

AIR WAR COLLEGE

AIR UNIVERSITY

Maximizing Space Investment:  
Tightening Link between Warfighters and Materiel for Space-Based Information

by

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## **Biography**

Lieutenant Colonel Janet W. Grondin is a student at Air War College, Maxwell AFB, AL. Her leadership assignments include Commander of the Global Positioning System (GPS) Advanced Control Squadron and Program Manager for the Operational Control Segment in the GPS Wing at Los Angeles AFB, California. Lt Col Grondin served 17 of her 21-year career in space systems acquisition.

As a Lieutenant, she served at Tinker AFB, Oklahoma providing engineering support for E-3 Airborne Warning and Control System aircraft. After earning her master's degree in Aeronautical Engineering from the Air Force Institute of Technology, Captain Grondin led development of subsystems for both the Delta II and Evolved Expendable Launch Vehicle space launch rockets at Los Angeles AFB. She transferred to Schriever AFB, Colorado in 1998 where she led an engineering team fielding a new launch control system and operating center for the National Reconnaissance Office. In 2001, Major Grondin was reassigned to the Pentagon as Program Element Monitor for space situation awareness and classified programs. In 2006, Lt Col Grondin returned to Los Angeles AFB to lead a team fielding two new GPS ground systems worth \$1B. Most recently, she led a prototype competition and successful source selection evaluation for a new, \$1B, net-centric GPS ground segment development contract.

## **Introduction**

At \$9-10B per year,<sup>1</sup> Air Force unclassified space funding represents roughly eight percent of the Air Force budget.<sup>2</sup> Recent Secretary of Defense (SECDEF) messages leave no question the entire Department of Defense (DoD) enterprise, including space, will be scrutinized for warfighter relevancy<sup>3</sup> and cost-efficiency.<sup>4</sup> Air Force investments in next-generation space systems will provide significantly enhanced warfighter capabilities over the next two decades that must respond to SECDEF Gates' dual challenges.

Today's military, economic, and political influences constrain programmatic action. The SECDEF's position reflects America's economic situation that is driving the need to rein in acquisition costs.<sup>5</sup> The warfighter, however, is engaged in military operations worldwide and wants the acquisition system to respond more rapidly to evolving needs.<sup>6</sup> At the same time, the Air Force is trying to re-establish credibility with Congress and is focused on stabilizing programs, not necessarily accelerating programs, to ensure delivery on time and on budget.<sup>7</sup> Most importantly, President Obama envisions space as a key economic sector where America's best and brightest reign. President Obama's charge to the space community is expansive: "Reduce programmatic risk through improved management of requirements and by taking advantage of cost-effective opportunities to test high-risk components, payloads, and technologies in space or relevant environments."<sup>8</sup> The need for continued US leadership in space affects not only military capability but the US economy and diplomatic relations as well.

This paper analyzes a critical segment of the Air Force's space capability, particularly the ability to link the ultimate user of space information with the warfighter's ability to extract and leverage that information for military operations. This paper considers economic, political, and

military pressures on fielding space capability for the warfighter and proposes small changes, coupled with a small investment, to manage change in today's warfighting and acquisition environments. The recommendations in this paper align with Gen Kehler's vision, as Commander of USSTRATCOM, for the military space community to "exploit electrons instead of spending money."<sup>9</sup>

In the following paragraphs, two historical cases are reviewed, current requirements and enabling concept development processes described, an analysis of the links between these processes presented, and a summary of the effectiveness of these processes is presented. Several recommendations for improving the link between system developers and warfighters are proposed to be consistent with senior leader visions for space operations and acquisition.

The value of space-based information to the US military is well understood.<sup>10</sup> Space systems underpin successful global operations by providing communication, navigation, weather, reconnaissance, and other data. The first Gulf War, dubbed the first "space war" by Generals McPeak and Fogelman, was clearly a success in adapting strategic space assets to the tactical fight.<sup>11</sup> The Air Force learned valuable lessons from that experience including the importance of space to the warfighter.

For example, during the first Gulf War, satellite operators and engineers adjusted Defense Support Program (DSP) satellite support to meet warfighter needs. DSP was originally built to detect strategic Soviet intercontinental and submarine ballistic missile launches in sufficient time for US missile crews to be alerted and launch a retaliatory attack, thereby assuring destruction of the Soviet Union should it initiate a nuclear attack on America. During the first Gulf War, however, DSP performance requirements were updated to detect Saddam Hussein's smaller tactical scud missiles. Hussein used scuds to harass coalition troops and antagonize Israel in an

effort to break up the coalition against Iraq. To counter the scud threat, warfighters identified theater information needs for missile warning to provide adequate time to defend against attack and take cover.<sup>12</sup> From theater requirements, the DSP team “tweaked the system”<sup>13,14</sup> so Patriot missile units received early warning of incoming Scud missiles, enabling sufficient time to launch defensive missiles and alert personnel to take cover. The space community’s innovative, responsive approach to warfighter feedback contributed to a strategic win for Coalition forces.<sup>15</sup>

As a direct outcome of lessons from the Gulf War, the Air Force created the 11th Space Warning Squadron and outfitted the unit with a prototype system to experiment with new concepts for using DSP data. The lessons learned from this prototyping effort fed the follow-on development program, Space Based Infrared System (SBIRS),<sup>16</sup> with new warfighter requirements for improving missile warning from space-based platforms. This pattern of developing prototype systems, enabling warfighter experimentation, obtaining feedback from simulations, then developing requirements to update the baseline system is an example of a tight, controlled feedback loop between warfighter and developer.

Another example of successful prototyping is the Talon NAMATH system, developed through the Air Force Tactical Exploitation of National Capabilities (AFTENCAP), to provide extremely high accuracy Global Positioning System (GPS) data to the theater. Talon NAMATH receives near-real-time GPS data, reformats the data to be compatible with joint forces, then pushes the final product to theater for operations requiring more accuracy than the signal-in-space currently provides.<sup>17</sup> Identified as a “good prototyping approach”<sup>18</sup> by (then) GPS Wing Commander Col Dave Madden, Talon NAMATH was developed and fielded in just over one year for only three million dollars.<sup>19</sup> Because of Talon NAMATH, warfighters executed bombing missions with minimum collateral damage and America reduced negative publicity

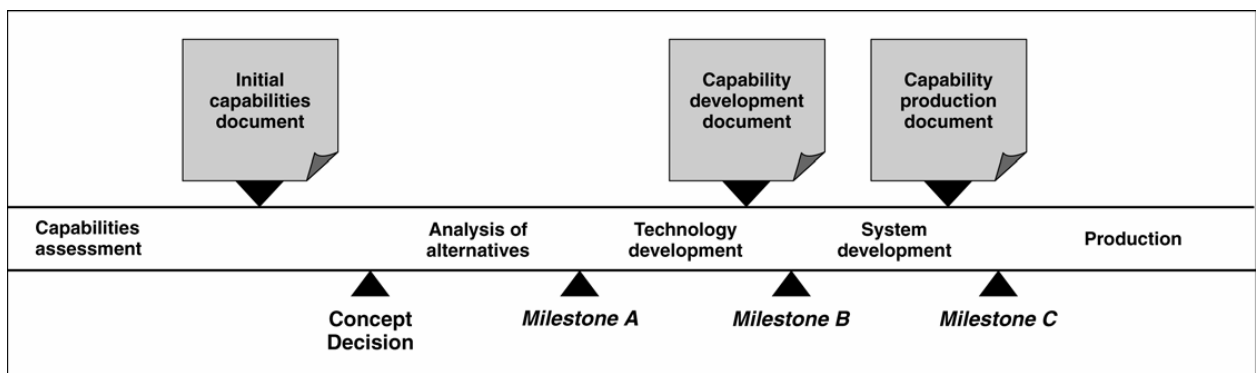


resulting from civilian casualties. The prototype data continues to be available for theater operations today.

Both DSP and GPS prototypes successfully adapted space system products to meet warfighter tactical needs, thus demonstrating the relevancy of space information to warfighters. However, both examples reflect unique approaches rather than a routine prototyping method. Efficiency favors repeatability; devising an efficient approach requires understanding current processes and the key links into those processes.

### Current Processes

When warfighters need new materiel, high level documents are produced to describe the capability gap that exists and identify desired system performance to fill the gap (e.g., system availability, accuracy, event reporting timelines). These capability requirements documents are approved by the Vice Chairman of the Joint Chiefs of Staff at the Joint Requirements Oversight Council (JROC). An updated JROC-approved document accompanies each acquisition milestone decision (Figure 1) to ensure warfighter requirements remain aligned with materiel as development progresses. Capability document development and staffing is nominally one to two years, depending on the maturity of the document.<sup>20</sup>



**Figure 1 - Capability Documents and Acquisition Milestones Relationship<sup>21</sup>**

The Enabling Concept (EC) is typically developed by the same team responsible for the JROC requirements documents. The EC documents how the system will be used in operations, thus providing context for warfighter requirements. An EC is expected to require several iterations and a lengthy staffing process unless changes are only administrative in nature.<sup>22</sup>

The two processes, requirements and EC development, produce foundational documents that define the characteristics required of a system and expected operational use of that system. These processes are largely linked through governing regulations, systems engineering and key personnel. Each link will be separately analyzed in the following paragraphs.

### **Process Link - Governing Regulations**

Air Force space ECs are developed in accordance with Air Force Space Command Instruction (AFSPCI) 10-102 to: “*explain an idea* of how to produce warfighting effects [and] *lead the requirements and acquisition processes* by articulating—in operational terms—the *necessary and supporting capabilities* to produce these *effects* [emphasis in original].”<sup>23</sup> Air Force Space Command (AFSPC) envisions ECs will evolve in parallel with system development until sufficient design maturity allows an initial operating concept to be developed. The initial operating concept will be used to develop tactical procedures, generate operational test scenarios, and define operator tasks.

Conversely, acquisition leaders emphasize the need to stabilize requirements and eliminate sources of requirements creep.<sup>24</sup> The space acquisition community, in particular, is concerned with the enormous up-front investment required to develop, build, and launch satellites.<sup>25</sup> As a result, space acquisition rules are geared toward ensuring early requirements stability, calling for an initial, partially complete EC at Milestone A followed by a final EC at Milestone B.<sup>26</sup> While the policy

allows for an EC update at Milestone C, the expectation is no design-driving requirements will be introduced.<sup>27</sup>

Acquisition regulations clearly expect requirements lockdown at Milestone B while AFSPCIs encourage EC evolution until the system is fielded. AFSPCIs don't identify the need to constrain EC updates within Milestone B requirements. Likewise, space acquisition regulations assume EC analysis conducted between Milestone B and Milestone C won't reveal unacceptable operational situations or identify new information needs that force requirements changes. Warfighters assume their needs will be reflected in the design as the operational environment is clarified, while program managers assume no changes will be made so cost and schedule commitments can be met.

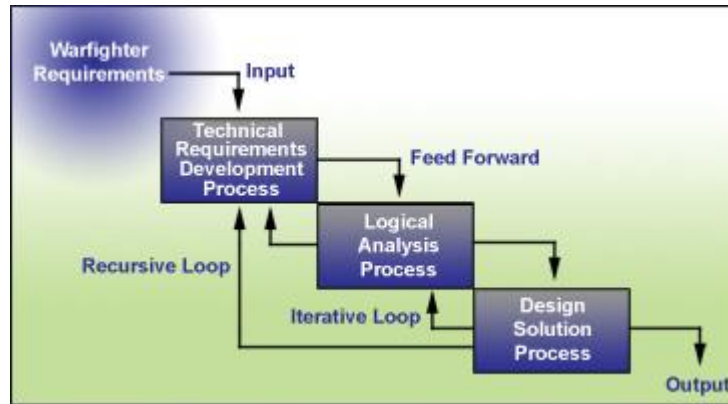
Programs can take several years to mature from Milestone B to Milestone C. During that time, these disconnected regulations encourage warfighters and acquisition teammates to manage requirements differently. This divergent management approach can result in unmet expectations, leading to organizational friction and wasted time if system features are incompatible with warfighter-envisioned operations.

While warfighter appetite for change must be realistically bounded, legitimate requirements changes can also arise. Program Managers have a legitimate need to minimize requirements creep. This source of conflict must be acknowledged and managed to ensure relevant space-based information capability is fielded. With the right tools, the systems engineering process can be the mechanism for managing this conflict.

### **Process Link - Systems Engineering**

The systems engineering process (Figure 2) is used to refine capability requirements from JROC-approved documents into lower level design requirements (e.g., crew size, skill levels, and basing locations). External requirements (e.g., environmental laws, information assurance requirements) are added to the capability requirements. The capability and external requirements

are linked together logically, then alternative design solutions are developed. Several iterations between requirements, logic, and design may be required before a complete set of requirements is baselined for product development.



**Figure 2 - Systems Engineering Process<sup>28</sup>**

The acquisition best practice is to establish the requirements baseline early, then leave the established baseline alone during design to avoid costly requirements creep. Typically, the only new requirements added after Milestone B are those needed to avoid mission failure. All remaining requirements changes are identified for planned upgrades after the system is fielded.

But changes postponed to future upgrades may not be added to the baseline for several years. New capability requirements must first be refined into design requirements so the contractor can estimate the effort. Then, the Government requests, receives, and evaluates the contractor's change proposal to ensure the work required is the work planned. Finally, the contract change is negotiated to ensure the Government receives a fair price. Once these steps are complete, the change is designed and built. This process is likely to take one to two years,<sup>29</sup> depending on how well the change is understood by both the Government and the contractor.

As a result of this lengthy effort, innovative warfighters charted a new course to avoid the lengthy contract modification process. Warfighters discovered prototype systems can meet

AFSPCI 63-104 criteria, be approved for operations, and fielded to meet warfighter need by creating a separate system baseline for the desired capability.

While this approach often works well in meeting the warfighter's urgent need, systems that comply only with AFSPCI 63-104 may not fully meet critical program requirements (e.g., information assurance) or include plans for lifecycle sustainment (e.g., software changes). Unless contractually connected to the program of record, off-line systems will likely require a separate sustainment effort for maintenance, upgrades, and spares to ensure the operational reliability and availability rates expected by the warfighter are met. In addition, because systems can be fielded without meeting all system-level requirements, off-line system data products may not carry the same level of mission assurance as the baseline system (e.g., data authenticity or integrity).

For example, Talon NAMATH was developed outside normal acquisition channels. Timely fielding of an effective warfighting tool was achieved; but, because prototyping was conducted outside the system baseline, long term sustainment, integration into the baseline system, and system-level requirements validation were minimally addressed. This set up Talon NAMATH to be a separate system, with a separate support contract, for the life of the program. Although efficiency of this approach is less than desirable, Air Force management can and did adapt to the Talon NAMATH arrangement because of the enormous warfighter benefit derived from the system. But, if the Talon NAMATH approach becomes the standard change process, every new data capability will require separate support systems for the life of the program. With numerous future capabilities in the development queue, this prototype process will result in unnecessarily complex ECs and inefficient sustainment practices due to multiple separate baselines.

Systems engineering can provide cost-efficient warfighter-relevant capabilities. But, without reducing the time to execute baseline changes, off-line solutions will continue to be attractive for meeting warfighter needs identified in EC updates.

### **Process Link - Decision Process**

To write an EC, action officers (AOs) from Air Force Space Command organize and lead a multi-organization team through a series of writing conferences. Per regulation, AOs are expected to both finalize the EC at Milestone B (DoD 5000.2) and evolve the EC into an initial operational concept<sup>30</sup> without introducing a new design driver at Milestone C (DoD 5000.2). In parallel, the AO builds or updates the capability requirements document. Presently, no automated tools are used to link the EC with requirements.<sup>31</sup>

AOs must close the regulation gaps while writing, rewriting, staffing, and maintaining synchronization of two foundational documents in order to describe needed warfighter capability. This third process link relies heavily on AO experience, drive, objectivity, determination, and workload. As new capabilities are delivered, AOs will need updated tools, regulations, and processes in order to keep pace with change.

### **Current Effectiveness**

Today's processes are effective because Air Force professionals work through the issues as they arise. However, with multiple new capabilities coming on line, the Air Force will likely find this inelegant "system" cannot keep up with the demand for new capability. On the other hand, if the Air Force relies on off-line development, more money will be needed to sustain multiple baselines – budget the Air Force is no longer expecting to have. Good stewardship of taxpayer money is only one aspect of meeting our commitment as "Guardians of the High Frontier."<sup>32</sup> To maximize capability from space system investments, AFSPC key personnel need a system, tools, and the

authority to manage evolving warfighter requirements so effectiveness and efficiency are addressed in the fielded product.

## **Recommendations**

A controlled method is needed to allow evolving EC requirements to drive space-based information capability design. Establishing this methodical approach requires three changes. First, regulations must be updated to balance requirements stability and evolving requirements. Second, systems engineering processes need to accommodate change while minimizing disruption when change is required. Third, formal decision processes, involving both program managers and warfighters, are needed to support change decisions.

### **Regulation Updates**

To close the expectation gap between warfighters and program managers, DoD 5000.2 and AFSPCIs need to be aligned. While DoD 5000.2 favors rejecting design-driving changes after Milestone B, changes that do not drive design are left to the Program Manager's discretion. If, for example, an enabling concept identifies a superficial change (e.g., a more efficient method for presenting information), DoD 5000.2 allows the program manager to consider the change, assuming cost, schedule, performance, and risk are acceptable.

Because change is not desired unless absolutely necessary, both AFSPCI 10-102 and AFSPCI 10-604 need to be updated to reflect the Milestone B constraints of DoD 5000.2 and limit EC changes to the greatest extent possible. However, change may be unavoidable and when it is deemed crucial to change, the systems engineering process must be sufficiently robust to consider the change while continuing the baseline development.

## **System Engineering Updates**

All programs are required to establish a systems engineering process at Milestone B to control the product baseline. A good systems engineering process should consider three aspects of change in order to minimize disruption of the design process: 1) timing of change in relation to the baseline stability, 2) impact of change to the baseline design and 3) fidelity of the change definition.<sup>33</sup>

First, the right time to introduce change is highly dependent on baseline stability.<sup>34</sup> Introducing requirements change during development can result in multiple changes to the same design element, causing confusion and slowing system maturity. However, changing aspects of the system that are stable can result in very little design impact. Disruption can be minimized if the change is introduced when the baseline is stable. Program managers are aware of the stability of the baseline through active participation in the contractor's configuration management boards. No change is needed to the existing systems engineering process provided programs are actively managed.

Second, the impact of the change drives the amount of resources needed to execute the change. For example, if a significant portion of the baseline is affected by a requirements change, more designers, testers, and test assets will be needed to work on the baseline change. Since these resources are also needed to design the baseline program, the change is likely to pull resources from the main development effort in order to work on the change. This will result in higher cost and longer development schedules. In some cases, additional personnel can be hired; however, new personnel are not always available or properly trained. The amount of resources needed to work on a change is critical information for gauging disruption created from adding



requirements. This knowledge comes from fully understanding the change and the resource constraints of the program.

Finally, fidelity of change definition is needed to properly scope cost, schedule, performance, and risk impacts resulting from baseline changes. Lower level baseline impacts are difficult to pin down if the developer is only provided with a capabilities-level requirement change. A method is needed to refine changes from EC updates, which tend to be capabilities-based, into technical requirements that can be used to determine baseline change impacts.

The ability to experiment with EC changes using an off-line system prototype would provide a mechanism for systems engineers to evaluate both the impact and fidelity of a proposed design change before any baseline change is directed. Facts can be gathered and requirements refined so cost, schedule, performance, and risk estimates are available to decision makers before any change decision is made.

The expected benefit of using a prototype to augment the systems engineering process (Figure 2) is reduced iteration time between each step through early, complete, identification of a change before the baseline is disturbed. For example, a prototype of a proposed EC change can provide an early instantiation of the operational concept, provide early indications of the baseline changes required, and be conducted off-line so primary development is not interrupted until the change is well understood. Because prototypes are not operational software, partial solutions can be demonstrated to the warfighter and his feedback incorporated before establishing requirements. In this manner, change can be managed off-line until requirements are sufficiently refined to quickly develop technical proposals that minimally disrupt established design activities. Once approved, the requirements will be subject to the full set of requirements applicable to the baseline system and be absorbed into the baseline sustainment program.

Between active program management and introduction of prototypes to define change, the systems engineering process can be established to manage change while minimizing disruption to the baseline. The key to increasing speed of the systems engineering process is ensuring adequate information is available to warfighters and developers so informed decisions are made.

### **Formal Decision Process**

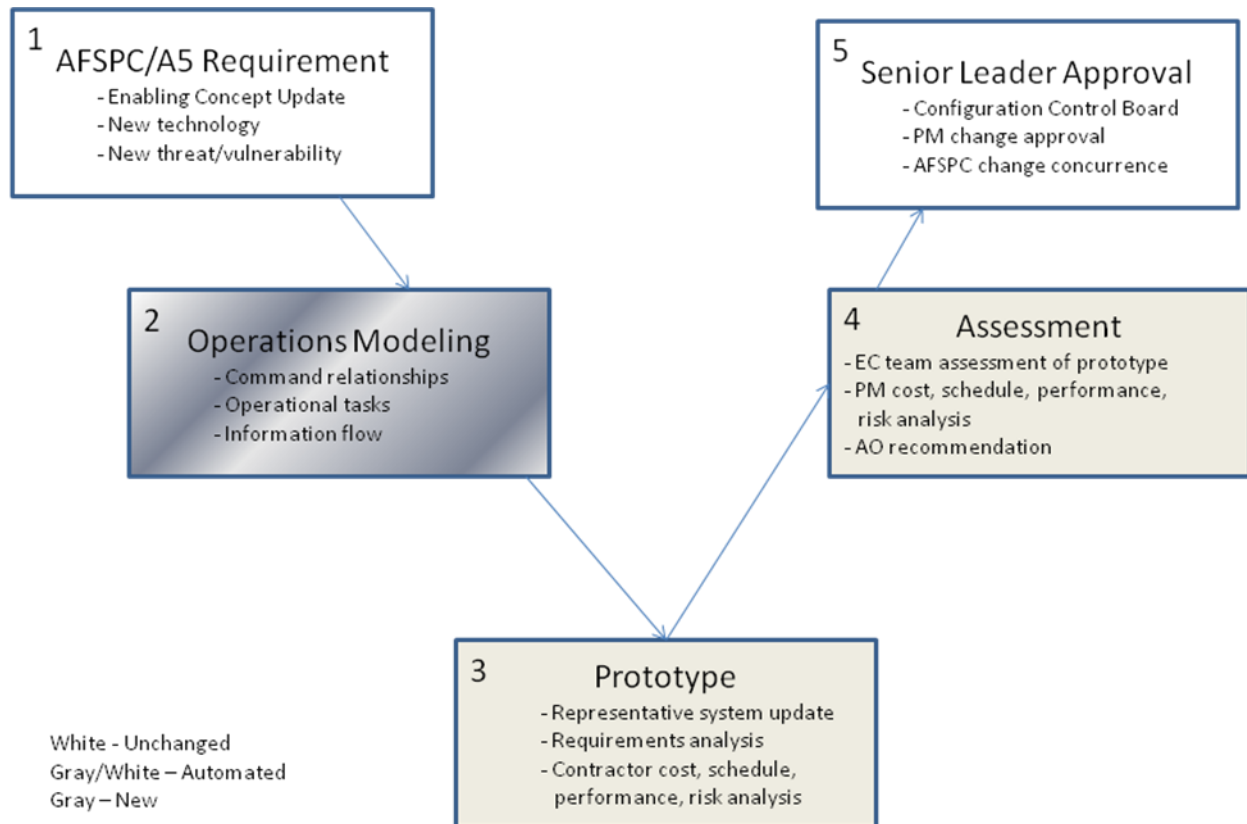
With facts from prototype activities available to decision makers, a fairly straight-forward decision process can be defined. Requirements changes ultimately need to be approved by the requirements manager in AFSPC/A5. Similarly, the development baseline can only be changed with concurrence from the Program Director. In the proposed decision structure changes, the Program Director retains the contract change management function, to include timing of change, so disruption to the baseline design is minimized. AFSPC/A5 ensures any change is truly required by warfighters. The AFSPC AO continues to be the key to connecting the EC and requirements processes facilitating all change decisions.

The process outlined in Figure 3 is one possible decision structure for refining requirements resulting from EC updates. First, through the EC update process, a new capability need is identified (e.g., merge three information displays into one). Next, the change is modeled with process tools<sup>35</sup> to visualize changes to operations decisions, tasks, and information flows (e.g., merging data may reduce task load for one operator but increase task load for another). If the change provides no operational benefit, no further action is required. If the change results in a positive effect, a prototype is developed to visualize the potential EC update. The developer should receive high level capability requirements and be directed to deliver cost, schedule, and

performance impacts, along with a risk assessment of turning the prototype into a change to the product baseline.

Once completed, the prototyped EC change should be reviewed by the EC team and an assessment of the benefit to operations provided to the AO. In parallel, the Program Manager (PM) should review the developer's deliverables and generate an independent cost, schedule, performance, and risk assessment to the AO. The AO's assessment, based on prototype results and the PM's assessment, should form a recommendation to the AFSPC/A5 and Program Director that AFSPC accept, reject, or delay the proposed baseline change.

Of note, steps 1 and 5 (requirement and approval) are unchanged from today's approach. Similarly, step 2 (operations modeling) is conducted today; however, it may not be conducted with automated tools that enable rapid assessment of the change and its impact on information flow. The new aspects of change approval are the additional information received from the prototyping effort, the EC team's ability to assess the change, and the detailed programmatic information now available to the PM to assess the proposed update's impact on the baseline development.



**Figure 3 - Decision Process for Baseline Change**

AFSPC, with the dual responsibility to field operationally useful systems and maintain acquisition program cost and schedule, should require any EC changes be successfully prototyped before being considered for a baseline change. This prototyping should support a cost/benefit analysis so demonstrated operational advantages are determined to be commensurate with the cost of the change. To ensure the acquisition remains on track, the PM must determine if the change can be incorporated into the on-going design (e.g., limited to repackaging information available in the baseline system design) or delayed to the next major upgrade (e.g., redesign of a subsystem). The organizational structure required to implement this guidance must ensure both the program office and headquarters have sufficient visibility and authority to consider the cost, schedule, performance, and risks associated with a proposed change.

## Conclusion

Prototyping is not a new concept; in fact, recent changes to acquisition law mandate competitive prototyping prior to Milestone B<sup>36</sup> because Congress believes prototyping reduces risk to the government. This paper proposes prototyping for risk reduction as well, but focuses on the post-competitive phase of acquisition by addressing the risk associated with changing requirements after establishing the design baseline.

This paper highlights the approaching situation where space-based information requirements will change after the baseline is established at Milestone B. Gaps exist between enabling concept and requirements processes that elongate timelines between warfighter need and fielded materiel solutions because current process rely on key personnel to identify and fix incompatibilities between enabling concepts and requirements. In addition, lack of a prototype impairs the ability of warfighters to visualize the system they will operate until the product is mature.

Implementing a prototype system requires some investment. Funding will be required for the prototype, contractor personnel manning, a prototype lab, and prototype projects. AFSPC will need to designate a dedicated team of experienced operators to interact with prototypes and determine if the enabling concept and system design are compatible. Once fielded, warfighter feedback will need to be rolled in to ensure system upgrade efforts are properly scoped.

An area requiring further study is integration of prototypes from organizations outside the program office. For example, AFSPC's Space Innovation & Development Center (SIDC) produces effective prototypes routinely. This organization brought both Talon NAMATH and the 11 Space Warning Squadron capabilities on line. If integrated into the EC updates and contractually linked to a program of record, SIDC prototypes may lead to an even tighter link

between warfighters and materiel developers – ultimately improving effectiveness and efficiency.

For a small investment (perhaps ten percent of program cost)<sup>37</sup>, AFSPC stands to gain significant credibility by leveraging post-award prototyping to ensure new capabilities are provided quickly to the warfighter. The risk associated with off-line prototyping is minimal as the baseline product is untouched until accountable managers decide the risk of disrupting the development with a new requirement is minimized. Prototyping requirements changes after Milestone B addresses the President’s charge to reduce risk by managing (not freezing) requirements, provides an opportunity to more rapidly insert warfighter capability, and can be implemented to maximize sustainment efficiencies. With several systems in the post-award phase and delivery just around the corner, the Air Force needs to prepare for success -- the implementation proposed in this paper is entirely within AFSPC’s authority and should be considered as a controlled approach to tackling several senior level concerns.

## **Endnotes**

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- <sup>1</sup> Butler, Amy, "Efficiency in Space," *Aviation Week and Space Technology* 172, no. 41 (15 November 2010): 40.
- <sup>2</sup> Percentage based on AF Blue Budget (\$119.6B) documented by United States Air Force, *FY11 Budget Rollout Brief* (Washington, DC): Secretary of the Air Force, 2010, 5, [www.saffm.hq.af.mil/budget](http://www.saffm.hq.af.mil/budget) (Accessed 11 January 2011). Percentage based on AF Blue Budget (\$119.6B).
- <sup>3</sup> Gates, Robert M., "Defense Budget Recommendation Statement" (Testimony, United States Congress, 6 April 2009).  
<http://militarytimes.com/static/projects/pages/gatesbudgetstatement.pdf> (accessed 11 January 2011)
- <sup>4</sup> Gates, Robert M., "Statement on Department Budget and Efficiencies" (speech, Pentagon, Washington, DC 6 January 2011),  
<http://www.defense.gov/speeches/speech.aspx?speechid=1527> (accessed 15 Jan 2011)
- <sup>5</sup> Gates, Robert M., "Defense Budget Recommendation Statement" (Testimony, United States Congress, 6 April 2009).  
<http://militarytimes.com/static/projects/pages/gatesbudgetstatement.pdf> (accessed 11 January 2011)
- <sup>6</sup> Lt Gen Deptula, "We cannot afford that long [acquisition] process in this era. We need to be able to operate much quicker, and inside our adversary's decision loop." Quoted in John A. Tirpak, "The Acquisition Course Correction," *Air Force Magazine* 93, no. 10 (October 2010): 31.
- <sup>7</sup> Tirpak, John A., "The Acquisition Course Correction," *Air Force Magazine* 93, no. 10 (October 2010): 33.
- <sup>8</sup> President, *National Space Policy of the United States of America* (28 June 2010): 6,  
[http://www.whitehouse.gov/sites/default/files/national\\_space\\_policy\\_6-28-10.pdf](http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf)  
(accessed 15 January 2011).
- <sup>9</sup> General Robert Kehler. Quoted in Amy Butler, "Staying Grounded," *Aviation Week & Space Technology* 172, no. 45 (13 December 2010).
- <sup>10</sup> Lambakis, Steven, J., *On the Edge of Earth: The Future of American Space Power* (Lexington, KY: The University Press of Kentucky, 2001), 5-36. Data originating from the high ground of space provides a critical warfighting edge. Warfighters around the world consume space information (processed data collected in and transmitted through space) in order to conduct synchronized operations across air, sea, space, cyberspace, and land domains. Navigation satellites provide positioning, navigation, and timing to ensure forces across the world operate from the same reference data and precision weapons hit their targets. Communications satellites instantly link warfighters providing command and control, urgent message traffic, and critical intelligence information directly to the battlefield. Missile warning satellites provide early detection and warning for attack verification, characterization, warning, and response decisions. Weather and reconnaissance systems provide massive amounts of information for planning, executing, and assessing operations.



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- <sup>11</sup> General Ronald R Fogelman, “The Air Force and the Military Space Program.” In *The U.S. Air Force in Space: 1945 to the 21<sup>st</sup> Century*, ed. R. Cargill Hall and Jacob Neufeld (Washington, DC: Government Printing Office, 1995), 5.
- <sup>12</sup> Scud flight time was approximately 7 minutes while DSP could typically detect an active missile within 30 seconds of launch. Benjamin S. Lambeth, *The Transformation of American Air Power* (Ithaca, NY: Cornell University Press, 2000), 237.
- <sup>13</sup> Ibid.
- <sup>14</sup> Col Steven Winters interview conducted 2 November 2010. Col Winters was a DSP crew commander during the Gulf War and participated in the DSP innovation to alert Coalition forces of incoming scud missiles. Col Winters stated system changes were minimal. Operational procedural changes enabled the DSP data to be used in theater along with reconfigured communication structure for passing critical missile data, such as location and intensity data.
- <sup>15</sup> Israel was defended from most Scud attacks, thus removing a threat to the coalition. Retaliation from Israel was considered unacceptable to some coalition members who were critical to the fight against Iraq. Richard P. Hallion, *Storm Over Iraq: Air Power and the Gulf War* (Washington, DC: Smithsonian Institution Press, 1992), 180 - 184.
- <sup>16</sup> Though the SBIRS system of systems delivery is behind schedule, the ground system was declared operational in 2001. The SBIRS control station at Buckley AFB currently controls DSP satellites and will control all SBIRS assets. Los Angeles Air Force Base official website, “Infrared Space Systems Directorate Fact Sheet”, <http://www.losangeles.af.mil/library/factsheets/factsheet.asp?id=5330> (accessed 15 January 2011). (*Los Angeles*).
- <sup>17</sup> Talon NAMATH reformats data for compatibility with the Link 16 datalink. GPS information is calculated every 15 minutes. However, due to limitations with satellite antenna access, satellites are uploaded with fresh updates roughly once every 24 hours. The fresh information ensures signal accuracy. For most applications, this frequency is sufficient; however, high accuracy missions benefit from Talon NAMATH because the data provided enables a more precise solution. For example, small diameter bombs use Talon NAMATH to reduce kill chain error and reduce collateral damage. Author experience based on 4 years of service in GPS Wing.
- <sup>18</sup> Col Dave Madden, Quoted in Jewell, “Leadership Talks,” *GPS World*, (1 October 2007) <http://www.gpsworld.com/defense/leadership-talks-back-basics-3160> (accessed 7 November 2010).
- <sup>19</sup> Col Roger Vincent, Commander, Space Innovation & Development Center, briefing: “Proactive Innovation as an AFSPC Core Competency,” 4 August 2010, 13.
- <sup>20</sup> United States Government Accountability Office, *Defense Acquisitions: DoD’s Requirements Determination Process Has Not Been Effective in Prioritizing Joint Capabilities*, GAO-08-1060. Washington, DC: GAO Report to the Committee on Armed Services, U.S. Senate, September 2008, 88.
- <sup>21</sup> Ibid, 6.
- <sup>22</sup> Air Force Space Command Instruction (AFSPCI) 10-102, *Concept Development*, 15 November 2008, 11.
- <sup>23</sup> Ibid, 3.

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- <sup>24</sup> Lt Gen Mark Shakelford. Quoted in Tirpak, “The Acquisition Course Correction,” *Air Force Magazine* 93, no. 10 (October 2010): 33
- <sup>25</sup> National Security Space Acquisition Policy (NSSAP) 03-01, *Guidance for DoD Space System Acquisition Process*, 27 December 2004, 4. Per Defense Acquisition University website: “On 23 Mar 08, USD/AT&L rescinded NSSAP 03-01. The interim guidance put in place was essentially a copy of NSSAP 03-01 with Defense Space Acquisition Board (DSAB) changed to Defense Acquisition Board (DAB) and Key Decision Point (KDP) changed to Milestone.” <https://acc.dau.mil/CommunityBrowser.aspx?id=339961> (accessed November 2010). Also, the term “system level conops” (used in NSSAP 03-01, *Guidance for DoD Space System Acquisition Process*) is equivalent to “enabling concept” per AFSPCI 10-102, *Operations Concept Development*, 3.
- <sup>26</sup> Ibid, 11-12.
- <sup>27</sup> Ibid.
- <sup>28</sup> Defense Acquisition University training module. “*RQM 110: Core Concepts for Requirements Management*.” Defense Acquisition University, Module 6, page 21 “Systems Engineering” July 2010 (training date).
- <sup>29</sup> Author experience based on 20 years of acquisition experience.
- <sup>30</sup> Air Force Space Command Instruction 10-102, *Operations Concept Development*, 15 November 2008, 3-4.
- <sup>31</sup> Author’s recent experience supporting HQ AFSPC efforts to establish the Enabling Concept for GPS Next Generation Operational Control Segment (2007 – 2010) in parallel with system preliminary design.
- <sup>32</sup> Air Force Space Command motto. <http://www.afspc.af.mil/heritage/afspcembem.asp> (accessed 6 Dec 2010)
- <sup>33</sup> Author’s opinion based on 20 years of acquisition experience.
- <sup>34</sup> Baseline control, or configuration control, is often overlooked as merely a data management function executed by technicians and not required to be tracked or understood by managers. However, for information systems in particular, configuration control is sometimes the only way to fully comprehend the product in development and planned enhancements (based on the author’s personal experience).
- <sup>35</sup> “Business Process Modeling (BPM) is the representation of current (“as is”) and proposed (“to be”) enterprise processes, so that they may be compared and contrasted. By comparing and contrasting current and proposed enterprise processes business analysts and managers can identify specific process transformations that can result in quantifiable improvements to their businesses.” Business Process Modeling Forum. <http://www.bpmodeling.com/faq> (accessed 16 January 2011). BPM can help the EC author visualize how information flows between commanders, operators, and decision authorities in order to optimize operations and understand how changes affect the overall system when incorporated. Since BPM products can be represented visually as process flows, accurate depiction of the current and future processes needed to execute a mission provides key information needed to fully understand the EC impact of a proposed system change. The author is indebted to MITRE corporation for introducing the concept of BPM and drawing analogies with the GPS ground system.
- <sup>36</sup> 111<sup>th</sup> Congress, *Public Law 111-23, 10 USC Section 203, Weapon Systems Acquisition Reform Act of 2009: Prototyping Requirements for Major Defense Acquisition Programs*, ” 22

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*May 2009.* <http://www.gpo.gov/fdsys/pkg/PLAW-111publ23/pdf/PLAW-111publ23.pdf>  
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<sup>37</sup> Cost will depend on the requirements in the contract.

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