Space based instruments

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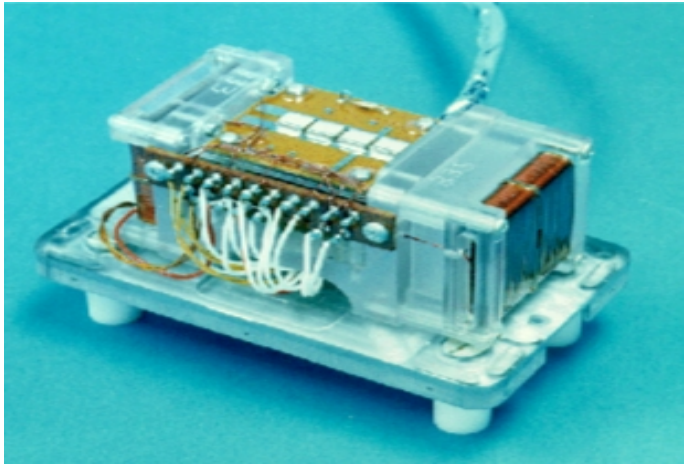
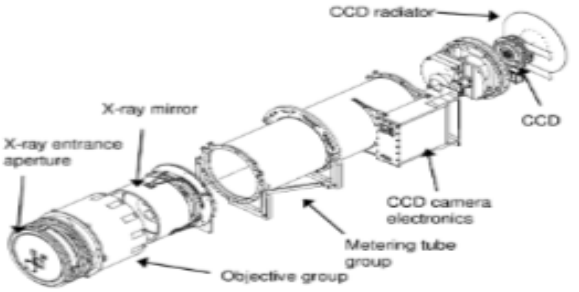
Magnetometers

- Satellite mounted magnetometers are the most common space-based scientific instruments
- They are used to study magnetic fields of planetary bodies, the interplanetary magnetic field, as well as for navigation and attitude control
- Useful for remote sensing of interiors of planetary bodies
- Long booms are often utilized to place the magnetometer outside of the spacecraft main body due to measurement contamination issues
- WIND satellite MFI fluxgate magnetometer



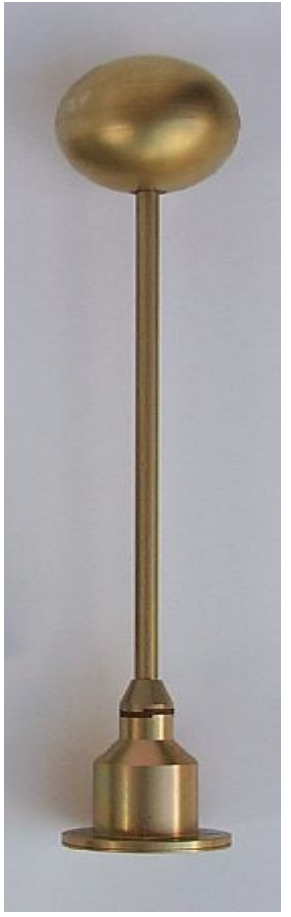
X-ray instruments

- Röntgen radiation telescopes are used to study the solar surface and different active phenomena
- Wavelengths from 10 – 0.01 nm
- Satellite mounted to avoid the Earth's atmosphere
- Highly useful for study of active solar phenomena, the basis of space weather activity
- GOES N Solar X-ray Imager depicted



Plasma instruments

- Plasma instruments are used to measure different parameters of space-born plasma, such as ion density, temperature and velocities
- Langmuir probes are the most common type
- They are essentially conductors with a bias voltage, which is varied and the current collected is measured as function of the voltage
- This relationship provides different plasma parameters
- Rosetta Langmuir probe depicted



Mass spectrometers

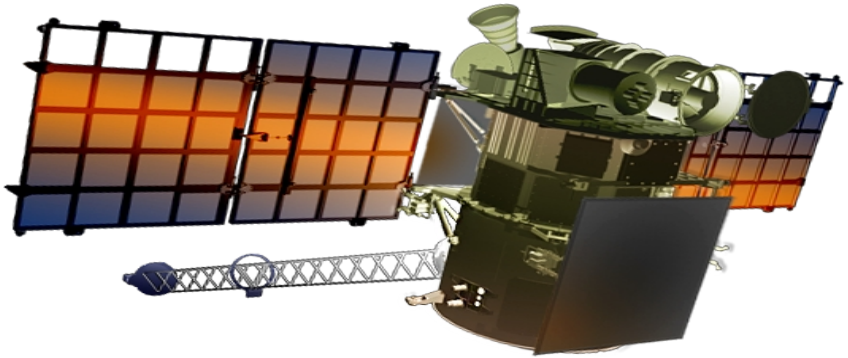
- Mass spectrometers determine the mass of atoms or molecules in a sample
- This can be used to produce a spectrum of masses of the particles in a given sample
- This is used to study solar wind conditions with satellites positioned *in situ*
- ACE Solar Isotope Spectrometer depicted

Advanced Composition Explorer (ACE)

- Most important space weather satellite of the last two decades
- Forward deployed to Lagrangian point L1 in a Lissajous orbit
- Provides crucial *in situ* solar wind and IMF measurements
- Numerous instruments, including magnetometer, several spectrometers and particle analyzers
- Data available real-time
- Planned lifetime of 5 years, now pushing 20 and still going strong
- Followed by Deep Space Climate Observatory (DSCOVR)

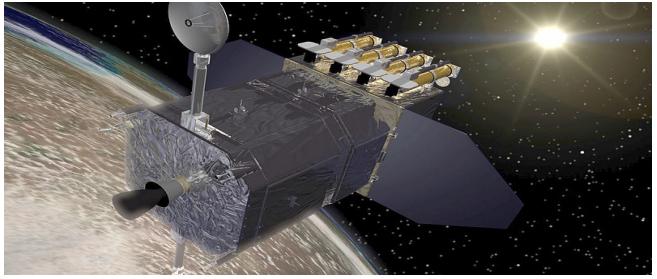
Deep Space Climate Observatory (DSCOVR)

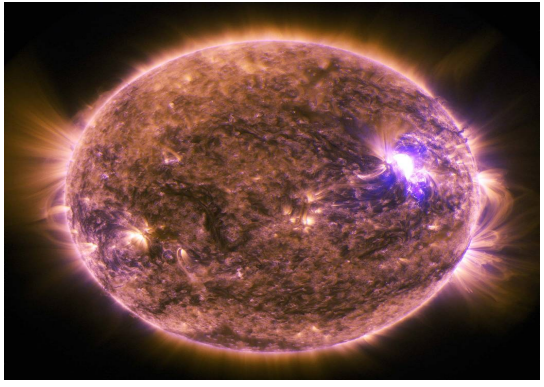
- Solar wind as well as Earth observation packages, also deployed to L1 in a Lissajous orbit
- Construction finished in late 1990s but kept in storage until launch in 2015
- PlasMag for measurements of solar wind parameters, consisting of a magnetometer, Faraday cup and an electrostatic analyzer
- The default source for NOAA SWPC (National Oceanic and Atmospheric Administration Space Weather Prediction Center) real time solar wind data



Solar Dynamics Observatory SDO

- L1 positioned solar observatory satellite mission
- Main focus is on studies of the Sun’s magnetic field and its structure and origin
- Furthermore provides high quality solar images in numerous different wavelengths for space weather prediction
- Launched in 2010, mission duration 5 to 10 years





Space weather services

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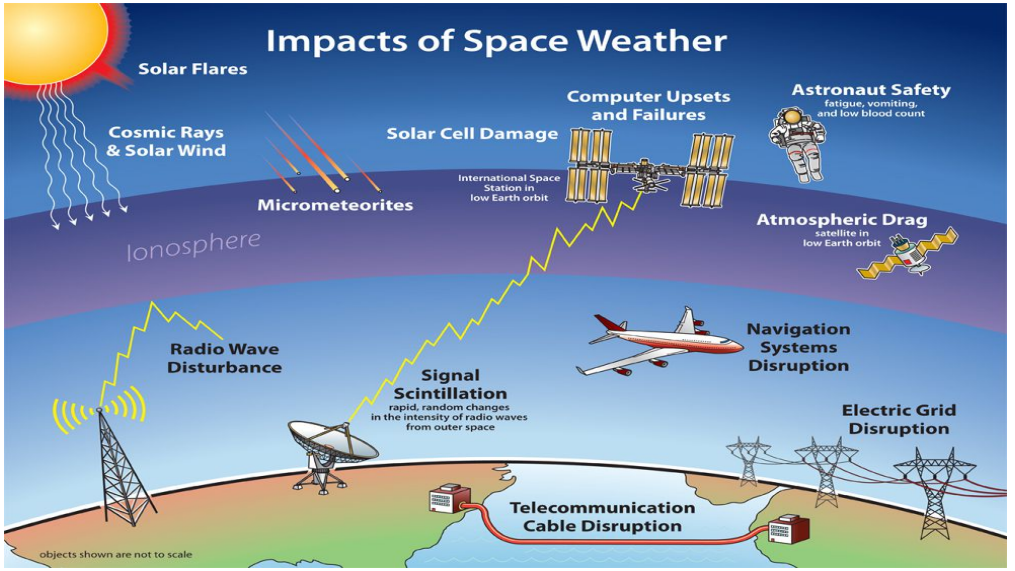
Where are space weather services utilized?

- Clients include power grid operators, power companies, oil and gas pipeline operators, oil drilling
- Transportation services such as airline companies affected by increased radiation dosage on polar flights
- Shipping companies affected by disruptions in radio communication
- Military communication also affected by radio disruptions
- Tourists in polar areas interested in occurrence of auroras
- Satellite operators



NOAA Space Weather Prediction Center

- Part of US government National Oceanic and Atmospheric Administration
- Official source for US Government concerning space weather alerts and warnings
- Provides reports of near-Earth situation, numerous data sources and simulations available
- NOAA Space Weather Scales *de facto* standard used worldwide
- https://www.swpc.noaa.gov/

Finnish Meteorological Institute

- Space weather forecasting provided by FMI (Finnish Meteorological Institute)
- Aurora prediction based upon magnetic field measurements obtained from IMAGE magnetometers, as well as general description of the current space weather situation
- Auroras now! Service also available for auroras
- https://twitter.com/FMIspace

Company introduction: Aurora Propulsion Technologies

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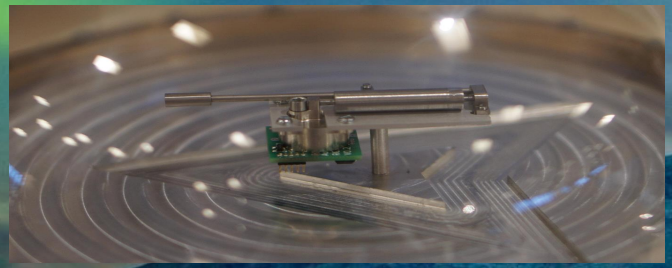
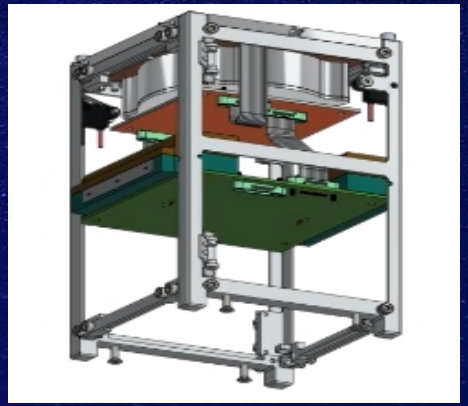
Aurora Propulsion technologies

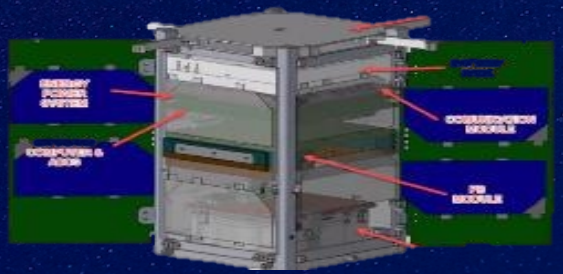
- We are a Finnish space technology company specializing in SmallSatellite attitude control, propulsion and deorbiting solutions
- Wide range of expertise from micromechanics to space technology and space physics
- Notable products include very small resistojet thrusters, the plasma brake deorbiting solution as well as the electric solar wind sail



AuroraSat-1

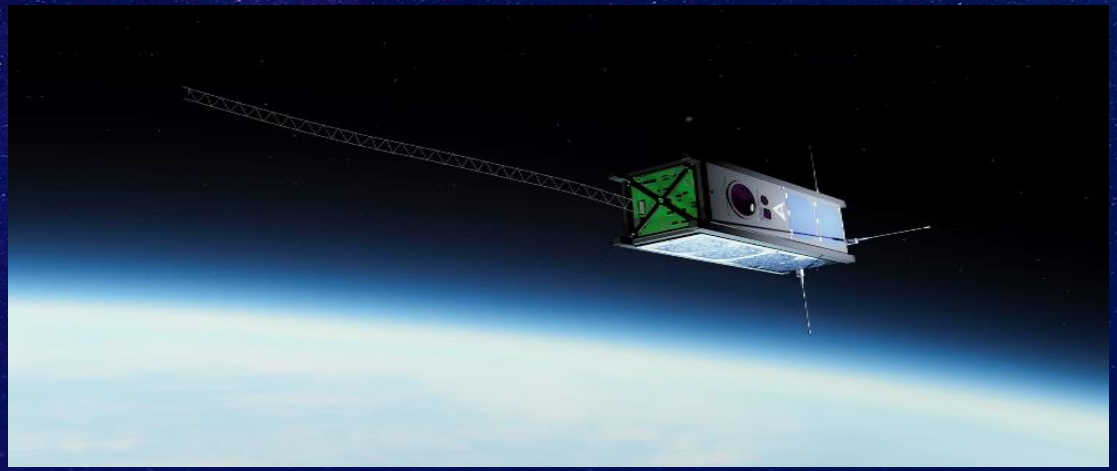
- We are launching our In-orbit-demonstration mission AuroraSat-1 in ANNOUNCEMENT COMING SOON to showcase our products and raise Technology Readiness Levels (TRLs) selected technologies
- AuroraSat-1 is 1.5 U CubeSat, the main payloads are two plasma brake tethers and a resistojet system for attitude control
- This is the third attempt to test the plasma brake technology in orbit





Plasma brake

- The plasma brake is a novel propellantless deorbiting technology
- It utilizes Coulomb Drag, to generate a deorbiting force from charged particles hitting a long charged tether deployed outward from the satellite
- Especially effective in orbits above approximately 400 km, where air drag is not very effective as a deorbiting force

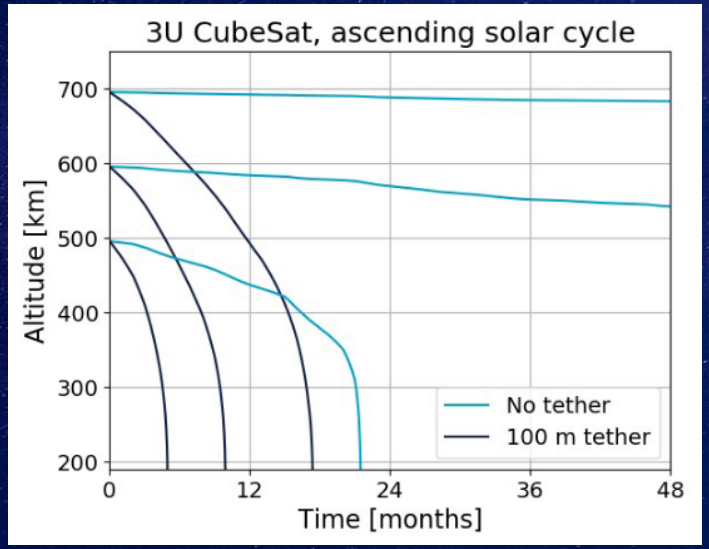


Satellite deorbiting simulations

- To calculate the effectiveness of our deorbiting solutions, detailed calculations for satellite deorbiting need to be conducted
- Our current model simulates satellite orbital motion in one second resolution by incorporating gravity, air drag and plasma brake Coulomb drag
- Atmospheric density and plasma density are obtained from IRI2016 and NRMLSISE atmospheric models, atmosphere is segmented in

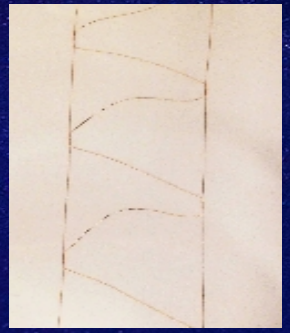
Satellite deorbiting simulations

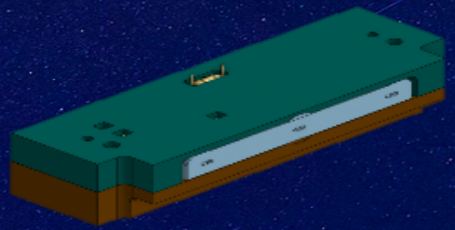
- Historical data is used to account for realistic solar cycle effects, diurnal variation is accounted for with solar angle calculations and separate values for day and night side
- Very long duration mission analysis is possible, achieving realistic simulations of long duration deorbiting cases
- Can account for any satellite sizes, mass affects gravity and satellite cross sectional area affects air drag effectiveness



Plasma brake

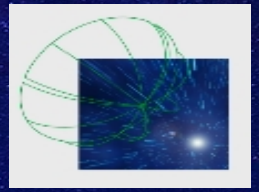
- System consists of a reel motor and a very thin microtether with a small end mass
- Total system mass is in the range of grams, depending on exact tether setup
- Total deorbit time depends on several parameters, mainly orbit and mass of satellite, along with solar cycle phase
- It is a spin-off from the electric solar wind sail (e-sail)

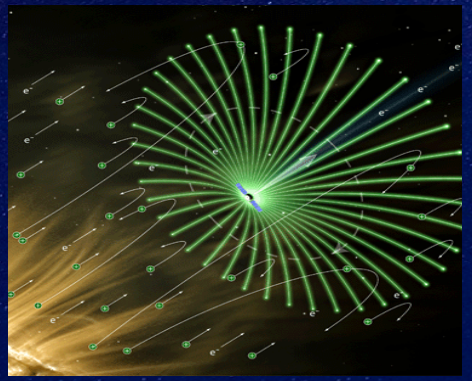




Electric solar wind sail

- The e-sail is a spacecraft propulsion technology utilizing solar wind to generate thrust, without the need for propellant
- The system consists of several kilometers long thin wires
- Not yet currently tested in orbit, but extensive research conducted on the subject
- Not to be confused with the solar sail





The North Star Mission

- We are preparing the North Star Mission as a test case for the e-sail technology
- The target is to perform a solar system exit in the timescale of 10 years, preceded by a boost to achieve required velocity
- Would allow measurements of the solar wind above the Sun’s northern poles, a previously unexplored region
- The mission is currently in the early Feasibility Study phase, with initial planning being showcased at several conferences

Thank you for listening!

Any questions?