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The Backbone of JADC2:
Satellite Communications for Information Age Warfare

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Why this report now?

"Data relay and satellite communications may be one of the most consequential activities that the U.S. Space Force will engage in for a long time."

General David Thompson, Vice Chief of Space Operations

Transition from GWOT to focus on great power competition and conflict imposes novel demands on DOD's SATCOM enterprise

1. New requirements to support DOD's emerging all-domain warfighting concepts
2. Specific requirements needed to operationalize JADC2 yet to be clearly defined
3. Growing threats to U.S. space assets, must increase SATCOM resiliency and agility

Maturing technologies including optical (laser) communications and new space architecture designs can meet these new requirements

Consolidating DOD's SATCOM enterprise within a single service for the first time in U.S. history offers unique opportunity to address these challenges and chart a more promising flight path

Current MILSATCOM systems developed to meet legacy requirements and have designs dating to Cold War

Primarily reside in GEO

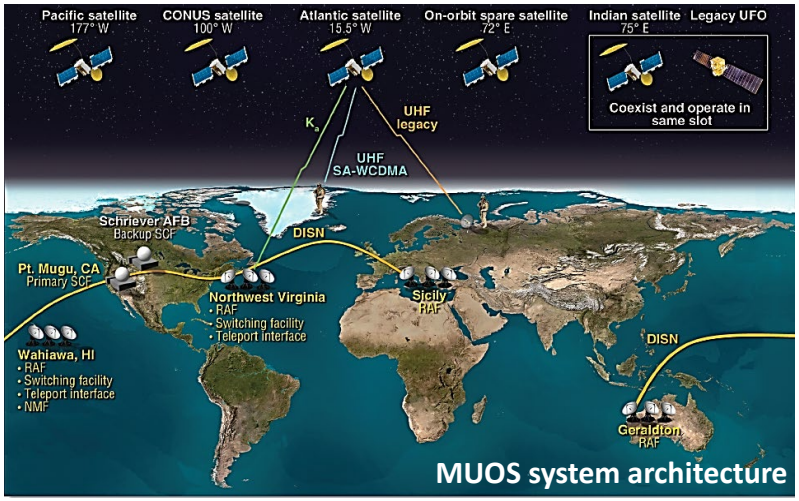
- Highly efficient and flexible
- Simplified satellite tracking and control

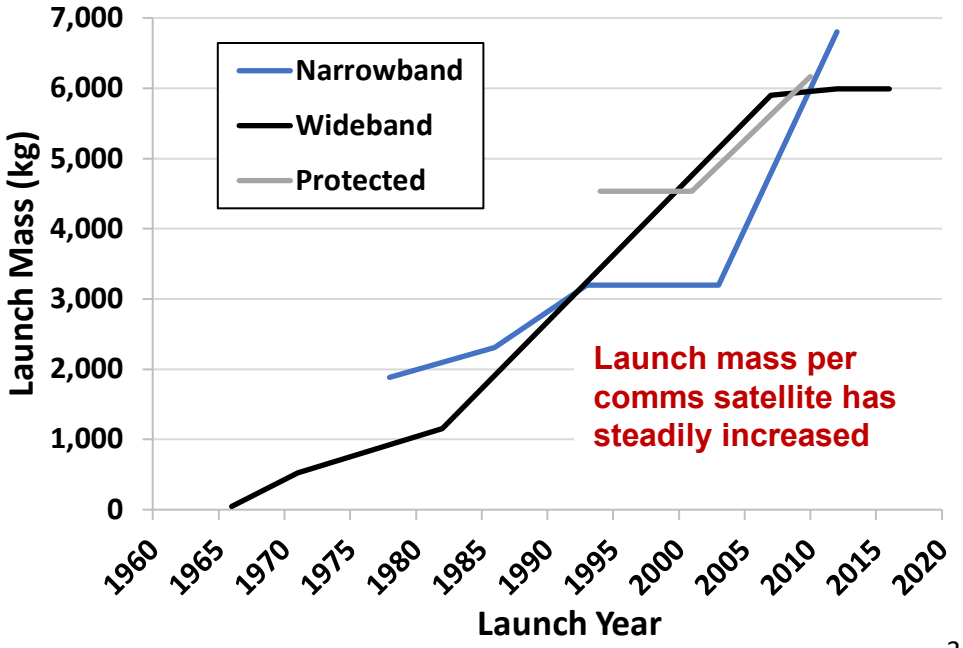
Over time became larger, more complex, expensive, and have long refresh cycles

- Requirements that prioritized performance and longevity
- Launch cost considerations

Closed, purpose-built, and often proprietary systems

- Numerous organizations focused on specific mission requirements
- Vendor proprietary equities
- Over-classification of program and mission data within space realm





Current systems and architectures not optimized to support new warfighting concepts such as JADC2

Insufficient bandwidth

- Demand – next generation weapon systems increasingly rely on external sources of information to function
- Supply - growth in data available to warfighters due to new sensor technologies, use of more data-intensive forms of ISR, and proliferation of cheap and ubiquitous sensors

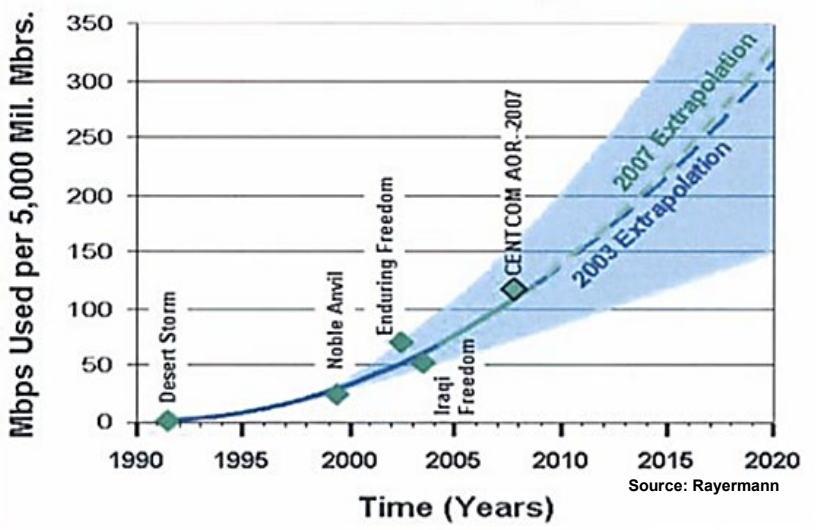
High latency

- Typical network delays created by transmitting data to and from satellites in GEO prohibitive for an increasing number of military tasks and processes

Lack of interoperability

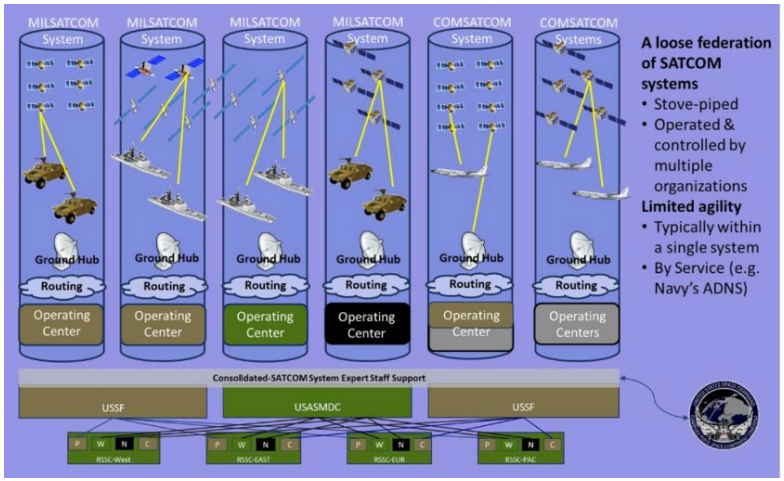
- Current stove-piped SATCOM capabilities hinder rapid, path-agnostic distribution of information to multiple users

Growth in bandwidth demand near exponential



Source: Rayermann

Series of stove-piped DOD SATCOM systems



SATCOM enterprise is highly vulnerable to adversary counterspace operations

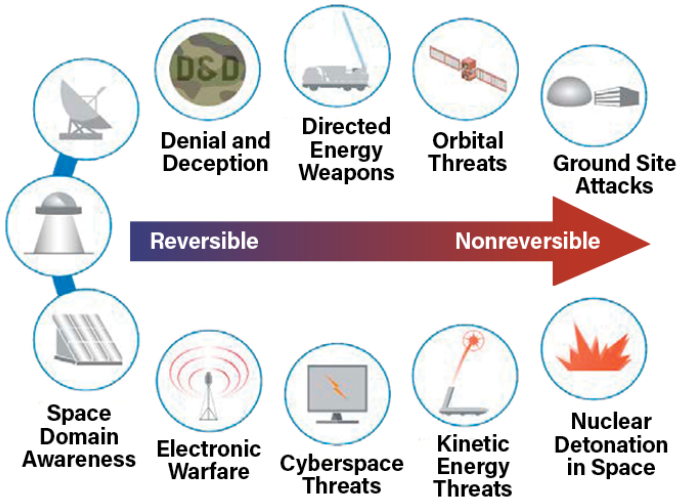
Both Chinese and Russian militaries adopting information-centric warfighting strategies

- Prioritize achieving information superiority as their main line of effort in conflicts
- Space-based capabilities are both a major source and conduit of information

China and Russia have developed their doctrine, organizations, and capabilities to contest or deny U.S. space operations

- Both recognize use of space domain has provided the U.S. with enormous warfighting advantages over the past 30 years
- View DOD's dependence on its brittle space architecture as exploitable vulnerability
- Have capabilities to target every aspect of the United States' space architecture

Planning to attack every aspect of U.S. space architecture



Russian SATCOM & GPS jamming station

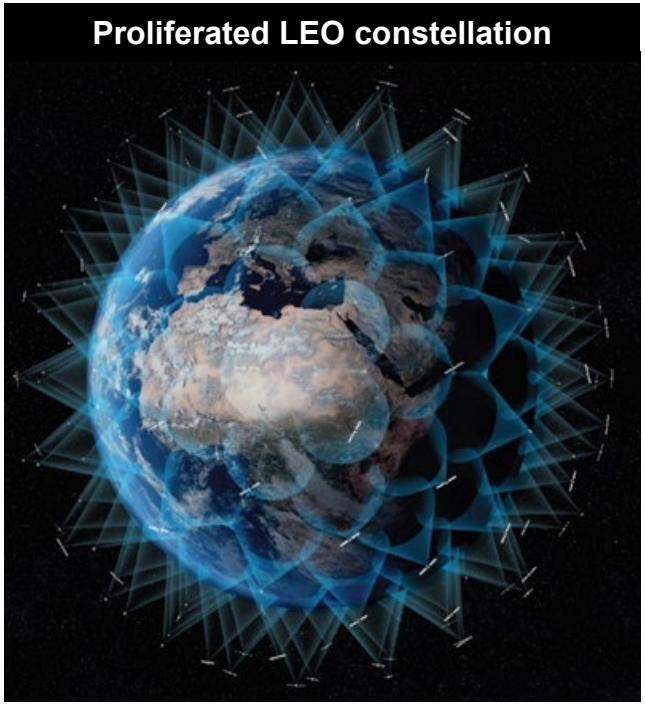
Part of the solution: proliferated, distributed, disaggregated, and diversified smallsats

Reduced latency: potentially lower latency over long distances than fastest terrestrial networks

Better overall coverage: higher probability that at least one satellite will be within a user's field of view, even in remote areas

Greater overall network capacity: result of much higher number of satellites in the network

Improved resilience: achieved through proliferation and ability to rapidly (and for less cost) reconstitute in response to an attack



Source: DARPA

Optical communications are the linchpin to realize full potential of proliferated, layered architecture

Laser communications can provide assured, high-bandwidth space-based communications

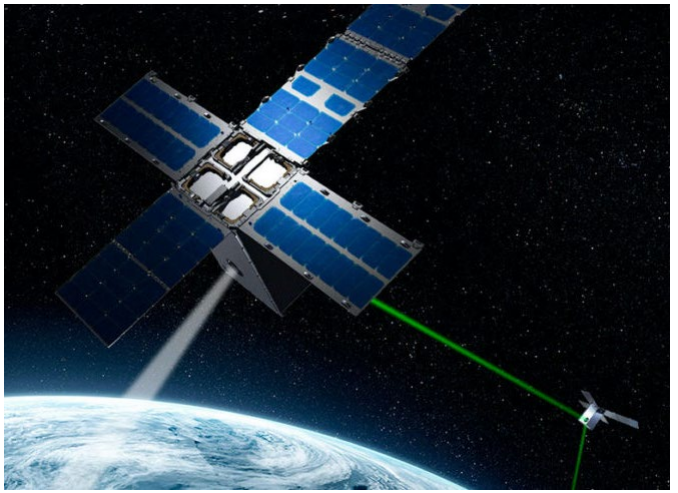
- Order of magnitude improvement in data rates
- More compact form factors that consume less power
- LPD/LPI capability that is very difficult to disrupt

Initial laser comm application: satellite crosslinks

- Connect satellites on same or adjacent orbital planes, across orbital regimes, into cislunar space
- Basis for creating “self-healing” mesh networks
- Potentially extensible across disparate commercial and government constellations

Optical communications will be key to new warfighting concepts and next-generation air, sea, and ground capabilities

- High altitude C2ISR platforms most promising initial candidate for integration of optical terminals



Recommendations

1. The U.S. Space Force should proliferate, distribute, disaggregate, and diversify its SATCOM options by deploying non-GEO satellite constellations—especially proliferated LEO satellites

2. The Space Force should aggressively develop and deploy optical inter-satellites links

3. DOD should conduct rapid experimentation and demonstrate optical terminals on airborne and terrestrial systems

4. The Space Force should explore options to expand partnerships for hosted payloads and leverage innovative cost models and material solutions for commercial SATCOM services

5. DOD should develop a terrestrial segment to fully realize the advantages of investments in the space and link segments

Recommendations (continued)

6. Sufficiently fund the Space Warfighting Analysis Center and other relevant organizations to conduct additional force structure analysis

7. The U.S. Space Force must prioritize and incentivize not just performance, but also cost reduction and manufacturability in its contracting

Graphic courtesy of BAE systems

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Flexible terminals and enterprise management and control capabilities necessary to support architecture

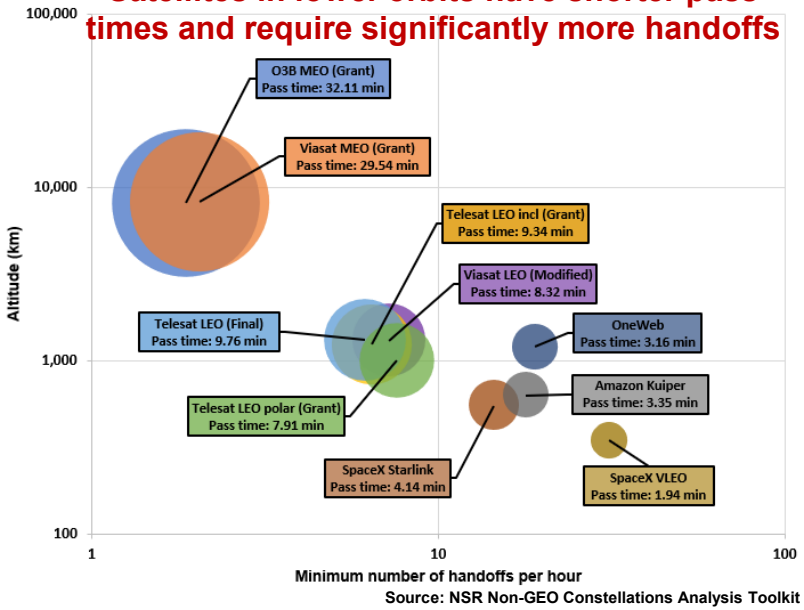
Phased array antennas necessary for both ground control stations and user terminals

- Simultaneously track and contact multiple satellites across different orbits, frequencies, and security levels
- Critical for non-GEO satellites that require frequent handovers

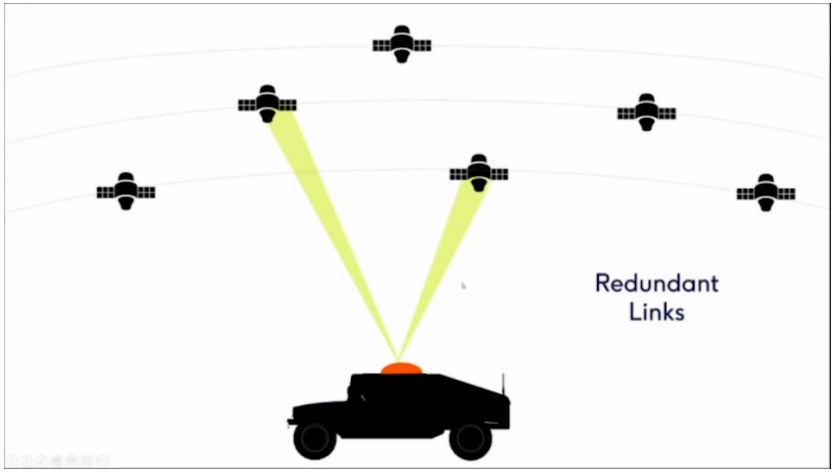
Flexible terminals that can roam between different service providers

- Leverage diverse and expanding set of SATCOM options
- Improves resilience against attack or other disruptions
- Combine flexibility at the terminal with cognitive enterprise management and control capabilities to manage complexity

Satellites in lower orbits have shorter pass times and require significantly more handoffs



Source: NSR Non-GEO Constellations Analysis Toolkit



Source: Isotropic Systems

Industrial base considerations

Manufacturability at scale for defense applications is a limiting factor to the import of more innovative and agile commercial space technology

- Industry will need to manufacture satellites at an unprecedented rate
- Defense primes can pivot to clean facilities, secure facilities, and facility clearances
- A wide range of innovative technology companies cannot pivot

U.S. Space Force must partner with industry to remove barriers to manufacturability at scale

Focus Air Force research investments on enabling technologies

Validate, publish, and do not overclassify integrated SATCOM strategy

U.S. Space Force must effectively communicate to Congress and the nation