The Canadian Advanced Nanospace eXperiment 7 (CanX-7) Demonstration Mission: Deorbiting Nano- and Microspacecraft

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Space Flight Laboratory

- SFL founded in 1998
- MOST: Canada’s First Space Telescope
- Canadian Advanced Nanospace eXperiment (CanX) Missions
  - Rapid, responsive, and highly capable
  - Low cost, quick to develop and launch
- Generic Nanosatellite Bus (GNB) and Nanosatellite for Earth Monitoring and Observation (NEMO) class missions
Space Debris

- Increased activity in space
- NORAD tracking ~20,000 objects
  - Decommissioned satellites, upper stages, debris from separations, explosions
  - Objects lost and found on regular basis
- Environment becoming increasingly dangerous for new missions

Space Debris Visualization [1]
IADC Guidelines

• Inter-Agency Space Debris Coordination Committee (IADC) Space Debris Mitigation Guidelines (2007)
  – Two protected regions (LEO, GEO)
  – LEO guidelines -> deorbit within 25 years from EOM

• Not the law (yet)...
  – Foreign Affairs and International Trade Canada (DFAIT), Industry Canada require debris plan as pre-requisite for licenses
  – Significant issue for Canadian satellites, particularly small, responsive missions
De-orbiting Small Satellites

- Several Approaches
  - Propulsive
  - Active solar sail
  - Electrodynamics tethers
  - Inflatable devices
  - Drag sails

Canadian Advanced Nanospace eXperiment (CanX-7)

- Mission Goals
  - Demonstrate a drag sail deorbit device for cubesats
  - Validate post-deployment de-orbit models
  - Operate secondary payload provided by COM DEV
CanX-7 Bus

- **Mechanical**
  - 10x10x34cm form factor
  - Passive thermal control

- **Power**
  - Generic Nanosatellite Bus electronics used
  - Body-mounted triple-junction solar strings
  - 4.8Ah Li-Ion battery
  - DET system with PPT functionality

- **C&DH**
  - Generic Nanosatellite Bus electronics used
  - Single housekeeping computer

- **TT&C**
  - Generic Nanosatellite Bus electronics used
  - 4 kbps UHF Rx, 32 kbps S-Band Transmitter
  - Existing SFL ground station used

- **ADCS**
  - Magnetometer, panel currents for determination
  - Three magnetorquers for magnetic stabilization
Expected Lifetime of the CanX-7 Satellite

![Graph showing the expected lifetime of the CanX-7 satellite with varying drag areas and altitudes represented by different lines and colors. The x-axis represents Drag Area (m²), and the y-axis represents Lifetime (Years). Legend includes 800km, Cd=2.4, 700km, Cd=2.4, 600km, Cd=2.4, 800km, Cd=2.2, 700km, Cd=2.2, and 600km, Cd=2.2, with 25 Years also marked.]
The Overall Effective Drag Area takes into account spacecraft attitude dynamics as well as the changing atmospheric density. It is determined in two steps:

1. Simulations are performed to determine the average projected area over several orbits at different atmospheric densities.
2. These results are then combined in a weighted average, where the weights are determined by the duration spent at each density over one solar cycle.

In order for CanX-7 to meet the 25 year de-orbit lifetime requirement in any initial orbit, the required overall effective drag area must be at least 0.5 m².

The primary factors affecting the overall projected drag area are:
- Spacecraft residual magnetic properties: 7 different configurations considered
- Orbit (altitude, LTAN, and inclination): 24 different orbits considered for each initial altitude
Overall Effective Area Results

### Orbit Properties

<table>
<thead>
<tr>
<th>LTAN [HHMM]</th>
<th>Inclination [deg]</th>
<th>Altitude [km]</th>
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<tbody>
<tr>
<td>0300 to 2400</td>
<td>80, 90, 100</td>
<td>500 to 800</td>
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</table>

### Spacecraft Residual Magnetic Dipole Moment Properties

<table>
<thead>
<tr>
<th>Magnitude [Am²]</th>
<th>Orientation [deg]</th>
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<tbody>
<tr>
<td>0.00, 0.05, 0.10</td>
<td>0, 45, 90</td>
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All combinations of the above parameters are simulated:

168 configurations per altitude
Drag Sail Design

Sail Module

Boom

Sail
Drag Sail Design

Reel

Roller

Sail Cartridge

Coiled Booms

Door
Deployment Test
Multi-Mission Use
Conclusion

• CanX-7 will be a de-orbiting demonstration mission
• Show de-orbit of a cubesat in LEO within the IADC period of 25 years
• Space qualify core drag sail design for cubesats, with future improvements for larger missions
• Ensure no hindrance to future small satellite launches
References

- Slide 3 Picture:

- Slide 5 Pictures: