CU on Orbit

Capstone Satellite Design Project

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- The 2025-2026 Satellite Design Project will run in concert with CUonOrbit, jointly working on the mission currently being pursued by CUonOrbit

- The tasks will be performed in a cooperative manner, meeting the objectives of both groups

Club/Capstone Collaboration

- Joint collaboration for CSDC competition
- Capstone will mainly focus on Mission Analysis, ADCS and Payload subsystems
    - Still collaborative with club members
- Focused on developing prototypes in-house for components that are usually bought
    - Student led design teams often don't have the expertise and resources to develop in house components such as reaction wheels
- Club goal is to design and build the satellite within the timeline provided by CSDC-7
    - Two-year long initiative (Sept. 2024 to May 2026)
    - 1st year (2025) focuses on design of the satellite (Phase 0, A, B) ← current
    - 2nd year (2026) focuses on assembly, integration and testing (Phase D)

Capstone Objectives (2025-26)

- Collaborative mission analysis for concept development and feasibility
- Design and development of an in-house SRAD* Attitude Determination and Control (ADCS) system for the satellite
  - Design + Prototype
- Development and integration of payload spectrometer on the satellite
  - Experiment design
  - In-house or COTS?
- Successfully build and implement design to CSDC-7 for simulated launch in June 2026
  - Min. functional engineering model/prototype

*Student Researched and Designed

Capstone Objectives (2026-27)

- Collaborative mission analysis for concept development and feasibility
- Design and development of an in-house SRAD Attitude Determination and Control (ADCS) system for the satellite.
    - Flight model + testing
- Future project collaboration

Future timeline (2026-27)

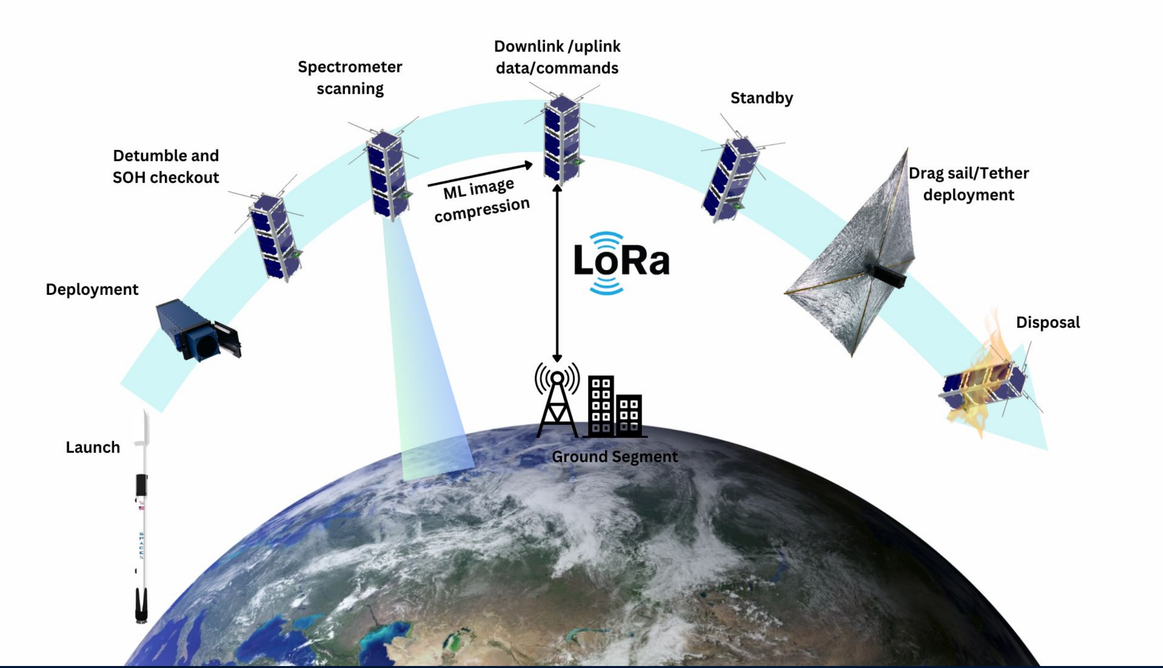
- Acceptance to CSA CUBICS program.
    - Collaboration on CUBICS mission payload
- If not accepted into CUBICS:
    - Compete in CSDC-8
    - Other CSA funding grants

CUonOrbit

- Carleton University's satellite design club
- Founded in 2023
- Members: 53 (engineering, sciences, public affairs & policy)
  - Active: 25-30
- What we do:
  - Satellite design
    - CSDC-7
  - High Altitude Balloon (HAB) launches
  - Conferences & networking events
  - Workshops

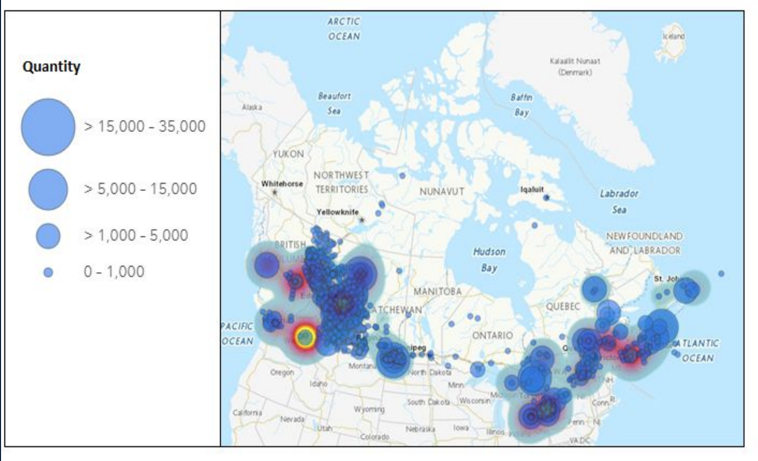
Our Satellite

- 3U (Unit) Cube Satellite
- 1 year mission + deorbit
- Anticipated launch in May, 2026
- 7 subsystems
  - Computation and Data Handling (CDH)
  - Communications (COMMs)
  - Attitude Determination and Control System (ADCS)
  - Payload
  - Mechanical (Structures and Thermal)
  - Electrical Power System (EPS)
  - Systems



Our Mission

- **Detect precursor chemicals to acid rain**
  - Measuring SO_2 concentration
  - Create heat map of Canada
  - Targeted at industrial plants
- **Compare to preexisting data**
  - Satellite and ground data
  - Verify air quality regulation compliance



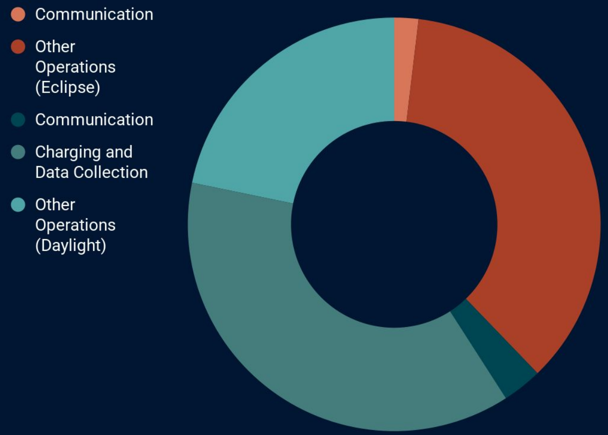
Canada, Environment and Climate Change. “Data Integration: Sulphur Dioxide.” Canada.ca, 18 Sept. 2024, www.canada.ca/en/environment-climate-change/services/national-pollutant-release-inventory/tools-resources-data/sulphur-dioxide.html.

Mission Analysis

- Combination of STK and MATLAB-Simulink models used to simulate the spacecraft in orbit.
- Both orbit configurations simulated in STK to obtain data for the following:
  - Link Budget
  - Power Generation
  - Ground Coverage of mainland Canada
- Simulink modelled magnetic field variations and orbit dynamics of the spacecraft with reaction wheels.
  - World Magnetic Model (WMM) used to quantify magnetic field variation.

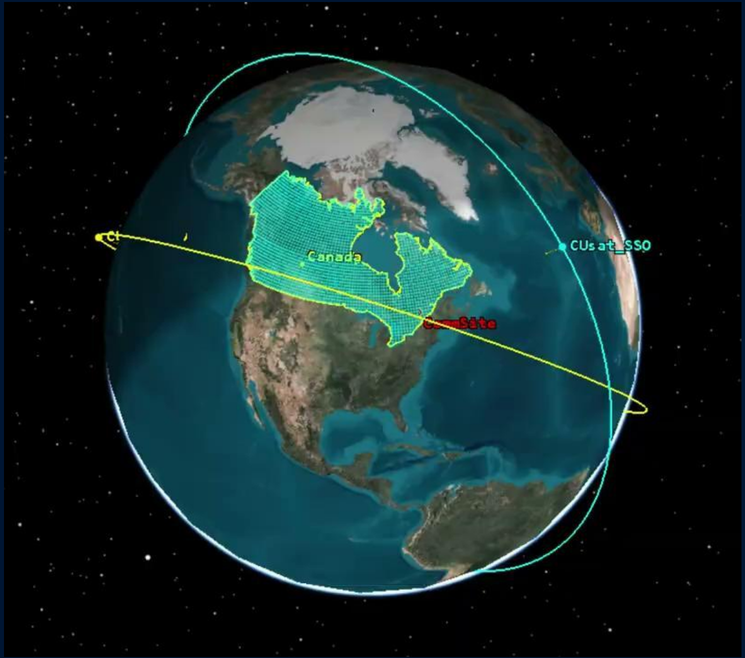
	SSO	LEO
Altitude	500-600 km	380-460 km
Coverage*	71.95%	23.75%
Inclination	97.-97.8 deg	51.6
Period	94.6-96.7 mins	91.9-93.8 mins
Eclipse Time**	35.5-35.8 mins	35.9-36.2 mins

Orbit Period Breakdown (Estimation)

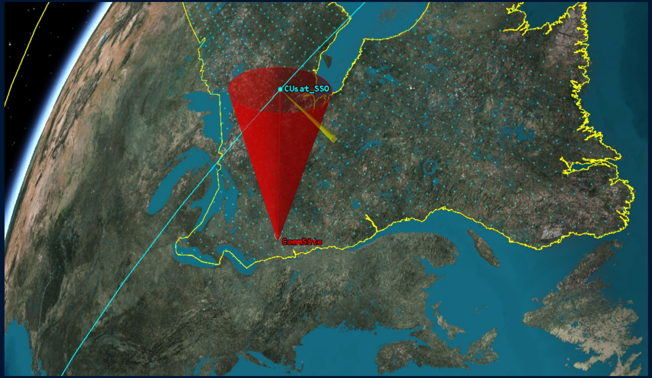


*Coverage area is calculated for the duration of entire mission with a daylight constraint
**Eclipse time is dependent on the ascending node and argument of perigee of insertion orbit

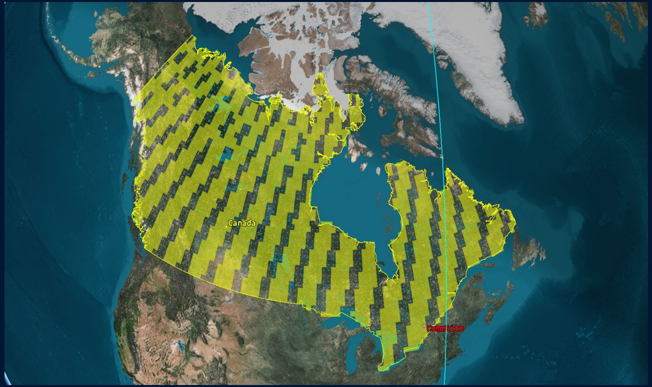
Mission Analysis



LEO and SSO Orbit Simulation



Ground Station @ Mackenzie Building Access



SSO Coverage over Canada for 1 Year Period

Payload

Requirements:

- Shall be able to observe wavelengths between 250-400 nm
- Satellite shall be capable of imaging an area of 2500 km^2
- Diffraction grating must have 1200 lines/mm
- Survival temperature shall be between -40°C and 80°C
- Operating temperature shall be between -20°C to 40°C
- Satellite shall maintain slew of 15° while collecting data

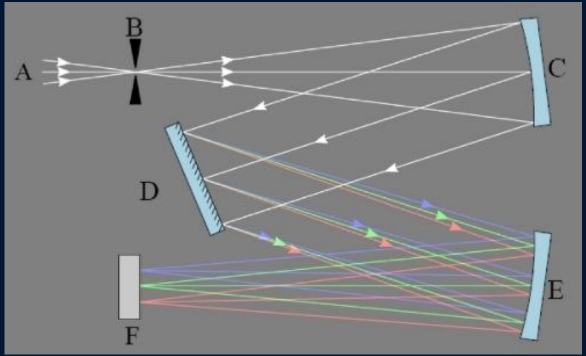
Diffraction grating spectrometer
- Separate UV light
- Sensor
- Analyze spectral composition

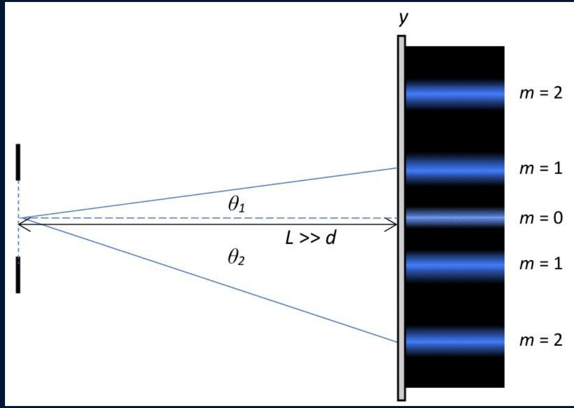
Grating
- 1200 lines/nm
- Better then prism
- Higher spectral resolution
- Narrow range of wavelengths

Layout
- Czerny-turner spectrometer
- Two mirrors
- Slit (~320 μm)
- Compact setup
- Reduces chromatic aberration

UV CMOS
- Further isolate wavelengths

Mirror reflectivity
- Aluminum coating

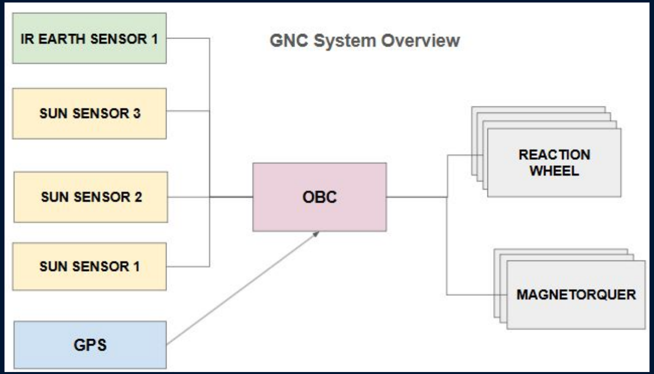


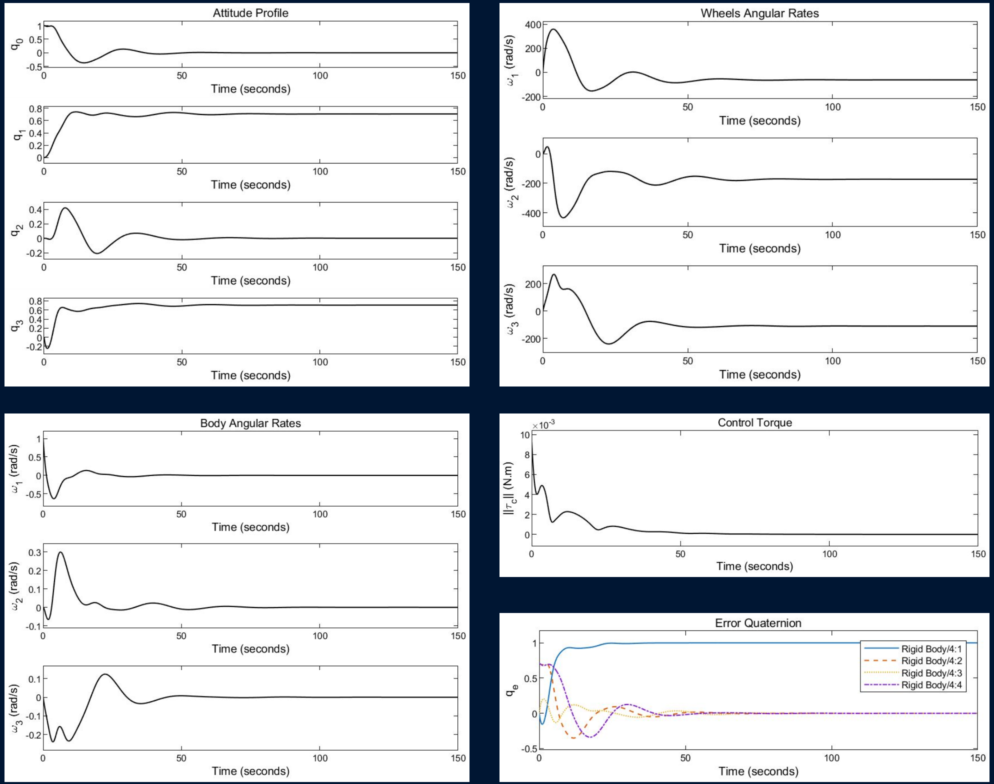


ADCS

Nonlinear Spacecraft Model with Reaction Wheels

- Demonstrated nonlinear spacecraft model to calculate control torque required to maintain pointing requirements
- Model integrates 3 reaction wheels along with a controller to simulate attitude correction





System Response for Attitude Control

ADCS

Design Requirements

- Low Earth Orbit
- Nadir Pointing Requirement
- High Pointing Accuracy
- Max LEO Perturbation torque (1.87 × 10^-5 Nm)

System Components

- Sensors
  - Sun Sensors
  - IR Earth-Horizon sensors
  - Gyroscope (needed?)
  - Magnetometer (integrated ADCS)
- Actuators
  - Reaction Wheels
  - Magnetorquers

REACTION WHEEL TRADE-OFF

Regular	CubeSpace Cube Wheel CW0017	Rocket-Lab - RW-0.003	Weight Factor
Torque (mNm)	0.23	1	1
Angular Momentum (Nms)	1.77	0.005 *peak*	0.2
Dimensions (mm)	28x26x28	33.5x33.5x17	0.2
Mass (g)	60	50	0.3
Cost ($USD)	*Request*	15,000	0.2
Power consumption	850 *mW peak* 336 *mW*	4.5 *V avg.* 9.0*V peak*	0.3
Total score	1.4	0.8	

HORIZON SENSOR TRADE-OFF

Regular	CubeSense Sensor	TensorFS S-15 - Fine Sun Sensor	Weight Factor
Pointing Accuracy (deg)	1	< 1	0.4
FOV (deg)	90x80	128	0.2
Dimensions (mm)	35x24x20	90x92x50	0.15
Mass (g)	18	120	0.1
Cost ($USD)	*Request*	*Request*	0
Power consumption	280 *mW peak* 200 *mW avg.*	Up to 30 mA and 5V	0.15
Total score	0.25	0.75	

SUN SENSOR TRADE-OFF

Regular	CubeSense Sensor	TensorFSS-15 - Fine Sun Sensor	Weight Factor
Pointing Accuracy (deg)	0.2	0.1	0.4
FOV (deg)	166	120	0.2
Dimensions (mm)	35x22x24	22x15x5.3	0.15
Mass (g)	15	4	0.1
Cost ($USD)	*Request*	1800	0
Power consumption	174 *mW*	< 2 *mA*	0.1
Total score	0.2	0.75	

Trade-Offs

2025-26 Schedule