration mission of 11 months to provide researchers the opportunity to observe effects of long-duration spaceflight on a woman to prepare for human missions to the Moon and Mars.

Meir became the 15th woman to spacewalk, and the 14th U.S. woman. It was the 43rd spacewalk to include a woman. Women have been performing spacewalks since 1984, when Russian cosmonaut Svetlana Savitskaya spacewalked in July and NASA astronaut Kathryn Sullivan spacewalked in October.

The faulty BCDU is due to return to Earth on the next SpaceX Dragon resupply ship for inspection. Station managers will reschedule the three battery replacement spacewalks for a future date. In the meantime, the five planned spacewalks to repair a cosmic particle detector, the Alpha Magnetic Spectrometer, are still on the calendar for November and December.

NASA
www.nasa.gov

All Four Engines Are Attached to the SLS Core Stage for Artemis I Mission



All four RS-25 engines were structurally mated to the core stage for NASA's Space Launch System (SLS) rocket for Artemis I, the first mission of SLS and NASA's Orion spacecraft. To complete assembly of the rocket stage, engineers and technicians are now integrating the propulsion and electrical systems within the structure. The completed core stage with all four RS-25 engines attached is the largest rocket stage NASA has built since the Saturn V stages for the Apollo Program that first sent Americans to the Moon. The stage, which includes two huge propellant tanks, provides more than 2 million pounds of thrust to send Artemis I to the Moon. Engineers and technicians at NASA's Michoud Assembly Facility in New Orleans attached the fourth RS-25 engine to the rocket stage Nov. 6 just one day after structurally mating the third engine. The first two RS-25 engines were structurally mated to the stage in October. After assembly is complete, crews will conduct an integrated functional test of flight computers, avionics and electrical systems that run throughout the 212-foot-tall core stage in preparation for its completion later this year. This testing is the first time all the flight avionics systems will be tested together to ensure the systems communicate with each other and will perform properly to control the rocket's flight. Integration of the RS-25 engines to the massive core stage is a collaborative, multistep process for NASA and its partners Boeing, the core stage lead contractor, and Aerojet Rocketdyne, the RS-25 engines lead contractor.

NASA
www.nasa.gov

Astrovan II

A Fifty-Year Caravan Into Orbit Continues

Since the Apollo missions to the moon, Airstream has played an important role in America's space program. With Astrovan II, we'll be right there again as American astronauts take the next step towards the stars

Taking the Next Step Together

Built in partnership with the Boeing Company, ASTROVAN II is the new crew transport vehicle for Boeing's CST-100 Starliner crew. As part of Boeing's Commercial Crew program, ASTROVAN II will transport Boeing astronauts from where they suit up in Cape Canaveral, Florida, out to the launchpad. At the conclusion of their 9 -mile journey in Astrovan II, the Boeing crew will board the Starliner spacecraft before launching to the International Space Station.

Built With Quality and Purpose

A modified Airstream Atlas Touring Coach, ASTROVAN II is a one-of-a -kind vehicle custom-built by the skilled craftspeople at Airstream's Jackson Center, Ohio touring coach manufacturing facility. Working hand in hand with Boeing's Starliner team, Airstream drew inspiration from the company's long history in the space program while keeping an eye toward America's bright future in orbit – and beyond.

Returning to Orbit

One member of Boeing's crew is a longtime Airstream fan. Astronaut Chris Ferguson (right) participated in three Space Shuttle missions – including commanding the final mission in 2011 – and will return to orbit on the Starliner in 2020. Chris is quick to profess his affection for ASTROVAN I, and he was instrumental in directing the Boeing Company back to Airstream for ASTROVAN II.

Since the Apollo program in the 1960s, Airstream has played an integral part in America's exploration of space. When Apollo 11 astronauts Neil Armstrong, Buzz Aldrin, and Mike Collins returned

from the moon they spent 3 ½ days quarantined in a Mobile Quarantine Facility (MQF) built by Airstream. A total of four MQFs were built by Airstream, three of which were used (Apollo 11, Apollo 12, and Apollo 14). A fourth was intended for use by the Apollo 13 crew. Today, three of the four MQFs are on display in museums – one on the USS Hornet, one at the U.S. Space and Rocket Center in Huntsville, Alabama, and one in the Smithsonian Air and Space Museum in Washington, D.C.

Airstream's involvement with the space program continued in the 1980s, when NASA commissioned Airstream to build a crew transport vehicle. From shuttle mission STS-9 in November 1983 to the final Space Shuttle mission in 2011, a modified 1983 Airstream Excella motorhome transported astronaut crews from the Operations and Checkout Building out to the launchpad for shuttle launches. That vehicle was nicknamed the ASTROVAN and is currently on display at NASA's Kennedy Space Center Visitor's Complex next to the Space Shuttle Atlantis.

Airstream
www.airstream.com

Orbital Flight Test Mission Taking Shape at Space Launch Complex 41

The United Launch Alliance (ULA) Atlas V rocket set to launch Boeing's CST-100 Starliner on its maiden voyage to the International Space Station for NASA's Commercial Crew Program is ready for the mating of Starliner to the top of the launch vehicle.

The United Launch Alliance (ULA) Atlas V rocket set to launch Boeing's CST-100 Starliner on its maiden voyage to the International Space Station for NASA's Commercial Crew Program is ready for the mating of Starliner to the top of the launch vehicle.

On Monday, Nov. 4, the Atlas V's first stage was lifted to the vertical position inside the Vertical Integration Facility at Space Launch Complex 41 at Cape Canaveral Air Force Station in Florida, followed by the mating of two solid rocket boosters to the booster. ULA teams then attached the Centaur upper stage and launch vehicle adapter atop the Atlas V first stage.

Boeing's uncrewed Orbital Flight Test (OFT) mission will rendezvous and dock the Starliner spacecraft with the space station. OFT will help set the stage for Boeing's Crew Flight Test (CFT), which will carry NASA astronauts Michael Fincke and Nicole Mann, and Boeing astronaut Chris Ferguson to the space station and return them safely home.

A Centaur upper stage is lifted at the Space Launch Complex 41 Vertical Integration Facility at Florida's Cape Canaveral Air Force Station on 8 November 2019, for mating to the United Launch Alliance Atlas V first stage in preparation for Boeing's Orbital Flight Test (OFT). The uncrewed OFT mission will rendezvous and dock Boeing's CST-100 Starliner spacecraft with the International Space Station as part of NASA's Commercial Crew Program. Starliner will launch atop the Atlas V rocket from Space Launch Complex 41.

Photo credit: NASA/Frank Michaux

Astronauts debut mission patch for SpaceX Dragon crewed flight test

The first NASA astronauts assigned to fly on a SpaceX Crew Dragon commercial spacecraft have provided a first look at their mission patch.

Bob Behnken and Doug Hurley joined NASA Administrator Jim Bridenstine and SpaceX chief executive Elon Musk for a press briefing at SpaceX's headquarters in Hawthorne, California on Thursday 10 October 2019. Although the event was largely focused on what work remains before Behnken and Hurley can safely launch on SpaceX's Demo-2 (DM-2) mission to the International Space Station — including another series of parachute trials and an in-flight abort test — the debut of the crew's mission patch offered a sign that they were at least one small step closer to taking flight.

Full Story at CollectSpace
www.collectspace.com

Patch design: Andrew Nyberg.

UK Space Agency confirms £7.35 million funding to support small satellite launch from Cornwall

The UK Space Agency will award £7.35 million to Virgin Orbit UK Limited, the UK branch of US launch operator Virgin Orbit, to enable horizontal launch of small satellites at Cornwall Airport Newquay, it was confirmed today (Tuesday 5 November).

The funding will help to develop advanced ground support equipment, including UK-based manufacturing of key equipment, and conduct mission planning. Together with funding from the Cornwall Council for spaceport infrastructure, this grant helps secure the first satellite launch from Spaceport Cornwall, which Virgin Orbit are planning for the early 2020s, pending regulatory approvals.

Spaceport Cornwall estimates a horizontal launch spaceport at Cornwall Airport Newquay could create 150 immediate jobs, with additional opportunities for local businesses in directly supporting the site.

Science Minister, Chris Skidmore said:

We want the UK to be the first country in Europe to give its small satellite manufacturers a clear route from the factory to the spaceport. That's why it's so important that we are developing new infrastructure to allow aircraft to take off and deploy satellites, a key capability that the UK currently lacks.

Today's announcement will help the UK to harness the commercial opportunities offered by the global space industry and put the UK firmly on the map as Europe's leading launch destination.

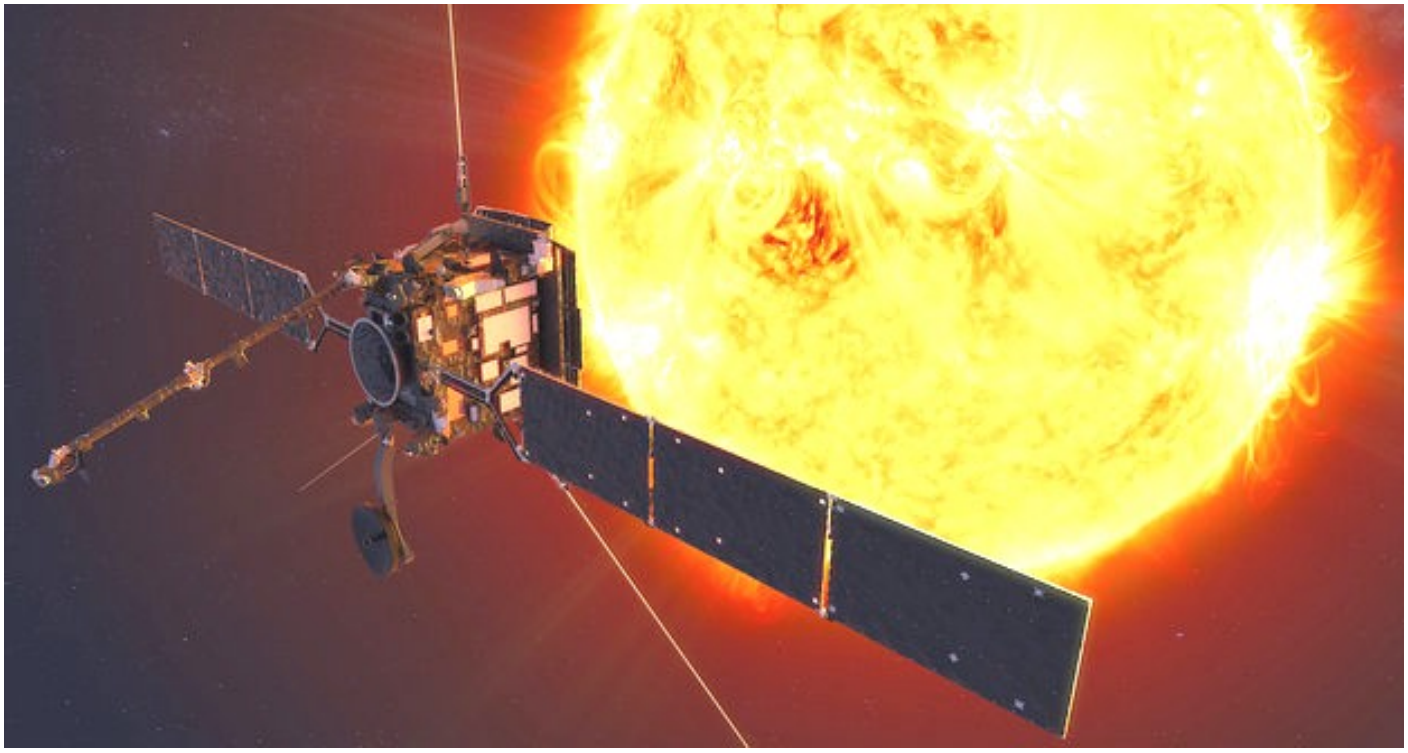
Access to space is a vital tool for global efforts to tackle climate change, as satellites give the science community key measurements of temperature, sea levels and ice cover, while improving management of natural resources. The government is clear that launch activities must not unduly affect the environment and independent research carried out by the University of Exeter demonstrates that Spaceport Cornwall is not expected to have a significant impact on Cornwall's overall greenhouse gas emissions and efforts to combat climate change.

The UK Space Agency originally announced its intention to award funding to Spaceport Cornwall and Virgin Orbit in June, subject to approval, as part of a wider £20 million funding package from Cornwall Council and the Cornwall and Isles of Scilly Local Enterprise Partnership. Today's announcement by the UK Space Agency follows the completion of the necessary due diligence and conclusion of the grant agreement with Virgin Orbit UK Limited. Cornwall Council are expected to confirm whether they will award £10 million capital funding to the project at a council meeting later this month.

This new funding will complement the recent award of £300,000 from the UK Space Agency's targeted development fund to further support Cornwall's ambition to be a centre for future flight technologies.

Pending regulatory approvals in the US and UK, Virgin Orbit plan to operate its LauncherOne system from Cornwall Airport Newquay using a modified Boeing 747 jet to carry the launcher system. Virgin Orbit will make its own contribution to the project of around £2.5 million, with the company's launch activities helping to attract new business and investment opportunities, as well as inspire the next generation of scientists and engineers.

Sun explorer spacecraft leaves for launch site



The UK-built Solar Orbiter spacecraft, which will investigate the workings of our Sun, is to leave the test facility in Germany and head for its launch site in the USA.

Due to launch in February 2020, Solar Orbiter will perform unprecedented close-up observations of the Sun. It will allow scientists to study the Sun in much more detail than previously possible and to observe specific features for longer periods than can be reached by any spacecraft circling the Earth. In addition, Solar Orbiter will measure the solar wind close to the Sun and provide high-resolution images of the uncharted polar regions of the Sun.

The UK has played a vital role in the conception and creation of this satellite, with STFC's RAL Space, University College London and Imperial College London leading international teams to design and build three instruments. UK scientists, including those from RAL Space, were instrumental in proposing the Solar Orbiter mission to ESA. The UK Space Agency funded the development of two out of the 10 scientific instruments on board the spacecraft, and contributed to a further two.

Science Minister Chris Skidmore said: "I am delighted that the UK has played such a leading role in this mission to observe uncharted regions of the Sun. From mobile phones to electricity networks, our scientists will make new discoveries about the impacts of space weather on our daily lives.

"Our commitment to the European Space Agency means UK research and engineering teams will continue to be at the heart of the new space age after we've left the EU, creating highly-skilled jobs and supporting our economy."

Solar Orbiter will carry 10 state-of-the-art instruments. Remote sensing payloads will perform high-resolution imaging of the Sun's atmosphere – the corona – as well as the solar disk. Other instruments will measure the solar wind and the solar magnetic fields in the vicinity of the orbiter. This will give us unprecedented insight into how the Sun works, and how we can better predict periods of stormy space weather, which are related to coronal mass ejections (CMEs) that the Sun throws towards Earth from time to time.

The Spectral Investigation of the Coronal Environment (SPICE) instrument, which was built by RAL Space, is a high resolution imaging spectrometer observing at extreme ultraviolet wavelengths. It will help solve one of the secrets of the Sun - where exactly does the solar wind come from and how does it speed up and escape from the Sun. RAL Space led the international consortium, under contract to ESA and with contributions from the UK Space Agency and other European countries.

RAL Space's Dr Andrzej Fludra, lead on the SPICE instrument consortium, said: "Building SPICE has been a great achievement for our international team, led by RAL Space. For several years, engineers and scientists from the UK, France, Germany, Norway, Switzerland, the US and ESA worked closely together on specifying the science requirements, designing, building and testing the instrument.

"We are now getting ready to make observations of the Sun, preparing software and on-board procedures that will control the instrument. I have great hopes and expectations that we will be able to solve the remaining mysteries about the solar activity and how it affects the heliosphere."

From the spacecraft's unique vantage point, SPICE will carry out the first-ever spectral observations of the solar polar regions. SPICE will help trace solar wind structures measured at the spacecraft to their sources at the poles inside dark, slightly cooler areas of the Sun known as coronal holes.

Science and Technology Research Council
https://stfc.ukri.org/news/sun-explorer-spacecraft-leaves-for-launch-site/

"A Small One For Me": Remembering Apollo 12, 50 Years On

By Ben Evans

Look up '1969' on Wikipedia and the image that appears time and again is related in some way, shape or form to Apollo 11, which saw astronauts Neil Armstrong, Mike Collins and Buzz Aldrin achieve humanity's long-held dream to set foot on another world. Making landfall on the Moon—and Armstrong's now-famous "one small step"—was only the first in a series of landing missions which would go on to see 12 sons of Earth walk the dusty lunar surface, go cross-country on its undulating terrain, find some of the most ancient rocks in the Solar System and suffer indigestion from potassium-laced orange juice. But only on Apollo 12, which flew 50 years ago this month, in November 1969, could astronauts declare that they had made up their own first words on the Moon; only on Apollo 12 could they truly say that they had used pictures of Playboy girls to guide them to their allotted tasks; and only on Apollo 12 would they return to lunar orbit and be instructed to float from one spacecraft to another, entirely in their birthday suits.

For only Apollo 12 could have had a crew quite like Commander Charles 'Pete' Conrad, Command Module Pilot (CMP) Dick Gordon and Lunar Module Pilot (LMP) Al Bean. Their friendship and camaraderie long preceded their selection into NASA's astronaut corps. Conrad and Gordon had been shipmates in the U.S. Navy, whilst Bean was one of Conrad's students at test pilot school. Conrad and Gordon flew together aboard Gemini and were teamed again for Apollo 12, alongside fellow astronaut Clifton 'C.C.' Williams. However, Williams' tragic death in late 1967 prompted Conrad to ask for Bean to replace him. As a crew, the three friends did everything together, even acquiring three gold Corvettes—their licence plates identifying their respective roles on the mission: CDR, CMP, LMP—from contacts at General Motors. Conrad even tried to smuggle a giant baseball cap into his personal belongings; an unsuccessful ruse which might have seen him bounce in front of the television camera on the Moon, wearing it over his helmet. It would give Earthbound audiences a chuckle, he hoped. Sadly, it was not to be.

But for a twist of fate, Conrad might well have become the first man to walk on the Moon, had Apollo 11 failed. In a conversation with the fiery Italian journalist Oriana Fallaci in the summer of 1969, he became infuriated by her insistence that Neil Armstrong's famous words had been put into his mouth by NASA brass. No amount of persuasion would change her mind, so Conrad bet her $500 that he would make up his own words when he set foot on the Moon. And on 19 November 1969, as he stepped off the footpad of the lunar module and onto the dusty surface of the Ocean of Storms, the smallest member of NASA's astronaut corps was true to his word. "That may have been a small one for Neil," he wisecracked, "but it's a long one for me!"

However, getting to the Moon proved problematic right from the start. Whilst Apollo 11 landed 4 miles downrange of its targeted spot in the Sea of Tranquility, Apollo 12's scope was expanded to achieve a precise touchdown, within walking distance of NASA's Surveyor 3 probe, which had alighted within a "nest" of craters on the Ocean of Storms in April 1967. And whereas Armstrong and Aldrin made a single Moonwalk, lasting barely 2.5 hours, Conrad and Bean would leave Intrepid on two occasions, totalling almost eight hours on the surface. The astronauts would visit Surveyor 3, pluck off a couple of its instruments to return to Earth and set up a monitoring station known as the Apollo Lunar Surface Experiments Package (ALSEP).

The naval backgrounds of Conrad, Gordon and Bean led them to designate their lunar module 'Intrepid' and their command and service module 'Yankee Clipper', choosing the names from dozens of suggestions posed by workers at North American and Grumman, who built the two spacecraft. Unfortunately, the Apollo 12 backup crew—Commander Dave Scott, CMP Al Worden and LMP Jim Irwin—happened to be an all-Air Force squad and this led to some significant 'ribbing' later in the mission.

Early on 14 November 1969, Conrad, Gordon and Bean left their crew quarters at Cape Kennedy to cold, grey and drizzly conditions, with rain showers 80 miles to the north and a thick layer of overcast cloud at 10,000 feet. It seemed probable that Apollo 12 would not launch that day. But the crew boarded Yankee Clipper and lay in their couches as storm clouds rolled overhead, the skies periodically brightening, then darkening. At length, Launch Director Walter Kapryan gave a definitive "Go for Launch" and Conrad responded that the Navy was always willing to support NASA's all-weather testing. It was a cocky statement that he would live to regret.

At 11:22 a.m. Eastern Standard Time, the Saturn V rocket roared aloft from Pad 39A, watched by more than 3,000 invited guests, including President Richard Nixon. Quickly, the rocket disappeared into the murky cloud. Then something went badly wrong. For the astronauts, a bright flash, a roar of static, the wailing master alarm and a caution-and-warning panel lit up like a Christmas tree gave them a shock; even their worst simulation had never shown up so many failures. All three fuel cells went down, the AC power buses were gone and Yankee Clipper's gyroscopic platform drifted. "Okay, we just lost the platform, gang," Conrad calmly radioed to Mission Control. "I don't know what happened here. We had everything in the world drop out."

What *had* happened was that the 36-story Saturn V had been struck by lightning. The first strike was clearly visible from the ground, hitting the rocket at 36.5 seconds into the flight and travelling down its long exhaust plume, all the way back down to Pad 39A. At 1.2 miles in length, Apollo 12 had unwillingly become the world's longest lightning rod. Yankee Clipper's systems shut themselves down in response to the massive electrical surge, but the worst was not over. In a view recorded by long-distance cameras at the launch pad, another strike knocked out its gyroscopes.

With the spacecraft running on backup batteries, Conrad's decision was to pull the abort handle and waste several hundred million dollars'-worth of Moonship or wind up in low-Earth orbit with an electrically-dead spacecraft. He chose to hold out as long as possible

and, fortunately, the Saturn V's guidance system was unaffected and delivered them smoothly into orbit. But Flight Director Gerry Griffin was convinced he would have to order an abort. Before he did so, he checked in with the 24-year-old Electrical, Environmental and Communications Officer (EECOM) John Aaron for a recommendation. And Aaron had seen this problem on a previous simulation. "Flight, try SCE to Aux," he told Griffin, instructing the crew to move a switch for the Signal Conditioning Equipment to its Auxiliary position. Bean promptly complied and the data returned to Mission Control's screens. SCE converted raw instrumentation signals into usable computer data and John Aaron had effectively saved the second manned landing mission to the Moon.

There was much guts-and-glory in Mission Control that day, none more so than Griffin himself, who made the decision to press on. "It was a decision that only Flight could make," recalled veteran flight director Chris Kraft. "Gerry made it… one of the gutsiest decisions in all of Apollo and I was proud of it."

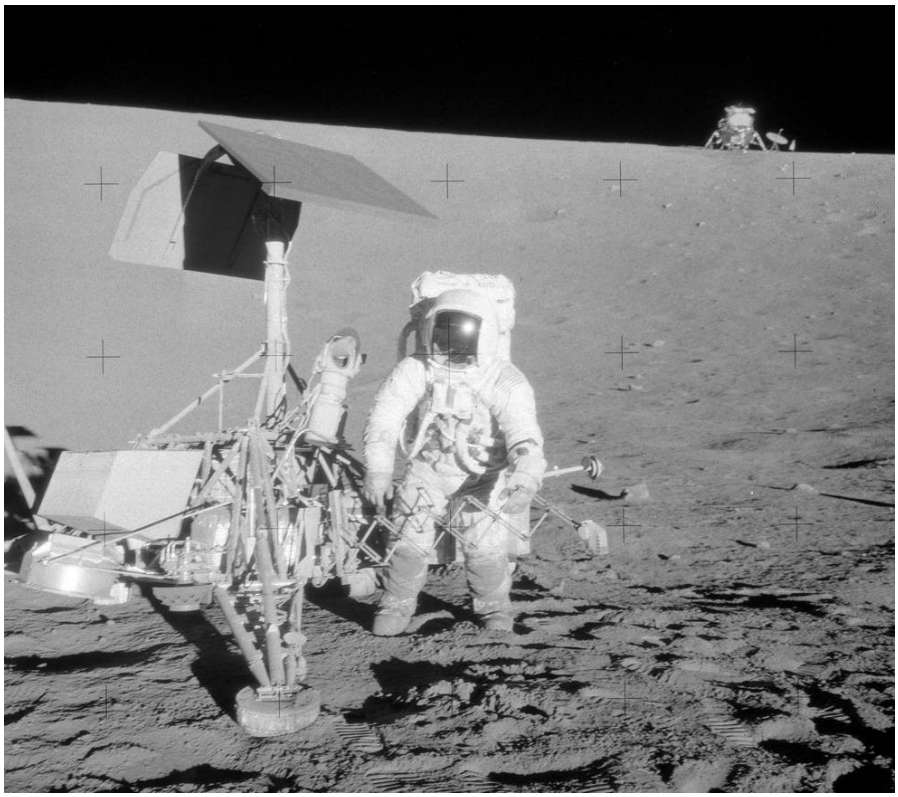
Halfway through their second orbit of the Earth, the crew fired the Saturn V's S-IVB third stage for the Translunar Injection (TLI) to set them on a three-day course for the Moon. Shortly thereafter, Gordon detached Yankee Clipper from the booster, performed an about-turn and extracted Intrepid. Early on 18 November, Apollo 12 entered lunar orbit and Gordon offered his crewmates some advice for the landing ahead. "Let's go over this again, Pete," he told his commander. "The *gas* is on the right; the *brake* is on the left!" Yankee Clipper and Intrepid parted company at 11:16 p.m. EST and began a sweeping, 2.5-hour curve to descend towards the Ocean of Storms, some 800 miles west of Armstrong and Aldrin's landing site in the Sea of Tranquility.

Photographs from NASA's Lunar Orbiter missions had given a pretty good topographical perspective of the target location, which resembled a snowman, with craters the astronauts had labelled Head, Left Foot, Right Foot and others. Conrad aimed for a relatively smooth spot near the 650-foot-wide Surveyor Crater, which he nicknamed 'Pete's Parking Lot'. He hoped that it would allow Bean and himself to walk without much difficulty over to the crater and Surveyor 3. But until Intrepid pitched over and he could actually see the surface with his own eyes, he remained sceptical at the trajectory planners' numbers. That scepticism ended when the lunar module's computer flipped them over from flying on their backs to flying almost vertically…and *there* was the snowman, laid out beneath them. "I think I see my crater…I'm not sure," yelled Conrad, tentatively. Then, after a few seconds, he was sure. "There it is! Son-of-a-gun, right down the middle of the road!"

At 1:54 a.m. EST on 19 November, Intrepid's footpads found alien soil and the second pair of human explorers were on the Moon. But having landed just past Surveyor Crater—and with no window in the 'back' of the lunar module—Conrad and Bean could not be certain how close they were to Surveyor Crater. It was Gordon, flying overhead, peering through Yankee Clipper's sextant, who determined that they had landed only 530 feet from Surveyor 3 itself.

The two pumped-up Moonwalkers-to-be were ready to explore, but were momentarily astonished when CapCom Ed Gibson advised them to "stand by" before opening the lunar module's hatch. "*Stand by*?" retorted Conrad. "You guys ought to be spring-loaded!" Shortly thereafter, the go-ahead was given and at 6:44 a.m. EST Conrad became the third human to set foot on the Moon. And he spoke his light-hearted words to secure his bet with Oriana Fallaci. Sadly for Conrad, she never paid up.

Joined in short order by Bean, the two men spent a few minutes acclimatising themselves to one-sixth lunar gravity, walking in a stiff-legged lope, running straight-legged, landing flat-footed, pushing off with their toes. Before long, their white space suits were black from the knees down with lunar dust. Even simple tasks were very different from their pre-flight simulations. Shovelling soil into a bag required them to hold the shovel differently, stopping before they would ordinarily stop on Earth and tilting it to dump the load more steeply, because the entire sample would slide off suddenly in the weak gravity. Then as Bean attempted to set up a colour television



The famous meeting of Apollo 12 Astronauts with Surveyor 3. More images from Apollo 12 can be found at the following NASA web site:

https://www.nasa.gov/feature/50-years-ago-apollo-12-on-the-moon-whoopee

camera, he inadvertently aimed it too close to the unfiltered Sun, burning out the light-sensitive coating on its vidicon tube. Perplexed, he tried tapping the camera with his hammer, but the camera was dead.

The astronauts set up the U.S. flag and unveiled a commemorative plaque on Intrepid's leg, then set to work collecting samples, taking photographs and setting up the ALSEP. They were aided in these tasks by small checklists on their space suit cuffs, which had received a number of additions, courtesy of backup crewmen Scott and Irwin. "Part of my job," wrote Scott in his memoir, *Two Sides of the Moon*, "was to keep some levity in the game, keep things light and loose, relieve the tension where I could." So he got a cartoonist to draw some sketches to stick in Conrad and Bean's cuff checklists and flight plans. Scott and Irwin also added some cut-out pictures of girls from Playboy. Each image was accompanied by a lewd comment, loosely connected to lunar geology. 'Don't forget the protuberances' was one example, whilst 'Seen any hills or valleys?' was another. But for Mission Control and a listening public—oblivious to the prank—there was confusion when Conrad would start cackling out loud every so often, for no apparent reason…

The ALSEP was a complex station, plutonium-powered, which was designed to provide *in-situ* measurements of the landing site. Its instrumentation included a seismometer to record subsurface quakes and tremors, a suprathermal ion detector to characterise the low-energy positive ions of a near-surface ionosphere, a solar-wind spectrometer to study the electrons and protons emanating from the Sun and their impact on the Moon, a magnetometer and a lunar dust detector. For almost eight years, until it was shut down in September 1977, Apollo 12's ALSEP returned a wealth of scientific data. This included more than 55 minutes'-worth of bell-like oscillations, recorded when Intrepid's ascent stage was purposely crashed into the Moon at the end of its mission.

Conrad and Bean's first Moonwalk ended after almost four hours, measured precisely from the depressurisation to repressurisation of the lunar module's cabin. Back inside, they stowed samples and recharged their suits' backpacks with oxygen and water for the second excursion the following day. They slept very uncomfortably in their suits, which Conrad sarcastically remarked was about as comfortable as sleeping in football pads. In the book *Rocketman*, the biography of her late husband, Nancy Conrad remarked that they could hardly make out stars in the black lunar sky, thanks to the harsh sunlight which bleached the surface. "It was all so cold," she wrote, "and as silent as silent got."

Even resting in beta-cloth hammocks made little difference and a mis-adjusted right leg of Conrad's suit made it too short and was causing him severe discomfort. He woke Bean and they undid and retied cords around the suit leg, ready for the second Moonwalk. To be fair, Bean had slept badly in the clammy cabin, despite taking a sleeping pill, and the astronauts were fully awake two hours earlier than intended, already preparing to go outside again. They were back on the surface by 11 p.m. EST on 19 November.

They checked the ALSEP's health, then trudged to several craters, collecting, documenting and photographing rocks and soil, digging trenches, taking core samples and describing the strange colours and textures of the surface: grey in some places, brown in others, depending upon the angle of the Sun. After two hours, they approached the southern rim of Surveyor Crater and saw Surveyor 3 itself, sitting on a 12-degree slope, about 150 feet inside the enormous bowl-like pit. Discoloured by 30 months of exposure to solar radiation, it appeared in otherwise good condition, as the astronauts descended into the crater. Bean photographed the spacecraft, whilst Conrad plucked off a piece of insulated cable, then a television camera and finally Surveyor 3's mechanised scoop to return to Earth.

Returning to Intrepid, the time came for some banter. Conrad's effort to smuggle a baseball cap aboard may have failed, but he did manage to sneak a little chrome Hasselblad timer into one of his space suit pockets. His plan was to get a photograph of himself and Bean standing in front of Surveyor 3 and puzzle their Earthbound audience with the question: *Who* took the picture? Unfortunately, the timer got stuck in the bottom of their tool carrier, which gradually filled up with rocks and soil. Bean rummaged for all a while, but the glint of chrome was nowhere to be seen. Disappointed, they gave up on their unique photo opportunity. But after returning to Intrepid, as he emptied to tool carrier, Conrad found the timer. He gave it to an exasperated Bean, who tossed it into the distance.

Intrepid's ascent stage lifted off from the Moon at 9:25 a.m. EST on 20 November, after spending 31 hours on the surface. During the return journey to Yankee Clipper, Conrad gave up his commander's prerogative to fly and handed control over to Bean for a few minutes. It was a touching moment, which occurred on the far side of the Moon. "Al would never forget the simplest, most natural gesture Pete offered," wrote his widow Nancy, "the only time it happened in the Apollo programme: the commander let the rookie fly."

But after docking with Yankee Clipper and opening the hatches to see a grinning Gordon, the Moonwalkers were in for a shock. He took one look at their filthy suits and refused to let them come aboard.

"You're not coming in my ship like that, Pete. Strip down."

"Say *what*?"

"You heard me. Get out of those suits and you can come in."

Gordon was not being awkward; he was acutely aware that the abrasive lunar dust could damage the systems of the spacecraft which would keep them alive for the three-day return to Earth, potentially clogging filters and hampering air flow. So it was that Conrad and Bean—naked as the day they were born—crossed from one ship to another, high above the Moon. And Conrad could not help but wonder: if something bad happened, at *that* precise moment, and a thousand years later someone found them, what *would* they think?

"That I'm a sick and lonely man," Gordon deadpanned, "and I went to a lot of trouble and expense for some privacy!"

Hatches were closed and Intrepid's ascent stage was cast adrift to crash into the lunar surface and provide some interesting data-spikes for the ALSEP. Four days later, on 24 November 1969, Yankee Clipper splashed down in the waters of the Pacific Ocean. With the safe return of Conrad, Gordon and Bean, the seemingly effortless campaign to put men on the Moon was beginning to bore a fickle public. By January 1970, there were mutterings that up to three Apollo lunar landings might face the axe of cancellation and in April of that same year Apollo 13 had to compete with regular television programmes when its crew launched on another 'regular' trip to the Moon. With that mission, however, no one would be left in any doubt that space exploration would always be a harsh and unforgiving mistress.

Ben Evans

New Companies Join Growing Ranks of NASA Partners for Artemis Program

NASA has added five American companies to the pool of vendors that will be eligible to bid on proposals to provide deliveries to the surface of the Moon through the agency's Commercial Lunar Payload Services (CLPS) initiative.

The additions, which increase the list of CLPS participants on contract to 14, expand NASA's work with U.S. industry to build a strong marketplace to deliver payloads between Earth and the Moon and broaden the network of partnerships that will enable the first woman and next man to set foot on the Moon by 2024 as part of the agency's Artemis program.

"American aerospace companies of all sizes are joining the Artemis program," said NASA Administrator Jim Bridenstine. "Expanding the group of companies who are eligible to bid on sending payloads to the Moon's surface drives innovation and reduces costs to NASA and American taxpayers. We anticipate opportunities to deliver a wide range of science and technology payloads to help make our vision for lunar exploration a reality and advance our goal of sending humans to explore Mars."

The selected companies are:

- **Blue Origin, Kent, Washington**
- **Ceres Robotics, Palo Alto, California**
- **Sierra Nevada Corporation, Louisville, Colorado**
- **SpaceX, Hawthorne, California**
- **Tyvak Nano-Satellite Systems Inc., Irvine, California**

In July, NASA announced an opportunity for American companies to propose lunar landers that can deliver heavier payloads to the surface of the Moon. These five companies, together with nine companies selected in November 2018, now are eligible to bid on launch and delivery services to the lunar surface. NASA already has awarded contracts to two vendors to send as many as 14 science payloads to the Moon in 2021 and expects to issue additional payload delivery orders.

"The CLPS initiative was designed to leverage the expertise and innovation of private industry to get to the Moon quickly," said Thomas Zurbuchen, associate administrator of the Science Mission Directorate at NASA Headquarters in Washington. "As we build a steady cadence of deliveries, we'll expand our ability to do new science on the lunar surface, develop new technologies, and support human exploration objectives."

Future payloads could include rovers, power sources, science experiments – including the agency's Volatiles Investigating Polar Exploration Rover (VIPER) – and technology demonstrations to be infused into the Artemis program. NASA expects to issue a regular series of task order proposal requests to expand the scope of agency payloads requiring transportation services to the lunar surface ahead of human landings.

"Buying rides to the Moon to conduct science investigations and test new technology systems, instead of owning the delivery systems, enables NASA to do much more, sooner and for less cost, while being one of many customers on our commercial partners' landers," said Steve Clarke, deputy associate administrator for exploration in NASA's Science Mission Directorate.

The CLPS contracts are indefinite-delivery/indefinite-quantity contracts with a combined maximum contract value of $2.6 billion through November 2028. The agency will look at a number of factors when comparing the bids from all vendors, such as technical feasibility, price and schedule.

For more information about CLPS, visit:
www.nasa.gov/content/commercial-lunar-payload-services

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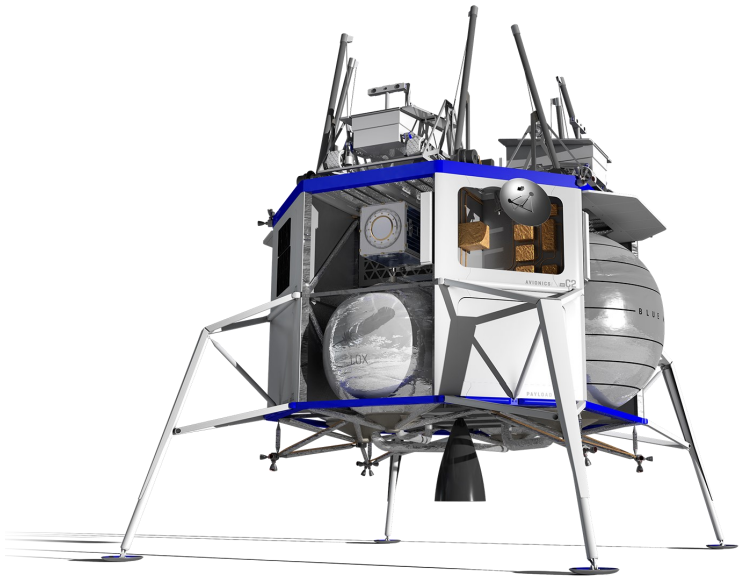


Artemis Updates

By Jim Hillhouse, Americaspace.com

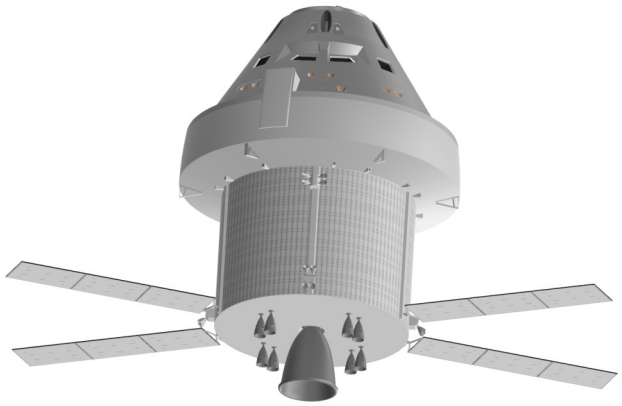
Orion will be the first crewed spacecraft designed to fly astronauts beyond low-Earth orbit in five decades. The demands of designing a deep space crewed spacecraft meant that Orion faced a great many challenges during its development that nobody had faced since Apollo. While the experience of those who designed and built Apollo remains in the form of flight articles at various NASA facilities, sadly many of those who created the Apollo spacecraft are gone, and with them their lessons learned. Persisting experience between generations has since the dawn of time been a perennial problem for civilizations.

So NASA had to learn as it designed and tested Orion, and do so without the bountiful budgets of the Apollo era. The operational and safety experience NASA gained from the Apollo through the Space Shuttle programs also informed the design of the Orion spacecraft. In particular, the heritage of Apollo is in plain view when looking at the Orion spacecraft; the outer mould-line of the Orion spacecraft is the same as; the parachute system of Orion, though bigger, is similar to, that of the Apollo command module. Yet, Orion is a more advanced crewed spacecraft able to carry crew of 4, not 3 as in Apollo, astronauts on a 21-day, not 14-day, mission.

One of the chief challenges of the Orion program, according to Ms. Debbie Korth, NASA's Orion Crew and Service Module Manager, has been getting the spacecraft to its designed weight, a perennial problem for any spacecraft. According to NASA's Johnson Space Center, the weight of the Orion system through various events of the mission are,

Orion System	Event	lbs	kg
LAS	Lift-off	17,000	7,711
CM	Lift-off	21,900	9,934
SM	Lift-off	31,100	14,107
SM Fairings	Lift-off	3,050	1,383
CSM SC Adapter	Lift-off	1,125	510
CSM	Lift-off	74,175	33,645
CSM	TLI	~54,500	~24,721
CSM	Post-TLI	~53,000	~24,040
SM	Jettison	15,135	6,865
CM	Landing	~19,500	~9,253

Weight of the Orion spacecraft matters for a number of reasons ranging from launch through landing. For launching, Orion can rely on the SLS. Even at SLS's lowest payload mass capability of 167,551 lb (76MT) for the Block 1A, the SLS has more than enough power to launch Orion and a crew of four to the Moon. So, every pound saved by keeping the Orion CSM within its targeted weight means additional payload mass that can be delivered to orbit. But in the event of an abort, the capabilities of the Orion parachutes must not be exceeded by the weight of a fully fuelled and loaded Orion crew module.

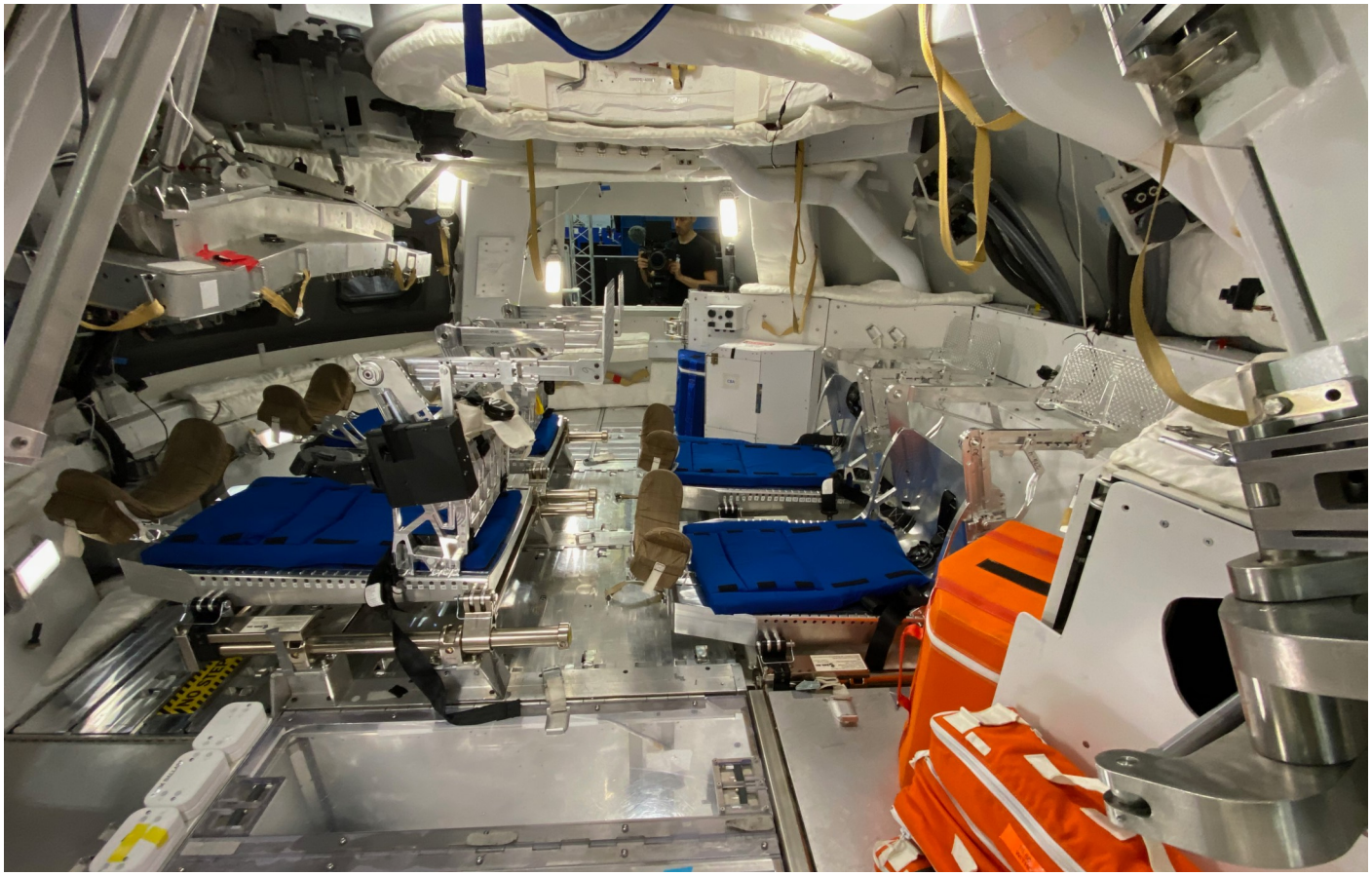


Orion CSM. Image and Model: Jim Hillhouse

The Orion parachute system, more precisely its capsule parachute assembly system (CPAS), is similar to the Apollo Earth Landing System design[1]. CPAS is designed to weight 1,124 lbs (510 kg) and, like Apollo, is stored in the Orion Crew Module forward bay beneath a forward heat shield that is jettisoned during subsonic flight prior to parachute deployment. Like Apollo command module (CM), the Orion crew module (CM) employs three main parachutes to land astronauts safely on the ocean. The Orion main parachutes are like those of Apollo, but are the largest ever built for a spacecraft. And as in Apollo, Orion's parachute system designed to enable just two main parachutes to safely land an Orion crew module either from low-altitude (pad abort) or high-altitude[2]. Although atmospheric reentry will initially slow the spacecraft from 20,000 mph (8,940 m/s) to 325 mph (145 m/s), the Orion main parachutes have the job of slowing down Orion to 20 mph (8.84 m/s) or less needed for a safe water landing. The design of the three Orion Kevlar/Nylon hybrid main parachutes resulted in each having a surface area 10,500 square feet, 116 feet diameter, and 310 lbs weight[3].

The resulting size of the Orion parachutes motivated a revision of Orion's exterior mouldline because the diameter at the top of Orion would not have allowed for sufficient packaging room for the Orion parachute system. As a result, Orion's nominal backshell angle was widened 2.5° to provide more packaging volume for the parachute system[4].

Orion certainly benefited from the Apollo program's parachute design and testing. During development of the Apollo command module parachute system in the early through mid-60's, several Apollo CM boilerplate test articles were destroyed[5]. The lessons learned from that experience meant that, after ten years of testing, the Orion Capsule Parachute Assembly System (CPAS) experienced only one failure during the Crew Development Test



Orion Interior. Photo: AmericaSpace.com

2, or CDT-2, that was conducted on 20 August 2008. And those on the parachute test program accurately point out that the one failure wasn't on Orion's Capsule Parachute Assembly System's part, but of the CPAS Pallet Separation System (CPSS) that was to separate the Orion parachute test vehicle (PTV) from the CPAS pallet[6]. The subsequent tests, including the 24th, and final, test of the Orion CPAS conducted on September 12, 2018, were successful. Orion's ultimate parachute test, EFT-1, occurred on December 4, 2014 when Orion re-entered the atmosphere at around 20,000 mph and landed safely.

One area where the Orion and Apollo spacecraft diverge is in personal space. The Orion spacecraft, at 314 cu.ft (8.89 cu.m), has more habitable volume than did Apollo at 210 cu.ft (5.95 cu.m). For each of the four astronauts, Orion's 78.5 cu.ft (2.22 cu.m) per astronaut makes it a roomier spacecraft than was Apollo at 70 cuft (1.98 cu.m). The layout of the Orion CM's interior is a clean, open architecture that consists of four seats and an instrument panel. The seats are arranged in two rows, one row for the commander and pilot and another for the mission specialists. Seated facing Orion's instrument panel are the commander and pilot. Below, or in Orion's coordinate system in the positive z-axis, the commander and pilot are the seats for the two mission specialists. According to Korth, which seat the commander and pilot will occupy has yet to be set in stone.

The design of the Orion occupant restraint system owes much to the Columbia disaster. The Columbia Accident Investigation found that the Shuttle occupant restraints, the seat and seatbelts, did a poor job of restraining the astronauts, although ultimately it wouldn't have made a difference in averting the disaster. Both the Orion seats and seatbelts were designed to better maintain astronauts in their seats during dynamic events, say tumbling, while accommodating a large size range, from females at 4'10" to males up to 6'4". A great deal of work was done in studying how difficult it was for astronauts to get into and out of their seats, or ingress and egress in NASA-speak[7]. After launch, each seat's footrest can be quickly disconnected and stowed to make for easier movement about the spacecraft cabin.

The Orion instrument panel is, according to Korth, fully software driven, unlike Apollo. It consists of three large screens, translation controllers on each end, and a plethora of buttons, but still far fewer than the 2,000 switches and controls on the Space Shuttle or hundreds on Apollo. The screens are both the primary display and input-output. Debbie Korth pointed-out that on each of the commander's and pilot's armrests is a device that looks like a game controller and is the instrument panel's mouse. Touch screens were eschewed in favor of a menu driven system actuated by buttons around each screen. The buttons on the instrument panel are not directly connected to instrumentation as in Apollo but instead activate software routine for their functionality. According to a ComputerWorld article[8], the Orion instrument is built by Honeywell International around the panel used on Boeing's 787 jet airliner. There are two main flight computers that use two radiation hardened IBM PowerPC 750FX single-core processors, a CPU introduced in 2002 and used in Apple computers such as the iBook G3 until 2005. While the two CPU's in each flight computer might be similar to the processor in the iBook G3 laptop, the rest of the flight computer bears little resemblance; the flight computers have been ruggedized for space travel with a larger housing, a thicker circuit board, and hardware to minimize vibrations. The two 750FX's in each flight computer don't error check each other but instead perform tasks

and then compare their results. If the processors don't get the same results, the flight computer will stop giving commands and reset itself, a process that takes 20 seconds, which is estimated to happen one-in-3.7 missions. If both main flight computers go down, a one-in-8,500 chance, there is a third flight computer that knows the state of the vehicle and acts as a source of truth for the Orion spacecraft's state data at the time the flight computers return online. The chance of losing all three computers at the same time is one in 1,870,000 missions.

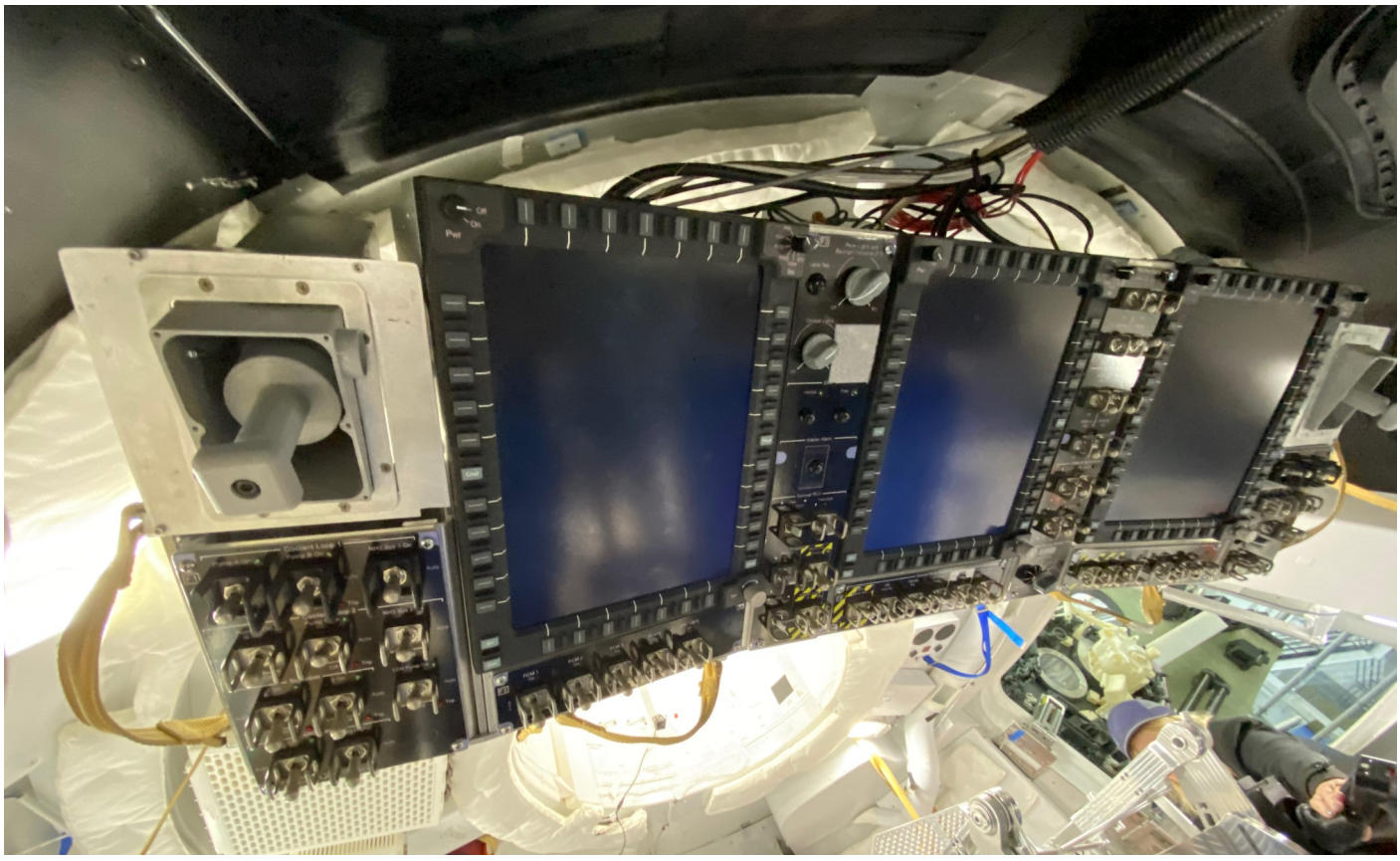
According to Orion CSM head Korth, for personal entertainment, astronauts will have tablets, with several spares in case radiation breaks some.

Speaking of radiation, one of the challenges of exploring beyond the relatively benign radiation environment of low-Earth orbit that is deep space is radiation[9]. The first study of deep space radiation occurred during NASA's rover Couriosity's trip to Mars using its Radiation Assessment Detector (RAD)[10]. Like an astronaut, RAD, which is a part of Curiosity's instrumentation, sat deep inside the spacecraft transporting Curiosity to Mars. The results of the trip, revealed in 2013[11], indicate that solar and cosmic background radiation, caused by solar energetic particles (SEPs) and galactic cosmic rays (GCRs), are much more intense that previously thought. A 21 day trip to, orbiting, and returning from the Moon would be equivalent to 1.75 times the annual radiation allowed. With that in mind, NASA started looking for ways to protect astronauts within the Orion spacecraft. One solution was to minimize the time astronauts would be exposed to radiation by optimizing Orion trajectory[12], which was also done during the Apollo program. Another step to protect astronauts was a collaboration between Lockheed Martin Space and StemRad Israel to develop the Radiation Vest for Astronauts, or AstrRad[13] that uses proprietary smart shielding to protect the most vulnerable organs.

To better understand how radiation in deep space affects humans on Orion, in May 2018, NASA approved the Matroshka AstroRad Radiation Experiment (MARE) that will use two female CIRS ATOM Dosimetry verification phantom test articles[14], Helga, weighing 79.1 lbs (35.88 kg), and Zohar, weighing 79.3 lbs (35.99 kg) to test the radiation environment within Orion on its unscrewed Artemis 1 flight. Zohar will on that flight wear an AstroRad Vest while Helga will not[15]. In 2016, human in the loop testing was conducted in the NASA JSC Orion medium-fidelity mockup to demonstrate how crew members might seek shelter during a radiation storm.

For Orion's Environmental Control and Life-Support System (ECLSS) is based on a amine swingbed system. The amine swingbed was originally developed by the U.S. Navy for its nuclear submarines. Orion will have three amine swingbed systems, two primary and one secondary. Each amine swingbed system will use an amine-based chemical combined with the vacuum of space to filter and renew cabin air for breathing. Removing carbon dioxide and moisture from consumed air using this system reduces the demand to supply new air. Orion's full ECLSS will be tested on the first flight with crew, Artemis 2. A fuller discussion on Orion's ECLSS can be heard on the **February 15, 2019 episode**, "Living Space", of the **Houston We Have a Podcast.**

One item that some might not know about but is critical for any



Orion Instrument Panel. Photo: Americaspace.com

long-duration crewed mission is that the Orion spacecraft will have a toilet. Officially known as the Universal Waste Management System (UWMS), it is a new compact commode for use on ISS and Orion[16].

Future exploration vehicles being developed by NASA have smaller habitable volumes than the ISS, and as habitable volumes decrease, so must the toilet hardware. UWMS was designed to be more compact through the use of a dual-fan-rotary-separator and concentric odor-bacteria filter. The UWMS is currently scheduled to be installed on the ISS in the fall of 2019 and fly on the Orion EM-2 flight. Long gone are the days of the Apollo Waste Management system's fecal bag[17], think of a zip-lock with adhesive, although those will be aboard in case the toilet breaks down. For removing liquid waste, chemical tablets are mixed with the liquid waste to prevent precipitates from forming before it vents the urine overboard. The solid waste is not disposed of but is torrified[18], that is it is heated-up to around 300°F to sterilize and remove any water, and then is compacted and stored. Biomass trash on Orion goes through a similar treatment in the Heat Melt Compactor (HMC), a device for reducing trash volume and stabilizing trash for long-term storage.

Like Apollo, Orion's Launch Abort System (LAS) is a puller-style system using a solid-fuelled tractor 400,000 pounds of thrust rocket designed to accelerate the Orion crew module far beyond its SLS launcher producing 8.8 million pounds of thrust[19]. It is designed to activate within milliseconds and offers the highest thrust and acceleration escape system ever tested. The Orion LASA is powerful enough to pull the Orion crew module beyond the debris field of the SLS rocket during an abort. And like Apollo, Orion successfully completed its Pad Abort Test (PA-1) on May 6, 2010 and its Ascent Abort (AA-2) test on 2 July 2019, both with flying colours.

Beyond weight, radiation, and waste management, there were other challenges that the Orion program faced, such as integrating the designs and requirements of the Orion crew and service vehicle, and the people building them. That meant getting NASA and the European Space Agency (ESA) to speak the same human spaceflight program language. ESA has never designed and built a crewed spacecraft while NASA has developed six (Mercury, Gemini, Apollo, Shuttle, and Orion). That means the perspective each agency comes from is different causing each to think differently about a great many things, from redundancy to testing, and so on. Over the years of working together, NASA and the ESA have learned how to bridge those differences in order to work together to design a safe and capable Orion service module, according to Korth.

The Orion service module, built by the European Space Agency, incorporates several different types of engines. Unlike the Apollo service module, the Orion service module has two means of propulsion to generate the velocity. There is the service module's Orion main engine (OME), an AJ10-190 built by Aerojet -Rocketdyne. This engine is based on the Space Shuttle's Orbital Maneuvering System's (OMS) AJ10-190. And Orion's service module also has 8 auxiliary Aerojet-Rocketdyne R-4D-11 engines that can generate sufficient velocity for such events as a trans-earth injection (TEI) burn. Additionally, Orion has 24 reaction control engines that allow Orion to change its orientation.

On 5 August 2019, NASA conducted a test to simulate an abort-to-orbit scenario, in which the Orion CSM separates from SLS second stage, either the Interim Cryogenic Propulsion Stage (ICPS) or the Exploration Upper Stage (EUS). The Orion service module's propulsion system was successfully tested on August 5, 2019 at White Sands Test Facility. The test used a qualification version of the Orion service module's propulsion system.

According to Korth, the Artemis 1 Orion has had all of the thermal protection material applied to the spacecraft's back heatshield. Orion is being prepared for its trip, expected on 14 November to Plumbrook on NASA's Guppy transport aircraft. Orion was expected to arrive in Plumbrook at the end of September, but the weight of the Orion spacecraft is such that the Guppy needed some modifications to address performance risks that could crop-up in certain phases of flight. Those modifications of the Guppy are nearing completion.

Jim Hillhouse is a Senior Writer for the Americaspace.com web site. This article has been included here with permission from the Authour and Americaspace.com. For more original pictures please visit www.americaspace.com/2019/11/04/artemis-updates-2019-11-03/

For information on NASA's Artermis program please visit: https://www.nasa.gov/specials/artemis/

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Go for Comet Chaser

An ambitious mission to investigate a comet that has not yet been discovered, has been given the go-ahead by the European Space Agency (ESA). Comet Interceptor was proposed by UK scientists and will be the first mission to travel to a comet before it reaches the inner solar system.

Due for launch in 2028, the mission will travel around a million miles from Earth to wait for a suitable comet to intercept. Astronomers will search for either a pristine comet, travelling from the far reaches of the solar system for the first time, or an interstellar object passing through our cosmic neighbourhood.

Comet Interceptor consists of three spacecraft – a mothership to make observations from a distance, and two smaller probes to study the target object in detail. ESA has designated the mission as 'fast', because it will use existing flight-proven technology to accelerate development.

The proposal for the mission was led by teams from University College London and the University of Edinburgh and involves an international consortium of scientists and engineers.

Previous comet missions, including Rosetta's recent rendezvous with comet 67P, have investigated comets that orbit the Sun. This new mission will target objects visiting the inner solar system for the first time. This means they have been untouched by the effects of the Sun and will provide scientists with an opportunity to study materials from the dawn of the Solar System.

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The Carolian Astronomy Society Martin Humphries Memorial Lecture

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

By Robin Davies (Head of Systems and Control) Reaction Engines Ltd

Venue: King Charles 1 Lower School, Borrington Road,

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All contributions intended for the January—February 2020 issue should be emailed to the editor by **Friday 13 December 2019**