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# Space Science and Engineering Laboratory

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Technical Capabilities Briefing: DOE Lab Days– October 8, 2019

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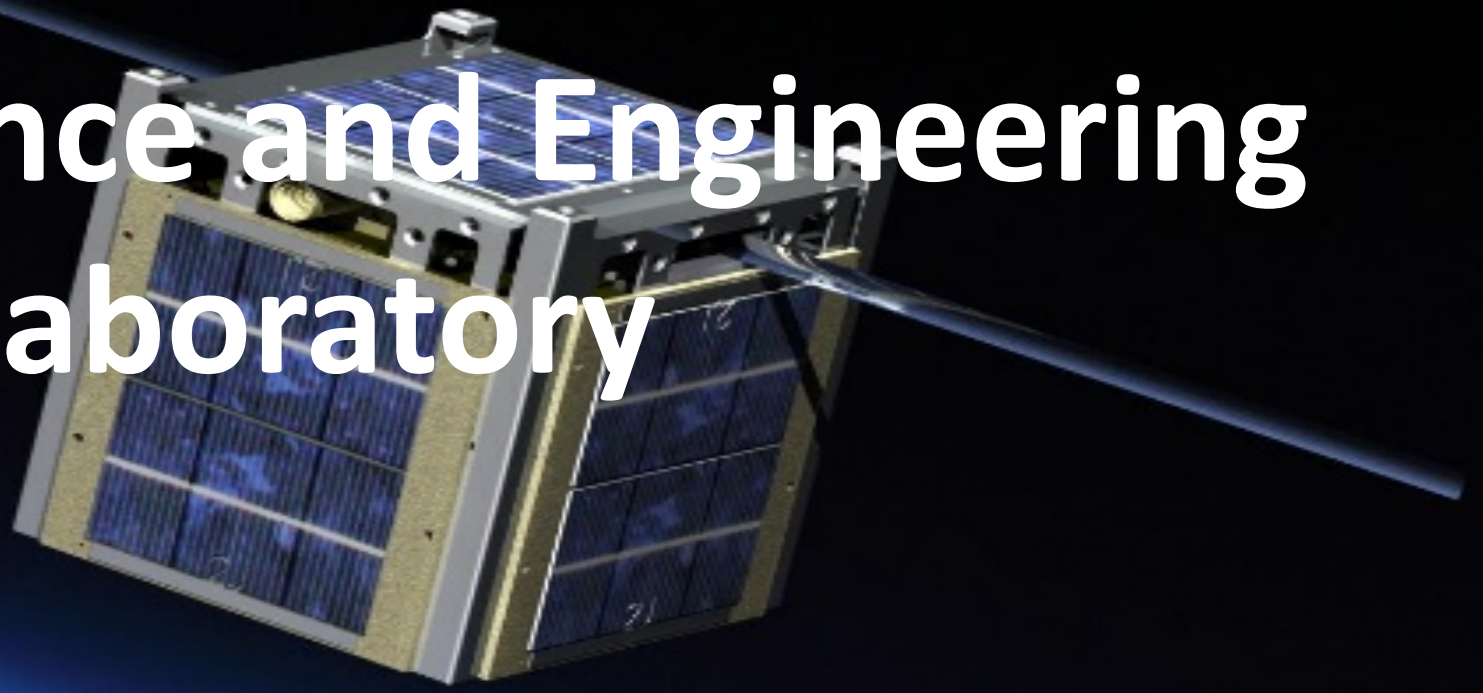

Montana State University SSEL Space Science & Engineering Lab

NSF NASA

MONTANA STATE UNIVERSITY

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Mountains & Minds

# What are we?

The Space Science and Engineering Laboratory at Montana State University is an interdisciplinary center for space research, space technologies and collegiate-level experiential hands-on training in spaceflight systems.

University Education/Workforce Training:

**"Today's students – Tomorrow's Engineers and Scientists"**

Hands-on training – develop professional skills "by doing" to jump-start the college to workplace transition.

Space Science and Operational Space

**Space Environent; Space Weather; Sun-Earth Connections**

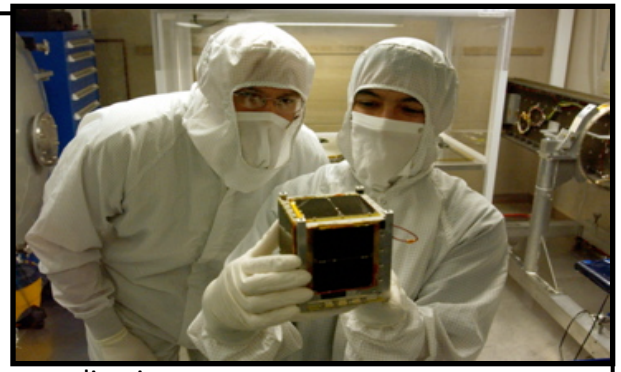
- Ionizing Radiation (Plasmas to MeVs)
- Radiation Belt dynamics (particles, X-rays)
- Ionospheric interactions
- Solar Physics - the active magnetic sun
- Lightning (X-, Gamma- Rays

**Space Situational Awareness**

- Naturally occurring phenomena
- Man-made unknown objects

Technologies/Capabilities

**Design, Develop, Integrate, Test, Fly, and operate highly capable small space systems.**



- Miniaturization technologies for space applications
- 1 kg - 40 kg spacecraft systems (CubeSats and AFRL University "NanoSats")
- Plasma detectors
- Sensors for ionizing radiation (electrons and ions, X and Gamma Rays)
- Space environment effects on COTS subsystems
- Extreme Ultraviolet Solar Radiation (EUV Optics)
- Imaging spectrometers (optical to EUV)
- Advanced Manufacturing technologies for spaceflight
- Rad hard reconfigurable electronics (with MSU and industry partners)
- Low power heterodyne LADAR ranging and imaging systems for SSA (w/ partners)
- Spaceflight qualification
- Space Operations; satellite tracking station and streamlined mission operations

# MSU/SSEL Orbital Space Systems

| Program Name / Launch Date | Size Description | Sponsor | Mission Duration | MSU Role | TRL (Begin/End) |
|---|---|---|---|---|---|
| NODES May 16, 2016 | 2 X 1.5U | NASA Ames | 16 months | Payloads | 7/9 |
| PRINTSAT Nov. 4, 2015 | 1U CubeSat | Private Consortium. MSU | Launch Vehicle Failure | Integration, Test, Launch Provision | 1/7 |
| EDSN Nov. 4, 2015 | 8 x 1.5U Cubesats | NASA Ames | Launch Vehicle Failure | Science Payload Development 14 Units | 3/7 |
| FIREBIRD-3, -4 Jan. 31, 2015 | 2x1.5U CubeSats | National Science Foundation | Operations continuing – 48 months in orbit | Mission Design, Spacecraft AI&T, Flight Qual. | 6/9 |
| FIREBIRD-1, -2 Dec. 6, 2013 | 2x 1.5U CubeSats | National Science Foundation | 6-months | Mission Design, Spacecraft AI&T, Flight Qual. | 3/8 |
| IRIS 27-Jun-13 | Small Explorer | NASA/ Lockheed Martin | Operations continuing – 67 months in orbit | Design, procure, characterize spectrograph optics | 5/9 |

| Program Name / Launch Date | Size Description | Sponsor | Mission Duration | MSU Role | TRL (Begin/End) |
|---|---|---|---|---|---|
| HRBE Oct. 28, 2011 | 1U CubeSat | NASA/MSGC | 33-months-plus | Complete Mission Responsibility | 5/9 |
| Explorer-1 Prime Mar. 4, 2011 | 1U CubeSat | NASA/MSGC | Launch Vehicle Failure | Full Mission Responsibility | 2/7 |
| MISSE Materials Mar. 13, 2008 | MISSIE-6 ISS attached payload | NASA/MSGC | 18-months | Full Investigation Responsibility | 2/9 |
| MISSE Electronics Mar. 13, 2008 | MISSIE-6 ISS attached payload | NASA/MSGC | 18-months | Full Investigation Responsibility | 2/9 |
| MEROPE Jul. 26, 2006 | 1U CubeSat | NASA/MSGC | Launch Vehicle Failure | Full Mission Responsibility | 1/7 |
| **In Development and Manifested for Launch** | | | | | |
| IT SPINS | 3U CubeSat | National Science Foundation | 12-months (design life) | Mission Design, Spacecraft AI&T, Flight Qualification | 4/6 |

# Canisterized SmallSats (aka CubeSat)

## Approximate SWaP

| Bus Size (cm) | Total Mass | Power (W) | Capability* | Payload Volume | Payload Mass (kg) |
|---|---|---|---|---|---|
| 10 x 10 x 10 (1U) | 1.33 kg | 3 | T | 0.2U | 0.3 |
| 10 x 10 x 30 (3U) | 4.5 kg | 20 | A,T,P | 1 U | 2 |
| 10 x 20 x 30 (6U) | 12 kg | 40 | A,T,P | 4U | 8 |
| 20 x 20 x 30 (12U) | 24 kg | 80 | A,T,P | 8U | 19 kg |

* capability

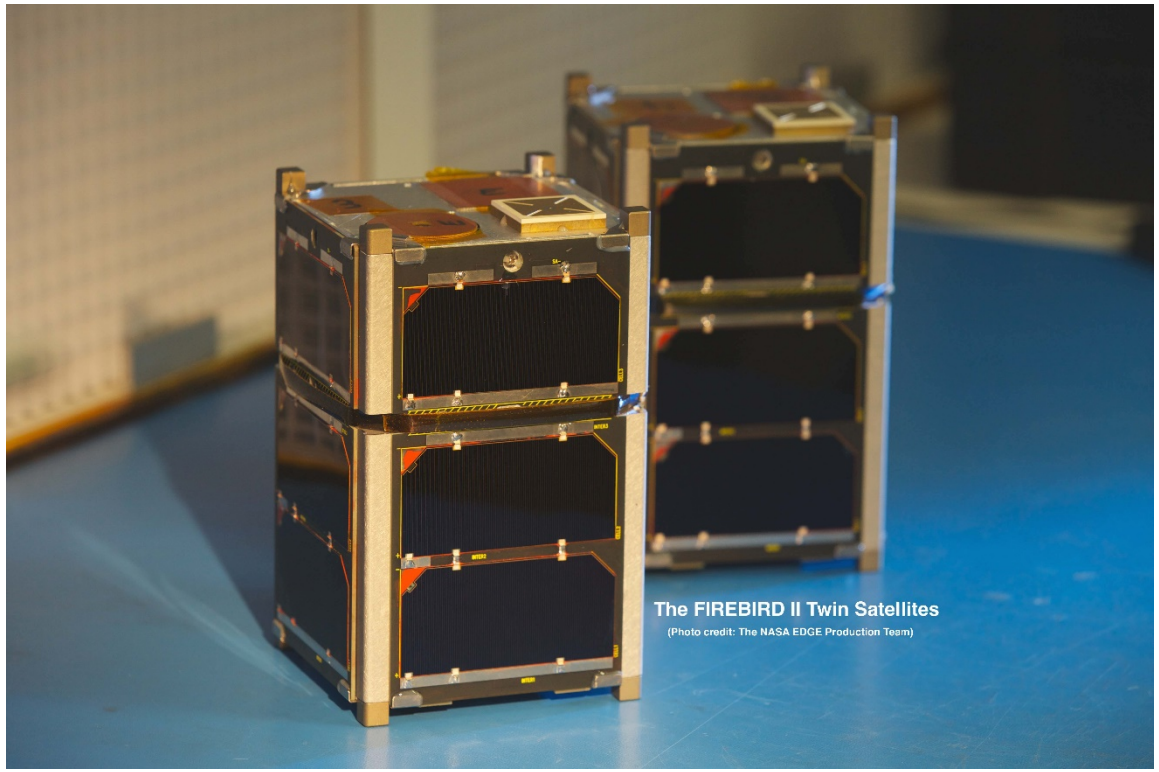
| | |
|---|---|
| P | Propulsion (electric) |
| A | ADCS (attitude control & pointing) |
| T | TT&C (telemetry & command) |

The strategic advance of SmallSats: deployment as swarms/constellations.
- Small, maneuverable platforms, providing multiple points of view and rapid revisit

# FIREBIRD II - Focused Investigations of Relativistic Electron Burst Intensity, Range, and Dynamics

2 satellites launched as a pair: 1/31/2015 (currently operating)

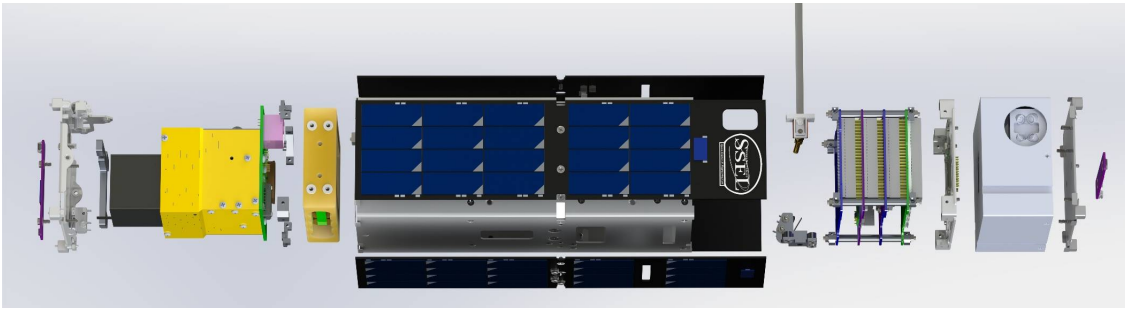
Continued Mission of FIREBIRD I




FIREBIRD Flight Units 3 and 4

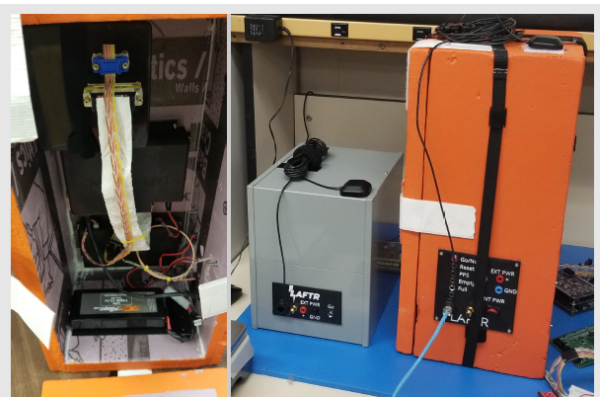
# Missions In Development

**IT-SPINS (The Ionospheric-Thermospheric Scanning Photometer for Ion-Neutral Studies)** The first two-dimensional (2D) tomographic imaging from a 3U research CubeSat, with the objective of addressing the basic nature of the nocturnal ionosphere.

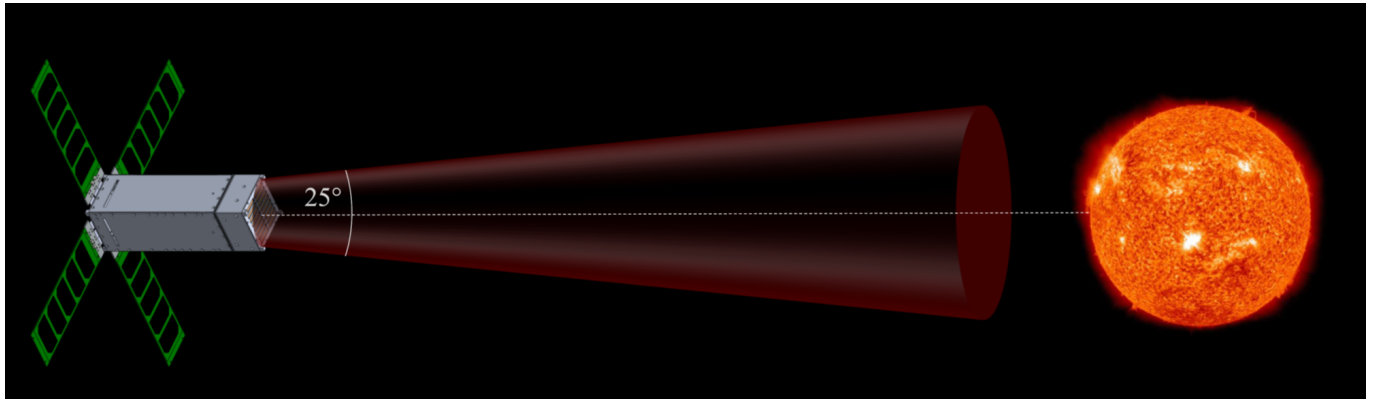


**BOOMS (Balloon Observations of Microburst Scales)** What does a microburst, studied for 60 years, actually look like? 1000kg payload carried to 40km altitude with x-ray imagers will tell us.

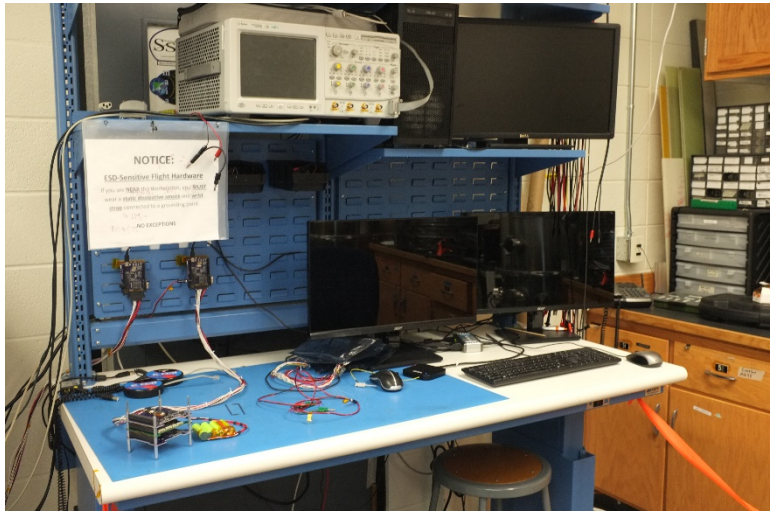
**LAFTR (Light and Fast TGF Recorder)** What is the cause of Terrestrial Gamma Ray Flashes? (TGFs)



**IMPRESS (IMpulsive Phase Rapid Energetic Solar Spectrometer)** Rapid time variation in electron acceleration during solar flares



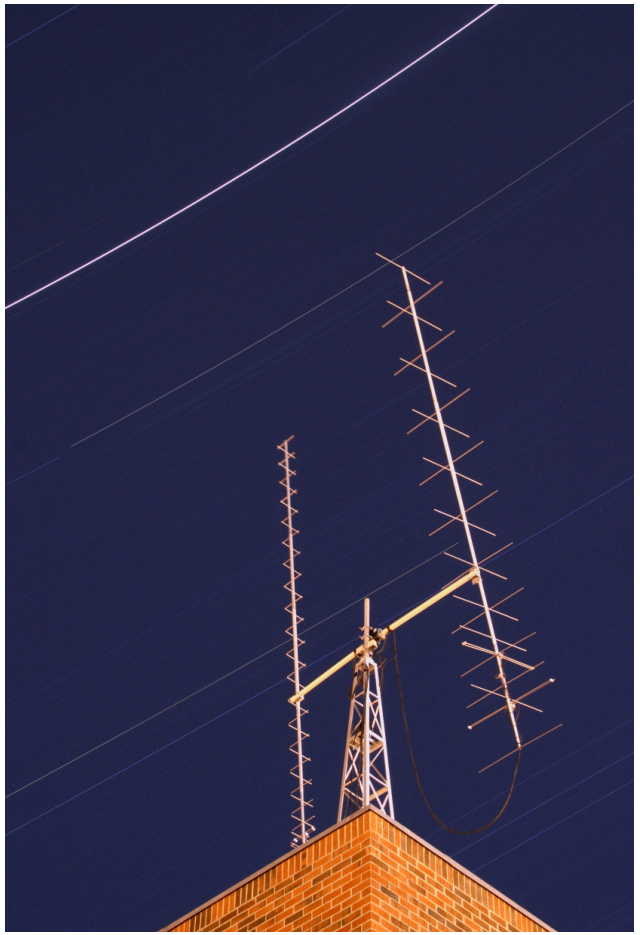
# SSEL Facilities




ESD Work stations; Laminar Flow


Thermal Environment

Ultra-clean T-Vac



24/7 ‘lights-out’ TT&C

# SSEL Associated Faculty

David Klumpar, Ph.D – Research Professor, Director SSEL

John Sample, Ph.D. - Assistant Professor of Physics

Charles Kankelborg, Ph.D. Professor of Physics

National Science Foundation Award to MSU team to hire an early career faculty member announced by NSF July 23, 2019.

???, Ph.D. Asst. Professor of Physics

# SSEL Professional Staff

Larry Springer Senior Research Engineer, Project Manager

Rubin Meuchel - Senior Research Engineer (ME)

Nevin Leh, Software Engineer

Skylar Tamke, Electrical Engineer