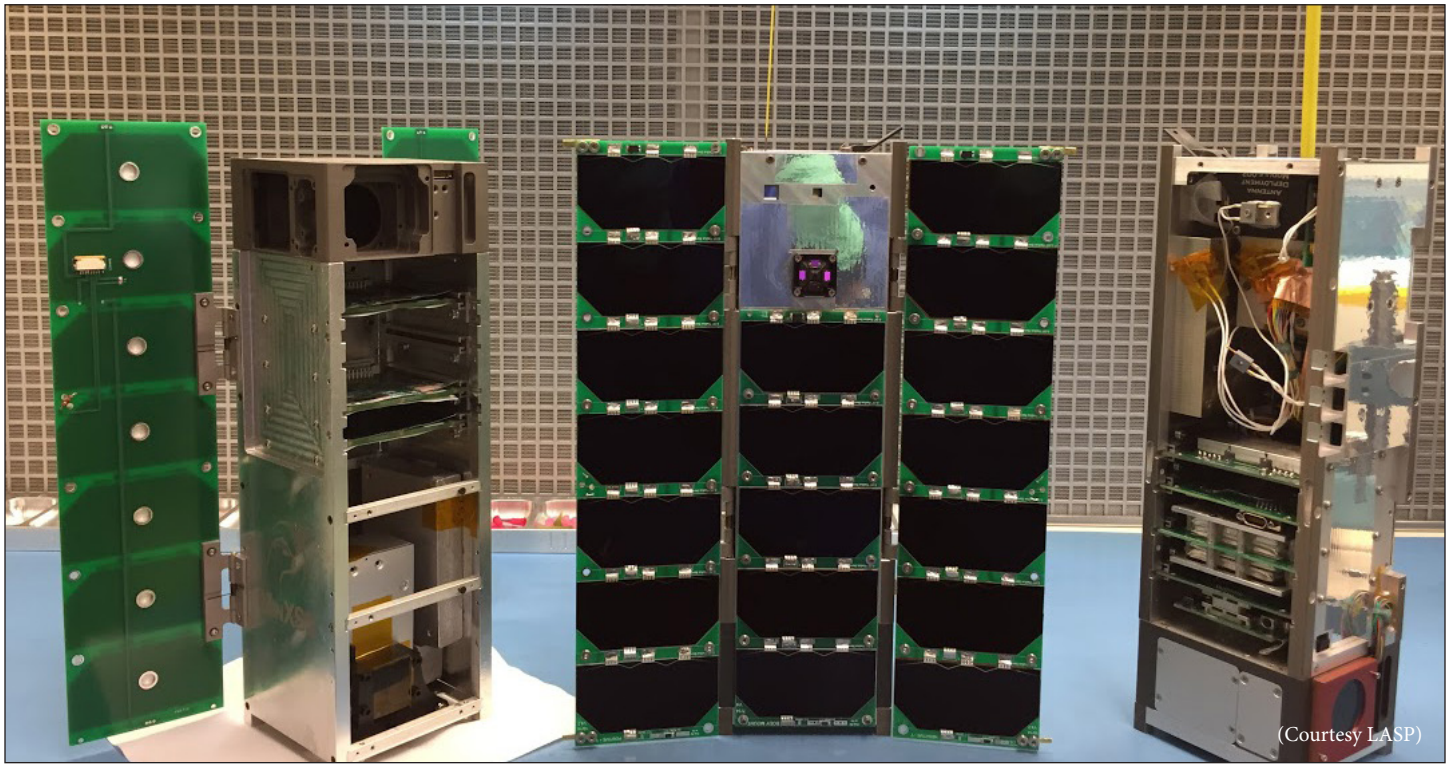
Small Satellite Missions

Designed, Built, Tested, & Operated by LASP

Laboratory for Atmospheric and Space Physics
University of Colorado **Boulder**



(Courtesy LASP)

LASP designs and operates small missions, and is interested in partnering on future small satellite missions. **Talk with us about how LASP could support your needs for small satellite development and operations.**

LASP's Small Satellite Missions

Student Nitric Oxide Explorer (SNOE)

The **S**tudent **N**itric **O**xide **E**xplorer (SNOE, launched in 1998) was part of NASA's Student Explorer Demonstration Initiative program (STEDI). The SNOE team designed and built two atmospheric instruments and one solar instrument along with all of the spacecraft subsystems (structure, C&DH, FSW, EPS, ADCS, COMM). LASP students and professionals operated SNOE successfully for six years before deorbiting the spacecraft.

Colorado Student Space Weather Experiment (CSSWE)

The nano-satellite **C**olorado **S**tudent **S**pace **W**eather **E**xperiment (CSSWE, launched in 2012) was part of NSF's Geoscience CubeSat program. The CSSWE team designed and built the energetic particle detector called REPTile, the EPS system including the DC-DC regulators, Li-polymer batteries, solar panels, passive magnetic ADCS, and the deployable antenna system for UHF communication down to the ground station located on the roof of LASP. CSSWE was operated successfully for two years and made important contributions to increasing our understanding of Earth's magnetosphere.

Miniature X-ray Solar Spectrometer (MinXSS)

The **Min**iature **X**-ray **S**olar **S**pectrometer (MinXSS, launched in 2015) is a ~$1 million NASA project to design, build, integrate, test, and operate a 3-unit (34cm x 10cm x 10cm) CubeSat. MinXSS observed the intensity of the solar soft x-ray spectrum from 0.4 keV (30 Å) to 30 keV (0.4 Å), with resolution of ~0.15 keV full-width half-max. This region is of particular interest for observations of solar flares and active regions. The MinXSS project embedded graduate student team members with scientists and engineers at the University of Colorado Boulder and LASP. More than 40 graduate students, 3 undergraduate students, and one high school student worked on MinXSS-1. MinXSS-1 was deployed from ISS in May 2016 and obtained thousands of new solar x-ray spectra before its re-entry in May 2017. MinXSS-2 is scheduled for launch in early 2018 into a higher (500 km), polar, and sun-synchronous orbit.

Colorado Ultraviolet Transit Experiment (CUTE)

The **C**olorado **U**ltraviolet **T**ransit **E**xperiment (CUTE, scheduled for launch in 2020) is a NASA CubeSat mission encompassing a low-resolution (R≈2500) near-ultraviolet (2500–3500 Å) spectrograph, which will carry out transmission spectroscopy of the nearest exoplanetary systems. CUTE is a 1-year science mission with the main goal of studying the physics of atmospheric escape. The 6U CubeSat mission is designed to monitor transiting hot Jupiters for evidence of atmospheric mass loss and magnetic

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fields. CUTE maximizes the available CubeSat space by means of an innovative optical system to achieve a projected effective area of ~22 cm^2, low sensor background signal, and a spectral resolving power over the entire science bandpass.

Compact Spectral Irradiance Monitor (CSIM)

The **C**ompact **S**pectral **I**rradiance **M**onitor (CSIM, scheduled for launch in 2018) represents a new approach to acquiring solar spectral irradiance (SSI) measurements to meet future needs for compact, robust measurement systems at reduced overall costs. CSIM covers a continuous wavelength range of 200-2400 nm and meets the required SI-traceable accuracy and on-orbit stability for climate quality data records. CSIM will make use of a new 6U CubeSat integrated platform for obtaining high priority measurements of SSI and reduce the risk to the continuity of the long-term climate data record. The complete effort takes advantage of new, emerging technologies in both instrument and small spacecraft developments demonstrating a cost efficient small satellite concept for long-term mission implementation. An emphasis on smaller platforms also potentially reduces access-to-space costs and delays through the use of smaller, single launch vehicles or using excess capacity on larger launch vehicles. Ultimately, implementing this lower cost approach based on redundancy, with overlapping measurements, in a small satellite constellation can reduce the overall risk to the long-term SSI climate data record.

INSPIRESat-1

The **In**ternational **S**atellite **P**rogram **i**n **R**esearch and **E**ducation (INSPIRE) integrates students, instructors, universities, and space agencies across specialties and across the globe in an ambitious endeavor to educate new engineers and scientists, build and launch new space missions, and drive leading-edge scientific discovery. Preliminary design work on INSPIRESat-1 started in January 2015. The first INSPIRE mission is proposed to be a three-unit (3U) CubeSat carrying the Compact Ionospheric Probe (CIP). The 3U spacecraft will be co-developed by LASP, the Indian Institute of Space Science and Technology (IIST), and the National Central University (NCU) in Taiwan. The CIP instrument measures the ion drifts and electron temperatures in Earth's ionosphere. Taiwan is providing the CIP instrument, which has flight heritage on FORMASAT-5.

LASP's Small Satellite Experience

LASP's experience encompasses all aspects of designing, analyzing, fabricating, testing, and operating satellites and space science instruments:

- **Science instruments** in x-ray, UV, VIS, & NIR: photometers, spectrometers, imagers, and particle detectors
- **Spacecraft bus:**
  - **Structures, mechanisms, and deployment systems:**
    - Aluminum and composite structures, one shot covers, bi-stable mechanisms, multi-axis pointing platforms, solar array deployment, and antenna deployment
  - **Electrical Power System (EPS):** Bus regulation, batteries, solar arrays, and high voltage power supplies
  - **Command & Data Handling (C&DH):** Microcontroller (rad-hard, embedded FPGA, and commercial options), real-time clock, memory (EEPROM, RAM, SD card), and serial interfaces (RS232/422, SPI, I^2C, and custom)
  - **Flight software:** Time slice custom real-time operating system, power control & monitoring, command/telemetry handling, instrument operations, fault protection & response, and mechanism control
  - **Attitude Determination and Control System (ADCS):** In-house designs for high-accuracy magnetometer and sun sensor; LASP is supporting Blue Canyon Technologies' development of a 3-axis ADCS for CubeSats using miniaturized star trackers, reaction wheels, and torque rods
  - **Communication (COMM):** Using commercially available solutions; LASP's X-band radio for CubeSats is now available
  - **Thermal control systems:** Passive thermal control systems designed with on-site mission thermal system analysis and test capabilities
- **Mission operations:** On-site mission operations experts and facilities implementing turn-key applications for commanding (OASIS-CC) and planning (OASIS-PS); on-site UHF and S-band ground station available for use
- **Data systems:** Hosted data centers, data processing experts, and web-based interactive data tools developers

For more information regarding collaboration or support on Small Satellites, please contact Tom Sparn at (303) 492-2475 or tom.sparn@lasp.colorado.edu or Rick Kohnert at (303) 492-6804 or rick.kohnert@lasp.colorado.edu.

The Laboratory for Atmospheric and Space Physics (LASP) combines all aspects of space exploration through our expertise in science, engineering, mission operations, and data management. As an institute at the University of Colorado Boulder, LASP includes students throughout our activities. Learn more at http://lasp.colorado.edu.