Pioneering Innovation in Space

30 Years of International Leadership

Brian Horais

30th Annual Conference on Small Satellites
Welcome, Keepers of the ‘Nonsense’

• 30th Smallsat – an honor to be presenting a perspective on this community’s record of Pioneering Innovation in Space

• “Any important breakthrough, before it happens, is often dismissed as nonsense. Those who find the breakthroughs need to have confidence in nonsense.”
  • Burt Rutan, May 2016, AW&ST ‘The Next 100 Years’

• The smallsat community has shown that they have the curiosity, creativity and courage over the last three decades to turn the ‘nonsense’ of small satellites into the lifeblood of innovation in the space industry today

Those who find the breakthroughs need to have confidence in NONSENSE
Questions to Address

• What lead up to the establishment of this Conference 30 years ago?
• Does the Smallsat community provide necessary and essential contributions to the space industry?
• Where is the Smallsat community and Space Technology going?
Space Innovation – The Early Years

- During its early years (60s and 70s) the US Space Program launched numerous R&D secondary payloads.
- As the space Industry matured, it lost much of its ability to conduct space component R&D because the risk of failure increased.

What Was Well Known by the Early Space Developers in the 60s and 70s had to be Rediscovered by the SmallSat Community in the 80s and 90s.
A Risk-Averse Space Industry Evolves

• As the cost, size and complexity of satellites has increased, the ability/capacity of satellite builders to accept risk has declined dramatically.

As risk taking decreases, so does innovation.
AMSAT: Early Experimenters Emerge

- AMSAT is a worldwide group of Amateur Radio Operators (Hams) who share an active interest in building, launching and then communicating with each other through non-commercial Amateur Radio satellites.
  - For the past 40 years largely volunteer international AMSAT groups have played a key pioneering role in significantly advancing the state of the art in the space sciences, space education and space communications technology.
- With the assistance of launch providers, AMSAT has successfully placed over 60 Amateur Radio satellites into Earth orbit. Today, over 20 of these satellites are operational.
  - The very first OSCAR satellites (OSCAR stands for Orbiting Satellite Carrying Amateur Radio) were launched in the early 1960s.
  - During the SmallSat Doldrums (1977-1987), AMSAT continued to build and launch amateur small satellites (5 satellites launched between 1978 and 1987).

Oscar III Satellite

Oscar I3 Phase III Satellite

Four Microsats on ASAP

SSC16-III-01
The Ups & Downs of SmallSat Launches

- After a surge of small satellite launches in the 60s and 70s, there was a rapid drop in launches.

Note: Microsats (Shown in Blue) are defined here as 10 to 100 kg mass. Nanosats (1 to 10 kg) are shown in green.

The Conference on Small Satellite Technology was founded in 1986

Source: 25 Years of Small Satellites - Siegfried Janson, Aerospace Corp. , AIAA/USU 25th Conference on Small Satellites, 2011
Conferences on Small Satellite Technology

- In response to this lack of opportunity to develop and launch small satellites, the emerging Smallsat Community organized two significant conferences on Small Satellites in 1987.
  - The first of these was a joint conference on Lightweight Satellite Systems organized by the American Institute of Aeronautics and Astronautics (AIAA) and the Defense Advanced Research Projects Agency (DARPA). This conference was held in Monterey, CA, at the Naval Postgraduate School in August 1987.
  - The second of these was the First Annual Utah State University (USU) Conference on Small Satellite Technology, held October 7-9, 1987 in Logan Utah.
- Participation in both of these conferences was strong and indicative of increased interest in small satellite technology and the expansion of space technology.
Secondary Payloads Return in the 1990s

- In the U.S., the launch industry was unwilling to carry secondary payloads due to their potential risk to the larger paying satellites.
- Ariane entered the secondary payload ‘market’ in 1990 with their Ariane Auxiliary Structure for Auxiliary Payloads (ASAP).
  - The first launch of the Ariane ASAP secondary payload adapter occurred on January 21, 1990 on Ariane 40.
- Converted Soviet ICBMs expanded the commercial availability of secondary payload launches:
  - DNEPR (converted SS-18 ICBM) in 1999
  - ROCKOT (converted SS-19) in 2002
Innovation Emerges: The KITSAT Story

- **Satellite Technology Research Center (SaTReC)**
  - established in 1989 in South Korea
  - University-based center for satellite technology research

- **Launched KITSAT-1 in 1992**
  - Scientific microsatellite developed jointly with University of Surrey (UK)
  - Ariane IV Launch (ASAP)

- **Launched KITSAT-3 in 1999**
  - Multi-spectral earth imaging satellite (Indian launch)
  - ISRO PSLV-C2 secondary launch

In 10 years, South Korea developed their own remote sensing satellite capability
CubeSats Enter the ‘Mix’

• Beginning in 1999, California Polytechnic State University at San Luis Obispo (Cal Poly) and Stanford University developed a very small and relatively inexpensive spacecraft concept – the CubeSat
  • *The objective was to help universities worldwide enable students and researchers to perform space science and exploration.*

• The CubeSat reference design was proposed in 1999 by professors Jordi Puig-Suari of California Polytechnic State University and Bob Twiggs of Stanford University
The Tide Begins to Turn

During the 1990s and early 2000s, Headlines indicated the lack of secondary payload launch opportunities in the U.S.

- Concerns were raised that the rest of the international space technology community was advancing faster than in the U.S. due to their ease of access to space launch capabilities

Other organizations in the U.S. were watching the progress of the CubeSat community

- They came to the realization that the multiple unit CubeSats offered significant opportunities for scientific exploration and the development of new concepts

Among these new CubeSat followers were:

- The National Reconnaissance Office (NRO)
- The National Science Foundation (NSF)
- The National Aeronautics and Space Administration (NASA)
NRO Aft Bulkhead Carrier (ABC)

• The Director of the NRO, Bruce Carlson, reported on their plans to develop the ABC at the 2011 AIAA/USU Conference on Small Satellites.
  • An Atlas V Centaur upper stage design was modified by United Launch Alliance (ULA) for longer missions – three small spherical helium tanks replaced with two large cylindrical tanks where the third 26” helium sphere used to be located.

• Why? The NRO saw value in the CubeSat standard as a means to develop and test new technologies.
  • Evidenced by their sponsorship of four launches of secondary payloads with over 40 CubeSats through the end of 2015.

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<th>NRO ABC CubeSat Launches thru 2015</th>
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<td>Atlas V OUTSat Launch 2012 Sep 13, 2012</td>
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<td>Atlas V GEMSat Launch 2013 Dec 6, 2013</td>
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<td>Atlas V ULTRASat Launch 2015 May 20, 2015</td>
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What is the Potential for CubeSat Missions?

• As the Small Satellite Community has evolved, the naysayers have always been quick to point out that small satellites can’t accomplish any real missions.

• Prof. Dave Klumpar, an expert on small satellites from Montana State University, points out that
  • “Perhaps the greatest scientific advance that very small low-cost satellites will enable is the ability to make many simultaneous synergistic measurements from multiple observing locations”

• Many emerging organizations are actively pursuing new CubeSat concepts and missions:
  • **PlanetLabs**
  • **LightSail**
  • **Mars Cube One (MarCO)**
How are We Doing So Far?

The trend on CubeSat Launches is continuing to improve.

This is a VERY Positive Indicator for the Small Satellite Industry.

Sources: [www.cubesat.org/missions](http://www.cubesat.org/missions), St. Louis University Cubesat Database, Gunter’s Space Page.
What Will the Future Hold?

Recent Announcements point to a Promising Future:

• Lunar CubeSats to the Moon (*6th Intnl. Workshop on Lunar Cubes, SEP 2015*)
• NASA Solar Sail CubeSats On 2018 SLS (*Space News JUL 2015*)
• NASA Developing Large (1.53 m²) Deployable S-Band Antenna for 6U CubeSats (*29th AIAA/USU Smallsat*)
• Spire Raises $40 Million For Weather Satellite Constellation (*Space News, June 2015*)
• United Launch Alliance (ULA) announces the CubeSat Launch Competition (*April 7, 2016*)
• NRO continues to expand secondary payload opportunities with its ABC (Aft Bulkhead Carrier) System on Atlas V Launches (*NROL-55, OCT 2015*)
• Dearth of Dedicated Smallsat Launchers Challenges Fledgling Industry (*AW&ST July 20, 2016*)
What will the next 30 Years Bring?

- The 1 AUG 16 Aviation Week and Space Technology Magazine (AW&ST) Cover Photo features two small imaging satellites being deployed from the International Space Station’s Nanoracks CubeSat deployer.
  - “Imagine what a reader in 1916 would have thought of that!” (AW&ST)

Based on the rate of innovation in the Small Satellite Community; What Will the Next 30 Years Produce?
Conclusions

• The last 30 years of pioneering effort by the small satellite community have shown that what many in the mature space industry considered ‘Nonsense’ is in truth the driving force for the development of new space technologies and concepts.

• If the increase in small satellite activity over the last five years is any indication, the pioneering spirit and dedication this community continues to devote to the ‘nonsense’ of small satellites is paying off.

• Keep going, you Keepers of Nonsense

“Any important breakthrough, before it happens, is often dismissed as nonsense.” Burt Rutan, 2016
Small Satellites
Revolutionizing our Knowledge of the Universe
SWARMS ENVISION