Overview

• Who We Are
• Strategic Context
• A Subset of our Investments
• Challenge To You
Our Vision

Be indispensable to our nation in improving AF and DoD space capabilities

Our Mission

Stay One Step Ahead in Space
Our Goals

1. Be the first call
2. S&T that makes a difference
3. Operate with agile business processes
4. Hire, develop and retain a world-class workforce

What We Value

Our Core Values

• S&T Excellence
• Boundary Pushing
• Professional Competency & Contribution
• Mission Focus

External

• Innovation
• Resiliency
• Synergistic Partnerships
• Skin in the Game
FY15 Funding Break Out
Received Amounts with Customer Funding
AFRL/Space Vehicles Directorate

Science and Technology 163.5M
Other Funding 56.1M
Total 219.6M

*All funding is shown as Received. Direct Cite/Reimbursable figures were obtained from the CCaR Incoming Document Report. S&T Funding consists of 6.1, 6.2, & 6.3 amounts. CRI pass-thru funding is not included.
World Class Facilities
AFRL/Space Vehicles Directorate

Existing Facilities – 55 Bldgs
- 420,000 Sq Ft – Kirtland AFB, NM
- 36,000 Sq Ft   - Holloman AFB, NM
- 31,000 Sq Ft   - HAARP, Alaska

Spacecraft Technology Laboratory

Aerospace Engineering Facility

Spacecraft Integration Facility

Fabrication and Testing Capabilities

Unique Test Equipment

IRREL characterizes Focal Plane Arrays

EO/IR Facilities

Space Electronics Facilities

Spacecraft Technology Laboratory

Spacecraft Integration Facility

Fabrication and Testing Capabilities

Unique Test Equipment

IRREL characterizes Focal Plane Arrays

Nuclear Radiation Simulation Lab

Imaging Spectroscopy Calibration Lab

Cold Atom Lab

Battlespace Environment Laboratory

Holloman

Balloon operations

HAARP **

Ionospheric research

** Now operated by UAF

ISOON

Solar observations

Comprehensive integration & test facilities for small, experimental satellites or spacecraft components at different security levels

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Space Vehicles Directorate

Mission: Stay One Step Ahead in Space

Technical Mission Areas

Space Situational Awareness
- Search, discover, track, and maintain custody of space objects
- Provide unique object ID and discrimination
- Understand and predict space domain behavior
- Characterize, assess, and resolve anomalies/attacks on space systems

Space Communications/Position, Navigation & Timing
- Extend frequency tradespace for space communication
- Address projected jamming threats
- Develop technology and create options for future GPS spacecraft

Intel, Surveillance, & Reconnaissance
- Support SBIRS and DoD unique terrestrial weather systems
- Provide capability to warfighters for over-the-horizon and traditional space-based ISR systems
- Provide key nuclear explosion monitoring technology

Defensive Space Control
- Evolve space resilience
- Holistic local awareness sensors
- Satellite intelligence technologies
- Passive protection and active agility
- Associated modeling, sim, assessment & testing

Vision: Be indispensable to our nation in improving AF and DoD space capabilities

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Strategic Context

- Growing commercial investment in and utilization of space
- Increased competition and diversity of launch options
- Acceleration of connectedness but mounting security stove-pipes
- Lag in government business practices
- Growing threats to space and launch systems
- Realization we can’t concede space
- Emerging DoD Space strategy
- Drastic increase is use of cubesats/smallsats
- Advanced manufacturing availability...additive and robotic
AFRL Advanced PNT Technology and Next Flight Experiment
# Advanced GPS Technologies

<table>
<thead>
<tr>
<th>Technologies</th>
<th>Capabilities</th>
</tr>
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<tbody>
<tr>
<td>• High efficiency GaN amplifiers</td>
<td>• Lower-SWaP spacecraft OR higher power signals</td>
</tr>
<tr>
<td>• On-orbit Reprogrammable Digital Waveform Generators</td>
<td>• Increased signal flexibility after launch</td>
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<tr>
<td>• New antenna concepts</td>
<td>• Lower cost OR increased capability payload</td>
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<tr>
<td>• Supporting electronics</td>
<td>• Increased signal strength</td>
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<tr>
<td>• Algorithms and new signal combining methods</td>
<td>• Information assurance designed-in from the start</td>
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<tr>
<td>• Satellite bus technologies for lower SWaP/</td>
<td></td>
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<tr>
<td>increased resiliency</td>
<td></td>
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<tr>
<td>• Advanced cyber technology</td>
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## Advanced L-Band Amplifier Technology

- **Functions of an L1 band On-Orbit Reprogrammable Digital Waveform Generator**

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Navigation Technology Satellites (NTS)

NTS-1 (Launched: 1974)
- “Timation” and “621B” programs merged to become NAVSTAR GPS program.
- NRL's Timation 3 satellite re-designated the NTS-1
- Two rubidium-vapor frequency standards (clocks)

NTS-2 (Launched: 1977)
- 1st NAVSTAR GPS Phase I satellite
- Cesium frequency standards (clock)
- Nickel-hydrogen battery
- Worldwide network for data acquisition
- Verified Einstein's relativistic clock shift

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NTS-3 is AFRL’s Next Flight Experiment

- Advance state-of-the-art satellite hardware and software
  - High gain antennas
  - High Power Amplifiers
  - Flexible digital payload
  - Atomic Clocks

- Explore new operations concepts
  - Know ephemeris though active control
  - Alternate TT&C and ground
  - Hosted payload

- Conduct wide variety of science experiments
  - Integrated space, ground and cyber
  - Examples: relativity experiments, advanced signals, active maneuver with precise OD, tactical TT&C, localized signals
Near-term & Current AFRL Space Experiments
DSX- Mission Objectives

- Nominal orbit: 6000 x 12000 km, 42 degree inclination
- Launch Sep 2016 on STP-2 Mission
  - SpaceX Falcon Heavy launch vehicle from KSC

Three Main Science Experiments:

1) Wave-Particle Interactions (WPIx) – prime payload
   - Determine efficiency of injecting VLF waves into space plasmas \textit{in situ}
   - Determine distribution of natural & man-made ELF-VLF waves
   - Characterize & quantify wave-particle interactions

2) Space Weather (SWx)
   - Map MEO radiation & plasma environment
   - Determine in-situ environment for wave generation experiments in (1)

3) Space Environmental Effects (SFx)
   - Quantify MEO environment effects on technologies (electronics, materials, coatings)
   - Determine physical mechanisms leading to materials’ breakdown in MEO radiation

MEO = Medium Earth Orbit, ELF = Extremely Low Frequency, VLF = Very Low Frequency, KSC = Kennedy Space Center

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## Small Satellite Program

Small satellites provide an extension of the lower-cost, higher-risk satellite paradigm that AFRL has helped pioneer (XSS-11, Tacsat-3, ANGELS) to even lower-cost, larger mission-assurance ranges.

### CHOMPTT
- 3U CubeSat precision timing satellite equipped with an atomic clock synchronized with a ground clock
- Demonstrate technology for enhanced GPS and future disaggregated navigation systems

### ARMADILLO – FOTON GPS
- Dual-Frequency GPS receiver with Nano-Satellite SWaP & Improved precision
  - 0.5U form-factor (8.3 x 9.6 x 3.8 cm)
  - ~1.5W orbit average w/ duty cycling

### GlobalStar...PNT Enabler
- Enables near-global PNT data availability
- Affordable method to gather TLM data

### Namaru GPS (Australian)
- Developed by AUS Defense Science and Technology Group (DSTG)
- Sub-Meter relative position accuracy when multiple units flown in formation

### SHARC
- Demonstrate the capability to perform critical calibration of over 120 Tri-Service C-Band radars
- Investigate the performance of Hypervisor on-orbit for DARPA
- Launch: April, 2015

### 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.

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AFRL Test Bed for Space Situational Awareness Algorithms
JSpOC Mission System

Background

AFRL & AF Space Missile Command Delivered Joint Space Operations Center (JSpOC) Mission System (JMS) Inc. 1

- Net Centric Service Oriented Architecture (SOA)
- User Defined Operating Picture (UDOP)

Space Missile Command JMS Inc. 2 Program

- Message Processing (C2)
- Observation Association
- Special & General Perturbations Catalog
- Conjunction Analysis & Break-up
- Reentry & Launch Assessment

JMS Inc. 3 – Draft Requirements

- Threat Indications and Warning
- Spectrum Common Operating Picture
- Modeling and Simulation/COA Development

Final Delivery: 2016

Inc.3 Program: 2016-2021

Legacy Systems

Air Force is delivering JMS to space operators – How do we keep adding capability?
Vision for ARCADE

An incubator for Joint Space Operations Center (JSpOC) Mission System (JMS) related applications

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Challenge and Conclusion

• “Space”scape is changing therefore we must:
  – Reorient to Resiliency
  – Induce Innovation
  – Seek Strategic Strengths
  – Prioritize Synergistic Partnerships
  – Greatly Grow GPS 😊

• AFRL is committed to a strong space S&T investments consistent with National priorities
  – SSA, Propulsive ESPA, space cyber, PNT, resilient pervasives, continued community experimentation