UTIAS SFL Space Flight Laboratory

Building Canada's Future In Space

Launches and On-Orbit Performance

An Update on Nanosatellite Missions at the UTIAS Space Flight Laboratory

Daniel D. Kekez, Robert E. Zee, Freddy M. Pranajaya

Space Flight Laboratory
University of Toronto
7 August 2010

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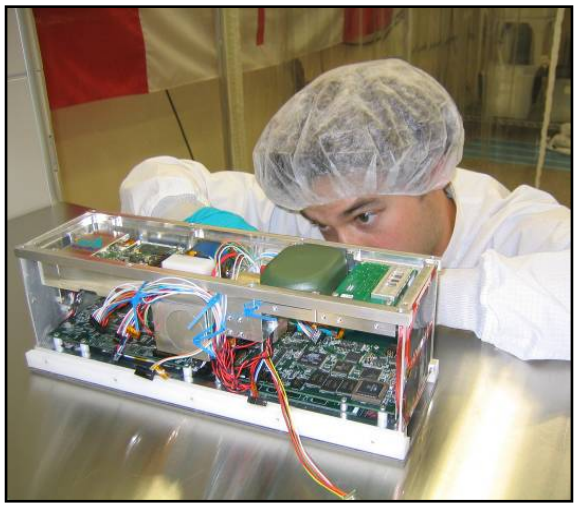
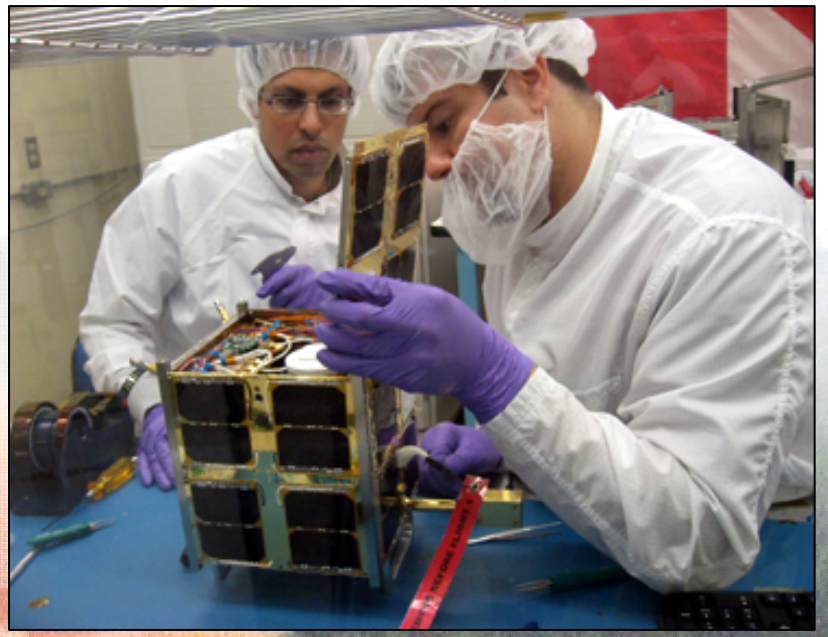
Building Canada's Future In Space

UTIAS Space Flight Lab

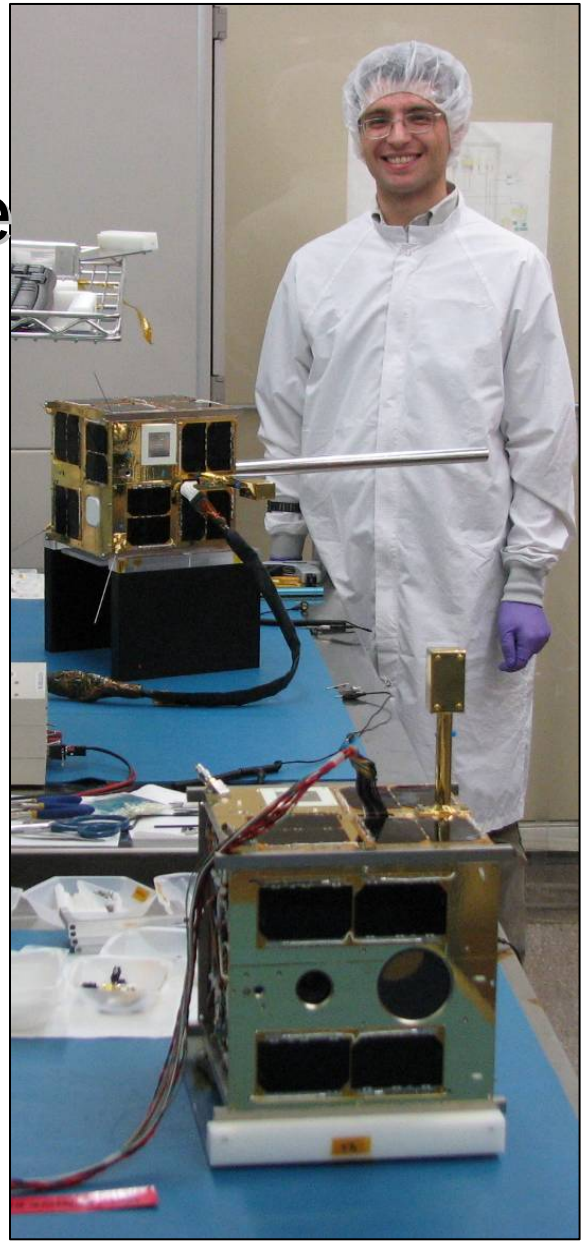
- Part of University of Toronto Institute for Aerospace Studies
  - M.A.Sc. curriculum: spacecraft system/subsystem design from concept to operational
  - Ph.D. curriculum: research on spacecraft system/subsystem
  - Full-time experienced staff to support students
  - 16 Engineering Staff
  - 18 M.A.Sc. Students, 1 Ph.D. Student
- Build Nanosatellites and Microsatellites

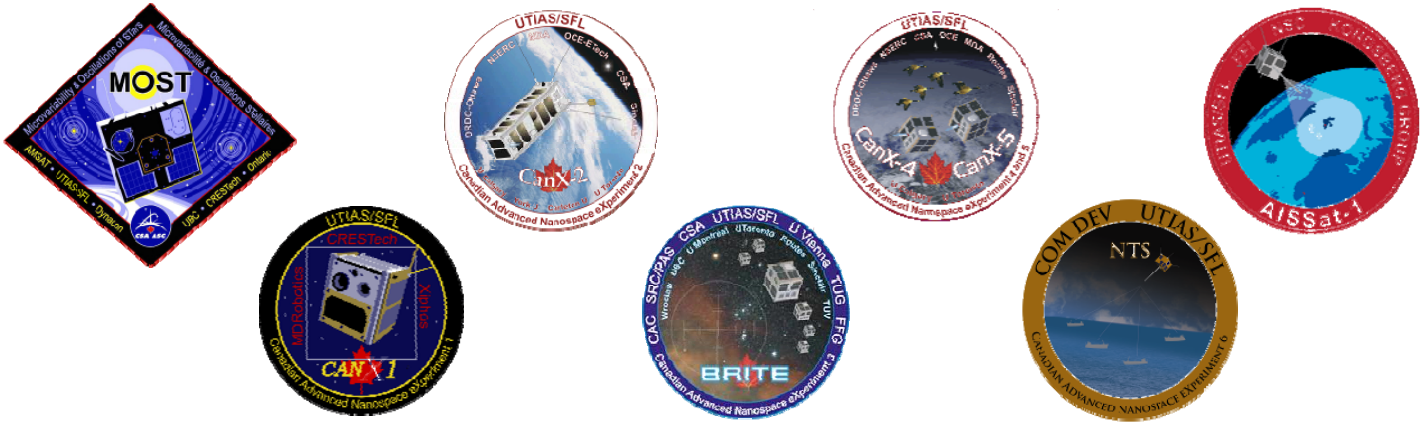




Outline

- SFL's Nanosatellite Launch Service
- Past Launches
  - NLS-4, including CanX-2
- Recent Launches
  - NLS-6: AISSat-1 and TIsat-1
- Upcoming Launch Opportunities





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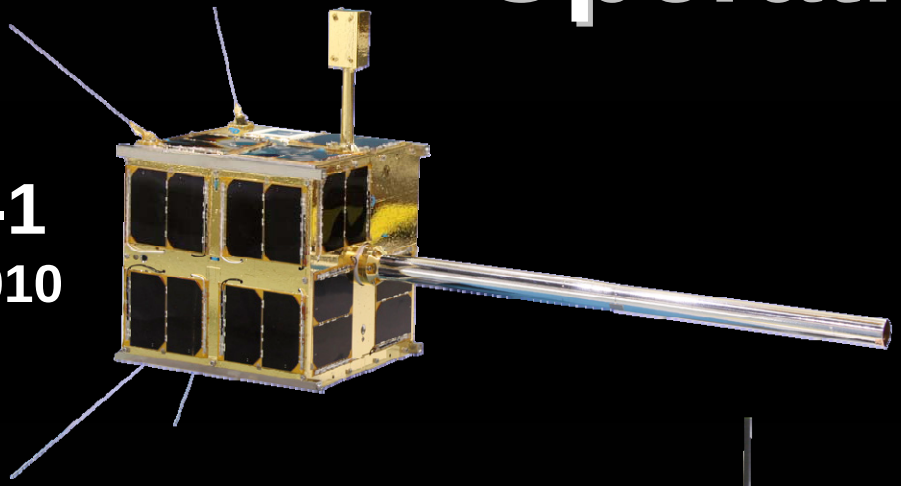
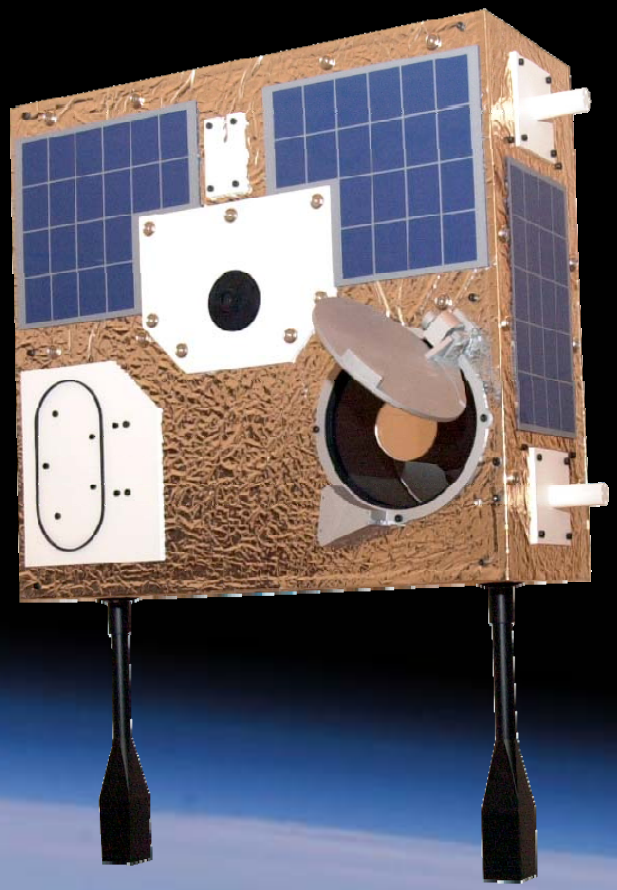
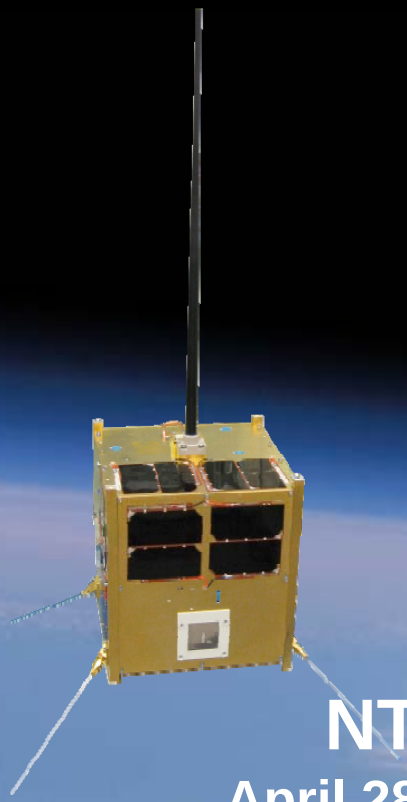
Operational On Orbit

AISSat-1
July 12, 2010





CanX-2
April 28, 2008



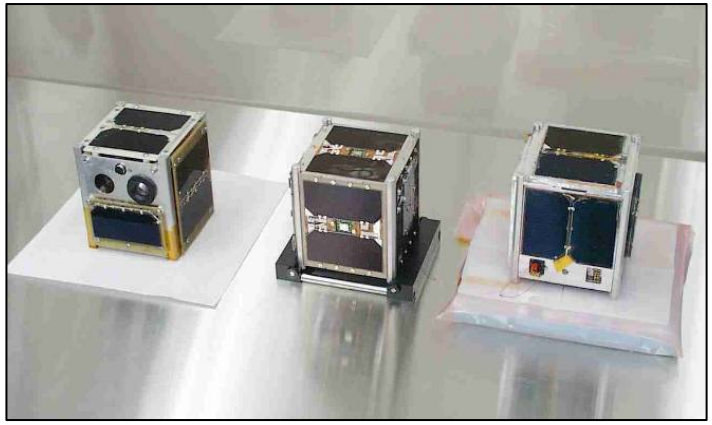
NTS
April 28, 2008

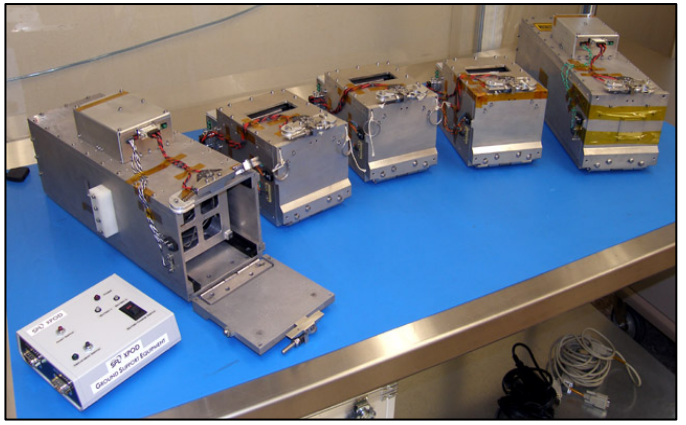
MOST
June 30, 2003

Nanosatellite Launch Service

Primary Objective

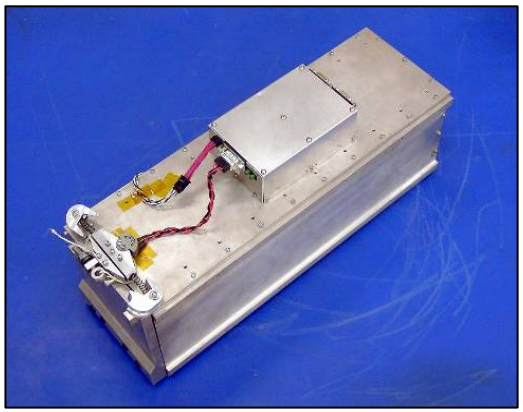
- Access to regularly scheduled launch
  in support of the SFL Nanosatellite missions and the UTIAS/SFL education curriculum





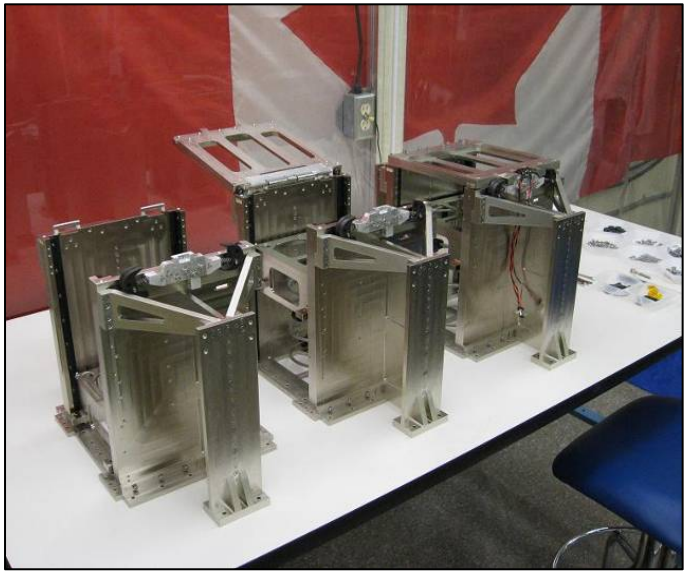
Nanosatellite Launch Service

Secondary Objectives



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

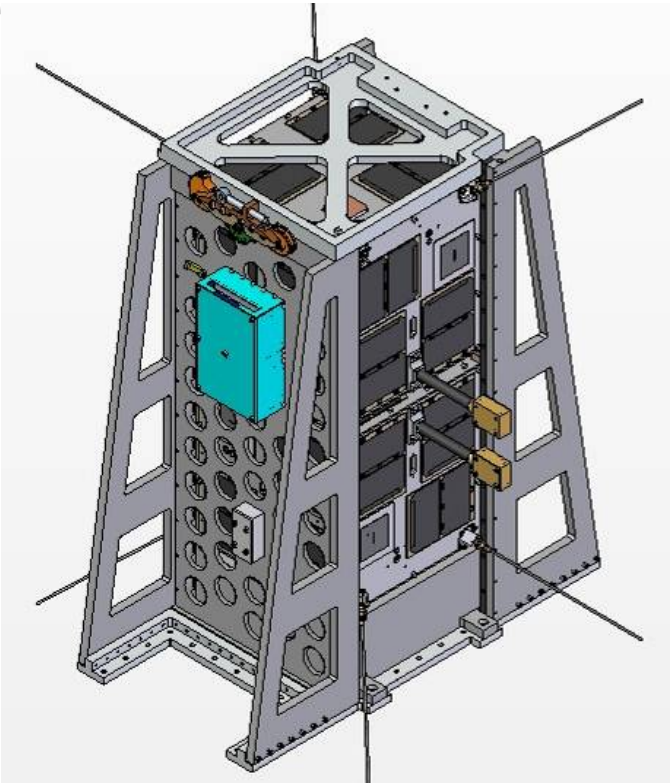
- Small number of participants simplifies LV integration, launch campaign logistics, post launch operations, schedule risks, therefore reducing
  the overall risk to all participants



XPOD Separation System

Flight-proven XPOD separation systems

- XPOD Single, Double, Triple
  - Compatible with the Stanford/CalPoly CubeSat standard
- XPOD GNB: 20x20x20 cm satellite
  - Target Missions: NTS, AISSat-1, BRITE Constellation
- XPOD DUO: 20x20x40 cm
  - Target Mission: CanX-4 & CanX-5, NEMO-AM

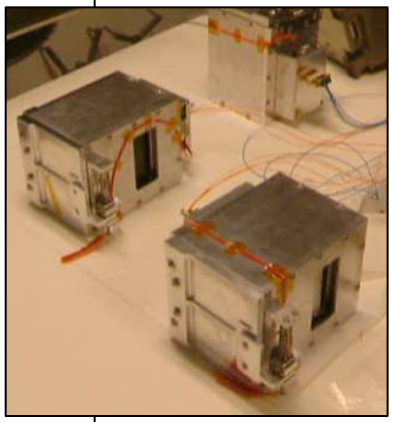


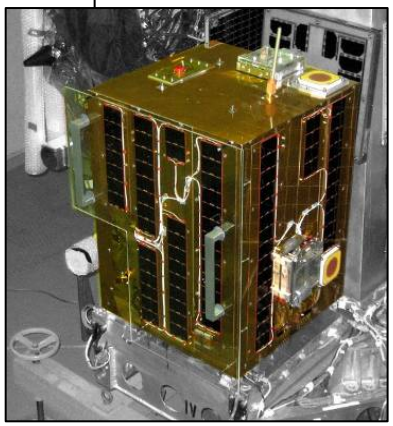
NLS Launches to Date

2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011

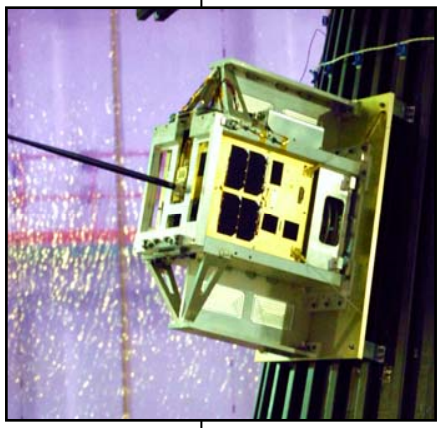
NLS-1 & 2

NLS-3

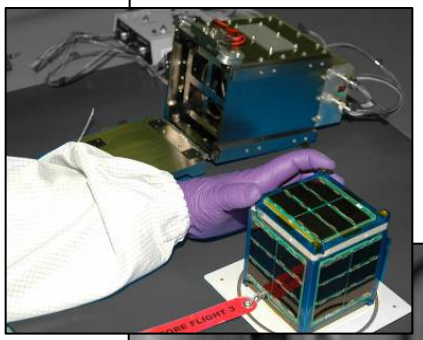


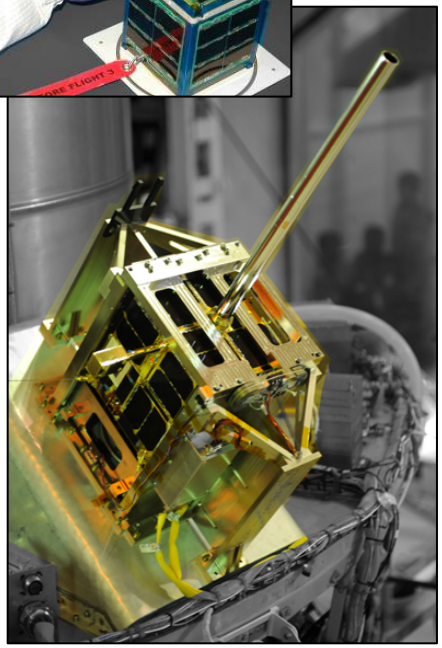


NLS-4 & 5



NLS-6



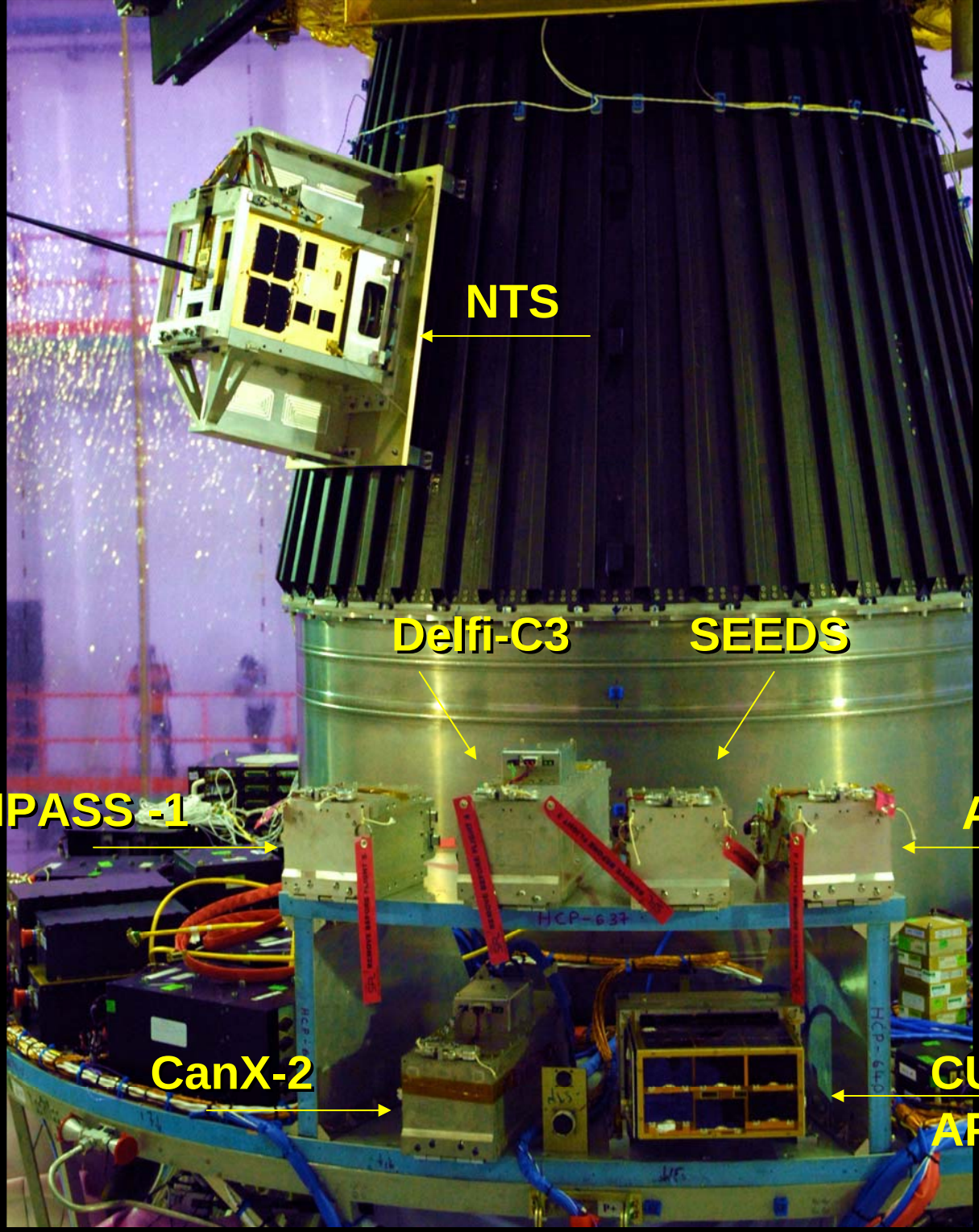


NLS-4 and 5

- **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) (NLS-5)**
  UTIAS Space Flight Lab, Canada

PSLV-C9 Upper Stage



PSLV-C9 Upper Stage

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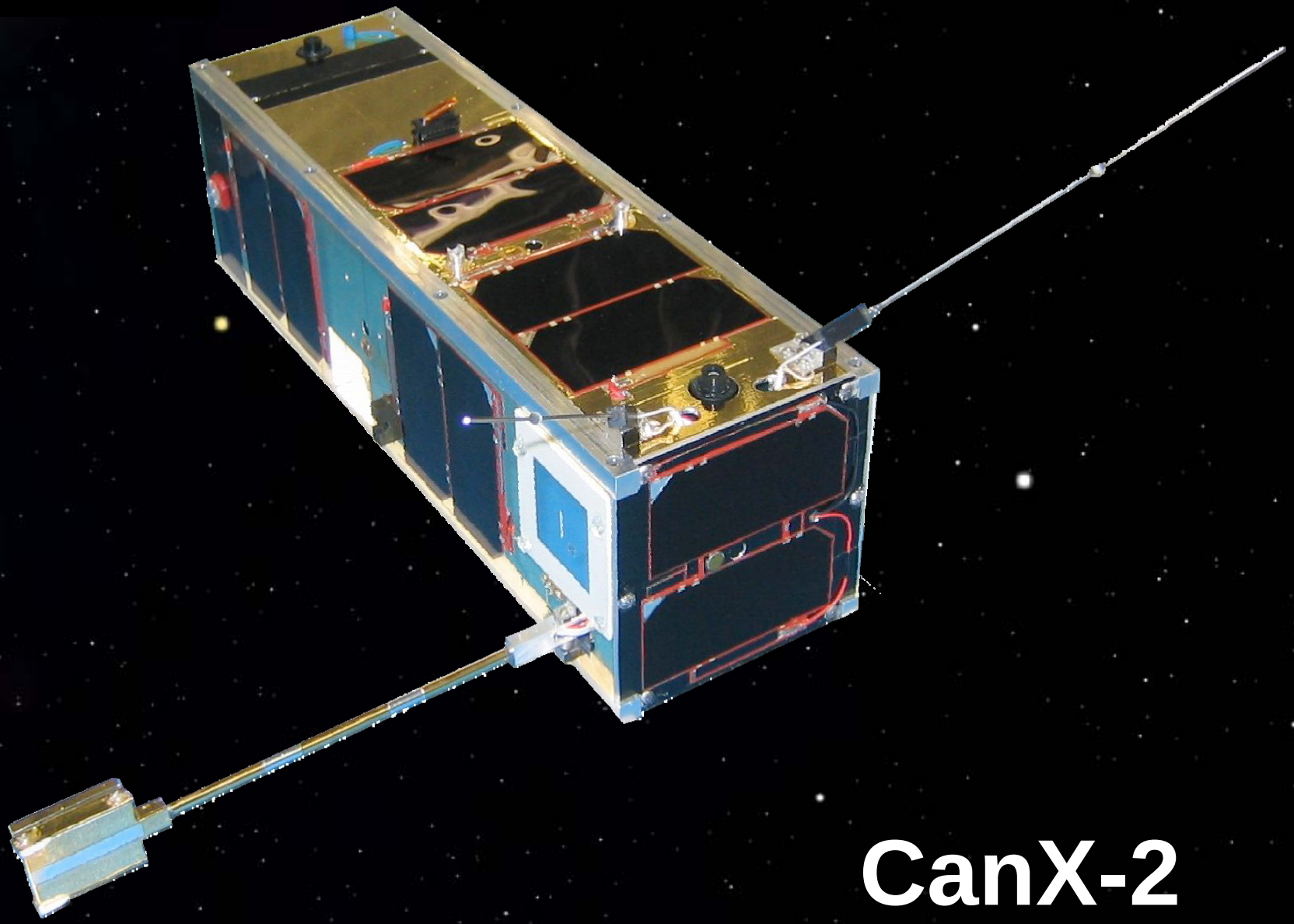
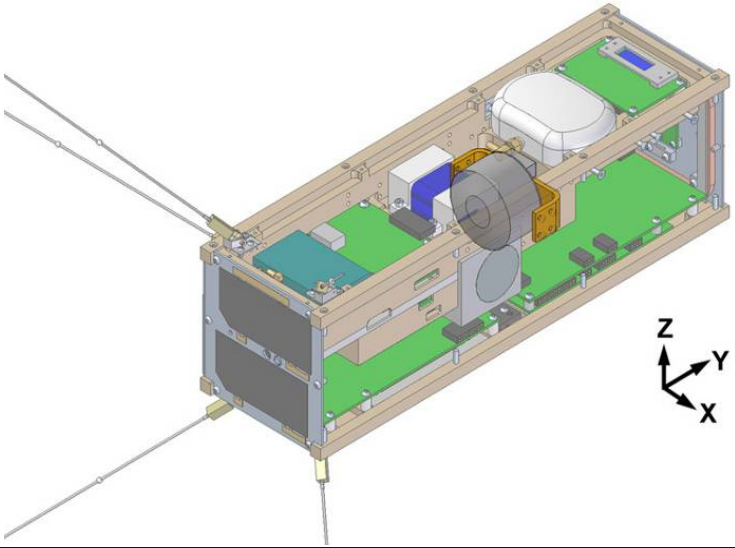


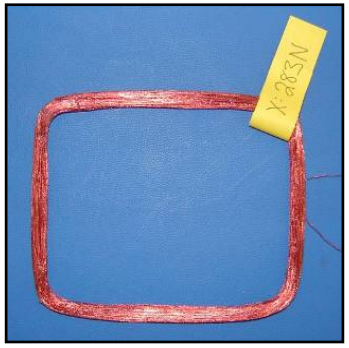
CanX-2

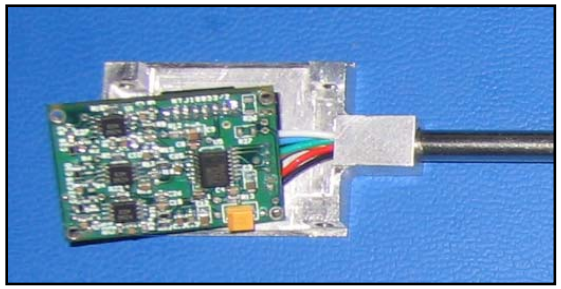
CanX-2 ACS On-Orbit

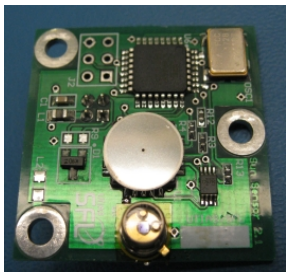
Architecture

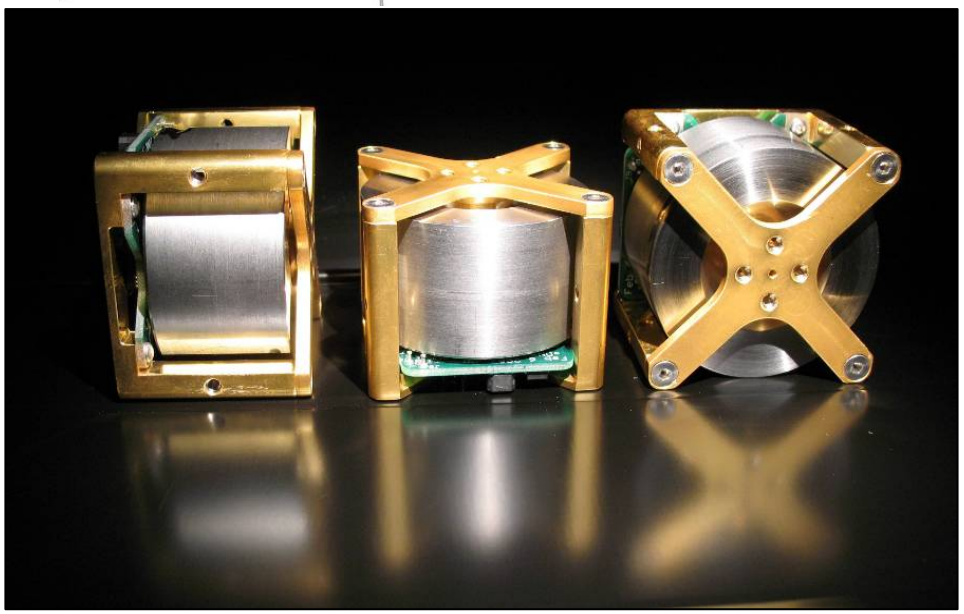
- Determination: 3-axis Magnetometer and Sun Sensors
- Control: Magnetic Torquers augmented by 1 wheel on long-axis











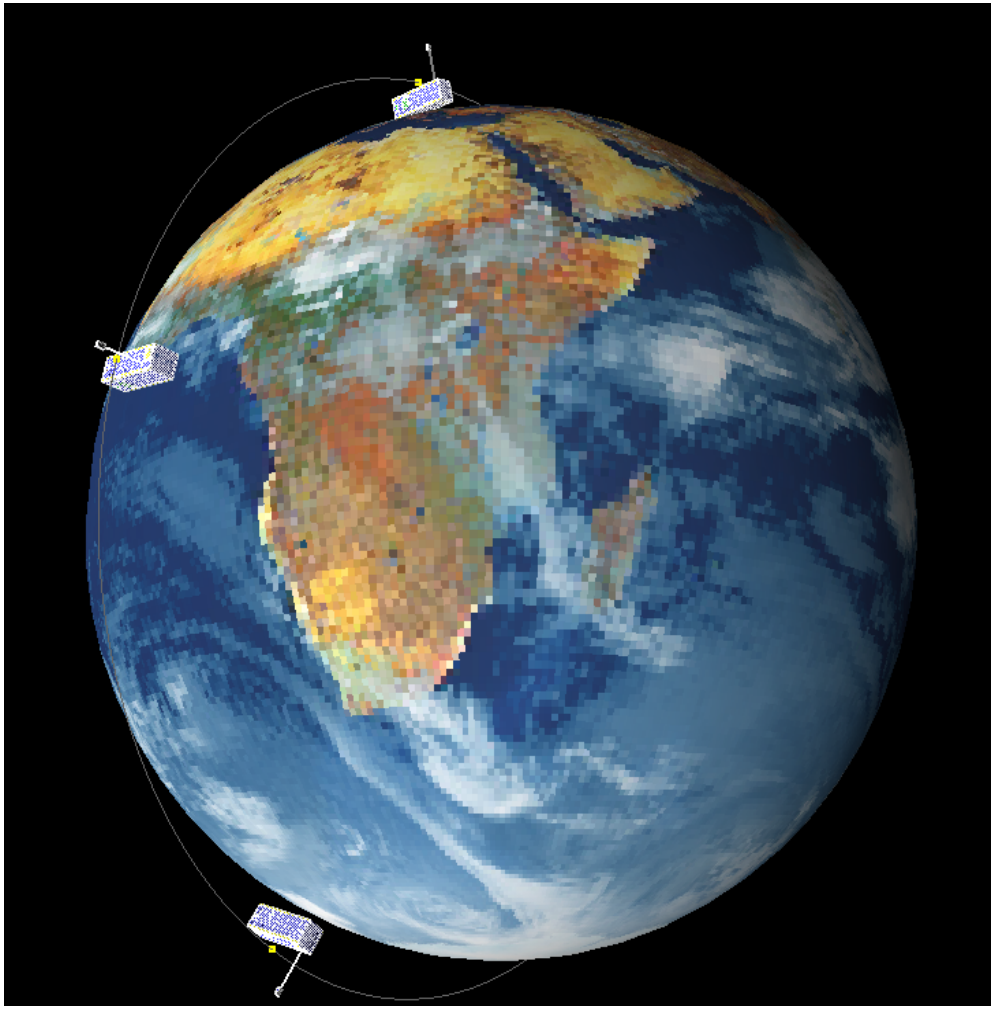
CanX-2 ACS On-Orbit

Architecture

- Determination: 3-axis Magnetometer and Sun Sensors
- Control: Magnetic Torquers augmented by 1 wheel on long-axis

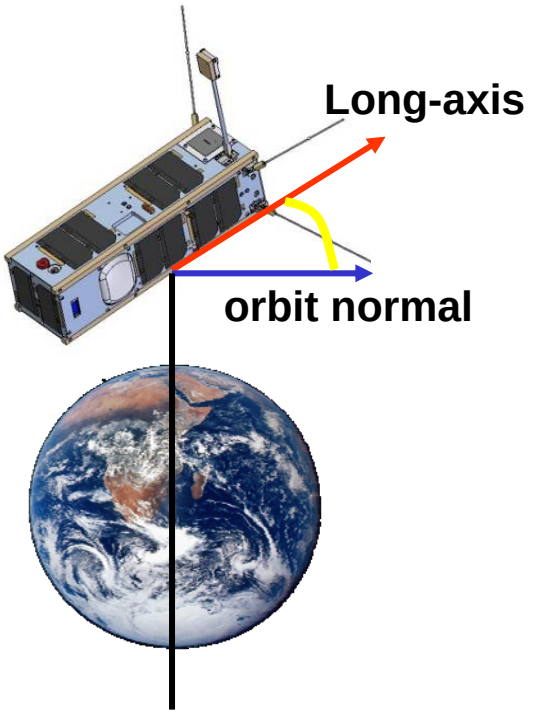
Performance

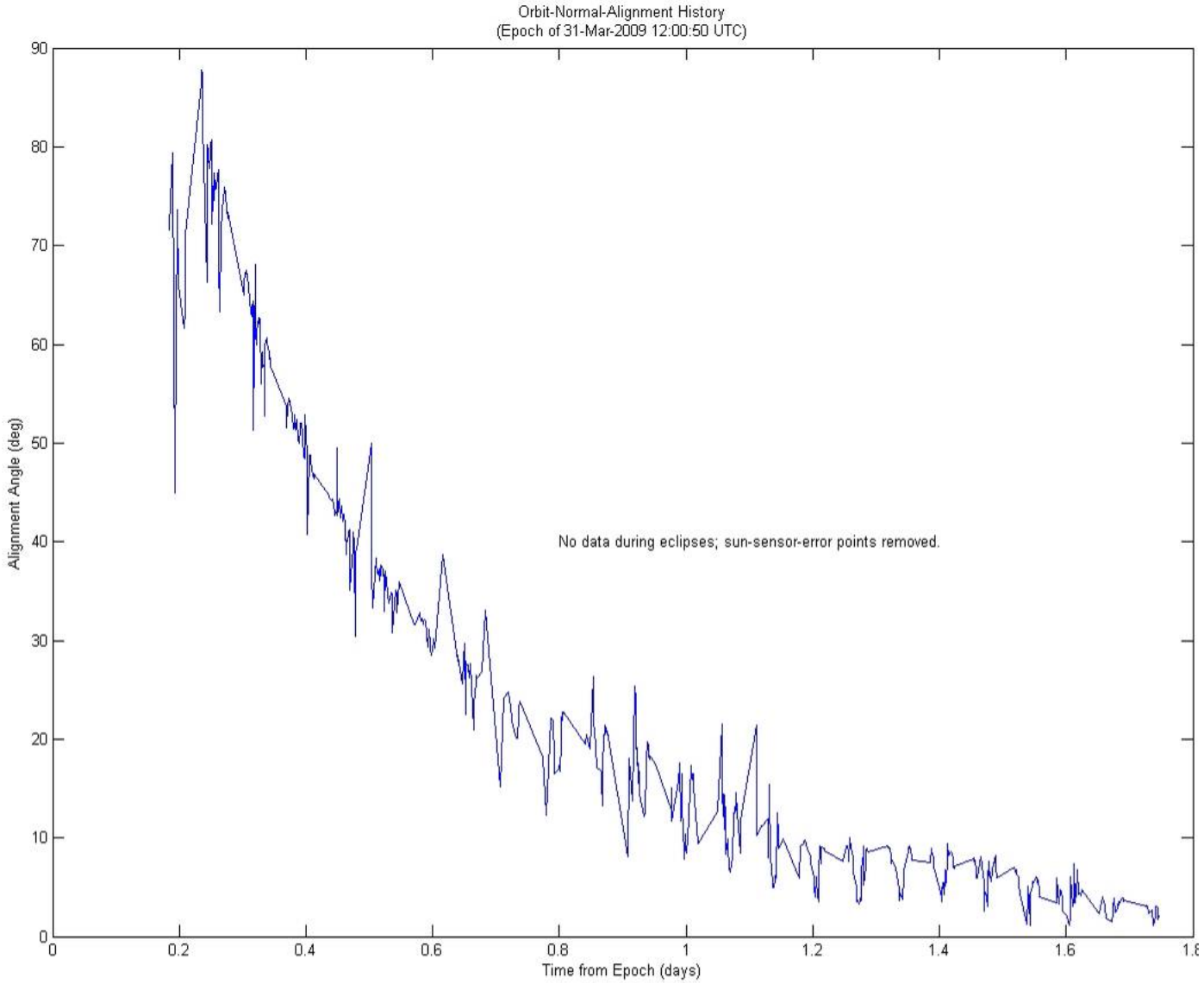
- All systems operational
- Wheel performance solid
- Attitude determination 1.5° in sunlight
- Capable of measuring body rates up to 145°/s
- Torque ripple appears < 1μNm over a 1 s attitude control frame
- Wheel's parasitic dipole is easily compensated with a counter dipole from a torquer



Nominal Controlled Attitude:
Orbit Normal Alignment of Long Axis

Momentum Alian Control

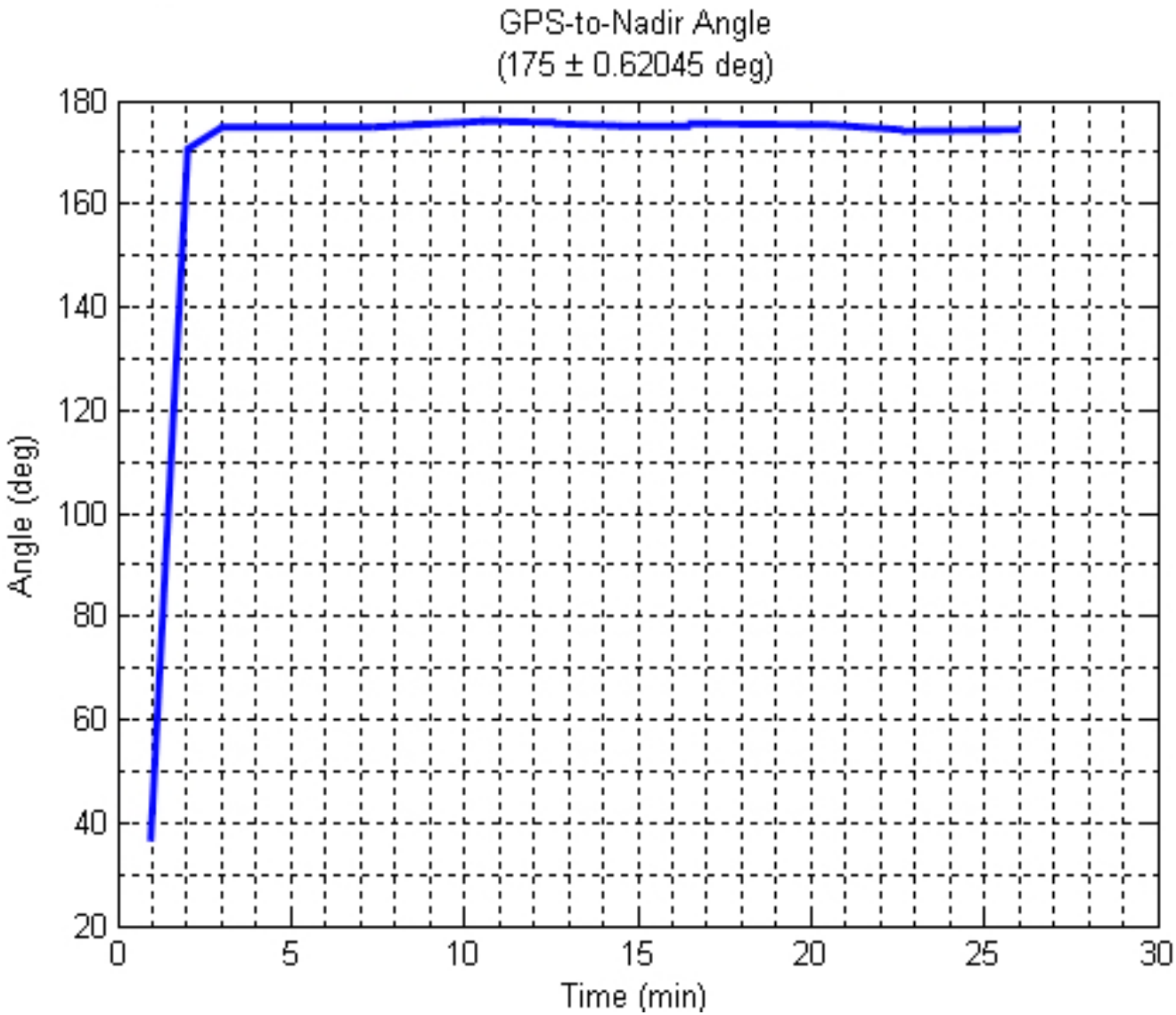




Momentum align controller reducing angle between spacecraft Y-axis and orbit normal towards 0º

Wheel Pitch Control

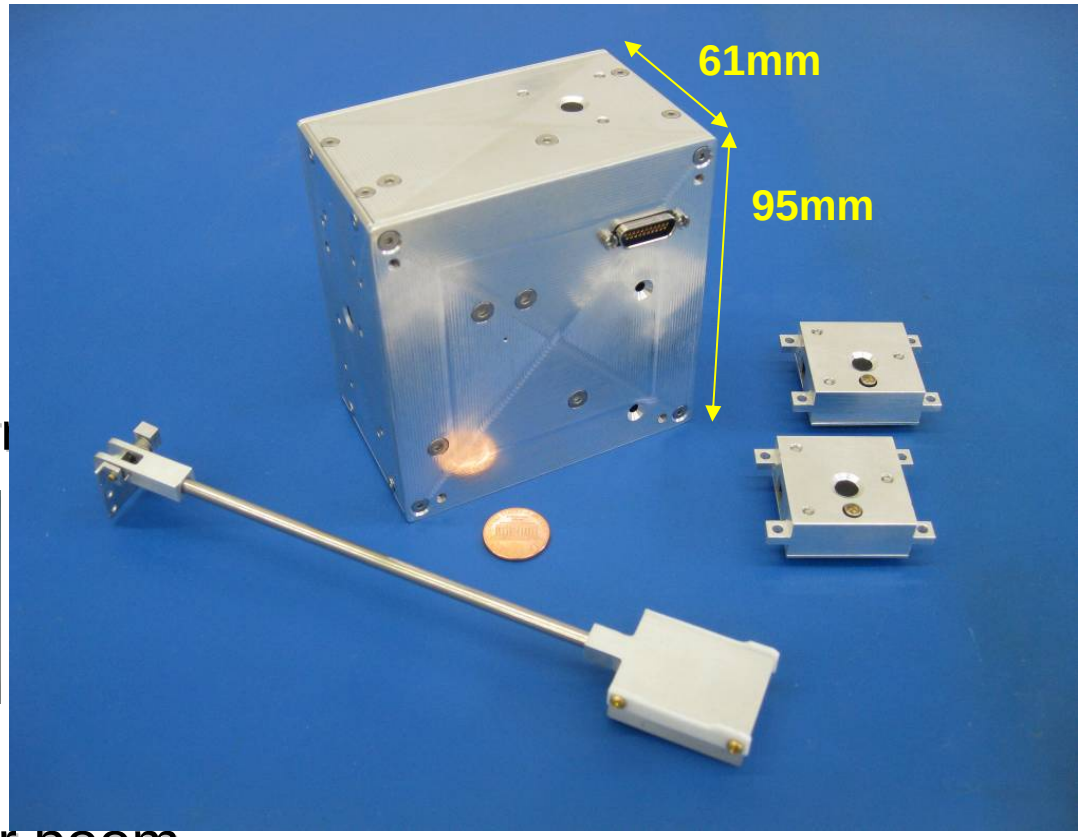
- Aligns payloads to targets of interest in orbit frame
- 135° slew in 60s
- <5° pointing accuracy
- 1° stability over 25 minutes

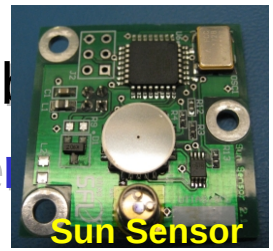


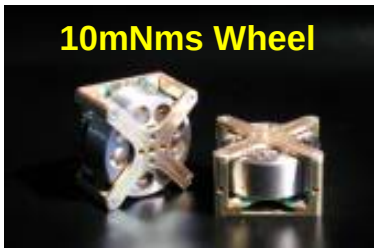
Wheel pitch controller aligning GPS antenna towards zenith

CubeSat Compact Three-Axis Attitude Actuator and Sensor Pack with Sinclair Interplanetary

- Three-axis, achievable pointing accuracy of 1-2 deg RMS
- Package includes:
  - 3 reaction wheels (10mNms)
  - 3 magnetorquers
  - 6 sun sensors (up to two are exter
  - 1 magnetometer (exter
- Power: < 1 W typical
- Mass: <1 kg
- Dimensions: 95x95x61 r
- Optional deployable magnetometer boom
- Easy-to-integrate box, compatible with Pumpkin Cu
- CanX-2 heritage (2.3 years) and proven on-orbit per

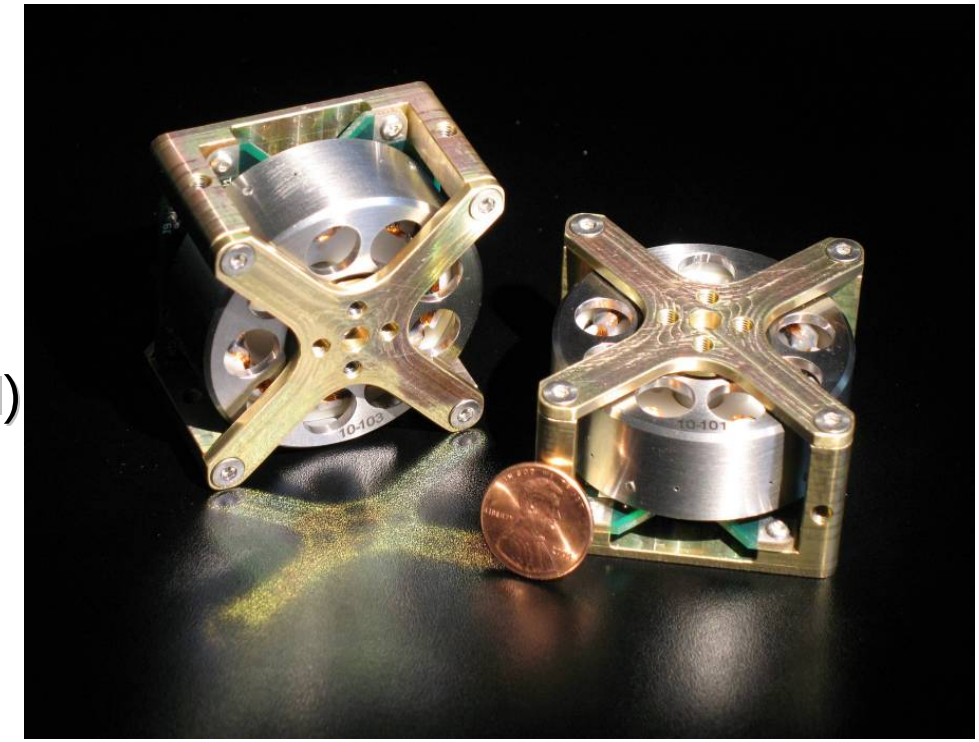






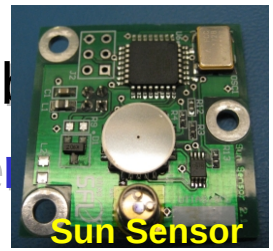
CubeSat Compact Three-Axis Attitude Actuator and Sensor Pack with Sinclair Interplanetary

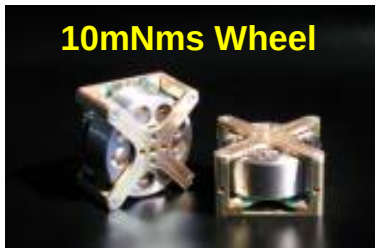
- Three-axis, achievable pointing accuracy of 1-2 deg RMS
- Package includes:
  - 3 reaction wheels (10mNms)
  - 3 magnetorquers
  - 6 sun sensors (up to two are external)
  - 1 magnetometer (exter
- Power: < 1 W typical
- Mass: <1 kg
- Dimensions: 95x95x61 r
- Optional deployable magnetometer boom
- Easy-to-integrate box, compatible with Pumpkin Cul
- CanX-2 heritage (2.3 years) and proven on-orbit per




Magnetorquer


Magnetometer


Sun Sensor

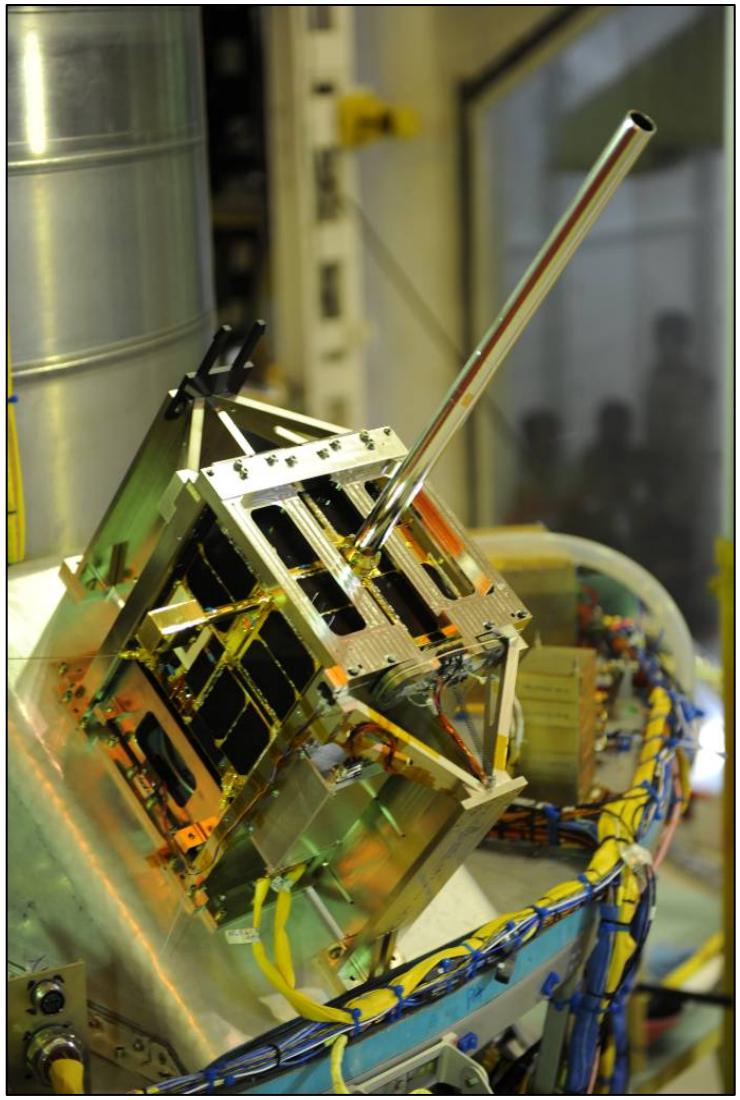

10mNms Wheel

NLS-6

- Launch on PSLV-C15
  - July 12, 2010, 03:52 UTC
- AISSat-1 and TIsat-1

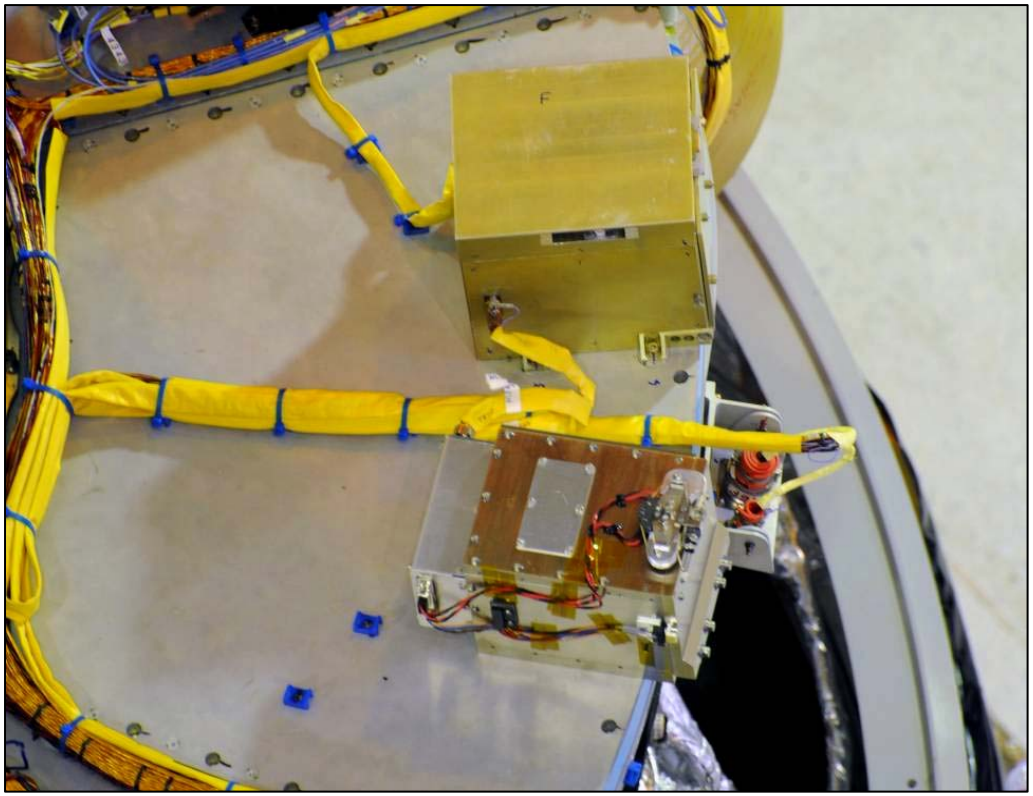
PSLV C-15 after the Mobile Service Tower (MST) has rolled back

NLS-6



AISSat1-1 and XPOD-15G Mounted to the EB Deck

NLS-6



TIsat-1 and XPOD Mounted to the EB Deck

Mounting of AISSat-1 and its XPOD on the PSLV EB Deck

Paolo Ceppi inspects TIsat-1

Inspection of AISSat-1

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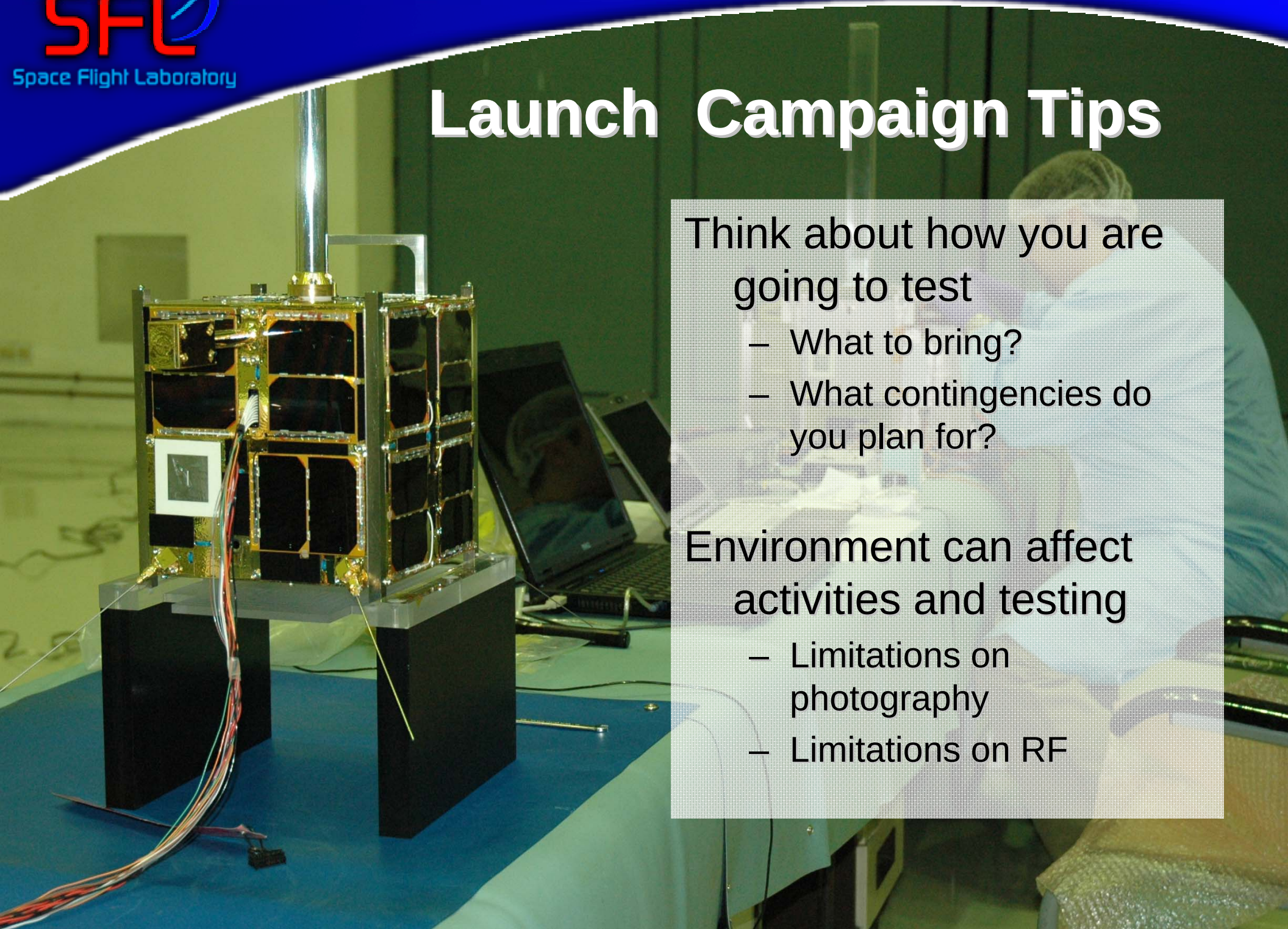
Launch Campaign Tips

Launch Campaign Tips



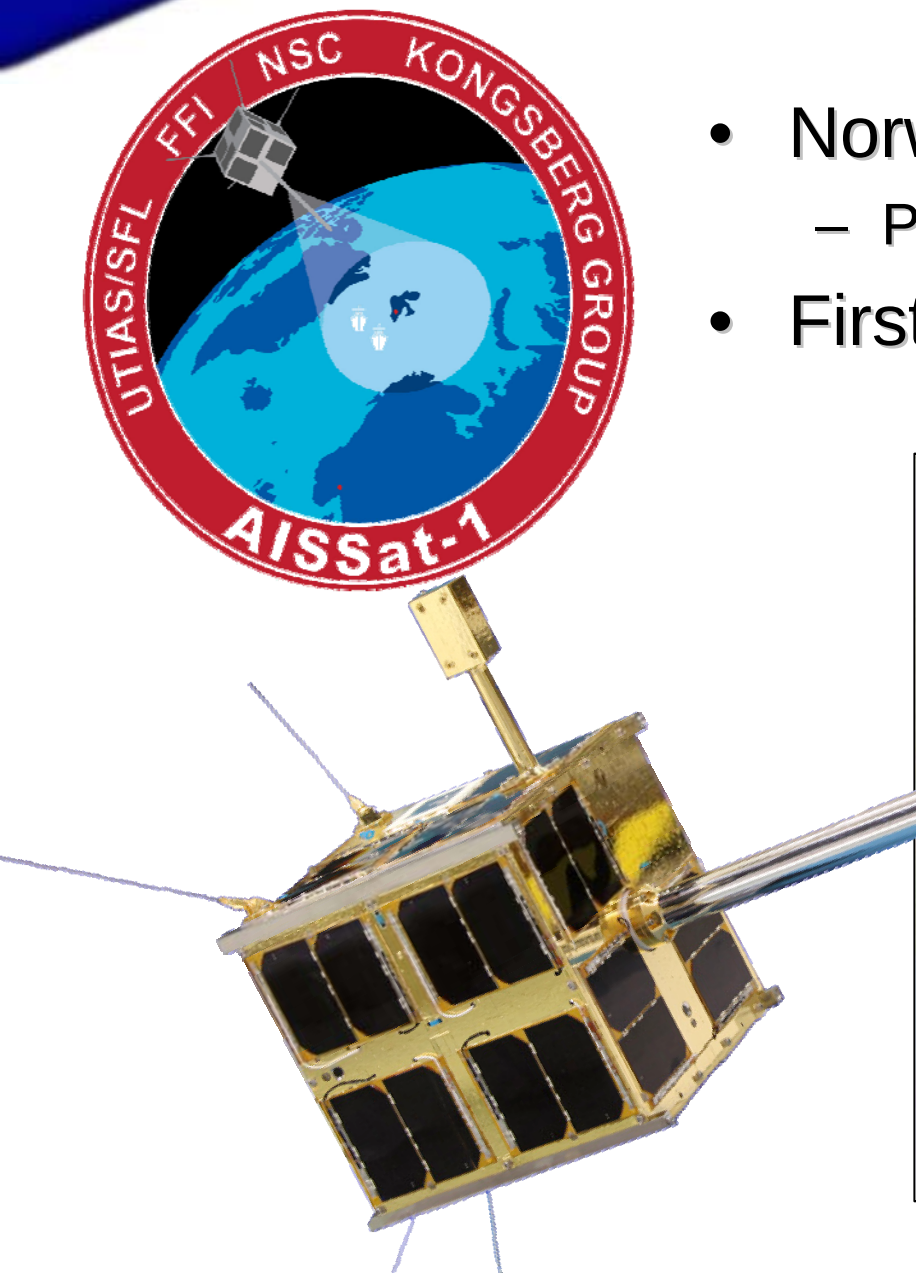
- Think about how you are going to test
  - What to bring?
  - What contingencies do you plan for?
- Environment can affect activities and testing
  - Limitations on photography
  - Limitations on RF

Launch – July 12, 2010

- Both AISSat-1 and TIsat-1 have been successfully delivered into orbit by PSLV-C15
- XPOD19S releases TIsat-1 on command from the PS4 at T+1169.4
- XPOD15G releases AISSat-1 at T+1219.4
- All Satellites successfully contacted by their teams

AISSat-1 Success!

- Norway's first observation satellite
  - Performing ship detection
- First ships captured within 24 hours!



Missions Under Development

- **BRITE Constellation (CanX-3)**
  - 6 Satellites: 2 Austrian, 2 Polish, 2 Canadian (TBC)
  - Differential Stellar Photometry
- **CanX-4 & CanX-5**
  - Autonomous Formation Flight
- **CanX-7**
  - 3U CubeSat deorbiting demonstration mission (CanX-2 class)
- **NEMO-AM**
  - Nanosatellite for Aerosol Monitoring
- **M3MSat**
  - Microsatellite performing space-based AIS for Canadian Government
  - Collaboration with COM DEV Ltd. (Prime)

Upcoming Launches

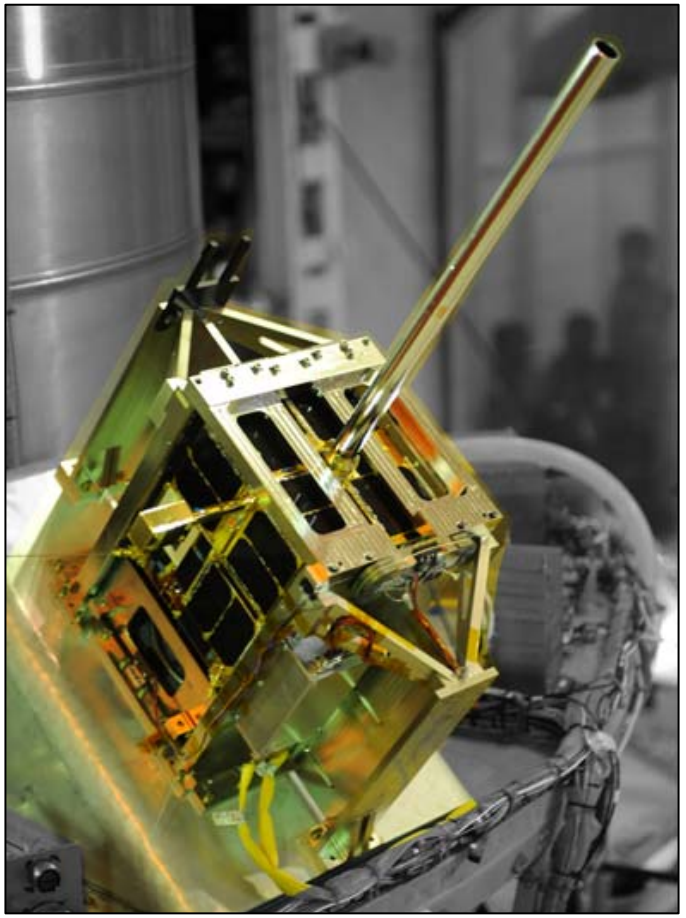
- Nanosatellite Launch Service 7 and 9
  - Indian Space Research Organization – PSLV-C19
  - Time frame: 2011 Q3
  - Orbit Parameters: SSO, 635-670 km, 09:00-10:30 LTDN
  - NLS-7: SFL Spacecraft: CanX-4, CanX-5
  - NLS-9: Partner Spacecraft (To be finalized this Fall)

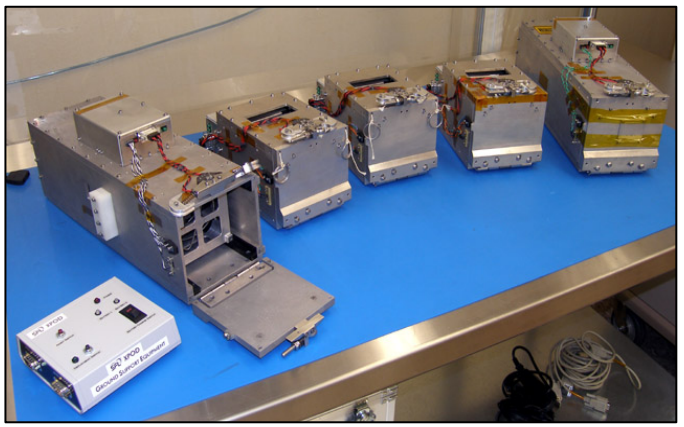
- Nanosatellite Launch Service 8 (NLS-8)
  - Indian Space Research Organization – PSLV-C20
  - Timeframe: mid-2011
  - Orbit Parameters: SSO, 800 km, 06:00 LTDN
  - SFL Spacecraft: CanX-3A/UniBRITE, CanX-3B/BRITE-Austria

- Additional launches under discussion:
  - 2011 Q4 SSO
  - 2012 Q2 SSO

Summary

- ✓ SFL's Nanosatellite Launch Service and XPOD Separations Systems provide a regular, reliable path to orbit
- ✓ CanX-2 and NTS have been operating for over 2 years
  - Over 3 GB data downloaded
  - Extended mission operations continue
- ✓ AISSat-1 and TIsat-1 successfully deployed on orbit and are operating well
- ✓ Come fly with us on future launches





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