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SPACE-BASED SPACE SURVEILLANCE LOGISTICS CASE STUDY: A QUALITATIVE PRODUCT SUPPORT ELEMENT ANALYSIS

by

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This research provides a qualitative analysis of the logistics impacts, effects, and sustainment challenges presented to the Space Based Space Surveillance Block 10 System. Two large program changes were the focus of this study: a change in operations concept from a contractor operated to a USG/Blue Suit operated system and a change in system security level. The qualitative analysis/case study was conducted using the 10 core Product Support Elements (PSEs) as outlined in the Defense Acquisition University's *Integrated Product Support Element Guidebook*. Findings presented that all 10 of the PSEs were affected, with 6 of the 10 core PSEs requiring substantial adjustment. Manpower and Personnel was arguably the PSE most affected by both system changes.

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SPACE-BASED SPACE SURVEILLANCE LOGISTICS CASE STUDY: A QUALITATIVE PRODUCT SUPPORT ELEMENT ANALYSIS

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ABSTRACT

This research provides a qualitative analysis of the logistics impacts, effects, and sustainment challenges presented to the Space Based Space Surveillance Block 10 System. Two large program changes were the focus of this study: a change in operations concept from a contractor operated to a USG/Blue Suit operated system and a change in system security level. The qualitative analysis/case study was conducted using the 10 core Product Support Elements (PSEs) as outlined in the Defense Acquisition University's *Integrated Product Support Element Guidebook.* Findings presented that all 10 of the PSEs were affected, with 6 of the 10 core PSEs requiring substantial adjustment. Manpower and Personnel was arguably the PSE most affected by both system changes.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACAT	Acquisition Category
AFSCN	Air Force Satellite Control Network
AFTO	Air Force Technical Order
DAU	Defense Acquisition University
DOD	Department of Defense
DSC	Defensive Space Control
GS	Ground Segment
GSOL	Ground Systems Operations Lab
ICE	Independent Cost Estimate
IPA	Independent Program Assessment
LC	Life Cycle
LS	Link Segment
MDA	Milestone Decision Authority
MIT/LL	Massachusetts Institute of Technology/Lincoln Labs
MP/MDP	Mission Planning/Mission Data Processing
MSX/SBV	Midcourse Space Experiment/Space Based Visible
NGMS	Northrop Grumman Mission Systems
OSC	Offensive Space Control
PDM	Program Decision Memorandum
PM/PSM	Program Manager/Product Support Manager/Management
PSE	Product Support Element
RSO	Resident Space Object
SBSS	Space Based Space Surveillance
SMC/SYSW	Space Missile Systems Center Space Superiority Systems Wing
SOI	Space Object Identification
SOPS	Space Operations Squadron
SS/SV	Space Segment/Space Vehicle
SSA	Space Situational Awareness

USAF	United States Air Force
USD/AT&L	Undersecretary of Defense/Acquisition Technology and Logistics
USECAF	Under Secretary of the Air Force
USG	United States Government
USN	Universal Space Network

EXECUTIVE SUMMARY

This research examines the effects to acquisition logistics and system sustainability for Space Based Space Surveillance (SBSS) Block 10 System when experiencing significant program changes to the operational concept and security posture. As a primary objective, the research presents the challenges for effective SBSS Block 10 life cycle sustainability that evolved as a result of the planned transition from a contractor operated system to a USG/Blue Suit Operated system. As a secondary objective, the research offers logistics challenges that were presented by a subsequent change in security level. This report also provides findings, results, conclusions, and recommendations, as well as presenting areas for future research.

The research analyzed data from multiple program sources, including system briefings and key program documentation such as the SBSS Block 10 Life Cycle Management Plan, Concept of Operations, Maintenance Plans, Labs-and-Links Support Briefs, and other system support documents. Other source documents included studies from the RAND corporation, Defense Acquisition University, and similar supporting studies. The main source and methodology for the qualitative logistics analysis was the Defense Acquisition University's *Integrated Product Support Element Guidebook*.

First, the SBSS Block 10 system operational concept acquisition logistics challenges and changes were presented using the Defense Acquisition University (DAU) Product Support Elements (PSEs). It was concluded that all 10 of the PSEs were affected, with 6 of the 10 PSEs impacted significantly and arguably the greatest impacts noticed in the Manpower and Personnel, Training, and Technical Data areas. All 10 elements required consideration for support impacts, with many elements significantly intertwined as the program changes evolved.

Second, the SBSS Block 10 system security level acquisition logistics challenges and changes were presented using the DAU PSEs. It was again concluded that all 10 of the PSEs were affected, with 4 of the 10 impacted significantly and arguably the greatest impacts noticed in the Manpower and Personnel, Facilities and Infrastructure elements.

All 10 elements required consideration for security impacts, with many security level changes requiring implementation of logistics related changes across functional areas.

Finally, the conclusions, and recommendations are presented. The findings from the research concluded that the acquisition logistics and sustainment baseline was impacted significantly as a result of the operational concept and security level program changes. All 10 PSE areas were impacted by these larger program changes, with the greatest changes to the Manpower and Personnel, Training and Training Support, and Facilities and Infrastructure. Product Support Management and Design Interface are also covered, but only in a general manner. Conclusions from the study were then outlined, with recommendations for areas of further research to close the report.

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This project would not have been possible without the support and supreme assistance of my advisors, Professor Brad Neagle and Professor John Dillard. Their steadfast patience and willingness to support three hectic deployments, a cross-country move, three new assignments, and an extensive international travel schedule over the last two years was paramount to completing this research. Ronda Spelbring in the front office and Janice Long in the Thesis Processing Office were both amazing, keeping me motivated, moving, and on task for all the required and last-minute Joint Applied Project submission requirements. I would also like to thank my current employer for allowing me to take time out of the office to apply my full concentration to this effort. Finally, I would like to thank my strongest supporters and biggest advocates, my friends and family.

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I. INTRODUCTION

"You will not find it difficult to prove that battles, campaigns, and even wars have been won or lost primarily because of logistics."

— General Dwight D. Eisenhower

Aboard a Minotaur IV launch vehicle, a revolutionary new space situational asset dubbed the Space Based Space Surveillance (SBSS) Block 10 satellite, took to orbit on September 20, 2010. This satellite was pegged as the next generation augment for the Space Situational Awareness battle-space/space fence concept and offered a significant enhancement for tracking resident space objects and space object identification. But the acquisition was not without challenges, experiencing numerous launch delays, from changes in system requirements, technical challenges in space vehicle development, to concerns with the launch vehicle and changes in software acquisition strategies.

Along with and directly tied to these program delays, were substantial program changes that subsequently rolled into new logistics and sustainment support challenges. The challenges spanned the logistics support elements enterprise, from maintenance and facilities/infrastructure to training and manpower. Despite these challenges, the government and industrial enterprise worked together to ensure a very complex and critical program was launched with a supportable operations and maintenance footprint. However, numerous lessons learned can be taken away from the acquisition, specifically, how critical program changes to operations and training concepts and security environment affected the overall support posture for the system, including potential impacts to system product support management.

A. BACKGROUND

1. Space System and Satellite Acquisition

Space System and satellite acquisition has always been a complex and challenging endeavor. The vast types of missions expected from these systems and satellites, the cutting edge technology needed to meet this missions, and the expected service life for today's satellites can create nightmares for DOD Program Managers expected to meet tighter and tighter budget and schedule constraints while ensuring continued system performance and either minimal or zero gap in mission coverage between existing and new capabilities. But those challenges can be amplified for a Space Product Support Manager or Acquisition Logistician who typically has much less decision making authority and even less cost and schedule flexibility. But in order to better understand the PSM's logistics challenges, let's examine the space system acquisition life cycle visually. Figure 1 is an excerpt from the Defense Acquisition University Executive Program Management Course presentation (Rosenthal, 2015, slide 44).

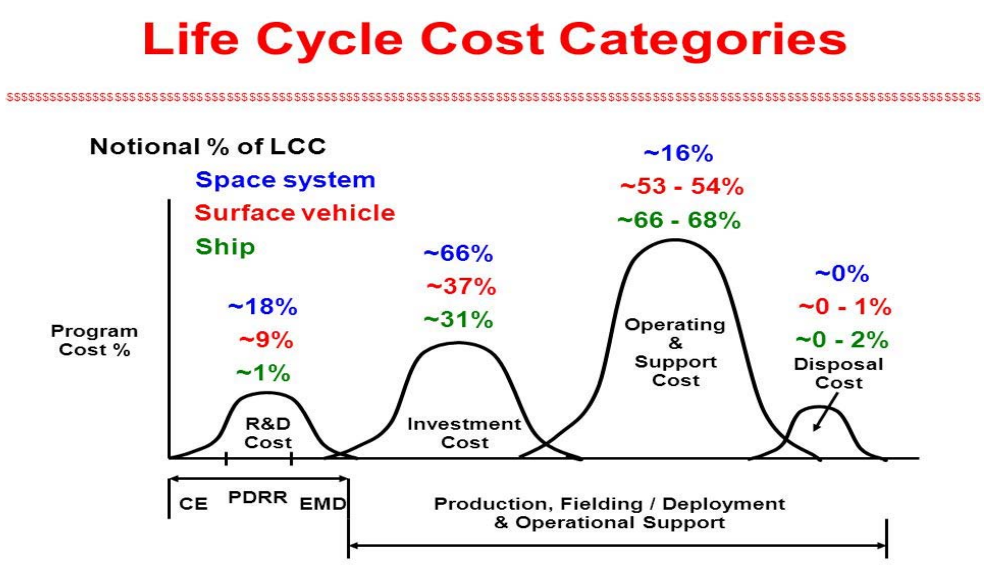


Figure 1. Space System vs. Traditional System Life-Cycle Cost Comparison. Source: Rosenthal (2015).

While the actual percentage of system life cycle costs for space acquisition varies from study to study (many core/non-space LC cost charts follow a 10–30-60 split for R&D, Investment, and Operations and Support respectively), the above chart provides an excellent comparison of these core/non-space or satellite systems when compared to most space systems similar to SBSS Block 10. Over 80% of space system life cycle cost is expended during the R&D and Investment, leaving only 20% for system operations and sustainment. However, there are many reasons why this is a logical construct for acquiring space systems.

According to the RAND published “Acquisition of Space Systems: Past Problems and Future Challenges,” there are a few important reasons why much of space system life cost is dedicated to the R&D and Investment phases. Most space acquisitions include low-quantity buys (greatly increasing unit cost), have a limited industrial base (requiring highly technical skills with significant levels of education), require very stringent standards for components (space qualified with high reliability), are technologically complex with limited to no ability to repair hardware on-orbit cost effectively. (Axelbrand, et al., 2015, pp.41-44). For these reasons, up-front expense on satellite programs is significant.

With this in mind, many Program Managers are simply focused on the investment and research and development stages, as that is where most of the up front budget and schedule is allocated. There is also a mindset among PM’s is that Acquisition Logistics is something that can be “fixed later” or assume their Acquisition Logisticians or Sustainment Engineers are “handling the issues.” Some PM’s are simply focused on keeping the program alive or keeping the program moving (since many USG PM’s are only leading a program for 3–4 years) so they can get to operations and sustainment, which can certainly make planning for logistics and sustainment challenging, even more so when you have less resources (maybe 20% of program’s budget) to address any challenges that may arise. To put it simply, Space System Acquisition Logistics and Sustainment can be a hair-raising experience. The next section will try to cover the types of logistics challenges programs may experience outside of the limited acquisition logistics and operations and sustainment budget and mindset's that are prevalent in space system acquisition.

2. Space and Satellite System Logistics Support and Sustainment Challenges

As outlined in the previous section, space system and satellite acquisition can be a difficult and complex task. The logistics and sustainment aspects can be equally as challenging, since many of the repercussions of management decisions must be solved in a reactive manner due to the ever-evolving and complex nature of these programs. These challenges span the logistics enterprise and although not necessarily specific to space programs, they can take on a life of their own.

One challenge always present is the highly complex and cutting edge nature of the space and satellite programs. Many times, acquisition and sustainment logisticians are trying to plan to support a system that provides capabilities or is executing a mission not seen before. In these cases, parametric analysis of like or similar systems is sometimes the best (and only) means to plan for sustainment. The "like systems" science isn't perfect, but it provides a bedrock for solid system support analysis. Another logistics and sustainment challenge present in supporting space systems is ensuring planning for systems requiring an evolutionary acquisition approach. While it's possible for some ground system footprints that support a satellite to effectively support future satellites or satellite capabilities, future capabilities and the infrastructure support for these capabilities must be considered. Although requirements may be met for an initial space system or satellite spiral, accounting for future spiral capabilities is critical for follow-on system success.

Probably the biggest challenge to space acquisition logistics and sustainment is the ever-present danger of a change in requirements (Lorell, 2006, p. 61). Long development cycles for space systems generate more opportunities for requirements changes, obsolescence, or unanticipated technical problems. Additionally, changes in any one system segment often require changes in the other segments with significant cost and schedule implications. Acquisition and sustainment logisticians must plan for change as much as possible, and at times, react to these changes as quickly as possible in a constrained fiscal environment and time frame. And though adjustments for system requirements changes by logistics aren't always immediately needed, many changes require significant lead time and compete with R&D and Investment funding for execution (Lorell, 2006, p. 117).

In an effort to understand some of SBSS Block 10's logistics and sustainment challenges, it is important to review the acquisition history of SBSS Block 10.

3. MSX-SBV & Space Based Space Surveillance Block 10 Program History

The SBSS Block 10 program was a new program start in FY02 originally programmed to follow a normalized acquisition process. However, given a forecasted operational gap caused by the expected end-of-life for MSX/SBV (the predecessor/pre-cursor of SBSS), the SBSS program was given additional funding through an FY03 Program Decision Memorandum to accelerate SBSS Block 10 and effectively replace the MSX/SBV sensor. This acceleration resulted in a unique acquisition strategy and contractual structure in order to meet the goal of launching SBSS Block 10 by its original target launch date of Dec 2006. Problems with this construct and challenges with satellite development necessitated a contract restructure and program re-baseline in 2006–07 (SMC, 2009).

The Milestone Decision Authority (MDA) for SBSS was initially delegated from Under Secretary of the Air Force (USECAF) to Air Force Program Executive Officer for Space, who approved the acquisition strategy for the SBSS Block 10 program in Mar 03. Consistent with the original program funding levels and MDA delegation, SBSS was designated an ACAT 2 program (SMC, 2009).

In order to meet the FY03 Program Decision Memorandum (PDM) schedule, the government required a streamlined acquisition approach. At that time, Northrop Grumman Mission Systems (NGMS) was on contract with the Space Superiority Systems Wing (SYSW), providing system and engineering services across the entire SYSW portfolio. The contract vehicle also allowed for them to support or lead acquisition efforts such as preparing solicitations, executing source selections, and awarding contracts; this construct was put into effect for the SBSS Block 10 effort. NGMS subsequently awarded a subcontract to the Boeing/Ball/Harris Team in early 2004 to develop, build, and launch the SBSS Block 10 program, after a prolonged source selection due to a change in the government strategy for launch vehicle procurement (to the Minotaur IV). The delay in contract award shifted the target launch date from Dec 06 to Jun 07 (SMC, 2009).

Due to cost growth through 2005 and the 3-tiered contractor structure limiting government visibility and control, the government and contractor team initiated a significant overhaul in program structure. NGMS relinquished the majority of the role as prime contractor, retaining only contract administration responsibilities. The government negotiated agreements to gain direct access to Boeing as the prime for all but contract administration matters. Additionally, Massachusetts Institute of Technology / Lincoln Laboratory (MIT/LL) was added to the team to develop and deliver Mission Planning / Mission Data Processing (MP/MDP) capability, leveraging their expertise with MSX/ SBV. Due to past cost growth, on 22 Dec 2006 the USECAF notified Undersecretary of Defense for Acquisition, Technology, & Logistics (USD/AT&L) that SBSS had exceeded the cost threshold for Acquisition Category 1 (ACAT 1). (SMC, 2009) As the new program Milestone Decision Authority (MDA), USD/AT&L directed generation of an Acquisition Program Baseline (APB), and the conduct of an Independent Cost Estimate (ICE), an Independent Program Assessment (IPA), and for the program to meet a Defense Space Acquisition Board (DSAB).

During this process, the SBSS program office conducted a detailed Integrated Baseline Review (IBR) to set a high-confidence, risk-reduced, and executable cost and schedule baseline. This baseline captured system safety elements (including logistics support, operations & maintenance, and mission assurance) not built into the original program due to budgetary constraints and the original acquisition strategy. The APB objective and threshold dates for launch availability are June 09 and December 09 respectively, with an objective program cost of $825.8M (TY) (SMC 2009). The launch was eventually changed to September 2010 due to concerns with the launch vehicle.

Thus, a program that was scheduled to take 4 years from inception to launch to almost 8 years and 3 times the budget.

4. Summary

The previous background provides important context for the research that will be presented in this report. Both space system and satellite acquisition are difficult endeavors with unique life cycle considerations and challenges. These considerations and challenges were briefly covered, with a short history of SBSS Block 10 offered for additional report context.

B. PROBLEM STATEMENT

The Problem Statement for this research is best summarized as outlined in a RAND Project Air Fore study authored by Lorell, Lowell, and Younossi:

> "In Evolutionary Acquisition Systems such as SBSS,
> Logistics ends up taking it in the shorts"
>
> — Random program manager

While this colorful phrase was made to characterize the evolutionary, or Block build nature, of the SBSS System, it's no less accurate when it comes to how significant programmatic changes can affect acquisition and life cycle logistics and system sustainment.

Large program changes can complicate logistics planning (and life-cycle cost analysis) by leading to a proliferation of different system logistics challenges. While most life cycle logisticians can anticipate and plan for some significant system level changes, large program scope changes can create additional complexities and costs that will be incurred and may not be affordable under the established program baselines. It is these second and third level effects to logistics and sustainment that must be considered when moving forward in a space system acquisition such SBSS and the hope is to illustrate some of these effects in this research paper.

C. RESEARCH OBJECTIVES

The objective of this research to present the overarching acquisition logistics and sustainment impacts that can be experienced by a satellite program when system baseline changes are introduced. While these program changes are not typical (operations ownership/organizations and security levels are typically decided at program inception), the subsequent logistics and sustainment impacts are far from routine. The overarching objective is to present the SBSS Block 10 System as a case study for other similar systems that may undergo similar operations concept and security requirements changes so others can account for similar program changes on future space or satellite systems.

D. RESEARCH QUESTIONS

Primary Research Question: The main question of this research is to answer the question, “What challenges for effective SBSS Block 10 life cycle acquisition logistics and sustainability evolved as a result of the planned transition from a contractor operated system to a USG/Blue Suit Operations?”

Secondary Research Question: The secondary question we outlined is, “What logistics and sustainment challenges were presented to the SBSS Block 10 System by the change in security level?”

E. PURPOSE/BENEFIT

The purpose of this paper is to present changes experienced during the development and acquisition of SBSS Block 10 and methodically outline the logistics impacts and the challenges that arose from these changes, using the DAU Integrated Product Support Elements of Life Cycle Logistics, and qualitatively asses the sustainment impact of each change. The overall goal and benefit of this research is to provide experienced logistics changes from the SBSS Block 10 acquisition and give other space system logisticians an idea of how military operations and program management decisions above execution level can affect integrated product support and sustainability at the lowest level. This research also provides a foundation of noticeable changes to SBSS Block 10 program cost, schedule, and performance that these two major system changes may have impacted. The purpose is not to present every logistics element change or exhaustively examined, but outline some of the more noticeable and impactful changes that an acquisition logistician may experience in similar circumstances.

F. SCOPE/METHODOLOGY

The scope of this research is limited to the SBSS Block 10 satellite system. The SBSS Block 10 system in this research refers to the ground segment, space segment, link segment, and the supporting labs and sustainment facilities necessary to execute 24 hours a day/7 days a week/365 days a year operations and maintenance activities. The methodology used for this analysis is qualitative in nature, although some quantitative data is also presented to support the analysis. The main analysis tool used for this research is the DAU *Integrated Product Support Element Guidebook* and the Product Support Framework presented in that document. The core ten elements outlined in the DAU *Integrated Product Support Element Guidebook* provide the majority of the core analysis, with the overarching two elements (Design Interface and Product Support Management) mentioned briefly.

G. THESIS STATEMENT

This study will present the impacts and challenges that two major changes to SBSS Block 10 System acquisition. The focus will be on a significant change in operations concept and change in the system security baseline. The analysis is qualitative in nature and will use DAU’s 10 core Integrated Product Support Elements to describe the logistics and sustainment changes experienced by the Acquisition Logisticians as these two major program baselines were implemented. The two overarching elements of Product Support Management and Design Interface will be discussed briefly in the findings section.

H. REPORT ORGANIZATION

Chapter I of this research provides key background information for the research presented to included space program life cycle planning, typical space system logistics and sustainment challenges, and the SBSS Block 10 system acquisition history. Chapter

II presents the main tools used in the research, as well as a system description to provide the context for how these tools relate to SBSS Block 10. Chapter III provides a qualitative product support element-by-element review for both research questions. Chapters IV and V present the findings, results, conclusions and recommendations.

I. SUMMARY

This chapter outlined space system life cycle background information for space and satellite acquisition and common logistics and sustainment challenges experienced in space acquisition. A History of SBSS Block 10 acquisition was also provided to help set the stage for the follow-on research questions and objectives, purpose/benefits, scope/methodology, and overarching thesis statement.

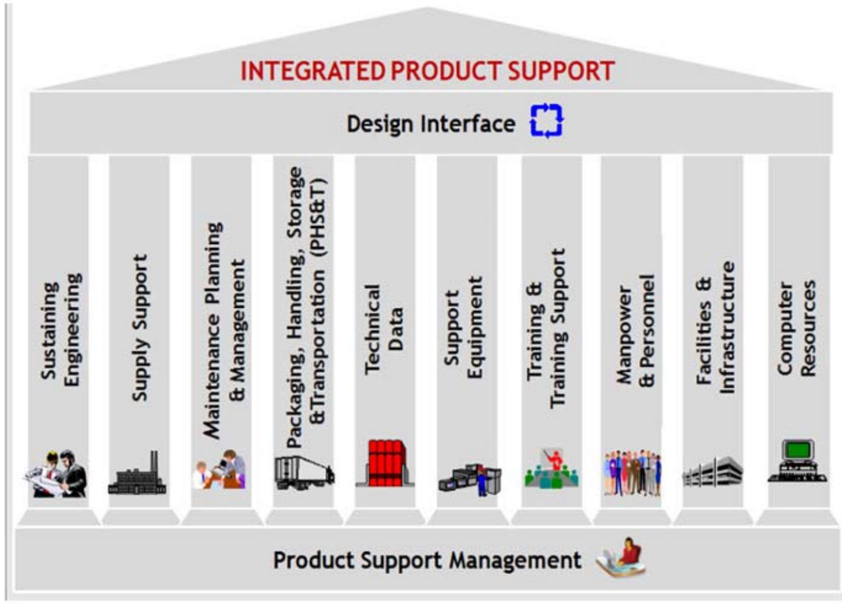
II. INTEGRATED PRODUCT SUPPORT ELEMENT AND SYSTEM REVIEW

This chapter outlines the basis for the qualitative analysis presented in this research paper. The first objective is to present the Defense Acquisition University (DAU) Product Support Elements (PSE) used for the analysis, as well as the Life Cycle Logistics Support Framework that these PSEs construct. Additionally, the SBSS Block 10 system description that these PSEs would be analyzed against should also be presented to provide the reader with the context needed to understand the impacts to sustainability of the system and the individual system components (Space Segment, Ground Segment, and Links) that are required to execute SBSS Block 10's daily mission.

A. DEFENSE ACQUISITION UNIVERSITY PRODUCT SUPPORT ELEMENT GUIDEBOOK

Defense Acquisition University (DAU) has long been at the leading edge of Acquisition Logistics and Product Support Studies and Analysis for defense systems. Although space systems are inherently different from both an acquisition and sustainment perspective, the elements set forth by DAU still serve as an effective means to plan for and analyze the support posture.

The 10 PSEs at the core of this qualitative analysis are outlined below. As part of this outline, typical space system applications of these elements are also presented. Product Support Management and Design Interface are not covered as part of the core PSEs, but are included as the glue that bring these 10 core elements together. The PSE space considerations are not comprehensive or all-encompassing, but rather provide the author with the context that a typical Product Support Manager, Space Acquisition Logistics Manager, or Sustainment Specialist would have as a general foundation for their work. A graphical representation of these elements can be found in Figures 2 and 3.



a

b

Figure 2. Two Variations: DAU Integrated Product Support Elements. Source: DAU (2017).

NOTE: DAU has presented two interpretations of the PSE construct. The first focuses on the core ten elements represented in Figure 2a, with Design Interface and Product Support Management as overarching PSEs intertwined with the core 10 PSEs. DAU most recently outlines twelve PSEs, with Design Interface and Product Support

Management part of the Technical Management and Life Cycle Sustainment, respectively, and assessed independently (outlined in Figure 2b). For the purpose of this research, we will be focusing on the core ten elements represented in Figure 2a.

Sustainment Engineering (Technical Management) – "The objective of the Sustaining Engineering Element is to support in-service systems in their operational environments" (DAU, 2017e). For space systems, sustainment engineering typically focuses on collection and analysis of operations and maintenance performance data (to include root cause analysis and failure and correction action) and system characterization Diminishing Manufacturing sources is also another key focus area, with additional stress placed on technical refresh and anomaly resolution.

Supply Support (Life Cycle Sustainment Management) – "Supply support consists of the management actions, procedures and techniques necessary to acquire, catalog, receive, store, transfer, issue and dispose of spares, repair parts, and supplies" (DAU, 2017l). In the context of space and satellite systems, supply support typically refers to the initial provisioning efforts, how initial and spare assets are stored at production, lab, and operations facilities, and how these assets are transferred and issued.

Maintenance Planning and Management (Life Cycle Sustainment Management) – "Maintenance planning and management involves developing, implementing and managing the maintenance requirements, concept, and detailed procedures for a system" (DAU, 2017k). For many space and satellite systems, this includes both preventive and corrective maintenance actions/procedures needed to keep the system at maximum efficiency, as well as an on-orbit maintenance required such as degassing, satellite movements, or other space vehicle centric activities.

Packaging, Handling, Storage, and Transportation (PHS&T) (Life Cycle Sustainment Management) – "PHS&T refers to the combination of resources, processes, procedures, design, considerations, and methods to ensure that all system, equipment, and support items are preserved, packaged, handled, and transported properly, including environmental considerations, equipment preservation for the short and long storage, and transportability" (DAU, 2017h). For space and satellite systems, this includes Packaging and Handling for Operations Center and Lab Support assets, as well as transportation of the space vehicle and launch vehicle to the pre-launch destinations. Environmental considerations tend be strictest for the space and launch vehicle development pre-launch, with the highest standards paid to clean room conditions. Post-launch focus for PHS&T typically stress the safe, secure, and effective movement of ground support assets (servers, simulators, computer components, associated spares, etc.). Asset sanitization, physical security, and electrostatic discharge protection are paramount.

Technical Data (Technical Management) – "Technical Data represents recorded information of a scientific or technical nature regardless of form or character necessary to acquire, operate or support the weapon system" (DAU, 2017g). For space and satellite systems, this element is central to maintaining and updating space system operations, maintenance, and engineering support documentation. These include operations and maintenance checklists, technical orders, and on-orbit engineering books. Secondarily, technical data for the ground system (ops floor and maintenance room) drawings are also included, but tend to remain fairly static in a post-launch environment.

Support Equipment (Infrastructure Management) – "Support equipment consists of all equipment (mobile or fixed) that is not inherently part of the primary weapon system but is required to support the operation and maintenance of the system" (DAU, 2017i). For space and satellite systems, post-launch support equipment tends to be fairly generic and commercially available (multimeters, ESD benches, etc.). Pre-launch support equipment can be more specialized, specifically support equipment needed at the launch and space vehicle manufacturing facilities.

Training and Training Support (Infrastructure Management)- For space systems, "training and training support includes the policy, processes, procedures, techniques, Training Aids Devices Simulators and Simulations (TADSS), planning and provisioning for the training base including equipment used to train civilian, contractor, and military personnel to acquire, operate, maintain, and support the system" (DAU, 2017f).

Manpower & Personnel (Infrastructure Management) – "The Manpower and Personnel function for space systems involves the identification and acquisition of personnel (military and civilian, contractor and general schedule) with the skills and grades required to operate, maintain, and support systems over their lifetime" (DAU, 2017j). Most manpower and personnel supporting space systems is held at the operations ground locations, with additional personnel supporting the space system at the ground support labs, depot facilities, and factories.

Facilities and Infrastructure (Infrastructure Management) – "Facilities and infrastructure consists of the permanent and semi-permanent real property assets and infrastructure required to support a system, including studies to define types of facilities and infrastructure, or facility and infrastructure improvements, location, space needs, environmental and security requirements, and equipment" (DAU, 2017d). For most space systems, this is focused on the ground station, operations centers, and associated depot and lab support facilities that support the ground stations and ops centers.

Computer Resources (Technical Management) – "Computer resources are the information technology resources and infrastructure required to operate and support mission critical systems to include manpower, personnel, hardware, software, and documentation such as licenses and services" (DAU, 2017a). For space systems, especially ground systems, the computer resources requirement is substantial, with multiple towers of servers, modems, and data processing equipment to support mission execution. The Product Support Management and Design Interface Product Support Elements are the "glue" that hold the core 10 elements together.

Product Support Management (Life Cycle Sustainment Management) – "Product Support Management (PSM) is the development and implementation of product support strategies to ensure supportability is considered throughout the system life cycle" (DAU, 2017b). Space systems, from an enterprise PSM perspective, are treated similarly to other operational systems in USAF inventory, although the PSM tends to be significantly more focused since space systems typically only have a small number of ground support locations and satellite systems on a support network (although there are larger systems like the Global Positioning System that can be massive in size).

Design Interface (Technical Management) – "Design interface is the integration of the quantitative design characteristics of systems engineering (reliability, maintainability, etc.) with the functional logistics/integrated product support elements" (DAU, 2017c). For space systems, there is a substantial focus on the reliability and (Insert reference from GAO/Space Ops Study) and maintainability, especially on the space vehicles since once they launch, there are no physical means to repair broken components (all repairs are typically done with software patches submitted across a linked network).

B. SBSS BLOCK 10 SYSTEM DESCRIPTION

SBSS Block 10 is a DOD Space Acquisition Category (ACAT) 1C program that provides space surveillance capabilities to satisfy Space Situational Awareness (SSA) needs of the warfighter. This system represents a significant improvement in SSA for Resident Space Objects (RSO) and Space Object Identification. SBSS achieves space superiority through the execution of successful Offensive Space Control (OSC) and Defensive Space Control (DSC) missions. SSA is the enabling function of OSC and DSC missions. To achieve SSA, SBSS employs capabilities with the coverage and sensitivity to completely sense the entire area of regard. The level of awareness of the operational environment provided by SBSS Block 10 permits commanders to correctly anticipate future conditions, assess changes to the operational picture, establish priorities, exploit emerging opportunities, and act with a degree of speed and certainty not matched by adversaries (Perkins, 2007, p. 2–6).

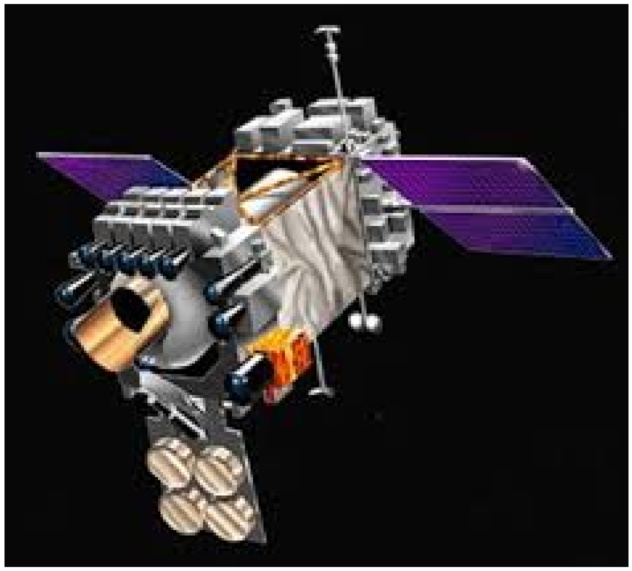


Figure 3. MSX-SBV — The Predecessor to SBSS Block 10. Source: Gunter (2017).

The mission of SBSS Block 10 is to perform space-based space surveillance operations as part of a Family of Systems (FoS) in support of the United State Strategic Command Space Control mission. SBSS Block 10 supports space situational awareness (SSA) objectives by collecting metric and Space Object Identification (SOI) data of man-made resident space objects (RSOs). SBSS Block 10 searches on a nominal state vector, or on a specified volume or area in space. SBSS Block 10 operates 24 hours a day, 7 days a week to serve users who require space situation awareness of deep-space objects. SBSS Block 10 contributes data from observations to the Space Surveillance Network to update the Space Catalog (Perkins, 2007, p. 5).

SBSS Block 10 delivers space surveillance capabilities to satisfy SSA needs of the warfighter, filling the gap left by MSX/SBV's end-of-life (EOL) (See Figure X). As a new capability, SBSS Block 10 is part of a "Family of Systems," interoperable with existing systems, and enhancing the global reach of command, control, communications, computers, and intelligence (C^4I) for Air Force Space Control. (Perkins, 2007, p. 2)

The Space Operations Center (SOC) receives and responds to mission tasking from outside agencies. Satellite ground stations (e.g. Air Force Satellite Control Network (AFSCN), Universal Space Network (USN)) located within the U.S., U.S. territories and/

or leased facilities located in neutral and allied nations provide the data network. The SOC handles the SBSS satellite telemetry, tracking and commanding. Figure 5 below is a graphical representation of the SBSS Block 10 System Life Cycle (Cooper, 2011, p. 3).

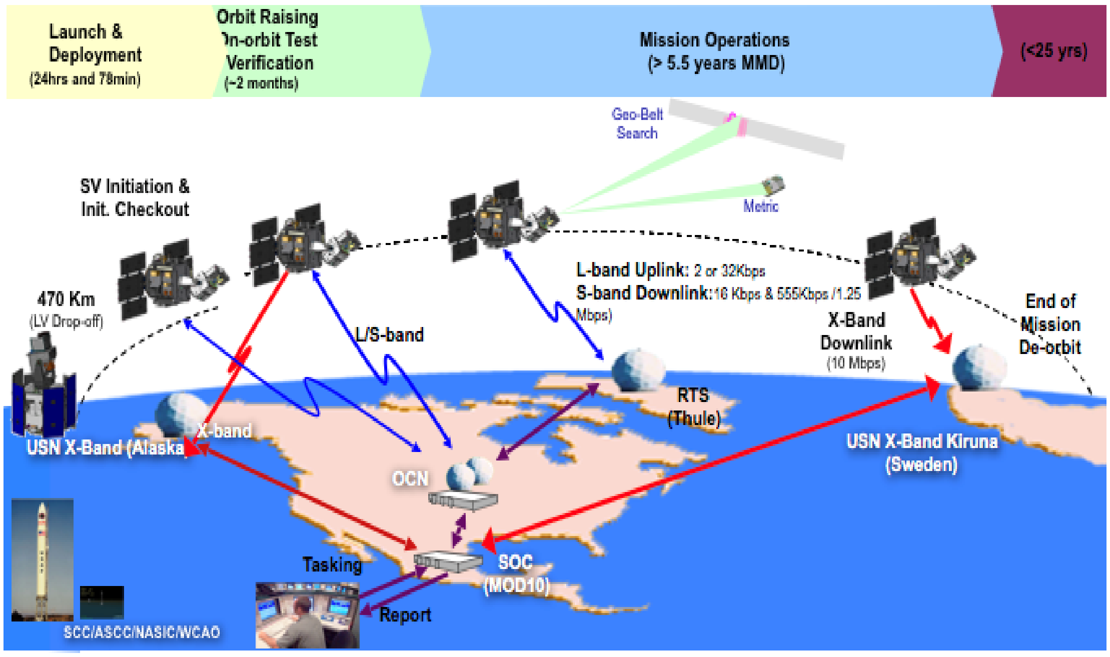


Figure 4. SBSS Block 10 System Life Cycle. Source: Cooper (2011).

SBSS Block 10 is an end-to-end space control system comprised of three segments: a space segment, a ground segment, and link segment.

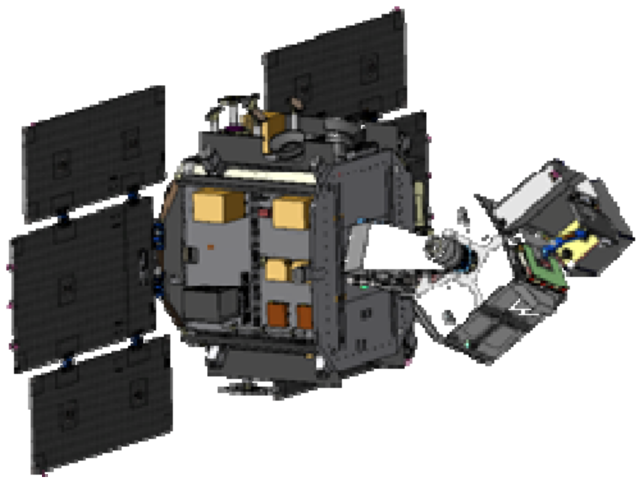


Figure 5. SBSS Block 10 Space Vehicle (SV): Source: Amedee (2007).

The Space Segment (SS) consists of a single satellite with a spacecraft bus, the surveillance sensor(s), and sensor subsystems. The SS also consists of Space Vehicle (SV) launch support test equipment which includes the Spacecraft Test Operations Console (STOC). The SV encompasses the various subsystems required to provide the on-orbit operational capability. The SV is further divided into spacecraft bus and payload (both pictured above in Figure 6).

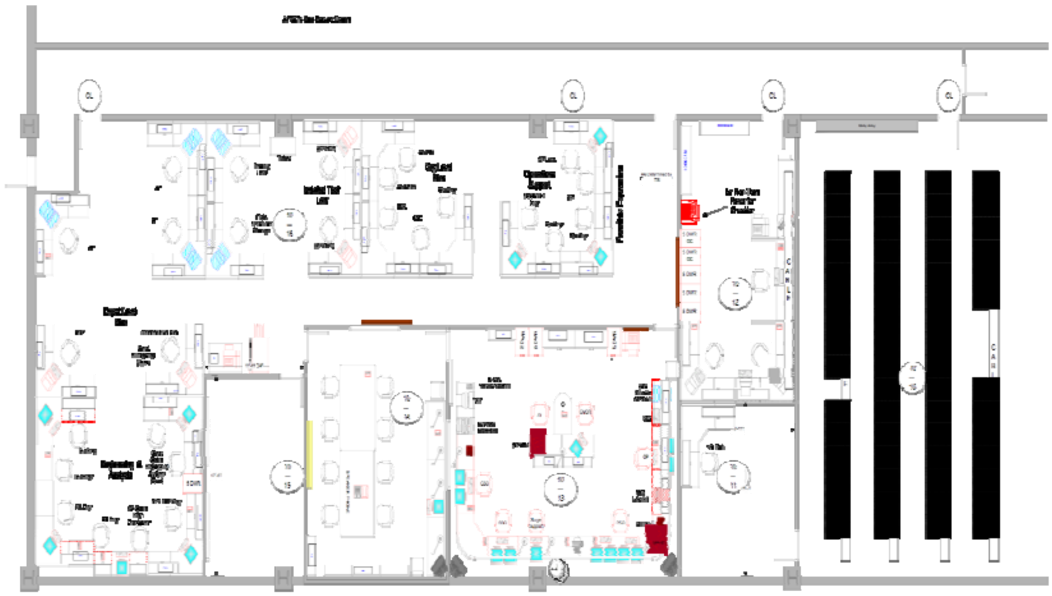


Figure 6. SBSS Block 10 MOD Layout. Source: Bacon & Anderson (2009).

The ground segment (GS) provides satellite control, mission operations, and interfaces to users and the command structure (e.g., for SSA) operated from the Satellite Operations Center (SOC) in MOD 10. (Bacon/Anderson, 2009, pp. 10-C-5) The Ground Segment (GS) consists of a SOC, the associated hardware and software, and the supporting organizations. The GS components are:

- Ground facilities and equipment
- Data processing
- Interfaces to communications
- Maintenance and logistics resources
- Training and Simulation resources

The GS provides the focal point for operational command and control of the SBSS Block 10 system. The GS is responsible for all aspects of mission and satellite space operations, including initial and ongoing on-orbit operations, maintenance, and anomaly resolution. The GS is comprised of both dedicated and shared resources. The GS provides the interface to receive mission tasking and SBSS Block 10 operational direction, and to transfer requested observations, data and system status to the requesting agencies. A visual diagram of Ground Station interconnectivity is presented below.

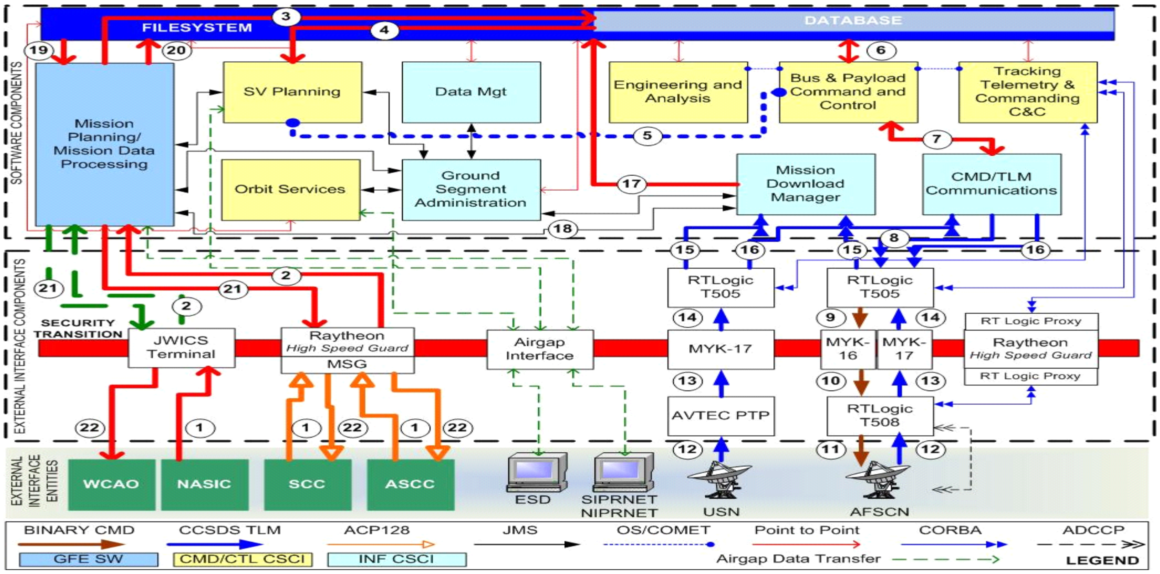


Figure 7. SBSS Block 10 Ground Segment Layout. Source: Bacon & Anderson (2009).

The Links consist of the Air Force Satellite Control Network (AFSCN) uplink and down-link and a high-data rate service provider (Universal Space Network) downlink. The closed loop communications links provides the infrastructure needed to perform command and control (S-Band) and mission operations (S-Band and commercial X-band). The mission data links are of sufficient capacity to support mission operations.

C. SUMMARY

This chapter provided the DAU PSEs that will be used for the qualitative analysis central to this research, as well as the system description that will provide further context for how these PSEs were affected by the selected system changes. The next chapter will provide the qualitative analysis of the DAU Product PSEs.

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III. DATA ANALYSIS

This chapter presents the 10 core PSEs analyzed for the SBSS Block 10 System and the qualitative impacts to those PSEs when assessed in reference to the primary and secondary research questions presented in Chapter II. Section A will present the core PSEs and the outcomes experienced in regards to those PSEs when the program made the decision to transition from contractor to Blue Suit operations. Section B will address the secondary research question and present potential challenges or impacts to SBSS Block 10 PSEs as a result of the program change in security levels. The final two PSEs will be addressed in the Findings and Results details in Chapter IV.

A. PRIMARY RESEARCH: TRANSITION FROM CONTRACTOR TO BLUE-SUIT OPERATIONS: PRODUCT SUPPORT ELEMENT ANALYSIS FOR SUSTAINABILITY

In March 2006, HQ Air Force Space Command was designated as operational control for the Space Based Space Surveillance Block 10 system and assigned the 1st and 7th Space Operations Squadrons (1 SOPS/7 SOPS) as the units responsible for carrying out day-to-day mission execution. With this designation, the operations concept changed from a contractor operated system by Boeing and Ball System specialists to United States Air Force Officer and Enlisted crews, or Blue Suit personnel. With this new Blue Suit operations concept came numerous changes to the Logistics and Product Support requirements for SBSS Block 10. The data analysis for the core 10 product support elements is presented below.

1. Sustainment Engineering

Sustainment engineering, or the support of in-service systems in their operational configuration, was certainly affected by the transition from contractor operations to USAF operations. Instituting Blue Suit Operations changed the way that maintenance data would be collected, analyzed, and stored. In a greater and related sense, anomaly resolution processes and discrepancy reporting procedures were adjusted to adhere to normalized Blue Suit operations protocols rather than any contractor established anomaly or discrepancy reporting processes. Finally, additional consideration for system upgrades and technology refresh options was now needed, ensuring minimal interruption to Air Force and external customer operations and battle rhythms.

Throughout system inception and development, Program Managers expected that contractor maintenance data collection methods would be used throughout the SBSS Block 10 System life cycle. This collection of data was to be accomplished on a contractor-selected maintenance data collection (MDC) system and if required, reported to Air Force higher HQ through a Maintenance Functional Representative stationed at AFSPC. However, when Blue Suit operations were dictated, the requirement evolved to ensure SBSS Block 10 maintenance data was accounted for on an approved MDC, such as the Integrated Maintenance Data Collection System (IMDS) or a properly classified system such the Logistics Information and Operations Network (LIONs) (Nelson, 2010, Slide 4). While this wasn't a significant long term complication, this created a duplication of maintenance data reporting by the contractor maintenance team until the proper database infrastructure was established in the USAF approved system.

Anomaly resolution and discrepancy reporting was also slightly affected by the introduction of Air Force operations. Boeing and Ball Aerospace, for the most part, did a great job mirroring Air Force Anomaly Resolution and Discrepancy Reporting processes. However, when these processes were initially developed, the contractors assumed their main interface for reporting system issues involved both high level 1 and 7 SOPS (Operations Officers and Commanders), 50 SW, and AFPSC leaders. When Blue Suit crews were introduced, the initial involvement required Air Force incorporation as low and the Air Force Crew Commander (typically a Captain or Lieutenant) and required inclusion of Air Force crew and support tram members throughout the Anomaly Resolution and Discrepancy Reporting processes. While the change was small, it was an important change to ensure that USAF personnel were involved in both Space Vehicle and Ground System problems as soon as an issue was identified by contractor operations, maintenance, and engineering entities. A sample process diagram incorporating Blue Suit agencies is presented below.

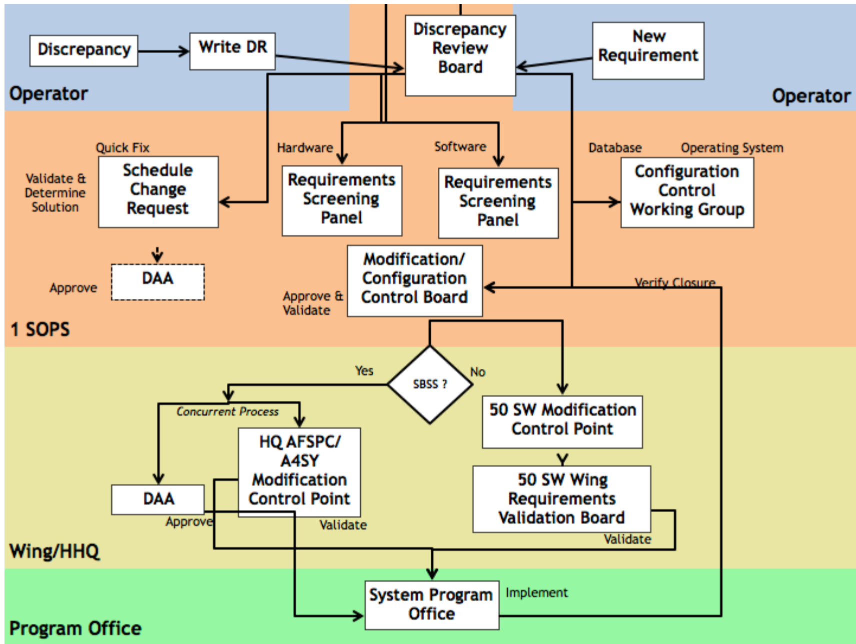

Figure 8. 1-7 SOPS Discrepancy-Anomaly Resolution Process. Source: Thompson (2009).

SBSS Block 10 Technological Refresh and System Upgrade Rules of Engagement were also slightly modified due to the change from contractor to Blue Suit operations. The plan or systems upgrade or technical refresh would always require significant USAF coordination after on-orbit operations commenced because of the requirement to support all SBSS Block 10 customers with minimum system downtime. Ground System Hardware and Software Upgrade Builds would always have to be done independently of the Operations LAN and system battle rhythm, with a large amount of testing and interface assessments conducted at the Ground Systems Operations Lab, System Support Facilities, or in the final stages, the mirrored Sustainment LAN. However, with the introduction of Blue Suit operations, the contractor now had to consider Blue Suit Operations, Training and Maintenance events before introducing significant changes to the system orientation. Additionally, many of these changes would require significant modifications to the technical and training documentation baseline supporting the Blue Suit crews. While the overall coordination points would be minimal, the changes to Blue Suit support products introduced during a system upgrade or modification are massive, potentially delaying implementation of a system upgrade or technical refresh activity for weeks or months.

2. Supply Support

Instinctually, many logisticians might think the supply support concept might be altered substantially by a change from contractor to Blue Suit operations. However, sound supply chain management practices were considered from program inception regardless of whether the system was to be operated by contractor or USAF personnel. Likewise, initial provisioning for supplies and support equipment, remained consistent regardless of the operations concept for SBSS Block 10, with only minimal modification to support timelines to account for additional asset processing.

The main difference between the contractor and Blue Suit operations for Block 10 supply support was the new level of coordination required when planning to ship assets off station and additional cataloguing required to maintain inventories in the appropriate supply accounting systems. With the Air Force now managing operations, Air Force personnel must also know when system assets will be down and important items will be moved off station and into the supply system to ensure the highest mission availability (Cooper, 2011, Pages 27–28). Additionally, with the required Air Force operational use of the Standard Base Supply System (SBSS) to track some of these assets, the contractor was required to catalogue many commercial assets into the supply chain management systems required to be used by the Air Force. These changes weren't substantial, but still required consideration for providing logistics supply support.

3. Maintenance Planning and Management

Maintenance Planning and Management didn't change too significantly when the Blue Suit Operations were designated instead of contractor operations. Maintenance, in a general sense, was always planned to be a contractor performed function. This included organizational level maintenance performed on equipment in the MOD 10 equipment room, as well as maintenance at the supporting intermediate maintenance locations such as Boeing Support Center/Ground Systems Operations Lab in Colorado Springs and depot maintenance locations such as the Ball Aerospace Space Vehicle Support Facility in Boulder, Colorado, Ogden Air Logistics Center at Hill AFB, Utah, and MIT Lincoln Labs in Lexington, Massachusetts. Despite the lack of change in the relative maintenance concept, there were some special considerations that needed to be addressed regarding maintenance planning and management.

One of these considerations was Air Force control of maintenance windows and special coordination of maintenance planning windows with outside Air Force and other DOD agencies. Because SBSS Block 10 has the flexibility to be tasked in relatively short mission planning windows/cycles by multiple outside agencies, maintenance down time had to be carefully coordinated to ensure that mission data customers were aware of and approved of necessary system down time. While this was anticipated to a certain extent anyway since these agencies were always planned as end users/customers of SBSS Mission data, Air Force instruction and communications policies needed for Blue Suit mission support required additional coordination with 50 SW and Schriever AFB Maintenance organizations. Contractor crews would have had additional flexibility to conduct maintenance operations that Blue Suit crews would not due to the already established external agency reporting requirements. Blue Suit approval and support for contractor and maintenance activities could also be required, further lengthening the maintenance planning cycles.

A second maintenance planning and management consideration was the contracted reliability and system availability requirements levied on the contractor by AFSPC, SMC, and SYSW. Prior to Blue Suit transition, USAF events that could affect the contracted system dependability were minimal and the contractor had considerable leverage to plan around and schedule any events that may have an effect on the reported dependability metrics. However, when USAF personnel were introduced, the contractor was required to make additional considerations (especially scheduled USAF maintenance and training events) when reporting system uptime and down-time. Additionally, there were now other events (like incorporation of 50 SW or unit-level exercises) that could effect when the system would be available to be tasked by outside agencies or external customers.

4. Packaging, Handling, Storage, and Transportation (PHS&T)

Changes to the PHS&T PSE wasn't necessarily attributable to the migration from contractor to Blue Suit operations. Operations and maintenance locations that were established to support Blue Suit facilities would have been established regardless of the operations entity. Since many SBSS mission assets remained stationary and permanent once installed at the SBSS Block 10 SOC (and some support locations), most shipping and handling activities entered around spare commercial assets not yet introduced to the system or items that were required at the intermediate support or depot facilities. Some pre-launch activities required Blue-Suit escort and specialized handling and containers, especially the movement of the space vehicle from factory to the launch site (Cooper, 2011, pp. 30–32). Occasionally, the requirement for USG/Blue Suit operations escort and coordination of classified and sensitive system materials from USAF facilities to contractor facilities could affect PHS&T timelines. For the most part, though, changes to PHS&T timelines attributable due to the Blue Suit Operations concept, overall, were minimal.

5. Technical Data

One of the largest changes experienced as a result of designation of Blue Suit operations was to the technical data. Not only did the manuals need to move from contractor format to Air Force Technical Order (TO) specifications, but numerous operations checklists needed to be generated in an effort to expedite and smooth and seamless transition to Blue Suit operations. Maintenance and engineering manuals so support Anomaly Resolution in a "TO-like" format were also required in the event that maintenance operations eventually transitioned to Blue Suit/uniformed personnel.

During the early development of the Space Operations Center Operations Manuals and procedures, Boeing and Ball Aerospace were only required to develop manuals to their own company/internal specifications and were generally able to cater the manuals to the expected level of education that would be held by their floor operators, who typically had a college, graduate, and sometimes postgraduate computer science/ engineering degrees and/or significant experience (8-10 years for operations, and up to

15–20 years for their back shop and space vehicle engineering positions) in Space Operations or Information Technology development. Upon HQ AFSPC assignment of 1 and 7 SOPS as the operational authority for SBSS Block 10, the technical data strategy changed significantly.

Of particulate note, the background of the designated Air Force operators varied significantly from their would-be contractor counterparts. Although perfectly capable of handling the SBSS Block 10 mission work-load when provided the proper training, a typical USAF space operator expected to pull ground crew duty/and operations floor shift had only a high school diploma (and maybe some college) and 5–10 years (sometimes less) of actual space operations experience. Their technical school and associated ops floor experience provided a solid foundation for them to "learn the ropes" of SBSS Block 10, but the learning curve was steep and margin for error, even more so.

In an effort to prepare the Air Force operators for work on a program along the complexity of SBSS Block 10, the contractor (with the help 1 and 7 SOPS seasoned space operators) began work on streamlined operations checklists and Blue Suit Technical Orders that provided step-by-step instructions for routine day-to-day operations scenarios. These manuals needed to be written in approved Air Force Technical Order format (Nelson, 2010, Slide 7). Once these manuals were certified and verified (by a combined contractor and USAF team), they could only be changed using a rigid and formalized Technical Order change process called the Air Force Technical Change Order Form 22 (AFTO 22) process. While contractor data and contractor changes to the technical would require a robust change management process as well, the AFTO technical data management process is catered to USAF processes and procedures and required the contractor support team to issue all future updates in an approved AFTO format.

The Blue Suit Operations team were not the only USAF personnel that needed to be accounted for during the system transition. When Blue Suit Engineers were brought in to support USAF operations, it was determined that Anomaly Resolution would be performed by a combined seasoned contractor and USAF Anomaly Resolution team. In this case, the contractor technical documentation supporting back shop engineering required some modifications to accommodate USAF engineers, although this change was minimal (only “TO-like’ at most) since most engineers initially brought in to support SBSS Block 10 were seasoned in space operations. That being said, Ball Aerospace satellite support engineers typically arrived with a more focused engineering background and most had significant years of experience in satellite operations/engineering support, while USAF Engineers earned degrees spanning from civil, electrical, and aeronautical to electrical engineering, requiring some time up front for system familiarization. Overall, while the experience levels between contractor and Blue Suit engineers could vary substantially, only minor inconveniences existed since Air Force Specialty Code 62E’s (Engineering) and Boeing/Ball Space Vehicle Engineers would work together to solve any on-orbit issues that may arise.

6. Support Equipment

Support equipment for SBSS Block 10, regardless of operations responsibilities, did not vary significantly. In some space acquisitions, there are USG/Blue Suit Only owned support equipment used in daily operations and sustainment activities (Cooper, 2011, pp. 27). However, these systems are rare and if they do exist, are many times readily available to contractor personnel, especially if the contractor if operated for a USG owned/operated facility. Additionally, the contractor is also typically required to design space and satellite systems similar to SBSS Block 10 to be supportable with standard support equipment, most of which is commercially available. Since most satellite ground stations also use a significant amount of commercial equipment (severs, computers, cables, racks, etc.) in their design, standard and non-unique support equipment is built-in by default.

7. Training and Training Support

The training concept supporting SBSS Block 10 changed radically once an Air Force unit was designated to take over system operations. As mentioned earlier, technical documentation supporting the training required significant re-formatting to accommodate officer and enlisted USAF personnel. Instead of the engineers that designed the system, some with many years of operational experience, the Air Force would man the operations center. The education levels and background of the USAF crew commanders and ground crews would vary greatly from the contractor manned force, as would the crew construct and supporting engineering and backstop engineering expertise. Additionally, an Air Force Training Flight/Element/Training Shop was required, Air Force test standards and test documentation needed to be established, and any Training Devices required certification (also called the SIMCERT process) and creation to Air Force training standards.

Since many of the Air Force operators would be enlisted with various educational backgrounds (from high school education to undergraduate degrees and 5–10 years in space operations was the baseline standard), the training documentation used to support the SBSS Block 10 training program needed to be generated to support the lowest experience and education level of an operations crew member. This was done via a Type-1 Training Program, or a Train-the-Trainer, where a small cadre of more experienced and educated USAF operators were trained by the contractor, provided contractor courses, and given all SBSS Block 10 System documentation to develop an “in-house” training program (Colarco, Benz, & Haywood, 2010, p. 30). This small cadre of Air Force operators then generated their own Air Force conducted and maintained training program for both current 1/7 SOPS operators or any new operators that may be on the system in the future.

After the USAF training program was developed, a Training Flight needed to be established. This shop consisted about three or four USAF Officer and Enlisted personnel that were responsible for generating and maintaining all training documentation to include crew certification exams, personnel training records, simulator and emulator training standards, and all classroom instruction materials.

The Training Flight (DOUT referenced in Figure 10 above) also became responsible for all Squadron refresher training, currency training for all 1/7 SOPS crew personnel, and re-training for any operators that may be have been de-certified on crew during on-orbit operations (Colarco, Benz, & Haywood, 2010, pp. 12–15). While the Training Shop may have been a small piece of the puzzle, it was a vital function required for USAF personnel to ensure continuous and effective SBSS Block 10 on-orbit mission execution since contractor operators would only be needed to maintain training for the initial operations period and only for contractor operators. In addition to the change in the Training Materials and the Organization needed to maintain them, a USAF certified/ approved simulator was also required for steady-state SBSS Block 10 training. Initial Type-1 and Air Force Training was conducted using multiple contractor-developed tools such the Space Vehicle Simulator, Mission Simulator, On-Board Mission Data Processing Tool, and the Sustainment Local Area Network. However, these were mainly developed for contractor training use and were not adequate for sustained Air Force Training requirements.

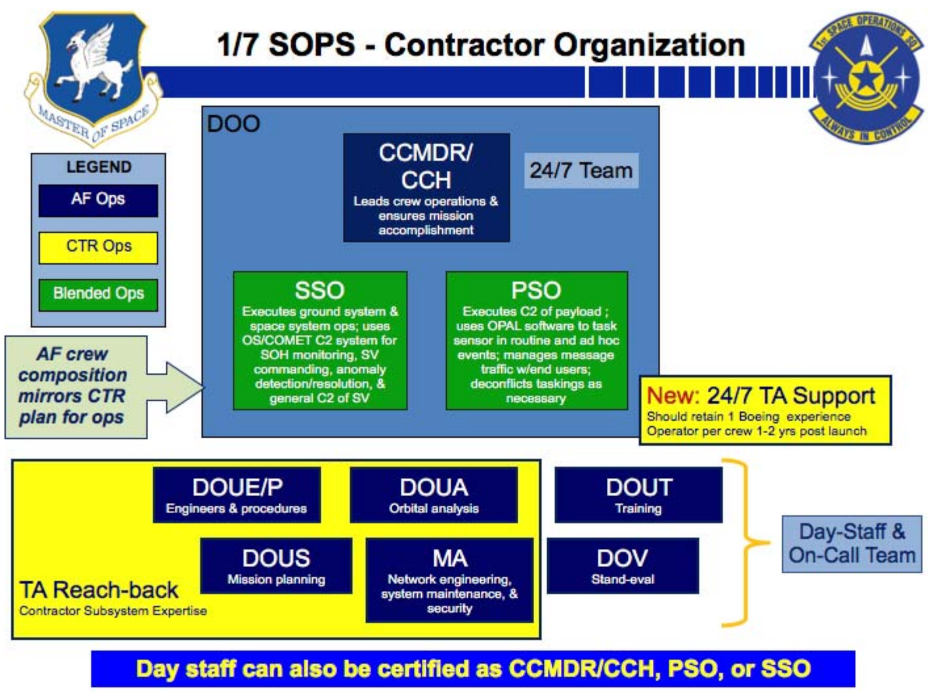

Figure 9. 1/7 SOPS Contractor Organization and Crew Structure. Source: Thompson (2009).

Air Force Space Command (AFSPC) requires that all Air Force utilized system training devices go through a stringent certification and approval process (called SIMCERT) before sustained use by Air Force operators. (Colarco, Benz, & Haywood, 2010, pp. 18–19). Additionally, AFPSC also levied a new requirement on SBSS Block

10: a new Space and Missile System Center program called the Standardized Space Trainer (SST) that was intended to standardize training simulators across the space portfolio. While SST would eventually provide SBSS Block 10 with a Simulator that would meet AFSPC SIMCERT requirements, it was a capability that was not budgeted in the original program baseline. So while SBSS Block 10 waited for the SST requirements to be fleshed out, modifications to the existing contractor training systems were executed to meet most SIMCERT requirements, as well technical documentation and training waivers to support both Type-1 Training and USAF Training programs.

8. Manpower and Personnel

As stated in the Background, the original plan for Block 10 was to have a "turn-key" system where development and operations contractors were responsible for designing, developing, launching, and operating the satellite for an aggressive FY06 launch deadline. This "Space Cowboys" concept would replace a contractor operated extension of the MSX/BV demonstration that had proved itself as a great source of space track and ROI data. However, it was limited in maneuverability and was on it's last legs for providing useful operations data. As the utility of MSX/SBV was necessary to complement the situational awareness, the Air Force stepped in as the agency chosen to operate the follow-on system, SBSS Block 10.

With this new operations agency, the operations concept changed dramatically. In order for HQ Air Force Space Command and 1/7 SOPS to take control of the system, the Blue Suit manpower requirement needed to be generated. After similar space mission and parametric manpower analysis, it was projected that it would take around 33 Air Force manpower billets (11 officer, 22 enlisted) (1-7 SOPS, 2007). HQ AFSPC then sent the requirement to USAF HQ A1 HQ Air Force function (Manpower and Personnel), who validated the requirement and allocated needed budget in the Program Objective Memorandum (POM) for Operations and Maintenance personnel. Once the budget was received and approved, a Unit Manning Document was socialized and the Air Force began assigning personnel that have the right skill sets and experience to operate the system. The manning request and allocation process took a significant amount of time, and at a basic level, only acquired the people at the operational locations in the positions they are intended to fill. This took around 1.5 years of planning and did not account for the system specific training that the space operations crews needed prior to arriving to 1/7 SOPS.

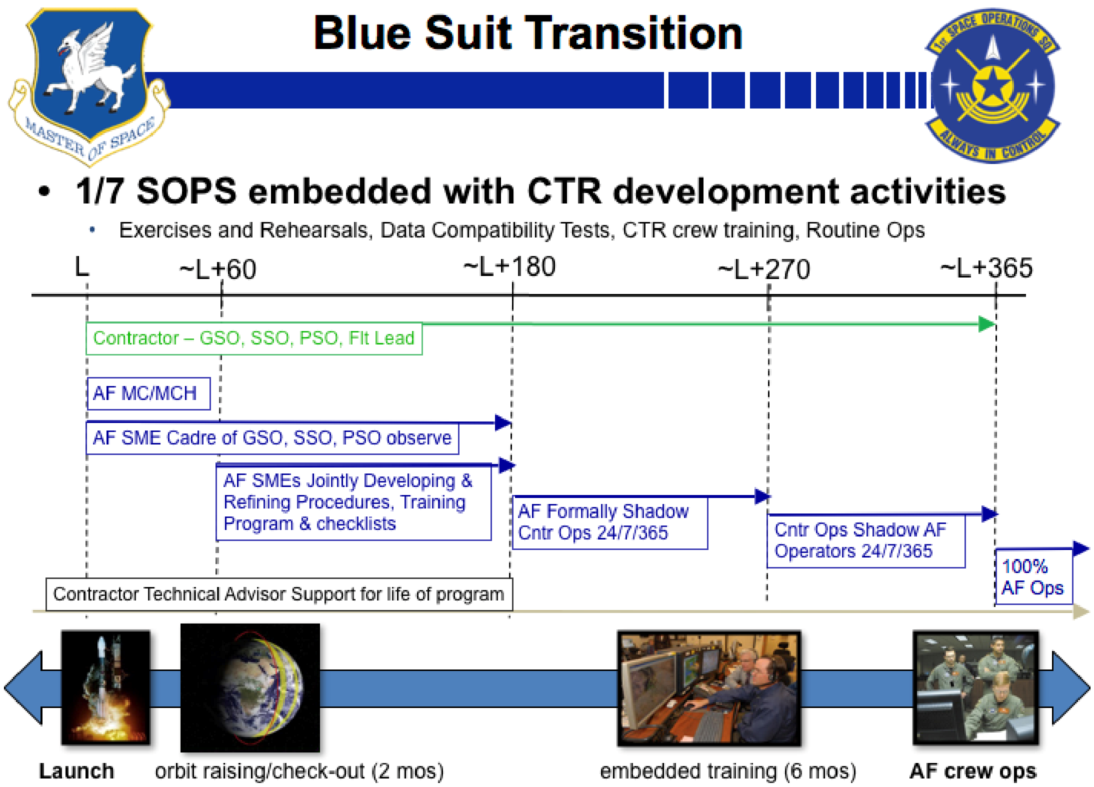

Figure 10. Transition Timeline Blue-Suit to Contractor. Source: Thompson (2009).

9. Facilities and Infrastructure

Facilities and infrastructure experienced minimal change as part of the system evolution from contractor to Blue Suit operations. The plan since program inception was to operate out of a U.S. installation (Schriever AFB) with limited contractor facilities support and no facilities location change was necessary as a result of assigning 1 or 7 SOPS as the operational owner. The location was always planned at MOD 10, and any associated depot support and test facilities in support of MOD 10 would have been required regardless of the whether the system was contractor operated or maintained.

However, there were modifications to existing facilities required to accommodate some of the Blue Suit operations and maintenance training. This included training and test terminals that were installed at the depot to provide off-line training when Space Operations training assets were unavailable to train Air Force operators. This also, for a short time, included test and training connections to the Sustainment LAN at the SOC (which was dual proposed as a training system). Additionally, and while not necessarily specific to Blue Suit Operations, a more robust space vehicle simulation suite was added to the SOC (Mission and Space Vehicle Simulators) to provide a more realistic training system for use by Blue Suit Operators when conducting off-line system training.

10. Computer Resources

Computer resources at the operational location weren't necessarily affected by the change to Blue Suit operations, but as already mentioned, additional resources were added to the Space Operations Center to accommodate Blue Suit training. This included the more robust SV simulator (an entire new rack of computer equipment) and the institution of a Training Virtual Local Area Network, also referred to as the Sustainment LAN. Although these assets are key training components for Air Force operators, many of the contractor personnel were part of the system design team and generated many of the contractor operations procedures and tools needed for them to train on the system.

B. SECONDARY RESEARCH: ACQUISITION LOGISTICS AND SUSTAINMENT CHALLENGES PRESENTED BY THE CHANGE IN SBSS BLOCK 10 SYSTEM SECURITY LEVEL

This section presents the 10 core PSEs analyzed for the SBSS Block 10 System and the qualitative impacts to the secondary research question presented earlier in Chapter III. For this particular section, no mention of specific classification levels will be mentioned, only the changes required of the SBSS Block 10 program due to the change in security levels.

1. Sustainment Engineering

Sustainment engineering was definitely impacted by the change in system security level. Maintenance data was required to be collected, maintained, and reported on a different classification of Maintenance Data Collection System. Also, anomaly resolution processes and discrepancy reporting procedures had to be adjusted to ensure that during any system anomaly or discrepancy data (and supporting corrective and support actions) were communicated and maintained at the appropriate classification levels. Additional consideration for system upgrades and technology refresh options was needed, ensuring any added external interfaces or new system hardware/software was encrypted and protected at the proper classification levels.

SBSS Block 10 System Maintenance Data was always expected to maintained by the contractor and reported in accordance with approved SOC standards, but the change in classification added a new wrinkle. Maintenance data needed to be moved to different maintenance data system called LIONS (Nelson, 2010, Slide 7). Any communications for anomalies and discrepancies had to be communicated over appropriate secure phones or computer networks that were at the same level of the reported anomaly or discrepancy and any new system hardware or upgrades not only had to meet the strict technical requirements to meet/exceed mission requirements, but also had to be accredited and certified to the same standard.

2. Supply Support

Supporting SBSS Block 10 became a bit more challenging with the evolution in the security environment. Any supply assets entering the SOC or associated support facilities required additional review and scrutiny, at the points of receipt, as well as prior to entering any operational environment. Also, supply assets requiring repair underwent a rigorous review and sanitization effort prior to leaving the SBSS Block 10 Space Operations Center or associated support facilities. Any mission assets entering the disposal phase required a significant sanitization and/or destruction phase. Between asset review, sanitization, and disposal actions, outside of an emergency protocols, supply support for the SBSS Block 10 could be delayed an extra 3–5 days.

3. Maintenance Planning and Management

The maintenance planning and management function wasn't too affected by the change in security level. Since almost all maintenance for SBSS Block 10 was done in secured ground facilities (with the exception of SV software maintenance patches), there was little to no impact to on-equipment maintenance actions. There was some additional security coordination required to move any system patches on disk that couldn't be sent via email, but procedures for moving software had been established and were already in place for all units occupying a MOD on Schriever AFB. Maintenance actions on SBSS Block 10 could also take longer due to additional security and approval steps required before maintenance could begin and end, as well as additional security steps that may have been needed during patch installation or server removal processes. Overall, however, changes to maintenance due to security level were manageable.

4. Packaging, Handling, Storage, and Transportation (PHS&T)

The Package, Handling, Storage, and Transportation functions experienced some changes as a result of the change in security level. Whether it was a simple change to how components were readied for shipment or as complex as how an asset should be sanitized or destroyed upon disconnection from the SBSS Block 10 mission system, additional considerations were notable.

Packaging and Handling program assets or system components for SBSS Block 10 took special care and consideration. Packaging changes focused especially on ensuring accurate security markings on both the asset itself and the packaging used to move the asset. Handling of certain mission assets could only be done by properly approved and personnel cleared to the correct security levels. Handling throughout the SOC was typically done at the same security level, however, certain material handling needed to be restricted to designated locations in the SOC.

Storage and Transportation mechanisms also needed to be adjusted. Heavy duty safes constructed to specific DOD standards were required for specific system hard drives, and any mission system or support media needed to catalogued, tracked, and properly accounted for (by an assigned media custodian) until it was destroyed.

Additional secure taping and locking mechanisms were required for moving mission system and support assets from one location to another. Some transportation movements also now required more than one courier, increasing manpower needed for carriage of items from one geographic location to another.

5. Technical Data

Technical Data management was also a special consideration for security once the SBSS Block 10 system began system operations. While many process checklists could remain at a lower classification level, there were checklists and support documentation needed to adjusted to account for the appropriate classification. Some of these changes were as simple as an adjustment in security markings, yet others required changes in how these assets were managed, both inside and outside of the MOD 10 SOC.

Initial operations procedures for contractor operations were generic in nature and generated mainly to support the planned support concept for contractor operations and support. Once the security level changed, these operations procedures needed to be reviewed and moved to an Air Force managed network at a different classification of network. Any changes to these procedures required approval not only through the USAF Operations, Training, and Maintenance Flights, but required additional approval through the agency security offices (Schumacher, 2009, p. 12).

6. Support Equipment

Support equipment for SBSS Block 10, regardless of security posture, did not vary significantly. As outlined earlier, most system support equipment is standard to most space ground systems and most of this equipment is commercially available (servers, computers, cables, racks, etc.) in their design and standard and non-unique support equipment is built-in by default (oscilloscopes, multi-meters, etc.). The only major change is how this support equipment was handled once it was introduced into a specific security environment. Any support equipment was required only to be kept at the initial introduction location (operations or maintenance) and any movement required significant review or desensitization procedures or destruction if entering the disposal phase.

7. Training and Training Support

Training due to security level was affected, but mainly up-front and for new personnel that had not been exposed prior to certain security levels. Since almost all of the USG personnel involved in 1/7 SOPS and PMO's were already operating at the required security levels, very little training on security changes was required with the exception of small amounts of training that may have been required due to new hardware introduced as part of the security change. Numerous contractor personnel also were hired or had history at the required security levels, so typically, that training was also minimal. Occasionally, personnel required re-training on SOC or GSOL security processes and procedures, but this was often done with little to no effect to daily operations tempo.

8. Manpower and Personnel

The manpower and personnel requirements grew considerably when SBSS Block 10 security levels changed. The changes to the program were vast, affecting both the USAF and DOD organizations and development contractors. The manpower footprint grew substantially across the enterprise, costing the SBSS Block 10 operations and support programs precious time and effort while ensuring properly cleared personnel for operations across the SBSS enterprise. It was always suspected the both the contractor and Blue Suit manpower footprint would grow as the launch date grew closer, the security level change added many new requirements that further complicated the manpower and personnel requirement.

SBSS Block 10 required the proper security clearances for all individuals (Blue Suit and contractor) that operated and maintained the system. This clearance was required for all of those on the operations floor, maintenance back shops, depot facilities, and factory support locations. Since all locations supporting SBSS Block 10 were at the same security level, all individuals working in these facilities needed to properly vetted and cleared. Additionally, proper clearance was vital for those USG personnel supporting acquisition and development actions at the Program Offices and Headquarters organizations supporting Block 10. In addition to all support personnel, more security personnel were needed to manage security accesses and visitor requests at all locations.

As suspected, the timelines for obtaining proper security clearances could be significant, requiring both the contractor and USAF to begin hiring and vetting actions for multiple job/position candidates in case discrepancies were noted during background investigations that disqualified candidates. Because security clearance vetting was handled by the Office of Personnel Management, clearance actions could be back-logged months or even years, significantly limiting the work that those were hired and waiting this clearance. While the SBSS Block 10 goal was to hire people with the proper clearances from the program inception, even those with the proper designation required additional vetting. Some personnel that had been with the program had to be pulled away and allocated to other non-SBSS mission tasks while they waited for the appropriate security clearances to be awarded.

9. Facilities and Infrastructure

The change in security environment probably had one of largest impacts on the Facilities and infrastructure required to support the SBSS Block 10 program. The impacts included significant facility modifications at multiple locations, to include significant IT infrastructure changes required to support the transfer of higher security files from one location to another. These changes were not just required of the Satellite Operations Center (SOC), but across the enterprise supporting the SOC (Vigil, 2010, Slide 2).

As the development of the SBSS Block 10 program progressed, the interest from customers across the SSA enterprise increased. This interest morphed into evolved and derived system requirements, leading to the development of capabilities and interfaces required to support those customers, most to them requiring their mission data to be delivered at various security levels. These changes in customer included modifications to the hardware required at the operational location, changes to the link/data infrastructure, and facility modifications at both the operational location and depot/test/ integration facilities.

The data link infrastructure changes to accommodate the security level of all of the customers SBSS Block 10 supports evolved as more customers were added and the mission set for SBSS Block 10 grew. All links within MOD 10 and Schriever AFB required appropriate encryption and because customer and depot support facilities were spread across the country, the links needed to be properly encrypted and data pipelines established with all potential customers at the correct security levels (Vigil, 2010, Slide 2). The links needed to be protected not only at the SBSS Block 10 MOD and support SBSS support facilities, but they also needed to be protected at any external customer facilities on their receiving nodes.

The facility modifications at MOD 10 at Schriever AFB didn't significantly change in the security level. The real changes required were needed at locations that supported the sustainment and support for the SBSS Block 10 Facility such as, the Ground Systems Operations Lab in Colorado Springs, the Space Vehicle Factory in Boulder, and to a lesser extent, the software support facilities in MIT Lincoln Labs in Boston, Massachusetts. The facility changes varied from changes in clearance for server heights and separate of mission support assets to changes in the type of doors and alarms needed to protect the facilities. These changes were also required across the enterprise, from the Factory locations to the local support/reach back facility in the Colorado Springs. Additionally, as Government depots at Hill AFB, Utah were brought online through the Depot Activation process, robust facility modifications to accommodate supporting SBSS Block 10 were also required.

10. Computer Resources

Changes to the computer hardware and software due to security level change were notable. Multiple racks of hardware were added to the MOD 10 equipment room floor, not only to support the evolving customer base, but to support the transfer of data to multiple test and support locations at the proper security level. The hardware expense alone was a multi-million-dollar investment, requiring the purchase of expensive servers and cryptology and specialized/modified test equipment to ensure data was stored on all hardware at the appropriate security levels. The hardware needed also included workstations to share data across multiple, already established DOD networks, as well as hardware needed to test at the proper security level before introducing to the operational system.

System software also required modifications to support the change in security level. Multiple software algorithms needed to be developed to accommodate the new cryptology devices, as well significant modifications to the Mission Planning and Mission Data Processing modules. Software interfaces for external customers were created as well, both internal to the SBSS Block 10 System, as well as the unaccounted for program costs experienced by any customer receiving data from SBSS Block 10.

C. SUMMARY

This Chapter provided the qualitative provided the qualitative analysis for each of the core 10 PSEs for SBSS Block 10 in relation to the primary and secondary research questions presented earlier in the Chapter. The next chapter will provide the findings and results.

IV. FINDINGS AND RESULTS

Chapter III provided the qualitative analysis for each of the core 10 PSEs for SBSS Block 10 in relation to the primary and secondary research questions posed in Chapter I. This Chapter will detail the General Findings and Results based on the data of Chapter III. While it can be difficult to say which changes were the most impactful to the logistics and sustainment baselines since all Product Support Elements were affected in some form or fashion, the findings below present general findings in relation to the primary and secondary research questions.

A. PRIMARY RESEARCH FINDINGS: FINDINGS RELATED TO THE CHALLENGES OF TRANSITIONING SBSS BLOCK 10 FROM CONTRACTOR TO BLUE SUIT OPERATIONS

Primary research Question Number 1 asks what challenges arose for effective SBSS Block 10 life cycle acquisition logistics and sustainability evolved as a result of the planned transition from a contractor operated system to a USG/Blue Suit Operations.

As outlined in Chapter III, each of the core 10 PSEs had qualitative impacts to their implementation. Some, like supply support and computer resources, had only a few minor process changes or other smaller impacts that needed to be addressed. Others like the Manpower and Personnel, Training and Training Support, and Technical Data PSEs had more significant impacts, from creating brand new operations and training documentation to bringing in 33 new USAF personnel. Because of the time needed to create new systems documentation, training, and sourcing a significant number of new 1 and 7 SOPS personnel, it can be argued that these PSEs were impacted the most.

B. SECONDARY RESEARCH FINDINGS: FINDINGS RELATED TO SECURITY LEVEL CHANGE IMPACTS ON SYSTEM SUSTAINABILITY

Primary research Question Number 2 asks what logistics and sustainment challenges were presented to the SBSS Block 10 System by the change in security level.

As outlined in Chapter III, each of the core 10 PSEs were also affected by the change in security level. The impacts were a bit more diverse, with arguably the greatest impacts felt across the Life Cycle Sustainment Management, Technical Management, and Infrastructure Management components, specifically, the Facilities and Infrastructure, Manpower and Personnel, and Computer Resources functions. Because of the significant time and resources it takes to hire cleared personnel (for both contractor and Blue Suit), purchase new equipment to ensure proper security of system assets, and set up and modify new facilities to accommodate the change in security level, there is strong case that these elements were affected more than others.

C. OTHER FINDINGS: PRODUCT SUPPORT MANAGEMENT AND DESIGN INTERFACE

Because of the overarching nature of the Product Support Management and Design Interface functions, these PSEs were not covered in detail in either qualitative analysis in Chapter III. However, it doesn’t make these components any less important. A Product Support Manager must consider all changes to these PSEs and then work with the PM’s to understand the affects to system cost, schedule, and performance and adjust the support posture to ensure a supportable system. Design Interface could be impacted by many of the changes made to all of these PSEs, with much of design changes experienced with new link interfaces, facilities, and equipment.

D. SUMMARY

This chapter discussed the findings from the data presented from Chapter III. It was found that perhaps the biggest changes to the PSEs for SBSS Block in reference to the primary research question had the most to deal with Technical Management and Infrastructure management components, specifically, Manpower and Personnel, Training and Training Support, and Technical Data PSEs. For the secondary research question related to impacts of system sustainability due to change in security level, the largest impacts were a bit more diverse, with the greatest impacts felt across the Life Cycle Sustainment Management, Technical Management, and Infrastructure Management components, specifically, the Facilities and Infrastructure, Manpower and Personnel, Computer Resources, and Packaging, Handling, Storage and Transportation. The conclusions and recommendations from these findings will be presented in the final chapter, as well opportunities for future research.

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V. CONCLUSIONS, RECOMMENDATIONS, SUMMARY AND AREAS FOR FURTHER RESEARCH

A. CONCLUSIONS AND RECOMMENDATIONS

The findings from this research can lead to a few conclusions about the impacts on the SBSS Block 10 PSEs, and subsequently, the acquisition logistics and sustainment, due to the transition from contractor to Blue Suit operations and changes to system security level.

First, we can see that the logistics requirements for United States Government personnel operating a system can be more detailed and specific than for a contractor operating a space system. Whether it’s due to the level of education, experience, or turnover of USAF Blue Suit personnel or specific operational/maintenance personnel nuances, evolving from a contractor Operated System to a Blue Suit Operated System is no small task. Numerous considerations must be accounted for, from the type of personnel needed and the background needed to operate the system, to the processes the procedures that need to be modified or adjusted to account for the incorporation of any Blue Suit operations elements.

Second, we can see that security level change impacts are also not insignificant and are vast across the acquisition logistics and sustainment enterprises. While SBSS Block 10 was able to overcome many of these challenges, on other programs, the amount of time and assets required to address a change in security level could lead to significant program delays. It can take up to 1 year or longer at times to clear or source appropriate Blue Suit and contractor personnel, creating significant delays if a change to USAF operations is made late in a system development life cycle. While the personnel change impact can be huge, facilities and hardware required to support a security level is equally as significant, especially since facility modifications can take anywhere from 6–18 months, as well as the procurement, certification, and accreditation of any hardware that must be procured to support the change in security level.

Third, while both transition to Blue Suit Ops and the changes of security level impacted all core PSEs, arguably the biggest change experienced by the Manpower and Personnel piece of the logistics puzzle. The Blue Suit impact was mostly displayed by the increased “in-place”/transition times and the increase in the time that both contractor and Blue Suit personnel were on the Operations Floor. To accommodate new SBSS ground crews at the appropriate security level, Training and Technical Data Documentation needed to authored to proper education and experience level by new Blue Suit personnel and maintained at the appropriate security level. Finally, additional manpower (in addition to contractor personnel already hired and working) increased by 33 positions, with a significant increase also to the Security Manpower required across the portfolio.

B. SUMMARY

This research provides a qualitative analysis of the logistics impacts, effects, and sustainment challenges presented to Space Based Space Surveillance Block 10 System. Two large program changes were the focus of this study: a change in operations concept from a contractor operated to a USG/Blue Suit operations system and a change in system security level. The qualitative analysis/case study was conducted using the 10 core Product Support Elements (PSEs) as outlined in the Defense Acquisition University’s *Integrated Product Support Element Guidebook.*

C. AREAS FOR FURTHER RESEARCH

One area that could be further researched is the analysis of any potential schedule impacts/delays that could be directly tracked to the change in operations concept or security posture. While we know that SBSS Block 10 experienced many schedule delays, we can’t specifically attribute any of these to to the PSE changes experienced as a result of the operations concept and security level system changes. Luckily, SBSS Block 10 System PSE changes brought on by the change in operations concept and security level coincided with other technical system challenges related to both the SV and LV, so they were able to be solved as other system challenges were also being addressed by the engineering and launch Integrated Product Teams. However, if either of these presented system changes were experienced independent of SV and LV challenges (and subsequent delays caused by these challenges), it could be added value to illustrate (qualitatively and quantitatively) how these changes could have impacted both the launch and operations preparations needed to effectively man and operation the SBSS Block 10 System.

Another area for additional research is system cost data analysis to further detail any potential manpower cost impacts directly attributable to the change in operations concept, both from a pre-launch and a life cycle cost perspective. Presented below is a life cycle cost chart table for both the operations and maintenance areas of SBSS Block 10 that outline general post-launch costs for contractor operations and maintenance activities (Ward, 2016).

Table 1. SBSS Manpower Life-Cycle Cost Estimate. Source: Ward (2016).

Contractor Operations and Logistics Support

	CY08 & CY09	CY10	CY11	CY12	CY13	CY14	CY15
Contractor Operations	$9.4M						
Contractor Logistics Support	$12.0M						
Ctr Ops Support (CY09)	$13.1M						
Ctr Ops Support (CY10)		$8.5M					
Ctr Ops Support (CY11)			$3.1M				
Ctr Logistics Support (CY09)	$28.2M						
Ctr Logistics Support (CY10)		$35.3M					
Ctr Logistics Support (CY11)			$26.9M				
Ctr Logisitcs Support (CY12)				$24.8M			
Ctr Logistics Support (CY13)					$23.4M		
Ctr Logistics Support (CY14)						$20.8M	
Ctr Logistics Support (CY15)							$10.8M

Again, any cost impacts brought on by the change of operations concept and security level are difficult to track because they also coincided with delays introduced by SV and LV technical challenges, not necessarily any changes to systems operations readiness by contractors/USAF personnel or security support posture for pre-/post-launch operations. However, the above life cycle cost chart accompanied with more detailed front end cost data could expose some costs that may have been avoided if Blue Suit operations were identified sooner or if the security levels were better known at program inception.

LIST OF REFERENCES

1-7 Space Operations Squadron Unit Manning Document. (May 2007). HQ Air Force Space Command. 12 pages. Schriever AFB, CO.

Amedee, Kelly. (2007). SBSS program management review charts: system description. Space and Missile Systems Center. Space Superiority Systems Wing.

Axelbrand, Elliot & Shelton, William et al.. (2015) *Acquisition of Space Systems: Past Problems and Future Challenges.* RAND Corporation. Santa Monica, CA.

Bacon, Dave, & Anderson, Steve. (2009). *Maintenance Concept of Operations and Maintenance Manual for Space Based Space Surveillance for (SBSS) Block 10 Maintenance and Operations Requirements Program.* Boeing Company. Colorado Springs, CO.

Colarco, Richard, Benz, Richard, & Haywood, James. (2010). *System Training Plan for Space-Based Space Surveillance System Block 10*. HQ Air Force Space Command/A5 Requirements. Peterson AFB, CO. 22 pages.

Cooper, Jerome & Guthrie Vaccaro, Michel. (2011). *Life Cycle Sustainment Plan (LCSP) for Space Based Space Surveillance.* (SBSS Block 10). Space and Missile Systems Center. Space Superiority Systems Wing. 27 pages.

Cooper, Jerome & Guthrie Vaccaro, Michel. (2012). *Space Based Space Surveillance (SBSS Block 10) Depot Maintenance Activation Plan*. Space and Missile Systems Center. Space Superiority Systems Wing. 45 pages.

Defense Acquisition University. (2017a). Integrated Product Support Elements: Computer Resources. Retrieved from https://www.dau.mil/cop/log/pages/topics/Computer%20Resources.aspx

Defense Acquisition University. (2017b). Integrated Product Support Elements: Product Support Management. Retrieved from https://www.dau.mil/cop/log/pages/topics/Product%20Support%20Management.aspx

Defense Acquisition University. (2017c). Integrated Product Support Elements: Design Interface. Retrieved from https://www.dau.mil/cop/log/pages/topics/Design%20Interface.aspx

Defense Acquisition University. (2017d). Integrated Product Support Elements: Facilities and Infrastructure. Retrieved from https://www.dau.mil/cop/log/pages/topics/Facilities%20and%20Infrastructure.aspx

Defense Acquisition University. (2017e). Integrated Product Support Elements: Sustaining Engineering. Retrieved from https://www.dau.mil/cop/log/pages/topics/Sustaining%20Engineering.aspx

Defense Acquisition University. (2017f). Integrated Product Support Elements: Training and Training Support. Retrieved from https://www.dau.mil/cop/log/pages/topics/Training%20and%20Training%20Support.aspx

Defense Acquisition University. (2017g). Integrated Product Support Elements: Technical Data https://www.dau.mil/cop/log/pages/topics/Technical%20Data.aspx

Defense Acquisition University. (2017h). Integrated Product Support Elements: Packaging, Handling, Storage, & Transportation. Retrieved from https://www.dau.mil/cop/log/pages/topics/Packaging%20Handling%20Storage%20and%20Transportation%20PHS%20and%20T.aspx.

Defense Acquisition University. (2017i). Integrated Product Support Elements: Support Equipment. Retrieved from https://www.dau.mil/cop/log/pages/topics/Support%20Equipment.aspx.

Defense Acquisition University. (2017j). Integrated Product Support Elements: Manpower and Personnel. Retrieved from https://www.dau.mil/cop/log/pages/topics/Manpower%20and%20Personnel.aspx.

Defense Acquisition University. (2017k). Integrated Product Support Elements: Maintenance Planning and Management. Retrieved from https://www.dau.mil/cop/log/pages/topics/Maintenance%20Planning%20and%20Management.aspx.

Defense Acquisition University. (2017l). Integrated Product Support Elements: Supply Support. Retrieved from https://www.dau.mil/cop/log/pages/topics/Supply%20Support.aspx.Gunter’s Space Page. (2017). MSX (Midcourse Space Experiment). Retrieved from http://space.skyrocket.de/doc_sdat/msx.htm.

Lorell, Mark, Lowell, Julia, & Younassi, Obaid. (2006). *Evolutionary Acquisition: Implementation Challenges for Defense Space Programs.* Logistics. Page 117. RAND Corporation. Santa Monica, CA.

Nelson, Matt. (2010) SBSS block 10 logistics: systems space group briefing for HQ Air Force Space Command. Technical Data. Slide 7.

Perkins, Mark. (2007). *Operating Concept for Space-Based Space Surveillance System Block 10*. HQ Air Force Space Command/A3 Operations. Peterson AFB, CO. 22 pages.

Rosenthal Ellen. (2015). Defense Acquisition University. Executive Program Management Course. http://slideplayer.com/slide/4020580/. Slide 44.

Schumacher, Earnest. (2009). *Space Based Space Surveillance (SBSS) Block 10 Technical Order Management Plan. (TOMP)*. Space and Missile Systems Center. Space Superiority Systems Wing. 12 pages.

Space and Missile Systems Center. (2009) Space Superiority Systems Wing Contracting Office. *SBSS Acquisition and Contract History. Pages 1–4.*

Thompson, Matthew & Rollins, Henry. (May 2009). Path towards SBSS blue suit operations. Briefing to HQ Air Force Space Command/A3. Schriever AFB, CO. 27 slides.

Vigil, Gary. (11 May 2010) Space based space surveillance space logistics review to HQ Air Force Space Command/A4. Peterson AFB CO. 4 Slides.

Ward, William. (2016) Space Based Space Surveillance Life Cycle Cost Estimate. Space and Missile Systems Center. Space Superiority Systems Wing.

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