Space Weather with Cube Satellites in Canada: The Experimental Albertan Satellite #1 (Ex-Alta 1), the Canadian Cubesat Program, and beyond.

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Thanks to the whole Ex-Alta-1 team

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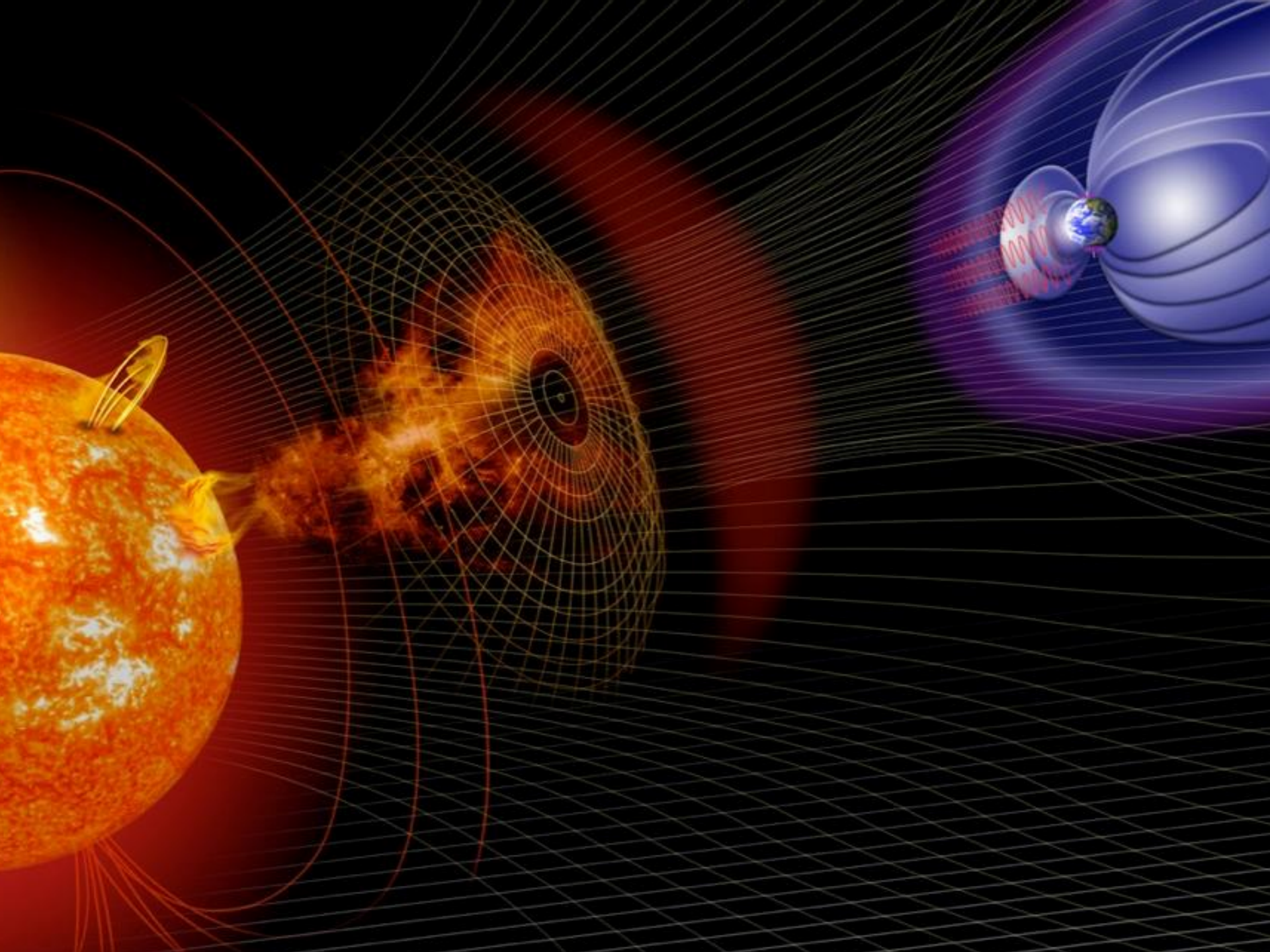

Space Physics

- Fundamental plasma physics with universal application, including to fusion plasmas, astrophysical plasma systems, and space weather.

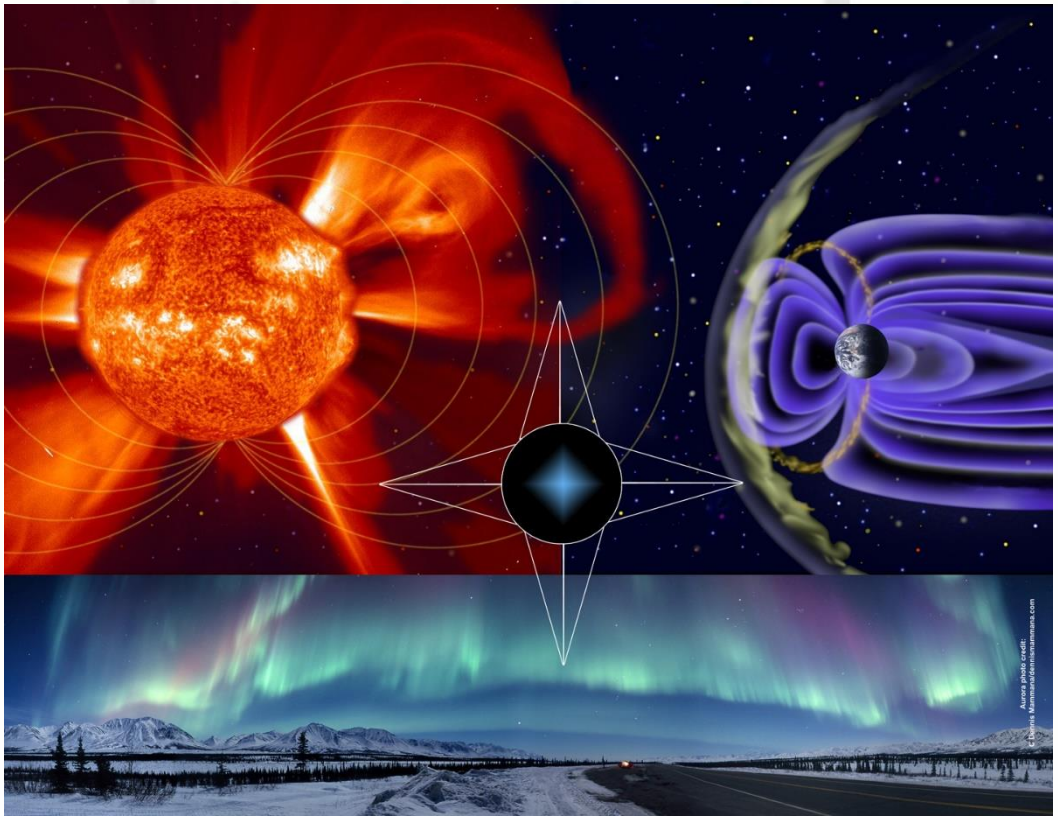

Image courtesy of NASA.

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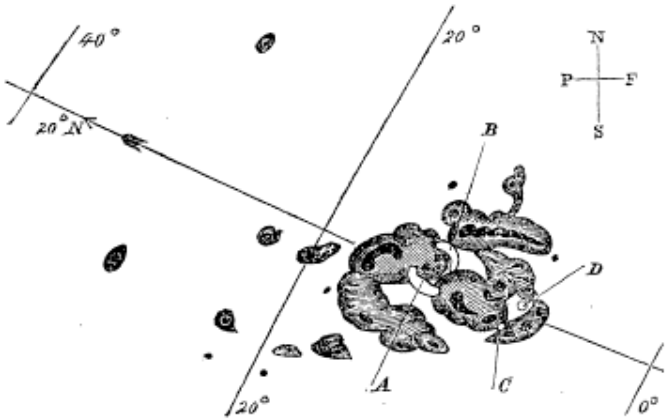
Solar flaring and the connection to geospace: discovered in 1859

On a curious Appearance seen in the Sun.
By R. Hodgson, Esq.

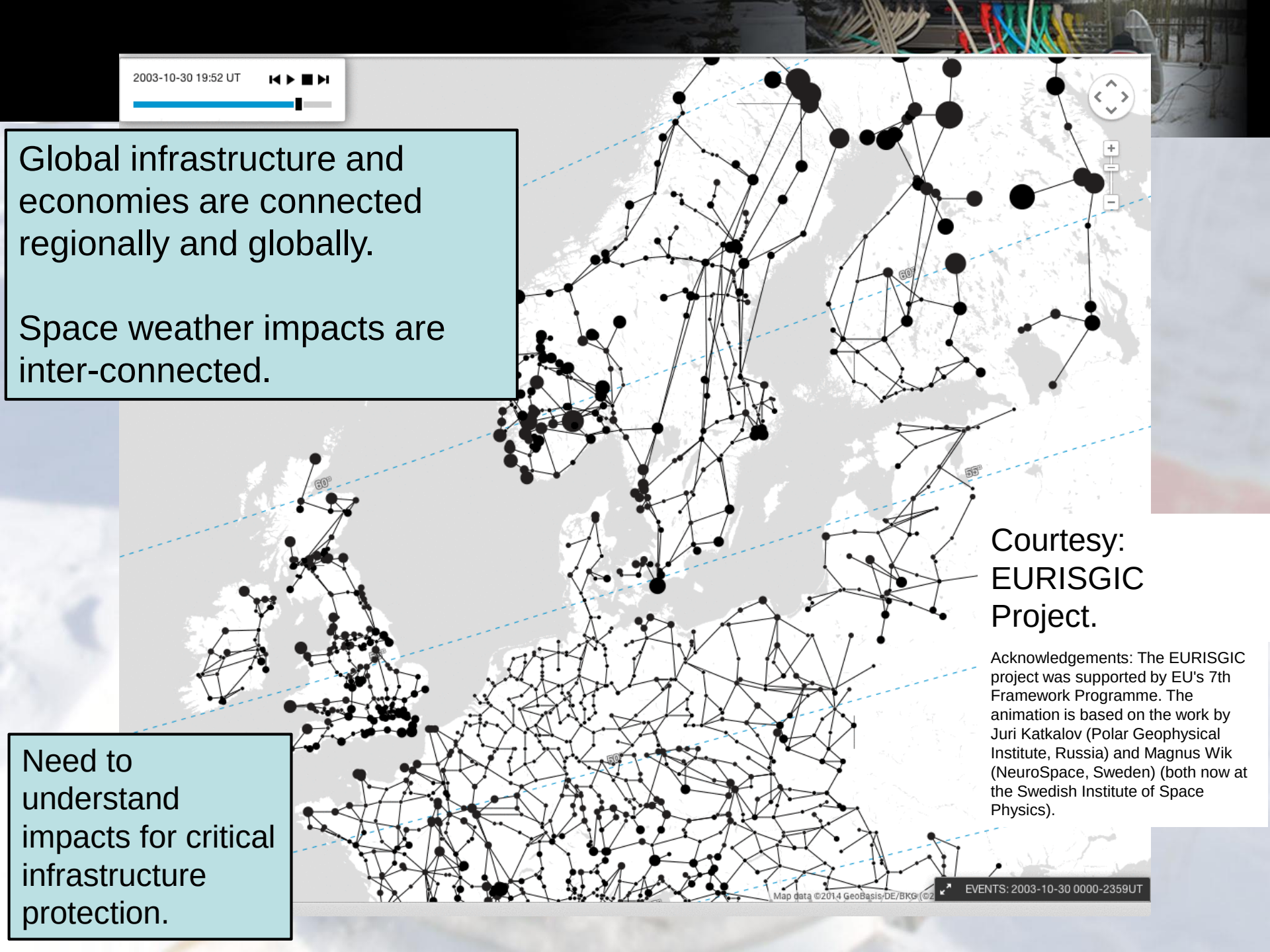
"While observing a group of solar spots on the 1st September, I was suddenly surprised at the appearance of a very brilliant star of light, much brighter than the sun's surface, most dazzling to the protected eye, illuminating the upper edges of the adjacent spots and streaks, not unlike in effect the edging of the clouds at sunset; the rays extended in all directions; and ng brilliancy of the ge telescope with s, and disappeared pe used, an equa-

Description of a Singular Appearance seen in the Sun on September 1, 1859. By R. C. Carrington, Esq.

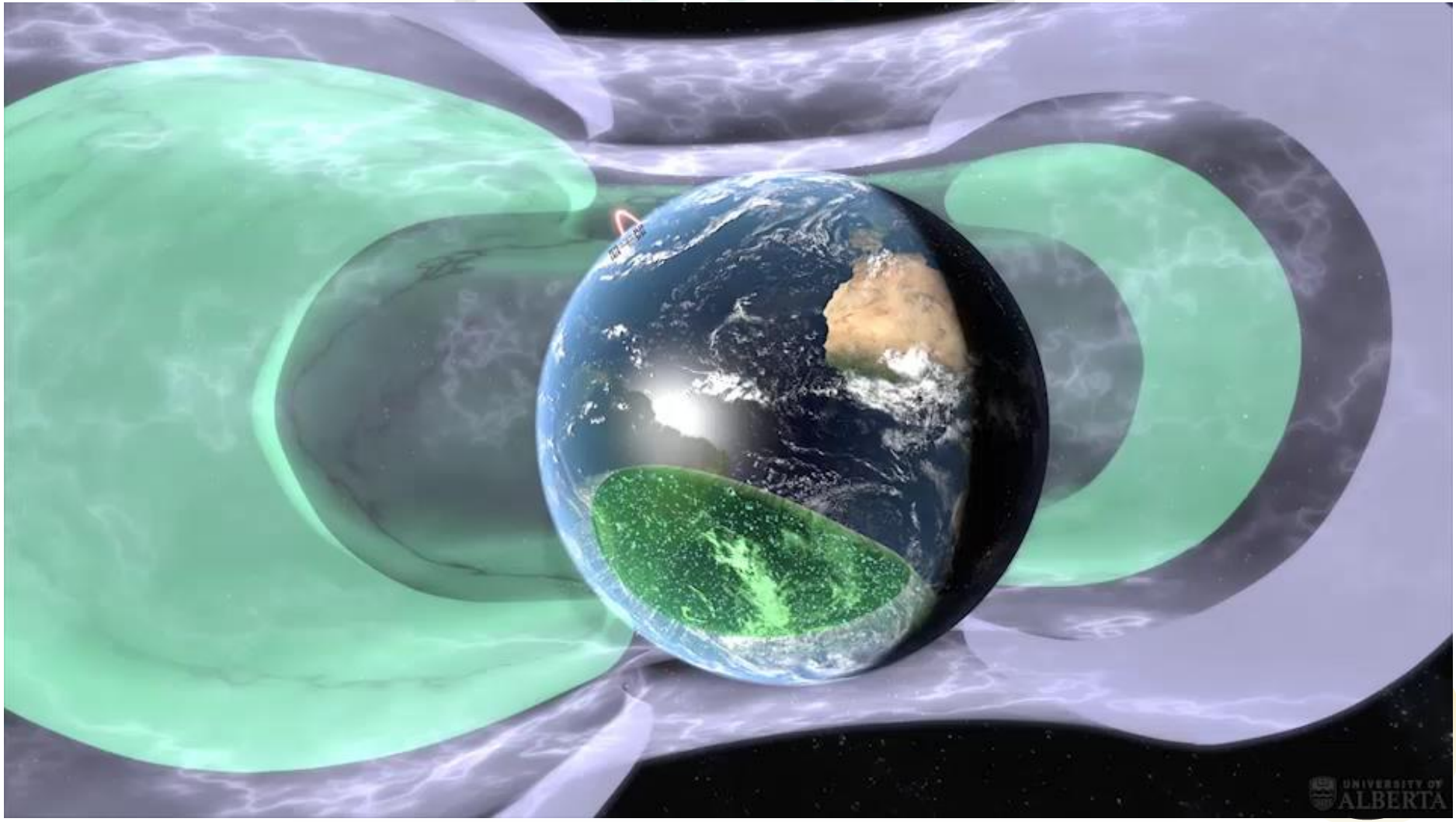
While engaged in the forenoon of Thursday, Sept. 1, in taking my customary observation of the forms and positions of the solar spots, an appearance was witnessed which I believe to be exceedingly rare. The image of the sun's disk was, as usual with me, projected on to a plate of glass coated with distemper of a pale straw colour, and at a distance and under a power which presented a picture of about 11 inches diameter. I had secured diagrams of all the groups and detached spots, and was engaged at the time in counting from a chronometer and recording the contacts of the spots with the cross-wires used in the observation, when within the area of the great north group (the size of which had previously excited general remark), two patches of intensely bright and white light broke out, in the positions indicated in the appended diagram by the letters A and B, and of the forms of the spaces left white. My



first impression was that by some chance a ray of light had penetrated a hole in the screen attached to the object-glass, by

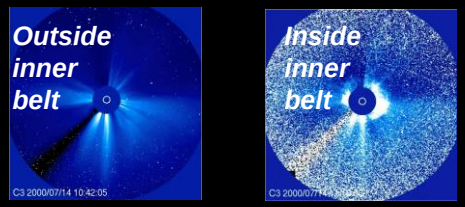

2003-10-30 19:52 UT
Global infrastructure and economies are connected regionally and globally.
Space weather impacts are inter-connected.
Need to understand impacts for critical infrastructure protection.
Courtesy: EURISGIC Project.
Acknowledgements: The EURISGIC project was supported by EU's 7th Framework Programme. The animation is based on the work by Juri Katkalov (Polar Geophysical Institute, Russia) and Magnus Wik (NeuroSpace, Sweden) (both now at the Swedish Institute of Space Physics).
EVENTS: 2003-10-30 0000-2359UT

Radiation Belts and South Atlantic Anomaly



Space Environment Hazards

False stars in star tracker CCDs



Surface degradation from radiation

Solar array power decrease due to radiation damage

Electronics degrade due to total radiation dose

Solar array arc discharge

Single event effects in microelectronics: bit flips, fatal latch-ups

1101 ⇒ 0101

Spacecraft components become radioactive

Electromagnetic pulse from vehicle discharge

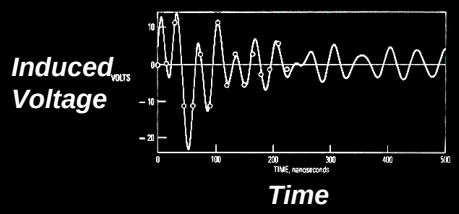


Figure courtesy of Joe Mazur, The Aerospace Corporation

THE AEROSPACE CORPORATION

The Experimental Albertan Satellite #1 (Ex-Alta-1)

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Review the Ex-Alta 1 and AlbertaSat story on YouTube!

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QB50 Mission

The Experimental Albertan Satellite #1

Ex-Alta 1

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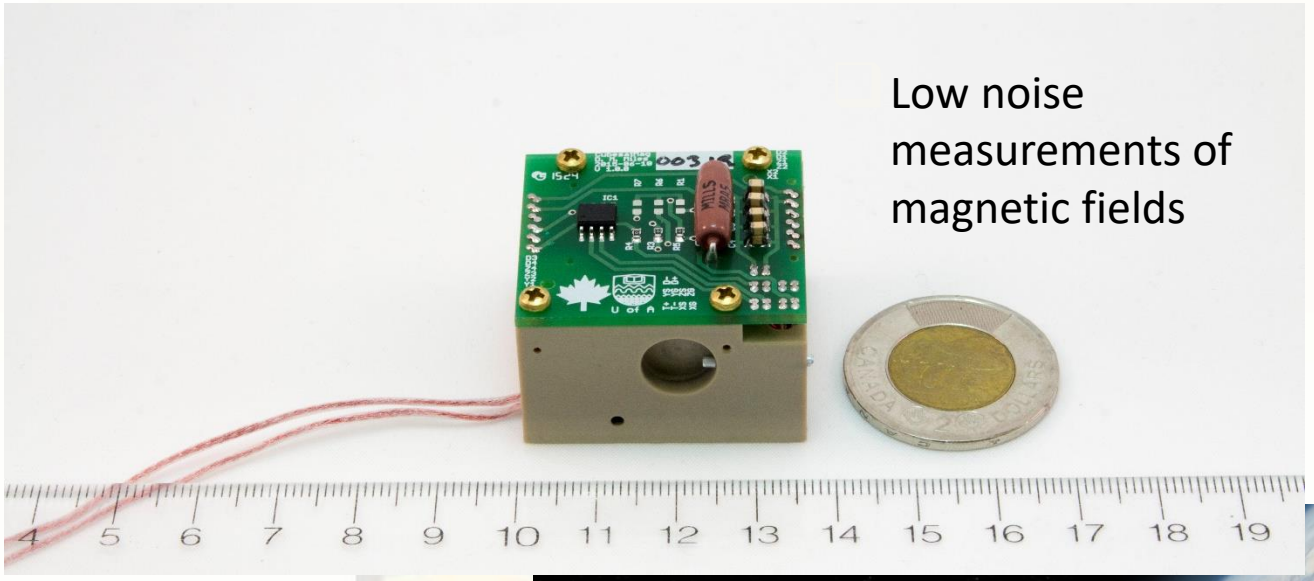
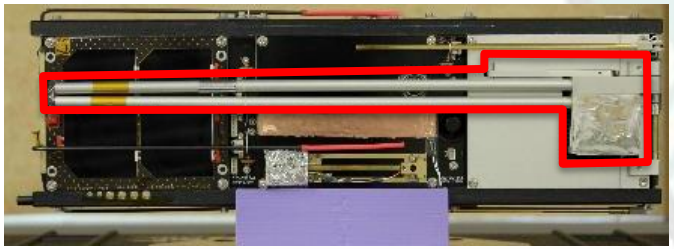
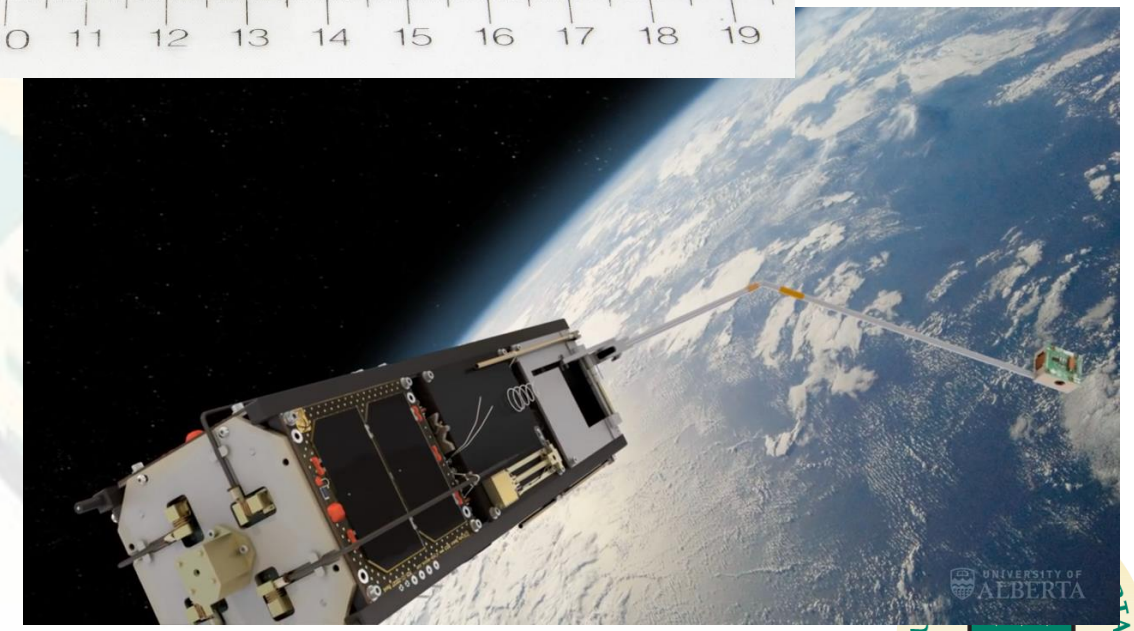
Payloads: Digital Fluxgate Mag. (DFGM)







Magnetometer at end of 60cm boom to minimize magnetic interference

Video courtesy of Andy Kale

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Payloads: Multi-Needle Langmuir Probe (MNLP)

Provides high time resolution measurements of electron density and temperature

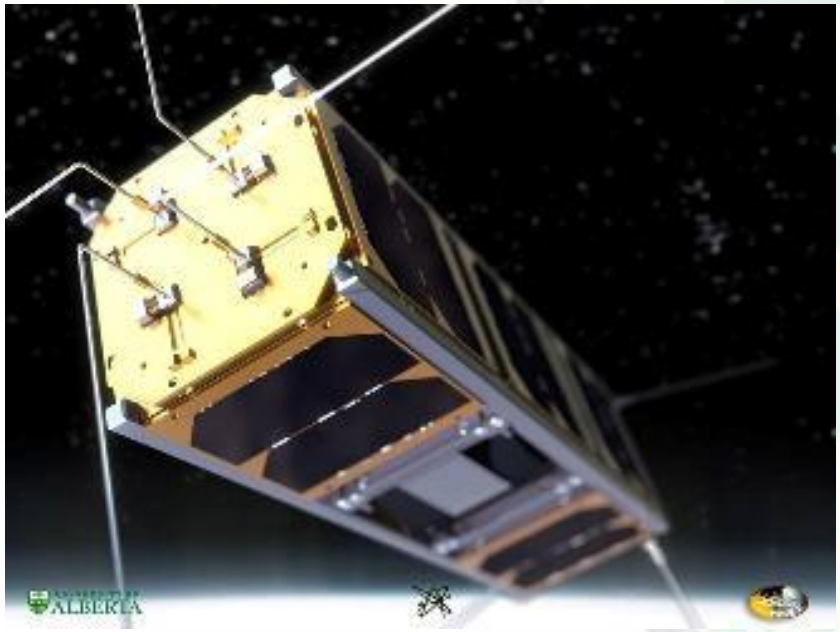

Image courtesy of Andy Kale

University of Oslo instrument

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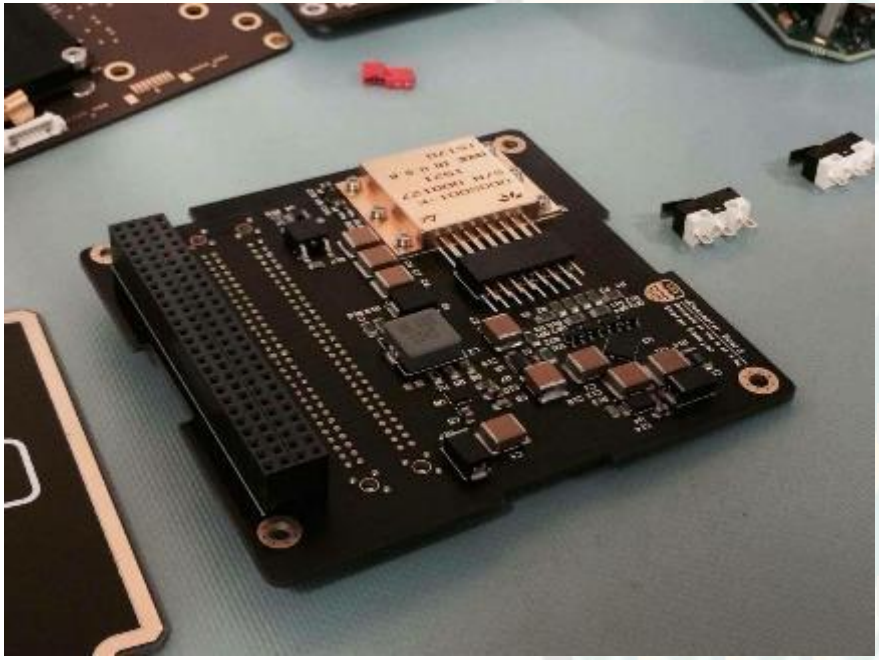
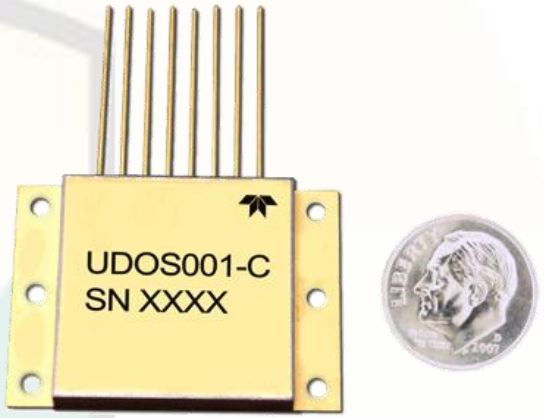
Payloads: Teledyne Radiation Dosimeter





Commercial non-ITAR part. Flew to moon on NASA LADEE mission

Enables routine monitoring of spacecraft radiation environment.

Assessment of dose as a function to time; impacts from South Atlantic Anomaly.

Assess on-board anomalies?

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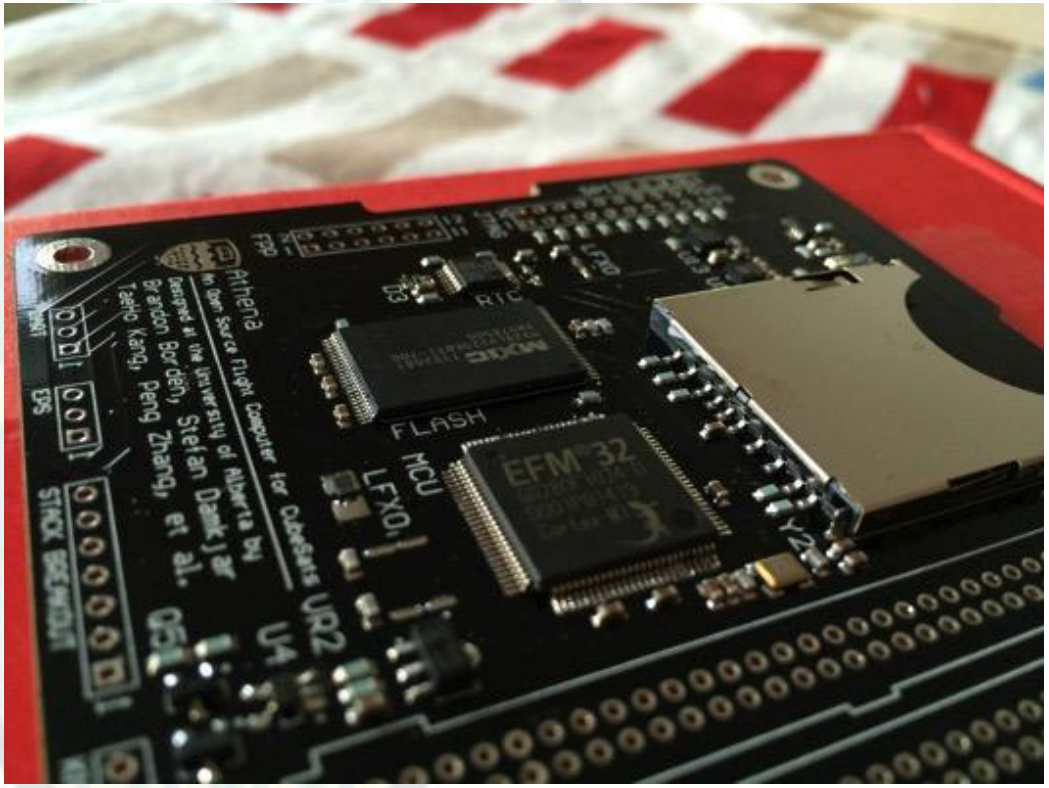
Payloads: Athena Open Source On-Board Computer (OBC)

- Goal: to create an open source suite of U of A cubesat subsystems
- Opportunity for student-led hardware and software development
- A second iteration of this board will fly on Ex-Alta 2.



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A Multidisciplinary Student Team

Mostly undergraduate students!

Photography by John Ulan

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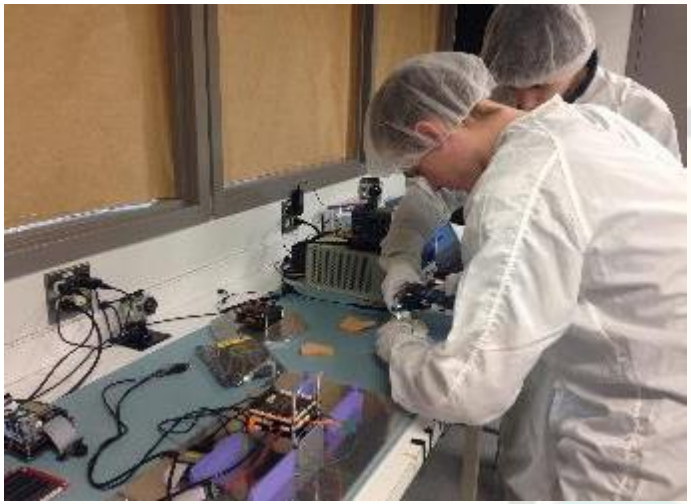
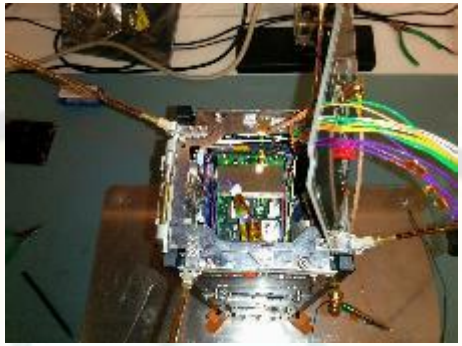

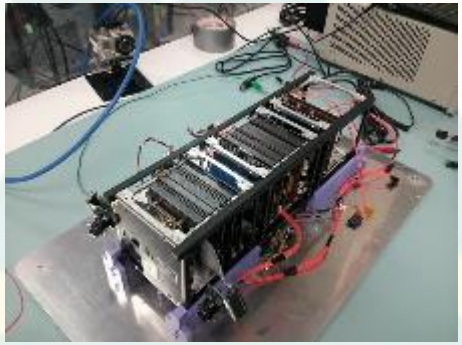

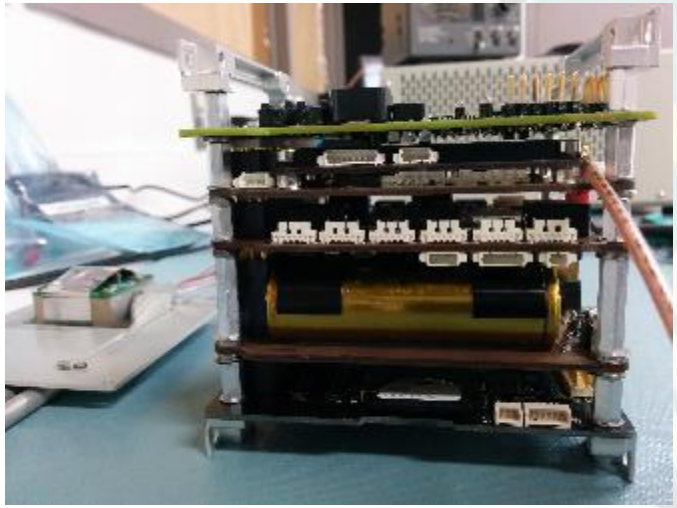

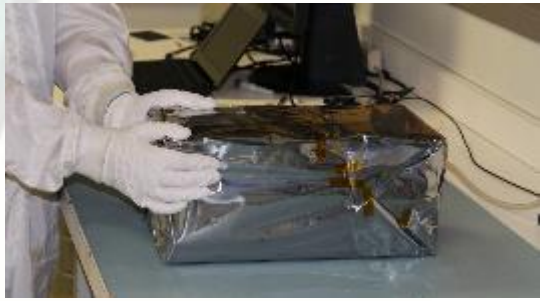

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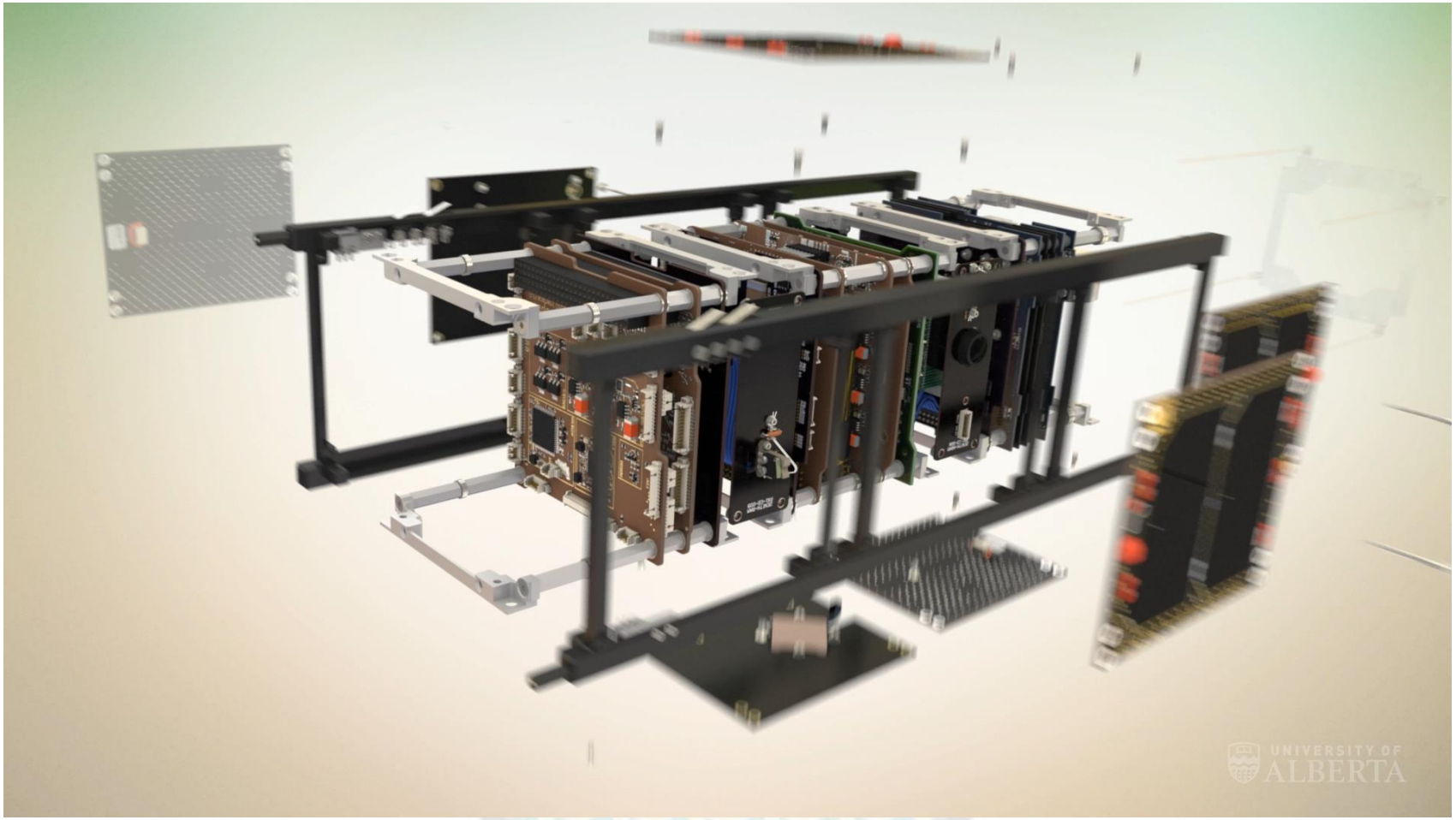
Ex-Alta 1:

Integration



Introducing Ex-Alta 1

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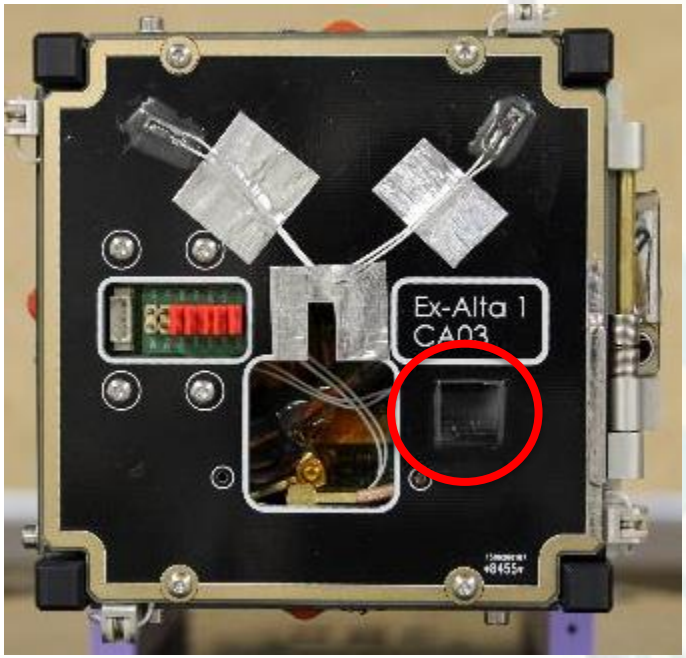
Rendering courtesy of Andy Kale

Crowd-Sourcing!



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Ex-Alta 1:

Launch

April 18, 2017 | Cape Canaveral, Florida

Courtesy of NASA.

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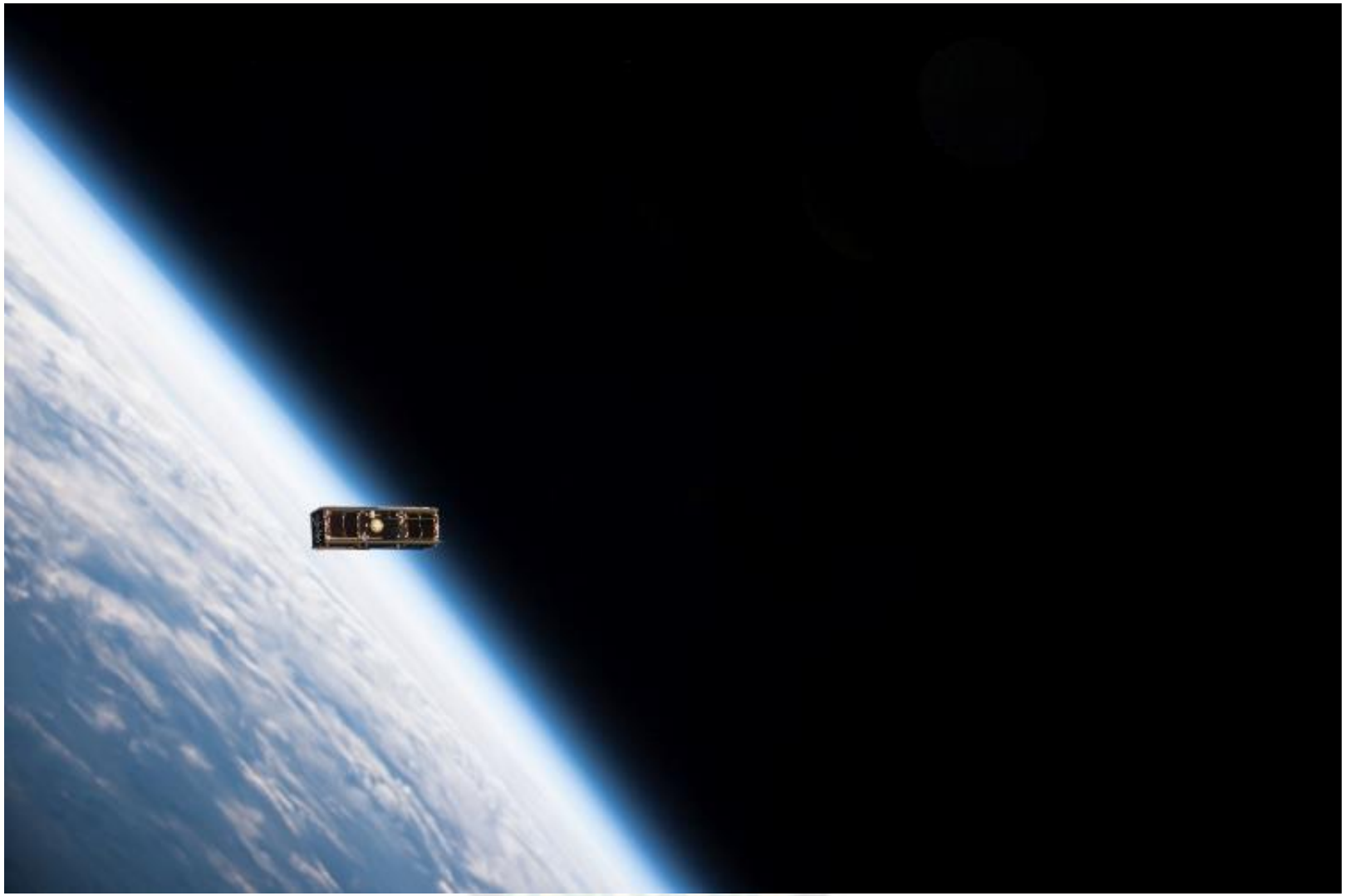
Ex-Alta 1:

Deployment

Courtesy of NASA and Nanoracks.



Ex-Alta 1:

Deployment

Courtesy of NASA and Nanoracks.

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Ex-Alta 1:

First Two-Way Contact

Canadian Space Agency

Canadian CubeSat Project

(CCP)

Canadian Space Agency | Agence spatiale canadienne

Canada

Canada "Spacescape"

- Canada has a population of 37M spread over 10 provinces and 3 territories
  - The top 4 provinces account for 76% of the population
- The space industry is highly concentrated in only 4 provinces
- In the academia, space science (including astronomy), atmospheric science, and spacecraft engineering subjects are available in almost all provinces
- There is virtually no space education or industry in the 3 territories
- Canada has no direct access to a launch vehicle

CCP Initiative

- CCP goal is to launch at least 13 nanosats from post-secondary institutes representing all 13 Canadian provinces and territories

- CCP requires the involvement of professors/teachers who act as Principal Investigator of the project and are responsible for supervising the student team to design, build, test and operate the CubeSat

- 15 mission teams selected in 2U and 3U Cubesats, with Proposals have very diverse mission objectives: education, science, technology, astronomy, Earth observation, etc.

	Proposal	Selected
2U	13	12
3U	4	3
Total	37	33

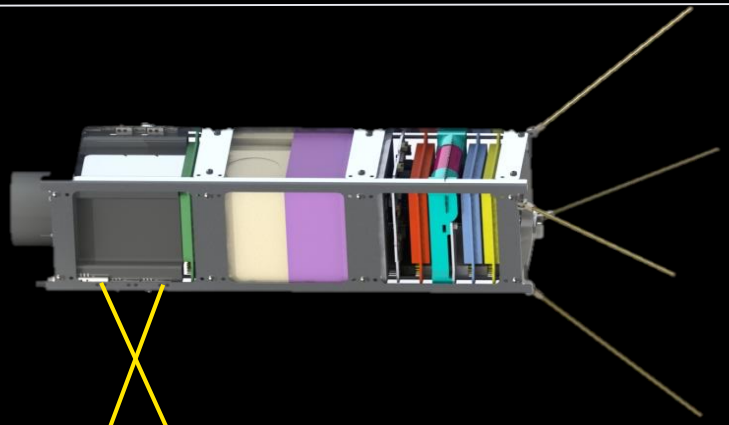
- CCP satellites to be launched in two constellations by NanoRacks from ISS.

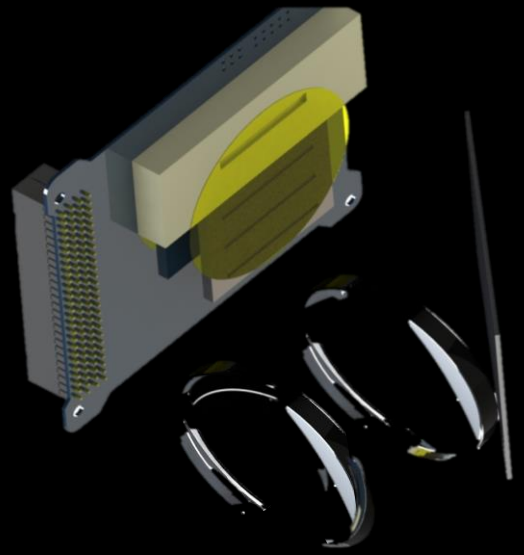
Ex-Alta 2: Mission

Prediction | Monitoring | Postburn Effects

Ex-Alta 2:

Multispectral Imager





Spectral bands relevant to wildfire detection and analysis:

Band	Spectrum [*nm*]
1	620 - 670
2	841 - 876
3	459 - 479
4	2105 - 2155

Science with CubeSats?

Fundamental plasma physics with universal application, including to fusion plasmas, astrophysical plasma systems, and space weather.

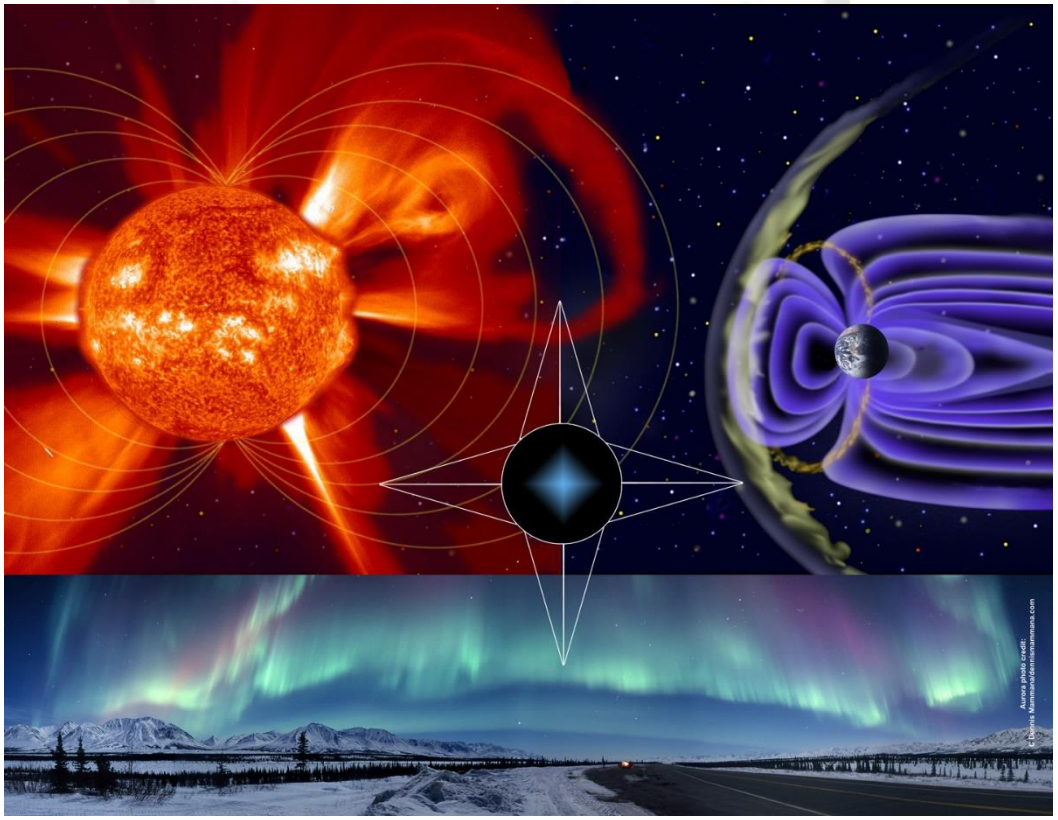


Image courtesy of NASA.

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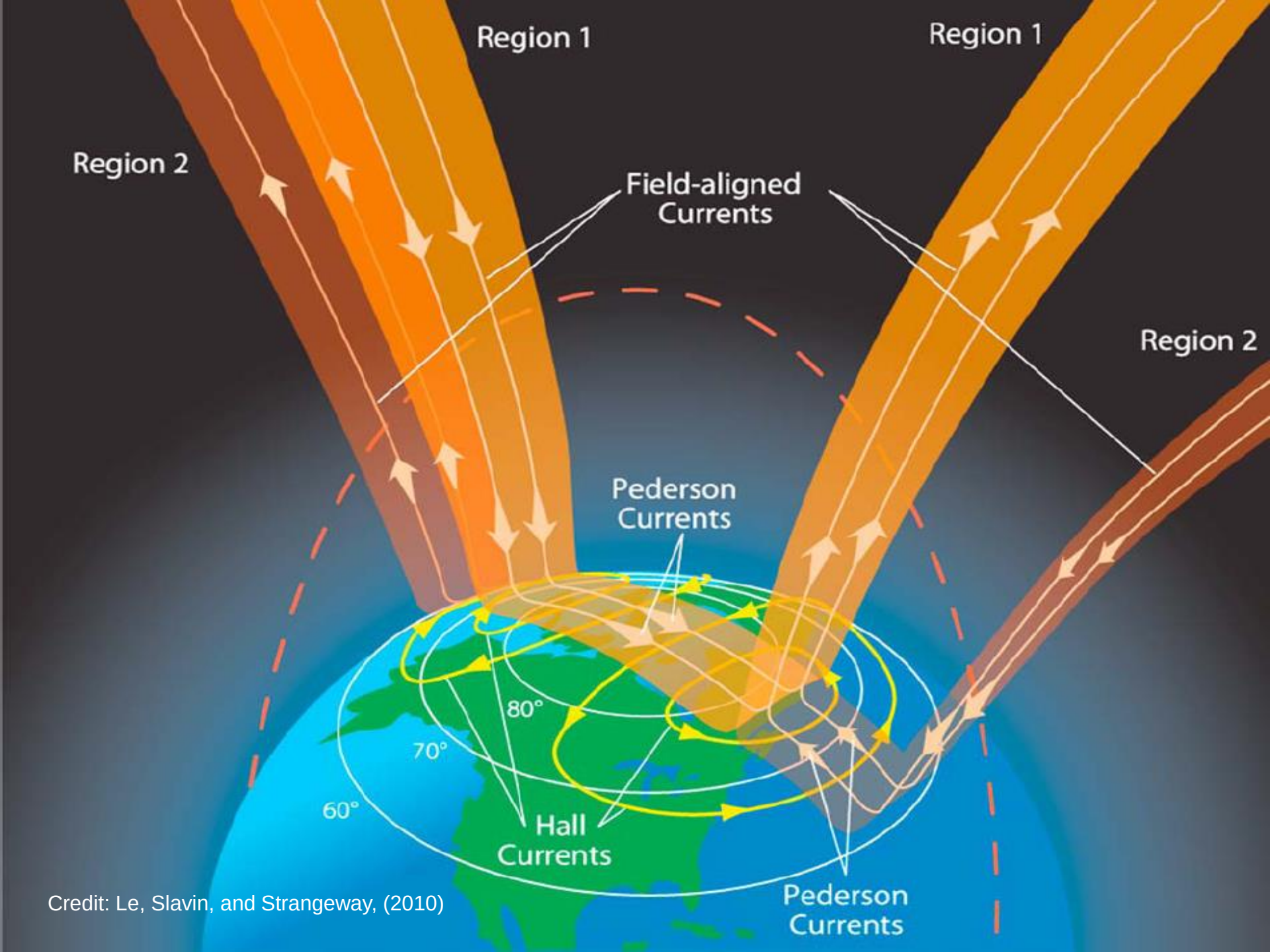

Credit: Le, Slavin, and Strangeway, (2010)

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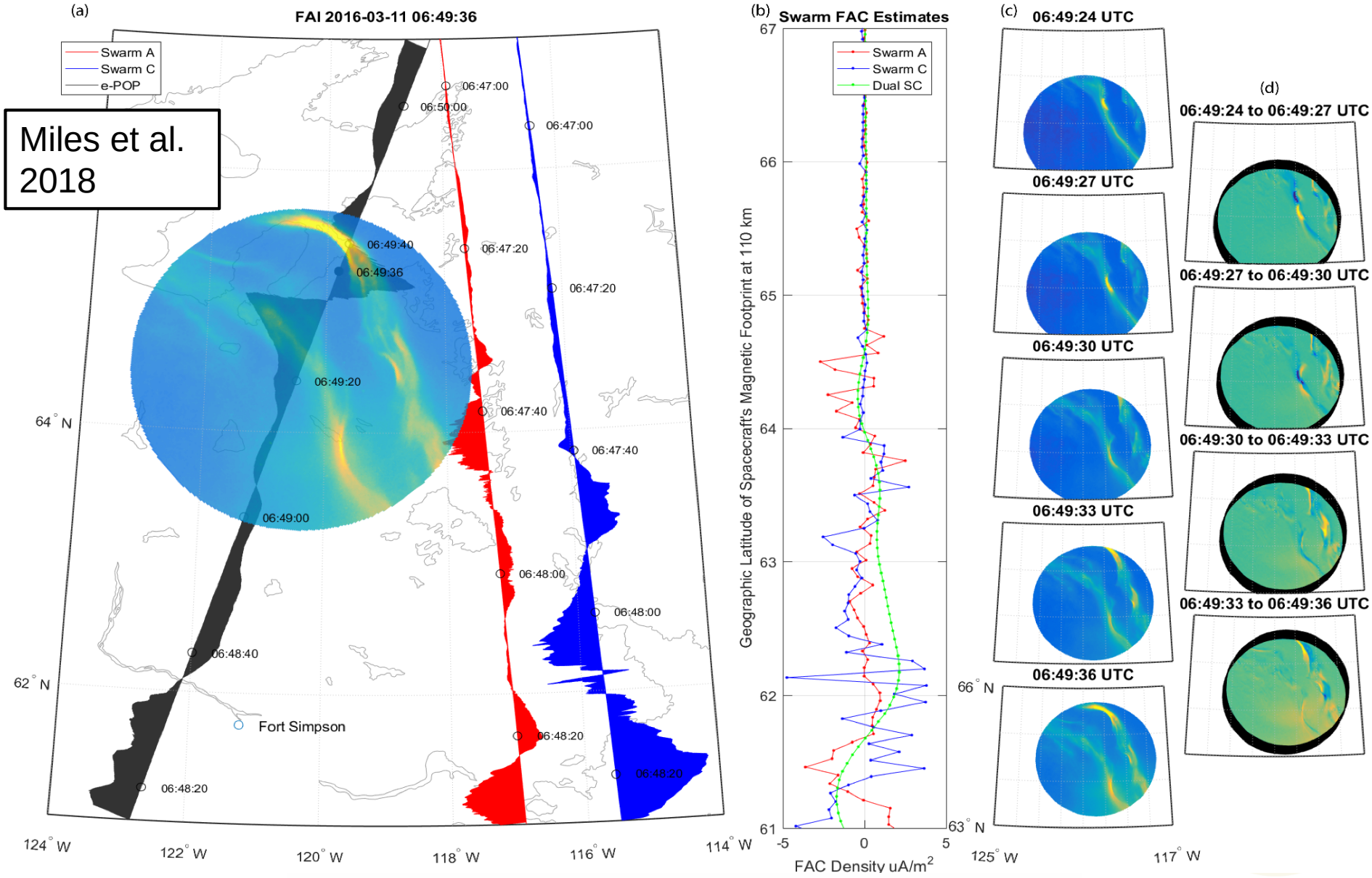
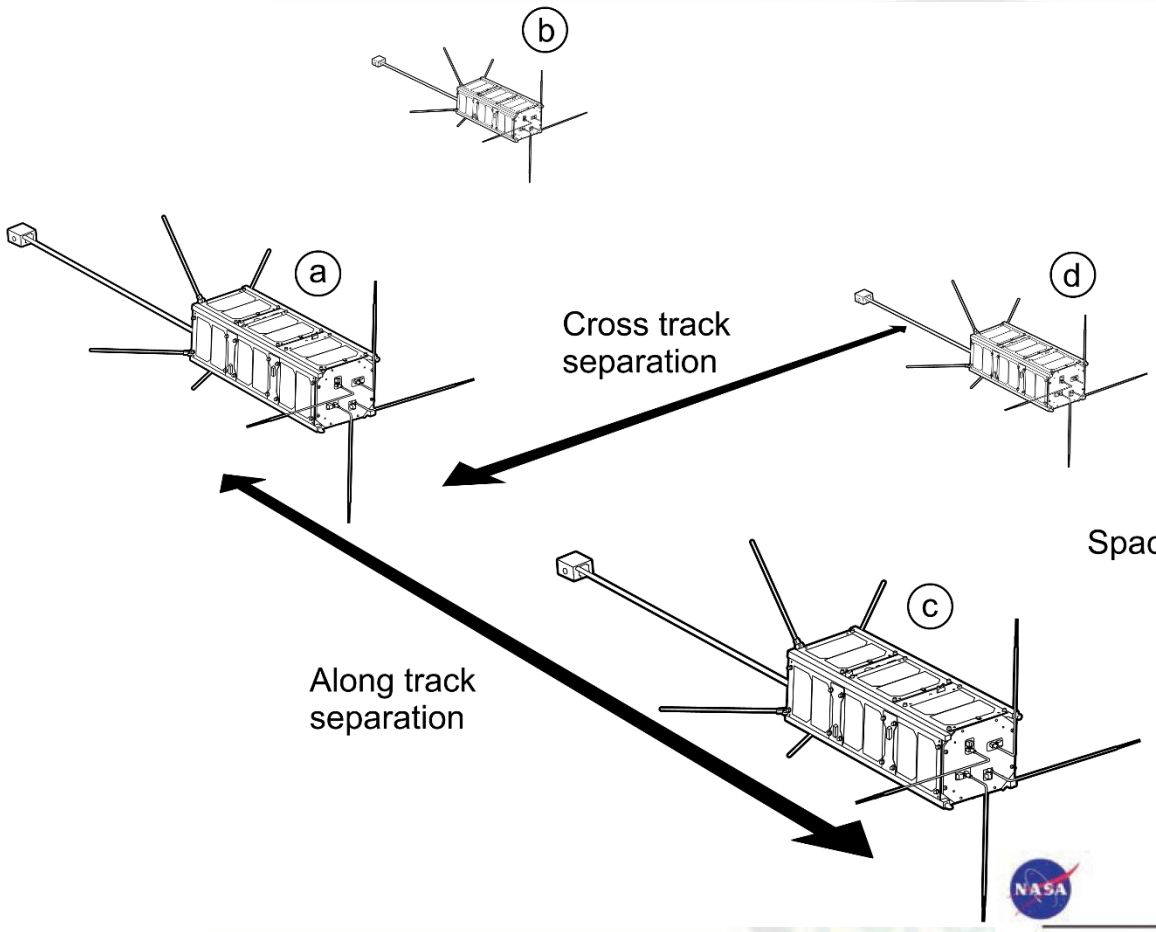
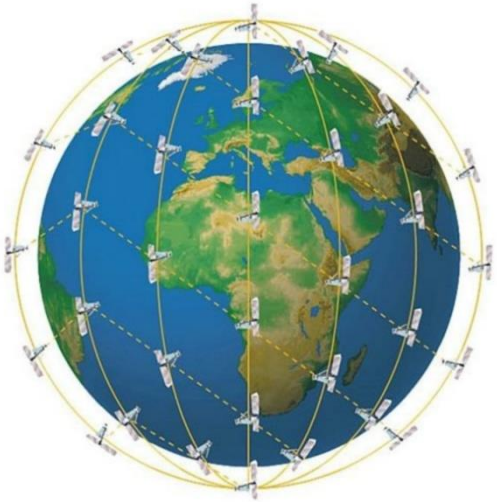
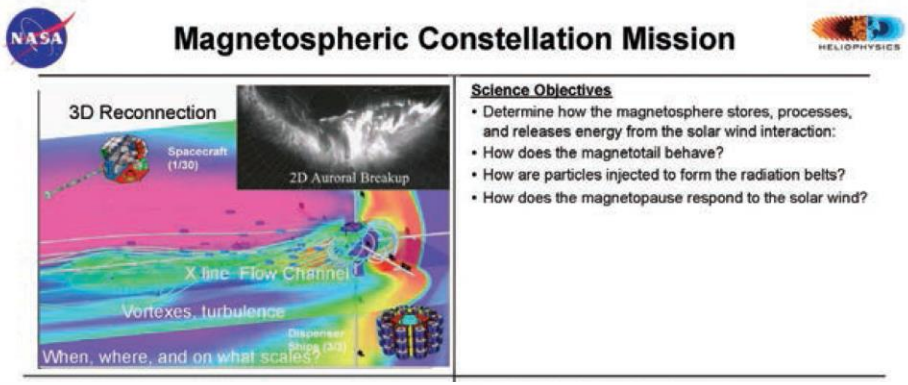
Non-time stationarity and fine structure of Magnetosphere-Ionosphere Coupling



Cubesat Constellation for Magnetosphere-Ionosphere Coupling ?







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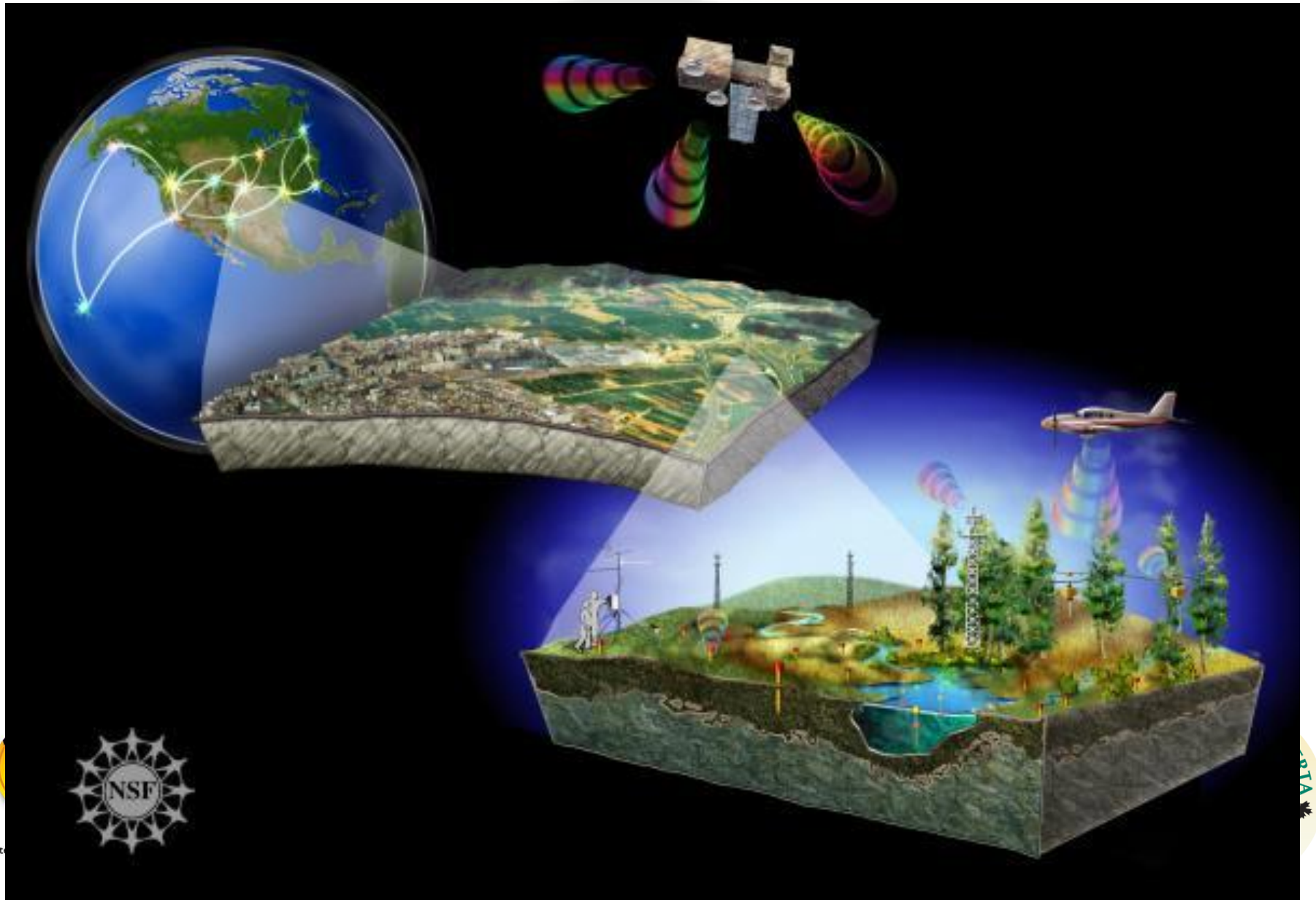
Nano-Satellite Constellations



Summary and Conclusions

- The AlbertaSat project and data from Ex-Alta-1 continue to offer exceptional student hands-on learning and research opportunities.
- Future U. Alberta missions in development, including a FireSat mission targeting forest fires, and future space science constellation class missions, with a goal of a cubesat every 2 years.
- Great science opportunities for genuine space physics research and discovery with constellations of cube satellites – for example the Canadian CubeSat Program (CCP).
- Future opportunity for international Space Weather cubesatellite constellation - perhaps a partnership between UN OOSA, COSPAR, Space Agencies and Member States?

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Review the AlbertaSat and Ex-Alta 1 story on YouTube!