Tethered Nanosatellites Development

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Outline of Presentation

- Drivers for Tethered Nanosatellite Technology
- Technical Challenges
- Current Research Activities at York
- Needs for Capacity Building
- Demonstration Missions
Drivers for Tethered Nanosatellites

Nanosatellites:

Pros:  
- More affordable
- Can fly frequently and new technology
- Short development time
- More responsive to emerging needs

Cons:  
- Limited functionality and payload capacity
- Cannot carry out complex task
- Poor attitude control accuracy
- Cannot carry out critical mission
Drivers for Tethered Nanosatellites

Possible Solutions to the limitations:

(a) Increase NanoSat’s capacity and control functionalities
   - Larger monolithic satellite – against the nanoSat concept

(b) Formation fly of a cluster of nanosatellites
   - Very desirable for future space missions
Drivers for Tethered Nanosatellites

Formation fly of a clusters of micro/nano/pico-satellites has been recognized to be more affordable, robust and versatile than building a large monolithic satellite in implementing next generation space missions requiring large apertures or large sample collection areas and sophisticated earth imaging/monitoring.

Limitation for Nanosatellite Formation Fly:

Prohibitive for nanosatellites to carry the required fuel.
Drivers for Tethered Nanosatellites

Alternative Solution:

Tethered formation fly of a cluster of nanosatellites for increased performance by combining two technologies

- Tethered spacecraft technology
  - maintaining the orbiting tethered vehicles without fuel cost
- Formation flying technology
  - spatially reconfiguring the free-flying vehicles on demand
Advantages of Tethered NanoSat

Maintain formation fly of nanosatellites without fuel cost

Propellantless Propulsion – Electrodynamic tether

- Enable propellantless propulsion to
  - attitude control of nanosatellites
  - change orbits of clusters for difference mission tasks
  - de-orbiting the clusters after their mission

- Enable formation fly of nanosatellite clusters for
  - higher angular & spatial resolution imagery and interferometry
  - GPS occultation
  - robust & redundant fault-tolerant system architectures
  - networks dispersed over clusters of satellites in space
Advantages of Tethered NanoSat

- Enable variable baseline for interferometric observations by varying tether length
- Enable continuous coverage of the observation by spinning the formation cluster
- Enable larger coverage of the observation by multiple sensors
Technical Challenges

Tethered Satellite Concept is not new but tethered nanosatellites is not yet demonstrated

The challenges:

- Tether Deployment and Control
- Formation Sensing and Control
  (non-Keplerian motion of tethered nanosatellites)
- Decentralized Control and Stabilization
  (gravity-gradient, aerodynamic and electrodynamic)
Related Researches at York
Space Engineering Design Lab

15 years experiences in Low-tension tether dynamics and tether handling system

- Nanosatellite termination using electrodynamic tether
- Deploying/Recovering neutrally buoyant sonar array on-board nuclear submarine
- Aerial refuelling house/drogue system
- Design Tool Development
  - Novel Nodal Position Finite Element Method for Tether Dynamics
  - *Dynatow* for sonar array handling system, licensed to several navy establishment
  - *Aerotow* for aerial refuelling system, licensed to one air force
Tethered Nanosatellite formation flying testbed – Funded by NSERC
Related Researches at York
Space Engineering Design Lab

Low-cost, GPS-aided inertial integrated navigation technology to enable the autonomous navigation capability
Related Researches at York
Space Engineering Design Lab

Educational QuickSat*

Structural Frame

Solar Panel

* - Built under CSA’s educational license
Needs for Capacity Building

- Build and test the tethered nanosatellite formation fly – a enabling technology for future space missions
- HQP training support to carry out the research
- Develop expertise in the field of Tethered nanosatellite
- Acquire expertise and resources which are available within the university
Technical Demonstration Mission
Tethered Nanosatellites

On-Orbit Testbeds

Seeks to demonstrate tethered nanosatellite technology:

- Deployment of tethered nanosatellites
- Orbital and attitude control using electrodynamic tether
- Enhanced measurement of air quality (CO₂, water) using multiple low-cost miniature instruments onboard tethered nanosatellite formation