An Information Session on Canadian Cubesat Project

Presenter:

Dr. Johanne Heald
Webinar Goal

• To provide professors in post-secondary institutions across Canada with information on the upcoming Canadian CubeSat Project (CCP) Announcement of Opportunity (AO);

• To answer questions and to seek constructive comments from the community on this initiative.
Presentation Outline

• Canadian CubeSat Project (CCP) description
• Canadian CubeSat examples
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CCP Objectives and Scope

- Canadian CubeSat Project (CCP) is an initiative aimed at providing a grant to faculty members in post-secondary institutions (colleges and universities) in order for them and their student teams to design, build, test and operate CubeSats.

- CCP aims to launch up to 13 CubeSats from post-secondary institutes representing all 13 Canadian provinces and territories.

- CCP aims to provide an opportunity to post-secondary students in every province and territory in gaining valuable knowledge and skills in space-related Science, Technology, Engineering & Mathematics (STEM), as well as business and communications.

- CCP scope includes:
  - the development and operations of the CubeSats funded through CSA grants;
  - Launch service arrangement provided by CSA.
Announcement of Opportunity (AO)

• An Announcement of Opportunity will be posted to solicit proposals from Canadian post-secondary institutions throughout Canada.

• Only professors can submit proposals in response to the AO.

• Each proposal will be evaluated on four criteria:
  • Benefits to Canada;
  • Results;
  • Mission;
  • Project implementation.

• The AO will provide the details of the evaluation criteria:
  • The bidder should include pertinent and sufficient information in the proposal in response to all the criteria.

• Proposals that have obtained the minimum score will be retained for funding consideration with a grant.
• Professors will be given nine (9) weeks to prepare the proposal
CCP Grant

• Selected bidders can obtain up to $200,000 to finance the project:
  ▪ The launch cost is the responsibility of CSA

• Eligible expenditures may include satellite components and hardware, license for software and radio, acquisition of lab equipment, laboratory tests, materials and consumables, student salary, bursary, travel cost for conference or workshop attendance, consultant fee, etc.

• Detailed list of eligible expenditure will be provided in the AO

• Reminder: only cost incurred after the receipt of grant agreement is eligible
CubeSat Development Process

- NanoRacks can only accept CubeSats that have successfully passed the three Safety Reviews.
## Development Timeline

<table>
<thead>
<tr>
<th>Project Stage</th>
<th>Phase</th>
<th>Schedule A</th>
<th>Schedule B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mission Definition</td>
<td>A</td>
<td>2 month</td>
<td>4 months</td>
</tr>
<tr>
<td>Mission Concept Review</td>
<td>Milestone</td>
<td>KOM + 2 months</td>
<td>KOM + 4 months</td>
</tr>
<tr>
<td>Preliminary Design</td>
<td>B</td>
<td>6 months</td>
<td>8 months</td>
</tr>
<tr>
<td>Preliminary Design Review (1st Safety Review)</td>
<td>Milestone</td>
<td>KOM + 8 months</td>
<td>KOM + 12 months</td>
</tr>
<tr>
<td>Detailed Design</td>
<td>C</td>
<td>7 months</td>
<td>12 months</td>
</tr>
<tr>
<td>Critical Design Review (2nd Safety Review)</td>
<td>Milestone</td>
<td>KOM + 15 months</td>
<td>KOM + 24 months</td>
</tr>
<tr>
<td>Assembly, Integration and Testing</td>
<td>D</td>
<td>9 months</td>
<td>12 months</td>
</tr>
<tr>
<td>Flight Readiness Review (3rd Safety Review)</td>
<td>Milestone</td>
<td>KOM + 24 months</td>
<td>KOM + 36 months</td>
</tr>
</tbody>
</table>

- **KOM**: Kick-off Meeting
- **Schedule A** is the suggested schedule for teams that have some experience in building a satellite;
- **Schedule B** is the suggested schedule for teams that have no experience in building a satellite.
CubeSat Launch Process

- NRCSD integration will take place in NanoRacks at Houston, TX.
- Rocket launch will take place in either Cape Canaveral, FL (SpaceX Falcon 9) or Wallops Island, VA (Orbital Antares)
- Viewing of launch at Cape Canaveral or Wallops Island is open to Canadians:
  - It is the responsibility of the grantees to fund this trip. CSA funds can only be used for the development of the Cubesat, not for such a trip.
Building a CubeSat

- One reason for the popularity of CubeSat is the standard on size, mass, and volume.
- There are at least 20 companies worldwide that provide components or turnkey CubeSat solution (www.cubesatshop.com).
- Additional factors to consider in making build vs buy decision is: team experience.

![Graph showing the relationship between the percentage of purchase components and cost.](image-url)
CubeSat Project Team (1/2)

• Building a satellite demands a disciplined project approach:
  • It requires a team with clear responsibility for each member;
  • It is important to implement version control on all documents;
  • Documents required by the launch provider need to be produced.
## CubeSat Project Team (2/2)

<table>
<thead>
<tr>
<th>Role</th>
<th>Assignment</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI</td>
<td>Professor</td>
<td>PI must be a professor from the province or territory where he/she teaches. Key responsibilities include managing the budget, interface with CSA, assign responsibility to team members.</td>
</tr>
<tr>
<td>Co-PI</td>
<td>Professor</td>
<td>Support PI in all responsibility areas. Since the Co-PI can be from different institutions, it is essential that PI and Co-PI maintain regular communications.</td>
</tr>
<tr>
<td>Project Manager (PM)</td>
<td>Professor or 1 Student</td>
<td>The PM shall be the conduit between the PI and the team. It is essential that the PM collaborates with all the team leads. The key responsibility is monitoring the progress of the work packages, planning the schedule and budget.</td>
</tr>
<tr>
<td>Team lead</td>
<td>1 student</td>
<td>It is strongly recommended to have at least four team leads: electrical, mechanical, software, RF communications, systems, business manager and outreach communications. The team lead is responsible for the delivery of the assigned work packages.</td>
</tr>
<tr>
<td>Team member</td>
<td>1-3 students</td>
<td>It is recommended that each team has one Lead and at least one member. This would also ensure a backup in each key activity.</td>
</tr>
</tbody>
</table>
Collaboration

- CCP encourages collaboration between post secondary institutions (universities and/or colleges), as well as with provinces, territories and industry
- Collaboration is particularly important for teams that have no or little space experience
- Other ideas of collaboration:
  - Sharing of laboratory, equipment, and spare components;
  - Sharing of ground station;
  - Transfer of technical and business expertise.
CubeSat Orbit

- CubeSat launched will have similar orbit characteristics as the ISS orbit inclination of 51°, altitude at 410 km and an orbital period of 92 min.
- Due to the relatively low altitude, CubeSat experiences drag and loses its altitude until eventually deorbited.
- Past experience indicates that CubeSat will last between 6-12 months, depending on the satellite geometry as well as solar activity.
Contacts with CubeSat over 10 Days

- The contact depends on the geographic latitude of the ground station
- Further north region has smaller number and duration of contacts.

<table>
<thead>
<tr>
<th>City</th>
<th>Latitude</th>
<th>Total Number of Contacts</th>
<th>Minimum Contact Duration (sec)</th>
<th>Maximum Contact Duration (sec)</th>
<th>Average Contact per day (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Victoria</td>
<td>48.4º</td>
<td>56</td>
<td>94</td>
<td>499</td>
<td>2460</td>
</tr>
<tr>
<td>Edmonton</td>
<td>53.5º</td>
<td>49</td>
<td>152</td>
<td>496</td>
<td>2087</td>
</tr>
<tr>
<td>Winnipeg</td>
<td>49.8º</td>
<td>54</td>
<td>92</td>
<td>499</td>
<td>2370</td>
</tr>
<tr>
<td>Toronto</td>
<td>43.6º</td>
<td>60</td>
<td>109</td>
<td>499</td>
<td>2615</td>
</tr>
<tr>
<td>Montreal</td>
<td>45.5º</td>
<td>58</td>
<td>145</td>
<td>499</td>
<td>2575</td>
</tr>
<tr>
<td>Whitehorse</td>
<td>60.7º</td>
<td>36</td>
<td>132</td>
<td>406</td>
<td>1207</td>
</tr>
<tr>
<td>Yellowknife</td>
<td>62.5º</td>
<td>32</td>
<td>101</td>
<td>361</td>
<td>937</td>
</tr>
<tr>
<td>Iqaluit</td>
<td>63.7º</td>
<td>29</td>
<td>51</td>
<td>317</td>
<td>720</td>
</tr>
</tbody>
</table>
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Canadian Satellite Design Challenge (CSDC)

- CSDC is a Cubesat building competition for university students
- CSDC was initiated in 2011 and managed by a non-profit CSDC Management Society (CSDCMS)
- University student teams designed, built and tested a 3U CubeSat engineering model over 18 month period
- The 4th CSDC was kicked-off in October 2016 with 12 university teams from 6 provinces
- CCP and CSDC are complementary to each other:
  - Students working on CSDC can also work on CCP;
  - Workshops and design reviews for CSDC will be open to CCP teams;
  - CSDC and CCP are committed to create opportunities for students from both sides to meet and network.
### Examples of CubeSats Mission Concepts from 3rd CSDC

<table>
<thead>
<tr>
<th>Team</th>
<th>Cubesat Mission Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concordia University</td>
<td>Testing a self-healing material in microgravity</td>
</tr>
<tr>
<td>École Polytechnique de Montréal</td>
<td>A deployable drag sail to reduce end-of-life time on orbit. The project team also collaborates with University of Bologna, Italy</td>
</tr>
<tr>
<td>University of Manitoba</td>
<td>Testing the resilience of extremophile bacteria to survive in the space environment</td>
</tr>
<tr>
<td>University of Toronto</td>
<td>Testing the pathogenicity of yeast strains in micro-gravity conditions</td>
</tr>
<tr>
<td>University of Victoria</td>
<td>Testing the use of a diamagnetic material for spacecraft attitude control</td>
</tr>
<tr>
<td>York University</td>
<td>Camera to detect airglow, a possible earthquake precursor</td>
</tr>
</tbody>
</table>
Canadian CubeSats: Ex-Alta 1

- Started initially as a student project in Canadian Satellite Design Challenge
- It was selected as one of the two Canadian CubeSats for EC QB50 competition
- Satellite was completed and shipped to the launch supplier NanoRacks in the summer 2016
- Launched on an ISS cargo flight from Wallops on April 18th, 2017
- Deployed into space by an astronaut on May 26, 2017 – last Friday!
CubeSat Mission Ideas

• Enhanced mission ideas reflect the improved capability of micro-electronics: imaging camera, lightning detection, biology, Earth observation, etc.:
  • Examples of high resolution images taken from CubeSats can be found at: https://www.planet.com/gallery/

• CubeSat has also been flown for communications, technology demonstration, animal tracking, aircraft and ship tracking, etc.

• US National Science Foundation published “Achieving Science with CubeSats: Thinking Inside the Box (2016)” provides a good summary of all Cubesat science missions.
Resources on CubeSat

- There is a tremendous amount of material available on the web;
- A good starting point is [www.cubesat.org](http://www.cubesat.org) where documents on CubeSat standards and CubeSat CAD drawings can be downloaded;
- Prof. Michael Swartwout of St. Louis University maintains an extensive CubeSat [database](http://www.cubesat.org) which could provide mission ideas.
Appendices
CubeSat Project Team Structure (1/2)

• **Electrical**
  • The electrical team looks after the power conversion and supply, battery, circuit board manufacturing (or procurement) and assembly, as well as electrical systems integration and testing.

• **Mechanical**
  • The mechanical team looks after the satellite structure manufacturing and assembly (including solar panels), thermal environment, mechanism (inhibits) design and installation, and bill of materials.

• **Software**
  • Each CubeSat will have its own unique payload and hardware. The software team is responsible for writing and testing codes to ensure proper functioning from ground to space and from space to all subsystems onboard the CubeSat.
• **RF Communications**
  • The RF communications team looks after the testing and programming for the radios. It will also be responsible for setting up the ground station and determining the operations schedule.

• **Systems**
  • The systems team is responsible for the requirements of the missions. It supports every team in requirement definition and validation.

• **Business Management**
  • The Business Management team is responsible for the business requirements. It develops and maintains investment related documentation such as the Business Case.

• **Communications and Outreach**
  • The Communications team is responsible for developing outreach activities with the goal of increasing the awareness of the project in the general population in the province/territory.
CubeSat History

• Prof. Twiggs (now with Morehead U in Ky) introduced the CubeSat in 1999:
  • $4'' \times 4'' \times 4''$ and weighs 3lbs;
  • He promised it could be built and launched for <$US50K$;
• Prof. Jordi Puig-Suari of CalPoly San Luis Obispo came up with the P-POD concept for the deployment of CubeSat:
  • Presented in Utah Smallsat Conference in 2000;
  • Became an instant hit with the audience.
Classification

- The original proposed configuration quickly evolved into other formats which are multiples of the original.

<table>
<thead>
<tr>
<th>Form Factor</th>
<th>Dimension (cm)</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1U</strong></td>
<td>$10 \times 10 \times 10$</td>
<td>1.3</td>
</tr>
<tr>
<td><strong>2U</strong></td>
<td>$10 \times 10 \times 20$</td>
<td>2.6</td>
</tr>
<tr>
<td><strong>3U</strong></td>
<td>$10 \times 10 \times 30$</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Source: Radius Space
www.radiusspace.com
CubeSat Revolution

• On the same launch as MOST (Canada’s first astronomy microsatellite) on June 30, 2003, 6 CubeSats from US, Japan, Denmark and Canada were also onboard;
• Since this historic launch, 510 CubeSats from more than 50 countries have been launched;
• The creation of a CubeSat standard, rapid evolution of micro-electronics and the availability of CubeSat-kit have all contributed to the increased interest in CubeSats;
• CubeSats are particularly appealing to universities, colleges and even primary and secondary schools – they can be built by a small team with a low budget.
Example of Canadian CubeSats: Canadian Advanced Nanospace Experiment (CanX)

- University of Toronto Institute of Aerospace Studies (UTIAS) Space Flight Laboratory (SFL) has built and launched successfully a series of CubeSats:
  - CanX1 – 1U;
  - CanX2 and CanX7 – 3U;
  - CanX3 (BRITE), CanX4 and CanX5 – 8U (an uncommon CubeSat format).