LASP SPACE
Laboratory for Atmospheric and Space Physics
University of Colorado **Boulder**
Issue 10 • December 2017

Features: **Cassini's final discoveries • New vacuum test facility • Ground station capabilities • Big data and analysis products**

Letter from the director

Dan Baker

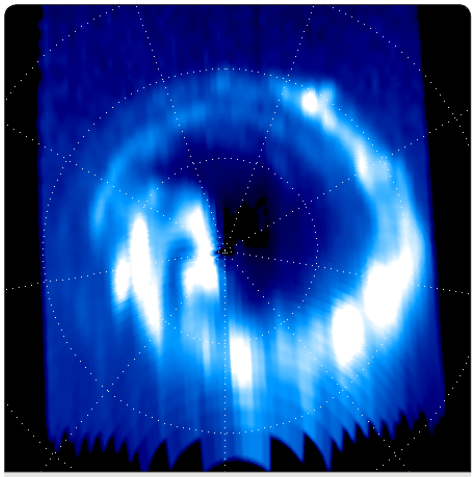
Since the U.S. presidential election of November 2016, it would be fair to say that the situation for federally-funded research and development has been volatile. In light of this, it has never been more important to have strong, enduring support for Earth and space science from our Colorado congressional delegation. We have Senate and House members who clearly understand the goals and needs of CU Boulder researchers. Their unfaltering commitment can assure that our forefront activity will not lose its momentum. However, beyond this, it is especially crucial that academia and industry speak with one voice to Congress, so that programs of basic and applied research will move forward for the benefit of our entire technological society.

LASP welcomes the opportunity to join with Colorado's powerful and highly successful aerospace industry to advocate for present space programs and for exciting future opportunities. By working together with Congress, a balanced and effective space program can be maintained even in light of more general political uncertainty.

IN FOCUS

Cassini's final discoveries—Saturn as never seen before

The NASA Cassini orbiter ended its 13-year exploration of the Saturn system on September 15, burning up in the planet's atmosphere as planned. The UltraViolet Imaging Spectrograph (UVIS) took data through the last moment of the final 22 orbits, which began in April and brought the spacecraft closer to Saturn than any mission before.



The final UVIS auroral image shows bright emission spots, including one never seen before closest to Saturn's north pole. They are created by electrons from Saturn's day and night sides. *(Courtesy University of Liege/LPAP)*

UVIS was designed, built, tested, and operated by LASP with the initial NASA contract beginning in 1990. Even though the mission has ended, team members worldwide will continue to interpret instrument observations and publish results in scientific journals for years to come.

During the six months preceding Cassini's dramatic finale, UVIS collected valuable information that was too risky to obtain earlier in the mission. These discoveries include the closest images ever obtained of Saturn's auroras, and the glowing air of Saturn that enveloped the spacecraft during Cassini's final data transmission, sent a minute before the spacecraft burned up. The final auroral image reveals a never-before-seen bright spot of emission closest to Saturn's north pole. The final UVIS spectrum shows glowing hydrogen from the atmosphere and nitrogen from the spacecraft's thrusters, experienced in situ for the first time.

Although the end of the mission was bittersweet for all involved, Cassini's

Continued on next page

epomail@lasp.colorado.edu
LASP • 1234 Innovation Drive, Boulder, CO 80303-7814 • 303-492-6412 • http://lasp.colorado.edu

Mission & technical stats

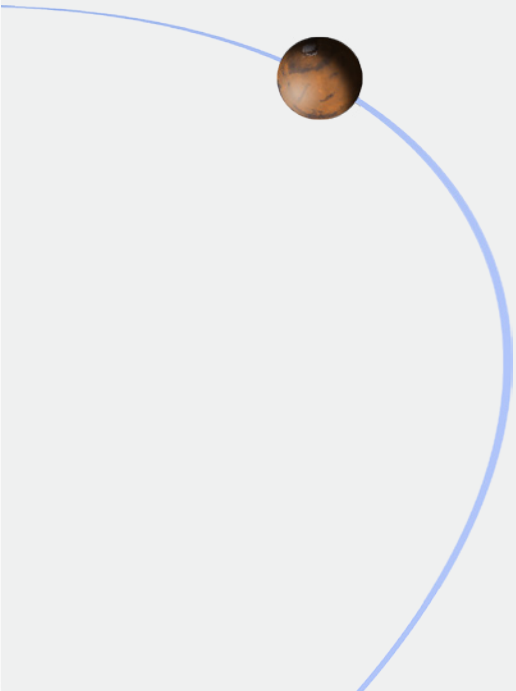
- LASP operates 4 satellites.
- LASP operates 124 instruments on 21 spacecraft.
- LASP is currently developing 4 spacecraft and 20 instruments for 15 missions.

Staff stats

(October 1, 2017)

Scientific researchers	65
Tenure-track faculty	21
Visiting faculty	3
Professionals	314
Graduate students	46
Undergraduate students	131
Others (retirees and temps)	23
Total	**603**
Affiliates	247
Open positions	18

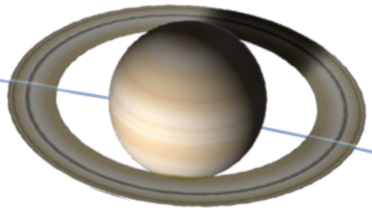
For employment information, visit http://lasp.colorado.edu/home/about/jobs.



"Grand Finale" ensured that its entire payload, including UVIS, contributed awe-inspiring and unique science data right up to its final moments. Cassini deepened our understanding of the universe and heightened our connection to the outer solar system. At its conclusion, it will be remembered as one of the most scientifically rich and impactful voyages yet undertaken.

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

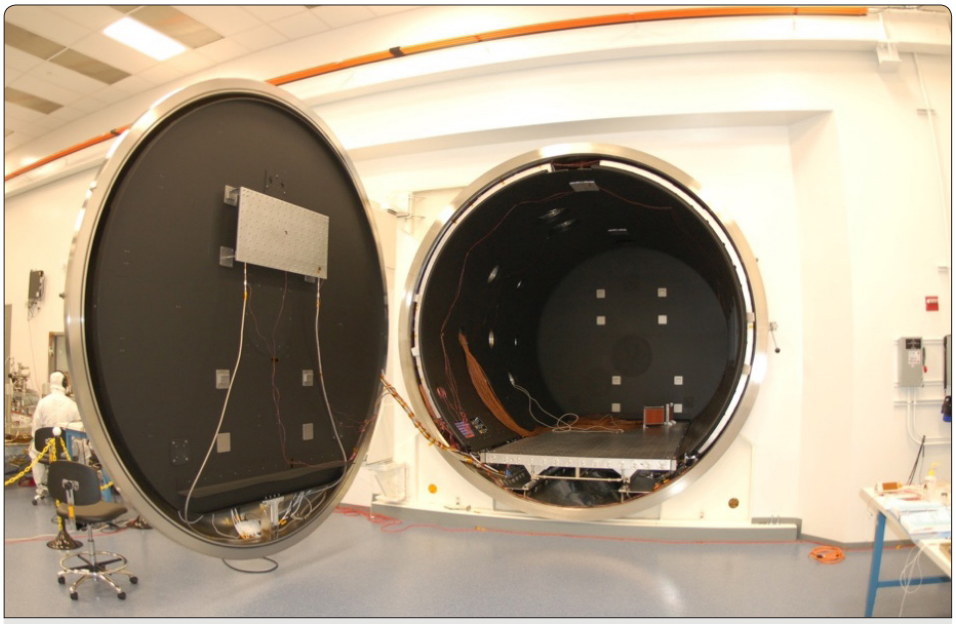
By Larry Esposito, Cassini-UVIS principal investigator, research scientist at LASP, and professor of astrophysical and planetary sciences at CU Boulder.



TSIS initiates new vacuum test facility

LASP's newly renovated clean room in the nearby Astrophysics Research Laboratory provides an efficient and unique environment in which LASP engineers can build, assemble, and test instruments and operations, as well as conduct spacecraft component integration.

The class-10,000 clean room features a large thermal vacuum tank, nicknamed "Jimmy," which can also be used for bake-out. The cryogenic-based chamber pumps down to 10^{-8} Torr, is clean enough for testing UV optics, and has five independent thermal zones, capable of temperatures from +150ºC down to -180ºC. With an internal diameter of 10



LASP's new Jimmy tank is ready and available to perform testing. *(Courtesy Matt Triplett/LASP)*

ft., Jimmy can support hardware up to 2,000 kg.

The LASP-built Total and Spectral Solar Irradiance Sensor (TSIS) was the first flight hardware tested in the Jimmy chamber last spring, and the dual-instrument package performed exceptionally well through thermal balance and cycling tests. Jimmy proved to be uniquely qualified, in that automation of the chamber allowed for smooth operation and precise temperature control, which enhanced testing quality.

For more information on LASP engineering, visit http://lasp.colorado.edu/home/engineering/.

By Edith Knehans, engineering coordinator at LASP.

LASP expands ground station capabilities

Building on two successful CubeSat missions—the Colorado Student Space Weather Experiment (CSSWE) and the Miniature X-ray Solar Spectrometer (MinXSS)—LASP is taking the next step in developing CubeSat capabilities. The lab is adding a 4.2 m S-band antenna with Mbit/second downlink rates that will allow more sophisticated science instruments like the Compact solar Spectral Irradiance Monitor (CSIM) to fly on CubeSat platforms.

In the spring of 2018, the new antenna with radome will replace the existing observatory on LASP's Space Technology Building (LSTB). Beginning in May, the new LASP CubeSat Student Operations Center will be ready to operate MinXSS-2, CSIM, and others using both the existing UHF and the new S-band station at LSTB, and the recently installed LASP UHF station in Fairbanks, AK.

The new ground station will be installed on the LASP Space Technology Building roof after the existing observatory is removed. *(Courtesy LASP)*

This new communications capability provides increased access to space for a broader range of CubeSat science investigations, the advancement of hardware and software for larger scale flight missions, and increased opportunities for testing operations software and new students and professionals.

For more information on MinXSS, visit http://lasp.colorado.edu/home/missions-projects/quick-facts-minxss/.

By Rick Kohnert, systems engineer at LASP.

Big data and analysis products available from LASP

LASP specializes in developing tools for accessing and visualizing large volumes of varied and complex data. The importance of such tools has only grown in today's world where terms like "big data" have entered the mainstream vernacular. More than ever, diverse users need the ability to zero-in on salient features that may be embedded deeply within a vast trove of data—the proverbial needle in a haystack. Providing easy access to interrogate and make decisions using these data is crucial across the space science enterprise.

LASP meets these needs by providing solutions from satellite operations to scientific data visualization. The lab offers a variety of tools including: the publicly available LISIRD solar irradiance data portal, which uses a powerful back-end data service engine that permits

Mission status

Instrument Development (Pre-Phase A)
- MatISSE LAMA

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

Phase C (design and fabrication)
- Compact SIM CubeSat

Phase D (assembly and test)
- Emirates Mars Mission (EMM)
- GOES-T/EXIS, GOES-U/EXIS
- Parker Solar Probe (PSP)

Launch/Early Orbit [launch date]
- TSIS-1 [Dec. 2017]
- GOLD [Jan. 2018]
- GOES-S/EXIS [Mar. 2018]
- MinXSS-2 CubeSat [July 2018]

Prime Mission [end date]
- GOES-16/EXIS [2026]

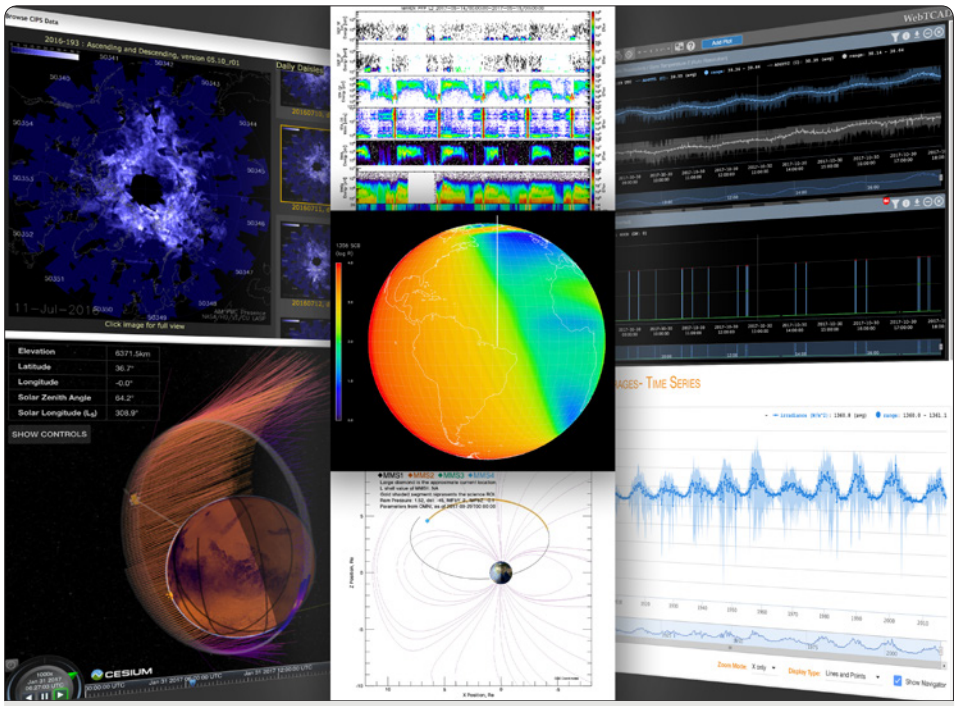
Extended Mission [end date]
- MAVEN [2018]
- New Horizons/SDC [2018]
- QuikSCAT [2018]
- STPSat-3/TCTE [2018]
- Van Allen Probes REPT/FIELDS [2018]
- Kepler/K2 [2019]
- SORCE [2019]
- AIM [2020]
- SDO/EVE [2020]
- THEMIS and ARTEMIS [2020]
- TIMED/SEE [2020]
- MMS, four spacecraft [2022]

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

interoperability with other systems and a front-end interactive data plotting capability; the LASP WebTCAD tool that monitors and assesses spacecraft and instrument health and safety; and the MAVEN 3D data visualization browser, which uses 3D gaming technology to power science displays, that facilitates the study of fundamental scientific data.

For more information on LISIRD, visit http://lasp.colorado.edu/lisird/.
For more information on MAVEN 3D, visit https://lasp.colorado.edu/maven/sdc/public/pages/maven3d/.
For more information on WebTCAD, visit http://lasp.colorado.edu/home/mission-ops-data/tools-and-technologies/webtcad/.

By Chris Pankratz, LASP Data Systems manager and project manager.



A sample of data visualization products available from LASP Data Systems. *(Courtesy LASP)*

FIELD NOTES

In the smoke with ORACLES suborbital mission

Almost a third of Earth's biomass burning emissions stem from "slash-and-burn" agricultural practices in central Africa. Smoke particles are lifted up and transported to the southeast Atlantic where they form a layer above semi-permanent low-level clouds—altering their radiative effect, composition, and dynamic behavior.

Although this layer has a significant impact on local air quality and weather as well as on global climate, this region had rarely been studied before NASA's ObseRvations of Aerosols above CLouds and their intEractionS (ORACLES) mission. Current satellites only provide limited information in this area, so suborbital aircraft campaigns are necessary to understand the smoke's effects, including

Student news

Lauren Blum, who graduated in 2014, is now working at Goddard and was selected for the Basu United States Early Career Award.

Alysa Derks received a bachelor's degree in astrophysical and planetary sciences in the spring of 2017 and is now a graduate student in solar physics at Montana State.

Keri Hoadley graduated last spring with a Ph.D. in astrophysics and is now a postdoc at Caltech.

Robert (Parke) Loyd has a postdoctoral position at Arizona State University, having graduated with a Ph.D. in astrophysics in the spring of 2017.

Chris Moore graduated this fall with a Ph.D. in astrophysics and will be a postdoc at the Harvard/Smithsonian Center for Astrophysics.

Allison Youngblood is now a postdoctoral fellow at Goddard after receiving a Ph.D. in astrophysics in spring of 2017.

To support LASP research and to find out more about donating to, or applying for, related scholarships and fellowships, visit: http://lasp.colorado.edu/home/about/givingtolasp.

its cooling or heating potential.

In August, LASP participated in the second ORACLES campaign—this year from São Tomé—on NASA's P-3 aircraft. LASP's leveling platform ensured accurate measurements from the spectral shortwave radiation instrument that quantifies how the smoke layer affects the underlying clouds. CU Boulder graduate students were actively involved and are now analyzing the measurements. Their research will help improve future satellite observations.

For more information on these missions, visit https://espo.nasa.gov/oracles/content/ORACLES.

The NASA P-3 research aircraft lands on São Tomé Island, with a fire plume in the background. *(Courtesy Jhony Zavatela, NASA Earth Science Project Office)*

By Sebastian Schmidt, research scientist at LASP and associate professor of atmospheric science at CU Boulder.

INNER SPACE

News

TSIS-1 launched December 15, extends 40-year climate data record

The dual-instrument Total and Spectral Solar Irradiance Sensor-1 (TSIS-1) launched to the International Space Station on December 15 with the LASP-built Total Irradiance Monitor (TIM) and Spectral Irradiance Monitor (SIM) on board.

TIM will measure total solar irradiance (TSI), the sun's total energy input into Earth incident at the outer boundaries of the atmosphere; and SIM will measure solar spectral irradiance (SSI) from 200 nm to 2400 nm (96 percent of the TSI) to study how Earth's atmosphere responds to changes in the sun's output. Satellites have measured the sun's energy input to Earth since 1978. TSIS-1 will advance this Climate Data Record (CDR) by taking state-of-the-art measurements with unprecedented accuracy and precision.

The CDR is critical to our understanding of the sun's influence on Earth's radiation, ozone layer, atmospheric circulation, and ecosystems, and the effects that solar variability have on the Earth system and climate change.

TSIS launched during publication of this newsletter. Look for an in-depth update in the next issue of LASPSpace.

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

Administrative update

Looking forward

In April, LASP completed its portion of an Academic Review and Planning Advisory Committee (ARPAC) study. ARPAC is a CU campus-level committee that identifies program strengths and weaknesses, and

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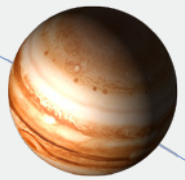

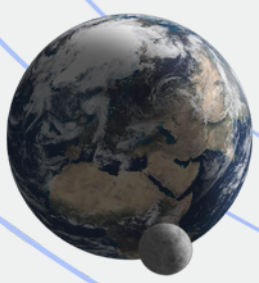

reports to the provost. LASP is currently receiving findings and recommendations from an independent external review panel.

As a result of the ARPAC study, LASP has already instituted two initiatives: Fran Bagenal and Alex DeWolfe are leading a grassroots effort to achieve a more inclusive and diverse working environment, and LASP leadership has initiated an external information technology (IT) assessment to optimize the effectiveness of IT resources and services in support of our unique research requirements.

LASP's pursuit of future space research endeavors has been quite active lately, with more than 50 grants (exceeding $22M) and 10 sponsored research contracts (over $10M) in the works. We currently have more than 25 grants and several contracts in the proposal phase.

Education and Outreach

A bleary-eyed audience witnesses Cassini's demise

In the early morning of September 15, about 125 people gathered at LASP to witness the "Grand Finale" of the Cassini spacecraft. The audience solemnly watched NASA TV as mission operators at the Jet Propulsion Laboratory deliberately plunged Cassini—and its LASP-built Ultraviolet Imaging Spectrograph (UVIS)—deep into the atmosphere of Saturn, ending the mission after nearly 20 years in space.

Local and international news crews were on hand to record the reactions of mission team members and the public as they shared in the bittersweet afterglow of this groundbreaking space emissary.

Before Cassini's final moments, Bill Possel and Alain Jouchoux of UVIS mission operations gave presentations on the launch, operation highlights, and a sneak preview of the last data to arrive early that morning. To celebrate the end of an era in space exploration, the audience was treated to a "ring food" breakfast of bagels, donuts, and more.

Achievement awards

LASP postdoc Hong Zhao won the 2017 American Geophysical Union (AGU) Scarf Award for outstanding Ph.D. thesis in space physics. The award recognizes exemplary graduate work and early career contributions. Among other benefits, Zhao received a $1,000 prize and an invitation to present a talk on the dissertation topic at the AGU fall meeting in New Orleans, Louisiana.

Peter Pilewskie, LASP atmospheric scientist, was honored as a 2018 American Meteorological Society (AMS) Fellow. The award recognizes those who have made outstanding contributions over a substantial period of years to the atmospheric or related oceanic or hydrologic sciences. Pilewskie will receive his recognition at the 98th AMS Annual Meeting in Austin, Texas in January.

On October 31, Nick Schneider, LASP research associate, CU Boulder professor of astrophysical and planetary sciences, and instrument lead for the MAVEN Imaging UltraViolet Spectrograph, was awarded the NASA Exceptional Scientific Achievement Medal (ESAM) for his work on the MAVEN IUVS instrument. ESAM is awarded for unusually significant scientific contributions toward achievement of the NASA mission.