Perspectives on Integrating SmallSats into the DoD

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Portfolio Objectives

- Objective 1: Determine how SmallSats can meet Air Force objectives (1kg-50kg)
- Objective 2: Workforce Development

Objectives will be met through:
- research performed at AFRL
- partnerships between AFRL and other government labs, industry, and academia
- 2+ Cubesats per year

1U (10cm x 10cm)
A History of Small Satellite Missions

Launch Date

1990 8yrs 1998 7yrs 2005 6yrs 2011 5yrs 2016 1yrs 2017 1yrs 2018

MSTI-1 168 kg
MSTI-2 170 kg
MSTI-3 210 kg

TacSat-1 370 kg
TacSat-2 370 kg
TacSat-3 400 kg

XSS-10 28 kg
XSS-11 100 kg

NFIRE 395 kg

C/NOFS 395 kg

ANGELS 120 kg

DSX 1200 kg

EAGLE 1000 kg

Launch Failure

Warfighter-1 355 kg
TacSat-2 370 kg
TacSat-3 400 kg

MightySat-1 64 kg
MightySat-2 120 kg

3 CornerSat 50kg
LinkedIn

FASTRAC 50kg

GEARRS 1&2 5kg

CELTEE 1kg

ARMADILLO 6kg

ASCENT 14kg

Prox-1 60kg

VPM 8kg

Oculus-ASR 75kg

8 more CubeSats in 2019

DoD Space Test Program sponsorship
NRO Launch Sponsorship

Distribution A – Approved for Public Release
SmallSat Portfolio

AFRL Missions

Small Satellite Portfolio
~<50kg

Community Interactions
- Studies
- Collaborations with other agencies

Missions
- In-House
- Industry

Parts Database
- Academia
  - STEM
  - Science and Technology Demonstrations

Large Satellite Missions
~>50kg
Very low frequency Particle Mapper (VPM)

Pursuing High Impact Science

- Critical augmentation for the AFRL Demonstration and Science Experiment (DSX) satellite
- Answers key DSX physics: Can we transmit VLF across the space plasma sheath into the far-field.
- Sensors to observe precipitating energetic particles induced by DSX
Satellite for High Accuracy Radar Calibration
Science/Technology Demonstration

- Demonstrate the capability to perform critical calibration of over 120 Tri-Service C-Band radars.
- Calibration is needed to meet tracking requirements of orbital objects
- Demonstrate low latency delivery of data (min vs days)
Globalstar Experiment And Risk Reduction: Rapid Technology Demonstration

- **Challenge:** Can we use commercial comm to operate AF spacecraft?
  - Potential lower cost than current AFSCN
  - 60% global coverage for duplex
- **Experiment:** Characterize the Globalstar network for LEO spacecraft comm for both the Duplex and Simplex radios

Variants:
- SV ↔ GS Duplex
- SV ↔ GS Simplex
- GS ↔ Ground
Perspectives of CubeSat Utility: An Air Force Example

Categories of Utility

- **Category 1:** New Capabilities
  - Constellations, servicing, ...
- **Category 2:** Augmentation of current missions
  - Gap filling, calibration, ...
- **Category 3:** Rapid Technology and Science Demonstrations
  - Prototyping, TRL increasing, proof-of-concept, ...
- **Category 4:** Workforce Development
  - Universities, National Labs, FFRDCs, ...

**Status**

- Limited use
- Barely started
- Moderate implementation
- Substantial, but could do more
Classes of CubeSats

- Need to integrate CubeSats into technology development roadmaps and science investigation roadmaps
  - STTRs, SBIRS
  - NAS Study: “Fly, Learn, Fly”
- SmallSats greatly increases the “dynamic range” of tools available to space architects
“New Space” needs to be more than just risk-tolerant missions, but an integration of missions of various risk postures together to meet agency needs.
USG Working to Leverage the SmallSat Platform

• There are a lot of conversations between USG agencies on how to appropriately leverage this platform
  – Large ships don’t turn instantly
  – Good representation of SmallSat-minded folks in these discussions

• There is a sincere desire to leverage the SmallSat platform without breaking what makes this platform attractive
  – Challenges include: technical, programmatic, cultural, …
  – This is a dynamic time where there will be lessons learned in implementation

• Many USG missions require a higher mission assurance
  – Still have a long way to quantify small satellite reliability
  – Architectural reliability is an exciting new capability, but work needs to be done to better understand constellation reliability

NASA hosted a Multi-Agency TIM in June to look at areas of overlap with investing in Small Satellites. More details to come at Thursday afternoon session.
(POC: Dr. Merri Sanchez AFSPC, Ms. Faith Chandler NASA HQ)
Integrated Space

• We see small satellites working well with current trends toward enhancing mission assurance to DoD missions
  – Space Enterprise Vision
  – 3rd Offset

• Small Satellites provide the ability to system architects to enhance the “dynamic range” of platforms available to meet mission needs

• We need to understand how to mix cross-platform missions in a reliable method
Backup
The SmallSat Trade Space

Extension of the AI&T floor in space

- **Tech Demos**
  - Ready Now

- **Research**
  - Ready Now

- **Science Missions**
  - Single point
  - Multi-point
  - Ready Now

- **SmallSat**
  - Operational

- **Augmentation**
  - Near and far Term
  - Mostly far Term

**Research Mission Attributes**
- Mixed timeline
- Scaled mission assurance
- Multiple launch platforms
- Large Cost Range

**Operational Mission Attributes**
- High reliability
- Longer timelines
- DoD launches (dedicated)
What do CubeSats Really Cost?

The Third Dimension

Mission Assurance

$100k $1M $10M $100M $1B
Total Cost

Launch

• Significant amount of low-cost access to space today
• Key challenge was dispensers/adapters (several)
• Integration costs is key cost for CubeSat launch

Actual AFRL Missions

(total cost: SV, Ground System, OPS)
(Shown on log scale to emphasize small satellite tradespace)