

Tethered Nanosatellites Development

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Canadian Space Agency Workshop

On Suborbital Platforms and Nanosatellites

April 14 – 16, 2010



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

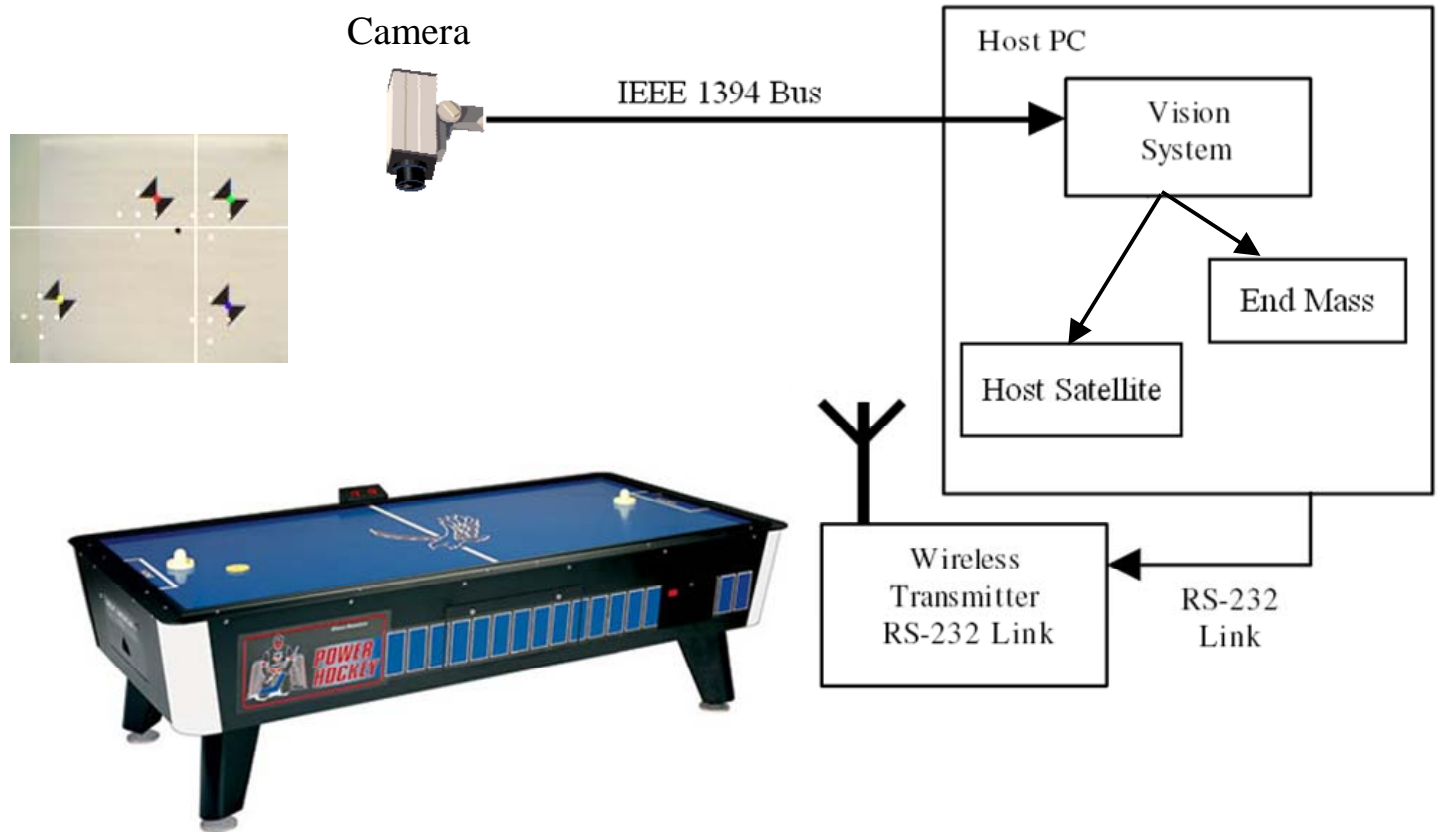
Space Engineering Design Lab

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**

Related Researches at York

Space Engineering Design Lab



**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



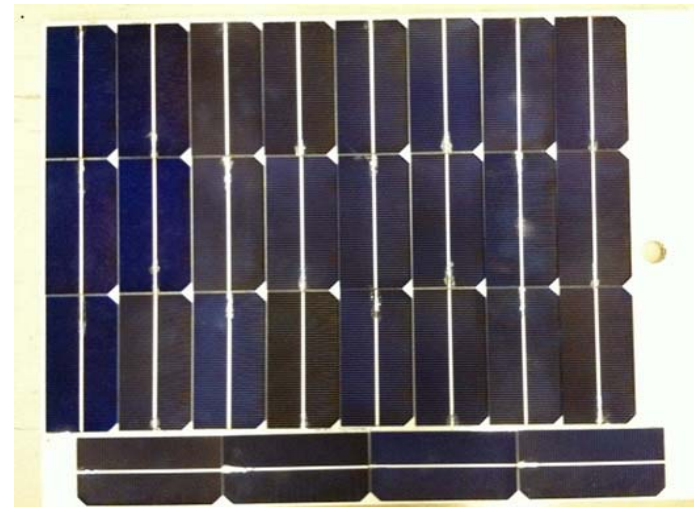
Related Researches at York

Space Engineering Design Lab

Educational QuickSat*



Structural Frame



Solar Panel

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