SSC08-I-3

The Challenges of Developing an Operational Nanosatellite

David Homan
Lockheed Martin
Space Systems Company

LOCKHEED MARTIN

Quinn Young
Space Dynamics Laboratory

Space Dynamics LABORATORY
Utah State University Research Foundation

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 <u>OPERATIONAL</u> 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***

	Reliability		Performance		SWAP	
	Unproven	High	Low	High	Low	High
Needed Capability		√		√	√	
Current Capability 1		√		√		√
Current Capability 2	√			√	√	

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

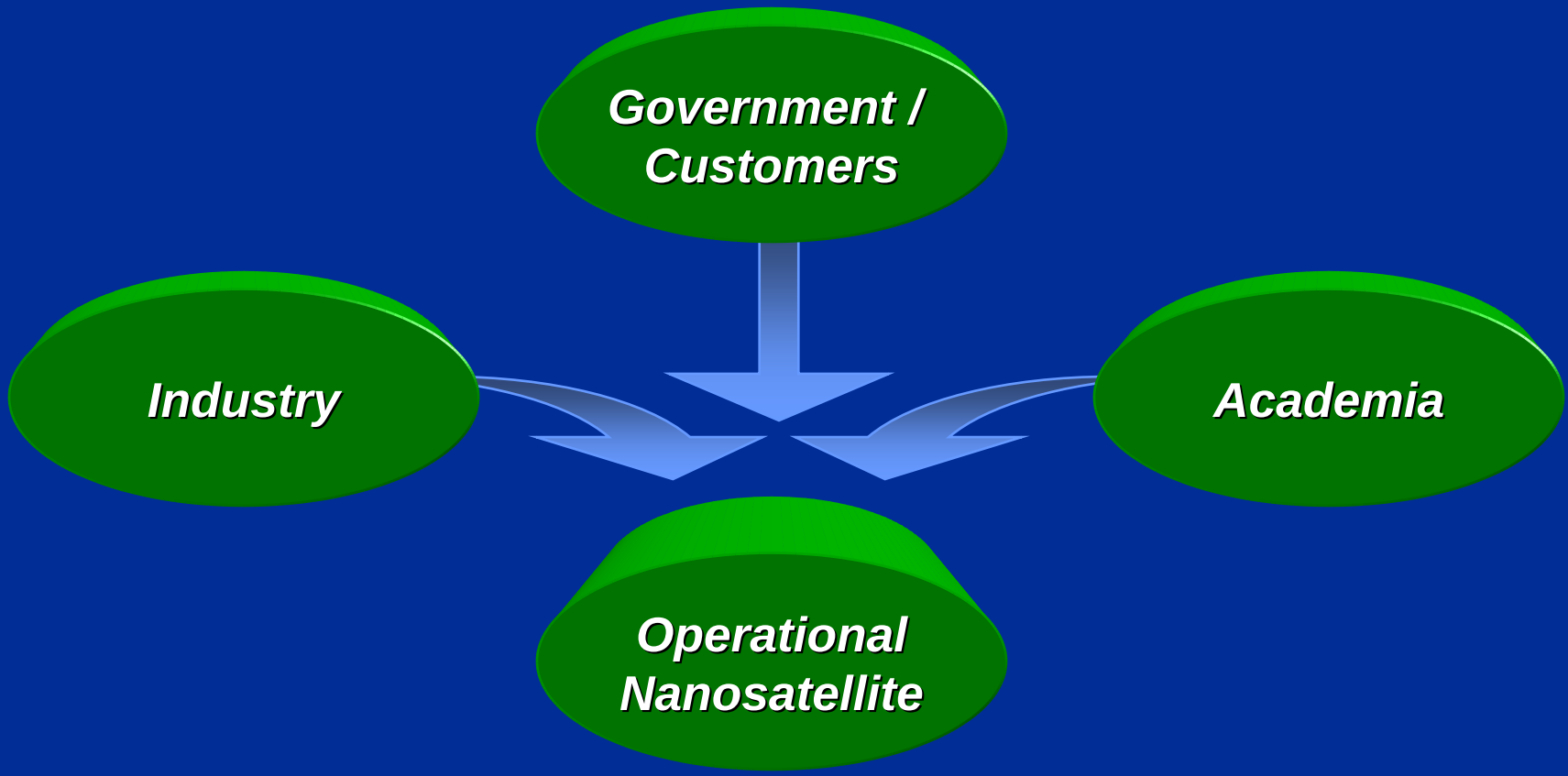
- ***Greatest Challenges:***
  - ***Connectors scale with power and I/O NOT spacecraft size***
  - ***Physical separation becomes more challenging***
- ***Upside:***
  - ***Lightweight, CUSTOM harnesses using flight heritage hardware are available***
- ***Conclusion:***
  - ***Developing components with 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***

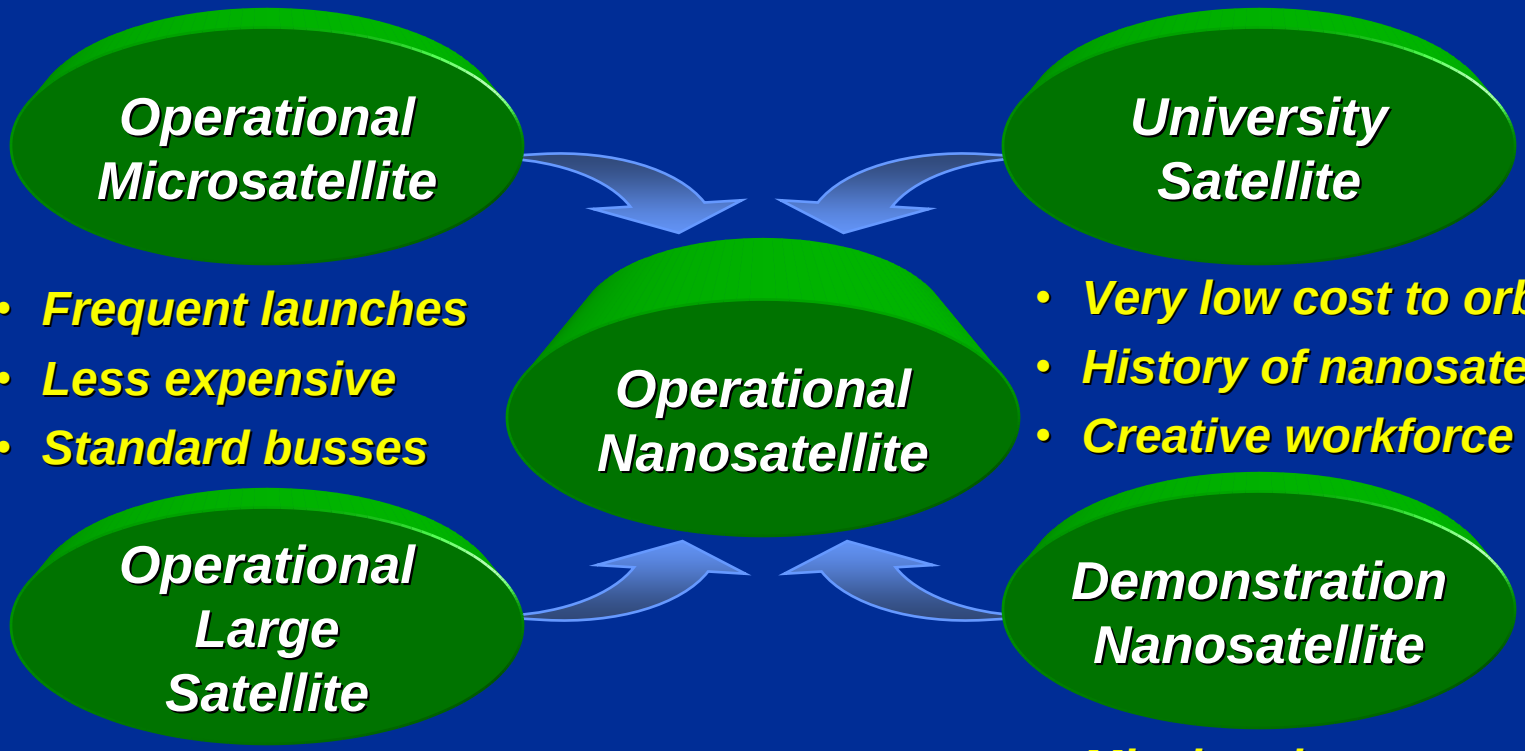
Proposed Roadmap

- ***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***



- *Frequent launches*
- *Less expensive*
- *Standard busses*

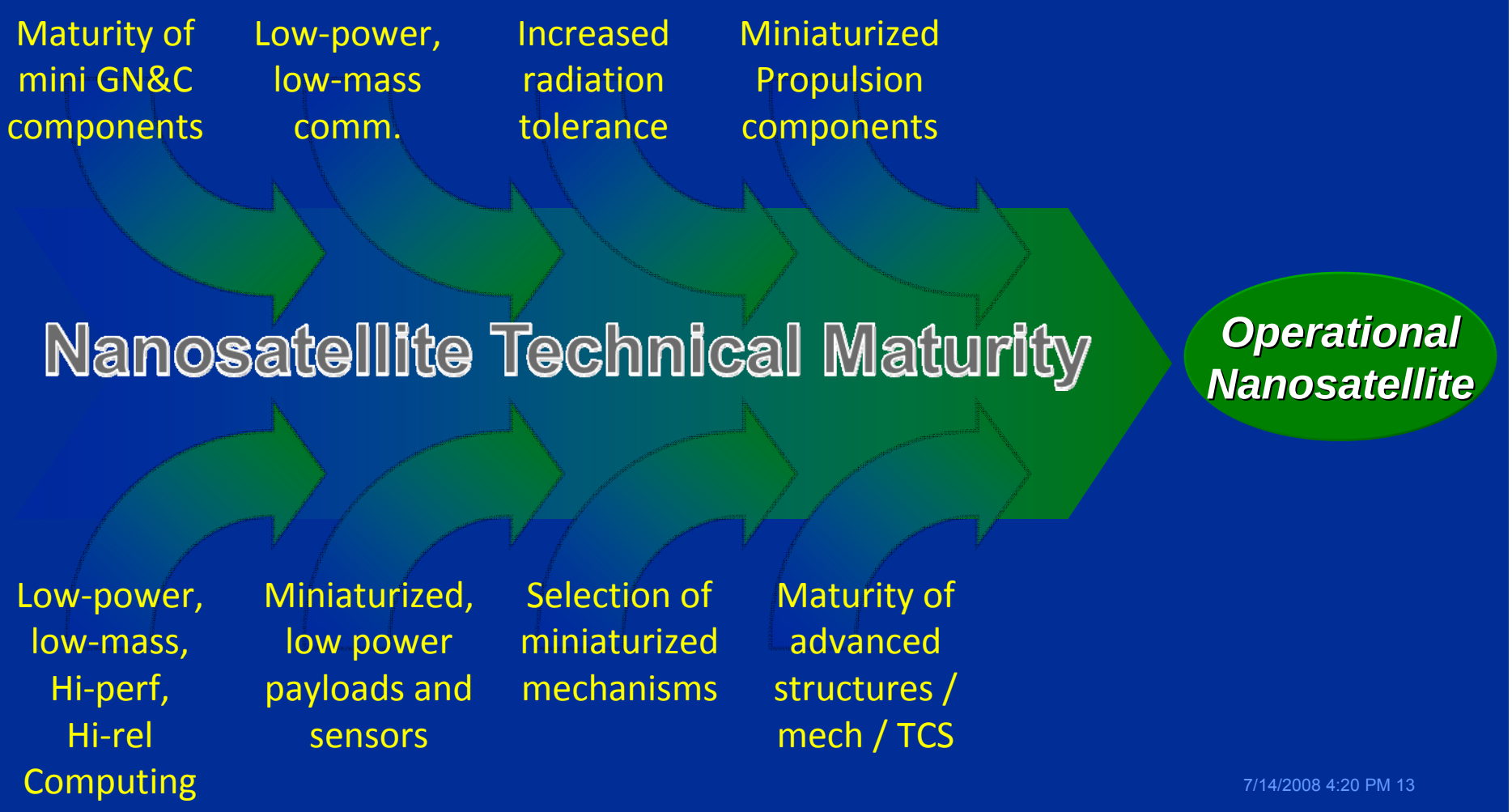
- *Very low cost to orbit*
- *History of nanosatellites*
- *Creative workforce*

- *Access to MEO and GEO*
- *Long duration*

- *Mission demonstrations*
- *System demonstrations*

Proposed Roadmap

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



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*

Acknowlegments

- ***The AIAA/Small Satellite Conference and organizing committee***

- ***Andrew Grimes from Lockheed Martin Space Systems Company***

- ***YOU – The Conference Attendees***

QUESTIONS?