# NAVAL POSTGRADUATE SCHOOL

**MONTEREY, CALIFORNIA**

# THESIS

**OPTIMIZATION MODELS TO SUPPORT A LIMITED OBJECTIVE TEST/EXPERIMENT (LOT/E) OF A BILLET MARKETPLACE FOR ASSIGNING USMC OFFICERS**

by

Martin K. Nganga

September 2020

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This research investigates how to optimally assign U.S. Marine Corps (USMC) officers to billets. Currently, the USMC relies on monitors to manually develop the assignment solution based on limited information. This leaves the USMC with a suboptimal use of its resources, and with officers whose human capital is not fully developed or who consider attrition. The research shows essential features of a marketplace from other military branches. Emphasis is placed on those features directly related to meeting the billet requirements, the preferences of Marines and Marines' career paths. This marketplace system requires a substantial amount of information from billet owners, monitors, and officers. Data from a subset of the aviation community were collected and processed to develop optimization models that balance two goals: permanent change of station cost, and Marines' priorities. The models are amenable to extensions that consider additional goals and requirements, as data become available. Experimentation shows insightful tradeoffs in the two objectives and provides efficient solutions, which are useful in presenting alternatives.

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**OPTIMIZATION MODELS TO SUPPORT A LIMITED OBJECTIVE TEST/EXPERIMENT (LOT/E) OF A BILLET MARKETPLACE FOR ASSIGNING USMC OFFICERS**

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Submitted in partial fulfillment of the
requirements for the degree of

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**September 2020**

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# ABSTRACT

This research investigates how to optimally assign U.S. Marine Corps (USMC) officers to billets. Currently, the USMC relies on monitors to manually develop the assignment solution based on limited information. This leaves the USMC with a suboptimal use of its resources, and with officers whose human capital is not fully developed or who consider attrition. The research shows essential features of a marketplace from other military branches. Emphasis is placed on those features directly related to meeting the billet requirements, the preferences of Marines and Marines' career paths. This marketplace system requires a substantial amount of information from billet owners, monitors, and officers. Data from a subset of the aviation community were collected and processed to develop optimization models that balance two goals: permanent change of station cost, and Marines' priorities. The models are amenable to extensions that consider additional goals and requirements, as data become available. Experimentation shows insightful tradeoffs in the two objectives and provides efficient solutions, which are useful in presenting alternatives.

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# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AMOS | Additional Military Occupation Specialty |
| BMOS | Billet Military Occupation Specialty |
| CMC | Commandant of the Marine Corps |
| DMDC | Defense Manpower Data Center |
| DoD | Department of Defense |
| GAO | Government Accountability Office |
| HECMAM | Hierarchical $\varepsilon$-Constraint Method Assignment Model |
| IP | Integer Programming |
| MCC | Monitored Command Code |
| MMOA | Manpower Management Division Officer Assignment |
| MNA | My Navy Assignment |
| MOE | Measure of Effectiveness |
| MOS | Military Occupation Specialty |
| MSC | Major Subordinate Command |
| PCS | Permanent Change of Station |
| PMOS | Primary Military Occupation Specialty |
| USMC | United States Marine Corps |
| WESMAM | Weighted Sum Method for Assignment Model |

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# EXECUTIVE SUMMARY

The U.S. Marine Corps (USMC) Manpower Management Division Officer Assignment (MMOA) is responsible for assigning approximately 20,000 active duty officers to appropriate billets throughout the fleet. Currently, MMOA relies on individual community monitors to manually develop assignment solutions based on limited information scattered in different systems. This lengthy assignment process leaves the USMC with a suboptimal use of its resources and assignment solutions that does not fully utilize Marines' human capital. To efficiently assign Marines to billets, the USMC is exploring the capabilities of a talent marketplace and the utilization of an optimization model to automate the assignment process.

The lack of a talent marketplace system has significantly impacted assignment process. First, lack of suitable fit between Marine skills and assigned jobs has led to underutilization of Marines' human capital. Second, strict business rules are restricting billets that Marines desire to pursue in their careers. Last, the current assignment process lacks a flexible assignment system that adheres to changing departmental policies and budgetary requirements. This thesis examines other branches' talent marketplace systems and highlights features with potential to fit the USMC: we review general assignment problems, formulate multi-objective models, use them with data from the aviation community, and run sensitivity analysis on some key model's inputs. Our research recommends the development of a talent marketplace system that incorporates a multi-objective optimization model.

Talent marketplace systems have greatly improved assignment processes in the Department of Defense (DoD). In December 2019, the U.S. Navy implemented a marketplace called MyNavy Assignment (MNA) system (Navy Personnel Command 2005). MNA enables the Navy to manage its force structure and readiness. Sailors have capability to research and apply for jobs online. The detailers can ensure sailors are applying only to jobs for which they are qualified. In 2019, the U.S. Air Force launched another talent marketplace called MyVector (U.S. Air Force 2019). The MyVector platform provides transparency of all the available jobs in a cycle, highlights airmen's job

preferences, and incorporates commands' input into the assignment process. The web-based system is easy to use and has greatly improved airmen detailing process. In 2019, the U.S. Army Talent Marketplace Task Force created system called Army Talent Alignment Process. The Army has showed that a mathematical algorithm can be incorporated into a marketplace in order to optimize objectives in assigning soldiers to billets.

We review personnel assignment models such as the Hungarian method, Gale-Shapley deferred acceptance algorithm, Marine Security Guard Assignment Tool (formulated by Enock), and Ground Officer Assignment Tool (formulated by Alger). Our research develops two multi-objective models: Weighted Sum Method for Assignment Model (WESMAM) and Hierarchical $\varepsilon$-Constraint Method Assignment Model (HECMAM). The two objectives at stake are Marine preference and permanent change of station (PCS) cost. Data were collected and processed to be used in our models, which are implemented using Pyomo software. The subset of USMC aviation community assignment problem tested includes 187 Marines that require assignments to 196 available billets.

In WESMAM, a planner-provided weight is assigned to Marines' preferences. This weight can be used for sensitivity analysis of the solution: higher weights naturally result in optimal assignments that favor Marines' preferences over PCS cost, and vice versa. Figure 1 shows the convex, approximated efficient frontier. The points above the efficient frontier are infeasible assignment solutions (i.e., unattainable). The points below are dominated (i.e., attainable, but not desired as we can attain an alternative assignment that improves one objective without worsening the other). This tradeoff curve is useful for presenting alternatives.

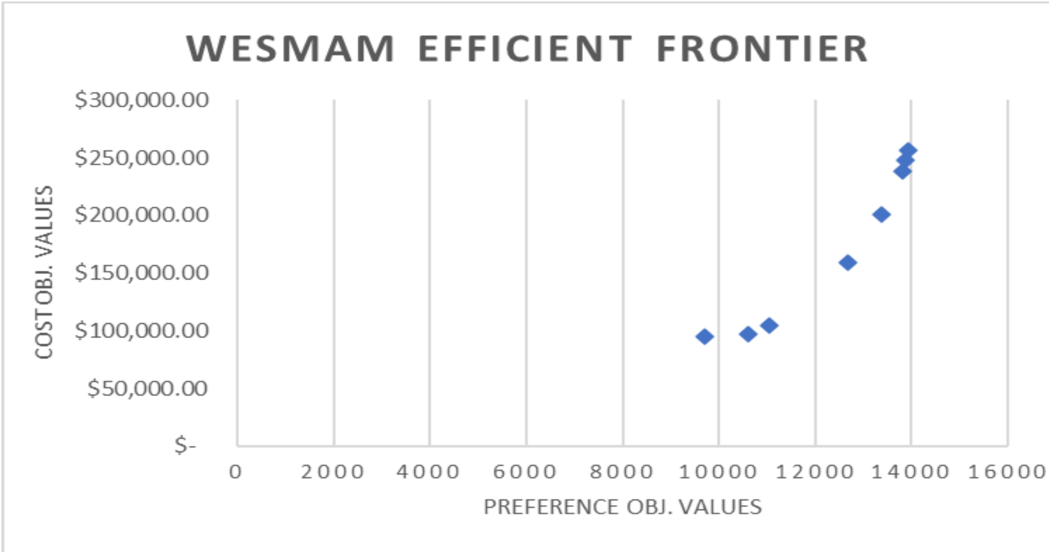


Figure 1. WESMAM Model Graph

In HECMAM, a user-provided parameter controls the fraction of ideal preference (primary objective) to sacrifice in order to reduce the PCS cost (secondary objective). We accomplish this by converting the preference (initially the objective function) into a constraint; this allows PCS cost to become the new objective function. Of course, HECMAM allows the roles of the primary and secondary objectives to be swapped. Like WESMAM, HECMAM provides a useful tradeoff analysis. For example, we observe that by relaxing PCS cost by 15% when optimizing preference objective, we can achieve a preference increase of 6%; but in contrast, by relaxing the preference objective value by 15% when optimizing PCS cost, we can decrease (improve) the PCS cost by 80%.

WESMAN and HECMAM can be used to generate efficient solutions as their user-provided controls vary. However, both models can be useful to planners who wish to approach the problem from either angle: weighing relative goal importance or optimizing the one goal while setting a target value on the other goal.

We find important that the USMC develop a talent marketplace for a standardized assignment cycle to promote fairness and transparency. This marketplace would benefit from a multi-objective optimization model. We recommend MMOA to compile the following data for future use in extensions of the optimization models developed in this research: Marines' skills and qualifications, job skill requirements, monitors' preferences, oversea control dates, and special consideration data. In addition, it would be desirable that textual data inputs by the Marines be processed and incorporated in the models, too.

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# I. INTRODUCTION

## A. UNITED STATES MARINE CORPS

### 1. Brief History

The Marine Corps was formed in 1775 to serve as the landing force in the U.S. Navy. The U.S. Marine Corps (USMC) is considered a separate department embedded in the U.S. Navy. Marine Corps is a deployable force that serve onboard naval vessels, provide security on U.S. naval installation, and undertake diplomatic missions abroad (O'Connell 2012).

Today, according to the highlights of the Department of the Navy fiscal year 2020 (FY 2020) budget, the USMC has an active duty end strength of 186,200 and reserve end strength of 38,500 (Department of the Navy [DON] 2020). This is an approximately 2% increase from recorded population in 2019. This growth supports building a force with more experienced, well-trained, and increased capabilities by increasing the number of Marines with special skills (DON 2020).

### 2. USMC Duty Stations

Hopper and Ostrin (2012) highlight the 10 major installations where most Marines currently serve:

- Marine Corps Air Ground Combat Center, Twentynine Palms, CA, U.S.;
- Marine Corps Base Camp Pendleton, CA, U.S.;
- Marine Corps Air Station Miramar, CA, U.S.;
- Marine Corps Base Kaneohe Bay, HI, U.S.;
- Marine Corps Air Station Yuma, AZ, U.S.;
- Marine Corps Base Quantico, VA, U.S.;
- Marine Corps Base Lejeune, NC, U.S.;

- Marine Corps Air Station Cherry Point, NC, U.S.;
- Marine Corps Air Station Beaufort, SC, U.S.; and,
- Marine Base Japan.

Figure 1 shows all major installations where Marines can be stationed in the world:

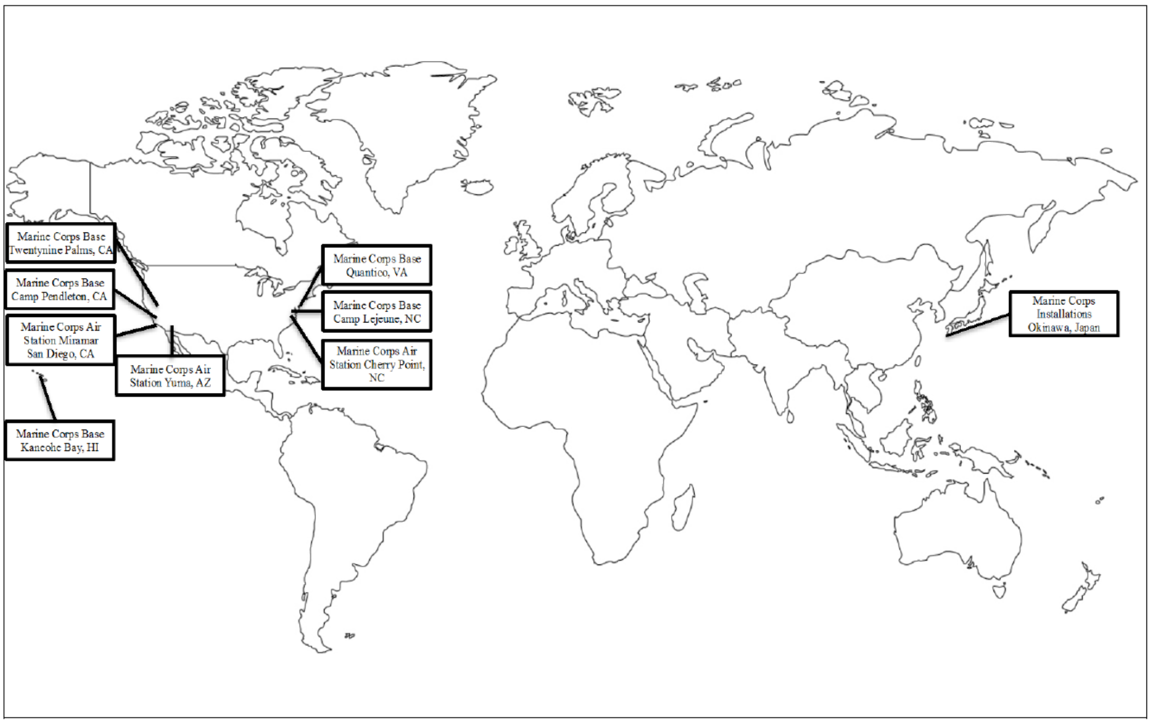


Figure 1. Map of Major Corps Installations. Source: Hooper and Ostrin (2012).

## B. OVERVIEW OF USMC OFFICER ASSIGNMENTS

According to the Marine Corps Manpower and Reserve Affairs (M&RA), the USMC is responsible for ensuring more than 20,000 active duty officers have been assigned to appropriate billets throughout the fleet. This arduous task falls on the Manpower Management Officer Assignments (MMOA) office to manage the assignment process through monitors. Every cycle (depending on the community, a cycle period is approximately 6-9 months), large number of Marines become available for new assignments and in the process numerous billets become vacant. MMOA usually schedules

Marines to rotate from one job to another every 2-4 years. With every job rotation a vacant position is created to be filled by others (Liang et al. 1986). Some Marines are required to attend advanced training before reporting to their new duty stations. For example, some Marines are detailed to the Naval Postgraduate School (NPS) to earn a master's degree to enhance their skills in preparation for challenging billets in their careers. The monitors use Marine Corps Orders as guides in the assignment process. The following are the instructional orders used by monitors:

### 1. Marine Corps Order 1300.8S—Marine Corps Personnel Assignment Policy

This is the Marine Corps personnel assignment policy, which provides monitors policy on assigning Marines. Through this order, the USMC can transfer a limited number of Marines to support combat readiness. The order also ensures that there is equitable treatment and observation of Marines' career development. According to the Commandant of the Marine Corps (CMC) (2014), the Marine Corps order 1300.8S emphasizes on reassigning Marines to commands in the same geographical location to minimize permanent change of station (PCS) and permanent change of assignment (PCA) cost.

### 2. Marine Corps Order P1000.6G—Assignment, Classification, and Travel System Manual

This order outlines general policies for classification, distribution, assignment, and transfer of Marines. The manual provides instructions and guidelines to assign Marines to vacant billets. The instructions are somewhat vague, thus giving the monitors flexibility within the system to assign Marines to certain billets.

### 3. Marine Corps Order 5320.12H—Precedence Levels for Manning and Staffing

According to the CMC, Marine Corps order 5320.12H provides the USMC with a budgetary reality report which determines billets that are required to be filled and the order of billet fulfillment. The assignment process, also known as "manning the fleet" is governed by the Authorization Strength Report (ASR) which informs M&RA on the number of billets to support.

From the three Marine Corps' instructional orders, MMOA relies on individual monitors to manually develop assignments based on limited information. For example, monitors use Marines' grade, primary military occupational specialty (PMOS), and their preferences to make these crucial assignments throughout the fleet. However, career paths requirements or billet-specific restrictions impede certain Marines to serve in desired billets. In addition, monitors lack a formal methodology or analytical aid to, for example, optimize those assignments within a budget. This process leaves the USMC with a suboptimal use of its resources, and with many Marines whose human capital is not fully utilized separating from service. In some years, the actual number of separations exceeds the expected number, increasing demand on recruiters and drill instructors. A high attrition rate also increases the cost of training new recruits.

## C. CIVILIAN TALENT MARKETPLACE

Organizations in the private sector are recognizing the importance of a talent marketplace in the assignment process of workers. Career mobility within the organization allows the employees to pursue new opportunities leading to "job satisfaction." Job satisfaction in the workforce improves the company's employee retention rate reducing the cost of employee turnover. Organizations like The National Aeronautics and Space Administration, International Business Machines Corporation, and American Express have launched talent marketplaces to actively search, find, and improve the assignment of people to jobs within their organizations. LinkedIn has been noted as a successful marketplace platform that connects job seekers and job owners. The company operates with more than 500 million members in over 200 countries and territories (Geyik et al. 2018). Effective resource allocation allows mobilizing talented people for complex tasks in the organization. Assignment problems have been studied for decades resulting to creation of numerous algorithms that are used to mathematically assign workers to jobs.

## D. USMC ASSIGNMENT PROBLEM

The Department of Defense (DoD) acknowledges the need for a talent marketplace to give military forces the capability to effectively assign service members across the world where their human capital will be utilized to accomplish missions. The lack of a talent management system in the Marine Corps has significantly impacted staffing. First, lack of suitable fit between Marine skills and assigned jobs has led to underutilization of Marines' human capital. Second, defined career paths, in which Marines are directed through a strictly defined series of key assignments to promote to the next rank, put the careers of Marines who take assignments outside of their defined career path at risk. Last, billets are coded with specific restrictions, guidelines, and requirements that allow only certain personnel to serve in those billets. For example, for an infantry officer to progress to Major, a company command tour is highly favorable. Although Company Commander billet is a good test for O-3s to promote to O-4 rank, the USMC can identify potential leaders as early as the O-2 rank. The process of creating and filling billets can take years; requests must be channeled into a tedious process, be approved, prioritized against other assignments, and finally filled when a cohort of transferring Marines becomes available.

Assigning Marines to billets requires considering a combination of objectives, such as job skill requirements, career progression, Marines' job preferences, cost to transfer, and overseas duty rotation. Some objectives, such as transfer cost and career progression, may (in some cases) be mutually conflicting. Thus, a Marine Corps assignment problem can be formulated as a multi-objective model. Solving an assignment problem requires collection of data from a group of Marines scheduled to be transferred to new assignments. A talent marketplace system can be used to collect the required data, process the data, and run the multi-objective optimization model to assign Marines to billets.

## E. SPONSORSHIP OF THE THESIS

The Marine Corps through the Manpower Management Officer Assignments (MMOA) 3, Plans and Programs stationed in Quantico, VA, proposed the research with collaboration with NPS faculty and students. The research is also conducted with collaboration from the Naval Research Program at NPS. The sponsor agreed to oversee delivery of data required for the research project.

## F. CONTRIBUTION OF THESIS

The current USMC officer assignment process is basically a manual process with lots of deficiencies, such as time consuming and costly to process assignments, lack of transparency for all parties involved in the selection process, and inability to optimize the multiple policy objectives outlined in the Marine Corps' orders. This thesis addresses these issues and gives recommendations. We review talent marketplace systems of other branches of the military and highlight best practices that will fit the USMC. We review general assignment problems and then develop and computationally implement a multi-objective assignment problem specifically tailored for the USMC. We run test experiments on the aviation community and draw recommendations.

# II. ASSIGNMENT PROBLEMS

## A. U.S. MILITARY ASSIGNMENTS

As the private sector corporations improve their assignment processes through advanced talent marketplace systems, various military branches have also developed their own to meet unique demands. Inside the DoD, the Defense Manpower Data Center maintains a DoD personnel, workforce report and publications site that reflects most up to date strength figures in the military.

According to Table 1, as of February 2020, the overall active duty military members stood at 1,336,055. The individual branch strength breakdown can be visualized in Figure 2.

Table 1. Armed Forces Strength Figures for February 29, 2020 compared to February 28, 2019. Source: Defense Manpower Data Center (2020).

| | 2/28/2019 | 2/29/2020 | CHANGE | |
|---|---|---|---|---|
| | | | Absolute | Percent |
| | | | | |
| **Total Armed Services** | 1,359,778 | 1,377,870 | (18,092) | -1.33% |
| Army | 470,565 | 478,469 | (7,904) | -1.68% |
| Navy | 333,071 | 339,429 | (6,358) | -1.91% |
| Marine Corps | 186,106 | 185,051 | 1,055 | 0.57% |
| Air Force | 327,827 | 333,106 | (5,279) | -1.61% |
| **Total DOD** | 1,317,569 | 1,336,055 | (18,486) | -1.40% |
| Coast Guard | 42,209 | 41,815 | 394 | 0.93% |

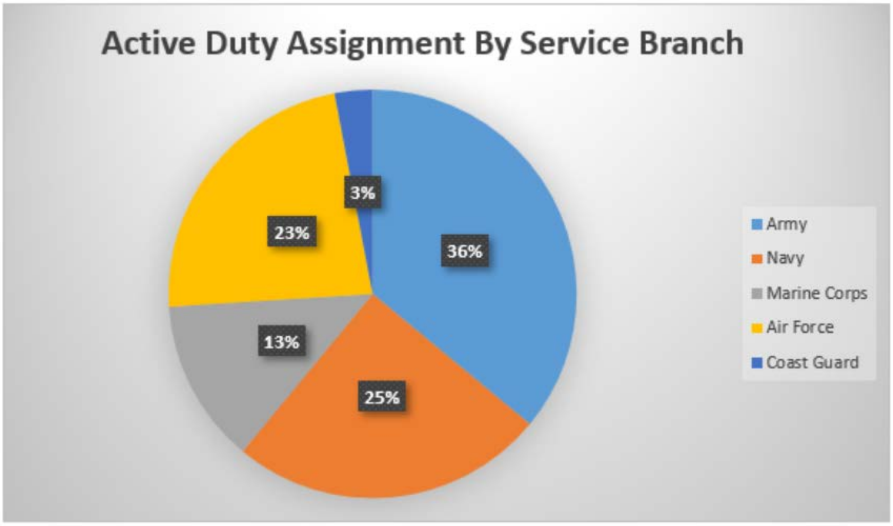


Figure 2. Breakdown of Assigned Active Duty Member by Service Branch. Source: Defense Manpower Data Center (2020).

Figure 2 shows the varying populations of each U.S. military branch. A branch's population and mission define the organizational structure. Due to the difference in that structure, each branch has created its own unique talent marketplace system. In the following sections, we shall review the three main branches' talent marketplaces and highlight best practices that can be adapted by the USMC.

### 1. U.S. Navy

The Navy has implemented several versions of a talent management system in recent years. As of December 2019, My Navy Assignment (MNA) is the most current version of Navy's detailing marketplace system. MNA is a web-based interface detailing system that provides sailors with various job options, greater flexibility, and increased transparency in the detailing process. Some of the favorable features of the MNA are:

- Advertising billets in an assignment cycle.
- Providing sailors with the capability to research and apply for jobs online. Sailors can discuss their career goals with their career counselor using the MNA as a supportive tool.
- Being used as the Navy's career management support system.

- Showing qualification match indicators that display a sailor's match to each job.
- Showing application eligibility indicators that prevent invalid application submissions and alert sailors to policies that may hinder their selection for certain jobs.
- Providing sailors with the capability to highlight their skillsets to detailers and prospective commands through "My Resume" (Beta) feature of the MNA.

***a. Detailing Process***

MNA provides six phases each month in an assignment cycle. In the assignment cycle, sailors apply for jobs, commands review applications, and detailers assign sailors to available billets. According to the Navy Personnel Command the six phases are as follows:

- Closed—In this Phase, MNA is processing latest personnel data, aligning sailors to jobs while determining job vacancies. Normally, closed sessions happen after working hours.
- Scrub—Current job vacancies are identified in MNA then Navy Personnel Command Human Resource (HR) officers validate jobs.
- Application—Sailors who are scheduled to transfer can apply for advertised jobs. Sailors can also view all the other job openings.
- Command Comments—Commands can view and comment on sailors' job applications.
- Selection—Detailers and Assignment Coordinators (placement officers) coordinate to compute for an assignment solution.
- System Maintenance—MNA undergoes software upgrades and maintenance.

### *b. Detailing Schedule*

The six MNA phases are carried out in a fixed pre-determined timeframe to accurately assign sailors to available billets. Table 2 depicts a process that starts on 3 June 2020 ending 28 July 2020. In the table, we observe that the assignment process can be reduced to a standard two-month period.

Table 2. MNA Schedule For Active Duty and Full Time Support. Source: Navy Personnel Command website (2020).

| | | |
|---|---|---|
| APPLICATION RESULTS / ALIGNMENT REVIEW. Results will be available through the requisition scrub period. | | |
| Down for REQ Load | TYCOM Requisition Review | Integrated Readiness Requisition Review |
| NPC Requisition Scrub | Available for AC/FTS Applications | Command Comments Only (No Applications allowed) |
| Detailers Make Selections | Down for Maintenance | Down for REQ Cycle Alignment (2100 - 2330 CST) |
| MyNavy Assignment (MNA) Down for System Processing | | |

**JUNE 2020**

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|---|---|---|---|---|---|---|
| | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 2100 - 2300 (CDT) 7 | 8 | 9 | 1730 - 2200 (CDT) 10 | 11 | 12 | 0430 - 0600 (CDT) 13 |
| 2100 - 2300 (CDT) 14 | 15 | 16 | 17 | 18 | 1700 (CDT) 1800 (CDT) 19 | 0430 - 0600 (CDT) 20 |
| 2100 - 2300 (CDT) 21 | 22 | 23 | 1730 - 2200 (CDT) 24 | 25 | 1700 (CDT) 1800 (CDT) 26 | 0430 - 0600 (CDT) 1400 - 2200 (CDT) 27 |
| 2100 - 2300 (CDT) 28 | 29 | 30 | | | | |

**JULY 2020**

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | 1 | 2 | Holiday 3 | 0430 - 0600 (CDT) 4 |
| 2100 - 2300 (CDT) 5 | 6 | 7 | 1730 - 2200 (CDT) 8 | 9 | 10 | 0430 - 0600 (CDT) 11 |
| 2100 - 2300 (CDT) 12 | 13 | 14 | 15 | 16 | 17 | 0430 - 0600 (CDT) 18 |
| 2100 - 2300 (CDT) 19 | 20 | 21 | 1730 - 2200 (CDT) 22 | 23 | 24 | 0430 - 0600 (CDT) 1400 - 2200 (CDT) 25 |
| 2100 - 2300 (CDT) 26 | 27 | REQ Cycle Alignment 28 | 29 | 30 | 31 | |

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#### *c. Selection Process*

As of December 2019, the Navy has not implemented an optimization model in the MNA that would generate assignments automatically. Although there is a lack of an automated system, the MNA has made the detailing process easier compared to its previous processes. Initially, the detailers were responsible for going through multiple systems retrieving all the necessary information for each sailor to determine their best fit. This process was cumbersome and ineffective. Through the Navy Personnel Research, Studies and Technology department in Millington, TN, optimization models have been proposed and are undergoing prototyping.

#### *d. Selection Consideration*

In a study conducted by the Navy Personnel Research, the Studies and Technology department outlined key criteria for measures of effectiveness to assign sailors to billets. The following are the attributes (Navy Personnel Command 2005):

- Command and sailors' preferences;
- Permanent Change of Station (PCS) cost;
- Training/Skill acquiring cost;
- Qualification/ Paygrade match; and,
- Fleet balance.

The detailer assigns each sailor a score for the above features and jobs. A high-valued combined score for a job signals to the detailer that the sailor is a best fit for that job. Depending on the scale of the assignment problem, the detailer may use Excel Solver to optimize the assignment problem by maximizing the total scoring value.

#### *e. Distribution Incentives*

The Navy has embraced the idea of rewarding sailors that undertake undesired and challenging duties. For example, duties that require a sailor to live outside the country for two years without his or her family are normally compensated for as a hardship. Navy Personnel Command (2005) highlight a list of current incentives in the Navy:

- Overseas tour incentive;
- Assignment incentive pay;
- Selective reenlistment bonus;
- Special duty assignment pay;
- Tax free zones;
- Career sea pay;
- Cost of living allowances;
- Hardship duty pay-location; and,
- En-route training allowances.

Distribution incentives act as tools for the sailor, detailer, and command to negotiate and compromise. Inside the MNA system, sailors can view all the incentives and then make an application or rank job preferences having those incentives in mind. The MNA system allows the Navy HR Office to identify the hard-to-fill billets and therefore allocate an incentive to attract sailors to apply. Navy HR can also do the same for critical billets maintaining a well-balanced fleet with more than 90% manning.

### 2. U.S. Air Force

The U.S. Air Force talent marketplace, also known as MyVector, offers transparency of available jobs, highlights airmen's job preferences, and incorporates commands' input into the assignment process (U.S. Air Force 2019). MyVector has three main areas: mentoring, career development and knowledge sharing. The following subsections describe capabilities found in MyVector.

#### *a. Ability to Manage Mentoring Connections / Relationships*

MyVector enhances the mentoring experience by enabling the mentor and airman to build a career plan. Upon the first logon, the airman will have the ability to create a mentoring profile. Airmen can use the "Finding A Mentor" option to locate mentors with different mentoring perspectives. The "Direct Connect" option allows airmen to correspond with a mentor with whom they wish to connect. This feature makes it easy for airmen to find the right mentors and stay on the right track in their careers. The USMC can incorporate this idea in their marketplace to allow flexibility in career progression requirements. With some additional features, the Marines will not be required to stay in a strict career path for advancement.

#### *b. Ability to View Experiences*

This capability allows airmen to determine how much breadth and depth of experience they have and identify areas to work on for advancements. Airmen have access to their career experience, completed training and education, and their career field experience codes (U.S. Air Force 2019).

#### *c. Education and Training*

This feature of MyVector allow airmen to capture education and training completed during their careers. Airmen can self-report training and skills received from uncommon sources like Coursera (U.S. Air Force 2019). Figure 3 shows an example of airman's education and training summary.

AF Military Education | Other - Self Reported

View your Education and Training entries from MILPDS.

**Education:**

| Code | Description | Level | School | Award Date |
|---|---|---|---|---|
| 1BAA | MIL OPERATIONAL ART/SCI | AWARDED MASTERS DEGREE | AIR UNIV AL | 07 Jun 2010 |
| 1AGY | ENGINEERING MGT | AWARDED MASTERS DEGREE | UNIV DAYTON OH | 14 Aug 2005 |
| 4MYY | MECHANICAL ENGINEERING | AWARDED BACCALAUREATE DEGREE | AUBURN U AL | 01 Jan 1998 |

**Professional Military Education:**

| Code | Description | Level | Residence | Award Date |
|---|---|---|---|---|
| II | IDE-AIR COMMAND AND STAFF COLLEGE (ACSC) | IDE | RESIDENCE | 01 Jun 2010 |
| QA | PDE - SQUADRON OFFICER SCHOOL (BEFORE 2005) | PDE | RESIDENCE | 23 Aug 2002 |

**Acquisition Certification:**

| Code | Description | Level | Award Date |
|---|---|---|---|
| A | PROGRAM MANAGER | INTERMEDIATE LEVEL (II) - CONT AREA SPEC/BROADEN EXPERTISE | 11 Jan 2012 |
| 4 | OTHER PROGRAM MANAGEMENT | ENTRY LEVEL (I) - TRAINEE EXPOSED TO ACQ FUNCS/ROLES & SPEC | 10 Mar 2002 |
| T | TEST AND EVALUATION | ENTRY LEVEL (I) - TRAINEE EXPOSED TO ACQ FUNCS/ROLES & SPEC | 01 Jun 2000 |
| Q | DEVELOPMENTAL ENGINEER | ENTRY LEVEL (I) - TRAINEE EXPOSED TO ACQ FUNCS/ROLES & SPEC | 01 Feb 2000 |

**Acquisition Training:**

| Training | Description | Level | School | Award Date |
|---|---|---|---|---|
| No current Acquisition Training items. | | | | |

**Formal Training Courses:**

| PDS Code | ID | Title | Award Date | Areas of Expertise |
|---|---|---|---|---|
| No current Formal Training items. | | | | |

Figure 3. Education and Training. Source: U.S. Air Force (2019).

The self-reporting tab is a very powerful feature as it highlights some skillsets that airmen might acquire that might be utilized by gaining commands. For example, machine learning for analytics certificate from Coursera can be self-reported for billets that conduct data analysis. This feature enhances the utilization of the service members' skills at all levels of their careers. Figure 4 shows how the airman can self-report unique skills to the gaining command.

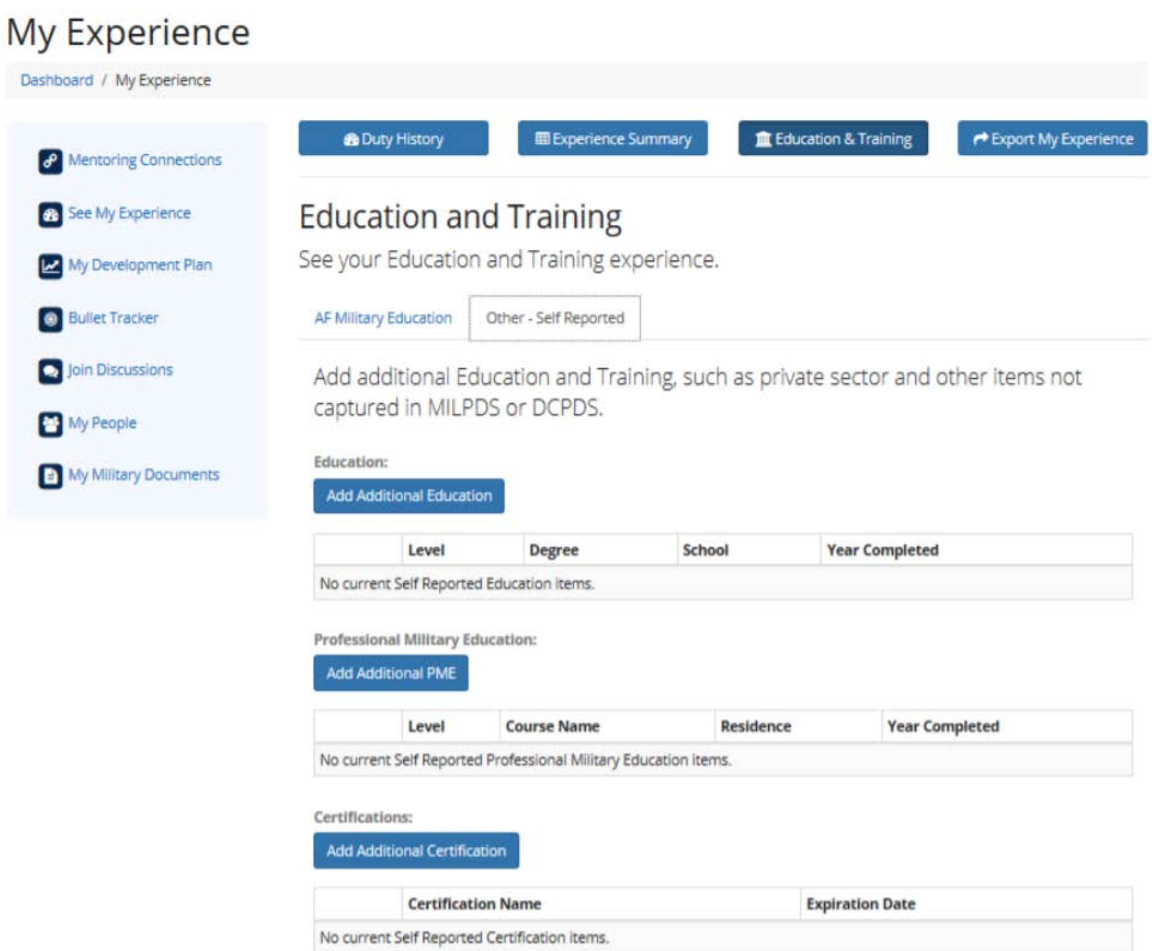


Figure 4. Self-reported Education and Training. Source: U.S. Air Force (2019).

### *d. Development Plan*

Development plan allows airmen to communicate billet preferences, express their desire for advanced training and update their professional goals (U.S. Air Force 2019). Figure 5 shows the "My Development Plan" from an officer's perspective.

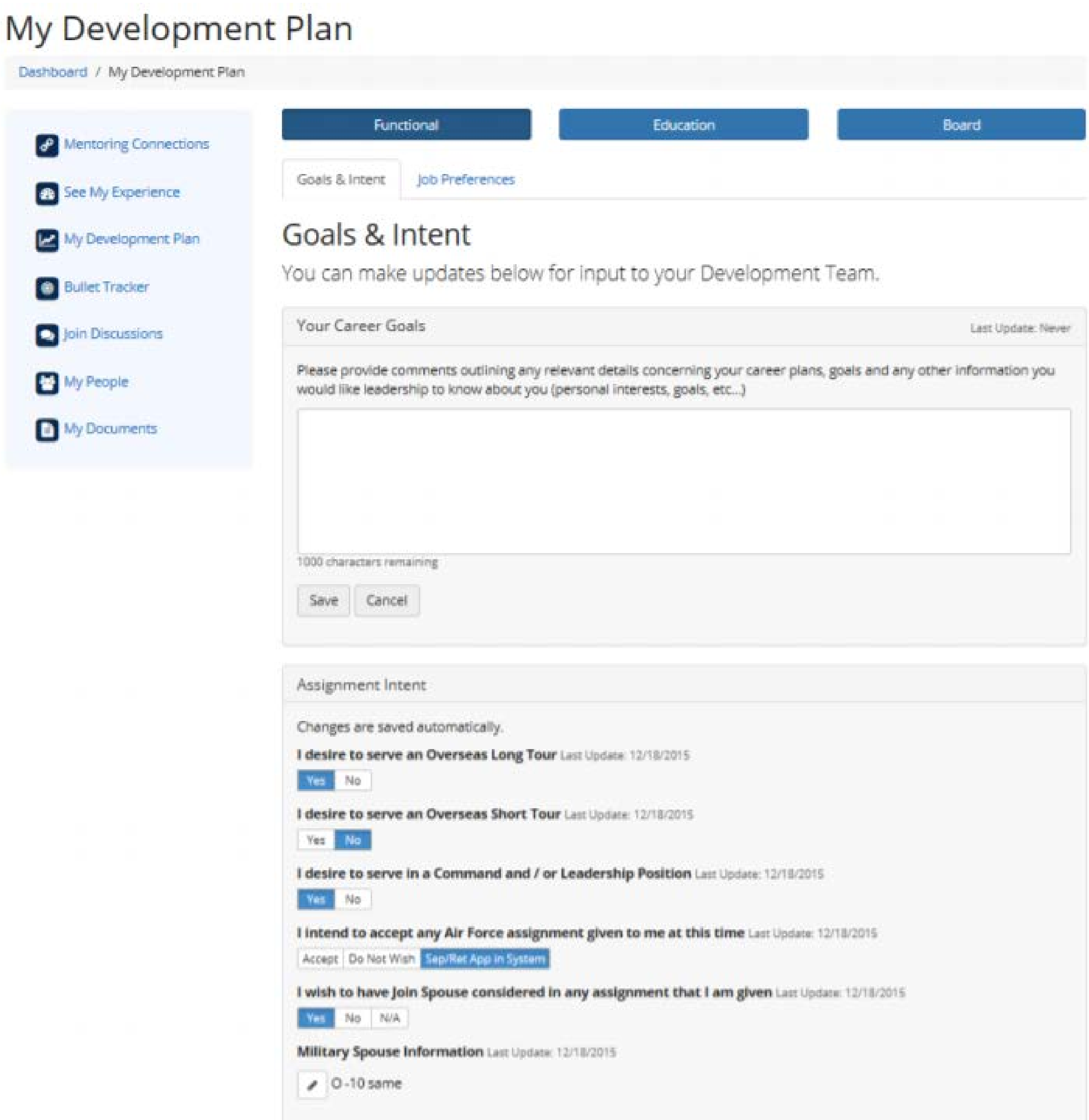


Figure 5. Goal and Intent Tab for U.S. Air Force Officers. Source: U.S. Air Force (2019).

Part of the "My Development Plan" tab is a "Job Preference" tab that allows airmen to provide their preferences to available billets. This allows transparency among all involved parties and encourages airmen to service longer if they get one of their top choices. Figure 6 shows the "Job Preference" tab from the officer's perspective.

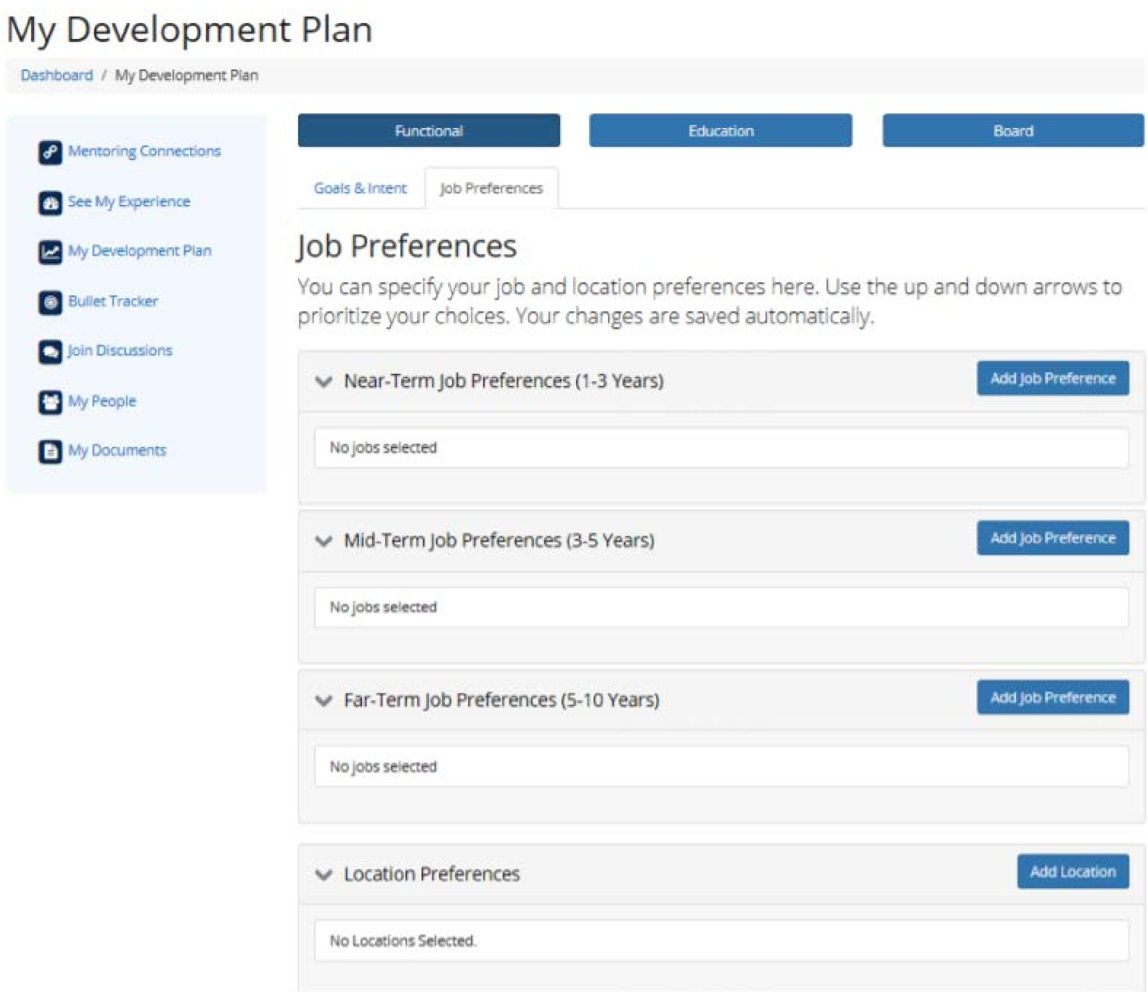


Figure 6. Job Preferences. Source: U.S. Air Force (2019).

#### *e. Military Documents*

This feature allows the airmen to access their military documents pertaining to their professional military careers (U.S. Air Force 2019). This feature of MyVector acts as a one-stop shop for all the documents an airman might need for career planning. Figure 7 shows how to access the documents.

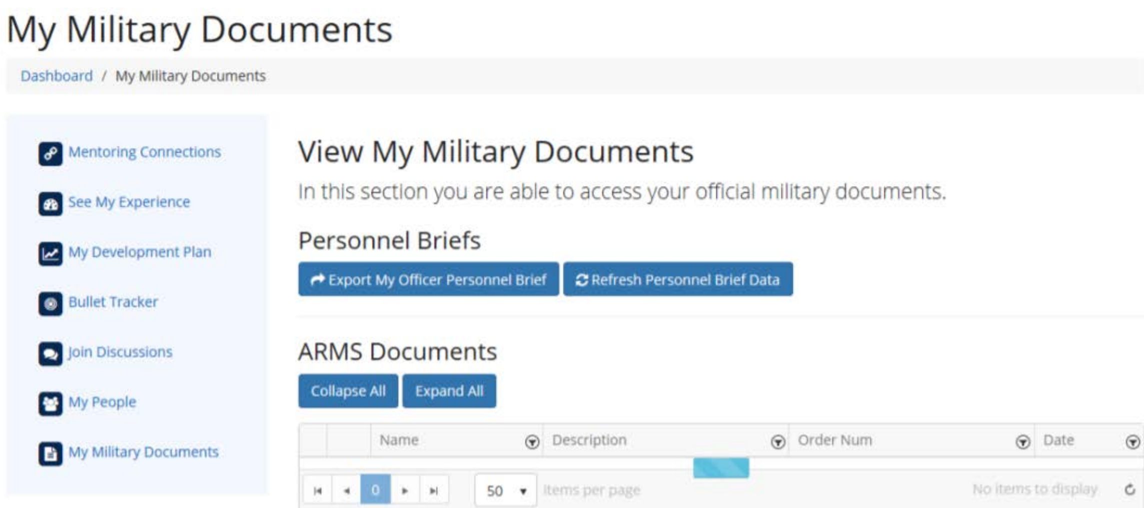


Figure 7. My Military Documents Tab. Source: U.S. Air Force (2019).

According to the Air Force, as of 2017, they are exploring an agile assignment solution through a system called Air Force Talent Marketplace (AFTM), which is an adaptation of the Gale-Shapley deferred acceptance algorithm. Currently, the Air Force Personnel Center (AFPC) uses a manual process to assign airmen to available billets. MyVector has made the process slightly easier with all the necessary documents located in one platform.

### 3. U.S. Army

The U.S. Army views the talent marketplace as a system that capitalizes on the unique talent of its people. The Army Talent Marketplace Task Force (ATMTF) created a talent management process known as the Army Talent Alignment Process (ATAP). The U.S. Army (2019) define ATAP as a decentralized hiring market system that is used to assign soldiers to billets based on preferences. The Army uses a web-based system called Assignment Interactive Module 2.0 (AIM 2) to provide a platform for officers and command to make billet assignment decisions. Like the Navy and Airforce, the ATAP provides vast information to the decision makers to participate in the assignment process.

#### *a. Benefits of ATAP*

The U.S. Army (2019) highlights the following benefits of the ATAP:

- Transparency in the system;
- Preference of service member has a higher priority;
- Management of career is in the hands of the officers;
- Readiness is improved by employing officers' talent effectively; and,
- Retention of officers is enhanced long-term.

#### *b. The Army Talent Alignment Algorithm*

The Army Talent Alignment Algorithm (ATAA) is a mathematical algorithm used to assign soldiers to billets (U.S. Army 2019). Currently, the U.S. Army is the only branch in the DoD that uses a mathematical optimization algorithm for assigning service members to billets. The ATAP process is executed in the following three phases.

**Phase 1: Set the Market**

This begins with commands listing vacant billets and transferring officers. Units will inventory their officers, validate desired report dates for new officers, and post detailed job descriptions of the vacant billets in AIM 2.0. Officers that are scheduled to transfer will update their resumes with an opportunity to add self-professed skills, talents, and experiences that the U.S. Army HR may have not recorded.

**Phase 2: Execute the Market**

Officers review the vacant billets, interact with commands to gather more information, and then rank their job preferences (U.S. Army 2019). The gaining commands will review available officers' resumes, interact with the officers, conduct interviews, and provide their officer preferences (U.S. Army 2019).

#### Phase 3: Clear the Market

In this phase, the alignment algorithm is carried out in a sequential manner where one officer is matched at a time. Officers and job preferences will be the primary factor to determine assignments (U.S. Army 2019). The officers' professional development and career progression are used as secondary assignment consideration in case they are anomalies in the pool of officers or the vacant billets.

## B. OVERVIEW OF ASSIGNMENT PROBLEMS

The number of possible assignments, $N$, of $m$ people to fill $n$ jobs, where $n \geq m$, is given by $N = n!/(n-m)!$. Even though $N$ can be notably reduced by restricting each person to the jobs they are qualified to perform, $N$ can still be very large even for modest values of $m$ and $n$.

In the case of the U.S. military, the detailer or monitor receive a list of available service members and billets. Following stipulated rules and regulations, the detailer or monitor select the "best" match from all the possible service member/billet combinations (Liang et al. 1986). An automated personnel assignment system is necessary because it is humanly impossible to compute an optimal solution from all the possible combinations while considering policy objectives and constraints. Liang et al. (1986) suggest that an assignment optimization model should be able to solve a large-scale multi-objectives problem within a reasonable computational time and cost.

In the past, assignment problems have been studied where algorithms have been designed to address some of the policy objectives for any given organization. In the subsections below, we describe some of the most popular algorithms created to solve assignment problems.

### 1. Hungarian Method

The Hungarian method is an optimization algorithm that is commonly used to solve assignment problems in polynomial time (Kuhn 1955). The algorithm was designed to find optimal allocation cost for a given matrix of cost (or preference) associated with assigning a worker to a job.

The algorithm can only solve an assignment problem with a single objective. The Hungarian algorithm is considered a one-side matching process, that is, where workers need to be matched to homogenous jobs. The only input is from one side of the matching process, that is, the cost (or preference) of each person to be assigned a certain job.

### 2. Gale-Shapley Deferred Acceptance Algorithm

The Gale-Shapley algorithm was formulated by Gale and Shapley (1962) to solve the stable matching problem. Given an assignment problem where the number of jobs available is equal to the number of workers Gale and Shapley (1962) guarantee a "stable" match. A stable match is where there are no two pairs of job/worker that would prefer each other to their current match (Gale and Shapley 1962, p. 387). The stable matching problem requires both the workers and jobs owners to provide their preferences in a ranking order. The most popular application of the Gale-Shapley algorithm is matching graduate medical students to residency programs in various hospitals (Roth and Peranson 1999). The Gale-Shapley algorithm models the assignment problems as a two-sided matching process, in which parties in one side of the market (medical graduate students) need to be matched with parties on the other side (hospitals), and each party has preferences over possible matches. The algorithm takes polynomial time to find a solution.

### 3. Marine Security Guard Assignment Tool

Enoka (2011) develops an integer programming model called the Marine Security Guard Assignment Tool (MSGAT). This model assigns 1,500 Marine Security Guards to 149 embassy detachments annually (Enoka 2011). The model is used in the Marine Corps Embassy Security Group (MCESG) which is considered a closed market system where assignments are made within the group. Although the MSGAT has had quantifiable impact in the MCESG, it is designed with special features applicable only to this specific group of Marines.

### 4. Ground Officer Assignment Tool

Alger (2019) develops the Ground Officer Assignment Tool (GOAT) to optimize Marine Corps assignment, focusing on minimizing the cost of PCS. The underlying GOAT mathematical model includes weighted penalties associated with each possible assignment to calculate the PCS cost. Like a job recommendation system, GOAT makes recommendations on which Marine or billets are best to leave unassigned (Alger 2019). Extending Alger's model, this thesis will focus on outlining the objectives and constraints from collected or derived data and optimizing the USMC assignment problem as a multi-objective problem.

# III. DATA COLLECTION AND METHODOLOGY

## A. OVERVIEW

The formulation model for an assignment problem is presented here as a discrete optimization model. A discrete optimization model is considered a pure integer program (IP) when the variables are confined to a finite or countable set of values (Rardin 2016, p. 56). For example, in the USMC assignment problem, the choices are only whether to assign a Marine to a specific job. More formally, decision variables are specified as follows:

$$x_{ij} = 1 \text{ if Marine } i \text{ is selected for job } j \text{ and } = 0 \text{ otherwise.}$$

Unlike a traditional algorithm such as Gale-Shapley deferred acceptance, the IP model can include constraints based on factors such as USMC policy. For example, the USMC may adopt a policy where partners in a dual-military couple ought to be stationed within 100 miles of each other. The policy can be implemented as a constraint in the model so that the solution adheres to it. Another advantage of using an IP is the flexibility of adjusting either the objective functions or constraints to fit special circumstances. For example, we can create a subset of Marines that must be assigned to a pre-determined pool of billets. This concept can be guided by the need to have certain Marines stationed at locations where we can satisfy their special needs or meet a policy objective, such as receiving special medical services.

### 1. Multi-objective Optimization Model

A multi-objective optimization model can be used to capture all the goals simultaneously or sequentially. In the Marine Corps Order P1300.8S, the CMC orders the monitors to assign Marines to billets based on the following priorities:

- Needs of the Marine Corps;
- Career progression (e.g., operating forces, supporting establishment, seniority);
- Overseas control date (OCD);
- Individual preference; and,

- Restricted officers (warrant officers and limited duty officers) must only be assigned to restricted officer billets within their respective MOSs. (CMC 2014, p. 2-1)

This thesis addresses how to formulate the following objectives:

- Individual preferences; and,
- Cost of moving (PCS cost, training cost, etc.)

The multi-objective IP will be formulated to yield a solution that monitors can use as a starting point to address requirements of Marine Corps Order P1300.8S.

### 2. Multi-objective Optimization Problems

#### *a. Value Function*

The objective function of a multi-objective model has the form

$$\text{“}minimize\text{”}\ F\left[z_1(x), z_2(x), \ldots, z_g(x)\right]$$

$$\text{s.t.}: x \ \in X$$

where *z* represents objectives, *g* represents the number of objectives to optimize, *x* represents a set of decision variables, *X* represents all possible billet/Marine combinations, and *F* is a scalar function of the objective function values (Newman et al. 2009). Note: for convenience, Newman et al. (2009) suggest redefining all the maximization functions as their negation to implement them as minimization functions.

If there is a unique solution that simultaneously satisfies all the constraints and optimizes each objective function, then we have a clear solution, but this “ideal solution” cannot be guaranteed (Newman et al. 2009). In fact, the “ideal” solution for an objective is defined as the best possible solution for that objective (individually considered).

#### *b. Efficient Solution*

A feasible solution in the set of assignments $x \in X$ is said to be an efficient solution if there is no feasible solution $x' \in X$ exists such that $Z_g\,(x') \ \leq \ Z_g\,(x)$ for all $g$, with at least one $g$ with a strict inequality condition (Ehrgott 2005). In a single-objective optimization model, the superiority of a solution can be easily be determined by comparing the optimized objective function values at the optimal point and at any other point. In a multi-objective problem, the superiority of a solution is determined by dominance (Ehrgott 2005). For example, if solution $x_1$ is no worse than solution $x_2$ in all objectives and solution $x_1$ is strictly better than solution $x_2$ in at least one objective, then $x_1$ dominates $x_2$.

### c. *Efficient Frontier*

In most multi-objective problems, we find a set of solution that would prove to be the best for one of the objectives but worse for the others. In such a case we can generate numerous efficient solutions to our optimization problem. Efficient solutions are also referred to as Pareto-optimal set or non-dominated solution set (Ehrgott 2005). Pareto-optimal solution can be specifically be defined as a solution derived from improving one objective that leads to making at least one of the other objectives worse off (Newman et al. 2009). The "boundary" shape defined by the Pareto-optimal set (a convex function if all objectives are minimization) gives the efficient frontier, which we can generate (or approximate) and can be useful for illustrating different alternatives (Newman et al. 2009).

## 3. Methods of Solving Multi-objective Problems

### a. *Weighted Sum Method*

The weighted sum method is a technique whereby a set of objectives are scalarized into a single objective function (Newman et al. 2009). For each objective, weight $w_g$ is determined by the decision maker. The weights are multiplied by their respective objectives and then summed up into one objective function. The single objective can be formulated into the following standard mathematical problem:

$$\min_{x \in X} \sum_{g \in G} w_g \, Z_g(x)$$

For example, in the USMC assignment problem, the weight can be chosen in proportion to the relative importance of the objective to the decision maker (MMOA). One of the main advantages of the weighted sum method is the simplicity that it provides in solving multi-objective optimization problems. Also, multiplying a weight on the objective gives the decision maker control to find an assignment solution based on the organization's mission and policy objectives. One of the drawbacks of weighted methods is that it assumes a constant tradeoff rate between two given objectives, regardless of the level of attainment in each objective.

### *b. Hierarchical Optimization*

This method assumes a prioritized list of objective functions, and then optimizes them in a sequential manner (Newman et al. 2009). Newman et al. (2009) emphasizes that the optimal objective function value of the higher priority objective becomes a constraint in the subsequent optimization of the lower priority objective. Newman et al. (2009) discusses the technique as solving a sequence of increasingly restricted single objective problems ($H_g$), for $g$ =1 ,…, G :

$$(H_g): \quad z_g^* = min\, z_g(x)$$

$$\text{s.t.:} \quad x \in X$$

$$z_{g'}(x) = z_{g'}^*, \forall g' < g$$

### *c. ε-Constraint Method*

The idea in this method is to convert all but one of the goals ($g'$, objective $Z_{g'}$) into constraints (Ehrgott 2005). The decision maker selects the target levels $Z_g^T$ , $\forall g \neq g'$ and then solve the following standardized formulation:

$$\min_{x \in X} Z_{g'}(x)$$

$$\text{s.t.:} \quad Z_g(x) \le Z_g^T, \forall g \neq g'$$

For simplicity, the target levels can be set as a percentage of the ideal value.

### *d. ε-Constraint Method with Hierarchy*

In a situation where the hierarchy of the objective can be easily be determined then we have a hybrid approach of the ε-Constraint method combined with hierarchy method. The following is the sequence of computations to carry out for objectives $g$ =1,…$k$:

(1) Set $g'$: =1.

(2) Solve the following restricted, single-objective problem:

$$\min_{x \in X} \quad Z_{g'}(x)$$

$$\text{s.t.:} \quad Z_g(x) \leq Z_g^T, \forall g \neq g'$$

(3) Set a target level for $g'$: $Z_g^T = Z_{g'}(\tilde{x_g})(1+\varepsilon)$, where $\tilde{x_g}$ is the optimal solution to the targeted objective.

(4) If $g' < k$ set $g'$: $= g' + 1$ and then solve the next restricted, single-objective model in Step 2.

## 4. Modelling

We focus on the two most popular techniques of solving multi-objective problems: weighted sum method and ε-constraint method with hierarchy. Specifically, we develop Weighted Sum Method for Assignment Model (WESMAM) and Hierarchical $\varepsilon$-Constraint Method Assignment Model (HECMAM). We will explore these two models using data generated from the FY 2020 "Aviation LtCol Movers Survey" provided by the USMC to aid in this research.

## 5. Multi-objective Formulations

Index Sets

$i \in I$ index for Marine set;

$j \in J$ index for job set;

Given Data

$c_{ij}$ cost of assigning Marine *i* to job *j* [$];

$w$ weight given to Marine preferences (if the weighted average model is used) [$/unit of preference];

$\varepsilon$ tolerance parameter, indicating the fraction of the hierarchically superior goal that is admissible to lose while optimizing the hierarchically inferior goal. This is used in the hierarchical model with: (a) cost hierarchy over preference, or (b) preference hierarchy over cost;

$P_{ij}^{S}$ Marine *i* preference to job *j* [preference units];

$P_{ij}^{MOS}$ qualifying MOS characteristic: 1 if Marine *i* is MOS-qualified for job *j*, and 0 otherwise

Derived Data

$I_j \subseteq I$ subset of qualified Marines for job *j;*

$J_i \subseteq J$ subset of jobs for which Marine *i* is qualified;

Decision Variables

$x_{ij}$ assignment decision: $x_{ij} = \begin{cases} 1, & \text{if Marine } i \text{ is assigned to job } j \\ 0, & \text{otherwise} \end{cases}$.

WESMAM Formulation**:**

Maximize $wZ_1 - Z_2$

subject to:

$$\sum_{j \in J_i} x_{ij} = 1 \qquad \forall i \in I \tag{1}$$

$$\sum_{i \in I_j} x_{ij} \leq 1 \qquad \forall j \in J \tag{2}$$

$$\boldsymbol{Z_1} = \sum_{i \in I} . \sum_{j \in J_i} P_{ij}^{S} x_{ij} \tag{3}$$

$$\boldsymbol{Z_2} = \sum_{i \in I} . \sum_{j \in J_i} c_{ij} x_{ij} \tag{4}$$

$$x_{ij} \in \{0,1\} \qquad \forall i \in \mathrm{I}, j \in J_i \tag{5}$$

WESMAM's objective function combines our two objectives into a single objective, expressed in dollars. It also includes the following constraints:

- Each Marine must be assigned to exactly one position (1).
- Each job can be filled or left vacant (2).
- Capture the total preference objective (3).
- Capture the total cost objective (4). And,
- Decision variables must be binary (5).

<u>HECMAM Formulation—Step I: HECMAM-I</u>

If the hierarchical model is used with cost hierarchy over preference, the following formulation follows:

Maximize $Z_1$

subject to:

$$\sum_{j \in J_i} x_{ij} = 1 \qquad \forall i \in I \tag{6}$$

$$\sum_{i \in I_j} x_{ij} \leq 1 \qquad \forall j \in J \tag{7}$$

$$\boldsymbol{Z_1} = \sum_{i \in I} . \sum_{j \in J_i} P_{ij}^{S} x_{ij} \tag{8}$$

$$\boldsymbol{Z_2} = \sum_{i \in I} . \sum_{j \in J_i} c_{ij} x_{ij} \tag{9}$$

$$x_{ij} \in \{0,1\} \qquad \forall i \in \mathrm{I}, j \in J_i \tag{10}$$

Call $Z_1^{\text{HECMAM-I}}$ to the optimal objective function value of HECMAM-I.

HECMAM Formulation—Step II: HECMAM-II

Minimize $Z_2$

subject to :

$$\sum_{j\in J_i} x_{ij} = 1 \qquad \forall i \in I \tag{11}$$

$$\sum_{i\in I_j} x_{ij} \leq 1 \qquad \forall j \in J \tag{12}$$

$$\boldsymbol{Z_1} = \sum_{i\in I} . \sum_{j\in J_i} P_{ij}^S x_{ij} \tag{13}$$

$$\boldsymbol{Z_2} = \sum_{i\in I} . \sum_{j\in J_i} c_{ij} x_{ij} \tag{14}$$

$$\boldsymbol{Z_1} \geq \boldsymbol{Z_1^{\text{HECMAM-I}}} \cdot (1-\varepsilon) \tag{15}$$

$$x_{ij} \in \{0,1\} \qquad \forall i \in \text{I}, j \in J_i \tag{16}$$

On the other hand, if the hierarchical model is used with preference hierarchy over cost, HECMAM require the following updates:

- HECMAM-I:
    - Replace the objective by Minimize $Z_2$.
    - Call $Z_2^{\text{HECMAM-I}}$ to the optimal objective function value of HECMAM-I.
- HECMAM-II:
    - Replace the objective by Maximize $Z_1$.
    - Replace constraint (15) by $\boldsymbol{Z_2} \leq \boldsymbol{Z_2^{\text{HECMAM-I}}} \cdot (1+\varepsilon)$

## B. DATA COLLECTION AND PROCESSING

Our algorithm requires data from five main datasets to be implemented into an optimization software. An NPS Institutional Review Board (IRB) Human Subject Research Determination was filled out to request demographic data on FY 2020 Aviation Lieutenant Colonel Movers' Survey. Movers are considered as Marines that are scheduled to transfer to new jobs in the Marine Corps. We requested all personally identifiable information and contacts removed by the sponsor prior to the data being sent to NPS. The sponsor anonymized the data using universally unique identifiers or response identifiers to identify all the unique movers. The IRB board determined that the requested data did not require an IRB review and NPS president approval. This determination was forwarded to the Marine Corps IRB for concurrence and the data was released to support the research.

### 1. FY 2020 Aviation Lieutenant Colonel Movers Survey

The sponsor conducted a survey on the aviation lieutenant colonels who were eligible to transfer to new billets. The survey is a monitor's questionnaire that is used in the assignment process. An example of the survey taken is shown in Appendix A of this thesis. For simplicity, we only consider the aviation community as a closed centralized market system where selections can be made only within the aviation community.

The survey was taken as an open survey which means that anyone who was anticipating to transfer could take it. This resulted in a mismatch of the number of Marines who filled out the survey and the number of Marines that were in the final mover's list. The survey was meant to collect Marines' preferences of the available billets. In the "Billet Preference" section of the survey, Marines were asked to choose and rate 15 total billets from a list of 196 available billet jobs. At least five rated billets must be coded "8006/any code" (see below for billet coding details). Using a slider to weigh the 15 preferences, large values indicated a high desirability for that assignment. For officers with fewer MOS options to select, for example a Marine with MOS designator "6602," could select more than five billets coded "8006." The survey also provided a frame of reference, so that: a weight between 70 and 100 indicates the Marine would be ecstatic about the assignment; between 40 and 60 would reflect contentment; and, below 30 indicates a least-preferred assignment. The survey allowed MMOA to build a data file of Marines' job preferences in matrix form. The rest of the billets (the other 181 not selected) were weighted with a zero.

The resulting Marines' preference data were processed using code developed in Python. In an exploratory analysis, there are 360 rows and 205 columns in the data frame. The excerpt in Table 3 shows the following relevant columns: "(Universally Unique Identifiers) UUID," "(Military Command Code)MCC," "MCC2," "(additional MOS 1)AMOS1," "AMOS2," "AMOS3," "AMOS4," "AMOS5," "PMOS," and the 196 columns containing the jobs. After further data preprocessing, we have 187 Marines and 196 billets.

Table 3. Excerpt of the Marines' Preference Data

| UUID | MCC | MCC2 | AMOS1 | AMOS2 | AMOS3 | AMOS4 | AMOS5 | PMOS | [007 / 7506 / HQ MCCDC QUANTICO VA] | [022 / 7506 / MCAS CHERRY POINT NC] | ... | [NBP / 8006 / HQ USCENTCOM (JT-BIL) MACDILL AFB FL] | [NBR / 7503 / JOINT STAFF J7 (JT-BIL) SUFFOLK VA] | [NBR / 8006 / JOINT STAFF J7 (JT-BIL) SUFFOLK VA] | [NBW / 8006 / JOINT CHIEFS OF STAFFJ5 (JT-BIL) WASHINGTON DC] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **10352** | QAQ | QAM | 7208 | 7277 | 8220 | 0 | 0 | 7202 | 0.0 | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 |
| **14701** | G63 | J59 | 7577 | 7588 | 0 | 0 | 0 | 7557 | 0.0 | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 |
| **18665** | 63 | 1JW | 571 | 8862 | 0 | 0 | 0 | 6602 | 0.0 | 0.0 | ... | 0.0 | 0.0 | 0.0 | 60.0 |
| **29968** | VMJ | 1ET | 7502 | 7513 | 0 | 0 | 0 | 7565 | 0.0 | 90.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 |
| **30264** | VLE | 1TC | 7502 | 7513 | 7577 | 0 | 0 | 7565 | 0.0 | 0.0 | ... | 0.0 | 0.0 | 0.0 | 0.0 |

The format for each available billet is "[(MCC) / MOS Code / Major Subordinate Command (MSC) description]." For example, [007 / 7506 / HQ MCCDC QUANTICO VA]. A subset of the Marines' preference data is a Marines' preference score data. An example of Marines' preferences is shown in Table 4.

Table 4. Excerpt of Marine Preference Scores

| UUID | [007 / 7506 / HQ MCCDC QUANTICO VA] | [022 / 7506 / MCAS CHERRY POINT NC] | [022 / 7596 / MCAS CHERRY POINT NC] | [023 / 7506 / MCAS MIRAMAR SAN DIEGO CA] | [032 / 7505 / MCAF QUANTICO VA] | [048 / 6002 / FLEET READINESS CENTER EAST CHERRY PT NC] | [057 / 7505 / MCAS CAMP PENDLETON CA] | [057 / 7505 / MCAS CAMP PENDLETON CA].1 | [070 / 5902 / MC SYSCOM QUANTICO VA] | [086 / 7506 / TRAINING AND EDUCATION COMMAND QUANTICO VA] | ... | [NBP / 8006 / HQ USCENTCOM (JT-BIL) MACDILL AFB FL] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10352 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ... | 0.0 |
| 14701 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ... | 0.0 |
| 18665 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ... | 0.0 |
| 29968 | 0.0 | 90.0 | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 | 100.0 | 0.0 | 0.0 | ... | 0.0 |
| 30264 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | ... | 0.0 |

### 2. MOS Qualifications

The USMC MOS manual NAVMC 1200.1F outlines the military occupational specialties (coded skills) that enable Marines to be assigned to billets. The MOS is a four-digit code constructed on the concept that occupations with similar skills, knowledge, or functional application requirements are grouped together in one single code (DON 2020).

Among all the available billets there are 21 unique MOSs. The MOS manual is used to determine for each billet military occupational specialty (BMOS) which Marines' PMOS and/or AMOS qualifies a Marine for assignment to a job. Table 5 shows a constructed billet to MOS mapping.

Table 5. Billet MOS Mapping

| Billet MOS | Qualifying PMOS | AMOS |
|---|---|---|
| 7506 | 7509, 7516, 7518, 7521, 7523, 7524, 7525, 7531, 7532, 7543, 7553, 7554, 7555, 7556, 7557,5578, 7580, 7588, 7598, 7511, 7513, 7560, 7562, 7597, 7563, 7564, 7565, 7566, 7567, 7568 | |
| 7596 | ANY MOS | 7596 |
| 7505 | 7511, 7513, 7560, 7562, 7597, 7563, 7564, 7565, 7566, 7567, 7568 | |
| 6002 | 6002 | |
| 5902 | 5902 | |
| 6302 | 6302 | |
| 6502 | 6502 | |
| 7503 | 7507, 7509, 7516, 7518, 7521, 7523, 7531, 7532, 7543, 7553, 7554, 7555, 7556, 7557, 7598 | |
| 7202 | 7202 | |
| 6602 | 6602 | |
| 7518 | 7518 | |
| 7523 | 7523 | |
| 7509 | 7509 | |
| 7566 | 7566 | |
| 7315 | 7315 | |
| 8006 | ANY MOS | |
| 7532 | 7532 | |
| 7577 | ANY MOS | 7577 |
| 8005 | ANY MOS | |
| 8059 | 8059 | |
| 7588 | 7588 | |

Our Python code extracts the four-digit MOS identifier for easy identification of jobs that each Marine is qualified to perform. Table 6 below shows an excerpt of these data where a “1” means the Marine can perform the job, and otherwise it shows a “0.”

Table 6. Excerpt of Marine to Job Data

| UUID | [007 / 7506 / HQ MCCDC QUANTICO VA] | [022 / 7506 / MCAS CHERRY POINT NC] | [022 / 7596 / MCAS CHERRY POINT NC] | [023 / 7506 / MCAS MIRAMAR SAN DIEGO CA] | [032 / 7505 / MCAF QUANTICO VA] | [048 / 6002 / FLEET READINESS CENTER EAST CHERRY PT NC] | [057 / 7505 / MCAS CAMP PENDLETON CA] | [057 / 7505 / MCAS CAMP PENDLETON CA].1 | [070 / 5902 / MC SYSCOM QUANTICO VA] | [086 / 7506 / TRAINING AND EDUCATION COMMAND QUANTICO VA] | ... | [NBP / 8006 / HQ USCENTCOM (JT-BIL) MACDILL AFB FL] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10352 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ... | 1 |
| 14701 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | ... | 1 |
| 18665 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | ... | 1 |
| 29968 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | ... | 1 |
| 30264 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | ... | 1 |

### 3. PCS Cost

PCS involves moving military personnel to new duty station after serving two to four years in current billets. The DoD is committed to minimizing the PCS cost due to yearly reduction in the defense budget (GAO 2015). The PCS cost data collection begin when the Marine receives orders and then arranges the PCS move. The Marine is expected to use either a government credit card or a personal credit card to cover for all allowed expenses. Allowed expenses are reimbursed under Chapter 8 of Title 37 of U.S. Code and are specified in DoD’s Joint Travel Regulation (GAO 2015). Once the PCS move is completed, the Marine files for reimbursement through the gaining command. It is at this point that DoD will capture the actual PCS cost for that Marine. Due to this limitation, this research uses an estimated PCS cost based on the distance between the previous command and the new command. To calculate an estimated PCS cost, two datasets are utilized: MCC’s zip code dataset and zip code’s geographical position dataset.

#### *a. MCC's Zip Code Dataset*

We requested data that shows all the MCC's zip codes so that we can place each Marine and each billet at a zip code. The zip codes identify the Marines and billets' geographical positioning allowing computation of the distance between Marines' current duty station to all billets. Table 7 shows an example of the MCC's zip code data.

Table 7. Excerpt of MCC's Zip Code Data

| MCC | ZIPCODE |
|---|---|
| 0 | 92055 |
| 1 | 29904 |
| 2 | 92145 |
| 3 | 22134 |
| 4 | 92055 |

#### *b. Zip Codes' Geographical Position Dataset*

From the National Bureau of Economic Research's Zip Code Tabulation Area (ZCTA) distance database we retrieved data that contain the geographical position (latitude and longitude) for U.S. zip codes. Since we have eight overseas postal codes from both the Marines and the billets' MCC, we used Google maps to determine their geographical positions. The postal codes and their respective latitude and longitude coordinates were manually added to the "zip code's geographical position" dataset (see excerpt in Table 8).

Table 8. Excerpt of Geographical Position of Zip Codes

| | zipcode | lat | long |
|---|---|---|---|
| 0 | 71937 | 34.398483 | -94.39398 |
| 1 | 72044 | 35.624351 | -92.16056 |
| 2 | 56171 | 43.660847 | -94.74357 |
| 3 | 49430 | 43.010337 | -85.89754 |
| 4 | 52585 | 41.194129 | -91.98027 |

#### *c. Processed PCS Cost Dataset*

We use a standard mileage reimbursement rate for PCS move added to a fixed cost. We assume that only Marines who are transferring to duty stations located more than 50 miles will be compensated a fixed per-diem PCS of $2,000. According to GAO, for PCS travel, the mileage allowance in lieu of transportation (MALT) rate is $0.17 per mile. Although this rate is just an estimate (subject to each individual case), we use it as a surrogate to estimate PCS cost. To calculate the distance (in miles) we determine the great-circle distance between two geographical points given their latitudes and longitudes (Sanchez and Canton 1999). Table 9 shows an excerpt of the PCS cost data.

Table 9. Excerpt of the PCS Cost Data

| UUID | [007 / 7506 / HQ MCCDC QUANTICO VA] | [022 / 7506 / MCAS CHERRY POINT NC] | [022 / 7596 / MCAS CHERRY POINT NC] | [023 / 7506 / MCAS MIRAMAR SAN DIEGO CA] | [032 / 7505 / MCAF QUANTICO VA] | [048 / 6002 / FLEET READINESS CENTER EAST CHERRY PT NC] | [057 / 7505 / MCAS CAMP PENDLETON CA] | [057 / 7505 / MCAS CAMP PENDLETON CA].1 | [070 / 5902 / MC SYSCOM QUANTICO VA] | [086 / 7506 / TRAINING AND EDUCATION COMMAND QUANTICO VA] |
|---|---|---|---|---|---|---|---|---|---|---|
| 10352 | 0.000000 | 2040.703821 | 2040.703821 | 2334.355144 | 0.000000 | 2040.703821 | 2331.608222 | 2331.608222 | 0.000000 | 0.000000 |
| 14701 | 2355.106951 | 2367.965778 | 2367.965778 | 2061.037424 | 2355.106951 | 2367.965778 | 2060.952248 | 2060.952248 | 2355.106951 | 2355.106951 |
| 18665 | 2331.734218 | 2338.696158 | 2338.696158 | 0.000000 | 2331.734218 | 2338.696158 | 0.000000 | 0.000000 | 2331.734218 | 2331.734218 |
| 29968 | 2329.231793 | 2336.258600 | 2336.258600 | 0.000000 | 2329.231793 | 2336.258600 | 0.000000 | 0.000000 | 2329.231793 | 2329.231793 |
| 30264 | 2308.104763 | 2313.958279 | 2313.958279 | 2025.936160 | 2308.104763 | 2313.958279 | 2023.889659 | 2023.889659 | 2308.104763 | 2308.104763 |

## C. SOFTWARE IMPLEMENTATION

The mathematical formulations developed in this thesis have been computationally implemented in Pyomo (a Python interface for mathematical optimization). Pyomo's modelling objects can be leveraged in optimization as they are embedded in Python, which is a powerful programming language (Hart et al. 2017, p. vii). We use "cbc" as the optimization engine to solve our models (A Mathematical Programming Language [AMPL] 2020).

## D. DEMONSTRATION OF PYOMO IMPLEMENTATION

For verification and validation of our methodology, we test a small scenario that we refer to as "demonstration problem" and resembles datasets from our USMC problem. In our demonstration problem we have 20 Marines to be assigned to 25 billets. From this small-scale demonstration problem, we ensure our methodology is logically and mathematically accurate and look for special cases such as jobs that cannot be filled because of lack of qualified personnel. The following paragraphs describe the data used for this small case.

### *a. Preference Data*

The preference data was developed using the same strategy as the real-world preference survey that was administered, where Marines were only required to rank a few of the billets in an order of their preference. In our small scenario, Marines are required to rank at least five billets with values between 0 and 100. Table 10 shows the data that was randomly generated.

Table 10. Demonstration Problem Marine Preference Data

| Response ID | job1 | job2 | job3 | job4 | job5 | job6 | job7 | job8 | job9 | job10 | job11 | job12 | job13 | job14 | job15 | job16 | job17 | job18 | job19 | job20 | job21 | job22 | job23 | job24 | job25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 64 | 0 | 0 | 0 | 0 | 0 | 69 | 0 | 0 | 40 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 48 | 0 |
| 2 | 0 | 0 | 0 | 33 | 0 | 0 | 0 | 0 | 0 | 36 | 0 | 0 | 91 | 0 | 0 | 0 | 78 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 38 | 0 | 70 | 0 | 0 | 74 | 0 | 0 | 85 | 0 | 89 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 68 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 0 | 0 | 0 | 0 | 59 | 0 | 82 | 0 | 0 |
| 5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 79 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 7 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 31 | 0 | 60 | 0 | 0 | 0 | 0 | 24 | 0 | 0 | 0 | 0 | 67 | 0 | 0 | 0 | 71 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 0 | 44 | 0 | 0 | 0 | 0 | 0 | 82 | 0 | 0 | 0 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 71 | 0 | 51 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 72 | 0 | 0 | 5 | 0 | 89 | 0 | 86 | 0 |
| 9 | 0 | 0 | 72 | 0 | 0 | 87 | 0 | 0 | 0 | 71 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 58 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 20 | 0 | 0 | 53 | 0 | 0 | 0 | 0 | 60 | 0 | 0 | 82 | 0 | 0 | 0 | 99 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 0 | 71 | 0 | 0 | 0 | 0 | 0 | 73 | 0 | 0 | 20 | 0 | 0 | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 75 | 0 | 0 | 0 | 0 |
| 12 | 7 | 0 | 0 | 0 | 0 | 0 | 31 | 0 | 0 | 0 | 51 | 0 | 0 | 0 | 35 | 0 | 0 | 0 | 39 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 0 | 0 | 26 | 0 | 0 | 22 | 0 | 0 | 28 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 4 | 0 | 0 | 46 | 0 | 8 | 0 | 0 | 0 | 0 | 81 | 0 | 0 | 62 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 0 | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 64 | 0 | 14 | 58 |
| 16 | 29 | 0 | 0 | 41 | 0 | 0 | 45 | 0 | 49 | 0 | 0 | 0 | 0 | 0 | 0 | 67 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 0 | 24 | 85 | 0 | 0 | 0 | 0 | 90 | 0 | 0 | 0 | 0 | 0 | 0 | 88 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | 0 | 0 | 0 | 0 | 15 | 0 | 59 | 0 | 0 | 57 | 0 | 0 | 0 | 21 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | 74 | 81 | 0 | 0 | 0 | 84 | 0 | 0 | 33 | 0 | 0 | 56 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 47 | 0 | 0 | 0 | 0 | 0 |
| 20 | 0 | 0 | 0 | 75 | 0 | 0 | 0 | 53 | 0 | 0 | 74 | 0 | 0 | 0 | 41 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 72 |

### *b. MOS Qualification Data*

In this dataset we intentionally set two jobs: *"job1"* and *"job13"* as jobs that none of the Marines in our pool of movers is MOS-qualified. We also have *"job17"* through *"job25"* where all Marines are equally qualified. Once we identify billets to which the Marines can be assigned, Table 11 is generated to show (for each Marine) those billets.

Table 11. MOS-qualified Data for Demonstration Problem

| Response ID | Job1 | Job2 | Job3 | Job4 | Job5 | Job6 | Job7 | Job8 | Job9 | Job10 | Job11 | Job12 | Job13 | Job14 | Job15 | Job16 | Job17 | Job18 | Job19 | Job20 | Job21 | Job22 | Job23 | Job24 | Job25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 5 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 7 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 11 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 12 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 13 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 14 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 15 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 16 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 17 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 18 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 19 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 20 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

### *c. PCS cost data*

For simplicity, we simulate PCS costs where every PCS cost is uniformly distributed between $0 and $25,000 as shown in Table 12.

Table 12. Mover’s PCS Cost for Demonstration Problem

| Response ID | job1 | job2 | job3 | job4 | job5 | job6 | job7 | job8 | job9 | job10 | job11 | job12 | job13 | job14 | job15 | job16 | job17 | job18 | job19 | job20 | job21 | job22 | job23 | job24 | job25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11376 | 11665 | 3132 | 10636 | 14872 | 20714 | 12911 | 17154 | 92 | 1649 | 24374 | 17488 | 3561 | 23941 | 22503 | 20541 | 9778 | 17092 | 13109 | 16760 | 16886 | 13067 | 17069 | 14931 | 20746 |
| 2 | 10515 | 15870 | 5465 | 11050 | 20195 | 20586 | 9536 | 12701 | 9694 | 9542 | 24578 | 7803 | 4185 | 16224 | 10446 | 110 | 621 | 4821 | 12426 | 7206 | 18552 | 11353 | 885 | 3534 | 12135 |
| 3 | 23519 | 21959 | 21873 | 3916 | 16431 | 19871 | 13644 | 24091 | 21291 | 18744 | 8064 | 20375 | 13383 | 20553 | 7221 | 141 | 24099 | 18170 | 20675 | 9977 | 16132 | 3452 | 2410 | 15666 | 24033 |
| 4 | 520 | 10446 | 3774 | 17039 | 15453 | 3136 | 14176 | 12634 | 5684 | 5008 | 2518 | 13753 | 4551 | 23458 | 20400 | 14917 | 20076 | 2015 | 7787 | 15994 | 8506 | 10016 | 10309 | 1360 | 6413 |
| 5 | 8767 | 2908 | 4721 | 23726 | 7866 | 23166 | 24600 | 6687 | 17814 | 11353 | 12165 | 21440 | 17800 | 8040 | 19010 | 8536 | 9690 | 11691 | 18549 | 15491 | 13514 | 13154 | 1946 | 1895 | 22994 |
| 6 | 21135 | 21757 | 7850 | 4879 | 8731 | 17785 | 272 | 11618 | 23337 | 15153 | 1680 | 8089 | 19527 | 1123 | 126 | 16828 | 14350 | 20749 | 19611 | 11062 | 23578 | 13552 | 17649 | 2278 | 9992 |
| 7 | 8816 | 15441 | 961 | 12803 | 6201 | 2899 | 4763 | 23950 | 21029 | 18316 | 15528 | 15302 | 17707 | 1570 | 20551 | 13516 | 12879 | 2169 | 21654 | 19666 | 6205 | 19959 | 22400 | 6055 | 17012 |
| 8 | 14720 | 21645 | 2560 | 17188 | 19368 | 23096 | 12636 | 1089 | 4439 | 6430 | 10366 | 1457 | 24056 | 1552 | 12988 | 5069 | 19547 | 16178 | 18891 | 4482 | 14218 | 4688 | 1889 | 14913 | 24682 |
| 9 | 19026 | 20259 | 12486 | 898 | 16454 | 4217 | 414 | 11759 | 19189 | 14439 | 18346 | 8486 | 643 | 4331 | 2599 | 13949 | 19993 | 15272 | 5254 | 6774 | 12169 | 6922 | 8619 | 16979 | 7358 |
| 10 | 18964 | 12376 | 2406 | 19946 | 2693 | 21074 | 9663 | 7735 | 2052 | 17061 | 15877 | 13155 | 23798 | 6540 | 16112 | 23529 | 3612 | 7481 | 19029 | 15945 | 12839 | 2746 | 9585 | 6500 | 9367 |
| 11 | 6166 | 8415 | 4565 | 21465 | 22206 | 22813 | 7962 | 13514 | 3627 | 3512 | 11876 | 10403 | 17610 | 826 | 18579 | 22204 | 12772 | 9036 | 15827 | 167 | 4309 | 15350 | 19580 | 24568 | 89 |
| 12 | 24806 | 21202 | 20006 | 7843 | 1494 | 13230 | 9238 | 10911 | 9862 | 7096 | 17061 | 16936 | 21077 | 7744 | 231 | 23040 | 3480 | 2295 | 6540 | 24012 | 2453 | 7295 | 4727 | 19306 | 16829 |
| 13 | 16108 | 15371 | 11377 | 2670 | 7055 | 3089 | 10249 | 15616 | 8326 | 1349 | 5316 | 7314 | 10380 | 5327 | 11778 | 17779 | 24488 | 22452 | 17432 | 1462 | 2078 | 3768 | 5306 | 23981 | 24782 |
| 14 | 21782 | 16124 | 20115 | 23555 | 9502 | 8352 | 2733 | 14397 | 23369 | 18808 | 7109 | 2945 | 12515 | 11841 | 19232 | 7530 | 14451 | 13255 | 11983 | 425 | 4124 | 6459 | 2989 | 22333 | 12259 |
| 15 | 3990 | 1734 | 20763 | 16031 | 14012 | 20801 | 1775 | 22866 | 17288 | 13323 | 18704 | 2658 | 10532 | 7730 | 7910 | 19987 | 20809 | 15630 | 3279 | 18552 | 15531 | 9293 | 2605 | 9699 | 5479 |
| 16 | 21520 | 13173 | 564 | 19680 | 18551 | 3249 | 4689 | 14804 | 5114 | 9078 | 135 | 16223 | 6946 | 7350 | 16094 | 15185 | 18060 | 10548 | 15957 | 7060 | 24458 | 17235 | 14636 | 18865 | 14722 |
| 17 | 22383 | 5532 | 21503 | 9270 | 15829 | 7132 | 9929 | 1558 | 21178 | 17079 | 22057 | 22435 | 13669 | 9067 | 5960 | 23555 | 23242 | 8640 | 3779 | 3874 | 23622 | 15022 | 18235 | 12796 | 1808 |
| 18 | 11608 | 12019 | 17495 | 10126 | 13401 | 6804 | 14788 | 18390 | 22960 | 12745 | 22115 | 24594 | 12913 | 16151 | 2952 | 11851 | 8381 | 22840 | 21236 | 12966 | 22950 | 1171 | 14664 | 14878 | 12765 |
| 19 | 12832 | 13747 | 24376 | 16809 | 4362 | 560 | 17647 | 14651 | 4968 | 12360 | 7675 | 12332 | 24414 | 24512 | 18596 | 17410 | 811 | 1807 | 370 | 16570 | 6346 | 6895 | 9284 | 19282 | 20023 |
| 20 | 6672 | 21816 | 20656 | 3994 | 14024 | 16222 | 18376 | 9498 | 1759 | 23186 | 20216 | 8190 | 14848 | 2878 | 19362 | 21232 | 22994 | 21627 | 2073 | 22063 | 11928 | 22356 | 20068 | 16649 | 24878 |

For the demonstration problem, we solve using WESMAM model with weight *w* = 5000 and HECMAM with epsilon $\varepsilon$ = 0.05. In Chapter IV, we report the results of the demonstration problem and analyze the results. We also solve the large-scale USMC assignment problem using both WESMAM and HECMAM models. We also perform sensitivity analysis using different parameters and features.

# IV. RESULTS AND ANALYSIS

## A. REPORT RESULTS OF THE DEMONSTRATION PROBLEM

Table 13 shows the solution for the demonstration problem using WESMAM model with the (preference) weight parameter $w$ = 5,000.

Table 13. Demonstration Problem Solution Using WESMAM Model

| UUID | Billets | Preference Value | PCS Cost |
|---|---|---|---|
| 1 | job8 | 69 | $17,154 |
| 2 | job17 | 78 | $621 |
| 3 | job9 | 85 | $21,291 |
| 4 | job5 | 68 | $15,453 |
| 5 | job10 | 79 | $11,353 |
| 6 | job3 | 60 | $7,850 |
| 7 | job23 | 71 | $22,400 |
| 8 | job24 | 86 | $14,913 |
| 9 | job6 | 87 | $4,217 |
| 10 | job12 | 82 | $13,155 |
| 11 | job21 | 75 | $4,309 |
| 12 | job19 | 39 | $6,540 |
| 13 | job18 | 26 | $22,452 |
| 14 | job11 | 81 | $7,109 |
| 15 | job22 | 64 | $9,293 |
| 16 | job4 | 41 | $19,680 |
| 17 | job15 | 88 | $5,960 |
| 18 | job7 | 59 | $14,788 |
| 19 | job2 | 81 | $13,747 |
| 20 | job25 | 72 | $24,878 |

From Table 13, we observe that "*job1*" and "*job13*" were not filled, as expected, by any Marine since none of the Marines are MOS-qualified. Excluding these jobs, there are 23 other jobs to be assigned to 20 Marines. The WESMAM model assigns all Marines and leaves three unfilled jobs: "*job14*," "*job16*," and "*job20*." Such an output can be used to determine how many Marines received their top options and at what cost. Using the same data, Table 14 shows an assignment solution derived from using HECMAM model with cost hierarchically superior to preference, and tolerance parameter $\varepsilon = 0.05$. The assignment solution is different from WECMAM with weight $w = 5{,}000$.

Table 14. Demonstration Problem Solution Using HECMAM Model

| UUID | Billets | Preference Value | PCS Cost |
|---|---|---|---|
| 1 | job24 | 48 | $14,931 |
| 2 | job17 | 78 | $621 |
| 3 | job6 | 74 | $19,871 |
| 4 | job23 | 82 | $10,309 |
| 5 | job10 | 79 | $11,353 |
| 6 | job3 | 60 | $7,850 |
| 7 | job5 | 44 | $6,201 |
| 8 | job22 | 89 | $4,688 |
| 9 | job19 | 58 | $5,254 |
| 10 | job12 | 82 | $13,155 |
| 11 | job21 | 75 | $4,309 |
| 12 | job15 | 35 | $231 |
| 13 | job18 | 26 | $22,452 |
| 14 | job11 | 81 | $7,109 |
| 15 | job25 | 58 | $5,479 |
| 16 | job9 | 49 | $5,114 |
| 17 | job8 | 90 | $1,558 |
| 18 | job7 | 59 | $14,788 |
| 19 | job2 | 81 | $13,747 |
| 20 | job4 | 75 | $3,994 |

Like the WESMAM model, the HECMAM model also assigns all Marines and leaves three unfilled jobs: "*job14*," "*job16*," and "*job20*." The demonstration solutions verified and validated the methodology that we use to process the data and optimize the full-scale USMC assignment problem for the Lieutenant Colonel aviation community.

## B. REPORT RESULTS OF THE USMC ASSIGNMENT PROBLEM

First, we identify five jobs that none of the Marines are MOS-qualified to fill. The jobs require Marines with the following PMOS: 5902, 6302, 6502, and 8059. Figure 8 shows the Python preprocessing output from our computational implementation.

```
Warning: Job  [070 / 5902 / MC SYSCOM QUANTICO VA]  Does not have any MOS-qualifying Marine
Warning: Job  [111 / 6302 / HQ MARFORCOM NORFOLK  VA]  Does not have any MOS-qualifying Marine
Warning: Job  [111 / 6502 / HQ MARFORCOM NORFOLK  VA]  Does not have any MOS-qualifying Marine
Warning: Job  [T52 / 6502 / OFC OF THE CNO OP 00 WASHINGTON DC]  Does not have any MOS-qualifying Marine
Warning: Job  [NJV / 8059 / J8 FORCE STRUCTURE, RESOURCE, ASSESSMENT (ARLINGTON)]  Does not have any MOS-qualifying Marine
```

Figure 8. Python Printout for Unassigned Billets

Running the optimization models (WESMAM and HECMAM) with different parameters can yield multiple efficient solutions. Table 15 shows each Marine identified by "UUID" and their optimal job placement using the WESMAM model with the (preference) weight parameter set to *w*=5. The entire assignment solution can be found in Appendix B.

Table 15. Excerpt of an Assignment Solution Using WESMAM Model

| | UUID | Billets |
|---|---|---|
| **0** | 10352 | [QAJ / 8006 / C4 DEPT HQMC WASHINGTON DC] |
| **1** | 14701 | [TD4 / 7577 / JOINT ELECTROMAGNETIC PREP FOR A... |
| **2** | 18665 | [143 / 6602 / 3DMAW MIRAMAR CA] |
| **3** | 29968 | [057 / 7505 / MCAS CAMP PENDLETON CA].1 |
| **4** | 30264 | [1FJ / 8006 / MARFORNORTHCOM NEW ORLEANS] |
| **5** | 31723 | [1FV / 8006 / MARCOR INSTALLATION COMMAND, WAS... |
| **6** | 34251 | [TD4 / 7577 / JTF HQ FOR EW/CAS NELLIS AFB NV] |
| **7** | 42820 | [1GF / 8006 / WARFIGHTING LAB] |
| **8** | 48036 | [444 / 7523 / US FLEET FORCES CMD (USFFC) NORF... |
| **9** | 51975 | [T9B / 6002 / NAV AIR SYS CMD PATUXENT RIVER MD] |

The HECMAM model (with cost hierarchy over preference) results in a partially different assignment that can be found in Appendix C. Table 16 shows an excerpt of the assignment solution using the HECMAM model with the tolerance parameter set to $\varepsilon$ = 0.05.

Table 16. Excerpt of an Assignment Solution Using HECMAM Model

| | UUID | Billets |
|---|---|---|
| 0 | 10352 | [QAB / 8006 / HQMC WASHINGTON DC].3 |
| 1 | 14701 | [JBG / 8006 / SNCO ACADEMY CAMP BUTLER OKINAWA] |
| 2 | 18665 | [T52 / 6602 / OFC OF THE CNO OP 00 WASHINGTON DC] |
| 3 | 29968 | [057 / 7505 / MCAS CAMP PENDLETON CA] |
| 4 | 30264 | [TD4 / 7577 / JOINT ELECTROMAGNETIC PREP FOR A... |
| 5 | 31723 | [1FV / 8006 / MARCOR INSTALLATION COMMAND, WAS... |
| 6 | 34251 | [TD4 / 7577 / JTF HQ FOR EW/CAS NELLIS AFB NV] |
| 7 | 42820 | [1GF / 8006 / WARFIGHTING LAB] |
| 8 | 48036 | [1FY / 8006 / HQ MARFORSOUTH DORAL FL] |
| 9 | 51975 | [T9B / 6002 / NAV AIR SYS CMD PATUXENT RIVER MD] |

## C. SENSITIVITY ANALYSIS

We run sensitivity analysis to determine how the preference and PCS cost objective values differ with varying the relative importance of objectives and/or the level of retention of one goal if optimized hierarchically. We also examine the consequences of swapping the hierarchical order of the objectives. We inspect, for example, how a model produces an optimal solution by one criterion but performs poorly on another. To deal with such conflict we generate an approximated efficient frontier.

Effective sensitivity analysis yields useful insight that can be considered prior to the prototype development of a talent marketplace system. We focus on how parameters can impact the quality of the assignments, judged by the number of Marines who receive their “top” billet options (defined as any preferences ranked between 70 and 100) , and at what PCS cost.

#### *a. WESMAM Model Analysis*

We now conduct a sensitivity analysis on the parameter *w*, which is the preference weight built into our weighted sum method. Table 17 shows the objective values found for each selected *w*.

Table 17. Sensitivity Analysis on Parameter *w*

| ***w*** | **Preference Objective Value** | **Cost Objective Value** |
|---|---|---|
| 0.02 | 9,693 | $95,245.60 |
| 10.00 | 10,616 | $96,931.50 |
| 20.00 | 11,043 | $104,311.75 |
| 50.00 | 12,684 | $159,499.20 |
| 75.00 | 13,368 | $200,701.70 |
| 100.00 | 13,802 | $238,723.70 |
| 150.00 | 13,871 | $247,563.70 |
| 200.00 | 13,924 | $256,736.30 |

As more weight is given to Marines' preferences, WESMAM model is focusing more on optimizing Marines' preference than PCS cost. For the USMC to achieve a high preference objective value, which means more Marines assigned to their top billet preference, it must be at a relatively higher PCS cost. If preference weights *w* are in the range between 0.02 to 10.00, then the potential preference increase for the remaining Marines does not outweigh the extra cost; but it does progressively for higher values of the preference weight. The convexity of the function in the WESMAM efficient frontier is useful in examining alternatives. Figure 9 shows this graph where points above the efficient frontier are infeasible assignment solutions (i.e., unattainable). The points below are dominated (i.e., attainable, but not desired as we can attain an alternative assignment that improves one objective without worsening the other).

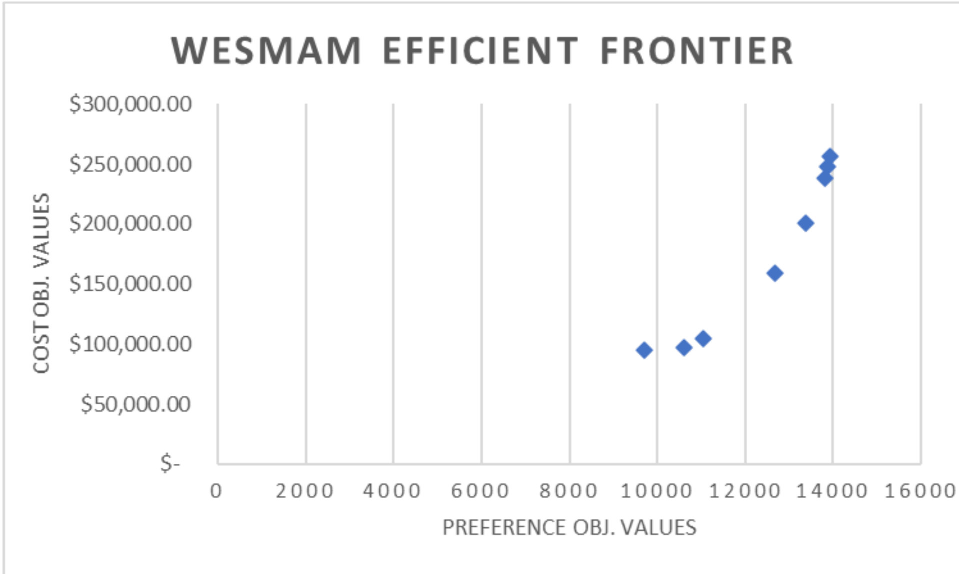


Figure 9. WESMAM Model Approximated Efficient Frontier

An analysis for each weight *w* parameter can reveal the quality of an assignment solution. For example, $w$ = 0.02, 84 Marines (45%) were assigned to jobs that they ranked between 70 and 100. For $w$ = 10, this increases to 100 Marines (53.5%) that receive their top billet preference.

### *b. HECMAM Model Analysis*

We first consider examining the objective values with Marines' job preference as the hierarchically superior goal in the hierarchical order. Table 18 is an illustration of the optimization excursions where we assign various levels of preference retention. Tolerance parameter $\varepsilon$ controls the fraction of ideal preference that we allow to lose in order to reduce the PCS cost (treated as secondary objective). Figure 10 shows the efficient frontier generated from the selected range of $\varepsilon$. The differences between WESMAM and HECMAM efficient solutions are due to the choice of parameters ($w$ and $\varepsilon$).

Table 18. Sensitivity Analysis on Parameter ε

| Epsilon *(ε)* | Preference Objective Value | Cost Objective Value |
|---|---|---|
| 0.02 | 13,716 | $230,703.30 |
| 0.05 | 13,297 | $195,786.10 |
| 0.08 | 12,945 | $173,222.50 |
| 0.10 | 12,595 | $155,772.80 |
| 0.15 | 11,896 | $128,201.70 |
| 0.20 | 11,201 | $108,384.00 |
| 0.25 | 10,497 | $96,347.70 |
| 0.30 | 9,810 | $95,335.20 |
| 0.50 | 7090 | $95,206.40 |

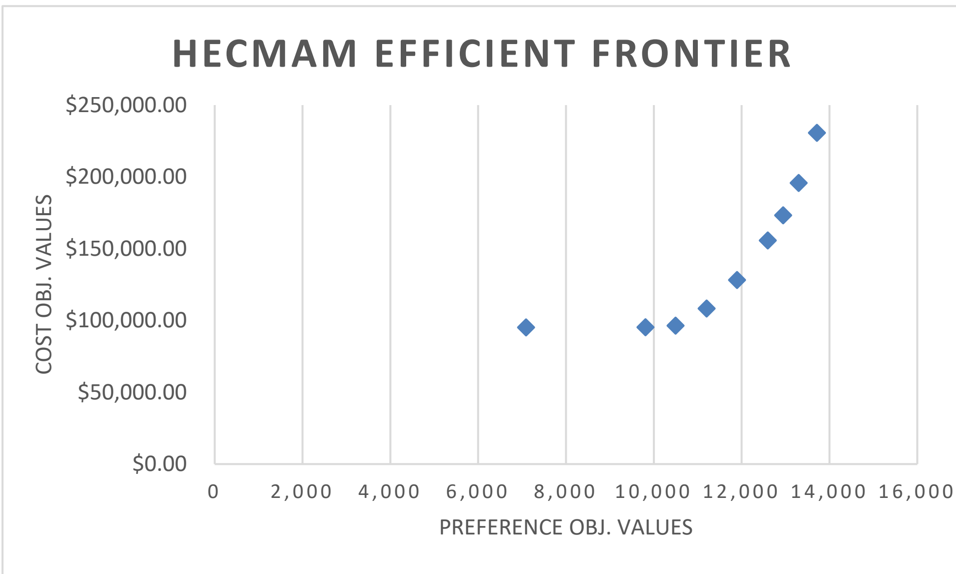


Figure 10. HECMAM Model Approximated Efficient Frontier

With ε = 0.02, that is, retain 98% of the preference objective value while optimizing PCS cost, 133 Marines (71%) are placed in their top billet preference but at the expense of $230,703 for PCS moving cost. Achieving a high Marine job placement satisfaction comes at a great cost. The HECMAM model yields only 91 Marines to be assigned without incurring a PCS cost at ε = 0.02. With ε = 0.50, that is, retain 50% of the preference objective value, 61 Marines (33%) received their top options at an expense of $95,206. Both WESMAM and HECMAM model yield 144 Marines (77%) assigned without incurring PCS cost if the parameters are set appropriately. This fact does not mean those assignments are "optimal" for those Marines, or for the entire Marines population studied, given that we are optimizing all assignments simultaneously and therefore tradeoffs and compromises are needed.

#### c. *Varying Hierarchical Order*

We will examine the sensitivity in the objective values if we vary the hierarchical order of the HECMAM model (i.e., making PCS cost the hierarchically superior goal) and compare those to the original hierarchy for the same tolerance.

We use three tolerances for cost increase with respect to the minimal (ideal) cost: 5%, 20%, and 50%. For each of these tolerances, Tables 19, 20, and 21, respectively, compare the solution of the HECMAM model where PCS is optimized first, and then preference is optimized subject to PCS cost (plus tolerance).

Table 19. Objective Values when Tolerance Is 5%

| Hierarchy | Preference Objective Value | Cost Objective Value |
|---|---|---|
| Preference - 1st Priority | 13,297 | $195,786.00 |
| PCS Cost - 1st Priority | 10,777 | $99,583.00 |

From the experiment, if Marines' preference is given precedence (optimized first) in the HECMAM model, and then we retain 95% of preference for optimizing PCS cost, the model yields 105 Marines (56%) with a job placement at no PCS cost to the USMC.

On the other hand, if PCS cost is initially optimized, naturally, we expect a very low cost, at the expense of (possibly unrealistic) preference assignments. Then, when the preference objective is optimized subject to relaxing the PCS cost constraint up to 105% of ideal PCS cost, the modified HECMAM model places the maximum feasible number of Marines, 144, in billets with no PCS cost. From this hierarchical order, only 17 Marines (9%) are assigned in their top billet preferences.

This first analysis for 5% tolerance on either objective shows that the PCS cost objective is somewhat more flexible than preferences. That is, we can find a wide range of preferences near the lowest theoretical cost: It is worth increasing cost a bit to substantially increase preference. The gain in cost within 5% of the maximum theoretical preference also exists but is less pronounced. An example of alternative solutions generated by modifying the weights or tolerances is the following: If we allow a 15% PCS cost increase (from $99,585 to $114,220), we can improve the preference objective value by 6% (from 10,777 to 11,433 preference units). In contrast, if we allow a 15% preference decrease (from 13,297 to 11,201) then we can improve (reduce) PCS cost by 80% (from $195,786 to $108,384).

Table 20. Objective Values when Tolerance Is 20%

| Hierarchy | Preference Objective Value | Cost Objective Value |
|---|---|---|
| Preference - 1st Priority | 11,201 | $108,384.00 |
| PCS Cost - 1st Priority | 11,433 | $114,220.70 |

We repeat the above analysis by now setting the tolerance to $\varepsilon = 0.20$. We observe a greater, different set of solutions. The first experiment optimizes PCS cost objective subject to retaining 80% of the ideal preference objective. Here, 139 Marines (74%) are placed in their top billet preferences without incurring PCS cost.

The second experiment optimizes the preference objective subject to relaxing the PCS cost constraint up to 120% of the ideal PCS cost. 144 Marines (77%) are placed in billets without incurring PCS cost.

Table 21. Objective Values when Tolerance Is 50%

| Hierarchy | Preference Objective Value | Cost Objective Value |
|---|---|---|
| Preference - 1st Priority | 7,090 | $95,206.00 |
| PCS Cost - 1st Priority | 12,297 | $142,783.15 |

Lastly, we set ε = 0.50. First, when preference is the first priority, 144 Marines (77%) are placed in billets without incurring PCS cost. This experiment gives the lowest preference objective function value because the actual hierarchy is modest, given that we highly relax the constraints in order to further optimize PCS cost. Table 22 shows an excerpt of the assignment solution when PCS cost is optimized subject to retaining 50% of the preference objective value. This assignment solution varies widely compared to the previous solution presented in Section IV.B.

Table 22. Excerpt of Assignment when Preference Is the First Hierarchical Priority

| | UUID | Billets |
|---|---|---|
| 0 | 10352 | [QAB / 8006 / HQMC WASHINGTON DC].2 |
| 1 | 14701 | [NGG / 7588 / STRATCOM, JOIC (JT-BIL) SAN ANTO... |
| 2 | 18665 | [JAB / 8006 / SNCO ACADEMY CAMP PENDLETON] |
| 3 | 29968 | [057 / 7505 / MCAS CAMP PENDLETON CA].1 |
| 4 | 30264 | [TD4 / 7577 / JOINT ELECTROMAGNETIC PREP FOR A... |
| 5 | 31723 | [1FV / 8006 / MARCOR INSTALLATION COMMAND, WAS... |
| 6 | 34251 | [TD4 / 7577 / JTF HQ FOR EW/CAS NELLIS AFB NV] |
| 7 | 42820 | [1GF / 8006 / WARFIGHTING LAB] |
| 8 | 48036 | [444 / 7523 / US FLEET FORCES CMD (USFFC) NORF... |
| 9 | 51975 | [T9B / 6002 / NAV AIR SYS CMD PATUXENT RIVER MD] |

In the second part of experiment, when cost is the first priority, 144 Marines (77%) are placed in billets without incurring PCS cost. Although both analyses show 77% of the

Marines are assigned in billets without incurring PCS cost, the assignment solution is partially different. Table 23 shows an excerpt of the assignment, which compared to Table 22, shows a partially different assignment. There is a significant tradeoff between the objectives when ε = 0.50.

Table 23. Excerpt of Assignment when PCS Cost Is the First Hierarchical Priority

| | UUID | Billets |
|---|---|---|
| **0** | 10352 | [QAJ / 8006 / C4 DEPT HQMC WASHINGTON DC] |
| **1** | 14701 | [TD4 / 7577 / JOINT ELECTROMAGNETIC PREP FOR A... |
| **2** | 18665 | [T52 / 6602 / OFC OF THE CNO OP 00 WASHINGTON DC] |
| **3** | 29968 | [057 / 7505 / MCAS CAMP PENDLETON CA].1 |
| **4** | 30264 | [JBF / 8006 / SNCO ACADEMY CAMP LEJEUNE] |
| **5** | 31723 | [1FV / 8006 / MARCOR INSTALLATION COMMAND, WAS... |
| **6** | 34251 | [TD4 / 7577 / JTF HQ FOR EW/CAS NELLIS AFB NV] |
| **7** | 42820 | [1GF / 8006 / WARFIGHTING LAB] |
| **8** | 48036 | [444 / 7523 / US FLEET FORCES CMD (USFFC) NORF... |
| **9** | 51975 | [T9B / 6002 / NAV AIR SYS CMD PATUXENT RIVER MD] |

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# V. CONCLUSIONS AND RECOMMENDATIONS

## A. SUMMARY

This thesis formulates the WESMAM and HECMAM models that analyze tradeoffs in the policy objectives presented when assigning Marine officers to billets. Our research illustrates the importance of using an appropriate optimization model in a talent marketplace environment. In a complex organization like the USMC, which involves hundreds of thousands of highly skilled enlisted Marines and officers, the talent marketplace system offers monitors the opportunity to bind the interests of Marines to those of individuals commands. We show how mathematical optimization models can be leveraged in the assignment process. It can provide monitors with additional guidance in the process of finding the best billet assignment, which currently relies, solely, on manually generated decisions. We highlight the important features of a talent marketplace system.

First, the talent marketplace system should be informative to all service members. It must have clearly defined jobs that need to be filled. This can be done using well-formatted job descriptions. A description should summarize the assignment by specifying its title, duties and responsibilities of the job, location, duration, and additional specific information about the billet.

Second, the system should allow equal opportunity for all transferring Marines to submit applications for jobs they prefer or be able to rank the jobs in an order of preference. Ranking of job preferences can be done through a formal survey or as part of their job application submitted online through a web-based talent marketplace system. In addition, monitors should be allowed to provide their inputs based on Marines' career progression and/or general fitness to billets.

Third, an appropriate optimization model implemented in the talent marketplace can improve the assignment process. This model can produce an automated solution that monitors can tweak and refine, as needed, to incorporate factors not considered in the mathematical models. In this project, we have applied our WESMAM and HECMAM models to the lieutenant colonel aviation community assignment problem for 187 Marine officers seeking to be assigned optimally to 196 available billets. We show that both models can produce the same efficient solutions but, in the process of arriving to those solutions, the interpretation of the models by planners can be substantially different. In our sensitivity analysis, we show how the preference and PCS cost objectives will differ with varying the relative importance of objectives and/or the level of retention of one goal if optimized hierarchically. Both models show tradeoffs in the attainment of the preference and PCS cost goals. In the WESMAM model, by increasing the value of the preference weight, more focus is on optimizing the Marines' preference than PCS cost. In the HECMAM model, we show how the relaxation of ideal achievement in the hierarchically superior goal can be used to improve the attainment of the secondary goal. For example, we observe that by relaxing the ideal PCS cost by 15% when optimizing preference objective, we can achieve a preference increase of 6%; but in contrast, by relaxing the preference objective value by 15% when optimizing PCS cost, we can improve (reduce) the PCS cost by 80%. The WESMAM and HECMAM models provide efficient solutions that can be explored depending on the policy objectives that need to be optimized. The efficient solutions provide the basis to run a prototype that will determine the appropriate optimization model and parameters to implement in the talent marketplace system.

Last, we have shown the importance of designating and authorizing the monitor as the middleman to facilitate the assignments in the talent marketplace. The monitors will ensure that stipulated protocols and standard operating procedures are followed by all stakeholders participating in the talent marketplace.

## B. RECOMMENDATIONS

### 1. Continuation of the Talent Marketplace System

We recommend continued development of the talent marketplace concept, and initiation of the first phase, which is to build a prototype system. This prototype can be used to assign Marines to billets in a small community. Trials can be conducted using the optimization models we have developed in this thesis. After successful trials, the system can be made available to the entire USMC.

### 2. Additional Data Collection

The aviation lieutenant colonel movers' preference survey was a step in the right direction to collect data that are used to assign Marines to billets. Given more flexibility in possible career paths that Marines can take, the monitor will need a web-based marketplace that will aggregate the following recommended data:

#### *a. Marines' Skills and Qualifications*

Currently, monitors use the MOS code system to identify billets to which Marines can be assigned. We recommend collecting all the Marines' skills, including those that are not associated with any MOS code in accordance with the MOS manual. For example, we recommend including self-reported skills from external institutions.

#### *b. Job Skill Requirement Data*

Web-based marketplaces are utilized by the other services to enhance transparency for all available billets to the service members. We recommend the USMC commands to list job descriptions and requirements for all the billets posted in the marketplace. The skills should be reported with few precise words. We also understand that some skills, such as "leadership" or "attention to detail," can be termed as subjective and/or universal. Caution should be exercised when considering such skills.

#### *c. Monitors Preferences*

The monitors' input can reinforce the idea of career progression and rank Marines' ability to perform jobs for which they are qualified. This ensures that individual Marines are selected and assigned to billets that will benefit their careers and increase retention rate in the Marine Corps. The monitors may consider all Marines and assign higher scores to those who need a specific billet type, for example, a Marine who needs an A-type billet.

#### *d. Special Consideration Data*

We recommend aggregating data on the movers that must be assigned in certain locations due to special circumstances like dual military household transfers. Below we describe other categories of special cases that can have the same treatment in the model.

The data can include, for example, “Marine with Response ID 5 must be stationed in zip code 93942 or 93940” or “Marines with Responses IDs 6 and 7 must be stationed in the same zip.” An extension of the optimization models presented here can easily incorporate these specifications.

Marine Corps Order 1300.8S (2014) stipulate, just to mention a few, the following special consideration for assigning Marines:

(1) Single Parents;

(2) Exceptional Family Member Program (EFMP);

(3) Temporary Limited Duty (TLD) Status;

(4) Expedited Transfer of Marines Who File Unrestricted Reports of Sexual Assault;

(5) Assignment of Sex Offenders service members; and,

(6) Assignment of Human Immunodeficiency Virus service members.

### 3. Model Enhancement

The IP models formulated in Chapter III optimize the most important objectives (Marines’ preference and PCS cost) while accounting for essential constraints. The advantage of using an IP model is the flexibility that it offers the monitors in charge of the assignments. Depending on the mission and demands of the Marine Corps, the monitor can add or delete objectives and constraints to better serve the USMC. We did not have the data to address Marine’s career progression and overseas control date, but we note these policy objectives can be handled similarly to skill requirements.

## C. FUTURE WORK

This thesis can serve as a starting point for creating an optimization framework prototype within a talent marketplace system to better assign Marines to billets. Given the capabilities and flexibility of IP models, future work may include implementing Natural Language Processing (NLP) for textual data processing, creating machine learning algorithms for predicting billet assignment outcome, and standardizing assignment cycle.

First, NLP can be used to extract and process textual data into structured information entities that can be used in a machine learning algorithm to identify clusters of related skills and quantify textual skills. Some of the essential data points on Marines exists in textual form and hence they are not fully utilized. An example is data that can be extracted from Fitness Reports using an NLP to quantity Marines' skills and experiences and eventually implement the output into an optimization model as an input.

Second, machine learning algorithms can be used to find statistical patterns in the data that are hard to detect visually, which could allow MMOA to predict career outcomes more effectively. Using the same concepts in machine learning, a job-recommender system can be developed as part of the talent marketplace to recommend certain billets to Marines as they provide their job preferences. LinkedIn and Indeed are examples of such powerful systems.

Last, business rules should be established to guide all the stakeholders about when they will be required to act in the marketplace. The marketplace can be programmed to control the assignment process throughout the cycle. Once all stakeholders have systematically provided their inputs, the monitors can review all inputs, adjust the optimization model, and run the optimization software to obtain an initial assignment solution.

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# APPENDIX A. FY20 AVIATION LTCOL MOVERS SURVEY. SOURCE: MMOA (2020)



## FY20 Aviation LtCol Movers [SCN USMC-MRA-PENDING]

Welcome to the FY20 Slate Questionnaire. There are two parts to this survey:

**1. Identifying info** (EDIPI, Last Name, etc)

**2. Billet preferences**.

You'll be asked to choose and rate 15 total billets. At least 5 must be 8006/any officer billets. Do your best to convey your desires while still providing us something to work with in the event your top choice isn't available. Lack of diversity in your list may inform us your desire to fly or live out the Sound of Music, but it functionally decreases your number of choices. Your knowledge of probabilities should help you shape your survey responses.

Use the sliders to weight your 15 preferences. Large values, intuitively, indicate a high desirability for that assignment. For those officers with very few PMOS choices (e.g. 6602), you will select more than (5) 8006 billets. 8006 is an "Any Officer" billet.

Your survey should candidly reflect your interests. As a frame of reference, a weighting of 70-100 indicates you would be ecstatic about your assignment. A weighting of 40-60 would reflect contentment with the assignment. A weighting below 30 would indicate "thanks for orders, I still need a job." The weighted ranking will allow us to build and ordinal ranking of your preferences. The rest of the billets (the other 150 not selected) will be weighted with a zero.
There are 6 questions in this survey.

## PERSONAL INFORMATION (NAME / RANK / EDIPI / PMOS)

Enter Last Name *

Please write your answer here:

### Enter First Name *

Please write your answer here:

### Enter EDIPI *

*Only numbers may be entered in this field.*

Please write your answer here:

### Enter your Primary MOS (6002, 7202, 7523, 7532...) *

*Only numbers may be entered in this field.*

Please write your answer here:

### Enter your current rank; either LtCol or Maj (LtCol Select) *

Please write your answer here:

## PREFERENCES

**Choose and rate 15 total billets. At least 5 must be 8006/any officer billets.**

Do your best to convey your desires while still providing us something to work with in the event your top choice isn't available. Lack of diversity in your list may inform us your desire to fly or live out the Sound of Music, but it functionally decreases your number of choices. Your knowledge of probabilities should help you shape your survey responses.

Use the sliders to weight your 15 preferences. Large values, intuitively, indicate a high desirability for that assignment. For those officers with very few PMOS choices (e.g. 6602), you will select more than (5) 8006 billets. 8006 is an "Any Officer" billet.

Your survey should candidly reflect your interests. As a frame of reference, a weighting of 70-100 indicates you would be ecstatic about your assignment. A weighting of 40-60 would reflect contentment with the assignment. A weighting below 30 would indicate "thanks for orders, I still need a job." The weighted ranking will allow us to build and ordinal ranking of your preferences. The rest of the billets (the other 150 not selected) will be weighted with a zero.

**Note: Several of the JOINT billets have changed. This is the final list.

- *Each answer must be between 0 and 100*
- *The sum must be at least 0*
- *Only integer values may be entered in these fields.*

Please write your answer(s) here:

007 / 7506 / HQ MCCDC QUANTICO VA

022 / 7506 / MCAS CHERRY POINT NC

022 / 7596 / MCAS CHERRY POINT NC

023 / 7506 / MCAS MIRAMAR SAN DIEGO CA

032 / 7505 / MCAF QUANTICO VA

048 / 6002 / FLEET READINESS CENTER EAST CHERRY PT NC

057 / 7505 / MCAS CAMP PENDLETON CA

057 / 7505 / MCAS CAMP PENDLETON CA

070 / 5902 / MC SYSCOM QUANTICO VA

086 / 7506 / TRAINING AND EDUCATION COMMAND QUANTICO VA

111 / 6002 / HQ MARFORCOM NORFOLK VA

111 / 6302 / HQ MARFORCOM NORFOLK VA

111 / 6502 / HQ MARFORCOM NORFOLK VA

111 / 7503 / HQ MARFORCOM NORFOLK VA

142 / 7202 / 2DMAW CHERRY POINT NC

142 / 7506 / 2DMAW CHERRY POINT NC

142 / 7506 / 2DMAW CHERRY POINT NC

142 / 7506 / 2DMAW CHERRY POINT NC

142 / 7506 / 2DMAW CHERRY POINT NC

142 / 7596 / 2DMAW CHERRY POINT NC

143 / 6602 / 3DMAW MIRAMAR CA

143 / 7506 / 3DMAW MIRAMAR CA

143 / 7506 / 3DMAW MIRAMAR CA

143 / 7506 / 3DMAW MIRAMAR CA

143 / 7596 / 3DMAW MIRAMAR CA

145 / 6602 / 1STMAW OKINAWA JAPAN

145 / 7506 / 1STMAW OKINAWA JAPAN

145 / 7506 / 1STMAW OKINAWA JAPAN

145 / 7506 / 1STMAW OKINAWA JAPAN

1C0 / 7506 / HQ I MEF CAMP PENDLETON CA

1DX / 7505 / CE 5TH MEB MARFOR CENTCOM BAHRAIN

1EP / 7506 / HQ 31ST MEU OKINAWA JAPAN

1ER / 7506 / HQ 24TH MEU CAMP LEJEUNE NC

1ES / 7506 / HQ 13TH MEU CAMP PENDLETON CA

1ET / 7506 / HQ 11TH MEU CAMP PENDLETON CA

1F1 / 7506 / HQ II MEF CAMP LEJEUNE NC

1GF / 7506 / THE MARINE CORPS WARFIGHTING LAB QUANTICO VA

1JA / 7503 / HQ MAG-11 3D MAW SAN DIEGO CA

1JA / 7518 / HQ MAG-11 3D MAW SAN DIEGO CA

1JB / 7503 / HQ MAG-12 1ST MAW IWAKUNI JAPAN

1JC / 7503 / HQ MAG 13 3DMAW YUMA AZ

1JC / 7518 / HQ MAG 13 3DMAW YUMA AZ

1JD / 7503 / HQ MAG-14 2DMAW CHERRY POINT NC

1JD / 7503 / HQ MAG-14 2DMAW CHERRY POINT NC

1JE / 7505 / HQ MAG 16 3DMAW SAN DIEGO CA

1JF / 7505 / HQ MAG 24 1STMAW KANEOHE BAY,HI

1JG / 7505 / MAG-26 2DMAW JACKSONVILLE NC

1JH / 7505 / HQ MAG 29 2DMAW JACKSONVILLE NC

1JH / 7505 / HQ MAG 29 2DMAW JACKSONVILLE NC

1JL / 7505 / HQ MAG 36 1STMAW FUTENMA OKINAWA JAPAN

1JL / 7505 / HQ MAG 36 1STMAW FUTENMA OKINAWA JAPAN

1JM / 7505 / HQ MAG 39 3DMAW CAMP PENDLETON CA

1PA / 7202 / HQ MACG-28 2D MAW CHERRY POINT NC

1PH / 7506 / MWSG-27 2D MAW CHERRY POINT NC

1XH / 7506 / MWSG-37 3D MAW SAN DIEGO CA

444 / 7523 / US FLEET FORCES CMD (USFFC) NORFOLK VA

452 / 7509 / COMNAVSURFLANT FLAG ALLOW NORFOLK VA

454 / 7566 / FA COMNAVSURFPAC CORONADO CA

462 / 7523 / FLAG ALLOWANCE COMNAVAIRPAC SAN DIEGO CA

D93 / 7506 / SITE SPT CLR 4 4TH MLG FT LEWIS WA

G76 / 7315 / MAD NAS PATUXENT RIVER MD

G78 / 7506 / MATSG-21 TRNG COM NAS PENSACOLA FL

G91 / 6002 OR 6602 / MATSG-23 TRNG CMD NAS PENSACOLA FL

J34 / 6602 / NAV ED & TRN CTR NEWPORT RI

LAW / 7506 / MC REP US NAVAL WAR COLL EDU COM NEWPORT RI

QDC / 8006 / DEPUTY COMMANDANT FOR INFORMATION WASHINGTON DC

QDC / 7315 / DEPUTY COMMANDANT FOR INFORMATION WASHINGTON DC

S2A / 7202 / HQ MACG-48 4TH MAW GREAT LAKES IL

S7A / 7505 / HQTRS MAG-49 4TH MAW MCGUIRE AFB NJ

S8F / 7202 / HQTRS 4TH MAW NEW ORLEANS NAS LA

T52 / 6002 / OFC OF THE CNO OP 00 WASHINGTON DC

T52 / 6502 / OFC OF THE CNO OP 00 WASHINGTON DC

T52 / 6602 / OFC OF THE CNO OP 00 WASHINGTON DC

T52 / 7506 / OFC OF THE CNO OP 00 WASHINGTON DC

T52 / 7506 / OFC OF THE CNO OP 00 WASHINGTON DC

T52 / 7523 / OFC OF THE CNO OP 00 WASHINGTON DC

T52 / 7532 / OFC OF THE CNO OP 00 WASHINGTON DC

T9B / 6002 / NAV AIR SYS CMD PATUXENT RIVER MD

T9B / 6002 / NAV AIR SYS CMD PATUXENT RIVER MD

T9B / 6002 / NAV AIR SYS CMD PATUXENT RIVER MD

T9B / 6002 / NAV AIR SYS CMD PATUXENT RIVER MD

TD4 / 7577 / JTF HQ FOR EW/CAS NELLIS AFB NV

TF4 / 7506 / INSPECTOR GENERAL OF THE USMC ARLINGTON VA

TMG / 6002 / HQ MARFOR CENTCOM, MACDILL AFB, TAMPA, FL

TZ3 / 7506 / NAVY WARFARE DEVELOPMENT COMMAND NORFOLK VA

U61 / 7202 / FAA WASHINGTON DC

007 / 8006 / HQ MCCDC

007 / 8006 / HQ MCCDC

007 / 8006 / HQ MCCDC

007 / 8006 / HQ MCCDC

011 / 8006 / H&S BN HQMC HENDERSON HALL ARLINGTON VA

014 / 8006 / MCB CAMP PENDLETON

063 / 8006 / MARINE CORPS LOGISTICS COMMAND ALBANY GA

068 / 8006 / EDUCATION COMMAND

068 / 8006 / EDUCATION COMMAND

068 / 8006 / EDUCATION COMMAND

068 / 8006 / EDUCATION COMMAND

068 / 8006 / EDUCATION COMMAND

068 / 8006 / EDUCATION COMMAND

080 / 8006 / PMD QUANTICO - MARSH CENTER

080 / 8006 / PMD QUANTICO - MARSH CENTER

080 / 8006 / PMD QUANTICO - MARSH CENTER

080 / 8006 / PMD QUANTICO - MARSH CENTER

086 / 8006 / TRAINING AND EDUCATION COMMAND

091 / 8006 / MCB KANEOHE BAY HI

097 / 8006 / MCI EAST CAMP LEJEUNE

097 / 8006 / MCI EAST CAMP LEJEUNE

097 / 8006 / MCI EAST CAMP LEJEUNE

097 / 8006 / MCI EAST CAMP LEJEUNE

104 / 8006 / MARCOR ADVS CO SUPPORT GREAT LAKES IL

110 / 8006 / MARFORPAC CAMP SMITH HI

124 / 8006 / 3D MARDIV

129 / 8006 / MCI CAMP MUJUK (ROK) KOREA

1C0 / 8006 / I MEF

1C0 / 8006 / I MEF

1C0 / 8006 / I MEF

1CC / 8006 / 3D MEB

1CC / 8006 / 3D MEB

1EE / 8006 / COMMARFOREUR STUGGART GERMANY

1EM / 8006 / MARINE FORCES AFTRICA COMMAND GERMANY

1F2 / 8006 / CE MEF INFO GROUP II MEF

1F5 / 8006 / CE MEF INFO GROUP I MEF

1FJ / 8006 / MARFORNORTHCOM NEW ORLEANS

1FV / 8006 / MARCOR INSTALLATION COMMAND, WASHINGTON DC

1FY / 8006 / HQ MARFORSOUTH DORAL FL

1FY / 8006 / HQ MARFORSOUTH DORAL FL

1GF / 8006 / WARFIGHTING LAB

1K1 / 8006 / MARFOR STRATCOM OFFUTT

1K3 / 8006 / EOTG III MEF

1K4 / 8006 / EOTG I MEF

1WL / 8006 / MARINE CORPS LIAISON OFFICE BETHESDA

1WW / 8006 / WOUNDED WARRIOR REGIMENT QUANTICO

442 / 8006 / US PACIFIC FLEET / USNAVCENT PEARL HARBOR

442 / 8006 / US PACIFIC FLEET / USNAVCENT PEARL HARBOR

J02 / 8006 / AIR UNIVERISTY MONTGOMERY AL

J56 / 8006 / NAVAL WAR COLLEGE NEWPORT RI

JAB / 8006 / SNCO ACADEMY CAMP PENDLETON

JBF / 8006 / SNCO ACADEMY CAMP LEJEUNE

JBG / 8006 / SNCO ACADEMY CAMP BUTLER OKINAWA

KA4 / 8006 / TRAIN THE TRAINER SCHOOL CAMP LEJEUNE

QAB / 8006 / HQMC WASHINGTON DC

QAB / 8006 / HQMC WASHINGTON DC

QAB / 8006 / HQMC WASHINGTON DC

QAB / 8006 / HQMC WASHINGTON DC

QAE / 8006 / M&RA DIV HQMC

QAJ / 8006 / C4 DEPT HQMC WASHINGTON DC

QAP / 8006 / P&R WASHINGTON DC

QAP / 8006 / P&R WASHINGTON DC

QAP / 8006 / P&R WASHINGTON DC

QAP / 8006 / P&R WASHINGTON DC

QAQ / 8006 / PP&O

QAQ / 8006 / PP&O

QAQ / 8006 / PP&O

QBN / 8006 / FAMILY READINESS DEPT HQMC

QLA / 8006 / OFFICE OF LEGISLATIVE AFFAIRS

T49 / 8006 / DIR NAV COUNC OF PERS BDS WASHINGTON DC

T49 / 8006 / DIR NAV COUNC OF PERS BDS WASHINGTON DC

T52 / 8006 / OFC OF THE CNO WASHINGTON DC

T52 / 8006 / OFC OF THE CNO WASHINGTON DC

T52 / 8006 / OFC OF THE CNO WASHINGTON DC

T52 / 8006 / OFC OF THE CNO WASHINGTON DC

TCR / 8006 / DET 2 TECHNICAL SERVICES ARLINGTON VA

TDU / 8006 / USA SPACE & MISSILE DEF CMD, ARFORSTRAT, PETERSON AFB

TF4 / 8006 / INSPECTOR GENERAL OF THE USMC ARLINGTON VA

TFQ / 8005 / KUWAIT TECH ASSIST FIELD TEAM MACDILL AFB (8005 BILLET)

TFQ / 8005 / KUWAIT TECH ASSIST FIELD TEAM MACDILL AFB (8005 BILLET)

TJD / 8006 / DTRA ON SITE INSPEC DIRECT EUROPE

TKP / 8006 / US ARMY COMMAND AND STAFF COLLEGE

TLG / 8006 / CMDR EXPEDITIONARY STRIKE GROUP 3 SAN DIEGO

TM6 / 8006 / MCATSU

TMG / 8006 / MARFOR CENTCOM TAMPA

TMG / 8006 / MARFOR CENTCOM TAMPA

TRG / 8006 / MARINE CORPS CYBERSPACE OPEARTION GROUP

APH / 8006 / JTF ODRP CHIEF OPERATIONS DIVISION - PAKISTAN

JOINT / N28 / 7506 / HQ US FORCES KOREA (JT-BIL) YONGSAN

JOINT / NA6 / 7506 / HQ USEUCOM (JT-BIL) STUTGART GERMANY

JOINT / NA6 / 7506 / HQ USEUCOM (JT-BIL) STUTGART GERMANY

JOINT / NA6 / 7506 / HQ USEUCOM (JT-BIL) STUTGART GERMANY

JOINT / N26 / 8006 / NATIONAL SECURITY COUNCIL (WHITE HOUSE)

JOINT / NAG / 7506 / USPACOM (JT-BIL) CAMP SMITH HI

JOINT / NBB / 7506 / EUCOM, JUSMAG (JT-BIL) SPAIN

JOINT / NJN / 7506 / NATIONAL DEFENSE UNIVERSTIY (JT-BIL) NORFOLK VA

JOINT / NBM / 8006 / HQ USSOCOM (JT-BIL) MACDILL AFB FL

JOINT / NJV / 8059 / J8 FORCE STRUCTURE, RESOURCE, ASSESSMENT (ARLINGTON)

JOINT / T15 / 8006 / J6 DIRECTOR FOR C4 (ARLINGTON)

JOINT / TD4 / 7577 / JOINT ELECTROMAGNETIC PREP FOR ADV COMBT (NEVADA)

JOINT / NBP / 8006 / HQ USCENTCOM (JT-BIL) MACDILL AFB FL

JOINT / NBR / 7503 / JOINT STAFF J7 (JT-BIL) SUFFOLK VA

JOINT / NBR / 8006 / JOINT STAFF J7 (JT-BIL) SUFFOLK VA

JOINT / NBW / 8006 / JOINT CHIEFS OF STAFFJ5 (JT-BIL) WASHINGTON DC

JOINT / NBW / 8006 / JOINT CHIEFS OF STAFF J8 (JT-BIL) WASHINGTON DC

JOINT / NDS / 8006 / HQ USTRANSCOM (JT-BIL) SCOTT AFB IL

JOINT / NFN / 8006 / HQ US STRATCOM (JT-BIL) OFFUTT AFB NE

JOINT / NGG / 7588 / STRATCOM, JOIC (JT-BIL) SAN ANTONIO TX

JOINT / NSJ / 7505 / STRIKFORNATO (JT BIL) LISBON, PORTUGAL

JOINT / N28 / 8006 / COMBINED FORCES (KOREA / CAMP HUMPHREYS)

Thank you for your input.

We'll do our best to put you in the right assignment with due consideration to your desires, needs of the Marine Corps, and equity among the population. Building the slate over the next two months is a time and a half job. Please be patient. Anxious emails and phone calls don't make your assignment better or result in orders being issued faster. As things firm up, expect an email or phone call to further discuss your next assignment. To help manage expectations, you can expect orders NLT late February; earlier if you're an OCONUS mover.

Submit your survey.
Thank you for completing this survey.

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# APPENDIX B. ASSIGNMENT SOLUTION USING WEIGHTED SUM METHOD (PREFERENCE WEIGHT W=5).

| | UUID | Billets |
|---|---|---|
| 0 | 10352 | [QAJ / 8006 / C4 DEPT HQMC WASHINGTON DC] |
| 1 | 14701 | [TD4 / 7577 / JOINT ELECTROMAGNETIC PREP FOR ADV COMBT (NEVADA)] |
| 2 | 18665 | [143 / 6602 / 3DMAW MIRAMAR CA] |
| 3 | 29968 | [057 / 7505 / MCAS CAMP PENDLETON CA].1 |
| 4 | 30264 | [1FJ / 8006 / MARFORNORTHCOM NEW ORLEANS] |
| 5 | 31723 | [1FV / 8006 / MARCOR INSTALLATION COMMAND, WASHINGTON DC] |
| 6 | 34251 | [TD4 / 7577 / JTF HQ FOR EW/CAS NELLIS AFB NV] |
| 7 | 42820 | [1GF / 8006 / WARFIGHTING LAB] |
| 8 | 48036 | [444 / 7523 / US FLEET FORCES CMD (USFFC) NORFOLK VA] |
| 9 | 51975 | [T9B / 6002 / NAV AIR SYS CMD PATUXENT RIVER MD] |
| 10 | 55308 | [080 / 8006 / PMD QUANTICO - MARSH CENTER].2 |
| 11 | 57960 | [TFQ / 8005 / KUWAIT TECH ASSIST FIELD TEAM MACDILL AFB] |
| 12 | 62153 | [1F1 / 7506 / HQ II MEF CAMP LEJEUNE NC] |
| 13 | 62433 | [1EP / 7506 / HQ 31ST MEU OKINAWA JAPAN] |
| 14 | 62464 | [068 / 8006 / EDUCATION COMMAND].5 |
| 15 | 63609 | [APH / 8006 / JTF ODRP CHIEF OPERATIONS DIVISION - PAKISTAN] |
| 16 | 64071 | [143 / 7506 / 3DMAW MIRAMAR CA] |
| 17 | 67747 | [097 / 8006 / MCI EAST CAMP LEJEUNE].1 |
| 18 | 68391 | [T52 / 7523 / OFC OF THE CNO OP 00 WASHINGTON DC] |
| 19 | 70065 | [QAB / 8006 / HQMC WASHINGTON DC].3 |
| 20 | 76441 | [1JE / 7505 / HQ MAG 16 3DMAW SAN DIEGO CA] |
| 21 | 94215 | [1F2 / 8006 / CE MEF INFO GROUP II MEF] |
| 22 | 94293 | [D93 / 7506 / SITE SPT CLR 4 4TH MLG FT LEWIS WA] |
| 23 | 96192 | [JBG / 8006 / SNCO ACADEMY CAMP BUTLER OKINAWA] |
| 24 | 99290 | [T52 / 6602 / OFC OF THE CNO OP 00 WASHINGTON DC] |
| 25 | 99970 | [J56 / 8006 / NAVAL WAR COLLEGE NEWPORT RI] |
| 26 | 106694 | [007 / 7506 / HQ MCCDC QUANTICO VA] |
| 27 | 110732 | [1PA / 7202 / HQ MACG-28 2D MAW CHERRY POINT NC] |
| 28 | 119312 | [QAP / 8006 / P&R WASHINGTON DC].2 |
| 29 | 119865 | [TMG / 8006 / MARFOR CENTCOM TAMPA] |
| 30 | 128675 | [124 / 8006 / 3D MARDIV] |
| 31 | 132912 | [1FY / 8006 / HQ MARFORSOUTH DORAL FL] |
| 32 | 133910 | [143 / 7506 / 3DMAW MIRAMAR CA].1 |
| 33 | 135283 | [057 / 7505 / MCAS CAMP PENDLETON CA] |
| 34 | 137125 | [QDC / 8006 / DEPUTY COMMANDANT FOR INFORMATION WASHINGTON DC] |
| 35 | 137177 | [142 / 7506 / 2DMAW CHERRY POINT NC].1 |
| 36 | 139540 | [007 / 8006 / HQ MCCDC] |
| 37 | 139602 | [142 / 7596 / 2DMAW CHERRY POINT NC] |
| 38 | 149250 | [111 / 6002 / HQ MARFORCOM NORFOLK VA] |
| 39 | 152201 | [1EE / 8006 / COMMARFOREUR STUGGART GERMANY] |
| 40 | 152623 | [T52 / 7506 / OFC OF THE CNO OP 00 WASHINGTON DC] |

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|---|---|---|
| 41 | 158333 | [1K3 / 8006 / EOTG III MEF] |
| 42 | 163019 | [145 / 7506 / 1STMAW OKINAWA JAPAN].2 |
| 43 | 163049 | [KA4 / 8006 / TRAIN THE TRAINER SCHOOL CAMP LEJEUNE] |
| 44 | 172287 | [NFN / 8006 / HQ US STRATCOM (JT-BIL) OFFUTT AFB NE] |
| 45 | 177318 | [QBN / 8006 / FAMILY READINESS DEPT HQMC] |
| 46 | 179810 | [068 / 8006 / EDUCATION COMMAND].4 |
| 47 | 190258 | [048 / 6002 / FLEET READINESS CENTER EAST CHERRY PT NC] |
| 48 | 194082 | [007 / 8006 / HQ MCCDC].1 |
| 49 | 202826 | [1XH / 7506 / MWSG-37 3D MAW SAN DIEGO CA] |
| 50 | 219851 | [TMG / 8006 / MARFOR CENTCOM TAMPA].1 |
| 51 | 228796 | [TLG / 8006 / CMDR EXPEDITIONARY STRIKE GROUP 3 SAN DIEGO] |
| 52 | 245337 | [NBR / 8006 / JOINT STAFF J7 (JT-BIL) SUFFOLK VA] |
| 53 | 247836 | [T9B / 6002 / NAV AIR SYS CMD PATUXENT RIVER MD].2 |
| 54 | 248984 | [QAP / 8006 / P&R WASHINGTON DC].3 |
| 55 | 249176 | [1PH / 7506 / MWSG-27 2D MAW CHERRY POINT NC] |
| 56 | 256414 | [1FY / 8006 / HQ MARFORSOUTH DORAL FL].1 |
| 57 | 257976 | [1ET / 7506 / HQ 11TH MEU CAMP PENDLETON CA] |
| 58 | 267120 | [1JC / 7503 / HQ MAG 13 3DMAW YUMA AZ] |
| 59 | 274024 | [1JF / 7505 / HQ MAG 24 1STMAW KANEOHE BAY,HI] |
| 60 | 276636 | [T49 / 8006 / DIR NAV COUNC OF PERS BDS WASHINGTON DC] |
| 61 | 277214 | [G78 / 7506 / MATSG-21 TRNG COM NAS PENSACOLA FL] |
| 62 | 279107 | [QAB / 8006 / HQMC WASHINGTON DC] |
| 63 | 286732 | [NBW / 8006 / JOINT CHIEFS OF STAFF J8 (JT-BIL) WASHINGTON DC] |
| 64 | 302119 | [S2A / 7202 / HQ MACG-48 4TH MAW GREAT LAKES IL] |
| 65 | 302303 | [T52 / 6002 / OFC OF THE CNO OP 00 WASHINGTON DC] |
| 66 | 304114 | [091 / 8006 / MCB KANEOHE BAY HI] |
| 67 | 317031 | [1ER / 7506 / HQ 24TH MEU CAMP LEJEUNE NC] |
| 68 | 327914 | [1K1 / 8006 / MARFOR STRATCOM OFFUTT ] |
| 69 | 328313 | [142 / 7202 / 2DMAW CHERRY POINT NC] |
| 70 | 333489 | [1C0 / 8006 / I MEF] |
| 71 | 346699 | [1C0 / 8006 / I MEF].2 |
| 72 | 354829 | [111 / 7503 / HQ MARFORCOM NORFOLK VA] |
| 73 | 363675 | [TFQ / 8005 / KUWAIT TECH ASSIST FIELD TEAM MACDILL AFB].1 |
| 74 | 365150 | [T52 / 8006 / OFC OF THE CNO WASHINGTON DC].1 |
| 75 | 372176 | [QAP / 8006 / P&R WASHINGTON DC].1 |
| 76 | 375868 | [NBM / 8006 / HQ USSOCOM (JT-BIL) MACDILL AFB FL] |
| 77 | 380750 | [097 / 8006 / MCI EAST CAMP LEJEUNE].2 |
| 78 | 395050 | [1ES / 7506 / HQ 13TH MEU CAMP PENDLETON CA] |
| 79 | 396562 | [143 / 7596 / 3DMAW MIRAMAR CA] |
| 80 | 397628 | [NBR / 7503 / JOINT STAFF J7 (JT-BIL) SUFFOLK VA] |
| 81 | 400438 | [080 / 8006 / PMD QUANTICO - MARSH CENTER] |
| 82 | 405986 | [NBW / 8006 / JOINT CHIEFS OF STAFFJ5 (JT-BIL) WASHINGTON DC] |
| 83 | 421363 | [NA6 / 7506 / HQ USEUCOM (JT-BIL) STUTGART GERMANY].1 |
| 84 | 444667 | [007 / 8006 / HQ MCCDC].3 |
| 85 | 450262 | [QAQ / 8006 / PP&O].1 |
| 86 | 465781 | [145 / 7506 / 1STMAW OKINAWA JAPAN].1 |
| 87 | 470627 | [145 / 7506 / 1STMAW OKINAWA JAPAN] |
| 88 | 471470 | [1JH / 7505 / HQ MAG 29 2DMAW JACKSONVILLE NC].1 |
| 89 | 475902 | [1JH / 7505 / HQ MAG 29 2DMAW JACKSONVILLE NC] |
| 90 | 484313 | [011 / 8006 / H&S BN HQMC HENDERSON HALL ARLINGTON VA] |

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| 91 | 484491 | [129 / 8006 / MCI CAMP MUJUK (ROK) KOREA] |
| 92 | 485009 | [442 / 8006 / US PACIFIC FLEET / USNAVCENT PEARL HARBOR].1 |
| 93 | 494595 | [S7A / 7505 / HQTRS MAG-49 4TH MAW MCGUIRE AFB NJ] |
| 94 | 496134 | [063 / 8006 / MARINE CORPS LOGISTICS COMMAND ALBANY GA] |
| 95 | 496795 | [T9B / 6002 / NAV AIR SYS CMD PATUXENT RIVER MD].3 |
| 96 | 496956 | [LAW / 7506 / MC REP US NAVAL WAR COLL EDU COM NEWPORT RI] |
| 97 | 533701 | [1CC / 8006 / 3D MEB] |
| 98 | 536162 | [NDS / 8006 / HQ USTRANSCOM (JT-BIL) SCOTT AFB IL] |
| 99 | 543501 | [1EM / 8006 / MARINE FORCES AFTRICA COMMAND GERMANY] |
| 100 | 547525 | [014 / 8006 / MCB CAMP PENDLETON] |
| 101 | 549199 | [007 / 8006 / HQ MCCDC].2 |
| 102 | 556194 | [QAB / 8006 / HQMC WASHINGTON DC].1 |
| 103 | 556407 | [TZ3 / 7506 / NAVY WARFARE DEVELOPMENT COMMAND NORFOLK VA] |
| 104 | 558771 | [1JD / 7503 / HQ MAG-14 2DMAW CHERRY POINT NC] |
| 105 | 565808 | [097 / 8006 / MCI EAST CAMP LEJEUNE] |
| 106 | 567717 | [1JL / 7505 / HQ MAG 36 1STMAW FUTENMA OKINAWA JAPAN] |
| 107 | 569447 | [TKP / 8006 / US ARMY COMMAND AND STAFF COLLEGE] |
| 108 | 573577 | [086 / 8006 / TRAINING AND EDUCATION COMMAND] |
| 109 | 582657 | [462 / 7523 / FLAG ALLOWANCE COMNAVAIRPAC SAN DIEGO CA] |
| 110 | 586851 | [1WW / 8006 / WOUNDED WARRIOR REGIMENT QUANTICO] |
| 111 | 590067 | [T52 / 8006 / OFC OF THE CNO WASHINGTON DC] |
| 112 | 592829 | [1K4 / 8006 / EOTG I MEF] |
| 113 | 618031 | [N28 / 8006 / COMBINED FORCES (KOREA / CAMP HUMPHREYS)] |
| 114 | 619839 | [JAB / 8006 / SNCO ACADEMY CAMP PENDLETON] |
| 115 | 635270 | [TM6 / 8006 / MCATSU] |
| 116 | 637213 | [454 / 7566 / FA COMNAVSURFPAC CORONADO CA] |
| 117 | 643021 | [142 / 7506 / 2DMAW CHERRY POINT NC].3 |
| 118 | 648967 | [T9B / 6002 / NAV AIR SYS CMD PATUXENT RIVER MD].1 |
| 119 | 651332 | [080 / 8006 / PMD QUANTICO - MARSH CENTER].3 |
| 120 | 664175 | [TF4 / 7506 / INSPECTOR GENERAL OF THE USMC ARLINGTON VA] |
| 121 | 667431 | [068 / 8006 / EDUCATION COMMAND].2 |
| 122 | 670238 | [032 / 7505 / MCAF QUANTICO VA] |
| 123 | 682837 | [097 / 8006 / MCI EAST CAMP LEJEUNE].3 |
| 124 | 682973 | [T52 / 8006 / OFC OF THE CNO WASHINGTON DC].2 |
| 125 | 684790 | [022 / 7506 / MCAS CHERRY POINT NC] |
| 126 | 686498 | [068 / 8006 / EDUCATION COMMAND].1 |
| 127 | 686942 | [142 / 7506 / 2DMAW CHERRY POINT NC].2 |
| 128 | 702466 | [T15 / 8006 / J6 DIRECTOR FOR C4 (ARLINGTON)] |
| 129 | 703509 | [068 / 8006 / EDUCATION COMMAND] |
| 130 | 706309 | [023 / 7506 / MCAS MIRAMAR SAN DIEGO CA] |
| 131 | 714204 | [NJN / 7506 / NATIONAL DEFENSE UNIVERSTIY (JT-BIL) NORFOLK VA] |
| 132 | 715157 | [NBB / 7506 / EUCOM, JUSMAG (JT-BIL) SPAIN] |
| 133 | 720575 | [QAQ / 8006 / PP&O].2 |
| 134 | 721009 | [143 / 7506 / 3DMAW MIRAMAR CA].2 |
| 135 | 724365 | [1JM / 7505 / HQ MAG 39 3DMAW CAMP PENDLETON CA] |
| 136 | 729460 | [068 / 8006 / EDUCATION COMMAND].3 |
| 137 | 739981 | [022 / 7596 / MCAS CHERRY POINT NC] |
| 138 | 744835 | [1CC / 8006 / 3D MEB].1 |
| 139 | 748700 | [086 / 7506 / TRAINING AND EDUCATION COMMAND QUANTICO VA] |
| 140 | 760489 | [442 / 8006 / US PACIFIC FLEET / USNAVCENT PEARL HARBOR] |

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| 141 | 765673 | [QDC / 7315 / DEPUTY COMMANDANT FOR INFORMATION WASHINGTON DC] |
| 142 | 766568 | [N26 / 8006 / NATIONAL SECURITY COUNCIL (WHITE HOUSE)] |
| 143 | 769460 | [1C0 / 7506 / HQ I MEF CAMP PENDLETON CA] |
| 144 | 770641 | [J02 / 8006 / AIR UNIVERISTY MONTGOMERY AL] |
| 145 | 781816 | [1JG / 7505 / MAG-26 2DMAW JACKSONVILLE NC] |
| 146 | 788739 | [110 / 8006 / MARFORPAC CAMP SMITH HI] |
| 147 | 796370 | [1WL / 8006 / MARINE CORPS LIAISON OFFICE BETHESDA] |
| 148 | 802006 | [080 / 8006 / PMD QUANTICO - MARSH CENTER].1 |
| 149 | 808638 | [TF4 / 8006 / INSPECTOR GENERAL OF THE USMC ARLINGTON VA] |
| 150 | 808929 | [J34 / 6602 / NAV ED & TRN CTR NEWPORT RI] |
| 151 | 810088 | [TDU / 8006 / USA SPACE & MISSILE DEF CMD, ARFORSTRAT, PETERSON AFB] |
| 152 | 817854 | [T52 / 7532 / OFC OF THE CNO OP 00 WASHINGTON DC] |
| 153 | 830781 | [TRG / 8006 / MARINE CORPS CYBERSPACE OPEARTION GROUP] |
| 154 | 838365 | [104 / 8006 / MARCOR ADVS CO SUPPORT GREAT LAKES IL] |
| 155 | 839866 | [T49 / 8006 / DIR NAV COUNC OF PERS BDS WASHINGTON DC].1 |
| 156 | 841764 | [TCR / 8006 / DET 2 TECHNICAL SERVICES ARLINGTON VA] |
| 157 | 844097 | [1JD / 7503 / HQ MAG-14 2DMAW CHERRY POINT NC].1 |
| 158 | 847770 | [T52 / 7506 / OFC OF THE CNO OP 00 WASHINGTON DC].1 |
| 159 | 855243 | [QAB / 8006 / HQMC WASHINGTON DC].2 |
| 160 | 856367 | [NA6 / 7506 / HQ USEUCOM (JT-BIL) STUTGART GERMANY] |
| 161 | 857981 | [1GF / 7506 / THE MARINE CORPS WARFIGHTING LAB QUANTICO VA] |
| 162 | 867052 | [S8F / 7202 / HQTRS 4TH MAW NEW ORLEANS NAS LA] |
| 163 | 869810 | [QAP / 8006 / P&R WASHINGTON DC] |
| 164 | 881543 | [QAE / 8006 / M&RA DIV HQMC] |
| 165 | 884040 | [NGG / 7588 / STRATCOM, JOIC (JT-BIL) SAN ANTONIO TX] |
| 166 | 890559 | [1DX / 7505 / CE 5TH MEB MARFOR CENTCOM BAHRAIN] |
| 167 | 892776 | [1F5 / 8006 / CE MEF INFO GROUP I MEF] |
| 168 | 906996 | [N28 / 7506 / HQ US FORCES KOREA (JT-BIL) YONGSAN ] |
| 169 | 907027 | [NBP / 8006 / HQ USCENTCOM (JT-BIL) MACDILL AFB FL] |
| 170 | 920732 | [TJD / 8006 / DTRA ON SITE INSPEC DIRECT EUROPE] |
| 171 | 926723 | [NA6 / 7506 / HQ USEUCOM (JT-BIL) STUTGART GERMANY].2 |
| 172 | 929870 | [T52 / 8006 / OFC OF THE CNO WASHINGTON DC].3 |
| 173 | 930139 | [QAQ / 8006 / PP&O] |
| 174 | 940520 | [G76 / 7315 / MAD NAS PATUXENT RIVER MD] |
| 175 | 953905 | [U61 / 7202 / FAA WASHINGTON DC] |
| 176 | 957106 | [1C0 / 8006 / I MEF].1 |
| 177 | 957144 | [G91 / 6002 / MATSG-23 TRNG CMD NAS PENSACOLA FL] |
| 178 | 959477 | [NAG / 7506 / USPACOM (JT-BIL) CAMP SMITH HI] |
| 179 | 960962 | [NSJ / 7505 / STRIKFORNATO (JT BIL) LISBON, PORTUGAL] |
| 180 | 975166 | [1JA / 7503 / HQ MAG-11 3D MAW SAN DIEGO CA] |
| 181 | 983475 | [TMG / 6002 / HQ MARFOR CENTCOM, MACDILL AFB, TAMPA, FL] |
| 182 | 983858 | [JBF / 8006 / SNCO ACADEMY CAMP LEJEUNE] |
| 183 | 984740 | [145 / 6602 / 1STMAW OKINAWA JAPAN] |
| 184 | 987340 | [142 / 7506 / 2DMAW CHERRY POINT NC] |
| 185 | 992454 | [QLA / 8006 / OFFICE OF LEGISLATIVE AFFAIRS ] |
| 186 | 995027 | [1JB / 7503 / HQ MAG-12 1ST MAW IWAKUNI JAPAN] |

# APPENDIX C. ASSIGNMENT SOLUTION USING EPSILON-CONSTRAINT METHOD WITH PCS COST HIERARCHY (TOLERANCE EPSILON =0.05)

| | UUID | Billets |
|---|---|---|
| 0 | 10352 | [QAB / 8006 / HQMC WASHINGTON DC].3 |
| 1 | 14701 | [JBG / 8006 / SNCO ACADEMY CAMP BUTLER OKINAWA] |
| 2 | 18665 | [T52 / 6602 / OFC OF THE CNO OP 00 WASHINGTON DC] |
| 3 | 29968 | [057 / 7505 / MCAS CAMP PENDLETON CA] |
| 4 | 30264 | [TD4 / 7577 / JOINT ELECTROMAGNETIC PREP FOR ADV COMBT (NEVADA)] |
| 5 | 31723 | [1FV / 8006 / MARCOR INSTALLATION COMMAND, WASHINGTON DC] |
| 6 | 34251 | [TD4 / 7577 / JTF HQ FOR EW/CAS NELLIS AFB NV] |
| 7 | 42820 | [1GF / 8006 / WARFIGHTING LAB] |
| 8 | 48036 | [1FY / 8006 / HQ MARFORSOUTH DORAL FL] |
| 9 | 51975 | [T9B / 6002 / NAV AIR SYS CMD PATUXENT RIVER MD] |
| 10 | 55308 | [APH / 8006 / JTF ODRP CHIEF OPERATIONS DIVISION - PAKISTAN] |
| 11 | 57960 | [TFQ / 8005 / KUWAIT TECH ASSIST FIELD TEAM MACDILL AFB] |
| 12 | 62153 | [1F1 / 7506 / HQ II MEF CAMP LEJEUNE NC] |
| 13 | 62433 | [1EP / 7506 / HQ 31ST MEU OKINAWA JAPAN] |
| 14 | 62464 | [068 / 8006 / EDUCATION COMMAND].2 |
| 15 | 63609 | [TMG / 8006 / MARFOR CENTCOM TAMPA].1 |
| 16 | 64071 | [1JM / 7505 / HQ MAG 39 3DMAW CAMP PENDLETON CA] |
| 17 | 67747 | [097 / 8006 / MCI EAST CAMP LEJEUNE].1 |
| 18 | 68391 | [T52 / 7523 / OFC OF THE CNO OP 00 WASHINGTON DC] |
| 19 | 70065 | [1JA / 7518 / HQ MAG-11 3D MAW SAN DIEGO CA] |
| 20 | 76441 | [1JE / 7505 / HQ MAG 16 3DMAW SAN DIEGO CA] |
| 21 | 94215 | [JBF / 8006 / SNCO ACADEMY CAMP LEJEUNE] |
| 22 | 94293 | [D93 / 7506 / SITE SPT CLR 4 4TH MLG FT LEWIS WA] |
| 23 | 96192 | [TJD / 8006 / DTRA ON SITE INSPEC DIRECT EUROPE] |
| 24 | 99290 | [QAQ / 8006 / PP&O].1 |
| 25 | 99970 | [NA6 / 7506 / HQ USEUCOM (JT-BIL) STUTGART GERMANY].1 |
| 26 | 106694 | [007 / 7506 / HQ MCCDC QUANTICO VA] |
| 27 | 110732 | [1F2 / 8006 / CE MEF INFO GROUP II MEF] |
| 28 | 119312 | [QAP / 8006 / P&R WASHINGTON DC].2 |
| 29 | 119865 | [142 / 7506 / 2DMAW CHERRY POINT NC] |
| 30 | 128675 | [QAJ / 8006 / C4 DEPT HQMC WASHINGTON DC] |
| 31 | 132912 | [TDU / 8006 / USA SPACE & MISSILE DEF CMD, ARFORSTRAT, PETERSON AFB] |
| 32 | 133910 | [143 / 7506 / 3DMAW MIRAMAR CA].2 |
| 33 | 135283 | [023 / 7506 / MCAS MIRAMAR SAN DIEGO CA] |
| 34 | 137125 | [QDC / 8006 / DEPUTY COMMANDANT FOR INFORMATION WASHINGTON DC] |
| 35 | 137177 | [142 / 7506 / 2DMAW CHERRY POINT NC].3 |
| 36 | 139540 | [QAB / 8006 / HQMC WASHINGTON DC].1 |
| 37 | 139602 | [142 / 7596 / 2DMAW CHERRY POINT NC] |
| 38 | 149250 | [111 / 6002 / HQ MARFORCOM NORFOLK VA] |
| 39 | 152201 | [1EM / 8006 / MARINE FORCES AFTRICA COMMAND GERMANY] |
| 40 | 152623 | [T52 / 7506 / OFC OF THE CNO OP 00 WASHINGTON DC] |

| | | |
|---|---|---|
| 41 | 158333 | [1K3 / 8006 / EOTG III MEF] |
| 42 | 163019 | [145 / 7506 / 1STMAW OKINAWA JAPAN].2 |
| 43 | 163049 | [097 / 8006 / MCI EAST CAMP LEJEUNE] |
| 44 | 172287 | [NFN / 8006 / HQ US STRATCOM (JT-BIL) OFFUTT AFB NE] |
| 45 | 177318 | [080 / 8006 / PMD QUANTICO - MARSH CENTER].2 |
| 46 | 179810 | [068 / 8006 / EDUCATION COMMAND].3 |
| 47 | 190258 | [048 / 6002 / FLEET READINESS CENTER EAST CHERRY PT NC] |
| 48 | 194082 | [007 / 8006 / HQ MCCDC].1 |
| 49 | 202826 | [1XH / 7506 / MWSG-37 3D MAW SAN DIEGO  CA] |
| 50 | 219851 | [145 / 7506 / 1STMAW OKINAWA JAPAN] |
| 51 | 228796 | [TLG / 8006 / CMDR EXPEDITIONARY STRIKE GROUP 3 SAN DIEGO] |
| 52 | 245337 | [NJN / 7506 / NATIONAL DEFENSE UNIVERSTIY (JT-BIL) NORFOLK VA] |
| 53 | 247836 | [T9B / 6002 / NAV AIR SYS CMD  PATUXENT RIVER MD].2 |
| 54 | 248984 | [J56 / 8006 / NAVAL WAR COLLEGE NEWPORT RI] |
| 55 | 249176 | [142 / 7506 / 2DMAW CHERRY POINT NC].1 |
| 56 | 256414 | [1FJ / 8006 / MARFORNORTHCOM NEW ORLEANS] |
| 57 | 257976 | [1ET / 7506 / HQ 11TH MEU CAMP PENDLETON CA] |
| 58 | 267120 | [1JC / 7503 / HQ MAG 13 3DMAW YUMA AZ] |
| 59 | 274024 | [091 / 8006 / MCB KANEOHE BAY HI] |
| 60 | 276636 | [T49 / 8006 / DIR NAV COUNC OF PERS BDS WASHINGTON DC] |
| 61 | 277214 | [G78 / 7506 / MATSG-21 TRNG COM NAS PENSACOLA FL] |
| 62 | 279107 | [QAP / 8006 / P&R WASHINGTON DC] |
| 63 | 286732 | [T15 / 8006 / J6 DIRECTOR FOR C4 (ARLINGTON)] |
| 64 | 302119 | [S2A / 7202 / HQ MACG-48 4TH MAW GREAT LAKES  IL] |
| 65 | 302303 | [T52 / 6002 / OFC OF THE CNO OP 00 WASHINGTON DC] |
| 66 | 304114 | [QAQ / 8006 / PP&O] |
| 67 | 317031 | [T52 / 7532 / OFC OF THE CNO OP 00 WASHINGTON DC] |
| 68 | 327914 | [KA4 / 8006 / TRAIN THE TRAINER SCHOOL CAMP LEJEUNE] |
| 69 | 328313 | [1PA / 7202 / HQ MACG-28 2D MAW CHERRY POINT NC] |
| 70 | 333489 | [1CC / 8006 / 3D MEB] |
| 71 | 346699 | [1CC / 8006 / 3D MEB].1 |
| 72 | 354829 | [1JC / 7518 / HQ MAG 13 3DMAW YUMA AZ] |
| 73 | 363675 | [NBR / 7503 / JOINT STAFF J7 (JT-BIL) SUFFOLK VA] |
| 74 | 365150 | [T52 / 8006 / OFC OF THE CNO WASHINGTON DC].3 |
| 75 | 372176 | [QAP / 8006 / P&R WASHINGTON DC].3 |
| 76 | 375868 | [NBM / 8006 / HQ USSOCOM (JT-BIL) MACDILL AFB FL] |
| 77 | 380750 | [097 / 8006 / MCI EAST CAMP LEJEUNE].3 |
| 78 | 395050 | [1FY / 8006 / HQ MARFORSOUTH DORAL FL].1 |
| 79 | 396562 | [444 / 7523 / US FLEET FORCES CMD (USFFC) NORFOLK  VA] |
| 80 | 397628 | [111 / 7503 / HQ MARFORCOM NORFOLK  VA] |
| 81 | 400438 | [080 / 8006 / PMD QUANTICO - MARSH CENTER] |
| 82 | 405986 | [N28 / 8006 / COMBINED FORCES (KOREA / CAMP HUMPHREYS)] |
| 83 | 421363 | [1ES / 7506 / HQ 13TH MEU CAMP PENDLETON CA] |
| 84 | 444667 | [007 / 8006 / HQ MCCDC].3 |
| 85 | 450262 | [T52 / 8006 / OFC OF THE CNO WASHINGTON DC].1 |
| 86 | 465781 | [1JL / 7505 / HQ MAG 36 1STMAW FUTENMA OKINAWA JAPAN] |
| 87 | 470627 | [124 / 8006 / 3D MARDIV] |
| 88 | 471470 | [1JH / 7505 / HQ MAG 29 2DMAW JACKSONVILLE NC].1 |
| 89 | 475902 | [1JH / 7505 / HQ MAG 29 2DMAW JACKSONVILLE NC] |
| 90 | 484313 | [011 / 8006 / H&S BN HQMC HENDERSON HALL ARLINGTON VA] |

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|---|---|---|
| 91 | 484491 | [129 / 8006 / MCI CAMP MUJUK (ROK) KOREA] |
| 92 | 485009 | [442 / 8006 / US PACIFIC FLEET / USNAVCENT PEARL HARBOR].1 |
| 93 | 494595 | [S7A / 7505 / HQTRS MAG-49 4TH MAW MCGUIRE AFB NJ] |
| 94 | 496134 | [063 / 8006 / MARINE CORPS LOGISTICS COMMAND ALBANY GA] |
| 95 | 496795 | [T9B / 6002 / NAV AIR SYS CMD  PATUXENT RIVER MD].3 |
| 96 | 496956 | [097 / 8006 / MCI EAST CAMP LEJEUNE].2 |
| 97 | 533701 | [022 / 7596 / MCAS CHERRY POINT NC] |
| 98 | 536162 | [NDS / 8006 / HQ USTRANSCOM (JT-BIL) SCOTT AFB IL] |
| 99 | 543501 | [QAB / 8006 / HQMC WASHINGTON DC] |
| 100 | 547525 | [014 / 8006 / MCB CAMP PENDLETON] |
| 101 | 549199 | [007 / 8006 / HQ MCCDC].2 |
| 102 | 556194 | [QAP / 8006 / P&R WASHINGTON DC].1 |
| 103 | 556407 | [NA6 / 7506 / HQ USEUCOM (JT-BIL) STUTGART GERMANY] |
| 104 | 558771 | [1JD / 7503 / HQ MAG-14 2DMAW CHERRY POINT NC] |
| 105 | 565808 | [1JD / 7503 / HQ MAG-14 2DMAW CHERRY POINT NC].1 |
| 106 | 567717 | [S8F / 7202 / HQTRS 4TH MAW NEW ORLEANS NAS LA] |
| 107 | 569447 | [TKP / 8006 / US ARMY COMMAND AND STAFF COLLEGE] |
| 108 | 573577 | [068 / 8006 / EDUCATION COMMAND].1 |
| 109 | 582657 | [462 / 7523 / FLAG ALLOWANCE COMNAVAIRPAC SAN DIEGO  CA] |
| 110 | 586851 | [1WW / 8006 / WOUNDED WARRIOR REGIMENT QUANTICO] |
| 111 | 590067 | [QBN / 8006 / FAMILY READINESS DEPT HQMC] |
| 112 | 592829 | [1K4 / 8006 / EOTG I MEF] |
| 113 | 618031 | [J34 / 6602 / NAV ED & TRN CTR NEWPORT RI] |
| 114 | 619839 | [JAB / 8006 / SNCO ACADEMY CAMP PENDLETON] |
| 115 | 635270 | [TM6 / 8006 / MCATSU] |
| 116 | 637213 | [454 / 7566 / FA COMNAVSURFPAC CORONADO CA] |
| 117 | 643021 | [142 / 7506 / 2DMAW CHERRY POINT NC].2 |
| 118 | 648967 | [T9B / 6002 / NAV AIR SYS CMD  PATUXENT RIVER MD].1 |
| 119 | 651332 | [080 / 8006 / PMD QUANTICO - MARSH CENTER].3 |
| 120 | 664175 | [TF4 / 7506 / INSPECTOR GENERAL OF THE USMC ARLINGTON VA] |
| 121 | 667431 | [145 / 7506 / 1STMAW OKINAWA JAPAN].1 |
| 122 | 670238 | [007 / 8006 / HQ MCCDC] |
| 123 | 682837 | [T52 / 8006 / OFC OF THE CNO WASHINGTON DC] |
| 124 | 682973 | [T52 / 8006 / OFC OF THE CNO WASHINGTON DC].2 |
| 125 | 684790 | [022 / 7506 / MCAS CHERRY POINT NC] |
| 126 | 686498 | [1C0 / 8006 / I MEF].1 |
| 127 | 686942 | [1JG / 7505 / MAG-26 2DMAW JACKSONVILLE NC] |
| 128 | 702466 | [NBW / 8006 / JOINT CHIEFS OF STAFFJ5  (JT-BIL) WASHINGTON DC] |
| 129 | 703509 | [068 / 8006 / EDUCATION COMMAND] |
| 130 | 706309 | [TMG / 8006 / MARFOR CENTCOM TAMPA] |
| 131 | 714204 | [TZ3 / 7506 / NAVY WARFARE DEVELOPMENT COMMAND NORFOLK VA] |
| 132 | 715157 | [NBB / 7506 / EUCOM, JUSMAG (JT-BIL) SPAIN] |
| 133 | 720575 | [QAQ / 8006 / PP&O].2 |
| 134 | 721009 | [143 / 7506 / 3DMAW MIRAMAR CA] |
| 135 | 724365 | [057 / 7505 / MCAS CAMP PENDLETON CA].1 |
| 136 | 729460 | [068 / 8006 / EDUCATION COMMAND].5 |
| 137 | 739981 | [086 / 8006 / TRAINING AND EDUCATION COMMAND] |
| 138 | 744835 | [1C0 / 8006 / I MEF] |
| 139 | 748700 | [086 / 7506 / TRAINING AND EDUCATION COMMAND QUANTICO VA] |
| 140 | 760489 | [442 / 8006 / US PACIFIC FLEET / USNAVCENT PEARL HARBOR] |

| | | |
|---|---|---|
| 141 | 765673 | [NBR / 8006 / JOINT STAFF J7 (JT-BIL) SUFFOLK VA] |
| 142 | 766568 | [N26 / 8006 / NATIONAL SECURITY COUNCIL (WHITE HOUSE)] |
| 143 | 769460 | [1C0 / 7506 / HQ I MEF CAMP PENDLETON CA] |
| 144 | 770641 | [NBP / 8006 / HQ USCENTCOM (JT-BIL) MACDILL AFB FL] |
| 145 | 781816 | [T49 / 8006 / DIR NAV COUNC OF PERS BDS WASHINGTON DC].1 |
| 146 | 788739 | [110 / 8006 / MARFORPAC CAMP SMITH HI] |
| 147 | 796370 | [1WL / 8006 / MARINE CORPS LIAISON OFFICE BETHESDA] |
| 148 | 802006 | [080 / 8006 / PMD QUANTICO - MARSH CENTER].1 |
| 149 | 808638 | [TF4 / 8006 / INSPECTOR GENERAL OF THE USMC ARLINGTON VA] |
| 150 | 808929 | [143 / 6602 / 3DMAW MIRAMAR CA] |
| 151 | 810088 | [NSJ / 7505 / STRIKFORNATO (JT BIL) LISBON, PORTUGAL] |
| 152 | 817854 | [1JF / 7505 / HQ MAG 24 1STMAW KANEOHE BAY,HI] |
| 153 | 830781 | [TRG / 8006 / MARINE CORPS CYBERSPACE OPEARTION GROUP] |
| 154 | 838365 | [104 / 8006 / MARCOR ADVS CO SUPPORT GREAT LAKES IL] |
| 155 | 839866 | [1C0 / 8006 / I MEF].2 |
| 156 | 841764 | [068 / 8006 / EDUCATION COMMAND].4 |
| 157 | 844097 | [TCR / 8006 / DET 2 TECHNICAL SERVICES ARLINGTON VA] |
| 158 | 847770 | [T52 / 7506 / OFC OF THE CNO OP 00 WASHINGTON DC].1 |
| 159 | 855243 | [QAB / 8006 / HQMC WASHINGTON DC].2 |
| 160 | 856367 | [032 / 7505 / MCAF QUANTICO VA] |
| 161 | 857981 | [1GF / 7506 / THE MARINE CORPS WARFIGHTING LAB QUANTICO VA] |
| 162 | 867052 | [1K1 / 8006 / MARFOR STRATCOM OFFUTT ] |
| 163 | 869810 | [NBW / 8006 / JOINT CHIEFS OF STAFF J8 (JT-BIL) WASHINGTON DC] |
| 164 | 881543 | [QAE / 8006 / M&RA DIV HQMC] |
| 165 | 884040 | [NGG / 7588 / STRATCOM, JOIC (JT-BIL) SAN ANTONIO TX] |
| 166 | 890559 | [1DX / 7505 / CE 5TH MEB MARFOR CENTCOM BAHRAIN] |
| 167 | 892776 | [1F5 / 8006 / CE MEF INFO GROUP I MEF] |
| 168 | 906996 | [1JL / 7505 / HQ MAG 36 1STMAW FUTENMA OKINAWA JAPAN].1 |
| 169 | 907027 | [1ER / 7506 / HQ 24TH MEU CAMP LEJEUNE NC] |
| 170 | 920732 | [LAW / 7506 / MC REP US NAVAL WAR COLL EDU COM NEWPORT RI] |
| 171 | 926723 | [NA6 / 7506 / HQ USEUCOM (JT-BIL) STUTGART GERMANY].2 |
| 172 | 929870 | [142 / 7202 / 2DMAW CHERRY POINT NC] |
| 173 | 930139 | [N28 / 7506 / HQ US FORCES KOREA (JT-BIL) YONGSAN ] |
| 174 | 940520 | [G76 / 7315 / MAD NAS PATUXENT RIVER MD] |
| 175 | 953905 | [U61 / 7202 / FAA WASHINGTON DC] |
| 176 | 957106 | [143 / 7506 / 3DMAW MIRAMAR CA].1 |
| 177 | 957144 | [G91 / 6002 / MATSG-23 TRNG CMD NAS PENSACOLA FL] |
| 178 | 959477 | [NAG / 7506 / USPACOM (JT-BIL) CAMP SMITH HI] |
| 179 | 960962 | [1EE / 8006 / COMMARFOREUR STUGGART GERMANY] |
| 180 | 975166 | [1JA / 7503 / HQ MAG-11 3D MAW SAN DIEGO CA] |
| 181 | 983475 | [TMG / 6002 / HQ MARFOR CENTCOM, MACDILL AFB, TAMPA, FL] |
| 182 | 983858 | [J02 / 8006 / AIR UNIVERISTY MONTGOMERY AL] |
| 183 | 984740 | [145 / 6602 / 1STMAW OKINAWA JAPAN] |
| 184 | 987340 | [1PH / 7506 / MWSG-27 2D MAW CHERRY POINT NC] |
| 185 | 992454 | [QLA / 8006 / OFFICE OF LEGISLATIVE AFFAIRS ] |
| 186 | 995027 | [143 / 7596 / 3DMAW MIRAMAR CA] |

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