UTIAS SFL Space Flight Laboratory

Building Canada's Future In Space

SFL Nanosatellite Missions and Launches in 2007-2009

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SPACE FLIGHT LABORATORY

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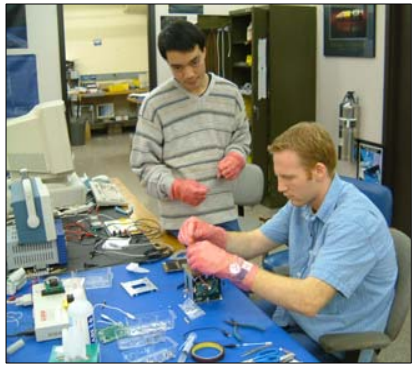
Presentation Outline

- The Space Flight Laboratory
- Nanosatellite Missions
  - Under-development: CanX-3/BRITE, CanX-4 & CanX-5
  - Deep Space Missions: Lunette, MOMENT
- XPOD Family of Separation Systems
  - XPOD Triple, Single, DUO, GNB
- Launches in 2007-2009
- Conclusion

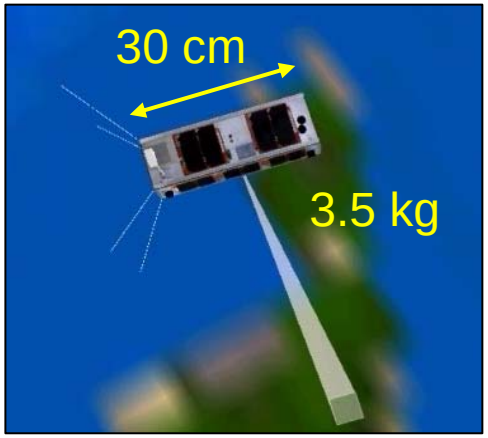
CanX Missions

Canadian Advanced Nanospace eXperiment (CanX) program was established in 2001 for two purposes:



– *Train students* in building real spacecraft:
  - Complete development cycle experience in 2 years.
  - Exploit staff expertise and facilities at SFL.

– *Cost-effective, rapid, regular access to space* for miniature payloads, technologies, experiments:



  - Aggressive experimentation, manage moderate risks, the "X" in CanX – mixture of microspace and X-plane philosophies.
  - Nanosatellites (satellites under 10 kilograms).
  - Service to all Canadians and international partners.

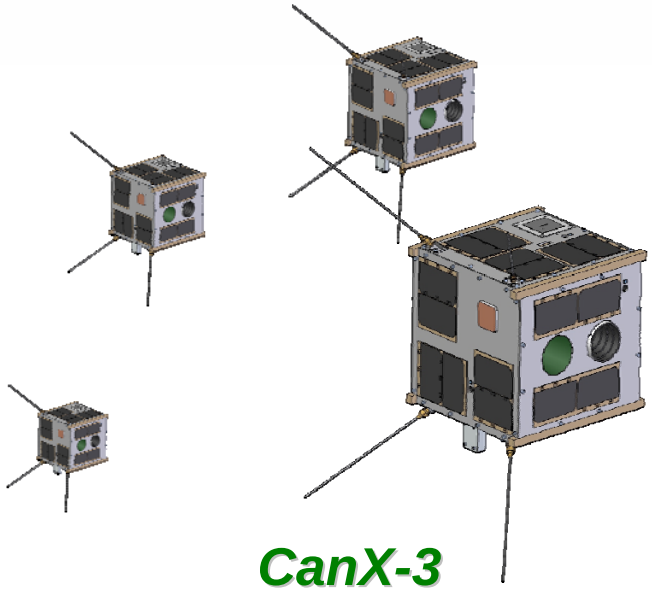
CanX Approach
Program

- Collaborative Staff/Student Team:
  - Staff provides day-to-day mentoring.
  - Staff creates critical technologies.
  - Staff fills in capability gaps.
  - Typically 8-10 Master students in team.
- Use SFL facilities, including ground stations.
- Develop satellites in approx. 2 year cycles.
- New technology development permitted, although heritage technology used where possible.
- Use bottom up and top down approaches.
- Collaborate with engineering and scientific PIs.

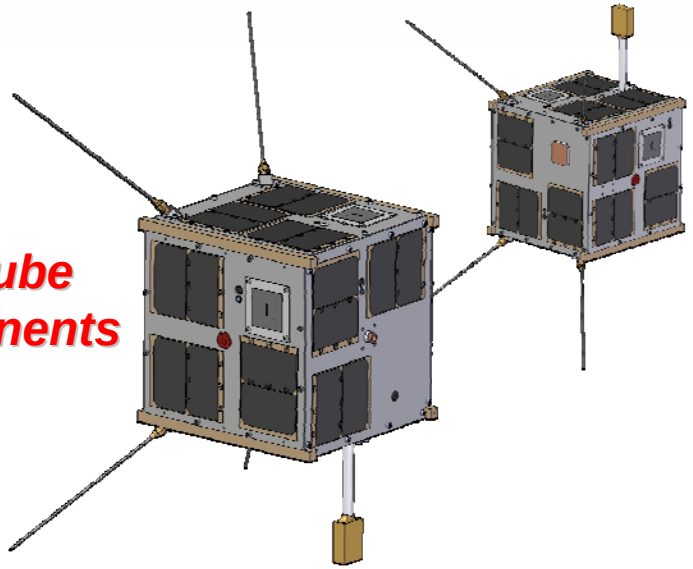
CanX Mission Horizon

- BRIght Target Explorer (BRITE) Constellation
  - Space astronomy with four nanosatellites.
  - Collaboration with Austria.
  - CanX-3A, 3B, 3C, 3D (2008-2009)
    - UniBRITE (U Vienna) Status: CDR 19 April 2007
    - BRITE-Austria (TUG) Status: CDR 19 April 2007
    - BRITE-Toronto, BRITE-Montreal Status: CSA Proposal
    - PI (Canada): Prof. Anthony Moffat (U Montreal)
    - PI (Austria): Prof. Werner Weiss (U Vienna)
    - Science Team: Profs. Marten van Kerkwijk (UofT), Slavek Rucinski (UofT), Stefan Mochnacki (UofT), Rainer Kuschnig (UBC), Jaymie Matthews (UBC), John Percy (UofT)
- Precise Formation Flying
  - CanX-2 (Q3 2007) Status: PSLV Launch, Sep/Oct 2007
  - CanX-4/CanX-5 (2008-2009) Status: CDR 12 April 2007
  - Co-I's: Prof. Elizabeth Cannon (U Calgary), Prof. Christopher Damaren (UTIAS)

Multi-Mission Design

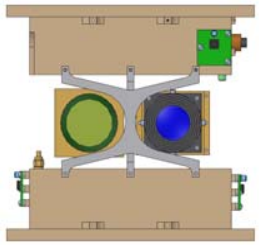


<7 kg, 20 cm cube
Common components



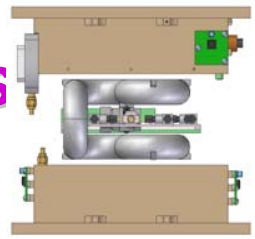
CanX-3
BRITE Constellation
(no formation control)

CanX-4 and CanX-5
Formation Flying
(formation control)



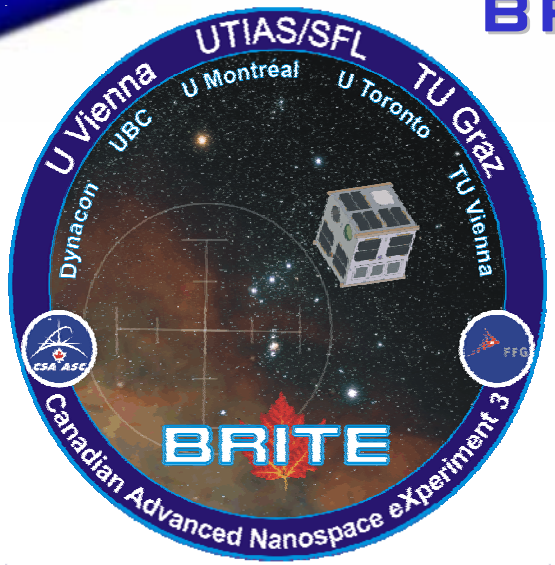
Multi-Mission or "Generic" Nanosatellite Bus

- To minimize costs, design a common bus …



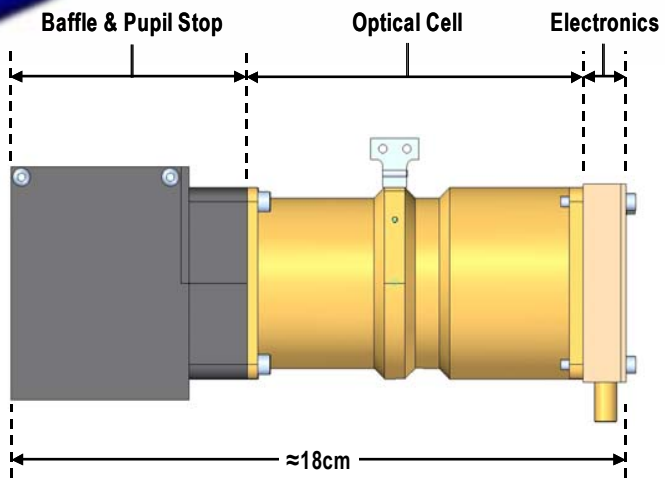
CanX-3

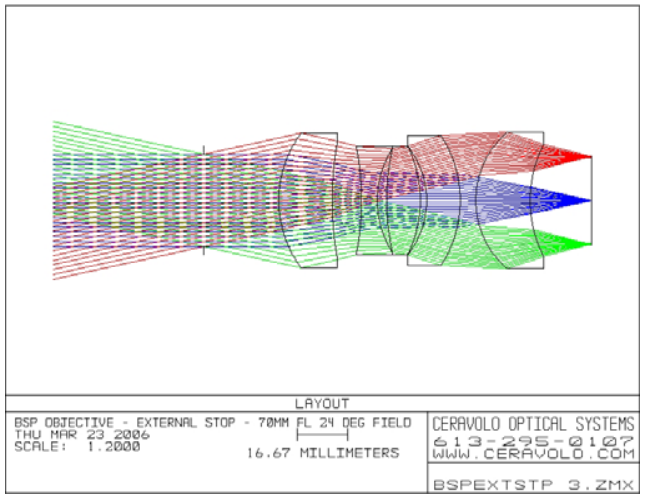
BRIght Target Explorer (BRITE)



- **Asteroseismology**:
  - Internal pressure waves and gravity waves cause a star's brightness to oscillate.
  - Use long duration photometric time series to extract frequencies of oscillation.
  - Use frequencies of oscillation to deduce core composition, size, age, internal structure.
- Similar to MOST science, but targeting the brightest stars in our galaxy with extremely long periods of oscillation (up to months).

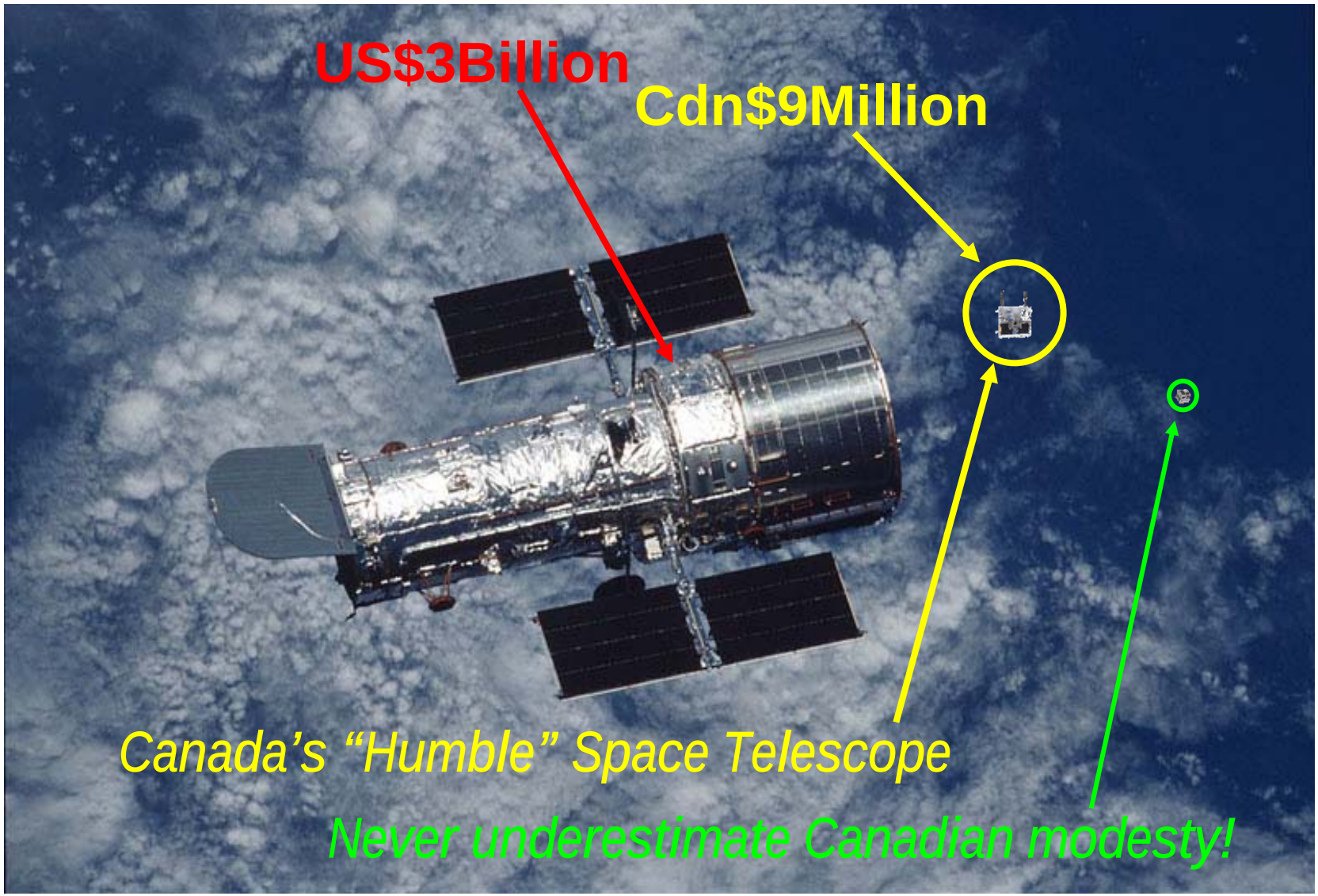
BRITE Instrument





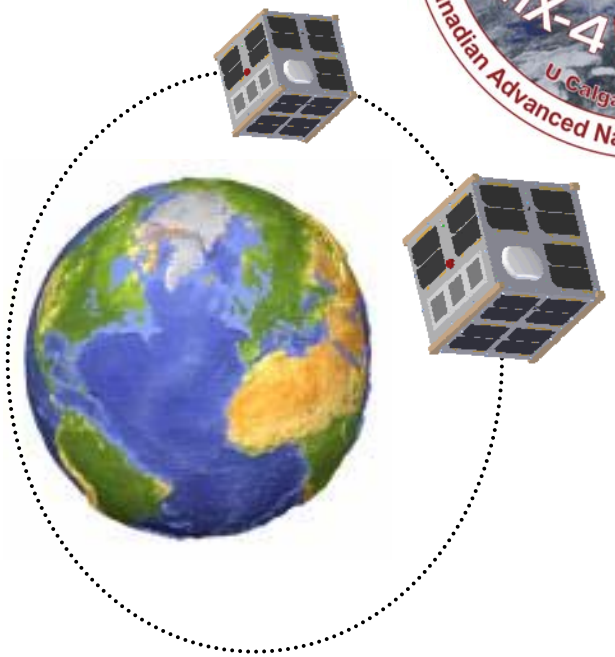
- Photometry
  - Differential photometry with 0.1% precision.
  - Error amplitude spectrum <20 ppm, > 1 month.
- Timing
  - Exposure times 0.1-100s, known to 0.01%
  - Absolute time accuracy better than 0.1s.
- Optics
  - Gaussian PSF
  - No vignetting, telecentric, minimum ghosting.
  - Blue and Red Filter (one filter in each spacecraft)
  - 3 cm aperture telescope, 24 degrees FOV.
- Detector
  - Detector temperature low, measured to 0.1ºC.
  - SNR: 1000 per 100s exposure at V=+3.5
  - Design out sun stare risk, no shutter or door.
- Stray Light – Baffle and light-tight instrument.

Hubble vs. MOST vs. BRITE



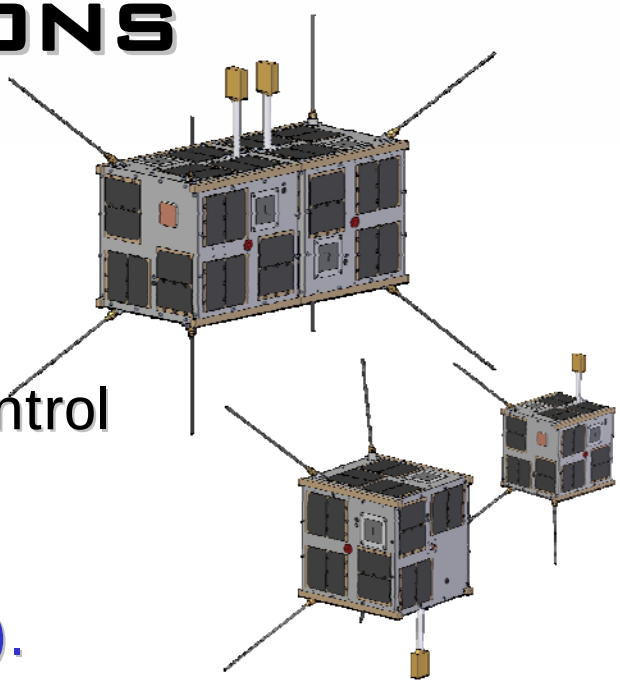
CanX-4 and CanX-5
Formation Flying Mission

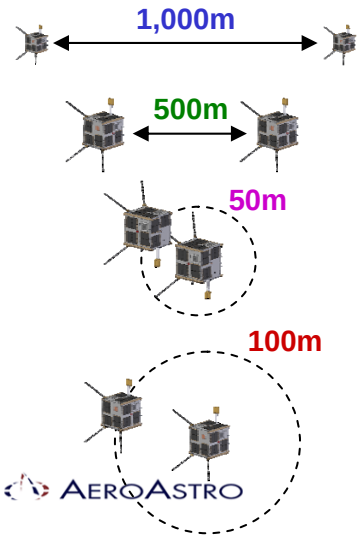
- Demonstrate precise formation flying in space.
- cm-level relative position determination (Cannon, U Calgary).
- Sub-meter accurate position control (Damaren, UTIAS).
- Each <7 kg, 20x20x20cm.
- Nanosat Propulsion
  - 22 m/s, SF_6, 40s Isp, 5 mN,
- Differential GPS.
- Inter-satellite communications.
- Three-axis attitude control.
- Target launch in 2008.



Formation Flying Operations

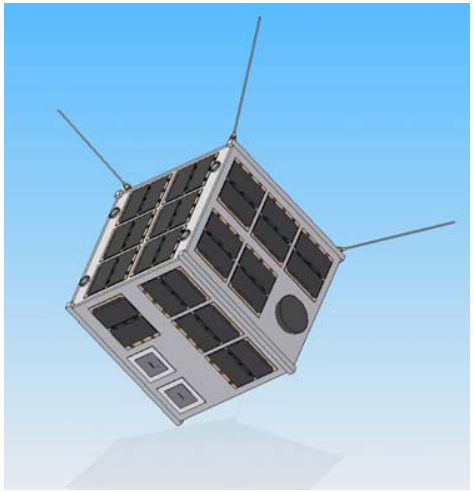
- Satellites stay together during commissioning. Don't want satellites to drift apart to keep fuel requirements within reason.
- Satellites separate, drift to 1 km, formation control begins. Control out secular perturbations to reference trajectories.
- Maneuver into 1000m Along Track Orbit (ATO).
- Transfer to 500m ATO, coarse and fine control.
- Transfer to 50m Projected Circular Orbit (PCO).
- Transfer to 100m PCO.
- Fine control for > 50 orbits in each configuration.
- Only one spacecraft is nominally controlled





LUNETTE

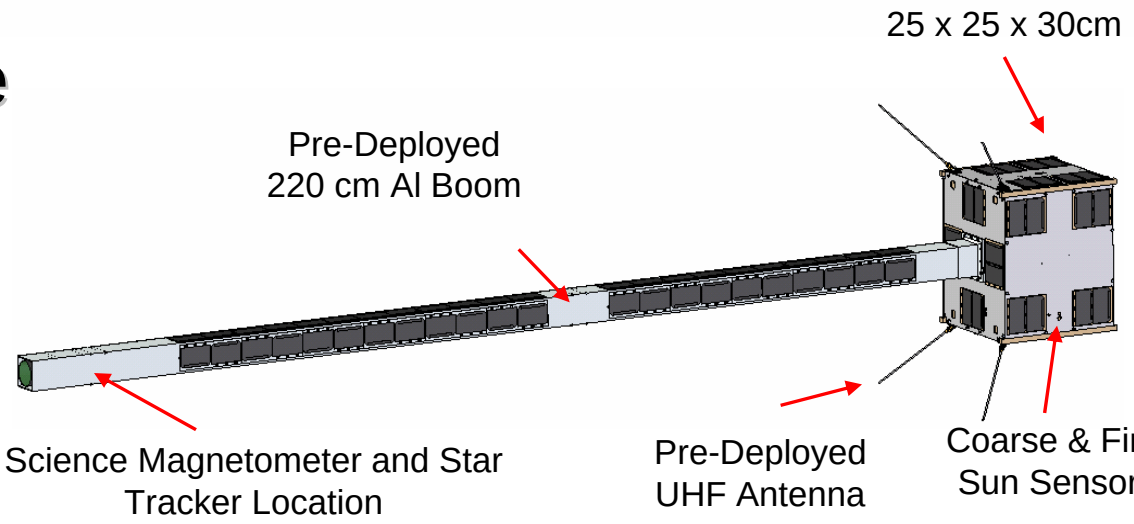
A Lunary Far-side Gravity Mapping Nanosatellite



- Nanosatellite to improve knowledge of lunar far-side gravity
  - Radio-tracking from a parent spacecraft to measure differential accelerations
  - Fly in formation at 100 km at initial lunar orbit, then lowers perilune for high-res mapping
- 10-20 mGal resolution
- GNB-based design with enhancements
  - Warm gas propulsion system
- Selected by ESA for the 2011 ESMO mission following international competition and review
- Phase A underway, subsequent proposal being prepared

MOMENT

Magnetic Observation of Mars Enabled by Nanosatellite Technology



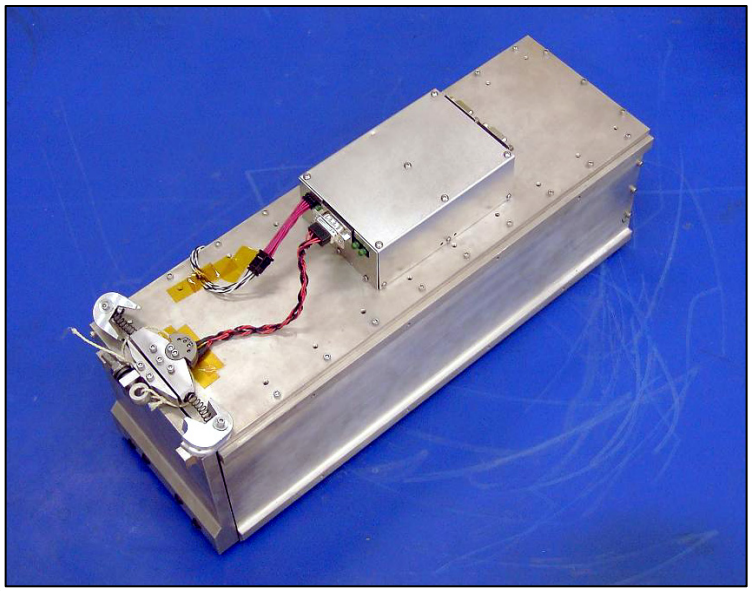
- Concept to study the remnants magnetic field in Mars
- NanoTesla-accurate magnetometer
- GNB-based design with enhancements
  - H2O2 propulsion
  - UHF system (Proximity-1 derivative)
  - Custom XPOD
- Parent spacecraft for interplanetary and injection phase
- Phase A completed, shows feasibility

XPOD™ Separation System

- Continuing evolution since 2003
  - **2003**: 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 Triple, Triple-M1, and Singles; passed qualification; five to be flown on NLS-4 in 2007
  - **2007**: XPOD DUO and XPOD GNB; passed CDR, to be qualified by Q3-2007, for spacecraft of arbitrary dimensions, up to ~14kg, with fixed appendages; four planned for flights in 2008 and 2009

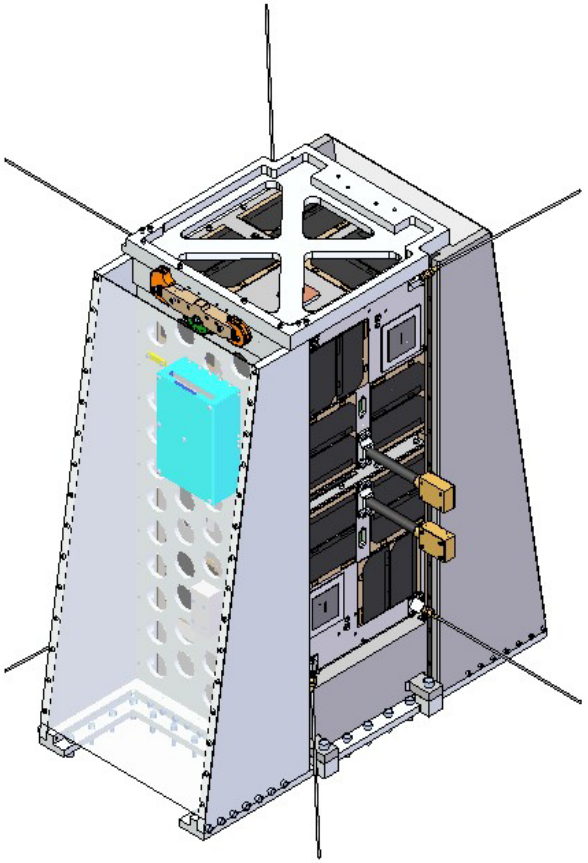
XPOD Triple

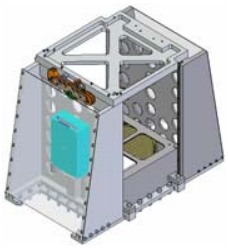
- Characteristics:
  - Fully-enclosed design
  - Clamp-type mechanism
  - Spacecraft damper
  - Deployment sensors
  - Fail-safe, single failure tolerant
  - Full s/c deployment test in 1-g
  - Compatible with Cubesat Specification
  - Scalable for spacecraft with arbitrary dimensions, up to 5 kg
- Derivatives:
  - XPOD Single
  - Custom-designs



XPOD DUO

- Characteristics:
  - Open-concept design, permitting fixed appendages
  - Clamp-type mechanism
  - Spacecraft damper and lock-system
  - Deployment sensors
  - Fail-safe, single failure tolerant
  - Full s/c deployment test in 1-g
  - 20 x 20 x 40 cm, 14 kg spacecraft customizable
- Derivatives:
  - XPOD GNB
  - XPOD LUNETTE, MOMENT





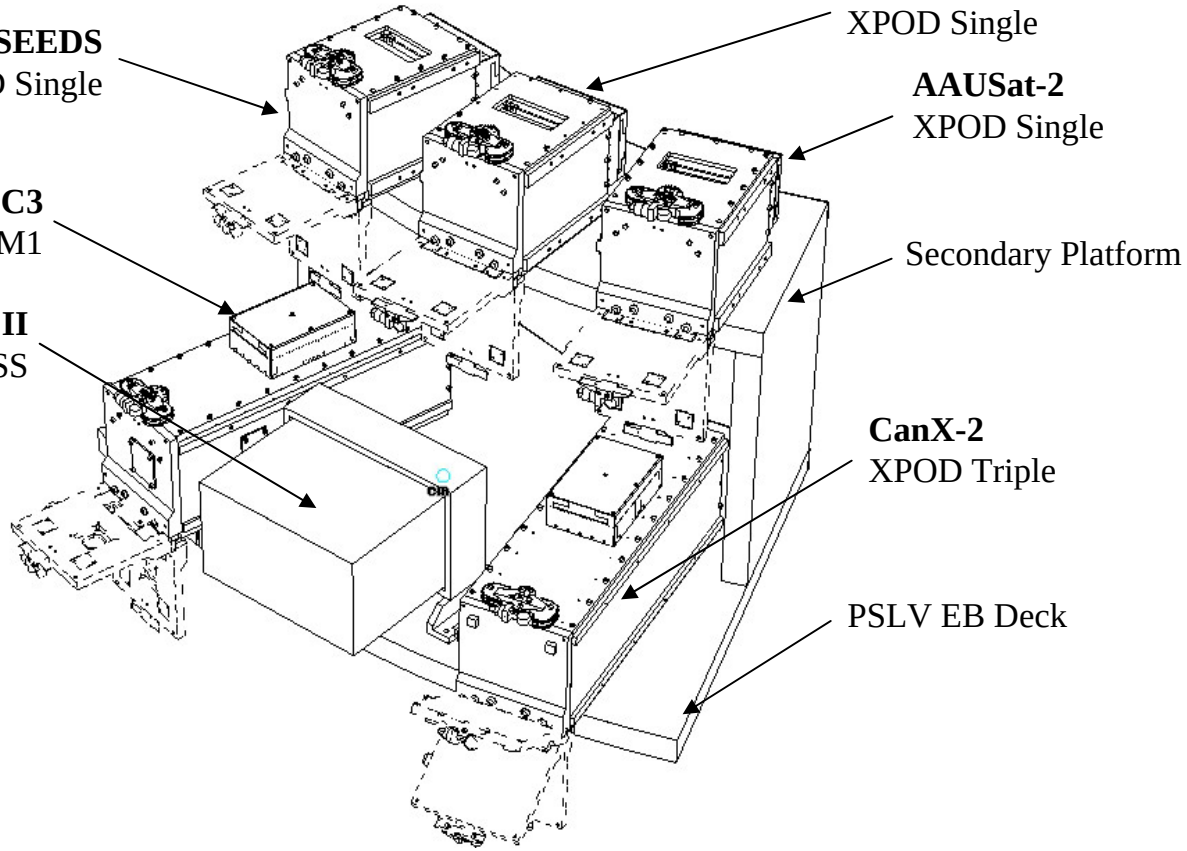
Launch in 2007

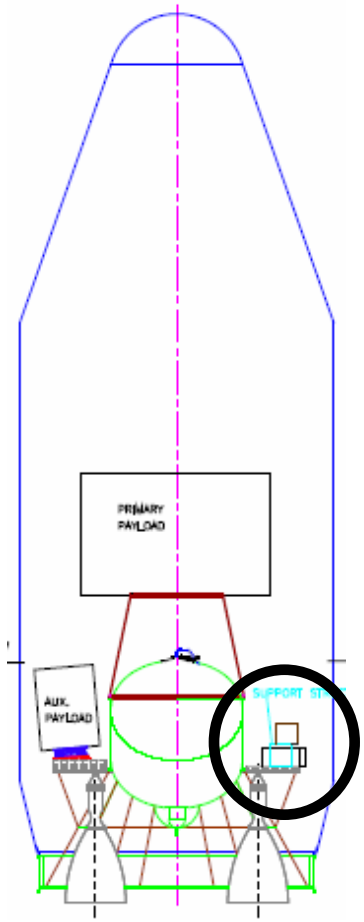
- NLS-4 launch on PSLV-C9

Spacecraft	Separation System	Organization
CanX-2	XPOD Triple	UTIAS Space Flight Laboratory, Canada
AAUSat-II	XPOD Single	Aalborg University, Denmark
COMPASS-1	XPOD Single	University of Aachen, Germany
Cute 1.7+APD II	Cute Sep. System	Tokyo Institute of Technology, Japan
Delfi-C3	XPOD Triple-M1 (custom)	Technical University Delft, The Netherlands
SEEDS	XPOD Single	Nihon University, Japan

- MOU signed July 2006, LSA signed August 2006

NLS-4 on PSLV-C9





Launch in 2008/2009

- Launch targets Q4 2008 and Q2 2009
- Orbits
  - Sun-Synchronous 0930 LTDN, 650km
  - Sun-Synchronous 0930 LTDN, 650km (1200 LTDN, 700km)
- Timeline
  - T-13 Month: MOU signing
  - T-12 Month: LSA signing
- Spacecraft complement to include CanX-3/BRITE and CanX-4 & CanX-5
  - Potential launch partners have been identified
  - Additional partners are welcomed

Partners and Sponsors