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AFRL Small Satellite Portfolio

Ground System Architectures Workshop

Session 11F: Ground System Enablers and Future Small Sat Development

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Outline

- Overview Small Satellite Portfolio Objectives
- Small Satellite Applications: S&T
- Small Satellite Applications: Operational Use
- Limitation of Small Satellite Missions

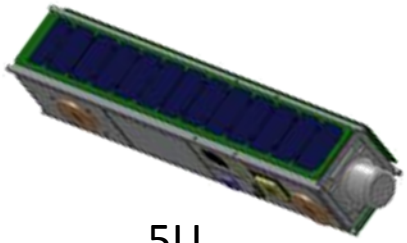
AFRL Small Satellite Portfolio Objectives

- **Objective 1: Determine how CubeSats can meet Air Force objectives (1kg-50kg)** ***What is the art of the possible?***
- **Objective 2: Workforce Development**

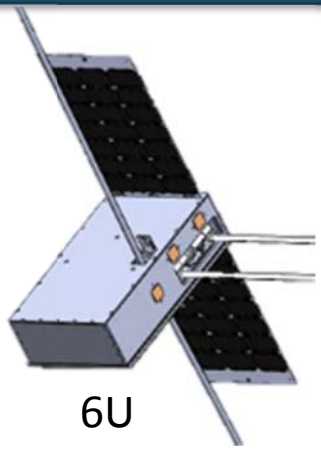
Objectives will be met through:
- researched performed at AFRL
- partnerships between AFRL and other government labs, industry, and academia
- At 2+ Cubesats per year

1U (10cm x 10cm)

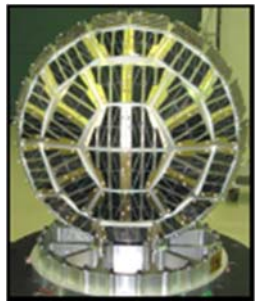
3U



5U



6U



50kg

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AFRL Small Satellite Portfolio Objectives

- Design spacecraft with a tailored mission assurance approach

  Provide both an extension of the lab bench in space

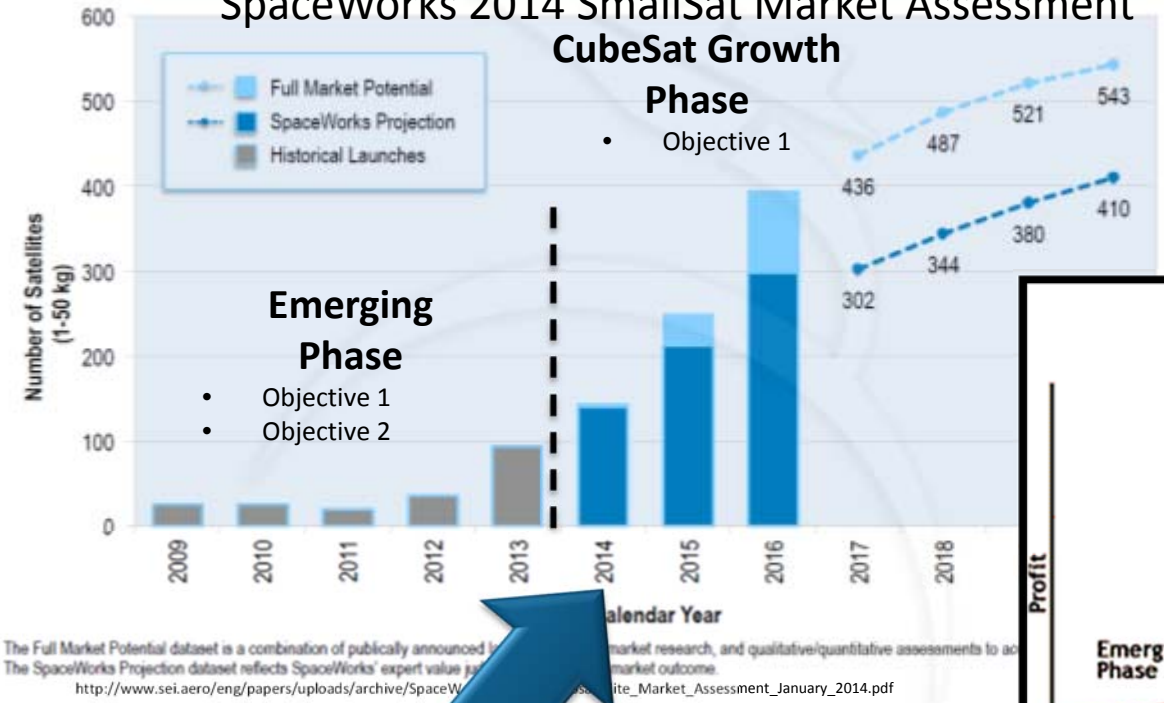
  &

  Provide for higher fidelity scientific measurements

- Flight missions (VPM, etc) which need technology or systems demoed to lower the risk profile have risk reduction missions ahead of the main flight with pointed technology goals
  - GEARRS – Commercial Communications Network Access
  - SHARC – Turn-key Attitude solution demonstration, flight software system demonstration

An exciting time for SmallSats

SpaceWorks 2014 SmallSat Market Assessment



Emerging Phase

- Objective 1
- Objective 2

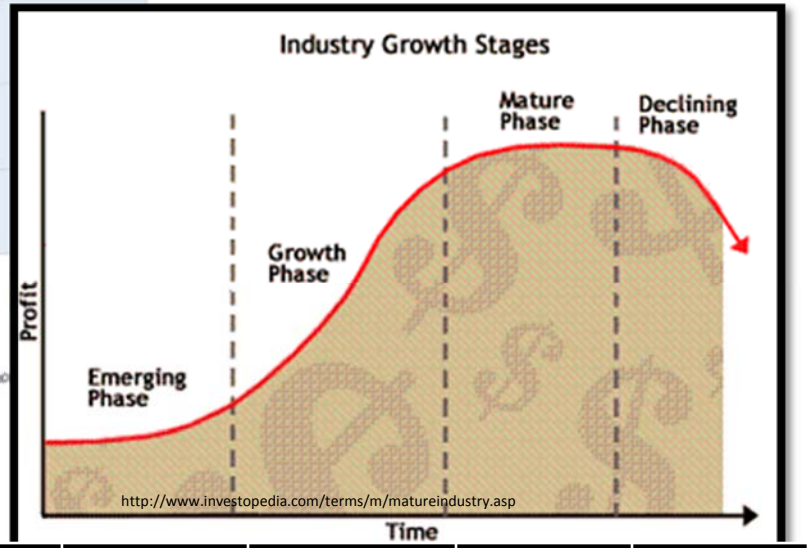
CubeSat Growth Phase

- Objective 1

The Full Market Potential dataset is a combination of publically announced l… market research, and qualitative/quantitative assessments to ac…
The SpaceWorks Projection dataset reflects SpaceWorks' expert value ju… market outcome.
http://www.sei.aero/eng/papers/uploads/archive/SpaceW… ite_Market_Assessment_January_2014.pdf

Should the Air Force be interested in CubeSats? Absolutely!

Typical for new technology



	Emerging	Growth	Mature	Declining
Audience	Early Adopters	Mainstream	Late Adopters	Laggards
Market	Small	Growing	Large	Constricting
Competition	Low	Moderate	High	Moderate
Business Focus	Awareness	Market Share	Customer Retention	Transition
Design Focus	Tuning	Scaling	Support	Transition

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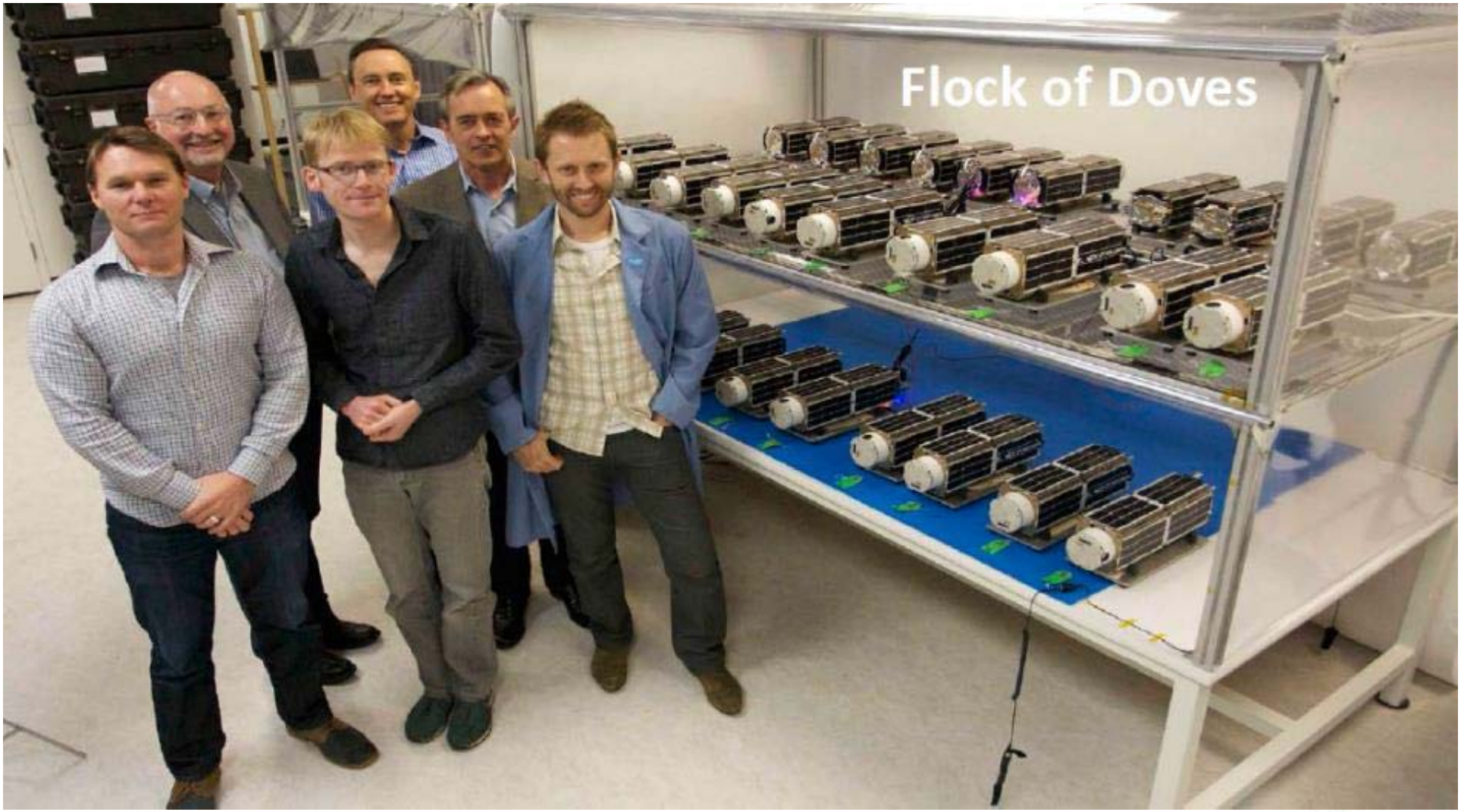
NanoRacks

Steve Jurvetson, 2014 SmallSat Keynote

PlanetLabs



Steve Jurvetson, 2014 SmallSat Keynote

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Small Satellite Applications:

Science and Technology

Note: All examples are from the University Nanosat Program

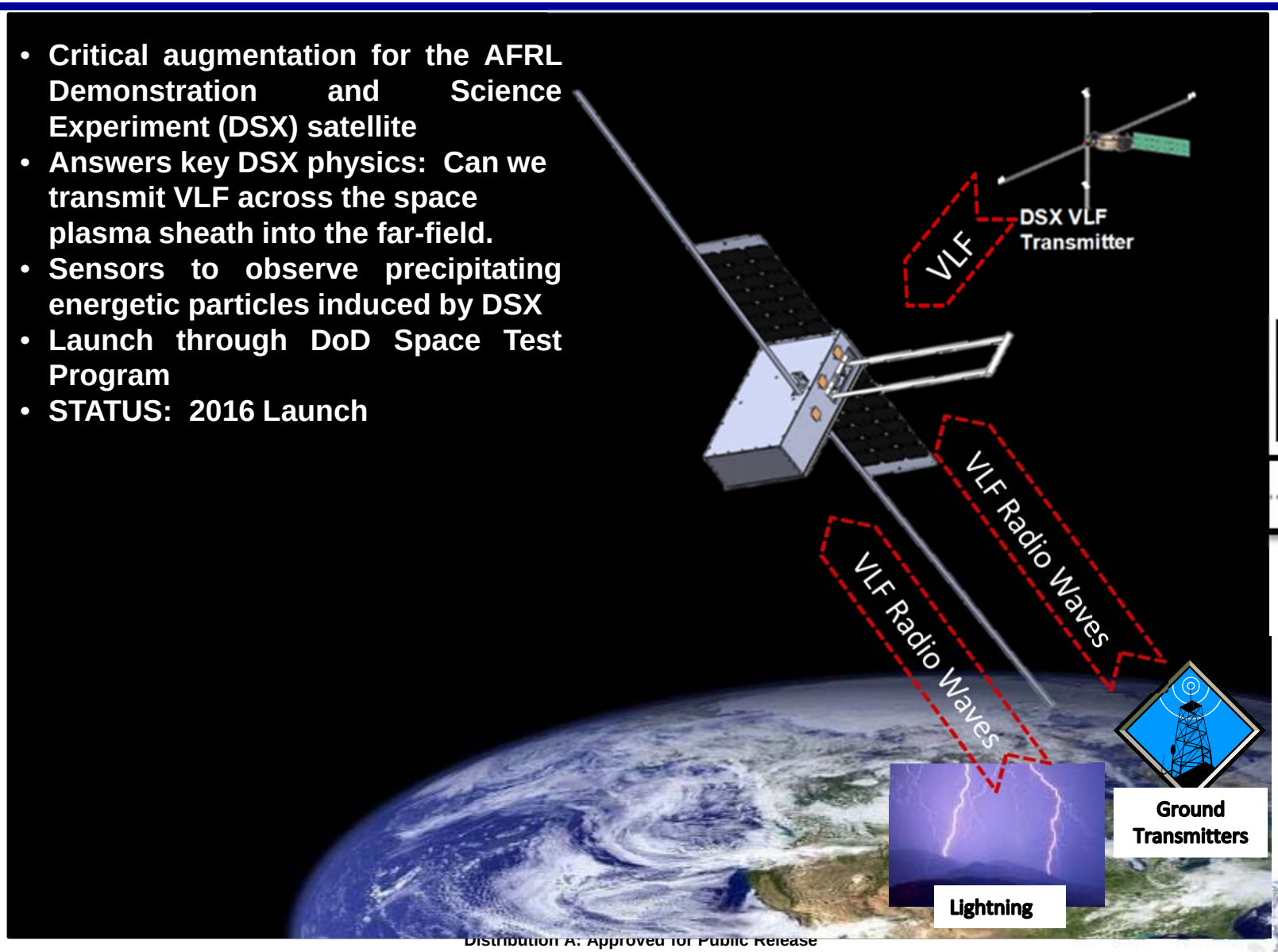
Science Investigations

- Small satellites excel at examining a particular, well-defined, science investigation (***Case Study 1***)
- Small Satellites can meet the need for multiple, in-situ measurements (global scale) needed for many space weather models (***Case Study 2***)

Case Study 1: DANDE	
Mission	Investigate atmospheric drag
Method	Spherical sat. with accels. and a neutral mass spec.
Mass	43 kg
School	University of Colorado
Case Study 2: VPM	
Mission	Multipoint VLF wave and particle measurements
Method	6U CubeSat with particle detector payload
Mass	8 kg
School	AFRL

Case Study 2: Very low frequency Particle Mapper (VPM)

- 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
- Launch through DoD Space Test Program
- STATUS: 2016 Launch



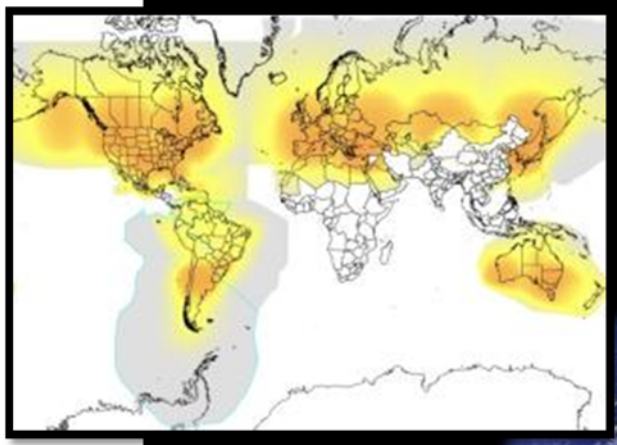
Technology Demonstrations

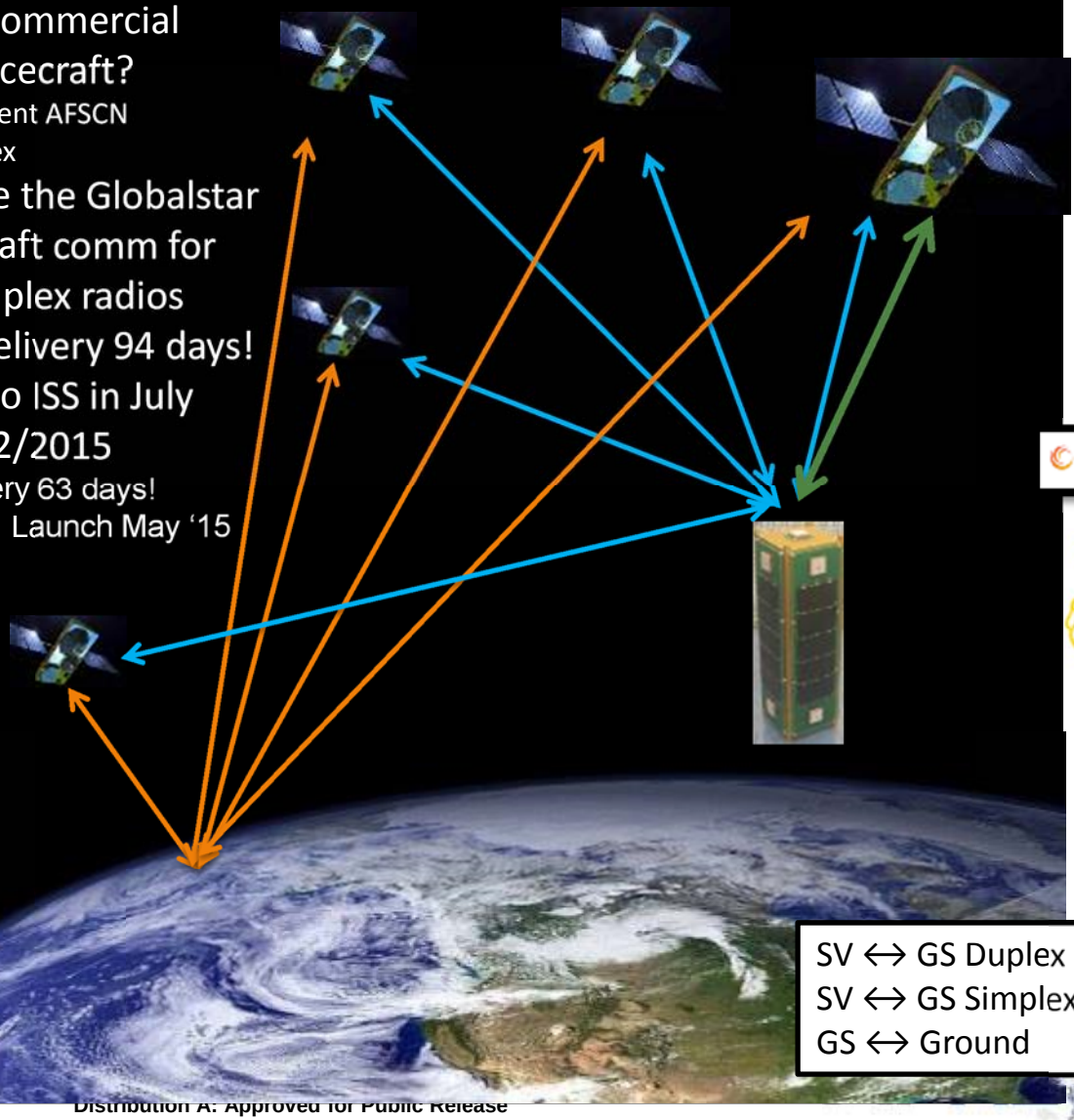
- Small Satellites provide a low-cost testbed for evaluating new algorithms (***Case Study 3***)
- Small Satellite provide opportunities for risk reduction of components for high value programs (***Case Study 4***)
- Small Satellites enable future missions (***Case Study 5***)

Case Study 3: M.Sat	
Mission	Circumnavigation of RSO
Method	Two small sats one with stereoscopic imager for prox-ops
Mass	~50 kg
School	Missouri S&T
Case Study 4: GEARRS	
Mission	Demonstrate Commercial C2
Method	3U CubeSat with Globalstar radios
Mass	3.9 kg
School	AFRL
Case Study 5: P-Cube	
Mission	Demonstrate Precision Timing between ground and CubeSats
Method	1U flying atomic clock, corner cube
Mass	2 kg
School	University of Florida

Case Study 4: Globalstar Experiment and Risk Reduction Satellite

- 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
- GEARRS-1: Concept to delivery 94 days!
  - Status: Launched to ISS in July 2014. Deployed 3/2/2015
- GEARRS-2: Concept to delivery 63 days!
  - Status: Delivered to LV, Launch May '15





Small Satellite Applications:
Operational Use

Operational Applications

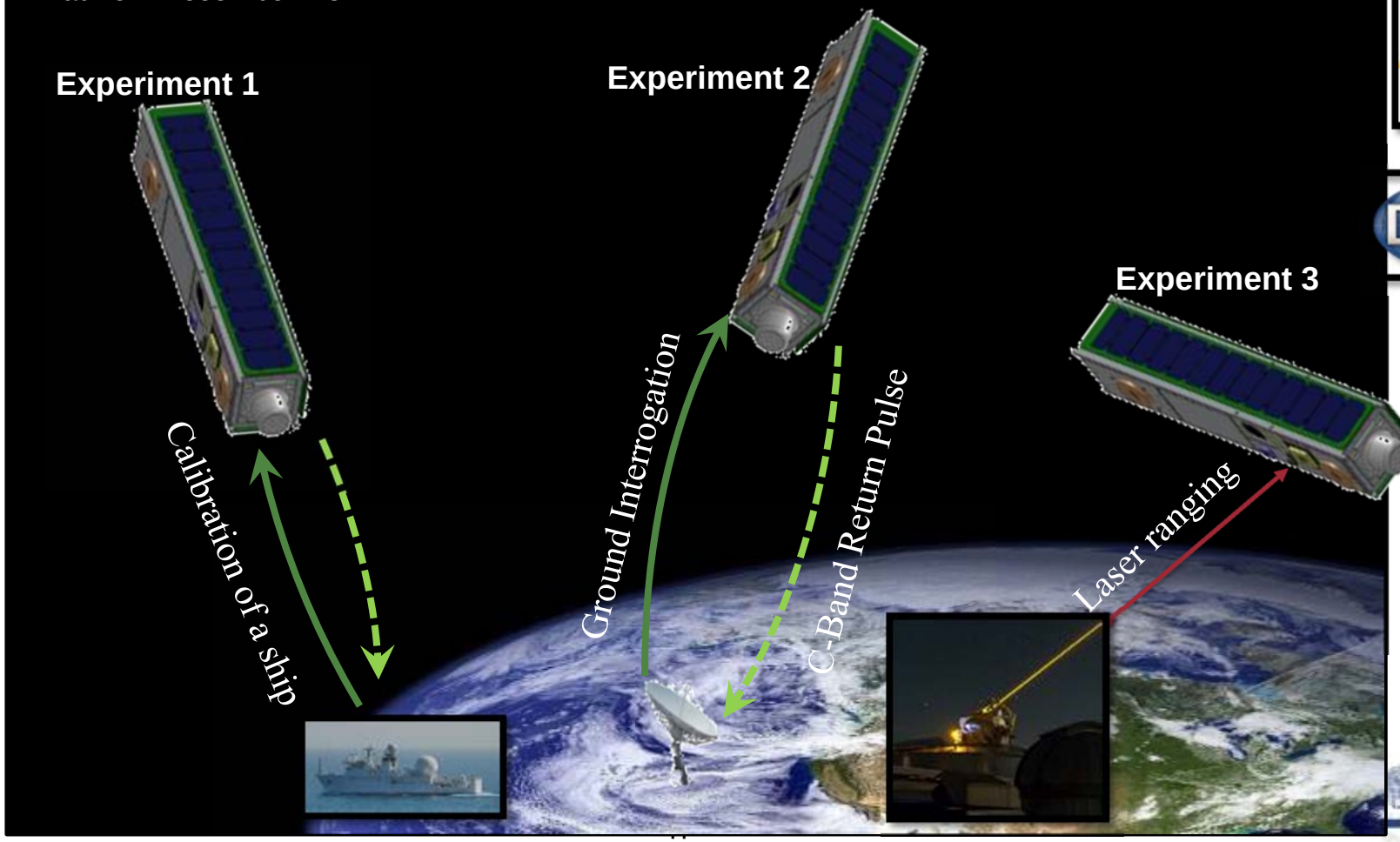
- Small Satellites can offload some of the work from operational high value assets allowing them to be allocated to critical areas of interest (***Case Study 6***)
- Small Satellites can perform routine missions for operational customers (***Case Study 7***)

Case Study 6: GLADOS	
Mission	Investigate RSO characteristics via glint and spectroscopic analysis
Method	6U with imager and spectrometer
Mass	9 kg
School	University at Buffalo
Case Study 7: SHARC	
Mission	Provide radar calibration for ground based radars
Method	5U Cubesat with transponder and GPS
Mass	5 kg
School	AFRL

Note: Operational applications is not a goal of the University Nanosat Program

Case Study 7: Satellite for High Accuracy Radar Calibration

- 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)
- Launch: December ‘15



Small Satellite:
Limitations
&
Ground Segment Development

Common Poor Approaches to Small Satellite Missions

- Attempt to cram a 500kg mission into a 50kg bus
  - Small satellite missions must be well scoped for the capability of the platform
  - There platforms are great when there is a pointed experiment series with clear exit criteria
- Assume just because it's small it's easy
  - Small satellites (especially Cubesats) are highly integrated systems, especially when considering HOW the vehicle is flown
  - There are many interdependencies between systems
- Leverage big space approaches to small satellites
  - Small Satellites allow for new paradigms for acquisition, on-orbit operations and mission assurance
  - Coordination efforts (frequency, access, etc) are not an effective means to iterate on these missions

Ground System Enablers and Future Small Sat Development

What mission(s), regardless of size, can you NOT do today because you do not have the ground services to support the mission(s)?

What ground services do you need and when do you need them?

How is your constituency working toward developing these ground service needs?