The Challenges of Developing an Operational Nanosatellite

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22nd Annual AIAA/USU Conference on Small Satellites
Logan, UT
11 August 2008
Introduction

- We looked at nanosatellite development with a slight twist . . . Experiments are fun but . . .

- Could an OPERATIONAL nanosatellite be developed using components that are readily available today?
  - Unique design challenges?
  - Current state of unique nanosatellite hardware?
  - How to address these challenges in coming years?
    - Become a viable and healthy part of the industry
    - Become viable secondary payload
Why do it? Timing seemed right

- Great potential for real, high value operational missions
  - Space Situational Awareness
  - Operationally Responsive Space

- Operational microsatellites are a reality
  - Operational nanosatellites are logical next step
  - Apply microsatellite space flight heritage hardware

- CubeSats and academic programs have advanced hardware miniaturization and performance
  - Apply this state-of-the-art hardware

- MANY companies and universities build nanosatellites
  - How hard can this be?
Definitions and Assumptions

- **Nanosatellite:**
  - The 1 – 10 kg definition is an oversimplification
  - We chose a 5-50 kg functional definition for our study
    - < 5kg highly integrated design for very specific purpose
    - < 50kg requires innovation to adapt larger satellite hardware

- **Operational:**
  - Critical government or commercial mission
  - Substantial operational life – typically three years or greater
  - Does NOT demonstrate new technologies or concepts
  - Does NOT focus on technology demonstration or education

- **High mission utility:**
  - Directly supports mission needs
  - High level of autonomy and capability
  - High level of performance, reliability, and mission success
Design Challenges

- **Greatest Challenge:**
  - Availability of highly reliable, high performance, space qualified components with nanosatellite SWAP
  - Missing either proven reliability or low SWAP

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Design Challenges – C&DH

• **Greatest Challenge:**
  - Availability of highly reliable, space qualified components with nanosatellite SWAP
    - Flight heritage outside LEO
    - Redundancy, flight safety

• **Currently Available:**
  - High-reliability, high performance, high SWAP
  - Unproven reliability, high performance, low SWAP

• **Conclusion:**
  - Several innovative, capable, low SWAP processors in development that need space flight heritage
Design Challenges – GN&C

• **Greatest Challenge:**
  – Availability of highly reliable, space qualified components with nanosatellite SWAP

• **Upside:**
  – 9 new reaction wheel designs in development
    • 6 have system mass impact of < 1 kg

• **Conclusion:**
  – A good selection of reaction wheels available in the foreseeable future
  – The reaction wheels in development will need flight heritage
  – SWAP for GN&C not primary driver - except visible sensor
Design Challenges - Comm

• Greatest Challenges:
  – Availability of highly reliable, space qualified components with nanosatellite SWAP
  – Performance is coupled to size and/or power
  – SWAP issues accentuated if COMSEC required

• Upside:
  – Some existing hardware can squeeze into a nanosatellite
  – Several innovative, capable, low SWAP communication systems are in development that need space flight heritage

• Conclusion:
  – Communication systems in development need flight heritage
  – Perform system level trades to balance SWAP between communications and C&DH subsystems
Design Challenges - Harness

• **Greatest Challenges:**
  – Connectors scale with power and I/O NOT spacecraft size
  – Physical separation becomes more challenging

• **Upside:**
  – Lightweight, CUSTOM harnesses using flight heritage hardware are available

• **Conclusion:**
  – Developing components with lower power and I/O requirements decreases harness size and mass.
  – Custom harnesses needed for operational nanosatellites
Design Challenges – Overall Bus

• **Greatest Challenges:**
  – *Radiation survivability with extended mission duration and orbits beyond LEO*
  – *Fewer EEE parts in the 50-300 Krad range*

• **Upside:**
  – *Several innovative radiation mitigation approaches in development that need space flight heritage*
  – *Many operational nanosatellite missions in LEO*
  – *Most experimental missions operate in LEO (Good and Bad)*
  – *Many miniature components available for LEO environments*

• **Conclusion:**
  – *Radiation mitigation in development needs flight heritage*
  – *Additional shielding with spacecraft bus difficult within 50 kg*
Proposed Roadmap

- Three “players” need to all focus on the next level of operational satellite development
Proposed Roadmap

- **Four Existing Areas**
  - ALL could feed nanosatellite-scaled, space-flight heritage hardware into future operational nanosatellite programs

  - Operational Microsatellite
    - Frequent launches
    - Less expensive
    - Standard busses

  - Operational Large Satellite
    - Access to MEO and GEO
    - Long duration

  - University Satellite
    - Very low cost to orbit
    - History of nanosatellites
    - Creative workforce

  - Demonstration Nanosatellite
    - Mission demonstrations
    - System demonstrations
Proposed Roadmap

• **Start Solving the Big Picture One Subsystem at a Time**

- Maturity of mini GN&C components
- Low-power, low-mass comm.
- Increased radiation tolerance
- Miniaturized propulsion components

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Nanosatellite Technical Maturity

- Low-power, low-mass, Hi-perf, Hi-rel Computing
- Miniaturized, low power payloads and sensors
- Selection of miniaturized mechanisms
- Maturity of advanced structures / mech / TCS

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Operational Nanosatellite
Conclusion – Is now the time?

• **The time is right for operational nanosatellite missions**
  – *Space Situational Awareness*
  – *Operationally Responsive Space*

• **Hardware development needs a cohesive effort**
  – *Government, Industry, and Academia*
  – *Limited high TRL, space flight heritage nano-scale hardware*

• **Operational nanosatellites are a significant challenge**
  – *Performance and reliability with nanosatellite SWAP is lagging*

• **This is an exciting time for nanosatellite development**
  – *Operational nanosatellites are achievable in the near future*
  – *Nanosatellite hardware development is good for all sizes of satellites*
Acknowledgments

- The AIAA/Small Satellite Conference and organizing committee
- Andrew Grimes from Lockheed Martin Space Systems Company
- YOU – The Conference Attendees

QUESTIONS?