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A Flight-Proven 2.4GHz ISM Band COTS Communications System for Small Sats

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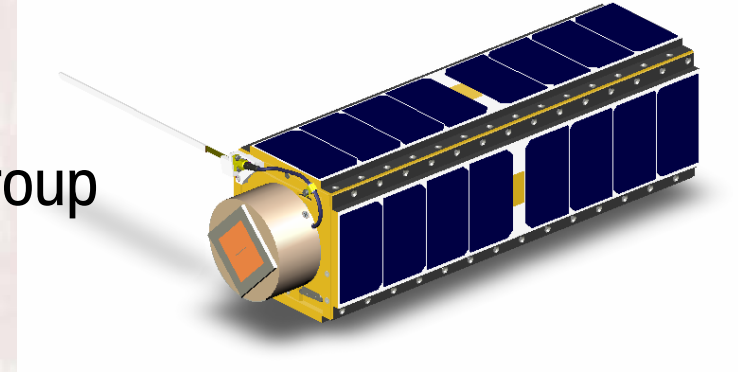
Overview

- GeneSat Mission Overview
- Communications System Description
- Earth Station
- Design Analysis
- Space Qualification
- Flight Results
- Conclusions

GeneSat-1 Mission Overview

- Technology Demonstration to Validate in-situ Biological Research
- Triple-CubeSat Package
- Led by NASA Ames Astrobionics Group
- Strong University Participation
- Launched December 16th 2006
- Successfully completed primary and secondary mission objectives
- Current Status: Operational



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Communications System Selection

- Why Industrial-Scientific-Medical (ISM) band?
  - Licensing issues
  - Fast Integration
  - Low-cost
  - Wide variety of COTS hardware

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Communications System Description

- COTS MHX-2400 from Microhard Corp.
- 2.4GHz ISM Band
- Frequency Hopping Scheme
- 1 Watt Output Power
- Serial Interface
- Plug-n-Play Radio-Modem

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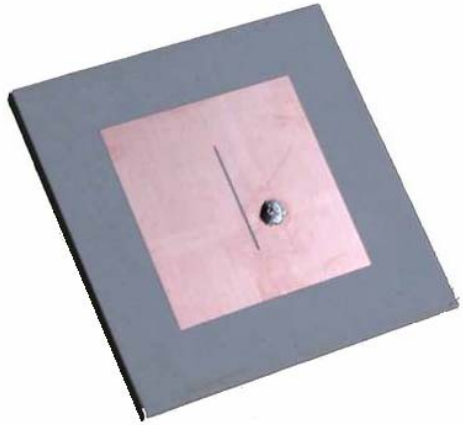
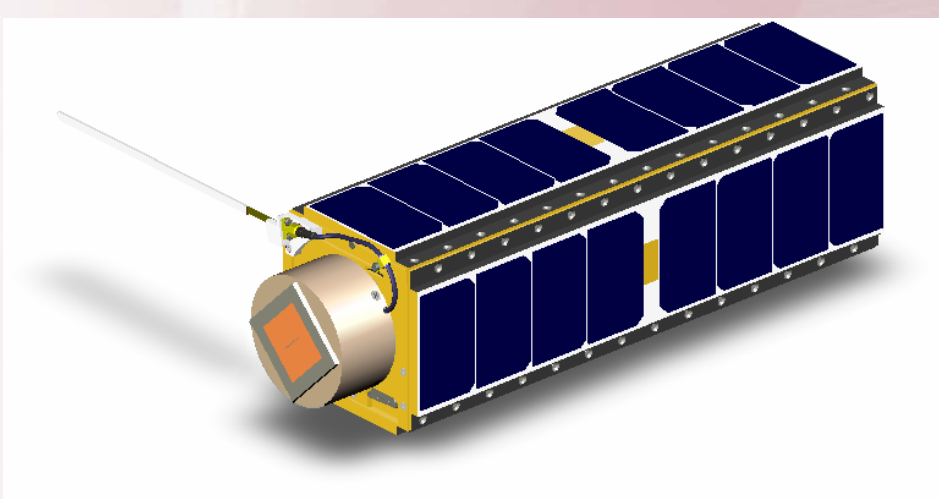
Communications System Description

- In-house Antenna Design
- Circularly Polarized Patch Antenna
- Passive Attitude Control





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Earth Station

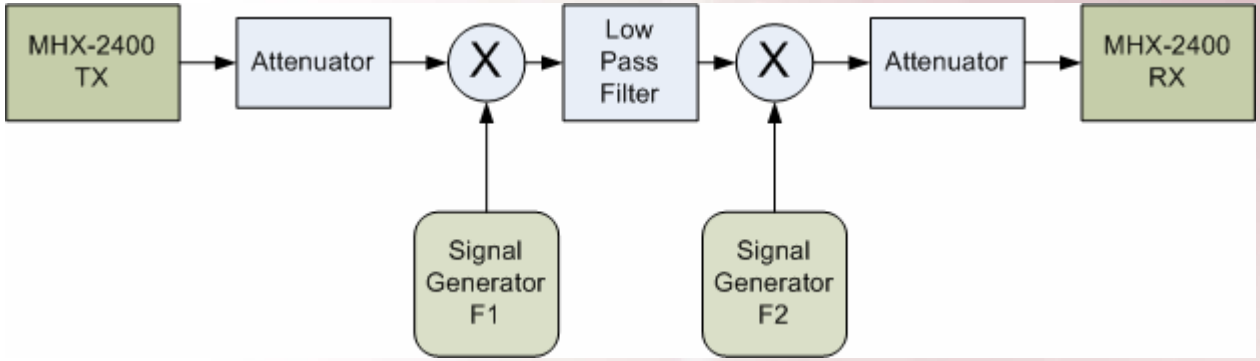
- 18-meter Dish, only illuminated over 10 meters
- Owned by SRI International
- Computer-controlled tracking software
  - Pointing Error: 0.02 deg.
- Uses same MHX-2400 radio modem

Design Analysis

- Link Margin: ~10dB @ min. Elevation
- Access Time: 3.5 min Average, 6 min Max.
- Throughput: 9600 bps, can be increased
- Power Consumption: 1 Watt Rx, 4.5 Watt Tx
- Pointing Budget: 0.38 deg max. pointing error
- Security: built-in data encryption

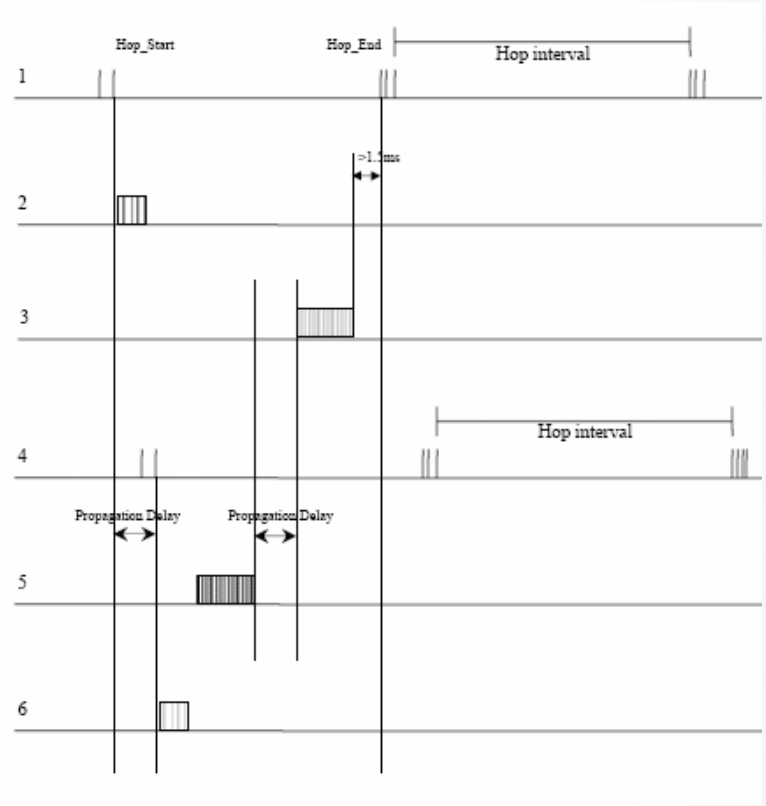
Space Qualification

- Doppler Shift
  - Max Shift for the mission: ~50KHz
  - Tested in the lab: The radios can accommodate the shift



Doppler Shift Test Setup

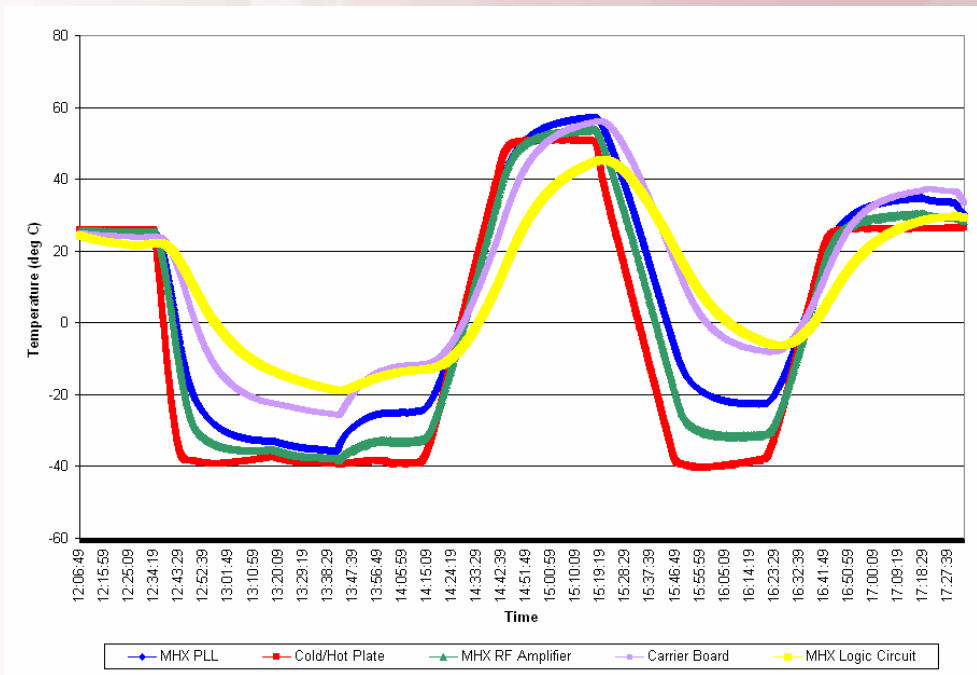
Space Qualification



- Path Delay
  - Radio-Modems follow a frequency hopping pattern
  - Propagation delay can put radios out of synch.
  - Solution:
    - Set the Hop Interval and packet size so any packet transaction finishes before next freq. hop

Space Qualification

- Thermal-Vac Cycling
  - Cycled in Thermal-vacuum Chamber
  - Survived -40° to 60° C



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Flight Results

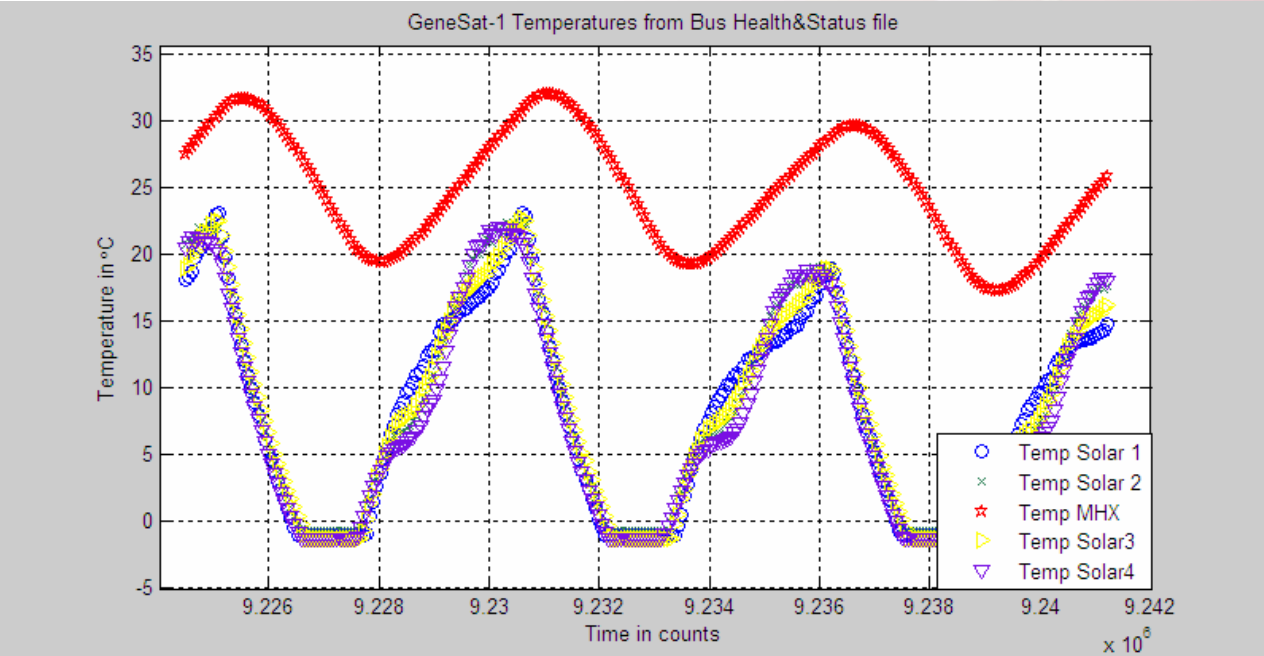
- Launched December 16th, 2006 on Minotaur-1 as piggyback
- 410km, 40.5 deg inclination orbit
- Successful link established using first TLEs provided by NORAD

- Access Time Statistics:

Access Time	Predicted	In-Flight Measured
Average	3’48’’	3’04’’
Max.	6’00’’	5’10’’

Flight Results

- Thermal Profile:



Transceiver:

- Max. Temp:
  - 34°C
- Min. Temp:
  - 15°C

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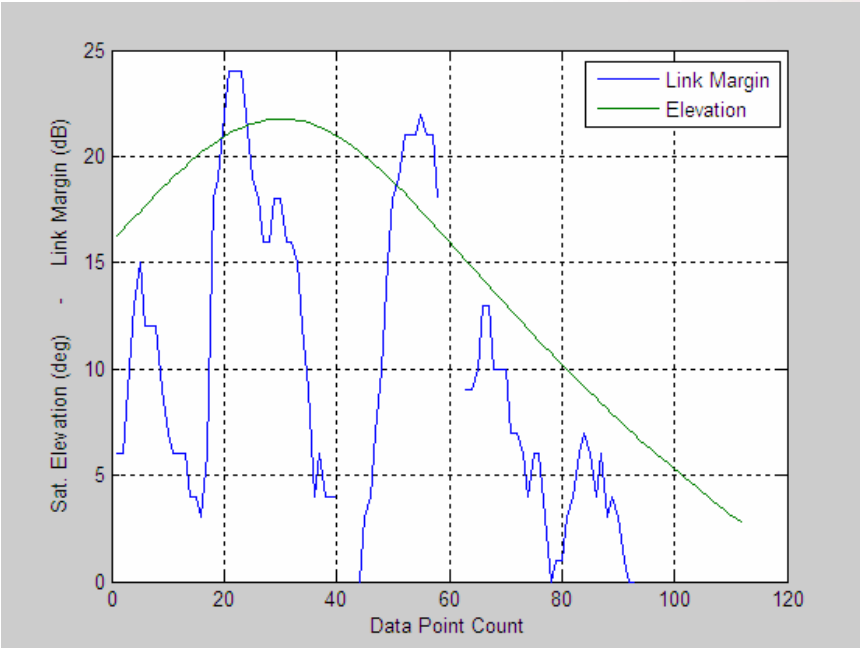
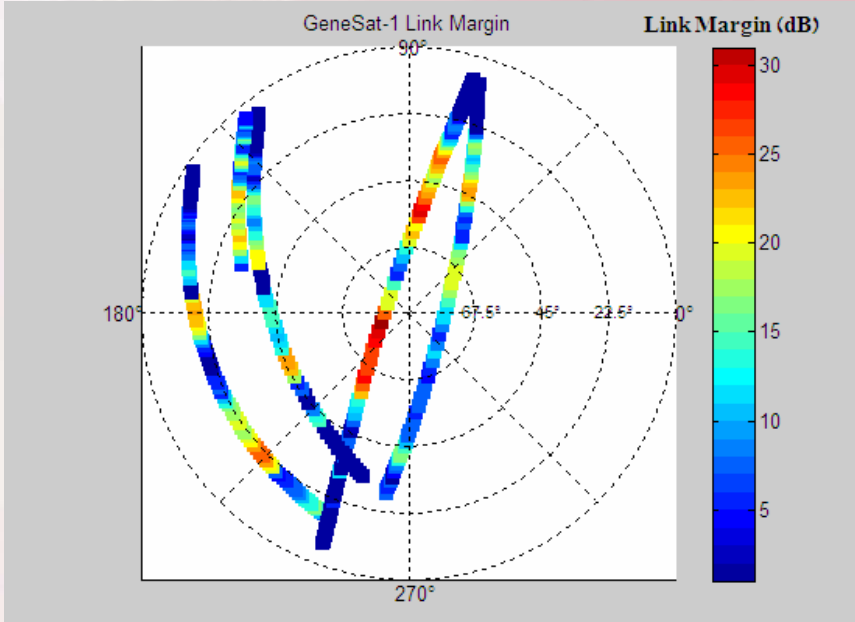
Flight Results

- Link Margin Measurements:





- Good Link Margin
- Large Variations due to Passive Attitude Control

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Conclusions

- COTS Transceiver flown with no modifications
- Low Cost – Fast Integration
- Significant Earth Station infrastructure – but may be reduced
- Fewer licensing requirements given it is not an amateur band
- Not the best solution, but it may work for your mission
- Many universities/companies are planning on using this system in future missions
  - MAST Mission has already flown the Microhard Succesfully
  - GeneSat-1 has been operating for 8 months

Acknowledgments

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