LASP SPACE
Laboratory for Atmospheric and Space Physics
University of Colorado **Boulder**
Issue 9 • June 2017

Features: GOES-R/EXIS launches • LASP leads INSPIRE consortium • Extended missions • Tracing TIM's genealogy

Letter from the director

Dan Baker

Changing government without losing steam

November 2016 brought the election of a new U.S. president and with it, the likelihood of major changes in government programs and policies. The Trump administration put new players in agency leadership roles and is discussing big changes in the near future. Much speculation is taking place about how shifts in the federal government might affect the U.S. space program.

LASP is dependent on NASA, NOAA, NSF, and other federal agencies. Our programs in Earth and space science have been built up over years, and in some cases decades. Maintaining the powerful momentum of these highly successful programs during the transition is a matter of utmost priority for LASP, and really for the nation.

It is not clear what programs might be threatened—or for that matter bolstered—in the coming months. Rather than prematurely speculating or picking fights about policy issues, LASP should continue to do what it does best: the finest science and engineering, and to do this in the service of society. Using our political, societal, and industrial alliances, we can, as in the past, find ways to assure that in change there is opportunity.

IN FOCUS

Worth the wait—GOES-R/EXIS launches

An artist's conception of the GOES-R satellite shows the spacecraft in geostationary orbit around Earth. *(Courtesy Lockheed Martin)*

In an ironic twist, the launch of NOAA's newest, most advanced weather satellite, GOES-R, was delayed by a month last fall due to weather. Hurricane Matthew hit Florida, causing the launch team to place the satellite in safe mode and evacuate the area. When they were allowed to return, damage to facilities (but not the satellite) caused even more delays. On November 19 all was ready for launch. Then faulty sensors caused delays in the first half of the hour-long launch window, followed by a wayward boat needing to be escorted out of the down-range area chewing up the last half. Finally, at the very last opportunity in the window, GOES-R was carried aloft in a perfect launch. Once in geostationary orbit—22,236 miles above the Earth's equator—the satellite lost its letter "R" and became GOES-16, the latest in a four-decade-long series of NOAA satellites to monitor the weather and the space environment.

Built by LASP, the Extreme Ultraviolet and X-Ray Irradiance Sensors (EXIS) instrument measures the output of the sun that drives changes in the Earth's upper

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Mission & technical stats

- LASP operates 5 satellites.
- LASP operates 125 instruments on 22 spacecraft.
- LASP is currently developing 3 spacecraft and 13 instruments for 9 missions.

Administrative stats

(April 18, 2017)

Scientific researchers	66
Tenure-track faculty	21
Professionals	295
Graduate students	54
Undergraduate students	100
Total	**536**
Open positions	22

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

Achievement Awards

LASP's AIM Flight Operations Team received a NASA Group Achievement Award for its exceptional engineering and innovative achievement enabling the AIM mission to continue operations without uplink commands. The group was one of only eight to be recognized in the award ceremony on November 9. Mission operator Dave Welch attended the ceremony at NASA headquarters in Washington, DC to accept the award.

atmosphere and ionosphere. EXIS is one of a suite of instruments on GOES-16 to monitor changes on the sun that impact everyday modern life on Earth. People understand how terrestrial weather can affect their lives, but modern technology has made our world vulnerable to changes in space weather too. Eruptions, magnetic storms, and other activity on the sun change and disrupt the upper atmosphere and magnetosphere of Earth, affecting satellite operations, telecommunications, GPS navigation and power grids.

The instruments on GOES-16 went through post-launch testing during the spacecraft's first three months in orbit. Results showed that they are all living up to their promise of better monitoring and improved forecasting. The following period has been spent characterizing the measurements and preparing the flow of data and products for use by NOAA and their customers to safeguard our nation's security, operation, and commerce.

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

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

LASP leads INSPIRE satellite education consortium

Building upon 70 years of space mission excellence, LASP is spearheading an international alliance in spacecraft design, scientific exploration, and student education. The International Satellite Program in Research and Education (INSPIRE) brings together students, instructors, universities, and space agencies to develop small satellites.

A new paradigm in space education, INSPIRE is a collaboration between CU Boulder/LASP and the Indian Institute of Space Science and Technology (IIST) of the Indian Space Research Organization (ISRO), Taiwan's National Space Organization (NSPO) and National Central University (NCU), Singapore's Satellite Research Center (SaRC) at Nanyang Technological University, and Oman's Sultan Qaboos University (SQU) in Muscat.

Participants of the first INSPIRE workshop at NCU gather at the NSPO facility in Taiwan in July 2016. *(Courtesy NSPO)*

INSPIRE's first mission, INSPIRESat-1, is a 3U (10x10x30cm) cubesat co-developed by LASP, IIST, and NCU. It carries the Compact Ionosphere Probe developed by NCU and NSPO. ISRO will launch INSPIRESat-1 in early 2019 onboard a Polar Satellite Launch Vehicle with ground station support provided by SaRC and SQU. The science team includes researchers from CU, NCU and ISRO.

INSPIRE is also developing an engineering and instrumentation training curriculum that will help foster the next generation of space engineers and scientists.

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

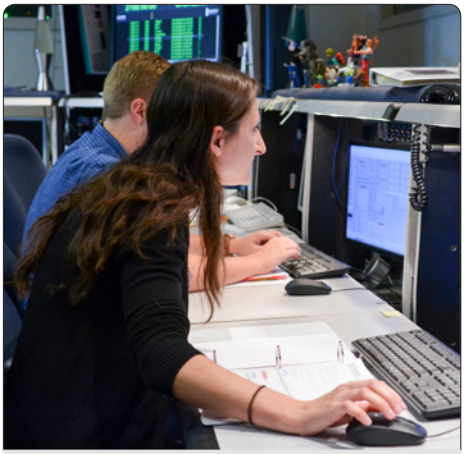
By Amal Chandran, engineer and project manager for INSPIRE at LASP.

Extended missions call for unique operations

"Extended mission" is a term that the LASP operations group has come to know well, as more than 75% of the satellites they control fall into that category. The primary phase of a NASA mission is aimed at collecting data to achieve the mission's main science goals. Thus, spacecraft are built to sustain the instruments until these goals are met. After the primary mission is over, many of the satellite components continue to function and can be leveraged to answer additional science questions during a period of extended operations.

Along with the help of students, the mission operations staff at LASP has been able to solve a variety of problems to keep the satellites healthy enough to provide valuable science data. The team has battled declining battery health on SORCE, failing reaction wheels on Kepler, and numerous instrument component issues on several other satellites. The ingenuity of the operations team at LASP has provided new ways to continue producing valuable science despite aging spacecraft.

For more information, visit http://lasp.colorado.edu/home/mission-ops-data/mission-highlights/.



Mission operations students work at the Kepler spacecraft console. Kepler is currently in an extended mission phase dubbed *K2*. *(Courtesy University of Colorado)*

By Colin Stewart, spacecraft systems engineer at LASP.

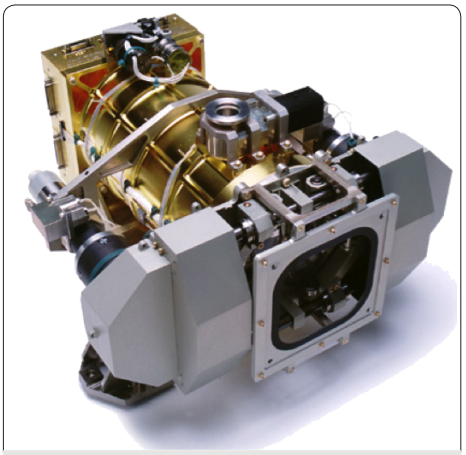
Tracing TIM's genealogy

The sun provides nearly all the energy powering Earth's climate system. Long-term fluctuations in the sun's total solar irradiance (TSI) due to solar variability cause climate change both globally and regionally. Thus, accurate climate modeling requires ongoing measurements of TSI. And because most incident sunlight is absorbed or scattered in the Earth's atmosphere, precise measurements require space-based instruments.

LASP built Total Irradiance Monitors (TIMs) for NASA's SORCE, Glory, TCTE, and TSIS missions to continue a record of TSI measurements that began in 1978. The SORCE TIM, launched in 2003, established more accurate and stable TSI values than prior instruments. Due to a rocket fairing failure, the entire Glory mission was lost—including its TIM—in 2011. A replacement TIM was expeditiously readied for TCTE in 2013 to avoid a gap in what is now an uninterrupted 39-year-long measurement record.

Expectations are that the TCTE TIM, plus the stalwart SORCE TIM, will overlap with the TSIS TIM—currently scheduled to launch to the International Space Station in late 2017—to maintain this important and continuous solar climate data record.

For more information, visit http://lasp.colorado.edu/home/sorce/instruments/tim/.



TIM measures the total light coming from the sun at all wavelengths, called total solar irradiance (TSI). *(Courtesy LASP)*

By Greg Kopp, senior research scientist at LASP.

INNER SPACE

Mission status

Instrument Development (Pre-Phase A)
- MatISSE LAMA

Phase A/B (funded concept study)
- Europa Clipper/SUDA
- CLARREO Pathfinder
- TSIS-2
- CUTE CubeSat

Phase C (design and fabrication)
- Emirates Mars Mission (EMM)
- IIP Compact SIM (CSIM)

Phase D (assembly and test)
- GOES-S/EXIS, GOES-T/EXIS, GOES-U/EXIS
- TSIS-1
- Parker Solar Probe (PSP)

Launch/Early Orbit [launch date]
- MinXSS-2 CubeSat [Oct. 2017]
- GOLD [Fall 2017]

Prime Mission [end date]
- MinXSS-1 CubeSat [2017]
- MMS, four spacecraft [2017]
- GOES-16/EXIS [2026]

Extended Mission [end date]
- AIM [2020]
- Cassini/UVIS [2017]
- QuikSCAT [2017]
- SDO/EVE [2020]
- SORCE [2019]
- STPSat-3/TCTE [2018]
- THEMIS and ARTEMIS [2020]
- TIMED/SEE [2020]
- Van Allen Probes REPT/FIELDS [2017]
- MAVEN [2018]
- New Horizons/SDC [2018]
- Kepler/K2 [2019]

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

LASP to provide mission operations for IXPE

On January 14, the Imaging X-ray Polarimetry Explorer (IXPE) was selected for launch to study black holes, neutron stars and pulsars under NASA's Explorers Program. LASP will provide the mission operations. The IXPE team will study what happens around black holes as it can't see what happens inside of them. "We're very excited to be part of this mission," said Bill Possel, director of mission operations and data systems. "Our students will play a major role in developing the operations procedures and performing operations once the spacecraft is in orbit." IXPE is slated to launch in 2020.

Student news

Chris Fowler received his PhD in Astrophysical and Planetary Sciences in the fall of 2016. He was awarded a John T. Gosling Endowed Fellowship last July for his studies of solar wind interaction with Mars using data from the MAVEN mission.

Eddie Nerney received a BS in Astrophysics in the summer of 2016. Now a grad student in physics, he was awarded a John T. Gosling Endowed Fellowship last July for research with the Juno mission on Jupiter's Io plasma torus.

Skylar Shaver, a junior at CU Boulder, was awarded the 2016 Charles A. Barth Scholarship in Space Research last July for her work on the MAVEN mission studying the magnetic field of Mars and how the planet lost its atmosphere.

For more information on these scholarships and to apply or donate, visit http://lasp.colorado.edu/home/about/givingtolasp/scholarships-and-fellowships/.

Administrative update

Distinguished visitors

LASP hosted Congressman Jared Polis (D-CO 2nd District) on April 20 for a CO-LABS-sponsored roundtable. CU and industry participants discussed potential budgetary impacts and how federally funded research is a major economic and societal contributor to our region. Polis toured LASP with Dan Baker to gain an understanding of LASP capabilities and projects.

Thomas Zurbuchen, NASA associate administrator for science, visited LASP on February 16. He toured LASP's new ARL cleanroom and met with several LASP personnel: Tom Sparn explained TSIS, CLARREO Pathfinder, and LASP's engineering capabilities; James Mason and Rick Kohnert provided a demonstration on the MinXSS-2 cubesat; Pete Withnell discussed EMM and LASP's collaboration with the UAE; Bill Possel and students shared their experiences working on MMS; and Daniel Baker talked about current LASP initiatives related to space weather and the INSPIRE project.

For more information on these missions, visit http://lasp.colorado.edu/home/missions-projects/.

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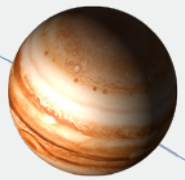

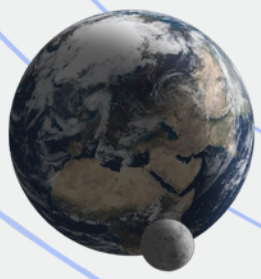

Key hires

We are pleased to announce two senior management personnel advancements at LASP.

Mike McGrath has taken on the newly created role of LASP senior advisor for international program development. He has done an exceptional job as LASP's director of engineering for the past 15 years. Mike also played key roles in project management for several large missions and actively engaged with counterparts in India, Taiwan, Singapore, and many other parts of the world on education, training, and research efforts.

To fill Mike's shoes, LASP has promoted Tom Sparn to director of engineering. Tom has been with LASP since 1978, achieving extraordinary success in engineering, data systems, mission ops, and project management. He has also liaised with Congress and staff members in successive federal administrations to ensure that our programs in solar, Earth, and space science continue to be implemented.

We congratulate Mike and Tom in their new roles.

ARL cleanroom ready for large programs

On January 26, after six months of planning and construction, LASP received a certificate of occupancy for the Astrophysics Research Laboratory (ARL) cleanroom.

The cleanroom project renovated existing labs within ARL and constructed an adjacent 3,400 sq. ft., class 10,000 cleanroom. The cleanroom will increase the lab's capacity for large spacecraft programs. The relocation and upgrade of a thermal vacuum chamber was integral to the improvement of cleanroom capabilities and allows for a more efficient build, assembly, and test of instrumentation, operation, and spacecraft component integration. The project was self-funded by LASP as part of its enduring plan to refresh, refurbish, and recapitalize its laboratory infrastructure to keep pace with the advancements in space research and technology.

LASP's Total and Spectral Solar Irradiance Sensor (TSIS) instrument team will be the first to use the new cleanroom in the spring of 2017. TSIS is scheduled to launch to the International Space Station in late 2017.

LASP's newly constructed 3,400 sq. ft., class 10,000 cleanroom looms above the adjacent ARL building. *(Courtesy LASP)*