UTIAS SFL Space Flight Laboratory

Building Canada's Future In Space

NanoSatellite Activity at the UTIAS Space Flight Laboratory

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Overview

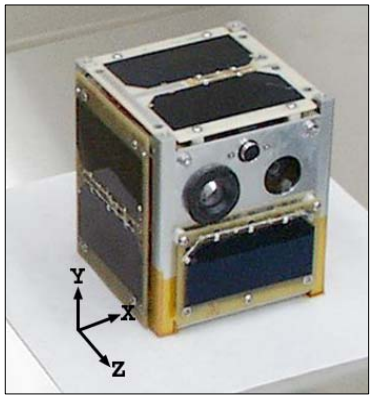
- Intro to CanX Program, CanX-1
- NanoSat Launch System (NLS) Program. First CubeSat launch, NLS-1 and NLS-2.
- CanX-1 Lessons Learned (or how not to forget the obvious).
- Lessons Learned in Arranging Launches (SSC03-VI-1)
- NLS-3: SSETI Express, ESA student microsat with CubeSats
- NLS-4: CanX-2 launch
- CanX-2 Project
- CanX-3 Concept
- Frequency Coordination (I.e. reassurance of abuse-free usage)
- How we can help other university programs.

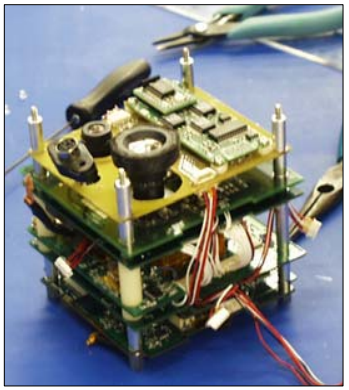
CanX Program

Canadian Advanced
NanoSpace eXperiment

Est. 2001

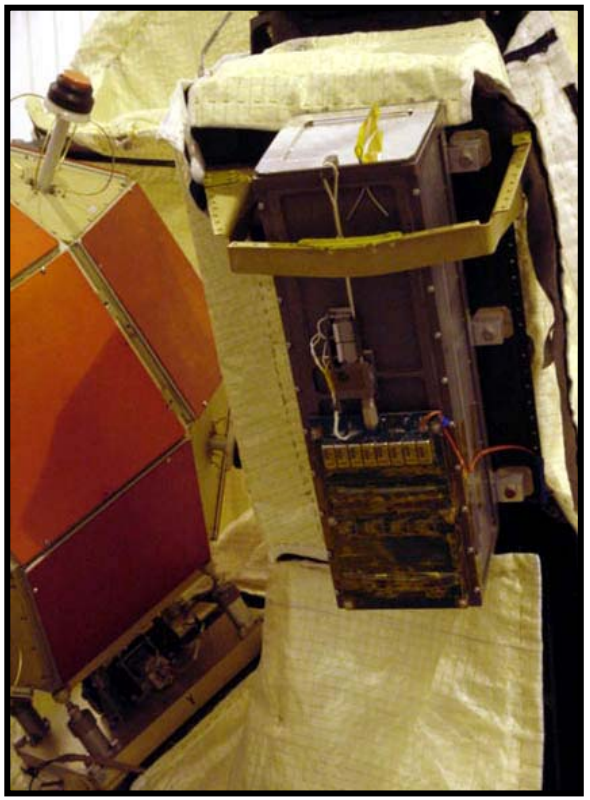
- Graduate students build their own nanosatellite (< 10 kg) in 2 years.
- First satellite, **CanX-1**, launched on 30 June 2003. Completed in 22 months.
  - Imaging of Earth, Moon, stars using CMOS Imagers
  - Star/horizon tracking experiments
  - Demonstration of GPS from space
  - Magnetic attitude control
  - ARM7 on-board computer (OBC)
  - Triple Junction Cells, Li-ion battery
  - Custom UHF Transceiver



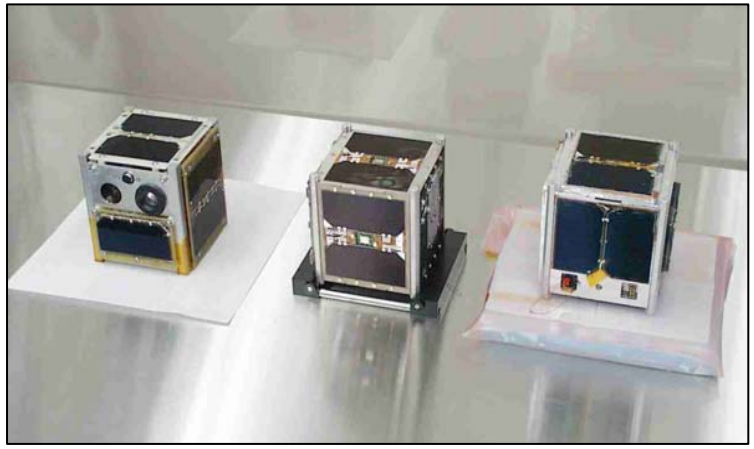


Nanosatellite Launch System

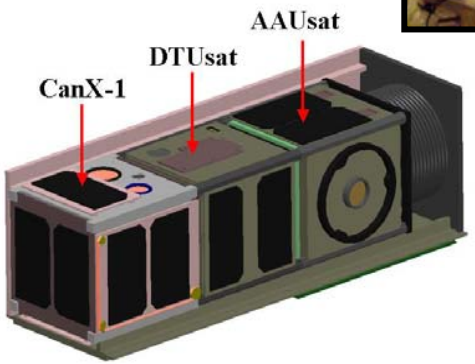
- UTIAS/SFL arranged launch for **NLS-1** (containing **CanX-1**, **DTUSat**, **AAUSat**) and **NLS-2** (containing **QuakeSat**) and provided integration, test, and launch support.
- CalPoly provided P-POD launch tubes and associated support.
- Liftoff 14:15 UTC 30 June 2003, Plesetsk, Russia – "Rockot" Launch Vehicle.



NLS-1 Mounted to Upper Stage of Rockot LV (modified SS-19 ICBM) at Plesetsk Cosmodrome Russia



UTIAS Clean-Room



CanX-1 Lessons Learned

Separation System

- Ensure separation environment fully characterized. Test satellites under those conditions as well, e.g. shock.
- Perform as high fidelity separation system tests as possible esp. when sharing a launch tube.
- Mutual review of launch partner satellites.
- Release satellites separately if possible and put them in different orbits.

Need Experience For Quick Turnaround

- Acquire reliable components for critical subsystems – have students focus on satellite, not components.
- Quick turnaround, requires increased involvement of professionals for mentoring and management.

Conservative Design

- Start out bigger, then go smaller.
- Overdesign critical items (communications, power) & be conservative.
- Full-duplex communications if possible.

Testing

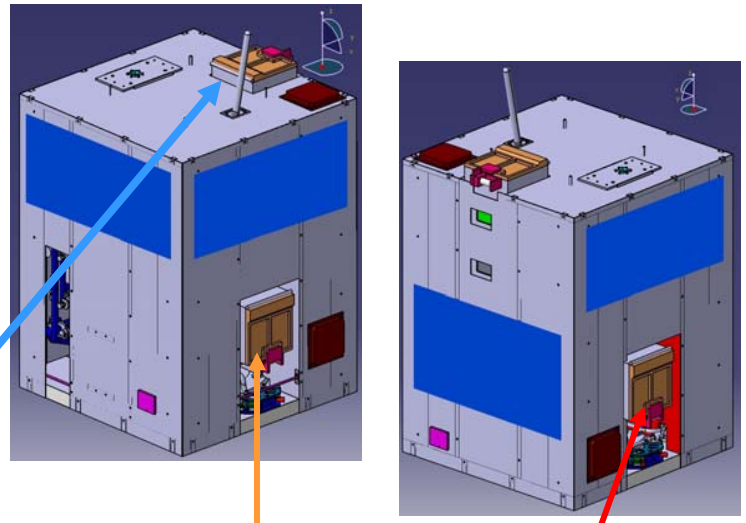
- Antenna modeling and testing.
- Choose connectors for reliability, but also for ease of testing.
- All deployables must be testable in 1-G environment.

Launch Arrangements

- Paper in last year's conference on our recipe for nanosat launch success. Includes decentralized export licensing and a MOU hierarchy to ensure payment coordination and risk mitigation for all (SSC03-VI-1)
  - Coordinate with launch provider – get draft launch agreement early.
  - Sign MOUs with CubeSat groups sharing launch. Terms should be consistent with launch contract.
  - Sign launch contract and provide copies to CubeSat groups.
  - Decentralize export licensing, place onus on CubeSat groups to deliver. Clear consequences of missing deadlines in MOU (follows from what they would experience if they were launching their satellite on their own).
  - Decouple multiple launch contracts to minimize risk.
  - Watch hidden costs.
- Plan is to continue to help arrange launches – want to launch CanX satellites every two years on average.

NLS-3 on SSETI Express

- Educational microsat coordinated by ESA, over 100 students in 12 countries.
- Will have three CubeSats ejected from SSETI Express microsat.

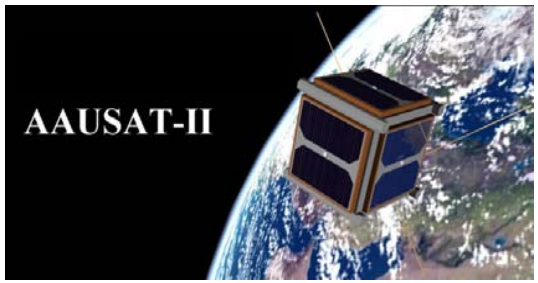


- Asked by ESA to help coordinate CubeSat launch.
- Collaborating with Japanese on independent separation systems for CubeSats.
- Launch in early 2005.

NLS-4: CanX-2 Launch

- Planning 2005 launch of CanX-2 (Canada), PRISM (Japan), CUTE-2 (Japan), and AAUC-2 (Denmark).

CANX-2

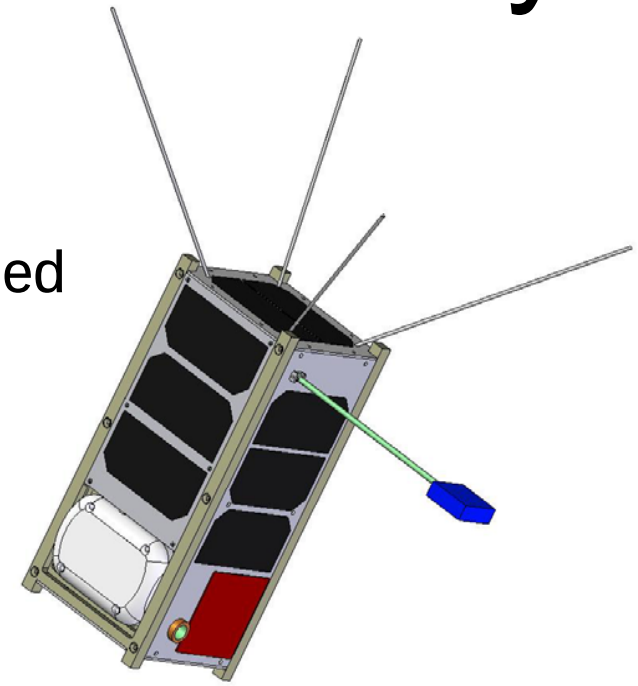


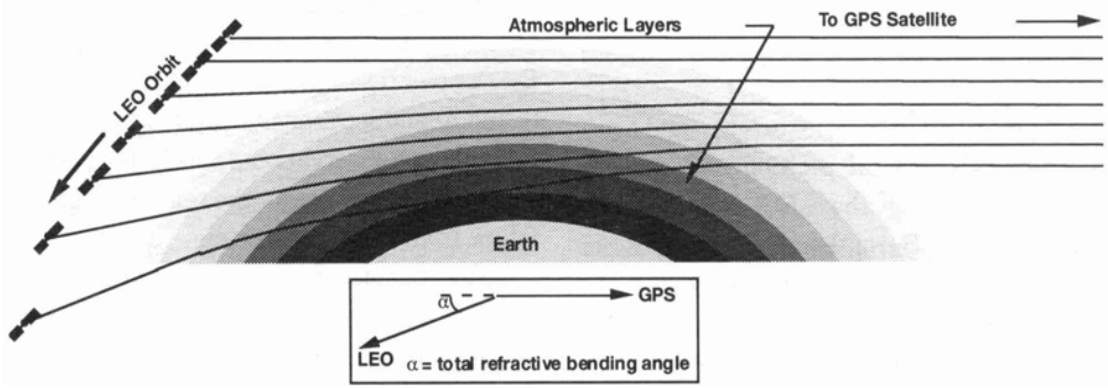
CUTE-2
Cubical TUTech Engineering Satellite
Tokyo Institute of Technology
Lab. for Space Systems

Intelligent Space Systems Laboratory, PRISM Project
The University of Tokyo
PRISM

CanX-2 Project Underway

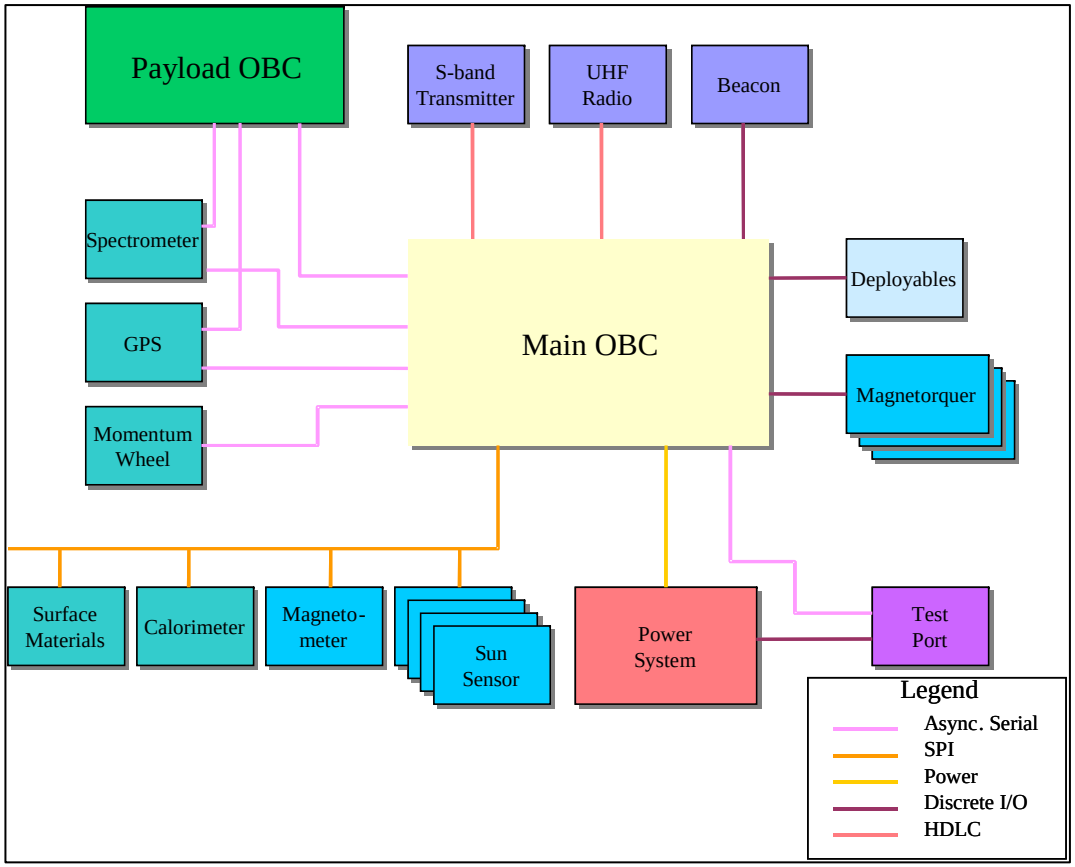
- Mission Objectives
  - Evaluate new systems
  - Some scientific investigations planned
    - GPS Radio Occultation (Calgary)
    - Materials Experiment (Toronto)
    - Atmospheric Spectrometry (York)
    - Nanotechnology (Toronto)
    - Novel Comm Software (Carleton)
  - Target late 2005 launch.
- Design
  - "Double CubeSat" (10x10x20 cm)





CanX-2 Technology

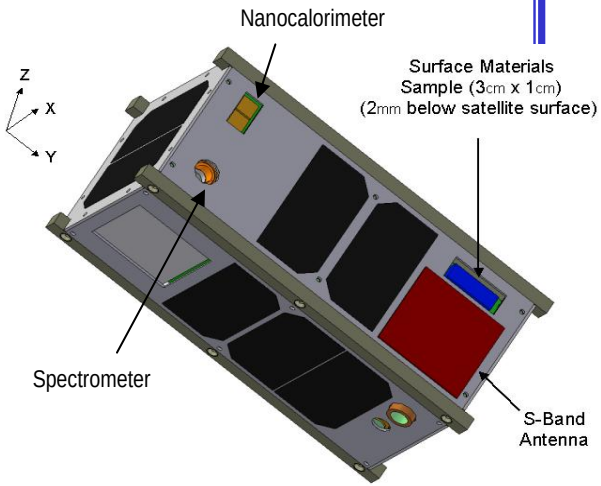
- Custom ARM Computers
- CMOS imagers on OBC
- UHF up and S-band down (32 kbps to 1 Mbps).
- Triple Junction Cells and Li-ion battery.
- High performance L1/L2 GPS receiver.
- Momentum bias ACS with Dynacon NanoWheel.



- Custom Sun Sensors (100° FOV, approx. 1° accuracy).

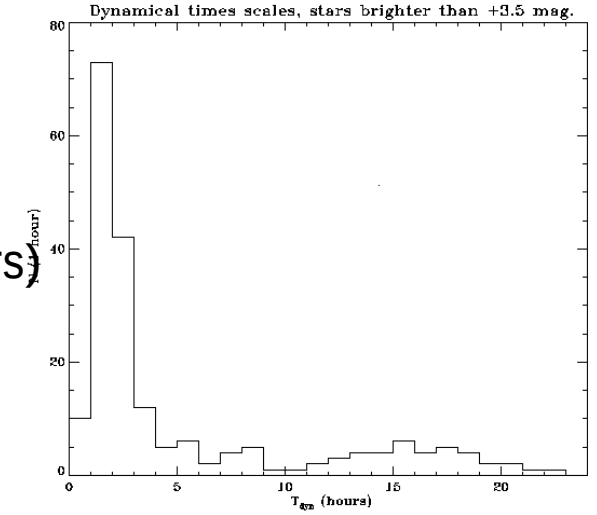
CanX-2 Improvements

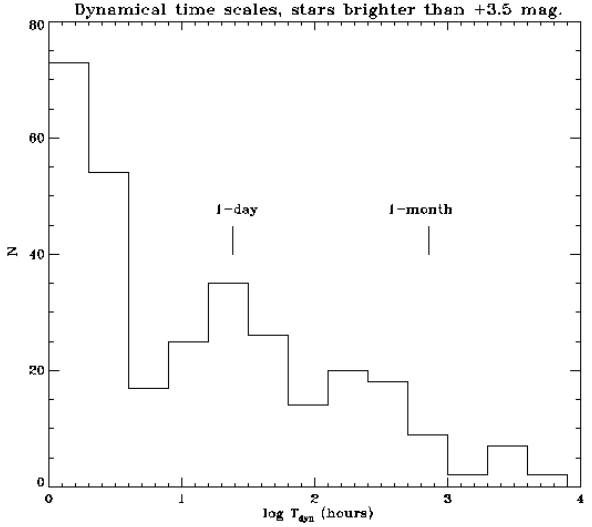
- Increased staff involvement:
  - Critical components, radios, computers, power system, for reliability of essential systems. Allows students to focus on satellite design rather than component design.
  - Project management for tight schedule and budget control.
  - Mentoring, working side-by-side with students.
- Larger satellite, bigger margins.
- Separation system testing and shock analysis.
- Extended environmental testing requirements.
- Antenna simulation and testing.
- Full duplex communications.
- Adopt lessons from CanX-1 and experience from MOST.

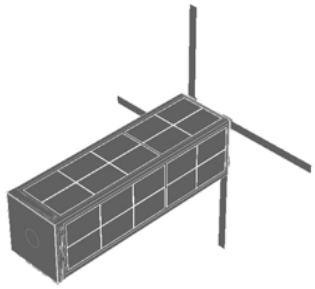


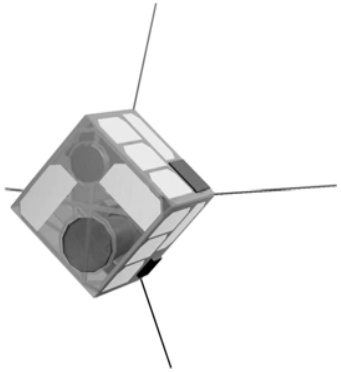
CanX-3 (aka BRITE)

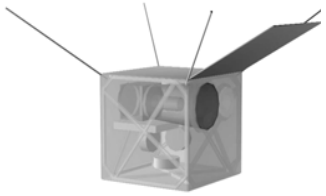
- Primary Mission: Bright Star Photometry
- Stellar frequencies:
  - MOST: minutes to hours (solar type stars)
  - CanX-3: hours to weeks (bright, luminous stars)
- May detect burst phenomena in optical band.
- PI: Prof. Slavek Rucinski (Toronto)
- Three-Axis Stabilized Nanosatellite
  - 2-3 kilograms
  - Similar support systems to CanX-2
- Target launch in late 2006, early 2007.









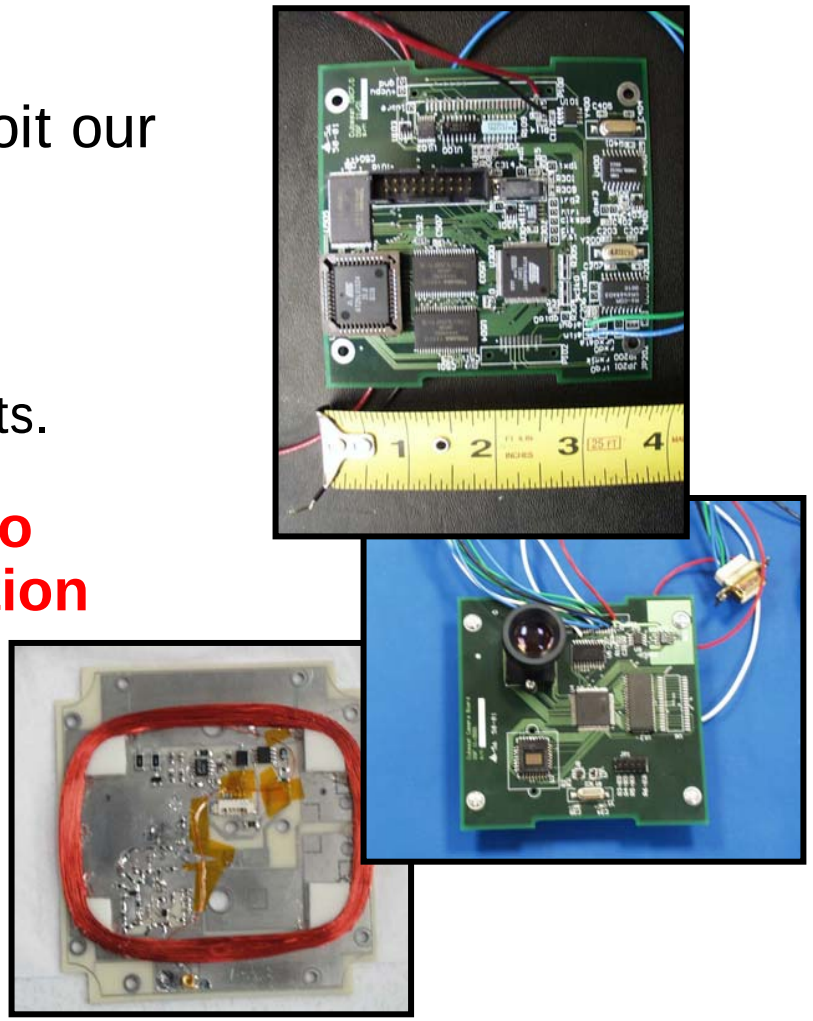


Frequency Coordination

- Future CanX satellites may contain mixture of amateur radio and science elements.
- Will use amateur frequencies for amateur radio part of mission.
- Will use science frequencies for science activities.
- Canadian Space Agency helping to secure science frequencies in S-band.
- Will use one set of frequencies for multiple missions by implementing satellite addressing protocol. Saves bandwidth and eases coordination.

Ways UTIAS/SFL Can Help University Programs

- Other university programs can exploit our existing infrastructure. We can:
  - **Provide components at cost.**
  - Collaborate on joint satellite projects.
  - **Arrange and share launches to reduce cost. Support separation system integration and test.**
  - Support commissioning efforts for other satellites sharing our launches.



Conclusion

- UTIAS/SFL's CanX-1 among first CubeSats to be launched into space in 2003.
- Lessons learned from CanX-1 and launch campaign are helping CanX-2 project currently underway.
- Continuing involvement in arranging and supporting launches.
  NLS-3: SSETI Express (mid 2005)
  NLS-4: CanX-2 (late 2005)
- Welcome collaboration:
  provide components at cost,
  help arrange future launches.

Building Canada's Future in Space ...

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dynacon

NSERC CRSNG

ONTARIO
Research and Development Challenge Fund

CRESTech

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NovAtel

raymond emc

Stanford University

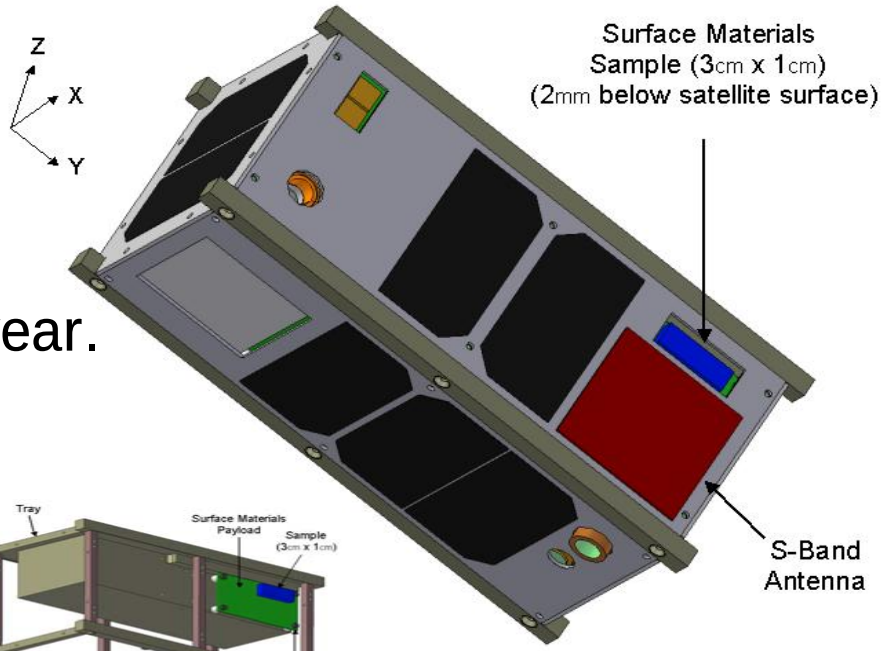
The MathWorks

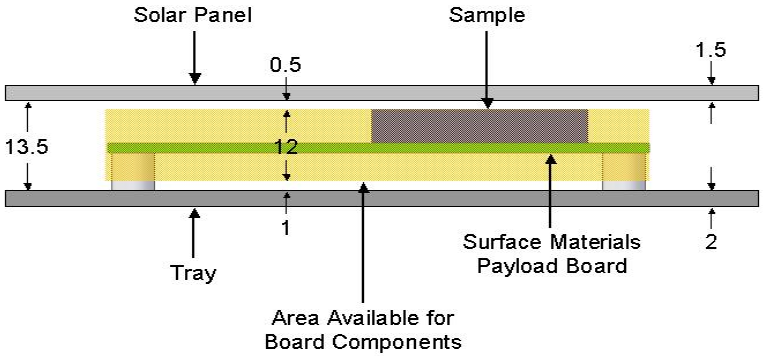
AeroAntenna Technology, Inc.

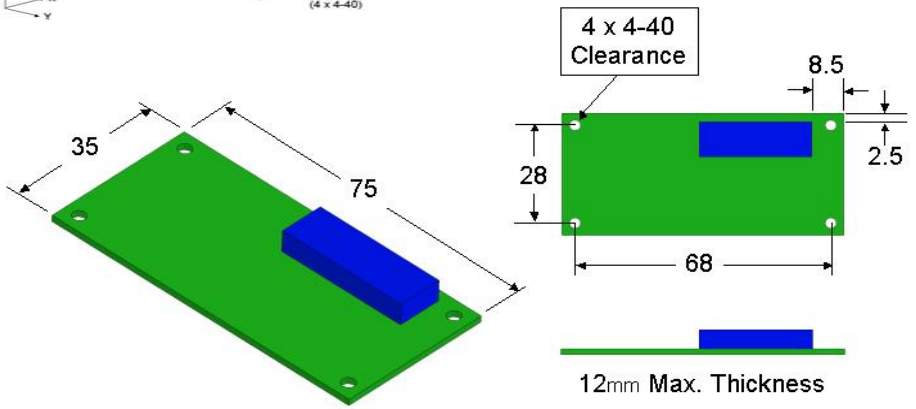
Texas Instruments

CanX-2 Materials Experiment

- Kleiman/ITL Experiment
- Translucent Material Samples
- Surface treatment + untreated
- Effect of AO erosion over one year.
- Photon receptors to determine thickness of material.
- Telemetry once a day.







CanX-2 Nanowhisker Experiment

- Prof. Harry Ruda (University of Toronto)
- Semiconductor nanowhiskers.
- Conductivity changes resulting from radiation induced defects.
- Voltage sweep, measure currents.
- Possible application in nanocalorimetric detector arrays for X-rays or elemental particles.