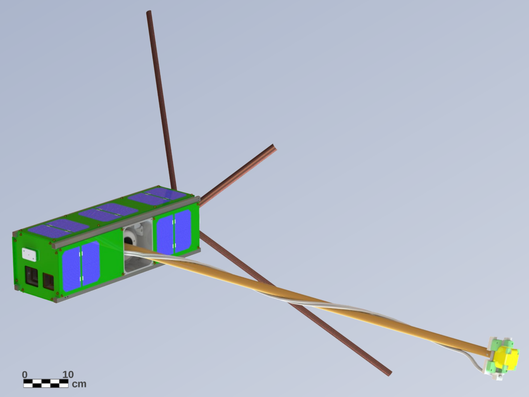


ELFIN

Electron Losses and Fields Investigation

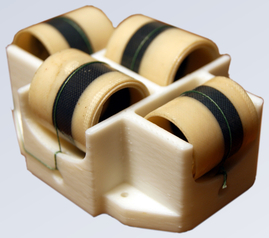
UCLA

THE AEROSPACE CORPORATION

Structures, Mechanisms, and Fabrication

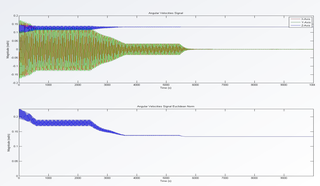
ELFIN's chassis is a modified C2B customized to use the stacer can and torquer coils as structural elements. Vibration simulations are conducted in SolidWorks. The spacecraft antennas are stowed, coiled in the P-POD 3U+ Plus “tuna can” volume.

All aluminum and plastic components of ELFIN are fabricated in-house, including the spacecraft chassis and Energetic Particle Detector shells. ELFIN uses a Haas TM-1 CNC mill, and directly export SolidWorks CAD files using the CAMWorks plugin.



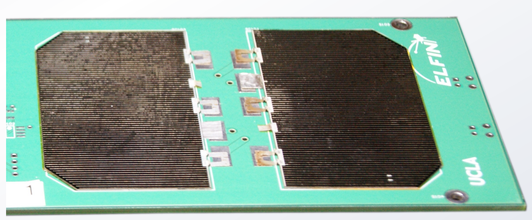
ADCS

Two torquer coils, comprised of aluminum wire on plastic spools, provide spin and precession capability to ELFIN. Periodic (daily/weekly) scheduled maneuvers are executed with these coils using onboard control laws and a magnetoresistive magnetometer. Coarse sun sensors and a fine sun sensor, as well as the fluxgate magnetometer, provide supplementary Data for ground based attitude determination.



Power

The magnetically clean solar panels contain 20 total UTJ cells that are arranged in opposing pairs and distributed along the 3U faces. The body mounted panels mean only some cells will be illuminated at a time for a given attitude. Two power boards, equipped with PIC microcontrollers, manage the four Lithium-ion batteries (18650 2.2Ah each) and provide +5V for the spacecraft bus.



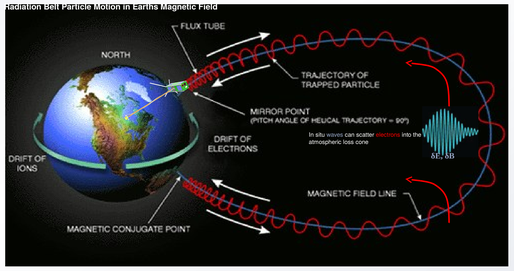
Mission Overview

ELFIN’s mission is to study the losses of relativistic electrons in Earth’s Van Allen radiation belts. It is a 3U+ CubeSat spin stabilized to approximately orbit normal. The science payload is comprised of two Energetic Particle Detectors and a Fluxgate Magnetometer on a 75cm stacer boom. ELFIN requires a high inclination (≥70°) orbit to observe electron behavior about Earth’s poles.

ELFIN is a participant in the NS-8 round of the AFRL’s University Nanosatellite Program and is funded by grants from NSF and NASA LCAS. Delivery is planned for Q3 2016. With a nominal mission life of six months, the spacecraft should be able to observe two electromagnetic storm events. ELFIN’s avionics are developed in collaboration with The Aerospace Corporation.

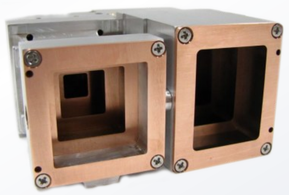
Science Overview

Charged particles from the Sun interact with Earth’s magnetic field and travel along field lines in a spiral or helical fashion, and the angle between a particle’s velocity vector and the direction of the field line is known as a pitch angle. Those that travel within a characteristic range of pitch angles, known as a loss cone, can collide with atmospheric particles and get lost in the atmosphere to create phenomenon such as auroras.



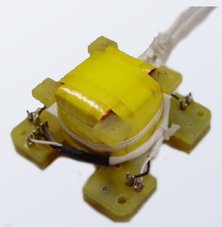
Particles sometimes come close enough to Earth such that the stronger magnetic field causes them to reverse direction, and particles that continuously oscillate due to these mirror points are said to be trapped and become highly energetic. When these trapped particles precipitate into the loss cone, damage towards critical assets can occur, ranging from single event upsets, losses of satellites, and even terrestrial blackouts.

Modeling suggests that equatorial electromagnetic ion cyclotron (EMIC) waves may be the primary cause of trapped electron losses, but the contribution from other effects have not been determined observationally. The ELFIN mission will address this contentious issue by determining whether electron losses bear the characteristic signatures of EMIC wave scattering.



Energetic Particle Detectors

Two Energetic Particle Detectors (EPDs) will resolve pitch angle distributions of charged particles in the loss cone of Earth’s radiation belts. One detector is dedicated to detecting electrons (EPD-E) and the other for ions (EPD-I). They are made of aluminum and tantalum, and their design was driven by Geant4 simulations.



Fluxgate Magnetometer

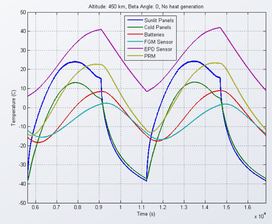
ELFIN’s Fluxgate Magnetometer (FGM) enables correlation of pitch angle information with energetic particle spectra by making 3-axis magnetic field measurements. Requirements for the FGM are shown in the tables below. UCLA has a long history with magnetometer design, and the FGM is based on a previously delivered magnetometer.

Detector	Energy Range	Energy Resolution	Field of View	Geometric Factor	Time Resolution	Flux
EPD-E	0.50 – 4.00 MeV	ΔE/E ≤ 50%	< 28°	0.100 cm^2•sr	24 sectors/spin	10^2 – 10^6 counts/(cm2•s•sr)
EPD-I	0.05 – 0.30 MeV	ΔE/E ≤ 50%	< 28°	0.005 cm^2•sr	24 sectors/spin	10^3 – 10^7 counts/(cm2•s•sr)

Magnetic Field Range	Relative Stability	Noise @ 0.1 Hz	Noise @ 1.0 Hz	Digitization	Orthogonality	Frequency Range (DC)	Sampling Rate
50,000 nT	0.5 nT/hr	0.2 nT/√Hz	0.1 nT/√Hz	>20 bits	< 1°	10 Hz	≥ 1 vector/s

Thermal

Passive thermal stabilization is particularly important for the Energetic Particle Detectors, the Fluxgate Magnetometer sensor, and Li-ion batteries. The FGM sensor is thermally stabilized with MLI blankets, and overall heat input into the spacecraft will be reduced with aluminized Kapton. In addition to an in-house MATLAB simulation, ELFIN is beginning to use Thermal Desktop for validation and improved fidelity.



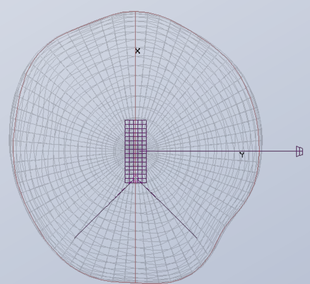
Command and Data Handling

The Flight Computer monitors the satellite, collects housekeeping data, executes scheduled tasks, and commands the Watchdog, ADCS Main PIC, two Power PICs, and radio. The Watchdog provides a layer of redundancy by heartbeating the flight computer and conducting scheduled resets of the entire spacecraft.

Communications

ELFIN has applied for allocation as amateur experimental:
- 19k2 GFSK UHF downlink and international beacons
- 9k6 VHF uplink

An Astrodev He-82 (modified form factor of the He-100) transmits and receives using two bent dipoles antennas deployed out of the 3U+ "tuna can" volume. These elements are made from magnetically clean fiberglass tape springs (with Beryllium copper Inlays).



Earth Station

UCLA's primary Earth Station uses:
- Quad array 436CP42UG cross polarized UHF Yagis
- Dual array 2MCP22 cross polarized VHF yagis
- RAS-1 rotor with Arduino/LSM303 based controller
- Icom IC-910H, soundmodem

An additional high gain OSCAR station at Worcester Polytechnic Institute (Ma) completes ELFIN's data volume and provides geographic diversity.