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Made in America

NASA astronauts launch from U.S.

A SpaceX Falcon 9 rocket carrying the company's Crew Dragon spacecraft is launched on NASA's SpaceX Demo-2 mission to the International Space Station with NASA astronauts Robert Behnken and Douglas Hurley onboard May 30 at NASA's Kennedy Space Center in Florida. The Demo-2 mission was the first launch with astronauts of the SpaceX Crew Dragon spacecraft and Falcon 9 rocket to the International Space Station as part of the agency's Commercial Crew Program. The test flight was an end-to-end demonstration of SpaceX's crew transportation system. A new era of human spaceflight begin as American astronauts once again launched on an American rocket from American soil to low-Earth orbit for the first time since the conclusion of the Space Shuttle Program in 2011. *See related article on page 2.*

NASA/Bill Ingalls

We knew him when

Pilots recall going to school with Robert Behnken

By Teresa Whiting
NASA Armstrong Public Affairs

In 1998 when NASA Armstrong research pilots Troy Asher, Jim Less and Tim Williams attended the U.S. Air Force Test Pilot School (TPS) on Edwards Air Force Base with classmate and now astronaut Robert Behnken, they did not know he would make this big of a mark on spaceflight.

Behnken, or as they fondly call him "Dr. Bob," was one of two astronauts on the Crew Dragon Demo-2 mission to launch American astronauts from U.S. soil for the first time in nearly a decade May 30. Behnken flew in two NASA space shuttle missions in the early 2000s, but this mission was his signature on history.

"Bob is a very humble guy, but in TPS he had a solution to every problem and always knew the answer," Williams said. "We thought early on, wow, this guy is impressive."

It is rare for a young engineer to come to TPS with a doctorate and Behnken did just that after graduating with honors from the California Institute of Technology.

"Everywhere he has gone he has impressed people," Less said. "In Houston they were so impressed that he became the chief of the astronaut office and then he got to fly this first-time mission."

At TPS, Behnken graduated as a flight test engineer, while the others graduated as test pilots. They went on to work on groundbreaking Air Force test projects and then the four former classmates found themselves at NASA, three as test pilots, and one as an astronaut. It is

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NASA/Kim Shiflett

NASA astronauts Douglas Hurley (left) and Robert Behnken wave as they exit the Neil A. Armstrong Operations and Checkout Building at the agency's Kennedy Space Center in Florida. They were preparing for transport to Launch Complex 39A to launch on NASA's SpaceX Demo-2 mission.

U.S. Air Force Test Pilot School class of 1998 B stand in front of a Northrop YF-23. The class included NASA pilots Jim Less and Troy Asher (top row, fourth and fifth from left). The class also included pilot Tim Williams and astronaut Robert Behnken (top row, third and fourth from right).

Photo courtesy of the United States Air Force Test Pilot School/Edwards Air Force Base

Photo courtesy of Troy Asher

NASA Armstrong pilots from left: Jim Less, Tim Williams and Troy Asher at NASA's Kennedy Space Center in Cape Canaveral, Florida to watch their U.S. Air Force TPS classmate's launch May 27.

Saving lives

Skoog recognized for efforts in development of system that saves lives

AFRC2019-0195-14 NASA/Carla Thomas

The U.S. Air Force F-16D Automatic Collision Avoidance Technology aircraft flew at low levels above the Sierra Nevada Mountains to test the ACAT Fighter Risk Reduction project in 2010. The goal was to develop collision avoidance technologies for aircraft to reduce the risk of ground collisions. This testing lead to the Auto GCAS system.

By Teresa Whiting
NASA Armstrong Public Affairs

NASA Armstrong's Mark Skoog won the 2020 United States Geospatial Intelligence Foundation's (USGIF) achievement award. The honor was bestowed on him for his work on the terrain system development and evaluation for the Automatic Ground Collision Avoidance System (Auto GCAS).

The USGIF award recognizes an individual or team from a government organization who successfully enhances mission effectiveness using geospatial intelligence-related capabilities.

Mark Skoog, Armstrong principal Investigator for Autonomy, and Loyd Hook, the head of the Vehicle Autonomy and Intelligence Lab (VAIL) at the University of Tulsa, along with their NASA team and partners in the U.S. Air Force, the Office of the Secretary of

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AFRC2019-0195-14 NASA/Lauren Hughes

Mark Skoog, center, is recognized for his role in the 2018 Collier Trophy award to the Auto Ground Collision Avoidance System (Auto GCAS) Team at the NASA Armstrong Honor Awards Aug. 25. From left are Janet Karika, former NASA chief of staff, Skoog and Center Director David McBride. Skoog, NASA Armstrong principal investigator for Autonomy, recently won the 2020 United States Geospatial Intelligence Foundation's achievement award, also for Auto GCAS work.

News at NASA

NASA

Lightning is complex

Lightning flashes from a storm cloud to strike the ground. Such bolts represent only a small part of the overall phenomenon of lightning. The most powerful activity occurs high above the surface in Earth's upper atmosphere.

Up there, lightning creates brief bursts of gamma rays that are the most high-energy, naturally produced phenomena on the planet. Researchers recently measured these high-energy terrestrial gamma-ray flashes, or TGFs, using instruments on the International Space Station. The work helps reveal the mechanism behind the creation of the bright flashes we call lightning.

The instruments are part of the Atmosphere-Space Interactions Monitor (ASIM), an Earth observation facility on the outside of the space station used to study severe thunderstorms and their role in Earth's atmosphere and climate.

This photo of the ASIM investigation installed on the International Space Station's Columbus External Payload Facility was taken by the ground-controlled External High Definition Camera 3.

FOSS in space

Fiber Optic Sensing System readied for space use

By Jay Levine
X-Press editor

An enhanced system that can take thousands of measurements along a fiber optic wire about the thickness of a human hair soon will be tested for use in space. Successful tests could lead to using the system to monitor critical spacecraft systems for the Artemis missions to return to the Moon and prepare for landing astronauts on Mars.

The Fiber Optic Sensing System (FOSS) developed at NASA Armstrong for use on aircraft for collecting strain and other measurement data is in development for use in spacecraft. Uses of the space FOSS could include temperature and strain information critical to space flight safety, said Allen Parker, FOSS senior research engineer.

To meet that goal, four space FOSS units soon will be shipped out to NASA's Langley Research Center in Virginia for about five months of testing in that NASA center's environmental laboratories. Space FOSS is expected to be more robust and sturdier to manage the severe conditions of a space launch than FOSS units developed for aircraft.

"Rockets and spacecraft are very complex systems and have a multitude of different parameters to be measured and we want to keep the first uses of space FOSS simple," Parker said. "This new space-rated FOSS will measure distributed temperatures on the Low-Earth Orbit Flight Test of an Inflatable Decelerator, or LOFTID."

AFRC2020-0053-03 NASA/Ken Ulbrich

AFRC2020-0053-06 NASA/Ken Ulbrich

Above, *Frank Pena and Jonathan Lopez work on securing a Fiber Optic Sensing System unit developed at NASA Armstrong. The unit is one of five developed to test a new variant of the technology researchers have developed to withstand the harsh environments of a rocket launch and space travel.*

At left, *Jonathan Lopez prepares a FOSS unit developed at NASA Armstrong for transportation and testing at NASA's Langley Research Center in Virginia.*

Artemis Support

Once FOSS is rated for use in space, the Advanced Cislunar and Surface Capabilities (ACSC) enhanced tempFOSS sensor could be used to support the Artemis mission to monitor distributed cryogenic temperatures.

"A fiber optic sensor that can withstand extreme conditions to measure distributed temperatures in a cryogenic environment is a key requirement," Parker said. "The other element of that is to develop a small, economical and hardy FOSS version. A new technology based on a temperature-tunedlaser (TempTuned FOSS) is under development to accomplish that task."

The team is improving upon the sensor fabrication techniques and discussing performing a potential test of the sensors at NASA's Ames Research Center in California to support the study of the new technology. In addition, the team is working on software updates for the TempTuned FOSS unit.

"Launch vehicles are complex and have a number of different thermal and mechanical subsystems," Parker said. "Once space FOSS is vetted, we envision a system that will provide measurements of many different kinds of parameters. "We imagine the use of FOSS technologies on the cryogenic tanks, not just on the outside of the tank but possibly also on the inside to measure fuel level."

Heat Shield

One of the four FOSS units going to Langley for testing is slated for the LOFTID, which is a technology under development at that NASA center. The project's test article is designed to decelerate and protect heavy payloads from the intense heat of atmospheric re-entry.

"We will be monitoring

AFRC2019-0282-09 **NASA/Ken Ulbrich**

The Fiber Optic Sensing System (FOSS) team at NASA Armstrong is working to extend the uses of FOSS to space applications. From left are Paul Bean, John Sternio, John Rudy, Jonathan Lopez, Skyler Szot, Shideh Naderi and Allen Parker. Team members who are not in the picture include Patrick Chan, Phil Hamory, Eric Miller and John Del Frate.

AFRC2019-0282-05 **NASA/Ken Ulbrich**

Allen Parker, Fiber Optic Sensing System (FOSS) senior research engineer at NASA Armstrong and Jonathan Lopez show how FOSS in aeronautics is used on a wing to determine its shape and stress on its structure.

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temperatures on the back side of the inflatable decelerator shield," Parker said. "In measuring those temperatures, we will give the engineers a thermal map of how the decelerator is heating up."

In preparation for that, the team is working on a space FOSS experiment that will travel as a self-contained experiment on the Blue Origin New Shepard rocket though NASA's Flight Opportunities program. The NASA Armstrong engineering development unit (EDU), which is separate from the four space-rated FOSS boxes heading to Langley, is in the same state of readiness for launch.

"It's a risk reduction opportunity for us to put our EDU system on the flight early on," Parker said. "We will measure strain and temperature with the EDU in our own locker on the vehicle. In addition to the electronics, a mission-critical commercial grade laser in the box is mechanically isolated and dampened to increase operability onboard the research vehicle. The system also was developed to dissipate heat developed by the unit's electronics and by way of conduction, or moving the heat away from the unit, due to a lack of air in space. The system will be self contained and essentially ready for plug and play use."

AFRC2020-0014-24 **NASA/Ken Ulbrich**

Allen Parker, Fiber Optic Sensing System (FOSS) senior research engineer at NASA Armstrong, works with U.S. Navy staff. The California Naval division is interested in a microFOSS that can take a long-term look at tracking corrosion on Navy ships and informing crew members about developing challenges that could lead to system failures.

The other three FOSS boxes going to Langley are slated for use in by the Launch Services Program in partnership with United Space Alliance on a flight of the Vulcan heavy-lift launch vehicle.

MicroFOSS

The Armstrong FOSS team also is developing the next generation of FOSS systems called microFOSS, which is a much more compact, economical and robust variant that potentially could be used for space applications.

The effort is in partnership with the U.S. Navy and has expanded to other organizations within the Navy to include monitoring the stress loading on its vessels that transport a heavy load, such as aircraft and tanks, Parker explained. The Navy wants to monitor stress loading on the hulls and decks of those vehicles.

In addition, a capability to monitor power buses that provide large amounts of current to the ship's systems is desirable. Corrosion due to a seaward environment impacts the reliability of those buses and the Navy wants a health monitoring system that will let them know when and where unfavorable conditions are emerging. TempTuned FOSS is being considered as a possible solution because this application does not require high data rates. Navy personnel can look at the thermal mapping along the length of the power buses and see if there are any variations that could be an indication of corrosion.

"The microFOSS may expand the uses of the fiber optic system because of its condensed packaging, capability and more economic production costs," Parker said. "For example, a number of different industries such as oil, gas, dairy and medical previously inquired about a simpler system that can help with a number of different applications."

No matter what the application, Parker and his team are working on solutions.

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Defense and Lockheed Martin, developed the Auto GCAS system. The system prevents imminent collisions with the ground. The work involved with the terrain system development and evaluation enabled the development of Auto GCAS. The system has saved the lives of 10 F-16 pilots to date.

"Dr. Hook and I have worked for many years, myself 35 years, bringing digital terrain information into the world of aviation safety," Skoog said. "It has really been us leveraging the tremendous work of the mapping community. To have that mapping community recognize us in such a special way is truly an honor."

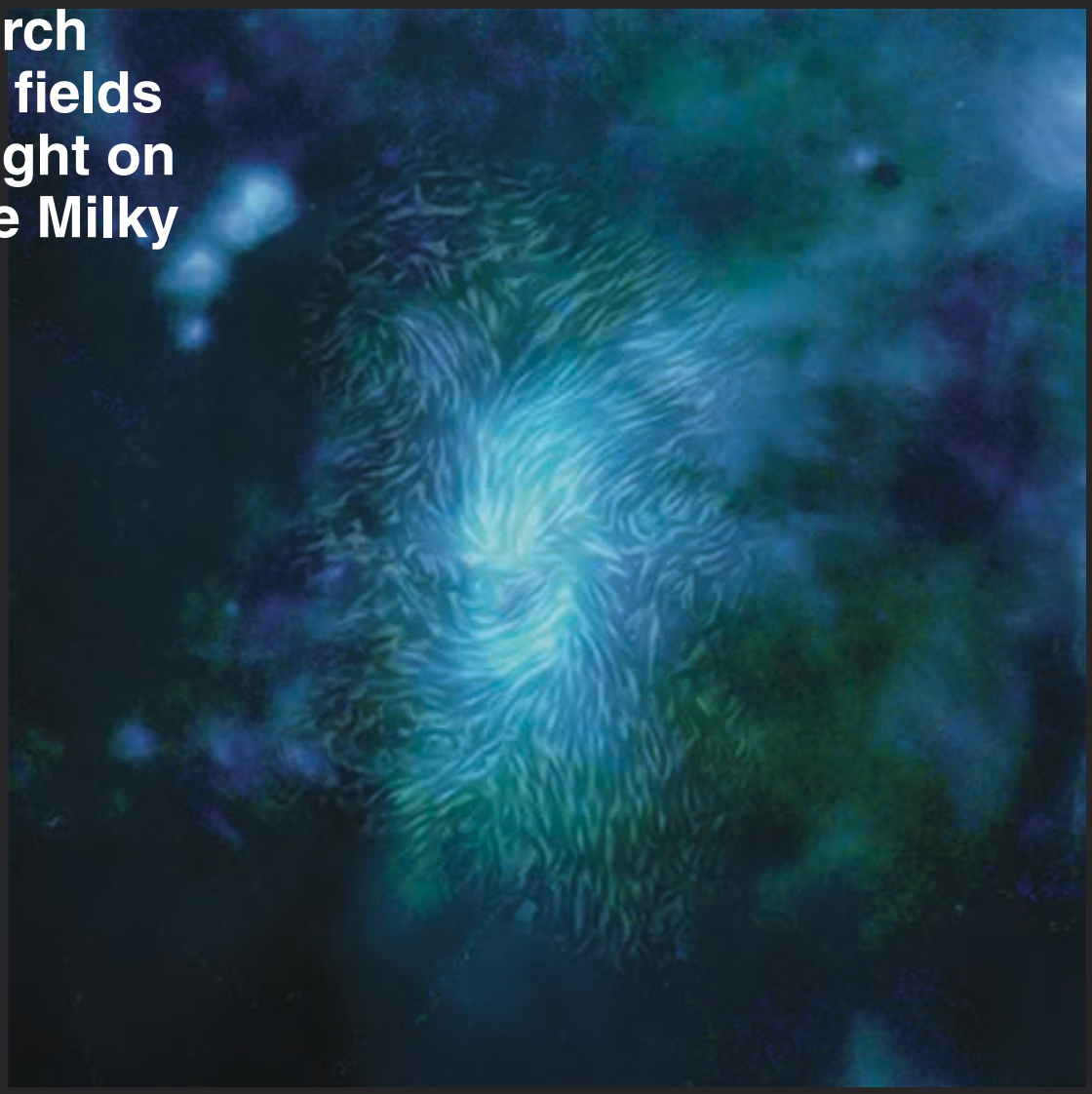
The USGIF award citation reads: "Auto GCAS is the culmination of a decades-long effort to bring geospatial intelligence to aircraft safety. This work involved traveling the world, evaluating myriad digital terrain from Sweden to Hawaii. The team extensively tested the system to ensure against every category of controlled flight into terrain mishaps and found it would have prevented every one, which resulted in 10 lives saved thus far in the USAF operations."

NASA's involvement with Auto GCAS began in the mid-1980s under the Aeronautics Research Mission Directorate (ARMD). Further development of the technology continues at NASA Armstrong, as part of the Resilient Autonomy effort, which is a joint collaboration with the Federal Aviation Administration, and the Office of the Secretary of Defense and numerous U.S. Department of Defense services and commands.

Previously, the National Aeronautic Association awarded the Auto GCAS program with the 2018 Robert J. Collier Trophy. Each year, the greatest achievement in aeronautics or astronautics in America receives this prestigious award.

New perspective

SOFIA research on magnetic fields sheds new light on center of the Milky Way galaxy



NASA/SOFIA/L. Proudfit; ESA/Herschel; Hubble Space Telescope

This is a composite image of the central region of our Milky Way galaxy, known as Sagittarius A. SOFIA found that magnetic fields, shown as streamlines, are strong enough to control the material moving around the black hole, even in the presence of enormous gravitational forces. This can help answer long-standing, fundamental questions about the galactic center region: why the star formation rate is significantly lower than expected and why our galaxy's black hole is quieter than those in other galaxies. SOFIA data is shown in green (37 microns) and dark blue (25 and 53 microns). The light blue is from Herschel Space Observatory (70 microns) and the gray is from the Hubble Space Telescope.

By Kassandra Bell
Senior Communications Specialist

The area around the supermassive black hole at the center of our Milky Way galaxy is dominated by gravity, but it's not the only force at play. According to new research from NASA's airborne telescope, the Stratospheric Observatory for Infrared Astronomy, or SOFIA, magnetic fields may be strong enough to control material moving around the black hole.

The research, presented this week at a meeting of the American Astronomical Society, could help answer longstanding mysteries about why our black hole is relatively quiet compared to others, and why the formation of new stars in our galaxy's core is lower than expected.

Using its newest infrared instrument to study celestial dust grains, which align perpendicular to magnetic field lines, SOFIA was able to produce detailed maps of our galactic center, showing the behavior of these otherwise invisible magnetic fields around the black hole.

"There are still aspects of our galaxy's black hole that we can't explain with gravity alone," said Joan Schmelz, SOFIA senior science advisor and director at the Universities Space Research Association, in Columbia Maryland. "Magnetic fields may be able to help solve these mysteries."

Scientists have often relied on gravity to explain their results because measuring celestial magnetic fields is extremely challenging. But the data from SOFIA now compel scientists to consider their role. Magnetic fields control the plasma of the solar atmosphere, called the corona, because the pressure created by magnetic fields is greater than the pressure created by heat, or thermal pressure. In the Sun's corona, the dominance of magnetic pressure creates dramatic loops and powerful flares. The research team is using SOFIA's data to study the pressure created by magnetic fields at the center of our galaxy. They found that the

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common for many members in a TPS class to apply to become astronauts, and class 98B had Behnken, and astronaut Terry Virts make the cut. The school trains pilots and engineers like astronaut Michael Collins to be the first one brave enough to fly new experimental planes and spacecraft.

"Flying is never routine and manned spaceflight is a lot like flight test," Less said. "It is all about safety review and risk mitigation. This was the first manned mission of this spacecraft and they were conducting a flight test."

Williams also said TPS prepares pilots and engineers for this type of first flight scenario.

"This was the first flight of the Dragon vehicle with a person, which will be similar to the first flights for the X-57 and the X-59 aircraft," Williams said. "We learned in TPS to think way ahead and create efficient and effective build up to flight test."

Asher added that flying a first flight scenario is one of the most sought-after career milestones a test pilot can complete. Asher as Armstrong's director for flight operations, and with a military background, has only flown a few from conception to flight in his career.

"Bob and Doug flew in some of the very last space shuttle missions, so they chose the two most qualified pilots you can find to kick off the next generation of spaceflight," Asher said. "Who better to fly it than the two who have been intimately involved in the design from the beginning?"

The three remarked about what an honor it was to see their classmate kickoff a new era of spaceflight, and the sense of national pride it brought to see NASA astronauts launch from U.S. soil again.

"He has been involved with this program for many years, and now we got to see the first flight," Williams said. "When I saw the video of him getting strapped in, it raised goosebumps. It is such a privilege and very personal to see someone you know up there."

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magnetic pressure is greater than the thermal pressure created by gas in the region, and therefore may be strong enough to control matter in a way that's similar to the solar corona.

More research is needed to understand magnetic fields' role at the center of our galaxy and how these strong forces fit in with gravity. However, these preliminary results can enhance our understanding of at least two long-standing, fundamental questions about star formation and black hole activity in our galactic center region. Even though there's plenty of raw material to form stars, the star formation rate is significantly lower than expected. Additionally, our black hole is relatively quiet compared to those at the centers of many other galaxies. The strong magnetic field could explain both – it could keep the black hole from swallowing the matter it needs to form jets and also suppress the birth of stars.

Studying magnetic fields in the far reaches of the galaxy and beyond requires remote observations by telescopes like SOFIA. Flying at an altitude of 45,000 feet, above 99% of the Earth's water vapor, SOFIA is able to capture a unique view of the infrared universe, while landing after each flight so that it can be upgraded with the latest technology. For this result, SOFIA used the High-resolution Airborne Wideband Camera-Plus, or HAWC+ instrument, which was built at NASA's Jet Propulsion Laboratory in Pasadena, California, to study magnetic fields.

"The data provide the most detailed look yet at the magnetic fields surrounding our galaxy's central black hole," said David Chuss, a coauthor of the paper at Villanova University in Pennsylvania. "The HAWC+ instrument has improved the resolution by a factor of 10 and increased the sensitivity, which represent a revolutionary step forward."

SOFIA, the Stratospheric Observatory for Infrared Astronomy, is a Boeing 747SP jetliner modified to carry a 106-inch diameter telescope. It is a joint project of NASA and the German Aerospace Center, DLR. NASA's Ames Research Center in California's Silicon Valley manages the SOFIA program, science and mission operations in cooperation with the Universities Space Research Association headquartered in Columbia, Maryland, and the German SOFIA Institute (DSI) at the University of Stuttgart. The aircraft is maintained and operated from NASA Armstrong.

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