Retro-Directive Transceiver System for Communication Needs of Formation Flying (Swarm) CubeSats

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Outline

- Introduction
- Methodology
- Procedures
- Results
- Conclusion
- Design
- Questions
- References

Introduction

- Synthetic Aperture Radar (SAR)
- Moving transceiver to generate large, high resolution images
- Swarms of Cube Satellites to implement SAR (rapidly moving sensors)
- Managing the swarm
- Calculating the position and orientation of each of the cubesats in reference to both the earth and one another
- 3 phases of testing are proposed:
  - Design, manufacture, and test the retro directive array on a mobile platform
  - Satellite to house the system will be prototyped
  - Satellite will be fabricated and tested for deployment
- This will allow faster and cheaper deployment of SAR systems.

Methodology

- Swarms of small satellites or cubesats offer a new sensor configuration/ architecture for Earth science remote sensing from space as well as for planetary observations.
- It is possible to realize:
  - 1) synthetic aperture radars for Earth sensing system,
  - 2) large aperture for space telescope,
  - 3) space borne phased array system.
- To implement such configuration adaptively without external commands, it is essential that each satellite in a swarm to is equipped with a robust communication system that will allow constant communication between members of the swarm at all times.
- Omnidirectional antennas reduce the power in desired direction, cause low data rate and vulnerability to external interference.
- We design and validate a communication system based on retro-directive array concept that will enable a cubesat to adaptively establish communication link between itself and other members of swarm.

Procedures

- Retro-directive array concept is cost effectiveness and compact.
- It transmits a signal back to the interrogator's position without any a priori knowledge of the incoming angle or relying on sophisticated digital signal processing algorithms.
- The retro-directive transceiver does not need complex phased array architecture to achieve the above mentioned functionality.
- Robust channels will be given priority over less robust channels.
- A scheduler will have to be developed using the FPGA fabric on SDR.
- Retro-directive arrays do not need prior positional information.

Results

- In order to generate a Synthetic Aperture Radar (SAR) Image, accurate position and timing must be known of array elements.
- In an unorganized swarm environment this can be particularly difficult.
- This research proposes to design and validate a communication system for swarm cubesats using retro-directive arrays to gather time and positional data.
- Central to the implementation of SAR on a cubesat platform is managing the swarm and calculating the position and orientation of each of the cubesats with reference to both the Earth and one another to enable a SAR algorithm.

Conclusion

- This Research will investigate retro-directive arrays for the use of Formation Flying CubeSats, particularly for the use with Synthetic Aperture Radar (SAR), and large aperture for space telescopes.
- Retro-directivity will be achieved using a heterodyning approach in which mixers oscillating at twice the frequency of the carrier cause a negative phased signal to be retransmitted back to the source thereby steering the beam of the array.
- This is particularly useful for the above applications as they all require precise timing and positional information due to the dynamic nature of the CubeSat swarm.
- Adaptive Time Domain Multiplexing will be used to prevent interference as well as save on power by placing priority over robust cross links. In this way, swarm elements furthest away from one another will not have to directly communicate with one another.

Design

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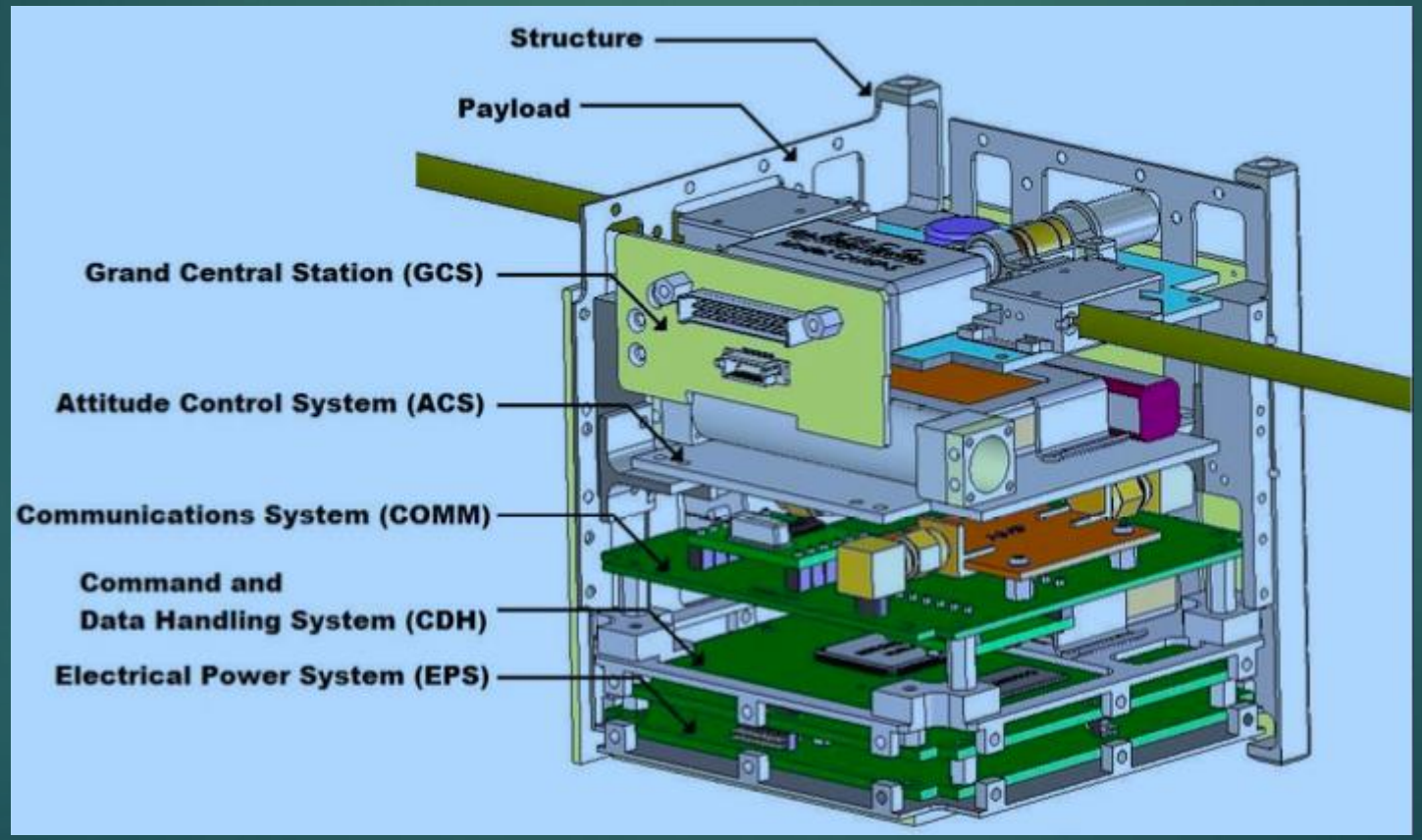

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Questions?

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