UTIAS SFL Space Flight Laboratory

Building Canada's Future In Space

The SFL Nanosatellite Launch Service

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Space Flight Laboratory

University of Toronto Institute for Aerospace Studies

Overview

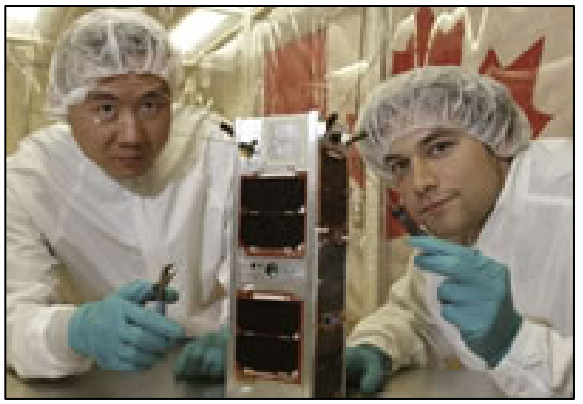
- The Space Flight Laboratory (SFL) at the University of Toronto Institute for Aerospace Studies (UTIAS)
- Nanosatellite Launch Service (NLS)
  - Launches to Date
- XPOD Separation System
  - Heritage
  - Qualification
- Future NLS Payload Packages
  - Partners and Spacecraft Complement
  - System outline and tentative ICD

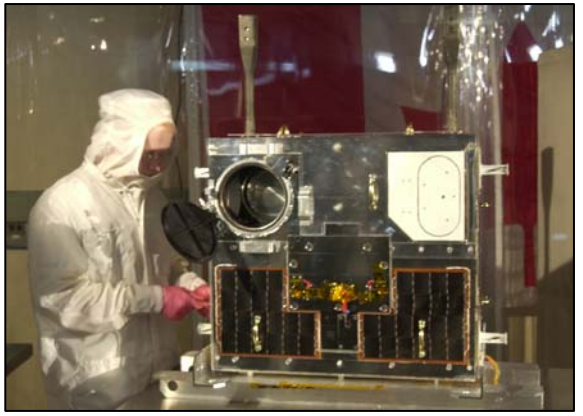
UTIAS Space Flight Lab

- Part of University of Toronto Institute for Aerospace Studies
  - M.A.Sc. curriculum: spacecraft system/subsystem design from concept to operational
  - Ph.D. curriculum: research on spacecraft system/subsystem
  - Full-time experienced staff to support students
  - 10 students and 6 staff

UTIAS/SFL Research Projects

- Canadian Advanced Nanospace (CanX) Program: State-of-the-art research with nanosatellites (<10kg)
- Nanosatellite Launch System (NLS) Program: Regular launches for CanX spacecraft (and others)
- Radiation Test Program
- Microsatellite Projects (<100kg) to use proven technologies





CanX Mission Horizon

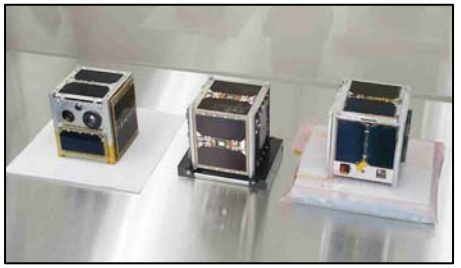
- Precise Formation Flying
  - CanX-2 (Q2 2007) Status: Final Qual. in Summer 2006
  - CanX-4/5 (2008-2009) Status: PDR in June 2006
- BRIght Target Explorer (BRITE) Constellation
  - Space Astronomy with four nanosatellites
  - CanX-3A, 3B, 3C, 3D (2008-2009)
    - UniBRITE (U Vienna) Status: PDR in June 2006
    - BRITE-Austria (TUG) Status: PDR in June 2006
    - BRITE-Toronto Status: CSA Proposal Under Review
    - BRITE-Montreal Status: CSA Proposal Under Review
- Multi-Mission (or "Generic") Nanosatellite Bus
  - Use same bus for CanX-3A/B/C/D,4,5

NLS Program

- 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
- Nanosatellite Separation Systems
  - Flight-proven XPOD separation systems

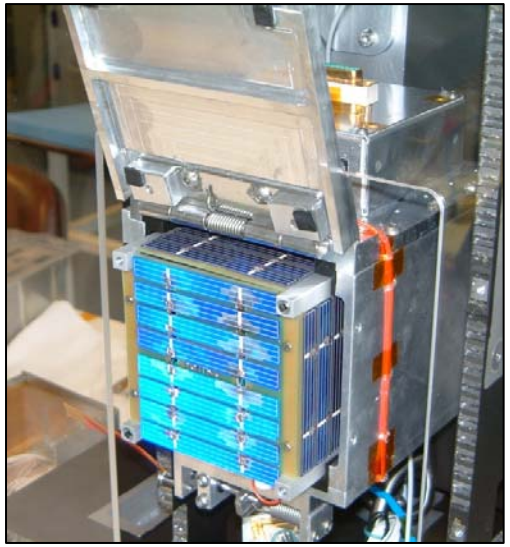
Launches To Date

- **NLS-1:** Rockot Launcher, June 20, 2003
  P-POD Mk. I Separation System
  - **CanX-1** – UTIAS Space Flight Laboratory, Canada
  - **DTUsat** – Danish Technical University, Denmark
  - **AAUSat** – University of Aalborg, Denmark
- **NLS-2:** Rockot Launcher, June 30, 2003
  P-POD Mk. I Separation System
  - **QuakeSat** – Stanford University, United States
- **NLS-3:** Cosmos-3M, October 25, 3006
  T-POD 1.7 Separation System in SSETI-Express
  - **NCUBE-2** – Norwegian Space Centre, Norway
  - **UWE-1** – University of Würzburg, Germany
  - **XI-V** – University of Tokyo, Japan



NLS-3 Lessons Learned

- Redundant firing system
  - Tolerant to single failures
- Sensors
  - Door sensor: indicates successful activation
  - Pusher-plate sensor: indicates successful ejection
- Reliable components
  - Improved screening and testing of critical parts
  - High-performance materials
- Extensive system- and subsystem-level testing
- One spacecraft per separation system
  - Minimizes overall risk



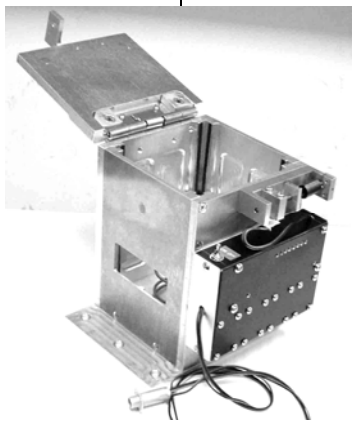
XPOD Development

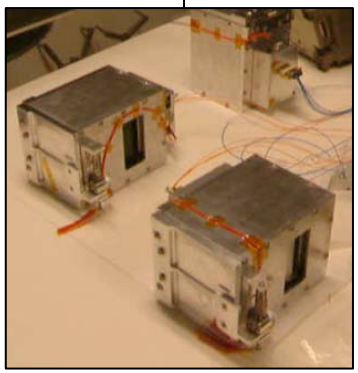
Flight-proven separation system

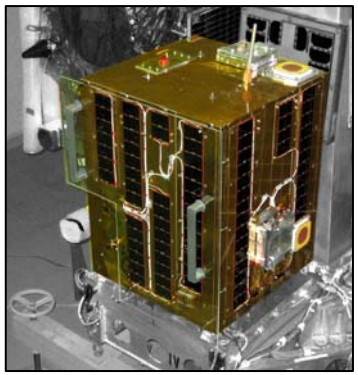
- **2003**: T-POD
  - Original design by U. of Tokyo, flown on Rockot
- **2005**: T-POD 1.7
  - UTIAS/SFL and U.of Tokyo joint design; three flown on ESA SSETI-Express/Cosmos-3M
- **2006**: XPOD (formerly known as T-POD II)
  - Passed vibration and thermal vacuum qualification; five to be flown (three different sizes) on NLS-4 in 2007
- **2008/2009**: XPOD-II
  - Under development for spacecraft of arbitrary dimensions, up to ~12kg, with fixed appendages; five planned for flights in 2008 and 2009

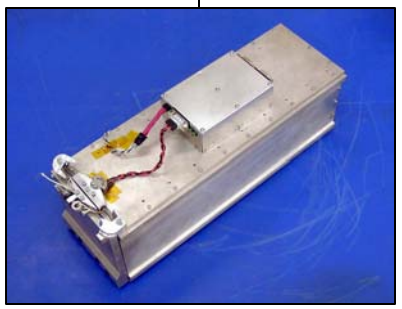
XPOD Development

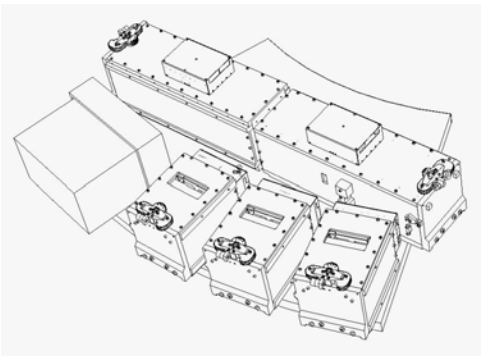
2003	2004	2005	2006	2007	2008	2009







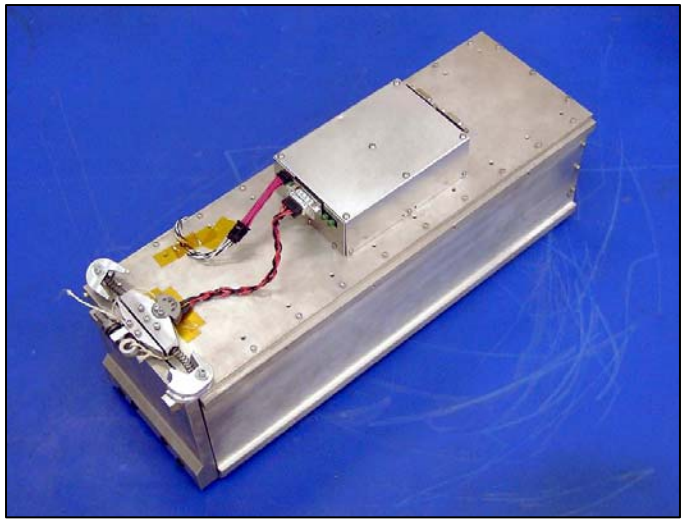




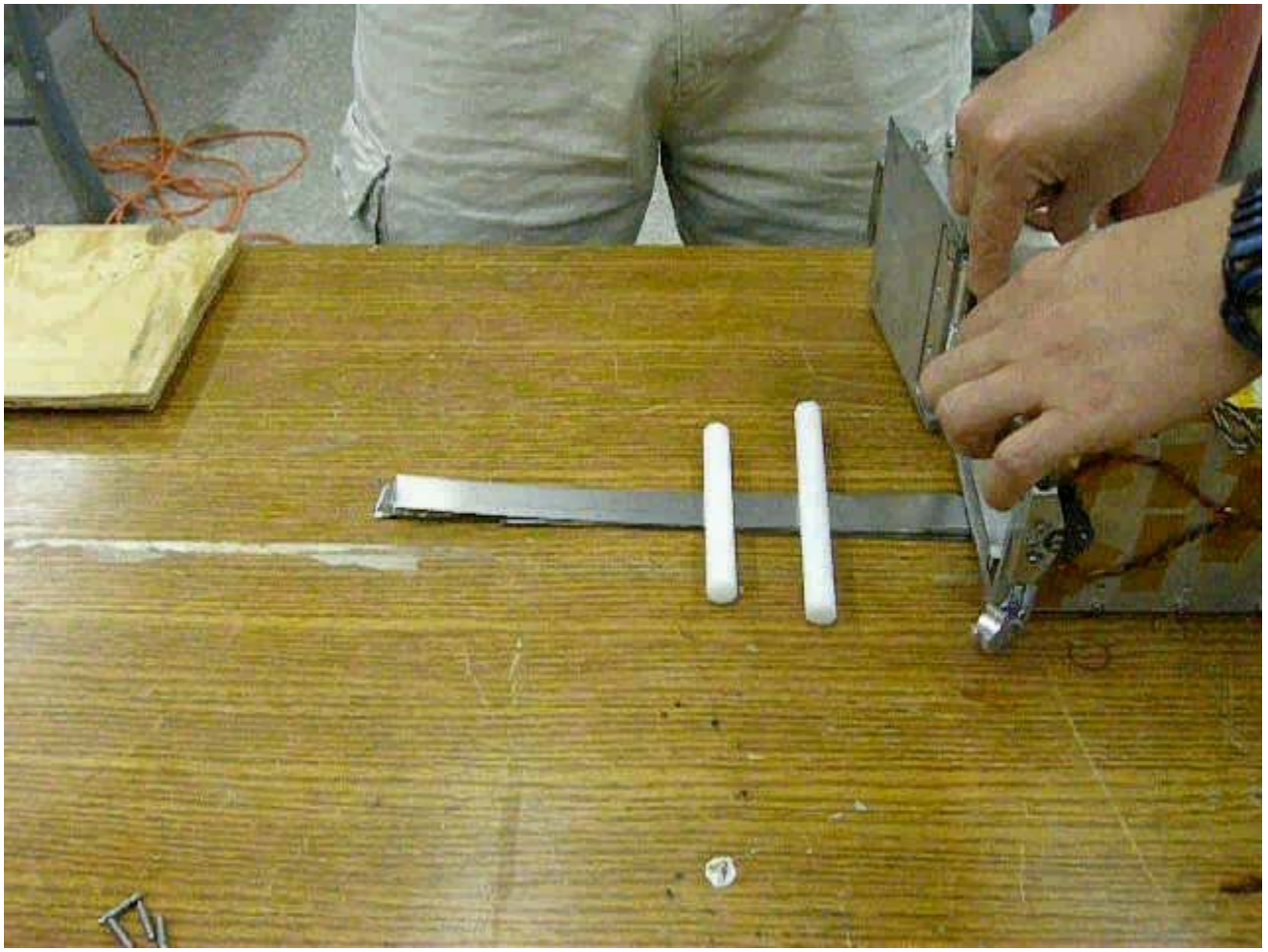
NLS-5
NLS-6
XPOD,
XPOD-II

XPOD Features

- Scalable design for spacecraft of arbitrary dimensions up to 5 kg; one XPOD per S/C
- Closing Mechanism
  - In-house design
  - Implemented features to minimize the risk of jamming
- Redundant firing system
- Door and pusher plate sensors
- Improved spacecraft contacts
- High performance materials
- Capable of full S/C deployment test in 1-g



XPOD Deployment Test

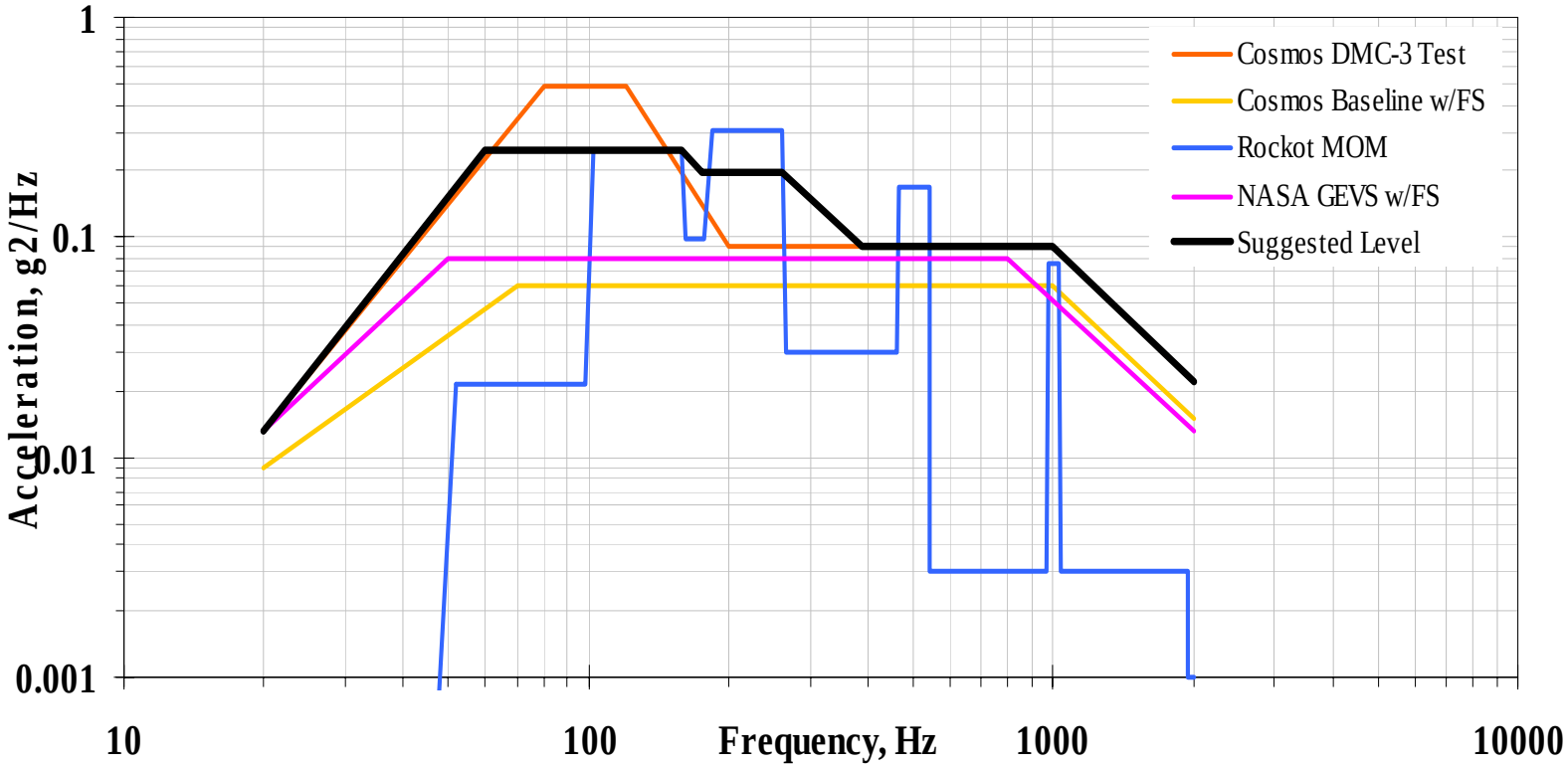


XPOD Qualification

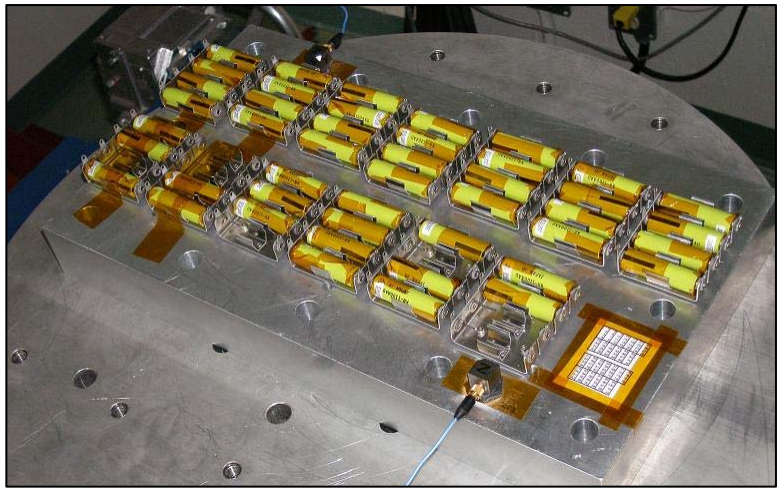
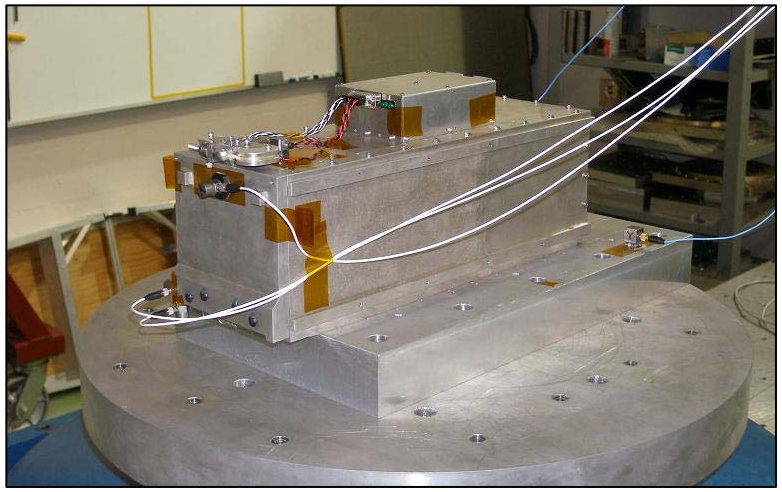
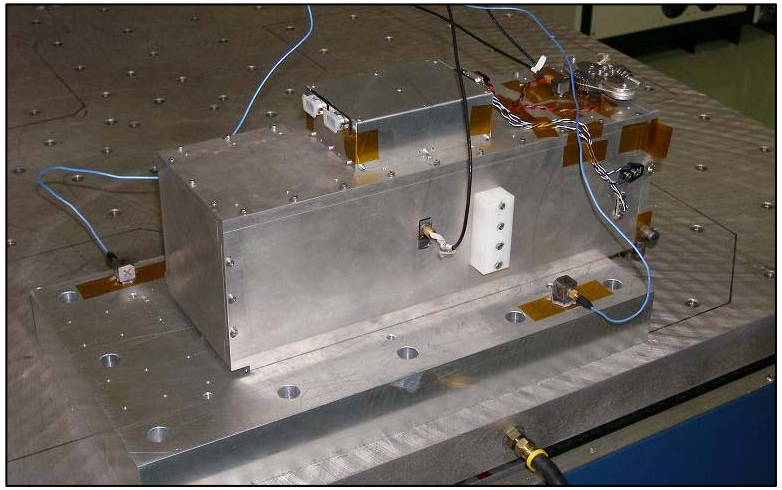
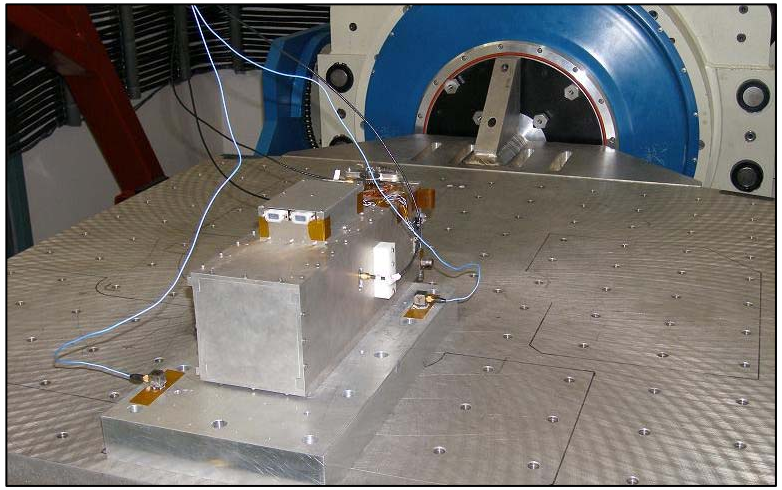
- Approach to Vibration Testing:
  - Worst case combined vibration load from multiple LVs: Rockot, Dnepr, Cosmos-3M, NASA GEVS.
  - 1.5 Safety Factor
- Vibration Test Campaign:
  - Sine-Burst: 14.9-15.1Hz @ 9.75g
  - Sine-Sweep: 5-10Hz @ 0.8g, 10-100Hz @ 0.8-3.0g
  - Random Vibration: 13 g_{RMS}

XPOD QUALIFICATION

- Random Vibration Spectrum



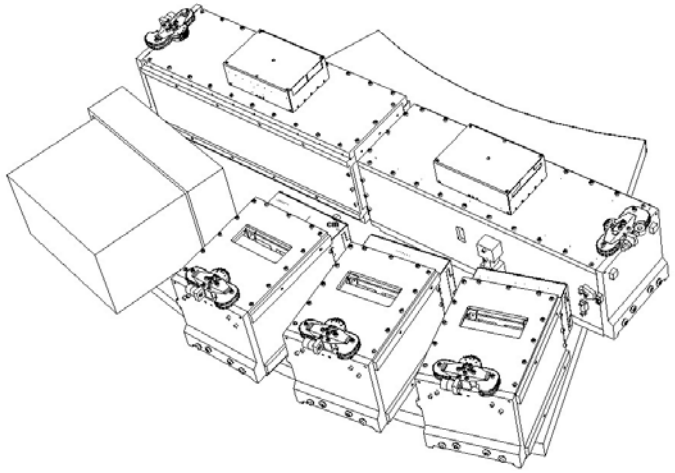
XPOD Qualification

XPOD Qualification

- Approach to Thermal Vacuum Testing
  - Operational testing at worst case temperature condition
  - Min operational temperature -35°C
  - Max operational temperature +65°C
- Thermal Vacuum
  - Operational Testing at -35°C and +65°C
  - 10^{-5} Torr or better
  - All tests show consistent performance under thermal vacuum conditions, both before and after qualification vibe

NLS-4 Payload Package



- Lead Partner:
  - UTIAS Space Flight Laboratory Canada
    Spacecraft: CanX-2
- Launch Partners:
  - Aalborg University, Denmark — AAUSat-II
  - Tokyo Institute of Technology, Japan — Cute-1.7 +APD II
  - University of Aachen, Germany — COMPASS-1
  - Technical University Delft, The Netherlands — Delfi-C3
  - Nihon University, Japan — SEEDS
- Separation systems: XPOD (5) and Cute-SS (1)

Future Launches

- NLS-5 in 2008/9
  - UniBRITE (CanX-3A), CanX-4, CanX-5
  - Launch Vehicle: TBD
- NLS-6 in 2008/9
  - BRITE-Austria (CanX-3B)
  - Launch Vehicle: TBD, would like to place CanX-3B into an orbit that is different than CanX-3A
- Additional launch partners are welcome
  - Choice of XPOD or XPOD-II
  - Each spacecraft to have its own dedicated separation system

Working Together

Building Canada's Future in Space

Partners

Sponsors

www.utias-sfl.net

Back-up Slides

NLS 3: What Happened to N-Cube 2

- On Dec 21, 56 days after launch, NORAD tracked a separate object moving away from SSETI-Express
- Analysis based on the separation dynamics suggest that this object might be N-Cube 2
- What happened?
  - The object was deployed late
  - Impossible to determine what exactly happened due to absence of telemetry

NLS 3: What Happened to N-Cube 2

- Hypothesis:
  - Connection failure
    T-POD not receiving separation signal, therefore was not activated.
  - Electrical failure in the T-POD
    T-POD receives the separation signal, but failed to activate
  - Mechanical failure in the T-POD
    T-POD activates, but failed to complete ejection
  - Ejection failure due to external factors
    T-POD activates, but failed to complete ejection due to factors external to the T-POD