National Aeronautics and Space Administration

The Dryden X-Press X-tra

First Science

The Stratospheric Observatory for Infrared Astronomy successfully completes its first science missions

By Jay Levine
X-Press Editor

The Stratospheric Observatory for Infrared Astronomy showed with its first three science flights that the airborne observatory is ready to deliver world-class astronomical data.

The SOFIA is an international collaboration between NASA and the German Aerospace Center, Deutsches Zentrum fur Luft und Raumfahrt (DLR). The SOFIA is a heavily modified Boeing 747SP that will allow researchers to better understand a wide range of astronomical phenomena, including how stars and planets are born, how organic substances form in interstellar space, and how super massive black holes feed and grow.

"The early science flight program validates SOFIA's capabilities and demonstrates the observatory's ability to make observations not possible from Earth-based telescopes," said Bob Meyer, NASA's SOFIA program manager. "It also marks SOFIA's transition from flying test bed to flying observatory, and it gives the international astronomical research community a new, highly versatile platform for studying the universe."

The flights are a good start to the science mission.

"This is the beginning of the science and it represents a decade's worth of work," Meyer said. "It is exciting to see what we have all worked for and [to] get to the point where we can conduct science missions. The development work, the testing – all of this was to get to where we could [collect] science data."

Thomas Keilig, the German telescope assembly manager, said the telescope performed well. The SOFIA missions looked at Orion, or M42, and M82, a nearby galaxy that is undergoing a burst of star formation, and S140. M42 and S140 are regions forming stars in the Milky Way galaxy.

"The pointing stability – keeping the telescope centered on the target – was very good. You have to keep in mind that we are making observations from a flying airplane with an open door that causes a lot of excitations on the telescope, and our control loop has to work with all of these disturbances and aircraft vibrations," Keilig said. "We have to keep the telescope stable. We had the pointing stability within one arc second."

An arc second is the size of a dime viewed at one mile. The engineering flights prior to the first three science missions allowed the SOFIA crew and staff to learn how the observatory would function for those flights, as well as to tune the control system.

"We learned a lot under real science operation conditions. We have a saying, that the telescope operator has to understand the needs of the scientists and the scientists need to understand what the telescope operator needs. That worked out well on these flights," Keilig said.

The series of flights was conducted with the Faint Object Infrared Camera for the SOFIA Telescope, or FORCAST, instrument. It was developed by researchers at Cornell University, Ithaca, N.Y.

These initial flights were geared toward answering questions with the FORCAST instrument about star formation and conducting a star census on several areas within the Milky Way galaxy where stars are being formed, said Terry Herter, FORCAST principal investigator. The telescope and the FORCAST instrument provided high-resolution images that allowed researchers to identify the heart of these star-forming cores and individual stars or individual stellar groupings. The census was taken to gather information on learning how the stars are distributed and to seek answers on the maximum mass at which a star can be born.

"I'm pleased with both the performance of our instrument and the observatory. The two are intimately linked together in achieving our science goals. The observatory has delivered excellent image quality earlier than expected, and we have benefited from this. The performance of FORCAST is close to what we expected from our laboratory testing," Herter said.

The FORCAST instrument takes images in the mid- and far-infrared part of the electromagnetic spectrum. He likened the instrument to thermal detectors used by police to spot fleeing suspects at night or by heating technicians surveying a house for energy leaks from a home.

"FORCAST needs SOFIA to produce images and to get above the water vapor in the atmosphere so we can see the sky. Otherwise, the atmosphere is opaque in much of the spectrum we observe.

"Unlike regular cameras, FORCAST takes pictures at up to a rate of 500 times per second and adds them together to make a single exposure. We do this with custom-built electronics. When combined with SOFIA, FORCAST obtains the highest-resolution pictures to date in the far-infrared part of the electromagnetic spectrum," Herter said.

Eric Becklin, chief science advisor for the SOFIA, said the airborne observatory will contribute much to study of the heavens. The SOFIA's predecessor, the Kuiper Airborne Observatory, was groundbreaking in its time and many SOFIA staff members were associated with it. However, Becklin said he looks forward to maximizing use of the bigger telescope on the SOFIA, which has three times the clarity of the KAO, he said.

"We are going to see detail other space observatories could not. The instrumentation development has increased very steeply, a lot like the microprocessors have, and infrared detectors and imagers we are going to fly are orders of magnitude more powerful than were flown on the Kuiper," he said.

The only big astronomy platform on which instruments could be changed was the Hubble Space Telescope, and that required a shuttle mission, Becklin said. The SOFIA is the only NASA mission that permits upgrading of instrumentation on a regular basis. However, there are other significant capabilities the SOFIA also offers.

"In the infrared, you can both look through the dust and see what is happening behind the veil of dust and actually see the emission from the dust at the same time," he explained. "The dust obscures what you can see in the visible wavelength, but in the infrared there are a number of phenomena you can see beyond the dust. The infrared is a prime place to look for regions where stars are forming or where black holes are forming at the center of our galaxy and other galaxies. Our view will be the best ever seen."

The science community is excited about the potential of the SOFIA. About 60 proposals were submitted for just 75 hours of available research hours on the flying observatory for next spring and summer – more than three and a half times the available number of research hours, said Erick Young, SOFIA science mission operations director for Universities Space Research Association director. The future is even more exciting, as seven instruments are either complete or in development for science flights aboard the SOFIA, he said.

During the next flight series, set for spring, when those researchers will be on board the SOFIA, the German Receiver for Astronomy at Terahertz Frequencies, or GREAT, instrument will be premiered.

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Front cover, *the Stratospheric Observatory for Infrared Astronomy NASA 747SP sits beneath a full moon during nighttime telescope operations at NASA's Dryden Aircraft Operations Facility, Palmdale, Calif. (NASA Photo ED10 03225-68 by Tom Tschida)*

At left*, Jim DeBuizer, lower right, studies data with FORCAST instrument principal investigator Terry Herter, left. In the bakckground, Eric Becklin and Mark Morris, right, look on during preparations for the initial SOFIA science flight.*

ED10 0366-33 **NASA Photo by Tom Tschida**

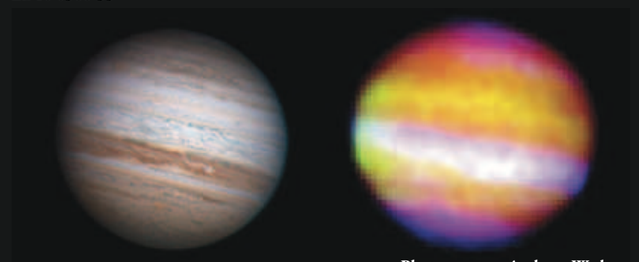

Photo courtesy Anthony Wesley

Above*, the composite infrared image of Jupiter, right, was obtained by Cornell University's FORCAST camera during the SOFIA's "first light" flight in May. A recent visual-wavelength picture of Jupiter is shown for comparison.*

ED10 0366-33 **NASA Photo by Tom Tschida**

Above*, the SOFIA's flight deck is prepared for the first science mission.*

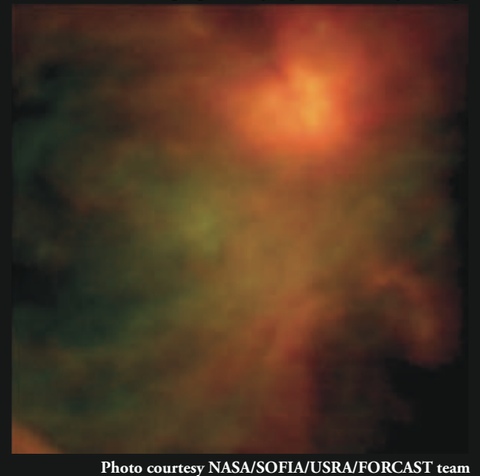

Photo courtesy NASA/SOFIA/USRA/FORCAST team

The FORCAST instrument captured this infrared image of the heart of the Orion star-formation complex.

Fast facts

The SOFIA is designed to help scientists:

- Discover how stars and new planetary systems form by looking into molecular clouds
- Seek evidence on the origin of life by studying complex biogenic molecules in the interstellar medium
- Study objects in the solar system to improve understanding of chemical composition, structure and origin
- Unravel how galaxies evolve over time, by studying dust and gas within them
- Effective diameter of primary telescope mirror: 98 inches (2.5 meters)
- Weight of telescope assembly: 44,100 pounds (20,000 kilograms)
- Observation time at altitude: eight hours or longer
- About 25 crewmembers will be aboard on missions, including flight crew, technicians, astronomers and educators

ED10 0366-56 NASA Photo by Tom Tschida

Above, *Stratospheric Observatory for Infrared Astronomy team members took time out the night before the first science flight for a photo. Front row, from left, are Randolf Klein, Nancy McKown, Karen West, Randy Grashuis, Sybil Adams and Allan Meyer. Back row, from left, are Jim DeBuizer, John Miles, Brett Stroozas, Charlie Kaminski and Ed Harmon.*

ED10 0366-55 NASA Photo by Tom Tschida

Above, *members of the Stratospheric Observatory for Infrared Astronomy FORCAST team include, from left, Luke Keller, Terry Herter, George Gull and Justin Schoenwald.*

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It was developed by a team led by the Max-Planck-Institut fur Radioastronomie of Bonn, Germany.

That instrument has already been checked out and is performing well in a laboratory at the Dryden Aircraft Operations Facility in Palmdale, Calif., where the SOFIA is based, Young said. The GREAT instrument will be installed on the telescope in preparation for use during the spring science flights.

"In our field of infrared, we are still on that part of the slope of electronics and sensor technology that's growing exponentially. You are always going to have the cutting-edge technology to take advantage of advances. On SOFIA we also can change that technology much easier than we can on a space platform," Young said.

"The SOFIA is designed to have a long-life mission, so the way to really make it viable is to be able to bring on new capabilities because both science and technology change that means the facility really has to evolve over the years."

Pam Marcum, SOFIA project scientist, said the flight went better than expected.

"Our earlier flights give us some insight regarding performance, but we don't know how the whole system is really going to work until the rubber hits the road, which is what happened with these flights. The extraordinary data that was collected demonstrates that the observatory is open for business," she said.

"The objects that were observed with the SOFIA and the FORCAST instrument have never been observed at these wavelengths with such a high degree of clarity. This data is truly unique. The science team will actually be able to answer fundamental questions with these very first data sets that were acquired," Marcum said.

The SOFIA is fitted with a 100-inch-diameter airborne infrared telescope. The aircraft's instruments can analyze light from a wide range of celestial objects, including warm interstellar gas and dust of bright star-forming regions, by observing wavelengths between 0.3 and 1,600 microns. A micron equals one millionth of a meter. For comparison, the human eye sees electromagnetic radiation, or visible light, with wavelengths between 0.4 and 0.7 microns.

Dryden manages the overall program and has responsibility for the NASA 747SP platform, which is based at the Dryden Aircraft Operations Facility in Palmdale, Calif. NASA's Ames Research Center at Moffett Field, Calif., manages the SOFIA science and mission operations in cooperation with the Universities Space Research Association in Columbia, Md., and the Deutsches SOFIA Institut at the University of Stuttgart, Germany.

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