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SYSTEMS ENGINEERING ANALYSIS FOR OFFICE SPACE MANAGEMENT

by

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September 2017

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Organizations have many challenges with respect to managing and allocating office space. In addition to fiscal constraints on space and resources, organizations may face competing mission priorities and changes in mission requirements. Through the application of the systems engineering method, this thesis develops a multicriteria decision-making framework applicable to space allocation decisions for organizations with competing objectives and finite resources. The methodology is employed first to develop an organization's requirements, stakeholders, and resource constraints and second to apply these data in a multicriteria decision-making framework to develop space allocation decisions. The approach prioritizes office space needs based on mission requirements while accounting for current resource constraints. Los Angeles Air Force Base is used as a case study in the successful test of the framework's effectiveness. By implementing this framework, federal agencies that are faced with the challenge of balancing resources to meet multiple objectives would have a systematic approach for determining how to allocate resources across their organization to best meet their identified goals.

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SYSTEMS ENGINEERING ANALYSIS FOR OFFICE SPACE MANAGEMENT

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ABSTRACT

Organizations have many challenges with respect to managing and allocating office space. In addition to fiscal constraints on space and resources, organizations may face competing mission priorities and changes in mission requirements. Through the application of the systems engineering method, this thesis develops a multicriteria decision-making framework applicable to space allocation decisions for organizations with competing objectives and finite resources. The methodology is employed first to develop an organization's requirements, stakeholders, and resource constraints and second to apply these data in a multicriteria decision-making framework to develop space allocation decisions. The approach prioritizes office space needs based on mission requirements while accounting for current resource constraints. Los Angeles Air Force Base is used as a case study in the successful test of the framework's effectiveness. By implementing this framework, federal agencies that are faced with the challenge of balancing resources to meet multiple objectives would have a systematic approach for determining how to allocate resources across their organization to best meet their identified goals.

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LIST OF ACRONYMS AND ABBREVIATIONS

61 CELS	61st Civil Engineering and Logistics Squadron
AF	Air Force
AFB	Air Force base
AFBI	Air Force base instruction
AFI	Air Force instruction
AFPD	Air Force policy directive
AFSPC	Air Force Space Command
AFSPC/CC	Air Force Space Command commander
BDR	behavioral decision research
CAE	component acquisition executive
CFL	core function lead
CFSP	Core Function Support Plan
DA	decision analysis
DAE	defense acquisition executive
DOD	Department of Defense
DODI	Department of Defense instruction
FFRDC	federally funding research and development center
FLOE	four lines of effort
FTE	full time equivalent
GPS	Global Positioning System
GS	general schedule
HAF	Headquarters Air Force
HQ	headquarters
ISR	intelligence, surveillance, and reconnaissance
ITS	Innovative Technical Solutions, Inc.
JCIDS	Joint Capabilities Integration and Development System
LAAFB	Los Angeles Air Force Base
LaRC	Langley Research Center
MAJCOM	major command
MCDM	multicriteria decision-making

MILSATCOM	Military Satellite Communications
MP	Malcom Pirnie, Inc.
NASA	National Aeronautics and Space Administration
NSS	national security space
ORS	Operationally Responsive Space
PEO	program executive officer
PPBE	planning, programming, budgeting, and execution
SAE	service acquisition executive
SAF/AQ	Assistant Secretary of the Air Force (Acquisition)
SECAF	Secretary of the Air Force
SMC	Space and Missile Systems Center
SMC/AD	Advanced Systems and Development Directorate
SMC/CC	Space and Missile Systems Center commander
SMC/GP	Global Positioning Systems Directorate
SMC/LE	Launch Enterprise Directorate
SMC/RN	Range and Network Systems Division
SMC/RS	Remote Sensing Systems Directorate
SMC/SL	Space Logistics Directorate
SMC/SY	Space Superiority Systems Directorate
SMC/XP	Directorate of Strategic Plans and Programs
U.S.	United States
US JS	United States Joint Staff
USAF	United States Air Force
USD(AT&L)	Under Secretary of Defense for Acquisition, Technology, and Logistics

EXECUTIVE SUMMARY

Managing and allocating office space is a challenge for federal organizations due to a variety of factors, including space reductions and limited resources in a constrained fiscal environment, conflicting priorities, and changes in mission requirements. Based on recent initiatives such as *Freeze the Footprint*, *Reduce the Footprint*, and Air Force policy directive 32–90, *Real Property Asset Management*, organizations are required to "maximize use of existing real property assets prior to acquiring new real property" (United States Air Force [USAF] 2007, 2) and additionally, freeze (United States White House 2017a) or reduce (United States White House 2017b) the size of their real estate holdings. These constraints on an organization's real property assets do not reduce their requirements to improve worker productivity as detailed in *Assignment and Utilization of Space,* 41 C.F.R. § 102–79 (2011). Additionally, most federal organizations have multiple missions or programs that compete for the same space and resources. Making decisions on space and resources assignments in a constrained environment with multiple priorities is difficult and the choice can impact an organization's ability to meet its goals and objectives.

This research focuses on developing a method for organizations to make smarter, more defensible decisions on resource allocation that consider the current and future mission objectives of competing programs and how they align with the organization's mission and maximize its effectivity. This research thesis uses multicriteria decision-making and systems engineering to examine space allocation management. In addition to developing a methodology that can be applied across organizations, the Los Angeles Air Force Base (LAAFB) is used as a case study to validate the methodology and provide insight into how this methodology would increase the effectiveness of resource allocation decisions. This methodology applies across the federal government to agencies that need to balance limited resources to meet competing objectives and provides them a method to make smarter resource management decisions that will ultimately translate into increased effectivity for their organization and across the federal government as a whole.

This research focuses on a methodology to holistically manage office space instead of on space optimization tools that increase office space utilization. Optimization techniques that focus on this aspect of space allocation, such as the National Aeronautics and Space Administration Langley Research Center's "space allocation and planning software system" (National Aeronautics and Space Administration 2017) have been developed; but, tools such as these are only as good as the inputs provided to the system and highlight the need to apply systems engineering methods. Organizations in the past have generally relied on decision by committee, without published objective procedures or measures. This research focuses on the adaptation of the systems engineering method and a multicriteria decision-making framework and applying it to the space allocation problem to develop these inputs.

The systems engineering method is separated into four major activities: requirements analysis, functional definition, physical definition, and design validation (Kossiakoff et al. 2011). Requirements analysis was the primary systems engineering activity utilized to identify objectives. Functional definition was not entirely applicable to this research; however, this systems engineering step could be applied through the development of a tool to analyze objectives. The physical definition activity was not relevant to this research and therefore not applicable. Design validation was accomplished through using LAAFB as a case study to mature the proposed method. The application of the systems engineering method yielded a comprehensive list of objectives for the organization by understanding the entities that impact the organization and of these, which impose requirements upon it. The requirements analysis activity also identified the constraints and assumptions that must be considered as part of space allocation decision-making process for an organization. Based on requirements decomposition and mapping, goals were decomposed into objectives and sub-objectives that were then mapped to programs within the organization such that resources could be allocated by sub-objective.

For LAAFB, five goals (mandates) were identified, traced from higher-level strategic plans and missions that support LAAFB's mission "to deliver resilient, affordable, and sustainable space capabilities for the nation" (USAF 2015, 6). These goals on their own do not provide insight on how to allocate requirements but were decomposed into objectives that are supported by sub-objectives (commitments) identified on an annual basis by the directorates within LAAFB. This mapping provides clarity on how each directorate supports LAAFB's goals and supports the multicriteria decision-making process to allocate resources to support LAAFB's mission. LAAFB's organizations decomposed into two main types of units, staff offices and program offices. Based on how resources are allocated for each type of organization, this research thesis focused on decision-making associated with program office resource allocation. Of the five goals (mandates) identified for LAAFB, three objectives trace to the program offices and this was used as the basis for the multicriteria decision-making process.

The multicriteria decision-making process applies the data identified through the systems engineering method through several steps: set the decision context, specify the objectives, apply attributes and value functions, identify the relative importance of objectives, and identify alternatives to achieve the objectives. The steps identified here are derived from Gregory and Keeney (2002) whose study focuses on decision-making for environmental management.

Prior to implementing the steps identified as part of the multicriteria decision-making process, a leadership team should be identified that has the authority and knowledge to make decisions on office space management. This team is derived from the list of stakeholders previously identified through the systems engineering method. The team should be made up of a diverse set of individuals who cover the decision space and have the knowledge of programs and resource requirements to apply in the decision-making process. For LAAFB, the proposed leadership team comprises the base commander and the military and civilian deputies, the 61st Air Base Group commander, along with the director of each directorate, and systems engineering support personnel for tool development and guidance. Additionally, depending on the decision context, program managers for specific programs may be part of the team given their detailed knowledge on specific programs and their resource requirements.

A model was developed to aid in the decision-making process and captures the relative importance of each goal, objective, and sub-objective, along with the value of each organization’s current full-time equivalent (FTE) staffing level as compared to the number of FTE required for maximum and minimum effectiveness. The staffing level was used as a proxy for office space under the assumption that each FTE requires a certain amount of office space. This model helps support the leadership team in making a decision on resource allocation that supports increasing the organization’s overall effectiveness and is logical and defensible.

To apply the model to LAAFB, notional organizational data was used based on publicly available information. Additionally, the model incorporated notional weights to calculate the effectivity of LAAFB. The weights were based on an interpretation of Air Force guidance documents. Three goals were identified for LAAFB that the program offices trace to, which were decomposed into 12 objectives with a total of 32 sub-objectives that map to the goals. Based on the goals that the program offices support, LAAFB is 76.6% effective.

Different methods of assigning resources are possible. One method is to review sub-objectives with the largest delta between their maximum effectiveness to the organization and their current effectiveness, and assign additional FTEs to these sub-objectives to increase the organization’s effectiveness. A second method, which can be used within the constraint of maintaining the current number of FTEs for the organization, is to review sub-objectives with the lowest global weight as well as the smallest value function slope for resource reallocation and reduce these sub-objectives to their minimum effectiveness. The resources that are no longer assigned to these sub-objectives can then be applied to the sub-objectives with the highest global weight, thereby increasing the organization’s effectiveness. By using the model and clearly identifying the organization’s objectives, an organization can more clearly align its decision to meet those objectives and have data to support the product.

By applying the systems engineering method and the multicriteria decision-making framework to resource allocation management, organizations can more clearly align resource decisions to support their goals and mission. These tools do not provide a definitive answer but support bounding the problem and providing leadership teams the ability to focus on realistic alternatives to determine the best course of action.

References

Gregory, Robin, and Ralph Keeney. 2002. “Making Smarter Environmental Management Decisions.” *Journal of the American Water Resources Association* 38 (6): 1601–1612. http://libproxy.nps.edu/login?url=https://search.proquest.com.libproxy.nps.edu/docview/201268094?accountid=12702.

Kossiakoff, Alexander, William Sweet, Samuel Seymour, and Steven Biemer. 2011. *Systems Engineering Principles and Practice.* 2nd. Hoboken, NJ: John Wiley & Sons.

National Aeronautics and Space Administration. 2017. “Space Utilization Optimization Tool.” NASA. Last accessed July 5. https://technology.nasa.gov//t2media/tops/pdf/LAR-TOPS-107.pdf.

United States White House. 2017a. “Freeze the Footprint.” Last accessed July 10. https://www.performance.gov/initiative/freeze-footprint.

———. 2017b. “Reduce the Footprint.” Last accessed July 10. https://www.performance.gov/initiative/manage-property/reduce-footprint.

United States Air Force (USAF). 2007. *Real Property Asset Management*. Air Force Policy Directive 32–90. Secretary of the Air Force, August 6. http://static.e-publishing.af.mil/production/1/af_a4_7/publication/afpd32-90/afpd32-90.pdf.

———. 2015. “USAF Strategic Master Plan.” http://www.af.mil/Portals/1/documents/Force%20Management/Strategic_Master_Plan.pdf.

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I. INTRODUCTION

Managing and allocating office space is a challenge for federal organizations due to a variety of factors, including space reductions and limited resources in a constrained fiscal environment, conflicting priorities, and changes in mission requirements. Currently, “the Federal Government owns or leases roughly 1.1 million real property assets, including land, buildings, and structures” (United States White House 2017b, Real Property Portfolio: Background). Initiatives such as *Freeze the Footprint, Reduce the Footprint*, and Air Force Policy Directive (AFPD) 32–90, *Real Property Asset Management,* require organizations to “maximize use of existing real property assets prior to acquiring new real property” (United States Air Force [USAF] 2007b, 2) and to freeze (United States White House 2017a) and reduce (United States White House 2017b) the size of their real estate holdings. Based on these recent policies and initiatives, the United States (U.S.) federal government is working toward maximizing the use of existing assets and reducing its total holdings. The federal government’s aim to downsize its footprint does not relieve federal agencies of the mandate to improve worker productivity as detailed in *Assignment and Utilization of Space*, 41 C.F.R. § 102–79 (2011). Within the constraints of existing real property holdings, in *Assignment and Utilization of Space*, 41 C.F.R. § 102–79.10 (2011), the U.S. federal government states that “executive agencies must [also] provide assignment and utilization services that will maximize the value of Federal real property resources and improve the productivity of the workers housed therein.”

In addition to space constraints, most federal organizations have multiple missions or programs that compete for space and resources. Moreover, these missions and programs are not static and change over time based on requirements and the government’s priorities. The National Aeronautics and Space Administration (NASA) Langley Research Center (LaRC) is an example of this type of organization. NASA LaRC supports wind tunnel research (Esri 2009) as well as “many other disciplines including structures and materials, flight electronics, and atmospheric sciences” (Esri 2009, 1). Each of these disciplines needs space and resources to meet its requirements, and each of these disciplines supports the agency's goals (National Aeronautics and Space Administration Langley Research Center [NASA LaRC] 2016a). LaRC recently underwent a significant mission shift to support new space vehicle developments (Esri 2009). Esri (2009) describes how this change in requirements affected NASA LaRC and how the center redistributed its personnel to meet these changes. Space allocations cannot remain static with changing mission requirements, but must continue to adapt to meet the current needs of the organization. When there is limited space and competing projects, assigning space to each project becomes increasingly challenging.

As noted by Ulker (2013) in "Office Space Allocation using Mathematical Programming and Meta-Heuristics," research exists for analytical approaches to support space allocation decisions, especially with optimizing the efficient use of space. Ulker's (2013) research provides evidence that additional research is needed to develop the process of determining an organization's unique mission requirements and constraints and ensure successful implementation of a space allocation decision-making process. This thesis will focus on the competing priorities and changes in mission requirements aspects of space allocation management and implementing them in a multicriteria decision-making (MCDM) model that can be applied by federal agencies in space allocation decisions to best support project-level and agency-level goals. The Los Angeles Air Force Base (LAAFB) will be employed as a case study to demonstrate the application of the model to office space allocation management.

A. BACKGROUND ON LOS ANGELES AIR FORCE BASE

The Los Angeles Air Force Base, located in El Segundo, CA, has a footprint of approximately 0.09 square miles (Innovative Technical Solutions, Inc. and Malcom Pirnie, Inc. [ITS and MP] 2008). The Los Angeles Air Force Base's current facilities were built in 2005 and it is "home to the Space and Missile Systems Center (SMC), 61st Air Base Group Wing, and numerous Operating Locations and Detachments" (ITS and MP 2008, 1). Currently, SMC has nine major directorates and divisions (United States Air Force Los Angeles Air Force Base [USAF LAAFB] 2017), and has many staff organizations that support the program offices. The program and staff offices are all vital to SMC’s mission “to deliver resilient and affordable space capabilities” (United States Air Force Space Command [US AFSPC] 2017a).

While all bases need to manage real property, LAAFB is uniquely challenged due to its small footprint in a high property value area. The small size of the main base is the limiting factor for how many personnel can support the mission on location. LAAFB is already over capacity and leases space from the Aerospace Corporation to support multiple missions. With no reduction in requirements, LAAFB needs to be able to optimize its space allocation to support existing programs and be flexible in supporting emerging mission areas.

An example that addresses space constraints, limited resources, and mission changes is the development and use of LAAFB’s parking structure. During its construction, the new parking structure was required to comply with new policies that impacted the parking arrangement and reduced the number of spaces available for tenants (ITS and MP 2008). LAAFB leased parking space for approximately 1,000 vehicles from the Raytheon Company’s parking lot nearby; the personnel who parked in this location would then be shuttled to base (ITS and MP 2008, 3). There was a heavy emphasis on telework and different work schedules to balance the amount of people on base. To alleviate the need for contracting out parking, a parking structure was constructed and opened in 2012 (USAF LAAFB 2012b). Unfortunately, the original plans called for an increase of 1,044 spaces (ITS and MP 2008) but requirements and funding constraints resulted in an increase of approximately 200 spaces (USAF LAAFB 2012b).

The current LAAFB was built through a deal made with a developer and the surrounding cities for new office buildings to be constructed in exchange for land that would be given to the developer (ITS and MP 2008). In addition to the parking concerns, spaces issues with the newly constructed base arose shortly after the LAAFB base construction was finished. To address this issue, the United States Air Force (USAF) partnered with the Aerospace Corporation, a federally funded research and development center (FFRDC) to use some of its building space for LAAFB offices.

The mission requirements that LAAFB was constructed around have changed since its completion. Several mission areas including the Global Positioning System (GPS), which has programs in development beyond its original projections (Gruss 2016b), and the Weather Satellite System, which has multiple programs underway as the Defense Meteorological Satellite Program is concluded, have been expanded and require additional personnel based on current requirements (Gruss 2016a). The requirements and commitments of LAAFB now exceed what the current workforce can fulfill and the base leadership must be able to determine within these constraints how to make the best office space management decisions.

B. PROBLEM STATEMENT

With increasing requirements and limited space and resources, federal agencies are at risk of failing to meet mission requirements unless office space management can be optimized. In the case of LAAFB, the current process for space allocation is based on the timeliness of filling billets and does not account for a program's staffing percentage of its required workforce. This means that the program that fills an open billet first is allocated space. This process favors the program that can best "sell and defend" its requirements. Therefore, program missions can be impacted since programs that need space and personnel do not automatically get the necessary resources. In addition, current personnel may be tasked to move office space locations without fully understanding the rationale. This can create opposition and delay progress since some of the stakeholders may belong to a union such as the government civilian workforce under the general schedule (GS) system.

Since LAAFB's mission requirements require more resources than are currently available, the USAF has been hiring personnel to address the manning shortages. Organizations would go out with hiring actions, but instead of strategic investment, it would essentially be each organization that went out and did its own hiring action. This approach led to whichever organization was first, got the additional personnel. The organization that received the additional personnel first could then request office space.

There appeared to be a lack of a holistic approach to ensure the right people were hired at the right time for the right organization. LAAFB is comprised of many units and each is incentivized to accomplish its specific objectives. The challenge was for the base to find a way to systematically manage its resources to meet a myriad of mission requirements.

Office space allocations need to consider current and future mission objectives of competing stakeholders, balance manpower resources to successfully achieve the objectives, and do so within limiting physical, regulatory, and fiscal factors. Based on these challenges, this study will apply a systems engineering approach to understand the objectives, requirements and constraints to manage office space resources.

C. RESEARCH OBJECTIVES

This research will use a systems engineering approach to create a MCDM framework that will help organizations of all shapes and sizes make facility space allocation decisions that balance multiple objectives with their available resources. This framework will support federal agencies to make decisions on how space should be allocated to best meet the needs of each individual program but also to support the agency's mission as a whole. This study will apply the MCDM framework and methodology to LAAFB to test the model as well as to provide insight into real world application of the tool.

D. RESEARCH METHODOLOGY

This research thesis uses MCDM and systems engineering to examine space allocation management. MCDM methods are critical to developing a framework and tool that addresses many priorities. Research in this area will focus on understanding MCDM framework and applying it to office space allocation. The unique aspects of office space allocation management are considered and addressed in the MCDM framework. A process on how to balance different priorities for office space allocation will be developed from this research.

After developing a methodology for applying MCDM to office space allocation, the methodology is tested using LAAFB as a case study. Ultimately, the Space and

Missile Systems Center commander (SMC/CC), company president, owner, and others need to decide on how resources will be balanced to meet an objective. Systems engineering is key to ensuring a holistic approach is used to identify stakeholders and various factors to ensure that the proposed solution addresses these variables.

E. BENEFITS OF STUDY

At a top level, examination of this topic benefits federal agencies faced with the challenge of balancing resources to meet multiple objectives. This study provides a MCDM framework and process that could be applied to specific office space allocation scenarios. This will support leadership teams within these organizations make the decisions on how to prioritize their resources within space constraints. United States Air Force units in general would benefit by providing a relevant framework that would require minimal manipulation to apply to various bases and organizations. Disparate units within the USAF face similar bureaucratic challenges and ideally the model developed for LAAFB could be applied to other bases with minimal effort since the requirements documents and overarching hierarchy are the same. At the executive level within the USAF, this would translate into a more objective approach to how units manage their resources to meet the USAF's strategic goals.

At the major command (MAJCOM) level, this would translate into more efficient use of resources. MAJCOMs are comprised of many units and bases; therefore, this approach could be applied at the MAJCOM level thereby supporting an improved execution of objectives at a higher level. This could have a cascading effect at the base level: if objectives are decomposed holistically, then this would help to create a culture that at the lowest level of work being done would be in support of the larger objective.

At the base level, a key benefit of this research is the possibility of transparency in the decision-making process because it is defendable and provides rationale as to which programs get support. One of the challenges of being at the working level of programs doing the day-to-day management is the lack of explanation when people and funding are moved within the base. A possible benefit of this research is that giving people the whole story as to why programs are cut or offices rearranged benefits the organizational construct because people have a vested interest when they are kept informed. It comes down to expectation management since people are affected by what weapons systems are chosen to be developed and where people are assigned to work.

This approach could result in efficiencies to develop products faster and ultimately improve support for the warfighter. SMC exists to develop and deploy national security space (NSS) assets in support of the warfighter. Today, space and cyber systems are an integral part to how we plan and engage with our enemies. Faster development cycles mean that SMC can deliver products faster to the warfighters to give them the edge to win today's and tomorrow's battles.

Besides the USAF, other government agencies would also benefit. While the USAF units would require the least amount of adjustment to the model, other services and government organizations have the similar challenges in today's budget-constrained environment. Specific processes may differ between service and agency; however, government organizations ultimately follow the same budget cycle and process. Additionally, government organizations are continually challenged to do more with less and receive similar guidance; therefore, this framework could help government organizations in general balance their resources with achieving their objectives.

F. TERMINOLOGY

Key terms that are used throughout this research thesis are defined in Table 1. The purpose of this table is to provide a baseline understanding of common terms used herein. This is to mitigate possible misunderstandings of the concepts discussed.

Table 1. Terminology Definitions

Term	Definition
Environment	External factors and elements to the organization of interest
Doctrine	"Fundamental principles that guide the employment of United States military forces in coordinated action toward a common objective and may include terms, tactics, techniques, and procedures" (United States Department of Defense 2017, 125).
Leadership Team	Formal person or body responsible for, and empowered to, make decisions for the organization, this team may include key stakeholders.
Goals/Mission	The description of the tasks an organization is charged with. Akin to a purpose statement, the mission provides a generic description of what an organization does
Multicriteria Decision-Making	Decision-making framework that supports making complex decisions that involve stakeholders with competing priorities
Objective	Contribute to the achievement of identified goals by the organization
Office Space	Generic term for physical areas workers use to perform business functions for respective organizations. This includes desks, cubicles, common areas, and meeting rooms.
Office Space Allocation	Is the task of allocating office space (rooms, hallways, etc.) to several entities subject to additional constraints (Ulker 2013, 9)
Requirements	The amount and type of space required to accomplish an organizations mission
Real property	"Lands, buildings, structures, utilities systems, improvements, and appurtenances. Real property includes equipment attached to and made part of buildings and structures (such as heating systems); it does not include movable equipment (such as plant equipment)" (USAF 2016a, 40).
Stakeholder	Applies to individuals, groups of people, and organizations that have a role in influencing office space and/or are affected by the results of changes to office space. Stakeholders can be primary, secondary, tertiary, etc., and dependent upon the degrees of separation from direct change to the office space.
Systems Engineering Method	"The systematic application of the scientific method to the engineering of a complex system" (Kossiakoff et al. 2011, 91).

G. CHAPTER SUMMARY

This chapter introduced the issues associated with space allocation management for federal agencies and provided details of the specific challenges at LAAFB, which led to the genesis of this research. MCDM and systems engineering will be used to develop a framework and model that can be used by federal agencies to ensure a given workforce is resourced and aligned to satisfy both unique program goals and its parent agency's goals.

II. REVIEW OF LITERATURE

This chapter focuses on three areas of study that support the need to develop a MCDM model for federal agencies to use in space allocation: current decision-making practices in space allocation, existing techniques for space allocation optimization, and MCDM and its application to space allocation decisions.

A. DECISION-MAKING PRACTICES IN SPACE ALLOCATION

Many organizations use subjective means of managing office space. Extensive research on LAAFB's method, as well as those of other Air Force bases (AFB), using Air Force instructions (AFI) and Air Force base instructions (AFBI) such as AFBI 32–1084 for Robins Air Force Base demonstrates that current decision-making practices in space allocation for the USAF are subjective (United States Air Force Robins Air Force Base Commander 2015). Subjective decision-making for space allocation exists outside of government organizations as discussed by Ulker (2013) and supported by the University of Michigan's (2012) guidelines for research space. Without using a logical framework to bound the space allocation decision-making process, "[space allocation] can become a political decision-making process as powerful groups and individuals wield their influence over others" (Blanchette 2012, 65).

A detailed description of the current decision-making process for LAAFB is provided, which is based on consultation with two previous office space managers, Nelson and Polanco, to gain an understanding of the background on the problem.

As previously mentioned, LAAFB's current facilities were built in 2005. When the base was developing requirements for the facilities, each tenant unit on base was tasked to project their manpower and associated office space needs. These needs were considered when the new buildings were designed. There was a strategic plan as to where each unit would be located with respect to the planned buildings and floors. The manning requirements considered what the units could project regarding their needs at the time. Therefore, the original process was what we call a zero-baseline effort in which each organization outlines from scratch the people and space requirements essential to accomplish their mission. Once this was finalized and incorporated into the building designs, there was not a need per se for “office space management.” The units determined their requirements and facilities were designed to meet those requirements.

While in concept this could have worked, several things changed which impacted the office space management process (or lack thereof) for LAAFB. First, after 9/11 and the increased terror threat, base requirements changed as far as location of parking with respect to buildings. This impacted the layout and design of buildings. Additionally, NSS assets, while important, were not as ingrained into military operations as much as it has become over the last 15 years. Therefore, the demand for NSS assets has increased, and now a much larger workforce is required to meet the demand for new systems. Lastly, the systems that were in development at the time were expected to enter what the acquisition community calls “operations and sustainment.” Developing space assets proved to be more difficult than previously thought, which impacted manpower requirements and created a need for additional personnel and office space on LAAFB.

Since the need for people exceeded the capacity of the base, staff organizations were charged with managing the process in which changes were made as units requested more personnel. The previous process was managed by two organizations on base called the Directorate of Strategic Plans and Programs (SMC/XP) and the 61st Civil Engineering and Logistics Squadron (61 CELS). SMC/XP managed the administrative and organization requirements while 61 CELS managed the contract execution of any modifications needed by office space requests. When organizations on base needed adjustments to their office space, they developed a staff package which outlined the details of the request (e.g., cubicle changes, wiring). The staff package would be submitted for review by SMC/XP and, if deemed appropriate, the package would be reviewed by a senior officer working group. If the working group approved the change to the office space, then a work order would be submitted to 61 CELS, who would then start the process to put a company on contract to complete the necessary changes.

Further research into the management processes of other bases yielded similar results. AFIs published by other bases such as Robins Air Force Base which outline the administrative process to include templates, but the actual decision-making process was left to working groups (United States Air Force Robins Air Force Base Commander 2015). There is a benefit to providing flexibility in processes outlined in AFIs, since there are nuances to every base and situation; however, there appears to be a lack of codified objectivity in the process to determine how office space is managed. This means it is left up to the working groups to decide what factors are included in the decision-making process.

The University of Michigan, Ann Arbor, as discussed by Ulker (2013, 10) has one of the most extensive office space guidelines and demonstrates how office space allocation is managed by a university (Ulker 2013, 10).

> At the top of the responsibility of allocation in University of Michigan is the Provost. The hierarchy from top to bottom is as follows: Provost, Vice President, Deans/Unit Directors, Department Chairs, and Faculty members. (Ulker 2013, 10)

In terms of how space is allocated, it is based on "programmatic needs and priorities as determined by the dean or director of a school/college/unit in consultation with his/her faculty and staff" (University of Michigan 2012, 1). While the University of Michigan (2012) does discuss that there are priorities that need to be determined, these guidelines do not provide the dean or the decision-making body a logical method for determining those priorities and as Blanchette (2012) states, the process becomes political when priorities are based on the consultation with staff.

B. SPACE ALLOCATION OPTIMIZATION TECHNIQUES

While the intent of this research is not to do optimization through the use of linear programming and other techniques, optimization is discussed because it is a recurring approach used in space allocation as shown by the various studies and research (Esri 2009, Pereira et al. 2010, NASA LaRC 2016b, and Huron Consulting Group 2015). Ulker (2013) supports the concept that the most obvious method of addressing the space allocation problem is to "optimise the efficient usage of space" (Ulker 2013, 2).

Research on this topic leads to multiple optimization approaches to solve space limitations and manage space efficiently for a given organization. There are many optimization tools and techniques that could be applied; however, this study is focused not on how to solve the space optimization problem, but instead to create a systematic decision-making process. Three specific examples of space allocation optimization are presented here to demonstrate the variety and wealth of research on this topic.

Pereira (2010) researched the use of "tabu search [as] an effective technique for obtaining high quality solutions to office space assignment problems" (Pereira et al. 2010, 117) and applied it to the scenario of a large-scale move in which all employees in an organization are reassigned to new locations. This research thesis focuses on the other type of "office space allocation problem that occur[s] in practice" (Pereira et al. 2010, 112), that of the assignment of personnel as they join the organization from filling billets or personnel transfers.

NASA's LaRC "developed a space allocation and planning software system to allow for more effective and efficient facility usage" (National Aeronautics and Space Administration [NASA] 2017) and the software "determines over-crowding and/or underutilization of…space" (NASA 2017). Like Pereira (2010) states, the LaRC software tool was originally developed to support the LaRC's large-scale reorganization (Esri 2009) instead of on general hiring and personal relocations due to turnover.

The Huron Consulting Group, contracted by the University of Colorado Boulder, assessed the University's current space allocation and made recommendations on methods to increase space utilization and briefly discussed new decision-making capabilities to needed to support this increase (Huron Consulting Group 2015).

These studies (Huron Consulting Group 2015; Esri 2009; Pereira et al. 2010) focus mainly on making a space more efficient. While determining the most efficient space allocation/layout addresses the space allocation problem, once an organization reaches maximum efficiency, or no longer has funding for additional space allocation arrangements, decision-making on prioritization for existing space becomes critical.

C. MULTICRITERIA DECISION-MAKING AND APPLICATION TO SPACE ALLOCATION

"The ability to make smart decisions is fundamental to the success of any resource manager" (Gregory and Keeney 2002, 1601). As noted by Blanchette (2012), it is important to establish a “process for space management decision making” (Blanchette 2012, 70). This is echoed by the Huron Consulting Group (2015) in their study of the University of Colorado Boulder’s campus, in which they recommended that to make lasting changes in the University’s use of space, they needed to develop new decision-making methods for space allocation. Since the 1950s, decision-making, both theory and application, have been improving, and this improvement is focused on two specific areas, behavioral decision research (BDR) and decision analysis (DA) (Gregory and Keeney 2002, 1602). This research thesis centers on DA, which “focus[es] on how prescriptive techniques can be used to improve the quality of individual and group choices” (Gregory and Keeney 2002, 1603).

There are many methods of MCDM and it can be applied to different facets of the space allocation problem. For example, NASA’s LaRC space optimization software used many attributes and constraints to develop an array of possible solutions to maximize office space utilization (NASA 2017). The software tool developed by NASA’s LaRC is an expression of the systems engineering and MCDM considerations necessary for office space management. The USAF has an application, called an S-file, which is used to track all the real property owned by a base and documents the resources available to aid the decision process. NASA’s LaRC expands on this concept and can analyze space allocation to create multiple alternatives for decision makers (Esri 2009). Once again, while both provide a way to visualize the available resources, they do not present a methodology to manage office space holistically.

Keeney (1988) as well as Gregory and Keeney (1994) have performed studies that implement MCDM in several ways. As discussed by Keeney and Gregory (2005) in “Selecting Attributes to Measure the Achievement of Objectives,” a key part of making a decision is to have a clear set of objectives. Gregory and Keeney implement three steps for decisions which involve stakeholders which are “setting the decision context, specifying the objectives to be achieved, and identifying alternatives to achieve these objectives” (Gregory and Keeney 1994, 1036). Gregory and Keeney (2002) also implement a method called “PrOACT” which postulates there are certain elements that improve decision-making in complex scenarios, which are “Clarifying the Problem, Identifying Key Objectives, Creating Alternatives, Assessing Consequences, and Explicitly Addressing Tradeoffs" (Gregory and Keeney 2002, 1603). This method is specifically applied to water use planning projects but could be extended to space allocation projects as well. These methods presented by Gregory and Keeney (1994) and (2002) focus on the decision-making process and developing techniques to provide decision makers the right information to make complex decisions with conflicting priorities. These are applied outside of the subject of space allocation projects but could be leveraged for this specific application.

D. CHAPTER SUMMARY

This chapter discussed three main areas of study that support the presented problem statement, current decision-making practices in space allocation, existing techniques for space allocation optimization, and MCDM and its application to space allocation. Organizations in the past have generally relied on decision by committee, without published objective procedures or measures. Optimization techniques have been applied to this problem, but tools such as these are only as good as the inputs provided to the system and highlight the need to apply systems engineering methods. There are existing methods that can be adapted and applied to the space allocation problem to develop these inputs.

III. MODEL DEVELOPMENT

The purpose of this chapter is to apply the systems engineering method and MCDM framework to develop a method for organizations to allocate office space. The method is unique in that it uses MCDM to quantify the effectiveness of resource allocation based on the contribution to overall mission effectiveness. This approach can be applied to different types of organizations with a focus on federal agencies, and is specifically applied to the LAAFB as a case study of this methodology.

A. SYSTEMS ENGINEERING METHOD

"The systems engineering method…[is] the systematic application of the scientific method to the engineering of a complex system" (Kossiakoff et al. 2011, 91). There are many different systems engineering methods and processes that have been developed (Kossiakoff et al. 2011, 89–91). The specific methodology used in this research is that proposed by Kossiakoff (2011), which consists of four main activities: "requirements analysis, functional definition, physical definition, and design validation" (Kossiakoff et al. 2011, 91). The systems engineering method is represented in all phases of a program and consists of "the set of activities that tends to repeat from one phase to the next" (Kossiakoff et al. 2011, 89). Kossiakoff (2011, 255) states that the application of the systems engineering method can be used to aid in the decision-making process.

This section discusses the application of systems engineering method as it applies to the stated problem, as well as specifying areas where this research diverges from the described method. This provides context and rationale for using specific parts of the systems engineering method. Additionally, an explanation of where this research does not implement systems engineering processes is used to illustrate that the process was considered, and there was a rationale to the way that the parts to be implemented were chosen. A top level systems engineering method, which will be applied to the problem of interest, is shown in Figure 1. The relevance or omission of each step will be further explained as it relates to an organization in general. The purpose of this is to illustrate a general methodology of applying the systems engineering method to this problem. This methodology will then be described for a specific organization, the LAAFB, which is captured in Chapter IV.

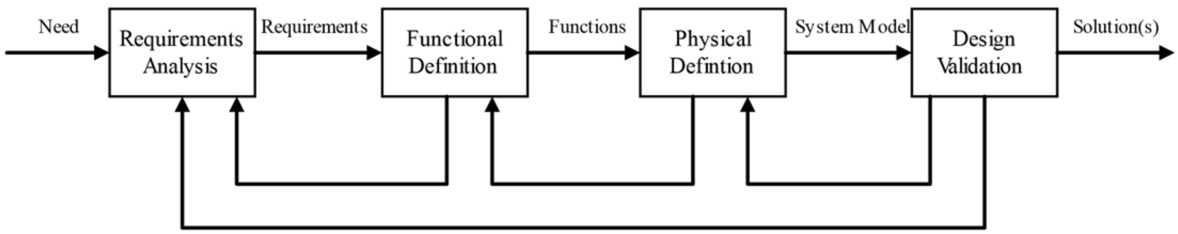


Figure 1. Systems Engineering Method. Adapted from Kossiakoff et al. (2011, 92).

1. Requirements Analysis

Requirements analysis involves the clarification of requirements definition such as operational needs, constraints, environment, and higher-level objectives (Kossiakoff et al. 2011, 93). Requirements analysis is a key part of this research since this will inform the development of objectives outlined as specified in the MCDM method as developed by Gregory and Keeney (2002). An organization will undergo a series of actions, as described below, to mature requirements. The requirements discussed in this section refer to those that the organization needs to perform to support its goals as well as any parent organization's goals.

a. Context Diagram

"Models [are used] to represent systems, or parts thereof, so we can examine their behavior under certain conditions" (Kossiakoff et al. 2011, 263). A context diagram is used to show external entities and how they interact with the system, with the objective of understanding how these external entities need to be accounted for in developing the system requirements and constraints (Kossiakoff et al. 2011, 266).

The organization creates a context diagram to initially document the various groups related to the organization's operation and to understand the relationships within the surrounding community. An example of an organization's context diagram, and an outline of the generic relationships that an organization may have that inform the varied objectives that they are trying to meet, is presented in Figure 2.

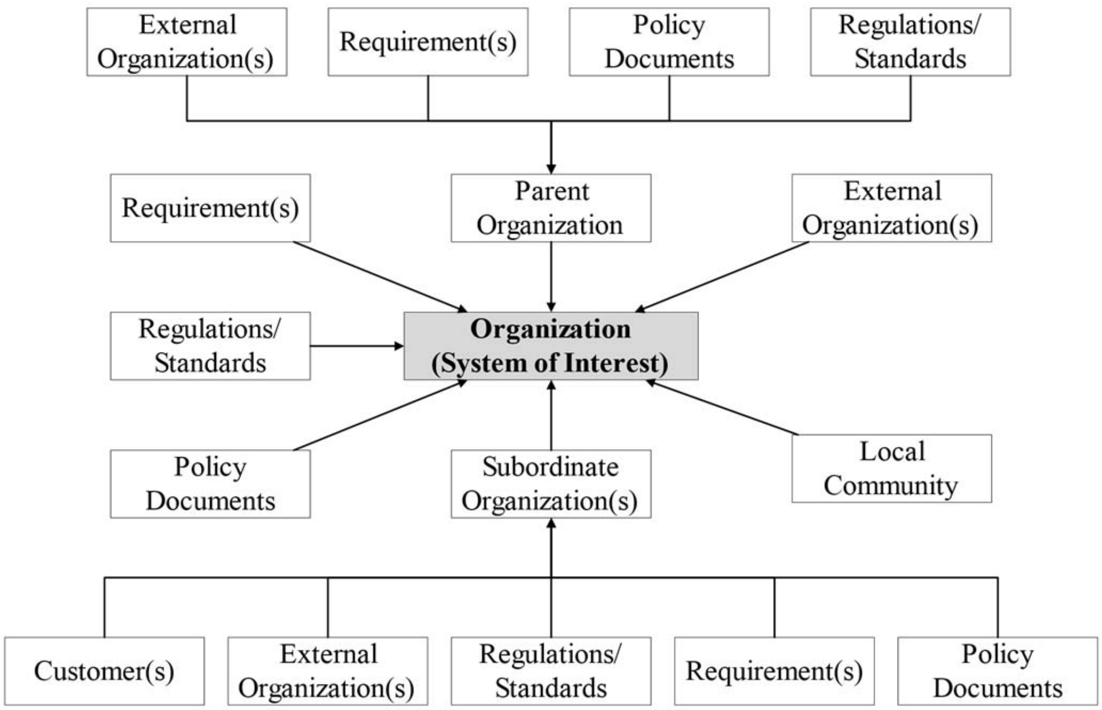


Figure 2. Context Diagram for Organization Relationships

A context diagram that represents at a top-level the entities and external factors that impact the organization during the requirements development process is depicted in Figure 2. Generally, an organization will have both a parent organization and subordinate organizations which need to be considered. Subordinate organizations are included in this context diagram since each of these may have requirements, stakeholders, or other external entities that do not directly relate to the organization of interest. Regulations, policies, and requirements are levied at different levels and do not necessarily flow down sequentially and so are represented at all three levels (parent organization, organization of interest, and subordinate organization). Additionally, there could be external agencies that impact some levels within the organization.

b. Stakeholder Analysis

"Understanding who the stakeholders are with respect to a decision needs to be established before a decision is made" (Kossiakoff et al. 2011, 258). An organization needs to understand both how it falls within its own hierarchy as well as the stakeholders that are affected by the organization and its decisions. This will support the identification of objectives as well as support the MCDM process to determine which stakeholders are a part of the decision space.

An organizational chart is developed to provide context for where the organization of interest falls within its own hierarchy. The highest level within the hierarchy should be the one that approves funding for the organization of interest, since any changes that would be implemented come at a cost, and the office that approves and provides the funding will be affected. Additionally, the organizational chart should reflect to the lowest level at which work is differentiated in support of an overall objective for the organization. For example, if the organization has five objectives, the organizational chart should have enough detail to identify unique commitments that support each objective. A basic organizational structure is shown in Figure 3. The lowest level, defined as "Program" would represent unique commitments that could be traceable to the objectives. The "Higher-Level Organization" represents where funding decisions are made for the organization. Developing this structure will support the requirements elicitation process and identification of the objectives. This may be an iterative process since, as the objectives are developed, the organization breakdown identified in Figure 3 may need further refinement to ensure it is decomposed to a level that can have separable items mapped to the commitments that support each objective.

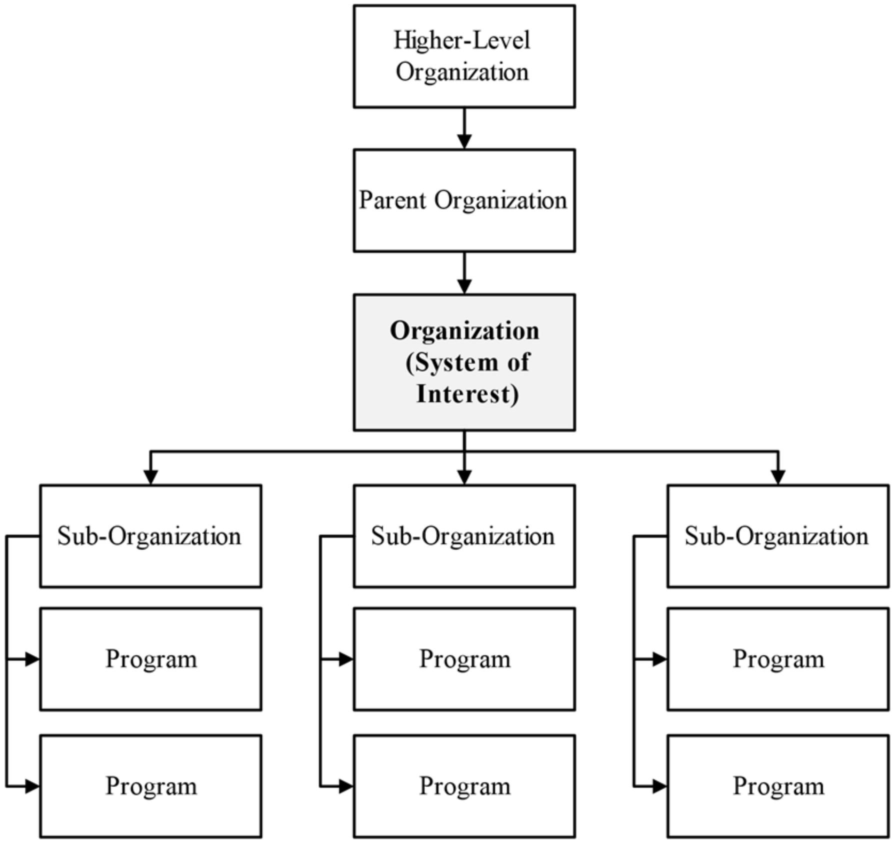


Figure 3. Organizational Hierarchy

Both within the organization structure, as depicted in Figure 3, as well as external to it, there are stakeholders who are affected by the organization's goals and objectives. Identifying the stakeholders to the organization and its missions supports the requirements elicitation and analysis. The development of the organizational chart, as shown in Figure 3, is the first step to identifying the stakeholders for the organization. This organizational chart would be further detailed out to break down organizations and individuals affected by decisions and performance of the organization of interest.

Next, an examination of external organizations, customers, and the local community would identify additional stakeholders. Recall the context diagram represented in Figure 2, which identified external entities to the system. The context diagram supports the stakeholder identification external to the organization. For example, consider the end-user or customer of the product that is the responsibility of one of the programs that is within the organization, shown in Figure 3. The companies and individuals who are part of the supply chain for this product could be considered stakeholders for the organization. This would include individuals who build or manufacture the product as well as the suppliers of the raw materials. Additional external stakeholders would include external agencies that have relationships with the organization such as oversight agencies which have a vested interest in the organization adhering to its rules and regulations. The surrounding communities of all the stakeholders previously identified may be affected by each stakeholder's success, and therefore would be affected by certain decisions made by the organization.

As Kossiakoff (2011) states, "stakeholders have values that will affect the decision and, in turn, will be affected by the decision" (Kossiakoff et al. 2011, 262). Once the list of stakeholders is compiled, the specific benefits and interests of each stakeholder should be analyzed as well as how they are impacted by the organization of interest. Stakeholders should be annotated as to where they fit into the objectives and priorities of the organization of interest. Also, it would be important to note possible objectives and priorities not previously considered that are generated through the stakeholder identification and analysis. This provides context for the weight and influence stakeholders have on a given objective. The impact to these organizations would need to be considered as that would influence the overall effect and impact of the objectives most important to the organization.

c. Identification of Objectives

After developing the organization's context diagram and identifying its stakeholders, the focus shifts to identifying and structuring its objectives. The context diagram helps provide an initial set of source documentation that impacts the organization. Using these source documents, such as strategic plans, vision and mission statements, data are gathered on objectives for the organization. The information is analyzed to identify specific objectives for the organization with traceability to the source document as shown in Table 2. This will be used in the MCDM process as part of determining each objective's priority. As demonstrated in Table 2, the same objective may be captured in multiple source documents such that multiple sources are driving an organization to have the same specific objective. An understanding that some objectives are traceable to multiple sources will support the development of an objective's priority during the MCDM process.

Table 2. Mapping Source Documentation to Objectives

Document / Objective	Document 1	Document 2	Document 3	Document 4	Document 5
Objective 1	X	X		X	X
Objective 2	X	X		X	
Objective 3	X		X		
Objective 4	X	X	X		
Objective 5	X	X			X

After the benefits and interests of each stakeholder are documented, the organization compiles a refined list of objectives, to include both those identified through source documentation as well as any additional objectives or supporting objectives identified through the stakeholder analysis. The mapping previously created, as shown in Table 2, is then mapped to the associated stakeholders. A mapping of the disparate objectives and how they relate to each stakeholder is presented in Table 3. This provides an understanding of which stakeholders have a greater interest in the objectives of the organization, and how these various stakeholders may influence the decision-making process. For example, Stakeholder 2 has a vested interest in two objectives while Stakeholder 1 has an interest in four objectives. This is a data point for consideration in the overall MCDM model to support a logical method of determining objective prioritization. Three stakeholders are included in Table 3 as an example, but this could be extended based on the number of stakeholders identified by an organization.

Table 3. Mapping Stakeholders to Objectives

Objectives \ Factor	Document 1	Document 2	Document 3	Document 4	Document 5	Stakeholder 1	Stakeholder 2	Stakeholder 3
Objective 1	X	X		X	X	X	X	
Objective 2	X	X		X		X		
Objective 3	X		X			X		X
Objective 4	X	X	X			X		
Objective 5	X	X			X		X	

d. Structuring the Objectives

The objectives previously identified should be reviewed to determine if some are instead of being objectives are instead means to achieve another objective identified. Gregory and Keeney state that once the list of objectives is developed, “they will need to be organized so as to distinguish between objectives that are means to an end and those that are ends in themselves” (2002, 1606). Gregory and Keeney’s technique is to ask “why” five times, which helps to determine whether an objective has been fully developed or still represents a means to an end (Gregory and Keeney 2002). An example of an organization of goals and objectives is shown in Figure 4 where goals are identified as the items an organization is focused on achieving (usually stated as the organization’s missions) and objectives contribute to the achievement of those goals. Often, higher level objectives must be decomposed into sub-objectives to better define the effectiveness of the system.

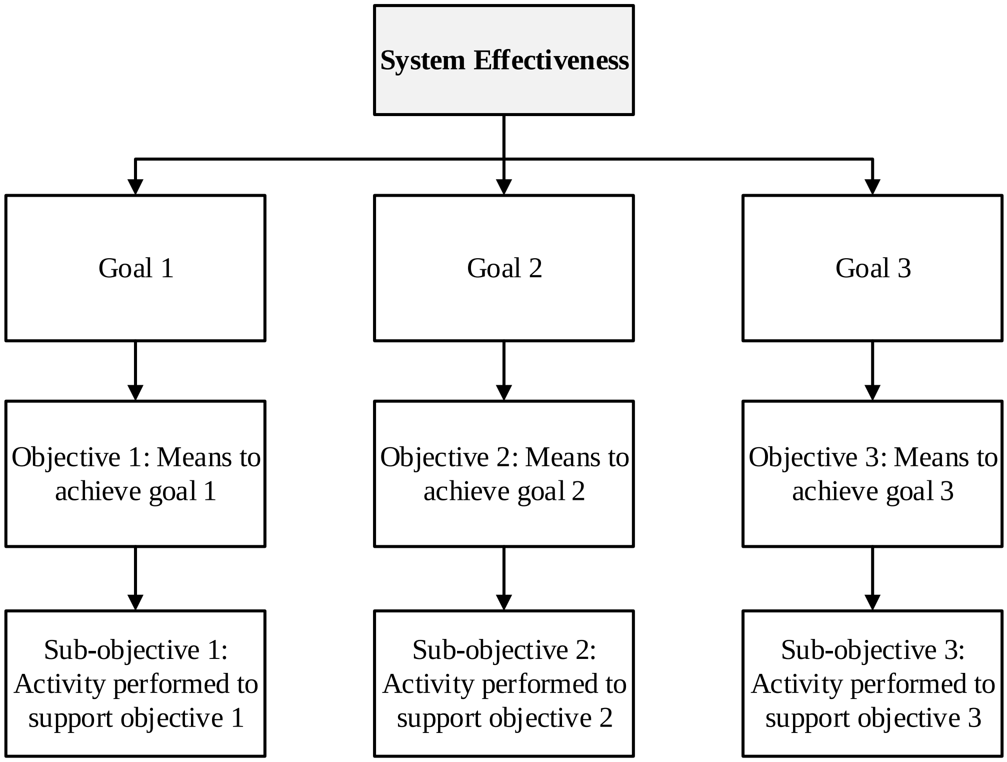


Figure 4. Organization of Goals and Objectives

After the objectives have been decomposed, the lower level sub-objectives can be mapped to specific programs and units responsible for achieving those objectives as shown in Figure 5. This mapping supports the MCDM process by providing a method of separating out each program and its support to the organization's goals and objectives. As shown in Figure 5, some programs may map to multiple sub-objectives. If this type of mapping occurs, either from having a program map to multiple sub-objectives or having multiple programs map to a single sub-objective, the organization should decompose the sub-objectives or programs further to achieve a one-to-one mapping, as represented in Figure 6.

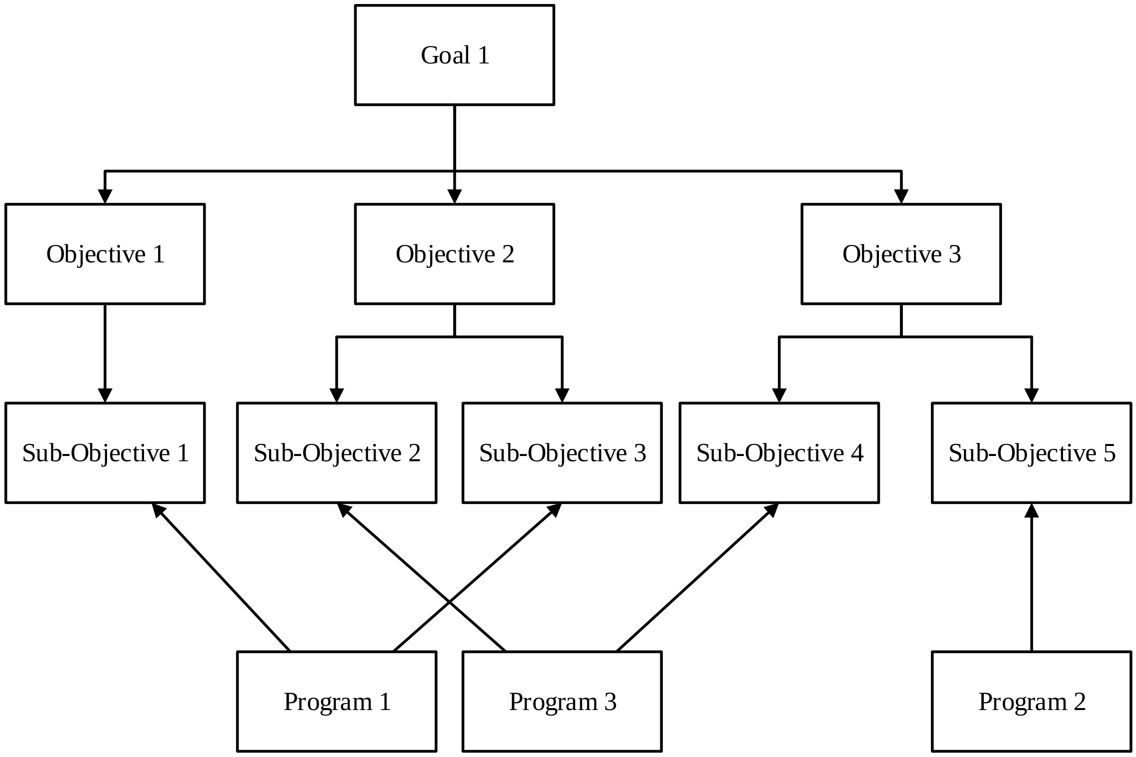


Figure 5. Mapping Programs to Objectives that Support the Organization's Goals

When a single sub-objective traces to a single program element, represented in Figure 6, it is easy to identify the resources that are required to achieve the sub-objective. When programs support multiple sub-objectives, also depicted in Figure 6, it will be necessary to allocate each program's resources among the different sub-objectives to avoid double counting. When more than one program supports a single sub-objective, the amount of support will have to be allocated between the programs so that the percentages add up to 1. The mapping of program resources to sub-objectives also supports transparency and understanding by both leadership and the programs that resources are given to as to which objectives those resources are meant to support. The development of relative importance weights for the goals, objectives, and sub-objectives will be discussed as part of Chapter III Section B, but this initial mapping provides insight into which stakeholders may be affected the greatest by personnel and resource decisions on the base as well as which units or programs support which objectives.

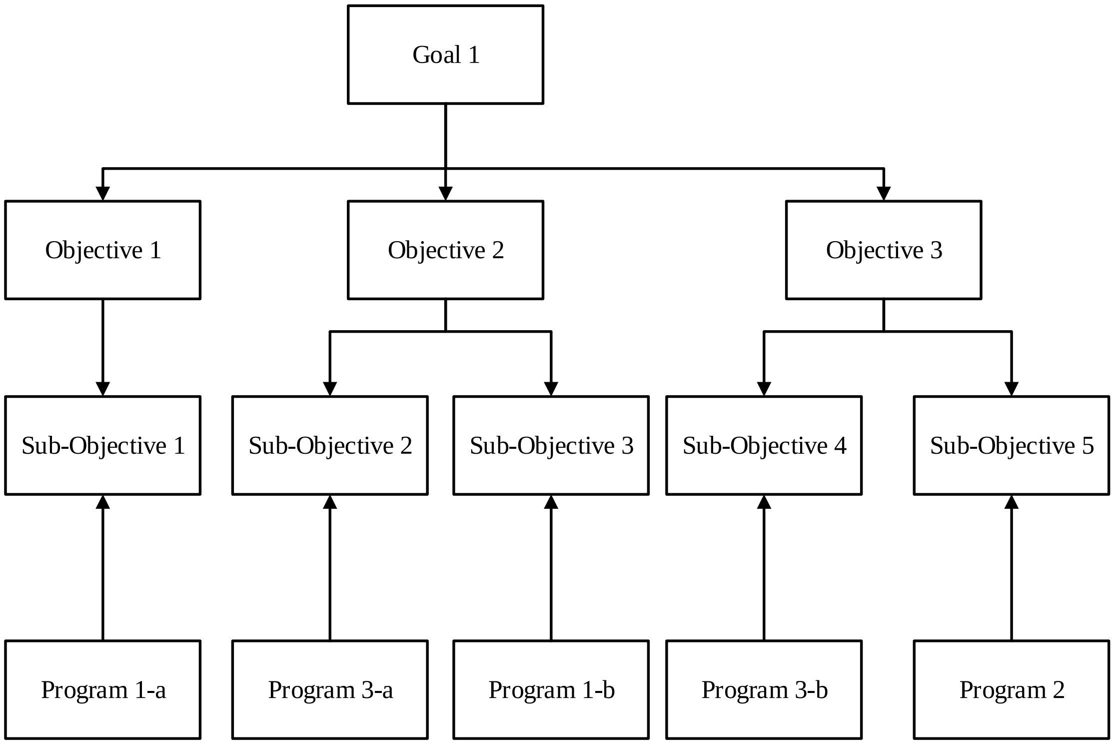


Figure 6. Decomposition of Programs and Objectives to Achieve One-to-One Traceability

e. Identification of Constraints and Assumptions

The identification of constraints and assumptions is a part of the requirements analysis activity by helping to clarify the requirements and what constraints it must fit (Kossiakoff et al. 2011, 93). To inform the decision space, constraints and assumptions need to be identified by the organization. Following a similar process to define the objectives, source documentation and stakeholders should be reviewed to identify possible constraints and assumptions. Since this research is intended to help manage office space allocation, general constraints that apply to this area have been identified. In addition, there may be unique constraints or assumptions for an organization, its objectives, and its set of stakeholders. An organization should use this list as an initial set and further refine the constraints and assumptions using the information previously gathered through the requirements analysis activity. A mind map, displayed in Figure 7, was used to generate the initial set of constraints for office space allocation and was separated into three main areas: financial constraints, physical limitation, and administrative limitations.

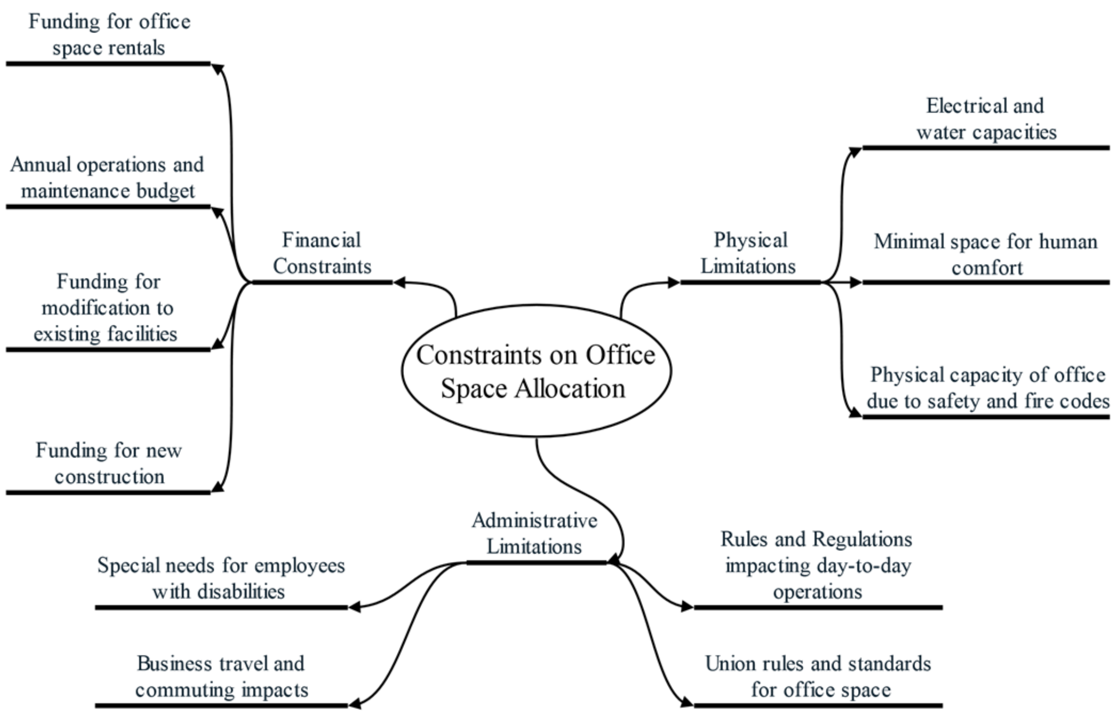


Figure 7. Mind Map of Constraints on Office Space Allocation

Financial constraints of an organization focus on both the funding and budgetary considerations an organization must consider when making office space allocation decisions. Some specific financial constraints are:

- budgeting for the annual operations and maintenance as provided by the approving office identified in the hierarchy
- funding for modifications to existing facilities
- funding for office space rentals
- funding for new construction

Physical limitations focus on a space’s ability to accommodate additional personnel regardless of whether funding is available to make the space available. Some specific physical limitations are:

- physical capacity of the current office space regarding how many bodies can occupy the space in accordance with (IAW) fire codes
- electrical and water capacities that limit the amount of people to not degrade the facilities

Administrative limitations focus on limitation to how an office can be modified due personnel considerations. Some specific administrative limitations are:

- special needs for employees with disabilities
- union rules and standards for office space
- business travel and commuting impacts to inform the amount of people who will physically be present and an indication of the times they will be present
- rules and regulations impacting the day-to-day operations of the organization

The identified constraints are analyzed and mapped to the objectives and stakeholders. This provides a traceability to help understand which factors are driving the constraints on the system. An example of this mapping is provided in Table 4.

Assumptions should also be documented to help bound the problem. Based on the previous steps to understand the stakeholders and limitations, this will provide insight into basic assumptions that can be applied to any model developed. For example, if the leadership team above the organization of interest knows that funding will be limited in the upcoming year, a basic assumption can be made that modifications to existing office space will not be an acceptable option.

Table 4. Mapping Source Documents and Stakeholders to Constraints

Constraint \ Factor	Document 1	Document 2	Document 3	Document 4	Document 5	Stakeholder 1	Stakeholder 2	Stakeholder 3
Constraint 1	X	X	X	X	X	X	X	
Constraint 2	X	X		X				
Constraint 3		X		X			X	
Constraint 4		X					X	X
Constraint 5		X	X				X	

2. Functional Definition

Traditionally, the next step in the systems engineering method would be to perform functional definition to "translate requirements…into functions" (Kossiakoff et al. 2011, 93). The functional definition step does not apply in this thesis since the focus of this research is not to develop a product but to propose a decision-making process. There is not a physical or software product that is being developed, but rather a decision-making methodology based on systems engineering practices.

While this research project does not perform a transformation of requirements into functions, during the MCDM process, developing a tool to support the prioritization of objectives is needed. As described in Chapter IV, for the LAAFB, this tool captures and documents the prioritization of the goals, objectives, and sub-objectives, and ultimately suggests which commitments should be given resources based on values and weightings developed by the organization and its stakeholders. A functional decomposition of the tool's functions, illustrated in Figure 8, an example of the tool is described in Chapter IV. In general, this step would not apply since the overall objective of this research is to develop a process; the tool developed is only meant to aid this process. Understanding the functions needed to support the development of the objectives' prioritization will aid in the MCDM process and support the organization making a more informed decision for office resource management.

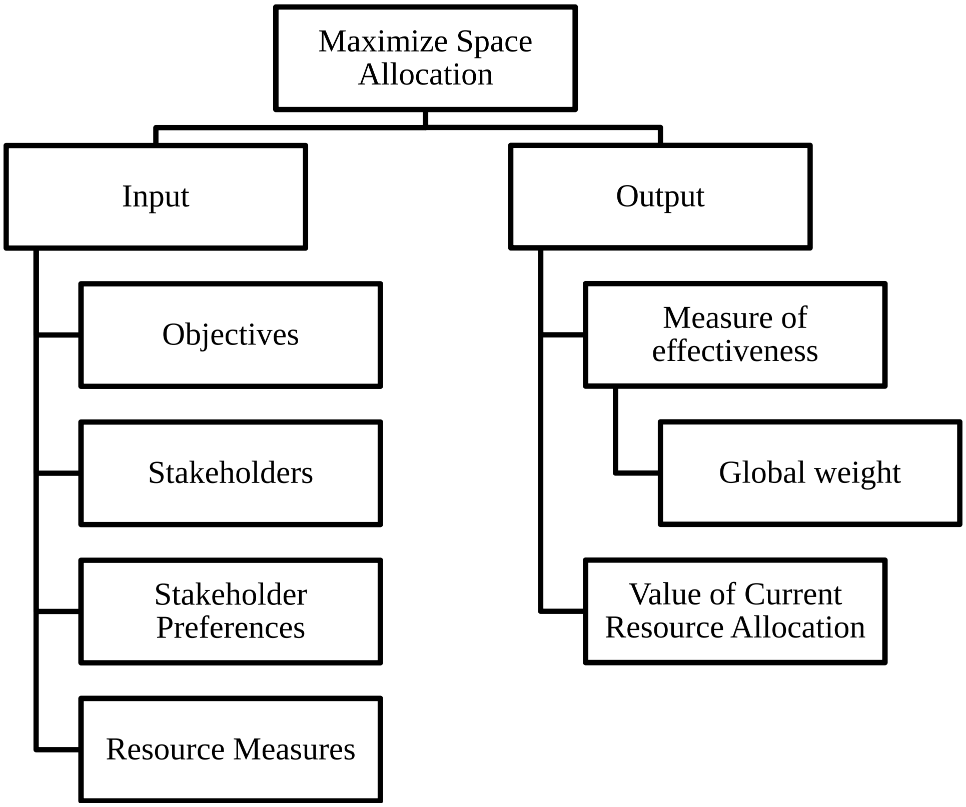


Figure 8. Functional Decomposition for MCDM Model Tool

3. Physical Definition

Physical definition "is the translation of the functional design into hardware and software components, and the integration of these components into the total system" (Kossiakoff et al. 2011, 97). This step of the systems engineering process does not apply since there is no physical definition of the objective of this research. As an extension to the tool described to aid in the development of the objectives' priorities, as part of it development, it could go through the physical definition process of the systems engineering method. For example, if there are alternate software programs that could be used, interfaces with outside systems for inputs from external entities, this activity should be performed.

4. Design Validation

Kossiakoff states that "to validate a model of the system, it is necessary to create a model of the environment with which the system can interact to see if it produces the required performance" (2011, 99). The design validation process is accomplished through the development of the tool incorporating MCDM process. This provides a means to apply different test cases to the tool prior to becoming operational. This step is essentially "designing models of the system environment" (Kossiakoff et al. 2011, 93) of which the tool development reflects the office space management environment.

B. MULTICRITERIA DECISION-MAKING APPLICATION

"Choices that require multiple stakeholders to balance conflicting objectives are among today's most controversial decisions" (Gregory and Keeney 2002, 1601). Multicriteria decision-making supports making decisions under these conditions, such as space allocation decisions, which will utilize inputs derived from the systems engineering method. Systems engineering provides a holistic approach to determining objectives for the organization given multiple stakeholders. The process developed herein supports the ability for an organization to make resource decisions while balancing so many different objectives. "When either objectives or alternatives are inadequate, the usual result will be a poor decision" (Gregory and Keeney 2002, 1604). If the developed objectives are inaccurate or wrong, the end decision may be poor.

For the case of space allocation decisions for an organization, requirements analysis is used to develop a comprehensive list of objectives and their mapping to their source documents, impacted stakeholders, as well as constraints. Inputs generated for these areas will provide the necessary data for a leadership team from the organization to utilize the MCDM process effectively.

To apply the MCDM method, a leadership team from the organization needs to be identified to shepherd this process. The same person or team that performed the systems engineering analysis for the organization could be used, but they may not necessarily be the same. Therefore, since MCDM will drive decisions that affect the organization, a leadership team is needed to be the formal person or body responsible for considering the factors identified in the systems engineering process and thereby applying MCDM to these factors. The leadership team should include stakeholders, which is supported by Gregory and Keeney's (1994, 1036) model, where stakeholders should support and guide the decision process and provide early input into the decision process. The leadership team will be determined by the leader in charge of the organization but the information gathered on the stakeholders should be considered as part of the development of this team. The organization's leadership team will follow Gregory and Keeney's three-step process for MCDM: "set the decision context, specify the objectives to be achieved, and identify alternatives to achieve these objectives" (Gregory and Keeney 1994, 1036). To implement the MCDM process, the organization uses the data collected from the systems engineering method.

1. Setting the Decision Context

"The decision context typically is set by those facing the decision and those with factual knowledge about the decision" (Gregory and Keeney 1994, 1036). This is essentially managing expectations to ensure a shared understanding to bound the problem. Gregory and Keeney discussed instances where, the stakeholder seeking a change affecting other stakeholders, did not include options that would directly contradict their position even if it was likely favorable to the opposition (Gregory and Keeney 2002). The example used by Gregory and Keeney (2002) was a company seeking approval for offshore drilling, but when defining the decision context, the option not to drill at all was omitted. This step helps reduce rework by removing assumptions that affect the outcome. With respect to the organization, application of the systems engineering process produces the products to help set the "decision context."

Documentation on the objectives, stakeholders, constraints, and context diagram can be used by the decision makers to baseline an understanding of the environment. The organization leadership team uses the context diagram as a starting point. The context diagram provides insight into what the current environment is for the organization. The context diagram highlights the various relationships and external factors that impact the objectives for the organization. The stakeholder analysis would also provide insight on the background of how different stakeholders relate and interact with each other. The organization leadership team will need to review and constraints and assumptions to understand second and third order impacts. After a review of the items above, the leadership team can determine if any additional stakeholders need to be included or if the team can proceed to specifying the objectives to be achieved.

2. Specifying Objectives

The next step is to "specify the objectives to be achieved" (Gregory and Keeney 1994, 1036). The objectives that were identified in the systems engineering process are presented in Table 2 and Table 3. These identify objectives and describe ideal end states of the various stakeholders. Gregory and Keeney (1994) discuss two types of objectives: fundamental objectives that refer to the end-state, and means-objectives that refer to how the fundamental objectives are achieved. The initial development of this separation between goals and objectives is captured in Figure 4. The organization's leadership team reviews the identified goals as well as the objectives to achieve them and ensure that these cover the decision context and are specified to a level that can be identified with unique programs or commitment. After all objectives are identified, stakeholders then rank or assign a numerical value to prioritize objectives. First, objectives are prioritized within each stakeholder's submission, then, discussions are held among the stakeholders to prioritize the aggregate list (Gregory and Keeney 2002). One means of capturing this information is with a spreadsheet, which is the method used for the LAAFB case study.

3. Attributes and Value Functions

In addition to understanding an organization's objectives, a solution needs to recognize how an organization intends to achieve and measure the achievement of its objectives. This research develops a method to manage office space allocation based on the overall effectiveness of an organization. The organization's effectiveness can be measured by its ability to support objectives, as illustrated in Figure 6. Subordinate units are responsible for achieving objectives and their success depends to a great extent on the resources they have available to support those objectives. The particular resource of interest for this thesis is office space. Our initial assumption will be that each person requires a fixed amount of office space, and we will use number of people as the proxy for office space. People are the resource an organization levies to achieve objectives, and represent a measurable attribute for effectiveness. A value function is used to indicate the value associated with the number of people available to support each objective. The value function allows the decision maker to recognize the fact that different objectives require different amounts of resources (people) and that there are minimums and maximums to the amount of resources required. At some minimum point there are too few people to perform the functions required provide any level of support to an objective, so the value is zero. On the other hand, there is a point at which all the functions are fully staffed and the value of that level of staffing is 1. Adding one more person beyond the maximum level adds no value and therefore the value remains at 1. The value of staffing levels between the minimum and maximum can be modeled with a linear function that maps the level of staffing to a number between zero and one.

An example of this is illustrated in Figure 9. The value function for an organization with a minimum number of full-time equivalents (FTE) to be effective, as shown in Figure 9, is five and 10 FTE is the maximum required to be fully effective. If this organization has fewer than five FTE it cannot perform its mission. On the reverse side, if the organization has over 10 FTE, it does not provide any improvements over having the maximum (10 FTE) to achieve its objectives. If the current staffing level is eight FTE, it would receive a value of 0.6 based on the linear value function, which in this example has a slope of 0.2, meaning each additional FTE over five adds a value of 0.2 up to the maximum of 10 FTE (value of 1).

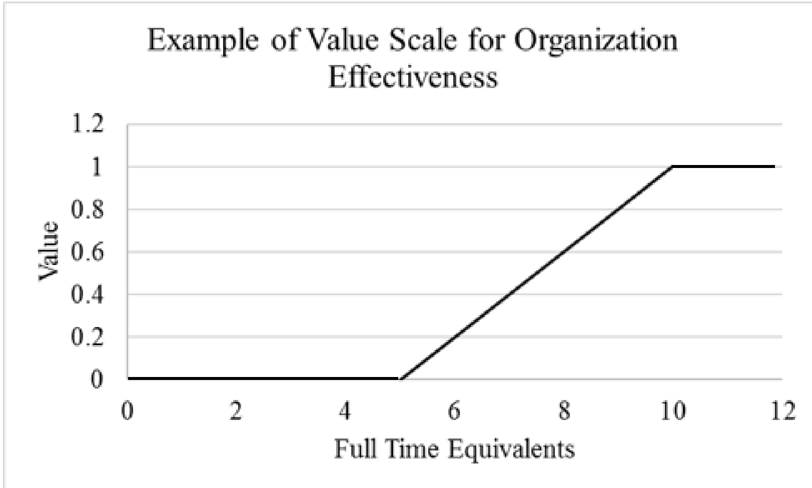


Figure 9. Example of a Value Function for Organization Staffing

To support balancing multiple objectives in the decision-making process, the trade space needs to be understood for each objective. More specifically, both the minimum and maximum values for the required resources to effectively perform the objective need to be identified. Understanding the minimum value ensures that resources are not wasted by assigning people to functions that cannot be performed with the given level of staffing. For example, if an objective requires a minimum of 25 FTE, but only 20 FTE are available, the organization would be 0% effective towards achieving that task. The 20 FTE applied to this objective could be reassigned to other priorities. This disconnect would not be visible without identifying the minimum FTE required to perform an objective. There may be instances where even though an organization is below the minimally effective number of FTE, the resources would remain with the organization; identifying that an organization is below its minimally effective number of FTE would still be value added for the leadership team to know.

The corollary to understanding the minimum values is recognition of the maximum amount of people that can meaningfully contribute towards a specific objective. There comes a point for a given objective where additional people add little or nothing to the effort and redistribution needs to occur in order to increase the overall effectiveness of the organization. For example, if an objective had a maximum of 50 FTE, having 100 FTE assigned to the effort does not yield an effectiveness of 200%.

This would indicate that the organization has 50 additional FTE that could be reassigned to help additional objectives, thereby increasing the overall effectiveness of the organization.

Each program needs to identify both the minimum and maximum FTE required to perform the functions required to achieve an objective that is linked to its program (linkage is shown in Figure 6). Since the hierarchal structure has already been developed to show how each objective is decomposed into its respective sub-objectives, by understanding the resource requirements for each sub-objective an overall effectiveness of each staffing level can be determined. This also supports making decisions between multiple programs that support the same objective. The same amount of resources applied to different programs may not achieve the same level of effectiveness depending on the importance of the objective and the minimum and maximum resources required to achieve the objective. Each program's effectiveness would be compiled to develop an overall effectiveness for each objective and this value combined with the weighting of each objective helps determine how to allocate resources effectively to achieve the organization's objectives.

4. Relative Importance of Objectives

The top-level goals and objectives for the organization that have been agreed to by the stakeholders are captured; the stakeholders individually assign weightings and then these individual weightings are compiled into a single list through discussions with the all the stakeholders. An example of this step in the MCDM process is represented in Table 5. The weightings used in Table 5 are percentages with the total across all goals adding to 100% which is an example of a relative scale, that is, the goals are rated relative to one another (Natural Resources Leadership Institute 2011). Another method of weighting is using an ordinal scale, such that all goals are rated against the same scale for satisfying a specific interest (Natural Resources Leadership Institute 2011). There are different weighting schemes that can be used by an organization, the main purpose is to have a system that can be applied uniformly and helps separate the objectives from each other in terms of their priority.

Table 5. Weighting of Goals

	Weight		Weight		Weight
Goal 1	40%	Goal 2	35%	Goal 3	25%

The top-level goals have been further decomposed into objectives and sub-objectives that can be assigned to specific programs and units. Once the weights of the top-level goals of an organization have been agreed to by the stakeholders, the process is repeated for each level. An example of how the weightings could be developed below the top-level goal is shown in Table 6. The weighting system uses a relative scale and the sum for both the objectives and the sum of sub-objectives within each objective is 100 to confirm that the weightings have been applied appropriately. As shown in Table 6, the mappings to the individual programs are also captured so the weightings of the sub-objectives, objectives and goals can be tied to programs to determine where resources need to be allocated.

Table 6. Weightings for Objective and Sub-objectives for a Single Objective

	Weight
Goal 1	40%
Objectives Sum	100%

	Weight			Weight			Weight	
Objective 1	55%		Objective 2	25%		Objective 3	20%	
Sub-Objective 1 Sum	100%	Program	Sub-Objective 2 Sum	100%	Program	Sub-Objective 3 Sum	100%	Program
1.1	12%	1	2.1	55%	3	3.1	55%	1
1.2	35%	2	2.2	45%	2	3.2	45%	3
1.3	25%	1						
1.4	28%	3						

The “global” weight for each sub-objective is determined by multiplying the weights of the goals, objectives, and sub-objectives together. This weighting represents the relative importance of each sub-objective to support the organization’s overall effectiveness. As an example, the global weight for sub-objective 1.1 (from Table 6) is calculated as (0.40)x(0.55)x(0.12) = 0.0264 or 2.6%. The global weights for all the sub-objectives under Objective 1 from Table 6, are shown in Table 7.

Table 7. Global Weights of Sub-objectives under Objective 1

Sub-Objectives	**Global Weight**
1.1	2.6%
1.2	7.7%
1.3	5.5%
1.4	6.2%

5. Calculating the Measure of Effectiveness

After data are gathered on the program’s current staffing and how that level of staffing is valued (using the value functions described in Chapter III Section B-3) as well as its relative importance to the organization’s mission, the program’s and organization’s effectiveness can be calculated. A program’s effectiveness at performing an objective is a combination of its current staffing value and the relative importance of the objective to the organization’s mission. This is calculated by multiplying the value of the current staffing times the relative importance (shown in Table 7). We assume an additive value function so that the sum of all the program’s effectiveness measures adds up to the organization’s total effectiveness. As resources are applied and rearranged between objectives, the organization’s total effectiveness provides a measure of how these decisions impact an organization’s ability to meet its mission. Once the effectiveness for each sub-objective is calculated, the model can be used by decision makers to determine how best to allocate resources in a logical and defensible manner.

6. Using the Model to Improve Effectiveness

Gregory and Keeney's last step is "identifying alternatives to achieve these objectives" (Gregory and Keeney 1994, 1036). Stakeholders use the prioritized aggregate list to develop alternatives to meet the objectives. While this thesis does not suggest alternatives, the model developed in this thesis will allow stakeholders to evaluate alternative resource allocation choices by observing changes in the effectiveness of the organization. Stakeholders would be able to see the impacts their decisions have on the organization to make an informed choice on a solution(s).

C. CHAPTER SUMMARY

This chapter developed a method for organizations to support decision makers in making resource allocation decisions by applying the systems engineering method and MCDM framework. This chapter focused on developing steps that can be used by a diverse set of organizations and adapted to fit individual needs of an organization.

IV. MODEL APPLICATION

The purpose of this chapter is to apply the systems engineering method and MCDM process described in Chapter III to LAAFB's office space management process. This will illustrate how these processes can be used to develop a framework, while creating a product that is directly applicable to LAAFB and that can be extended to apply to other installations.

A. SETTING THE DECISION CONTEXT

As part of the decision process, a leadership team should be determined for LAAFB that is responsible and authorized to make decisions on office resource allocations. The leadership team should include stakeholders that are part of the decision context and who are knowledge of LAAFB's structure and units as well as the resource requirements and constraints for the individual elements mapped to commitments. The leadership team may change depending on the specific decision context but would include several key members:

1. SMC/CC
2. military and civilian deputy to SMC/CC
3. program office directors
4. program manager(s) for specific commitments
5. 61st Air Base Group commander
6. systems engineering support personnel for tool development and guidance

The SMC/CC and his or her deputies lead the base, and define its mission and values and have the overall responsibility for delivering the capabilities of each unique program on base. The 61st Air Base Group commander is responsible for overseeing base support functions. The program office directors lead the individual offices and have day-to-day responsibility for the missions and programs as part of their office. Program managers for specific commitments may need to be a part of the leadership team depending how the commitments are traced to individual programs and how much knowledge on each program is required. The role of the systems engineering support personnel for tool development and guidance is based on Gregory's recommendation to have "analysts chosen to provide guidance to the decision makers" (Gregory and Keeney 1994, 1036). This part of the leadership team would facilitate the other members in making decisions and guide them through the process.

The leadership team needs to form a consensus on what the decision context is and the specific question they are focusing their decision around. The decision context should not be set too narrowly or rule out certain alternatives as this may cause disagreement between the stakeholders (Gregory and Keeney 1994, 1036). Some examples of the types of decisions that this leadership team could face are projecting the prioritization of resource allocation, identification of which organization will receive the next available resources, and re-allocating resources to be more effective.

B. CONSTRAINTS AND ASSUMPTIONS

To define the scope of this research, the following constraints and assumptions were considered. Constraints focus the methodologies and tool described herein to illustrate systems engineering and MCDM concepts. Assumptions help provide context the values and reasoning used to illustrate various concepts.

Constraints:

- Source documents: Due to the wealth of guidance information within the Department of Defense (DOD), guidance information used to derive SMC mandates, goals, and commitments were constrained to the USAF Strategic Master Plan (SMP), Air Force Space Command commander (AFSPC/CC) Strategic Intent, and the SMC Strategic Plan.
- Program offices: This research was constrained to consider only the program office organizations within SMC to ensure similar structured and purposed organizations were compared to each other (i.e., the SMC/CC would not have to choose providing basic needs such as health care over support for an acquisition program).

- Minimum FTE: A minimum number of FTE could be directed that would constrain the tool to ensure specific commitments and organizations were provided support. A minimum number of FTE is currently not included in the model, but is documented here since special interest items and regulations could easily dictate required support.

Assumptions:

- Program office FTE: The FTE within each program office is based on publicly available information and does not reflect current staffing levels. Additionally, FTE numbers were assumed for the Global Positioning Systems Directorate (SMC/GP) and the Operational Responsive Space (ORS) Office based on a general understanding of the two organizations compared to other SMC organizations.
- Maximum FTE: Maximum FTE were assumed based on the author's personal knowledge and experience
- Minimum FTE: Minimum FTE were based on 70% of the maximum FTE required for a given commitment. 70% was assumed based on the author's best judgement of the staff required.
- Linear relationship: A direct linear relationship between the minimum and maximum FTE is assumed, such that more personnel are more effective than less personnel.

C. REQUIREMENTS ANALYSIS

The systems engineering method applied to LAAFB is based on Kossiakoff's (2011) systems engineering method as discussed in Chapter III. The steps that are applied to the LAAFB case study are presented in Figure 10. The key change from the method described by Kossiakoff (2011) is that there is not a *Physical Definition* step since the objective of this research is to develop a framework as opposed to a physical product for LAAFB.

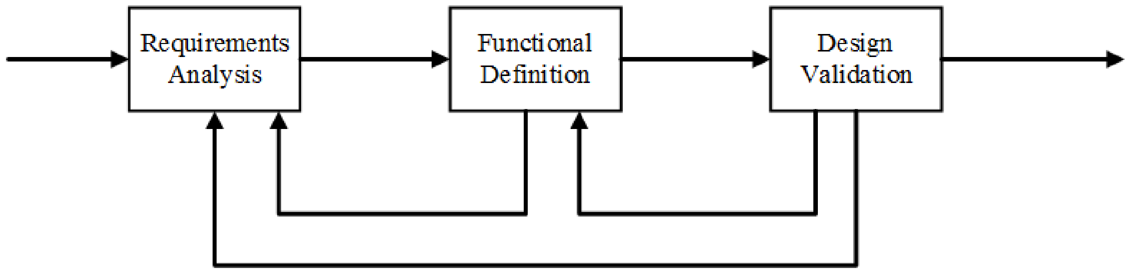


Figure 10. Systems Engineering Method Applied to LAAFB Office Space Allocation. Adapted from Kossiakoff et al. (2011, 92).

By performing requirements analysis, a complete list of objectives for LAAFB can be developed. These objectives will be weighed during the MCDM process. Los Angeles Air Force Base is organized in a hierarchal structure with a diverse set of programs, as such, a variety of factors need to be considered to determine the requirements for the base. Many other military bases and federal organizations have a hierarchal structure like LAAFB and the process applied herein can be extended to these organizations.

1. Context Diagram

Identifying an organization's objectives first requires an understanding of its environment. A context diagram of LAAFB was developed to illustrate the initial external entities that could drive requirements and thereby the objectives for the base. At a top-level, some of the key considerations that influence the objectives for the base, presented in Figure 11, the context diagram depicts how LAAFB has influences from guidance documents, parent organizations, customers, industry partners, as well as the sub-organizations. As represented in Figure 11, LAAFB needs to consider both doctrine and people in the decision-making process.

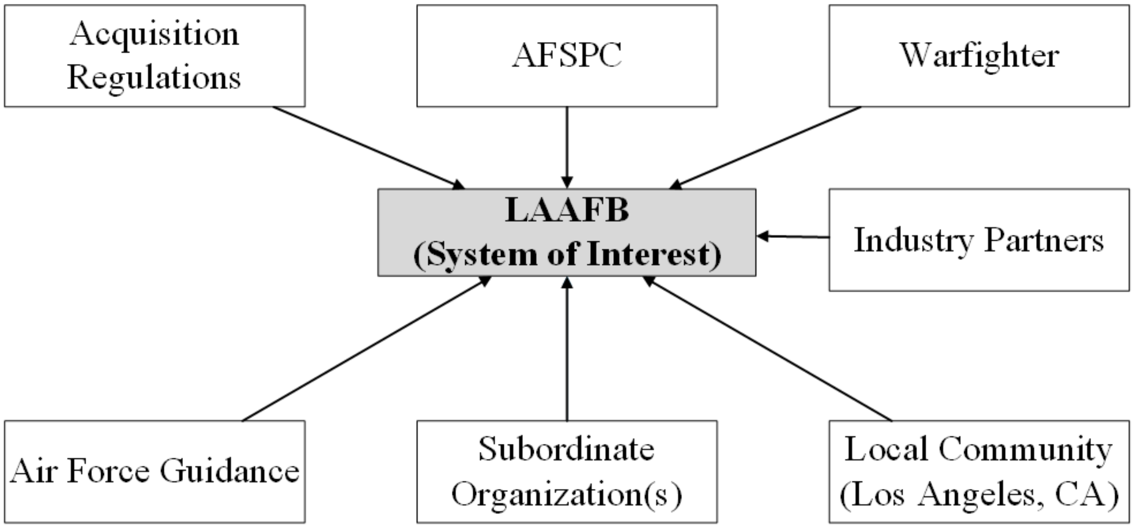


Figure 11. Context Diagram of LAAFB

2. Stakeholder Analysis

Based on the methodology described in Chapter III, stakeholder analysis for LAAFB is separated into two tasks; identify stakeholders who are within the organizational hierarchy and those who are external to it. The organizational hierarchy displays how LAAFB falls within its own hierarchy and is shown in Figure 12, 13, and 14.

Los Angeles Air Force Base has two lines of authority regarding how decisions are made on base: acquisition and operations. The operational hierarchy is focuses on the "organize, train, equip, prepare, and maintain" (United States Joint Staff [US JS] 2013, II-2) functions of the base, presented in Figure 12. The SMC/CC is responsible for these functions and is under the authority of Air Force Space Command (AFSPC), followed by the Air Force (AF), and then the DOD. The SMC/CC has "responsibilities for care and provisioning of the AF forces on that installation, regardless of organization" (USAF 2007a, 51). These higher-level organizations may influence decisions when it comes to personnel, especially in regard to the "organize, train, equip, prepare, and maintain" (US JS 2013, II-2) functions and should be considered when making strategic decisions on personnel.

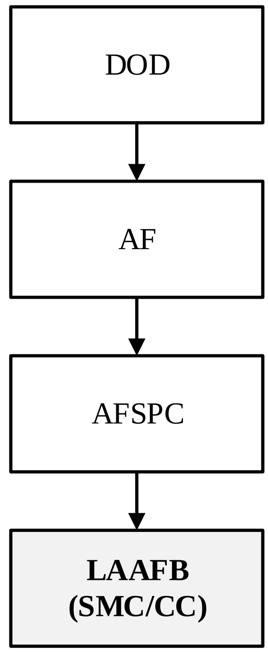


Figure 12. Operational Hierarchy

The acquisition hierarchy for SMC, illustrated in Figure 13, was developed from the Assistant Secretary of the Air Force for Acquisition (SAF/AQ) guidance (USAF 2017) and the Department of Defense instruction (DODI) 5000.02 (Under Secretary of Defense for Acquisition, Technology, and Logistics [USD[AT&L]] 2017). DODI 5000.02 outlines guidance for the Defense Acquisition System, including procedures, and roles and responsibilities to which the AF and SMC must adhere (USD(AT&L) 2017). Within DODI 5000.02, part of the acquisition process that is described is the milestone events that essentially govern acquisition programs development progress. To move along the process, acquisition programs must pass these "milestones" and the approval authority for these milestone events is the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)), who is identified as the defense acquisition executive (DAE). The DAE can delegate approval down to service component chiefs, in this case, the Secretary of the Air Force (SECAF), and the SECAF can delegate acquisition approval to SAF/AQ. The decision chain of authority is important because it illustrates how priorities and objectives within the defense acquisition community are passed down. As depicted in Figure 13, a dotted line is shown to reflect the flow of guidance and direction from USD(AT&L) to SAF/AQ since SAF/AQ is empowered to serve as the component acquisition executive (CAE) or service acquisition executive (SAE), and is responsible for all acquisitions for the AF. Headquarters Air Force (HAF) Directive 1–10 further states that "acquisition execution and management responsibility flows directly, without interruption, from the SAE to the Program Executive Officers (PEO) to the program managers" (USAF 2016b, 2). The acquisition title for the SMC/CC is the PEO for Space Systems and reports to SAF/AQ.

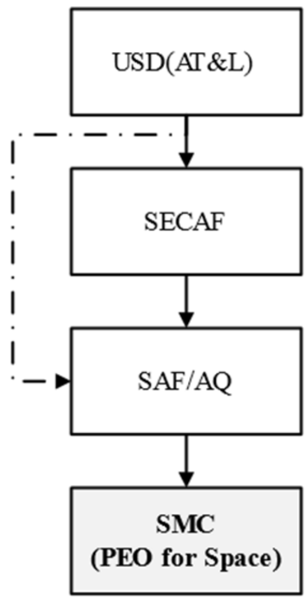


Figure 13. Acquisition Hierarchy

There are different programs and units that are part of the base and support SMC's mission and vision. Los Angeles Air Force Base can be split into two main types of organizations: program offices and staff units. These two types of organizations should be treated separately as they have distinct goals and functions. Staff functions support the program offices in accomplishing their tasks but still have distinct commitments of their own. Their staffing also is based on the number of programs and resources required for the program offices as their staffing levels have a direct relationship with them. This research thesis focuses on the program offices and provides some areas for future work to incorporate staff functions. The program office structure for LAAFB is illustrated in

Figure 14. Each of these programs has a unique mission with the purpose being that each of these missions supports the overarching mission and vision of the base.

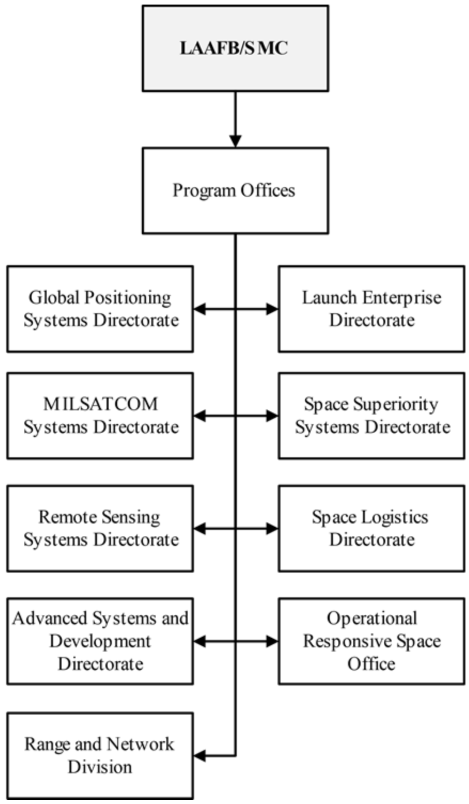


Figure 14. LAAFB Program Office Organizational Structure. Adapted from USAF LAAFB (2017).

The program offices are can be decomposed into their unique directorates, each of which is responsible for acquiring a unique set of capabilities. There are nine program offices that are part of SMC, each of their missions are provided for reference. Note that Space Logistics Directorate (SMC/SL) is located at Peterson AFB (USAF LAAFB 2017) therefore resource allocation is not part of total SMC FTEs assigned since FTEs are used as a proxy for space allocation. As a geographically separated unit, the space allocation for SMC/SL would need to be considered as part of the decision space for Peterson AFB. The SMC/SL Director as well as the SMC/CC and their deputies may be part of the leadership team that determines space allocation for Peterson AFB but this directorate is considered outside the decision context for this research thesis.

1. The Range and Network Systems Division (SMC/RN) "is responsible for modernizing and sustaining the world-wide Air Force Satellite Control Network as well as the nation's Launch and Test Range Systems" (USAF LAAFB 2017).

2. The Remote Sensing Systems Directorate's (SMC/RS) "mission is to develop, deploy, and sustain surveillance capabilities in support of missile warning, missile defense, battlespace awareness, technical intelligence, and environmental monitoring mission areas" (USAF LAAFB 2017).

3. The Advanced Systems and Development Directorate's (SMC/AD) mission "is to drive future Space capabilities through collaborative innovation, development planning and demonstrations" (USAF LAAFB 2017).

4. SMC/SL "sustains and modifies worldwide USAF/DOD space weapon systems to include terrestrial and space weather, global position systems, launch range control, satellite command and control, secure communications, and missiles early earning" (USAF LAAFB 2017).

5. SMC/GP is responsible for "developing and producing Global Positioning System (GPS) satellites, ground systems and military user equipment" (USAF LAAFB 2012c).

6. The Space Superiority Systems Directorate (SMC/SY) "is responsible for equipping the joint warfighter with unrivaled offensive and defensive counterspace, space situation awareness and special access capabilities required to gain, maintain and exploit space superiority" (USAF LAAFB 2017).

7. The Launch Enterprise Directorate (SMC/LE) "provides DOD and the National Reconnaissance Office with assured access to space through launch systems modernization, sustainment and development of worldwide range capability for all national security missions" (USAF LAAFB 2017).

8. The Military Satellite Communications (MILSATCOM) Systems Directorate (SMC/MC) "plans for, acquires and sustains space-enabled global communications in support of the president, secretary of Defense, and combat forces" (USAF LAAFB 2017).

9. ORS Office's mission is "to plan and prepare for the rapid development of highly responsive space capabilities that enable delivery of timely warfighting effects and, when directed, develop and support deployment and operations of these capabilities to enhance and assure support to Joint Force Commanders' and other users' needs for on-demand space support, augmentation, and reconstitution" (USAF LAAFB 2017).

In addition to the stakeholders identified from the organizational structure, there are external entities that interact with LAAFB that need to be considered. From the context diagram, depicted in Figure 11, some external entities identified were industry partners and the local community. Each of the units on base has interactions with external entities, such as suppliers, support contractors, developers. The resources that each unit is allocated will impact its ability to perform its mission and have peripheral or more direct effects on the external organizations with which it interacts. A directorate that is below its effective resource requirements level may need to cancel certain acquisitions due to their inability to meet cost, schedule, or performance requirements, having a direct impact on the company(s) on contract for the acquisition. The local community around LAAFB is also impacted when there are changes in personnel due to changes in business at local shops, real estate sales, and an impact on revenue for the city and state. Both identified external entities would have a peripheral interest in day-to-day staffing changes but would be more involved with strategic decisions such as removing a directorate, cancelling an acquisition, or moving personnel to another location to support the current missions.

3. Identification of Objectives

The context diagram, presented in Figure 11, shows possible external factors that influence or direct requirements down to LAAFB. The environment described within Figure 11 can be broken down generically into stakeholders and source documents. The stakeholder analysis previously discussed outlines the people and organizations that have an interest in the performance of LAAFB. Source documents include guidance and policy intended to provide insight into the priorities of the service. This is important because these documents specifically outline the goals of the USAF and form the basis upon which lower level organizations such as LAAFB derive requirements and objectives. These objectives follow the operational and acquisition hierarchies presented in the stakeholder analysis.

Operational objectives in this case refer to objectives based on priorities established through the operational hierarchy above LAAFB. The flow of priorities starting with the Air Force Strategy is illustrated in Figure 15. The Air Force Strategy is comprised of two documents, “America’s Air Force: A Call to the Future” (USAF 2014) and “USAF Strategic Master Plan” (USAF 2015a). The USAF SMP establishes the following five strategic vectors, which will be used to inform lower level goals and objectives. The USAF SMP includes many additional directives, however to bound the scope of this research the five strategic vectors were selected because they capture at a top level the overall goals of the USAF:

1. “Provide Effective 21st-Century Deterrence” (USAF 2015a, 3)
2. “Maintain a Robust and Flexible Global Intelligence, Surveillance, and Reconnaissance (ISR) Capability” (USAF 2015a, 3)
3. “Ensure a Full-Spectrum Capable, High-End Focused Force” (USAF 2015a, 3)
4. “Pursue a Multi-Domain Approach to our Five Core Missions” (USAF 2015a, 4)
5. “Continue the Pursuit of Game-Changing Technologies” (USAF 2015a, 4)

The commander of AFSPC considers the overall Air Force Strategy to include “A Call to the Future” to develop its own strategic intent. Per AFPD 13–6 and AFPD 17–2, AFSPC is assigned as the core function lead (CFL) for Space and Cyberspace Superiority, and is therefore charged with development of Core Function Support Plans (CFSP) that support two of 12 core functions of the USAF. The SMP also states that the primary audience includes the “…the Air Force Major Commands (MAJCOMs), and the Core Function Leads (CFLs) that reside within the MAJCOMs who are responsible for planning, programming and budgeting (PPB&E)” (USAF 2015a, 3). The interaction between AFSPC and the Joint Capabilities Integration and Development System (JCIDS) process, which evaluates requirements and establishes funding for acquisition programs at LAAFB, is illustrated in Figure 15. These documents are used to inform the development of the AFSPC Strategic Intent, resulting in the following priorities (US AFSPC 2017b):

AFSPC Priorities (US AFSPC 2017b, 4)

1. Win today's fight

2. Prepare for tomorrow's fight

3. Take care of our Airmen and our Families

Commanders Intent (US AFSPC 2017b, 7)

1. We must increase the resilience of our enterprise and our people in everything we do

Four lines of effort (FLOE) (US AFSPC 2017b, 8)

1. Reconnect as Airmen and Embrace Airmindedness

2. Preserve the Space and Cyberspace Environments for Future Generations

3. Deliver Integrated Multi-Domain Combat Effects in, from, and through Space and Cyberspace

4. Fight through Contested, Degraded, and Operationally-Limited Environments

Based on the priorities and goals mentioned in the USAF SMP and AFSPC Strategic Intent, SMC derived the following top-level goals called "mandates" which are documented in the "SMC Strategic Plan" (United States Air Force Space and Missile Systems Center [USAF SMC] 2015) forming a foundation for guiding the efforts of the directorates at SMC and are presented below for reference.

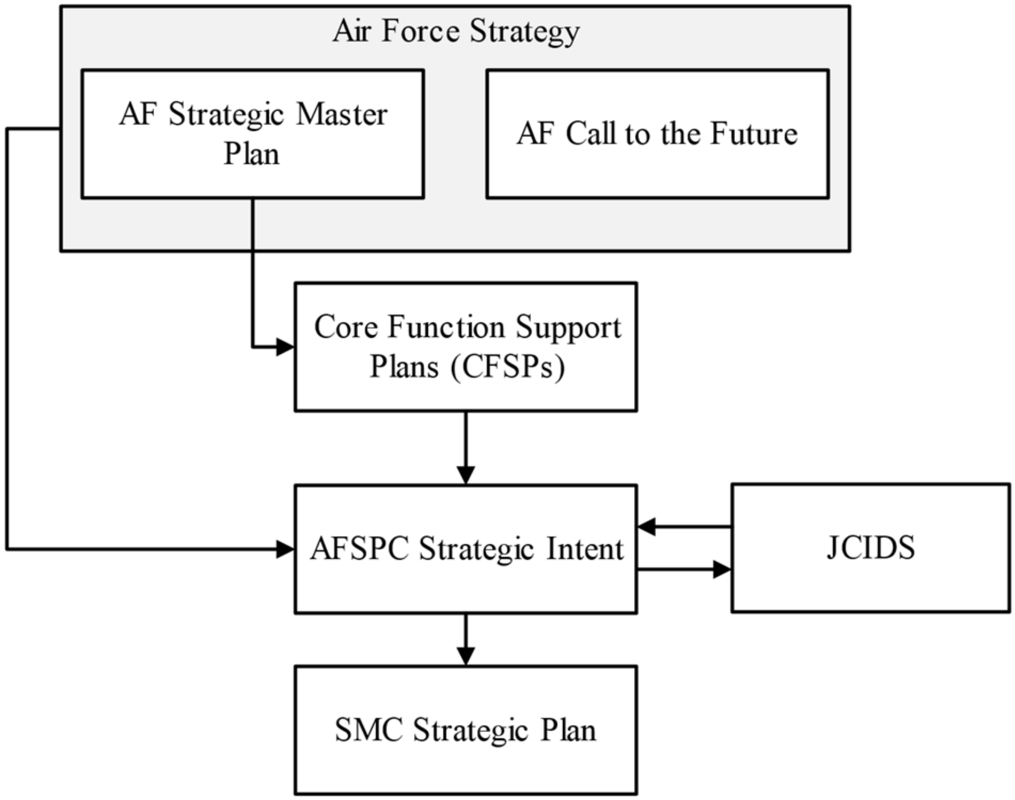
1. "Deliver war-fighting capability by maintaining momentum on improving and executing programs" (USAF SMC 2015, 3)

2. "Focus on making today's space systems more affordable" (USAF SMC 2015, 3)

3. "Evolve and implement new system architectures that are affordable and resilient" (USAF SMC 2015, 3)

4. "Take care of our people" (USAF SMC 2015, 3)

5. "Provide mission ready Airmen" (USAF SMC 2015, 3)



Adapted from USAF (2015b); USAF (2014); and USAF (2015a, 9–10).

Figure 15. Flow Down of Air Force Guidance Documents

D. STRUCTURING OF OBJECTIVES

The “SMC Strategic Plan” defines the top-level goals called “mandates” which correspond to goals in the MCDM model described in Chapter III. To be consistent with the guiding documents, the term “mandate” will be used in this chapter. These mandates (goals) are based on SMC’s mission and vision and ensure that SMC “aligns with Air Force, SAF/AQ [Secretary of the Air Force for Acquisition], and HQ [headquarters] AFSPC Strategic guidance and fulfills the AF vision for SMC” (USAF SMC 2015, 6). Based on the requirements analysis phase described in Chapter IV Section C, the goals identified are comprehensive and no additional goals were added based on the stakeholder analysis and source documentation review. Each of the top-level mandates (goals) in the “SMC Strategic Plan” (USAF SMC 2015), is further decomposed into “goals” (objectives), as shown in Figure 17. The terminology used by SMC is mapped to the MCDM specific terminology in Figure 16 for clarification. The “goals” in Figure 17 correspond to “objectives” in Figure 4. It is unfortunate that the term “goal” is used by SMC to describe what is more accurately described as an objective in the literature, but the SMC term “goal” will continue to be used in this chapter to be consistent with the guiding documents.

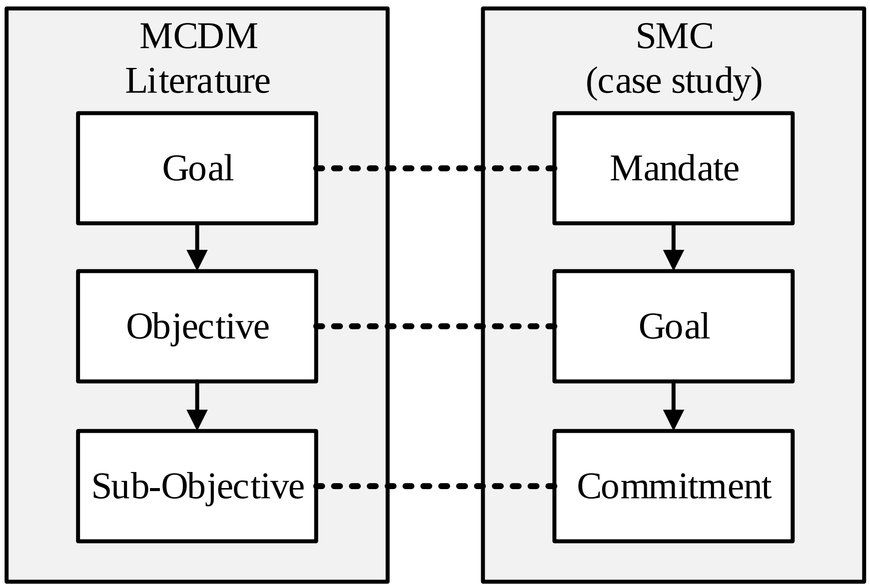


Figure 16. Mapping Terminology between MCDM Literature and SMC Documentation

A description of each of SMC’s mandates (goals), goals (objectives), and commitments (sub-objectives) are provided in Appendix B. Goals and objectives marked in gray in Figure 17 are not part of the SMC resource allocation decision use case because they pertain to staff organizations, and this thesis will focus only on the program offices.

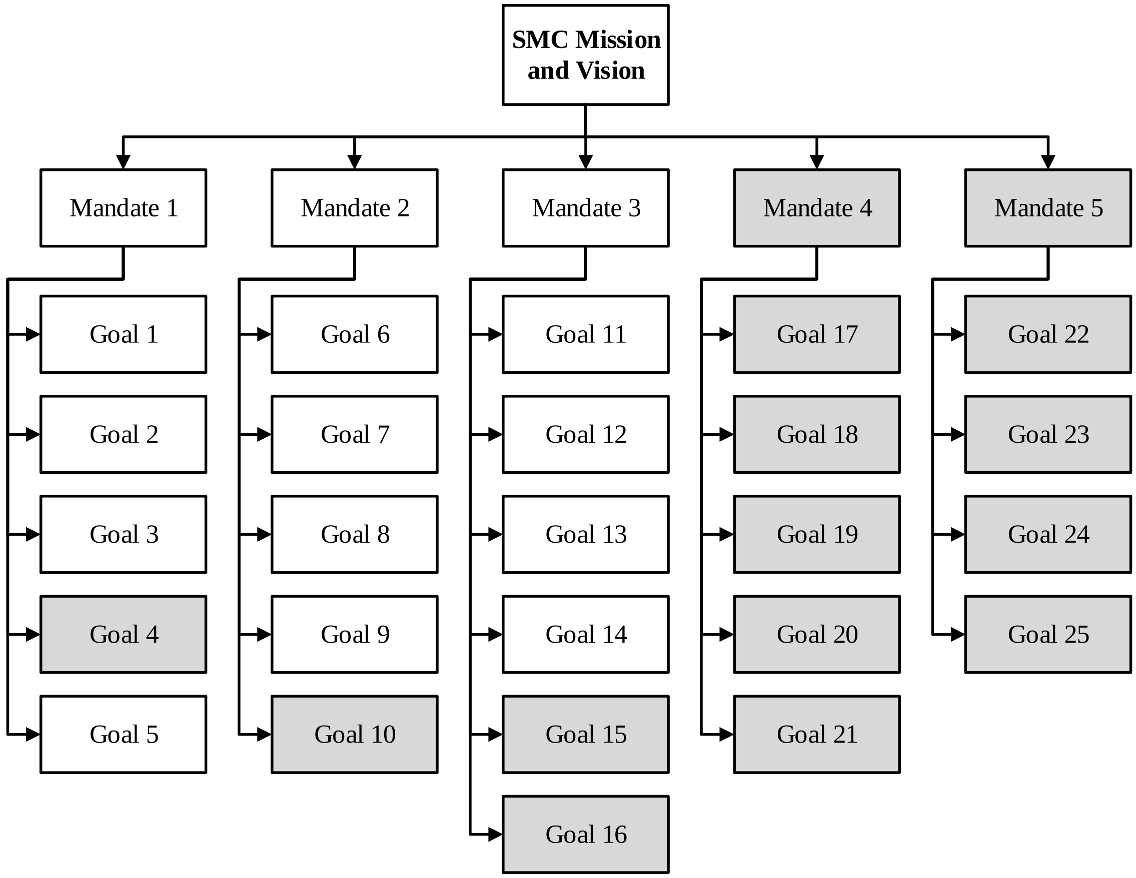


Figure 17. Decomposition of SMC Mandates into Goals. Adapted from USAF SMC (2015).

The directorates within SMC derive annual commitments from the goals (USAF SMC 2015, 7) identified in Figure 17 and ensure that each directorate's commitments support SMC's vision and mission. Space and Missile Systems Center's "commitments" are the equivalent of sub-objectives in the MCDM model. The term "commitment" will continue to be used in this chapter to be consistent with the guiding documents. The list of commitments should be reviewed by the leadership team to ensure it is comprehensive and provides a complete mapping of unique commitments to SMC goals. Some commitments may not be completed within the annual period but should be identified to ensure that all directorate commitments that support each goal are identified. The full hierarchal structure of mandates, goals, and commitments for SMC used in the model is captured in Appendix A, with a subset provided herein that will be used to discuss how the model was developed and the results of the MCDM process.

Mandate 1 for SMC is to "deliver war fighting capability by maintaining momentum on improving and executing programs" (USAF SMC 2015, 8). As described in the "SMC Strategic Plan," Mandate 1 has defined five goals (objectives) to support accomplishing this mandate, these objectives are provided here for clarity:

1. "Deliver world-class space and ground systems to assure global space operations and warfighting capability to Combatant Commands and Coalition partners" (USAF SMC 2015, 8).

2. "Provide assured access to space and explore partnerships with commercial and government agencies to maintain mission assurance and reduce launch cost" (USAF SMC 2015, 8).

3. "Enhance space situation awareness capability to better predict and operate in a contested, degraded, or operationally limited space environment" (USAF SMC 2015, 8).

4. "Strengthen inclusiveness and communication with Congress by providing focused, consistent engagement that promote transparency" (USAF SMC 2015, 8).

5. "Develop effective ways to create partnerships with Joint, interagency, intelligence, academic, diplomatic, commercial, and international partners" (USAF SMC 2015, 8).

The directorates within SMC provide commitments (sub-objectives) that support each of these goals. The commitments are the unique tasks to which resource needs and allocations can be applied. For Mandate 1, Goal 1, there are 11 commitments identified that support it. As noted previously, SMC/SL, shown in gray in Figure 18, is not part of the decision space for SMC space allocation since it is located at Peterson AFB (USAF LAAFB 2017) and is removed from the model for this analysis since it is not considered part of the trade space for space allocation in this research thesis. The traceability between directorates and commitments for Goal 1 is shown in Figure 18. While the directorates are shown mapping to multiple commitments, each commitment corresponds to a unique set of tasks that require separate resources from other commitments. As such, the resources in each directorate can be assigned in whole or in part to separate tasks so that there is no duplication. If there is duplication, as stated in Chapter III, these commitments should be further refined until the resources for each can be identified separately.

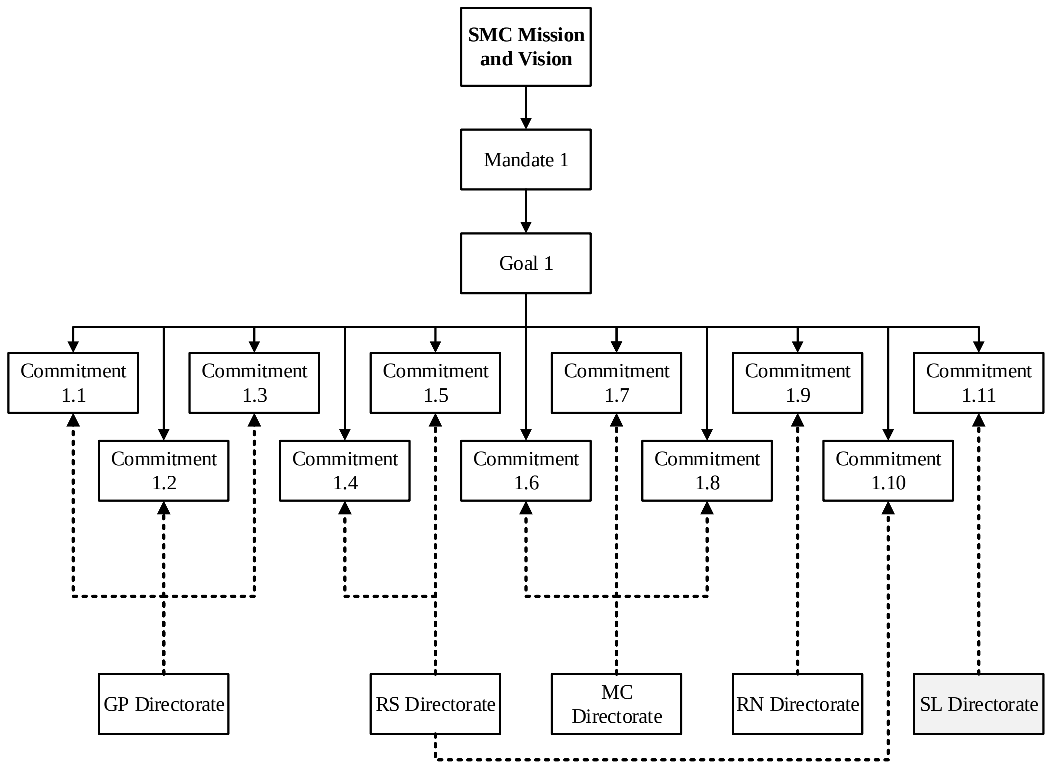


Figure 18. Directorate Mapping to Commitments.
Adapted from USAF SMC (2015, 15)

A full list of the commitments and their respective organization is shown in Appendix A. As previously stated, this research thesis will focus on the program office commitments. Based on the final mapping of all the organizations within SMC, Goals 4 and 5 were removed from the model as they mapped directly to the staff organizations. Staff commitments would be mapped separately and weighed separately since staff organizations and the program offices serve very different functions. Staff organizations could be added to the model in the future for a more complete picture of the resource allocation problem, but doing so would require development of a staffing function for support organizations that is dependent on the program office staffing. Such a model was beyond the scope of this thesis.

Each of the program office's commitments is represented in Table 8, based on information compiled from the "SMC Strategic Plan" (USAF SMC 2015). This mapping of commitments to directorates will be used in the model to understand how each program supports the goals and mandates of SMC. After the goals for SMC have been decomposed into commitments with specific directorates assigned to each commitment, resource metrics are developed for each of the directorates for their commitments.

Table 8. Commitments for Each SMC Program Office. Adapted from USAF SMC (2015).

Directorate	Commitments
AD	11.1, 12.1
GP	1.1, 1.2, 1.3
LE	2.1, 2.2, 9.1, 13.1, 13.2
MC	1.6, 1.7, 1.8, 7.1, 14.1
ORS	7.3, 14.2
RN	1.9, 7.2, 8.1
RS	1.4, 1.5, 1.10, 5.1, 5.2
SL (Note 1)	1.11
SY	3.1, 3.2, 6.2, 6.3, 9.2

Note 1: The Space Logistics Directorate is located at Peterson AFB (USAF LAAFB 2017); resource allocation is not part of total SMC FTEs assigned.

E. ATTRIBUTES AND VALUE FUNCTIONS

Each commitment requires a certain level of resources to be achieved, and this amount is defined by the directorate that is mapped to the individual commitment as shown in Figure 18. The number of people (FTEs) assigned to each commitment is a proxy measure of how effectively the commitment can be accomplished and is the attribute that will be measured in our model. For each commitment, the responsible directorate should provide the current FTE, as well as the minimum and maximum FTE required to meet the commitment. The minimum and maximum FTE information will be used to build a value function for each commitment. As an initial development, 70% of the maximum FTE is calculated to be the minimum required FTE to perform a commitment. This percentage is a notional number and is based on the author’s personal understanding of LAAFB and the amount of personnel required to perform a commitment effectively. The percentage can be changed by the leadership team and can be set individually for each organization. Ideally, the minimum FTE required should be provided directly instead of calculating the value as a percentage of the maximum FTE. In this thesis, since we are using a percentage, only the maximum FTE and current FTE numbers are provided, since the minimum FTE number is calculated from the provided maximum FTE value. The FTE numbers used for the directorates in this case study are based on publicly available information and when this method is employed by LAAFB, would be further refined by each directorate to ensure the numbers align with the latest records. The currently available numbers for each directorate's resource levels are shown in Table 9. For SMC/GP and ORS the numbers are notional based on the author's personal knowledge of SMC and could not be confirmed from a publicly available source.

Table 9. Current FTEs for each SMC Directorate

Directorate	**FTEs Assigned**	**Source**
MC	952	(USAF LAAFB 2013a)
GP	950	Personal knowledge of SMC
RS	800	(USAF LAAFB 2016b)
AD	740	(USAF LAAFB 2015)
SL	550 (Note 1)	(USAF LAAFB 2017)
LE	540	(USAF LAAFB 2016a)
RN	380	(USAF LAAFB 2013b)
SY	350	(USAF LAAFB 2012a)
ORS	150	Personal knowledge of SMC

Note 1: The Space Logistics Directorate is located at Peterson AFB (USAF LAAFB 2017); resource allocation is not part of total SMC FTEs assigned.

Each directorate's resource levels are separated into individual resource levels that currently support its commitments. An example of this is shown for SMC/RN in Table 10. This table also shows the minimum and maximum FTE required to be effective for each of SMC/RN's commitments. The information provided in Table 10 (current FTE, minimum and maximum FTE required) is used to generate the value function for each of the directorate's commitments. The maximum FTE value is notional for each directorate and is based on the author's personal knowledge of the base as well the personnel required to perform each commitment.

Table 10. SMC/RN FTE Requirements by Commitment

Objective	Goal	Commitment	Current FTE	Min FTE Required	Max FTE Required
1	1	1.9	205	161	230
2	7	7.2	100	70	100
2	8	8.1	75	56	80

A direct linear relationship between the minimum and maximum FTE is assumed, such that more personnel are more effective than less personnel, up to a point. The maximum FTE for a directorate's commitment is the number beyond which additional personnel will not contribute to the effectiveness of a mission. The leadership team needs to define what is "minimally" effective or acceptable to help inform the lower boundary. The current assumption of 70% of the maximum FTEs is the method used to determine the lower bound in this case study. As such, for commitment 1.9, the minimum FTE required is 70% of the maximum FTE number of 230 FTE, or 161 FTE.

With a direct linear relationship between the minimum and maximum FTE, the value function takes the form of $y = ax + b$ and both the slope (a) and intercept (b) can be solved by using the minimum and maximum FTE (x variable) along with their associated values (y variable), zero and one, respectively. Once the slope and intercept are determined, the value (y) of the current FTE (x) is calculated using the equation for the line. The slope of the line provides information on how much the value is derived from each additional position (FTE) assigned to a commitment. From a decision-making standpoint, if there is one FTE to apply and two commitments are equally ranked, the slope of the line can help inform which organization's value would increase the most due to the addition of an FTE. As the value of the slope increases from zero to one, the more the addition of a FTE will increase the value provided by that FTE. For example, as shown in Table 11, three different slopes are provided for commitments 1.9, 7.2, and 8.1, which are 0.01, 0.03, and 0.04, respectively. The addition of five FTEs will increase the current value of commitment 8.1 more than commitment 1.9 or 7.2 since it has a higher slope. Beyond the increase of five FTEs though, there would be no additional increase in value for commitment 8.1 since it would reach its maximum FTE required to be effective. The calculated slope and corresponding value based on the current FTE for each of SMC/RN’s commitment is shown in Table 11. Below and above the minimum and maximum FTE, respectively, the slope goes to zero. This is because the effectiveness does not change beyond these values, as shown in Figure 9. Adding more resources once the maximum FTE is reached will not increase a program’s effectiveness; below the minimum effectiveness, decreasing resources does not decrease a program’s effectiveness below zero.

Table 11. SMC/RN Calculated Current Value by Commitment

Commitment	**Current FTE**	**Min FTE Required**	**Max FTE Required**	**Slope**	**Current Value**
1.9	205	161	230	0.01	64%
7.2	100	70	100	0.03	100%
8.1	75	56	80	0.04	79%

To illustrate how the current value changes based on the current resource level, five scenarios are presented for SMC/RN’s commitment 1.9 and are summarized in Table 12. Scenario 1 shows that SMC/RN’s current value is calculated as 64% when the current FTE is 205, which is between the minimum and maximum FTE required to be effective. If the current FTE value is changed and is now 230 FTE, shown as Scenario 2 in Table 12, the current value would be 100%. If 10 additional FTEs are provided toward this commitment, shown as Scenario 3 in Table 12, so that the current FTE is 240, the value would remain at 100%. On the other hand, if the FTEs for SMC/RN’s commitment 1.9 are reduced to the minimum FTE required to be effective (161 FTE), shown as Scenario 4 in Table 12, the current value would be calculated as 0%. If the resources for SMC/RN’s commitment 1.9 are further reduced to 150 FTE, represented as Scenario 5 in Table 12, SMC/RN’s effectiveness would remain at 0%.

Table 12. Scenarios on Calculated Current Value for SMC/RN Commitment 1.9

Scenario	Commitment	Current FTE	Min FTE Required	Max FTE Required	Slope	Current Value
1	1.9	205	161	230	0.01	64%
2	1.9	230	161	230	0.01	100%
3	1.9	240	161	230	0.01	100%
4	1.9	161	161	230	0.01	0%
5	1.9	150	161	230	0.01	0%

F. RELATIVE IMPORTANCE OF OBJECTIVES

The goals (objectives) that align with the program offices commitments (mandates 1–3) were weighted based on the following information from the USAF (USAF 2015a) and the AFSPC (US AFSPC 2017b), summarized below:

1. "Deliver war fighting capability by maintaining momentum on improving and executing programs" (USAF SMC 2015, 3)

    - This mandate is assigned a 50% relative importance based on directly supporting the USAF strategic vectors 1, 2, and 4, (USAF 2015a, 3–4) and AFSPC's first priority, as well as supporting the three of the four lines of effort (FLOE).

2. "Focus on making today's space systems more affordable" (USAF SMC 2015, 3)

    - This mandate weighted at 20% based on directly supporting USAF strategic vectors 4 and 5, as well as Better Buying Power and AFSPC's second priority.

3. "Evolve and implement new system architectures that are affordable and resilient" (USAF SMC 2015, 3)

    - This objective is weighted at 30% based on directly supporting the USAF strategic vectors 4 and 5, AFSPC's second priority, the AFSPC Commander's Intent, as well as three of the FLOE.

After the relative importance of SMC's mandates are agreed to by the leadership team, the process is repeated for each successive level (goals and commitments). Mandate 1 will be used to illustrate this process. Mandate 1 has four goals that trace to program offices' commitments. The first goal is to "deliver world-class space and ground systems to assure global space operations and warfighting capability to Combatant Commands and Coalition partners” (USAF SMC 2015, 8), and directly supports the defined intent of Mandate 1. As such, Goal 1 is ranked the highest in priority with 55%. Both the second and third goals were ranked at 20% in priority to achieving Mandate 1. The second goal is to “provide assured access to space and explore partnerships with commercial and government agencies to maintain mission assurance and reduce launch cost” (USAF SMC 2015, 8). The third goal is to “enhance space situational awareness capability to better predict and operate in a contested, degraded, or operationally limited space environment” (USAF SMC 2015, 8). While both goals are important to achieving Mandate 1, they are supportive functions compared to Goal 1 and are ranked as such. The fourth goal is tertiary to achieving Mandate 1 and deals with fostering communication and expanding partnerships with other entities. The fourth goal was ranked at 5% based on its contribution to achieving Mandate 1. The relative ranking of Mandate 1’s goals is represented in Table 13 (all values are notional). This process is repeated for each of the remaining four Mandates for SMC. With a leadership team, this process would be performed individually and then as a group, and the team would agree on the final weighting in terms of the relative importance for each goal. The final notional weights for all the goals of SMC’s Objectives are shown in Appendix A. After each goal’s importance weight is established, the process is repeated for the commitments that reprise each goal, as shown in Appendix A.

Table 13. Prioritization of Goals[1] that Support SMC Objective 1

Goal # for Mandate 1	Importance Weight (%)
1	55%
2	20%
3	20%
5	5%

Note 1: Goal 4 is directly traceable to staff organization, so it is not part of decision space

After the importance weights of each of the individual commitments are generated, the "global" weight of each commitment can be calculated, by multiplying the mandate, goal, and individual commitment weighting together. This weighting represents the relative importance of each commitment to SMC's mission and vision. This is illustrated in Table 14 for the commitments that are part of Goal 1. The combined weighting is shown in the column "Global Weight" of Table 14. For example, the global weight for commitment 1.1 is (0.50)x(0.55)x(0.12) = 0.033 or 3.30%.

Table 14. Global Importance Weight for Goal 1 Commitments

Mandate (Weight 50%)	**Goal (Weight 55%)**	**Commitment**	**Commitment Weight**	**Global Weight**
1	1	1.1	12%	3.30%
1	1	1.2	10%	2.75%
1	1	1.3	10%	2.75%
1	1	1.4	14%	3.85%
1	1	1.5	14%	3.85%
1	1	1.6	9%	2.48%
1	1	1.7	9%	2.48%
1	1	1.8	9%	2.48%
1	1	1.9	9%	2.48%
1	1	1.10	4%	1.10%

Each commitment's contribution to SMC's effectiveness can then be calculated using the global weights and the value functions for FTEs described in earlier. A commitment's current contribution to SMC's effectiveness is calculated by multiplying the global weight by the value of the current FTEs assigned to that commitment. The "Global Weight" column, shown in Table 14, represents commitment's maximum contribution to the overall effectiveness of SMC since if a commitment is at its maximum FTE required to be effective, the current value would be equal to one and the calculation would simply yield the global weight. The contribution to SMC effectiveness of each commitment that traces to Goal 1 is shown in Table 15.

Table 15. Effectiveness of each Commitment for Goal 1 Commitments

Objective	Goal	Commitment	Global Weight	Current Value (Bounded)	Effectiveness
1	1	1.1	3.30%	78%	2.6%
1	1	1.2	2.75%	84%	2.3%
1	1	1.3	2.75%	63%	1.7%
1	1	1.4	3.85%	100%	3.9%
1	1	1.5	3.85%	86%	3.3%
1	1	1.6	2.48%	97%	2.4%
1	1	1.7	2.48%	100%	2.5%
1	1	1.8	2.48%	52%	1.3%
1	1	1.9	2.48%	64%	1.6%
1	1	1.10	1.10%	82%	0.9%

A directorate's current effectiveness contribution is the sum of the effectiveness measures of all its commitments. This number represents how well the directorate is contributing to the SMC mission with the current resources (FTEs) provided. To illustrate, consider a directorate that has three commitments. Commitment 1 has a global weight of 5%, commitment 2 has a global weight of 3% and commitment 3 has a global weight of 2%. That means that the directorate can contribute a total of 10% to the overall effectiveness of SMC (which means other directorates contribute the remaining 90%). If all the commitments were staffed at the maximum value the directorate would be contributing the full 10%. Now, suppose that commitment 1 is staffed at the maximum FTE so that staffing level has a value of 1, commitment 2 is only staffed at 50% of the maximum FTE, so that staffing level has a value of 0, and commitment 3 is staffed at some level between the maximum and the minimum such that it has a value of .8. The directorate's contribution to the overall effectiveness of SMC is calculated as (0.05)x(1)+(0.03)x(0)+(0.02)x(0.8) = 0.066 or 6.6%. We can calculate the individual "effectiveness" of this directorate by dividing the current effectiveness score (6.6%) by the total possible effectiveness score (10%) and we find that the directorate is at 66% of its total possible effectiveness score.

To summarize the data gathered in this case study a model was generated, the categories for which, listed in Table 16, provide a way of visualizing the data gathered to decide on the overall prioritization of objectives. These columns are used in the model and are shown in Appendix A with the representative data.

Table 16. Columns used in Objective Prioritization Spreadsheet

Column Name	Description
Mandate	Identify the top-level mandate (goal) associated with the commitment
Mandate Weight	Identify the weighting of the mandate associated with the commitment
Goal	Identify the goal associated with the commitment, depending on how value is specified can include the commitment value (e.g., 1.10 is Goal 1 Commitment 10)
Goal Weight	Identify the weighting of the goal associated with the commitment
Commitment Weight	Identify the weighting of the commitment
Global Weight of Commitment	Calculated by multiplying the commitment's, goal's, and mandate's weightings together
SMC Unit	Program or Organization traced to the commitment
Current FTE	Current FTE assigned to the program
Minimum FTE Required	Minimum number of FTE required to effectively perform commitment, below this value, program is not effective; this can also be calculated by using a percentage of the maximum FTE required to be effective
Maximum FTE Required	Maximum number of FTE required to effectively perform commitment; above this value, program does not increase its effectiveness when additional people added to the program
% Needed to be Effective	Percentage of maximum FTE required to be minimally effective; used to calculated minimum FTE required if not provided as its own unique value (method used in case study)
Slope	Slope of value function between minimum and maximum FTE required to be effective; direct linear relationship assumed between minimum and maximum FTE
Current Value	Calculated using linear equation, current value of the program based on its FTE and the equation that defines its value
Current Value (bounded)	This is the same as current value but for those values that are above or below one (above the maximum FTE or below the minimum FTE required), the value is set at one or zero so that the weighting is not impacted by values that are artificially above or below the value functions boundaries
Effectiveness	Current effectiveness which is calculated by multiplying the current value by the percentage of Organization Weight
Delta between Maximum and Current Effectiveness	Represents the delta between the maximum effectiveness and the current effectiveness, used to show how changing the resources for a commitment could impact the organization's effectiveness as a whole

G. FINDINGS

The model used FTEs as a proxy for office space requirement under the assumption that each FTE requires a certain amount (square footage) of office space. Although we will present our findings based on FTEs, the FTEs can be easily converted to office space (square footage) and the interpretation of the findings would be the same. Based on the notional data used in the MCDM model, the current effectiveness for SMC is 76.6%. This effectiveness does not account for the staff functions and their resource levels but focuses on the commitments that the program offices support. The most important individual commitment for SMC, based on its "Global Weight" of 10.5%, is Commitment 11.1, which is performed by SMC/AD. This commitment is to "deliver long-term enterprise ground architecture transition plan to AFSPC component commander in anticipation of responsive and emerging threats" (USAF SMC 2015, 17). The commitment that has the most room for improvement based on the delta between its current and maximum effectiveness is Commitment 2.1, which is performed by SMC/LE. Its current contribution to effectiveness for SMC is 2.4% but its maximum contribution to effectiveness for SMC is 5.5%, a delta of 3.1%.

The five commitments that have the largest delta between their current effectiveness contribution to SMC and their potential (maximum) effectiveness contribution are shown in Table 17. These commitments represent the programs that, if given the right number of resources, could have the most impact on SMC's effectiveness. These five commitments' delta in effectiveness sum to 10.2%, which is only 3% less than all of the remaining 26 commitments delta in effectiveness (13.2%).

Table 17. Top Five Commitments with Largest Delta between Current and Maximum Effectiveness to SMC

Commitment	Directorate	Slope	Current Effectiveness	Maximum Effectiveness	Delta
2.1	SMC/LE	0.01	2.4%	5.5%	3.1%
11.1	SMC/AD	0.01	8.2%	10.5%	2.3%
13.1	SMC/LE	0.06	1.3%	3.0%	1.7%
13.2	SMC/LE	0.06	1.3%	3.0%	1.7%
7.3	SMC/ORS	0.17	1.5%	3.0%	1.5%

Within the five commitments represented in Table 17, the number of resources available would dictate which commitments should be provided with resources. Commitment 13.1, 13.2, and 7.3, have a significantly higher slope than the first two commitments, 2.1 and 11.1, in Table 17. With limited resources available, these would be the best organizations to provide additional resources to maximize SMC's effectiveness. The required resources to maximize these three commitments is 23 FTE, which would increase SMC's effectiveness 4.83% to 81.43%. To gain the same increase in effectiveness for the first two organizations would require an increase of 65.2 FTE. By focusing on the organizations with the largest delta in effectiveness as well as the highest slope, the leadership team can focus on increasing SMC's effectiveness with the minimal amount of resources. Since FTEs are used as a proxy for space in the model and SMC is constrained in its space allocation, this model indicates the programs and commitments which would provide the most benefit to SMC if they were allocated more space (FTEs).

As a comparison, as shown in Table 18, the commitments are ranked by their maximum contribution to effectiveness, or global weight. By increasing these commitments to their maximum effectiveness, SMC's effectiveness would increase by 8.3% to 84.9%. If all the commitments depicted in Table 17 were increased to their maximum effectiveness, SMC's effectiveness would be 86.82%. In terms of space and resources, maximizing the top five commitments with the highest global weight would require 95 FTE versus maximizing the top five commitments with the largest delta between the maximum and current effectiveness which would require 93 FTE.

Table 18. Top Five Commitments by Maximum Effectiveness

Commitment	**Directorate**	**Slope**	**Current Effectiveness**	**Maximum Effectiveness**	**Delta**
11.1	SMC/AD	0.01	8.2%	10.5%	2.3%
12.1	SMC/AD	0.01	6.7%	7.5%	0.8%
2.1	SMC/LE	0.01	2.4%	5.5%	3.1%
3.1	SMC/SY	0.03	4.7%	5.5%	0.8%
3.2	SMC/SY	0.03	3.1%	4.5%	1.4%

This comparison illustrates the important contribution the MCDM value function makes to the decision problem. It shows how it is more advantageous to review organizations not just in terms of their global weight (relative importance) to the organization but in terms of which organizations have the largest potential to increase the organization's effectiveness. These results are based on the effective use of office space only and obviously cannot account for other organizational factors that may contribute to overall effectiveness, since those factors were not included in the model.

As discussed previously, federal agencies are space constrained, and may not be able to expand their currently allocated space to account for additional FTEs. The model developed can also support analysis in the scenario that no new FTEs can be added but must be realigned within the commitments to maximize the organization's effectiveness. In this instance, the commitments with the lowest global weight as well as the smallest slope should be considered as areas for resource reassignment. The 15 commitments with the lowest maximum contribution to the organization's effectiveness are shown in Table 19. This is not based on their current effectiveness but the maximum possible. These organizations, even when they are at their maximum effectiveness, have the least contribution to SMC's effectiveness.

When the leadership team is reviewing which commitments should have resources removed, beyond considering which ones contribute the least to SMC's effectiveness, the commitments that have the largest difference between the maximum and minimum resources required to be effective should be selected for redistribution, which is represented by the smallest slope. A commitment that requires 240 FTEs to be minimally effective and 250 FTEs to be at maximum effectiveness would have a slope of 0.10. As compared to a commitment that requires 200 FTEs to be minimally effective and 250 FTEs to be at maximum effectiveness would have a slope of 0.02. Regardless of the total number of FTEs required, the difference between the minimum and maximum number of FTEs required to be effective should be reviewed since the organization should maximize how FTEs are able to be moved while minimizing the impact to the organization's effectiveness.

Table 19. Bottom Fifteen Commitments Based on Maximum Effectiveness

Commitment	**Directorate**	**Maximum Effectiveness**	**Current FTE**	**Minimum FTE**	**Maximum FTE**	**Slope**
1.10	SMC/RS	1.10	180	133	190	0.02
5.2	SMC/RS	1.13	85	63	90	0.04
5.1	SMC/RS	1.38	120	84	120	0.03
13.3	SMC/AD	1.50	140	105	150	0.02
9.2	SMC/SY	1.80	30	21	30	0.11
6.2	SMC/SY	2.00	50	38.5	55	0.06
8.1	SMC/RN	2.00	75	56	80	0.04
6.3	SMC/SY	2.00	60	42	60	0.06
14.2	SMC/ORS	2.03	16.15	13.3	19	0.18
9.1	SMC/LE	2.20	75	52.5	75	0.04
14.1	SMC/MC	2.48	50	38.5	55	0.06
1.6	SMC/MC	2.48	327	231	330	0.01
1.7	SMC/MC	2.48	350	245	350	0.01
1.8	SMC/MC	2.48	150	122.5	175	0.02
1.9	SMC/RN	2.48	205	161	230	0.01

There are three organizations shown in Table 19 that have the smallest slope of 0.01, commitments 1.6, 1.7, and 1.9. These three commitments, when the FTEs provided to support them are lowered to the minimum required to be effective, provide 245 FTEs that can reallocated to other commitments. This value is generated by reducing commitment 1.6 from 327 FTEs to 231 FTEs, a reduction of 96 FTEs, commitment 1.7 from 350 FTEs to 245 FTEs, a reduction 105 FTEs, and commitment 1.9 from 205 FTEs to 161 FTEs, a reduction of 44 FTEs. The sum of these is 245 FTEs. A review of the remaining commitments that contribute to SMC's effectiveness shows that the difference between the sum of their maximum FTEs required to effective and the sum of the FTEs currently assigned to each commitment is 295.85 FTEs. Reallocating the 245 FTEs to the remaining commitments based on their maximum effectiveness contribution (starting at the highest), increases SMC's effectiveness to 88.68%, a 12.08% increase from its starting value of 76.6%. This shows by that the organization, by reviewing how much each commitment contributes to the organization's effectiveness and redistributing resources based on this information can have a significant impact on the organization's effectiveness.

As a comparison, simply reducing the three commitments that are ranked as the lowest contributors to SMC's effectiveness (commitments 1.10, 5.2, and 5.1) to their minimum required FTEs to be effective would provide 105 FTEs. Reallocating the 105 FTEs to the remaining commitments based on their maximum effectiveness contribution (starting at the highest), increases SMC's effectiveness to 82.74%, a 6.14% increase from its starting value of 76.6%. Like the previous comparison, this illustrates the important contribution the MCDM value function makes to the decision problem. These results do not account for other factors within an organization that may contribute to its effectiveness since this model focuses solely on the effective use of office space.

The model provides options and supports the leadership team developing decisions that can be justified and defendable. It also provides an easy tool for doing what-if analysis. By changing office space allocation (FTEs) between different commitments and programs, decision makers can see the impact of different allocation schemes on the overall SMC mission effectiveness. To further develop the options to maximize an organization's effectiveness, Linear Programming (optimization) could be used with the results of this model. Implementing this type of optimization model was beyond the scope of this thesis and is discussed in further detail as part Chapter V as part of the Future Work section.

H. CHAPTER SUMMARY

The chapter applied the systems engineering method and MCDM process described in Chapter III to LAAFB's office space management process and illustrated how these processes can be used to develop a framework, while creating a product that is directly applicable to LAAFB that the leadership team can use to develop logical, defendable decisions on office space allocation.

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V. CONCLUSION

The objective of this research was to apply a systems engineering approach to create a MCDM framework that will help organizations make facility space allocation decisions that balance multiple objectives with their available resources. This thesis describes the systems engineering method and MCDM framework and applied this process to LAAFB office space management as a use case to validate the process.

A. INTRODUCTION

Managing and allocating office space is a challenge for federal organizations due to a variety of factors. Based on current initiatives such as *Freeze the Footprint* (United States White House 2017a), *Reduce the Footprint* (United States White House 2017b), and AFPD 32–90, *Real Property Asset Management* (USAF 2007b), federal agencies are constrained to work within their current assets when making resource allocation decisions but are still charged with maximizing the productivity of their workforce as detailed in *Assignment and Utilization of Space*, 41 C.F.R § 102–79 (2011). To support federal agencies in making decisions where there are competing priorities, a decision-making methodology was developed. This methodology uses the application of the systems engineering method and MCDM framework to support making logical and rational decisions as opposed to politically or emotionally driven ones.

B. FINDINGS

The application of this methodology can be a powerful tool that provides insight into office space management decisions that support the prioritization and effectiveness of an organization. By using the systems engineering method, an organization can clearly understand its objectives as well as the how each program's commitments support them. The systems engineering method was applied with an emphasis on requirements analysis to develop clear objectives for an organization. The requirements analysis is separated into five key activities: developing a context diagram, stakeholder analysis, identification of objectives, structuring the objectives, and identification of constraints and assumptions. Using this methodology, a comprehensive list of objectives as well as the boundaries of the problem are identified for an organization. For LAAFB, this led to the concurrence on the identified five mandates (objectives) that support its mission and vision and specifically with three mandates (objectives) that the program offices' commitments support.

Through the LAAFB case study, a comprehensive list of objectives that the organization seeks to meet were developed. The objectives were mapped through the requirements analysis process to individual programs and commitments (sub-objectives) where unique resource allocations could be assigned. This case study identified 32 unique items that support LAAFB's three mandates traceable to program office commitments. Based on the notional data used in the tool, SMC's current effectiveness was calculated to be 76.6%. By organizing the commitments by the delta between their current effectiveness to SMC and the maximum effectiveness they could provide, the model suggests that increasing the number of FTE by 23 (or increasing the corresponding office space), would increase SMC's effectiveness 5.5%. Since FTEs are used as a representation of space, this is a minimal increase that will help SMC further meet its mission. This illustrates how this model can be used to determine which commitment should be provided additional resources. The model also helps determine each commitment's relative importance and current contribution to SMC effectiveness, increasing the probability that decisions on office space management will maximize the organization's ability to meet its objectives. The methodology described herein leads decision makers, as stated by Gregory, "to make smarter and more defensible choices" (Gregory and Keeney 2002, 1611). Each organization clearly understands its role and how its commitments support the overall mission as well as its own effectiveness. Decision makers can identify the decision context and develop alternatives that can be reviewed in a logical fashion using the model.

C. RECOMMENDATIONS

In order to implement the approach presented in Chapter IV, SMC should formally establish a leadership team to manage office space allocation for the base, with a key component being the systems engineering support personnel. Formal documentation is important to ensure organizations within SMC provide the requisite personnel to the leadership team and to ensure organizations follow the guidance and direction established by the leadership team. Additionally, SMC should revisit overarching documentation used to derive mandates, goals, and commitments, since there have been recent changes in both operational and acquisition hierarchies since the last SMC Strategic Plan was published. This is an opportunity to manage expectations with organizations above SMC and shape the work-focus of organizations within SMC.

D. FUTURE WORK

For a more holistic office space management approach within SMC, the model could be expanded to analyze staff organizations. Staff organizations were originally excluded since they have a different set of guidance documents and their size should essentially be based on the size of the program offices. The size correlation between staff and program office would therefore also need to be examined.

Outside of SMC, the model can be modified for application by other bases and organizations. Organizations that have not used a systems approach to managing resources would benefit review of this study to identify possible areas not previously considered. A more relevant application would be for AF organizations as opposed to private industry since the overarching guidance is both of similar vernacular and format. However, other military, government, and private industry organizations would still benefit and would simply need to follow the developed process to develop a model for their organization.

After this methodology has been instated within an organization, additional attributes could be developed to refine the model and provide decision makers with more granularity in the decision space. For example, the tool currently uses the FTE as the metric to determine value and effectiveness, but this could be broken down by type of personnel or area of expertise. Depending on how decisions are made on resource allocations for an organization, this may be useful information to ensure that organizations are getting the right resources to accomplish their commitments. Analysis of the relationship between the minimum and maximum effectivity of a unit and whether a direct linear relationship fully captures this relationship or it should be refined to a different curve between these two values.

As discussed in the Chapter II, there are existing tools available on space allocation optimization. There is significant research available on optimization techniques that could be applied and after an organization has used the methodology described herein to analyze effectiveness, they may be willing to explore additional methods that further automate the process. The combination of this methodology with a space allocation optimization tool utilizing linear programming could provide decision makers with a powerful method of maximizing the organization's effectiveness across both personnel and space allocation for both large scale and individual moves.

APPENDIX A. MODEL FOR LAAFB OFFICE RESOURCE DECISION-MAKING

The weighting used for each of SMC's mandates, goals, and commitments and their corresponding directorate is shown in Table 20. These represent the elements that were used as part of the model. The full list of commitments and their corresponding directorates is provided as part of Appendix B. The model used as part of the decision-making process is shown in Table 21 where the commitments are organized by their number (e.g., 1.1 before 1.2). The values shown in Table 21 are the baseline values and do not represent the different scenarios discussed in Chapter III to maximize SMC's effectiveness.

Table 20. Complete List of Weightings for SMC's Mandates, Goals, and Commitments

SMC Effectiveness
100%

	Weight
Objective 1	50%
Goals Sum	100%

	Weight	
Goal 1	55%	
Commitments for Goal 1 Sum	100%	Org
1.1	12%	GP
1.2	10%	GP
1.3	10%	GP
1.4	14%	RS
1.5	14%	RS
1.6	9%	MC
1.7	9%	MC
1.8	9%	MC
1.9	9%	RN
1.10	4%	RS

	Weight	
Goal 2	20%	
Commitments for Goal 2 Sum	100%	Org
2.1	55%	LE
2.2	45%	LE

	Weight	
Goal 3	20%	
Commitments for Goal 3 Sum	100%	Org
3.1	55%	SY
3.2	45%	SY

	Weight	
Goal 5	5%	
Commitments for Goal 5 Sum	100%	Org
5.1	55%	RS
5.2	45%	RS

	Weight
Objective 2	20%
Goals Sum	100%

	Weight	
Goal 6	20%	
Commitments for Goal 6 Sum	100%	Org
6.2	50%	SY
6.3	50%	SY

	Weight	
Goal 7	50%	
Commitments for Goal 7 Sum	100%	Org
7.1	40%	MC
7.2	30%	RN
7.3	30%	ORS

	Weight	
Goal 8	10%	
Commitments for Goal 8 Sum	100%	Org
8.1	100%	RN

	Weight	
Goal 9	20%	
Commitments for Goal 9 Sum	100%	Org
9.1	55%	LE
9.2	45%	SY

	Weight
Objective 3	30%
Goals Sum	100%

	Weight	
Goal 11	35%	
Commitments for Goal 11 Sum	100%	Org
11.1	100%	AD

	Weight	
Goal 12	25%	
Commitments for Goal 12 Sum	100%	Org
12.1	100%	AD

	Weight	
Goal 13	25%	
Commitments for Goal 13 Sum	100%	Org
13.1	40%	LE
13.2	40%	LE
13.3	20%	AD

	Weight	
Goal 14	15%	
Commitments for Goal 14 Sum	100%	Org
14.1	55%	MC
14.2	45%	ORS

Table 21. SMC MCDM Model

SMC Total Weight	100.00%	*Items in red are notional values based on publicly available data
SMC Effectiveness	76.60%	

Mandate	Mandate Weight	Goal	Goal Weight	Commitment Weight	Global Weight of Commitment	SMC Unit	Current FTE	Minimum FTE Required	Maximum FTE Required	% Needed to be effective	Slope	Current Value	Current Value (bounded)	Effectiveness	Delta between Maximum and Current Effectiveness
1	50%	1.1	55%	12%	3.30%	GP	350	262.5	375	70%	0.01	78%	78%	2.6%	0.7%
1	50%	1.2	55%	10%	2.75%	GP	200	147	210	70%	0.02	84%	84%	2.3%	0.4%
1	50%	1.3	55%	10%	2.75%	GP	400	315	450	70%	0.01	63%	63%	1.7%	1.0%
1	50%	1.4	55%	14%	3.85%	RS	180	126	180	70%	0.02	100%	100%	3.9%	0.0%
1	50%	1.5	55%	14%	3.85%	RS	230	168	240	70%	0.01	86%	86%	3.3%	0.5%
1	50%	1.6	55%	9%	2.48%	MC	327	231	330	70%	0.01	97%	97%	2.4%	0.1%
1	50%	1.7	55%	9%	2.48%	MC	350	245	350	70%	0.01	100%	100%	2.5%	0.0%
1	50%	1.8	55%	9%	2.48%	MC	150	122.5	175	70%	0.02	52%	52%	1.3%	1.2%
1	50%	1.9	55%	9%	2.48%	RN	205	161	230	70%	0.01	64%	64%	1.6%	0.9%
1	50%	1.10	55%	4%	1.10%	RS	180	133	190	70%	0.02	82%	82%	0.9%	0.2%
1	50%	2.1	20%	55%	5.50%	LE	250	210	300	70%	0.01	44%	44%	2.4%	3.1%
1	50%	2.2	20%	45%	4.50%	LE	135	101.5	145	70%	0.02	77%	77%	3.5%	1.0%
1	50%	3.1	20%	55%	5.50%	SY	110	80.5	115	70%	0.03	86%	86%	4.7%	0.8%
1	50%	3.2	20%	45%	4.50%	SY	100	77	110	70%	0.03	70%	70%	3.1%	1.4%
1	50%	5.1	5%	55%	1.38%	RS	120	84	120	70%	0.03	100%	100%	1.4%	0.0%
1	50%	5.2	5%	45%	1.13%	RS	85	63	90	70%	0.04	81%	81%	0.9%	0.2%
2	20%	6.2	20%	50%	2.00%	SY	50	38.5	55	70%	0.06	70%	70%	1.4%	0.6%
2	20%	6.3	20%	50%	2.00%	SY	60	42	60	70%	0.06	100%	100%	2.0%	0.0%
2	20%	7.1	50%	40%	4.00%	MC	75	56	80	70%	0.04	79%	79%	3.2%	0.8%
2	20%	7.2	50%	30%	3.00%	RN	100	70	100	70%	0.03	100%	100%	3.0%	0.0%
2	20%	7.3	50%	30%	3.00%	ORS	17	14	20	70%	0.17	50%	50%	1.5%	1.5%
2	20%	8.1	10%	100%	2.00%	RN	75	56	80	70%	0.04	79%	79%	1.6%	0.4%
2	20%	9.1	20%	55%	2.20%	LE	75	52.5	75	70%	0.04	100%	100%	2.2%	0.0%
2	20%	9.2	20%	45%	1.80%	SY	30	21	30	70%	0.11	100%	100%	1.8%	0.0%
3	30%	11.1	35%	100%	10.50%	AD	280	210	300	70%	0.01	78%	78%	8.2%	2.3%
3	30%	12.1	25%	100%	7.50%	AD	320	231	330	70%	0.01	90%	90%	6.7%	0.8%
3	30%	13.1	25%	40%	3.00%	LE	50	42	60	70%	0.06	44%	44%	1.3%	1.7%
3	30%	13.2	25%	40%	3.00%	LE	50	42	60	70%	0.06	44%	44%	1.3%	1.7%
3	30%	13.3	25%	20%	1.50%	AD	140	105	150	70%	0.02	78%	78%	1.2%	0.3%
3	30%	14.1	15%	55%	2.48%	MC	50	38.5	55	70%	0.06	70%	70%	1.7%	0.8%
3	30%	14.2	15%	45%	2.03%	ORS	16.15	13.3	19	70%	0.18	50%	50%	1.0%	1.0%

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APPENDIX B. SMC MANDATES, GOALS, AND COMMITMENTS

The information presented in Table 22 through Table 27 is directly drawn from the "SMC Strategic Plan" (USAF SMC 2015) and represents the full mapping of SMC's mandates, goals, and commitments.

Table 22. Commitments for SMC's Mandate 1, Goal 1.
Source: USAF SMC (2015, 15).

MANDATE 1: Deliver war fighting capability by maintaining momentum on improving/executing pgms [sic]		
COMMITMENTS		(ECD)[OPR]
Goal 1: Deliver and sustain world-class space and ground systems to ensure global space operations and the delivery of warfighting effects to our Combatant Commands and Coalition partners		
1.1	Complete GPS IIF Space Vehicles (SV) 9 Production & Provide GPS IIF SVs (10, 11, 12) available for launch to meet CY15 scheduled launch dates to achieve dominant capabilities while controlling life cycle costs	(3Q) [GP]
1.2	Complete GPS III SV01 Thermal Vacuum Testing	(4Q) [GP]
1.3	Complete OCX Initial Block 0 Configuration Item Qualification Test	(3Q) [GP]
1.4	Deliver SBIRS HEO-4 Payload as a response to emerging and modernizing threats	(2Q) [RS]
1.5	Deliver SBIRS GEO-3 Space Vehicle to facilitate a response to emerging and modernizing threats	(3Q) [RS]
1.6	Provide WSG-7 available for launch	(2Q) [MC]
1.7	Complete all assigned AEHF Initial Operational Capability (IOC) criteria to support the June 2051 IOC	(2Q) [MC]
1.8	Conduct FAB-T Milestone-C Production and Deployment	(3Q) [MC]
1.9	Obtain Electronic Schedule Dissemination (ESD) 3.0 PEO Certification	(4Q) [RN]
1.10	Achieve command and control cutover of SBIRS GEO, SBIRS HEO, & DSP to Mission Control Station – 2 (MCS-2)	(4Q) [RS]
1.11	Fully develop and implement product support assessments and reviews to ensure product support planning and execution are innovative, effective, and affordable	(4Q) [SL]

Table 23. Commitments for SMC's Mandate 1, Goal 2–5.
Source: USAF SMC (2015, 15).

MANDATE 1: Deliver war fighting capability by maintaining momentum on improving/executing pgms [sic]		
COMMITMENTS		(ECD)[OPR]
Goal 2: Provide assured access to space and explore partnerships with commercial and government agencies to maintain mission assurance and reduce costs of launch		
2.1	Meet current manifest requirements by maintaining mission success one launch at a time	(1-4Q) [LR]
2.2	Support SpaceX Falcon 9 v1.1 certification, expanding the launch competitive environment for DOD	(2Q) [LR]
Goal 3: Maintain and enhance a viable space situational awareness capability to better predict and operate in a contested, degraded, or operationally limited space environment		
3.1	Complete GSSAP Space Vehicles 1 and 2 Satellite Control Authority (SCA) transfer	(2Q) [SY]
3.2	Obtain JSpOC Mission System (JMS) Service Pack 9 PEO Certification	(4Q) [SY]
Goal 4: Strengthen our inclusiveness and communication with Congress by providing focuses, consistent engagements that clearly and deliberately capture the Command and Center's narrative; promote transparency in dealings with legislators and their staffs		
4.1	Establish SMC program engagement plans to meet Space Debris Policy	(2Q) [EN]
Goal 5: Develop effective ways to create partnerships with Joint, interagency, intelligence, academic, diplomatic, commercial, and international partners		
5.1	Obtain Technical Intelligence Operational Acceptance of SBIRS GEO 1 & 2 Starer Payloads strengthening our partnership with the Intel Community	(3Q) [RS]
5.2	Deliver 15 Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC-2) sensors to Taiwan's National Space Organizations	(2Q) [RS]

Table 24. Commitments for SMC's Mandate 2.
Source: USAF SMC (2015, 16).

MANDATE 2: Focus on making today's space systems more affordable		
COMMITMENTS		(ECD) [OPR]
Goal 6: Strengthen and expand should-cost management process		
6.1	Expand Should-Cost based management by completing 29 ACAT I-III Single Best Estimates and CCaR-implemented Should-Cost Estimates	(4Q) [FM]
6.2	Award Space Based Space Surveillance (SBSS) Sustainment Contract that focuses on affordability and process efficiency as the satellite ages	(3Q) [SY]
6.3	Award Counter-Communications System (CCS) B10.2 production contract at a value that ensures the program's affordability cap is maintained	(3Q) [SY]
Goal 7: Improve program baseline planning process and technical baseline execution entrance and exit criteria process		
7.1	Award Combined Orbital Operations Logistics Sustainment (COOLS) contract to improve the effectiveness and productivity of MILSATCOM technical services	(2Q) [MC]
7.2	Complete competitive source selection and award CAMMO contract	(3Q) [RN]
7.3	Award ORS-5 competitive launch vehicle contract	(3Q) [ORS]
Goal 8: Create and maintain competitive environments and increase small business participation to the maximum extent possible		
8.1	Award Western Modernized Network (WMN) incentive-fee contract to small business prime contractor via competition	(2Q3Q) [RN]
8.2	Derive lessons learned from small businesses to identify barriers to small business participation in SMC competitive opportunities %	(3Q) [SB]
Goal 9: Implement BBP 3.0 principles and form stronger partnerships with industry in the Pre-Award acquisition process		
9.1	Award competitive contract for next EELV Phase 1A missions, fostering a competitive environment and a more affordable EELV program	(4Q) [LR]
9.2	Award virtual range contract using a fee structure that incentivizes productivity	(3Q) [SY]
Goal 10: Expand acquisition lessons learned process and promote forums to share these lessons internally and with our industry partners		

Table 25. Commitments for SMC's Mandate 3.
Source: USAF SMC (2015, 17).

MANDATE 3: Evolve and Implement new system architectures that are affordable and resilient		
COMMITMENTS		(ECD) [OPR]
Goal 11: Design and develop enterprise ground architecture that consolidates and automates our ground systems to better deliver integrated effects to warfighters around the world		
11.1	Deliver long-term enterprise ground architecture transition plan to AFSPC/CC in anticipation of responsive and emerging threats	(4Q) [AD]
Goal 12: Develop acquisition strategies where the Air Force owns the technical baseline, defines common architectures, ensures modularity, and are responsivene [sic] to Airmen's needs in a dynamic strategic environment		
12.1	Complete STP-2 Mission Design Review-2B	(4Q) [AD]
Goal 13: Identify "pivot points" within our existing programs, requirements, and acquisition processes that allow us the agility to change/adjust our direction due to emerging threats or for technology insertion		
13.1	Release RFP for partnering with industry and investing in Rocket Propulsion Systems to begin transition to two or more domestic, commercially viable launch providers that also meet National Security Space launch requirements	(3Q) [LR]
13.2	Revitalize the propulsion industry by placing the Booster Propulsion Tech Maturation Efforts on contract with two or more providers	(3Q) [LR]
13.3	Remove barriers to commercial technology utilization by collecting the Re-Entry Break Up Recorder-Wireless 2 (REBR-W2) data on the European Space Agency's Automated Transfer Vehicle-5	(4Q) [AD]
Goal 14: Increase resiliency by designing space vehicle capabilities in smaller capacity increments, distributed across more but smaller satellites or hosted payloads.		
14.1	Award competitive Protected Tactical Service Field Demo contracts to respond to emerging SATCOM threats	(4Q) [MC]
14.2	Successfully launch ORS-4 Super Strypi mission	(4Q) [ORS]
Goal 15: Advance our space situational awareness infrastructure to move beyond routine catalog maintenance towards a predictive, time-critical battle management command, control and communications environment		
Goal 16: Reaffirm strategic development planning across the Center		
16.1	Deliver SMC Strategic Plan and Annexes for 2015–2017 consistent with BBP 3.0, the USAF Strategic Plan, and AFSPC/CC's Strategic Intent	(2Q) [XP]
16.2	Develop action plans aligned with the AF's Enterprise Engineering Strategic Plan for improving AF governance, decision making, standardization, & workforce development	(2Q) [EN]

Table 26. Commitments for SMC's Mandate 4.
Source: USAF SMC (2015, 18).

MANDATE 4: Take Care of our People		
COMMITMENTS		(ECD) [OPR]
Goal 17: Airmen will proactively check on Airmen. Extend Wingman culture to families at all levels to foster support, success, and resiliency on the home front and at deployed locations		
17.1	Provide each of our Airmen 4 hours of Resiliency training through wingman days and reoccurring resiliency training sessions	(4Q) [61ABG]
17.2	Educate and familiarize our families at LAAFB on what our Airmen experience during deployments through OPERATION KUDOS	(1Q) [61ABG]
Goal 18: Reinvigorate and refresh programs that leverage the expertise of all installation helping agencies and inform how to access care		
18.1	Conduct 60-minute small group suicide awareness discussions versus ADLS Computer-Based Training as directed by AF Community Action and Information Board	(3Q) [61ABG]
18.2	Complete 90-minute SAPR training and 3 small group discussions (supervisor-led) for all Airmen	(4Q) [61ABG]
Goal 19: Provide resources for financial aid, financial counseling, career and education guidance, and legal advice to address family and individual issues for uniformed and family members		
19.1	Advocate for student permits (as necessary) and address issues with youth school registration in the local school system	(3Q) [61ABG]
19.2	Provide 100% of deployers with pre-deployment briefing on legal issues including the importance of establishing a will and power of attorney prior to deployment	(4Q) [JA]
Goal 20: Ensure there are many opportunities for social interaction to build our support structures and for all important fun		
20.1	Take care of deployed families by hosting at least 3 base-wide events and monthly outings for deployed families	(4Q) [61ABG]
Goal 21: Become the best installation within AFSPC		
21.1	Provide state-of-the-art, 24 hour accessible fitness facilities at the main base to encourage health and wellness for fit-to-fight Airmen	(4Q) [61ABG]
21.2	Program and implement projects to reduce irrigation water consumption by 25% at Ft MacArthur	(3Q) [61ABG]
21.3	Convert vehicle fleet to plug-in/hybrid electric vehicles and implement vehicle-to-grid operations	(4Q) [61ABG]
21.4	Deliver fully integrated closed-circuit television security camera and alarm system	(4Q) [61ABG]
21.5	Incorporate GSUs into exercise and real-world notifications via the At-Hoc system	(1Q) [61ABG]

Table 27. Commitments for SMC's Mandate 5
Source: USAF SMC (2015, 19).

MANDATE 5: Provide Mission Ready Airmen		
COMMITMENTS		(ECD) [OPR]
Goal 22: Instill and foster a culture of professionalism and respect—Ensure institutional processes and culture value individual initiative, support productive failure in pursuit of innovation, provide latitude to experiment, and instill a cost-conscious mindset		
22.1	Stand-up the Diversity and Inclusion Committee and Barrier Analysis Working Group to identify and implement at least two diversity initiatives across the Center	(4Q) [DP/EO/PI]
22.2	In conjunction with 2-Ltr Directors, ensure completion of in-person scenario-based Ethics Training for all OGE450 filers	(3Q) [JA]
Goal 23: Recruit individuals with demonstrated potential for critical thinking, adaptive behavior, character, initiative, and those with contemporary mission-critical skills		
23.1	Develop and implement a strategic hiring plan to ensure SMC fills critical civilian positions with highly-qualified candidates	(3Q) [DP]
23.2	Each functional will deliver a strategic manpower plan detailing how to recruit, hire, retain, mentor & promote personnel in order to strengthen SMC's organic resources	(2Q) [EN/FM/PI/PK/SL]
23.3	Assess work requirements and fill existing civilian and military vacancies to fullest extent authorizations and funding allow	(4Q) [61ABG]
Goal 24: Train, cultivate, and retain Space experts and implement a life-long approach to education; Establish stronger professional qualification requirements for all acquisition specialties		
24.1	Complete Functional Civilian Career Development Panels for SMC workforce, promoting higher standards for key leadership positions and strengthening professional competency requirements	(2Q) [DP]
24.2	Complete organizational change from "inspection ready" to "daily mission ready" to be validated by the Unit Effectiveness Inspection	(3Q) [IG]
Goal 25: Prepare and train our airmen for deployments across multi-domain activities in theater		
25.1	Provide Contingency Contracting Officer (CCO) training that annually covers the AQC-mandated 52 topics	(3Q) [SMC/PK]

LIST OF REFERENCES

Blanchette, Sandra. 2012. “Space & Power in the Ivory Tower: Effective Space Management and Decision Making - What’s the Problem and What’s the Process?” *Planning for Higher Education* 41 (1): 64–74. http://libproxy.nps.edu/login?url=https://search.proquest.com.libproxy.nps.edu/docview/1519532578?accountid=12702.

Esri. 2009. “Space Utilization Optimization.” *Esri White Paper*. Esri, June. https://www.esri.com/library/whitepapers/pdfs/space-utilization.pdf.

Gregory, Robin, and Ralph Keeney. 1994. “Creating Policy Alternatives Using Stakeholder Values.” *Management Science* 40 (8): 1035–1048. doi: http://dx.doi.org/10.1287/mnsc.40.8.1035.

———. 2002. “Making Smarter Environmental Management Decisions.” *Journal of the American Water Resources Association* 38 (6): 1601–1612. . http://libproxy.nps.edu/login?url=https://search.proquest.com.libproxy.nps.edu/docview/201268094?accountid=12702.

Gruss, Mike. 2016a. “In wake of canceled DMSP launch, Air Force plans three new weather satellites.” *SpaceNews*, February 15. http://spacenews.com/in-wake-of-canceled-dmsp-launch-air-force-plans-three-new-weather-satellites/.

———. 2016b. “Air Force pits Boeing, Lockheed and Northrop for next group of GPS satellites.” *SpaceNews*, May 5. http://spacenews.com/air-force-pits-boeing-lockheed-and-northrop-for-next-group-of-gps-satellites/.

Huron Consulting Group. 2015. “Space Utilization and Optimization Final Report, University of Colorado - Boulder.” University of Colorado Boulder. http://www.colorado.edu/capital-asset-management/sites/default/files/attached-files/cu_boulder_space_utilization_and_optimization_final_report_august_2015.pdf.

Innovative Technical Solutions, Inc. and Malcom Pirnie, Inc. (ITS and MP). 2008. “Environmental Assessment, Los Angeles AFB Parking Structure.” Defense Technical Information Center. https://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA610518.

Keeney, Ralph. 1988. “Structuring Objectives for Problems of Public Interest.” *Operations Research* 36 (3): 396–405. http://libproxy.nps.edu/login?url=https://search.proquest.com.libproxy.nps.edu/docview/219168990?accountid=12702.

Keeney, Ralph, and Robin Gregory. 2005. “Selecting Attributes to Measure the Achievement of Objectives.” *Operations Research* 53 (1): 1–11, 177–178. doi:http://dx.doi.org.libproxy.nps.edu/10.1287/opre.1040.0158.

Kossiakoff, Alexander, William Sweet, Samuel Seymour, and Steven Biemer. 2011. *Systems Engineering Principles and Practice.* 2nd. Hoboken, NJ: John Wiley & Sons.

National Aeronautics and Space Administration (NASA). 2017. "Space Utilization Optimization Tool." NASA. Last accessed July 5. https://technology.nasa.gov// t2media/tops/pdf/LAR-TOPS-107.pdf.

National Aeronautics and Space Administration Langley Research Center (NASA LaRC). 2016a. "Countdown to a New Century - Langley Research Center 2016." NASA (National Aeronautics and Space Administration). https://www.nasa.gov /sites/default/files/atoms/files/larc-2016-countdown-to-a-new-century.pdf.

———. 2016b. "System and Method for Space Utilization Optimization and Visualization." *NASA Tech Briefs* 40 (10): 54. http://libproxy.nps.edu/login?url =http://search.proquest.com/docview/1840844443?accountid=12702.

Natural Resources Leadership Institute. 2017. "Multi-Criteria Decision Analysis." North Caroline State University. Last accessed July 5. https://www.ncsu.edu/nrli /decision-making/MCDA.php.

Pereira, Rui, Kevin Cummiskey, and Rex Kincaid. 2010. "Office Space Allocation Optimization." *2010 IEEE Systems and Information Engieering Design Syposium.* 112–117. doi: https://doi.org/10.1109/SIEDS.2010.5469670.

Ulker, Ozgur. 2013. *Office Space Allocation by Using Mathematical Programming and Meta-Heuristics.* PhD diss., University of Nottingham. http://eprints.nottingham.ac.uk/id/eprint/13604.

United States White House. 2017a. "Freeze the Footprint." Last accessed July 10. https:// www.performance.gov/initiative/freeze-footprint.

———.2017b. "Reduce the Footprint." Last accessed July 10. https://www.performance.gov/initiative/manage-property/reduce-footprint.

University of Michigan. 2012. "Research Space Guidelines—Ann Arbor Campus." Last modified August 1. http://www.provost.umich.edu/space/other /ResearchSpaceGuidelines.pdf.

United States Air Force Space Command (US AFSPC). 2017a. "Space and Missile Systems Center." http://www.afspc.af.mil/About-Us/Fact-Sheets/Display/Article /1012587/space-and-missile-systems-center/.

———. 2017b. "Air Force Space Command: Commander's Strategic Intent." Last accessed August 4. http://www.afspc.af.mil/Portals/3/Commander%20Documents /AFSPC%20Commander%E2%80%99s%202016%20Strategic%20Intent.pdf?ver =2016-05-09-094135-810.

United States Department of Defense (US DOD). 2017. “DOD Dictionary of Military and Associated Terms.” http://www.dtic.mil/doctrine/new_pubs/dictionary.pdf.

United States Joint Staff (US JS). 2013. Doctrine for the Armed Forces of the United States. Joint Publication 1. Washington, DC: Joint Chiefs of Staff, March 25. http://www.dtic.mil/doctrine/new_pubs/jp1.pdf.

United States Air Force (USAF). 2007a. Operations and Organization. Air Force Doctrine Document 2. Secretary of the Air Force, April 3. https://fas.org/irp/doddir/usaf/afdd2.pdf.

———. 2007b. Real Property Asset Management. Air Force Policy Directive 32–90. Secretary of the Air Force, August 6. http://static.e-publishing.af.mil/production/1/af_a4_7/publication/afpd32-90/afpd32-90.pdf.

———. 2014. “America’s Air Force: A Call to the Future.” http://airman.dodlive.mil/files/2014/07/AF_30_Year_Strategy_2.pdf.

———. 2015a. “USAF Strategic Master Plan.” http://www.af.mil/Portals/1/documents/Force%20Management/Strategic_Master_Plan.pdf.

———. 2015b. “Air Force Future Operating Concept.” http://www.af.mil/Portals/1/images/airpower/AFFOC.pdf.

———. 2016a. Acquisition of Real Property. Air Force Instruction 32–9001 United States Air Forces in Europe Supplement. Secretary of the Air Force, July 27. http://static.e-publishing.af.mil/production/1/usafe/publication/afi32-9001_usafesup_i/afi32-9001_usafesup_i.pdf.

———. 2016b. Assistant Secretary of the Air Force (Acquisition). Headquarters Air Force Mission Directive 1–10. Secretary of the Air Force, September 2. http://static.e-publishing.af.mil/production/1/saf_aq/publication/hafmd1-10/hafmd1-10.pdf.

———. 2017. “Air Force Acquisition.” Last accessed August 3. http://ww3.safaq.hq.af.mil/Organizations/.

United States Air Force Los Angeles Air Force Base (USAF LAAFB). 2012a. “Space Superiority Systems Directorate.” http://www.losangeles.af.mil/About-Us/Fact-Sheets/Article/343733/space-superiority-systems-directorate/.

———. 2012b. “Parking Garage Officially Opens with Ribbon Cutting Ceremony.” http://www.losangeles.af.mil/News/Article-Display/Article/343835/parking-garage-officially-opens-with-ribbon-cutting-ceremony/.

———. 2012c. “Global Positioning Systems Directorate.” http://www.losangeles.af.mil/About-Us/Fact-Sheets/Article/343713/global-positioning-systems-directorate/.

———. 2013a. “Military Satellite Communications Systems Directorate.” http://www.losangeles.af.mil/About-Us/Fact-Sheets/Article/343704/military-satellite-communications-systems-directorate/.

———. 2013b. “Range and Network Systems Division.” http://www.losangeles.af.mil/About-Us/Fact-Sheets/Article/343699/range-and-network-systems-division/.

———. 2015. “Advanced Systems and Development Directorate.” http://www.losangeles.af.mil/About-Us/Fact-Sheets/Article/734570/advanced-systems-and-development-directorate/.

———. 2016a. “Launch Enterprise Directorate.” http://www.losangeles.af.mil/About-Us/Fact-Sheets/Article/812286/launch-enterprise-directorate/.

———. 2016b. “Remote Sensing Systems Directorate.” http://www.losangeles.af.mil/About-Us/Fact-Sheets/Article/812306/remote-sensing-systems-directorate/.

———. 2017. “Units.” Last accessed August 5. http://www.losangeles.af.mil/Units/.

United States Air Force Robins Air Force Base Commander. 2015. *Space Optimization*. Robins Air Force Base Instruction 32–1084. Air Force Materiel Command. August 13. http://static.e-publishing.af.mil/production/1/robinsafb/publication/robinsafbi32-1084/robinsafbi32-1084.pdf.

United States Air Force Space and Missile Systems Center (USAF SMC). 2015. “SMC Strategic Plan.”

Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)). 2017. Operation of the Defense Acquisition System. Department of Defense Instruction 5000.02. Washington, DC: Under Secretary of Defense for Acquisition, Technology, and Logistics. February 2. http://www.acqnotes.com/wp-content/uploads/2014/09/DOD-Instruction-5000.02-The-Defense-Acquisition-System-2-Feb-17-Change-2.pdf.

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