



NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

**OPTIMIZING ARMY COMMUNITY SERVICE TO
GUIDE INVESTMENT STRATEGY**

by

Beaux B. Lane

June 2020

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**OPTIMIZING ARMY COMMUNITY SERVICE TO GUIDE INVESTMENT
STRATEGY**

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ABSTRACT

The Army Community Service (ACS) lacks a quantitative evaluation methodology to determine the value generated by its portfolio of programs. This thesis follows a systems engineering approach to construct value models that determine the programmatic value scores based on performance. The programmatic performance supports the optimization of funding to maximize the organization's value. This thesis executes an iterative approach to incorporate the budgetary constraints from past years, attribute weights from qualitative analysis, and value scores through quantitative calculations. The Employment Readiness Program generates the most value because it satisfies more attributes than the other programs. This thesis helps identify the strengths and weaknesses of individual programs to shape training and to address areas of weakness. The thesis also supports future work that similarly explores all programs that compete for funding.

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List of Acronyms and Abbreviations

ACS	Army Community Service
AHP	analytical hierarchy process
AR	Army Regulation
BRAC	Base Realignment and Closure
CBR	cost-benefit ratio
CFD	cumulative frequency distribution
CONUS	continental United States
CPM	Capital Planning Model
CYS	Child and Youth Services
DA	Department of the Army
DoD	Department of Defense
EAP	Employee Assistance Package
ERP	Employment Readiness Program
FAP	Family Advocacy Program
FMWR	Family, Morale, Welfare, and Recreation
FRG	Family Readiness Group
FRP	Financial Readiness Program
FY	fiscal year
ICE	interactive customer evaluation

IMCOM	Installation Management Command
INCOSE	International Council on Systems Engineering
IOMA	Institute of Management and Administration
MADM	Multi-Attribute Decision Making
MDSS	Mobilization and Deployment / Stability Support
MWR	Morale, Welfare, and Recreation
NAF	nonappropriated funds
NEO	Noncombatant Evacuation Operations
OCONUS	outside the continental United States
OSD	Office of the Secretary of Defense
PCS	permanent change of station
POM	program objective memorandum
QACS	Qualified Army Community Services
ROI	return on investment
SOS	Survivor Outreach Services

Executive Summary

The Installation Management Command (IMCOM)-Pacific Army Community Services (ACS) currently lacks a quantitative evaluation method to determine the optimal funding strategy based on program performance. Specifically, ACS lacks criteria and data to support the evaluation process to ultimately determine future investments. This thesis develops a methodology and evaluation process to develop a funding strategy based on maximizing total program value for IMCOM-Pacific ACS programs at Schofield Barracks, HI. The thesis collected and evaluated data from individual soldiers, family members, and retirees to support evaluation of programs. The program evaluations anchor the secondary investment analysis to maximize ACS value.

ACS supports the IMCOM-Pacific by providing unique programs that promote problem solving skills to improve soldier readiness. ACS delivers, “programs that support self-confidence, build resilience, and reduce stress on soldiers and their Families, enabling readiness and furthering the objectives of a globally responsive, all volunteer Army” [1, p. 3]. The full spectrum of programs offered through ACS ensures contact with each soldier at the beginning of a tour during a newcomer’s orientation through the completion of a tour with relocation services. ACS leveraged the Naval Postgraduate School (NPS) to develop a methodology, collect data, and analyze the results to evaluate its programs. Following the program evaluation, the thesis calculates an investment strategy that maximizes the value generated by the programs.

The thesis followed a sequential mixed-methods research approach to systematically determine the individual program value scores and to calculate the optimal investment strategy. Figure 1 illustrates the qualitative, quantitative, and optimization phases used to evaluate ACS programs.

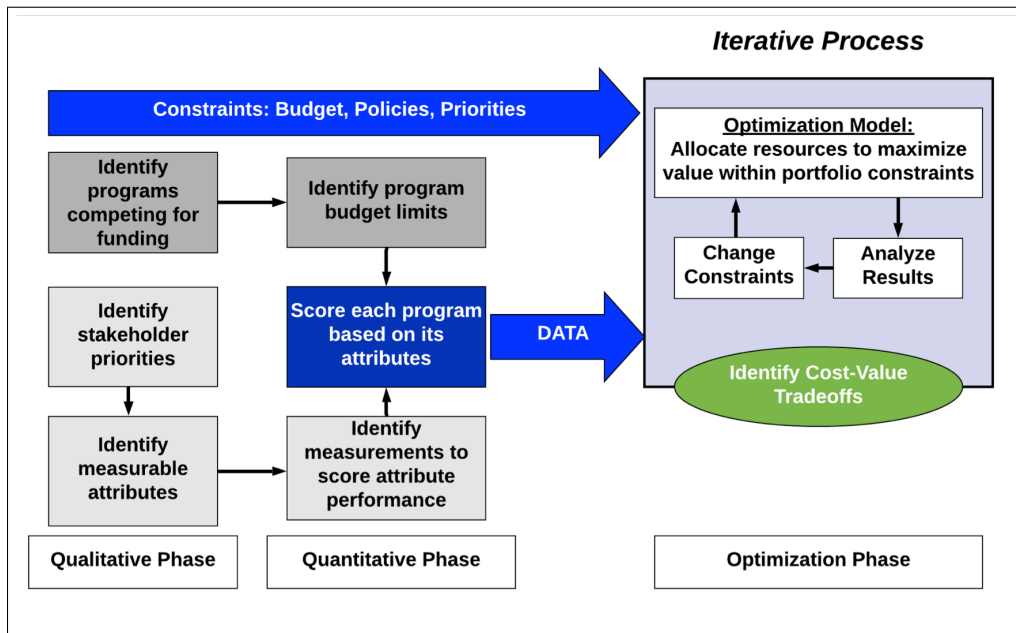


Figure 1. ACS Analysis Approach. Adapted from [2].

The qualitative phase initiated the project and established lines of communication through which the project would operate. This phase produced three outputs: identification of the competing programs, measurable program attributes, and attribute weighting by stakeholder priorities. Table 1 displays the attributes and weights which concluded the qualitative phase.

Table 1. IMCOM-Pacific Calculated Attribute Weights. Source: [3].

Attribute	Weight
Debt Reduction	0.11
Financial Confidence	0.14
Utility	0.15
Resource Confidence	0.23
Skill Confidence	0.10
Secure Environment	0.27

Previous efforts to construct a research framework [3] concluded that the overall objective for ACS is to improve soldier readiness and suggested four objectives to evaluate soldier readiness: financial capability, well-being, morale, and safety. The qualitative phase of

this research confirmed the previous findings and provided a framework through which to proceed with quantitative analysis phase.

The quantitative phase utilized the value modeling technique to evaluate all the programs. The attribute value achieved v_i by an ACS program j can be calculated by determining the importance of each attribute through weighting w , converting the program's performance x of individual attributes i into a value score, and adding the scaled attributes within the program together. The conversion of the programmatic performance occurred with a value curve derived from empirical data or theoretical expectations. The study analyzed both curves and evaluated the performance with the curve that reduced the variance between actual data points and predicted data. With six attributes, the descriptive equation displayed by Equation 1 calculated the individual program's value, PV .

$$PV = \sum_{i=1}^n w_i \times v_i(x_i), \quad i = 1, \dots, n \text{ attributes} \quad (1)$$

Next, the phase established a collection strategy, analysis criteria, and tool set to analyze data points for programmatic evaluation. The NPS Institutional Review Board (IRB) reviewed thesis surveys and determined the collection methods did not require IRB approval. The surveys contributed to the evaluations on financial capability, well-being, and morale. The family advocacy reports provided data to support the evaluation on the secure environment attribute. The total value of ACS programs as an organization is the unweighted sum of the individual program values across all programs as shown by Equation 2.

$$ACS \text{ Value} = \sum_{j=1}^m \sum_{i=1}^n w_i \times v_i(x_{ij}) \quad (2)$$

$i = 1, \dots, n \text{ attributes} \quad j = 1, \dots, m \text{ programs}$

The final phase of optimization focused on the funding strategy to maximize the value outlined by Equation 2. The optimization phase incorporated the budgetary constraints from historic budgets and program performance from the quantitative phase. The optimization made the following assumptions before calculating the funding distribution:

- Each weighted ACS program value scores is constant.
- A program's value to ACS is proportional to the percent of budget that is allocated to it.
- The total expenditures for all programs will not exceed the maximum ACS budget from FY15, FY16, and FY19.
- Programs for which no data was available to compute value is not a part of the optimization formula.
- Specific ACS program budgets do not exceed their historic maximum program budgets.
- No monies will be left in reserves.

Equation 1 and Equation 2 describe the general equations for value modeling. The optimization model calculates the optimal funding strategy by varying the investment percentages, I_j , across the programs, j , between the minimum and maximum historic levels. The program value, PV_j , for each program j from Equation 1 accrue to calculate ACS Value. The investment percentage scales the actual value achieved according to the investment allocated. The study calculated the optimal funding strategy with Equations 3-6.

$$\begin{aligned} \text{Maximize}_{ACS} \quad & I_j \sum_{j=1}^m PV_j \\ & j = 1, \dots, m \text{ programs} \end{aligned} \quad (3)$$

Subject to:

$$\sum I_j \times Budget_{j,Max} = 100\% \times Max\ FY(Budget_{ACS}) \quad (4)$$

$$I_j \geq \frac{Min(Budget_j)}{Max(Budget_j)} \quad (5)$$

$$I_j \leq \frac{Max(Budget_j)}{Max(Budget_j)} \quad (6)$$

Constraint Equation 4 ensures that the total expenditures across all programs do not exceed the ACS budget. During each evolution of potential solutions, the model limits the expenses to the organizational budget. Individual programmatic investment boundaries manifested in constraint Equations 5 and 6. The historic budgets established the minimum and maximum funding levels for future spending. This ensures each program gets funded at minimum funding levels to accomplish the mission.

The thesis systematically evaluated ACS programs through weighted attributes, program performance, and an optimal investment strategy. Stakeholder analysis confirmed the finding of previous work and incorporated the values into the value model.

The quantitative phase evaluated the data collected to convert the programmatic performance into a value score. Table 2 displays the program value scores derived from attribute performance. The historic budgets provided the basis to establish the minimum and maximum values for the optimization phase.

Table 2. ACS Program Value Scores

ACS Program	Program Value Score
FAP	0.65
MDSS	0.30
FRP	1.19
SOS	1.03
Relocation	0.00
ERP	1.23
Total	4.41

The result of the calculated program values with the attribute weights and program performances created a priority list based on overall program values. Programs with the highest total value scores became a higher priority for funding resulting in the following prioritized list:

1. Employment Readiness Program
2. Finance Readiness Program
3. Survivor Outreach Services
4. Family Advocacy Program
5. Mobilization and Deployment / Stability Support

ACS achieves the maximum value of 4.41 if all programs are fully funded. Figure 2 explores the impacts of budget cuts at 10% intervals. At 90% of the FY19 budget, three programs remain fully funded and ACS achieves 5% less value. After another reduction to 80% of the FY19 budget, the three lowest priority programs get funded at minimum levels. ACS generated 20% less value with this 20% budget cut. The dashed red line indicates the point at which all programs are funded at their historic minimum levels. Below the minimal funding levels the solution becomes infeasible because the model can not satisfy all constraints. However, when all programs get funded at minimum levels, ACS achieves a value score of 2.63, a loss of 40% value.

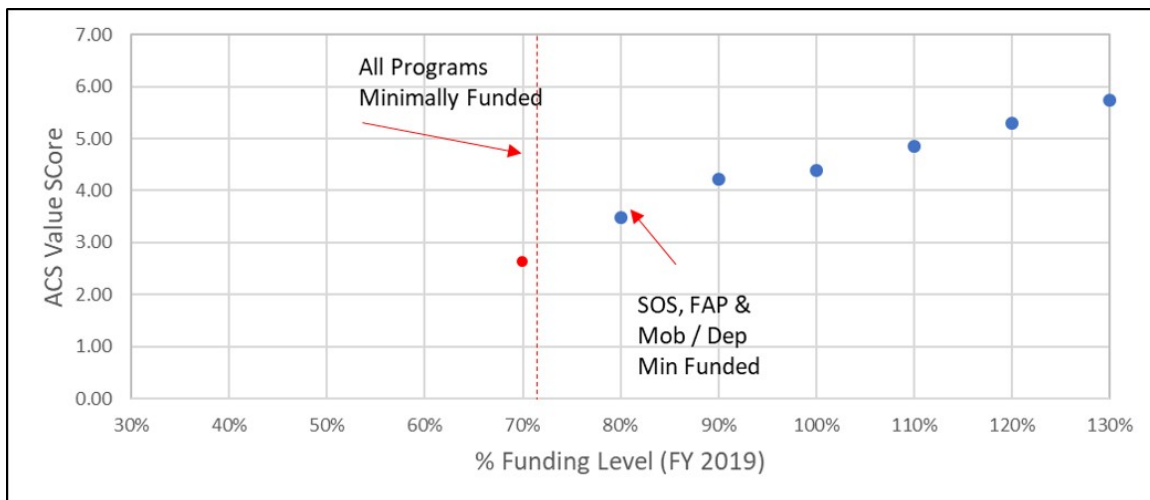


Figure 2. Impacts of FY19 Budget on ACS Value

The study measured all programs according to common attributes which allowed the comparison of all programs. The comparison set a priority list for the investment strategy. Figure 3 displays the calculated optimal funding levels to maximize the ACS value. The success of the study allows the stakeholder to critically look at the program's performance for future budgeting decisions.

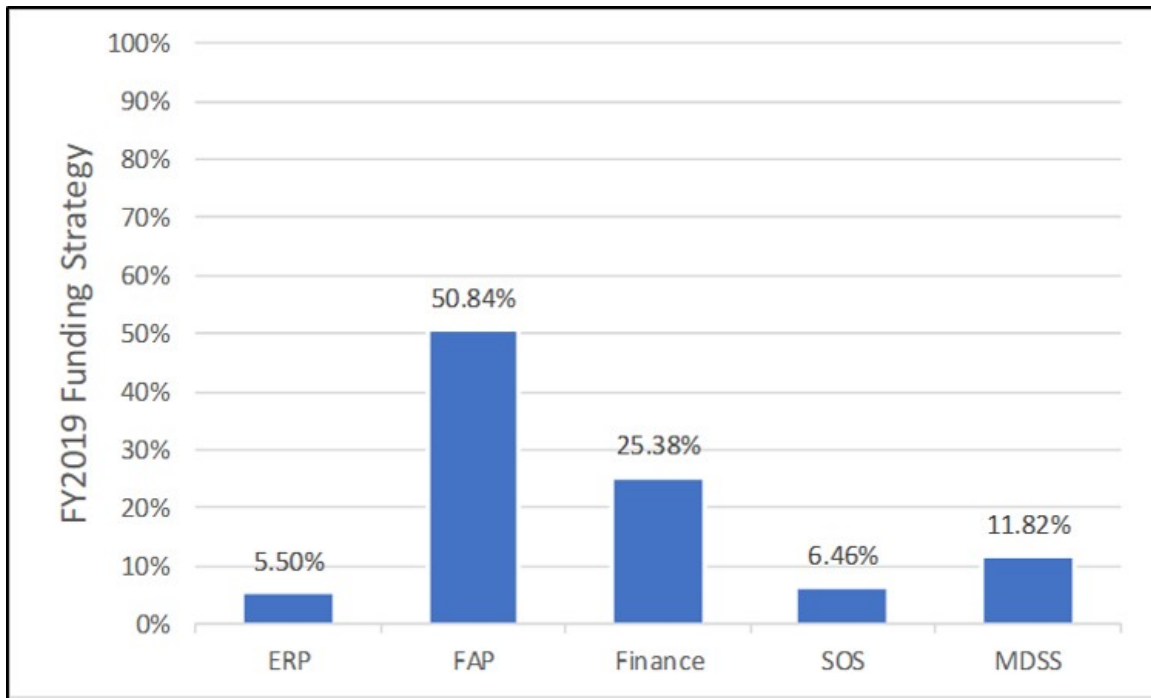


Figure 3. Optimal Allocation for FY 2019 ACS Budget

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- [2] Army Deputy Chief of Staff G-8, "Capital Planning Model," presented at Pentagon, Washington, DC, 2011.
- [3] S. Albahari, T. Doane, A. Hines, M. Miskowski, and J. Williams II, "Developing an assessment framework to aid the Installation Management Command IMCOM-Pacific investment strategy," M.S. thesis, Naval Postgraduate School, Monterey, California, 2019.

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CHAPTER 1:

Introduction

1.1 Purpose

The focus of this thesis is to assist the Army Community Service (ACS) operating in the Pacific Region to determine the optimal investment strategy for their portfolio of programs. Currently, ACS operates as a system of systems reliant on organizational funding to maximize its value. This research requires a systems engineering approach to evaluate the common system attributes through measurements and individual value curves to calculate the most optimal investment strategy through goal programming. The optimal resource funding strategy returns the largest organizational value score while accounting for budgetary constraints, attribute weights, and a program's performance.

1.2 Background

ACS supports the Installation Management Command (IMCOM) – Pacific by providing unique programs that promote problem solving skills to improve soldier readiness. ACS delivers on the mantra, “programs that support self-confidence, build resilience, and reduce stress on soldiers and their Families, enabling readiness and furthering the objectives of a globally responsive, all volunteer Army” [1, p. 3] advertised by the G9-Family, Morale, Welfare, and Recreation (FMWR). The full spectrum of programs offered through ACS ensures contact of each soldier at the beginning of a tour during a newcomer's orientation through the end while training lessons learned for improved relocation practices.

The funding of all FMWR programs, which ACS falls under, originates from direct appropriations, appropriated funds, and nonappropriated funds [1]. ACS is funded by Qualified Army Community Services (QACS) and OSD 97 Family Advocacy Program (FAP) direct appropriations which earmark a designated amount of money against personnel, training, continuing education, certifications, and supplies. Since ACS relies on appropriated funding, evaluations cannot rely on traditional metrics of profits and losses to determine success or failure [2]. Responsible funding requires an evaluation of all programs against common

attributes to ensure ACS generates the most value while being good stewards of resources.

The current evaluation framework lacks a quantitative strategy to identify programmatic values to justify any follow-on investment plan. Critical analysis requires a data collection plan to calculate the quantifiable metrics of each attribute. ACS has leveraged the Naval Postgraduate School to develop a collection plan, evaluate individual programs according to the common attributes, and calculate the optimal distribution of funds to generate the maximum value.

1.3 Problem Statement

ACS leadership currently lacks quantitative data to justify an investment strategy to maximize the organization's value. The absence of a validated strategy to collect measures of the common attributes inhibits the ability to effectively understand the potential impacts of their investment decisions. This thesis attempts to address this shortcoming by answering two questions:

1. How can the value of each ACS program and its aggregate be computed in terms of soldier readiness?
2. What is the most effective investment strategy to maximize the value of ACS to improve soldier readiness?

1.4 Scope and Boundaries

ACS has offices throughout the Department of the Army landscape with unique needs depending on the individual location. This thesis focuses efforts in evaluating the programs offered to the 25th Infantry Division at Schofield Barracks, Hawaii. The Schofield Barracks ACS offers a Family Advocacy Program, Mobilization and Deployment / Stability and Support Operations Readiness, Financial Readiness Program, Survivor Outreach Services, Relocation Readiness Program, and an Employment Readiness Program. While the thesis focuses on a single installation, the application supports the various missions throughout the region. The thesis makes the following assumptions:

1. A single budget will account for all funding sources.
2. Data collection over a period of four months provides sufficient data to identify trends.

3. ACS can only improve soldier readiness during individual or mass instruction.
4. Each program's value has a linear relationship with the overall value of ACS.
5. ACS leadership will allocate all resources and not hold any in reserve.
6. The percentage of total budget spent on the individual programs will equal the percentage of value received from that program.

1.5 Thesis Objectives

This thesis has three objectives: validate proposed attribute weights, develop value curves, and calculate a funding allocation based on the optimal funding strategy. The first objective to validate the proposed attribute weights expands and refines the measures published in previous work. This refinement process will identify any measure that fails to impact the primary or subordinate objectives. After refining the measures, the next step will be to justify the appropriate value curve by at least one of three ways: theoretical, operational, or empirical. Each value curve will provide the basis by which each attribute contributes to the overall programmatic value score. Finally, the thesis will utilize the unique programmatic value scores to calculate an optimal funding strategy accounting for budgetary constraints.

1.6 Benefits of Thesis

Relevant, Defendable, Traceable and Repeatable Evaluation

Decision makers can use the set of value models developed in this thesis to make better and informed decisions. As data collection continues beyond the current period, periodic reviews to validate attribute weights and individual value scores could help refine future optimization of the ACS program operating models. Since the sample data will represent a relatively short period of time, the construct will support follow on refinements.

Quantify the ACS Value Towards Improving Soldier Readiness

The thesis extends previous works to develop the ACS analytical framework to quantify the value of the ACS program. As a result of this study, decision makers can better prioritize resources and trainings to maximize soldier readiness.

Application Beyond ACS program

The methodology used in this thesis to analyze data has potential use throughout Department of Defense (DoD) to systematically evaluate multiple programs competing for funds from a single source.

1.7 Organization of Thesis

Chapter II is a literature review to provide a background on the ACS mission and the references that justify the methodology utilized to evaluate the individual programs within ACS. Chapter III is a description of the methodology used to develop the data collection methods with supporting measures of effectiveness. Chapter IV reports the collected data and analyzes the findings of the value models developed. Chapter IV will also incorporate known budgetary constraints to calculate the optimized investment allocation to maximize value. Chapter V will conclude the thesis by outlining the individual ACS program contributions to the overall objectives of improving soldier readiness and provide insights and recommendations for future studies.

CHAPTER 2:

Literature Review

This chapter reviews archived information required to better understand the methodology for evaluating and funding ACS. The goals of the literature review establish a framework for the organizational context, value modeling, and linear programming for investment optimization. First, the chapter provides a background into the organizational hierarchy and funding conditions along with the services offered at IMCOM-Pacific. Next, the study describes a variety of approaches to sequence the quantitative components of value modeling: weighting options, utility metrics, and value curve development. Optimization incorporates the total value scores to effectively allocate funds. A review of optimization and its application provides justification for its necessity in programmatic funding. Lastly, the chapter will describe the appropriate data collection methods from current and historical records.

2.1 Overview of IMCOM-Pacific ACS

2.1.1 ACS Mission

This thesis references regulations and published guidance. ACS operates as a portfolio of programs under a single organizational office. The Army states that the ACS mission is to, “facilitate the commander’s ability to provide comprehensive, standardized, coordinated, and responsive services that support soldiers, Department of the Army (DA) Civilians, and families regardless of geographic location” [3, p. 1]. Since the ACS offices operate across a diverse set of geographical locations with varying needs, available services provided align with the commander’s priorities, mission, and specific geographical needs.

ACS supports the IMCOM – Pacific by providing unique programs that promote problem solving skills to improve soldier readiness. FMWR advertises the mantra, “programs that support self-confidence, build resilience, and reduce stress on soldiers and their families enabling readiness and furthering the objectives of a globally responsive, all volunteer Army” [1, p. 3]. Fully funding all programs at historic levels has become unrealistic under the current fiscally restrictive environment; therefore, ACS must have an evaluation process to better allocate its limited resources.

2.1.2 ACS Organizational Structure

Structure

ACS operates as a division underneath the IMCOM - Pacific G-9/FMWR along with Recreation, Business, Child and Youth Services (CYS), and nonappropriated funds (NAF) Support Services shown in Figure 2.1.

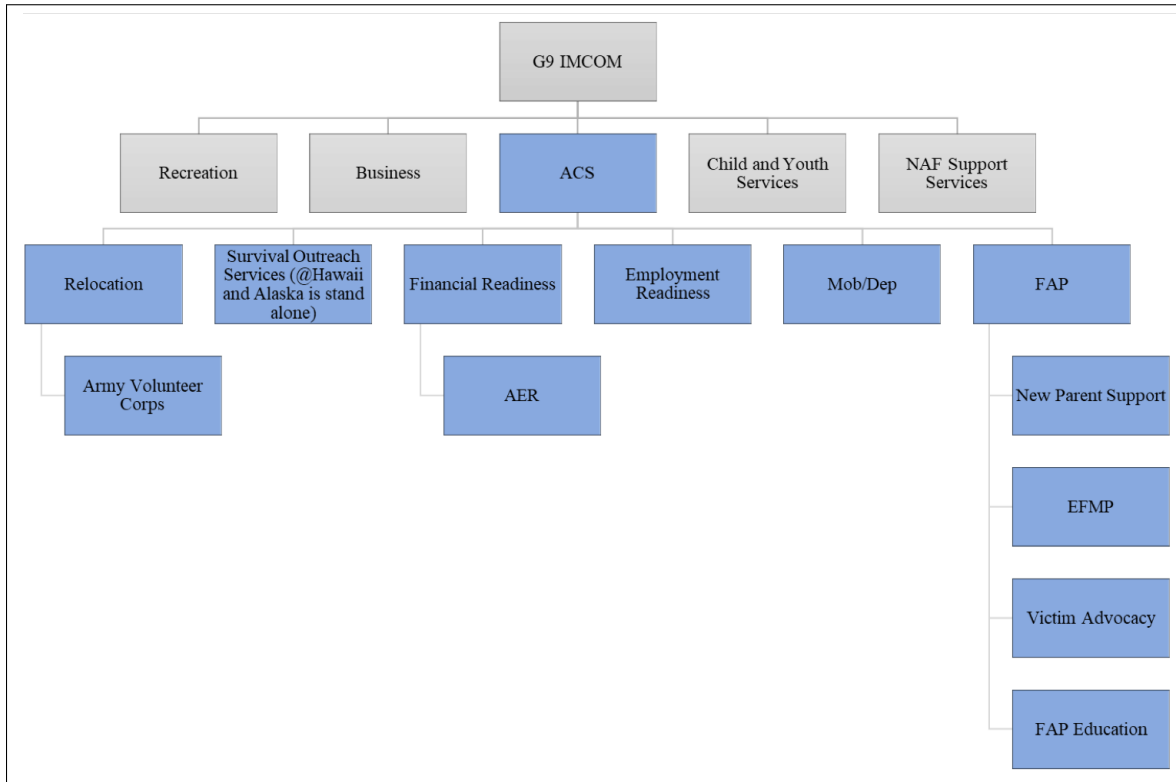


Figure 2.1. ACS Organizational Structure. Source: [2].

At the regional level, ACS works closely with the regional command team to integrate policies and report findings on family welfare to shape the commander's resourcing plans. At the headquarters, the ACS office advocates on behalf of the field offices for adequate resources to support the commander's priorities. An additional major function for the regional ACS office involves publishing guidance to the subordinate field offices to communicate the command's requirements and requests for information.

The direct interaction with soldiers and families occurs at the field office level through a

variety of contact opportunities. Before soldiers join their respective units, ACS initially contacts all soldiers through a newcomer's orientation to advertise services and provide contact information. ACS also interacts directly with battalion leadership teams to offer trainings that will satisfy the annual training requirements for domestic violence and prevention. While ACS always maintains the ability to educate and train in their own facilities, they have the flexibility of face-to-face counseling, class instruction, and community interactions as witnessed during a site visit.

Funding

G-9/FMWR funding originates from two primary sources: appropriated funds and nonappropriated funds. ACS does not generate funds. Therefore, direct appropriations through QACS and Office of the Secretary of Defense (OSD) P97 FAP earmark designated monies to go towards ACS personnel, trainings, continuing education, certifications, and supplies. Since ACS relies on appropriated funding, the decreases in appropriated funding could result in reduction of services or program closures [1]. In a funds generating program, funding is easily justified through a profit and loss statement. However, since ACS does not produce income, funding justification must expand beyond profits [2].

QACS funds also get divided further based on the post mission or region. For bases located throughout the continental United States, QACS funding gets divided to support the sustainment, readiness, and training missions. For those bases located outside the continental United States, the funds get separated into Pacific and European regions. Within the Pacific region, secondary division of funding goes to support the bases in Hawaii, Alaska, Korea, and Japan. With several locations competing for the same QACS funds, ACS must effectively allocate its funds wisely.

2.1.3 ACS Programs

Family Advocacy Program (FAP)

Family Advocacy hosts an assortment of classes and services that focus on the well-being of the individual family unit. These services include new parent support programs, family counseling, domestic violence prevention, and victim advocacy support to “provide sensitive, timely and effective support. . . to promote short-term recovery, long-term recovery,

and the return to a stable environment and mission-ready status following all-hazard incidents” [3, p. 17]. In a domestic violence situation, family advocacy can coordinate efforts to support medical recovery, legal advice, or law enforcement support for victims. In addition to Army regulations, additional supporting documentation include DODI 6055.17 DoD Installation Emergency Management Program and 10 USC 1059. These services include outreach services, family team building, family action planning, and emergency placement care.

Mobilization and Deployment / Stability Support (MDSS) Operations Program

Mobilization and Deployment helps families to plan for the additional stresses incurred throughout the deployment cycle beginning with deployment preparations and concluding with the reintegration. MDSS “will ensure that a comprehensive, realistic, effective, and coordinated assistance delivery system exists before military operations” [3, p. 15]. While preparing for deployments, MDSS works directly alongside unit commanders to offer full-service planning techniques to identify key rear detachment personnel, emergency personnel, community coordinators, personal service counselors, and an assortment of other contacts that have historical significance. During a deployment, MDSS works alongside Family Readiness Group (FRG) to identify any demands that may exceed local knowledge. These services include family care planning, FRG training, reunion briefings, and emergency family assistance.

Financial Readiness Program (FRP)

The FRP serves two primary objectives of soldier readiness, unit deployability and individual self-sufficiency [3]. To obtain security clearances, soldiers must undergo a required background check that investigates an individual’s financial history. For those that have demonstrated financial irresponsibility, the ability to receive or maintain a clearance becomes challenging for fear of financial compromise. FRP provides all levels of counseling, training, and education to prevent the consequences associated with financial hardships to include filing bankruptcy, poor credit scores, or qualifying for loans. The services include budgeting, debt liquidation, financial decision making, and consumer protection advocacy [4].

Survivor Outreach Services (SOS)

Survivor outreach services provide a connection to the surviving family members of a fallen soldier. Public Law 113-66, Section 633 outlines the requirements for military departments to continue support Gold Star Families without an expiration date. Support coordinators support families, “through this difficult transition by providing direct services as well as information, referrals, and recommendations” [5]. The services provided include facilitation to a local support group, spiritual resources, bereavement organizations, and financial counselors. SOS is the only program who will directly benefit a population external to the military member. This program also supports those selected as casualty assistance representatives by a unit to assist the families of fallen soldiers, fulfilling the requirement of Public Law 113-66, section 633.

Relocation Readiness Program

The Relocation Readiness Program assists the individual and family units to better prepare for the instability that occurs during a permanent change of station (PCS) move. A single term soldier will move at a minimum of three times during his service obligation which gets even more complicated when accounting for dependents. The Relocation Program seeks to “reduce or eliminate problems arising because of frequent moves” [3, p. 19]. Soldiers that fail to account for the additional time of travel to Hawaii can live weeks without household goods such as flatware, furniture, and clothing. The Relocation Program has established a lending closet to assist incoming and outgoing families with basic items to sustain normal life activities without having to purchase additional sets. Relocation services include overseas orientation, reentry workshops, newcomer orientations, and cross-cultural training.

Employment Readiness Program (ERP)

ERP “assists individuals in acquiring skills, networks, and resources that will allow them to participate in the work force” [3, p. 21]. With established relationships throughout the local community, ERP looks to leverage their experience with the needs of employers to shape prospective employees in current job openings. ERP also supports those seeking to sharpen their current skills, learn additional skills required, and plan a long-term career. These services include resume writing, job fairs, employment development locally and nationally, and networking.

2.1.4 ACS Objectives Traceability

ACS manages a portfolio of programs that offer services to improve soldier readiness [2] through four sub-objectives: increase financial capability, improve well-being, increase morale, and improve safety shown in Figure 2.2. Keeney suggests the need in developing metrics to measure the achievements of such objectives [6]. This quantifying step occurs through common attributes and achievable measures with data collection. Each measurement has a specified purpose and must trace back to an objective. “Subjectivity highlights the need for traceability and should provide an explanation that justifies the assessment” [7, p. 327]. For this reason, a well-documented traceability matrix shows the links between the higher-level objectives to the lower level measures also displayed in Figure 2.2. Most importantly, the matrix maps the individual data points that generate a measure; the measure quantifies the performance of an attribute; the attributes support the quantifiable achievement of an objective. The direct links between the identified measures to a specific sub-objective become the basis for data collection.

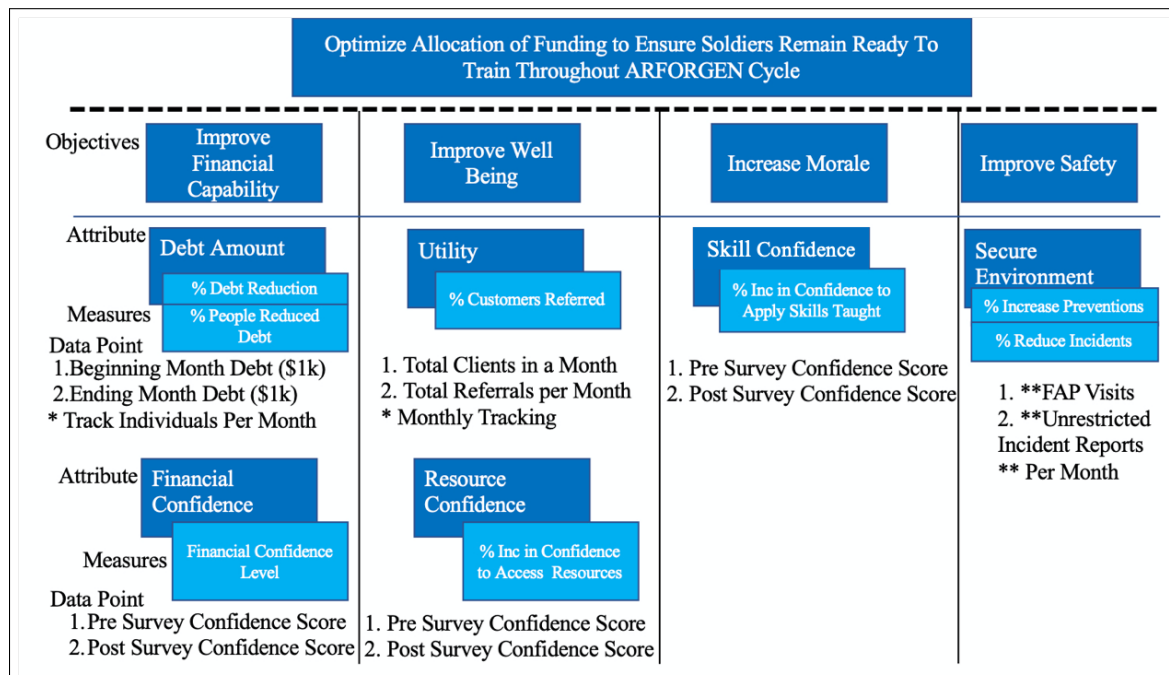


Figure 2.2. ACS Objectives Traceability Matrix. Adapted from [2].

Next, the programs operating under the umbrella of ACS enable the organization to perform

a host of functions. System functions can only add to the overall value once mapped to one or more of the previously identified system objectives. If the function does not map to an objective, the performance of that function does not get the stakeholder closer to the overarching objective. Figure 2.3 traces the documented functions to the approved objectives.

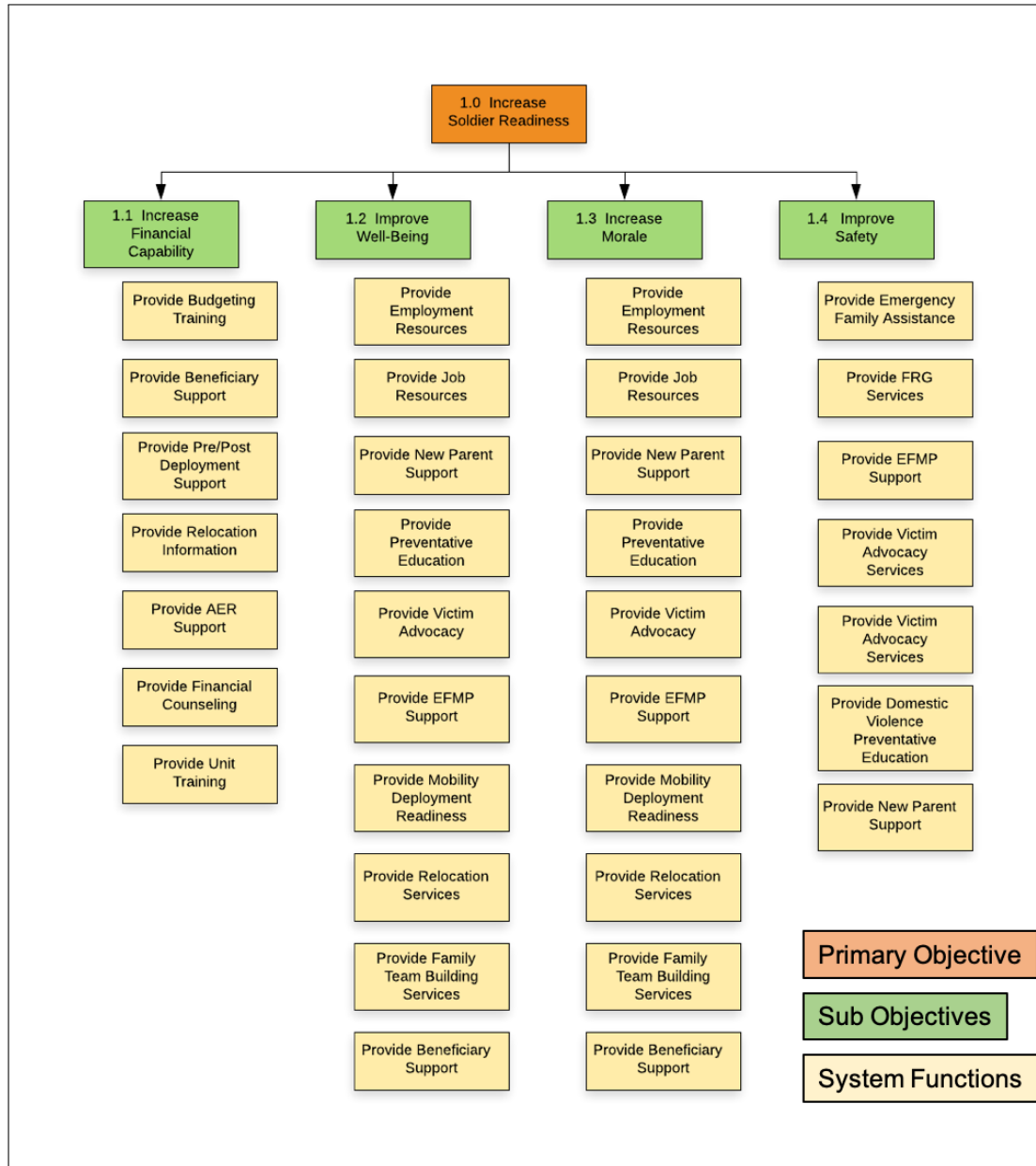


Figure 2.3. ACS Traceability of Functions to Objectives. Adapted from [2].

2.2 Systems Engineering Approach

Systems engineering has various approaches to develop capabilities based on the appropriate life cycle stages. While it may appear that the development follows a general pattern, the underlying process may indicate specific patterns that distinguish each approach. The International Council on Systems Engineering (INCOSE) describes three approaches that have unique characteristics to fulfill the needs of a project [8]:

- Iterative and Recursion
- Sequential
- Incremental and Iteration

2.2.1 Iteration and Recursion

The iteration approach incorporates updates and changes through feedback mechanisms that support learning and decisions over time [8]. The performance of a system depends on the underlying parameters which may result in insights into the individual system's performance levels. For example, every year the Army G-8 analyzes program funding levels to maximize the portfolio value with the Capital Planning Model (CPM) shown in Figure 2.4. The CPM incorporates the qualitative and quantitative techniques required to define stakeholder needs, identify measurable attributes, and measure the performance of the attributes. Most importantly, the optimization model uses the constraints and program performance data to choose a set of programs and funding options to maximize the value of the portfolio. The iterative process enables the analysis of a variety of combinations by altering the constraints of budget, policy, and priority conditions. Each combination produces a unique set of results with respect to cost and value. The analysis provides the decision maker a better understanding of the tradeoffs between the funding levels [9]. The relationships are initially unknown at the beginning of the process but the iterative approach ensures that learning over time has the opportunity to influence the final decision.

Recursion analyzes the impacts of a system's performance and requirements across multiple levels. "During the recursive application of the processes, the outputs at one level become inputs for the next successive level" [8, p. 32]. A system of interest often has design specifications to integrate into an existing system of systems with limited knowledge on the impacts. The recursion process ensures that an evaluation exists to determine how

one system's requirements will impact surrounding systems. Through the feedback loops, requirements analysis may discover some requirements are infeasible and force a redesign. The feedback loops are characteristic of both the iterative and recursion approaches for effective systems evaluations.

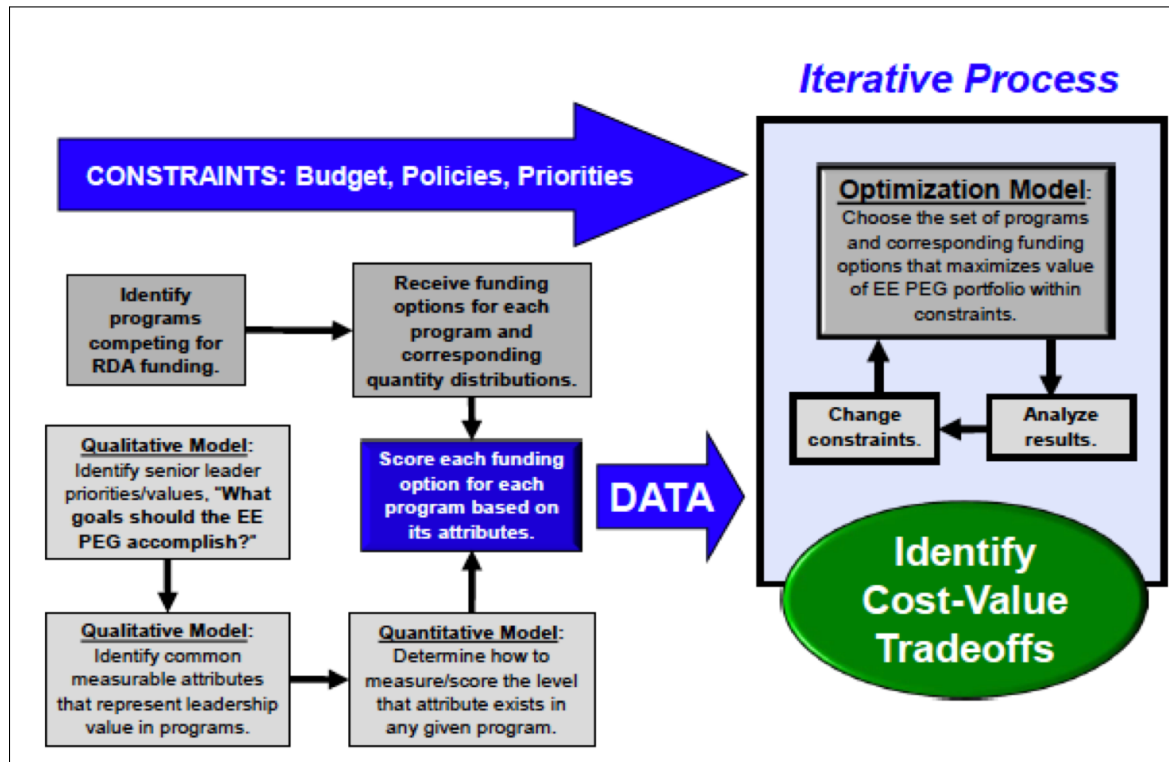


Figure 2.4. Army G-8 Capital Planning Model. Source: [9].

2.2.2 Sequential

The sequential approach follows a linear sequence of events where the conclusion of one step initiates the beginning of the following step. Forsberg and Mooz [10] created the Vee Model to capture the key technical aspects of a project's lifecycle as shown in Figure 2.5. The first half of the Vee Model displays the requirements decomposition and system design to satisfy user needs [11]. The project lead documents and gains stakeholder approval of the technical aspects before system entering the implementation phase. "Integration and verification flow up and to the right as successively higher levels of assemblies, units, components, and subsystems culminate at the system level" [10, p. 37]. The conclusion of this process only

occurs when a system satisfies the approved requirements from the earlier phases. The sequential method provides the advantages of a well established and repeatable process that incorporates stakeholder decision points before proceeding to subsequent phases.

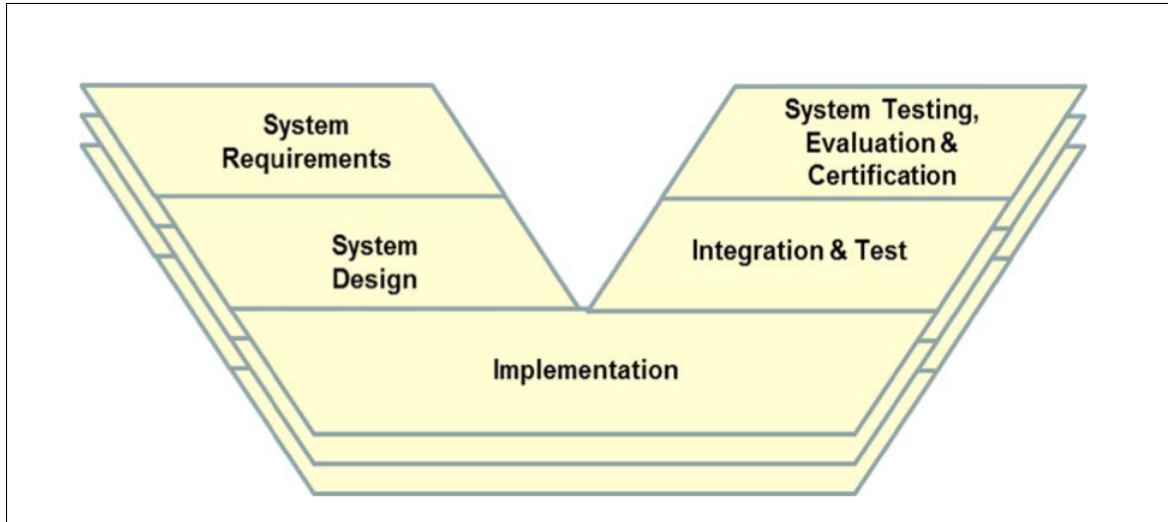


Figure 2.5. Key Elements of the Vee Model. Source: [12, p. 5].

2.2.3 Incremental and Iterative

The incremental and iterative approach allows for the delivery of an initial capability followed by subsequent upgrades to generate a system of interest [8]. In 2010, the Acting Secretary of the Army for Acquisition, Logistics, and Technology (ASA ALT) stated that incremental buys and incremental builds was the best strategy [13]. The Army no longer could tolerate long-term development for a single capability. This method also protects the stakeholder from large investments that potentially limit the investments of alternative programs. The incremental and iterative approach provides a method to generate and continually develop newer technologies to support the stakeholder needs in a more timely manner.

2.3 Multiattribute Decision Making

2.3.1 Overview

Multi-Attribute Decision Making (MADM) leverages value modeling to quantify a program's performance across several common attributes for comparison. This process involves developing common attributes, determining the importance of the attributes, and calculating the performance with respect to the attributes.

2.3.2 Value Modeling

The value generated by an ACS program can be calculated by determining the importance of each attribute through weighting w , converting the system's performance x of individual attributes i into a value score, and adding the scaled attributes within the program together. With six attributes, the descriptive equation displayed by Equation 2.1 will calculate the individual program's value.

$$Program\ Value = \sum_{i=1}^n w_i \times v_i(x_i), \quad i = 1, \dots, n\ attributes \quad (2.1)$$

ACS operates as a portfolio of programs and therefore must add all programs j together to gain an appreciation for its value. ACS value calculates according to Equation 2.2.

$$ACSValue = \sum_{j=1}^m \sum_{i=1}^n w_i \times v_i(x_{ij}), \quad i = 1, \dots, n\ attributes \quad j = 1, \dots, m\ programs \quad (2.2)$$

Weighting Factor

The weighting factor w determines the relative importance of each attribute to the overall objective. Weighting the attributes allows the stakeholder to prioritize the attribute's influence over the total value score [14], [15]. For example, performance levels in the highest priority attributes will dominate the impact on the total value score. When decision makers must consider the tradeoffs between purchase choices or allocating funding, not all options provide the same value. Weighting in value modeling “provides immediate insights into which alternatives are serious and which should be ignored” [11, p. 443]. Evaluators can

calculate this metric through multiple means: pairwise comparisons, rank order centroid method, swing weighting, or weight elicitation. Weighting occurs prior to calculating a program's performance ensuring preferred results are not artificially favored. The ACS attributes and weights are displayed in Table 2.1.

Table 2.1. IMCOM-Pacific Calculated Attribute Weights. Source: [2].

Attribute	Weight
Debt Reduction	0.11
Financial Confidence	0.14
Utility	0.15
Resource Confidence	0.23
Skill Confidence	0.10
Secure Environment	0.27

1. Pairwise Comparison

The pairwise comparison approach, also known as the analytical hierarchy process (AHP), allows the subjective comparisons of multiple attributes against one another to determine the criterion weight. Stakeholders can use subjective measures as listed in Table 2.2 or unique definitions to fit any study. The benefits of AHP leverages the stakeholders' preferences and judgement to determine the criterion weights with traceability. This structured approach can focus attention on the most important aspects of a problem in group environments with multiple stakeholders [16]. AHP allows the stakeholder to apply a preferential magnitude which will impact the associated attribute weight. [14], [15] In application, AHP has applied to decision making analysis, nodal characterization within social networking, and supplier performance within the timber industry demonstrating the flexibility across various industries [17]–[19]. Saaty points out the difficulty in measuring the magnitudes of difference based off of judgements. Judgements inherently fail to produce a universal scale to identify the magnitude of difference between each incremental rate of change. AHP accounts for lack of uniform rate of change and utilizes a hierarchic composition to derive composite priorities when considering multiple alternatives [20]. AHP can transform judgements into the comparative weighting metrics when capturing expert opinions.

Table 2.2. Fundamental Scale of Absolute Numbers. Source: [21].

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or Slight	
3	Moderate Importance	Experience and judgment slightly favor one activity over another
4	Moderate Plus	
5	Strong Importance	Experience and judgment strongly favor one activity over another
6	Strong Plus	
7	Very Strong or Demonstrating Importance	An activity is favored very strongly over another; its dominance demonstrated in practice
8	Very, Very Strong	
9	Extreme Importance	The evidence favoring one activity is of the highest possible order of affirmation

2. Rank Order Centroid

Using the rank order centroid method, the stakeholder ranks all attributes according to preference without indicating an associated magnitude. The method translates the ordinal values into the attributes' weight, w_i , by accounting for the total number of attributes, n , and the ranking of the attribute in question, r_i . The centroid's distribution of weighting results in a higher gap at the higher ranks, which more than likely better represents the sample population [22]. Barron and Barrett [23] calculate the weights derived through Equation 2.3 when using the rank order centroid method.

$$w_i = \frac{1}{n} \sum_{r_i=i}^n \frac{1}{r_i}, \quad i = 1, \dots, n \text{ attributes} \quad (2.3)$$

Roszkowska's research into comparing weighting methods concludes that the centroid method is preferable to AHP based on the accuracy and ease of use [24]. This method provides a simple mechanism for customers to provide feedback, and the reported accuracy ensures the responses provide insights into the true value. In application, the rank order centroid method helps reduce the uncertainty and subjectivity of weights when eliciting stakeholder feedback [22].

3. Swing Weight Method

The swing weight method elicits stakeholder input to categorize an attribute based on the associated level of importance and measurement variation. The analyst will assign a unitless value to the boxes and ensure that $A > B > C > D > E$. For all tables, the largest values will correspond to the High Importance - High Variation box, and the lowest value will correspond to the Low Importance - Low Variation Measures box as displayed in Table 2.3 [25].

Table 2.3. Elements of a Swing Weight Matrix. Adapted from [25, p. 5].

		Importance of the value measures to the decision		
		High	Medium	Low
Range of variation of the value measures	High	A 100	B2 80	C3 60
	Medium	B1 80	C2 60	D2 40
	Low	C1 60	D1 40	E 20

The stakeholders are solicited to assign each attribute to a corresponding box that satisfies the importance and measure range parameters. The associated value of the box represents the attribute's unnormalized value, f_i . The swing weight method normalizes the attribute values to determine the attribute weight. Equation 2.4 calculates the weight, w for the i th attribute by dividing the attribute's value, f_i , by the sum of all attributes.

$$w_i = \frac{f_i}{\sum_{i=1}^n f_i}, \quad i = 1, \dots, n \text{ attributes} \quad (2.4)$$

The Army Base Realignment and Closure (BRAC) study from 2005 [26] illustrates the swing weight approach in a real world application. The stakeholders quantified the attributes' importance based on the ability to change and variations of scale. The analysis considered 40 attributes Also to note, the value of each box decreases in the same manner as Figure 2.6.

Ability to change							
Variation of Scale	Large	Hvy mnvr area	Lt mnvr area	Inter-service partnering	Housing avail	RDTE diversity	Supply & Storage
		Direct Fire	Indirect Fire	Area cost factor	Crime Index		Operation / admin
		Bde Capacity			Maint. / manuf		Ammo Storage
		100	90	75	50	20	10
	Medium	Force deploy	Critical Infrastructure	Munition production	Work force avail	Military Ops	Applied instruction
		Material deploy	Test ranges	Urban sprawl		Urban Terrain	General instruction
		Airspace	Mobilization history	Accessibility			
		90	75	50		10	5
	Small	Buildable acres	Soil resilience	Job opportunity	Medical availability	C2 target bldg	
		Joint facilities	Water quantity	Noise contours			
			Installation unit cost	Air quality			
	75	50	Environment elasticity				
			Connectivity	20	10	5	1

Level of Importance		
High	Medium	Low

The benefit of categorizing attributes based on a simple determination of importance simplifies this weighting strategy. This strategy also provides flexibility in changing the box values. A simple change in value will change the attribute weight without changing the designation of importance or measurement range variation. The ACS framework analysis [2] utilized the swing weight method to calculate an attribute's weighted contribution to the overall value of ACS listed in Table 2.1.

Weight elicitation is simplified swing weight method. Instead of placing an attribute into a box to satisfy the conditions of importance and variation of measure, the stakeholders distribute a limited number of points among the attribute weighting [11]. The stakeholders directly control the attribute weight without the need for normalization. For example, a distribution of 100 points for the weight, w_i , gets calculated by dividing the stakeholder's attribute value distribution, x by 100.

$$w_i = \frac{x_i}{100}, \quad i = 1, \dots, n \text{ attributes} \quad (2.5)$$

Using 100 points makes the math easy, but relies heavily on stakeholders' opinion. The greatest benefit with weight elicitation occurs when the primary decision maker distributes their 100 points. Once the decision maker has given his feedback, no other information will override that opinion.

Formulation of System Value

The formulation of system value relies in the conversion of system performance into a unitless value [27]. This component of Equation 2.2, displayed as $v_i(x_{ij})$, translates the satisfaction or utility gained by the stakeholder through the programmatic performance [11], [28]. In practice, this conversion occurs through values developed through empirical data, theoretical expectations, or analogous systems. The value curves identify the relationship between the performance and value. The curve converts the performance to a value score and therefore directly traces back to the overall objective shown in Figure 2.7.

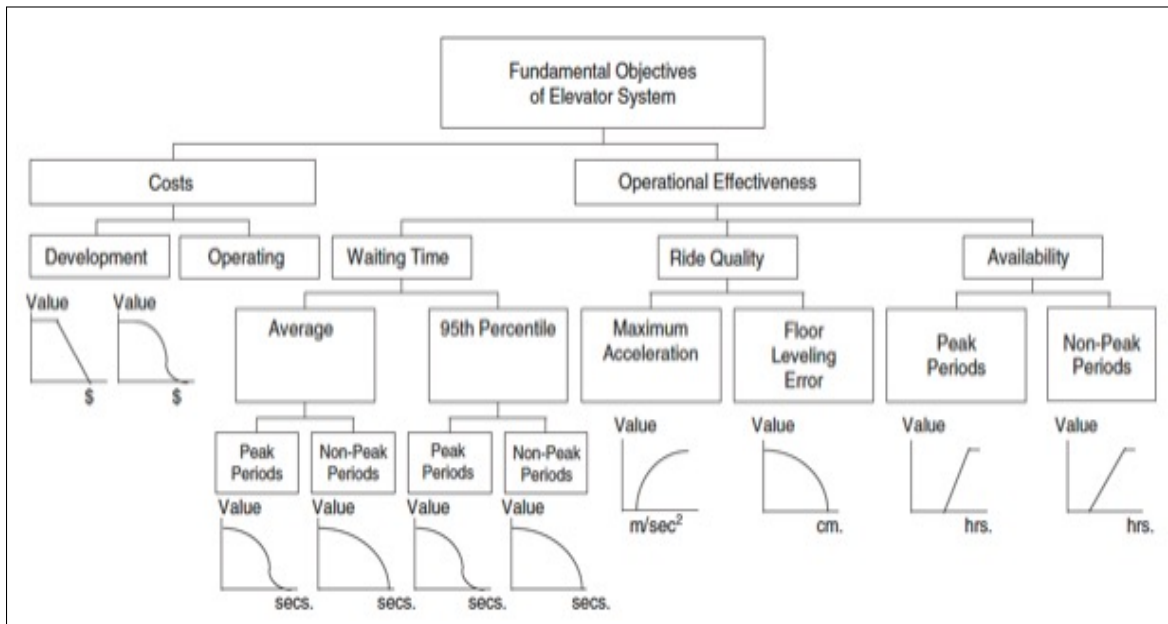


Figure 2.7. Value Curve Traceability to Objectives. Source: [11, p. 186].

The general slope of the curves will follow three shapes: linear, concave, and convex.

Linear shapes follow the concept that the change in a program's performance will have proportional gains constant in either the positive or negative direction as shown by Figure 2.8. The marginal utility remains constant throughout the value generation by a program [11], [28]. In our example, the system must have a performance level greater than minimum requirement, labelled as x_i^0 , before any value is generated. If performance exceeds the maximum performance desired, labelled x_i^* , no additional value above the maximum level of 10 which establishes the maximum value on the y-axis.



Figure 2.8. Linear Value Curve. Adapted from [11].

A concave shape displays the principle of diminishing returns [28]. The concave shape in Figure 2.9 shows that a system's performance increases the marginal gains in value decreases. This decreasing value over the span of system performance creates an asymptotic barrier at the maximum y-value. This graphically represents the stakeholder placing the highest value on early improvements in performance but less increases over the span of performance. A perfect example lies in the process development time, knowledge, and the impact on value. Gaining knowledge over time affects cost, quality, and the ability to meet requirements which generates corporate value [29]. The greatest gap in knowledge exists in the beginning of a new project when the greatest knowledge is gained. While knowledge continues to grow, the gap between known and unknown decreases.

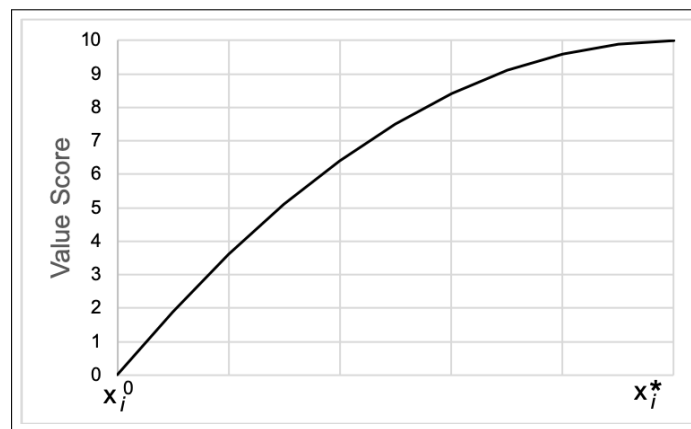


Figure 2.9. Convex Value Curve. Adapted from [11].

A convex shape displays the concept of increasing rates of value gains as performance improves [11], [28]. Minimal value is generated for a greater period of time until rapid growth. A significant value is achieved prior to the rapid growth. This curve is best associated with the demand analysis and predicting that demand from specific factors. Considering output, technology, capital investment, labor, and random disturbances water producers attempt to predict the future capacity needs of the area [30]. The value generated with the curve pays dividend if being able to predict the future supply needs.

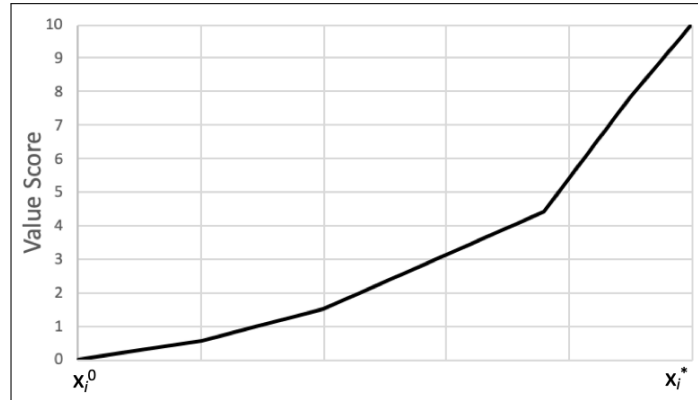


Figure 2.10. Convex Value Curve. Adapted from [11].

2.4 Optimization

The current fiscal environment forces leaders to seek out investments that best attain an organization's goals. This concept of investing into the programs to maximize an organization's value can be applied in a military or commercial context. Current military programs use optimization strategies over the course of an extended planning horizon to build new, maintain, and retire equipment. In fact, Secretary of Defense Robert McNamara adopted a five-year budgeting horizon with supporting analysis to procure systems too complex for single-year development [31].

One type of optimization example, known as the knapsack problem, has a fixed budget and a set number of investment programs. Each program has a value and cost associated, and the goal is to maximize the objective of a total value score of that portfolio at no greater cost than the allocated budget [31]. As discussed earlier, ACS offers a variety of programs j through which ACS generates value shown in Equation 2.2. Leadership

can influence value generation at organizational level through strategic allocation of the budget. Linear programming techniques can calculate a single value by implementing several budgetary constraints [16]. If no monies are held in reserves, the investment percentage I_j into all programs will sum to 100% or 1 if all minimum and maximums are identical. A minimum investment ensures each program gets funded to meet the minimum needs, and a maximum constraint will restrict spending when no additional value can be gained. The final constraint determines that all attributes that contribute to the objective w_i will be included. By including all applicable attributes, the decision maker can identify the accurate value generated by individual programs and the collective whole. The optimization strategy following the individual program analysis enables the decision maker to view ACS from a holistic viewpoint and is displayed by the following maximization set of equations. Equation 2.6 outlines the generic form of the optimization equations.

$$\begin{aligned}
&\underset{\text{Value}}{\text{Maximize}} && \sum_{j=1}^m I_j \sum_{i=1}^n w_i \times v_i(x_{ij}) \\
&&& i = 1, \dots, n \text{ attributes} \\
&&& j = 1, \dots, m \text{ programs} \\
&&& (2.6)
\end{aligned}$$

$$\begin{aligned}
\text{Subject to:} &&& \sum I_j = 1.0 \\
&&& I_j \geq I_{low} \\
&&& I_j \leq I_{high} \\
&&& \sum w_i = 1
\end{aligned}$$

Dantzig points out the effectiveness of linear optimization when analyzing the number of possible combinations that exist when combining personnel with jobs and the value of each combination set [32]. Computers today have the computing power beyond the historical brute force methods that took large amounts of time. Currently the ability to analyze investing money across six programs has exponentially more combinations can be solved rather quickly. In application, when constructing the program objective memorandum (POM) budget, the Army G-8 will analyze its budgeted programs to determine the potential value generated with policy decisions. For this reason, the office generated the CPM tool to shape

these policy decisions. Similar to ACS optimization model the G-8 CPM tool in Figure 2.4 was constrained by the budget, policies, and organizational priorities [9]. Optimization techniques provide a resource to analyze current and future decisions quickly.

2.5 Attribute Characteristics

Good measures are critical to accurately analyze a program's value [15]. "Measures are closely related to the objective being evaluated under a specific set of conditions. The measures reflect overall customer / user satisfaction" [8, p. 54]. Attributes provide an avenue through which to measure the program's performance and underlying value. Therefore, desirable characteristics of attributes and measures will translate into more accurate analysis of problem. The author describes three characteristics identified through research: measurability, operationality, and understandability.

Measurability

Data collection efforts seek to measure actual performance levels in comparison to a desired performance level. An attribute must "embody implicit value judgements that are appropriate and avoid those that are inappropriate" [33, p. 113]. Research on insurance products also highlight the importance for measurability to ensure that the measure and subsequent measurement provides a scale through which the stakeholder agrees [34]. These measurements require a quantified scale through observation, customer feedback, technical performance testing, or other means. The measurability component of attributes provides the ability to identify the magnitudes of performance that have traceability to a system's objective. Grauman notes in his research that measuring business results, trust, and liking were the attributes that derived the quality of personal relations between a reinsurer and customer [34].

Operationality

The characteristic of operationality provides the relevance to describe "possible consequences with respect to the associated objective and provide a sound bases for value judgments about the desirability of the various degrees to which the objective might be achieved" [33, p. 114]. In practice, operationality ensures the attribute's performance individually will impact the stakeholders' objectives [11], [34], [35]. If the attribute does not

influence an objective, it should be immediately removed from consideration to focus time on attributes that will ultimately add value.

Understandability

Understandability conveys information without loss or ambiguity on tradeoffs and consequences to clearly articulate the intent of the communicator [11], [33], [35]. Graumann articulates this very concept with the terminology “without distortion” to bring forth the aspect of clarity within understandability [34]. Researchers that administer qualitative surveys for customer feedback require clarity to ensure the feedback matches what the research needs. Misinterpretation leads to confusion and poor data that does not represent reality. To gain validity, stakeholders and study leaders need explicit verbiage to eliminate any confusion or misinterpretation.

2.6 Measures from Industry

2.6.1 Overview

Industry has attempted to quantify the value generation of customer services through two unique points of view, quantitative and qualitative measures. Employers seek to gather data to analyze the return on investment (ROI) and measure the future performance of employee assistance programs, employee benefits package, or total rewards programs through quantitative measures known as a cost-benefit ratio (CBR). These quantitative measures from industry include selected measures to demonstrate productivity along with their cost benefit. The additional qualitative perspective attempts to capture the organizational benefits of an Employee Assistance Package (EAP) to prevent any loss of employee performance to risky behaviors [36]. Employees now seek additional benefits beyond traditional compensation from their employers; therefore, companies attract and retain qualified employees through EAP selections [37]. “A valued reward is highly desirable by the employees, which is usually the case if they see it as instrumental in satisfying one or more of their needs” [38]. Typical value in industry can be calculated from a variation of a CBR; however, since ACS does not generate income, ACS value will be calculated through mainly qualitative metrics of the confidence gained by the targeted population. Industry gains the quantitative and qualitative data required for analysis through methods conducive for responses. The following sections

will describe data collection methods and data types.

2.6.2 Quantitative Focused Value Measures

Current companies seek to optimize the ROI or CBR from employee benefit packages using quantitative metrics for evaluations. The Bureau of National Affairs published the evaluation for employee benefits packages and found that compensation can account up to 65% of corporate expenses, the single largest expenditure for any organization [39]. “Quantitative metrics have applicable traceable numeric values that designate the performance of the system” [15, p. 596]. For the return on investment, metrics can include individual compensations as a cost and production time as a benefit. If cost remains the same and production improves or increases, the ROI or CBR will show a benefit to the organization. Incorporating quantitative measures validates analysis through traceability and dependability. ACS quantitative metrics include debts reduced, personnel served, and number of service rendered. ACS can trace these metrics through meetings, reports, and soldier feedback.

2.6.3 Qualitative Focused Value Measures

Organizations seek customers’ qualitative feedback to better improve services. Research into gathering data on consumer behavior through qualitative surveys are more common to measure individual rationality of individual expectations [40]. For example, a hospital produces surveys to measure a patients satisfaction with their doctor, nurse, appointment, facilities to provide indicators of quality care. Once analysis determines a specific hospital service performs below standard, processes are put in place for improvement [41]. This feedback loop allows a customer base to voice an opinion that results in a recommended change. Cleary notes, “newer surveys and reports can provide results that are interpretable and suggest specific areas for quality improvement efforts” [42].

One important survey type to determine the increase in skills and confidence is the pre and post surveys. This survey solicits information from a group of individuals within a target population to represent the characteristics of the whole. The initial survey or pre survey establishes a baseline through which the information campaign or training attempts to improve. After a period of time, participants receive a second survey with identical questions. The improvements in the test behavior result from the training or information received between the pre and post survey. A Canadian mass media campaign used the pre

and post survey type to inform women about the links between alcohol and cancer. The study performed two post surveys and saw improvements in audience's knowledge in the links between alcohol and cancer. The respondents in the final survey also significantly demonstrated the intent to reduce their alcohol consumption when compared to the first group [43].

Surveys are also valid mechanisms to calculate the consumer confidence and sentiments. Economists use surveys to predict trends on consumer attitudes and future expenditures. The result of such economic calculations results in stock market shifts and major market changes that follow consumer confidence and sentiment. Globally recognized, the Consumer Confidence Index and Index of Consumer Sentiment get analyzed to forecast future trends. As an example, the University of Michigan surveys a minimum of 500 households to represent the population on three broad areas of consumer sentiment. The four-quarter moving average from the consumer sentiment mirrors the change in Real GDP displayed in Figure 2.11. Both surveys use a positive, neutral, and negative response choice to indicate the respondent's expectations on the future. By sampling across the population, the calculations can reasonably expect to represent the population. The Consumer Confidence Index acts as a leading indicator for global economic trends as a consequence of ties with predicted consumer behaviors [44]. Similarly, companies solicit their employees input prior to investing resources that match employees values and needs. ACS qualitative metrics include the consumer confidence reported through customer surveys.

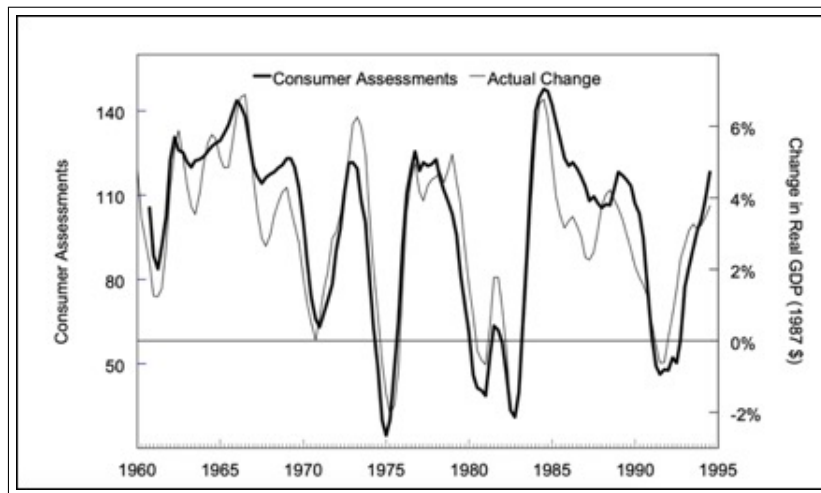


Figure 2.11. Consumer Assessments of Economic Conditions vs. Changes in Real GDP. Source: [45].

2.7 Summary

Over the course of this chapter, historical documentation has established methods to conduct research. Valid research methods provide a defensible approach to reach logical conclusions. MADM provides a mechanism to evaluate programs based on the common attributes and program performance. Data collection becomes critical to measure performance, and surveying customers provides a valid and reliable mechanism to gather user feedback. The ACS analysis executed the literature review to justify its approach and conclusions.

CHAPTER 3: Methodology

3.1 Overview

The following chapter outlines the methodology to answer the thesis questions:

1. What is the value generated by each program according to the approved common attributes that measure the overall objective of improving soldier readiness?
2. What is the most effective investment strategy to maximize the value of ACS to improve soldier readiness?

This thesis follows a modified CPM, shown in Figure 3.1 to systematically address the thesis objectives and the approach to support the findings. The model was chosen due to the structure of the problem and the embedded flexibility with the iteration approach to alter constraint parameters. Also, the characteristic feedback loops allow the stakeholders to provide the conditional changes to the budget, policy, and priority shifts of their operational environment. The three phases that make up this research program include the qualitative phase, quantitative phase, and optimization phase.

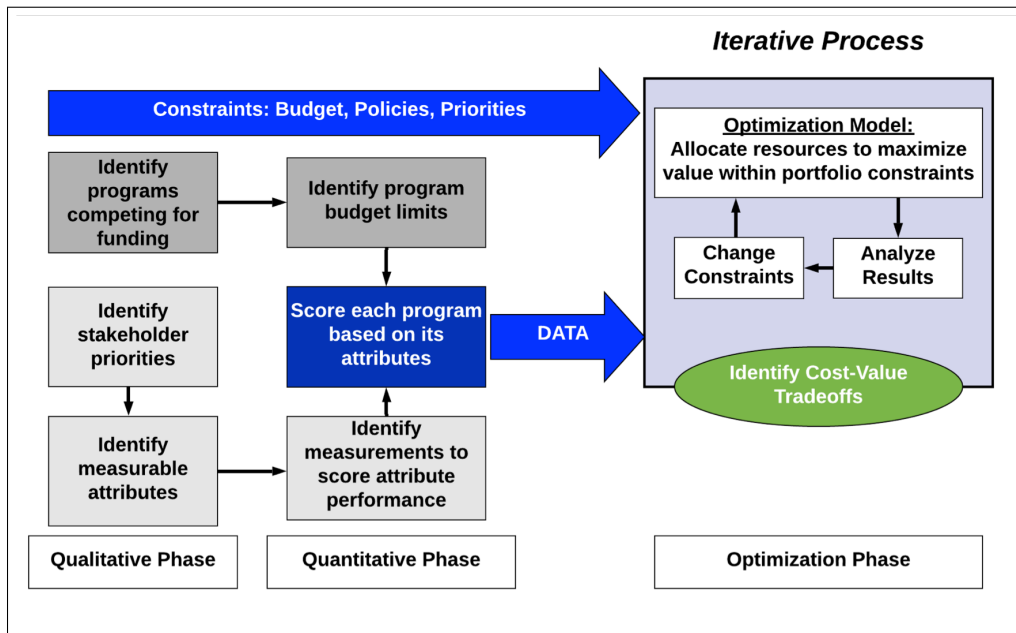


Figure 3.1. ACS Analysis Approach. Adapted from [9].

3.2 Qualitative Phase

The qualitative phase initiated the project and established lines of communication through which the project would operate. The three outputs of this phase included identifying the competing programs, measurable attributes, and stakeholder priorities in the form of attribute weighting. Previous efforts to construct a research framework concluded in December 2019 that documented the common attributes and stakeholder priorities [2]. Since time elapsed between the conclusion of an ACS qualitative analysis, the study required a recertification to validate the previous findings. The validation process ensured the final investment strategy matched the current state of stakeholder's priorities. This phase confirmed the findings and provided a framework through which the following quantitative analysis continued.

3.3 Quantitative Phase

The quantitative phase established the metrics to compare the programs against each other. The key outputs for this phase included the developmental processes to calculate the budget

constraints, a collection strategy to calculate a program's performance for each attribute, and programmatic value scores to compare program performances.

3.3.1 Budgetary Constraints Process

ACS relies on QACS and OSD funding sources to operate. If the funding sources do not cover the anticipated expenditures of the programs, a constraint must be placed to regulate funding. Historical records provided documentation through which a program's operational budget can be used to establish minimum and maximum levels of funding. The minimum and maximum operational budgetary constraints are calculated as a percentage of maximum funding. Total value gets realized when a program gets funded at the maximum level, or 100%. The value generated therefore gets discounted to the funding level according to the investment percentage.

$$I_{j,Min} = \frac{Min(Budget_j)}{Max(Budget_j)} \quad (3.1)$$

$$I_{j,Max} = \frac{Max(Budget_j)}{Max(Budget_j)} \quad (3.2)$$

The investment, I , into a program, j , depends on the budgetary constraints. The minimum investment percentage, I_{min} , accounts for all the minimum funding required to operate the program. The historical low amount, Min_{Budget} , gets divided by historical maximum amount spent by that same program, Max_{Budget} . The max investment percentage, I_{max} , divides the Max_{Budget} by the Max_{Budget} of the same program. A program fully funded will contribute the maximum program value to towards the overall organizational value.

3.3.2 Collection Strategy

The collection strategy required a unique format to capture qualitative and quantitative data to gather baseline confidence. ACS gathered data from survey forms generated by the author to score for the following attributes:

- Financial Confidence
- Resource Confidence

- Skill Confidence

At the conclusion of the contact, the same individual was asked to answer the same questions on a post survey to determine if the service improved the customer's confidence. The survey was voluntary and no personal or identifiable information was received. Quantitative data was also collected during the ACS contacts to calculate the quantitative value measures. The quantitative data was required to assess the programmatic performance of the following attributes:

- Debt Reduction
- Utility
- Secure Environment

On the surveys, additional questions asked for the customer to identify their current debt and the amount of debt ACS helped to reduce. A percentage was calculated to determine the attribute performance score by the following:

$$\% Debt Reduced = \frac{Debt Reduced}{Original Debt} * \times 100 \quad (3.3)$$

The utility attribute calculated the performance score by the percent of self referrals. Those customers that sought out ACS instead of being referred by command or other means were preferred. The marking of the surveys had to clearly designate "Self Referral", otherwise the response deferred to "Other".

The improvement to a secure environment equates to reduced cases of domestic violence, child abuse, or child neglect cases. A reduction in open incident cases provide a desirable metric for this attribute. If a report of abuse, neglect, or assault event occurs, ACS responds, and an incident case is opened. The study calculated the percent reduction of open cases over a period of three months to measure this attribute. Equation 3.4 outlines the calculation to measure the secure environment attribute.

$$\% \text{ Cases Reduced} = \frac{\text{Initial Month Open Cases} - \text{Final Month Open Cases}}{\text{Initial Open Cases}} \times 100 \quad (3.4)$$

Value Curve Development

The study attempted to produce value curves with three different types of data: empirical data collected throughout the study, the primary stakeholder's feedback, or analogous systems. Soldiers provided the empirical qualitative and quantitative data collected by ACS employees during customer contacts. A contact is defined as any interaction through a common medium to include face-to-face, class instruction, or workshop booth. The surveyed data produces a histogram through which a cumulative frequency distribution (CFD) generates a potential value curves. The value generated by the empirical data inverts the results of the histogram. The stakeholder feedback produced a value curve that translated their expert opinion on the program performance and expected value of that performance. The final method of analogous systems researches industry standards and documented value results from archived data. The value curve development process established the inputs into optimization strategy. The maximum value generated will have a limit of 10 and establishes the highest value for the y-axis on the value curves.

ACS leverages stakeholder feedback to identify the average program performance as the representative metric for the system. This representative metric is the input for the value curve for value conversion. In our example, referral value equals 4 because the system performance of 20 intersects the value curve at the point of 4 on the value score axis in Figure 3.2. The value curve translates the system performance on the x-axis to the value score from the y-axis.

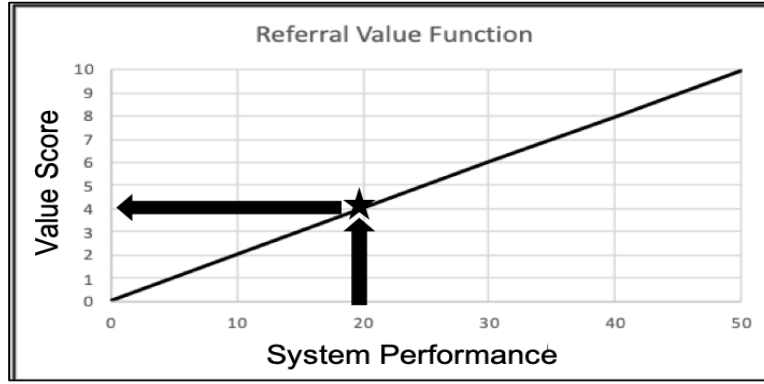


Figure 3.2. Converting System Performance Into Value

3.4 Optimization Phase

The optimization phase used the outputs of the attribute weighting scores, programmatic value scores, and organizational budget constraints as inputs. The optimization phase has the flexibility of the iteration characteristic to analyze several contingencies based on the stakeholders' changing operational environment.

3.4.1 Maximum Value Generated

The calculation process to determine the maximum value must first calculate the program value generated before optimizing. Therefore, ACS achieves a total value score by converting the performance x of i th attribute from the j th program to a value v_i . The weighting factor w_i accounts for the level of attribute importance. The sum total of all programmatic value scores calculates the ACS Value shown by Equation 3.5.

$$ACS\ Value = \sum_{j=1}^m \sum_{i=1}^n w_i \times v_i(x_{ij}) \quad (3.5)$$

$i = 1, \dots, n\ attributes$
 $j = 1, \dots, m\ programs$

The investment strategy uses an optimization set of equations to calculate the individual investment I of every program to maximize the ACS total value. The investment becomes

the decision variable and determined after program value scores are calculated. Equation 3.6 shows this by applying the investment I to the j th program after the program score calculates and before the programs sum together. Equations 3.7 forces all funding gets allocated with no reserve. Equations 3.8 and 3.9 introduces the budgeting boundaries to ensure all programs receive funding above historic minimums and below historic maximums.

$$\begin{aligned} \text{Maximize}_{ACS\ Value} \quad & \sum_{j=1}^m I_j \sum_{i=1}^n w_i \times v_i(x_{ij}) \\ & i = 1, \dots, n \text{ attributes} \\ & j = 1, \dots, m \text{ programs} \end{aligned} \quad (3.6)$$

$$\text{Subject to: } \sum_{j=1}^m I_j \times Budget_{j,Max} = 100\% \times Max\ FY(Budget_{ACS}) \quad (3.7)$$

$$I_j \geq \frac{Min(Budget_j)}{Max(Budget_j)} \quad (3.8)$$

$$I_j \leq \frac{Max(Budget_j)}{Max(Budget_j)} \quad (3.9)$$

Finally after calculating the maximum value score, scaling the score according the total investment makes the relative investments easier to compare. Therefore, divide the individual programs investment by the total budget shown in Equation 3.10.

$$Invest\ Ratio = \frac{I_j \times Max(Budget_j)}{\sum_{j=1}^m I_j \times Max(Budget_j)} \quad (3.10)$$

3.4.2 Maximum Potential Value

The maximum potential value generated by the ACS programs can only reach 10 according to the following reasoning. Prior to the allocation of funding, maximum value is generated when every program j performs at a level where each attribute value v_i is 10. Therefore,

the component of value $v_i(x_{ij})$ equals 10. Since the summative component of the attribute weights w_i must equal 1, the maximum total value cannot be above 10.

The next step of optimizing the investment allocation incorporates the investment percentage component I_j into the same optimization equation with the constraints listed in chapter 2. Once again if each program j performs at a level to maximize the attribute value v_i of 10, the maximum value remains 10 according to the following, $1 * 1 * 10 = 10$

3.4.3 Linear Programming

The thesis utilized the Solver Add-In package offered through Microsoft Excel. The solver package must be activated and highlighted by a blue check mark as in Figure 3.3.

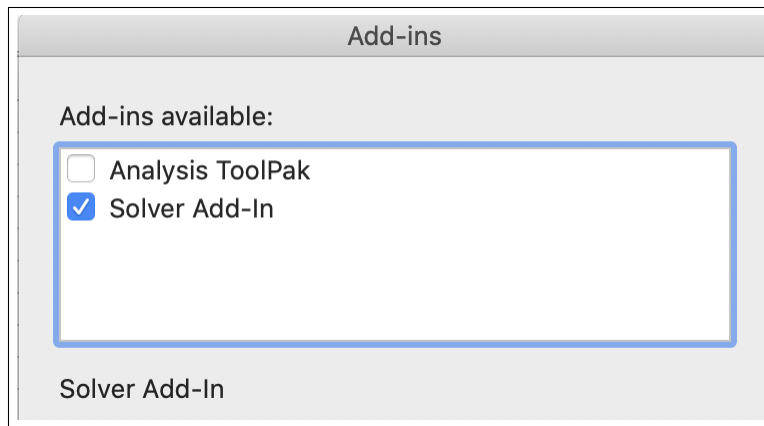


Figure 3.3. Solver Add-In Activated

The package is confirmed by the added icon shown in the Data toolbar with Figure 3.4.

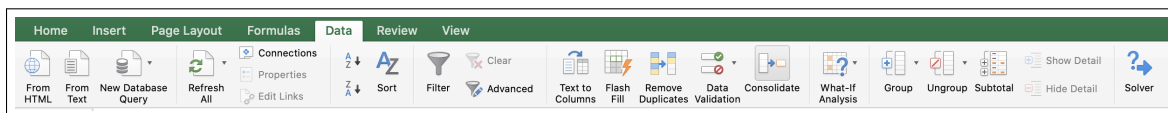


Figure 3.4. Data Tab with Solver Icon

Next, the analysis must set the parameters to identify the maximum value of ACS programs with the following display in Figure 3.5:

- Include the maximization equation in a cell and label it Max Value.
- Highlight cells designated for investment percentage and label them invest.
- Add the constraints to ensure the investment percentage is greater than the historical minimum and less than the historical maximum.
- Select the solving method to Simplex Linear Programming (LP).

The image shows the 'Solver Parameters' dialog box. The 'Set Objective' field contains 'Max_Value'. Below it, the 'To' section has three radio buttons: 'Max' (selected), 'Min', and 'Value Of:'. The 'Value Of:' field contains '0'. The 'By Changing Variable Cells' field contains 'invest'. The 'Subject to the Constraints' list contains three constraints: 'invest <= invest_high', 'invest = 1', and 'invest >= invest_low'. To the right of this list are buttons for 'Add', 'Change', 'Delete', 'Reset All', and 'Load/Save'. At the bottom, there is a checkbox for 'Make Unconstrained Variables Non-Negative' which is checked, and a 'Select a Solving Method' dropdown menu set to 'Simplex LP'. An 'Options' button is also present.

Figure 3.5. Solver Parameters for ACS Maximum Value

With known value scores and attribute weights, the analysis utilized linear programming to calculate the preferred investment strategy described by the knapsack problem in Chapter 2.

3.5 Summary

This chapter outlines the methods utilized throughout the course of the study to answer the thesis objectives. The ACS analysis approach utilized an iterative process to systematically confirm attribute weights, collect data, analyze program performance, and calculate an optimal investment strategy. The iterative process provides flexibility to iterate through changing constraints such as budget limitations to account for varying budget restrictions.

The methodology also encourages feedback from the stakeholder to gain support and buy in throughout the study.

CHAPTER 4:

Results

4.1 Overview

This chapter describes the quantitative results and analysis of the data collected to measure soldier readiness. Each program's quantitative value is based on over 1,600 responses from pre and post interactions between customers and ACS programs. Operational considerations and stakeholder opinions further refine the initial value curve. This value model converts programmatic performance measures into unitless value scores for ease of comparison.

For each attribute, several value model building methods are used to convert program performance to a representative soldier readiness value. This research finds that some methods are more appropriate to use with attributes over others, resulting in the use of several model building methods. Additionally, the appropriateness of the selected model building method is given with each attribute model. This research constructs value models for the following attributes:

1. Debt Reduction
2. Financial Confidence
3. Utility
4. Resource Confidence
5. Skill Confidence
6. Secure Environment

The chapter also describes the development of the optimization model based on weighted programmatic value scores, budgetary constraints, and program investments. Historic budgetary constraints establish the minimum and maximum investment levels for each program along with the given ACS budget. The optimization model finds the ACS investment strategy that maximizes soldier readiness. Section 4.2 discusses the development of each attribute model.

4.2 Value Model Development and Results

To begin the curve development process, the stakeholders provided feedback about their views on value and trends. This initial view became the first value model considered. The input also provided an initial expectation amongst the programs. We assume the financially focused programs to score higher on certain attributes. The data collected either confirmed initial curve assumptions or required follow-on analysis to properly convert performances into value scores.

The next value model considered the empirical data. The data generated a frequency histogram to graphically show the number of responses for each specified soldier readiness attribute. The following CFD sums all responses to the point of a given response value. The CFD produced a second potential value curve to convert program performance into a unitless value curve.

The third value model approach incorporated curve fitting software to fill in the empty spaces not accounted for by the histogram and CFD. Curve fitting followed a mathematical technique to reduce the Sums of Square Residuals between the y-value of the CFD curve and a predicted y-value. Additionally, the curve fitting algorithm can force a value of zero when no improvement is measured.

Lastly, the final value modeling approach inverts the curve fit model. This approach accounts for the operational context of each program. The operational context includes a desirable distribution of results and the commander's desire to remove distractions away from training.

At the conclusion of each attribute model, the researcher documented the reasoning for the chosen value model. The justification supports the operational context to convert program performance into a values based metric for the optimization model.

4.2.1 Debt Reduction Value Model

ACS identifies debt reduction as a goal to support Army retention and reduce stress in the household. The end result ensures a soldier has the ability to assume his duties free from worry about his and his family's circumstances. The debt reduction metric measures the percent reduction of a soldier's debt while receiving counseling from an ACS representative. The stakeholder defines a linear relationship between the value score and the percentage

debt reduced (Figure 4.1). The stakeholder determined the maximum value is achieved when the percentage debt reduction is 5% or more.

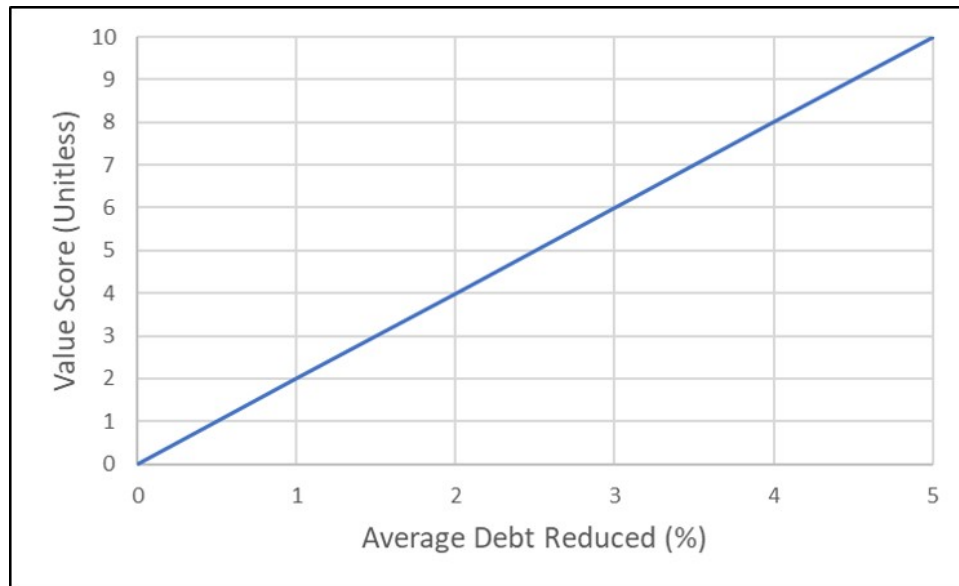
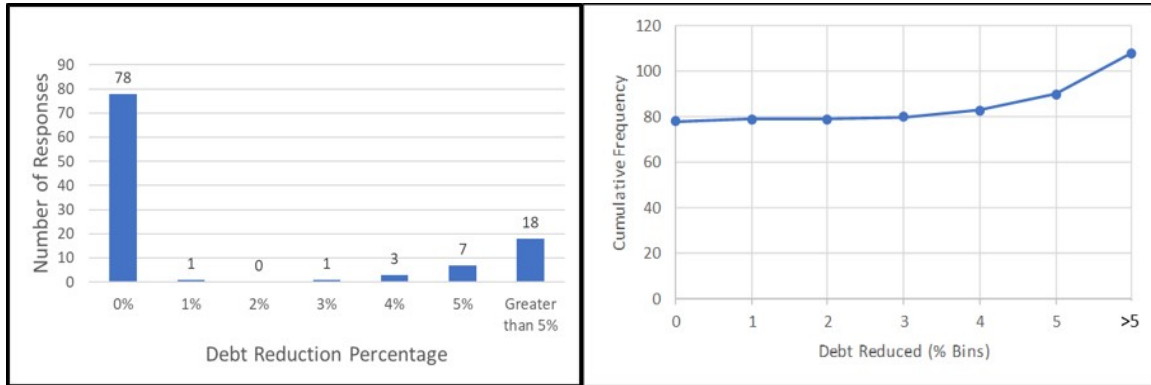


Figure 4.1. Stakeholder Initial View of Debt Reduction Value Curve

ACS collected data on 108 customers who worked to reduce their debt. Figure 4.2a displays the frequency distribution of 1% intervals up to 5%. The x-axis shows the percentage of debt reduction. Each bin is the amount of debt reduced up to but not exceeding the percentage category. For example, a customer who reduced debt by 2.5% would get counted in the 3% bin. An additional bin accounted for those who had exceeded the 5% debt reduction threshold for maximum value. Of the 108 responses, 78 (72%) had not reduced their debt. Figure 4.2b converts the histogram into a CFD of the data. As expected, the y-axis value for 0% debt reduced displays 78. A flat line between 1% and 4% debt reduced represents the small quantities of the debt reduced at those levels.



(a) Histogram of Debt Reduction (b) Debt Reduction Cumulative Frequency Distribution

Figure 4.2. Debt Reduction Attribute Empirical Data

If the CFD represented the value curve, it would assign a high value score for zero debt reduced. The CFD also fails to add value between 1% and 4% due to the lack of soldiers that achieved loss between the categorized amounts. The sharp increase after 4% represents the 25 customers who decreased more than 4% of their debt to include those that reduced greater than 5% of debt.

The CFD can be the basis of a value model; however, a value model based purely on the CFD would assign a high value score for achieving 0% debt reduction. This is not reasonable. Figure 4.3 displays the shape of a curve which used a curve fitting technique to transform the CFD into a monotonically increasing curve that begins at zero. The curve fit model represents a zero value when debt is not reduced. The model also indicates a significant increase with just a 1% reduction in value. Such a small percentage reduction should add value; however, the significant increase above a value of 6 may overestimate the actual value toward soldier readiness.

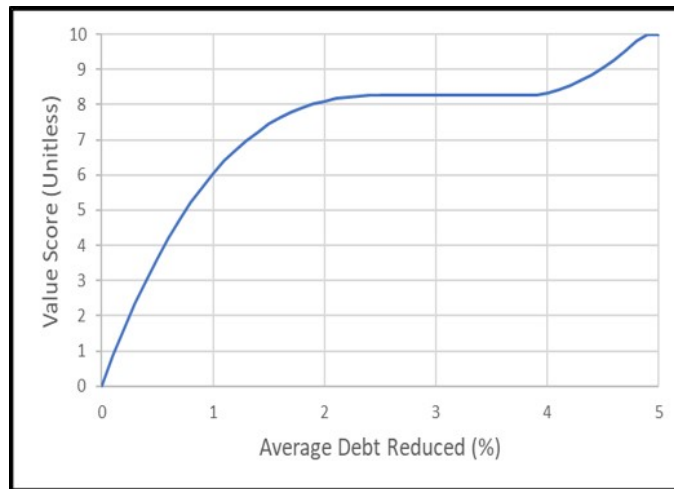
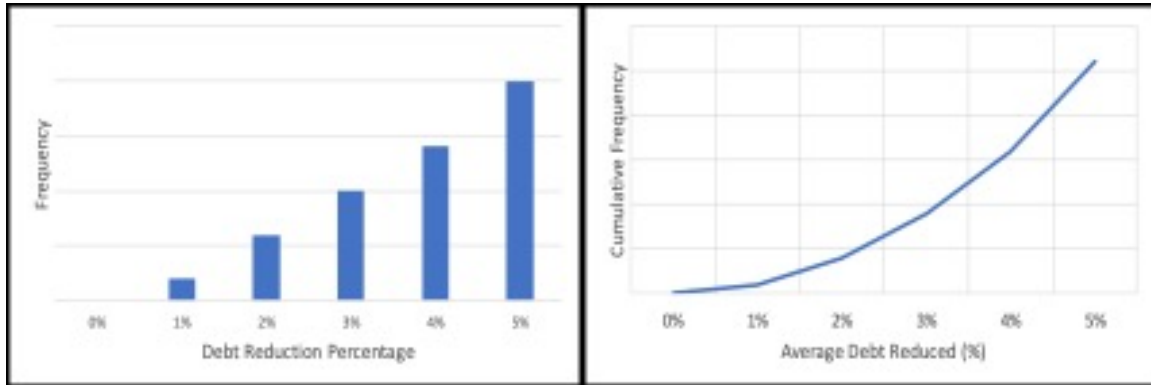


Figure 4.3. Debt Reduction Value Curve

Logically, ACS desires to reduce higher rates of debt across the population. ACS also improves the value towards soldier readiness at higher rates of debt reduction. This incremental gain in value increases as the percentage debt reduced increases. The value model should increase the rate of value in such a way to have increasing improvements as debt percent reduction increases. Figures 4.4a and 4.4b display a desired scenario where greater numbers of soldiers reduce higher amounts of debt.



(a) Histogram of Desired Debt Reduction (b) Desired Cumulative Frequency Distribution

Figure 4.4. Desired Debt Reduction Scenario

The following list provides sound reasoning to implement this new value curve.

- New value model converts zero debt reduction to a zero value.
- New value model represents a commander's desire to have soldiers reducing greater amounts of their debt.

The value curve converts performance data into a unitless value necessary for comparison. Using the value curve, each program's average debt reduced on the x-axis maps to an intersection point on the curve. Figure 4.5 displays that the soldiers participating in the FRP reduced debt an average amount of 3.56% which translates to a programmatic value of 4.25. Responses showed that five of the six programs had no impact on the customer's ability to reduce debt. Table 4.1 displays the average debt reduction results and the associated value achieved for each program.

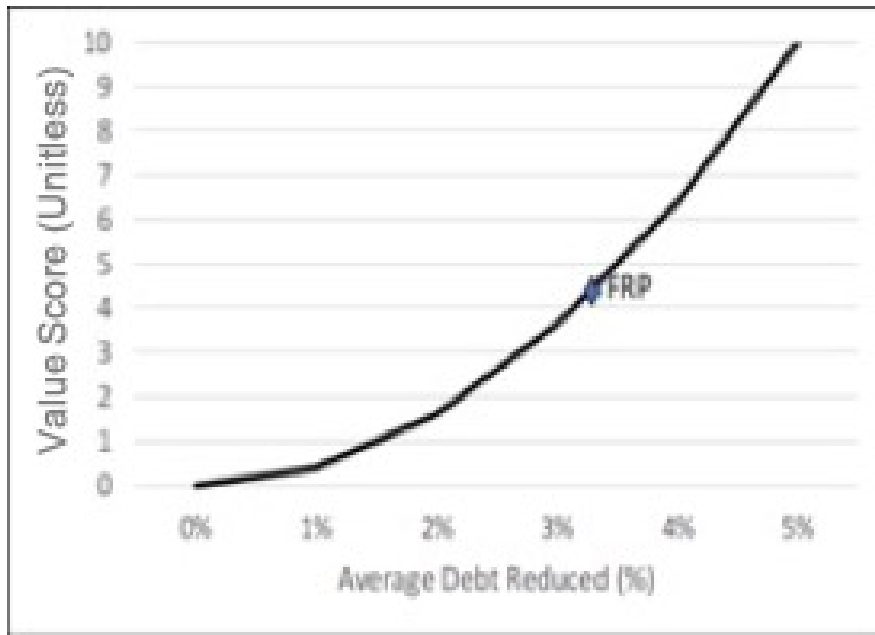


Figure 4.5. Value Curve Conversion for Debt Reduction Attribute

Table 4.1. Debt Reduction Attribute Value Score

ACS Program	Average Debt Reduction	Value Score
FAP	0.00%	0.0
MDSS	0.00%	0.0
FRP	3.56%	4.25
SOS	0.00%	0.0
Relocation	0.00%	0.0
ERP	0.00%	0.0

4.2.2 Financial Confidence Value Model

Financial confidence measures the ability of a program to improve a customer's confidence with financial decision making in preparation for the future. The stakeholder defined a step-wise relationship between the value achieved and the difference between pre- and post-

financial confidence. The survey used a Likert scale between one and five. Therefore, the minimum difference is zero, and the maximum difference calculates to four. Figure 4.6 displays the increasing value occurs at equal intervals with the maximum value being achieved when the average difference in confidence is between three and four.

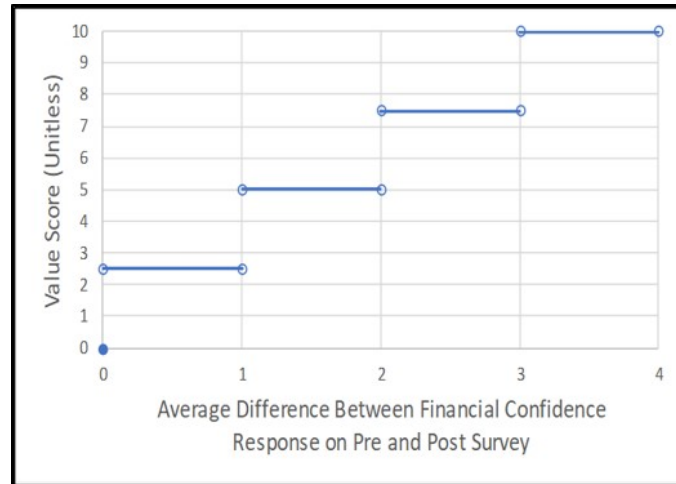
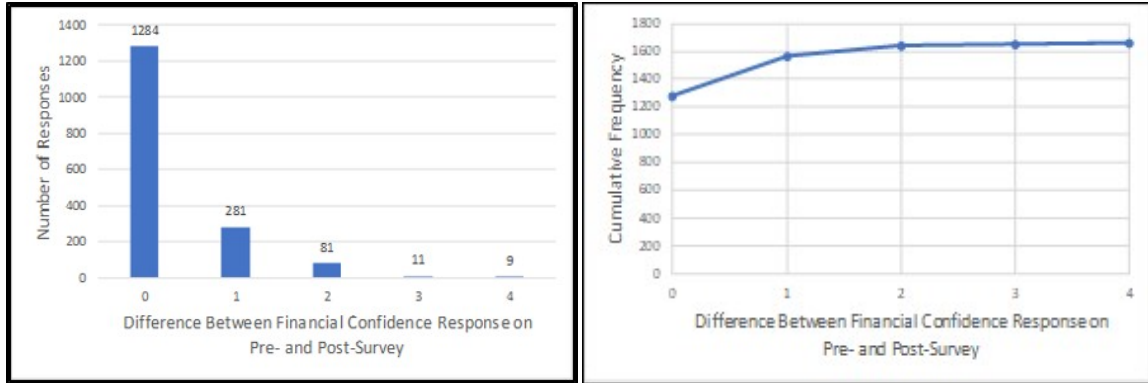


Figure 4.6. Stakeholder Initial View of Financial Confidence Value Curve

The development of the next value curve derives from the collected data. Figure 4.7a represents over 1600 responses on the customers' financial confidence before and after entering the ACS program. The histogram presents a frequency distribution of the difference between an individual pre- and post-survey Likert scale response. Of the 1666 surveys collected, 1284 (77%) reported no difference in financial confidence. As the difference increases, the quantity reported decreases. Figure 4.7b displays the corresponding CFD.



(a) Histogram of Financial Confidence (b) Financial Confidence Cumulative Frequency Distribution

Figure 4.7. Financial Confidence Attribute Empirical Data

The CFD becomes the basis of development for a value curve. However, if the CFD was used exactly as the value model, it would assign a high-value score for no gain in confidence. The value for zero difference should result in zero value. An appropriate curve should show no improvement results in zero value. Figure 4.8 displays the result from curve fitting. The concave curve shape represents a high value for the initial gains in confidence followed by a continual but incrementally smaller increase in value.

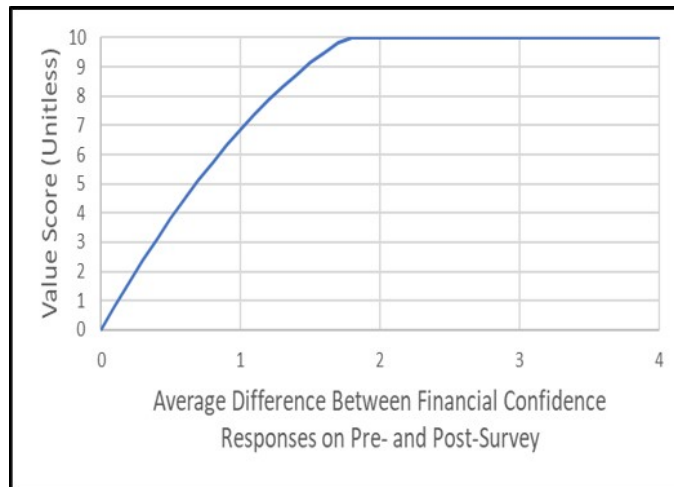


Figure 4.8. Modified Value Curve Conversion for Financial Confidence Attribute

Logically, the value curve represents the contribution that financial confidence offers soldier readiness. Soldier readiness does not improve when confidence has not improved. Soldier readiness would also achieve the greatest boost when the customer's confidence increases by a difference of four. When soldiers are already confident or strongly confident in their financial situation before services, then there is little room for improvement. The value curve must take into account the reported need or demand for improvement. Accounting for the baseline soldier confidence level Figure 4.9 displays a convex shape.

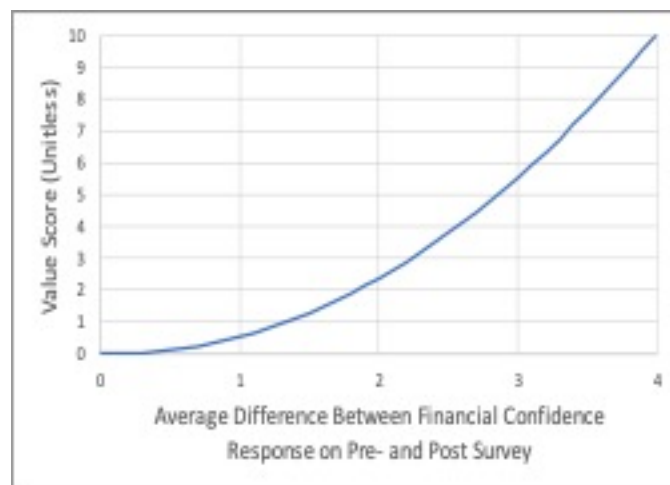


Figure 4.9. Financial Confidence Inverted Value Curve

The convex shape inverts the modified value curve in Figure 4.8 and more accurately represents the conversion of financial confidence into value for the following reasons:

- The value curve converts zero confidence improvement into a zero-value score.
- Accounts for the high number of soldiers who do not have a need for confidence improvement.
- Represents commander's desire to focus more on those with poor confidence.

Figure 4.10 represents a logical value model that represents the stakeholder's operational opinion of value, the analytics of the CFD, and a reasoned argument for the shape of the curve. The resultant value model is convex shape indicating increasing rates of change to value as the financial confidence increases. The curve logically converts zero improvement to a zero value and monotonically increases to the maximum value of 10 when the increase in financial confidence is four.

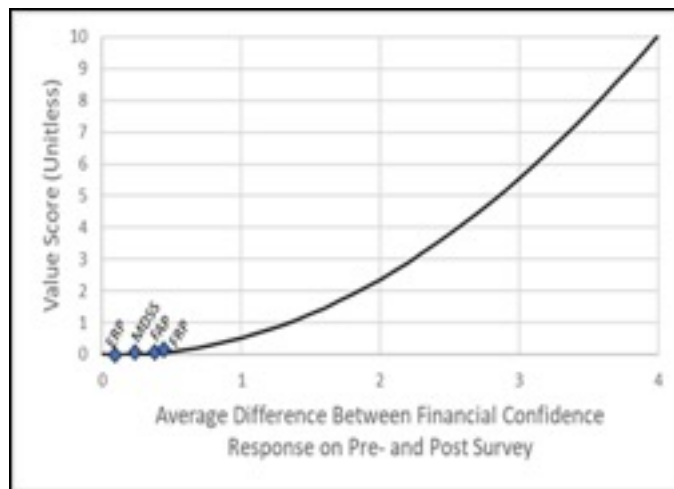


Figure 4.10. Value Score Conversion for Financial Confidence Attribute

Responses for financial confidence for each program show that four of the six programs impact the customer's financial confidence after receiving services. Those surveyed working with FRP reported the highest average improvement of 0.4. Table 4.2 lists the average improvement to financial confidence and the converted value scores. SOS and Relocation Program did not report any data to support a financial confidence score.

Table 4.2. Financial Confidence Attribute Value Score

ACS Program	Average Improvement to Financial Confidence	Value Score
FAP	0.38	0.04
MDSS	0.23	0.01
FRP	0.40	0.05
SOS	0.00	0.00
Relocation	0.00	0.00
ERP	0.05	0.01

4.2.3 Utility Value Model

The means that a customer comes to know an ACS program is an indicator for the willingness to put the teachings into practice. ACS advertises by word-of-mouth, a web page, hosting the newcomer's orientation, and leading several campaigns throughout the year. Regardless of how a customer learns about an ACS programs, the number of self-referrals is a reliable indicator of applying skills being taught. The percentage of self-referral from all customers that come to any ACS program became the metric from which the stakeholder can derive value. One hundred percent self-referred customers achieves the maximum value. Figure 4.11 shows the stakeholder's belief that the model is linear.

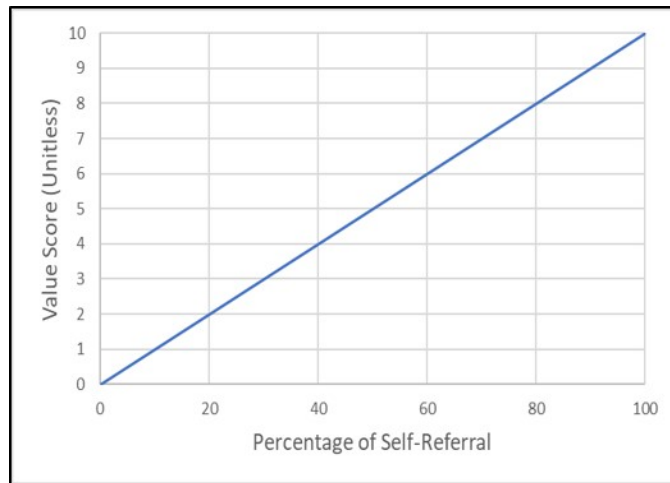
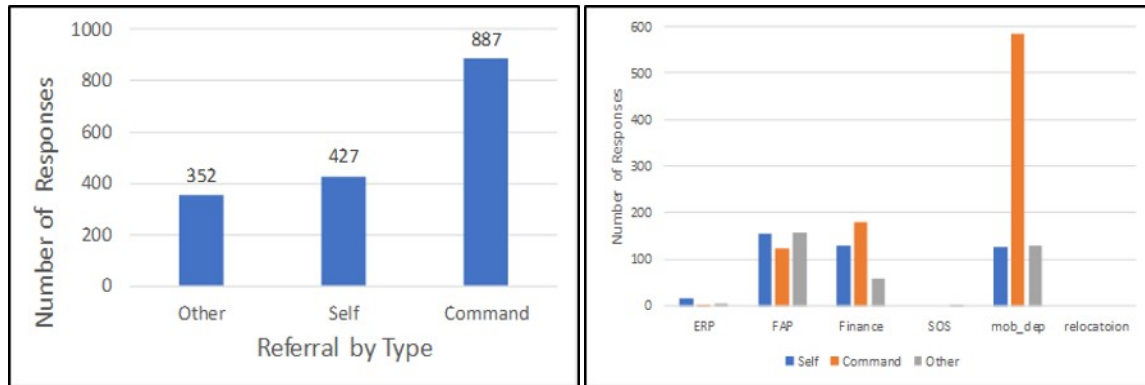


Figure 4.11. Stakeholder Initial View of Utility Value Curve

Figure 4.12a provides an initial look at the frequency distribution of referral types: other, self, and command. Figure 4.12b takes a closer look at referral types for individual ACS programs to gain better insights. For instance, analysis reveals that command referrals dominate MDSS. Because soldiers are required to receive ACS briefings prior to deployments, command referral contributed to over 70% of the MDSS customers. However, spouses and dependents could elect to attend and may be considered self-referrals.



(a) Histogram of Referral Types

(b) Referrals by Program

Figure 4.12. Utility Attribute Empirical Data

Years of experience and institutional knowledge serve as the stakeholder's basis for constructing a value curve. The resulting value model makes sense for the following reasons:

- Zero percent self-referrals equates to a zero value score.
- Maximum value achieved when 100% of customers self-refer.
- Increasing value as the percentage of self-referrals increase.
- Constant rate of change values per percent increase.

The value model converts the self-referral percentage into a unitless value. Figure 4.13 displays the intersection of a program's self-referral percentage with the stakeholder's operational value curve. ERP has the highest percentage of self-referrals; therefore, ERP has the highest value score across all programs.

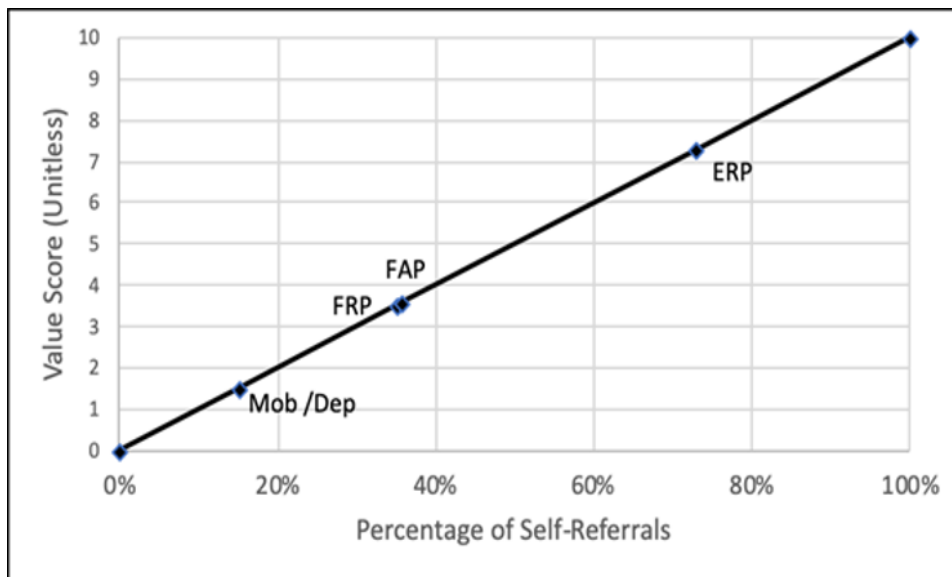


Figure 4.13. Value Curve Conversion for Utility Attribute

Table 4.3 lists the percentage of self-referrals per program and the converted value scores. The SOS and the Relocation Program did not report any self-referrals.

Table 4.3. Utility Attribute Value Score Results

ACS Program	Percentage of Self-Referrals	Value Score
FAP	36%	3.57
MDSS	15%	1.51
FRP	35%	3.51
SOS	0%	0.00
Relocation	0%	0.00
ERP	73%	7.27

4.2.4 Resource Confidence Value Model

An important element to the ACS services involves teaching customers about available resources. The stakeholder defined a step-wise relationship between the value achieved and

the difference between pre and post confidence in knowledge about available resources. The survey utilized a Likert scale between one and five. The minimum difference is zero, and the maximum difference is four. Figure 4.14 displays the increasing value occurs at equal intervals with the maximum value being achieved when the average difference in confidence is between three and four.

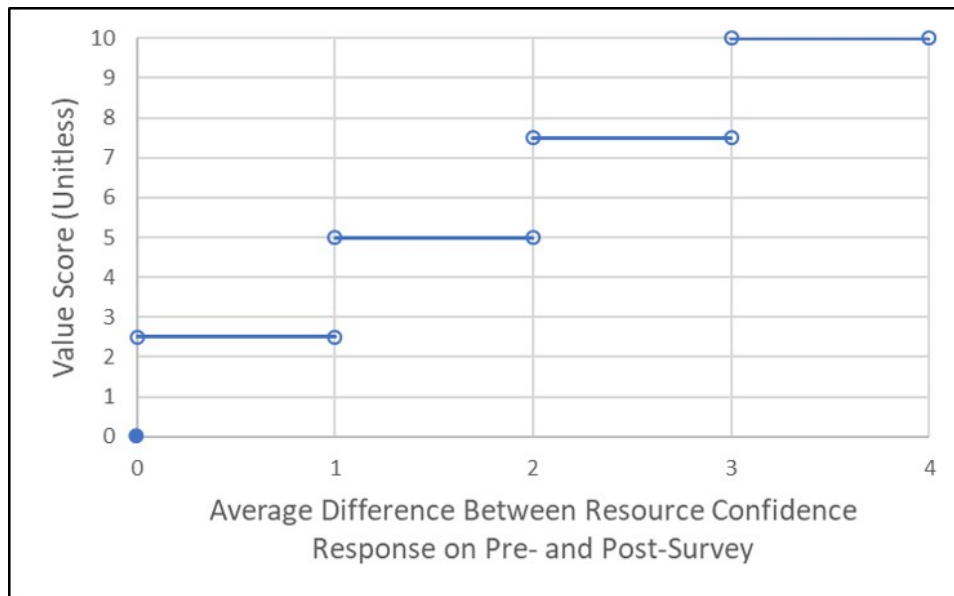
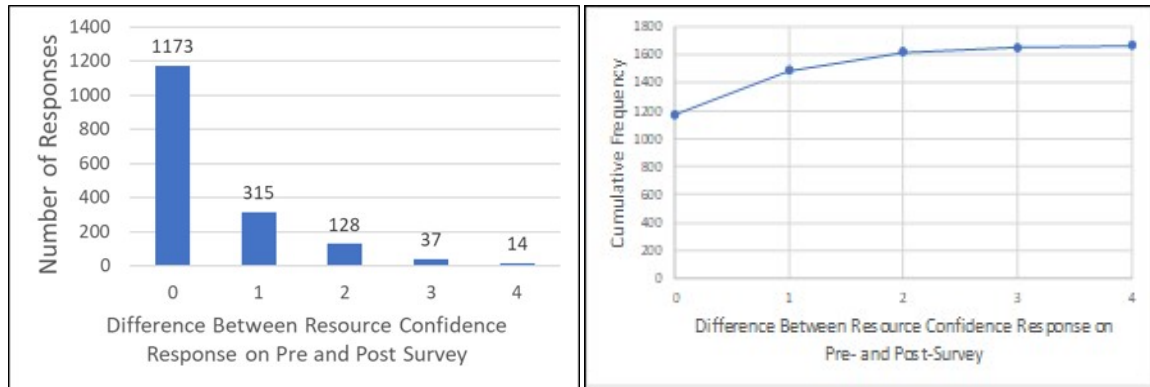


Figure 4.14. Stakeholder Initial View of Resource Confidence Value Curve

Figure 4.15a displays the responses from customers regarding their confidence about knowledge on available resources before and after entering the ACS program. The resulting frequency distribution summarizes responses from 1666 customers. Of these respondents, 1173 or 70% reported no difference in resource confidence. As the difference in resource confidence increases, the number of respondents decreases. Figure 4.15b displays the corresponding CFD for the resource histogram.



(a) Histogram of Resource Confidence (b) Resource Confidence Cumulative Frequency Distribution

Figure 4.15. Resource Confidence Attribute Empirical Data

The CFD is the basis for developing the value model. However, if the CFD were used exactly as the value model, it would assign a high-value score for no gain in confidence. Curve fitting forces the y-value to be zero when reports show no difference in resource confidence. The curve fitting algorithm ensures the values increase monotonically as the difference in resource confidence increases from zero to four. Figure 4.16 displays a concave curve shape that represents high-value gains for smaller changes in confidence about available resources. The curve continues with incrementally smaller value gains up to a four-point increase in resource confidence.

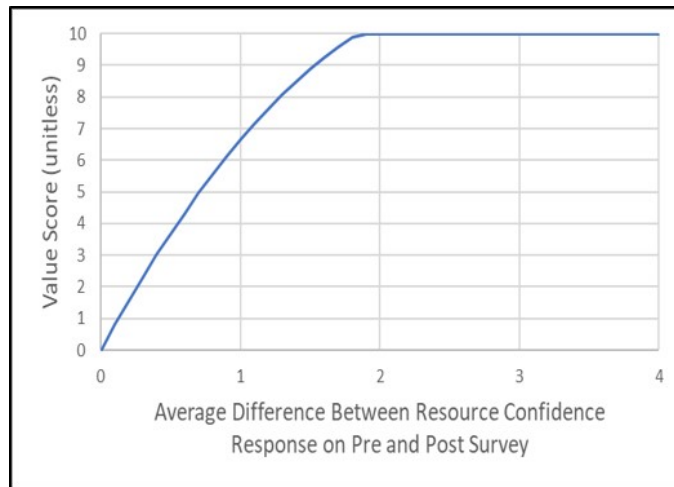


Figure 4.16. Resource Confidence Value Curve Based on the CFD

Logically, soldier readiness would not improve when resource confidence has not improved. Soldier readiness also achieves the maximum value when the customer's confidence increases by four levels on the Likert scale. Collected data shows that over 1200 soldiers are already confident or strongly confident in their knowledge about available resources. This provides little room for improvement. The value curve must take into account the reported need or demand for minimal improvement. Accounting for the baseline soldier confidence level, Figure 4.17 displays a convex shape.

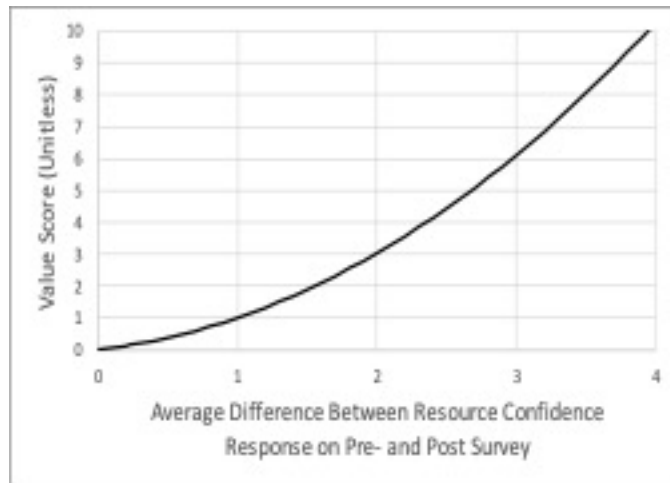


Figure 4.17. Resource Confidence Inverted Value Curve

The convex shape more accurately represents the conversion of resource confidence into value for the following reasons:

- Value curve equates zero confidence improvement into a zero-value score.
- Accounts for the great majority of soldiers who do not require confidence improvement.
- Represents commander's desire to focus more on those with poor confidence.
- Monotonically increases to the maximum value of 10.

Figure 4.18 represents a logical value model that represents the stakeholder's operational understanding of value, the analytics of the CFD, and a reasoned argument for the shape of the curve. The resultant value model is convex shape indicating increasing rates of change to value as the change in confidence about available resources increase.

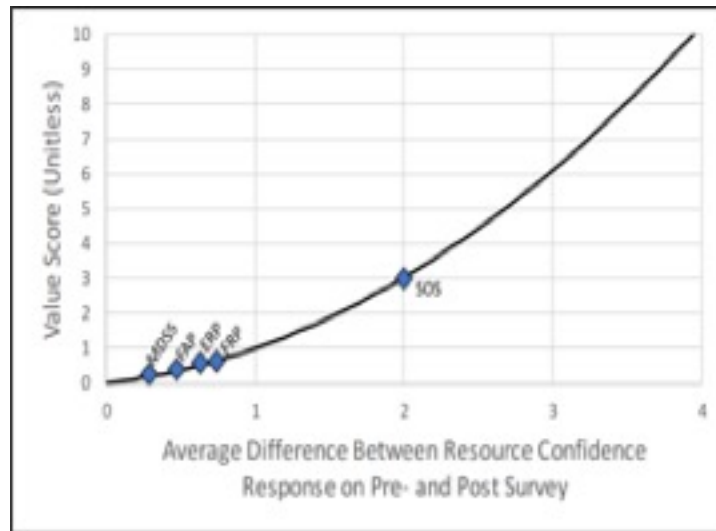


Figure 4.18. Resource Confidence Inverted Value Curve

Responses regarding confidence in knowledge about available resources show that five of the six programs affect soldier confidence. The data reveals that the SOS program provided the largest improvement to knowledge about available resources. Value score conversion from the average change in confidence level is presented in Table 4.4.

Table 4.4. Resource Confidence Value Score

ACS Program	Average Improvement to Resource Knowledge	Value Score
FAP	0.41	0.28
MDSS	0.32	0.21
FRP	0.73	0.63
SOS	2.00	3.04
Relocation	0.00	0.00
ERP	0.64	0.52

4.2.5 Skill Confidence Value Model

ACS has another goal of improving the confidence of the customer's ability to apply skills taught. The stakeholder defined a step-wise relationship between the value achieved and the change in confidence about applying skills taught in an ACS program. A Likert scale captured a customer's confidence level from one and five. Therefore, the average change would be between zero and four. Figure 4.19 displays equal gains in value with increased differences in confidence.

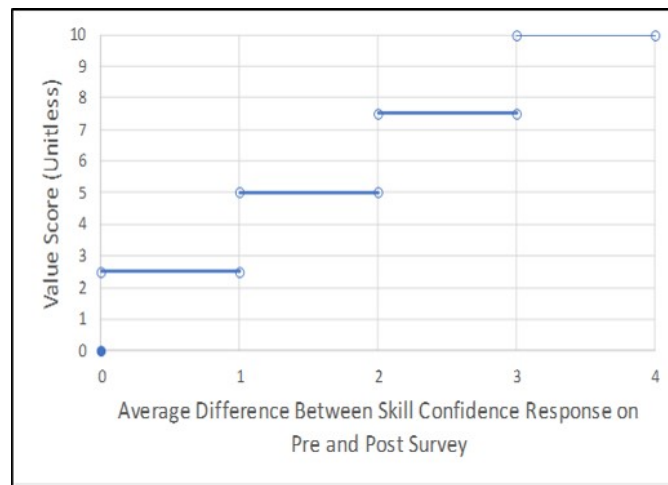
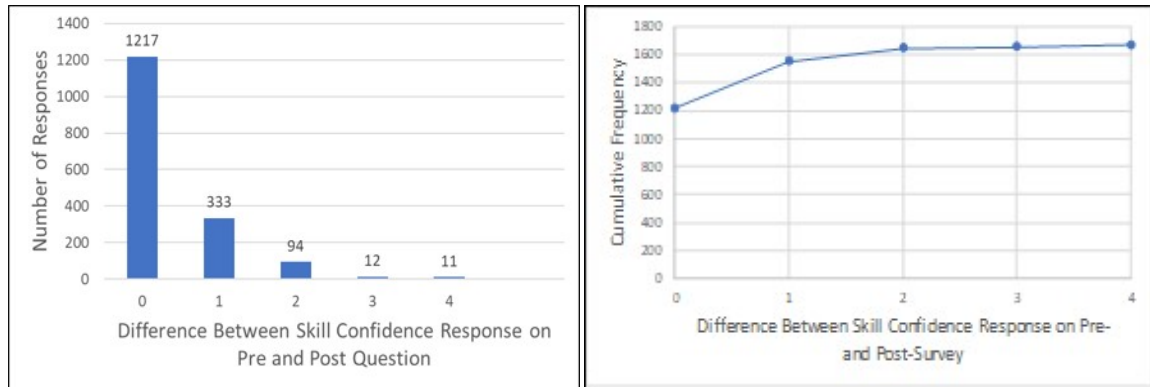


Figure 4.19. Stakeholder Initial View of Skill Confidence Value Curve

Figure 4.20a shows the histogram of 1666 responses to ACS surveys. Of the respondents, 1217 (73%) reported no difference in skill confidence. For greater changes in confidence improvements, the number decreases. Figure 4.20b displays the corresponding CFD to the histogram.



(a) Histogram of Skill Confidence (b) Skill Confidence Cumulative Frequency Distribution

Figure 4.20. Skill Confidence Attribute Empirical Data

The CFD is only the basis for developing the value curve. If the CFD were used exactly as the value model, it would assign an unreasonably high-value score for no gain in confidence. Curve fitting forces a value of zero when there is no change in confidence while ensuring that the curve increases monotonically. Figure 4.21 displays a potential value curve with a concave shape. This curve would assign a high value for the initial gain in confidence followed by incrementally smaller gains in improvement. Discussion with stakeholders and human nature does not agree with this initial curve.

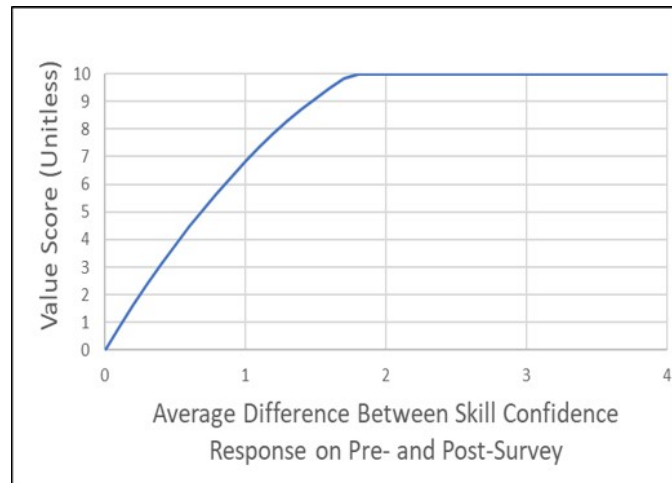


Figure 4.21. Skill Confidence Value Curve

A more reasonable approach considers a soldier's initial confidence. Data shows that 1222 soldiers are already confident or strongly confident in their current skill level. This provides little room for improvement. More likely, greater changes in confidence would be more valued and thus contribute more to soldier readiness. These considerations are represented by the value curve in Figure 4.22.

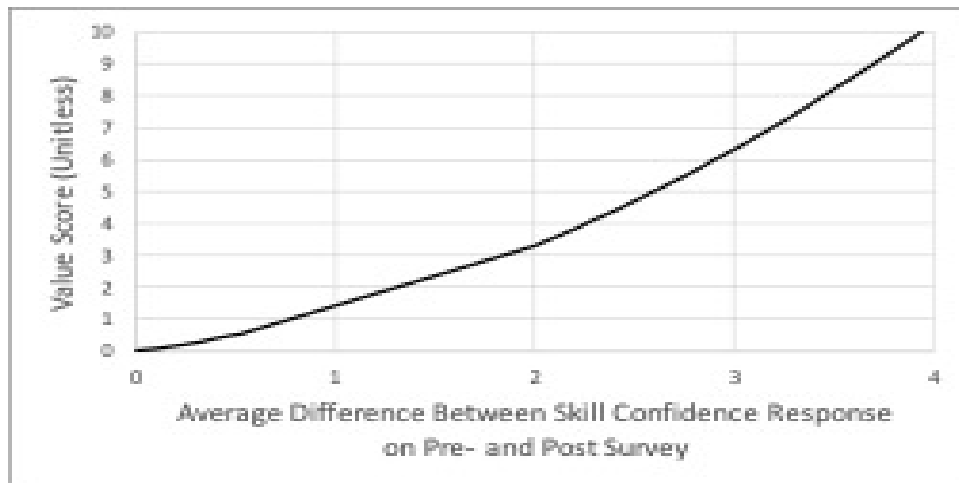


Figure 4.22. Skill Confidence Inverted Value Curve

The convex shape is more appropriate for converting change in skill confidence into value

for the following reasons:

- New value model assigns no value to zero change in confidence level.
- Accounts for the high number of soldiers who do not require confidence improvement.
- Represents commander's desire to focus more on those with poor confidence.

Figure 4.23 presents the resulting value model that accounts for the stakeholder's operational understanding of value, examination of the CFD, and a reasoned argument for the shape of the curve. The resultant value model is convex shape indicating depressed value scores for small changes in confidence levels, but changes greater than two score much higher. The curve begins at zero value for zero change and monotonically increases to the maximum value of 10.

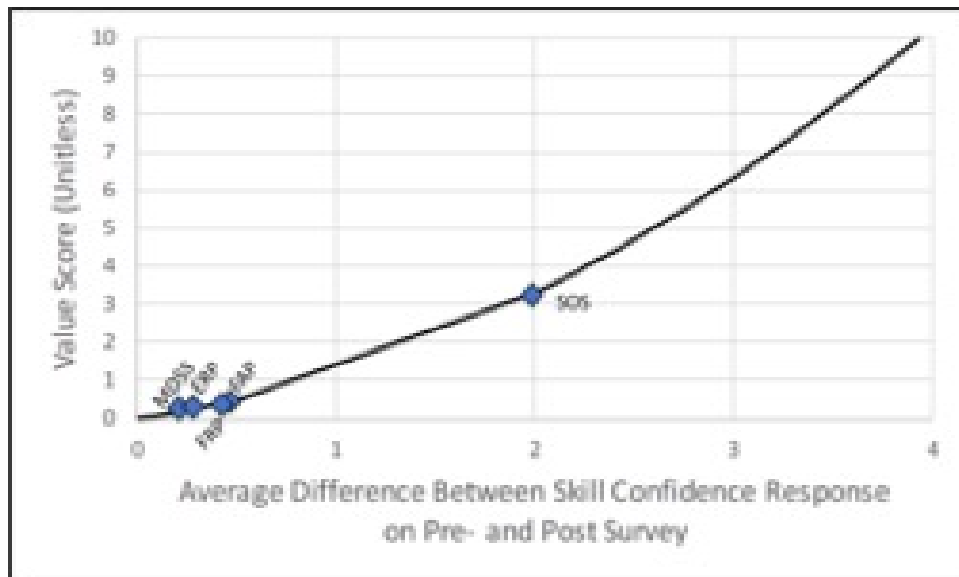


Figure 4.23. Value Curve Conversion for Skill Confidence Value

Reviewing data for each program shows that five of the six programs help customers increase their confidence in applying new skills. Those surveyed for the SOS program provided the largest average improvement in skill confidence. Table 4.5 lists value scores for each ACS program.

Table 4.5. Skill Confidence Value Score

ACS Program	Average Improvement to Skill Confidence	Value Score
FAP	0.47	0.44
MDSS	0.27	0.23
FRP	0.43	0.40
SOS	2.00	3.30
Relocation	0.00	0.00
ERP	0.32	0.28

4.2.6 Secure Environment Value Model

ACS aims to create a secure environment for soldiers and their families by bringing greater awareness of domestic violence and childhood neglect. The stakeholder defined a concave relationship between the value achieved and a percentage reduction in open incident cases and value. The program achieves maximum value when the number of open incident cases is reduced by at least 10% over a three month period. Reports can be filed anytime within the three month period. A reduction in existing open cases indicates a slowing of new domestic violence or childhood neglect cases. Figure 4.24 displays the graphical representation of the stakeholder's understanding of how the value curve would behave.

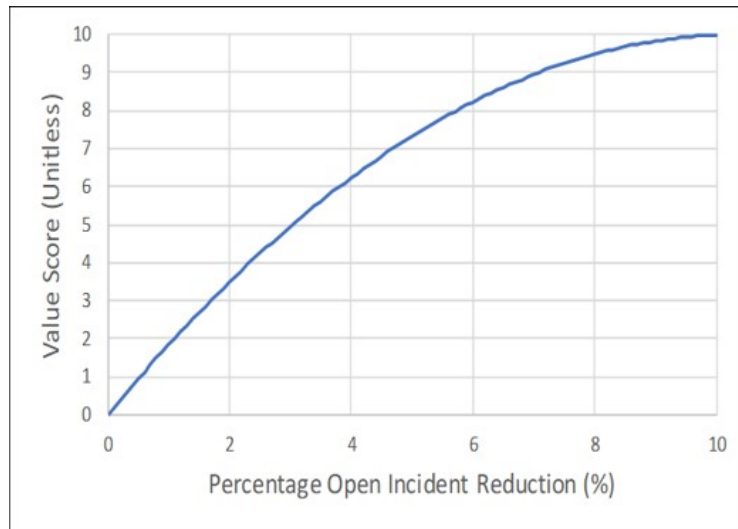


Figure 4.24. Stakeholder View of Secure Environment Value Curve

This value curve appropriately converts program performance into value because it represents real-world situations. Reductions in the caseload give the soldiers and commanders the ability to focus more on readiness.

We examine one such three-month period that was available for this thesis study. The monthly incident report from January 2020 established the baseline and the comparison metric for the secure environment attribute. The comparative metric used report totals from the end of March 2020. Figure 4.25 displays 66 open incident cases in January 2020. At the conclusion of the data collection period in March 2020, the open cases totaled 84. This open cases increased by 27%, which garners zero value. In future models, a negative value may be warranted. We leave this potential study for later studies.

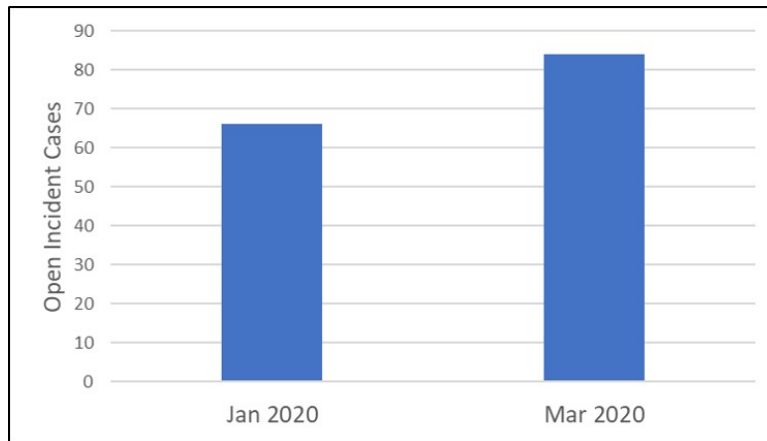


Figure 4.25. Number of Open Incident Cases

The empirical data shows an increase in open cases. During the data collection period, no program achieved value with respect to the secure environment attribute.

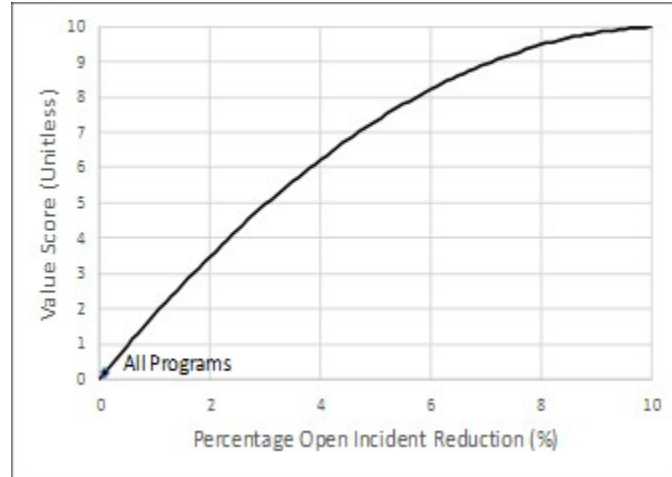


Figure 4.26. Value Curve Conversion for Secure Environment Attribute

4.2.7 Value Model Development Conclusions

The thesis evaluated all programs across six attributes. Each attribute required up to four value modeling techniques to convert performance into a value score. The value model ac-

counted for appropriateness based on the unique operational context. Next, we documented the justification for each attribute value model and measured each program's performance. The value model converted the performance into a unitless value score which gets used in the optimization model discussed in the next section.

4.3 Optimization Results

The optimization model seeks a maximum ACS value for a given budget. The result is a funding strategy for the different ACS programs that were considered in this thesis. The optimization model makes the following assumptions:

- Each weighted ACS program value score is constant.
- A program's value to ACS is proportionate to the percent of the budget that is allocated to it.
- The total expenditures for all programs will not exceed the maximum ACS budget from FY15, FY16, and FY19.
- Programs for which no data was available to compute value is not a part of the optimization formula.
- Specific ACS program budgets do not exceed their historic maximum program budgets.
- No monies will be left in reserves.

The individual attribute values per program is listed in Table 4.6. Combining these scores with the attribute weights from Chapter 2 results in the total program value scores.

Table 4.6. ACS Consolidated Value Score Table

ACS Program	Debt Reduction	Financial Confidence	Utility	Resource Confidence	Skill Confidence	Secure Environment	Total Program Value Score
FAP	0.00	0.04	3.57	0.28	0.44	0.00	0.65
MDSS	0.00	0.01	1.51	0.21	0.23	0.00	0.30
FRP	4.25	0.05	3.51	0.63	0.40	0.00	1.19
SOS	0.00	0.00	0.00	3.04	3.30	0.00	1.03
Relocation	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ERP	0.00	0.01	7.27	0.52	0.28	0.00	1.23
Total							4.41

The historic record of expenditures established the basis for budgetary allocations. Table 4.7 reports the minimum and maximum expenditures from historic records. Program expenses for FY15, FY16, and FY19 determined the program's minimum and maximum funding level: Min(Budget) and Max(Budget) values. Therefore, the investment percentage, I , for jth programs represent the funding percentage of the maximum historical expense. Equation 3.9 provides a mathematical expression to convert the investment percentage of the program's maximum budget into a percentage of the total ACS budget.

Table 4.7. Budgetary Constraints for Optimization

ACS Program	Min Budget (\$K)	Max Budget (\$K)	Min Funding (%)	Max Funding (%)
FAP	1431.10	1701.10	83	100
MDSS	287.40	402.60	71	100
FRP	575.70	852.10	68	100
SOS	117.00	217.00	54	100
Relocation	190.50	258.30	74	100
ERP	77.50	184.60	42	100

4.3.1 Mathematical Formulation

The model calculates the optimal funding strategy that best satisfies the conditions of a limited budget and program performance in terms of value. The historic budgets established the minimum and maximum funding levels for future spending. The optimization model examines all possible values for the decision variables, I , to arrive at an optimal solution. Constraints to the problem apply funding boundaries at the respective minimum and maximum levels. Additionally, the percentage of budget allocated to a program cannot exceed the maximum budget that the program had been funded under FY15, FY16, and FY19 budgets. Finally, the total budget for all programs cannot exceed the maximum budget received by ACS in FY15, FY16, and FY19. The investment strategy spends the entire budget. Table 4.8 gives the notation and definitions of the optimization model.

Table 4.8. Optimization Model Terms and Definitions

Notation	
I	Decision Variable: Percentage to be invested in a given program based on previous max budget
PV	Program value score
k	Budget year FY 2015, 2016, 2019
j	Designation for unique program: FAP, FRP, ERP, SOS, MDSS
$Min(Budget_j)$	$\min\{Budget_{jk} \quad \forall k\}$
$Max(Budget_j)$	$\max\{Budget_{jk} \quad \forall k\}$

Eq. 4.1 displays the specific formulation for the ACS Maximization Formulation to calculate the ACS value achieved:

$$\begin{aligned}
 \text{Maximize}_{ACS} \quad & I_{FAP} \times PV_{FAP} + I_{FRP} \times PV_{FRP} + I_{ERP} \times PV_{ERP} \\
 & + I_{SOS} \times PV_{SOS} + I_{MDSS} \times PV_{MDSS}
 \end{aligned} \tag{4.1}$$

Subject to:

$$\sum_{j=1}^m I_j \times \text{Max}(\text{Budget}_j) = 100\% \times \text{Max FY}(\text{Budget}_{\text{ACS}}) \quad (4.2)$$

$$I_j \geq \frac{\text{Min}(\text{Budget}_j)}{\text{Max}(\text{Budget}_j)} \quad (4.3)$$

$$I_j \leq \frac{\text{Max}(\text{Budget}_j)}{\text{Max}(\text{Budget}_j)} \quad (4.4)$$

Constraint Equation 4.2 ensures that the total expenditures across all programs do not exceed the ACS budget. During each evolution of potential solutions, the model limits the expenses to the total budget of ACS. Equations 4.3 and 4.4 define the individual programmatic investment boundaries from the historic expenses. This ensures each program gets funded at minimum funding levels to accomplish the mission.

4.3.2 What-if Analysis

Excursions with the optimization model evaluates likely budget scenarios. The optimization model calculates the optimal funding strategy when ACS receives its historic maximum budget. Next, the study examines the impact of ACS value at varying levels of budget cuts. The final analysis gains insights on how ACS may allocate funds if the budget increases. These analyses inform the stakeholder as different scenarios are considered.

Excursion 1

The optimization model provides the opportunity to analyze the distribution of funds according to the maximum historic budget of \$3.35M in FY 2019. Table 4.9 displays the results of the optimization model.

Table 4.9. Results of Investment Optimization

ACS Program	Program Value Score (Constant)	Investments Decision Variables (%)	Value Generated
FAP	0.65	100	0.65
MDSS	0.30	99	0.29
FRP	1.19	100	1.19
SOS	1.03	100	1.03
ERP	1.24	100	1.24
ACS Value Score			4.40

In this excursion, four of the five programs are funded at the maximum level and the fifth program at 99% before funds are expended. The high percentage of funding for each program ensures ACS gains the maximum value from each program. The model produced a budget strategy that achieved a total ACS value of 4.40 from a possible 4.41.

The investment into the individual programs depend on the number of personnel employed, required annual certifications, and trainings. Each program has unique demands which translates into individual budgeting requirements. Figure 4.27 converts optimal programmatic investment into the percentage allocated from the total ACS budget.

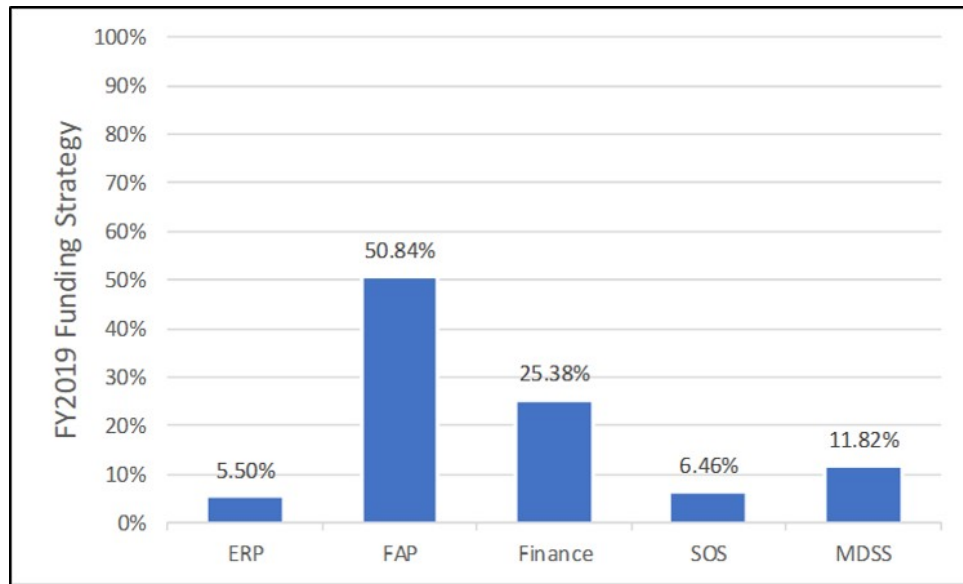


Figure 4.27. Optimal Allocation for FY 2019 ACS Budget

Excursion 2

In reality, ACS competes with other programs for funding. This results in budget cuts and continual reassessments to support internal programs when funding decreases. In this scenario, the thesis evaluates the impact on total ACS value when the budget gets cut at 10% intervals. Table 4.10 displays the results of budget cuts.

Table 4.10. Results of Excursion 2

ACS Programs	Program Value Score (Constant)	Investment Decision Variables (-10%)	Investment Decision Variables (-20%)	Investment Decision Variables (-30%)
FAP	0.65	87%	83%	83%
MDSS	0.30	71%	71%	71%
FRP	1.19	100%	80%	68%
SOS	1.03	100%	54%	54%
ERP	1.24	100%	100%	42%
ACS Value Score		4.23	3.50	2.63

The allocation strategy distributes the funding according to a two-step process. First, all programs get funded at minimum levels followed by a prioritized distribution according to program value. Reducing the ACS budget by 10% results in cutting MDSS to its minimum level and a subsequent reduction to FAP. The initial reduction by 10% resulted in a 5% loss in total ACS value when compared to Excursion 1 that used the FY 2019 budget. A reduction of 20% had a more substantial impact. At this point three of five programs received minimum funding and FRP no longer received 100% funding. This drop in value resulted in a reduction of 20% from total ACS value when compared to the FY 2019 budget (Table 4.9). A 30% cut failed to fund all programs at their minimum levels. This last reduction created an infeasible solution where the model could not satisfy the all constraints. ACS achieves a minimum value score of 2.63 when all programs receive minimum funding.

Excursion 3

The final excursion analyzes the improvements to ACS value with an increase to the ACS budget. For Excursion 3, we increased the maximum budget constraint of each program budget by the same percentage as the ACS budget. Additional increases did not take effect until all programs were funded to their new maximum funding level. For example, an ACS budget increase of 10% increases all program maximum budgetary constraints by 10% (Figure 4.11).

Table 4.11. Results of Excursion 3

ACS Programs	Program Value Score (Constant)	Investment Decision Variables (+10%)	Investment Decision Variables (+20%)	Investment Decision Variables (+30%)
FAP	0.65	110%	120%	130%
MDSS	0.30	108%	118%	128%
FRP	1.19	110%	120%	130%
SOS	1.03	110%	120%	130%
ERP	1.24	110%	120%	130%
ACS Value Score		4.85	5.29	5.73

For every 10% increase, four of the five programs remained fully funded and improved their program value by a proportional 10%. The total ACS value increase according to a linear relationship when funding exceeds maximum levels.

4.4 Summary

The programmatic value scores establish a priority of funding based on the ability to produce value. The funding priority initially satisfies every programs' minimum requirement before the allocation beyond minimums. With minimums satisfied, the subsequent allocations distribute funding according to the priority list. The allocation for the priority programs funds a program to the maximum level or until no additional funds remain. Based on collected data, analysis identifies the following program funding priority:

1. Employment Readiness Program
2. Financial Readiness Program
3. Survivor Outreach Services
4. Family Advocacy Program
5. Mobilization and Deployment / Stability Support

Figure 4.28 consolidates all excursions to graphically display the impacts of budget on

the ACS value score. The FY19 budget funds four of the five programs at their maximum historic levels and achieves a value of 4.40. The dashed red line identifies the point at which ACS satisfies the minimum funding for each program. Below the 70% funding threshold, the solution becomes infeasible identified by the red dot at 2.63. The 10% increase to the overall ACS budget funded four of the five programs at the new maximum levels. The relationship between value and budget follows a positive linear curve which identifies the proportional gain in value when total ACS budget increases.

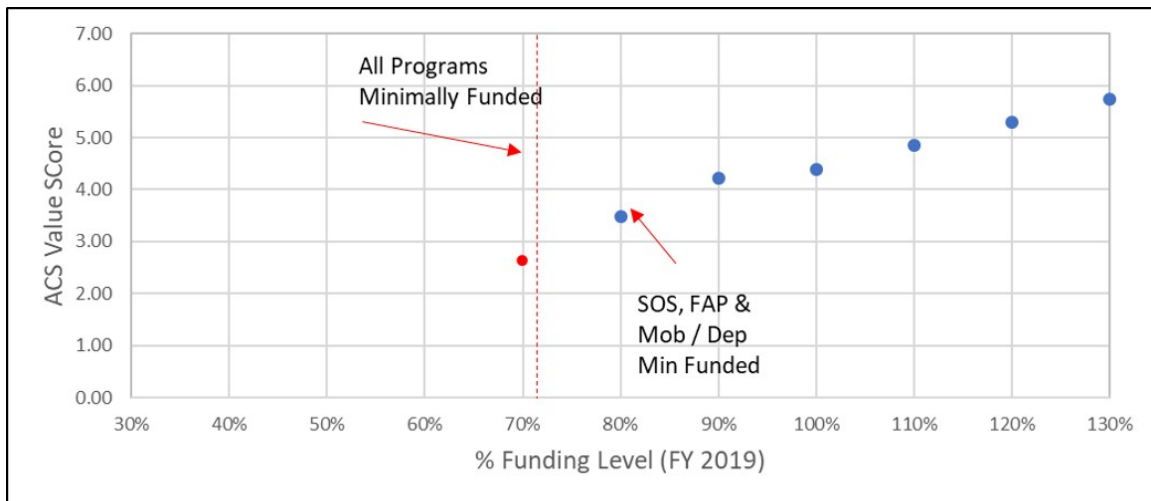


Figure 4.28. Impacts of FY19 Budget on ACS Value

CHAPTER 5:

Conclusions

5.1 Conclusions

The purpose of this thesis is to apply a systems engineering approach to quantitatively evaluate the ACS programs and inform future funding decisions. This thesis evaluated the ACS programs across six common attributes to calculate individual program value scores. The optimization model then incorporated the individual program value scores to determine the optimal funding strategy to maximize the total ACS value. This thesis satisfied these shortcomings by answering two questions:

1. How can the value of each ACS program and its aggregate be computed in terms of soldier readiness?
2. What is the most effective investment strategy to maximize the value of ACS to improve soldier readiness?

Programmatic Value Scores

This thesis answered the first question by developing a data collection plan to evaluate programmatic performance. ACS collected over 1600 responses and provided operational insights to construct the appropriate value models for each attribute of soldier readiness. The value models converted the performance measures into unitless value scores for comparisons. The weighting factor scaled the value of each attribute according to the stakeholder approved levels of importance. Table 5.1 lists the value scores for each program according to each attribute. The far-right column incorporates the weight factors to calculate the individual total program value scores. The resulting programmatic value scores determine the subsequent priority list for ! (!) budget allocations. The sum of all program value scores calculates the maximum ACS value achievable if all programs get fully-funded.

Table 5.1. ACS Consolidated Value Score Table

ACS Program	Debt Reduction	Financial Confidence	Utility	Resource Confidence	Skill Confidence	Secure Environment	Total Program Value Score
FAP	0.00	0.04	3.57	0.28	0.44	0.00	0.65
MDSS	0.00	0.01	1.51	0.21	0.23	0.00	0.30
FRP	4.25	0.05	3.51	0.63	0.40	0.00	1.19
SOS	0.00	0.00	0.00	3.04	3.30	0.00	1.03
ERP	0.00	0.01	7.27	0.52	0.28	0.00	1.23
Total							4.41

The prioritized program list based on program value in supporting soldier readiness resulted with the following:

1. Employment Readiness Program
2. Financial Readiness Program
3. Survivor Outreach Services
4. Family Advocacy Program
5. Mobilization and Deployment / Stability Support

The program's individual attribute value scores aggregated together determine the program's total value score. The process and findings satisfy the first thesis question.

Optimal Funding Strategy

The thesis answered the second thesis question with a linear programming optimization model. The model incorporated the individual programmatic value scores from Question 1 to calculate an optimal funding strategy for an ACS budget. The historic budgets from FY15, FY16, and FY19 established a program's minimum and maximum investment constraints. The historic budgets also established a maximum constraint for the total investment into ACS programs. FY19 provided a notional ACS budget that allowed maximum funding for four of the five programs and 99% funding of the fifth program. Figure 5.1 converts the optimal dollar allocations into a the percent allocation of the total ACS budget. The optimal allocation achieves an ACS value score of 4.40. The investment of the ACS budget according to the optimal budget answers the second thesis question.

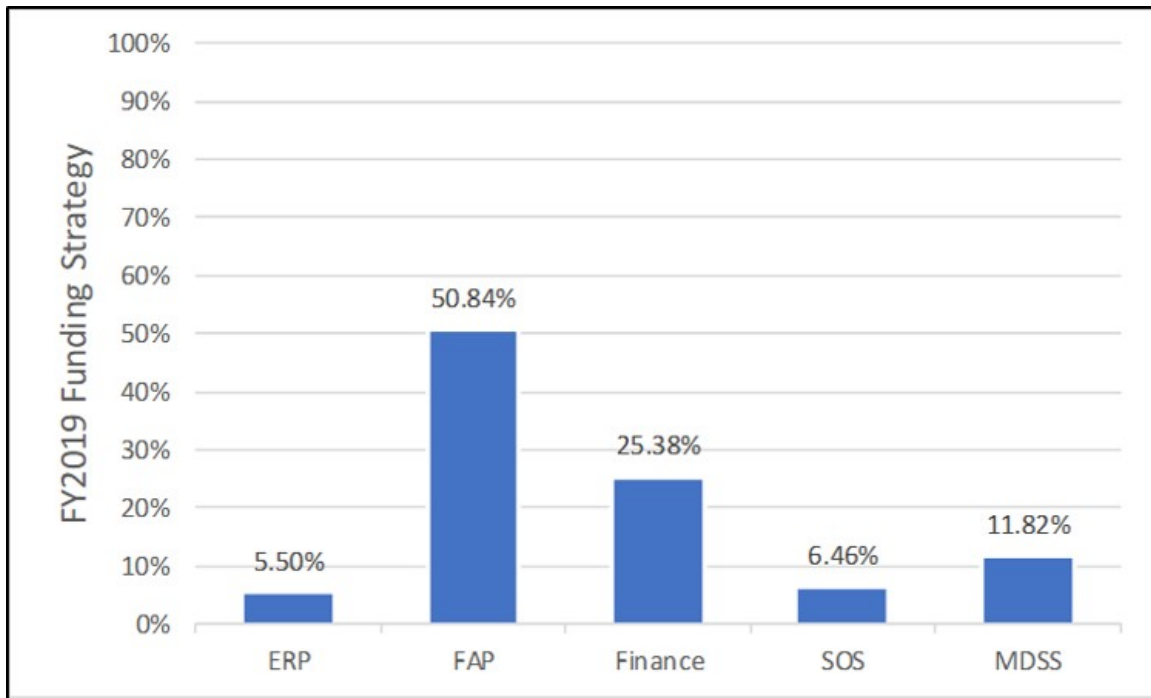


Figure 5.1. Optimal Allocation for FY 2019 ACS Budget

Excursion Conclusions

The value of the optimization model allows for critical trade-off analysis when the total ACS budget cannot fully fund all programs. The priority funding list from Question 1 dictates that higher valued programs receive additional funding after all programs meet minimum levels. Figure 5.2 illustrates the rate at which a program loses funding according to their priority. At the optimal funding level, ACS achieves a total value of 4.40 toward soldier readiness. After a 10% cut, the three top priority programs remain fully funded while the two lower priority programs absorb all the budget cuts. The 10% cut in the ACS budget results in a loss of 4% in value towards soldier readiness. A 20% cut in the ACS budget results in four of the five programs funded at minimum levels. ERP remains the only fully-funded program. The 20% budget cut reduced the ACS value by 20% compared to the optimal funding level. This drastic reduction in value is caused by the higher priority programs taking on the budgetary cuts once the lower priority programs reach minimum levels. The lowest value ACS achieves while satisfying all constraints is a 2.63. At this minimum funding level, the total value reduces by 40% compared to the fully-funded option.

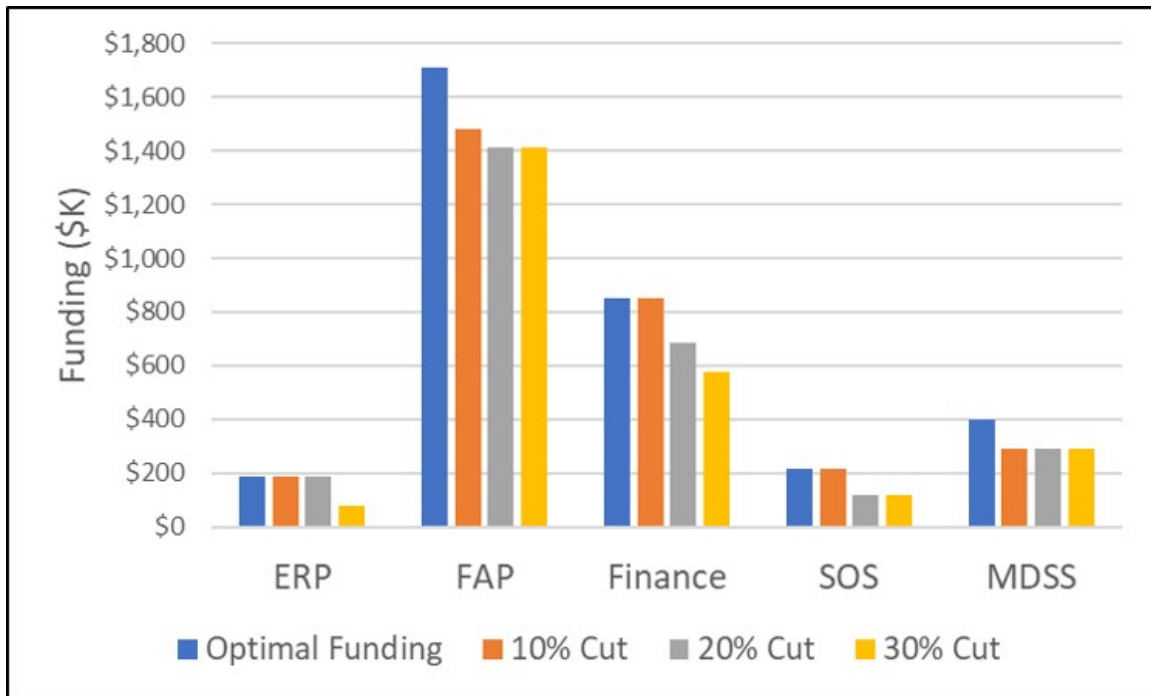


Figure 5.2. Optimal Budget Allocation Based on Funding Levels

The excursions provide a more complete analysis of the tradeoffs under increasingly restrictive conditions. The additional value of the optimization model lies in the flexibility to quickly identify the tradeoffs as the ACS budget gets cut. The flexibility in the model becomes more valuable when future budgets project lower than the historic minimums. "The proposed FY 2021 DoD budget requested \$7.2 billion less than the DoD spending in FY 2020" [46]. The model's quick modification allows for ACS to strategically cut lower priority programs before those that perform better to improve soldier readiness.

5.2 Future Work

Extend Timeline of Study

The current value models evaluated the programs on a three-month cycle from January 2020 through March 2020. This thesis evaluated programs and produced an optimal funding strategy based on three months of data. Time available for data collection and analysis to answer the study questions was limited. The limited time did not fully account for the

unique operational cycles of each program. While the Financial Readiness Program and ERP remain constant, the Relocation and FAP programs depend on soldier moving cycles and focused campaign efforts. Soldier deployment cycles drive the efforts of the MDSS program. Extended time for data collection and analysis could gain a better understanding of the program's performance and resultant value.

The study assumed a constant program value as a quantitative component of the optimization model. The increased timeline for data collection tests the specific assumption for further validation. Since programs operate on unique operational cycles, ACS may achieve higher value by allocating funds on a quarterly or semi-annual basis. Further refinement of results requires increased timelines for data collection. The additional timeline for data collection can support the identification of value trends, the reduction of uncertainty in results, and the complete analysis of funding on a quarterly, semi-annual, or annual basis. The extended timeline may also support an alternative funding strategy to increase ACS value to soldier readiness.

Expand Organizational Scope

The current analysis focused on the ACS funding strategy without consideration of the external programs competing for funding. Future work may expand the scope to include all programs receiving funding from IMCOM-Pacific. This future work will analyze IMCOM-Pacific objectives for alignment.

Expanding the scope of the study to the higher headquarters benefits those receiving funds in three unique ways. First, the expanded scope requires an evaluation of IMCOM-Pacific common attributes. These attributes generate criteria for subordinate organizations to prioritize work. This also ensures the organizations align future efforts with criteria that generate value. After a program quantifies its value according to the headquarter's criteria, it can justify an increased allocation of funding. ACS can justify a larger investment when it can quantify its value.

ACS CONUS Comparison

In this thesis, the study focused on the programs at Schofield Barracks, HI. Future work can implement the same framework, data collection methods, and analysis techniques to

compare program performance across CONUS and OCONUS locations. The comparison allows ACS to gain a better understanding of unique organizational functions that increases value.

Program funding accounts for performances that achieve the most value. CONUS and OCONUS locations have unique demands, but universally rely on funding from their respective IMCOMs. ACS may seek to increase their funding by improving their value to IMCOM. Expanded research requires data collection across several ACS locations to compare individual program values. The individual programs may then generate best practices. By incorporating best practices from the best programs, ACS can train underperforming programs to increase value. The increased value becomes the justification for funding.

APPENDIX: Example Survey

A.1 Pre-survey

1. What service(s) have you visited ACS in the past 3 months (circle all that apply)
 - Financial Readiness
 - Relocation
 - Survivor Outreach Support
 - Deployment
 - Family Advocacy Program
 - Employment
 - Other
2. Who referred you to ACS?
 - Self
 - Command
 - Other
3. According to the following statements, which number best applies
1 – Strongly Disagree 2 – Disagree 3 – Neither Agree or Disagree 4 – Agree
5 – Strongly Agree
 - I am confident in my ability to get hired.
 - I know what resources are available to assist me.
 - I have the ability to apply skills for employment.
 - I require employment to stabilize my finances.
4. I am (circle one)
 - Active Duty
 - Spouse
 - Retiree
 - Other

A.2 Post-survey

1. According to the following statements, which number best applies

1 – Strongly Disagree 2 – Disagree 3 – Neither Agree or Disagree 4 – Agree
5 – Strongly Agree

- I am confident in my ability to get hired.
 - I know what resources are available to assist me.
 - I have the ability to apply skills for employment.
 - I require employment to stabilize my finances.
2. Are you seeking assistance to reduce your debt? (Y / N)
 - If YES, what is your debt amount?
 - How much has your debt reduced while working with ACS?

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