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ENTERPRISE ARCHITECTURE FOR THE AIR FORCE SATELLITE CONTROL NETWORK

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ABSTRACT

Our cultural expectation about technology continually outpaces our ability to execute. In resource and financially constrained environments, delivering US Air Force space systems that operate independently [single purpose] is no longer an acceptable business case. The next-generation of space systems must leverage the many advantages available through integrative planning, modern technology, and commercial business models. Recent efforts have been undertaken to solve the problem; however, without an understanding of the relationships between space systems, selecting tradeoff alternatives and modernization solutions will be inconsistent. This presentation, using AFSCN* as an example, will demonstrate how an Enterprise Architecture approach creates a common terms of reference between space systems, technology, and the operational mission. An EA† will allow engineers and decision makers to assess mission demand/changes and current capabilities from select space systems that can be leveraged in the AFSCN for targeted investments and divestments.

if you're ever going to contest the United States in any environment, you better be able to contest space[1]

- *John E. Hyten, Commander, AFSPC*‡

INTRODUCTION

For over 50 years, the United States has operated satellites using the AFSCN. Over time, additional satellite and ground control networks were built. Some of these systems were developed independently from AFSCN. Reasons varied for independent development, from timing, to branch of service, reliability to required capabilities. Likewise, operations and acquisition were similarly organized and created independently.

In 2013 the GAO§ delivered a report on the state of satellite control ground segments in the DoD**[2]. Their findings identified the challenges to making enhancements to the network. The issues included planning, cost management, decision analysis, and implementation. The recommendation was twofold: 1) all new satellite programs should develop a business case for shared or independent satellite control system; 2) A DoD level plan for modernizing the AFSCN.

This paper, using AFSCN as an example, will analyze the current processes and make recommendations to address AFSPC's challenges.

* Air Force Satellite Control Network
† Enterprise Architecture
‡ Air Force Space Command
§ General Accounting Office
** Department of Defense

BACKGROUND

Starting operations in 1959, the AFSCN provides the standard in satellite control for the DoD[3]. Enabling satellite command and control, TT&C[††] and status of health, the AFSCN also provides launch, emergency operations, and disposal support[4] as depicted in Exhibit 1. The satellites were originally all controlled out of a single location at Sunnyvale, CA[5].

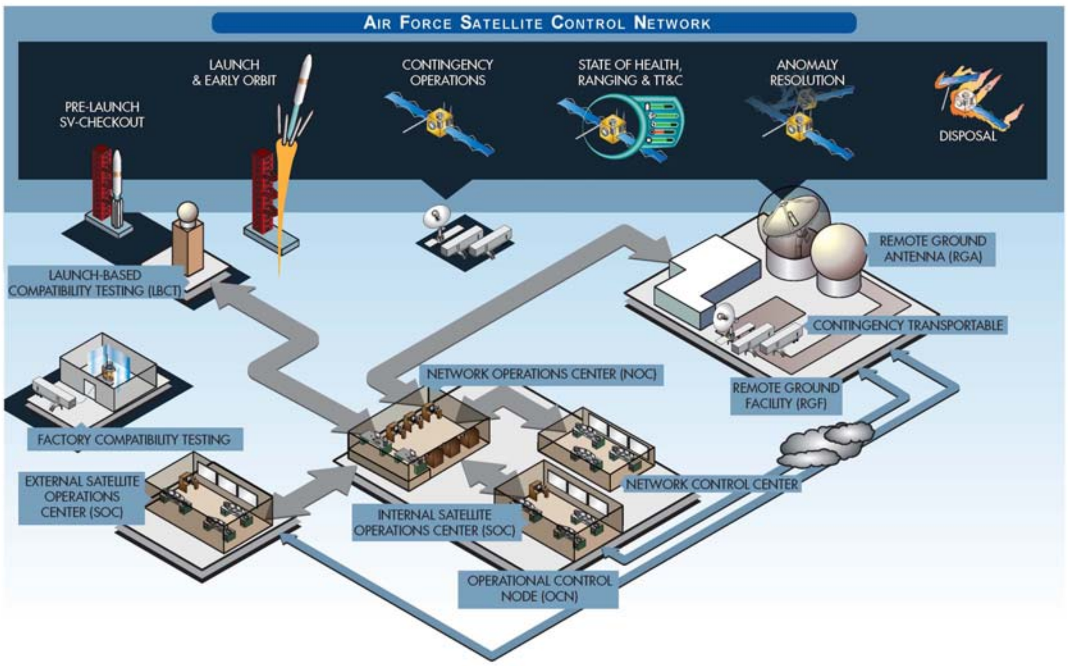

Exhibit 1: AFSCN Operational View.

As new satellites were designed, new satellite operation centers were built. To ensure performance requirements were met, some built dedicated ground systems[6]. All system requirements followed standard acquisition processes and were prototyped, developed and fielded, then moved into sustainment, or product support. The process is as summarized in the Defense Acquisition Guidebook, and is depicted in Exhibit 2[7].

the AFSCN, as it currently stands, without planned upgrades and modernizations, is not sustainable beyond 2020[8]

- *GAO Report*

[††] Tracking, telemetry, and commanding

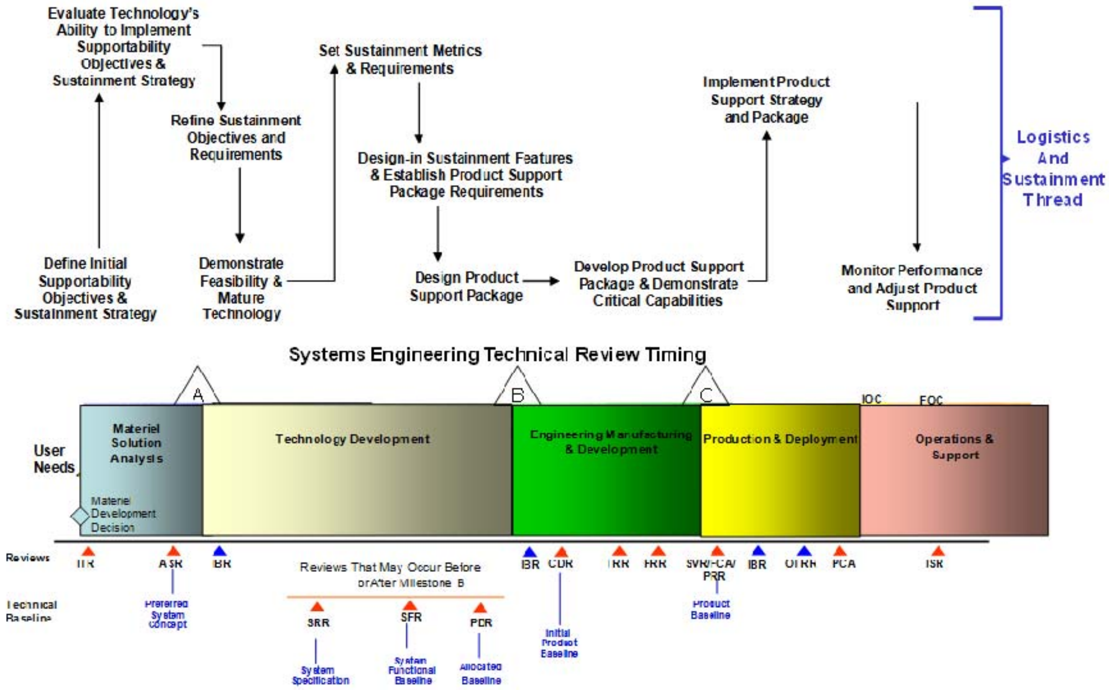

Exhibit 2: The Acquisition Lifecycle and Sustainment Support Process.

As depicted, the result is the establishment of the product baseline. This defines the standard of performance, and will guide what the system is and how it will be operated and supported until disposal. Let's take a look at the how the process works during operations and support using AFSCN as an example.

CURRENT ENVIRONMENT

AFSCN Operations and Support

The AFSCN is operated by the 50 NOG[‡‡] at Schriever AFB, CO. Modification and developments of new capabilities are performed by SMC[§§]. 50 NOG operates the AFSCN to meet the satellites users' requirements. If the AFSCN is unable to meet the users' needs, 50 NOG will engage SMC to repair or modify the system. The request will go through a multistep process to validate the need. It will pass through various approval boards, including attaining higher headquarters approval. This process is captured in Exhibits 3 and 4.

it's not just the acquisition process that we have to think about though. We have to think about our requirements process too, especially on the information technology in the command control side.[9]

- *John E. Hyten, Commander, AFSPC*

‡‡ 50th Network Operation Group

§§ Space and Missile Center

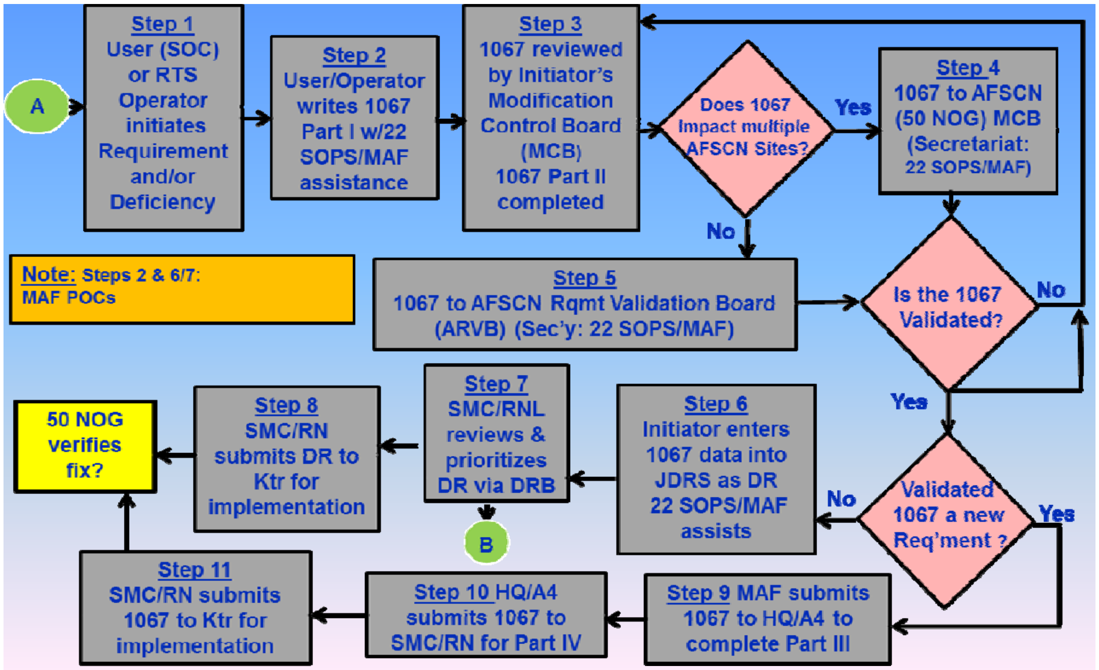

Exhibit 3: AFSCN Requirements process. Part I.[10]

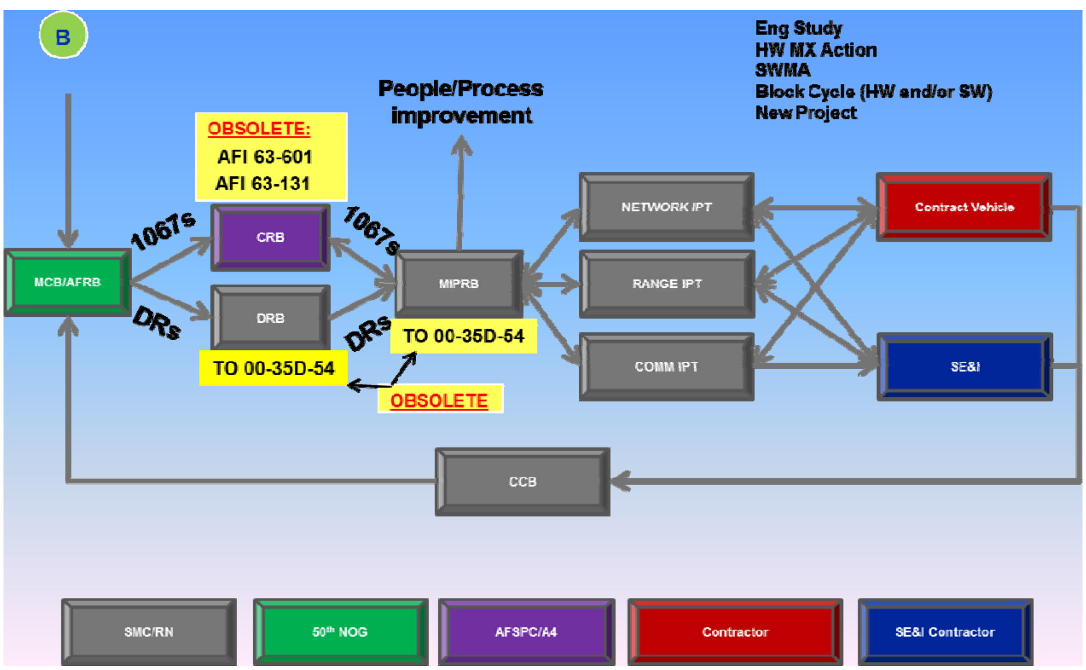

Exhibit 4: AFSCN Requirements process. Part II.[11]

AFSCN Users

The majority of satellite systems in the GAO report are in the sustainment portion of the acquisition lifecycle[12]. They follow a similar change approval process to the AFSCN. Many of these systems are located at Schriever AFB, CO and are depicted in Exhibit 5.

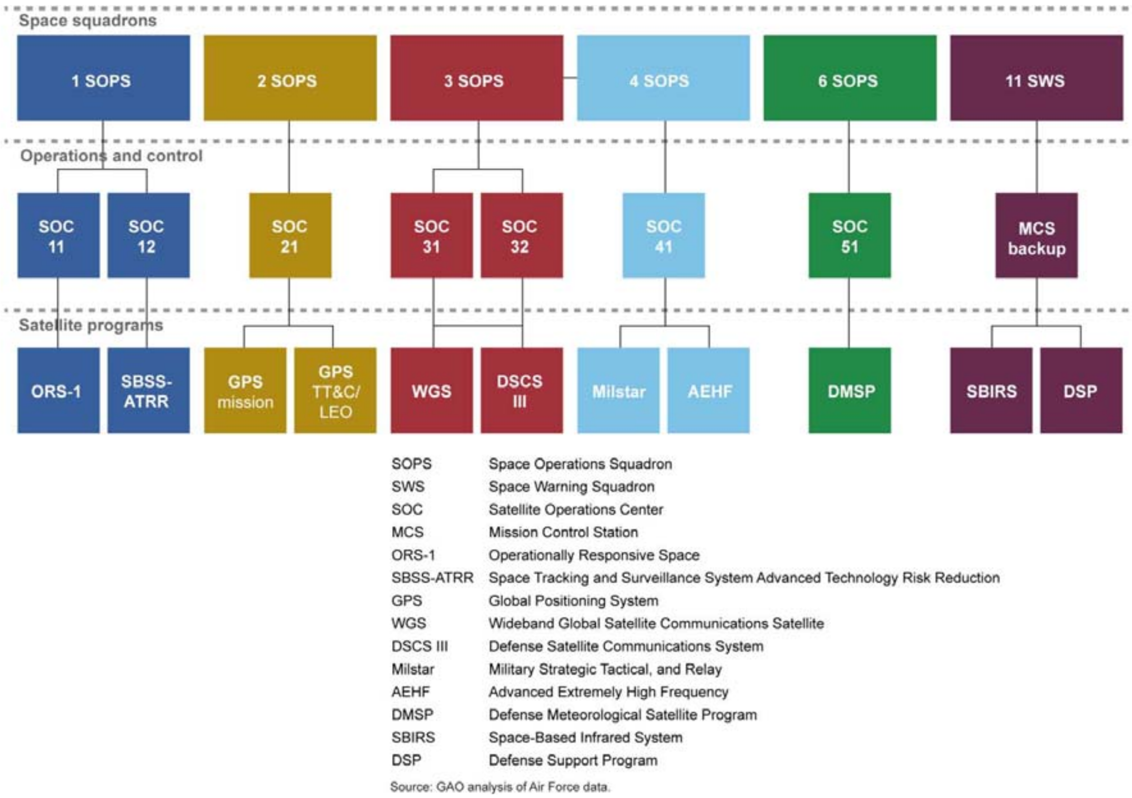

Exhibit 5: Satellite Program Organizational Structure at Schriever Air Force Base.[13]

Requirement changes can come from any source. In most cases, the operator or user generates the request for change. The focus of these changes is usually to maintain performance. However, there are other sources of guidance to change the AFSCN. The GAO report and S&T memo below are two examples of such inputs.

Integrated Operations Environment

In 2011, 50 SW began work on consolidating operations on a single operational floor. Christened the IOE[***], the effort would consolidate the 50 SW SOCs, providing real-time crosstalk between different missions and services. Exhibit 6 provides a pre-operational view. Operations began with 3 and 4 SOPS in February of 2013.[14]

GAO Report

In its 2013 report, the GAO identified several concerns with the current state of the satellite control network. They included the use of dedicated networks versus shared networks, lack of implementation of commercial practices, and modernization efforts that do not enhance capability[15].

Dedicated versus Shared

Over the past 50 years, and especially in the last ten years, dedicated networks have been developed rather than usage of the AFSCN. At least a dozen dedicated networks that do not share assets exist, resulting in satellite control inefficiencies. Although dedicated satellite control offers advantages to the specific systems, such as program tailored designs, shared networks may offer advantages DOD-wide by operating a variety of satellite systems simultaneously[16].

[***] Integrated Operations Environment

Exhibit 6: The Integrated Operations Environment at Schriever Air Force.

Commercial Practices

Commercial satellite companies told GAO they incorporate interoperability, automation, and other practices into their networks to decrease expenses and increase utilization[17]. Commercial satellite operators believe there is potential for improvement if the government adopts commercial practices. GAO asserts that both government and space industry studies have asserted that commercial practices such as interoperability and automation may improve the efficiency and effectiveness of government satellite operations. Although there is evidence that these practices could generate savings and improve efficiency, the Air Force has in general not implemented them in a concerted effort.

Modernization

The Air Force has budgeted about $400 million to modernize the AFSCN over five years. However, the modernization efforts will do little to increase capability. The efforts are focused on sustaining the current level of performance, despite research recommending more significant improvements.[18]

***S&T*†††**

S&T is the effort to find technology options that address urgent warfighter needs[19]. AFSPC has identified the long term challenges for space and cyberspace[20]. This guidance provides the vision for future capabilities. Among these system challenges are:

- Revolutionize capabilities of space and cyberspace operations and integrate with other multi-domain military operations.

††† Science and Technology

- Advance disruptive innovations, placing capabilities into space rapidly and at dramatically lower cost with significant performance increases.

- Develop advanced space and cyberspace technologies that provide real-time awareness, predictive awareness for phenomena, and rapid development and assessment of mitigative courses of action across all domains.

- Establish resilient space technologies that provide predictive threat analysis, and respond appropriately and effectively to allow operations through and recovery from these threats.

…determine a business case for proceeding with either a shared or dedicated satellite control system…[21]

- *GAO Report*

***EGS*‡‡‡**

As a result of the GAO study, the acquisition arm of AFSPC, SMC§§§, has begun an effort to standardize the satellite control ground segment across the command. The GAO recommended several commercial initiatives, such as interoperability, automation, use of COTS, and hybrid networks[22]. After researching the current state of satellite operations, the EGS program will provide a road map for Air Force satellite systems to move to a more common, shared and integrated architecture.

The major issues the EGS effort will address are:

- No commonality in applications and services across missions

- Contractors "own" the stack which defines the architecture

- Each mission area has its own hardware set

- Duplication, without commonality, of ground capability and costs

The benefits of the EGS will be:

- Common infrastructure

- Common services and applications for C2

- Common security practices

- Enterprise Ground Services[23]

A notional depiction of that solution is depicted in Exhibit 7.

‡‡‡ Enterprise Ground Services
§§§ Space and Missile Center

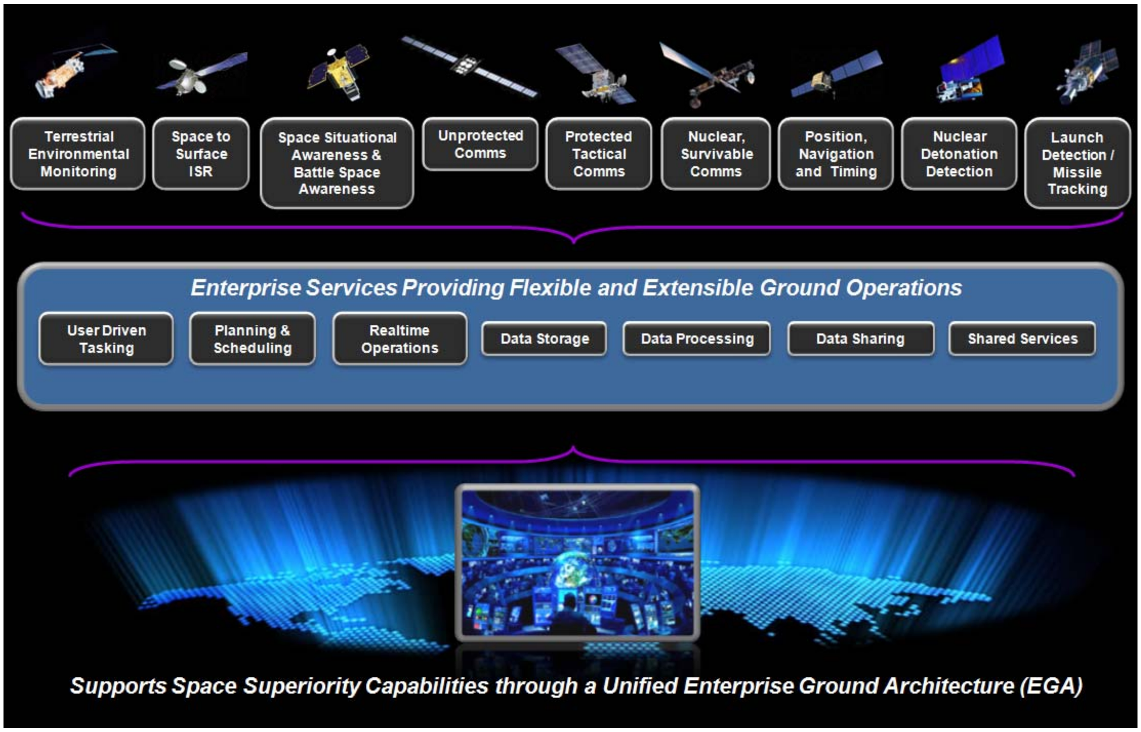

Exhibit 7: Notional End State for Satellite Control.[24]

EA[****] is a discipline for proactively and holistically leading enterprise responses to disruptive forces by identifying and analyzing the execution of change toward desired business vision and outcomes.[25]

Enterprise Architecture

A commercial practice that may answer the challenges documented in the GAO report is enterprise architecture. Using traditional planning practices to document information systems, the enterprise architecture defines the strategic vision to enable transformation.

The steps to an EA are straight forward. They are:

- Perform stakeholder analysis to ensure all stakeholders' capabilities are addressed.
- Develop road maps that focus on decision-making needs and styles to help stakeholders visualize future business outcomes so they can make well-informed investment decisions.
- Socialize road maps with stakeholders earlier rather than later to ensure they meet stakeholder expectations for being usable, useful and at the right level of detail.
- Time box and sequence iterations with the stakeholders to optimize the balance between socialization and efficiency.
- Deliver road maps that focus on new satellite control capabilities, and demonstrate when

[****] Enterprise Architecture

outcomes can be realized.[26]

The OMB[††††] has a documented process for implementing EA for federal systems. The EA concept is displayed in Exhibit 8.

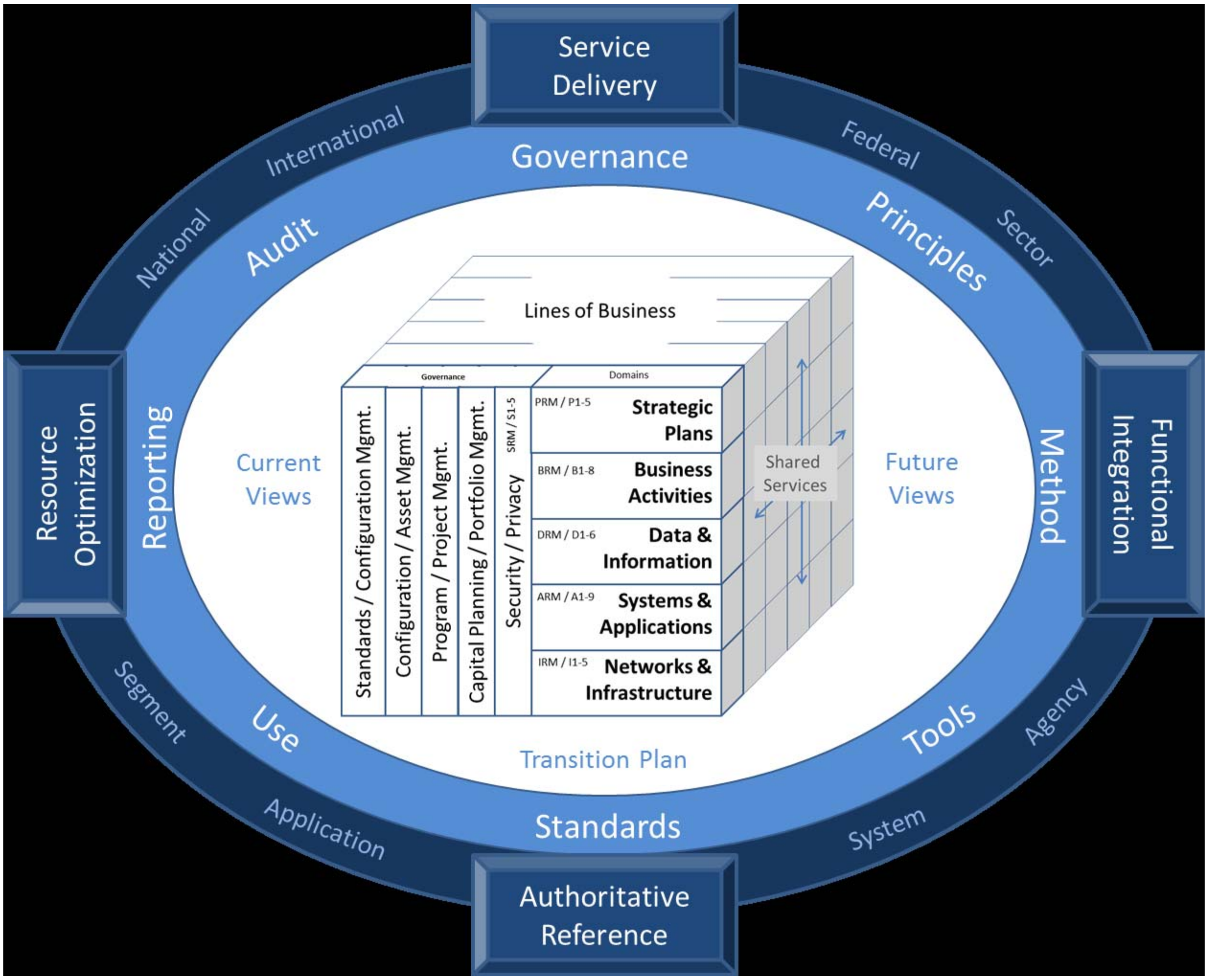

Exhibit 8: The Common Approach to Federal EA.[27]

GAP ANALYSIS

The GAO report and S&T memo provide the shortfalls and challenges to improving satellite control systems. Barriers identified point to no long term plan, lack of adequate cost controls, infrequent use of case analyses, and not enough decision authority. S&T challenges will require rapid incorporation of cutting edge technologies. As well, from the GAO report we learn that past guidance similar to the S&T memo was overlooked or not implemented for the last twenty years.

The GAO report comes to the right conclusion, that a long term plan must be established. However it does not press forward with a specific solution to change the current situation: an inability to leverage commercial practices to increase capability.

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†††† Office of Management and Budget

All current satellite control programs have a long term plan. The budget, change and management processes are well documented. The challenge is that the requirement standard is measured against the originally developed system requirements. Unless this standard is not met, no modification will be allowed. Further, without validation of a new requirement, no additional capability can be added, regardless of whether the capability is inherent in a replaced part or system. As noted in the GAO report, the offending capability will as often as not be turned off.[28]

All stakeholders must as well be involved in the solution, integrating changes physically and conceptually. Operationally, the IOE brought SOCs on to a common floor. This allows sharing of information in real time between the different, previously physically separated crews. However, as there is no requirement beyond colocation, leveraging all the potential benefits, such as common procedures, hardware and software, will be difficult to obtain without coordinated stakeholder involvement and concurrence.

The S&T memo and past studies recommended by GAO have recommended improved capability, such as increased satellite control operations efficiencies, improved interoperability, and consolidated functions.[29] Some of the capabilities have been recommended multiple times over the years. Although processes are in place, the improvements have not been incorporated because the requirement is not to improve the system. Instead, the requirement is to maintain the status quo.

The challenge is to establish a process that links vision to requirements. The vision captures the overarching need; however, there is no translation to the weapon system process to capture the envisioned capabilities in a requirements document and incorporate the improved capability.

EA offers many benefits to help visualize a future state. However, it does have its shortcomings. If the architecture does not align to the business needs, it will fail. Unless synchronized to the process, and monitored regularly, it will not provide added value.[30]

A way to look at the entire AFSPC portfolio, as well as offer executable guidance to each specific system, is required. This will provide the ability to make the tradeoffs necessary to meet the needs of tomorrow.

As an example, let’s assume the intent is to add a new cyber capability onto the AFSCN. The AFSCN configuration is currently divided into three major subsystems: Network, Range and Communications, as depicted in Exhibit 4. Designed using the configuration practices of that era, this approach can drive three separate implementation solutions for the same capability.

Although the cyber capability would be the same for each subsystem, the solution would have to be implemented three times. The increased cost would likely be too much to implement the solution and thus, never occur. A notional depiction is in Exhibit 9.

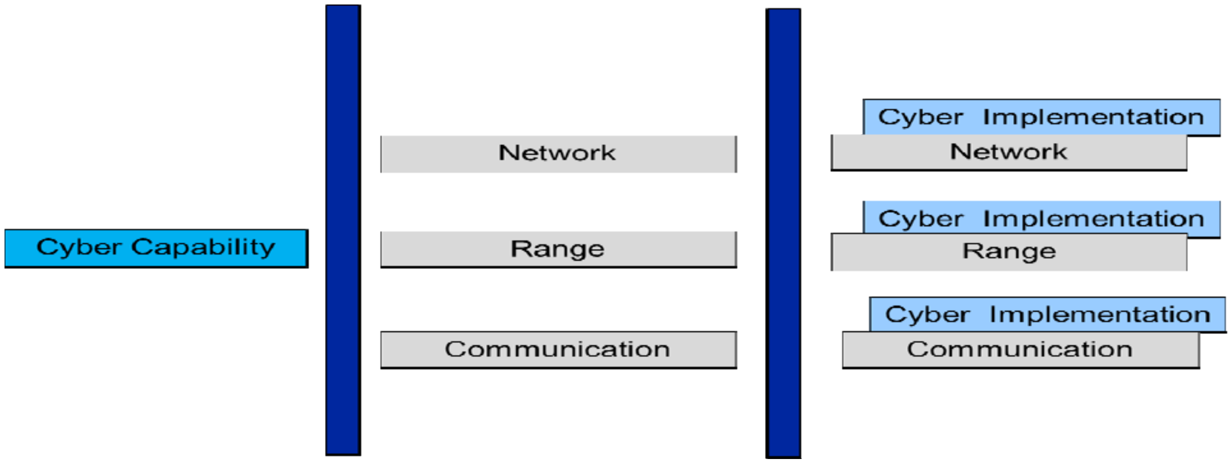

Exhibit 9: Cyber capability deployed across AFSCN.

Using an EA Approach, the capability could be built across the subsystems, and leveraged from other satellite control systems that might already have this functionality. A possible implementation is depicted in Exhibit 10.

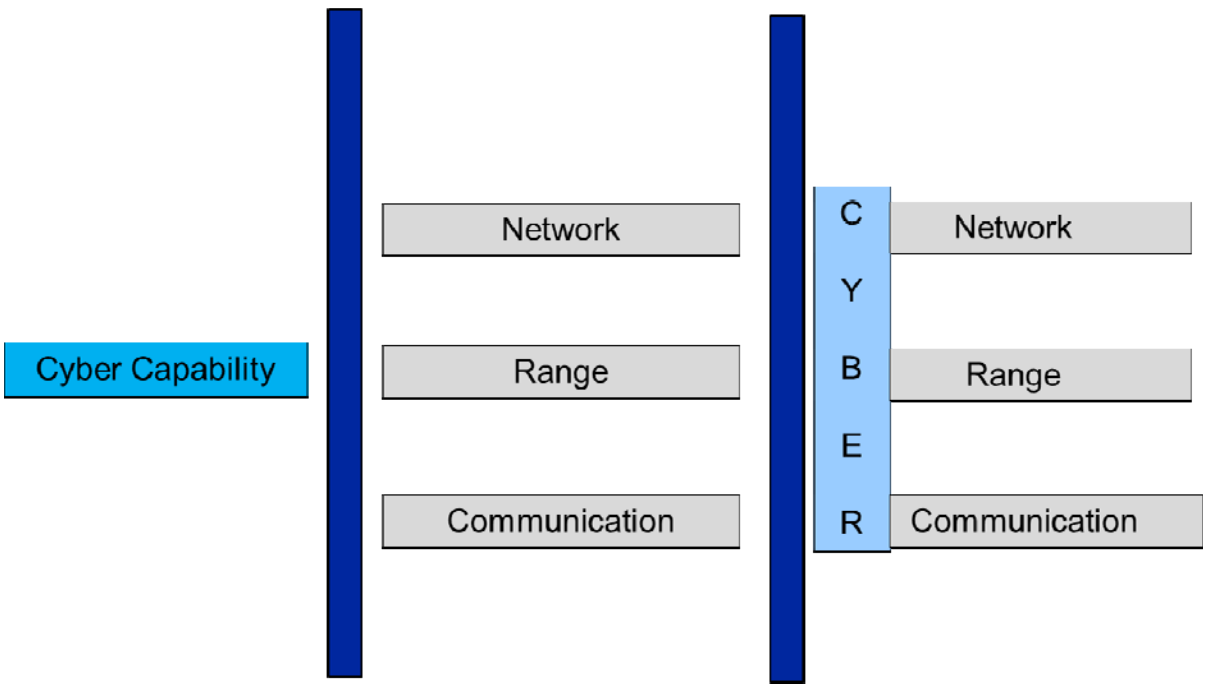

Exhibit 10: Cyber capability deployed across AFSCN using an EA approach.

The result is an integrative solution that adds capability one time rather than multiple times across each implementation.

An effort must be commissioned to create a multi-use space platform to drive developers and operators towards a new platform. Thinking of an aircraft analogy, consider air traffic control. There is not a different system for each type of aircraft that lands at an airport. A singular landing concept, to include runways, applies to all. A similar change is needed for current satellite control system planning to multi-systems and integrated planning.

RECOMMENDATIONS

To meet the future requirements for satellite control systems, AFSPC needs to manage the satellite control systems as an enterprise. As the EGS objectives point out, common hardware, software, processes, and operations, will bring lower costs, quicker enhancements, and reduced training to a smaller, more efficient workforce.

The benefits of the EGS are a great starting point to build an Enterprise Architecture:

- Common infrastructure
- Common services and applications for C2
- Common security practices
- Enterprise Ground Services[31]

Using these goals as the starting point to build the expected outcomes of the EA, the disruptions that can cause delays or changes can be identified. This will allow a risk adjusted value to be assigned on which changes to make and which to discard. As identified, AFSPC, the AF, and DoD in general can leverage the principles of governance, adopted for EA, to identify efficiencies and reduce costs. Using the process maturity of each satellite control system, establish the measures of success for each to guide development. This will produce an overarching EA ground element road map and define the requirements for satellite control system EA road maps.[32]

CONCLUSION

DoD satellite control has come a long way, and has a long vibrant future ahead of it. Developed from standardized processes, updated proven concepts must be embraced to meet the challenges ahead.

Enterprise Architecture will allow that challenge to be met. Using road maps and governance that align with the Commander’s vision, EA will enable innovation using commercial practices to update current processes for incorporating modern technology rapidly. EA, by its scalable nature, will allow integrative planning across current satellite control systems, allowing decision makers the ability to invest and divest as necessary.

The efforts may seem daunting. The numerous configurations, orbitology, and operational procedures, so varied and unique, will take time to unify. However, similar to the standardization of runways in the aircraft world, set with the right priorities and architecture, it can be done over the long run. And the value added by standardization, will be just as impressive: imagine unique runways for each type of aircraft; or if the Navy had different carriers for each type of plane. Why should it be different for satellite control?

For 50 years, the AFSCN has been the de facto standard. As it was in the beginning, so it can be again. Using EA, the goal of a single satellite control environment is possible. And a new paradigm of innovation, operationally and technically, can be attained.

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