Radio Frequency Sensor (RFS)

Overview and science goals

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Managed by Triad National Security, LLC for the U.S. Department of Energy's NNSA

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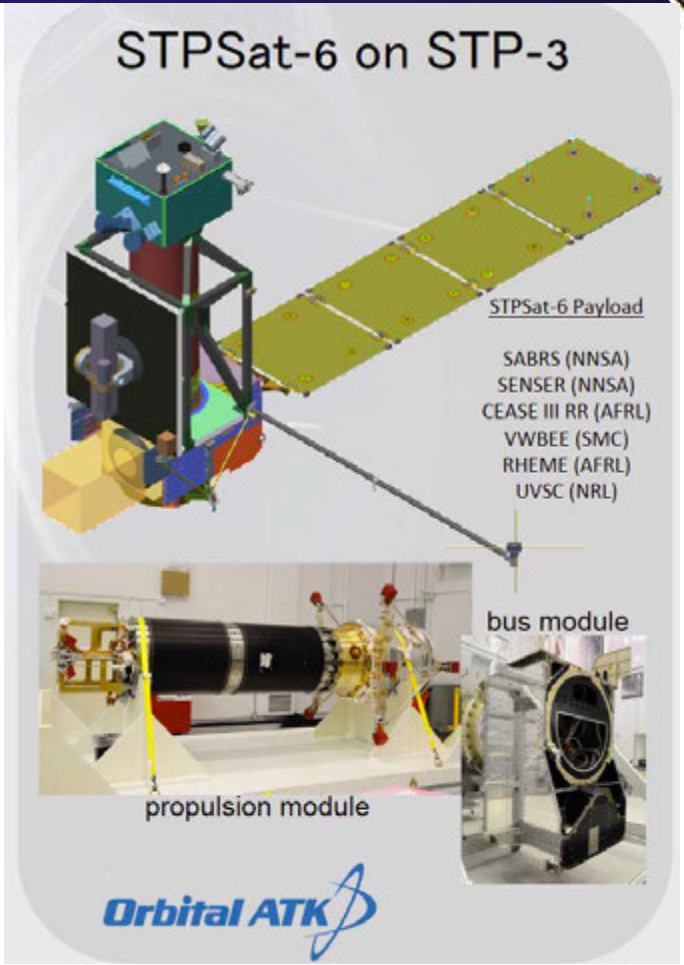
SENSER payload on board STPSat-6

- R&D experiment for NNSA
- Sensor development: LANL and SNL
- DoD Space Test Program supported vehicle integration, launch, data distribution
- Planned launch – Early 2021
- Geosynchronous orbit in western hemisphere slot



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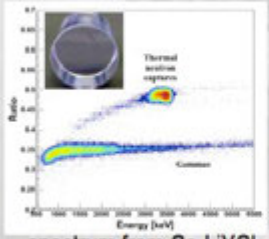
Sandia National Laboratories

NNSA National Nuclear Security Administration

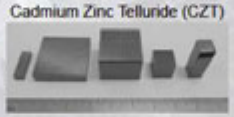
SENSER payload – led by LANL

Hard Radiation Experiment (HRE)

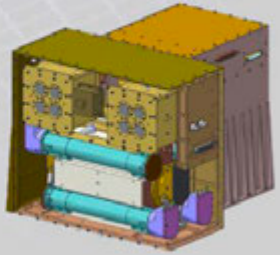


spectrum from Cs_2LiYCl_6

Cadmium Zinc Telluride (CZT)

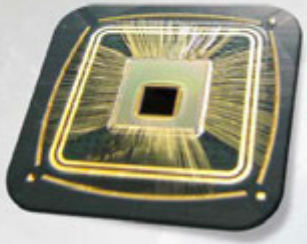


high-speed PG

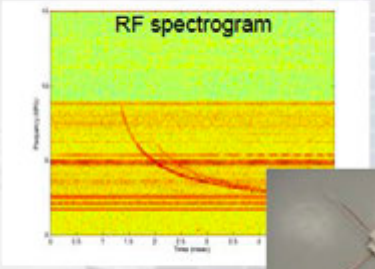


Risk-Reduction Optical Experiment (RROE)

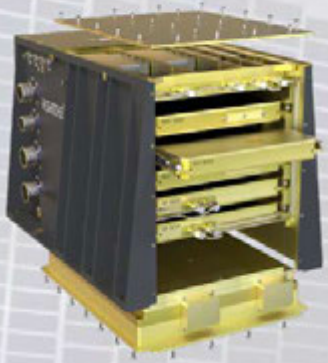
HTSP3 prototype of GBD III' SIGHTS FPA



Radio-Frequency Sensor (RFS) Experiment



RFS active antenna



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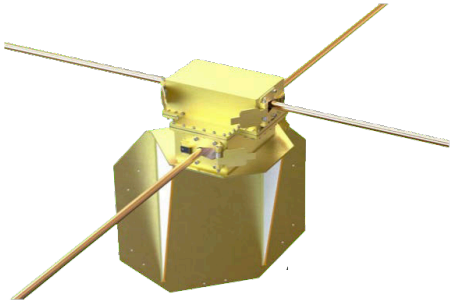
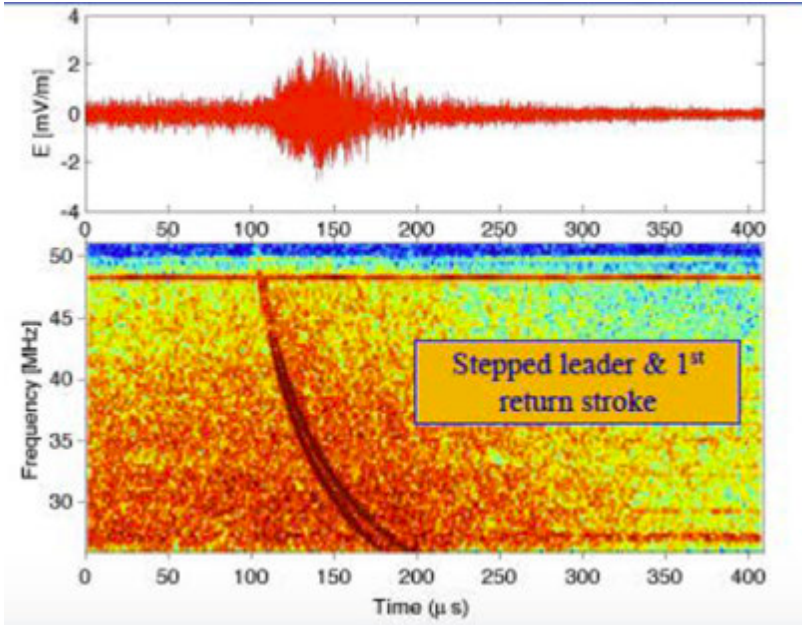
Radio Frequency Sensor : RF Lightning detection at GEO

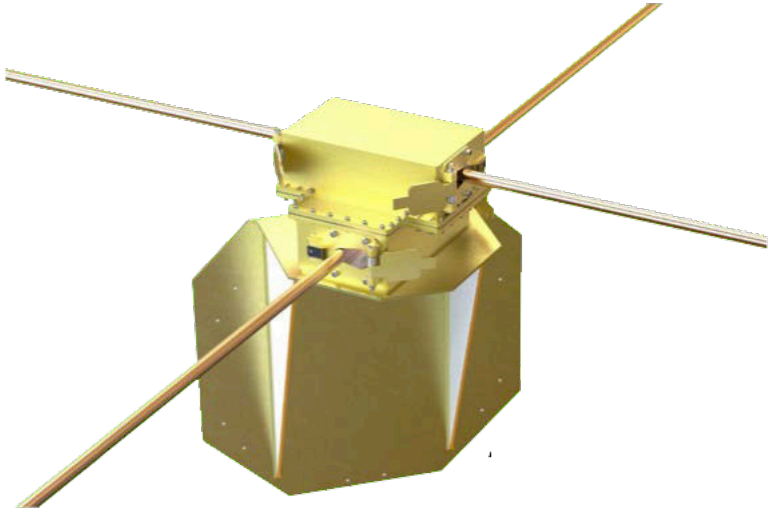
- First time for RF lightning detection in GEO
- Trigger on radio frequency transients from lightning
- Send full polarized waveform information to ground



Example lightning from FORTE



Radio Frequency Sensor : RF Lightning detection at GEO



RFS Antenna
(conceptual rendering)

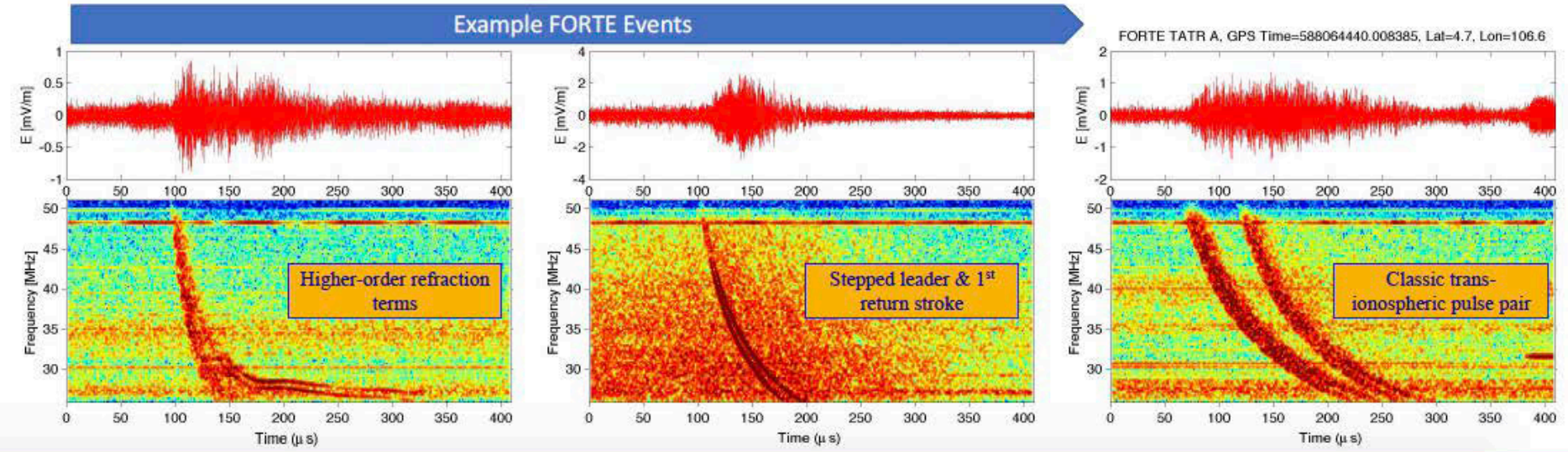
- Crossed dipoles
- Active antenna amplifier board to cover frequency range from HF to UHF
- Waveforms of both polarizations (H & V) can be transmitted to ground
- Ionospheric propagation modes can be reconstructed on ground

RFS introduction

RFS Main Unit *(conceptual rendering)*

- Main electronics
- Front-end filtering
- Event triggering
- Payload processing
- SV command processing and telemetry generation
- Direct-conversion receiver
- Software-defined radio: FFT & manual triggering available
- Two bands (10s of MHz of bandwidth each):
  - HF/VHF
  - VHF or UHF (selectable)
  - Cross band triggering

Examples of lightning in the RF



Data products planned for unclassified release

- Normalized voltage waveform
- Normalized power envelope
- Normalized power spectra, spectrogram
- Total electron content estimate
- Event rates
- Event time tags: precision TBD
- Polarization information

Science goals

- Unique opportunity at GEO orbit – first time RF sensor will detect lightning at GEO.
  - Persistent hemisphere scale monitoring of thunderstorms – storm evolution
  - Large-scale and seasonal total lightning RF climatology compared with optical climatology from GLM & RROE
  - Natural signal background, noise background

- Use of polarization information for:
  - Unwind phase through ionosphere to get polarization at source
  - Coarse single-satellite geolocation capability

Science questions

- How do RF signatures evolve over the duration of a storm?
- How does RF event evolution compare to optical event evolution?
- Using simultaneous LMA measurements, can we determine cloud electrification conditions necessary for certain RF signatures?
- What is the average RF frequency spectrum of lightning? Does this vary by type of storm?
- Evolution of storms with high rates of NBEs?
- What is the RF signature at GEO of lightning associated with TGFs? Can RFS detect VHF signatures from TGFs?
- What is the Earth's natural noise background?

Collaboration

- Which ground-based datasets would be most helpful in addressing these science questions?
- What other science questions would you like to try to answer in collaboration with RFS lightning measurements?

Abstract

- The Radio Frequency Sensor (RFS) is a specialized software-defined radio and direct conversion receiver and signal processor that detects, records, and reports impulsive broadband radio-frequency (RF) signatures from its actively amplified crossed-dipole sensing antenna. The linear feeds from each dipole feed into the direct-conversion software-defined radio. RFS operates simultaneously in two different detection bands in the HF, VHF, and UHF frequency domain. Its viewpoint from a Western hemisphere geosynchronous orbit will provide novel opportunities to study RF evolution of lightning signatures over the duration of a storm. The overlapping view with the Global Lightning Mappers (GOES-16 & 17) will enable additional study of optical/RF comparisons. The low frequency range in the low band encompasses the ionospheric maximum plasma frequency, allowing for interesting studies of RF propagation and cutoff through the ionosphere.