Using Nanosats as a Proof of Concept for Space Science Missions:

QuakeSat as an Operational Example

Scott Flagg
QuakeSat Mission Director
August 2004
Background

- Space science is expensive.
- Bus, Instrument & Launch just under $100M.
- Funding level not available for new and/or yet unproven scientific ideas.
- Need lower cost option: NanoSats.
• Past researchers have seen ELF signals coincident with earthquakes.
• Data set very small.
• Not specifically looking for earthquake signals.
• A number of countries and researchers pursuing this area now.
• Question: Does the correlation to earthquakes hold over a larger data set?
Our Science Mission

• Further investigate
  – What are the best frequencies to look for?
  – Necessary sensitivity?
  – Signal structure (wide or narrow frequency, etc)
  – Signal propagation path (needed to geo-locate signal origin, ie earthquake epicenter.)
  – What orbits best?
  – Other noise in the environment?
QuakeSat

- Triple CubeSat, under 5kgs
- Magnetometer payload (1-1000 Hz, 4 filter modes, 16bit A-D.)
- 66 MHz PC-104, 128Mb Flash memory
- Ham radio, 9600 baud, AX.25 packets
- Passive attitude control
- 12 solar panels (10 triple junction GaAs cells ea) plus 2 Li Ion batteries
QuakeSat Summary

• Launched June 30, 2003 from Plesetsk Russia
• 840km circular, sun synch orbit, “On the terminator”.
• 408 days On-orbit.
• Over 2000 magnetometer collections downloaded.
• Over 1000 satellite housekeeping TLM and support data files.
• Over 500 Mbytes raw, binary magnetometer data.
• Over 100 targeted locations collected.
• 27 Signal Event Types identified.
  – Natural Signals include Lightning and Polar Hiss.
  – Man Made/Self Generated Signals include QuakeSat modem, SA bus related tone, CPU processing, etc.
  – A number of signals are still not positively identified, possibly earthquake related: Analysis still on going.
Lightning and Whistlers
New Zealand 7.2M +5 Days

Frequency vs. Time Data: MG150HSNZ2CGM26Aug0727R (08/26/2003 07:27:34.76 UTF, Span = 0.256 - 182.638 sec)
[history: Loaded QuakeSat data file: MG150HSNZ2CGM26Aug0727R]
ELF data collection passes during the 2 weeks after the recent San Simeon earthquake in California with signal events identified. Data analysis still underway.
San Simeon 6.5M +7Days

Frequency vs. Time Data: MG2HXSanSim1M29Dec1415B (12/29/2003 14:15:29.08 UTC, Span = 0.512 - 177.518 sec)

[history: Loaded QuakeSat data file: MG2HXSanSim1M29Dec1415B]

Frequency (Hz) (0.97666 Hz resolution)  Time (Sec) (0.12799 sec resolution)
San Simeon 6.5M +8Days

Frequency vs. Time Data: MG2HXSanSim1M30Dec0133B (12/30/2003 01:33:26.39 UTC, Span = 0.512 - 180.846 sec)
[history: Loaded QuakeSat data file: MG2HXSanSim1M30Dec0133B]
Conclusions

• Science is possible with NanoSats
  – Provides insight into the problem.
  – Some science easier than others.
  – Increased performance (payload and bus) will give better results.
  – Helps address the “cost of entry” problem.