C2 of Next-Generation Satellites

Topic 7:
Architectures, Technologies, and Tools

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Strategic Context:
The Plan for U.S. Space Capabilities
NATIONAL SPACE POLICY
of the
UNITED STATES OF AMERICA

JUNE 28, 2010

NATIONAL SECURITY SPACE STRATEGY
UNCLASSIFIED SUMMARY
JANUARY 2011

Department of Defense
DIRECTIVE

NUMBER 310.1
October 18, 2011

SUBJECT: Space Policy

REFERENCE: See Enclosure 1

1. PURPOSE. This Directive supersedes DOD Directive 310.1 (Reference 1) to update and enhance DOD space policy and replace DOD Capabilities for space control (Reference 2) and the National Security Space Strategy (Reference 3). It addresses comprehensively the challenges posed in an increasingly congested, contested, and competitive space domain.

2. APPLICABILITY. This Directive applies to OSD, the military departments, the Office of the Chairman of the Joint Chiefs of Staff and the Joint Staff, the combatant commands, the Office of the Secretary of Defense, the Office of the Under Secretary of Defense, the Defense agencies, the DoD field activities, and the non-DOD entities within DoD (hereafter referred to collectively as the "DoD Components").

3. DEFINITIONS. See Glossary

4. POLICY. It is DoD policy that:

a. DoD space related activities shall encompass entry, sustainability, survivability, stability, and security in space, maintain and enhance the national security advantages afforded by the use of space, and sustain the space industrial base that supports U.S. national security.

b. The sustainability and security of the space environment, as well as the access to and use of space, are vital to U.S. national interests. Repeated interference with U.S. space systems, including their supporting infrastructure, will be considered an infringement of U.S. rights. Such interference could occur through acts committed deliberately, or inadvertently, or its interpretation in parameters and may be contrary to treaty or custom. The United States will meet the obligation to respond in the time and place of its choosing.

Navy Space Strategy

Chief of Naval Operations
Washington, DC
February 2011
The Strategic Environment Has Changed

“These changes not only pose tremendous technical challenges to military space systems, they also force rethinking of how we use space to maintain our national security.”

Then-Deputy Secretary of Defense William J. Lynn
June 2011
Congested

Satellite Catalog Growth

Source: National Security Space Strategy
Addressing the Congested Environment

Congested Environment: Ensuring “Sustainability, Stability & Free Access”

• International norms of responsible behavior
• Transparency and confidence-building measures
• Standards
• Information Sharing
• Shared space situational awareness
Contested

Number of Nations and Government Consortia Operating in Space

Source: National Security Space Strategy
Addressing the Contested Environment

Contested Environment: A Multilayered Deterrence Approach

- International norms of responsible behavior
- Alliances & coalitions
  - Combined Space Operations (CSpO) concept led by STRATCOM
- Resilient architecture & capacity to operate in denied environment
  - Cost-effective space system protection
  - Cross-domain solutions
  - Hosted payloads
  - Leveraging international & commercial partner capabilities
  - Responsive capabilities
- Response Options
Competitive


- World Revenue
- U.S. Revenue (in Billions of U.S. Dollars)
- U.S. Share of World Revenues

Source: National Security Space Strategy
Addressing the Competitive Environment

Competitive Environment: Maintaining the U.S.’ Competitive Advantage

- Acquisition reform
  - Multi-year contract authority
  - Co-investment for commercial space services
  - Hosted payloads
  - Disaggregated architectures
  - Guaranteed minimum number of launches

- Export control reform
  - Jan. 02, 2013: Passage of FY2013 NDAA
    - Sec. 1262, “Removal of Satellites and Related Items from the United States Munitions List”
  - May 24, 2013: Dept’s of State and Commerce published draft rules
The Navy will use space systems to enable net-centric warfare and information dominance and enhance combat effectiveness by providing Naval forces with command and control, communication, PNT, ISR, meteorological, oceanographic, and missile warning capabilities optimized for use in the maritime environment.
## Navy’s Role in Space

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<tr>
<th>Navy’s Space Investments</th>
<th>Navy’s Key Equities</th>
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| ■ Nearly 50% of Navy’s space budget is dedicated to UHF Follow-On (UFO) & Mobile User Objective System (MUOS) | ■ OTH Communications  
  ▪ MUOS capability |
| ■ Remainder apportioned to acquisition of: | ■ Positioning, Navigation and Timing  
  ▪ Various satellite receiver terminals & equipment for Navy units |
|  ▪ Space-based navigation, oceanography and meteorology | ▪ GPS-based PNT Service (GPNTS) |
| ■ “Modest” investments in Science & Technology / Research & Development | ■ Environmental Monitoring  
  ▪ Navy Global Environmental Model |
| | ■ Missile Warning & ISR  
  ▪ TENCAP initiatives |
A Way Ahead:
Next-Generation Nanosatellites
Disclaimer

This briefing may contain references to projected U.S. Government plans and potential capabilities. Mention of them in no way guarantees that the U.S. Government will follow these plans or that any of the associated system capabilities, if developed, will be available or releasable to foreign governments.
Mobile User Objective System (MUOS)

- Worldwide communications service provider based on 3G cellular services with geosynchronous satellites replacing cell towers
- Interfaces via DoD Teleports to provide access to DSN, SIPRnet and NIPRnet
- Improved connectivity in stressed environments
- MUOS enables Net-Centric use of UHF SATCOM
MUOS Cross-link Feasibility

- MUOS was intended for:
  - Hand held terminal similar in size to an AN/PRC-148 or AN/PRC-152 with < 7 watts EIRP
  - Terrestrial coverage <= 65 degrees latitude
  - Max terminal speed of hundreds of knots

- Eureka – hand held could be built into a nano-sat!

- Link budget verified, then modeled in STK
  - 700 km sun synchronous orbit
  - 3U CubeSat with SMDC-ONE power, omni antenna capabilities
  - Conservative estimates of radio characteristics
Operational View

WCDMA
RHCP
Bandwidth: 5MHz
Transmit : 300 – 320 MHz
Receive : 360 – 380 MHz

ICE-
Cap

MUOS

Ka MUOS ground link

SIPR Terminal
SIPR
Server
Transport
DIA
RAF

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.
MUOS Cross-link Requirements

- **Radio**
  - 5 MHz carriers in UHF range
  - Spectrally Adaptive Wideband Code Division Multiple Access (SA-WCDMA) waveform

- **High Assurance Internet Protocol Encryptor (HAIPE)**

- **Omni-directional antenna**

- **Size:** ~1/3 U
MUOS Cross-link Capability

• Coverage
  – 700 km circular LEO verified
  – Lower limit at poles needs to be evaluated
  – Upper limit at poles likely ~2000 km

• Data rate
  – 9.6 kbps guaranteed
  – 32 kbps most of the time

• Throughput
  – Assuming 2 watts housekeeping, 20 watts during transmit
  – On average can transmit 8 min/orbit or 9% of the time
  – 375 kilo bytes per hour @ 9.6 kbps
  – 1,250 kilo bytes per hour @ 32 kbps
Advantages

- Instantaneous, world-wide comms from LEO
  - Data up/down link at any time
- Direct access to/from NIPR or SIPR
  - CubeSat has it’s own IP address
- Lower cost and complexity for future missions
  - Drop in end-to-end comms solution
  - No monthly or per-byte fees
  - May eliminate need for ground stations altogether
- Improved security over commercial SATCOM
  - Type 1 Encryption
  - Always on a DoD network
Disadvantages

- Increased power
  - Greater path loss up to GEO than down to ground
- Increased system complexity
  - SA-WCDMA software is ~1 million lines of code
  - High Assurance Internet Protocol Encryptor (HAIPE) required
- Dependent on MUOS availability and capacity
  - Priority and pre-emption scheme
- Limited throughput compared to higher bands
- Type 1 crypto → no foreign launch
Demonstration

• Challenges:
  – No MUOS terminal operationally tested to date, even terrestrial
  – Traveling ~10x MUOS maximum terminal speed
  – Spot beam handovers
  – Information Assurance and Crypto certifications
• Radio and HAIPE under development soon using Small Business Innovative Research (SBIR) funds
• CubeSat integration mid 2014
• Ready for launch in late 2014
Questions?