7. Command, Control, and Communications

Area Description

Command, Control and Communications (C3) are the key to managing the battlespace and exploiting information superiority as enablers of all other operational and support missions. Effective C3 assures situational awareness and provides the ability to control terrestrial, aerospace and missile forces at all levels of command. It focuses on getting the right information to the right users at the right time. The C3 infrastructure supports the exercise of command and control (C2) authority and direction over assigned forces and includes the processing, analysis, use and dissemination of information to shape and dominate the battlespace. Maintaining aerospace superiority will enable the space-based portions of the C3 architecture to continue to service the operator as effectively as they have done to date.

Current DoD communications satellites and other links provide military forces with high-capacity, near-real-time voice, data and video communications, and assured information. These systems provide the essential conduits for information vital to the full range of successful military operations. The Satellite Communications (SATCOM) network provides near-global coverage and flexibility. Warfighters' access to mission-related information allows them to make near-real-time decisions critical to successful operations. No 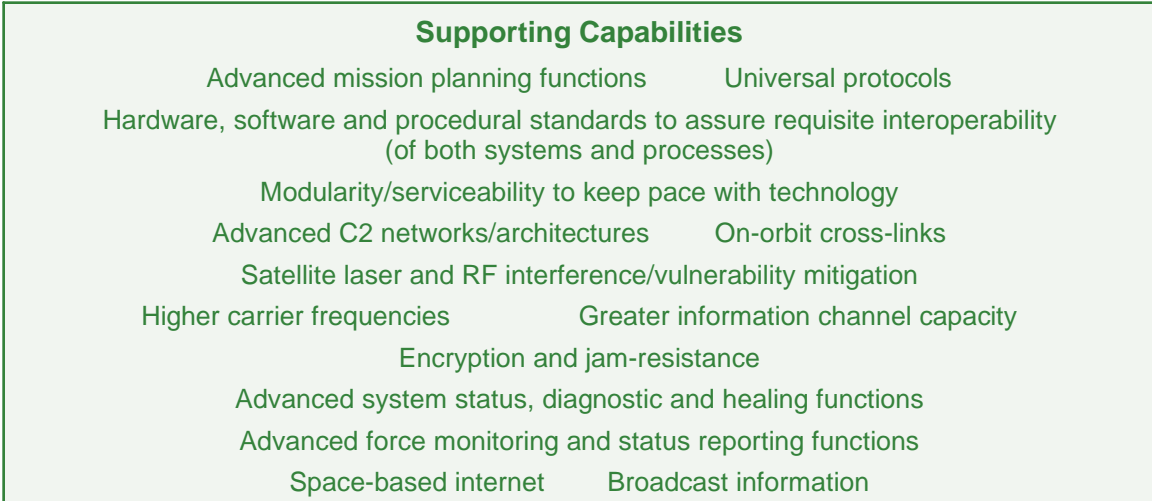other command and control system in the world must meet the same level of simultaneous requirements of security, mobility and surge envisioned for these C3 systems.

Critical space C3 operational functions and their enabling technologies include automated planning and collaborative decision tools, automated satellite operations, real-time aerospace systems integration to yield a common situational picture, integrated data fusion and wargaming, and near-real-time monitoring and assessment. Moreover, the increasing interaction and interdependence of C3 and ISR (themselves evolved combinations) — via their increasing reliance on computers — have led to their current recognition as a functional continuum: command, control, communications, computers, intelligence, surveillance, and reconnaissance, or C4ISR.

For the future, technology programs are in place to yield next-generation capabilities as summarized in this section. For the near and mid-terms, emphasis is on specific programs; for the far term, emphasis extends to generic technologies and capabilities to meet broader concepts and emerging needs. To lay the groundwork now for the future C3 and C4ISR environment, additional emphasis is needed in the areas of dynamic C2 and development of the Global Grid, as well as flexibility of resources to support the emerging mission of Information Operations.

Mission Area Objectives

Command and Control	Communications

• Monitor and assess global conditions and events; maintain a common situational picture
• Plan military operations (joint, coalition)
• Execute military operations (joint, coalition)
• Allocate, task, command and control one's own resources
• Collect, process and fuse data; store, retrieve and/or distribute information to warfighters
• Ballistic Missile Command, Control and Communications (BMC3) functions:
  – For national forces
  – In support of theater forces
	• Global, space-based, high-bandwidth, high-data-rate (HDR), robust, secure and seamless communications for national security requirements
	• Global high-bandwidth telecom infrastructure
	• Seamless data collection and information access
	• Fully integrated, interoperable, coalition-based communications network

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Supporting Capabilities

Advanced mission planning functions   Universal protocols

Hardware, software and procedural standards to assure requisite interoperability
(of both systems and processes)

Modularity/serviceability to keep pace with technology

Advanced C2 networks/architectures   On-orbit cross-links

Satellite laser and RF interference/vulnerability mitigation

Higher carrier frequencies   Greater information channel capacity

Encryption and jam-resistance

Advanced system status, diagnostic and healing functions

Advanced force monitoring and status reporting functions

Space-based internet   Broadcast information

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## Current Technology Initiatives   *(Highlights of Current FYDP)*

Near-term S&T projects and activities are focused on the attainment of robust C4ISR systems with abilities to:

- Provide a common situational picture

- Include a suite of integrated, automated planning tools

- Provide near-real-time monitoring and assessments

- Include an integrated wargaming capability

- Exercise more precise and reliable system timing to enable high-rate data transfers and fusion

- Integrate autonomous (ground and spacecraft) capabilities into general operations.

- Improve global satellite communications coverage, flexibility and robustness

- Enhance interoperability with commercially available communications systems

- Facilitate C3I link upgrades and automated operations

- Facilitate continuous surveillance capability (long-dwell connectivity and fusion of multiple satellite constellations)

- Reduce data collection, processing and dissemination times, which will especially benefit ISR, Space Control, and future Force Application functions.

Key projects include continuing work on:

- A high-bandwidth space vehicle data bus to meet ISR needs for greater throughput and near-real-time timelines, and high-bandwidth burst data to airborne C2 nodes

- Advanced laser technologies to provide acceleration-immune frequency standards.
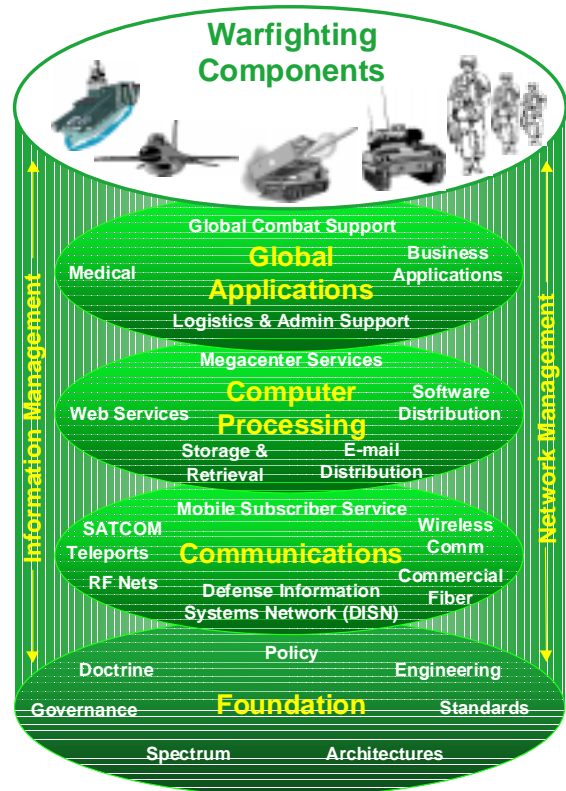
In turn, these capabilities will:
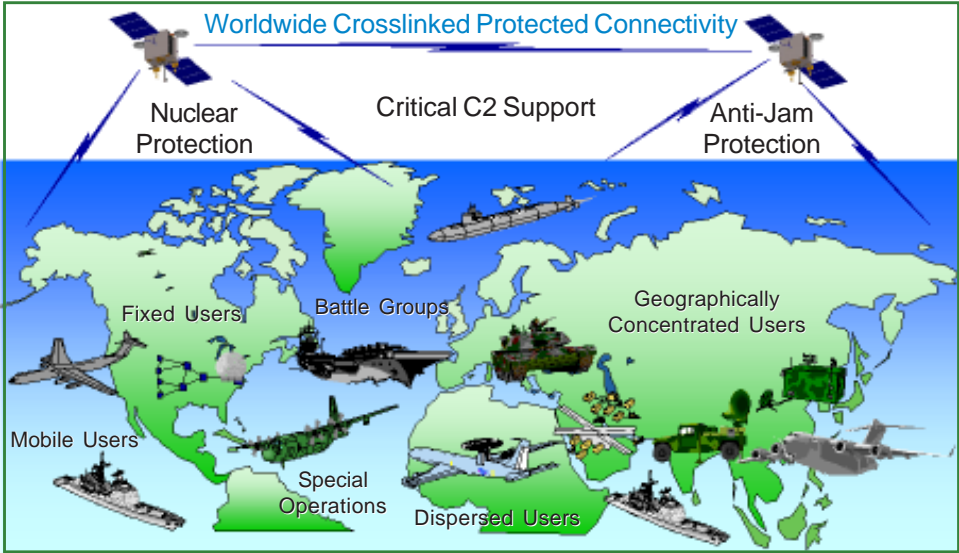
Advanced Extremely High Frequency (AEHF) Sytem Concept

Selected project detail is tabulated in "Projected Applications," below.

Enabling Technologies *(Unconstrained)*

- Technologies to protect/secure facilities and structures (materials, power, cooling, reconfigurability, shielding)

- High- and low-temperature superconductor device technology to enable frequency hopping, advanced spread spectrum

- Encryption technology (e.g., quantum cryptography and computing)

- On-orbit dimensional control and vibration mitigation techniques

- Improved precision time sources (10-ps timing accuracy) (atomic/laser clocks)
  - Network-centric communication synchronization techniques

- Laser/optical and microwave communications and associated acquisition/tracking/pointing for space-space, space-air, and space-ground applications

- Advanced waveforms for efficient, robust links

- Self-forming, self-healing terrestrial networks

- Cross-cueing, dynamic database fusion, synergy of imagery, spectral and signal functions, phenomena & information

- High-volume/speed processing, storage and display technologies

- Increased satellite onboard data processing and storage for timely data delivery

- High-performance RF front ends

- Efficient analog-to-digital (A/D) converters

- Reprogrammable radios and other electronics system components
  - Field programmable gate array (FPGA) technologies

- Advanced antennas
  - Improved performance land/shipboard/airborne SATCOM antennas
  - Robotic deployment and self-assembly techniques for very large antennas

  - Large, lightweight, electronically steerable antennas

- Efficient transmit/receive (T/R) modules

- Radiation hardening and shielding of components

- More efficient solar cells and batteries (chemically or thermally generated electricity, such as thermionic power generation and thermo-electric conversion)
  - E.g., lithium ion/polymer hybrid batteries
  - Affordable solar cell materials and manufacturing

- Human system interfaces for decision-making

- Intelligent software agents

- Human system interfaces for information exploitation and decision-making

- Control center technologies
  - Write once read many (WORM) storage
  - Archival mass storage.

Global Information Grid

Projected Applications

Category	Project / Activity	Status	Agencies
Data Fusion	• Joint Battlespace Infosphere (JBI)	M&S	Defense-wide
Sensor Fusion	• Moving target exploitation	M&S	Air Force
	• Sensor-to-decision-maker-to-shooter technologies	Technology	Air Force
Global Warfighter Decision-Making Tools	• Joint Aerospace Tasking Order (JATO) • Joint Targeting Toolbox (JTT) • Collaborative Engineering Environment (CEE) • The Multi-Sensory C2 Advanced Technologies (MCCAT) • Global Awareness Virtual Testbed (GAVT)	M&S and Technology development	Defense-wide
Effect-Based Operations	• Strategy-to-task software algorithms • Multiple scenario generation and potential outcomes	Technology development	Defense-wide
Advanced Communi-cations	• Global Grid infrastructure (to underlie and support information products) • Configurable Aerospace Command Center (CACC)'s optical intersatellite links (OISL) and lasercom to Airborne Command Posts (ACPs) and enroute operations centers • Intelligent network management technologies	Architecture and Network technology development	Defense-wide

Opportunities for Partnering

The military Services will continue to work with each other and with other organizations such as DARPA, NRO, BMDO, NASA, NOAA, NIMA and supporting industry to provide the joint C3-C4ISR space capabilities needed to meet existing operational requirements and projected needs. Requisite technologies include those to support automated/expert system satellite operations, real-time integration of aerospace systems, automated planning and collaborative decision tools, and development and distribution of a common situational picture from order of battle (OOB) through battle damage assessment (BDA). This capability will involve specific technologies and tools associated with automated mission planning and satellite operation, multi-source data fusion, and near-real-time monitoring, assessment, and display.

Specific Service partnerships include Air Force collaboration with NASA's JPL for optical communications, with BMDO for secure optical C2 technology, and with the National Institute of Standards and Technology (NIST) and the Naval Observatory for laser clocks. The Air Force will also continue to work with BMDO, NASA and JPL on laser communications, precision pointing, and advanced lasers. Work with the GPS Joint Program Office (JPO) on future timing technology includes the merging of navigation and communications. Under the Aerospace Command and Control, Intelligence, Surveillance and Reconnaissance Center (AC2ISRC) and with the Air Force as lead, the other Services and Defense Agencies will incorporate their data to yield a composite Data Fusion Roadmap.