LASP SPACE
Laboratory for Atmospheric and Space Physics
University of Colorado **Boulder**
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Features: EXIS update • New INSPIRE collaborations • SDC reaches Ultima Thule • Mars-like deltas in Patagonia

Letter from the director

Dan Baker

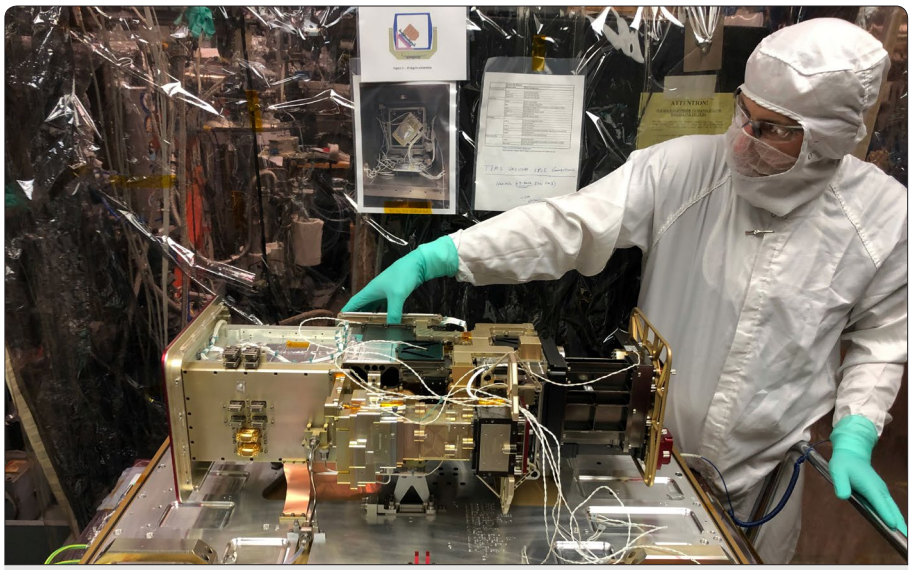
Space Age history is replete with conflicts between proponents of human spaceflight and those favoring robotic exploration. With a renewed interest and political commitment to a human return to the Moon, the age-old concern about budgetary impacts to scientific missions has resurfaced.

LASP is renowned for its robotic space program contributions. But the Lab has also worked with human spaceflight programs and begat astronauts who have accomplished remarkable space feats. It seems that the U.S. can, and must, pursue a vigorous program of both human and uncrewed exploration. A balanced portfolio assures that all stakeholders see the value and promise of space research.

Looking to LASP's traditional and emerging strengths, there are enormous roles the Lab can play going forward. Understanding more about the lunar space environment and surface properties, and about the threats of space weather impacts on humans and machines, demands skills that LASP has in abundance. Rather than taking an either/or posture, it seems wise to advocate for human and robotic exploration, hand-in-hand, through mutual support and advocacy.

IN FOCUS

EXIS update: Continuing to advance LASP capabilities



LASP engineer Colin Miller prepares EXIS-4 for vacuum chamber testing at NIST SURF to ensure it will meet requirements when delivered to the GOES spacecraft. *(Courtesy LASP)*

Over the past 13 years, LASP designed, built, and tested four Extreme Ultraviolet and X-Ray Irradiance Sensors (EXIS) for the NOAA Geostationary Operational Environmental Satellite (GOES) program. At $111M, EXIS is one of LASP's largest programs, and is its first operational, rather than research, instrument.

GOES is a line item in the congressional budget and, because the program provides critical weather forecasts and warnings, is considered a vital national asset. The level of oversight is beyond anything LASP has ever experienced, which provides an opportunity to raise the Lab's technical and management requirements to an even higher level. The government rarely awards operational instrument

Continued on next page

contracts to universities, but LASP has consistently received the highest praise and ratings on performance.

EXIS monitors solar irradiance, which is key to space weather forecasting and operations. It provides the first warning of solar flares, and measures their magnitude and the energetic photon input to the Earth's upper atmosphere. Our increasingly technological society has become correspondingly vulnerable to incoming solar radiation.

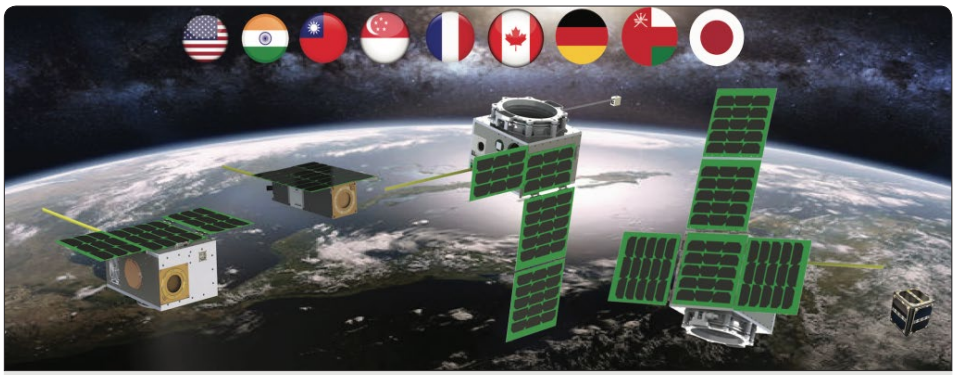
What is the status of the four LASP-built EXIS flight models? Two instruments are already in space on GOES-16 and GOES-17, and both are performing very well. The third EXIS has been integrated onto the GOES-T spacecraft at Lockheed Martin in Littleton, Colorado, and will launch no earlier than 2021. The fourth remains in storage at LASP, destined for the GOES-U mission, scheduled to launch in 2024 (GOES spacecraft are numbered when they become operational). With the mission ending in 2039, this may be one of LASP's lengthiest programs.

For more information on EXIS, visit http://lasp.colorado.edu/home/missions-projects/quick-facts-goes-r/.

By Frank Eparvier, EXIS lead scientist and senior research scientist at LASP.

New INSPIRE collaborations with Singapore

Since its inception in 2015, the LASP-led International Satellite Program in Research and Education (INSPIRE) has grown to a global consortium of 12 universities across the globe with five small satellite missions in development. The first INSPIRE satellite, carrying the LASP-built DAXSS payload, is scheduled for delivery and flight in late 2019 to study solar X-rays.



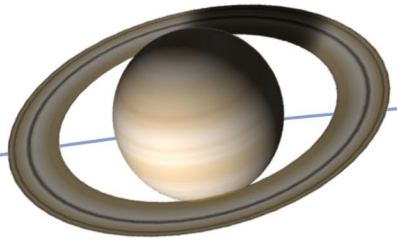
This rendering shows the series of five INSPIRE satellites currently in development and the flags of participating countries. *(Courtesy Amal Chandran)*

LASP recently partnered with the Satellite Research Centre at Nanyang Technological University in Singapore (SaRC at NTU) to build two 27-unit satellites (each unit is 10 cm^3). The Atmospheric Coupling and Dynamics Explorer (ARCADE), or INSPIRESat-4, is scheduled for flight in 2020. It will carry an electric propulsion thruster to make measurements of the thermosphere between 250–350 km. The second 27U satellite will carry the LASP-built Compact SOLSTICE (CSOL) instrument to study the thermosphere.

SaRC at NTU has built and operated eight satellites. Their ground station includes a UHF antenna and a 6.1 m S/X-band dish that the INSPIRE missions will use along with the LASP ground station to control their satellites.

For more on INSPIRE, visit http://lasp.colorado.edu/home/inspire/.

By Amal Chandran, engineer and project manager for INSPIRE at LASP and associate director for SaRC at NTU.



Mission status

Instrument Development (Pre-Phase A)
- AEPEX H-TIDeS

Phase A/B (funded concept study)
- CIRBE CubeSat
- CUTE CubeSat
- IMAP IDEX
- SPRITE CubeSat
- TSIS-2

Phase C (design and fabrication)
- CLARREO Pathfinder
- Europa Clipper/SUDA
- IXPE

Phase D (assembly and test)
- Compact TIM CubeSat
- Emirates Mars Mission (EMM)
- GOES-T/EXIS, GOES-U/EXIS

Launch/Early Orbit [launch date]
- GOES-17/EXIS [Mar. 2018]

Prime Mission [end date]
- GOLD [2020]
- Compact SIM CubeSat [Nov. 2020]
- MinXSS-2 CubeSat [Nov. 2020]
- TSIS-1 [2023]
- Parker Solar Probe [Aug. 2025]
- GOES-16/EXIS [2026]

Extended Mission [end date]
- MAVEN [2019]
- SORCE [2019]
- Van Allen Probes REPT/FIELDS [2019]
- AIM [2020]
- MMS, four spacecraft [2020]
- SDO/EVE [2020]
- THEMIS and ARTEMIS [2020]
- TIMED/SEE [2020]
- New Horizons/SDC [2021]

For more information on current missions, as well as full instrument and mission names, visit http://lasp.colorado.edu.

Student-led SDC reaches Ultima Thule

On January 1, 2019, the New Horizons spacecraft flew by the snowman-shaped Kuiper Belt Object (KBO) 2014 MU69, nicknamed Ultima Thule. At 6.6 billion kilometers from Earth, it became the farthest object ever explored in our solar system. Although full data download isn't expected until mid-2020, early returns show the object is about 35 kilometers long, has a red surface, and contains signatures of water, methanol, and organics.

Launched in 2006 with six other instruments on New Horizons, LASP's Student Dust Counter (SDC) was designed and built by CU Boulder students. Six generations of students have worked on the project, many using it as a springboard for space science careers. While the other instruments waited for Pluto and KBO encounters, SDC studied dust distributed throughout the solar system.

"SDC provided one of the first direct measurements of Kuiper Belt debris showing a low but constant concentration of dust in the outer solar system," said Marcus Piquette, CU Boulder graduate student. "Discoveries like this help to shed light on the processes that shape the dynamics of KBOs."

For more information on SDC, visit http://lasp.colorado.edu/home/sdc/.

This composite, enhanced-color image, compiled from data obtained on the Jan 1, 2019 flyby, highlights Ultima Thule's reddish surface. *(Courtesy NASA/JHU-APL/SwRI/Roman Tkachenko)*

By David James, calibration engineer at LASP and second generation SDC student.

FIELD NOTES

Mars-like deltas in Patagonia

LASP research scientist Brian Hynek, former visiting scientist Gaetano di Achille, and the Planetary Science Institute's Rebecca Williams, spent half of September 2018 in Patagonia—just east of the north Patagonia icefield—conducting NASA-sponsored research. Assisted by drones, they produced high-resolution geologic and topographic maps of deltas that formed at a variety of elevations due to changing conditions during the Pleistocene glaciation. The deltas are "perched" in elevation and often have multiple topographic steps. This is important because most of the ancient deltas on Mars show similar steps in their lobes. These steps are very rare on Earth, so by understanding the environmental

Mission & technical stats

- LASP operates 4 satellites.
- LASP operates 145 instruments on 17 spacecraft.
- LASP is currently developing 9 spacecraft and 21 instruments for 18 missions.

Staff stats

(August 1, 2019)

Scientific researchers	81
Tenure-track faculty	25
Visiting faculty	7
Professionals	349
Graduate students	56
Undergraduate students	104
Total	**622**
Affiliates	267
Open positions	9

For employment information, visit http://lasp.colorado.edu/home/about/jobs.

Student news

Nick Cenedella graduated in May 2019 with a master's degree in aerospace engineering and is now working at Millennium Space Systems in El Segundo, CA.

Reidar Larsen won the CU Student Employee of the Year Award then graduated in May 2019 with BS/MS degrees in aerospace engineering. Reidar now works as a systems engineer at NASA JPL.

controls when the Patagonia examples were deposited helps to better interpret the hydrology and climate conditions when the Mars deltas were forming.

This fieldwork helps constrain the team's computer simulations of delta formation on Earth and Mars and allows them to better interpret remote sensing data from Mars. Initial results suggest that the Mars examples were the result of fluctuating lake levels as well as glacial input.

For more information on astrobiology at LASP, visit http://lasp.colorado.edu/home/life/.

By Brian Hynek, research scientist at LASP and an associate professor of geological sciences at CU Boulder.

Brian Hynek uses a drone to perform high-resolution topographic mapping of an ancient delta in Patagonia. *(Courtesy Rebecca Williams/LASP)*

INNER SPACE

Administrative update

Celebrating LASP's 70th Anniversary

From its humble beginnings as CU's Upper Air Laboratory in 1948, LASP has seen decades of missions, personnel, and infrastructure growth. Over the last year, the Lab reflected on its 70-year history of accomplishments with various events and celebrations.

Kicking things off last summer, the Lab published a retrospective photo book and timeline (to order, visit *https://tinyurl.com/y5fpwjwp*). Then in October, LASP hosted an open house for staff and the local community that featured tours, as well as science talks and posters to recap many of the Lab's scientific highlights.

The grand finale was a March 1 gala held at the Stadium Club overlooking Folsom Field. The formal dinner included

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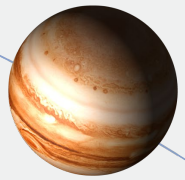

welcoming remarks from CU Chancellor Phil DiStefano, a Lab history talk by LASP Director Dan Baker, and a keynote speech by NASA Deputy Administrator Jim Morhard. In addition to staff and CU administrators, among the 300 attendees were U.S. Senator Cory Gardner, U.S. Congressman Ed Perlmutter, Colorado Lieutenant Governor Dianne Primavera, and former State Senator Penfield Tate III.

Achievement awards

LASP was well represented in the 2019 annual NASA awards bestowed during recent ceremonies in Greenbelt, Maryland. Recipients included: Bob Ergun—NASA Distinguished Public Service Medal (NASA's highest award for non-government personnel); Richard Eastes—NASA Exceptional Public Service Medal (awarded to a non-government individual for sustained performance embodying multiple contributions on NASA projects, programs, or initiatives); the GOLD instrument team—NASA Silver Achievement Medal (government and non-government individuals or teams for stellar achievement supporting one or more of NASA's Core Values); and the MMS Operations Team, for maneuver execution—NASA Group Achievement Award (any combination of government and/or non-government individuals for an outstanding group accomplishment that contributed substantially to NASA's mission).

Nick Schneider has been honored by the Astronomical Society of the Pacific with the 2019 Richard H. Emmons award. This award, which recognizes extraordinary teaching in astronomy for non-science majors, is the only such award given at the national level. Schneider is the first recipient to focus on planetary science, rather than astrophysics, since the award's inception in 2006.

Distinguished visitors

NASA Administrator Jim Bridenstine, CU Regent Linda Shoemaker, and Colorado congressional staffers visited LASP on August 23. They toured the Lab and discussed LASP ventures including the CLARREO Pathfinder instrument, the INSPIRE international satellite development program, other CubeSat projects, and new operations capabilities. The tour included a visit to CASA/ARL to view the EMM spacecraft and discuss opportunities for future international and industry partnerships.

Thomas Zurbuchen, associate administrator of NASA's Science Mission Directorate, visited LASP on June 5, before presenting a colloquium on CU Boulder's main campus. After a breakfast talk with local aerospace companies and CU faculty and staff, Zurbuchen met with students, scientists, and engineers.

On the same day, Jason Kalirai, civil space program executive at the Johns Hopkins University Applied Physics Laboratory, came to LASP to discuss opportunities for partnering on future space missions. Areas for potential cooperation included planetary, heliophysics, and Earth science.

On July 1—his first official day as president of the University of Colorado—Mark Kennedy visited LASP as part of a four-campus tour. LASP represented the many research activities and capabilities at CU Boulder. Kennedy spent time with scientists and engineers, visited mission operations, and talked with current and future student command controllers.