Air Force Scientific Advisory Board
FY 2021 Study

New Technology Options for NC3 Resiliency

Terms of Reference

Background

America's Nuclear Triad is undergoing multiple modernization efforts, yet the Nuclear Command, Control and Communications (NC3) system still has many elements that date back to the Cold War era. In a 2014 study the SAB identified shortcomings in then-planned upgrades to the system, its auxiliary infrastructure elements, their sustainment, and the ability to maintain mission assurance from a cyber-perspective. Since that time many technologies have evolved that could be relevant to a more resilient NC3 system, including data management, artificial intelligence, advancements in signal processing, video conferencing, blockchains and gits, and quantum computing/timing/ navigation/encryption. At the same time, efforts toward Joint All-Domain Command and Control (JADC2) and a family of Advanced Battle Management Systems (ABMS) are identifying technologies and architectures that could augment the NC3 system and its resiliency. Furthermore, space communication systems are proliferating, especially in LEO and in the commercial sector. While technologies have advanced in the seven years since the last SAB NC3 study, so has the diversity and complexity of threats to the NC3 system, and new acquisition approaches such as DEVSECOPS may be needed to address these changes. The Department will benefit from a study on modern NC3-relevant technologies, system-level approaches, CONOPS, and supporting acquisition approaches that could clarify an effective approach for NC3 modernization to support the U.S. nuclear deterrent.

Charter

The study will:

- Review the USSTRATCOM NC3 mission area and relevant vignettes; include requirements for Integrated Tactical Warning/Attack Assessment, and National Command conferencing and Course of Action presentations for decision makers.
- Refresh the 2014 SAB NC3 study characterization of existing NC3 system elements and their sustainability and viability to accomplish the NC3 mission; assess interoperability with modernized elements of the Nuclear Triad and support to US/NATO dual-capable aircraft.
- Review the evolving replacement NC3 Program-of-Record's engineering, architecture and acquisition strategy, as well as strategic guidance impacting requirements and the evolving linkages with Nuclear Triad modernization to understand proposed technologies in use.
- Assess potential natural and man-made threats to the currently-planned future NC3 system that will impact its resiliency and deterrent value, including EMP, cyber and space threats.
- Identify additional existing and emerging technologies and acquisition approaches that could enhance the security, resiliency, upgradeability, and affordability of the NC3 system.
- Recommend additional areas for S&T investment that could support planned and potential near, mid and far term improvements to these aspects of the NC3 system.

Study Products

Briefing to SAF/OS, USAF/CC, and USSF/CC in July 2021. Publish report in December 2021.

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Air Force Scientific Advisory Board
FY 2021 Study

Space-Based Radar for Surveillance and Targeting

Terms of Reference

Background

The U.S. Air Force has relied on large aircraft (E-3 Sentry AWACS, E-8C Joint STARS) with Moving Target Indication (MTI) radars to support dynamic targeting and engagement of air and surface targets. However, highly contested environments will challenge the survivability of these aircraft, so there is a growing interest in Space-Based Radar (SBR) as an alternative means for surveillance and targeting in these environments. SBR is currently employed by foreign countries to generate Synthetic Aperture Radar (SAR) imagery, and there are commercial efforts to deploy moderate-size SAR SBR constellations. Yet tracking moving targets via MTI from low Earth orbit requires near-continuous target coverage and thus a large constellation composed of hundreds of satellites. Further, to detect slowly moving targets each satellite needs a large antenna, which increases satellite cost. For these reasons, past efforts to develop MTI SBRs have not led to deployment of an operational system. Satellite size, weight and power were unable to achieve the needed performance within cost limits. However, recent commercial efforts are driving down the cost of proliferated LEO satellite constellations, including proposed constellations having thousands of satellites, with hundreds already launched. Furthermore, innovative concepts at the individual satellite level and the overall system level could also drive down the cost of satellites. Given these developments and the pressing need for a capability to support surveillance and dynamic targeting in highly contested environments, the Department would benefit from an independent assessment of the feasibility of developing and deploying a constellation of SBR satellites to meet this need.

Charter

The study will:

- Survey requirements for surveillance and targeting data for moving air and surface targets in highly contested environments; consider CONEMPS similar to those used with AWACS and Joint STARS but also new employment concepts (e.g., long-range kill chains).
- Determine needed SBR capabilities and constellation size to provide the required coverage.
- Assess technology availability and risks to develop the needed SBR capabilities, including consideration of innovative approaches (e.g., passive radar) and potential availability of data from commercial providers.
- Consider needed supporting systems and technologies, e.g., use of commercial satellite buses, antennas, and other components; innovative approaches to energy generation; tasking and radar resource management; communications systems to distribute and disseminate data, and tracking and fusion systems to combine data from individual satellites.
- Assess kinetic and non-kinetic countermeasures to such SBR systems, and assess possible counter-countermeasures.
- Propose science and technology investments needed in the to develop SBR constellations.

Study Products

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Air Force Scientific Advisory Board
FY 2021 Study

Technologies for Operationalizing Agile Basing Concepts

Terms of Reference

Background

The Department anticipates needing agile combat employment (ACE) options in response to threats to its fixed forward bases from theater ballistic missiles, cruise missiles, and other adversary capabilities. While significant work is being done in the DoD to explore the ability of future active defense technologies for improving base resilience, other aspects of ACE, including agile basing, strives to quickly establish a base to at least a minimal operational capability, under the threat of sustained attacks, with a potential need to relocate on short notice. These aspects of agile basing present substantial operational and logistical challenges that should be considered in concert with active defense and camouflage, concealment and deception techniques. Many aspects of such agile basing concepts and associated operational capabilities could be enabled by technologies that may already be mature, while others may require technologies that need to be matured. The Department will benefit from a study that examines current agile basing concepts and evaluates their enabling technologies to understand what basing concepts and resulting capabilities could be credibly achieved in the foreseeable future.

Charter

The study will:

- Survey current and foreseeable kinetic and non-kinetic threats to PACAF, USAFE and AFCENT bases, and characterize their impacts on essential base operations and functions.
- Identify current ACE and agile basing concepts being explored in these Commands; include relevant Joint and Coalition efforts and consider potential impacts on interoperability.
- Assess the interplay between base agility and increased base resilience via mobile shelters and fuel storage, runway repair, explosives and ordnance disposal, CC&D including physical and synthetic decoys, logistics, transportation, runway independent aircraft technologies, C3, energy sources such as Small Modular Reactors, etc.
- Determine possibly solutions to fully enable these ACE and agile basing concepts; include commercial and advanced concepts beyond those currently being explored.
- Identify near-, mid-, and far-term technologies that could potentially fill these gaps or enable these advanced concepts to provide needed combat generation capabilities.
- Assess effectiveness of these technologies in concert with active defenses and base hardening techniques in the face of adversary counters. Identify operational challenges to employing, deploying, or pre-positioning such systems as part of an overall ACE CONOPS.
- Propose Air Force science and technology investments in the near, mid and far term to enable these agile basing technologies and address their vulnerabilities and operational challenges.

Study Products

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Technologies for Increasing Satellite Energy and Power

Terms of Reference

Background

Power generation for satellite systems has traditionally relied on solar panels for on-orbit systems and nuclear thermal power generation for deep space systems, with on-board energy storage via batteries and flywheels. However, the resulting power generation rate and energy storage capacity impose substantial limits on electric propulsion systems and thrusters for on-orbit station-keeping and orbital maneuvers, as well as limits on the capabilities of satellite mission systems. Although existing approaches to satellite energy and power have sufficed for traditional satellite missions, Space Force satellites will increasingly need to perform a much wider and more demanding range of on-orbit mission functions. For example, due to increased threats to such systems, they need to maneuver far more frequently and rapidly, for defensive and other purposes. In many cases their anticipated mission functions will require substantially greater levels of energy and power than has traditionally been the case. There are technical options today, and others that are emerging, that could support these increased demands for satellite energy and power. At the same time, increased power and energy capabilities also impose substantial challenges to on-board thermal management systems. The Department will benefit from a study that clarifies the extent to which these current and emerging approaches can meet anticipated needs of its satellites in the near, mid, and far term, as well as the technical and operational challenges and risks that these approaches may entail.

Charter

The study will:

- Survey current and anticipated energy and power needs for satellite mission functions, including for station-keeping, maneuver, mission functions, and satellite defensive actions.
- Assess the extent to which current power generation and energy storage approaches can meet these needs; identify and characterize key gaps where new approaches will be needed.
- Identify current technology options for achieving increased on-board power generation, energy storage, and the associated thermal management challenges they present.
- Evaluate foreseeable impacts of technology advances in larger deployable arrays, lower-power electronics, advanced battery chemistries, energy harvesting, and power beaming.
- Organize these technology options for satellite energy and power based on various categories of satellite types, including specific types of functions and required lifetimes.
- Determine recommended satellite energy and power solutions for key classes of satellites and functions, and assess the improvements they can provide over current approaches.
- Recommend areas of science and technology investment that could lead to substantial further improvements in energy and power systems for Space Force-relevant satellite systems.

Study Products

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