
Educating Students in Experimental Space Physics and Heliophysics

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CENTER FOR
SPACE
ENGINEERING



UtahStateUniversity

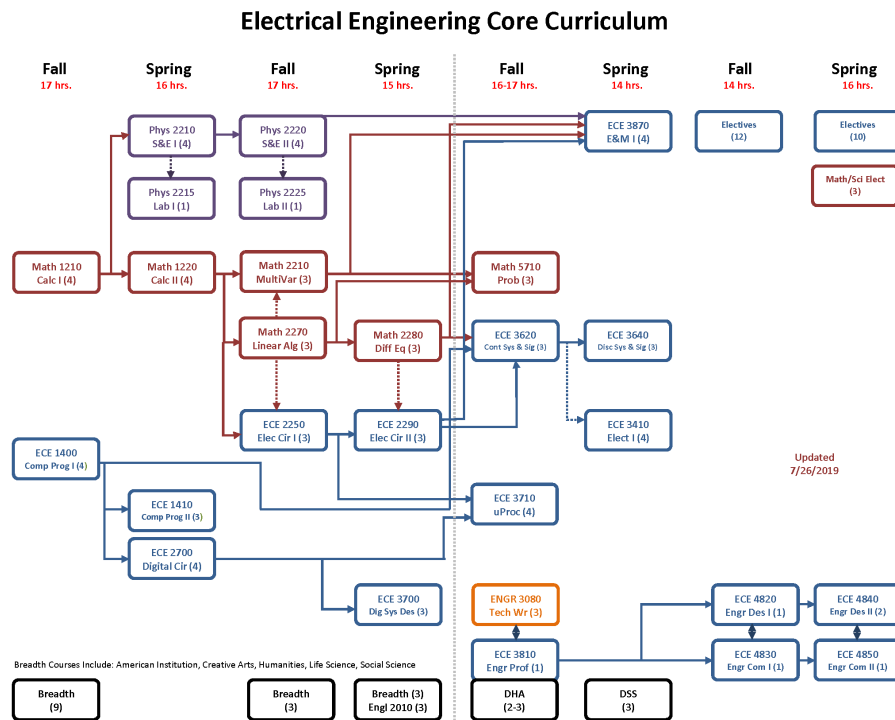
Guiding Principles

- **The most significant advances in space physics and Heliophysics, over the next decades are most likely to derive from new observational techniques.**
 - A sequence of courses is designed to develop an understanding of small satellites and experimental space science techniques.
- **The connection between advances in scientific understanding and technology has historically been demonstrated across many disciplines and time.**
 - Experimental space science requires good engineering practice.

Utah State University

- **Utah State University (8 colleges)**
 - College of Engineering (5 Departments)
 - Department of Electrical and Computer Engineering
 - BS in Electrical Engineering and Computer Engineering
 - MS/PhD in Electrical Engineering and Computer Engineering
 - MS Space Systems Engineering (new)

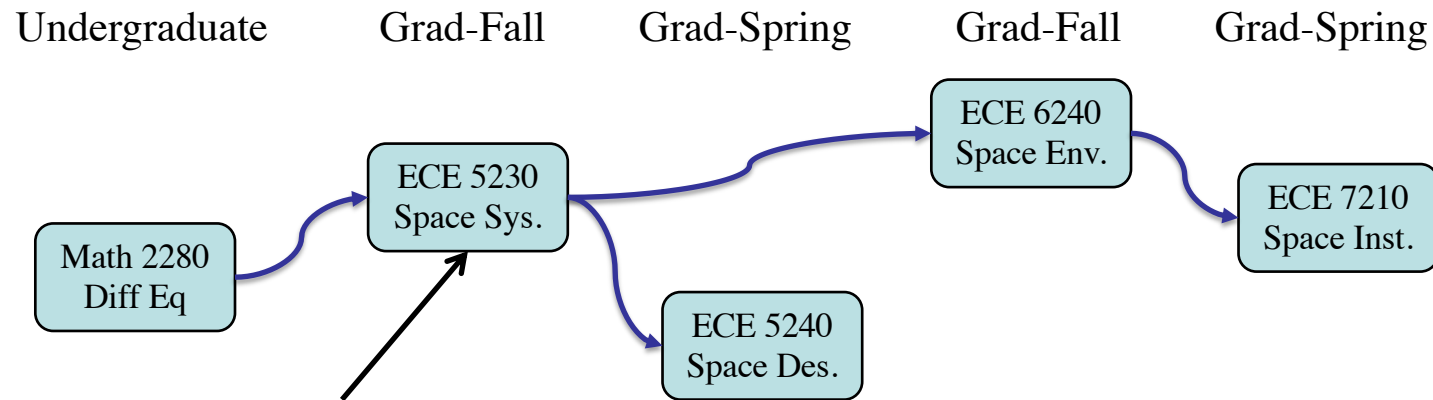
A Crowded Curriculum



- The electrical engineering BS major allows for 18 credits of technical electives (approximately 6 courses).

– Two space courses are offered at the undergraduate level and two at the graduate level in ECE.

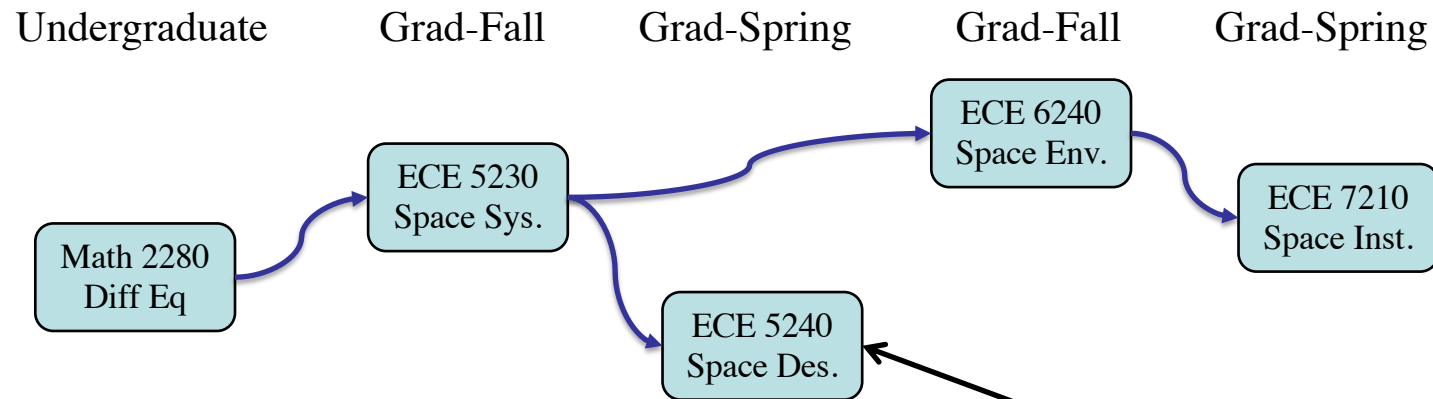
Space Systems Focus Area



Spacecraft Systems Engineering:

- Coordinate Systems / Orbital Mechanics,
- Mission Analysis,
- Spacecraft Subsystems:
 - Propulsion
 - Attitude Determination
 - Attitude Control
 - Power Systems
 - Thermal Systems
 - Communications
 - Command Data Handling
 - Costing

Space Systems Focus Area

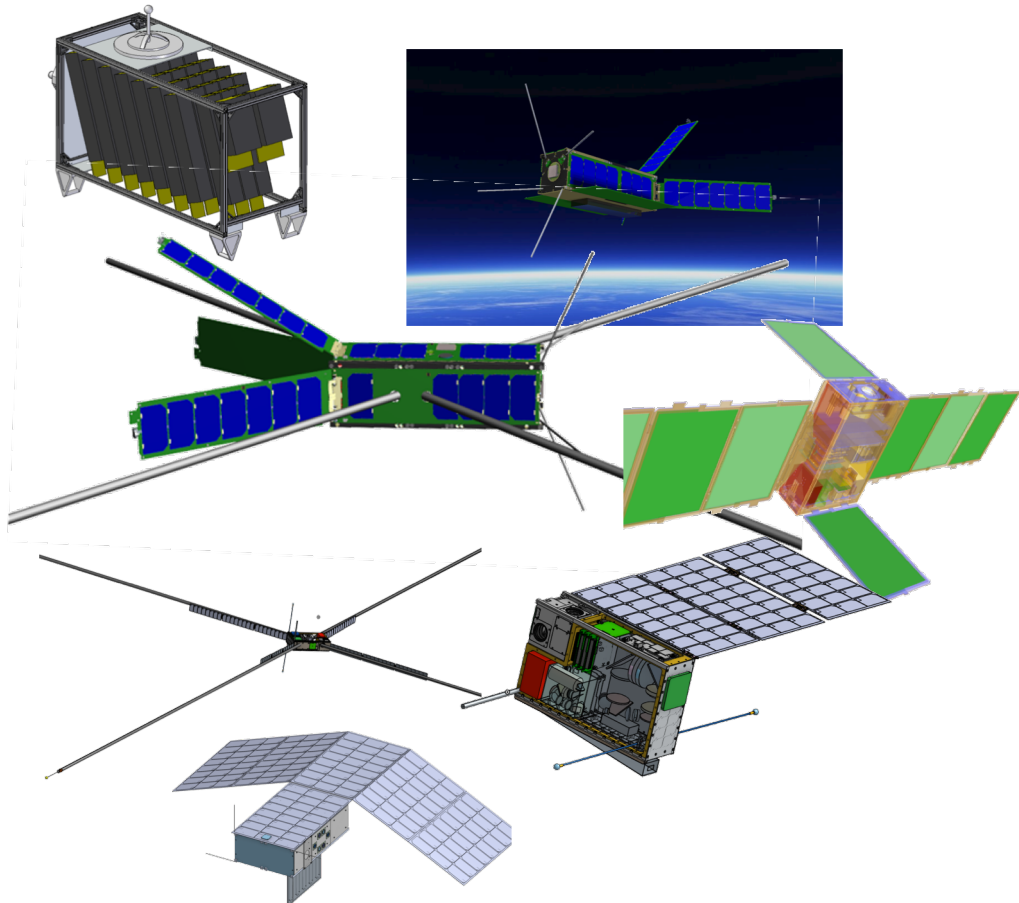


Space Mission Design:

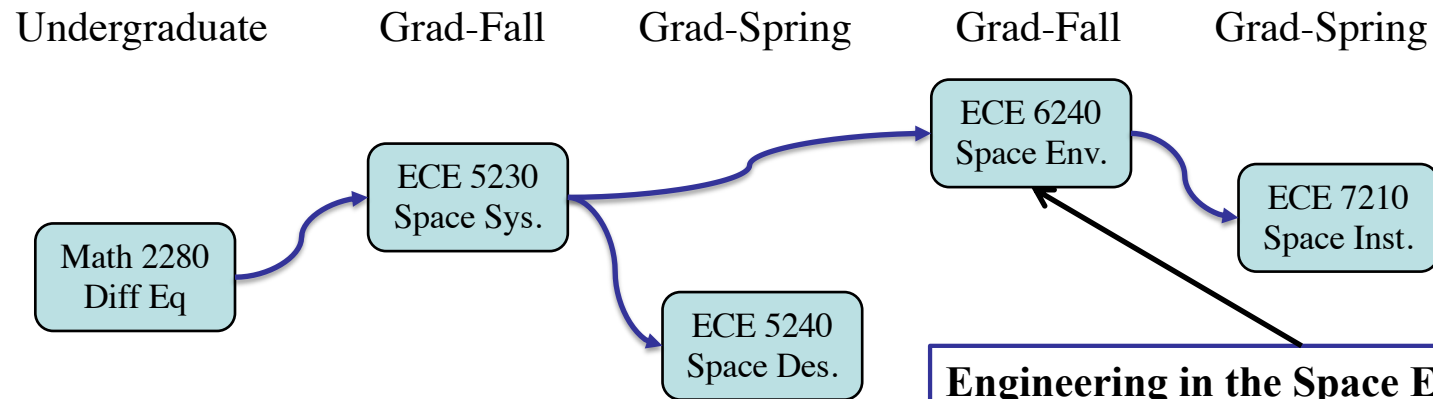
- NASA Systems Engineering Process,
- Scope, Concept of Operations,
- Requirements development and management,
- Resource Budgets, Margin, Gold Rules,
- Technical Readiness Levels,
- Conceptual Mission Design,
(Customer Based)

Previous Mission Design

- **Spring 2011: ICES**
 - Customer: NASA JSC
- **Spring 2012: SHARE**
 - Customer: USU Physics
- **Spring 2013: RAPTER**
 - Customer: RINCON
- **Spring 2014: RUNNER**
 - Customer: NASA JSC
- **Spring 2015: Marco-Polo**
 - Customer: Univ. Colorado
- **Spring 2018 MIASMA**
 - Customer: STC
- **Spring 2019 TUATARA**
 - Customer: USU Physics



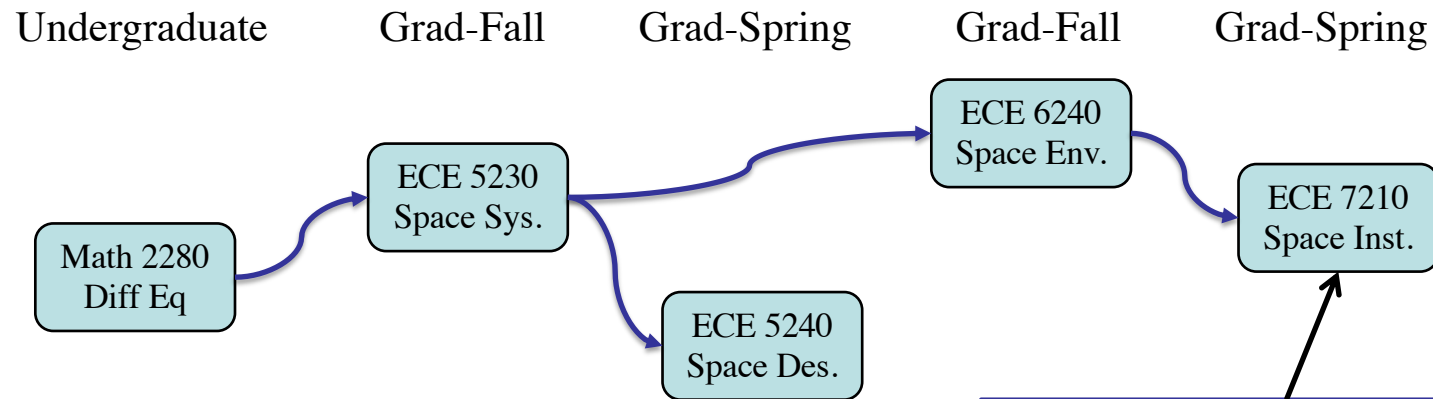
Space Systems Focus Area



Engineering in the Space Environment

- The Earth's Ionosphere,
- Radiation Environment,
- Models of the Space Environment,
- Plasma interactions,
- Debris,
- Chemical Reactions,
- Radiation Effects,
- Thermal Issues

Space Systems Focus Area



Introduction Space Science Instrumentation

- Review of science missions,
- Plasma physics,
- DC electric probes,
- AC electric probes,
- Magnetometers,
- Optical instruments,
- Sounders and radars,

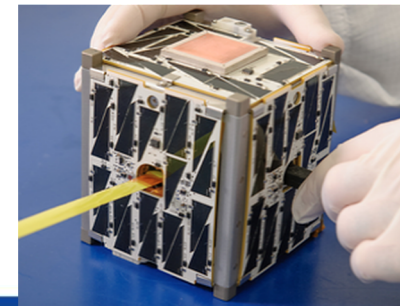
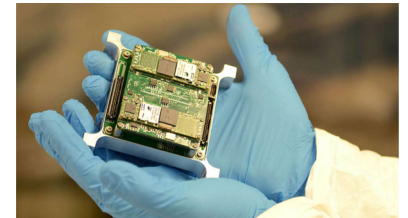
Instrumentation for Space Science

- Review Space Environment
- Starting Research Programs and working with government agencies.
- Review of Previous and Current Experimental Programs
- The physics of single charged particles
- Plasma Physics Overview I
- Response of plasma to Applied Potentials
- The Bohm Sheath
- Collection Currents and the Floating Potential
- Collection currents via OML theory
- Langmuir Probes
- Double Probes for Electric Field Measurement
- Ion Langmuir Probes Drift Meters
- Particle Detectors
- Plasma as a Dielectric, Plasma Oscillations
- Capacitance Probe Theory
- Antenna Impedance Theory
- Plasma Frequency Probes
- Magnetic field measurements
- Radiometric Quantities and Optical Detectors
- Instrumentation for Radiometry
- Ionospheric Sounders
- Ionospheric Radars

Faculty have produce a draft of
Textbook which is used in the course

MS in Space Systems Engineering

- **Goal:** To equip students to be technical leaders in the aerospace industry.
- **Joint effort between USU and SDL**
 - Some courses taught by SDL staff
- **Requirements: 30 credit hours**
- **Core courses: (12 credit hours)**
 - ECE 5230 Space System Engineering
 - ECE 6240 Space Environment and Engineering
 - ECE 5310 Dynamic Systems and Controls
 - MAE 5560 Dynamics of Space Flight



Space Systems Engineering - Electives

Space Environment, Instruments, Systems

ECE 5230 Space System Engineering
ECE 5220 Electro-Optical Engineering
ECE 6240 Space Environment and Engineering
ECE 7210 Spacecraft Instrumentation

Estimation Theory/Stochastic Processes

MAE/ECE 6560 Space Navigation (Spring)
MAE/ECE 7560 Adv. Est for Aerospace Systems (Fall)
ECE 6010 Stochastic Processes (Fall)
ECE 7030 Detection and Estimation

Controls

MAE/ECE 6340 Spacecraft Attit. Ctrl. - Theory (Fall)
MAE/ECE 6345 Spacecraft Attit. Ctrl. – Apps (Spring)
MAE/ECE 6320 Linear Multivariable Control (Fall)
MAE/ECE 7330 Nonlinear and Adaptive Controls (Spring)
MAE/ECE 5320 Mechatronics (Spring)
MAE/ECE 5310 Dynamic Systems and Controls (Fall)

Optimization

MAE 6570 Optimal Spacecraft Guidance (Spring)
MAE 5930 Optimization (Fall)
ECE 6040 Convex Optimization (Fall)

Aeronautics and Propulsion

MAE 5420 Compressible Fluids (Fall)
MAE 5540 Propulsion (Spring)
MAE 5500 Aerodynamics (Fall)
MAE 5510 Dynamics of Atmospheric Flight (Spring)
MAE 6530 Propulsion (Summer)

Dynamics

MAE 5560 Dynamics of Space Flight (Fall)
MAE 6540 Advanced Astrodynamics (Fall)
MAE 7540 Advanced Astrodynamics (Fall)

Graduate Level Math Courses

ECE 6030 Math Methods for Signals and Systems (Spring)
MATH 5410 Methods of Applied Mathematics

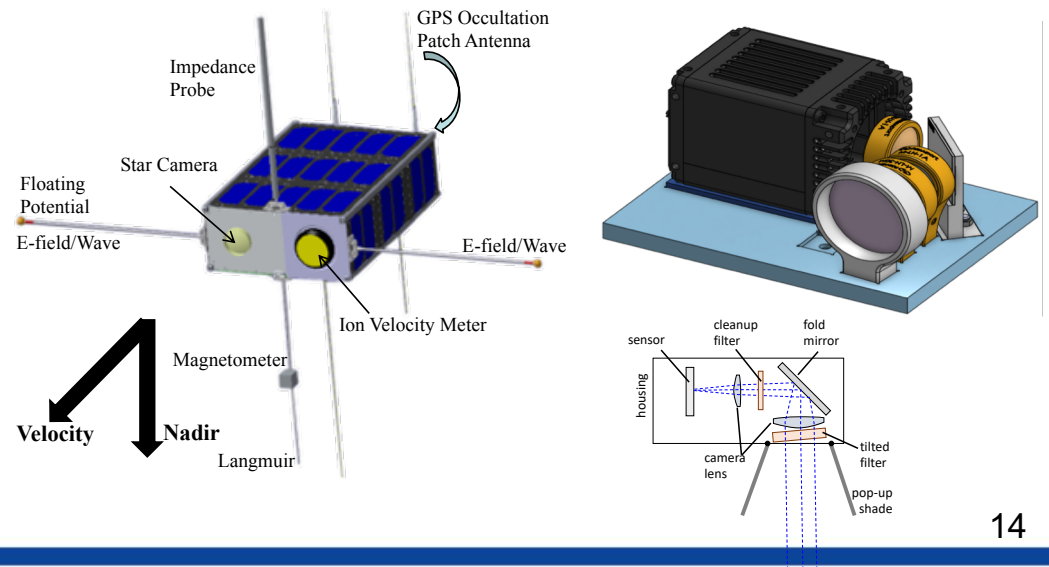
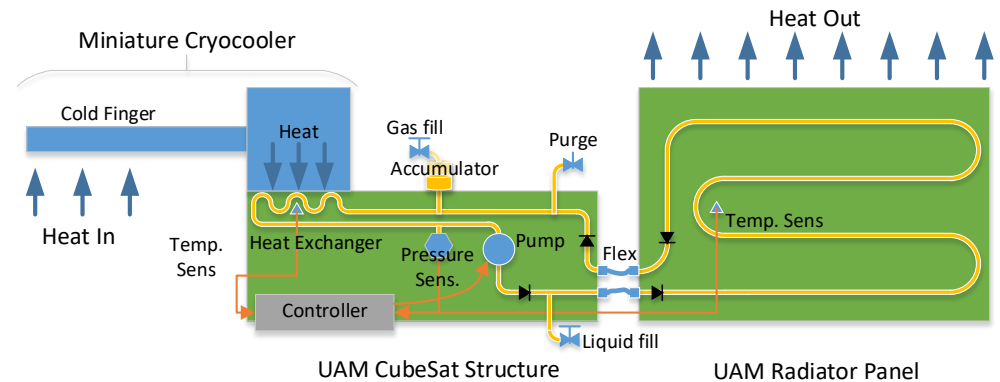
Center for Space Engineering

- **The Center for Space Engineering is a multi-disciplinary group of faculty who are principal investigators of programs with space applications.**
- **The Center's programs are basic university research and technology development involving faculty, students and professionals.**
- **Charles Swenson, Professor**
- **Ryan Davidson, Assistant Professor**
- **Alan Marchant, Research Professor**
- **Chad Fish, Research Associate**
- **Post Doc (Luke Anderson)**

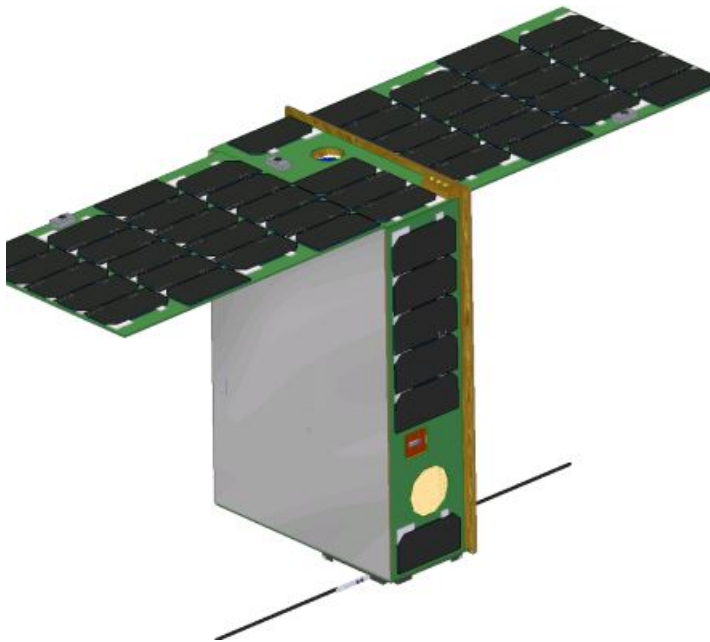


Current Research Programs

- **Active Cryo CubeSat and Active Thermal Architectures**
 - NASA STMD Funded
 - University Technology Partnership with JPL
 - How to get a miniature cryocooler to work in a 6U CubeSat
- **SPORT**
 - NASA SMD Heliophysics Funded
 - JOINT NASA-Brazil Space Weather CubeSat
- **FINIS**
 - USRA / USU / ASTRA funded
 - Instrument to Measure Methane in the Earths Atmosphere

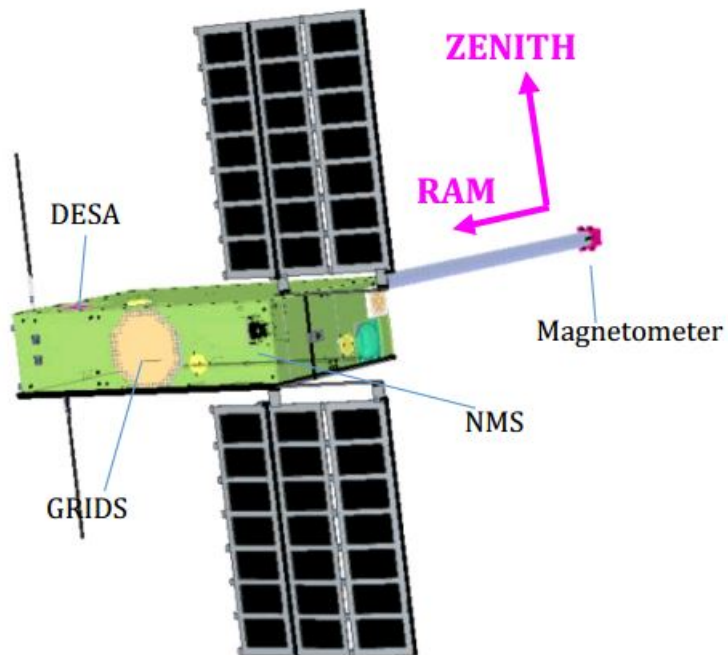


petitSat



- **NASA-sponsored CubeSat mission scheduled for launch in 2021**
- **Looking for links between plasma enhancements and waves in the neutral atmosphere**
- **USU providing one of two instruments (Gridded Retarding Ion Drift Sensor)**

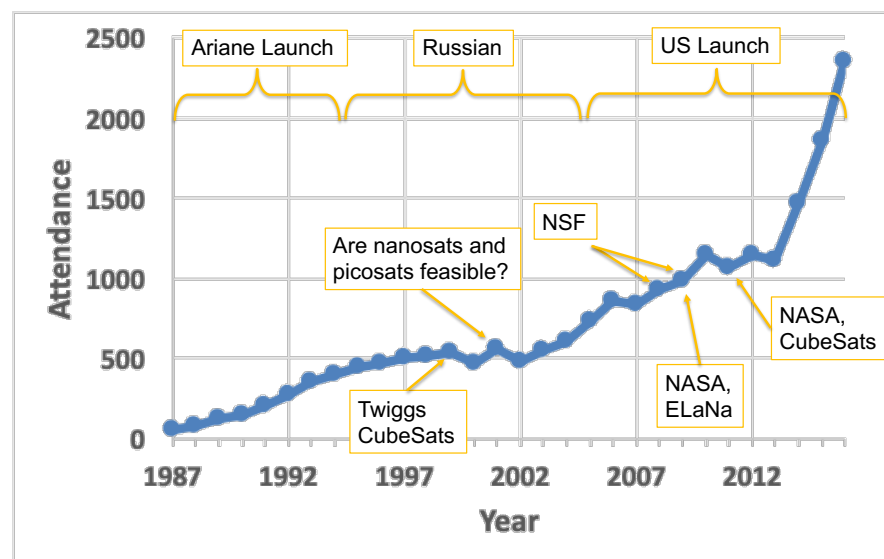
DIONE



- NASA-sponsored CubeSat currently in concept study
- Studying energy inputs in the high-latitude ionosphere and thermosphere
- USU providing the GRIDS sensor

USU Small Satellite Conference

- Conference in 34th Year
 - ~3000 attendance
- USU graduate students attend conference
- Small satellites are driving significant advances in space physics and Heliophysics



Questions

