CanX-2 and NTS
Canada's Smallest Operational Satellites

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Overview:

- Introduction to UTIAS/SFL
- Mission Overviews
  - CanX-2 and NTS (CanX-6)
- NLS-4 and NLS-5
- Launch Opportunities
Space Flight Laboratory

- Building low-cost spacecraft
- Part of University of Toronto Institute for Aerospace Studies
  - M.A.Sc. curriculum: spacecraft system/subsystem design from concept to operations
- Full-time experienced staff to support students
Operational On Orbit

MOST
June 30, 2003

NTS
April 28, 2008

CanX-2
April 28, 2008
Missions Under Development

• BRITE Constellation (CanX-3A, 3B, 3C, 3D)
  – Differential Stellar Photometry

• CanX-4 & CanX-5
  – Autonomous Formation Flight

• AISSat-1
  – Space-borne Receiver for Maritime
    Automatic Identification System
Mission Goals

- Technology demonstrator for future SFL spacecraft
  - Evaluate technologies critical for formation-flight (CanX-4 & 5)
- Scientific test-bed for Canadian researchers
  - Cost-effective access to space
Technology Validation

- GPS Hardware
- Sun Sensors
- Sinclair/SFL Reaction Wheel
- NANO Propulsion System
- On-Board Computers
- CMOS Imagers
- S-Band Transmitter
Science Payloads

- Atmospheric Spectrometer: Green-house gasses
- GPS Occultation: Water vapour (Troposphere) and Electron density (Ionosphere)
- Materials Science: Atomic oxygen resistance
CanX-2 Status

• Commissioning during the first month
  ✓ Power and Thermal Models Validated
  ✓ Attitude determination sensors and Extended Kalman Filter
  ✓ Attitude Actuators: Magnetorquers and Reaction Wheel
  ✓ NANO Propulsion System (NANOPS)
  ✓ UHF & S-band Radios
  ✓ Material Coating Experiment activated

• At Present
  – NANOPS Thrust Tests underway
  – ACS algorithm commissioning and refinement underway
  – Spectrometer and GPS Science to start in September

NO MAJOR DIFFICULTIES YET…!!
Telemetry: Temperature

CanX-2 Structural Panel and Battery Temperature
• **S-band Transmitter**
  – BPSK & QPSK modulation schemes demonstrated in orbit
  – Data rates up to 256kbps demonstrated in orbit

• **Data Downlink**
  • CanX-2 > 131 MB downloaded
  • NTS > 230 MB downloaded
Wheel Spin-up

Body-axes:
- x
- y
- z

- 10°/s
- 20°/s
NANO Propulsion System

- SF$_6$ Fuel Leakage: Negligible
- ISP: $\sim$ 46s
- Minimum Impulse Bit: $\sim$ 0.13 mNs
- Valve on-time (testing to date): 1ms - 500ms
- Upcoming Tests
  - Constant Thrust Test: Impulse and thrust-level determination at various pressures
Mission Objective
Validate on orbit the space-based AIS receiver payload developed by COM DEV Ltd.

• Result: NTS
The Nanosatellite Tracking Ships

• Responsive Space
7 months from concept to launch
  – Project Start: October 2007
  – Launch: April 28, 2008
NTS – Spacecraft Bus

- Structure based on SFL Generic Nanosatellite Bus
  - 20 x 20 x 20 cm
  - 6.5 kg mass including payload
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• CanX-2 Electronics
  – OBC, Power, TT&C

• Passive attitude control
• Footprint overlap between CanX-2 and NTS during the first month
  – Contacts were split between satellites: 1-2 for NTS

• Early Operations for NTS
  – April 28, 03:53:51 UTC: Launch
  – April 28, 04:13:02: Deployment and Wake-up
  – April 28, 15:13:18: AOS at UTIAS/SFL
  – May 2: Start of Payload Commissioning
  – May 6: Collection of First Data

• Data collection continues
Primary Objective

- Access to regularly scheduled launch in support of the CanX program and UTIAS/SFL education curriculum
Secondary Objectives

- Cost sharing with launch partners through launching a small group (4-5) of spacecraft

- Small number of participants simplifies LV integration, launch campaign logistics, post launch operations, schedule risks, therefore reducing the overall risk to all participants
Flight-proven X POD separation systems

- X POD Single, Double, Triple
  - Compatible with the Stanford/CalPoly CubeSat standard
- X POD GNB: 20x20x20 cm satellite
  - Target Missions: NTS, BRITE Constellation, AI SSat-1
- X POD DUO: 20x20x40 cm
  - Target Mission: CanX-4 & CanX-5
• CanX-2
  UTIAS Space Flight Lab, Canada
• AAUSat-II
  University of Aalborg, Denmark
• 2nd SEEDS
  Nihon University, Japan
• Delfi-C3
  University of Delft, Netherlands
• COMPASS-1
  Aachen University of Applied Sciences, Germany
• CUTE-1.7 + APD II
  Tokyo Institute of Technology, Japan
• NTS (CanX-6)
  – Originally scheduled for PSLV-C12
  – Moved up to C9
4-Stage Vehicle

- 4 - 6 Solid Strap-ons
- 1: Solid
- 2: N2O4/UDMH
- 3: Solid
- 4: N2O4/UDMH

- C9: 823 kg to SSO at 635 km
- Lift-off mass: 230 tonnes
LV Accommodation

Payload Launch Adapter

5 – CanX-2
6 – CUTE 1.7 + APD II
7 – Delfi-C3
8 – AAUSat-II
9 – COMPASS-1
10 – SEEDS
April 17: L-11 – NLS-5 is mounted on the PLA
April 18: L-10 – NLS-4 is mounted on the LV
NTS
CanX-2
PSLV
PSLV-C9 Upper Stage
CUTE-1.7 + APD 2
COMPASS-1
Delfi-C3
SEEDS
AAUSat-2
CanX-2
PSLV-C9 Upper Stage
Upcoming Launches

- **Nanosatellite Launch Service 6 (NLS-6)**
  - Time frame: Jun-Jul 2009
  - Orbit: Sun Synchronous, 800 km, 10:30 LTDN

- **Nanosatellite Launch Service 7 (NLS-7)**
  - Time frame: Jul-Sep 2009
  - Orbit: Sun Synchronous, 650-670 km, 10:15 LTDN

- **Nanosatellite Launch Service 8 (NLS-8)**
  - Time frame: Mid-2010
  - Orbit: Sun Synchronous, 800 km, 06:00 LTDN
• Both spacecraft are operating well on orbit.
• **CanX-2** is a clear example of what a triple-CubeSat is capable of accomplishing.
• **NTS** shows the opportunities from **responsive space**.