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C2 of Next-Generation Satellites

Topic 7:
Architectures, Technologies, and Tools

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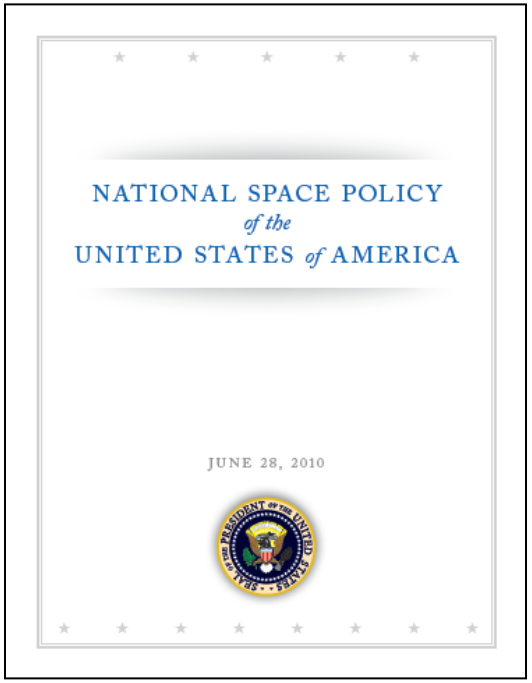
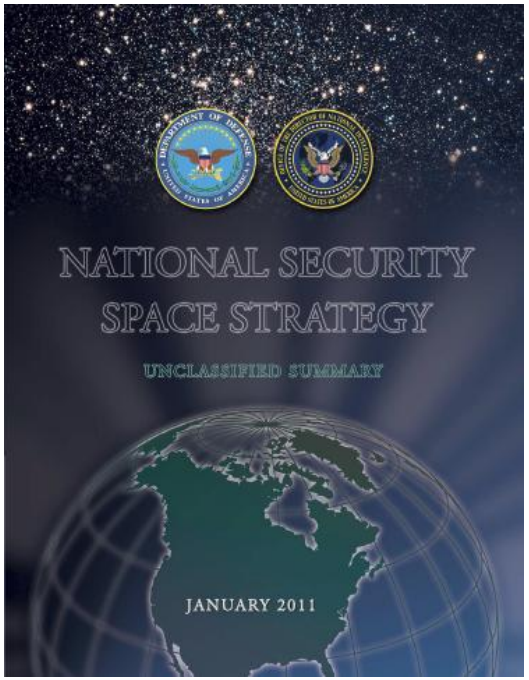
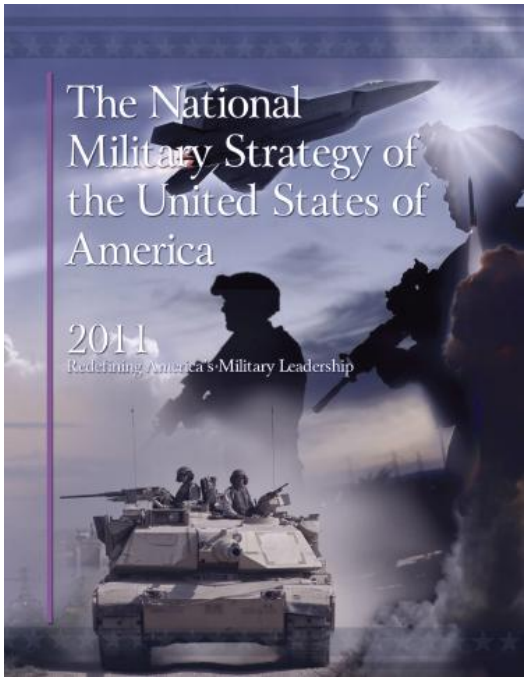
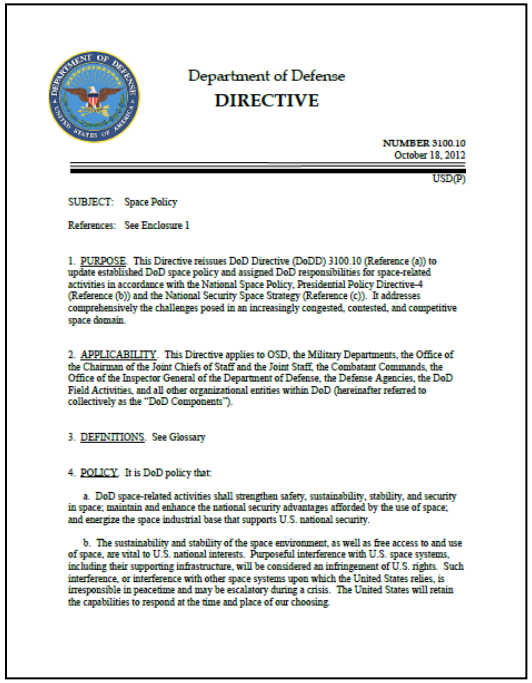
Strategic Context:
The Plan for U.S. Space Capabilities









Department of Defense
DIRECTIVE

NUMBER 3100.10
October 18, 2012
USD(P)

SUBJECT: Space Policy

References: See Enclosure 1

1. PURPOSE. This Directive reissues DoD Directive (DoDD) 3100.10 (Reference (a)) to update established DoD space policy and assigned DoD responsibilities for space-related activities in accordance with the National Space Policy, Presidential Policy Directive-4 (Reference (b)) and the National Security Space Strategy (Reference (c)). It addresses comprehensively the challenges posed in an increasingly congested, contested, and competitive space domain.

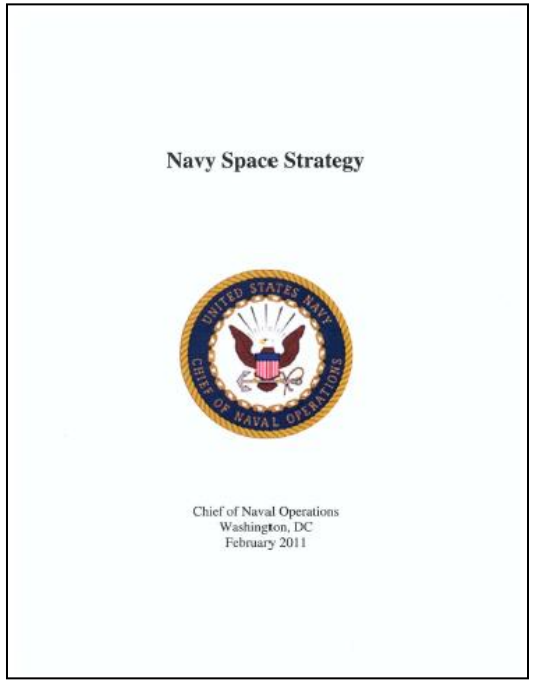
2. APPLICABILITY. This Directive applies to OSD, the Military Departments, the Office of the Chairman of the Joint Chiefs of Staff and the Joint Staff, the Combatant Commands, the Office of the Inspector General of the Department of Defense, the Defense Agencies, the DoD Field Activities, and all other organizational entities within DoD (hereinafter referred to collectively as the "DoD Components").

3. DEFINITIONS. See Glossary

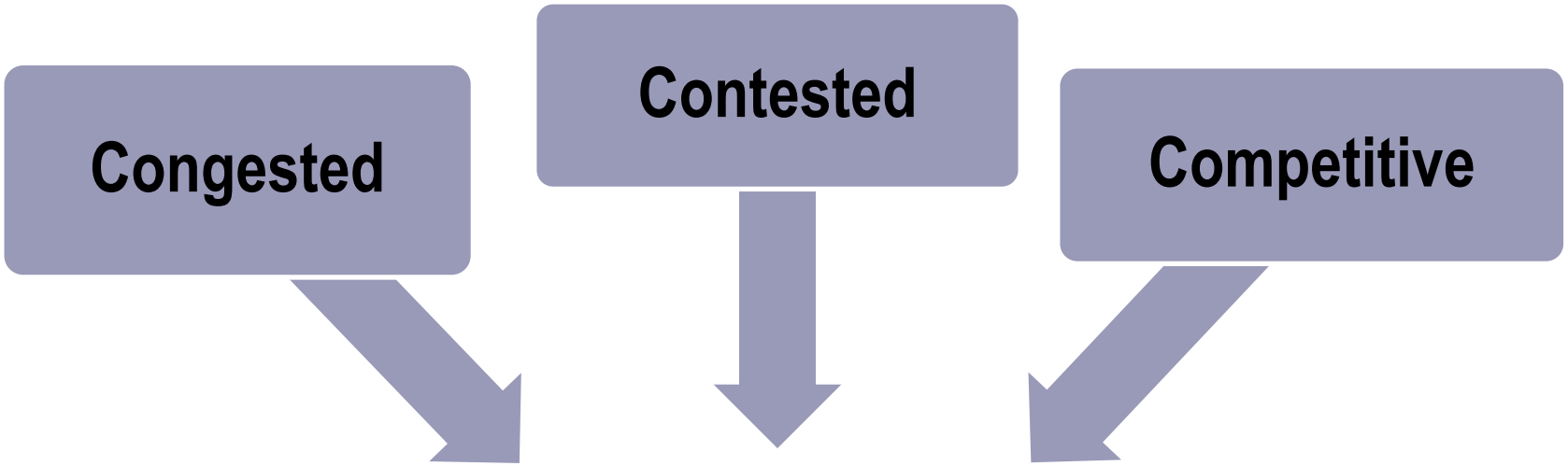
4. POLICY. It is DoD policy that:

a. DoD space-related activities shall strengthen safety, sustainability, stability, and security in space; maintain and enhance the national security advantages afforded by the use of space; and energize the space industrial base that supports U.S. national security.

b. The sustainability and stability of the space environment, as well as free access to and use of space, are vital to U.S. national interests. Purposeful interference with U.S. space systems, including their supporting infrastructure, will be considered an infringement of U.S. rights. Such interference, or interference with other space systems upon which the United States relies, is irresponsible in peacetime and may be escalatory during a crisis. The United States will retain the capabilities to respond at the time and place of our choosing.



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

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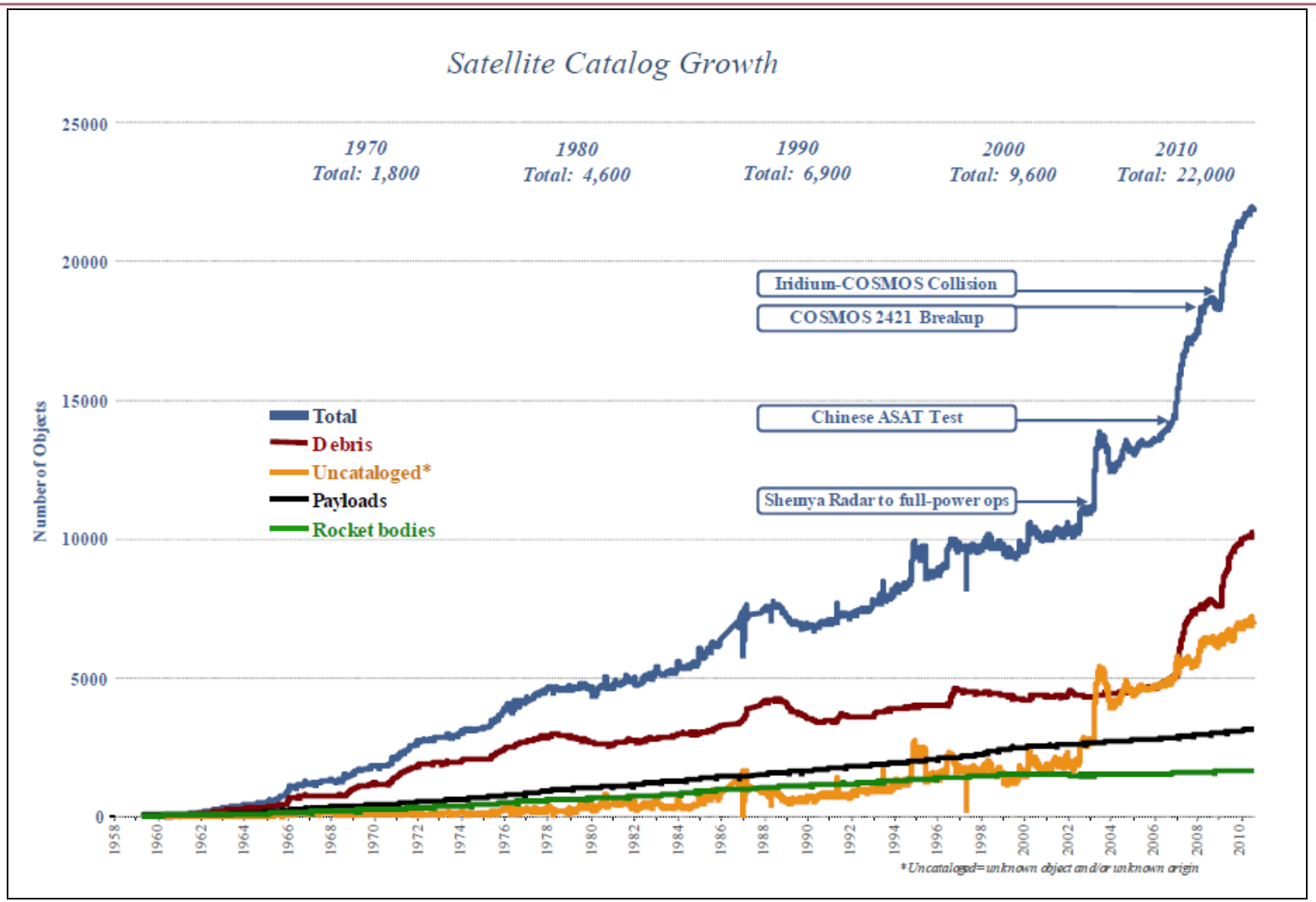
Congested



Source: National Security Space Strategy

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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

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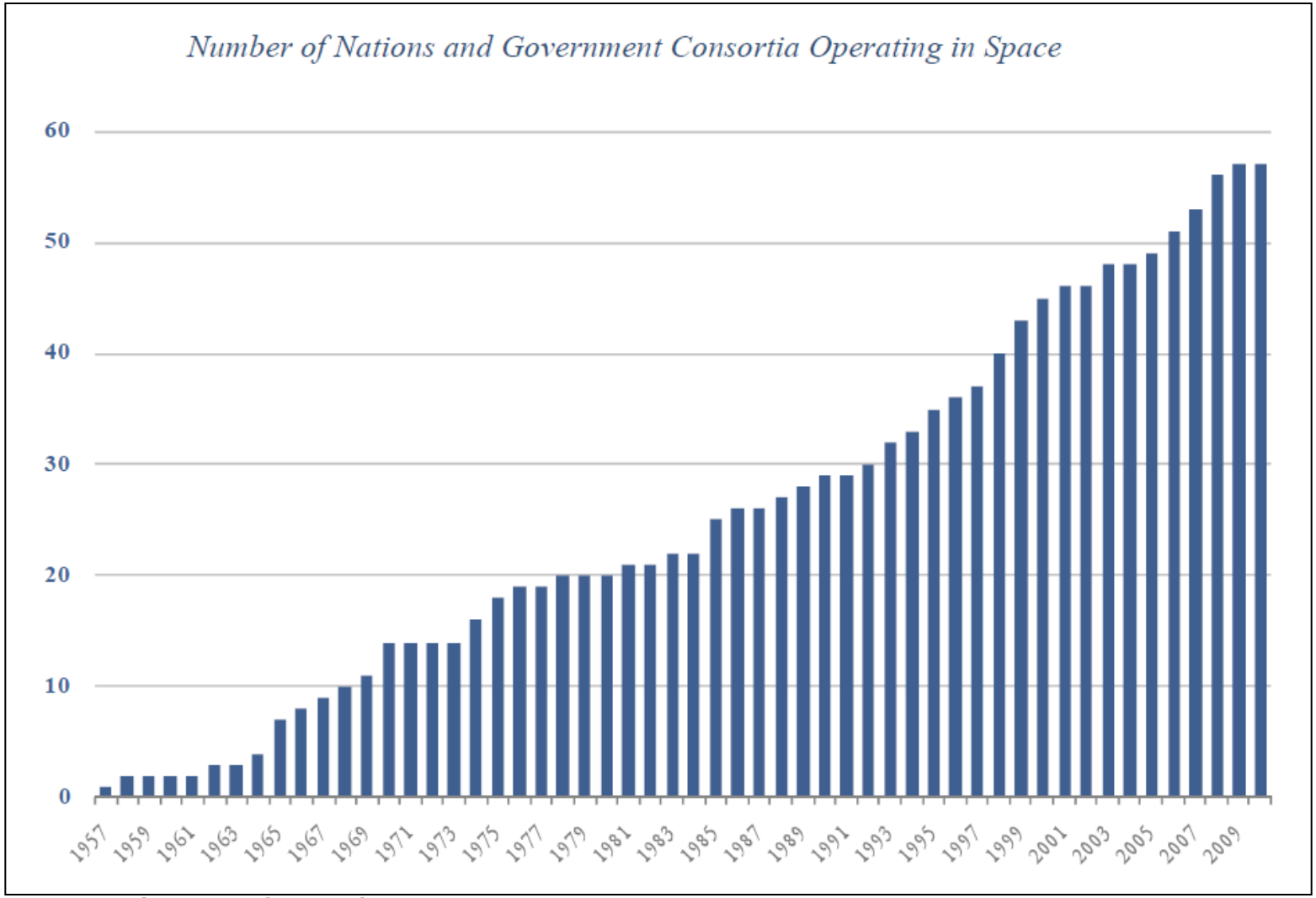
Contested



Source: National Security Space Strategy

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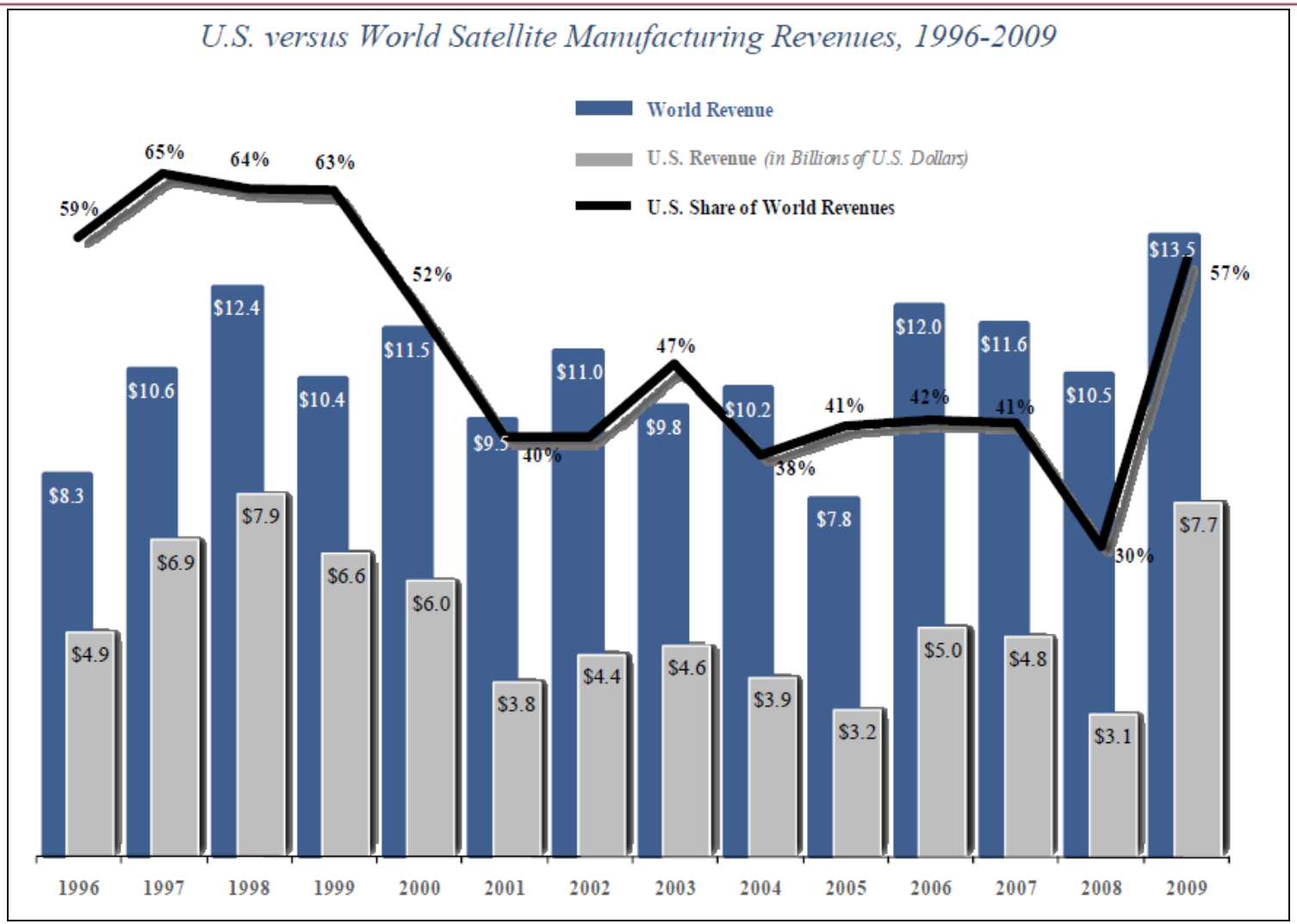
Addressing the Contested Environment

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



Source: National Security Space Strategy

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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

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Navy's Space Vision

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.

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Navy's Role in Space

Navy's Space Investments

- Nearly 50% of Navy's space budget is dedicated to UHF Follow-On (UFO) & Mobile User Objective System (MUOS)
- Remainder apportioned to acquisition of:
  - Various satellite receiver terminals & equipment for Navy units
  - Space-based navigation, oceanography and meteorology
- "Modest" investments in Science & Technology / Research & Development

Navy's Key Equities

- OTH Communications
  - MUOS capability
- Positioning, Navigation and Timing
  - GPS-based PNT Service (GPNTS)
- Environmental Monitoring
  - Navy Global Environmental Model
- Missile Warning & ISR
  - TENCAP initiatives

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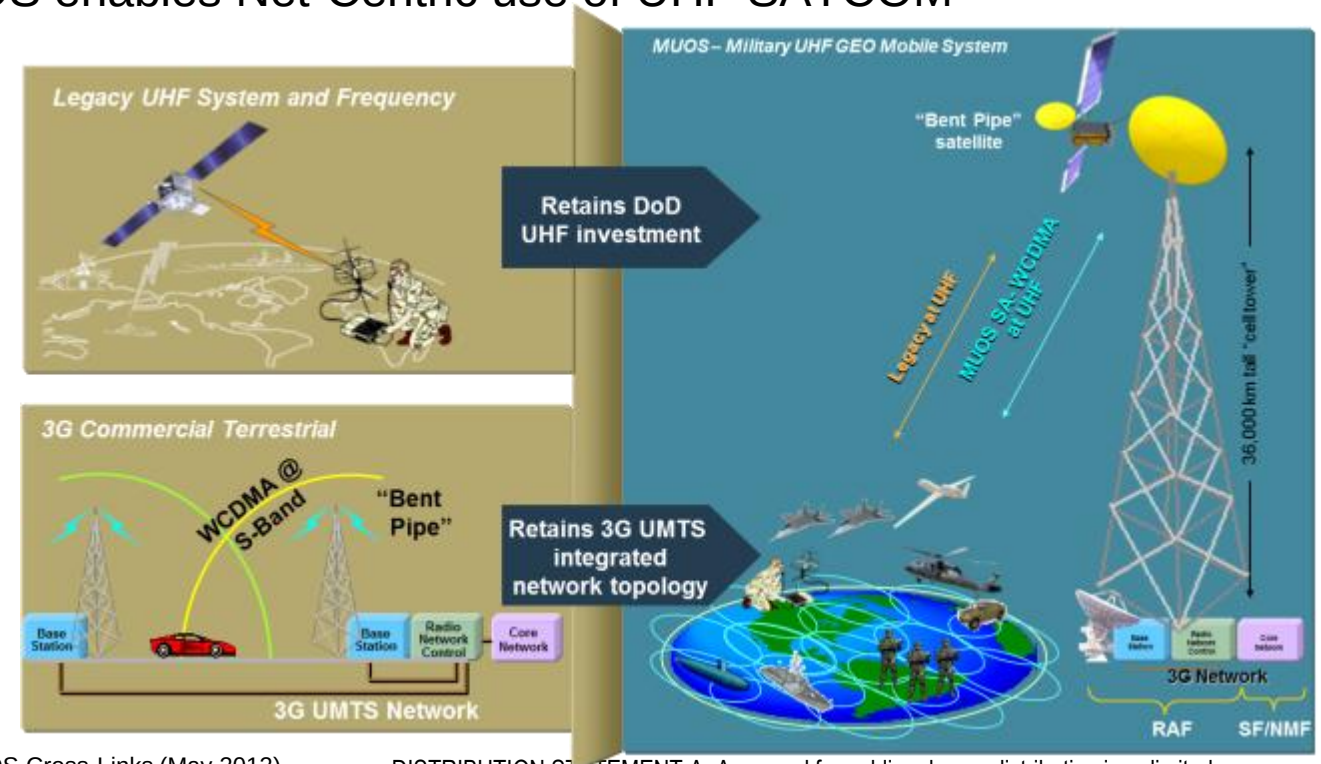
A Way Ahead:
Next-Generation Nanosatellites

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)

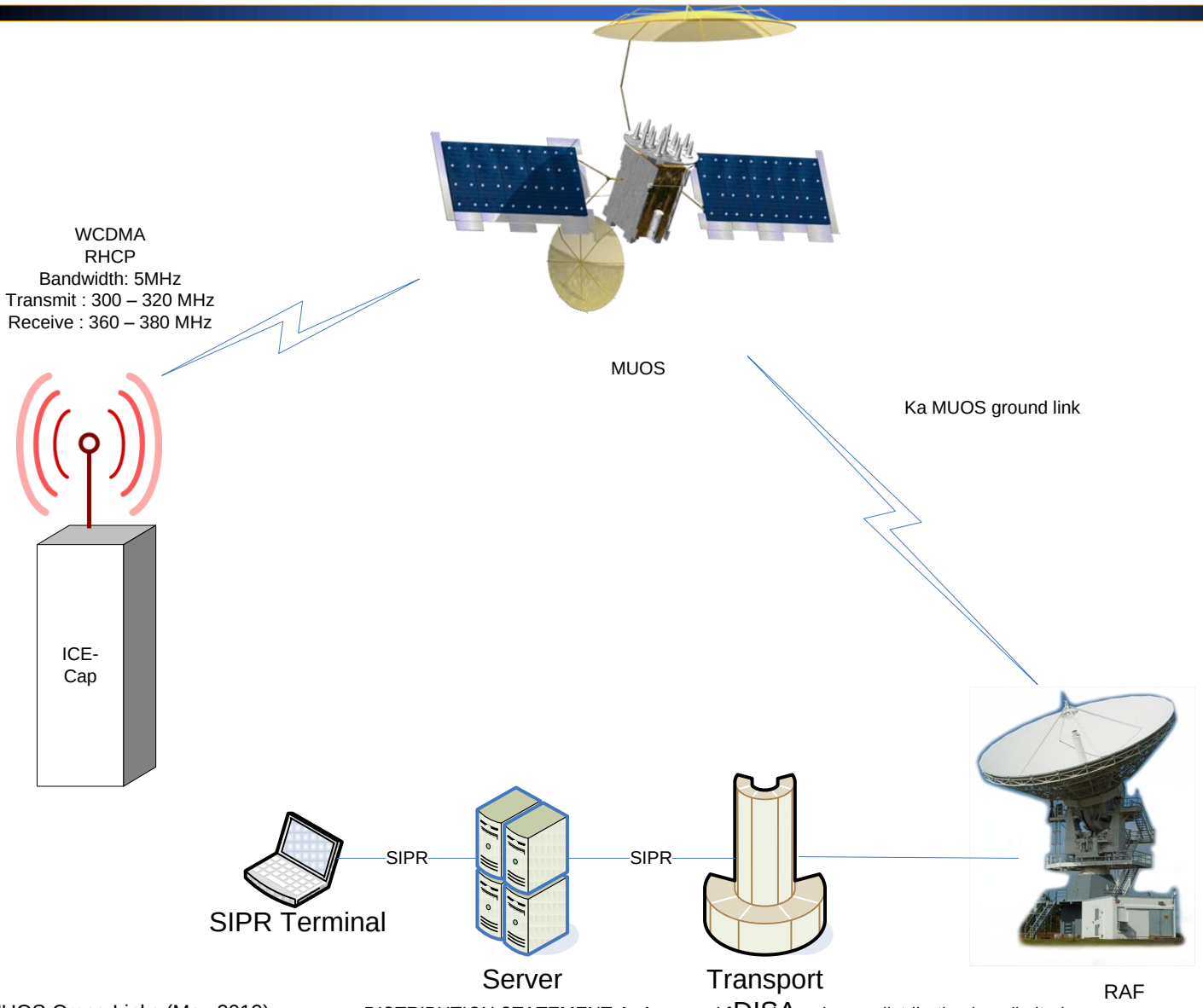
- Worldwide communications service provider based on 3G cellular services with geosynchronous satellites replacing cell towers
- Interfaces via DoD Teleports to provide access to DSN, SIPRnet and NIPRnet
- Improved connectivity in stressed environments
- MUOS enables Net-Centric use of UHF SATCOM



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



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

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Questions?