Horizontal takeoff and landing vehicle model.

U.S. Air Force

Architecting Space Programs

By STEPHEN J. FERRELL *and* HAL E. HAGEMEIER

In complex military and intelligence operations, senior leaders must make difficult choices on employing existing capabilities, improving them, and developing new capabilities. Decisions are becoming more intricate because of costs, technology, operational utility, threat uncertainty, system complexity, and system-of-systems relationships. As difficulties increase, policymakers continue to seek approaches that better support their decisions.

One popular technique is *architecting*—considering end-to-end capabilities in the context of related capabilities to meet expected needs. It is essentially focused on the big picture to provide insight on the utility and relationships of the components. The Joint Requirements Oversight Council realizes the importance of identifying the way that capabilities fit into an operating concept as implemented under

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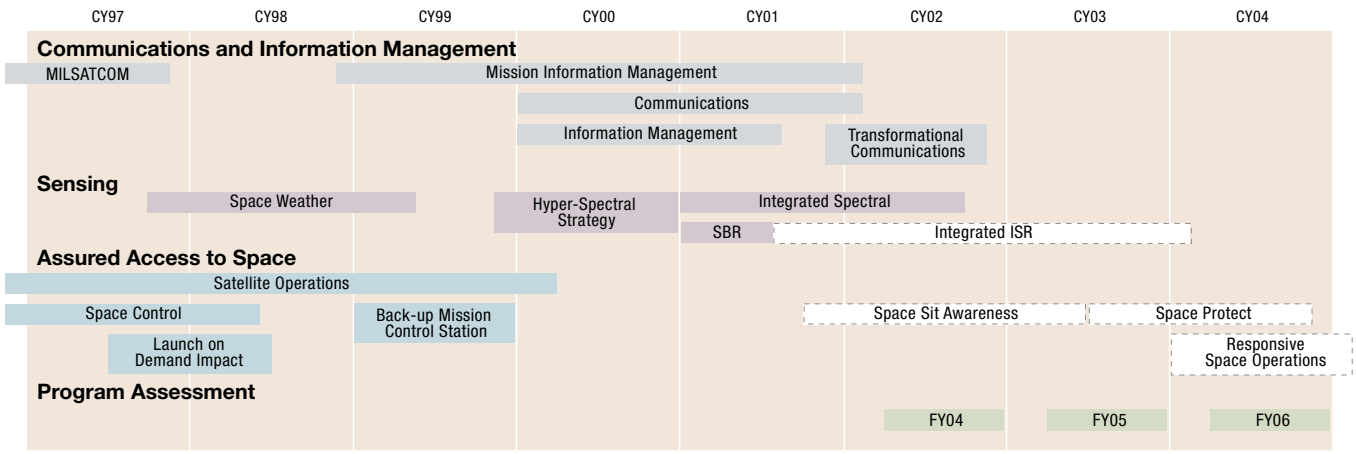
Major National Security Space Architect Efforts



a joint integrated architecture. Moreover, the defense acquisition process is being revised to include architectures as means of characterizing relationships among various capabilities in order to guide systems development and associated investments.

the Secretary of Defense and the Director of Central Intelligence established the National Security Space Architect

Architectures are the structure, relationships, and principles that govern the design and evolution of elements that are linked in accomplishing a specific purpose. They inform choices well before they have to be made. They help explain the possible and the practical. It is important to note, though, that architectures exist on multiple levels: from specific, existing systems such as global positioning and its many components to far-term architectures for an entire enterprise such as communications.

Although space architectures exist on multiple levels, this analysis focuses on the mid and far term. Such architectures are potentially the most important in developing mission capabilities by providing a broad context for decisionmakers. Yet they are probably the least understood because they extend well beyond the future years defense program. They are vectors to vision statements, capabilities-based strategies, and enterprise-wide plans. Architecting, in this sense, is the process of defining national security space far-term objectives, planning near- and mid-term steps to accomplish them, and implementing informed decisions. Producing space architectures requires a dedicated effort to consider end-to-end capabilities across multiple organizations to achieve integrated results.

The Space Architect

The Secretary of Defense and the Director of Central Intelligence established the National Security Space Architect to develop and integrate security space architectures for the mid and long term across the full range of defense and national space missions. This organization is uniquely positioned to develop architecture over the next 15 to 25 years for the entire national security space enterprise. Recently, it has been tasked to assess trade-offs between space and nonspace solutions as well as the appropriate integration of space with land, sea, and air solutions, and to report on the consistency of implementation of national security space programs with policy, planning guidance, and architectural decisions.

These architectures are long-range goals and objectives expressed in terms of a framework for system development. They represent what the community believes will provide capabilities in the far term. Starting with existing architectures and examining future ones that will be available in the near and mid term based on planned investments, they also analyze alternatives to determine the best long-term course, given technologies, operational concepts, needs, threats, and resources. The resulting recommendations are supported by an investment strategy and roadmap.

Architecture recommendations often advocate actions necessary to ensure that the national security space community develops desired capabilities. They are neither point designs nor specific system designs—stakeholder organizations are capable of designing and building specific systems with the best available technology. Architectures define capabilities, principles, and relationships for achieving the overall desired capability in the future.

The National Security Space Architect develops these architectures collaboratively with the representatives of other interested agencies, spanning the military, intelligence, civil, and commercial sectors. It does not develop, build, buy, or operate space systems; consequently, the organization can be objective in considering various competing concepts and capabilities. The

Space tracking and surveillance system.

Northrop Grumman

agency ensures that all relevant ideas, opinions, and concerns are thoroughly analyzed and considers both space and nonspace perspectives. It is as inclusive as possible in all architectures, studies, and activities it leads and relies heavily on stakeholders and other participants to bring their considerable expertise and knowledge to the table. Although it strives for consensus, the goal is to determine the best way ahead for future national space capabilities.

Past recommendations have been approved by the National Security Space Senior Steering Group, which is composed of agencies with a stake in the architecture or study. It is cochaired by the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence, the Deputy Director of Central Intelligence for Community Management, and the Director for Force Structure, Resources, and Assessments, Joint Staff (J-8). The group has also directed transitional planning to guide implementation of architecture and study results when appropriate. Stakeholders then develop transition plans to implement approved architecture and study recommendations.

As a result of the Space Commission, the National Security Space Architect will function as a multiagency organization that reports to the Under Secretary of the Air Force. It expects continued review from the national security space community to represent stakeholder organizations, provide advice, vet equities, and recommend options for reconciling major differences among stakeholders.

Architecture Results

Since 1995, the National Security Space Architect (and its predecessor organization, the DOD Space Architect) has completed architectures and studies and conducted the first national security space program assessment for fiscal year 2004. It is currently developing two architectures and preparing to assess the program for the next fiscal year. The architecture and study products fall into four areas: communications and information management, sensing, assured access to space, and program assessments. Communications and information management efforts include military satellite communications, communications, and information management architectures, and the transformational communications study. Sensing includes space weather and integrated spectral architectures, the hyperspectral strategy and space-based radar studies, and one architecture under development—integrated intelligence, surveillance, and reconnaissance. Assured access to space includes space control and satellite operations architectures, the launch on demand impact and back-up mission control station studies, and the other architecture currently under development, space situational awareness.

Communications/information management. The goal of mission information management was developing the architecture and strategy to guide technology investment, acquisition planning, and program execution for national security information management capabilities in the 2010–2025

era. Completed in 2001, it encompassed all aspects of providing mission-essential information to executing organizations and included DOD services and agencies, the intelligence community, civilian agencies (comprising the civil applications committee), and other offices concerned with national security. Mission information management was split into two related areas: an information management architecture and a communications architecture.

The information management architecture contained recommendations to better integrate information needs across communities, provide cross-domain satisfaction management, encourage smart delivery of information, and develop common information standards. It developed a concept for providing the structure to integrate information technology capabilities, thereby combining information needs across the national security community into a common needs picture—a concept known as national security information management (NSIM).

This concept helps make efficient and effective use of information to automatically deliver it when generated while protecting sources and methods. It is designed to analyze user information needs to determine commonalities and maintain the association of those needs to individual users. The national security information management function has been organized under chief information officers drawn from the defense and intelligence communities to guide management architectures by identifying resident developing capabilities (such as the multi-intelligence acquisition program and the DOD horizontal fusion effort) and providing feedback to achieve the information management architecture vision. This office has paid dividends by providing assistance in changing the operations concepts for managing information for users such as the Coast Guard (high seas drift net concept of operations), the Department of State (noncombatant evacuation operations), and 14th Air Force (information flow for Joint Air Operations Center generation of products such as the air tasking order).


Launching defense support program satellite.

U.S. Air Force

the communications achitecture team recommended an integrated network over space, air, and terrestrial environments

As information management architecture took the means of managing the information in the pipes into consideration, communications architecture examined the pipes themselves far more comprehensively than the architecture for satellite communications had done. The communications architecture team, consisting of 30 stakeholders from across the defense establishment, intelligence community, and National Aeronautics and Space Administration, developed an architecture for the 2010–2025 era that recommended an integrated network over space, air, and terrestrial environments with dynamic routing, prioritization, and bandwidth allocation; an airborne communications network; an integrated government space relay system; interoperable space cross-links; and the necessary interfaces to terrestrial optical networks. These capabilities will provide both more bandwidth and more accesses to the user.

The vision created by the communications architecture in turn became the inspiration for a study that outlined a relatively near-term plan for a truly transformational capability, increasing the bandwidth available to support the anticipated explosion of

user requirements by using long-desired technologies, some with great technical risk. It incorporated interoperable laser communications and other technologies to meet the growing needs in the defense and intelligence communities. The study examined broadcast, relay, and point-to-point military satellite communications, including low probability of intercept/low probability of detection/anti-jam protected communications to ensure that future capabilities are as good as or better than the advanced extremely high frequency capabilities planned for 2010. It also affirmed the feasibility of these efforts and outlined a roadmap to attain them. The recently organized transformational communications office is preparing the groundwork in architecture for the acquisition community to develop a network-centric capability to eliminate bandwidth constraints and connect more users to satellite communications. This is a clear example of long-term space architecting affecting near-term acquisition.

Sensing. If communications provide the how, then sensing technologies provide much of the what. The integrated spectral architecture and space-based radar studies established important groundwork for the ongoing integrated intelligence, surveillance, and reconnaissance architecture.

The integrated spectral architecture generated an integrated end-to-end spectral remote sensing architecture for the 2020 timeframe across DOD and the intelligence and civil communities. For the first time it identified fundamental capabilities where an integrated spectral remote sensing architecture might have utility:

- periodic Earth coverage for detecting both materials and changes
- periodic area search of theater-sized regions to detect and classify facilities, vehicles, and equipment
- focused in-depth target characterization
- near-continuous worldwide persistent surveillance
- a user-directed, network-centric environment where the user has direct control over most of the information product generation.

Earth from outer space.

DOD

The Road Ahead

The integrated spectral architecture considered that all five capabilities should be included to realize the full benefit of technology. It has also laid out a roadmap for achieving them before 2020. Some aspects of the plan are underway while others remain unfunded. From a military perspective, one of the most important capabilities is area search. A proposed program that demonstrates this capability is the enhanced hyperspectral experiment (Noble Eye), which would allow warfighters to detect vehicle-size targets over a broad area and cue other sensors to characterize the objects. This would confirm or deny the existence of targets in an area of operations and help optimize lethal targeting capabilities. The other critical consideration, which must be developed as sensor capabilities are fielded, is creation of an information environment where users have direct control of much of their own product generation.

Another potential capability of interest to military and intelligence planners is space-based radar. Its benefits are significant, but candidate systems have either been considered too expensive or the necessary technologies are seen as immature. That picture seems to be changing. A study by the National Security Space Architect in 2001 outlined a capabilities roadmap for the military, intelligence, and civil communities. It assessed the state of technologies required to realize radar for ground moving targets and related missions and identified the critical technologies for a capable, affordable space-based radar. The study also addressed an approach to satisfy as many common needs from across the communities as possible to prevent multiple competing acquisitions.

Spectral remote sensing and space-based radar represent aspects of a broader mission area: intelligence, surveillance, and reconnaissance. The integrated architecture for this mission area that is currently being developed has a cross-community investment strategy, with air and space study tasks being incorporated into the transformational space and airborne project. This study supports military, intelligence, and civil needs integrated across space and nonspace solutions for the

2015 timeframe and beyond. A major thrust is exploring new operational concepts and technologies and addressing the objective of persistence and achieving it in a mix of air and space capabilities. The architecture is expected to be complete this year.

Assured access to space. To collect and provide data through space, one must first have assured access. The National Security Space Architect is completing a space situational awareness architecture and will begin architectures for space protection and responsive space operations.

situational awareness is the basis of space control, the ability to ensure that the Nation can take advantage of space capabilities

Space situational awareness is addressing every aspect of the space environment, including tracking and cataloging space objects, charactering the objects (size, shape, payloads, capabilities, and activity), gathering information on the space environment, and managing related data. This effort will develop an end-to-end architecture for 2020 that provides space situational awareness to a wide range of customers. Situational awareness is the basis of space control, the ability to ensure that the Nation and its allies can take advantage of space capabilities and deny them to potential enemies. This architecture is scheduled to be completed in summer 2003.

Protection architecture will follow the space situational awareness effort. As dependence on space capabilities has increased, the requirement for protection has grown. However, existing approaches for mission assurance, risk assessment, and protection are usually focused on individual systems or segments, constrained by limited budgets, or overridden by a desire for utmost system performance. This effort will develop an architecture that optimizes space system mission assurance for national, warfighting, and civil users across the range of space assets and establish a priority for protecting those assets.

The responsive space operations architecture, expected to begin in late 2003, will examine the proper blend of space assets and capabilities encompassing launch, infrastructure, and payload designs to provide space capabilities for rapid response to world events, technological advances, evolving military doctrine, and other factors which drive changes in national security needs. This architecture will provide an integrated end-to-end solution as a foundation for more responsive, inherently flexible space operations and acquisition concepts providing transformational capabilities and assured support to defense, information community, and civil users.

Program assessment. Evaluating progress in planned architecture capabilities is essential. In 2002 the National Security Space Architect assessed the national security space program in the FY04–FY09 program objective memoranda. This assessment emphasized end-to-end architecture to determine if the programmed capabilities would satisfy major civil, defense, and intelligence policies and guidance. Based on the recommendations of the Space Commission, the defense and intelligence communities identified the elements that made up their respective space and space-related programs, referring to them as the virtual major force program for space. The assessment used these programs, together with other relevant programs, including key civil capabilities, for the FY04 assessment.

The program assessment highlighted areas of interest to senior policymakers, including the Under Secretary of the Air Force and Director of the National Reconnaissance Office, Director of Program Analysis and Evaluation within the Office of the Secretary of Defense, and Deputy Director of Central Intelligence for Community Management, to better synchronize funding across the space community. With the benefits of the space program assessment architectural perspectives on capabilities and other program reviews, leaders received information on which to base decisions on final adjustments to service and agency program costs prior to the budget submittal to Congress. The goal is ensuring unity of effort in acquiring and operating preeminent space capabilities.

Systems tend to be developed in an evolutionary and often stovepiped fashion, with each version an improvement on the last. The exceptions are usually represented by new technology or operational concepts—or a combination of both. But as the cost of systems has escalated without comparable increases in spending, the Nation cannot settle for the next generation to be simply better in incremental terms or exploit each new technology or operational concept, however revolutionary. Various systems must work in concert and provide capabilities to achieve the desired effects.

Leveraging the synergy among capabilities offers the best opportunity to achieve the highest possible utility and perhaps compensate for inadequate resources. Mid- and far-term architectures are key to developing integrated capabilities based on technical feasibility, the operational concepts within which the capabilities will be employed, and expected policy and resource constraints. They also focus science and technology on ensuring that future capabilities are available to joint warfighters.

Senior policymakers realize that long-term architectures provide a better understanding of relationships affecting complex decisions. Perhaps this is particularly true for space capabilities given their absolute dependence on technology, interdependencies among systems, long lead times, and numerous relations with terrestrial capabilities. The National Security Space Architect provides a unique perspective and cross-community approach to enable informed decisions. **JFQ**