DoD Space S&T Community of Interest
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Space Is Unique

- Space is an operating environment; not a technology area
- Space supports **all** aspects of the Joint Engagement Sequence (JES)
- Space has no “repair shop”
- Space asset behavior is predictable
- Multiple threats – natural, man-made, and adversary

**Military Space Enables all Facets of DoD Operations**
DoD Space S&T Strategy

- Biennial report to Congress – updated 2015
- Guides the development of the space-unique technologies that are essential to maintain existing U.S. conventional and asymmetric military advantages enabled by space systems at the strategic, operational, and tactical levels
- Looks across the entire DoD Space S&T Enterprise
- Prepared with the assistance of the DoD Space S&T Community of Interest
Space is no longer uncontested

**Space Threats**

<table>
<thead>
<tr>
<th>Threat</th>
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<tbody>
<tr>
<td>RF Jamming</td>
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<tr>
<td>Low power laser dazzling</td>
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<tr>
<td>High Power Laser Kill</td>
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<tr>
<td>LEO ASAT</td>
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<tr>
<td>GEO ASAT</td>
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<tr>
<td>On-Orbit Jammers</td>
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<tr>
<td>Co-orbital kinetic ASAT</td>
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<td>Adversary attachment</td>
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<tr>
<td>Cyber attack</td>
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<tr>
<td>Space nuclear detonation</td>
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</table>

**Capabilities needed to deliver the Threats**

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<th>Capability</th>
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<tr>
<td>Ground surveillance networks</td>
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<tr>
<td>World-wide ground SSA coverage</td>
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<td>Precision Tracking capability</td>
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- In last 5 years, potential adversary threat capability has sharply increased.
- National Space Policy (2010): We will protect our Space Capability from adversary hostile actions.
Space S&T COI Portfolio Overview

- **COI Description**
  - The goal of the Space COI is to 1) Facilitate collaboration and leveraging of complementary investments of the space S&T efforts across the community in support of the intent of the nation’s Space interests; and 2.) Identify gaps, establish and maintain a set of S&T roadmaps to guide Space Community research program investments, perform portfolio assessments, and provide future resource recommendations to leadership.

- **COI Purpose**
  - The Space S&T COI is a forum for sharing new ideas, technical directions and technology opportunities, jointly planning programs, measuring technical progress, and exchanging advances in space S&T

- **Portfolio Focus**
  - DoD S&T investments in space-unique technologies that are essential to maintain and advance existing U.S. conventional and asymmetric military advantages enabled by space systems at the strategic, operational, and tactical levels.

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**COI Taxonomy**

Technology Sub-Area 1
Satellite Communications
Technology Sub-Area 2
Missile Warning, Missile Defense, Kill Assessment and Attack Assessment
Technology Sub-Area 3
Positioning, Navigation and Timing
Technology Sub-Area 4
Intelligence, Surveillance and Reconnaissance
Technology Sub-Area 5
Space Control and Space Situational Awareness
Technology Sub-Area 6
Space Access
Technology Sub-Area 7
Space and Terrestrial Environmental Monitoring
Technology Sub-Area 8
Command and Control; and Satellite Operations
Technology Sub-Area 9
Space Enablers
Technology Sub-Area 10
Space Resilience (new subarea in FY15)
## Satellite Communications
- Provide seamless, end-to-end, space-based communications that is integrated and interoperable
- **Technical Challenges**
- Reduce SWaP-C and improve thermal management
- Develop V/W band RF and laser comms

## Missile Warning, Missile Defense, and Attack Assessment
- Provide timely and unambiguous detection of ballistic missile launches and nuclear detonations from space
- **Technical Challenges**
- Improved sensors for whole Earth staring
- Improved data fusion algorithms

## Positioning, Navigation and Timing
- Generating and using signals to enable determination of precise location, movement, and time
- **Technical Challenges**
- Improved anti-jam capability
- Improved atomic clocks
- Enhanced orbital navigation technology

## Intelligence Surveillance and Reconnaissance
- Space-based systems for SSA and GEOINT & SIGINT; National Technical Means, Commercial/Foreign Family of Systems, and small, rapid-response opportunities
- **Technical Challenges**
- Increased persistence of ISR
- Improved data compression
- Integrated space, air, ground based ISR integration

## Space Control and Space Situational Awareness
- Provide freedom of action in space to ensure: resilience to threats, ability to perform in degraded environment, and deny the adversary’s use of space against our forces in conflict
- **Technical Challenges**
- Improved space object detection and monitoring of potential threats

## Space Access
- Provide delivery, maneuvering, and recovery of payloads to and from space in a responsive, reliable, flexible manner, ensuring assured access to space in peace, crisis, and through the spectrum of conflict
- **Technical Challenges**
- Reduce cost and time cycle
- Higher performance on-orbit propulsion
- Enable fully reusable launch systems
### Space and Terrestrial Environmental Monitoring
- Provide remote sensing and monitoring of the operational Space environment and Earth weathercasting
- **Technical Challenges**
- Improved awareness of Earth/Sun environment
- Enable real-time threat warning due to weather
- Enable marine Meteorology and ocean conditions

### Command and Control; and Satellite Operations
- Provides the ability to operate over space forces and resources to monitor, assess, plan, and execute space operations at all echelons of command
- **Technical Challenges**
- Increased autonomy to reduce manning
- Space robotic capabilities for servicing/repair

### Space Resilience
- Provide the ability to support the functions necessary for mission success in spite of hostile action or adverse conditions
- **Technical Challenges**
- On-board adaptive planning
- Local area imaging sensors
- Laser survivability

### Space Enablers
- Development of pervasive technologies that facilitates the technical ability to perform successfully in the Space Arena
- **Technical Challenges**
- Standardized and miniature components and interfaces
- Carbon-based nanotechnology
- Ultra-high efficiency power systems
Space S&T COI Investment and Performers

COI Sub-Areas PB16

- Space Control: 9%
- Satellite Comms: 8%
- Missile Warning & Attack: 1%
- Command and Control, $23
- Space Environmental Monitoring, $42
- Satellite Operations: 17%
- ISR: 14%
- PNT: 11%
- Space Access: 29%

Component Investment

- Air Force: 49%
- Army: 36%
- Navy: 7%
- DARPA: 3%
- Other Components: 5%

Budget Activity

- BA 2: 39%
- BA 3: 61%

Intramural vs. Extramural split:
- Army: 6.2 47/53; 6.3 38/62
- Navy: 6.2 60/40; 6.3 40/60
- Air Force: 6.2 48/52; 6.3 20/80

Major Performers:
- Aerojet-Rocketdyne, APL, BAE Systems, Ball Aerospace, Boeing, Dynetics, Honeywell, Lockheed Martin, MIT-LL, Northrop Grumman, NRL, Orbital/ATK, Raytheon, Sandia National Laboratory, Teledyne Brown
SBIR Investment
FY14 Phase I and II Awards

FY14 Phase I*

- Sat Comms
- MW, MD & AA
- PNT
- ISR
- SC & SSA
- Sp Access
- Sp & Terr Enviro
- C2 & Sat Ops
- Sp Enablers
- Sp Resilience

100 Awards

*SBIR Phase I (project feasibility) awards normally do not exceed $150,000 total costs for 6 months.

FY14 Phase II*

- Sat Comms
- MW, MD & AA
- PNT
- ISR
- SC & SSA
- Sp Access
- Sp & Terr Enviro
- C2 & Sat Ops
- Sp Enablers
- Sp Resilience

42 Awards

*SBIR Phase II (project development to prototype) awards normally do not exceed $1,000,000 total costs for 2 years.
Space COI Relationship to Kill Chain

- FIND
- FIX
- TRACK
- TARGET
- ENGAGE
- ASSESS

**Satellite Communications**
- Missile Warning, Missile Defense, Kill Assessment and Attack Assessment
- Positioning, Navigation and Timing

**Intelligence, Surveillance and Reconnaissance**
- Space Control
- Space Situational Awareness

**Space Access**
- Space and Terrestrial Environmental Monitoring
- Command and Control; and Satellite Operations

**Space Enablers**
- Space Resilience

**Space Situational Awareness**
Space COI
Relationship to Kill Chain

FIND

Intelligence, Surveillance and Reconnaissance

Space Situational Awareness
Space COI
Relationship to Kill Chain

- FIX
- TRACK
- TARGET

Intelligence, Surveillance and Reconnaissance

Missile Warning, Missile Defense, Kill Assessment and Attack Assessment

Space Situational Awareness
Space COI
Relationship to Kill Chain

Intelligence, Surveillance and Reconnaissance

Missile Warning, Missile Defense, Kill Assessment and Attack Assessment

Space Control

Space Situational Awareness

ENGAGE

ASSESS

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Gaps

• **Understanding Allied Investments**
  – NATO countries
  – Long-term Allies & partners
  – Other cooperating nations

• **Understanding Investments of Potential Rivals**
  – Intent, Doctrine, ROEs & TTPs
  – Technical performance of systems

• **Understanding Benefits and Risks of Employing Commercial Systems**
  – Security, availability, responsiveness
  – Cost, limitations

• **On-Orbit Servicing & Repair**
  – DARPA Orbital Express – what’s next?

• **Trade-off: Cost v Schedule v Lifetime**
  – 10+ year on-orbit lifetime = high first cost but long replenishment schedule
  – Other paradigm – short life = low initial cost but short replenishment schedule
  – Which paradigm is the future?
Current Challenges Driving Space S&T Investments

• **Cost-effective manufacturing and acquisition of spacecraft**
  – Very few spacecraft (~3/year) – custom built vs. production line
  – Requirement is for highly specialized payloads – multi-year development required

• **Lower launch cost**
  – Reducing overall launch cycle time – traditional queues can be 2+ years or more

• **Adding protection and resiliency to our current space fleet**
  – Avoiding expensive block upgrades

• **Low data rate comms to dispersed units**

• **Cost-effective sustainment of existing constellations**
  • Budgets declining across the department

• **Improve Ability to forecast terrestrial and space weather**
Risks for Space S&T Public vs. Protected

- **Investing ahead of others and converse**
  - Many nations now acquiring space-based capabilities
  - Commercial systems offering ISR services
  - Cubesats are good – low cost test platforms and capabilities
  - Cubesats are bad – low cost enable many to test & develop space capabilities that were cost prohibitive in the past

- **International collaboration**
  - US space S&T collaboration with allies and international partners continues to increase

- **Classifications**
  - US space S&T conducted at multiple security levels
S&T Opportunities

- Exploiting expanding commercial space
- Ever growing and lucrative commercial satcom and ISR markets (GEO, MEO, and LEO)
  - Digital Global Systems
  - TerraSAR-X
  - COSMO-SkyMed
- Wealthy visionaries are investing in space tourism and transportation
- Commercial startups and international entrants are expanding micro and small sat capabilities
  - Future large “micro” & “small sat” constellations
    - SpaceX – 4,000 satellites
    - OneWeb – 2,400 satellites
    - Planet Labs – 128 satellites
    - SPIRE – 125 satellites
    - Black Sky - 60 satellites
    - Skybox – 24 satellites
- NASA investments are buoying new entrants for orbital and suborbital markets
Space Test Program
Recent Accomplishments

• NRL Electrically-Controlled Solid Propulsion Experiment Low-Cost Demonstration and Qualification - Successfully deployed Dec 14

• AFRL Automated Navigation and Guidance Experiment for Local Space - Successfully launched in July 14

• Successfully launched in Nov 13:
  • AFRL Strip Sensor Unit
  • NRL Small Wind and Temperature Spectrometer
  • U.S. AF Academy Integrated Miniaturized Electrostatic Analyzer
  • NASA/NOAA Total Solar Irradiance Calibration Transfer Equipment
  • AFRL Joint Component Research
  • AFRL De-orbit Module
  • Cubesats from BlackKnight-1 (West Point)
  • Cubesats from Solar Cell Array Tester (Naval Postgraduate School)
  • NASA 13U Cubesats

• Two payloads on SpaceX Cassiope commercial mission via NASA - Successfully launched Sep 13:
  • AFRL Drag and Neutral Density Explorer (University of Colorado Boulder)
  • AFRL CUSat (Cornell)
Army Space S&T Themes

Software Defined Radios
Low Size, Weight and Power, High Capacity, Flexible

Imagery
IR, Low Light, MSI

Satellite Down Link
Very High Data Rates

Encryption
High Throughput

Deployable Antennas
Reliable, High Gain, CubeSat Compatible

Constellation Management
Highly automated, common architecture, optimized planning and tasking

Tactical Launch
Low cost, responsive

Innovative, Affordable Space Technologies Support Future Battlefield Dominance
Navy Space S&T Themes - Research

Geospace
Observe and forecast, for enhanced situational awareness

Heliospace
Develop improved sensors, specification, monitoring and prediction tools for operational impacts and real-time threat warning

High Energy Space
Measure, simulate and model natural and artificial radiation and rad/nuke signatures, for detection and remediation

Experimentally-led sensing R&D integrated across three environmental areas that underpin, connect, and inform successful operations, with metrics to increase TRL from 0-1 to 2 and to identify transition potential
Navy Space S&T Themes - Technology

Advanced Spacecraft Technologies
Sub-systems, for new and prototype building-blocks; propulsion & control, towards precision maneuvering while minimizing fuel; materials resiliency characterization

Payloads & Sensing
Next-generation, to improve monitoring for threats

Connectivity
High-bandwidth, space-based, for disadvantaged users

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### Air Force Space S&T Themes

<table>
<thead>
<tr>
<th>Space Electronics</th>
<th>Space Remote Sensing</th>
<th>Space Platform &amp; Ops Tech</th>
<th>Space Environment Impacts &amp; Mitigation</th>
<th>Space Flight Experiments</th>
</tr>
</thead>
</table>
| • Space electronics physics to understand failure modes and improve reliability  
  • New space processors, solid-state amplifiers for GPS/Comm, A-D converters, memory  
| • Exploitation of collected photons (temporal, spectral, polarimetric)  
  • New sensors and components for missile warning  
  • Detectors, cryocoolers, algorithms, optics  
  • Nuclear explosion monitoring  
| • New technology to support AF-specific missions  
  • Solar arrays with 8X lower volume  
  • High-capacity thermal control  
  • Guidance, navigation  
  • Autonomous systems  
| • Models for spacecraft shielding and lifetime  
  • Anomaly resolution  
  • Astrodynamics for collision avoidance  
  • Reentry environment  
  • Space plasma physics & chemistry  
| • Space system & payload development  
  • Integration, test, & flight  
  • Modeling & simulation  
  • Space system engineering  

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Air Force Space S&T Snapshot

Near Term
- **SSA**: Local GEO SSA using ANGELS spacecraft
- **SSA**: Resolved imaging of GEO from ground telescopes
- **Protection**: Space testing of new tech-insert options
- **Comm**: New thermal technology to increase WGS bandwidth by 25% (at Boeing)
- **GPS**: Higher transmit power to increase A2/AD jam resiliency
- **JSpOC**: Rapid all-on-all conjunction analysis

Mid Term
- **SSA**: Robust space Indications and Warnings for Battlespace management (BMC2)
- **Protection**: Autonomous Resilient spacecraft bus
- **Comm**: Increase frequency trade-space into the W/V band
- **GPS**: All-digital GPS payloads lowers cost, increases acquisition options, increases anti-jam
- **Missile Warning**: Detect difficult theater missiles under clouds

Far Term
- **Comm & GPS**: Software agile systems for A2/AD
- **Pervasive**: e-Beam lithography for custom and trusted space electronics
- **AEHF Follow-On**
- **Staring OPIR for Battlespace Awareness**

W/V payload (Ktr: NG)

Detecting difficult theater missiles under clouds

Protected Tactical Comm Service
- **GPS – Next**
- **SBIRS and WFOV OPIR**

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DARPA S&T Theme
GEO Servicing

First robotic capability in GEO

Commercial providers expand coverage

Automated, scheduled refueling

LEO-to-GEO space tug

Technology development and investment

- On-orbit replaceable units
  - Modular spacecraft
- Reduced redundancy
- Lightly fueled at launch
- Assembly experiments

Space robotics = national-level growth potential

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Responsive Launch Programs

Experimental Spaceplane (XS-1)

- Reusable 1st stage, expendable upper stage
- Fly XS-1 10 times in 10 days (no payload)
- Design for recurring cost 10X < Minotaur IV
  - > 3,000 lb payload
  - < $5M/flight
- Launch subscale orbital demo payload once

PROGRAM OBJECTIVES

Enable routine space access and testing of hypersonic aircraft technologies

Approx Size Comparison

F-15 (Ref)  XS-1

Gov’t Reference Vehicle

62 ft

Airborne Launch Assist Space Access (ALASA)

- Mature and demonstrate technologies for cost effective, routine, reliable access to low earth orbit (LEO) from airfields
- Reduce cost to $1M/flight in the 100 lb mass payload class
- Improve responsiveness to a 24-hour call-up to fit in the air tasking order cycle
- Deliver capability to launch into any Low Earth Orbit
- Demonstrate ability to disperse from a threatened launch airfield and execute mission from elsewhere

PROGRAM OBJECTIVES

Enable small satellites to be deployed to orbit from an airborne platform, allowing performance improvement, reducing range costs, and flying more frequently, which drives cost per launch down

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**Army Program**

**Assured Communications**

**Operational/Technical Problem:**
- Continued need for beyond line of sight (BLOS) communications for disadvantaged users in remote areas
- Exfiltration of ground sensors can result in soldiers exposing their data receive position
- Demand from one Combatant Command can limit another Combatant Command’s communication access

**Technology Focus Areas:**
- Software Defined Radio
- Propulsion
- Encryption
- Power Generation
- High Gain Antenna
- Ground Station

**Program Milestone Plan:**

<table>
<thead>
<tr>
<th>MILESTONES</th>
<th>Yr 1</th>
<th>Yr 2</th>
<th>Yr 3</th>
<th>Yr 4</th>
<th>Yr 5</th>
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<tbody>
<tr>
<td>Non-recurring design &amp; procurement</td>
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<tr>
<td>Build of Nanosatellites</td>
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<tr>
<td>Ground test</td>
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<td>Launch</td>
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<td>On orbit checkout and Tech Demo</td>
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<tr>
<td>Operational Demo</td>
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<td>Joint Military Utility Assessment</td>
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**Enabling Technology Areas:**

**Constellation Management**
- Future potential: 3 orbital planes for near global coverage
- Low cost, responsive

**Nanosatellites**
- 10x10x34cm, 5.5 kg

**Tactical Launch**
- High data rate
Operational/Technical Problem:

Available Department of Defense & commercial imagery is insufficient to provide persistent Area of Responsibility surveillance, high priority to track targets. Imaging microsatellites could provide imagery data to support battlespace awareness, and battle damage assessment rapidly. Small, inexpensive satellites could be used in numbers to provide a persistent capability to the tactical warfighter.

Needs from On-Demand Imaging:

1. Tactical warfighters need situational awareness during combat ops
2. Ability to support persistence as an imaging source
3. Low production cost to support sufficient numbers of assets

Technology Focus Areas:

- System / Subsystem
  - Image Resolution and Waveband
  - Pointing Accuracy
  - Image Down Link Rate
  - Structure Mechanisms
  - Ground Station
  - Propulsion
  - Production Cost

Enabling Technology Areas:

- Constellation Management
  - Highly automated, common architecture, optimized planning and tasking

- Tactical Launch
  - Low cost, responsive

- Satellite Down Link
  - Very High Data Rates

On-Demand, small, imaging satellite program needs to determine mission areas, develop requirements, make design, build satellite(s), deploy, and demonstrate benefit via a Military Utility Assessment (MUA).

Program Milestone Plan:

<table>
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<tr>
<th>MILESTONES (THRUSTS)</th>
<th>Yr1</th>
<th>Yr2</th>
<th>Yr3</th>
<th>Yr4</th>
<th>Yr5</th>
<th>Yr6</th>
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<tr>
<td>Satellite Concept &amp; Design Develop</td>
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<tr>
<td>Functional Testing</td>
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<td>Space Qualification</td>
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<td>Launch Integration &amp; Deployment</td>
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<td>Initial Operations / Limited User Test</td>
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Navy Success Story
WindSat/Coriolis

- WindSat/Coriolis demonstrated the capability of polarimetric microwave radiometry to produce Ocean Surface Vector Winds (OSVW)
  - Successfully operating for 12 years and counting

- NRL provided the science, payload development, mission operations, vehicle integration, data product algorithms, and calibration/validation

- The only USA sensor providing global OSVW
  - Also provides soil moisture, sea ice age/concentration, imagery for tropical cyclone intensity/tracking, snow depth

- WindSat data are operationally assimilated into numerical weather models and used for other DoD and civilian applications
SSULI: an advanced ionosphere remote sensing system that supports DoD operational needs

SSULI is DoD-operational aboard the DMSP F18, F19 satellites

NRL SSD software provides SSULI electron density products at the Air Force Weather Agency (AFWA)

Concept for operational global EUV/FUV ionosphere/thermosphere monitoring

SSULI sensors and data analysis algorithms grew from NRL research investment 1980-2006. Ongoing DMSP USAF sponsorship is enabling NRL to provide the SSULI sensors and processed SSULI data for operations

Future: Next-gen ionospheric sensors for space weather science and myriad DoD applications

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Navy Success Story
TacSat 4 & VMOC

- Space S&T COI met at NRL to review NRL’s investment portfolio
- As a result of this COI interaction, Army SMDC leveraged current investment in NRL’s Common Ground Architecture project Neptune and VMOC satellite C2 capability
- Army SMDC will realize an initial cost savings of approximately $450K per Ka Ground Station
- By sharing world-wide antenna resources with NRL’s Blossom Point Tracking Facility, SMDC will avoid developing additional infrastructure which could cost up to $100M.

Cross-Service Leveraging Resulting from COI Interaction

- State-of-the-Art capabilities & automation … working well
Air Force
GEO SSA Challenge

Critical SATCOM and Missile Warning
DoD Assets at GEO

Sensing Challenge - GEO is 22,000 Miles from Earth

• DoD tracks >22,000 man-made objects in orbit
• Approximately 60 nations and gov consortia that own/operate satellites

Space is Becoming Increasingly Congested, Contested and Competitive.

Number of Nations/Gov Consortia Operating in Space (Left) and Satellite Catalog Growth (Right) per US National Security Space Strategy (2011)

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**Air Force Success Story**

**Roll-Out Solar Array (ROSA)**

**Revolutionary Solar Array Performance**

**Solar Cell Blanket**
- Multiple solar cell types (rigid, flexible)
- Lightweight & high voltage capable
- Extremely thin and compliant package

**Deployment and Support Structure**
- Passively, elastically deployed array
- Lightweight, yet 4x stiffer than panels

**Integrated Array**
- Incredibly simple; 65% fewer fabrication drawings
- Very mass efficient
- Large deployed area from small stowed volume

**ROSA flight experiment on the International Space Station; launch planned for August 2016**

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The Space Operational Environment will become increasingly complex over time (both in capacity and capability). Friendly, Coalition, and Threat forces will vie for Space capabilities and seek to deny others.

The future Army Operational Environment (Asymmetric warfare, Mega Cities, non-state operators, etc.) will be increasingly more dependent on tactical Space capabilities in multiple Mission Areas.
Navy Future Space Trends/ S&T Opportunities

- Multi-scale whole-atmosphere prediction of ionospheric effects, emphasis on Arctic and Tropical regions
- Terrestrial gamma-ray flashes observation base and background events modeling
- Characterize celestial pulsar sources for space-based GPS-stressed timing and navigation
- Investigate x-ray space-based communications
- Specification and prediction of geospace, heliospace, and high energy environmental effects for improved HF propagation, geolocation, SATCOM, orbital analysis, geomagnetic ULF resonance, and rad/nuke maritime detection and interdiction
- Imaging of GEO satellites from earth
- Cooperative, automatic space robotic capabilities
- Low-mass and novel active technologies for spacecraft propulsion systems
- Space sensor and analysis tools integrating on-orbit observations with modeling for improved SSA
- Lightweight articulation and sensing integrated space robotics architectures
- Spacecraft propulsion and control capabilities for precision maneuvering while minimizing fuel
- Low Earth Orbit radiation environment characterization payloads
Air Force Future Space S&T Trends

• **Space Comm:**
  – S&T to reduce risk on LEO constellation technology to support Air Dominance
  – Alternatives needed to AFSCN TT&C

• **Launch detection**
  – Near-term AFSPC/SMC focus is on low-cost disaggregation approaches.
  – Long-term DoD focus is on tactical missiles. AFRL Hyper-temporal is a major contribution, but gaps still exist.

• **PNT**
  – Resiliency needed for GPS space and control segments
  – PNT user equipment

• **SSA**
  – Leveraging commercial observations (ground and space) crucial to improve persistence
  – Key challenges are data trust, fusion, and interoperability with AF operational systems
  – Space-based, GEO focused SSA

• **Space Access**
  – Space Access
  – On orbit propulsion

• **Space C2 & Ops**
  – Leverage commercial systems.

• **Pervasives**
  – Protection and Resilience technology
  – S&T approaches to accelerate spacecraft manufacturing
Launch:
• Flexible, affordable access
  • Affordable, routine and reliable access to space
  • Aircraft-like space access to lower cost and increase capabilities

Satellite:
• Changing the paradigm of satellite operations
  • New satellite architectures for speed and robustness
  • GEO space robotics to repair and assemble very large satellites that could not be launched

Space Domain Awareness (SDA):
• Real-time space domain awareness
  • Real-time detection and tracking versus catalog maintenance and days to weeks of forensics