<u>Title:</u> **AlbertaSat-1: Greenhouse Gas monitoring for Industrial improvement**

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Need

There is a great need, especially in Canadian industrial sectors such as the Albertan oil sands, to improve the environmental impact. Heavy oil found which is extracted in these regions must be upgraded to meet standards, a process that releases large quantities if greenhouse gases. The Government of Canada has mandated an improved monitoring system for these harmful gases. AlbertaSat-1 is a University based project that seeks to aid the environmental improvement of these industries by supplying space-based local greenhouse gas concentration monitoring. This data will be used to improve these industries, as well as aid in the development of global climate models.

Mission Objectives

The AlbertaSat-1 primary mission objective is to deploy an Earth observing nano-satellite equipped with a near-infrared (1000-2400 nm) spectrometer that can distinguish the atmospheric absorption bands of CO_2, H_2O & CH_4 in order to derive atmospheric concentrations of these important Greenhouse Gases.

Objectives:

1. Monitoring emissions of large industrial regions (e.g. Oilsand operations in Northern Alberta) and the extent of their contribution to local atmospheric concentrations over a 5 year lifetime. Measure daily maximum [CO_2] during dawn due to less mixing of the low temperature stable atmosphere. [Reid and Steyn, 1997]
2. Expanding GHG observations to improve Global and Regional Climate Models through comparison of diurnal [CO_2] (~max and ~min): this should provide better estimates for characterizing the magnitude of CO_2 sources and sinks
3. Reduce uncertainties of CO_2 sources and sinks by improving global sampling (e.g. soil [Parkin and Kaspar, 2003], permafrost [Koven etal., 2011], industry and urban areas). Improved spatial coverage of [CO_2] will enable enhanced discrimination of sources and sinks of CO_2 [Miller et al., 2007; Zhiming et al., 2002]
4. Determining extent that CO_2 emissions contribute significantly to atmospheric composition

Concept of Operations

AlbertSat-1 has been conceived to use a standard 3U cubesat structure that can be launched using a PPOD launcher system. This keeps design simple, standardized, and allows for a wider array of launch possibilities dude to the PPOD's capability of piggybacking on larger payloads. The satellite is designed to link for upload and data downlink through two main ground stations located in Alberta, Canada and Andøya, Norway. Constant telemetry data will be broadcasted through amateur radio channels and linked back to operations at the University of Alberta. The following graphic outlines the Concept of Operations of AlbertaSat-1, detailing the course and fine control phases in Launch and Early Operations (LEOP), as well as nominal operations.

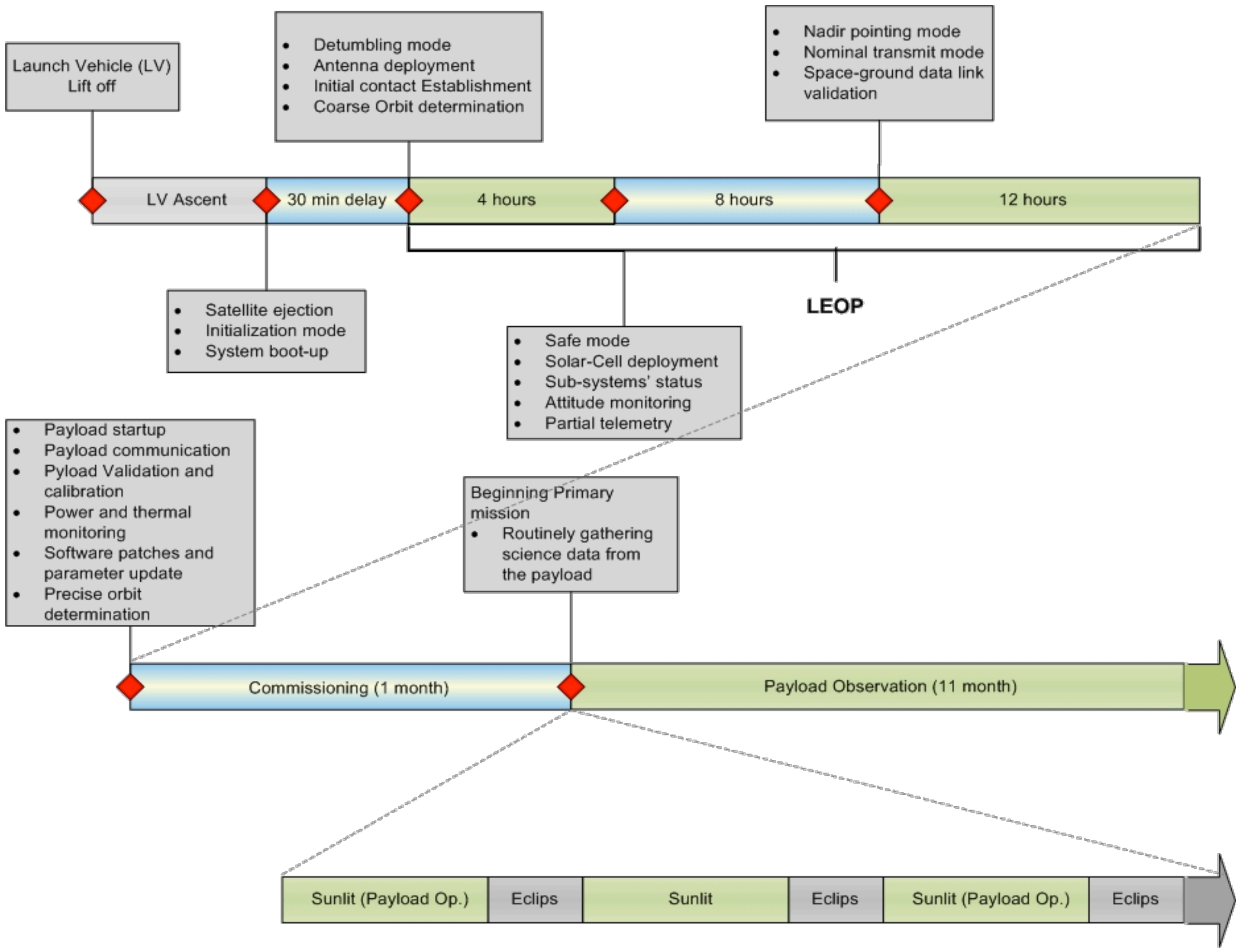

Figure 1: Concept of Operations Timeline of AlbertaSat-1

Key Performance Parameters

1. For proper detection of the greenhous gases, the AlbertSat-1 Payload was required to operate in the Near-Infrared Range of 1000-1700 nm. For this an Argus 1000 Spectrometer was chosen. This allows for the detection of **CO_2, H_2O and CH_4** absorption bands that we can use to derive concentrations
2. AlbertaSat will deploy in Dusk/Dawn 6am(descending)/6pm sun-sync orbit in an off-nadir viewing direction (30^o towards sun =~5^o longitude at Equator). This orbit will allow for increased acquisition capabilities (rarely eclipsed) as well as increased orbital average power. The chosen spectrometer is also significantly more sensitive to the three greenhouse

gas absorption bands as the downward path length is increased. By using a Dusk/Dawn orbit and pointing off Nadir, the path length increases. There are also many untested scientific hypotheses that can be explored on the atmospheric composition and diurnal variability of **CO_2, H_2O and CH_4** along the dusk and dawn terminator.

3. In order to monitor local industrial areas of interest using the payload with a 0.15° field of view, a pointing control accuracy of 1 degree is required. This requires attitude knowledge of current Euler angles, orbital position, geomagnetic field, and orientation to the Sun, as well as sufficient constant active control for zero roll angle in nadir pointing, zero-yaw angle for a sun-synchronous orbit optimization, and a constant pitch rate equal to the orbit rate.

Space Segment Description

As mentioned above, AlbertaSat-1 has been designed to conform to all cubesat-standards. In order to fit inside the 3U cubesat envelope upon launch, but optimize power, AlbertSat-1 has been designed to deploy four solar arrays and four antennas after launch using simple spring based hinges. The stowed and launch configurations can be seen below in Figure 2.

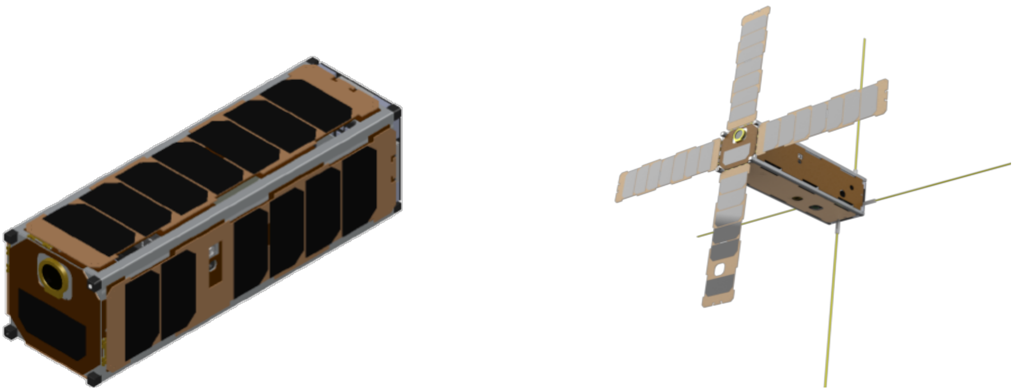

Figure 2: AlbertaSat-1 stowed (left) and deployed (right) configurations

Key **Specifications:**

Structure:

- Total mass (including margin): 3351.1 g
- Overall length (stowed): 340.5mm
- Overall width/height (stowed): 105 mm (100 mm between rails)

Power:

- Orbital average Power generated: 29.2 W
- Peak power consumed: 25.786 W
- Average power consumed: 9.354 W
- Average Power Margin: 3.117

ADACS:

- Two Sun Sensors (one fine and one coarse sensor) and two Earth Horizon Sensors

- Two 3-Axis Magnetometer and one 3-Axis Rate Gyro
- One GPS Receiver
- Three orthogonal Magnetorquer Rods (MTQ) and three orthogonal Reaction Wheels (RW)
- Orbit determination record rate: Southhemisphere: 0.01Hz / Northhemisphere: 0.1Hz

Phase	Ctrl. Mode	Requirement	Sensor/Accuracy	Act.	Alg.
LEOP	Detumbling	3 deg/s	Magnetometer/3deg	MTQ	B-dot
	Safe hold	2 deg/s pitch rate 10 deg	Magnetometer Coarse sun sensor/0.5deg GPS	MTQ	PD
	Unloading	Roll and yaw 0.1 deg/s 10 deg	Magnetometer Rate gyro/0.06deg/s GPS	MTQ RWs	Cross Ctrl.
Commissioning/ Observation	Nadir pointing	1.0 deg	Fine sun sensor/0.1 Earth sensor/0.5 deg GPS/20m	RWs	PID

Communications and Data Handeling:

- VHF Uplink (130-160 MHz)
- Periodic UHF Telemetry (400-450MHz)
- 256 Bytes of Telemetry and status every 20 - 200s
- UHF Data Downlink (400-450MHz)
- ~8400 s total daily coverage (@ 1200 bps) = ~ 1.2 MB down/day (raw)
- Min Downlink: 200s = 200 kB (Raw) Avg Downlink: 550s = 660 kB
- Min Uplink: 196s = 200kB Raw
- Processor: ARM CortexM3 (<=72Mhz)

Orbit/Constellation Description

As described previously, a Sun-synchronous Dusk/Dawn orbit was selected in order to improve the acquired data, optimize the power generated, and increase the daily ground track in order to obtain a more complete global ground track necessary for local monitoring. Figure 3 below depicts the ground track of AlbertaSat-1's sun-synchronous orbit with a 0600 hr (local time) descending node (dusk/dawn orbit). A preliminary Link Analysis shows approx 4200s daily cumulative communication time with Edmonton. Total communication time including Andøya ~ 8400s.

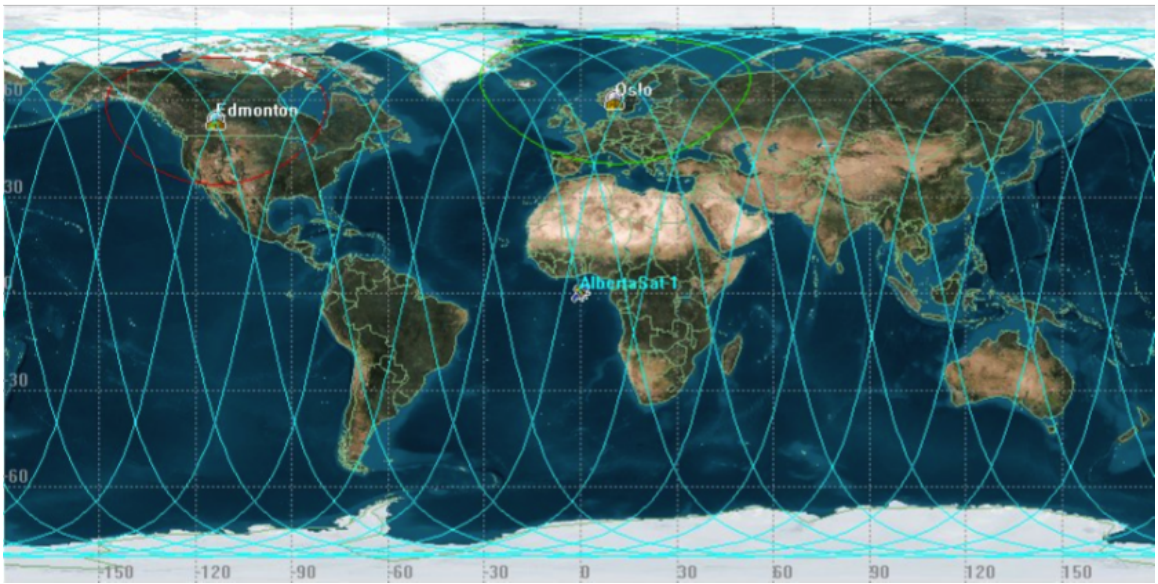

Figure 3: AlbertaSat-1 daily ground track and dual coverage zones in Edmonton and Oslo.

Implementation Plan

AlbertaSat-1 is attempting to implement the project throughthe aid of the University of Alberta, the Canadian Satellite Design Challenge, the Government of Alberta, and potential interested industrial partners from the Albertan Oil and gas Industry.

Cost Estimate:

- Hardware costs: $258,695.00
- Operations costs: $33,8078.00
- Total Costs: $292,502.00
- Launch Estimate: $20,000.00

Required infrastructure:

Basic Infrastructure supplied by the University of Alberta, Further testing facilities will be required, presumably supplied by the CSDC and CSA.

Organization:

A student team, with a hierarchy of subsystem leaders and project managers based on experience.

Schedule:

March 2012: The Critical design review has been completed with the CSDC.

September 2012: preliminary development and testing completed, environmental testing start

January 2012: all testing completed, operations plan completed, go for launch.

Risks:

1. Exit of a major sponsor, Under-Budget situation created.
2. Lack of supplied launch to designed orbit
3. Loss of an executive member and major contributor to the project.
4. Loss of preferred Orbit
5. Inability to complete total component simulation prior to component procurement