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War At The Speed of Information: Data Transport, Decision Advantage, and the Future of Military Communications

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Information at the Speed of War

- **Modern warfare is increasingly data-dependent**
 - Sensors, platforms, and operators generate and consume information across every domain
- **The volume and speed of operational data are accelerating**
 - Higher-resolution sensors, persistent collection, and distributed forces create growing transport demands
- **Information has value only when it reaches the right user in time to affect a decision**
 - Data must move securely and reliably from sensor to decision-maker to operational effect
- **Communications are part of the warfighting architecture**
 - The network increasingly determines how quickly forces can understand, decide, and act

Military advantage belongs to the side that moves information fastest

The Communications Challenge Has Changed



- **Data generation is growing exponentially**
 - Higher-resolution imagery, hyperspectral sensing, persistent surveillance, and proliferated constellations are producing unprecedented volumes of data
- **Warfighting depends on moving that data quickly**
 - Distributed forces and compressed decision timelines require information to move across domains, theaters, and users in near-real time
- **Much of today's communications architecture was built for a different era**
 - Legacy ground infrastructure and finite RF capacity were not designed for today's scale, speed, and increasingly contested environment



Our ability to collect data is outpacing our ability to move it...to the warfighters' detriment

The Network is Becoming the Bottleneck



Vandenberg Tracking Station



Thule Tracking Station at
Pituffik Space Force Base



New Boston Satellite
Control Network Station

- **RF capacity is finite—and increasingly crowded**
 - Growing military, commercial, and civil demand competes for limited spectrum
 - Higher data volumes place increasing pressure on available bandwidth
- **Existing architectures were not designed for today's scale and tempo**
 - Reliance on terrestrial ground stations creates capacity, access, and geographic limitations
- **Conflict makes the communications problem harder**
 - RF links face jamming, interference, detection, and other forms of disruption
 - Adversaries recognize communications networks as critical warfighting infrastructure

Communications—not sensors—are becoming the limiting factor

Modernizing the Communications Architecture: Three Lines of Effort



EXPAND OPTICAL COMMUNICATIONS



Add high-capacity links where optical offers operational advantage.

REDUCE THE DATA BURDEN



Process, compress, store, and route more information within the network.

OPTIMIZE THE RF FOUNDATION



Increase resilience, efficiency, protection, and capacity across existing RF systems.

RESILIENT, HIGH-CAPACITY COMMUNICATIONS

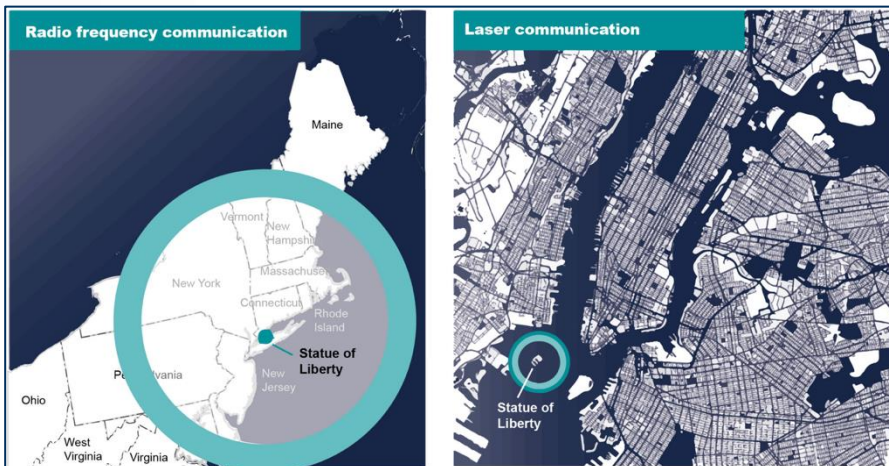
CONNECTING SENSORS, FORCES, AND DECISIONS
AT THE SPEED OF WAR

No single technology can solve the communications challenge

Why Optical Changes Everything



- **Dramatically greater data capacity**
 - Move far more volumes of data at high speed
 - Enables movement of increasingly data-intensive sensor products
- **Highly concentrated beams**
 - Reduces spillover, detection, interception, and interference



From LEO, an RF transmission focused on the Statue of Liberty spreads across much of the eastern seaboard, increasing exposure to detection, interception, and interference. An optical beam remains tightly concentrated, with a footprint barely larger than Liberty Island.

- **Freedom from RF spectrum constraints**
 - Adds capacity without competing for congested RF spectrum
 - Adds another transport pathway to the communications architecture
- **High-capacity links across the network**
 - Connects space, ground, air, and other nodes

Laser communications change what is operationally possible

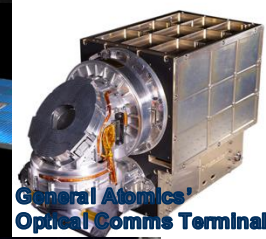
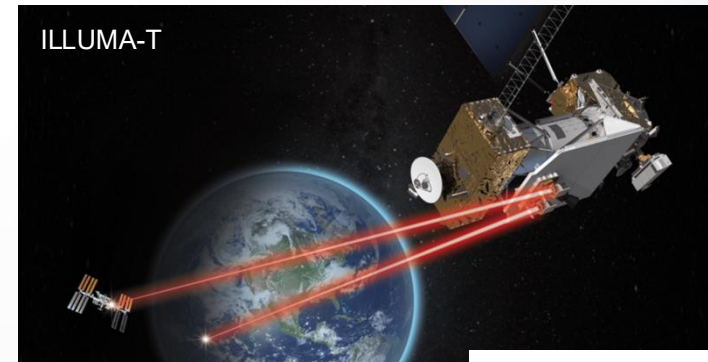
The Technology Has Arrived



- **Government has demonstrated operationally relevant performance**
 - NASA's LCRD/ILLUMA-T: high-rate space to Earth optical links
 - Artemis: extending optical communications into deep-space
- **Commercial industry is moving rapidly toward scale**
 - Proliferated constellations are using optical crosslinks to move data between satellites
 - Commercial terminals are pushing higher data rates, longer distances, and smaller form factors
- **Defense applications are moving from demonstration toward integration**
 - DoD proliferated architectures increasingly incorporate optical crosslinks
 - Industry is developing terminals and networking capabilities for operational military missions

LCRD: Laser Communications Relay Demonstration

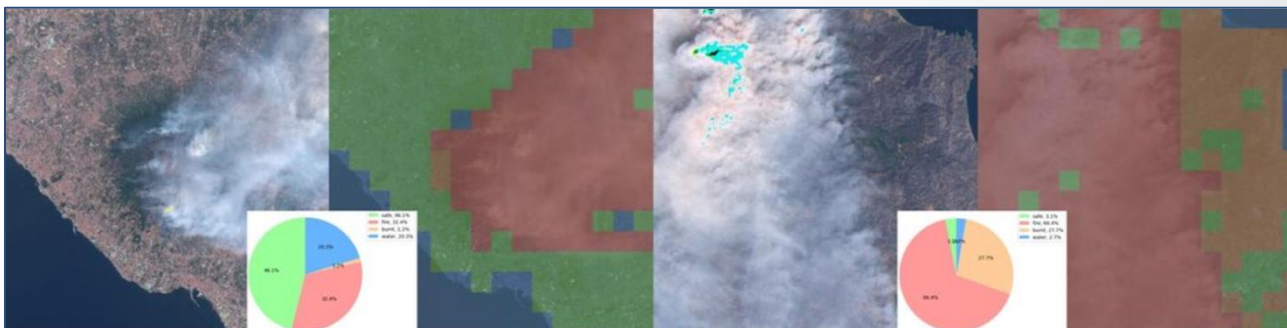
ILLUMA-T: Integrated LCRD LEO User Modem and Amplifier-Terminal



It's not whether optical works, but how fast we adopt it

Reduce the Data Burden

- **Process data closer to the source**
 - Edge processing and AI can identify and prioritize operationally relevant information before transmission
- **Reduce what must be transmitted**
 - Compression and efficient encoding can dramatically decrease bandwidth requirements
 - Send the information users need—not necessarily every bit the sensor collects
- **Store and route data within the network**
 - On-orbit storage can reduce dependence on immediate ground contact
 - Data can move toward the user through the most effective available pathway



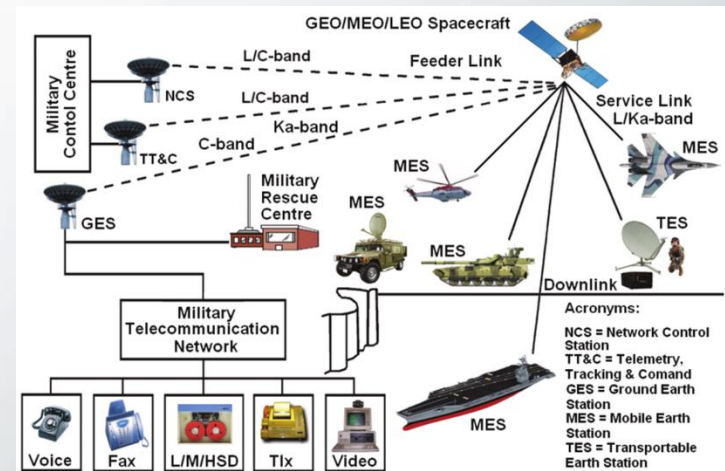
European Space Agency's PhiSat-2 PhiFireAI demonstrates how on-board processing can detect wildfires autonomously, lessening the need to downlink high-resolution raw imagery.

Move faster by moving less

Optimize the RF Foundation



- **Make RF harder to disrupt**
 - Protected waveforms, anti-jam capabilities, and spectrum agility increase resilience in contested environments
 - Encryption and data protection safeguard information moving across the network
- **Use finite spectrum more efficiently**
 - Dynamic spectrum management and more efficient waveforms can increase capacity
 - Match RF resources to missions that most need RF's unique advantages
- **Expand and diversify access**
 - Proliferated ground and space-based pathways reduce dependence on limited access points
 - Commercial and allied capabilities can add capacity, diversity, and resilience

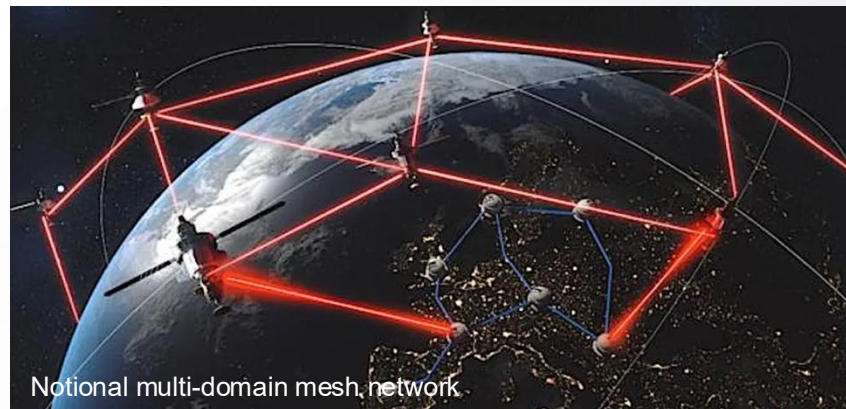


The future isn't RF or optical—it requires both

Building Tomorrow's Network



- **Integrate RF and optical into a hybrid architecture**
 - Route data across the best available pathway based on mission, environment, capacity, and threat
- **Move processing, storage, and routing into the network**
 - Reduce dependence on terrestrial infrastructure and enable data to move closer to the point of need
- **Build interoperability in from the beginning**
 - Common standards and interfaces allow government, commercial, and allied systems to connect and evolve

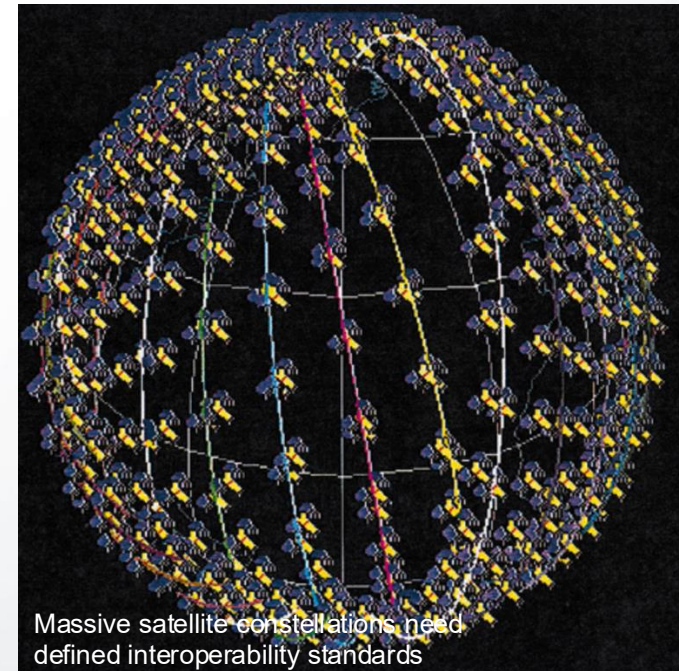


Tomorrow's network must be resilient, adaptive, and interconnected

America's Strategic Opportunity

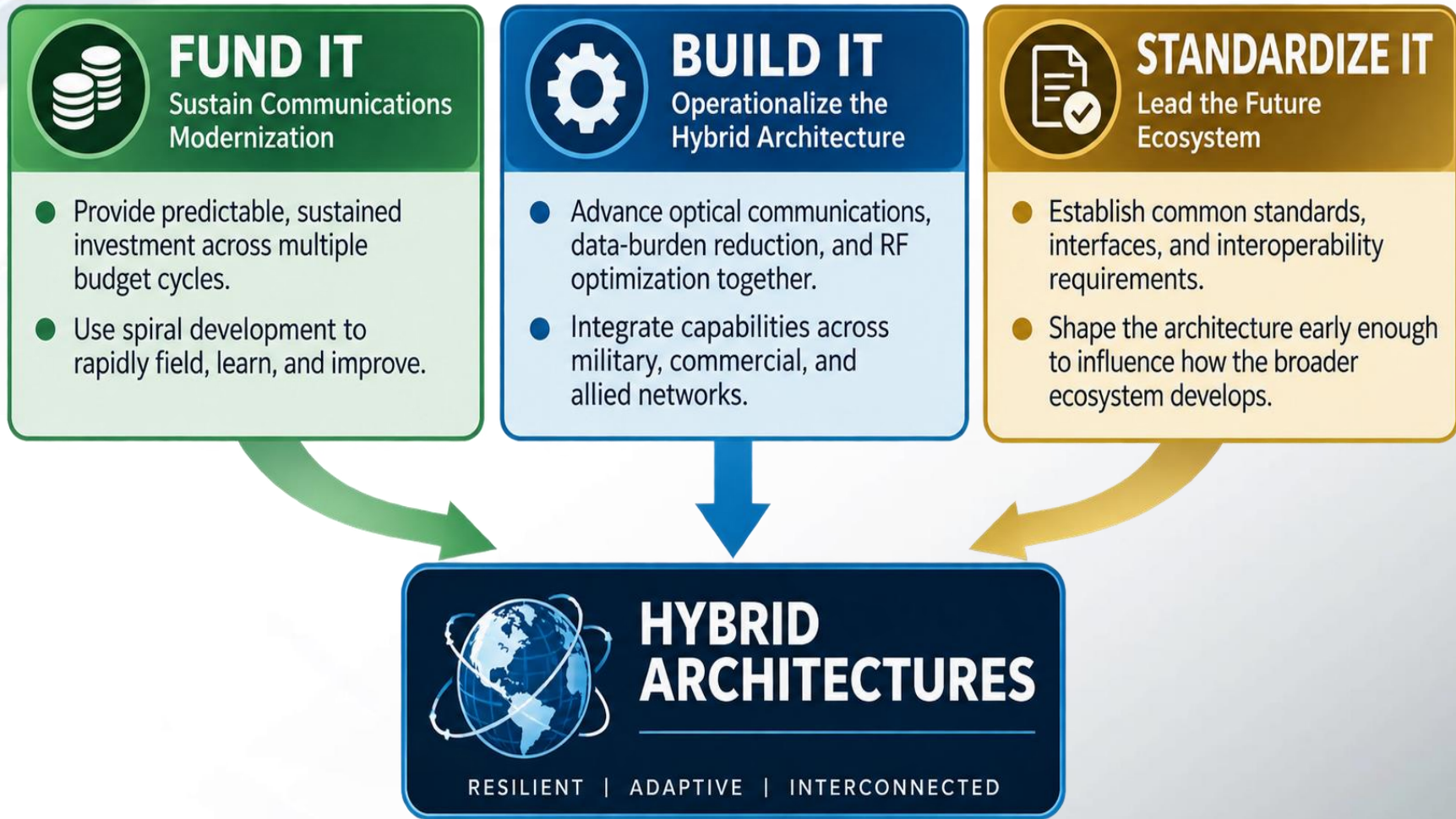


- **U.S. industry is driving rapid communications innovation**
 - Commercial investment is advancing optical terminals, proliferated networks, data processing, and hybrid architectures
 - DoD/DoW can leverage development outside traditional acquisition pathways
- **Early adoption helps shape the future ecosystem**
 - Technical standards and interfaces established today will influence future interoperability
 - U.S. leadership can strengthen integration across military, commercial, and allied networks
- **Strategic competitors are moving too**
 - China is investing in proliferated constellations, advanced networking, and optical communications
 - Waiting risks allowing others to shape technologies, standards, and markets the United States will later have to navigate



The U.S. must seize the window of opportunity before it closes

Recommendations



Modernization requires sustained investment, integrated execution, and common standards



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