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MARINE CORPS OFFICER ASSIGNMENTS: THERE HAS TO BE A BETTER WAY

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THESIS

MARINE CORPS OFFICER ASSIGNMENTS: THERE HAS TO BE A BETTER WAY

by

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March 2019

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One of the most crucial aspects of the development and retention of quality officers in the Marine Corps is effective assignment. This thesis takes an innovative approach to an old problem by proposing a technical solution: the Ground Officer Assignment Tool (GOAT) offers an optimization-based decision aid as well as a means by which to evaluate an existing personnel assignment based on several metrics. As a single commodity network flow problem, the GOAT tackles the personnel assignment problem using Python-based computational software packages. The model uses weighted penalties for the attributes of each assignment to calculate a cost for that assignment. The GOAT then minimizes those costs based on user-defined inputs and assigns each Marine to his or her optimal billet. With the added flexibility of testing multiple sample solutions in a short period of time and seeing the comparative cost, the GOAT can save monitors vast amounts of time while better equipping them to make crucial decisions that drive the efficiency of officer assignments. This thesis introduces a system that can aid in data processing with the intended purpose of better arming monitors, who are almost solely responsible for the effective assignment of Marine Corps officers.

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MARINE CORPS OFFICER ASSIGNMENTS: THERE HAS TO BE A BETTER WAY

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ABSTRACT

One of the most crucial aspects of the development and retention of quality officers in the Marine Corps is effective assignment. This thesis takes an innovative approach to an old problem by proposing a technical solution: the Ground Officer Assignment Tool (GOAT) offers an optimization-based decision aid as well as a means by which to evaluate an existing personnel assignment based on several metrics. As a single commodity network flow problem, the GOAT tackles the personnel assignment problem using Python-based computational software packages. The model uses weighted penalties for the attributes of each assignment to calculate a cost for that assignment. The GOAT then minimizes those costs based on user-defined inputs and assigns each Marine to his or her optimal billet. With the added flexibility of testing multiple sample solutions in a short period of time and seeing the comparative cost, the GOAT can save monitors vast amounts of time while better equipping them to make crucial decisions that drive the efficiency of officer assignments. This thesis introduces a system that can aid in data processing with the intended purpose of better arming monitors, who are almost solely responsible for the effective assignment of Marine Corps officers.

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List of Acronyms and Abbreviations

DSS	Decision Support Systems
EAM	Enlisted Assignment Model
FMOS	Free Military Occupational Specialty (MOS)
GLPK	GNU Linear Programming Kit
GOAT	Ground Officer Assignment Tool
MMOA	Manpower Management Officer Assignments
MMRP	Manpower Management Records and Performance
M&RA	Manpower and Reserve Affairs
MSGAT	Marine Security Guard Assignment Tool
MOS	Military Occupational Specialty
MCC	Monitor Command Code
OSGM	Officer Staffing Goal Model
ODSE	Operational Data Store Enterprise
PCS	permanent change of station
PMOS	Primary Military Occupational Specialty
PME	Professional Military Education
Pyomo	Python Optimization Modeling Objects
SME	subject matter expert
TFDW	Total Force Data Warehouse
WebMASS	web-based Monitor Assignment Support System

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Executive Summary

The Marine Corps is responsible for ensuring nearly 200,000 active duty Marines have appropriate jobs to fill. The assignment of these Marines falls squarely on the shoulders of assignment personnel known as monitors, and it is no small feat. Inside Manpower Management Officer Assignments (MMOA), monitors are responsible for placing thousands of Marine officers, approximately one-third of whom rotate each year. The gravity of this responsibility, coupled with the access to an over-abundance of information for each individual Marine, creates a substantial data-processing challenge.

This thesis takes an innovative approach to an old problem by proposing a technical solution: the Ground Officer Assignment Tool (GOAT) offers the monitor an optimization-based decision aid as well as a means by which to evaluate an existing assignment based on various metrics. Using the GOAT, a monitor can quickly weigh multiple assignment options and, with greater efficiency, make the best possible decision. This saves time and money while offering a better service to both Marines and the Marine Corps at large.

The monitors' mission is to "ensure that the right officers are assigned to the right billets at the right time, and remain, by assignment, competitive for advancement" (MMOA, 2018, slide 6). While the monitor does not hold the ability to grant an officer guaranteed advancement, officer assignments have arguably the single greatest impact on the retention of Marine Corps officers and the trajectory of their careers. This means ensuring officers fill appropriate prerequisite billets for future leadership positions and affording everyone the same competitiveness for advancement. The placement of each officer in an appropriate job not only satisfies the officer's need to be properly employed but sets the stage for future billets, ensuring the future of the organization.

The GOAT is based on a single-commodity network flow problem and tackles the personnel assignment problem using Python-based computational software packages. It assigns a penalty to suboptimal pairings of attributes and weights those attributes to obtain a cost for each possible assignment of Marine m to billet b. These costs are then minimized to find the optimal solution based on the inputs. The GOAT affords monitors the opportunity to specifically assign a Marine to a particular billet or restrict a Marine from certain billets utilizing the force/forbid capability. The monitors can also control the number of changes relative to an incumbent assignment when making subsequent assignments. Through the use of "ghost" Marines and billets, the GOAT makes recommendations on which Marines or billets are best to leave unassigned. This feature allows the monitor to manage lists of Marines and billets of differing length from each other.

To mirror the data available to the monitors, this data uses compiled archived information, primarily from Total Force Data Warehouse (TFDW) and Operational Data Store Enterprise (ODSE). Including pre-processing of the data, each model run of the GOAT takes approximately 35 minutes. This means in a matter of hours the GOAT produces assignments with multiple weighting schemes to compare to each other. This comparison, even taking multiple weeks to validate each potential solution, would reduce the monitors' time to conduct assignments from multiple months down to just one. Moreover, the GOAT has the potential to substantially improve performance. For example, in our historical data, 15% of Marines submitted preferences for a billet or geographic location. By weighting their preferences, the GOAT is able to assign over 85% of these Marines to their top geographic preference and over 75% to one of their top two billet preferences. This is compared to the monitors who effectively assigned 50% of these Marines to their top geographic preference and nearly 80% to a billet preference not even on their list.

The monitors currently process an abundance of data manually. It is of no surprise that it takes months for them to conduct their assignments. The GOAT offers a means by which the monitors can have a more organized presentation of the data. With refinement of the data collection and storage procedures for Manpower and Reserve Affairs (M&RA), the GOAT can optimize the data by the monitor established weighting scheme to afford them the opportunity to test multiple sample solutions and weigh their benefits before issuing any orders. The added benefit of the GOAT's evaluation feature allows them to see the cost to the Marine and the organization as a whole and adjust that balance. This flexibility and maneuverability avoids the additional recency bias that arises from an extended time to conduct assignments. The primary benefit of the tool is the vast time it saves the monitors while best equipping them to make the crucial decisions and drive the efficiency of officer assignments.

One of the most crucial aspects of the development and retention of quality officers in the

Marine Corps is effective assignment. Timely placement of an appropriate Marine in a good fitting billet potentially leads to better individual performance and greater levels of organizational efficiency. This thesis introduces a system that can aid in data processing with the intended purpose of better arming monitors, who are almost solely responsible for the effective assignment of Marine Corps officers. It highlights areas of inadequacy in data collection and management, while offering recommendations for ways ahead. Finally, it emphasizes that through this and any future studies the overarching objective must be increasing the effectiveness and efficiency of the monitors because the human aspect of assignment is essential. Computer-aided processing of quantifiable data allow human agents the necessary flexibility to address the unique human issues that inevitably arise. Weapons and tactics are continually developed to better arm combat troops, so why should development of systems and tools for those charged with management of the Marine Corps's most valuable resource, its personnel, be valued any less?

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CHAPTER 1: Introduction

> Assignment of individuals to positions in a manner which makes use of their skills while providing adequate job satisfaction is crucial to the smooth and economical function of the organizations....Military personnel assignment problems should, consequentially, be given a thorough quantitative analysis to determine effective decision alternatives. (Klingman & Phillips, 1984, p. 1362)

Assignment of personnel to appropriate jobs is a challenge in every career field that does not rely solely on the use of autonomous machines, and the United States Marine Corps (USMC) is no different. Even as the smallest branch of the Department of Defense (DoD), the Marine Corps is responsible for ensuring nearly 200,000 active duty Marines have appropriate jobs to fill. The assignment of these Marines falls squarely on the shoulders of assignment personnel known as monitors, and it is no small feat. Inside Manpower Management Officer Assignments (MMOA), monitors are responsible for thousands of Marine officers, approximately one-third of whom rotate each year. The gravity of this responsibility, coupled with the access to an over-abundance of information for each individual Marine, creates a substantial data-processing challenge.

Officer assignments currently take numerous personnel up to six months to complete. Individual monitors must manually process data and assign each of their constituents to an appropriate job. They must ensure competitiveness for advancement and the best possible return on investment to the Marine Corps. Each monitor is responsible for a subset of ranks and Military Occupational Specialties (MOSs). They must weigh proper career progression with Marine preferences while minimizing cost to the organization. Even with this limited scope of Marines to consider, a monitor's job is labor-intensive and requires months of work to generate a final assignment.

This thesis takes an innovative approach to an old problem by proposing a technical solution: the Ground Officer Assignment Tool (GOAT) offers the monitor an optimization-based decision aid as well as a means by which to evaluate an existing assignment based on various metrics. Using the GOAT, a monitor can quickly weigh multiple assignment options and, with greater efficiency, make the best possible decision. This saves time and money while offering a better service to both Marines and the Marine Corps at large.

CHAPTER 2:
Background / Literature Review

2.1 Importance of Officer Assignments

Of the over 20,000 officers in the USMC, nearly one third are assigned to new billets each year. The ratio of officers to enlisted is roughly 1:8, meaning officers influence a huge number of Marines, and as an officer's career progresses, the number of Marines he or she influences grows. An officer's influence can range from a few Marines in a specific section to thousands if commanding a regiment or larger. These officers are charged with mission accomplishment while being entrusted with the lives and well-being of their Marines and millions of dollars of government weapons and equipment.

Officer assignments have arguably the single greatest impact on the retention of Marine Corps officers and the trajectory of their careers. In economic terms, the human capital investment to build a Marine Corps officer is a substantial waste if the officer chooses to separate at the earliest opportunity. A properly assigned, adequately motivated officer can have a positive, lasting impact on the Marines under his or her charge. Conversely, a poorly assigned officer who feels that the organization does not value or properly utilize his or her talents will take that wealth of human capital elsewhere.

The placement of each officer in an appropriate job not only satisfies the officer's need to be properly employed but sets the stage for future billets, ensuring the future of the organization. While the monitor does not hold the ability to grant an officer guaranteed advancement, the monitor does directly influence the officer's career trajectory. The monitors' mission is to "ensure that the right officers are assigned to the right billets at the right time, and remain, by assignment, competitive for advancement" (MMOA, 2018, slide 6). This means placing officers to fill appropriate prerequisite billets for future leadership positions and affording everyone the same competitiveness for advancement.

2.2 Literature Review

This thesis's review of the literature delves into two major areas of study. The first is assignments and matching from an economics and business perspective. This section focuses on implications of proper assignments on the Marine and the organization. It looks at past research into Marine Corps Assignments and ends with a look at how human beings approach decision making, specifically in hierarchical organizations. The second part transitions from the policy and economic impacts of the decisions, to the human beings making the decisions and how tools can affect them. The second part also focuses on Decision Support Systems (DSS) and their impacts on decision makers, and it provides an overview of other optimization-based tools used in similar assignment processes.

2.2.1 Assignments / Matching

Modern labor economists extensively study the personnel assignment problem. Ensuring the right person is assigned to an appropriate job is applicable in and out of the military. Good assignments can lead to better job satisfaction, more efficient individual and unit operation, and increased retention. The converse of this is the additional cost from inefficiently assigning Marines to billets. A poor assignment process can lead to a waste of time for both the monitors, while conducting the assignment, and the Marines, as they must spend extra time to overcome a steeper learning curve than they would in a properly fitting job. Ultimately, the organization pays the cost by operating at less than optimal efficiency due to a poor fit of Marines in billets.

Klingman and Phillips

Klingman and Phillips (1984) look at enlisted Marine assignment as a preemptive multi-criteria assignment problem. They speak to the prioritization of certain assignments over others, similar to that of the Commandant's Manning Precedent (CMC, 2017). They look at mathematically modeling each Marine and billet by particular attributes and solving the overall optimization by solving various sub-problems. They examine six separate strategies for solving the assignment problem by focusing on different sub-problems. The result is that time for computation increases greatly as they begin to aggregate attributes or sorting criteria. This thesis builds on the concept of quantifying the attributes of Marines and billets while computing an overall cost of each assignment. In conjunction with greater computing capabilities, the GOAT offers greater results with less computation time.

Hooper and Ostrin

Hooper and Ostrin (2012) use an integer programming model for optimizing Marine Corps officer assignments. Their thesis demonstrates the idea of comparing assignments based on varying metrics from cost minimization to the balance of seniority or experience. Their model does not effectively penalize for differences in rank. To minimize cost, they simply assign lower ranking Marines to more expensive areas, which is one of the serious limitations of their model. The other limitation is using a very limited scope of individuals, MOS, and billets, all being solved using Microsoft Excel. This leads to an inability to adequately scale their model to a realistic scope. Because it is implemented in Python, the GOAT has adequate scalability and is suited for full monitor constituencies of thousands of Marines and billets without being limited to Excel Solver's 200-variable restriction.

The real contribution of their thesis is that their thorough review of the literature associated with assignments in the Marine Corps. Past research, as far back as 20 years (Tivnan, 1998), shows a dissatisfaction with assignments in the Marine Corps. Fecteau (2002) discusses overall effectiveness of the Enlisted Assignment Model (EAM) and makes recommendations for a consolidated information system to centralize monitor access to all pertinent information. Building on Fecteau's work, Ramirez and Park (2003) perform a qualitative analysis of the impact of assignments on retention and ultimately recommendation a web-based information system that allows access of all applicable data in a single location. This fits with the migration to use of web-based Monitor Assignment Support System (WebMASS). Their study was followed up by Morgan (2005) whose look at the importance of officer assignments shows how too much time in either Primary Military Occupational Specialty (PMOS) or secondary billets correlates with decreased promotion opportunity and increased likelihood of early separation. More in-depth review of these studies can be found in the thesis by Hooper and Ostrin. Their overall recommendation is that any tool developed for use by the monitors remains merely a tool. Though a tool may assist them in their duties, it should never force monitor assignments or completely remove the human element from the process.

Robards

Robards (2011) examines human decision making by first discussing the theory of bounded rationality and the limitations of manual decision making. He emphasizes that even with the known limitations of the process, large hierarchical organizations, such as the DoD, still use manual means of conducting assignment. He continues by discussing two sided matching as studied by Roth and Sotomayor (1990) and the necessity for rank-ordered preferences for each participant in the match. He then broadens his scope by delving into the effects of preference indifference. Next, he explores multi-attribute utility theory and the effectiveness of various weighting schemes on who ultimately benefits from a particular assignment based what attribute is most valued. He finally suggests "that a decision support system should [not] replace career managers or that such systems should produce assignments autonomously. However, a decision support system could quickly provide career manages with a range of options" (Robards, 2011, p. viii). Similarly, this thesis provides a more detailed option for a tool that may assist the monitors in their assignment process.

2.2.2 Decision Support Systems / Optimization

This thesis now examines technological aids and past examples of optimization-based tools similar to the GOAT. Much research has been done on optimization and decision support systems in reference to personnel assignment. This thesis expands on this research by offering implementation of modern computing to reduce the load on the monitors in their crucial duties of officer assignment.

Todd and Benbasat

Todd and Benbasat (1992) show that people will choose a DSS that saves effort, even if decision making does not improve. The key of their study is that a properly designed DSS did not necessarily improve the amount of information processed but that the benefit came in minimizing the cost of effort. The system must be easier than the current process and provide comparable, if not superior, results. The GOAT seeks to save overall decision time by automating the quantitative calculations involved in data pre-processing. Even with the additional step of validating the model, the time needed to conduct assignments should be cut by more than half.

Bausch et al.

Bausch, Brown, Hundley, Rapp, and Rosenthal (1991) show a network-optimization approach to mobilizing Marine Corps officers across the active-duty and reserve components, to include retirees, for a wartime scenario. With minimal computing power, they assign as many as 40,000 Marines to over 27,000 billets and print orders for each. They are then able to analyze the requisite time and quality of assignment. Their research does not put any emphasis on preference, and it is more important to simply fill all the billets. Their objectives are to fill all billets, match required attributes as closely as possible, and minimize the number of officers being displaced from currently assigned units. They approach the problem with two documents: the Wartime Officer Slate File (total officer inventory) and the Wartime Authorized Strength Report (wartime billets). The billets are given a priority, much the same as the Commandant's Manning Precedence today, and the officers are optimized based on grade, MOS, Monitor Command Code (MCC), sex, and limited-duty status. Similar to the GOAT, a perfect match of Marine to billet incurs zero cost, but any deviation from required to actual attributes incurs positive cost. The goal of their research is to find an alternative to the Officer Staffing Goal Model (OSGM) for use in mobilization exercises. They demonstrate computation times on the order of minutes, instead of days as in previous model. This thesis expands their objectives to account for preference and use modern computing power to solve a peacetime assignment while offering additional flexibility and functionality to the monitors.

Enoka and Craparo

Enoka and Craparo (2014) build on the earlier work of Enoka (2011) developing the Marine Security Guard Assignment Tool (MSGAT) to provide an automated assignment of Marine Security Guards (MSGs) to embassy detachments. The MSGAT reduces hours spent on assignments by 80%. Similar to the Officer Assignments problem, their task was previously completed manually. The Marine Corps officer assignment increases the number of traits of its constituency and the size of the constituency, but it simplifies the number levels of preferences that must be considered. Because MSGAT models detachment-level attributes such as the balance of various experience levels within a detachment, it is expresses as a multicommodity flow problem. The GOAT, in contrast, remains single-commodity because there is no intermediary "detachment" preference that must be considered. The GOAT also offers the means to evaluate the effectiveness of the assignment based on a number of characteristics to help validate goodness of fit by a specific attribute.

2.3 Summary

The business of MMOA is to maximize the return on investment of Marine officers to the Marine Corps. This assignment process requires large quantities of data, processed manually by the monitors, to make an informed decision. As current and past studies show, processing that much data and making decisions with this level of importance would benefit from some automated assistance. Automation can reduce time and better arm the monitors to make their most informed decisions. Chapter 3 will describe the model's mathematical formulation and software implementation, which can serve as a start to the necessary technical solution for officer assignments.

CHAPTER 3: Model

The GOAT is based on a single-commodity network flow problem. It assigns a penalty to suboptimal pairings of attributes and weights those attributes to obtain a cost for each possible assignment of Marine m to billet b. These costs are then minimized to find the optimal solution based on the inputs. The GOAT affords monitors the opportunity to specifically assign a Marine to a particular billet or restrict a Marine from certain billets utilizing the force/forbid capability. The monitors can also control the number of changes relative to an incumbent assignment when making subsequent assignments. Through the use of "ghost" Marines and billets, the GOAT makes recommendations on which Marines or billets are best to leave unassigned. This feature allows the monitor to manage lists of Marines and billets of differing length from each other. Force/forbid functionality, model persistence, and ghost assignments are further discussed in Section 3.1.10. Chapter 3 first describes the mathematical model behind the tool, then its software implementation.

3.1 Mathematical Formulation

3.1.1 Indices and sets

$m \in M$	Marines to be assigned
$b \in B$	Billets available
$a \in A$	Attributes

3.1.2 Input data

$p^a_{m,b}$	Penalty for Marine m, billet b, attribute a [0,1]
w_a	Weight given to attribute a
$f_{m,b}$	Force/forbid value: allows a monitor to manually force or forbid assignment of Marine m to billet b
d_{MAX}	Maximum number of differences between old and new assignments
$x^{OLD}_{m,b}$	Marine/billet assignment being modified
ε	Term to minimize number of differences used
g_b	Number of Marines that can be assigned to billet b;

$$= \begin{cases} 1 & \text{if real billet} \\ max(0, |B| - |M|) & \text{if ghost billet} \end{cases}$$

h_m	Number of billets that can be assigned to Marine m;

$$= \begin{cases} 1 & \text{if real Marine} \\ max(0, |M| - |B|) & \text{if ghost Marine} \end{cases}$$

3.1.3 Calculated Data

$$cost_{m,b} = \sum_a w_a p^a_{m,b}$$

3.1.4 Decision Variables

$ASSIGN_{m,b}$	binary; $ASSIGN_{m,b} = 1$ if Marine m is assigned to billet b, 0 otherwise
$DIFF_{m,b}$	binary; to record changes from old to new assignment, 0 if no change made

3.1.5 Formulations

$$\min_{\substack{ASSIGN\\DIFF}} \sum_{m,b} cost_{m,b} \cdot ASSIGN_{m,b} + \varepsilon \cdot \sum_{m,b} DIFF_{m,b}$$

$$s.t. \sum_{m} ASSIGN_{m,b} = g_b \qquad \forall b \qquad (3.1)$$

$$\sum_{b} ASSIGN_{m,b} = h_m \qquad \forall m \qquad (3.2)$$

$$ASSIGN_{m,b} = 1 \qquad \forall m, b : f_{m,b} = 1 \qquad (3.3)$$

$$ASSIGN_{m,b} = 0 \qquad \forall m, b : f_{m,b} = -1 \qquad (3.4)$$

$$DIFF_{m,b} \geq ASSIGN_{m,b} - x_{m,b}^{OLD} \qquad \forall m, b \qquad (3.5)$$

$$DIFF_{m,b} \geq x_{m,b}^{OLD} - ASSIGN_{m,b} \qquad \forall m, b \qquad (3.6)$$

$$\sum_{m,b} DIFF_{m,b} \geq 2 \cdot d_{MAX} \qquad (3.7)$$

$$ASSIGN_{m,b} \in \{0, 1\} \qquad \forall m, b \qquad (3.8)$$

$$DIFF_{m,b} \in \{0, 1\} \qquad \forall m, b \qquad (3.9)$$

3.1.6 Discussion

The model pairs a Marine m from the set of all available Marines M to a billet b from the set of available billets B. Each Marine and billet have a combination of various attributes a from the set of all attributes A. In the following paragraphs, this thesis defines the decision variables, objective function, constraints, penalties, assignability, and force/forbid inputs. This formulation calculates cost based on penalties weighted by attribute. The model gives a user-defined weight to each attribute. The model requires a table, as seen in Tables A.1 - A.3, for each attribute to define the penalty for making an assignment from a specific Marine attribute to a specific billet attribute (i.e., assigning a Marine Major to a Captain's billet or an 0802 Marine to an 0302 billet).

3.1.7 Decision Variables

The formulation utilizes two families of binary decision variables. The first, $ASSIGN_{m,b}$, denotes assignment of Marine m to billet b by 1 if assigned and 0 otherwise. The model ultimately creates of list of all possible m, b pairs and minimizes their costs. The second, $DIFF_{m,b}$, denotes a change from an original or incumbent assignment to a new solution and has a value of 1 if there is a change and 0 if not. This "persistence" capability is explained further in later sections.

3.1.8 Cost

Each m, b pair has an associated cost. That cost is the summation of weighted penalties for each attribute. Penalty tables assign a penalty between 0 and 1 to each pair of attributes. For each m, b pair, the penalty for each attribute is multiplied by that attribute's associated weight then summed to total the overall cost of that m, b pair.

3.1.9 Objective Function

The objective function minimizes cost of assignment by multiplying the aforementioned cost by an indicator of whether or not Marine m is assigned to billet b. The second term multiplies an arbitrarily small refinement term ε by the differences to add a small cost to making differences unnecessarily which slows down the processing time. When specifying the number of changes, this term becomes irrelevant but is necessary when formulating an original solution.

3.1.10 Constraints

The "assignability" terms g_b and h_m show the number of assignments with which each billet or Marine may associate. This allows the model to accommodate uneven lists where the number of Marines does not equal the number of billets. In the case that these lists are uneven, a "ghost" Marine or billet is created to absorb all remaining assignments after the real ones are made. For this reason, if a billet or Marine is real, then its assignability is equal to one. For a "ghost" Marine or billet, the value of assignability is equal to the remaining number of unassigned Marines or billets that need matches. Equation (3.1) shows that each billet receives only as many assignments as its assignability value (1 if real, 1 or more if ghost). Similarly, Equation (3.2) shows that each Marine may be assigned to exactly their assignability value (1 if real, more than 1 if ghost). The next two constraints reference the Force/Forbid matrix, which provides monitors with a great deal of control over the assignment. Marines can be forced into a billet in the case that an assignment has already been determined prior to run of the model. For example, a particular Marine may be restricted based on proximity to medical facilities for an exceptional family member. By forbidding Marine m from all billets not conforming to a prescribed list of locations, this feature would ensure that the Marine would be assigned to an appropriate base to care for their family. Constraints shown in Equations (3.3) and (3.4) direct the value of the $ASSIGN_{m,b}$ variable to either a 1 or 0 for that particular m, b pair. The next three constraints, Equations (3.5) - (3.7), pertain to the situation in which the monitor is using the model to make changes to an incumbent assignment. This incumbent assignment is represented by $x^{old}_{m,b}$, which, similar to $ASSIGN_{m,b}$, shows which m, b pairs were assigned in the incumbent solution. The model then records differences between the current assignment, represented by $ASSIGN_{m,b}$, and $x^{old}_{m,b}$; these differences are reflected in the $DIFF_{m,b}$ variable. The model then restricts the total number of changes allowed between the incumbent assignment and the new assignment. The final two constraints specify $ASSIGN_{m,b}$ and $DIFF_{m,b}$ as binary.

3.2 Software Implementation

This section explains the technological aspects of the GOAT. It explains the languages and programs used, the inputs/outputs and their format, and shows how all the separate parts interact to reach the optimal solution. The full code is not included in this thesis but is available by request.

3.2.1 Define the Pieces

The program is designed and built in the Python programming language. Python is a flexible, open-source programming language first released in the early 1990's. One of its main benefits is that it emphasizes readability of the code. It is relatively easy to use and scale for both personal and commercial use. The Python Optimization Modeling Objects (Pyomo) open-source software package is "a Python-based tool for modeling and solving optimization problems" (Hart et al., 2017, p. 1). The GOAT's data pre-processing is coded in Python with data inputs from Microsoft Excel, and its optimization model is implemented in Pyomo. The GOAT uses GNU Linear Programming Kit (GLPK) as its solver. GLPK is a package "intended for solving large-scale linear programming (LP), mixed integer programming (MIP), and other related problems" (GLPK, 2012).

3.2.2 Inputs and Outputs

The GOAT's inputs are Microsoft Excel worksheets, similar to the exports from WebMASS that the monitors currently use. For each set of assignments there is one Excel document with separate worksheets for Marines and billets, each with a column for each attribute (Rank, MOS, etc.). Additional worksheets in the document include the force/forbid list, as described in Section 3.1.10, and penalty tables, as mentioned in Section 3.1.8 and shown in the appendix.

Output from the GOAT is an exported Excel document listing the assignment recommendations. This output can easily be merged with existing data to create a spreadsheet showing each Marine and billet coupled with their associated attributes. This thesis demonstrates a similar approach when evaluating assignment scenarios in Chapter 4.

3.2.3 How the Pieces Work

Data Pre-process: Python / Excel

The GOAT first prompts the user for inputs as to whether or not they have an incumbent solution. If one exists, then they must specify the file name and whether they wish to limit the number of changes from that incumbent solution. If no incumbent solution exists, then the model runs an original assignment and look for a new solution. The GOAT then uses *PANDAS* (McKinney & PyData Development Team, 2019), a Python data handling package, to pull data in from the designated Excel document. The program conducts its pre-processing of the data into usable dataframes. It then processes the data into dictionaries with key-value pairs containing permutations of every possible combination of Marine and billet. For each pair, it compares each attribute. These pairs are looked up in the penalty tables and given a penalty value between 0 and 1. Using user inputted weights, w_a, and the imported penalty values, $p^a_{m,b}$, both discussed in Section 3.1.2, the program calculates a cost for each Marine-billet pair, shown in Section 3.1.3. This sets conditions to begin setting up the optimization.

Pyomo

The GOAT initializes Pyomo using a Concrete Model, meaning that all inputs are brought into the program instead of building a shell to simply apply to a data set. The GOAT then begins by initializing the sets, parameters, decision variables, and constraints for the optimization model. Once the parts are defined, it establishes GLPK as its solver and sets conditions for the model to be solved. With the model defined and initialized, the GOAT solves the optimization and exports a solution to an Excel file.

Incumbent Solution

When running the model from an incumbent solution, the GOAT affords the user the opportunity to specify the maximum number of changes to that solution that are allowed. For example, if the monitor has a solution and later determines that one Marine needs a change of orders, this feature allows a rerunning of the model while managing the amount of impact the change has on the incumbent solution. If a number of allowable changes, d_{MAX}, is specified then the model will find the minimum-cost solution in which the number of changes does not exceed the specified value as seen in Equation (3.7). If the user does not specify the number of changes allowed, the solver finds an optimal solution without regard to the number of changes. The model uses the ε term in the objective function in Section 3.1.5 to apply a minimal cost to differences from the incumbent solution. This small penalty discourages arbitrary changes that do not result in an improvement in the overall assignment quality.

3.3 Summary

As a single-commodity network flow problem, the GOAT tackles the personnel assignment problem using Python-based computational software packages. The model uses weighted penalties for the attributes of each assignment to calculate a cost for that assignment. The GOAT then minimizes those costs based on user-defined inputs and assigns each Marine to their optimal billet. Chapter 4 discusses the data, results, and analysis.

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CHAPTER 4: Results and Analysis

This chapter describes the scenarios run, their results, and additional features of the GOAT.

4.1 Monitor Process

An officer assignment cycle takes place once per year. The authorized billets for the Marine Corps and the available population of Marine officers are inputs to produce the OSGM. This model matches every Marine officer to an authorized billet. The model does not take into account career progression or who needs to move but is designed to simply give a general construct, based on inventory of Marine officers, of what the rank and MOS for each billet should be. The OSGM manager then removes the names and publishes that model. This model serves as the list of total billets in the Marine Corps. This list includes both primary and “B-” billets. Primary billets are those inside a Marine’s MOS community and B-billets are those typically requiring a general purpose officer of much less specific MOS requirements. Using WebMASS, the monitors determine, based on their own personal criteria including rotation dates, completion of certain billets, or recency of deployments, which billets from the OSGM are or will become vacant in the coming fiscal year and produce a vacancy list for their constituencies. By similar means, the monitors determine which Marines will likely move in an upcoming year.

Following the promotion and education board results, often released by the end of December, and armed with potential movers and vacancies, the monitors begin their assignment of Marines to billets. This assignment takes several months based on the large number of Marines to consider and the vast amounts of data available for each Marine. Monitors are broken down by some combination of grade and MOS but still often are assigning a group of several hundred Marines. For example, the Non-Infantry Combat Arms Company Grade Monitor has cognizance over the 0802, 1120, 1302, 1802, and 1803 MOSs of grades W-1 through O-3, while the Combat Arms Majors Monitor must consider all O-4s with MOSs 0202, 0302, 0370, 0802, 1302, 1802/3, and 3404. The scope of this thesis is a refined subset of three separate monitors and discussed further in Section 4.2. Monitors utilize WebMASS to access necessary information about each Marine to include, but not limited to, career history, fitness reports, dependent/family information, etc. WebMASS also gives them access to the Ground Mover's Survey results in which Marines can specify billet, geographic, and career trajectory preferences as well stating extenuating circumstances for consideration by the monitor.

The lack of standardized measures of effectiveness by which to evaluate the monitor solution is disservice to them and the Marines. Without a metric for them to compare and critique their solutions, the monitors do not have the necessary input to significantly improve their performance. Additionally, since the monitor has such a limited tour of duty it restricts a new monitor from effectively building on their predecessors' experiences, thus dampening the potential for development of institutional knowledge.

4.2 Data

For a decision support tool to effectively assist the monitors it must take its inputs from data that is readily available from their organic systems. The ideal method would be to obtain data directly from WebMASS or from a WebMASS export to Excel as the monitors are able to do. Unfortunately, this was method was not available for use in this research. To try and re-create that data, this thesis uses a constructed dataset compiled with data from Total Force Data Warehouse (TFDW), Operational Data Store Enterprise (ODSE), Manpower Management Records and Performance (MMRP), and MMOA. The data was cleaned to include only officers of paygrades O-1 through O-4 with MOS of 0302 Infantry Officer, 0802 Artillery Officer , 1302 Combat Engineer Officer, 1802 Tank Officer, and 1803 Assault Amphibious Vehicle Officer. The goal was to utilize individuals with a more structured career path prior to extenuating circumstances such as command screening. The data was further cleaned to remove Marines whose orders were for accession or separation because those rely very little on monitor decision. Additionally, individuals heading to or from board selected schools were removed to the greatest extent possible because their orders are also out of the monitor's hands. The parallel of the utilized dataset to the available data in WebMASS is limited but enough to prove the underlying concept. After cleaning and filtering the data, the sample size was 1166 Marine officers, 178 of which had a Ground Mover's Survey on file.

Since each monitor is focused on assignment of specific ranks and MOSs, a given monitor's set of orders is homogenous in that regard. For example, the 0302 monitor will have a list of 0302 Marines assigned to 0302 billets. With the data broken down by monitors who are concerned with a limited number of MOS and rank combinations at one time, the traits available to compare from this dataset are minimal. The ability to evaluate a larger population of Marines simultaneously allows for a better distribution among Free MOS (FMOS) billets, such as 8006, that can accept Marines from multiple PMOSs. Of the 1,166 usable individuals, only 178 actually completed the mover's survey, listing the Marine's preferences for billet, geographic location, and various other questions to assist the monitor in proper placement. The remaining 988 Marines were considered to have no preference in terms of move although the cause for not completing the survey could have been for various other reasons, such as being deployed without connectivity or not expecting to be a mover in that particular cycle. The surveys do not restrict all necessary answers so their formats do not conform to a standard. This increases the difficulty in effectively using the responses for comparison in an algorithmic approach.

4.3 Data Limitations

A primary challenge of any analysis is obtaining accurate, complete data. The other necessary components are measures of effectiveness that allow researchers to study based on an institutional metric for success. For officer assignments, the historical data is incomplete, at best. In many cases, there is no system in place for accurately archiving necessary data points needed for future analysis. To gauge how well a monitor conducts assignments, the monitor must have historical records of the Marines he or she was tasked to assign and what billets were available. Each of these lists should have appropriate data associated with them denoting their characteristics. At a minimum, the "primary grade" and "select grade" of the Marine, along with their primary and secondary MOS, should be maintained. For billets, the primary and billet MOS, along with the required or recommended grade, should be maintained. The preferences collected from the movers' surveys should also be archived along with what orders were actually issued. If this information was archived together then in the future, analysts could look at the effectiveness of an individual monitor or the aggregate results for an entire branch or pay-grade.

In addition to accurate and accessible quantitative data on the Marines and billets, lack of Marine preference is currently a shortfall of the monitor's ability to make informed decisions or for researchers to conduct accurate analysis. The current survey used to obtain Marine preference on billet, geographic location, and career trajectory is far too lengthy and not adequately formatted for quantitative analysis. The survey is often not maintained outside the current year, removing the ability for future research. An entire study could be done solely on the best questions and format for obtaining these preferences.

Career progression must be codified for each MOS to give any program a metric by which to gauge a Marine's next acceptable billet. This is more straightforward for the ground combat Marines, whose career path is reasonably predictable but for career fields without set primary and b-billets, the progression becomes less defined. The ability to ultimately run the program on a larger subset of Marines would allow for a greater distribution of billets that do not require a specific MOS but better metrics on career progression must first be established. Codification of which Marine needs a key billet and which billets meet the criteria as a key billet are necessary data cleaning steps. Spending time quantifying these data points in the beginning would lead to a more robust analysis that would save the monitors comparatively more time on the back end.

4.4 Model Setup

With the limited scope of data available the GOAT was able to conduct an assignment of 1,166 Marines into 1,166 billets. The GOAT has the ability to accommodate lists of Marines and billets that are not of equal length and prioritize which billets to leave empty, as discussed in 3.1.10, but that was unnecessary in this case. With access directly to WebMASS, the GOAT would have had a larger group of Marines and billets from which to choose and allow for greater abilities to weight one billet over another. Nonetheless, the results depicted in Figure 4.1 are telling of untapped potential in this type of analysis.

Each Marine is afforded the opportunity to rank his or her top five geographic preferences and least-preferred geographic location. In terms of billets, each Marine is asked to rank ten billet preferences by MCC, based on the availability that the monitor provides. The MCC identifies a unit down to the battalion level, causing slightly misleading results if a Marine were to be assigned to an identical, adjacent battalion, which would likely meet their preference requirements but not match their billet choice. In both the top and middle charts of Figure 4.1, *Not a Pref* shows those that were assigned to a geographic location or billet that were not in their stated preference. Only 178 surveys were completed out of the 1166 Marines assigned so the comparison on geographic and billet preference is limited to those with expressed preferences. The vacancy lists produced by the monitors also have billet grade and billet MOS which more fully specific what type of officer is required for each job but were not available for this analysis. Without these accurate historic lists, the assignments are limited to the primary rank and MOS of the Marine to whom they were assigned. This means that no meaningful comparison can be made of how rank and MOS distribution vary between monitor and the various simulations run.

The bottom chart in the figure categorizes all 1,166 assignments by region, serving as a proxy to symbolize financial cost of moving. $NONE$ means the Marine did not rate to conduct a permanent change of station (PCS) move at all. $LOCAL$ implies that the Marine was permitted a move, but remained in the same region such as a moving from Quantico, Virginia, to Norfolk, Virginia, or Camp Pendleton, California, to 29 Palms, California. $CONUS$ is any move that remains in the continental U.S. but spanning less than half the country. $XCONUS$ is any move spanning over half the country. $OCONUS$ is any move exiting or entering the continental U.S. or moving from overseas location to another overseas location such as Europe to Hawaii.

Each of the three charts compares the monitor assignment to three different assignments by the GOAT. The first run equally weights each of the inputs for rank, MOS, preference of the Marine, and monetary cost of the move. The second assignment increases the weight on the preference by a factor of 10 but keeps everything else the same as the initial run. The third assignment increases the weight of the monetary cost of the move by a factor of 10 but keeps everything else the same as the initial run. This allows for a visual comparison to the monitors assignment, shown by the red bar versus the GOAT assignments, in varying shades of blue. Each graph has the left scale showing actual counts of Marines meeting the particular quality and the right show their relative frequency in terms of percentage of the total group assigned.

4.5 Monitor Results

The monitors had perfect assignment in terms of rank and MOS. This stems from the fact that their assignment was the source of what rank and MOS each billet required. In reality,

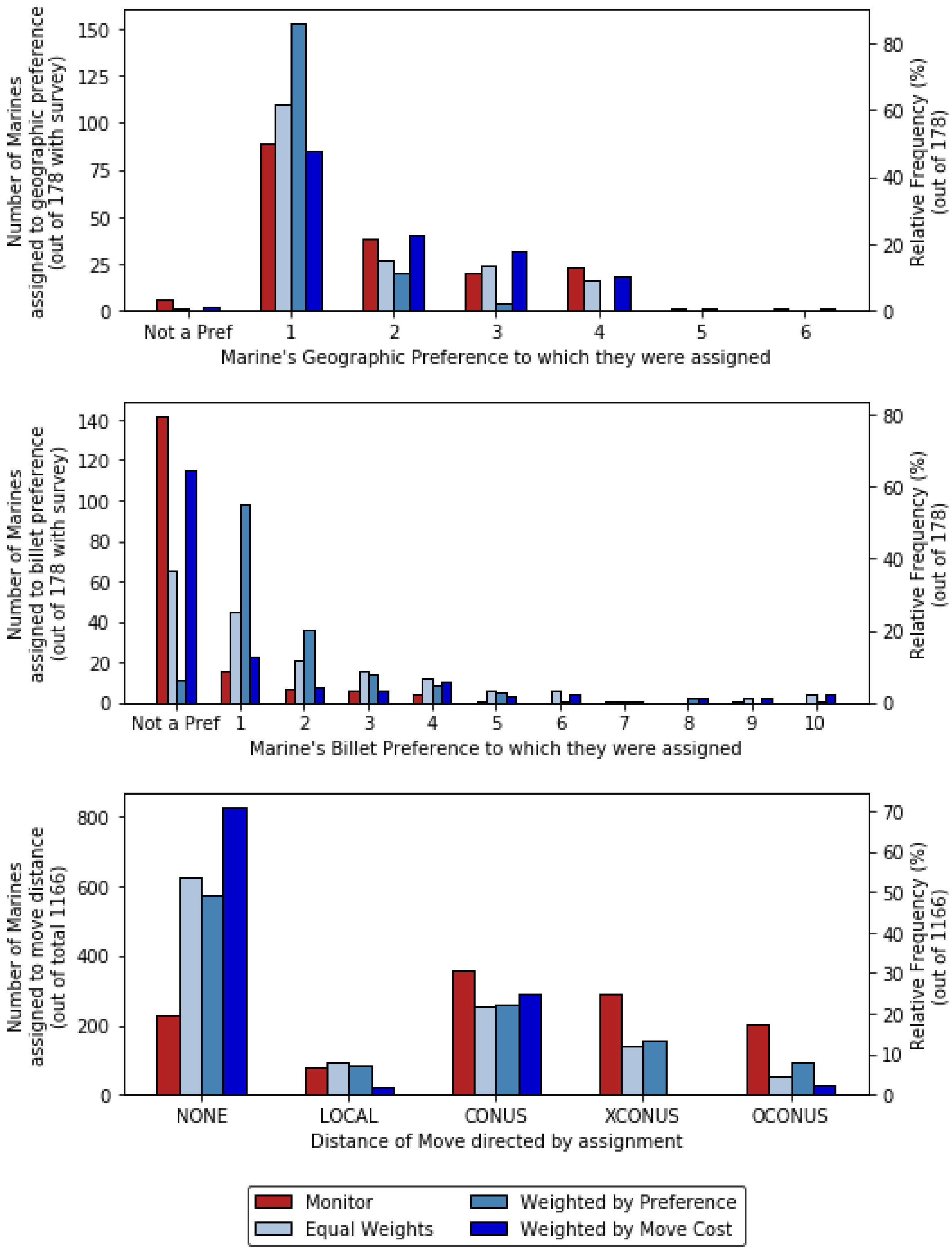

Figure 4.1. Monitor versus GOAT Assignments

the monitors' solution likely contains at least some Grade mismatches and possibly some MOS mismatches.

The monitors were able to assign 50% of their Marines to their top geographic preferences. They were able to assign over 90% to one of their top four geographic preferences. Only 1 Marine was sent to the one place they did not want to go and six Marines were assigned to a place not listed on their preferences.

The monitor performance on matching billet preference had much lower success rates; as previously stated, this could be largely due to the uncertainty of categorizing assignments to the battalion level because many of these units have four or five MCC in the same place. Nearly 80% of the monitor assignments, for those who submitted preferences, were to a unit not specifically listed in their preferences.

As expected, monitors have more than 40% of their orders assigned to or from $OCONUS$. This makes sense because often these billets will require two moves at once, one heading overseas and one returning to the continental U.S. Due to the proximity of Marine Corps bases to each other it is also unsurprising that over 50% of the moves are outside the local area $CONUS$ or $XCONUS$ moves.

4.6 GOAT Results

The GOAT processes the ranks and MOSs of three previously mentioned monitors simultaneously offering a greater flexibility in filling prioritized billets from each and then assigning the best Marines to the open MOS billets. Figure 4.1 shows three separate assignments run with various weighting schemes and each takes approximately 35 minutes, depending on computer processing speed, to complete the data pre-processing, calculate the costs, and perform the optimization for three monitors' worth of Marines. Even if the monitors spent the following month validating the recommendations, that would save them on average three months that could be spent tackling the specifically difficult assignments that require out-of-the-box thinking to accommodate needs of the Marine Corps, the Marine, or some combination of the two.

The weighting schemes for the three assignments run by the GOAT represent some of the key perspectives requiring balance in Marine Corps assignments. Marines have preferences and while everyone is advised to bloom where planted, individuals feel a sense of loyalty from an organization that values their opinion and allows them some input to their future. The assignments driven by monetary constraints resemble policies in the past 10 years surrounding sequestration and limiting long distance PCS moves when able. The equally weighted solution demonstrates a balanced approach where the GOAT can simply be used to help the monitor process and optimize all of their available data.

As weights are adjusted, the results seem to reflect the expected shifts in preferences assigned. With equal weights assigned to each attribute, the GOAT increases the number of Marines who received their first geographic preference as well as billet preference. The number of Marines who were assigned no move or a local move increases as well while the more expensive moves were relatively decreased.

By weighting the assignments by Marine preference, the GOAT assigned approximately 86% of the Marines to their first geographic preference with no one sent to a place they requested to avoid or to an assignment not listed in their geographic preferences. In terms of billet preferences, the GOAT assigned over 75% of Marines in one of their top two billet preferences.

When weighting favors monetary costs of moving, the GOAT reduced the number of *OCONUS* moves and executed no cross-country moves. Due to policy restrictions on assigning Marines back-to-back overseas billets, this assignment may not be feasible but still demonstrates a successful weighting of designated variables. Surprisingly, by minimizing the cost of the moves, nearly 50% of Marines are still offered their top geographic preference although 64% were sent to a billet that was not even on their list of billet preferences.

4.7 Limits of the Results

Figure 4.1 depicts the results of the GOAT simulations as straightforward but they require careful scrutiny in this form. Preferences exist for approximately 15% of the Marines in this sample. While it shows Marines across various ranks and MOSs, it is limited due the compilation of date from archived sources. This attempt to re-create a direct pull from WebMASS means there were likely additional billets from which to choose and other Marines who got extensions or moved early/late.

The other major factor that the GOAT, in its current form, does not yet accommodate is career progression and the fulfillment of key billets. There are specific billets required at each rank in order to remain competitive for the next level of command. Even with fitness report data, there is no guarantee that a Marine has successfully fulfilled his appropriate billet during a particular tour. Additional refinement of the program would add a means to account for various aspects of career progression.

4.8 What Else from the GOAT?

Limited data made some features of the GOAT unnecessary for these simulations but if applied to a real-time data pull would be crucial to its success. Through the assignment of ghost Marines or billets, the GOAT can prioritize which Marines should be left unassigned or billets to be gapped, (depending on which there are more of). The weight for a gapped billet can be adjusted to refine the cost of leaving billets unfilled. In addition to its use in evaluating assignments, as demonstrated here, the GOAT's built in persistence allows it to be used for optimizing changes to an incumbent assignment. By inputting an assignment the user can force a change in a specific billet while limiting the number of other changes to be made, thus limiting the ripple effect of a seemingly small change.

The GOAT currently accounts for rank, MOS, survey preferences, move distances, and number of changes from a previous solution. It also processes the Marines and billets of three separate monitors simultaneously. Which means that under more realistic circumstances, it could likely achieve a better solution than the monitors alone with respect to assignment of Marines to B-Billets. With refinement of the code and proper codification of quantifiable attributes of Marines and billets, the possibilities are endless.

4.9 Summary

The monitors currently process an abundance of data manually. It is of no surprise the months it takes for them to conduct their assignments. The GOAT offers a means by which the monitors can have a more organized presentation of the data. With refinement of the data collection and storage procedures for Manpower and Reserve Affairs (M&RA), the GOAT can optimize the data by the monitor established weighting scheme to afford them the opportunity to test multiple sample solutions and weigh their benefits before issuing any orders. The added benefit of the GOAT's evaluation feature allows them to see the cost to the Marine and the organization as a whole and adjust that balance. This flexibility and maneuverability avoids the additional recency bias that arises from an extended time to conduct assignments. The primary benefit of the tool is the vast time it saves the monitors while best equipping them to make the crucial decisions and drive the efficiency of officer assignments. Chapter 5 discusses final thoughts and recommendations for the future.

CHAPTER 5:
Conclusions / Recommendations

This thesis demonstrates potential future capabilities and identifies areas in which the Marine Corps can improve their processes and systems. The GOAT serves as proof of concept for using an automated data optimization system to assist the monitors, while limitations of the system reaffirms the continuous need for human interaction with assignment process. An automated system should not replace the monitors but rather arm them with decision support tools that allow them to work more efficiently. This allows them to exert their valuable time and effort in areas that require critical thought instead of tedious data crunching.

Before any tools or systems are developed to assist monitors and, potentially, aid in evaluation of the assignment process, metrics must be established for successful assignment. Determination of appropriate measures of effectiveness will help to identify any information deficits and drive the steps necessary for appropriate data collection, organization, and storage.

5.1 To Develop a Usable Tool

5.1.1 Scale for Use

A usable tool must be applicable to large- and small-scale assignment problems. The tool must be effective for assigning a single Professional Military Education (PME) class of 25 or the entire population of officer movers totaling in the thousands. The GOAT was tested on smaller problems but is limited on the larger end of the assignment problem based on computing limitations and a likely inefficiency in its coding. The code should be further refined before implemented in practice.

5.1.2 Implementation

Once coding is refined to ultimate efficiency and productivity, the user interface must be developed. This capability would be best suited if it were built directly into WebMASS, the monitors' current system that connects to all necessary data. This added accessibility would increase the likelihood that the monitors would utilize the system if offered. The inputs from the monitors must be user friendly and have fixed input options such as sliders or drop down menus. This prevents erroneous inputs that would lead to sub-par assignment recommendations and overall mistrust of the system.

Widespread use of any tool should be gradually introduced to allow for parallel processing of assignments until it is refined to meet specifications. A premature reliance on a decision support tool will lead to faulty, potentially miscalculated assignment recommendations that cause distrust of any future systems introduced for years to come.

5.2 Recommendations for M&RA

The biggest takeaway from any research is not what currently exists but what it means for the way ahead. In order to conduct future studies with any validity, a standardization of data collection and storage is required. This standard should be based on established measures of effectiveness. Once the standards and methods are in place, researchers can conduct necessary analysis on assignment effectiveness. In its current state, any analysis is speculative, at best.

After data handling procedures are in place, a close look at how to quantify each Marine, based on the requirements of each billet, would add standardization to the assignment process. This standardization would mitigate some of the personality-driven uncertainty that exists from one monitor to the next. As the data collection and archival becomes more robust and standardized, decision support tools could be better programmed to process the right data to meet the desired standards. This new ability to process data across MOS and rank would offer new alternatives to assignments. One such alternative could be pooling the monitors in such a way that monitors whose populations have similar career paths and billet type could be combined and instead of a single monitor solely handling assignments for a thousand people, a group of three or four monitors can collaborate on a much larger group with an initial recommended solution produced by a decision support tool. The initial assignment could be validated by a specific subject matter expert (SME) then briefed to the group of monitors allowing them to explain through processes aloud. This allows for further mitigation of personality driven decisions and helps expand the bounds of their rationality.

Mover's surveys have great potential to capture Marine preference and equip monitors with necessary knowledge and communication from individual Marines. The current process and survey are inadequate. The inputs are not standardized enough to be used effectively. The survey asks far too many questions asking Marines to rank up to 10 billet choices. Fitness reports ask a similar question but accept only three choices. The surveys should be evaluated as to what information would actually help the monitors make better decisions.

The final area that merits additional research is how the data for Marines is collected and updated. One potential solution would be a platform that allows Marines to check their real-time information and submit changes, while also having visibility of available billets and their requirements. This would add a level of transparency that ensures Marines can make the most informed decisions and afford the monitors the most up-to-date information and validated inputs.

5.3 Final Thoughts

One of the most crucial aspects of the development and retention of quality officers in the Marine Corps is effective assignment. Timely placement of an appropriate Marine in a good fitting billet potentially leads to better individual performance and greater levels of organizational efficiency. This thesis introduces a system that can aid in data processing with the intended purpose of better arming monitors, who are almost solely responsible for the effective assignment of Marine Corps officers. It highlights areas of inadequacy in data collection and management, while offering recommendations for ways ahead. Finally, it emphasizes that through this and any future studies the overarching objective must be increasing the effectiveness and efficiency of the monitors because the human aspect of assignment is essential. Computer-aided processing of quantifiable data allow human agents the necessary flexibility to address the unique human issues that inevitably arise. Weapons and tactics are continually developed to better arm combat troops, so why should development of systems and tools for those charged with management of the Marine Corps's most valuable resource, its personnel, be valued any less?

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APPENDIX: Penalty Tables

This appendix contains tables of penalty $p^{a}_{m,b}$ used by the GOAT to compute cost. This is the penalty for each attribute a associated with assigning Marine m to billet b.

Table A.1 shows the $p^{Rank}_{m,b}$ between 0.0 and 1.0 for assigning Marine m to billet b. 0.0 is no penalty, or a perfect match, and 1.0 is the maximum penalty, or the worst match.

		Billet			
		2ndLt	**1stLt**	**Capt**	**Maj**
Marine	**2ndLt**	0.0	0.5	0.9	1.0
	1stLt	0.5	0.0	0.5	0.9
	Capt	1.0	0.5	0.0	0.5
	Maj	1.0	1.0	0.8	0.0

Table A.1. Penalty $p^{Rank}_{m,b}$

Table A.2 shows the $p^{Rank}_{m,b}$ between 0.0 and 1.0 for assigning Marine m to billet b. It shows no penalty for an MOS that matches perfectly but a billet that requires a specific rank receives the maximum penalty if the Marine assigned is not of the appropriate MOS. 0.0 is no penalty, or a perfect match, and 1.0 is the maximum penalty, or the worst match.

		Billet				
		0302	**0802**	**1302**	**1802**	**8006**
Marine	**0302**	0.0	1.0	1.0	1.0	0.0
	0802	1.0	0.0	1.0	1.0	0.0
	1302	1.0	1.0	0.0	1.0	0.0
	1802	1.0	1.0	1.0	0.0	0.0

Table A.2. Penalty $p^{MOS}_{m,b}$

Table A.3 shows the assumed penalty based on the geographic distance of a move. $NONE$ is considering a PCA move that does not authorize a paid move, $LOCAL$ would be a move that remains in the same region, roughly 50 - 300 miles. $CONUS$ is a move that departs the $LOCAL$ area but is less than half the country. $XCONUS$ is a cross country move including everything from over half the country but still within the continental U.S. $OCONUS$ is anything leaving the continental U.S. 0.0 is no penalty, or no cost, and 1.0 is the maximum penalty, or the farthest/most expensive move.

Move Type	**Penalty**
NONE	0.0
LOCAL	0.1
CONUS	0.3
XCONUS	0.8
OCONUS	1.0

Table A.3. Penalty $p_{m,b}^{MOVE}$

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