Value Based Analysis of Acquisition Portfolios

By

Cheri Nicole Markt Burgess

B.S. Mechanical Engineering, April 2003

Brigham Young University

Submitted to the System Design and Management Program
In Partial Fulfillment of the Requirements for the Degree of

Master of Science in Engineering and Management

at the

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May 7, 2010
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Signature of Author

Cheri Nicole Markt Burgess
System Design and Management Program
May 7, 2010

Certified by

Ricardo Valerdi
Research Associate, Engineering Systems Division
Thesis Supervisor

Certified by

Patrick Hale
System Design & Management Program
Director

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Abstract

Currently, program-funding allocation is based on program performance. Funding cuts commonly lead to a poor reflection on the program management assigned to the given program. If additional factors such as program risk and benefit are objectively factored in, this may lead to a more effective exit strategy for program capabilities, which are no longer required.

An enterprise architecture analysis and applied framework case study were carried out to develop a methodology to quantify system-level value for the Office of the Assistant Secretary of the Air Force for Acquisition Research, Development, Test and Evaluation portfolio. Portfolio value is quantified in order to transition from a single program, single stakeholder value analysis to a program portfolio and stakeholder system composite analysis. This methodology is developed based on interviews, official organization literature, and a case study.

The results of the applied framework case study on a portfolio of seven programs showed a positive correlation between quantitative capability, execution and risk data at the portfolio level and access to a more informed and objective identification of programs of greatest interest and concern as compared to a qualitative program-by-program analysis when allocating Air Force Acquisition resources.

This system includes 17 stakeholder categories, which significantly influence the allocation of resources for a portfolio worth roughly 0.4% of the US GDP. Interviews include high-ranking leadership, including two 3-Star Generals in the US Air Force.

Thesis Supervisor: Dr. Ricardo Valerdi
Title: Research Associate
Lean Advancement Initiative

Biographical Summary of Author

Cheri Burgess began her professional career in the Oil and Gas Industry at the Novatek Company as a Synthetic Diamond Lab Engineer improving production processes. Following this first career assignment Cheri transitioned to the Defense Industry at Lockheed Martin as a Senior Mechanical Engineer. Within six years Cheri became a subject matter expert in the area of Computer-aided Design by leading infrastructure changes in processes, tools and training used across nine locations. Cheri has a six Sigma Lean Management Black Belt and thrives on exploring new technology to improve business practices. Cheri represented Lockheed Martin on five American Society of Mechanical Engineer Standard Committees and represented the United States as part of a Technical Advisory Committee to the International Standards Organization (ISO). Cheri is currently working as a Research Assistant for MIT's Lean Advancement Initiative. With this assignment, Cheri has interfaced with the U.S. Air Force to fulfill a contract to develop a methodology to evaluate the portfolio value of Air Force Acquisition Programs. Please stay tuned, as her next adventure is to be determined…

Cheri Burgess received a Bachelor of Science Degree in Mechanical Engineering from Brigham Young University in April 2003 and will graduate with a Masters Degree in System Design and Management from the Massachusetts Institute of Technology in June 2010.

Acknowledgements

Participation in the System Design and Management program has been a valuable experience for me and I would like to gratefully acknowledge Dr. Debbie Nightingale for admitting me into the Lean Advancement Initiative family of Research Assistants. This has provided research opportunities and invaluable friendships I will forever treasure.

I would like to thank my thesis advisor, Dr. Ricardo Valerdi, for providing insight and guidance to get me going and maintain my momentum in order to complete this research. Lt Col Fred Gregory has likewise been an invaluable resource in completing this research by providing opportunities to interview with Air Force Acquisition stakeholders.

I would like to dedicate this work to my family. To my husband who was willing to care for our little family while his crazy wife went to school on the opposite side of the country in search of dreams. To my son Joseph who motivated me by asking, "How many pages left mom? Are you done yet? I miss you..." To my son Brian whose face lights up when he looks at me... my beautiful boy.

Table of Contents

Abstract 4

Biographical Summary of Author 5

Acknowledgements 6

Table of Contents 7

List of Figures 9

List of Tables 10

List of Equations 10

Acronyms 11

1 Introduction 13

1.1 Statement of Problem 14

1.2 Thesis Objective and Value 15

1.3 Thesis Statement 16

1.4 Defense Industry and Air Force Background 17

1.5 Outline of Research 20

2 Literature Review 22

2.1 What is value? 22

2.2 What is a Portfolio? 24

2.3 Utility and Associated Value Theories 29

2.4 System Level Stakeholder Analysis of Portfolio Value 31

2.5 How is Enterprise performance measured? 35

3 Methodology 45

3.1 Definition Phase 45

3.2 Measurement Phase 45

3.2.1 Enterprise Organization View 46

3.2.2 Enterprise Strategy View 46

3.2.3 Enterprise Process View 46

3.2.4 External Factors View 47

3.2.5 Enterprise Information View 48

3.2.6 Enterprise Knowledge View 49

3.2.7 Enterprise Product View 49

3.2.8 Case Study 50

3.3 The Analysis Phase 51

3.4 The Design Phase 52

3.5 The Verification Phase *52*

4 Results **54**

4.1 Project Definition *54*

4.2 Measurement & Analysis *58*
4.2.1 Enterprise Organization View 59
4.2.2 Enterprise Strategy View 62
4.2.3 Process View 74
4.2.4 Policy and External Factors View 79
4.2.5 Information View 81
4.2.6 Funding View 84

4.3 Design *87*
4.3.1 Organization View 87
4.3.2 Strategy View 88
4.3.3 Process View 93
4.3.4 Policy and External Factors View 94
4.3.5 Information View 94
4.3.6 Funding View 94

4.4 Applied Framework Definition *95*

4.5 Applied Framework Data and Analysis *95*

4.6 Enterprise Architecture Validation *105*

5 Conclusions **108**

6 Recommendations For Future Work **109**

7 Bibliography **113**

List of Figures

Figure 1: Thesis Objective 16
Figure 2: World Share Defense Spending (Google GDP 2010) (SIPRI Yearbook 2009) 17
Figure 3: Historical Budget and GWOT Funding (Gates 2008) 18
Figure 4: DoD Budget by Category (Gates 2008) 19
Figure 5: DoD Budget by Branch of Military (Gates 2008) 19
Figure 6: Flow of Research 21
Figure 7: Enterprise Architecture Definition of Value (Crawley 2009) 23
Figure 8: Value Definition 24
Figure 9: Markowitz Variance and Expected Returns 25
Figure 10: Program Portfolios vs. Investment Portfolios 26
Figure 11: Multiple Portfolio Perspectives 27
Figure 12: Portfolio Value 33
Figure 13: Enterprise Model Framework for Customer Relationship Management 38
Figure 14: The Process Management Circle 40
Figure 15: DMADV (Simon 2010) 45
Figure 16: Swim Lane Example 47
Figure 17: Hybrid SIPOC and System Map 49
Figure 18: Data Measurement Approach 51
Figure 19: Conceptual Portfolio Value Results 52
Figure 20: FYDP Appropriations (DAU 2010) 56
Figure 21: PEO Portfolio Definition and Stakeholders 61
Figure 22: Resource Allocation Process 74
Figure 23: JCIDS Process 75
Figure 24: Acquisition Process 75
Figure 25: PPBE Process 76
Figure 26: Concurrent Program and Budget Review Process 77
Figure 27: Air Force PPBE Process 78
Figure 28: Leaders of Major Processes 79
Figure 29: The Program Manager's Environment (Brown 2009) 80
Figure 30: Macro Level Information View 82
Figure 31: System Information View 83
Figure 32: OMB Congressional Budget Breakdown 85
Figure 33: Budget Requests (Bradley 2010) 87
Figure 34: Tier 1 JCA Program Mapping 99
Figure 35: Short vs. Long Term Programs 100
Figure 36: Profile of Warfare Type 101
Figure 37: Balance of Development Phases 102
Figure 38: Portfolio Value 103
Figure 39: Portfolio Value Outlier Triage 104
Figure 40: Portfolio Performance Data 105
Figure 41: Portfolio Capability Benefit, Execution, and Risk 106
Figure 42: RDT&E Portfolio Value 111
Figure 43: Changes in Portfolio Value Over Time 112

List of Tables

Table 1: Value Definitions from Multiple Sources [adapted from Aykroyd (2008)] **22**
Table 2: Portfolio Definition References **24**
Table 3: Value Theory Literature Summary **29**
Table 4: Conditions Favorable to Value Articulation (Fischhoff 1991) **31**
Table 5: System Level Stakeholder Value **32**
Table 6: Enterprise Metric Literature Summary **36**
Table 7: List of Stakeholders **54**
Table 8: Portfolio Value Criteria Information Sources **84**
Table 9: System Stakeholder Value Strategy Map to Value Criteria **89**
Table 10: Value Criteria, Unit of Measure and Scoring Criteria **90**
Table 11: Applied Value Criteria Result Comments **96**
Table 12: Applied Framework Data **98**

List of Equations

Equation 1: Portfolio Value Equation **58**

Acronyms

A3/A5	AF, DCOS, Air, Space & Information Operations, Plans & Requirements
A8	Strategic Plans & Programs
ACAT	Acquisition Category
AF	Air Force
AFRC	Air Force Requirements Counsel
APPG	Annual Planning & Programming Guidance
AT&L	Acquisition Technology & Logistics
C2&CS	Command and Control and Combat Support Systems
CAPE	Capability Assessment and Program Evaluation
CBO	Congressional Budget Office
CFO	Chief Financial Officer
COCOM	Combat Commander
CPR	Chairman's Program Recommendation
CRRA	Capability Review & Risk Assessment
CSR	Chairman's Strategic Recommendation
DAES	Defense Acquisition Executive Summary
DAG	Defense Acquisition Guidebook
DCOS	Department of the Chief of Staff
DoD	Department of Defense
DoDAF	Department of Defense Architecture Framework
ESC	Electronic Systems Center
GAO	Government Accountability Office
GWOT	Global War on Terror
ICD	Interface Control Drawing
IPL	Integrated Priority List
J8	Force Structure, Resources, and Assessment Directorate
JCA	Joint Capability Area
JCAMS	Joint Capability Area Management System
JCIDS	Joint Capabilities Integration Development System
JPG	Joint Programming Guidance
MAR	Monthly Acquisition Reports
MBI	Major Budget Issues
NDS	National Defense Strategy
NMS	National Military Strategy
NSA	National Security Agency
OMB	Office of Management and Budget
OPLAN	Operational Plan
OSD	Office of the Secretary of Defense
PBD	Program Budget Decisions
PDM	Program Decision Memorandum
PEO	Program Executive Office
PM	Program Manager
POM	Program Objective Memorandum

PoPS	Probability of Program Success
PPBE	Planning Programming Budget and Execution
PPI	Preparation Instructions
QDR	Quadrennial Defense Review
SAF/AQ	Secretary of the Air Force / Acquisition Department
SAR	Selected Acquisition Reports
SIPOC	Supplier-Inputs-Process-Outputs-Customer
SMP	Strategic Master Plan
SPG	Strategic Planning Guidance

1 Introduction

> *Every gun that is made, every warship launched, every rocket fired signifies, in the final sense, a theft from those who hunger and are not fed, those who are cold and not clothed. We pay for a single fighter plane with a half-million bushels of wheat. We pay for a single destroyer with new homes that could have housed more than 8,000 people.* - President Dwight D. Eisenhower, April 19, 1953

There are 1000's of defense acquisition programs, and the challenge is significant to objectively determine program value at the portfolio level. However, it is imperative that the allocation of resources is done with excellence in order to responsibly provide for the defense of US citizens and its allies.

This research on the subject of Enterprise Transformation via Portfolio Risk vs. Benefit Analysis was initiated to address a set of needs for the Assistant Secretary of the Air Force for Acquisition. One of the key champions for this research, Lt Col Fred Gregory, recognized this opportunity to improve value of Acquisition portfolios from his experience serving in the Joint Staff and the Air Force Acquisition Staff. In 2006, he along with his Office of the Secretary of Defense (OSD) counterparts identified a group within DoD Acquisition who had an interest and also recognized a need for enterprise management. The approach is to look at portfolio value within the Program Executive Officers (PEOs) domain. They have the role of enabling successful execution of programs within their portfolio, but many external organizations are influential stakeholders of this activity. In addition to the current challenge of managing a system of stakeholders for the current PEO portfolios, there is a current change underway to divide the four major PEO portfolios into 15 PEO portfolios. This means that an objective method for evaluating value of programs is required in order to balance the several external interests across a set of several portfolios. The anticipation of this organizational transition and resulting increased need for an objective method to balance portfolio priorities and value has resulted in funding to support this research.

1.1 Statement of Problem

The following Problem Statement explains the needs that currently exist:

1. Typically acquisition program performance is reviewed and managed on an individual basis with no consideration for the portfolio of related programs
2. Databases and acquisition reporting systems exist that characterize individual program performance i.e., Probability of Program Success (PoPS), Monthly Acquisition Reports (MAR), Selected Acquisition Reports (SARS)
3. There is no current method to combine different acquisition programs into a portfolio and be able to objectively assess execution, risk and benefit of the entire portfolio (1000's of programs in a portfolio)
4. There is no universal unit of measure to objectively determine relative value for individual programs within a DoD Appropriation portfolio, which is tied to war fighter needs and is updated over time
5. There is a desire to be able to manage a portfolio of acquisition programs similar to the way financial portfolios are managed
6. There are several factors to be considered in an assessment of a program:
    a. How well a program is being executed
    b. The value of the program, including its contribution to war fighter needs
    c. The degree of risk inherent in the program
    d. The technical and non-technical risk that are common across multiple programs in a portfolio
    e. There are no standardized formal methods for managing groups of programs as portfolios, including recognized practices to be taken by portfolio managers to modify the performance of their portfolios

While the complete methodology will address value, execution, and risk profile methodology at the DoD Appropriation portfolio level, the case study research in particular is scoped to address portfolio value (9b above). By developing a methodology for determining portfolio value, the following objectives will be met:

- Determine the right fidelity of the data necessary for assessing individual program and portfolio value

- Define the most appropriate data collection procedures to ensure data integrity
- Developing a value equation for quantifying the contribution of an individual program towards the needs of the war fighter
- Validate the portfolio value assessment framework with a small set of homogeneous programs
- Refine value equation based on results from validation exercise and user input
- Provide prescriptive advice for managing portfolios of acquisition programs given certain value profiles
- Identify strategies for achieving a balanced portfolio of acquisition programs
- Identify goals and targets for Program Executive Officers to strive towards for program value

Identify organizational and policy issues associated with the implementation of portfolio management in acquisition

A key element of determining portfolio value is accomplished by developing a value equation. The value equation is described as a method of quantifying the contribution of an individual program towards the needs of the diverse stakeholders

- To reconcile the inputs of all pertinent stakeholders who help define the value of a particular program such as the war fighter, GAO, PEO, Congress, etc.
- Must be supported by government stakeholder resources to allow determination of an effective value measure

1.2 Thesis Objective and Value

Currently, program portfolios are reviewed one program at a time with respect to program execution i.e. cost, schedule and performance deviations from the original plan. Execution trends for the portfolio as a whole are typically not reviewed. Nor are portfolio level risk and capability assessments typically reviewed as part of the Acquisition Cycle. Each program's total value also varies between each stakeholder, so a different assessment of value may be provided based on which stakeholder you talk to. In order to assess portfolio value, which includes execution as well as risk and capability

assessment, with value trends over time while maintaining perspectives of multiple stakeholders a quantitative method was derived, see Figure 1.

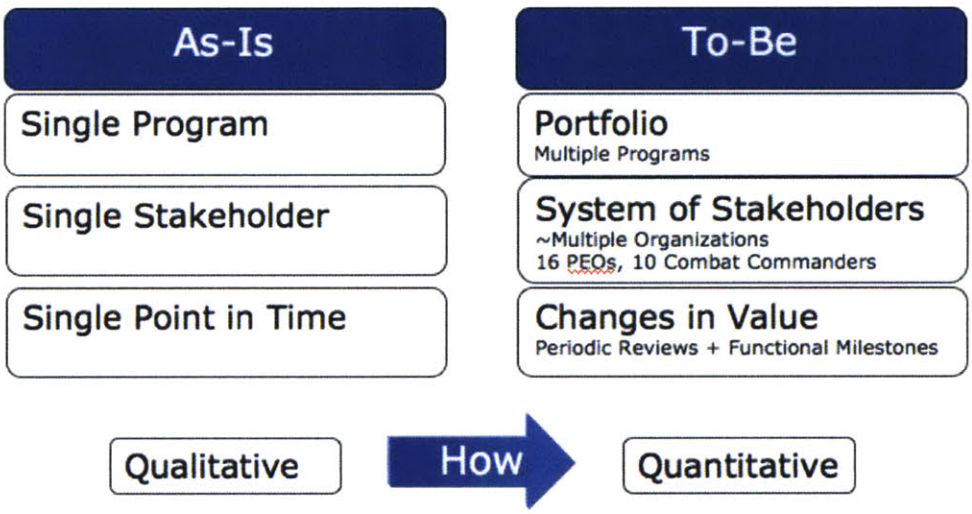


Figure 1: Thesis Objective

The objective is to develop a method for determining a portfolio system-level stakeholder value assessment and value trends within Air Force Acquisition programs to enable:

- More informed decision making
- Reduction of duplicate efforts
- Global prioritization of investments based on value
- Maintained war fighter value perspective
- Sensitivity analysis of stakeholder values
- Exit strategy for programs based on program value

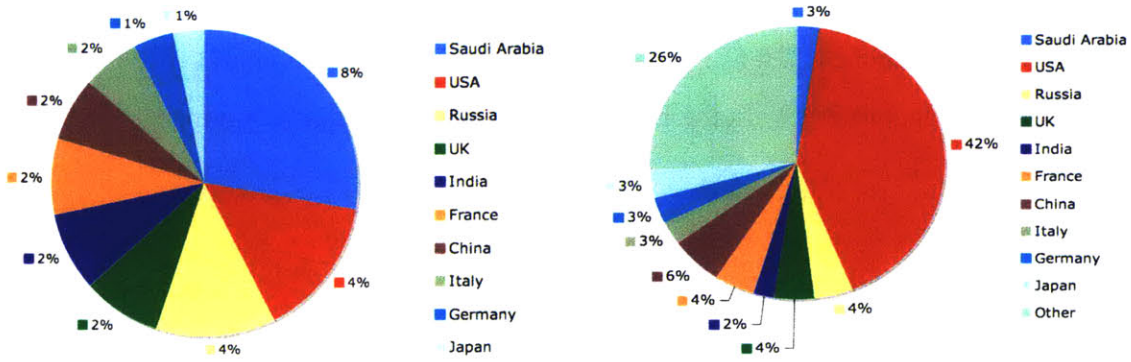
1.3 Thesis Statement

Analyzing system level portfolio value will provide a more informed and objective identification of programs of greatest interest and concern when compared to a program-

by-program execution analysis when allocating Secretariat for Air Force Acquisition resources.

1.4 Defense Industry and Air Force Background

The Defense budget in 2009 equaled $607 Billion dollars which amounts to 4% of the United States GDP. This is a significant investment by Congress on behalf of the American citizens to provide national security and defense. Compare the US Defense budget to the worldwide defense spending in 2009 by looking at both ratio of spending to GDP and relative spending in US dollars (Figure 2), and it is evident that national defense is a high priority of the American people (shown in red).



Relative Ratio: US Dollars Spent/GDP Absolute US Dollars Spent

Figure 2: World Share Defense Spending (Google GDP 2010) (SIPRI Yearbook 2009)

As can be seen from Figure 3 below, national defense budget has continued to increase over the past ten years in light of the Global War on Terror.

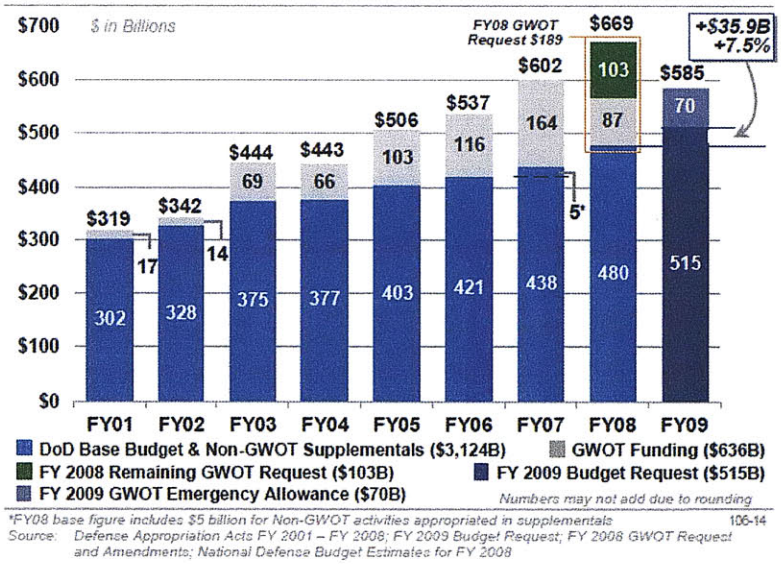


Figure 3: Historical Budget and GWOT Funding (Gates 2008)

Within the Department of Defense, investment in new innovation comprised 35% of the total Defense budget in 2009. In the DoD FY 2009 Budget Request Summary Justification, pg 19:

> "Strategic Modernization ($183.8 Billion)
>
> Maintaining our technological edge today is central to military superiority in the future. The Department requests $183.8 billion, or 35 percent, of its FY 2009 request for strategic modernization, which includes procurement and research and development."

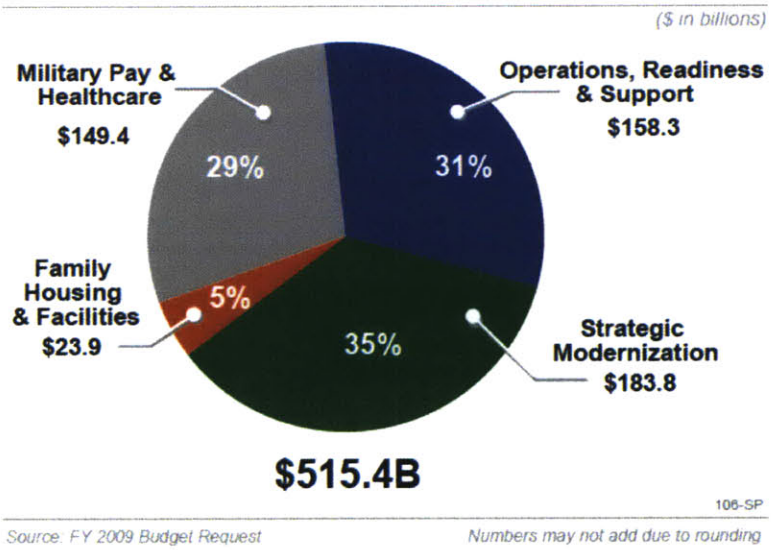


Figure 4: DoD Budget by Category (Gates 2008)

In 2009, the DoD allocated to the Air Force 28% of the total DoD budget, and part of those resources were allocated to support mission capabilities that can be addressed with acquisition programs, see Figure 5. Each program that is initiated has merit on the basis of meeting an identified war fighter need. However, the challenge lays in objectively comparing and prioritizing thousands of programs across an Air Force Portfolio to optimize taxpayer dollars.

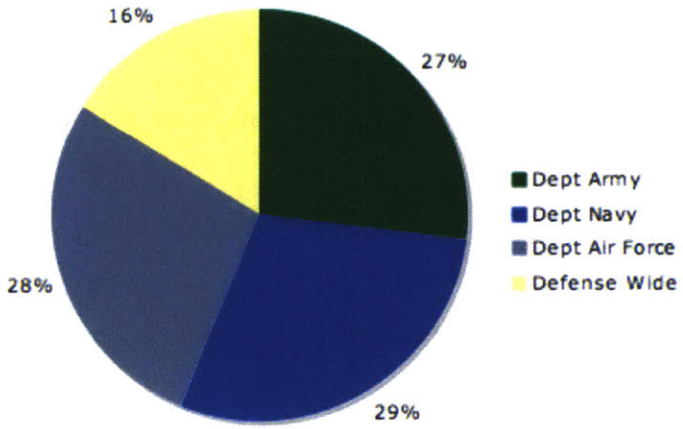


Figure 5: DoD Budget by Branch of Military (Gates 2008)

1.5 Outline of Research

A graphical view of this research is provided in Figure 6, and it consists of the following key components:

Literature Review

The research question described in Section 1.3 will be explored in the Chapter 2: Literature Review.

Methodology

A general Lean Management Define-Measure-Analyze-Design-Verify (DMADV) approach will be used in combination with tools from the domains of Enterprise Architecture and Systems Architecture in Chapter 3: Methodology.

Results

The results section in Chapter 4 has two iterations. The first set of results will be centered on the enterprise level data, analysis and proposed architecture for a DoD Appropriation level portfolio. The second set of results will be based on the applied proposed architecture using a case study approach with a PEO portfolio. It is in Section 4.5 that the case example portfolio value results are documented and analyzed. Following the case study results, the research question at the enterprise level is addressed in Section 4.6.

Conclusions

The results are then followed by conclusions in Chapter 5 and recommendations for future research in Chapter 6.

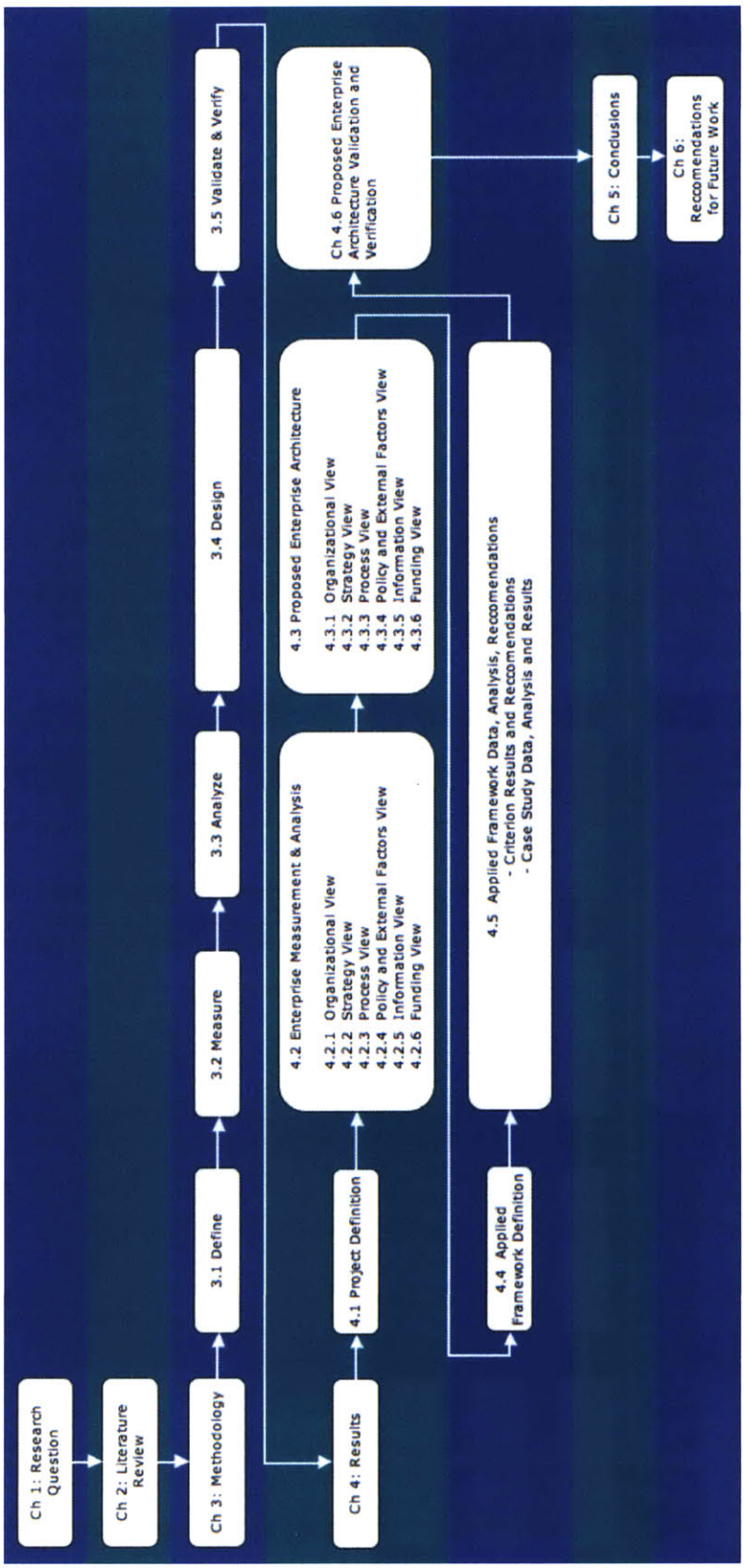


Figure 6: Flow of Research

2 Literature Review

The literature related to this research can be grouped into six major areas:

- Concept of Value
- Portfolio Definition
- Utility and Associated Value Theories
- Quantitative vs. Qualitative Data
- Quantifying Value
- Value as a Function of Time

2.1 What is value?

In order to address this topic of portfolio value, we will first address the definition of "value". There are a number of definitions provided in literature, including the following:

Table 1: Value Definitions from Multiple Sources [adapted from Aykroyd (2008)]

Value Definition
Value is the appropriate performance and cost. (Miles, 1961)
Lowest cost to reliably provide required functions or service at desired time and place and with the essential quality. (Mudge, 1971)
Value is function divided by cost. (Kaufman, 1985)
Value is the potential energy function representing the desire between people and products. (Shillito & DeMarle, 1992)
Value is a capability provided to a customer at the right time at an appropriate price, as defined in each case by the customer. (Womack & Jones, 1996)
The additional functionality of a product normalized by the cost of the additional functionality, or simply function divided by cost. (Cooper & Slagmulder, 1997)
Value is anything that directly contributes to the "form, fit, or function" of the build-to package or the buy-to package • Form: Information must be concrete format, explicitly stored • Fit: Information must be (seamlessly) useful to downstream processes Function: Information must satisfy end user and downstream process needs with an acceptable probability of working (risk) (LAI, 1998)
[Value is] balancing performance, cost, and schedule appropriately through planning and control. (Browning, 1998)
Value is a measurement of the worth of a specific product or service by a customer and is a function of: (1) Product's usefulness in satisfying customer needs; (2) Relative importance of the need being satisfied; (3) Availability of the product relative to when it is needed; (4) Cost of ownership to the customer. (Slack, 1999)
[Value is] a system introduced at the right time and right price which delivers best value in mission effectiveness, performance, affordability and sustainability and retains these advantages throughout its life. (Stanke, 2001)
Value is an outcome of balancing system level goals, function and cost. (Crawley 2009)

Value, n. 1: a fair return or equivalent in goods, services, or money for something exchanged; 3: relative worth, utility, or importance. 6f: The quality of a thing considered in respect of its power and validity for a specified purpose or effect. (Webster 2010)

A System Architecture definition of value in graphical form is provided in Figure 7 below. The product development context is used where the system level goals, functions, operations, costs and operators each contribute to the form or physical structure of the product. Within this context, "value" shown in green is defined as the intersection between "goals", "functions" and "cost" each shown in blue. Or in other words, the value of an item is determined by what the stakeholders are trying to accomplish, what method they intend to use to accomplish their objectives, and what resources will be required to achieve the specified goals in a given way.

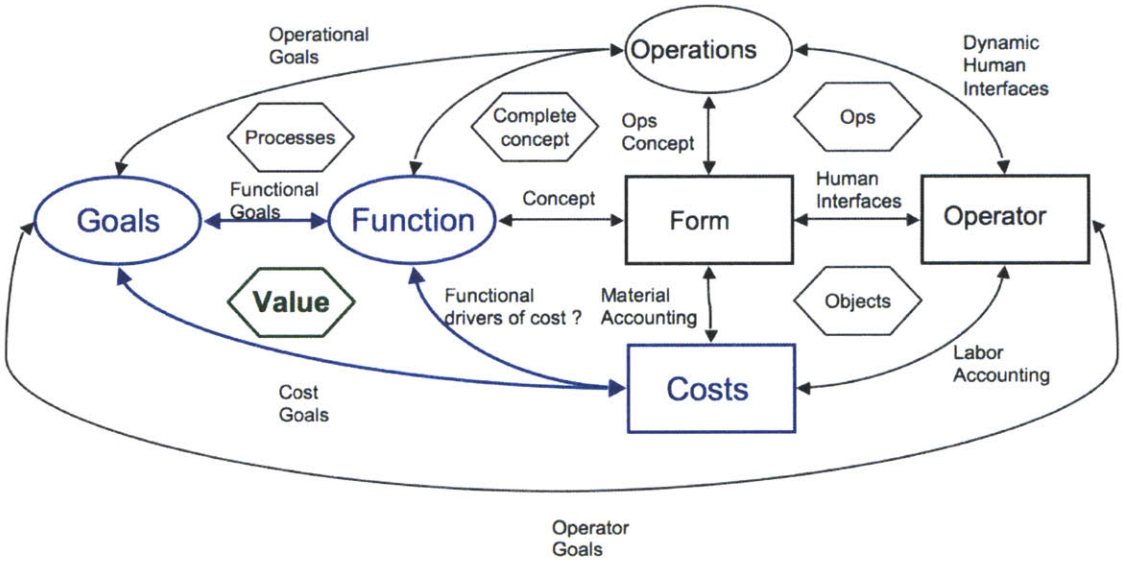


Figure 7: Enterprise Architecture Definition of Value (Crawley 2009)

Using this System Architecture definition as a starting point, the other definitions provided come together to provide a general definition of value. For example, take Mudge, Womack and Jones, Slack, Stanke's contribution to the definition, which includes appropriate timing to achieve value and include this under the "goal" heading where stakeholders communicate their capability requirements. Combine Mudge, Kaufman, Cooper and Slagmulder, Slack, LAI, Stanke, Crawley's contributions to the element of function to the definition which is discussed as function explicitly as well as

implicit references such as mission effectiveness, utility, and usefulness. Lastly, combine monetary product costs with opportunity costs and staffing expertise resource demands in a single "cost" category, and the following graphical definition results, see Figure 8.

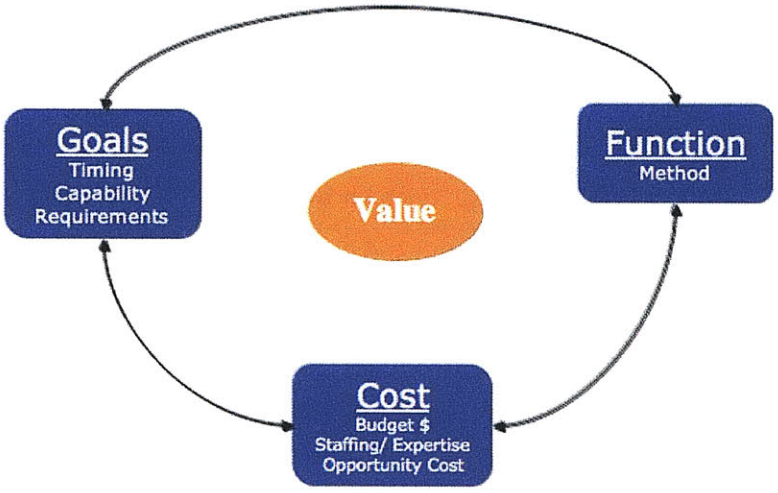


Figure 8: Value Definition

2.2 What is a Portfolio?

There are two main sources that provide insight into the definition of a portfolio. The first comes from a more traditional investment portfolio definition, and the second is specific to a program portfolio definition.

Table 2: Portfolio Definition References

Portfolio Definition
Portfolio Selection (Markowitz 1952)
Multi-Project Program Management (de Weck 2009)

Harry Markowitz, who won a Nobel Prize in Economics in 1990, addressed the topic of selecting a portfolio in order to optimize returns. In this case, the portfolio is a financial investment portfolio, and it is posed that an investor should diversify in order to have the actual yield turn out close to the expected yield on returns. In other words, the investor is able to gain higher returns by increasing variance in the composition of the portfolio. He identified two phases to selecting an optimized portfolio. The first is based more on tacit knowledge where a person will observe the environment and draw conclusions about the

future performance of investment options. Once a general sense of the landscape of opportunity is understood, the second phase begins. This is where a more quantitative analysis is performed on the options that have been identified in order to maximize returns. The general approach for the quantitative analysis is to compute variance and expected returns, and to then minimize variance while maximizing returns in order to achieve an optimum result. See Figure 9 below.

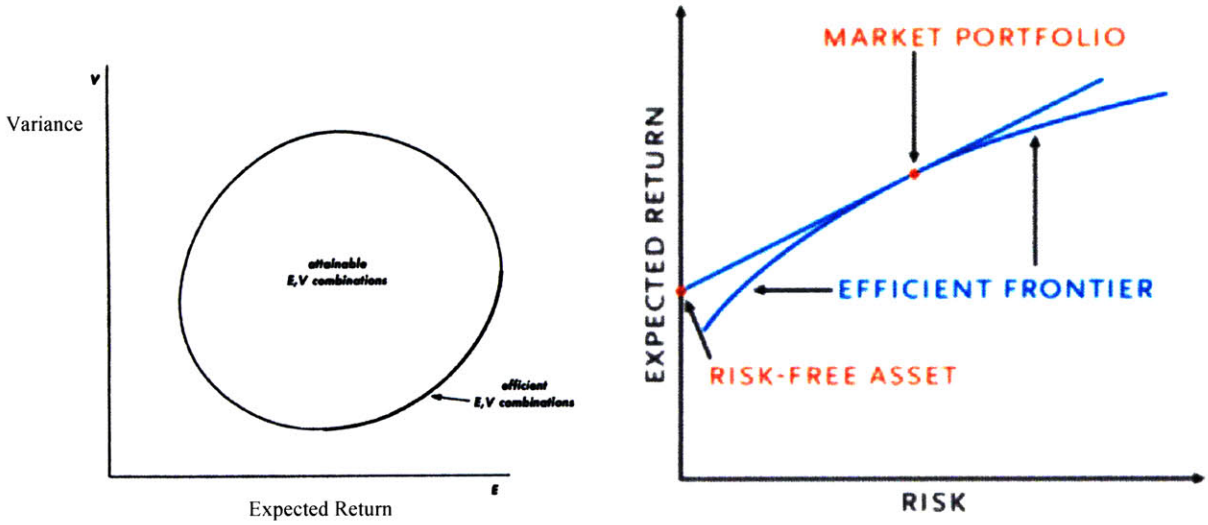


Figure 9: Markowitz Variance and Expected Returns

Another plausible definition for a portfolio is that of a collection of programs, which comprise different types of investments. In place of the more traditional stocks, bonds and mutual funds, a company may also invest in a portfolio of Research and Development programs as well as technology upgrades to improve the performance of current programs. The benefit of having a portfolio of programs is similar where the portfolio manager has the ability to balance risk and optimize the value of technology investment results (de Weck 2009). In the case of the U.S. Air Force, there are a variety of perspectives on what specifically constitutes a portfolio. In the Secretariat for Air

Force Acquisition, a portfolio consists of aircraft, weapons, and communication resources, see Figure 10.

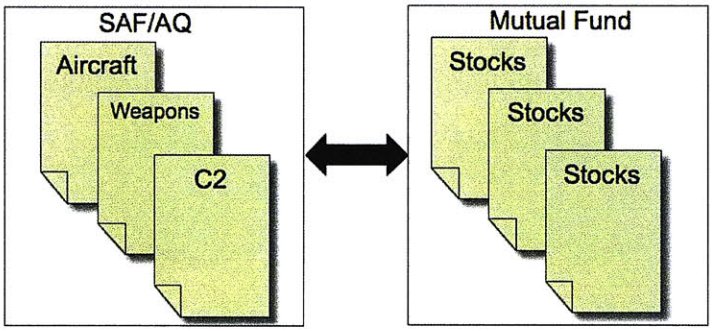


Figure 10: Program Portfolios vs. Investment Portfolios

However, there are a large number of programs, and these programs may be grouped several ways based on the many stakeholders who exist. For example, there are functional Major Commands, regional Combat Commanders, program based Program Executive Officers, Joint Capability areas, and lifecycle based funding resource managers. So, the same set of programs exists in multiple stakeholder portfolio views, see Figure 11.

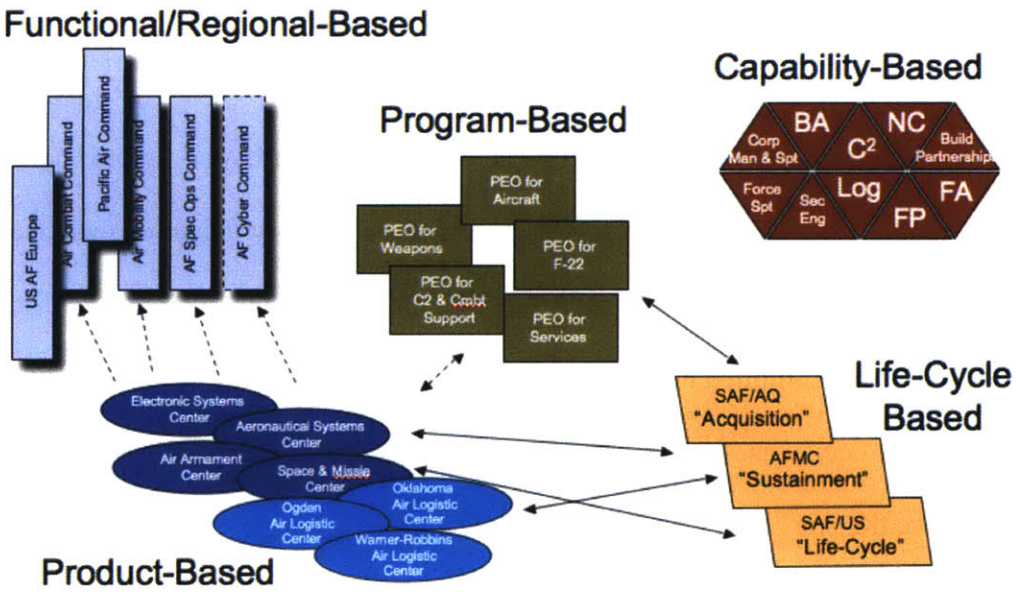


Figure 11: Multiple Portfolio Perspectives

In the case of this research, two portfolios will be addressed. First, a life cycle portfolio will be defined as the group of programs with funding from one of the life-cycle phases, namely Research, Development, Test and Evaluation (RDT&E). This portfolio will also be scoped to be a set of programs within a single year of the future year planning process (see Section 4.2.3). This portfolio optimization result will inform a second portfolio at the program based Program Executive Officer (PEO) level domain. For this research, the Electronic Systems Center (ESC) Command and Control and Combat Support Systems (C2&CS) PEO portfolio will be used to validate the methodology.

There are some differences to note between the more traditional financial portfolios and program portfolios. First, a stock option may be cashed out 'on-demand' and redeem a current value. In a program portfolio, the returns are not realized until the program is completed. In the case of a financial portfolio, there is a single unit of measure for

success, which is monetary. The value invested vs. the value returned can be measured and a return on investment may be calculated in a straightforward manner. In an Air Force program portfolio, a monetary investment is made which yields a non-monetary capability. In addition, each stakeholder measures this non-monetary value uniquely, so the ROI is different for each key person involved. In a more traditional approach, stock market indices and well-compiled historical information are available with which to base real-time investment decisions. In this Air Force program portfolio scenario, there is a monopsony, where the Air Force is the only buyer of a given set of products, which multiple sellers provide. Thus, the investment criteria used to fund portfolio programs can significantly influence the market behavior. There is also a limited supplier base, which limits the variety of options for investments. In a financial portfolio, there is liquidity, and an investor may cash out to receive the current value of the investment at any given point in time. In a program portfolio, the value is not realized until the program is completed and the technology research has developed to where it has materialized into an asset, which may be employed in the field. If an investor decides a program is a poor investment option midstream and pulls their support, they will incur a complete loss of resources invested to date. There are many differences in nature between financial and program portfolios, and it is important to keep in mind the program portfolio type is what will be explored in this research.

Key insights gained from the portfolio definition literature include the concept of selecting the composition of a portfolio to include a variance in order to optimize the future returns on the investment. Applying the concept of diversifying financial

investments to program portfolios may take the form of balancing how many short term vs. long term programs are in the portfolio, balancing basic research with technology development and tried-and-true production programs, and ensuring that all current strategic capabilities are being addressed. This first phase of portfolio selection would include first observing the set of program investment opportunities available and obtaining tacit information to guide the focus on what parameters to address in the portfolio analysis. This phase will also include observing the environment to understand the sources of variation that are most likely to contribute uncertainty to the success of the portfolio. Once the strategic goals are selected and associated uncertainties are identified, the quantitative analysis may be developed to optimize the selection of specific alternatives under consideration. The optimization for an Air Force acquisition portfolio in the future year planning process will be based on the amount of diversification in areas such as capabilities, technology maturity, and regional application.

2.3 Utility and Associated Value Theories

The following table presents literature on the topic of values theories, which define and then translate human value criteria into decisions made based on the criteria.

Table 3: Value Theory Literature Summary

Value Theories
Utility theory (von Neumann and Morgenstern 1947)
Prospect theory (Kahneman and Tversky 1979)
Taguchi Loss Function (Roy 1990)
Value Elicitation (Fischhoff 1991)
Value Focused Thinking (Keeney 1992)
Multiple criteria and attributes (Keeney and Raiffa 1993)
Types of utilities (experienced, remembered, decisional) (Kahneman and Tversky 2000)
Utility elicitation (Delquie 1989, de Neufville 1990, Seshasai 2002)

Decision analysis and multi-attribute utility theory are related to the psychology of value where utility functions corresponding with value criteria are used to capture and quantify value from which evaluation decisions can be made (von Neumann and Morgenstern 1947).

Prospect Theory indicates that people are much more concerned with losses than they are with gains and thus are naturally inclined to pursue risk adverse alternatives even when offered a potentially higher-value higher-risk alternative (Kahneman and Tversky 1979).

Value Focused Thinking is based on the approach of addressing the values and priorities of the decision maker to expand decision opportunities. This focus on value criteria instead of solutions allows for the creation of new values to emerge (Keeney 1992). The psychology of value addresses a value philosophy where the premise is made that value can only be determined in context or relative to something else (Fischhoff 1991).

The Taguchi Loss function addresses the potential loss of value that may occur as new value is created and seeks to minimize this value loss or in other words optimize value gained (Roy 1990). Table 4 provides an overview of conditions that contribute to how people articulate values.

Table 4: Conditions Favorable to Value Articulation (Fischhoff 1991)

Personally familiar (time to think)
Personally consequential (motivation to think)
Publicly discussed (opportunity to hear, share views)
Uncontroversial (stable tastes, no need to justify)
Few consequences (simplicity)
Similar consequences (commensurability)
Experienced consequences (meaningfulness)
Certain consequences (comprehensibility)
Single or compatible roles (absence of conflict)
Diverse appearances (multiple perspectives)
Direct relation to action (concreteness)
Unbundled topic (considered in isolation)
Familiar formulation

Key points from this literature address how decision-making is tied to human experience and context. In the scope of portfolio analysis, this applies by identifying the key decision makers, emphasizing the importance of identifying clear decision maker value criteria, and providing a methodology that will enable decisions to be made based on that core criteria.

2.4 System Level Stakeholder Analysis of Portfolio Value

"Wherever you have an efficient government you have a dictatorship."
Franklin D Roosevelt, April 28, 1959

This quote infers the value of having multiple stakeholders involved in a decision making process. While it may be more efficient to have a dictatorship to make a given decision, a republic with multiple representatives provides the opportunity to gain insights from multiple perspectives prior to selecting a decision with which to proceed. In this section, literature will be reviewed on the topic of identifying value for several stakeholders who

are influential in making decisions on how to distribute a single set of resources. This set of resources more specifically will be that of selecting and monitoring resources for a portfolio of Air Force Acquisition programs.

Table 5: System Level Stakeholder Value

Portfolio Definition
The only way for an enterprise to succeed is to create value for every success critical stakeholder. This includes: • Dependency Theory requires identifying all major success-critical stakeholders. • Utility Theory requires understanding what a success critical stakeholder wants. • Decision Theory requires identifying how needs translates into decisions. • Control Theory requires controlling value creation during change. (Boehm 2006)
Methodology to map stakeholders, their needs, and who satisfies those needs in a closed system format. Methodology uses a pictorial diagram to identify the flow of value from multiple stakeholders based on their individual objectives. (Cameron, Crawley, Loureiro, & Rebentisch 2007)
Architecting Principles for Systems of Systems (Maier 1998)

Building on the value definition for a program provided in Figure 8, Figure 12 illustrates the value of a portfolio of programs. While a single program requires a balance of goals, functions and cost, a portfolio of programs requires a balance of several goals, multiple functions or methods of achieving those goals with a single set amount of budgetary resources. This arrangement where multiple objectives are being worked with the same set of resources places several stakeholders in the position to be highly influential in the decisions that are made.

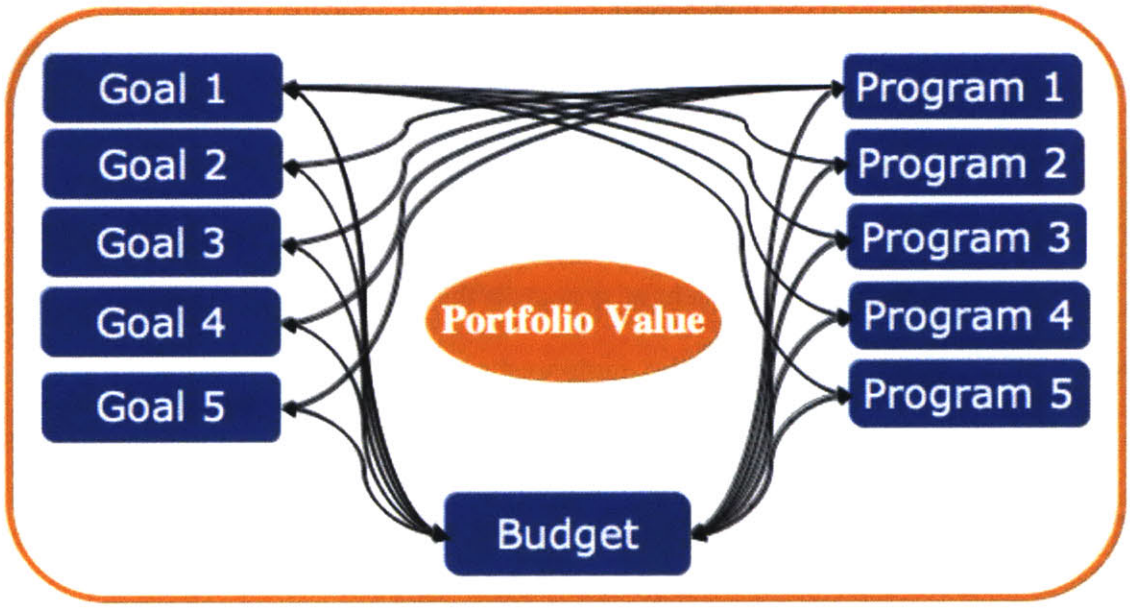


Figure 12: Portfolio Value

First, we will look at the nature of the decisions, which are made at the portfolio level. To do this, we will apply the characteristics of a system of systems to the management of a portfolio of programs. "A system of systems is an assemblage of components which individually may be regarded as systems and which posses two additional properties:

> Operational independence of the components: If the system-of-systems is disassembled into its component systems the component systems must be able to usefully operate independently. That is, the components fulfill customer-operator purposes of their own.
>
> Managerial independence of the components: The component systems not only can operate independently, they do operate independently. The component systems are separately acquired and integrated but maintain a continuing

operational existence independent of the system of systems (Maier 1998)." This is also true with program portfolios where each program can and does operate independently of the higher-level portfolio management system.

The second characteristic of a system of systems is the need for triage. Due to the high volume of programs within a portfolio, high-level portfolio managers are unable to review all programs in detail. This places decision makers in a position to triage portfolio performance and resource allocations.

The Triage: Let the dying die. Ignore those who will recover on their own. And treat only those who would die without help. (Maier 1998)

The objective for portfolio decision-making is to quickly identify outlier programs for further review. Outliers are determined by applying value criteria for each of the stakeholders in the system to each program in order to identify which ones are exceptionally high or low in terms of overall value, risk and performance relative to all other programs in the portfolio.

In light of the exhibited characteristics of a system of systems, a set of guiding principles is provided to enable successful, effective management of the portfolio by the portfolio managers. The first principle is to leverage interfaces between programs, and this may be accomplished by establishing standards of communication. The second method is considering a policy triage where points of leverage must be discerned and engagement is

done sparingly in program operations only when a clear value to the programs is evident. The third opportunity is to establish stable intermediate forms where programs may be expanded or cut both vertically and horizontally. In other words, the portfolio is both physically and organizationally designed with flexibility to be able to accommodate modifications in composition. The last guiding principle is to design incentives for collaboration at the portfolio level. Because each element can and does operate independently, the value criteria for each element must be considered to ensure positive participation at the higher level.

The steps in conducting a value analysis of a system of stakeholders are to identify: who the stakeholders are, the criteria of success for each critical stakeholder, how decisions are made based on value criteria, and how value is realized once decisions are made (Boehm 2006). There are different types of stakeholders within a given system. A primary beneficiary is the stakeholder who will benefit from the primary deliverable of the system. Secondary beneficiaries may exist to make financial decisions, to develop or use a given product in order to deliver the system value to the primary beneficiary. All of these stakeholders interact with each other by exchanging information or assets. A graphical flow diagram can be used to visually represent each of the stakeholders and how they interact with each other as part of the system (Cameron, Crawley, Loureiro, & Rebentisch 2007).

2.5 How is Enterprise performance measured?

When exploring the topic of Enterprise Performance Measurement Theory the literature addressed several sub areas as part of the knowledge base which include: how to define

an enterprise, how to define successful metrics, and how to know if an enterprise is successful. Once these areas are established, the literature then also addresses how to establish enterprise metrics and how performance measurements may influence the behavior of enterprises in practice. Table 6 shows the literature reviewed and how each relates to the above mentioned research questions.

Table 6: Enterprise Metric Literature Summary

Enterprise Metric Research Questions	Kueng 2000	Chan 2005	Hammer 2007	Nightingale, Rhodes 2010
How do you define an enterprise?	x	x	x	x
Why enterprise metrics?		x	x	x
How do you define successful metrics?			x	x
How do you know if an enterprise is successful?		x		x
How do you define enterprise metrics?	x	x	x	x
How do enterprise metrics influence enterprise behavior?	x	x	x	x
What are lessons learned from enterprise measurements in practice?	x			x

In an article titled "Toward a Unified View of Customer Relationship Management" by Joseph O. Chan, the enterprise is defined with a supply chain perspective to include customers, suppliers, distributors, and alliance partners. Enterprise metrics have become more important due to the current market trends which causes change in strategy from internal product focus to value within the supply chain and from a product centric to a customer centric strategy for value creation. There are three main challenges with achieving this enterprise customer centric strategy and they are a functional and process disparity, channel disparity, and operational analytical disparity. An example of function and process disparity is in some cases when customers may interact with sales and marketing but the key information does not get passed on to order fulfillment and inventory control groups. This disparity may also be created by functional systems which

are disconnected such as enterprise marketing automation, sales force automation, material requirements planning, distribution requirements planning, enterprise resource planning, supply chain management and knowledge management systems. This disconnected data provides a disconnected view of customer's needs and makes it challenging to respond to customer needs in a timely way. Channel disparity manifests itself in the form of organizational goals, structures and incentives that do not drive optimization at the customer level. Operational analytical disparity results from information buried in silos and not leveraged in analysis across the enterprise as well as the challenge of translating process transactional data into customer related value characteristics.

In Chan's article, an enterprise is successful when it is able to develop customer loyalty. Enterprise metrics are developed based on an Enterprise Model Framework for Customer Relation Management (CRM), which has three main components: operational, conceptual and internal CRM, see Figure 13. "The 3-Schema addresses the construct of data based on three levels of representation: the conceptual schema represents the logical view of data, the internal schema represents the physical data storage definitions, and the external schema represents the user application views of data" (Chan 2005). From this framework, enterprise metrics may be developed which combine existing functional metrics across functional and organizational boundaries in order to measure progress against achieving customer loyalty.

Figure 1: The Enterprise Model Framework for CRM

External CRM View				
OCRM (Operational CRM)	User Applications		ACRM (Analytic CRM)	User Applications
	Business Processes			Analytic Processes
	Organization Structures			Decision Structures
Conceptual CRM View				
CCRM (Conceptual CRM)	EDM Enterprise Data Model		ADM Analytic Data Model	
	OFM Operational Function Model		AFM Analytic Function Model	
Internal CRM View				
TCRM (Technical CRM)	Physical Data Storage & Structure	Software Components & Tools	Hardware Platforms	Communications Networks
EIR (Enterprise Information Roadmap) = {RELATIONS between the components of OCRM, ACRM, CCRM & TCRM}				

Figure 13: Enterprise Model Framework for Customer Relationship Management

Enterprise metrics influence enterprise behavior via accountability to customer driven goals and aligned customer data analysis in order to transition from multiple customer contact points and channels to a streamlined customer interface resulting in synchronized information and processes.

Key insights from this article include the significant focus on the value to the customer directly from the customer's perspective and allowing this to shape internal processes and information flows. It is also interesting to note the liberal definition of enterprise that includes alliances and suppliers in addition to the customer. With this broad scope definition, the mechanisms for implementing a change in the enterprise architecture will include negotiation with key stakeholders, because a top down approach will not apply.

In a second article titled, "The 7 Deadly Sins of Performance Measurement" by Michael Hammer, the enterprise is defined as a single top down organization. The author asserts that most managers believe that their current metrics, despite using sophisticated

measurement tools, do not help the company improve its performance or achieve its strategic goals. This topic of how to define enterprise metrics is introduced by illustrating how not to define enterprise metrics, in other words the seven sins, to include: vanity, provincialism, narcissism, laziness, pettiness, insanity, and frivolity. In order to correctly measure, there are two parts: determining what to measure and how to measure it. Determining what to measure is accomplished via balancing precision, accuracy and robustness. On the topic of how to measure, Hammer recommends incorporating the measurements into an existing business rhythm so that the indicators initiate treatment of problems rather than an analysis of what went wrong after the event has occurred.

While the purpose of enterprise metrics is to improve performance, the author also addresses the reverse i.e. how enterprise behavior influences enterprise metrics. The 7 Sins of enterprise metrics are typically not addressed by simply improving the specific measurement criteria, rather the understanding of what is important in order to achieve enterprise success needs to be developed and business objectives need to be tied to a formal operational process improvement methodology. Once the business enterprise strategy is refined, the appropriate enterprise metrics will become more evident.

Key insights from this second article include a rubric by which to self reflect on the clarity of enterprise goals and mechanisms to achieve those goals. If the metrics are subject to the 7 Sins, perhaps it is time to reflect on the organizational objectives, positioning in the external environment as well as on the internal structure and processes in order to understand what type of enterprise improvement is required.

In a third article titled "Process performance measurement system: a tool to support process-based organizations" by Peter Kueng (2000), an enterprise is defined as a process team. Kueng defines a process team as "two or more people who cooperate to achieve specified process goals." So, in this case, an enterprise could comprise a surgeon and an anesthesiologist in an operating room, a manager with subordinates, or any other combination of people who work toward a common goal. Financial measures alone are not sufficient to relate performance to process and thereby show improvement. Measurement results need to be actionable, motivating, and result in improvements in training methods and capabilities. Measurements are used not only to demonstrate that progress was made but also to inform how much progress remains. Successful measurement systems will gather process performance data, compare values against historic and target values, and disseminate the results.

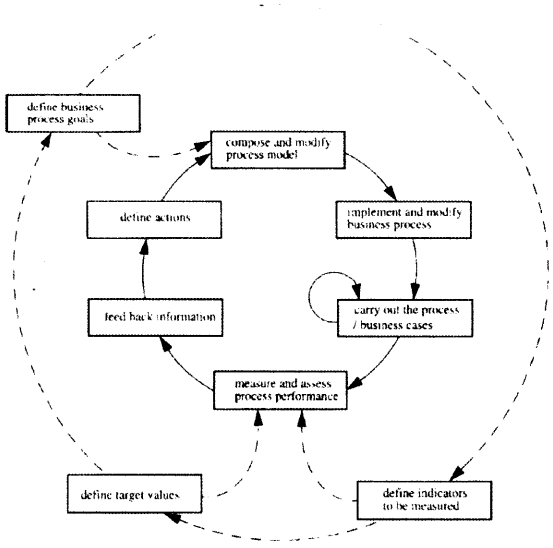


Figure 14: The Process Management Circle

Enterprise metrics should be based on processes not organizational units and be based on both quantitative and qualitative data. None of the several tools discussed in this article satisfied these criteria, so a new approach is proposed: process performance measurement approach from a stakeholder's point of view. The following criteria are provided for stakeholder analysis: performance is not absolute (it is relative), performance is multidimensional, and performance indicators are not independent. The five dimensions identified include: financial aspects, innovation aspects, societal aspects, customer aspects and employee aspects. The following steps are involved in eliciting appropriate process performance indicators: define high level process goals, derive performance indicators, derive subgoals, and refine and modify goal tree. Performance indicators need to address the following ilities: quantifiability, sensitivity, linearity, reliability, efficiency, and be improvement-oriented. Once the indicators are determined, the target values for each indicator, methods and instruments to gather the data, and an information system that stores collected data, distributes results and provides easy access to various user categories need to be determined.

Process metrics are derived from enterprise goals. Improvements are made at the process level. Process metric data informs the status of meeting the enterprise goals (see Figure 14). Lessons learned from enterprise measurements during a two-year project with four diverse enterprises are sited as a case example. These companies used traditional performance measurement systems based on financial measures, so process based measures needed to be developed. Process Managers were instrumental in achieving this task and they established these measures in part based on what data was currently

available and spent a significant amount of time determining what the right measures ought to be in order to capture customer value. A common trade off for measurements was the degree of detail to include. More detail is more informative but less-stable over time as processes evolve. Process Managers need to have a strong competency, decision-making authority and support from senior management in order to be successful in establishing enterprise process metrics. Data management needs to be made as easy as possible via automation and/or by minimizing the amount of required data. The stakeholder value criteria need to be validated prior to implementation. Measurement dysfunctions, where one area is improved at the expense of another area not measured, need to be identified and minimized where possible. Enterprise metrics alone will not change a process team or enterprise; they need to be used as a tool to support a social transformation.

Key insights from this article include the relationship between enterprise goals and the need for organizations to be process oriented vs. function oriented. It's interesting how the broad definition of enterprise was provided and the results are applicable to both small and large organizations. From the context of the article, however, it appears that the definition applies better to a hierarchical organization vs. a supply chain approach where there are external organization entities, because one of the key findings was the need for a Process Manager who has authority to implement changes across all elements within the enterprise.

The Enterprise Architecture class lecture no. 2 titled "Holistic Thinking for Enterprise Architecting" instructed by Dr. Deborah Nightingale and Dr. Donna Rhodes established the course definition for an enterprise as "one or more persons or organizations that have related activities, unified operation or common control, and a common business purpose." A couple weeks later during class lecture no. 5 titled "Overview of Performance Management" we discussed the topic of establishing enterprise metrics. In this lecture we learned that enterprise metrics are a valuable tool for enterprise leaders to influence organizational performance. The metric data informs leadership of organizational activity, and the metric goals inform the organization what the leadership expectations are.

Good metrics are meaningful, quantified measures, present data that enables resulting actions, tied to strategy and core processes, motivate organization continual improvement. Good measures should be strategic, quantitative and qualitative in nature. Enterprise metrics indicate success as a function of efficiency (doing the job right), effectiveness (doing the right job) and capability (do both the job right and the right job). Enterprise metrics are defined by incorporating inputs form internal influences, external influences, process issues, and transformational issues. A balanced score card and 12 Questions are examples of tools which may be used to comprehensively align performance metrics with enterprise strategy and vision.

There are several case studies presented as well as class projects in progress that illustrate the usefulness of enterprise architecting in practice, and one example is the Allegory of

the Humidifier: ROI for Systems Engineering by Mark Sampson. In this article a story is told where management decides to purchase an inexpensive commercial humidifier in lieu of a commercial grade humidifier to regulate environmental conditions in a printing room. As a result, employees are asked to refill water in the humidifier which results in poor employee morale, back injuries, expensive custom plumbing work, and eventual closing down of the company facility. From this example, we learn the importance of addressing issues at the right level in the organization, of being willing to listen to stakeholders and respond to their needs, and of leadership having the courage to reconsider a prior decision when evidence communicates poor performance.

3 Methodology

The nature of this research involves a significant change in the portfolio evaluation process, and it involves an enterprise-level analysis. To address the nature of exploring new territory, the research design will be structured using a Lean Management Define-Measure-Analyze-Design-Verify (DMADV) approach, see Figure 15. The specific methodology used in order to quantify value involves: identification of stakeholders, determination of value per stakeholder, and influence weighting of stakeholders. Once this quantitative data was available, guidance on portfolio level decision-making based on program value was provided such as how to balance short and long-term investments, frequency of reevaluation of program value, addressing changes in environmental conditions, and exit strategies.

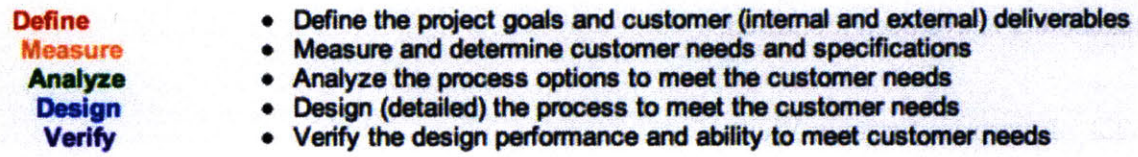


Figure 15: DMADV (Simon 2010)

3.1 Definition Phase

The Definition phase included identifying key stakeholders, clarifying project goals, scope and deliverables. This was completed via interviews with the sponsors of this project as well as each of the identified stakeholders.

3.2 Measurement Phase

The measurements involved in this project were first enterprise-level in nature followed by a specific sample case portfolio application. The methodology presented by Debbie Nightingale and Donna Rhodes in the Enterprise Architecture course at the

Massachusetts Institute of Technology was used to address the enterprise level analysis. This measurement involves eight enterprise views, and in this research seven of the eight views were applied: Strategy, Organization, Process, Product, Knowledge, Information and External Factors. The Service View does not apply to this particular research project (Nightingale 2010).

3.2.1 Enterprise Organization View

The enterprise organization view was used to identify all applicable stakeholders and to display how organizations relate to each other in regard to hierarchy and social communication patterns. A composite organization chart was developed to view all stakeholder positions in light of the complete system of stakeholders. This information was obtained from official organizational charts as well as interviews to ensure all stakeholders have been identified.

3.2.2 Enterprise Strategy View

Strategy View was used to identify the goals and value criteria of each stakeholder. This information was obtained from interviews with leaders in stakeholder organizations, current metrics, compliance documents, and other official published documentation.

3.2.3 Enterprise Process View

The enterprise process view was used to assess how program value criteria were used to make a decision in the acquisition process. More specifically, it will identify specific points in the process where decisions were made and who is ultimately responsible to make the decision. The methodology includes a swim lane style process flow in order to show each stakeholder's involvement in the process. An example is provided in Figure

16 where the process starting points(s) are shown in yellow ovals, process steps are shown in white boxes, and alternate paths are communicated with grey boxes. The alternating horizontal lines clarify each stakeholder's role in the overall process as a function of time.

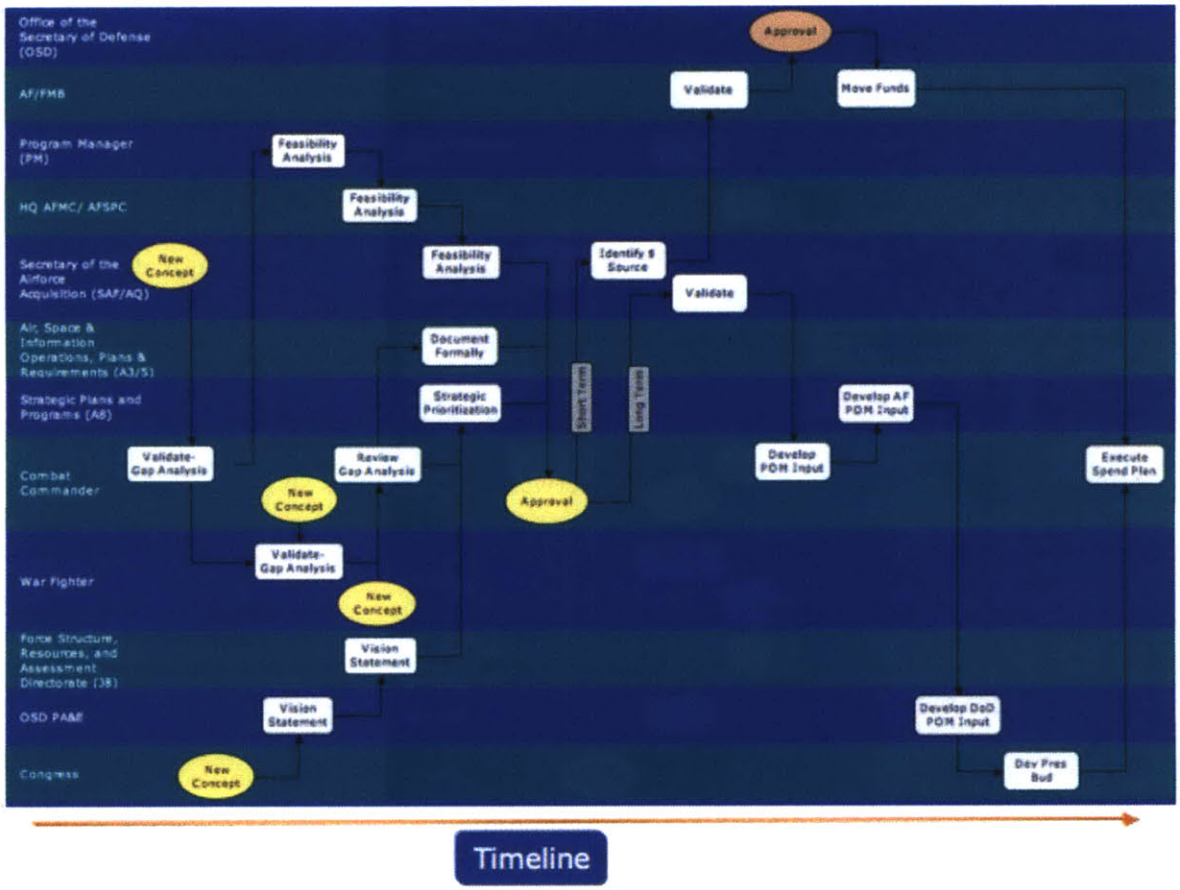


Figure 16: Swim Lane Example

3.2.4 External Factors View

In this view, system boundaries were defined and significant external influences were identified. The definition of system boundaries clarifies what stakeholders and processes were considered in scope and out of scope for the analysis. There were many external factors that may impact the performance of a system process but which were beyond the

domain of the current project to control. In this case, it is important to acknowledge the presence of these influences and to make in scope accommodations as necessary.

3.2.5 Enterprise Information View

In this view, the information flow was mapped to show what information is measured and how information is reported between stakeholders. Because there were many stakeholders involved, a hybrid Supplier-Inputs-Process-Outputs-Customer (SIPOC) Diagram and System Map analysis was applied. The SIPOC diagram shows who the suppliers were, what the inputs were that the suppliers provide, defines major steps in the process that was being addressed, and lists the outputs and customers who received the outputs from the process (Simon 2010). In this case the inputs and outputs were the formats in which information is exchanged between stakeholders and the processes that occur within each stakeholder's domain refer to the value criteria used to arrive at a decision. The System Map ties each of these stakeholder interactions into a single diagram where the relationship between all stakeholders can be seen from a single view. (Crawley 2009) An example of a hybrid SIPOC and System Map is shown in Figure 17 below where stakeholder goals, processes to achieve goals, information exchanged, and interfaces are identified in a single diagram.

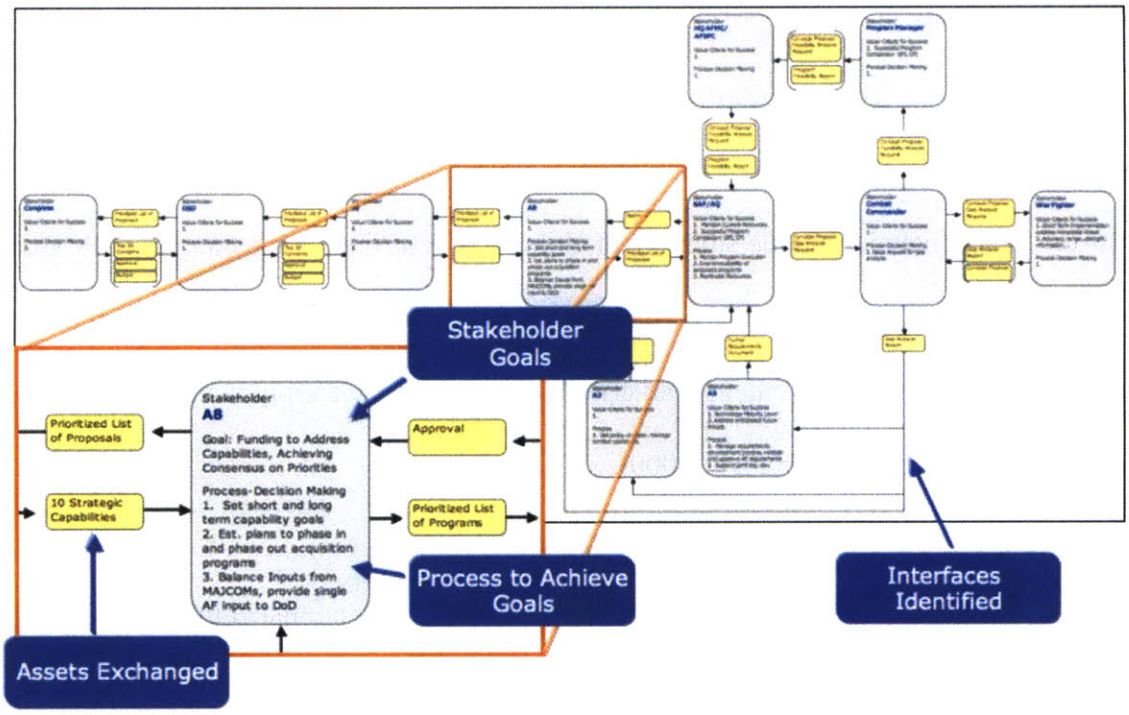


Figure 17: Hybrid SIPOC and System Map

3.2.6 Enterprise Knowledge View

In this view the location of core knowledge was addressed from the perspective of the key decision makers. The following are types of questions, which were answered as part of this analysis. Is the information required internally available or is it obtained from an external source? Is the requisite knowledge explicit or tacit information? How does this knowledge distribution influence the decision making process?

3.2.7 Enterprise Product View

The product view typically shows the physical interfaces between parts for a physical product. In this case, we addressed funding allocation across a program portfolio, so this product view was illustrated with the funding breakdown and allocation from the highest level to the specific program level within the system boundaries.

3.2.8 Case Study

Once the enterprise level framework is established, combinations of approaches were employed to develop a method of quantifying value for a specific program within a portfolio. This includes a trade study methodology as described in the context of Product Design and Development which lays out a methodology for how to identify stakeholder needs, derive specific requirements and criteria for success, and apply weighting to requirements (Ulrich and Eppinger 2000).

An example data sheet is shown in Figure 18, where the goals are listed in the first column for a given stakeholder, the criteria for success or measurements are shown in the second column, the weighing of the criteria is in the third column, followed by the specific program scores on the right. In some cases the scores are calculated at the portfolio level and not at the program level.

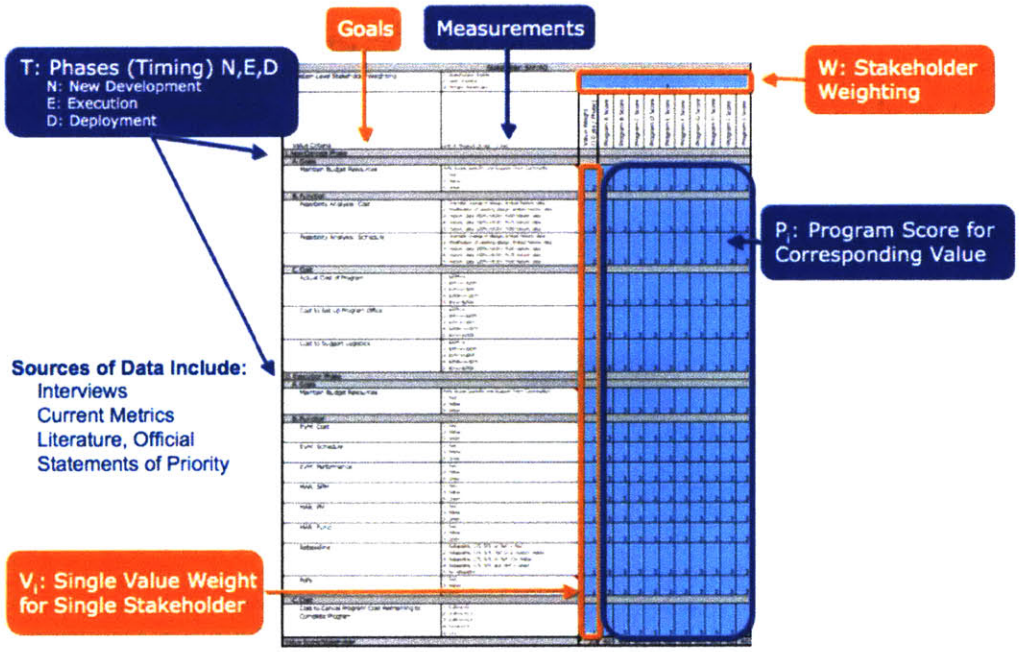


Figure 18: Data Measurement Approach

3.3 The Analysis Phase

The analysis was completed based on both the enterprise level criteria and the calculated sample portfolio data. The seven enterprise views were assessed to identify the current voice of the process or baseline, where errors commonly occur and where opportunities exist within the scope of this project. For the case study, the value data that is calculated for each program within the sample portfolio was displayed using both a histogram and a run chart for two scenarios. One was a function of changes in value and the second was a function of the actual value score, see Figure 19. The outlier programs that have significant changes in value merit additional focus and attention when allocating resources. The centeredness of the distribution indicates how well the portfolio as a whole is meeting the system level objectives.

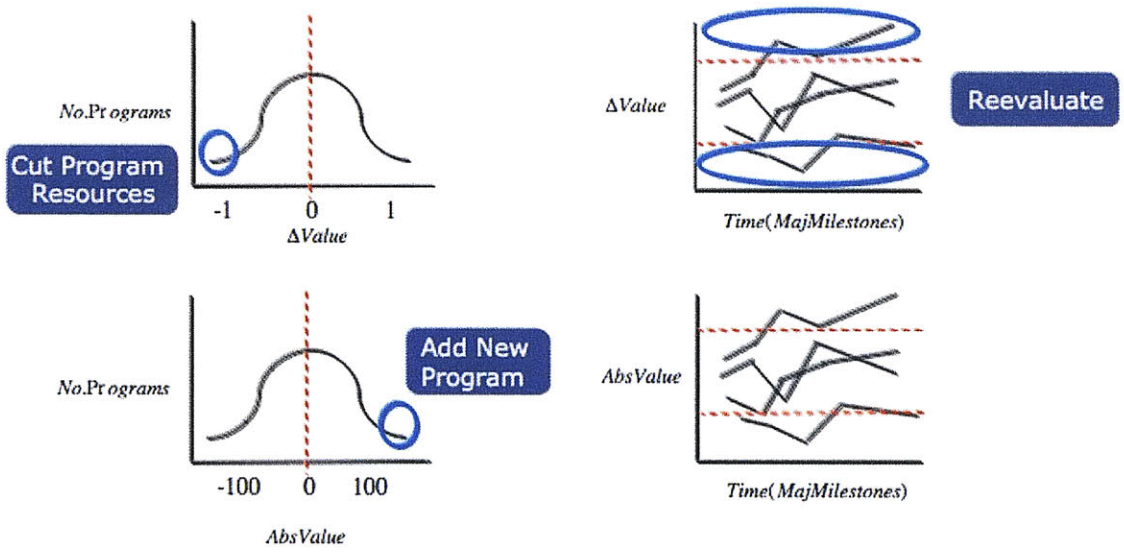


Figure 19: Conceptual Portfolio Value Results

3.4 The Design Phase

The design of the future state of the Secretariat for Air Force Acquisition portfolio review process will include Enterprise level recommendations as well as guidance on portfolio analysis interpretation. Enterprise level recommendations were provided based on the enterprise level analysis and thus will be related to strategy, organization, product, process, information, knowledge and external factors. The process view in particular will address frequency of portfolio level reporting and reviews. In addition to a description of a recommended future state, guidance was offered on a transition plan for implementation. Guidance on how to interrogate the data, interpret the sample portfolio results and associated recommended actions will also be provided.

3.5 The Verification Phase

This data will then be presented to current stakeholders of the sample portfolio to prove or disprove the research question regarding the effectiveness of quantitative portfolio

system value in the Acquisition resource allocation process. This is a qualitative measure that was obtained via survey and interviews. An "effective" quantitative portfolio system value measurement will enable the following capabilities:

- Maintain all stakeholder priorities in value evaluation
- Conduct sensitivity analysis based on changes in stakeholder priorities
- Observe changes in value over time
- Establish program exit strategy based on program value (not execution only)
- Balance of long term and short term programs, high and low risk technologies, programs to address all ten key capabilities identified by the Secretary of the Air Force, conventional and unconventional warfare capability.

4 Results

The following section presents the data and analysis resulting from the application of the value quantification methodology using the Secretariat for Air Force Acquisition process.

4.1 Project Definition

In order to focus the research, the following areas were scoped: stakeholders, components, DoD Appropriations, and Major Programs. The organizations listed in Table 7 were identified as influential stakeholders in the acquisition process and a combination of interviews and documentation reviews were used in order to gain an understanding of each of the organizational goals and priorities. For each stakeholder a brief description of the organization along with a summary of interests related to this project are listed.

Table 7: List of Stakeholders

	Stakeholder	Brief Description of Organization, Interest Related to Research
1	Air, Space & Information Operations, Plans & Requirements (A3/5)	Provide technical justification and review, draft program requirements. Evaluate portfolio programs based on technology maturity, avoid/ eliminate duplicate development efforts (Cooper and Zigler 2009)
2	Acquisition Technology Logistics (AT&L)	Provide OSD level technical oversight for ACAT I programs.
3	Capability Assessment and Program Evaluation (CAPE) Director	Ensure Joint Programming Guidance compliance, balance component programs, address deferred component issues and late breaking news. (DAU 2010)
4	Combat Commander (COCOM)	Lead regional mission execution. Provide regional capability requests to address current mission needs. (The Role of the Commander 2003)
5	Congressoinal Budget Office (CBO)	Provide an independent re-estimate of the President's budget proposal to Congress (CBO 2010)
6	Government Accountability Office	"Support congressional oversight by… auditing agency operations to determine whether federal funds are being

	(GAO)	spent efficiently and effectively… and reporting on how well government programs and policies are meeting their objectives" (About GAO 2010)
7	Joint Staff	Align service functions with joint operation concepts for the combat commander to conduct operations and to enable partnering with other nations. (Flowers 2010)
8	Major Commands and Agencies (MAJCOM)	"An operational command is a MAJCOM composed in whole or in part of combat forces, or else charged with flying directly in support of such forces. Support commands provide supplies, weapon systems, support systems, operational support equipment, combat materiel, maintenance, surface transportation, administration, personnel, training, advanced education, communications, and special services to the Air Force and other supported organizations." (Major Command 2010)
9	Office of the Secretary of Defense (OSD)	Allocate budget across DoD branches and prioritize regional threats and priorities (Lynn,W.J. 2009)
10	Office of Management and Budget (OMB)	In helping to formulate the President's spending plans, OMB evaluates the effectiveness of agency programs, policies, and procedures, assesses competing funding demands among agencies, and sets funding priorities. (OMB's Mission 2010)
11	President	Allocate budget across DoD and other government needs, prioritize regional threats. Goals include developing an exit strategy to address poor execution, excessive capability, immature technology, poor estimation & planning. (Obama 2010)
12	Program Executive Office (PEO)	Enable successful portfolio execution via insight/ oversight and optimizing allocation of staffing and budgetary resources. Quantitative portfolio value will assist via providing an objective understanding of program priority based on value to stakeholders to support allocation of expertise and resources in execution. (Bowlds, 2009)
13	Program Manager (PM)	Enable successful program execution via insight/ oversight. Prefer to have automated generation of reports and understanding of how data will be used. (Brown 2009)
14	Secretary of the Air Force (SecAF)	Support combat commanders in major combat operations, defending the homeland and meeting hybrid threats (Flowers 2010)
15	Secretariat for Air Force Acquisition (SAF/AQ)	Review current proposals for executability, monitor current programs for executability, highlight programs which require attention when reallocating budget. Quantitative portfolio value will provide a tool to objectively balance portfolios across 16 PEOs. (Shelton

		et al 2009)
16	Strategic Plans and Programs (A8)	Evaluate proposed program values based on meeting ten strategic capabilities, balancing short and long term objectives, identifying required assets to provide needed capabilities vs. desired capabilities. Quantitative portfolio value will provide a tool to support objective portfolio value evaluation (Miller 2009)
17	War Fighter	Lowest rank users of developed mission execution capabilities are interested in having a clear understanding of purpose and use, key performance characteristics, personal protection, and sustainability. (Brown 2009)

For each of these stakeholders a unique perspective on what constitutes a program portfolio may be provided. Programs may be grouped by capability, regional use, program execution, etc. To clarify the scope of this work, a portfolio was defined as the set of programs funded by the Secretariat for Air Force Acquisition or in other words programs which receive funding from the Air Force Research Development Test and Evaluation (RDT&E) budget, see Figure 20.

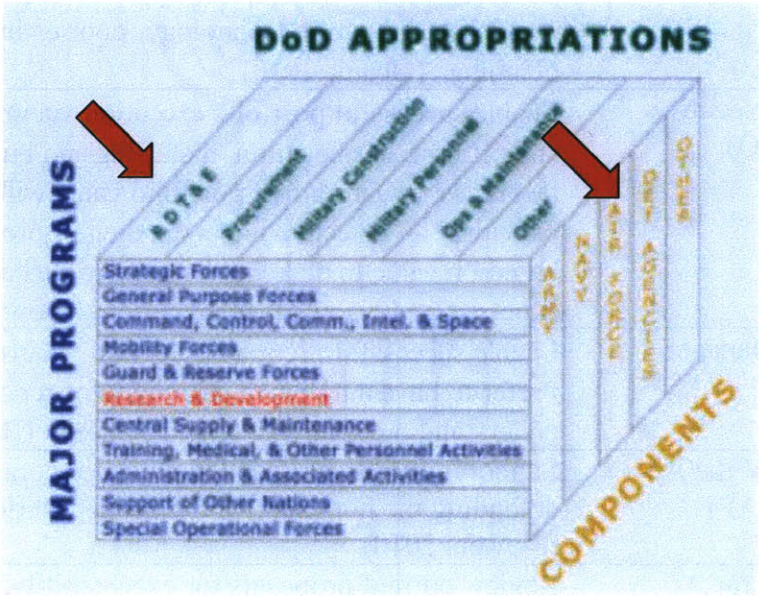


Figure 20: FYDP Appropriations (DAU 2010)

In order to further narrow down the scope to conduct a case study application, the ESC C2&CS PEO portfolio was selected. Seven of the unclassified, ACAT I Major Defense Acquisition Programs (MDAP) and ACAT II programs were included in the study based on availability within the alloted time frame. One program, which was originally thought to be an ACAT II, but was later discovered to be an ACAT III program, was also included in the results of the case study.

The Acquisition Category I program is defined as either having RDT&E total expenditure of more that $365M, procurement total expenditure of more than $2.190B, or MDA designation as special interest. Acquisition Category II programs are defined as not meeting ACAT I criteria, a Major System with either RDT&E funding > $140M or Procurement funding > $660M, or Milestone Decision Authority (MDA) designation. Acquisition Category III programs are defined as not meeting either ACAT I or ACAT II criteria. (Brown 2009)

A general constraint on the data used as a basis for the value quantification is to use existing data as much as possible. Significant effort is already in place to measure current program performance, and I have been encouraged to leverage this existing data to measure portfolio performance. Individuals from planning, programming, budgeting and execution focused organizations have been engaged in order to obtain data to support the case study completion. Commentary on the data gathering process for future broader scale implementation will be discussed in the Recommendations for Future Work section of this document. The goal for this research includes receiving concurrence that each

stakeholder's value criteria have been adequately addressed to support a portfolio evaluation via a sample case demonstration and survey of responses. The programs in the portfolio will include pre milestones A, B, and C (Brown 2009). Post milestone C will be left for future research to add in this piece of the portfolio perspective.

With the given scope identified, a value equation is proposed which is a function of both program and portfolio level value criteria per stakeholder and the corresponding program and portfolio level scores. Each stakeholder has a unique set of priorities to be addressed with a given portfolio, and some of these value criteria overlap between stakeholders. The stakeholder weighting is a sum of the number of stakeholders who have a vested interest in a given value criteria. Equation 1 mathematically shows this relationship of variables in the Portfolio Value Equation.

Equation 1: Portfolio Value Equation

$$V_P = \sum_{PFC=28}^{36} WS + \sum_{PGC=1}^{27} \sum_{PG=A}^{G} WS$$

PFC: Portfolio Value Criteria, see Table 10
PGC: Program Value Criteria, see Table 10
PG: Program, Letters represent program elements within a portfolio (Brown 2009)
S: Scores for Individual Criteria, see Table 12
V_p: Value of the portfolio
W: Stakeholder weighting, see Table 9

4.2 Measurement & Analysis

In order to provide a quantitative value assessment, each of the elements within Equation 1 need to be further developed. In order to begin developing the value criteria, an enterprise organizational view will be documented to assess relationships between

stakeholders. A strategy view will then be created to document goals, objectives and current measurements for success per stakeholder. These measures of success will be used as a basis for the value equation criteria and stakeholder weightings. An Enterprise Process view will be mapped out to show current processes and interactions between stakeholders as a function of time. This data will be used to determine who will benefit from the use of this portfolio level data and at what points in time. External factors will be documented in order to clarify project scope while acknowledging the influence of external entities. Information data flow will be documented to show how planning, programming, budgeting and execution data flow through the acquisition related organizations. This analysis of information data flow will be used to identify data sources for the case study application of the value equation. A knowledge view will be established to document where tacit and explicit knowledge resides in relation to key decision makers. The last enterprise level analysis will be addressing the breakdown of funding allocation and analyzing how this breakdown maps to the selection of a portfolio set of programs.

4.2.1 Enterprise Organization View

Using the stakeholders identified in Table 7, a structural organization view with the portfolio perspective and vested stakeholders highlighted is constructed and provided in Figure 21. Several organizations are involved, but only the key entities related to the scope of this portfolio value analysis are shown. Organizational documentation for the following have been referenced in order to create this composite organizational view:

- Secretariat for Air Force Acquisition (SAF/AQ Org Chart 2009)
- Office of the Secretary of Defense (OSD, 2008)
- Department of Defense (DoD, 2008)
- Executive & Legislative Branches, Office of the Secretary of Defense (Brown, 2009)

From this organizational view, it is clear that there are many influential stakeholders. Within the Air Force, there is leadership tied to congressional budget appropriations, program execution, strategy and capability. In addition to this internal portfolio complexity, Regional Combatant Commanders, Joint Staff, and the Office of the Secretary of Defense provide external priorities that directly impact the allocation of resources within the Air Force portfolios. Each of the stakeholders identified in Figure 21 contribute to the articulation of war fighter capability priorities, execution/ performance needs, or both. Some are involved in future year planning, current execution, and some are involved in all resource allocation processes. The primary beneficiary of the enterprise as a whole is the Combat Commander who possesses the charge of mission execution and whose responsibility it is to provide for the defense in a specified region. These tactical and strategic defense needs are communicated and multiple organizations respond as representative investors and users to support the Combat Commander's needs.

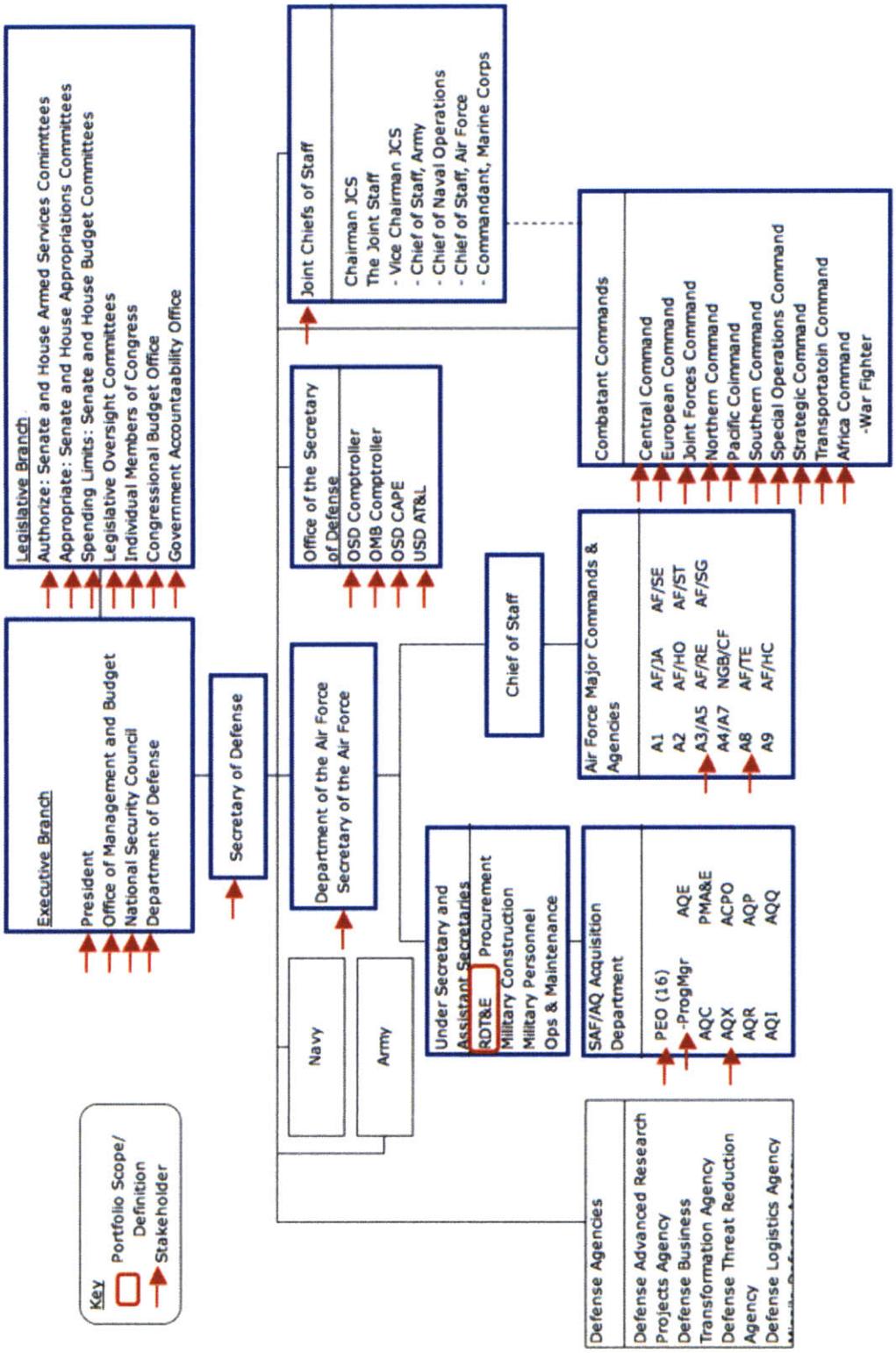


Figure 21: PEO Portfolio Definition and Stakeholders

4.2.2 Enterprise Strategy View

Stakeholder strategy and associated value criteria are described in the following section.

1. The Air, Space & Information Operations, Plans & Requirements (A3/5) value criteria were obtained via a focus group style interview with A3/5 staff (Cooper, M., Zigler, J. 2009). As part of this interview, we discussed the role of this organization. First a Major in Command fills out a request using a 3170 JCIDS template that captures both capability and ICD. Capability portfolio managers review the proposal, risks in the environment, and current technology capability gap. The priority determination is based primarily on tacit information provided during a Validation Counsel and Air Force Requirements Council (AFRC) from a subject matter expert who champions the given proposal request. Once a proposal is accepted for further development, requirements development and analysis is performed. When asked what elements are commonly discussed which factor in to the concept evaluation, the following were provided:
    - Technology Maturity Level, which is a technology maturity evaluation scale developed by NASA and adopted by the DoD, of six or higher on a one to nine scale is preferred for major programs. (Turner 2010).
    - Value related to immediate or upcoming threats
    - Air Force and OSD capability priorities
    - Map regional needs, shortfalls, and gaps to corporate structure development funding
    - Need vs. what is achievable

- Elimination of redundancy within capability development
- Sun setting programs, perhaps develop a technology degradation level to measure when modular updates to a new platform is justified over current legacy system
- DoD 5000 Acquisition Guidelines compliance
- War fighter current operational needs vs. threats beyond 15 years
- Need to identify unintended consequences of cutting programs (what happens to other programs when one program is cut?)
- Program Managers' performance is based on program performance (difficult to cut a program based on decreased capability need because it reflects poorly on the program manager)
- Congress interest (keep people employed within their congressional districts)
- Milestone decision authority (influences who will champion a given program)
- Timing (how much capability is needed, how well does solution meet the need?)

2. Acquisition Technology Logistics (AT&L) value criteria were inferred from the value criteria of Program Executive Officers (PEOs). ACAT I Programs that have AT&L milestone authority can be influenced for better or worse by OSD's intervention with budget cuts initiated by the Air Force. However, AT&L may have a slightly different viewpoint from ACAT II and ACAT III PEOs and direct interaction with this stakeholder group is recommended for future research.

3. Capability Assessment and Program Evaluation (CAPE) Director value criteria were obtained via training materials for the PPBE process (PPBE 2010). Direct interaction with this stakeholder group is recommended for future research and validation.

4. Combat Commander value criteria were obtained via review of the Staff Organization and Operations Field Manual (FM 101-5 1997). The Combat Commanders are responsible for developing the Operational Plans (OPLANs) which are used to communicate mission plans and anticipated capability requirements to war fighters within their organization. Integrated Priority Lists (IPLs) are also used to communicate a prioritized list of shortfalls in capabilities, which need to be filled as part of the PPBE process (IPL 2010). As a research assistant external to the Air Force, I am unauthorized to access this type of information, but someone with authority to do so may use these two documents as a basis for quantifying the use case for each asset in future research.

5. Congressional Budget Office value criteria were obtained via the organization web site information (CBO 2010). The three measurements featured on the home page included the unemployment rate, national deficit, and tax revenues. Two of the three key measurements are directly associated to Defense Acquisition programs. The acquisition programs provide employment in congressional districts; so one measurement is "how many congressional districts are provided with employment for each program?" The costs of the programs are associated with the national deficit, so program and program portfolio costs correspond with this second value criterion.

6. Government Accountability Office (GAO) documented criteria was based on a testimony before the Subcommittee on Defense, House of Representatives Appropriations Committee provided by the GAO (Francis 2010). There is a section of the document that speaks directly to the subject of how to improve the Acquisition Process, and the following value concerns have been captured: departmental cost growth, schedule overruns, and growth in volume of programs in development. The last recommended measure is seeking to address the concern that more new programs are added than the number of programs which are completed in a given year. This net increase in volume of programs while maintaining the same number of program managers results in a lesser quality of program management. However, there are unintended consequences to this particular metric, such as establishing larger programs rather than breaking programs down into smaller more manageable sub program sizes, and it precludes the option of hiring more managers. So, only the first two measures will be carried over into the value analysis for this research.

7. Joint Staff value criteria were obtained from the Manual for the Operation of JCIDS, 2009 as well as the National Military Strategy 2004 written by Richard B. Meyers, Chairman of the Joint Chiefs of Staff. There are ten core capabilities issues by the Joint Staff that each of the military branches needs to address in some way with current development work. Joint Capability Analysis data is currently measured in a Joint Capability Area Management System database where Joint Capabilities are mapped to program elements (JCAMS 2010).

8. Major Commands and Agencies value criteria were obtained from information in online documentation (Major Command 2010).

9. Office of Management and Budget (OMB) value criterion were obtained through their web site (OMB Mission) and through the PPBE training module (DAU 2010).

10. Office of the Secretary of Defense (OSD) value criterion for Air Force Acquisition program portfolios were obtained primarily from the DoD Strategic Management Plan written by the Deputy Secretary of Defense William J. Lynn III (Lynn 2009).

11. Presidential value criteria related to the Air Force Acquisition program portfolios were explicitly stated on the White House Defense Platform Issues web site under the topic of Reform Procurement, Acquisition and Contracting (Obama 2010). In this source, President Obama's message was to focus on achieving needed capabilities within planned resource allocations. In addition, the National Security Strategy document dated March 16, 2006 by President George W. Bush was also referenced to obtain Presidential value perspective and criteria.

12. Program Executive Office (PEO) value criteria were obtained via an interview with the current C2&CS PEO within the Air Force Electronic Systems Center (ESC), Lt Gen Ted F. Bowlds on December 14, 2009. While the performance data informs him of the current working status of the programs in his portfolio, the capability value

criteria from the perspective of the war fighter would be useful for him to understand how to staff and other wise provide resources accordingly during program execution.

13. Program Manager (PM) value criteria relates primarily to having sufficient resources i.e. staffing, budget, schedule, clear unchanging requirements to successfully execute a program according to plan. Several Air Force program managers were interviewed to discuss program value criteria (Bastien 2010, Eisenbies 2010, Farnsworth 2010, Manas 2010, Mc New 2009, Sullivan 2010, West 2010).

14. The Secretary of the Air Force's value criteria was obtained from the FY 2011 Budget Overview document published by the USAF Deputy Assistant Secretary of Budget, Maj Gen Alfred K. Flowers (Flowers 2010).

15. Secretariat for Air Force Acquisition (SAF/AQ) group initiated this research project with MIT, and several interviews were conducted over the course of this research. A formal interview was held with the Associate Deputy Assistant Secretary (Shelton et al 2009) where the leadership perspective on portfolio value was obtained. Values in this organization include:
    - Priorities shift over time, i.e. fuel efficiency has become a new value criteria. Need to consider external influential variables, identify and prioritize trends
    - Engineers get attached to what they are working on and use other funds to continue the work

- Cancel programs because technology is not yet mature, capability is no longer required
- Seek to optimize efforts at the portfolio level to get the most bang for the buck
- Can be unclear if program is actually meeting user's need
- IT develops fast, how often should we incorporate new technology?
- Metric reports are subjective, based on program office, prefer to rely on summaries used to communicate with upper management
- PoPs is a prediction tool, indicates hope for a program to get better
- Decisions to add or cut programs are made ongoing, as required
- Delays in communication indicating programs are in trouble because PEO's think when they ask for help they have failed
- Need to address political requirements with capability requirements
- Additional costs to estimated program cost include the cost to initially stand up program offices and cost to address logistics i.e. where will the planes go after they are built?
- How do you manage rebaselining? Do programs have a clean slate or do you keep in mind that they have been rebaselined?
- Congress asks for details on programs, interest based on congressional districts

Countless phone calls and email communications were exchanged with Lt Col Fred Gregory, Michael Foley, Maj Cliff Hicks, and Maj Joel Rudy in order to understand how SAF/AQ evaluates program value. Much of the program performance value criteria is

contained in the MAR, DAES Quarterly, PPBE, and SAR reports. The following value related topics surfaced in a focus group style interview (Gregory, et al 2009).

- Looking for trends across programs i.e. requirements creep
- Priorities change over time, based on enemy capabilities
- Generally quicker and faster capabilities are desired
- Stakeholders include: CFO, A8, A5, OSD
- Need to consider technical maturity, complexity of integration, whether a partnership is required
- Need to determine unit of measure for value? No. lives saved?
- Reports are reviewed program by program, capability is not considered
- Look at obligation and expenditure rate
- Congress reviews the SAR, tend to focus on geography & where jobs are, developed 60 days after President's budget is out, annual report, cost variance explanations
- OSD reviews DAES Quarterly
- SAE/AQ reviews the MAR
- PEO, PM Create the metrics
- CR Control Reporting Database- contractors use to report EVM
- From MAR, chose which programs to bring up in meeting to discuss- focus on programs in trouble
- Don't look at risk metric, there are already manifested issues if they are red
- Reference high level colors in pops, referenced as leading indicator
- Data is manually translated at each point in the roll up

- Congress can veto program cancellation plans
- Rework in approval process, next level up/ in the process rejects the decision from the previous group
- Change resources for one program, and multiple other programs are impacted with replanning as a result
- PEOs have staff to review data, but look at Durante to make decisions, could be more involved than they are today
- Address Micro and Macro Portfolio needs, PEO, SES
- Need consistent criteria of what to look for
- How influential is value vs. execution?
- New program requests from bottom and top and cut requests from bottom and top
- Resistance to change from top, bottom, and programs who become attached to the idea
- OSD tends to support OSD
- When do you reach the point of no return when it is no longer an option to cancel?
- When is a program no longer affordable? No longer valuable? Is there a point of no return?
- Subcontractor proposals can cause delays
- Technical capability of subcontractor, leadership track record
- Need reward, incentive for redistributing resources and portfolio
- Talk to someone in IT dept, A6?
- Focus is more on what's being dropped not on what's being gained

- Need to weigh opportunities vs. risk, elaborate risk categories, not currently effectively recording or managing risk, try contacting "active risk manager" for JSF, Lynn Hughes Civilian POC
- Weigh heavier on things you can control

16. It was an honor to obtain Strategic Plans and Programs (A8) value criteria through a focus group style interview with several 3-Star level staff on December 4, 2009:
    - Deputy Chief of Staff for Strategic Plans and Programs Lt Gen Christopher Miller
    - Director of Programs, Deputy Chief of Staff for Strategic Plans and Programs Maj Gen Robert Worley
    - Deputy Director, Air Force Strategic Planning, Deputy Chief of Staff for Strategic Plans and Programs Brig Gen Derek Rydholm
    - Associate Director of Strategic Planning, Deputy Chief of Staff for Strategic Plans and Programs Robert "Mike" Maxwell
    - Associate Director of Programs, Deputy Chief of Staff for Strategic Plans and Programs Dr. David Walker
    - Assistant Deputy Chief of Staff for Strategic Plans and Programs Ms. Barbara Westgate

    The main message on program value from this meeting was related to balancing a variety of interests such as addressing the ten core capabilities, balancing new capability development with tried and true resource investments, addressing the Global War on Terror and developing conventional assets, an meeting each of the

regional critical short-term resource needs while investing in longer term strategic projects. There was not an emphasis on a "good" or "bad" characteristic for a program, but rather a balancing act on the portfolio level. The following are notes taken during the interview on the subject of portfolio value:

- Service core, metrics from strategic planning, capability portfolio action officers
- Business, production capacity, manufacturing- diminishing returns
- Complete value equation
- Reevaluate across PEOs
- O6 project capability group
- Logistics, battle space awareness
- Combat and commander value measurement
- Capability gaps from above, top ten capabilities
- Interim requests, short term, executable, important
- Back to domain, service core functions, CPMs not working
- JCAs translators, good agnostic perspective
- Balance long and short term
- See how changes impact big picture (capability)
- Trades and synergy between programs
- Now, only look at single effect of a single system
- Tendency to look at cool stuff rather than basic needs and capabilities
- DoD rebalancing traditional vs. irregular warfare
- Need to understand who you're working with and what factors into the portfolio

- PoPs and MARs used to determine where to take from and give to, help or kill determination
- Phase programs to accomplish as much as possible
- Sometimes things are done to hurt executability in the name of affordability
- Target yellow metrics, red it's too late
- SAR, R Docs, P Docs, Comp Controller, OSD reviews, Milestone reviews
- How to determine if giving right amount? F22 example, funding was below the minimum threshold needed to achieve capability
- Not much dialogue with PEOs
- Measure how well requirements are met
- How to mitigate gap
- POM six year budget
- Clearly define sphere of influence

17. War Fighter perspective on program value was obtained primarily from two interviews with serviceman (Fiedel 2010 and McNew 2010). While a larger sample size than two is preferred, the value criteria discussed seem to pass the test of reason. Soldiers in the field are interested in force protection (protection designed for the soldier), sustainability (redundancy in navigation, power and weaponry), and survivability (protection designed for the asset in the field). These value characteristics are recorded in each program's key characteristics.

In review, there are three general categories that constitute value to the system of surveyed stakeholders: program management (cost, schedule, performance), risk factors, and capability (intended use applications). The program management variables are typically provided in quantitative form, risk is evaluated in a combination of quantitative and qualitative measures, and capability priority is highly qualitative.

4.2.3 Process View

The Resource Allocation Process has four major phases: Planning Programming Budgeting and Execution (PPBE), Enactment, Apportionment, and Allocation/ Execution. These phases are shown in Figure 22 below (Brown 2009). This research will focus on the bottom half of the Figure to include the interface between the Execution/ Acquisition and PPBE phases.

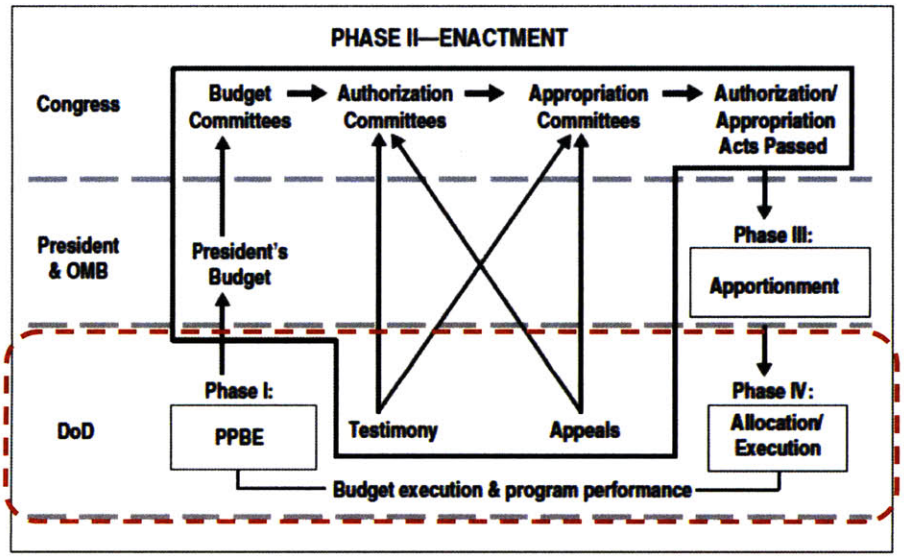


Figure 22: Resource Allocation Process

There are three major decision making systems: Joint Capabilities Integration and Development System (JCIDS), Defense Acquisition System, and Planning Programming

Budgeting and Execution (PPBE). JCIDS ties joint capabilities with programs being developed and the process is shown in Figure 23 below (Brown 2009).

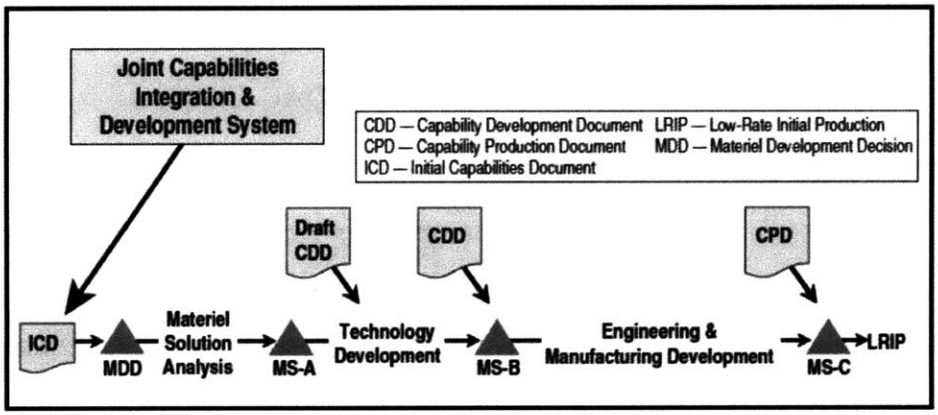


Figure 23: JCIDS Process

The Defense Acquisition System is set up to support the materialization of the program assets according to specified requirements and timeline using the resources allocated. See Figure 24 below (Brown 2009).

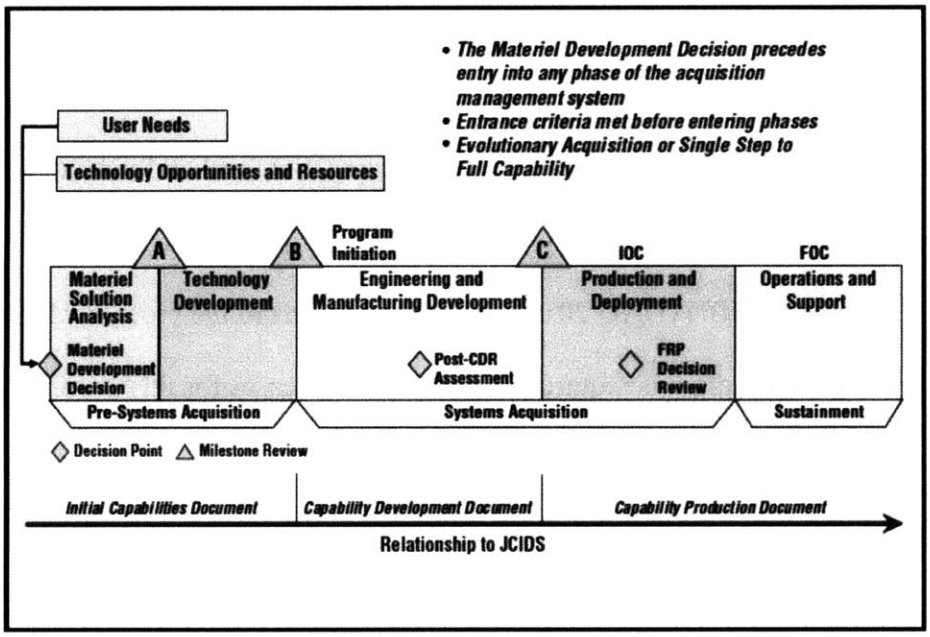


Figure 24: Acquisition Process

Both JCIDS and the Acquisition systems occur during the Phase IV Program Execution, and the PPBE system is located in Phase I. Figure 25 shows the major elements of the PPBE System: Planning, Programming and Budgeting (DAU 2010).

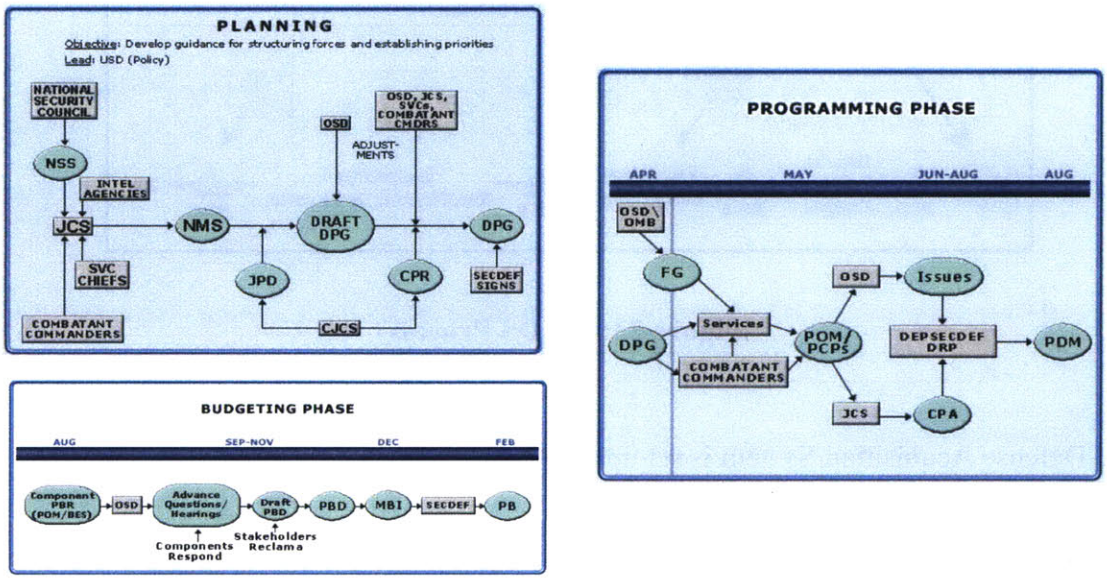


Figure 25: PPBE Process

The Planning Phase happens first, and the Programming and Budgeting Phases occur concurrently once the Planning Phase is complete. The flow chart in Figure 26 shows the interfaces between the two concurrent processes at the OSD level and indicates points where program components interface with OSD's review during Budget Hearings and Major Budget Issues (MBI) (DAU 2010). These two points in the process where program priority justification is required are potential use cases for this portfolio level value analysis, which quantitatively balances program capability scores with cost and execution data.

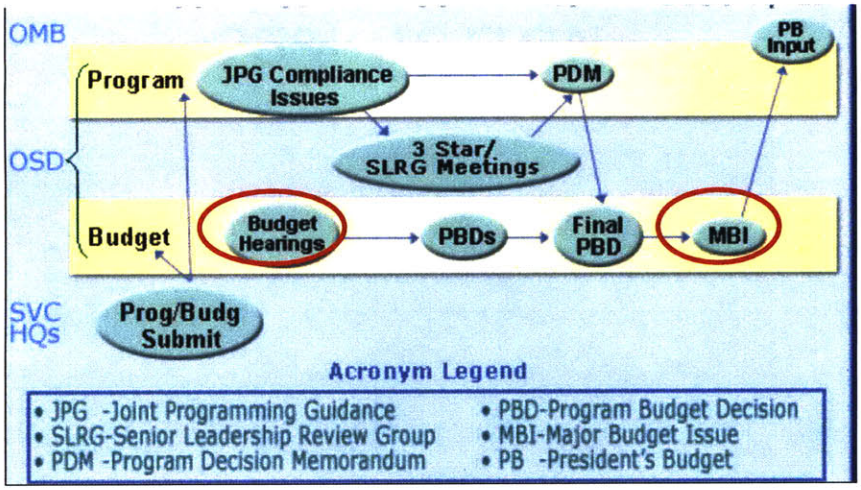


Figure 26: Concurrent Program and Budget Review Process

At the Air Force level, there are also concurrent programming and budgeting processes. There are many stakeholders in the process who may initiate a new concept for a program such as SAF/AQ, AFMC, Component Major Commands, Congress, and War Fighters in the field. These proposed new programs go through a series of budgeting and programming reviews. If they make the cut for each progressive review, they are included in a compiled and prioritized list created by AF/A8 for all of the Air Force future year inputs. A8 is focused on balancing a variety of capability priorities and SAF/AQ balances the portfolio management perspective. It is at this point when the full Air Force portfolio of programs are currently reviewed and balanced based on value criteria. This process flow is shown in a swim lane chart and the points of interest for quantitative portfolio value analysis implementation is highlighted with red circles, see Figure 27 (Gregory 2010).

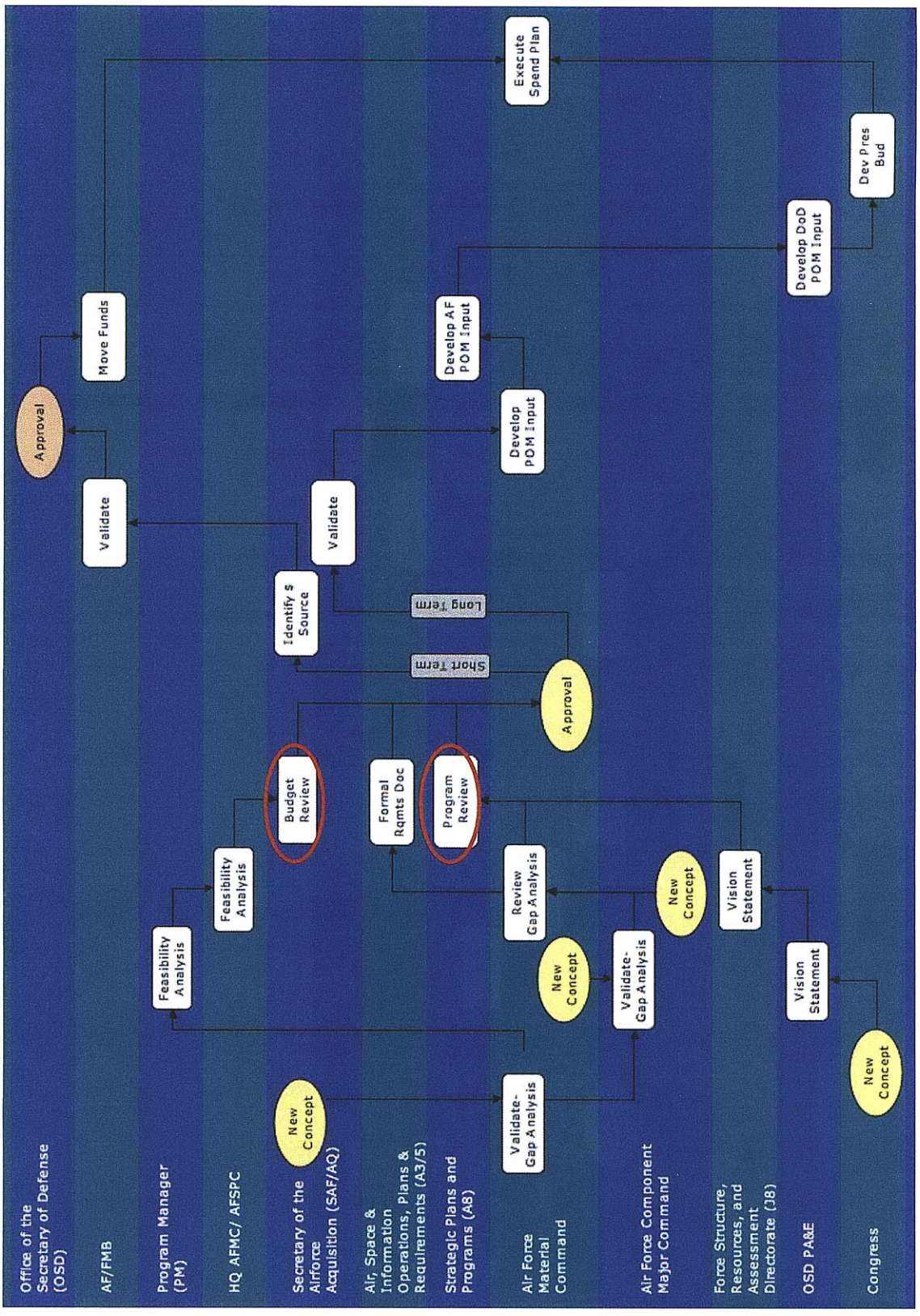


Figure 27: Air Force PPBE Process

For each of the major systems and processes described, there is a designated leader to see the process through to completion, and they are illustrated in Figure 28.

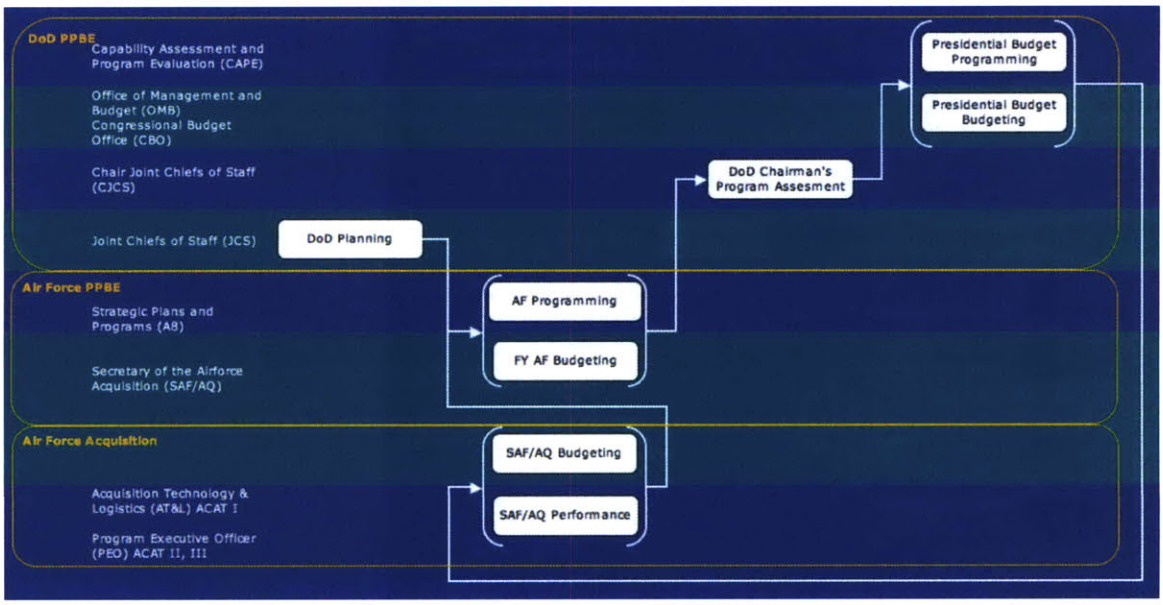


Figure 28: Leaders of Major Processes

This research will focus on The Air Force level PPBE System and the Air Force Acquisition System. The DoD level processes are shown for reference as external interfaces to these systems.

4.2.4 Policy and External Factors View

The future year planning cycle (PPBE) and the current year Acquisition cycle for new resource development have many external influences. For this research, the scope is centered on Air Force Acquisition programs and in section 4.2.3 the DoD level organizations have been defined as outside of the system boundaries. Entities outside of the specified boundaries are recognized as influential in how program development decision-making processes occur but these factors are considered out of the sphere of influence to control during this particular research analysis. In addition to the DoD, there

are additional influences to take note of. At a higher level, Congress, the Executive Branch, and Industry are major players in the end result of program prioritization. In addition to these consistent external players, there are some more spontaneous notable influences as well, which include the media, public opinion, Allies, hostile country activity, natural disasters, economic trends, etc, see Figure 29.

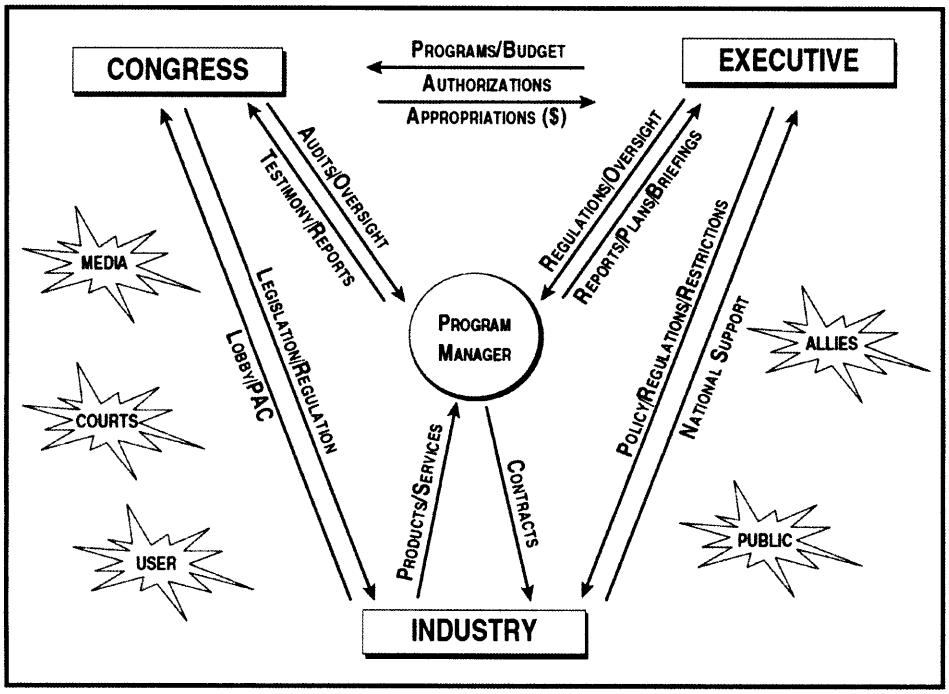


Figure 29: The Program Manager's Environment (Brown 2009)

These influences are constantly changing and need to be monitored and factored in to the value equation each year the portfolio is evaluated. Examples include updating value criteria based on a new Presidential Candidate's military platform, public speeches broadcast in the media, newly issued laws or regulations, and changes in regional conflicts.

4.2.5 Information View

The enterprise information view is used to show what information is exchanged between each of the stakeholders in the system. A macro level information view is provided first in Figure 28 followed by a scale view in Figure 29. Most of the data shown originates from a single source and is delivered to a single source, with few exceptions. These data objects are documentation with explicit program information, which is helpful in quantifying portfolio value. However, it is important to note that tacit, implicit information is often used as decision-making criteria in addition to information contained in these documents. In order to transition from a single stakeholder perspective to a system level perspective, this existing measurement data is available and may be leveraged. The macro view provides context and sources of data with which to monitor external stakeholder influences, see Figure 30. The scale view likewise illustrates existing sources of data to base value criteria metrics on, see Figure 31. Note, each data resource shown has it's own timeline (some are monthly, quarterly and annually) and reporting dates vary.

Some data sources are appropriate for developing value criteria, such as the National Security Strategy, National Military Strategy, Intelligence Assessments, Defense Planning Guidance, Operational Plans, and Integrated Priority Lists. While other data sources may be readily used for scoring a specific program or portfolio based on the identified criteria, such as Selected Acquisition Reports, Acquisition Program Baseline, Defense Acquisition Executive Summary, Monthly Activity Reports, and the Joint Capability Area Management System.

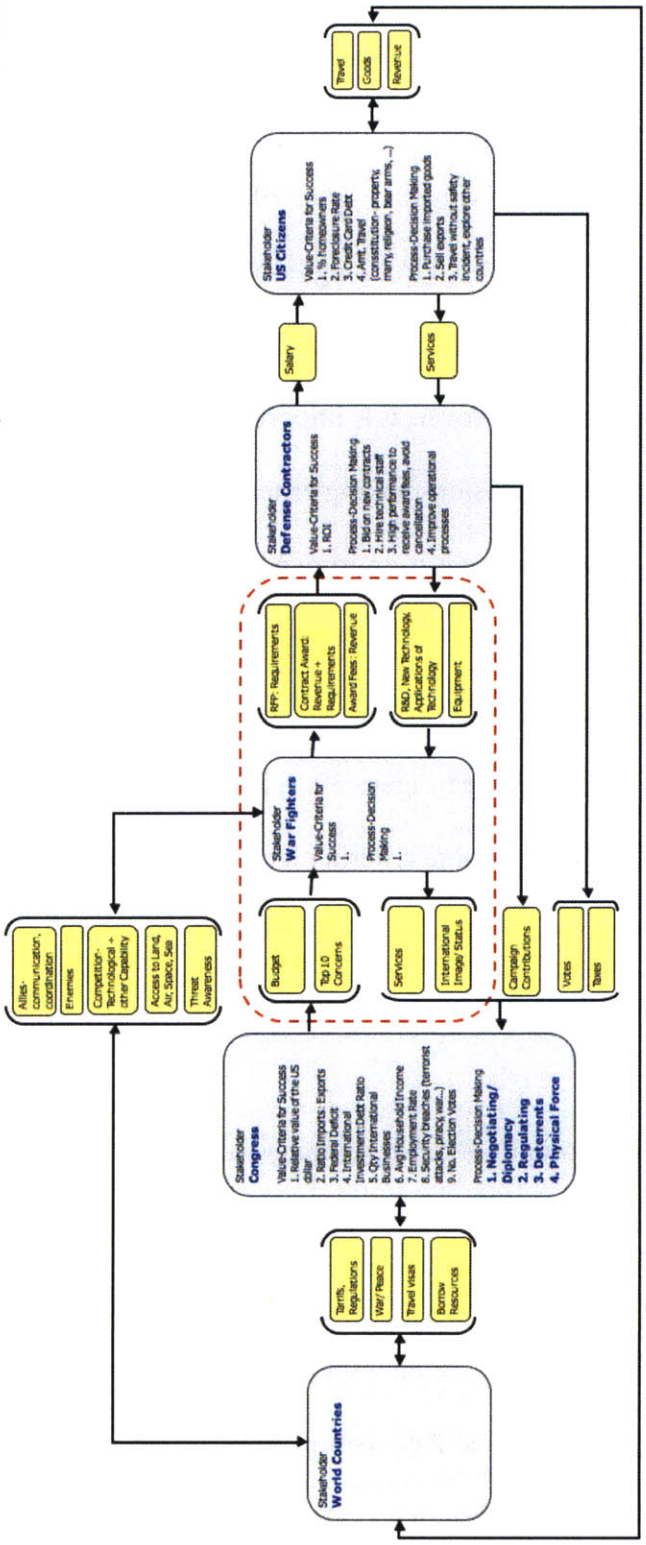


Figure 30: Macro Level Information View

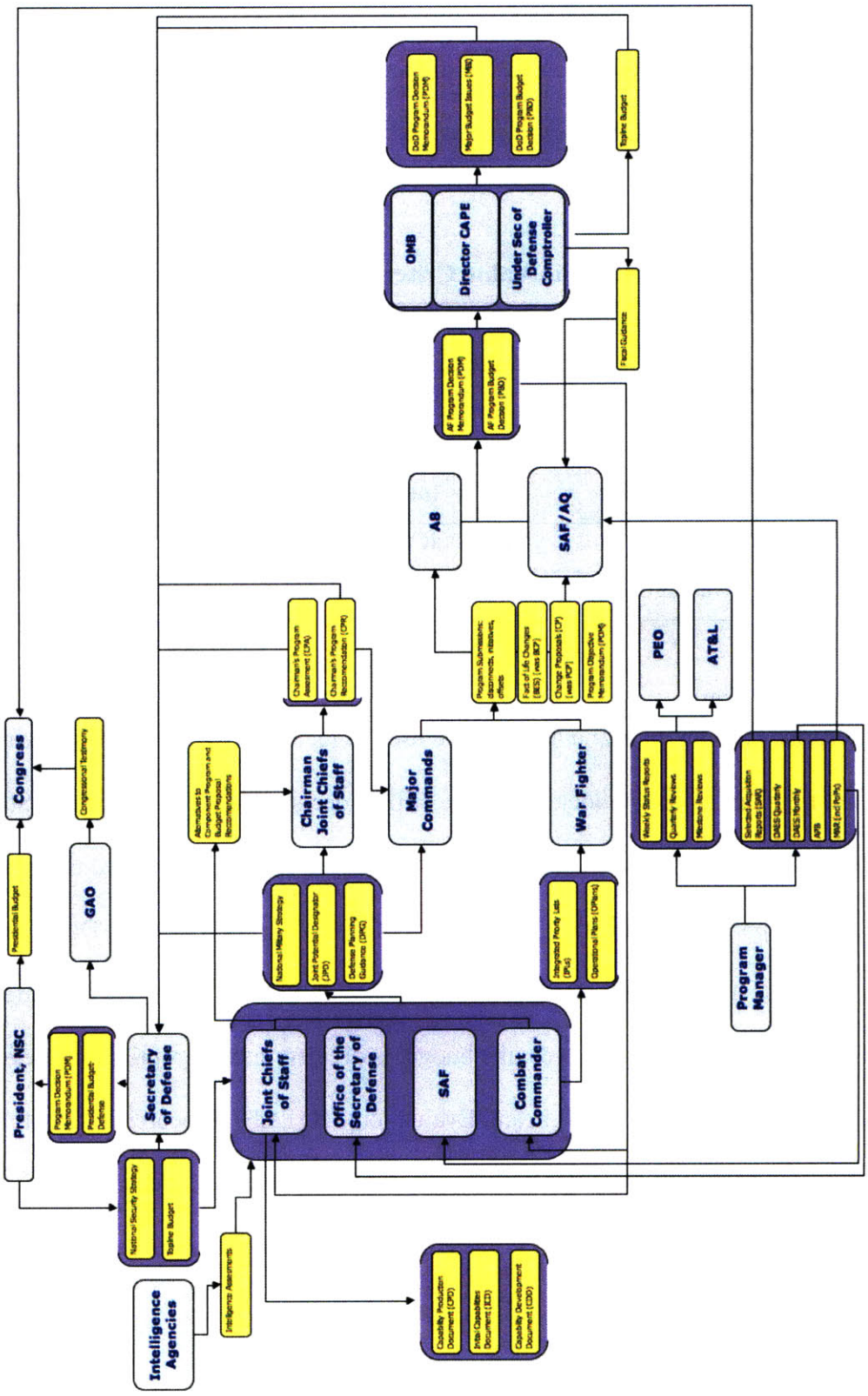


Figure 31: System Information View

For each of the value criteria identified in section 4.2.2, the following data sources (a subset of what is illustrated in Figure 31) contain the data needed to score programs based on the identified value criteria. Interviews are required for data that is not currently captured in reports.

Table 8: Portfolio Value Criteria Information Sources

POC	Report
SAF/AQ	MAR / DAES Quarterly
A3/5	Interview, DAES, DoDAF
Combat Commander	Interview, IPL, OPLAN
Joint Staff	JCAMS
Program Manager	Interview

4.2.6 Funding View

The enterprise funding view and analysis are used to identify how the funding breaks down and rolls up in order to identify where critical decision points are located. Starting with the Office of Management and Budget, the congressional appropriated budgetary resources for approved acquisition programs is allocated to the DoD. The DoD further breaks down the appropriated budget per component: Air Force, Navy, Army, Defense Agencies, etc. Within the Air Force, the budget is divided into appropriation categories, such as Research Development Test and Evaluation (RDT&E), Procurement, Military Construction, Military Personnel, Operations and Maintenance, etc, see Figure 32. For this research, the focus is on the Air Force component and the RDT&E appropriation funding.

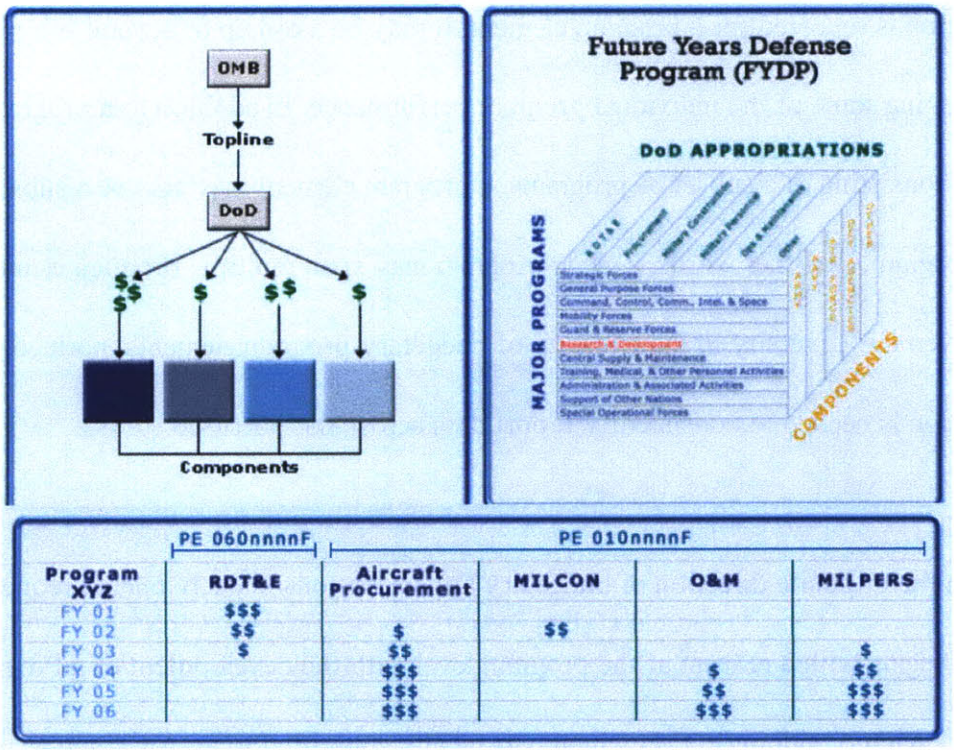


Figure 32: OMB Congressional Budget Breakdown

Also within the Air Force portfolio, there are program elements. Funding from multiple appropriations may be tied to a given program element, so a given program will have resources identified for all phases of development to ensure successful completion. This funding is identified for the current year as well as several future years for planning purposes as well. The program element is the lowest level element as part of the congressional funding breakdown. It is used as a reference to map JCAs, report program Acquisition Status, and allocate resources. However, it is noteworthy to mention that programs and program elements do not necessarily have a 1:1 ratio. There are some program elements which consist of a collection of programs each managed by a different program manager. These programs may or may not be related to each other. So, when

information is reported for a program element, it may be a roll up of several sub programs thus masking some of the individual program performance. In addition to a program element consisting of a subset of programs, a program element may also be a subset of a larger program. In other words, a given program may span multiple program elements as well. Given this diversity in the make up of budgetary program elements, both cognizance and caution is needed to consistently report data across the portfolio.

Going in the opposite direction of budgetary appropriations, namely budget requests, the process begins with a request at the program level with the development of a Program Objective Memorandum (POM) which is typically submitted to an Air Force Major Command. The budget required to support this program request is estimated, and a successful request will make the cut for the Major Command's priority list, Air Force Priority list, DoD priority list, Presidential Budget Executive Review, Congressional Budget Review, Appropriation and Execution, see Figure 33.

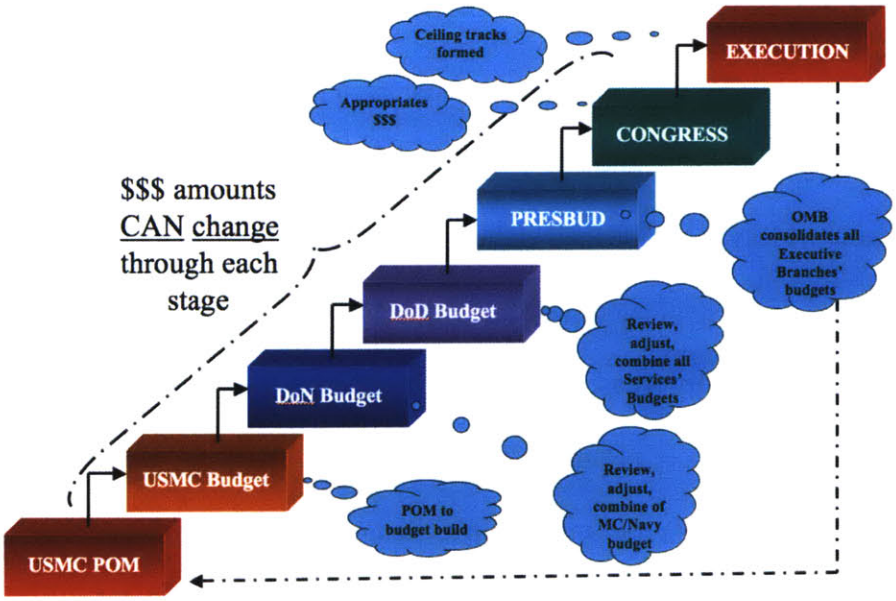


Figure 33: Budget Requests (Bradley 2010)

In light of the number of decision makers and approvals required, the Air Force portfolio perspective consists of balancing Air Force Programs + "taxes" = Air Force Appropriation Budget. The "taxes" are necessary to address overhead stemming from OSD oversight, Congressional adds, and/or Combat Commander high priority requests where Air Force resources are required.

4.3 Design

4.3.1 Organization View

One of the organizational changes currently taking place is the increase in number of Program Executive Officers to monitor program execution (Shelton 2009). This change will increase the complexity of balancing resources within the Secretary of the Air Force appropriation budgets and thus increases the need for a method that provides objective portfolio level cost benefit data.

In order for this objective analysis to be established, a specific organization needs to claim ownership of gathering and reporting data and a champion is required in an area where program priority is established. The PPBE System is the place where the full portfolio of programs is evaluated based on performance, risk and war fighter need. There are two concurrent processes led by two different organizations which coordinate to provide a prioritized list of programs for the Air Force portfolio: Secretariat for Air Force Acquisition provides program priority based on a program management perspective and the AF/A8 provides program priority based on capabilities-based framework. It is possible that one or the other of these organizations may claim ownership of gathering data for this analysis, or perhaps an entity within the Secretary of the Air Force which spans both the Assistant Secretaries and the AF Chief of Staff may be more appropriate. In either of these cases for data gathering, a champion will also be required in both SAF/AQ and AF/A8 to make decisions based on this quantitative portfolio value assessment in order for the benefit of the analysis to be realized.

4.3.2 Strategy View

The stakeholders and key influences listed in Table 7 are grouped by: Air Force Acquisition, Air Force Planning, Programming, Budget and Execution (PPBE), Executive Branch, Legislative Branch, and External Factors. The first two categories of stakeholders within the Air Force identify and initially prioritize a given set of programs, but the list is then modified and approved by several external entities during follow on processes. In order to address these strong external influences on the Air Force Planning process, some of these stakeholder strategies are considered as they relate to the Air

Force portion of the PPBE process. Table 9 maps out each stakeholder to their value criteria reference number in the left hand column. The orange rows (1-14) indicate program management type metrics, the green rows (15-27) indicate capability-based metrics, and the purple rows (11-14, 28-35) indicate portfolio level metrics. The program management metrics are fairly well-established, while the capability value metrics are newly identified. The program level metrics tend to have a positive or negative indication at the program level. The portfolio metrics use data measured at the program level but are only meaningful at the aggregated portfolio level.

Table 9: System Stakeholder Value Strategy Map to Value Criteria

	AF Acquisition			AF PPBE					Executive Branch						Legislative Branch				External Factors			
	SAF/AQ	PEO	Program Manager	Combat Commander	A8	Major Commands: Operational, Support	A3/A5	War Fighter	President, National Security Council	OMB Comptroller	Director CAPE	OSD	AT&L	Joint Staff	Senate and House Armed Services Committees	Senate and House Appropriations Committees	Congress	Congressional Budget Office	GAO	Present Threats to National Security	World Opinion	Media	Emergencies
1	x									x								x					
2	x	x							x	x			x										
3	x	x							x	x			x										
4	x	x							x	x			x										
5	x	x								x			x										
6	x	x								x			x										
7	x	x								x			x										
8	x	x								x			x										
9	x									x													
10	x		x						x	x		x											
11									x	x		x											
12									x	x		x											

13									x	x								x	
14									x	x								x	
15				x	x	x													
16				x	x	x													
17		x		x	x	x	x						x	x					
18				x	x	x			x										
19		x		x	x				x			x	x	x					
20					x							x		x					
21		x			x	x	x		x			x	x						
22					x		x		x			x							
23				x	x	x					x			x					
24				x	x	x	x	x	x					x					
25				x	x	x	x	x						x					
26				x	x	x	x	x						x					
27				x	x	x	x							x					
28										x		x							
29										x		x							
30										x		x							
31					x				x										
32									x								x		
33											x								
34											x								
35															X				

Table 10 lists each value and criteria for measurement, and the left hand column number refers back to Table 9 left hand column reference numbers. Specific criteria will be used in order to quantify how well each value criteria has been satisfied. The specific value criteria is developed based on current organizational strategy and indicators of success.

Table 10: Value Criteria, Unit of Measure and Scoring Criteria

	Value Criteria	Units of Measure	Scoring Criteria (5 high - 1 low)
1	Actual Cost of Program	$M	5 * (1 - cost of program/ cost of most expensive program in portfolio)
2	EVM: Cost	RYG	1- Red 3- Yellow 5- Green
3	EVM: Schedule	RYG	1- Red 3- Yellow 5- Green
4	EVM: Performance	RYG	1- Red 3- Yellow

			5- Green
5	MAR: SPM	RYG	1- Red 3- Yellow 5- Green
6	MAR: PEO	RYG	1- Red 3- Yellow 5- Green
7	MAR: Fund	RYG	1- Red 3- Yellow 5- Green
8	PoPs	PoPs Score numeric RYG	1- Red 3- Yellow 5- Green
9	Percent Complete	2 decimal places	5*(%)
10	No. Rebaselines	integer	1- 7+ 2- 5-6 3- 3-4 4- 1-2 5- 0
11	No Admin Changes	integer	5* (normalized no. of changes) inform portfolio level with Qty
12	No Content Changes	integer	5* (normalized no. of changes) inform portfolio level with Qty
13	Current cost increase from original baseline	$M	1- Increase $300B or more 2- Increase $1B-$300B 3- Increase $500M-$1B 4- Increase $0-$500M 5- No Change or Decrease
14	Amount of schedule increase from original baseline	No. months	1- Increase $5 years or more 2- Increase $3-5 years 3- Increase $1-3 years 4- Increase $1 month - 1 year 5- No Change or Increase
15	Number of Operational Plans addressed	integer	5(% OPLANS addressed)
16	Number of Integrated Priority Lists addressed	integer	5(% IPLs addressed)
17	Operational Timeliness for Threat or Need Date	multiple choice	1- Delays with significant risk of non-achievement 2- Significant delay 3- Minor extension 4- Available as planned to address specific mission 5- Available ahead of threat
18	Regional Priority	1- Peace Region 3- Threat of War 5- Current War	1- Peace Region 3- Threat of War 5- Current War
19	Integrated/ Jointness	No. interfaces with other assets (integer) interfaces with other branch assets (Yes/ No) Interfaces with international assets (Yes/ No)	1- Stand alone capability 2- Interchangeable/alternate resource for another asset 3- Integrated with assets within the Air Force 4- Interfaces with asset(s) from another military branch 5- Interfaces with International Ally Assets
20	Joint Capability Analysis- Qty Tier 1 JCAs addressed	integer (1-10)	5(% Tier 1 JCAs addressed)
	Qty per Tier 1 JCA	1	Indicate with an "x"
		2	Indicate with an "x"
		3	Indicate with an "x"

		4	Indicate with an "x"
		5	Indicate with an "x"
		6	Indicate with an "x"
		7	Indicate with an "x"
		8	Indicate with an "x"
		9	Indicate with an "x"
		10	Indicate with an "x"
21	Technology Maturity, Based on Technology Maturity Level (Turner 2010)	integer 1-9	1- TRL 1 2- TRL 2,3 3- TRL 4,5 4- TRL 6,7 5- TRL 8,9
22	Reduction of Risk via Incremental Development	1- Radically new platform 2- Some design reuse 3- Modular updates to an existing platform	1- Radically new platform 3- Some design reuse 5- Modular updates to a new platform
23	Capability Criticality	1- Top 10% (Critical) 2- 50-90% (Very Important) 3- Below 50%	1- Alternates available, low level capability 3- Required to meet desired capability 5- Critical element to provide high value capability
24	Force Protection Key Performance Parameters	integer	1 pt for each KPP: speed, maneuverability, detectability, countermeasures, armor, redundancy of critical components
25	No. Survivability Key Performance Characteristics	integer	1 pt for each KPP: speed, maneuverability, detectability, countermeasures, armor, redundancy of critical components
26	No Sustainment Key Performance Parameters	integer	1 pt for each kpp normalized scores f(availability, reliability, ownership cost)
27	Reduce Material Solution Analysis Cycle Time (via commercial dual use technology insertion)	Number of months between MDD and MS-A	5 * (1 - Number of months between MDD and MS-A / Longest no. months)
28	Reduce Technology Development Cycle Time	Number of months between MS-A and MS-B	5 * (1 - Number of months between MS-A and MS-B / Longest no. months)
29	Reduce Eng & Mfg Development Cycle Time	Number of months between MS-B and MS-C	5 * (1 - Number of months between MS-B and MS-C / Longest no. months)
30	Portfolio Ratio of short term, current operations (<15 years): long term, deterrence programs (>15 years)	Full Lifecycle Timeline (Years)	1- 4.1>x>0.6 2- 3.1>x>0.7 3- 2.1>x>0.8 4- 1.1>x>0.9 5- x=1
31	Employment Rate	No. congressional districts program work is performed (Prime + Major Subs)	5 * (no. congressional districts portfolio work is performed in / 50)
32	Balance conventional and irregular warfare (ratio of portfolio capability)	1- Principally irregular- GWOT 2- Principally conventional 3- Balanced 4- Deterrent	1- 0.5>x<1.5 2- 0.7>x>1.3 3- 0.8>x>1.2 4- 0.9>x>1.1 5- x=1

33	Balance Program Phasing (Equal no. programs at each AQ Milestone)	MS A, B, C...	Score = abs|%Pre MS A - %Pre MS B| + abs|%Pre MS B - %Pre MS C| + abs|%Pre MS A - %Pre MS C| 5 * (1 - Score / 200)
34	ACAT Level	I, II, III	inform portfolio
35	Congressional Add	Yes/ No	represent in a different color

The criteria listed in Table 10 above addresses many of the system level stakeholder value criteria. However there are additional criteria that have been omitted. One key value criteria is that of dependencies. A measurement is needed to quantify the influence one program has on other programs within the system. So, if a given program is cut, what will the resulting impact be on the remaining system capability? This item was omitted due to time constraints and is recommended for future research. Other items include a refined measurement on applicability of a given asset to current mission operations and the relative performance capability of an asset to the current international leader. Each of these areas play an influential role in program and portfolio value, but were not addressed in this research due to data sensitivity issues.

4.3.3 Process View

For future implementation of this quantitative portfolio analysis methodology, a specific event in the process needs to be identified as the point at which this analysis will be used to support resource allocation decisions. The future year planning program review step noted in Figure 25 is the general point at which this will occur, but a specific meeting with identified stakeholder attendees will need to be determined by leadership. Ideally this methodology will be incorporated into an already existing step in the process, so it will be in support of current processes and build on current infrastructure.

The Air Force Acquisition System will benefit from this portfolio value analysis, because the PEO who leads the execution of programs funded for the current year will benefit from understanding the value data captured during the future year planning process. This program value priority relative to the portfolio of programs could be used as an ongoing reference document to support staffing and budget allocation decisions as part of the management of current program execution.

4.3.4 Policy and External Factors View

In the proposed portfolio measurement system, the value criteria will be updated each year based on each stakeholder organization's current leadership priorities. The criteria need to be updated to include both internal as well as external environmental influences. So, if fuel prices become a high priority, all programs within the portfolio will have this same value criteria applied in a consistent objective manner.

4.3.5 Information View

In the future implementation of this portfolio analysis methodology, it is recommended to request value criteria information as part of the POM or similar accompanying form document in the future year planning cycle. Ideally, this form would be submitted in a digital format so data will be easily accessible for compilation at the portfolio level.

4.3.6 Funding View

In the future implementation of this methodology, some rules of thumb will need to be applied in order to consistently report value data for programs in light of the mismatch between program and program element reporting. This will include how to report data for multiple programs within oneprogram element and how to report data for a program

that is also being worked on separate additional program elements. In some cases the results may be based on an average or they may be cumulative.

4.4 Applied Framework Definition

In order to provide measurement data and show results related to the proposed enterprise architectural changes, the enterprise framework will be applied to a specific portfolio of programs in the form of a case study. It is important to note that the results of the case study are not statistically significant due to a very low sample size. The purpose is to develop the architecture sufficiently to be able to apply it and to show the type of results, which may be obtained if a more comprehensive analysis is performed. For this case study, there are three ACAT I programs, three ACAT II programs and one ACAT III program. They are all under a single PEO's portfolio of Acquisition Programs and are evenly distributed across phases i.e. some are pre-milestone A, post-milestone C and others are in-between.

4.5 Applied Framework Data and Analysis

The value criteria in Table 10 were applied to seven programs. The results for each criterion are discussed below, see Table 11. Some criteria were straightforward to gather data for, some require further research and some information was classified. The sensitive data will require someone who has the requisite access to determine the appropriate measures to apply as part of future research. It is important to note that this value equation will not be complete without this further research completed to fill in the identified elemental voids in the value equation.

Table 11: Applied Value Criteria Result Comments

	Value Criteria	Framework Result Comments
1	Actual Cost of Program	Risk, clearly understood measure
2	EVM: Cost	Execution, clearly understood measure
3	EVM: Schedule	Execution, clearly understood measure
4	EVM: Performance	Execution, clearly understood measure
5	MAR: SPM	Execution, clearly understood measure
6	MAR: PEO	Execution, clearly understood measure
7	MAR: Fund	Execution, clearly understood measure
8	PoPs	Risk, clearly understood measure
9	Percent Complete	Execution, clearly understood measure
10	No. Rebaselines	Execution, clearly understood measure
11	No Admin Changes	Execution, clearly understood measure
12	No Content Changes	Execution, clearly understood measure
13	Current cost increase from original baseline	Execution, clearly understood measure
14	Amount of schedule increase from original baseline	Execution, clearly understood measure
15	Number of Operational Plans addressed	Benefit, generally all programs are tied to an OPLAN and this is not deemed a differentiator. However, differentiating factors are typically Classified data and thus inaccessible for this research project. This measure will not be included in the value calculation.
16	Number of Integrated Priority Lists addressed	Benefit, IPLs provide prioritized regional capability gaps however, this is Classified data and thus inaccessible for this research project. This measure will not be included in the value calculation.
17	Operational Timeliness for Threat or Need Date	Benefit, based on program manager's understanding of required timing for delivery
18	Regional Priority	Benefit, some programs have general application while others are specifically designed for critical regional needs, this measure needs to be updated to differentiate these two responses in the future
19	Integrated/ Jointness	Benefit, clearly understood measure
20	Joint Capability Analysis- No. Tier 1 JCAs addressed	Benefit, clearly understood measure Although the Chief of Staff of the Air Force also issues 12 Core Functions which should also be measured in addition to the JCAs
21	Technology Maturity, Based on Technology Maturity Level (Turner 2010)	Risk, clearly understood measure
22	Reduction of Risk via Incremental Development	Risk, clearly understood measure

23	Capability Criticality	Benefit, unclear measurement criteria and sensitive data In the future, reference Air Force con ops to differentiate into two tiers: critical and enabling. Based on relative capability of leading world countries Based on dependencies to other programs, i.e. how does the capability of this program influence the capability of other required assets? Not able to access this data and thus eliminated from this case study value equation result.
24	Force Protection Key Performance Parameters	Benefit, unclear measurement criteria, typically 5 KPPs listed per program, not categorized this way
25	No. Survivability Key Performance Characteristics	Benefit, unclear measurement criteria, typically 5 KPPs listed per program, not categorized this way
26	No Sustainment Key Performance Parameters	Benefit, unclear measurement criteria, typically 5 KPPs listed per program, not categorized this way
27	Reduce Material Solution Analysis Cycle Time (via commercial dual use technology insertion)	Execution, inconsistent measurement data, not all programs have a MS A
28	Reduce Technology Development Cycle Time	Execution, inconsistent measurement data, not all programs have a MS B
29	Reduce Eng & Mfg Development Cycle Time	Execution, inconsistent measurement data, not all programs have a MS C
30	Portfolio Ratio of short term, current operations (<15 years): long term, deterrence programs (>15 years)	Execution, need clear beginning and end points, used general numbers for this study
31	Employment Distribution	Benefit, clearly understood measure
32	Balance conventional and irregular warfare (ratio of portfolio capability)	Benefit, clearly understood measure, added "deterrent" as an option
33	Balance Program Phasing (Equal no. programs at each AQ Milestone)	Risk, clearly understood measure
34	ACAT Level	Benefit, clearly understood measure (OSD champions ACAT I)
35	Congressional Add	Benefit, clearly understood measure

Data was collected based on Program Elements. Some program elements contained sub reports based on sub contractors or increments. For these cases criteria reference no.s 1, 10, 11, 12, 13, 14, 31 were cumulative results, and criteria reference no. 9 was averaged. Table 12 provides value scores for each of the seven programs "A-G" in the applied framework case study. Criteria 1-29 may be scored at the program level and shown graphically at the portfolio level for comparison. Criteria 30-36 are for information only at the program level, and they are not of value until shown at the portfolio level. There is no "good" or "bad" answer, rather the objective is to be balanced across many areas. Several criteria take on additional insight at the portfolio level as well.

Table 12: Applied Framework Data

Ref	Program A	Program B	Program C	Program D	Program E	Program F	Program G
1	3.7	4.8	4.5	4.4	4.6	0.0	5.0
2	3	5	5	0	3	5	3
3	3	5	1	0	3	1	3
4	5	5	3	0	3	5	3
5	3	5	1	0	3	1	3
6	3	5	1	0	3	1	3
7	5	5	1	0	1	3	3
8	5	5	1	0	3	5	1
9	4.4	4.0	3.9	0.5	2.3	3.8	4.2
10	5	4	5	5	4	5	5
11	3	4.55	4.7	5	2.9	5	4.6
12	2.3	2.2	5.0	5.0	5.0	5.0	4.9
13	4	5	4	5	1.6	5	2.55
14	5	5	4	5	4	3	4
15	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-
17	3	5	4	4	4	4	3
18	5	5	5	5	3	5	5
19	0.9	4	0	0	0.4	0	0
20	0.5	2	1	2	1	1.5	1.5
21	4	5	5	3	3	5	5
22	3	5	5	5	3	5	5
23	-	-	-	-	-	-	-

24	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-
29	-	-	-	-	-	-	-
30	9	6	8	1	5	33	2.5
31	0.8	0.2	0	0	0.4	0.1	0
32	3	1,4	3	3	4	3	3
33	B	Post C	B & C	Pre A	B	B	C
34	I	I	I	II	II	II	III
35	no	no	no	no	no	No	Yes
36	Yes	Yes	Yes	no	no	no	no

Criteria 20, Joint Capability Analysis, results are shown in the Figure below. For this case study portfolio, JCAs 2-7 are addressed in some way while 1, 8, 9 and 10 have not been addressed. Many programs address more than one JCA, and this Figure clearly shows how the programs cumulatively address the top ten joint capability areas. If this had been a full scale Air Force portfolio analysis, it would be recommended to adjust the programming to more evenly satisfy the joint capability requirements.

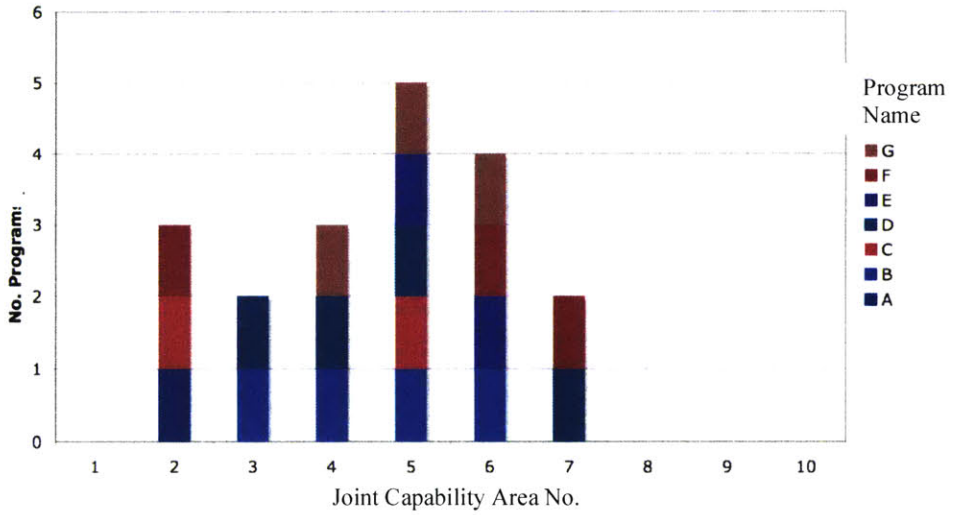


Figure 34: Tier 1 JCA Program Mapping

Criterion 30 is represented with a histogram in order to show the spread of short-term vs. long-term programs. There is some leadership discretion on how to balance near term requests with longer-term strategic investments, however the results in Figure 35 below, indicate that this portfolio is weighted more heavily on short term investments.

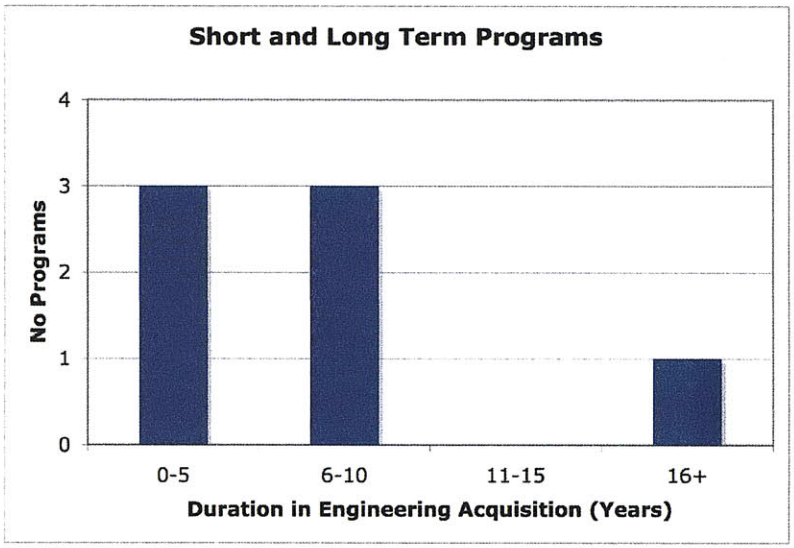


Figure 35: Short vs. Long Term Programs

Criterion 32 is represented with a histogram in order to show the spread of programs based on warfare type: Global War on Terror (GWOT), Conventional or Deterrent. This is another example of criteria which needs to be balanced, and this balance will be determined by a combination of leadership guidance and current events. Based on the results in Figure 36 below, this portfolio is weighted more heavily on conventional and GWOT applications.

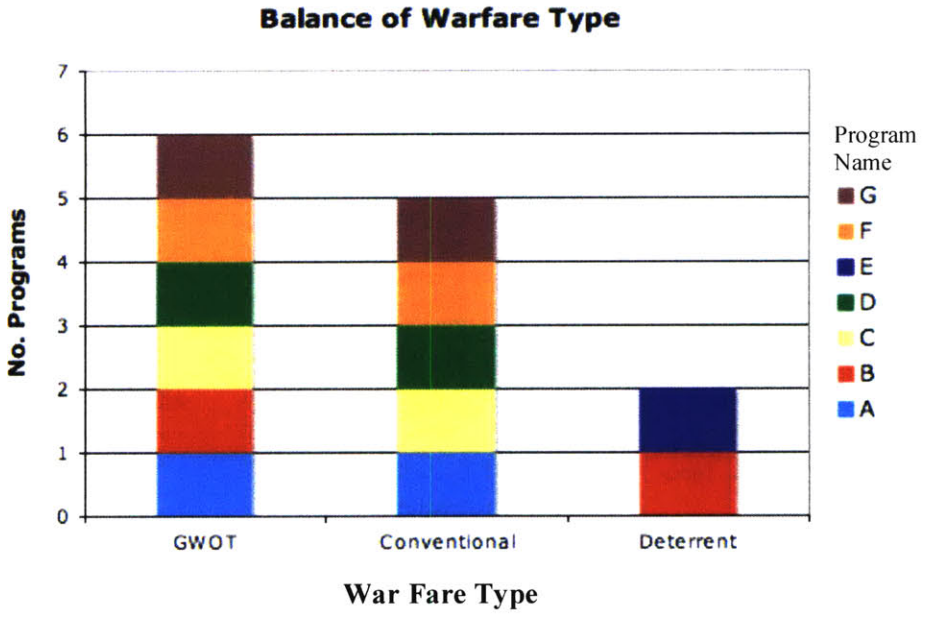


Figure 36: Profile of Warfare Type

Criterion 33 is represented with a histogram in order to show the spread of programs at various milestones. Evenly distributing programs based on milestone status reduces the overall risk of the portfolio and evens out the demand on acquisition resources. Based on the results in Figure 37 below, this portfolio is weighted more heavily on down-stream activity and new program capability research may be appropriate to add to the mix.

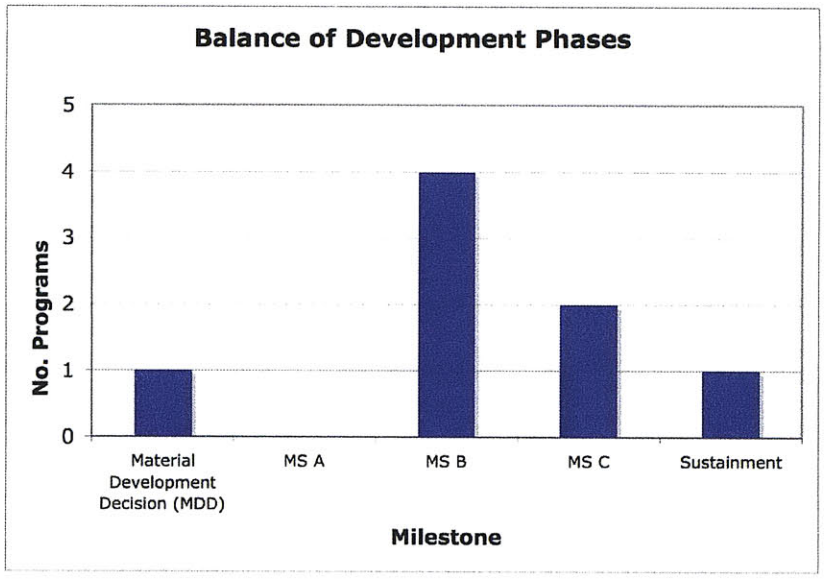


Figure 37: Balance of Development Phases

In addition to criteria 20, 30, 32, and 33 just illustrated, 34 and 35 also apply only at the portfolio level. However, these results will be combined with the cumulative value score results in a single illustration. In Figure 38, the value equation score addressing each of the value criteria in a resulting 1-5 scale, where five is the highest value, is displayed. The form of this illustration is similar to a run chart with an average, upper limit and lower limits each one standard deviation away from the mean. However, this graph is not a function of time. It is a display of several programs within a portfolio at the same point in time. This graph format is useful to display a large number of programs and objectively triage which programs require further attention. In this case, it may be worthwhile to look at program "A" to see what is causing the high value score as well as programs "D" and "E" to research the cause for low value scores.

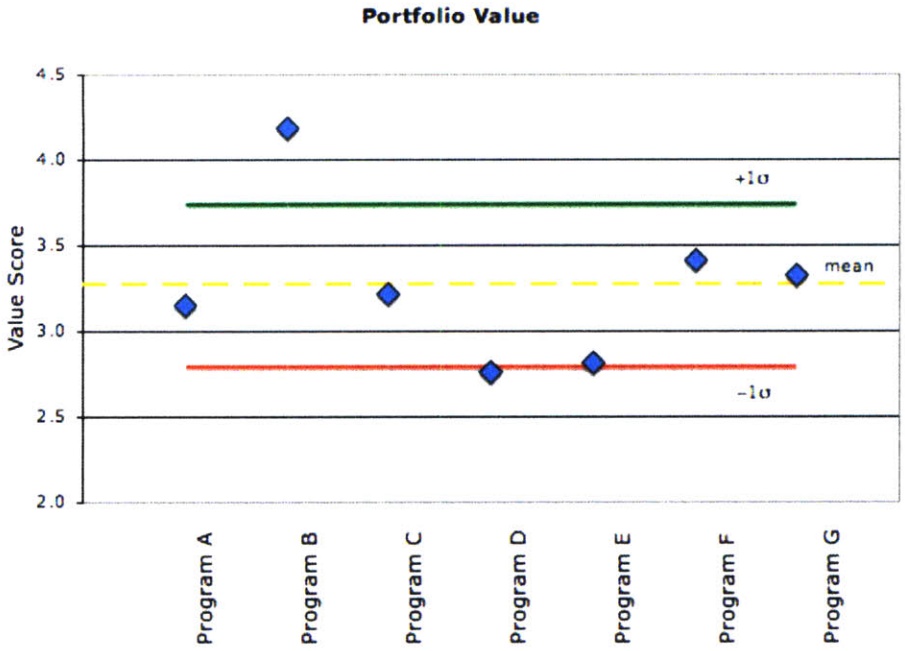


Figure 38: Portfolio Value

Because this case study includes only seven programs, it seems reasonable to research the outliers in this graph. However, when 1000+ programs are being evaluated, a second graph may provide useful insight as well. In Figure 39, a radar chart is used to show the relationship between program capability benefit, execution and risk. In addition to this comparison, it indicates who some of the higher-level stakeholders are. For example, Program A appears to be performing well, but is shown to have low value. However, it has OSD oversight, and decisions made by the Air Force to reduce funding are subject to being overruled. Program D on the other hand has high value and is struggling with execution. This program might benefit from additional funding. By highlighting these outliers identified in Figure 38, and providing this additional information in a graphical view, it can support objective informed decision making during the budgeting and programming reconciliation process.

For the outliers shown in Figure 39, the three main components of the value equation are broken down into benefit, execution and risk. The following are the criteria identifiers referenced in Table 10 which were used as a basis to quantify these three components:

- Risk: 3, 18, 48, 50, 61
- Benefit: 33, 34, 36, 37
- Cost: 5, 7, 9, 11, 13, 15, 19, 20, 22, 24, 28, 30

The value criteria scores on a zero to five-point scale were averaged for each of the three components. Indicators were added to communicate anticipated significant external stakeholder influence regarding Air Force resource reallocation decisions.

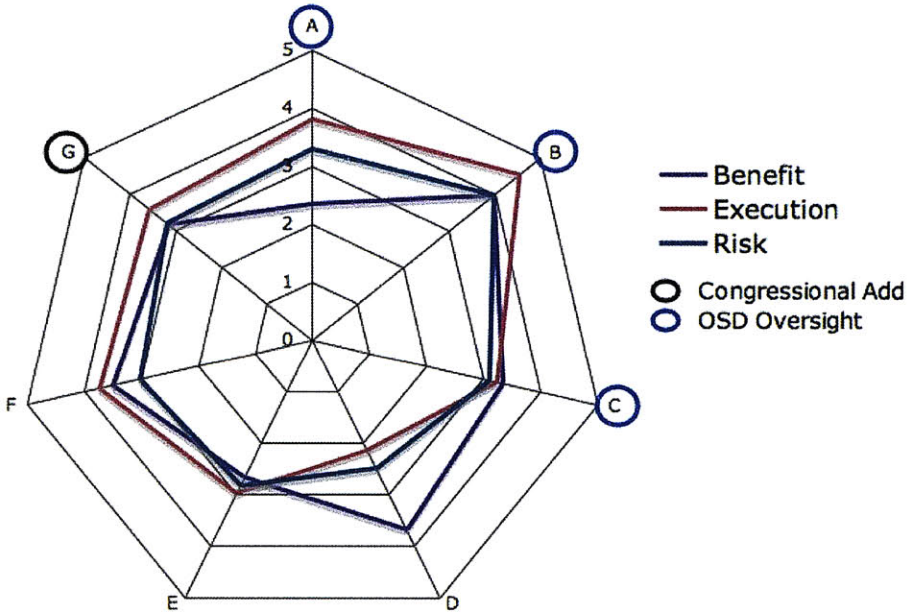


Figure 39: Portfolio Value Outlier Triage

Once this data has been captured over multiple time periods, the voice of the process will emerge and expected value score ranges may be developed and provided as target performance values. Once more data is obtained on regional capability priorities; value

scores may be interrogated to observe data for sensitivity for changes in environmental conditions and changes in stakeholder priorities. For example, if the war in the Middle East is resolved and the new focus is now on Pirates in Somalia, what assets change in value?

4.6 Enterprise Architecture Validation

Traditionally, the portfolio level triage of resources is based on program level performance data. An example of this performance data is shown in Figure 40.

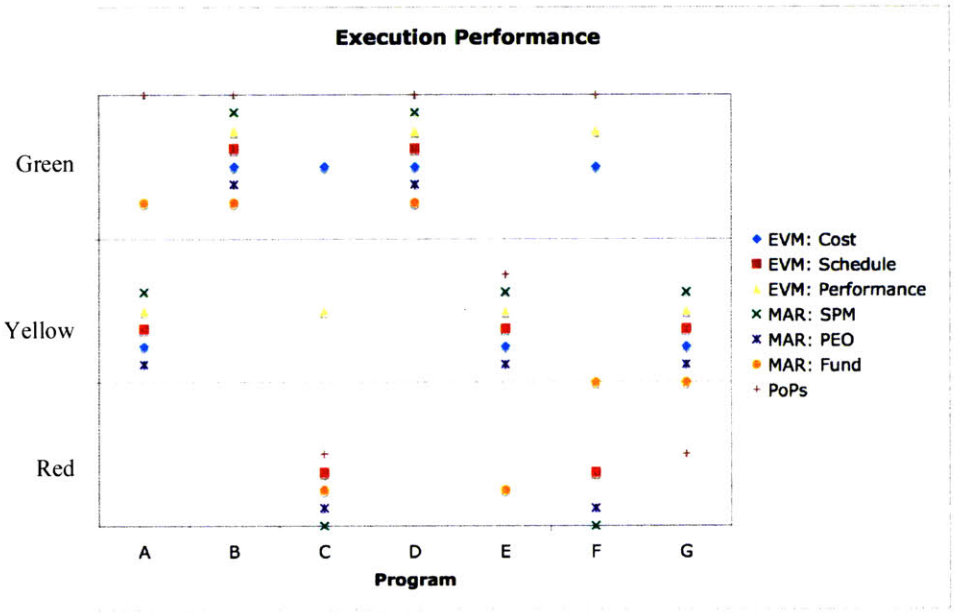


Figure 40: Portfolio Performance Data

While trends can generally be seen here, the capability priority element is not shown. However, in Figure 41 it can be seen that the factors of program risk and war fighter capability priority are not all equal to program performance. In some cases such as program A and D, these values vary widely, and in cases B, F, and G notable variation exists as well. So, in five out of seven cases benefit and risk factors communicate information not otherwise captured by performance data alone. This result supports the

hypothesis stated in section 1.3 which states "Analyzing system level portfolio value will provide a more informed and objective identification of programs of greatest interest and concern when compared to a program-by-program execution analysis when allocating Air Force Acquisition resources."

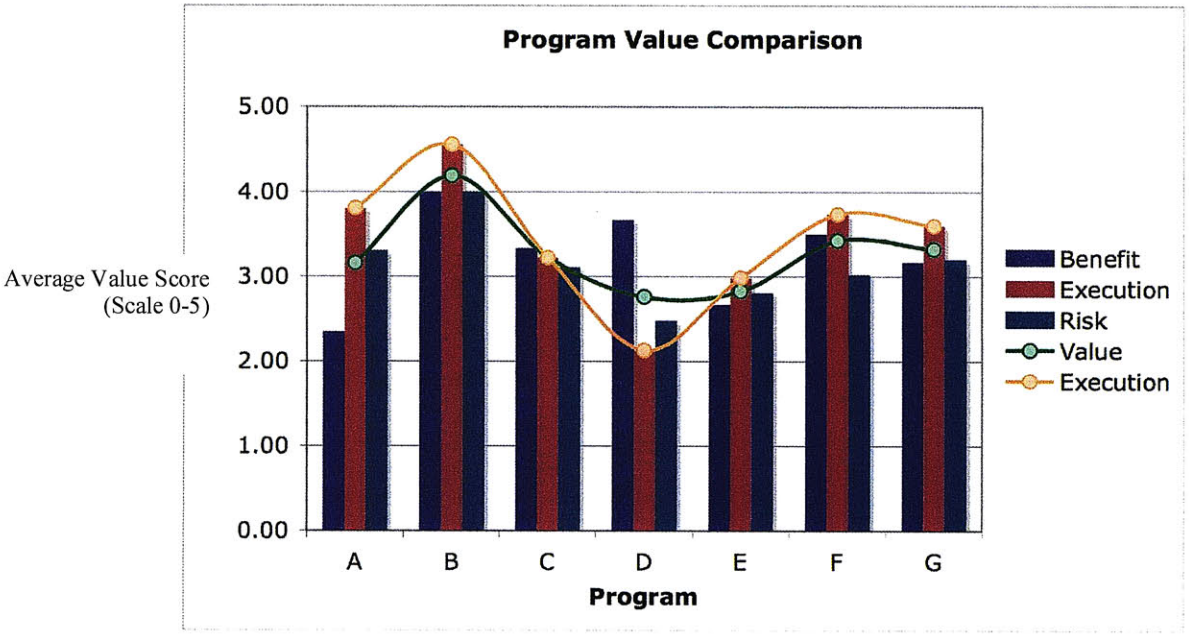


Figure 41: Portfolio Capability Benefit, Execution, and Risk

Referencing the execution data in Figure 41, Program D would be a likely candidate for being cut due to its low execution score. However, after considering the comprehensive value score, Program E would be the first to go. Although Program E's execution score element is higher, the benefit score for program D is one of the highest in the portfolio thereby indicating a critical capability need. Program A has a high execution score with a low value score indicating a lower criticality asset, and this characterizes a program who is a prime candidate for pulling resources to add to a program similar to B where the execution is high and the benefit score is the highest in the portfolio.

The positive results found when applying this value methodology where benefit and risk are evaluated along with performance and critical portfolio level value parameters are taken into account may also be achieved in other program portfolios as well. Additional organizations within the Department of Defense as well as Homeland Security, Department of Energy, Department of Transportation, etc. who also have large numbers of stakeholders involved in allocating a set of resources may also benefit from this quantitative system level value analysis to support high-level portfolio decision making.

5 Conclusions

Quantitative portfolio value analysis, which addresses the perspectives of multiple stakeholders, offers many advantages such as more informed, coordinated, and objective decision making. This ability to maintain the perspective of war fighter value based on capability priorities alongside performance data enhances the robustness of the resource allocation decision-making process. This objective perspective may be achieved by taking into consideration portfolio criteria such as what is shown in Figures 34, 35, 36, and 37 along with the cumulative program value score shown in Figures 38 and 39.

Currently, program-funding allocation is based on program performance. Funding cuts commonly lead to a poor reflection on the program management assigned to the given program. If additional factors such as program risk and benefit are objectively factored in, this may lead to a more effective exit strategy for program capabilities, which are no longer required.

In addition to these benefits in the Acquisition System, there are benefits to be had in the future year planning cycle as well. Graphs of portfolio level value data can assist in the programming and budgeting processes in order to achieve portfolio level capability goals, balance risk while meeting budgetary requirements. During the course of developing this analysis to support programming and budgeting decisions, value criteria and program priorities will be captured for use during the Acquisition phase of program execution to support staffing and resource allocation decisions.

6 Recommendations For Future Work

This work is a first step in the research of quantitative system-level portfolio value. In section 4.5, several value criteria were identified for future development due to data sensitivity concerns or simply limitations on resources to complete this initial research. Some key areas to develop include dependencies between programs where oneprogram influences the capability realized with other assets, relative capability competencies with other leading world countries, and factoring in regional priorities. In addition to Air Force Capability Priorities, the Combat Commander Regional Priorities, Legislative Branch priorities, and fluctuating external factors also need to be addressed in the value criteria. There are also potentially additional criteria in the risk category, which have not yet been explored.

Once these criteria have been identified, a regression analysis may be performed based on historical data to verify correlation between each value criteria and the program value realized. This data may be verified against data found from tracing changes to POMs, which occur during the programming phase to reflect values of the current system of stakeholders. Once the value criteria is verified via a regression analysis, there lies a potential for a portfolio optimization tool based on the specified value criteria.

In order to implement a portfolio level value analysis, the following four items need to occur. First, a specific organization needs to claim ownership of gathering and reporting data. Value criteria information may be requested as part of the POM or similar accompanying form document to support the future year planning cycle. Ideally, this form would be submitted in a digital format so data will be easily accessible for

compilation at the portfolio level. Rules of thumb will need to be applied in order to consistently report value data for programs in light of the mismatch between program and program element reporting. Second, a champion is required in both SAF/AQ and AF/A8 to make decisions based on this quantitative portfolio value assessment. Third, a specific event in the process needs to be identified as the point at which this analysis will be used to support resource allocation decisions, with plans to include a specific meeting and stakeholders who need to be represented. Lastly, a specific organization needs to be identified to be responsible for updating the value criteria each year based on each stakeholder organization's current leadership priorities. The criteria need to be updated to include both internal as well as external environmental influences.

Another area to be addressed is how to measure multiple PEO portfolio values within the larger scale RDT&E portfolio. This means that the value criteria developed will need to have sufficient detail to capture relative program and portfolio value while maintaining uniformity across many different platforms. An example of this type of analysis is shown in Figure 42.

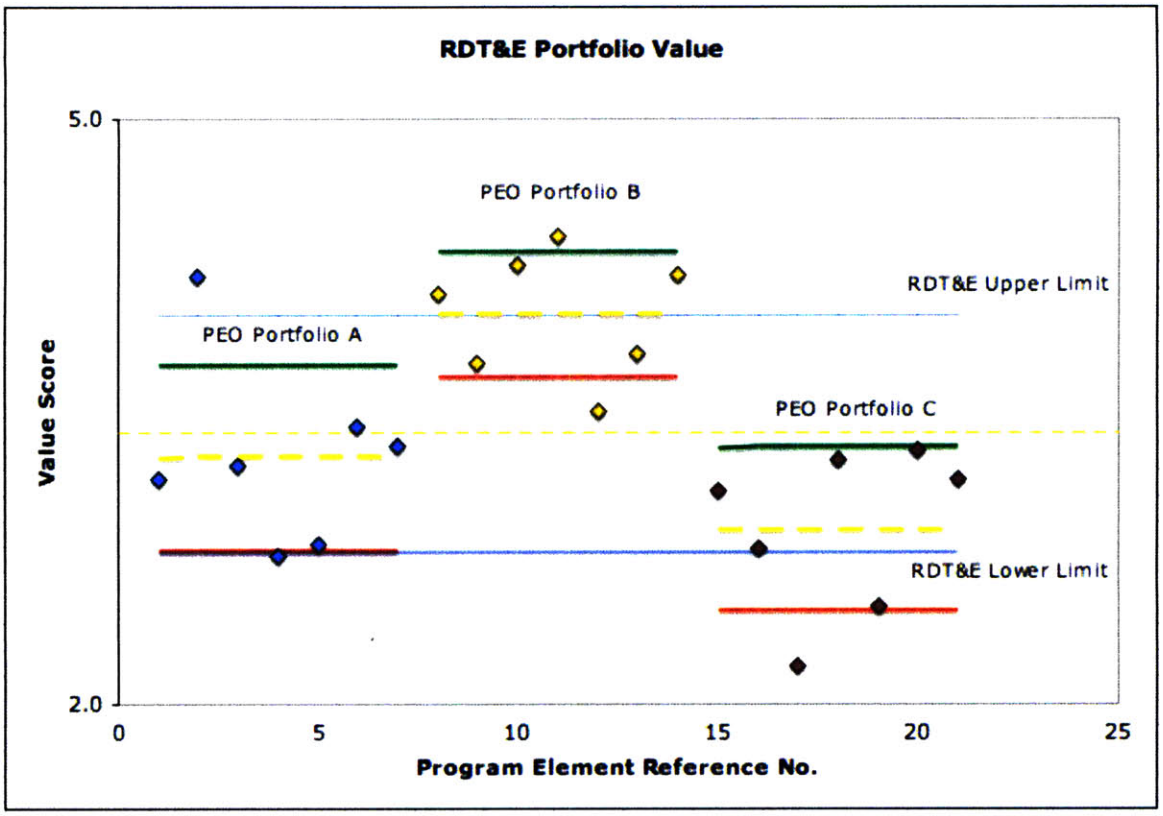


Figure 42: RDT&E Portfolio Value

In addition to broadening the scope of the number of program results displayed in the analysis, the portfolio value as a function of time may also be explored. This would show which programs increase and decrease in value when the value criteria have changed or program execution has changed over time. An example of this concept is shown with a histogram in Figure 43 below.

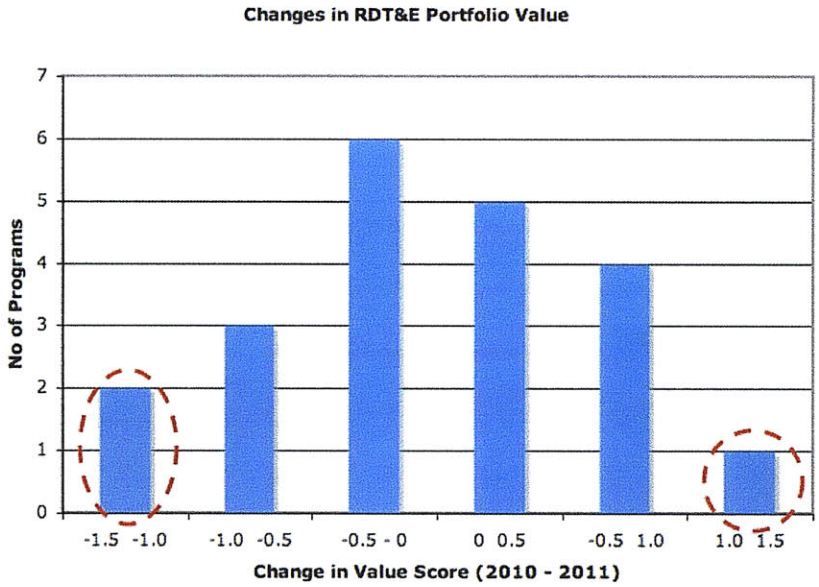


Figure 43: Changes in Portfolio Value Over Time

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