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A Decision Support Simulation to Analyze Scheduling Alternatives for Applicant Processing at Military Entrance Processing Stations (MEPS)

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Abstract

Applicant processing at Military Entrance Processing Stations (MEPS) is conducted via a batch arrival process by which all applicants arrive at the beginning of the processing day. Pursuit of alternate processing scenarios has never progressed beyond the pilot stage, possibly because the Command lacks a general decision support model to evaluate the impacts of proposed policies on applicant processing operations. This research creates a discrete event simulation of MEPS applicant processing operations and applies the model to three alternative applicant processing scenarios: split-shift, appointment-based, and express-lane. Results are examined and compared to benchmarks using multiple performance measurements. The results indicate that maintaining current policy operations is the risk averse and best option. Express lane policies are viable and may be useful for scenarios when significant numbers of delayed entry program (DEP) applicants need processing. Split-shift and appointment-based scheduling options are not recommended for implementation under current methods of operation due to excessive holdover numbers and reduced total applicant throughput.

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A DECISION SUPPORT SIMULATION TO ANALYZE SCHEDULING ALTERNATIVES FOR APPLICANT PROCESSING AT MILITARY ENTRANCE PROCESSING STATIONS

I. Introduction

In an unpredictable world and with the rise of near peer adversaries, the United States (U.S.) finds its position as a world power challenged. In response to this challenge, the Office of the Under Secretary of Defense for Personnel and Readiness (OUSD(P&R)) establishes a framework for policies in its strategic plan. With a strong correlation to the objectives of our research, this document establishes meaningful and executable guidance for the Department of Defense (DOD) to prepare the Total Force in a resource-constrained environment (15:1). As a result, the U.S. military is expected to answer the nation's need for a force capable of performing simultaneous and continuous military operations. The need for qualified men and women to fill the ranks of the armed forces has never been more crucial in sustaining the nation's military strength. Establishing appropriate policies and resources to process a sufficient number of military accessions during peacetime and mobilization is vital to national security (14:5).

The U.S. military employs a three-stage enlistment process for individuals interested in serving in the armed forces. The first phase involves recruitment operations that introduce and familiarize a potential candidate to the military profession. These initial efforts culminate in the third phase when an individual arrives to an armed service's initial basic training site. In between the two phases, the Office of the Secretary of Defense (OSD) established the United States Military Entrance Processing Command

(USMEPCOM) administers aptitude testing, medical examinations, and miscellaneous enlistment processing capabilities at 65 Military Entrance Processing Stations (MEPS) across the country. The USMEPCOM mission is a strategic and critical asset within the military personnel accession system (21:5). USMEPCOM directly supports the OUSD(P&R) strategic plan's first goal, "to provide the right policies coupled with state-of-the-art practices and tools to attract, train, educate, shape, sustain, and retain diverse talent to anticipate and meet the requirements of the 21st Century Total Force" (15:3). The geographic dispersion of all 65 MEPS within USMEPCOM are illustrated in Figure 1.1. The dispersion is significant information because the geographical location influences the number of applicants a MEPS processes, thus classifying a MEPS into one of three possible size categories: small, medium, and large. The output of MEPS processing is a status for each applicant: qualified or not qualified for military service, where qualified is determined by predefined service-specific standards. A detailed overview of the various MEPS processing sections, their purpose in the applicant processing operation, and the applicant process flow is discussed in Appendix A.

Figure 1.1. Geographical dispersion of MEPS within USMEPCOM
Source: USMEPCOM 18

1.1 Problem Statement

Historically, USMEPCOM processes applicants in one large batch that arrives to the MEPS at the beginning of the duty day. While successful, the issue is that the current processing strategy results in excessive waiting times for applicants. USMEPCOM seeks to improve or update its operations through analysis of the current process and to determine a better, if any, alternative approach for applicant scheduling. Simply put, USMEPCOM would like to know if there is a more efficient avenue toward mission accomplishment. The USMPECOM strategic plan addresses its use of stagnate processes and expresses a desire to modernize methods for mission fulfillment. Decision makers at USMEPCOM prioritize finding ways to update the Command's information technology capabilities while simultaneously harnessing technologies that have successfully been

employed in the civilian sector (21:1). This research leverages techniques proven to be successful in civilian sectors of industry to examine the MEPS processing operation.

Alternative approaches to scheduling applicants have been discussed by USMEPCOM leadership over the years but have never progressed beyond the pilot stage. One reason is that, to date, the Command lacks a decision-support model of MEPS operations that can be applied toward the analysis of different applicant arrival scenarios. Previous research studies model MEPS process flow operations but are not suitable to be used as a decision-support tool to be applied toward current USMEPCOM processes (Feo et al., 1992), (Maurina and Chakravarthy, 2015). Another study details the MEPS applicant process flow exceedingly well; however, the analysis of metrics is viewed solely through the prism of cost and no attempt was made to model this process (Bell, Huizinga et al., 2016). A significant result of our study bridges the gap between these past research efforts and modernizes the assumptions, methodology, and techniques to reflect the current applicant processing operations conducted by USMEPCOM.

1.2 Research Goals

The desired outcome for this research is a general application decision support model of the MEPS applicant processing operation. This model will be employed to analyze alternative applicant scheduling approaches and gain insight into more efficient ways for USMEPCOM to accomplish its mission. Upon conclusion of our research, the general decision support model is envisioned to be used for USMEPCOM studies for the foreseeable future.

Five prominent research goals are outlined which enable our efforts to provide USMEPCOM with a desired outcome. The first three research goals support the objective to develop a general-purpose decision support model of the MEPS process. The remaining two goals support the application of this model toward the investigation of alternate processing scenarios. The first research goal considers the service time distributions for applicant processing within the major sections in a MEPS. This goal is designed to identify the time it takes for processing activities to be completed in the MEPS sections. These service times are used as key input parameters and are an essential driving mechanism for an accurate representation of the system. The modeling of gender in conjunction with the various applicant category types in our study is a new contribution for MEPS modeling research and provides more accurate estimates of processing service times.

The second research goal solicits an answer to the probabilities associated with applicant flow from one MEPS section to another. This goal seeks to determine whether applicant flow is deterministic and ubiquitous across all MEPS locations or if there are divergent flows an applicant can take to complete enlistment processing. Should divergent flows be discovered, this study examines the most probable paths applicants take while transitioning from section to section. This goal facilitates the construction of an accurate model of the MEPS processing operation.

Third, our study aims to determine the probabilities associated with the type of service that an applicant may receive at a MEPS. Due to the multitude of applicant categories, this study examines the ratios of applicant category types that are processed

by a MEPS. This information is vital to creation of a baseline model that can be verified and validated by USMEPCOM Subject Matter Experts (SMEs). Parameter variations of these ratios will elicit insight toward recommendations for how best to utilize MEPS resources and bottleneck analysis.

The fourth research goal strives to identify metrics by which to compare one scheduling approach against another. This goal incorporates the MEPS applicant processing operation in its entirety. All-encompassing metrics do not exist in previous studies which concentrate on metrics through the limited perspective of cost or to the analysis of metrics in a specific processing section. The metrics aid in the construction of our model and empower insight into value focused recommendations for USMEPCOM.

Finally, the fifth research goal intends to provide a recommendation as to which, if any, scheduling approaches are preferable over another. This research goal utilizes the answers of the previous four goals and attempts to synthesize decision support recommendations for USMEPCOM. Our study not only considers the statistical significance of our analysis but also the practical significance for recommendations of a preferable approach.

1.3 Methodology

Under certain conditions, analytic methods provide exact solutions to a problem (1:23). However, the complexity and stochastic or random nature of the MEPS applicant processing operation makes an analytical approach for this study inappropriate. A complex system, such as a MEPS, requires the need for massive computing capabilities

as the dimensionality of the problem increases (1:22). For this reason, a discrete-event simulation has been chosen as the appropriate tool of choice for our study.

Discrete-event simulation is often used as a tool to aid industry professionals to understand how a system functions and to identify areas of improvement based on a simulated model (11:476). Simulation implementation is simple and has already been tested and validated in the private sector with much success (13:1415). Simulation for this study is intuitively appealing because it can replicate what happens in the MEPS processing operation and allows for the varying of parameters without impacting day to day operations of the real system. Generated output can be compared to outputs from the actual system which enables the analysis of different variations of the system with the same objective and quantitative metrics (1:23). The first three research goals facilitate development of a simulation model for applicant flow through the MEPS. After development of the model, an iterative process for verification and validation of model structures, data input assumptions, and generated outputs will occur.

Using the verified and validated baseline simulation, adjustment to the input parameters can be made to study a variety of scenarios with the use of statistical Design of Experiments (DOE). Scenarios, for purposes of this study, are the alternative applicant scheduling approaches. DOE refers to the scientific approach to the planning of experiments so that appropriate data will be collected and analyzed by statistical methods (12:11). Our research can investigate the individual effects from varying input parameters and determine whether any of those varied factors interact with each other (12:5). The different applicant arrivals resulting from varying applicant scheduling approaches are the factors varied in our study. Moreover, use of DOE aids in

investigating the areas where resources may be potentially reallocated to improve the efficiency of the MEPS system. The efficiency of the system can be studied using metrics identified by research goal four. These metrics include throughput, time in system, bottleneck areas, wastage, and utilization of the resources among others (11:476). This methodology facilitates the development of a general-purpose decision support model and permits the development of value focused recommendations for USMEPCOM thus answering research goal five.

1.4 Assumptions and Limitations

Key assumptions are made for the simplification of the model development process. The MEPS will operate on a 5-day workweek during normal operating hours in accordance with USMEPCOM regulation 601–23. No effort will be made to model Saturday openings, MEPS closure/non-processing days, local holidays and special events, and organization days all of which impact normal operating procedures for applicant processing operations. The no-show rate is assumed to be zero. No-shows are defined as an individual projected for processing who fails to arrive on the scheduled date at the prescribed time (23:150). The reasoning behind this assumption is that USMEPCOM standard operating procedures (SOPs) and penalties generally prevent and deter such instances. The probability of unusual circumstances occurring such as USMEPCOM Integrated Resource System (USMIRS) system going down, applicant injury, and misrouted shipper medical packets is assumed to be zero. Capacities and resources set forth by current MDC/A SOPs for staff and applicants are assumed constant with no fluctuation in staffing levels due to sickness, leave, or any other unforeseen circumstances.

Our study has a number of key limitations. First, service time distributions, probabilities associated with applicant flow from one MEPS section to another, and probabilities associated with the type of service that an applicant may receive at a MEPS are estimated using one fiscal year of data, 2019. The simulation assumes these service times and probabilities can be estimated with reasonable accuracy. Although USMEPCOM collects service time data as applicants check in and check out from section to section; data is not collected for the service times for individual tasks performed within each processing sections. USMEPCOM SMEs have provided average time estimates for these activities; however, it is worth noting that this data is an estimation, and no information is given to differentiate the amount of time an applicant is being processed versus the amount of time the applicant is waiting to be serviced. To lessen the potential impact of this lack of data, our research included three familiarization visits to two separate MEPS to gather empirical data of these processes. The empirical data, along with the historical, is used extensively for the verification and validation of our simulation output. The limited sample size of the empirical data is itself another limitation. Finally, the stochastic nature of computer simulation provides an approximation of the MEPS applicant processing operation; this research attempts to statistically bound these approximations.

1.5 Thesis Organization

The remainder of this paper is organized as follows. Chapter two provides a full literature review of strategies applicable to the study of our research. Chapter three presents the methodologies applied in this research. Chapter four presents the results and

analysis generated from the simulations. Chapter five provides insights and recommendations from our analysis and proposes directions for further studies.

II. Literature Review

2.1 Chapter Overview

This chapter is organized to detail three fundamental themes of interest: previous MEPS simulation studies, techniques and policies of alternative scheduling, and heuristics and scheduling-related studies. First, we discuss the two previous efforts to model a MEPS applicant processing operation. These previous studies examine similar MEPS systems and are integral to understanding lessons learned, successful techniques, and assumptions that can be applied to our research goals. To avoid duplication of effort, the analysis of the literature will detail concepts upon which our research builds and how they aid in our own investigation. Conceptual models of the past studies are presented to contrast research approaches and to highlight the differences of past efforts to our own research. This chapter closes with the literature review of techniques and policies of alternative scheduling and scheduling-related studies utilizing discrete event simulation and heuristic approaches.

Though our objective is to provide USMEPCOM with a decision support model capturing the entire applicant processing operation, historically, the MEPS medical section is arguably the most complex section (11:475). Due to the various service activities and limited resources to provide those services, effective improvement of this section by way of split-shift, appointment-based scheduling, or a hybrid of heuristic scheduling policies may improve efficiency of the entire operation. As such, our literary research is skewed toward heuristic policies for efficiency improvement techniques concerning civilian and military outpatient scheduling strategies. It is worth noting that

every effort is made to analyze the impacts that each alternative approach has on every processing section at a MEPS. Furthermore, we detail the High Demand High Capacity (HDHC) Express Lane (ELANE) processing initiative proposed by USMEPCOM in 2018 and contrast the strategy against the use of similar fast track approaches in emergency rooms (García et al., 1995). The alternative scheduling heuristics identified in this section inform the theory for development of experimental scenarios in our computerized simulation.

2.2 Previous MEPS Simulation Studies

Discrete event simulation has been used as a tool to model the MEPS applicant process flow. Feo et al. (1992) develop a high-level MEPS applicant flow model that seeks to maximize the throughput of a MEPS and reduce or eliminate the number of applicants unable to complete enlistment processing in a single day and must therefore return on a future date to complete processing (5:36). The authors examine cost-effective resource mix requirements through the adjustment of staffing levels to meet nominal and proposed demand levels. Figure 2.1 displays the baseline model of the 1992 applicant flow presented by Feo et al. (1992). This model attempts to emulate high level MEPS activities but does not contain intra-section processing activities such as blood pressure, hearing, or vision screenings. Verification and validation of the baseline model enable the development of experimental design scenarios where subsets of staffing level mixes could be tested to meet varied applicant demand levels and provide the efficient throughput of applicants while reducing the greatest number of residuals (5:39). Rather than varying the staffing levels to meet variable quantities of batch arrival applicants as

presented in Feo et al. (1992), our methodology varies the applicant arrival strategies and quantities while assuming staffing resources reflect the levels established by the MDC/A for the quantity of applicants arriving.

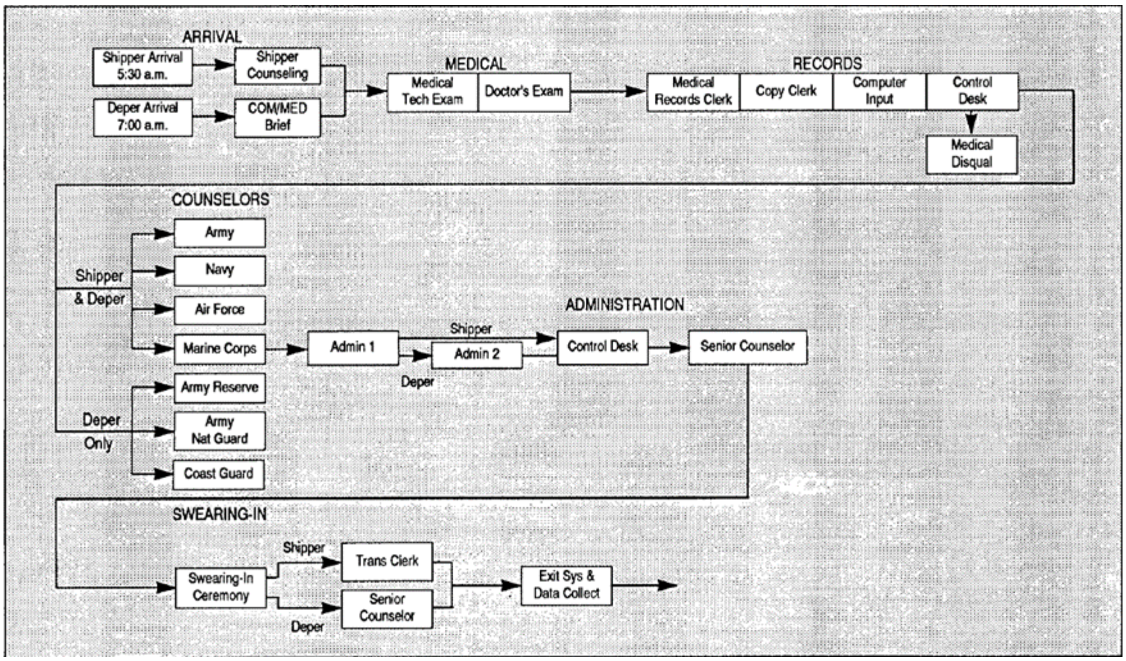


Figure 2.1. 1992 MEPS Process Simulation (Feo et al., 1992)

Feo et al. (1992) informs our research in four ways. First, the use of a minimum time plus a randomly generated sample observation from an exponential distribution with an appropriate mean for service times enlightens a path for our research in modeling similar processes (5:36). This information is pivotal in our efforts of providing answers with respect to service time distributions of various MEPS processing sections. Second, although the applicant processing sections modeled differ from our own, our research builds upon the simulation study methodologies established in their research with regards

to verification and validation of a baseline model that reflects the system currently in use. Third, the use of design of experiments to explore excursions of various scenarios and input parameters captures the essence of our attempts to provide valuable insights and recommendations towards an efficient applicant arrival schema. Fourth, the applicant types and resources made available in our research build upon those modeled by Feo et al. (1992) to include the separation of applicant gender, shipping applicants, DEP applicants, and the resources needed for applicant processing at a MEPS.

Maurina and Chakravarthy (2015) use discrete event simulation to examine the impact a stochastic applicant arrival scheme has on MEPS operations. The motivation arose out of a need for improving efficiency of the resources used in a generic MEPS (11:475). Rather than capturing a high-level model of a MEPS processing operation, Maurina and Chakravarthy (2015) focus solely on the medical examinations section. The authors establish a baseline process model of activities performed by the medical processing section, as illustrated in Figure 2.2, that examines the effects a batch Markovian Arrival Process (MAP) has on reduction of waiting times, thereby increasing the value of the time spent conducting the various medical activities (11:484). The objective was a strategy that minimized the non-value-added time associated with waiting (11:484). Various stochastic inter-arrival times for applicant arrivals via Erlang, exponential, and hyper-exponential distributions among others simulate applicant appointments enabling analysis for different applicant arrival scenarios (11:479).

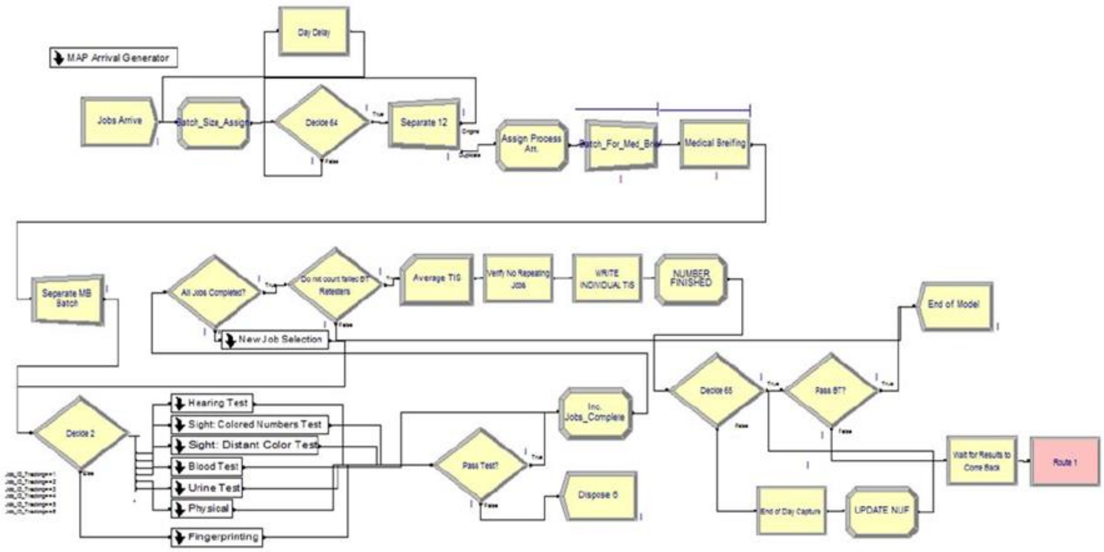


Figure 2.2. MEPS Medical Section Simulation (Maurina and Chakravarthy, 2015)

Maurina and Chakravarthy (2015) informs our study in two ways. First, the authors assume that because processing activities are located within the same general area, the walking time between one processing area to another is assumed to be negligible (11:477). The analysis leads the authors to conclude the contrary. This is an indication that the transit time from one processing activity to another within a major MEPS section contributes significantly to the total time in system an applicant spends. This result is relevant to our research because our study models several major processing sections, not just one. Due to the significance of intra-section transit time as discovered in Maurina and Chakravarthy (2015), the modeling of inter-section transit is expected to contribute meaningfully to our study and should be modeled accurately. Second, the authors introduce the concept of bottleneck analysis as a metric to measure a systems efficiency. This metric was not previously identified as a metric of interest for our study; however,

the successful utilization of this technique provides insight into possible system process improvement recommendations in our study. Overall, the assumptions made allow for the introspective examination for the validity of the modeling assumptions used in our study. Assumptions, guided by regulation and standard operating procedure, impact the quality of analysis and validity of our model and final recommendations.

2.3 Techniques and Policies for Alternative Scheduling

Policies, guidelines, and framework methods in areas of scheduling strategies, staff scheduling, and experimental design are included in our literature review. Informing our scenarios and methodology from successful theory and case studies presented in the literature establishes validity and credibility for our study. Furthermore, the inclusion of literature that establish industry standards enlightens our investigative intuition and when combined with input from USMEPCOM SMEs enables development of our alternative scheduling scenarios.

Appointment-based scheduling presents decision makers with several challenges and opportunities as the need to efficiently structure customer arrivals increases. Gupta and Denton (2008) provide a survey of appointment scheduling strategies that are commonly examined and applied in healthcare as well as introduce new concepts that inform our research. The authors introduce the concept of access rules which may be placed on the scheduling system to determine when and what type of customers can have access to services. Examples of access rules imposed by a MEPS include prioritizing applicant categories upon arrival and specifying the amount of each applicant category type a MEPS can process on a given day. Examination of MEPS access rules and

scheduling strategies provides the ability to evaluate applicant wait times to discover potential alternatives to the current operation.

Additionally, Gupta and Denton (2008) introduce factors that impact the performance of appointment systems. One key factor is that appointment systems are designed for a particular mapping of the actual patient appointment requests to a mapped arrival process (8:805). Given a length of time, or block, an appointment scheduling strategy must determine the number of customer arrivals and blocks for that scheduling period. Currently there is no variation in a MEPS arrival process because of the single batch arrival strategy. Evaluation of alternative scheduling strategies may enable the identification of any alternative strategies that may be superior to the current method of operation. Variable service times are a second identified factor that impacts the performance of appointment-based scheduling systems. Differences in patient types and variable service durations makes it difficult to determine the efficient allowance for service time requirements for appointment block scheduling (8:807). Applicant service activities can be classified as both deterministic and random in the MEPS processing operation due to the wide array of services a MEPS provides. Consideration of these key factors will inform the development of efficient alternative scenarios to use for comparison in our study. Given these important factors, Gupta and Denton (2008) discuss common solution approaches for determining efficient appointment scheduling strategies. Commonly used approaches are heuristics and simulation where heuristics are compared and evaluated via computer simulation (8:809).

Lian et al. (2010) examine the effect of improving efficiency of an appointment-based scheduling strategy by means of schedule defragmentation. The techniques for schedule defragmentation are useful because conventional appointment scheduling processes generate inefficiencies due to schedules for services containing fragmented time slots (9:127). A fragmented schedule generates difficulties for new accommodations to fill those time slots and lowers the staff utilization rate. As USMEPCOM seeks recommendations for a better way to achieve its mission via alternative scheduling approaches, issues caused by appointment scheduling fragmentation may compromise the performance of appointment-based scheduling scenarios. New accommodations, such as walk-in applicants, may not be able to receive service should a MEPS adopt an appointment-based scheduling policy that has fragmentation in the schedule. Lian et al. (2010) serves as a guiding aid for our study on allocating time slots to reduce schedule fragmentation scheduling, which in essence improves efficient use of limited resources to better serve appointment requests (9:133). The authors inform our research by providing onsite clinical survey data on the effects of the schedule defragmentation method in four clinics (9:130). Furthermore, information is gathered on the effectiveness of schedule defragmentation through the use of simulation modeling to assess performance metrics of proposed appointment scheduling process, the effects of time slot size, number of appointment requests, and the distribution of service times (9:128). Analysis of the simulated data and clinical surveys determined that schedule defragmentation will be most helpful for clinics that accept walk-ins and/or online booking and have a distribution of different appointment times (9:132). This information informs our study because, as established, a MEPS has the capability to

process walk-in applicants in addition to the projected applicants in USMIRS. A MEPS, with its mix of applicants, in conjunction with various service times based on the category and gender of an applicant, may theoretically benefit from the schedule defragmentation method during analysis of alternative scheduling scenarios.

Morgareidge (2015) establishes policy for simulation development to examine private sector and U.S. military healthcare systems (MHS). The author examines why simulation is the unrivaled design methodology recommended for the MHS and not a less rigorous approach to math programming techniques (13:1415). According to the author, the need to evaluate alternative design options and compare these alternatives using the same metrics to the system already in operation are the main reasons to implement simulation as the design methodology of choice (13:1416). The reasons provided by the author are in complete harmony with the reasons to adopt simulation as the preeminent design methodology for our study.

Furthermore, Morgareidge (2015) discusses influential factors that significantly influence the scope of a simulation. The influential factors, as identified by the author, affecting a simulation’s scope are the number of service departments, the number of unique entity types, and the number of scenarios to be simulated (13:1421). The different applicant category types (e.g. male or female shipping applicants and male or female DEP applicants), are substantial influencers for the scope of our simulation. For example, shipping applicants when compared to DEP applicants, travel through the system utilizing different MEPS resources or use the same MEPS staffing resources but for different lengths of time. Each applicant category type requires specific effort for

data collection, data analysis, simulation logic development, and reporting (13:1421). The complexity of the MEPS processing operation grows when considering all the applicant category types and major processing sections needed to complete enlistment processing. Furthermore, the number of alternative scheduling scenarios that are developed need to encompass every detail from which our baseline model analysis is evaluated.

Rashwan, Fowler, and Arisha (2018) developed a multi-method scheduling framework for medical staff that examines staffing levels and shift schedules that minimize understaffing and overstaffing needed to meet demand. Rashwan and others (2018) informs our research because we seek to identify a best alternative, if any, to the current USMEPCOM applicant arrival strategy given MEPS staffing constraints. The authors establish a framework theory from which our research can build scheduling scenarios that not only reduce applicant waiting time or increase throughput but are also feasible implementation from a staffing point of view. Moreover, the authors argue that improving efficiency of a staff schedule can play a fundamental role in enhancing the performance of organizations (16:1465). Finding the right balance of supply and demand is essential for work planning efficiency particularly for MEPS processing operations. The correct number of staffing resources need to be available to perform enlistment services to prevent bottleneck issues that arise from understaffing. Additionally, overstaffing MEPS resources may lead to excess idle time and poor utilization rates. Rashwan and others (2018) conclude that variability among processes, applicant flow rules, physical capacities and uncertain arrivals are significant factors that influence the staffing and scheduling decisions (16:1466). Lastly, the authors conclude that the most

efficient staffing pattern to meet demand utilizes variable shift lengths with flexible start times (16:1473). Enlightened by these conclusions, our study increases the opportunity of creating and identifying better recommendations for alternative scheduling strategies for implementation. The developed framework provides informed decisions regarding staffing and scheduling as a guide to create feasible alternative scheduling strategies supported by appropriate staffing resources.

An efficient experimental design is critical for evaluation of our alternative scheduling approaches. As such, Simpson et al. (2013) provide a framework for implementing and assessing a well-designed experiment provides solid theory that informs our research. Used concurrently with simulation, experimental design can be used to mitigate risk by revealing problems early in system design or operation (19:334). Identifying significant contributing factors, whether positive or negative, is an essential process for development of our study's scenarios as well as the subsequent analysis of those scenarios. Factors for our study, among others, include applicant arrival intervals, the times in which applicants arrive as well as the number of applicants arriving. The metrics identified in research goal four are used as our response variables from which alternative scheduling strategies can be evaluated and compared. Additionally, Simpson et al. (2013) propose a rigorous experiment planning process that our study follows to improve and evaluate our testing adequacy. Within the planning phase of the guideline, the authors stress the importance of stakeholder involvement when developing scenarios for testing (19:336).

USMEPCOM has provided SMEs to aid in our research and provide information for the development of our alternative scheduling scenarios. Simpson et al. (2013) emphasize the importance of screening tests for identification of significant factors. Typically, very few factors affect system performance, and the use of screening tests allows the experimenters to concentrate on only those factors that are significant toward a response (19:346). This informs our research because as scenario development includes factor levels, eliminating insignificant factors will allow our research to concentrate on designing scenarios that significantly affect the MEPS processing operation. By concentrating on the significant factors, our analysis allows us to identify scenarios that inflict the greatest positive or negative change to the applicant flow with fewer scenarios. Furthermore, DOE provides our research with the ability to calculate and report uncertainty intervals such as confidence and tolerance intervals for the expected performance of factor settings to USMEPCOM (19:350). While there are risks involved with any prediction, confidence intervals reduce the risk for decision makers through statistical analysis of response variable metrics. The future performance can be bounded in an interval where the expected performance of the system is expected to fall for a given confidence level. The application of a DOE for our research provides distinctive capabilities that separate it from other test strategies and benefits from the planning process detailed in this guideline.

2.4 Heuristic and Scheduling-Related Studies

Heuristic sequencing strategies coupled with SME experience will play a prominent role in the development of the alternative scheduling strategies for our research. Finding a balance between a customer's waiting time against a service provider's idle time is a difficult problem to solve by mathematical programming methods; thus we must rely on heuristic methods (17:295, 4:944). Although heuristic methods generate solutions of a variable degree of "goodness", these methods offer the only practical means to obtain feasible solutions toward large complex problems such as the MEPS applicant processing operation (4:944). Since heuristic methods provide starting solutions from which we can build, our research aims to limit the degree of uncertainty for the expected best and worst performances of these methods when compared to more efficient policies. Our research has identified two papers in which empirically based heuristic policies for scheduling are compared to efficient policies (Davis and Patterson, 1975), (Robinson and Chen, 2003). These studies inform our research by validating our use of heuristic methods toward development of our study's alternative scenarios as well as establish general performance estimates relative to efficient scheduling policies. Davis and Patterson (1975) conclude that the most significant factors that affect a heuristic's performance relative to the optimum is the interaction between project complexity, as measured by the number of activities, and resource requirements for those activities (4:952). This conclusion is significant for our research because given the numerous processing activities and the resources needed, we can expect the interaction between these factors to hinder our heuristic's performance. This means that the analysis of our metrics for the alternative scenarios developed may

deviate from the most efficient policy solution. The authors caution that this conclusion does not constitute a theory, however, these factors are worth investigating in our study (4:952). Through the use of DOE our study increases the probability of identifying significant factors influencing metric responses, thus validating, or discovering the contrary to Davis and Patterson (1975).

Furthermore, Robinson and Chen (2003) show that heuristic solutions on a best-case scenario perform within 0.5% of the most efficient policy while having a worst-case scenario performance within 20% of the most efficient policy (17:306). This conclusion is significant for our future analysis and toward the validity of our conclusions. To establish a test bed for heuristic policies the authors develop their scenarios to include scheduling up to a maximum of 16 patients (17:300). Since a MEPS currently processes applicants in batches, the inclusion of such a high number of patients in the test bed for evaluation of heuristic performance is notable for our research. This is because the high number of patients included in the test bed enables similar experimentation of equivalent and or more numbers in our study. Additionally, Robinson and Chen (2003) test the robustness of heuristic-based policies for service time distribution misspecifications. The authors conclude that the developed heuristic policy performed only slightly worse when given a service time distribution misspecification (17:305). This conclusion informs our study because, given the lack of service time data for our research, service time distribution misspecification may not significantly influence the metric responses. Heuristic-based methods have been shown to have a small divergence from more efficient strategies, but for purposes of our research heuristic-based policies offer the only

tractable means for identifying feasible solutions for the response metrics in our alternative scheduling scenarios.

The ability of an operation to satisfy the demand constrained by limited resources and service capacities introduces an operational challenge to decision makers. USMEPCOM is not unique in its quest to improve performance through the investigation of alternative arrival schema. Baril, Gascon, and Cartier (2014) examine an outpatient clinic seeking to reduce waiting times for patients while maintaining an acceptable utilization rate for the medical staff. Like a MEPS, this outpatient orthopedic clinic processes patients requiring multiple processing activities with limited resources and capacities during a fixed workweek schedule. The authors examine interactions between patient flow types, resource capacity, and appointment scheduling rules guided by heuristic scheduling rules to improve performance (2:286). To study the interactions between patient flows and scheduling rules, the authors conduct an experimental design of four decision factors and analyze their impact on performance metrics (2:289).

A significant conclusion from Baril and others (2014) is given a mixture of patient categories that are determined by the required processing activities, the most efficient appointment scheduling rule is to schedule patients in a way that a patient is always available when the orthopedist is ready. Additionally, throughout their experimentation, the authors discover that the status quo strategy for scheduling patients never minimizes the patients total time in system (2:292). These results are significant for our study because the mixture of applicant categories and the batch arrival strategy used by MEPS ensures that applicants are always available in a queue waiting to be seen

by a provider when he or she becomes available. This is typical for not only the medical section but is applicable to the service liaison / guidance counselor (SL/GC) offices and operations processing sections as well. This strategy aligns with an efficient rule for scheduling a mixture of patients requiring different flows discussed in Baril and others (2014). While this scheduling strategy may be efficient for the throughput of applicants and utilization rates for the staff at a MEPS, the applicant time spent waiting to be processed contributes significantly to the overall time spent in the processing system. This is consistent with the conclusions in Baril and others (2014). Overall, modifying scheduling rules allows the potential for a significant reduction of waiting times without affecting the number of applicants processed (2:297).

Improving patient flow is a major theme identified during literary research of outpatient clinics. Findlay and Grant (2011) examine a Troop Medical Clinic (TMC) in Fort Sill, OK to identify issues typically experienced by a civilian clinic and the appointment based or subset hybrid scheduling strategies that are used to alleviate these issues. Findlay and Grant (2011) is unique in that the authors apply experimentation of these techniques to improve a military clinic. However, unlike a MEPS, the TMC has no foreknowledge of who will be seeking care on any given day because the TMC baseline SOP handles patients on an exclusively walk-in basis (6:1166). A MEPS typically has a projected number of applicants that will arrive on a given day allowing a MEPS to allocate resources as established by the MDC/A to meet those projections. The TMC draws a unique parallel to a MEPS in that patients are transported by their training unit to the clinic, so arrivals occur primarily in batches (6:1168). Current MEPS transportation infrastructure limit SOP to transporting applicants in large groups resulting in batch

arrivals at a MEPS. The TMC provides an assortment of multi-step processing services following check-in at a triage station resulting in diverging flows with stochastic service times (6:1169, 1172). The motivation of the literature was the speculation that there may be better alternatives to operate the TMC and as a result Findlay and Grant (2011) evaluate current policies and potential alternatives using discrete-event simulation (6:1166). The motivation and research effort along with the processing activities correlate directly to our own research objectives and efforts.

The study of the TMC in Findlay and Grant (2011) yields interesting analysis, some of which applies to our research for USMEPCOM. The evaluation of a solely appointment-based model for the TMC caused a significant reduction in provider utilization while minimizing the average time in service resulting in a conflicting tradeoff of objectives (6:1175). Additionally, the authors conclude that the use of a 100% appointment-based system for the TMC is not practical. This is because training units would need to transport Soldiers to individual appointments. In an environment where resources and time are limited, this would lead to training units bringing Soldiers with appointments all at once (6:1175). The authors rationalize that this will result in Soldiers with earlier appointments experiencing faster service, thus limiting their overall time in the system. However, those Soldiers with later appointment times would simply wait on the benches positioned conveniently outside of the TMC's front entrance (6:1175). These Soldiers would not be checked into the system until their appointment times, hence allowing them to experience a shorter time in system to be serviced, but they would not experience any actual time savings due to waiting outside (6:1175). There would be no difference between the appointment model and status quo batch arrival scheme, so

patients would still be treated as walk-in arrivals, thereby relegating the appointment structure obsolete (6:1175). Like the TMC, MEPS lacks a robust transportation infrastructure to transport applicants to individual appointments potentially plaguing the implementation of a 100% appointment-based strategy.

Findlay and Grant (2011) also examine the impact a lunch break period has on patient flow. The SOP mandates that when the lunch period starts, patients present in the TMC not actively receiving service should be asked to leave (6:1169). The patients return after the lunch break to receive service, but their position in the queue was not preserved (6:1169). Furthermore, patients whose service was interrupted by the lunch break did not immediately return at the end of the lunch period (6:1172). The authors investigate several alternatives to alleviate the effects the daily lunch break has on patient flow. To this end, Findlay and Grant (2011) identify a staggered lunch and hybrid scheduling alternatives such that staff resources would always be available in the TMC to provide service to Soldiers during the lunch break period. These alternative results in a significant reduction in average TIS with no decrease in average provider utilization (6:1175). Similar lunch activities occur during the processing day at a MEPS which offers the potential for examination in our research to pursue alternatives to improve applicant flow issues that may be caused by this practice.

The outpatient examples discussed do not involve situations with the mixture of batch arrivals and walk-ins for multiple entity categories or the complex multi-stage processing activities conducted in a MEPS. This makes the MEPS applicant processing operation unique among those studied in the literature. Clearly, applications to outpatient

clinics, both civilian and even military, do not provide a complete basis of heuristic scheduling alternatives, metrics, or methodologies for understanding the MEPS processing system.

In 2018 USMEPCOM proposed an SOP for use of an express lane for applicant processing (USMEPCOM HDHC, 2018). This SOP established procedures for utilization of additional medical manpower and to explore ways of administering flexible, adaptable, and tailored processing for select applicants (25:2). MEPS leadership would need to discern if staffing requires an existing government physician or whether an additional dedicated ELANE FBP would be needed for processing activities (25:4). This is significant because this SOP shows that, prior to our research, USMEPCOM had already began to experiment with alternatives ways to process applicants in search of a more efficient means of conducting operations. USMEPCOM's ELANE SOP incorporates many of the methods and techniques for patient processing examined in the literature (Gupta and Denton, 2008), (Lian et al., 2010), (Morgareidge, 2015), (Rashwan and others, 2018). By utilizing a cross-trained staff with flexible shift scheduling, USMEPCOM experimented with a split-shift applicant arrival strategy. ELANE processing established a two-day schedule for applicants and imposed the requirement that applicants must already have a qualifying ASVAB score before their arrival to a MEPS (25:3). ELANE processing began within a certain time window on the first day that was reserved for full medical examinations and one additional processing activity (25:3). On the second day, processing began immediately upon opening of a MEPS to complete the remainder of enlistment processing activities resulting in an applicant entering the DEP (25:3).

Additionally, ELANE processing draws direct parallels to similar "fast-track" processes used in emergency room (ER) departments like the (Garcia et al., 1995). Like the ELANE proposed by USMEPCOM, use of a fast track in ERs provides a dedicated service to a particular type of patient with the intent of reducing their waiting time (7:1048). Through the development of alternative scenarios and simulation analysis, the authors conclude that select categories of patients greatly benefit from fast-track implementation (7:1052). Moreover, processing patients experiencing less severe ailments through the fast track did not negatively impact the wait time and TIS of patients with more severe ailments (7:1052). This conclusion informs our research because this indicates that ELANE/fast track implementation is an appealing alternative for applicant processing at a MEPS. Furthermore, examination of staffing level metrics indicated that current staffing resources could be used to supplement the fast-track resources and the inclusion of the fast-track did not require any modification to the physical layout of the ER (7:1052). The findings from Garcia et al. (1995) inform our research because as previously discussed, MEPS leadership decides whether to request an additional FBP or utilize existing government physicians for ELANE processing. Should MEPS leadership decide to utilize a physician already on staff, no additional costs of hiring new physicians will be incurred. Since ELANE processing utilizes an existing MEPS layout, no additional alterations to the physical layout to a MEPS or costs will be incurred to incorporate ELANE processing operations. Simulated studies conducted by our research seeks to determine whether ELANE processing is a viable alternative for MEPS operations.

III. Methodology

3.1 Chapter Overview

This chapter is organized to detail the methodology applied toward model construction and analysis. A general application decision support model of the MEPS applicant processing operation was constructed via a discrete event simulation and employed to analyze alternative applicant scheduling approaches. The model is envisioned to be applied toward proposed policy changes in general and to evaluate the impacts these changes have on applicant processing operations at a MEPS. Simio was chosen as the discrete event simulation software for model implementation. This chapter provides details for the following: model description, modeling assumptions, data discussion, model development, model limitations, variance reduction techniques, model verification and validation, and development of alternative applicant arrival scenarios.

3.2 Model Description

The simulation models applicant processing operations of a small, medium, or large MEPS, where size categories are determined by processing volume and influence model parameters such as resources available to process applicants. For an in-depth treatment of MEPS function and flow refer to Appendix A. The model can simulate a single processing day or any timeframe spanning an entire fiscal year. The applicants, henceforth referred to as model entities, arrive at various times during the simulation run according to the entity type. Processing begins at 0600 and generally concludes at 1630. Entities that have not completed processing at 1630 will be identified as a "holdover" and reneged. These entities are removed from their current paths, servers, or queues and are

vectored to a holdover sink to be tallied and removed from the system. Entities occupying the service liaison servers and paths are reneged at 1645 rather than 1630. This time differential simulates the service liaison's attempts to finish the processing of an applicant prior to the end of the processing day. Upon completion of processing, an entity exits the system thus assuring the system begins a new processing day in an empty and idle state.

The simulation model consists of three primary sections: aptitude, medical, and operations. To model applicant qualification, entities processing through select sections receive a state variable value of zero or one. A value of zero simulates the instance that there was no disqualifying issue discovered. A value of one simulates a disqualification utilizing alternative disqualification flows and logic. State variables are assigned using the discrete empirical distribution each with their own probabilities.

3.3 Primary Model Modules

The three primary applicant processing modules are the testing, medical, and operations section modules. The testing module, denoted TST, consists of one server object. This server employs the state variable, TSTProcessingTime, for entity processing. Entity processing times are assigned according to an entity's tester category and service branch. An entity's assigned service branch dictates which exams an applicant is administered, and its tester category dictates the processing times. Modeled service branch specific exams and tester category descriptions can be found below in Table 3.1 while testing section processing times and processing distributions can be found in Appendices G and H.

Table 3.1. Simulated exams by service branch and tester categories

Required Exams by Service Branch

Exam	Service Branch
ASVAB	Air Force, Army, Coast Guard, Marines, and Navy
Tailored Adaptive Test	Air Force, Army, and Marines
Cyber Test	Air Force, Army, Marines, and Navy
Mental Counter	Navy
Coding Speed	Navy

Applicant Testing Categories

Category	Description
0	Requires administration of a full ASVAB plus any required service specific tests
1	Requires administration of the PiCAT for test score verification plus any required service specific tests. 5% require the administration of a full ASVAB
2	Requires administration of a full ASVAB

The medical module has many diverging flows for processing according to the entity type and medical qualification status. Additionally, the medical section consists of several gender specific processing servers where, historically, female applicants require longer or additional services. Often, female medical processing activities require additional resources and processing capacities may be reduced during these activities. Furthermore, select processing activities in the medical section require the entities to be processed as a single batch of varying sizes. Using combiner nodes and combiner objects in conjunction with separator objects, the model simulates batch processing elements. A full list of medical section server objects, processing time distributions, resources required for processing, and capacities can be found in Appendix I.

The service liaison and operations section are modeled as one module that consists of a server object for each service branch and flows in the operations section according to the entity type. Entity flows diverge due to medical qualifications assigned upon an entity's exit from the medical section. While the medical section is arguably the most complex module in the simulation, the service liaisons are the most complex single server objects regarding logic and processing times. Entities process through the operations section using one of two processing flows with intermediate visits at the service liaison server. Combiner and separator objects replicate batch processing activities. A complete list of module servers, processing time distributions, resources required for processing, and server capacities for the operations section can be found in Appendix J while service liaison information can be found in Appendices K-M.

3.4 Model Sources

There are 14 source objects used to create the various entities modeled in our simulation. Each source assigns specific state variables to an entity upon creation providing a list of attributes an entity possesses during a simulation run. Table 3.2 displays the source objects and their assigned attributes. These attributes, such as gender, service branch, or tester category, are integral to the model's internal routing and processing logic. Additionally, each source employs a timer element to generate entities for each day of the week. Furthermore, each source object utilizes different arrival mode logic for entity creation. This section details each source's purpose, timer elements and arrival modes used for entity creation, and each source's capabilities and limitations.

Table 3.2. List of source objects and the attributes each source assigns

Source Object	Number of Sources	Arrival Mode	Attributes Assigned
DEP Source	5	Event Timer	Gender, Service Branch
Ship Source	5	Event Timer	Gender, Service Branch
ELANE DEP Source	1	Event Timer	Gender, Service Branch, Express Lane
SDP Source	1	Event Timer	Gender, Service Branch, Tester Category
Night Test Source	1	Rate Table	Service Branch, Tester Category
MSN Day Source	1	Arrival Table	Gender

Gender attribute: Male = 0, Female = 1
Service Branch: Air Force = 0, Army = 1, Coast Guard = 2, Marine Corp = 3, Navy = 4
Express Lane: Bypass CCBrief server = 1, Bypass CCBrief and MedBrief servers = 2

Delayed entry program (DEP) and ship sources account for 11 of the 14 sources used in our model. Historically, DEP and ship applicant arrival ratios change as a processing week progresses. Typically, there are more ship applicant arrivals than DEP applicant arrivals earlier in the week. As the week progresses, the number of DEP applicant arrivals increases while ship applicant numbers decrease. To model these changes in applicant ratios, a source for each day of the week was dedicated for DEP and ship entity creation. The arrival mode for these sources is deterministic, with timer elements governing the logic for number of and time between arrival windows.

Each DEP and ship source assigns entity attributes to all entities created from the source. As displayed in Table 3.2, the attributes assigned by these sources provide a dual purpose for entity modeling and are assigned using a discrete probability distribution. First, the gender mix distribution assigns a gender proportion to the entity population created from the source. The distribution, Random.Discrete (0, 0.77, 1, 1), assigns a

proportion of zero 77% of the time and a one the remaining 23% of the time. A gender attribute of zero simulates the creation of a male entity while a one simulates a female entity as displayed in Table 3.2. This distribution reflects accurate entity populations according to historical data as well as provides the capability to route entities to gender specific activities. A second attribute assigned by the DEP and ship sources, the service branch mix, assigns a proportion of service branch attributes to the entity population. The discrete empirical distribution, Random.Discrete(0, 0.1627, 1, 0.6354, 2, 0.649, 3, 0.8191, 4, 1), captures historical population data for applicant processing of each service branch. Zero indicates the creation of an entity processing for the Air Force, one indicates an Army entity, two is a Coast Guard entity, three is a Marine Corps entity, and four is a Navy entity as displayed in Table 3.2. Gender and service branch proportions can be altered for each day of the week providing flexibility to model alternative scenarios for different proportion mixes of each attribute.

The DEP express lane (ELANE) source assigns a ELANE attribute in addition to gender and service mix attributes. DEP entities are created from this source when evaluating alternatives with one or two DEP arrival windows and the express lane state variable is set to either a one or two. These attributes enable different entity routing in the transfer guide or medical output nodes according to the express lane scenario being modeled.

The same day processing (SDP) source uses the same arrival mode logic as the DEP and ship sources. However, because same day processing applicants typically only process at a MEPS on the first processing day of the week our model contains only one

same day processing source that creates entities on Mondays. This source possesses all the experimental features used for the DEP and ship sources and assigns the same gender and service branch proportions. Same day processing entities must also process at the testing module, so an additional tester category attribute is assigned using the empirical distribution Random.Discrete(0, 0.6125, 1, 0.975, 2, 1).

The night tester source creates entities Monday through Thursday using a rate table arrival mode. Rate tables provide the capability to model non-homogenous arrival rates governed by a Poisson process during different time intervals. The rate tables were constructed to provide 48 separate intervals allowing our team to model arrivals in 30-minute time windows. Each created entity is assigned a service branch and a tester category using the same empirical distribution used to assign the SDP tester category mix. The night tester source is programmed to begin entity creation at 1330 and cease at 1700. Separate rate tables were constructed for small, medium, and large MEPS. Reference properties provide the capability to alternate between size categories during experimentation. While providing unique arrival schemes, rate tables limit the experimental features available. As a result, alteration of the number of arrivals in a time interval or alteration of time windows for entity creation must be done prior to beginning an experimental run.

The mission (MSN) day source utilizes USMEPCOM's fiscal year 2022 operating schedule and an arrival table for mission day entity creation. An arrival table was chosen to model mission day applicant arrival because it provides the flexibility to model the irregular date patterns of USMEPCOM mission days. In the simulation, the arrival table

contains two columns. The first column indicates which MSN day entity will be created and the second column provides the date and time for entity creation. This source assigns a gender attribute, and all MSN day entities are created at 0600. Reference properties provide the capability for experimentation with the number of mission day entity arrivals for each entity type. Upon expiration of the current table, creation of a new arrival table is relatively trivial ensuring the ease of future maintainability for this feature. While use of an arrival table to model these entities provides the capability to simulate an entire fiscal year, the deterministic nature of the arrival scheme limits the experimental features available.

3.5 Model Entities

The model provides the capability to simulate applicant processing for nine different applicant types whose main modeled attributes and their associated priorities for routing and server utilization are listed in Table 3.3.

Table 3.3. List of entity types and main attributes

Model Entity Type	Attribute	Priority
DEP Applicant	Gender and Service Branch	4
Ship Applicant	Gender, Service Branch, Tester Category	1
SDP Applicant	Gender and Service Branch	2
Night Tester	Service Branch and Tester Category,	5
All MSN Day Applicants	Gender	3

All DEP entities are assigned an initial priority of four and arrive to the MEPS in a single batch when created at 0600 during the simulated day. The priority reflects the prioritization given to different categories of applicants by the MEPS staff upon arrival.

Entities with a smaller priority value are processed ahead of other entities at critical servers during a simulation run. Typical flows for the DEP entity can be found in the conceptual models in Figures 3.1 and 3.2.

Like DEP entities, the ship entities are created from dedicated source objects at 0600. Ship applicants maintain the highest prioritization for processing at a MEPS location and as such are assigned an initial priority of one. Typical flows for the ship entity can be found in the conceptual models in Figures 3.1 and 3.2.

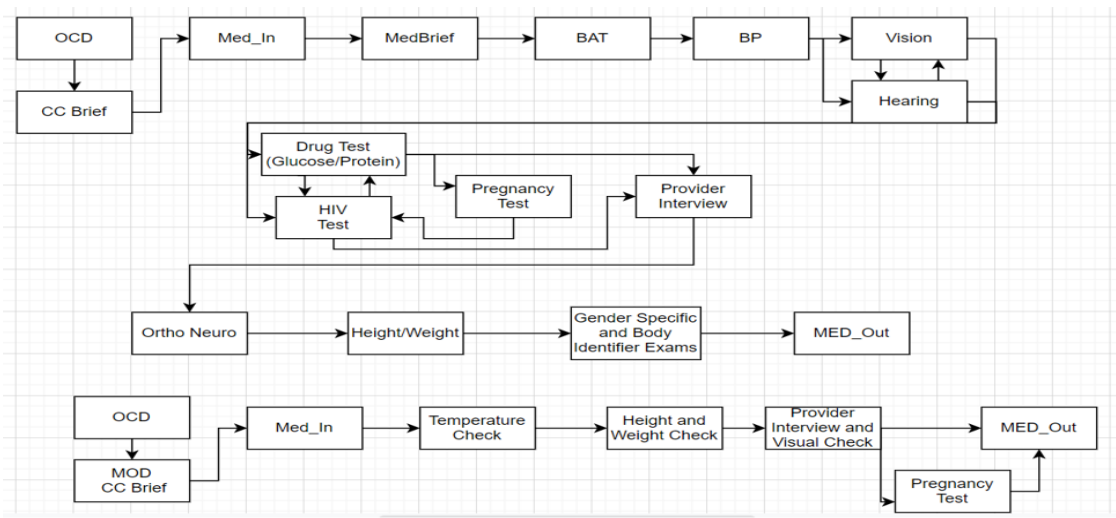


Figure 3.1. Medical section conceptual model for DEP and Ship flows

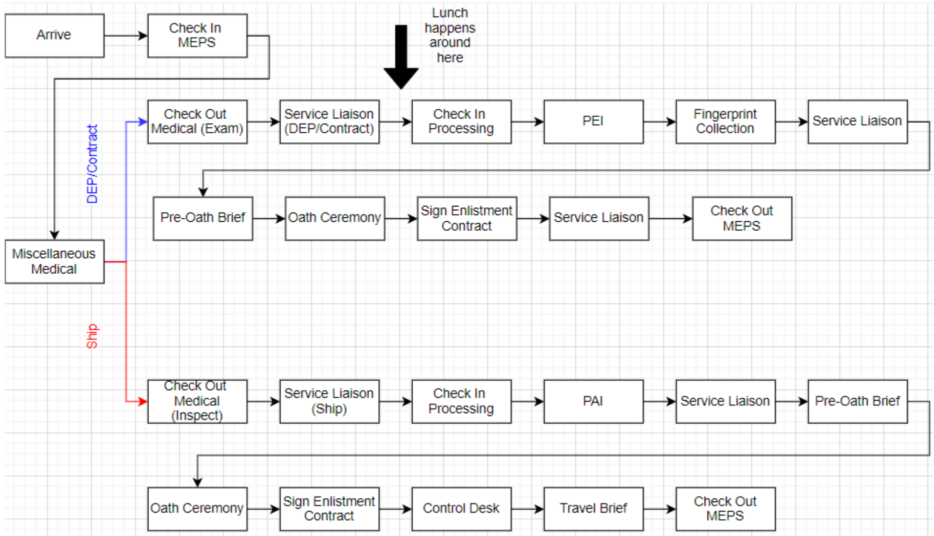


Figure 3.2. Service liaison and operations section conceptual model for DEP and Ship flows

The SDP entities are created from a dedicated source object at 0600. SDP applicants receive an initial priority of two for model processing. The SDP entity follows the same initial sequence assigned to the DEP entity. SDP entities exit the medical section and are routed to the testing section server after processing at the BP server. These entities re-enter the medical section after processing at the testing server to complete medical processing. Processing of an SDP entity from this point follows the same flow as the DEP entity and exit the system using the MOT_DEP sink.

The MSN day entities are created from a dedicated source object at 0600. MSN day entities are given an initial priority of three for model processing. There are five MSN day entities modeled in our simulation and are listed as follows: Army Active, Army Reserve, Army National Guard, Marine, and Navy. These entities follow the same routing flow and logic as the DEP entity. However, because MSN day entities are

specific to a service branch, these entities are created with an assigned service and do not require the service branch attribute for processing. MSN day entities exit the processing system through the MOT_DEP sink.

The night tester entity is created randomly from a dedicated source between 1330 and 1700 and is assigned a priority of five for model processing. The night tester entity possesses a unique initial sequence and is routed to the testing server after exiting the OCD server. Typically, the night testing window for processing begins at 1400 and closes at 1700. In the simulation model, night testing entities may arrive to the processing system prior to the start of the night testing window. This is designed to simulate the random arrivals of a night test applicant to a MEPS location prior to the start of the night testing window. Should this scenario occur during a simulation run, an entity waits at the input buffer of the testing server until 1400 when the night testing resource becomes available. Entity processing logic directs the server and night testing resource to complete all entity processing, after which the entities are routed back to the OCD where they exit the system using a MEPS out test sink.

3.6 Model Resources

This section details the methodology used for modeling MEPS applicant processing staff. The simulation model utilizes 12 unique resource objects. Each resource is assigned daily and weekly work schedules, which dictate the resources availability for entity processing. Each resource is assigned a value governing the number of each resource available according to the size category of the simulated MEPS. These values are in accordance with the staffing numbers modeled in USMEPCOM

medical and operations manpower models. The complete list of resources available and their values for each size category can be found in Appendix N.

The night test and SDP test administrator resources model the testing section staff at a MEPS. The night test administrator resource is made available for processing during the night tester entity arrival window. This resource is assigned a Monday through Friday work schedule with no variation in the number of test administrators available for a given size category of a MEPS. The SDP test administrator resource is available on Monday for SDP entity processing. Like the night test administrator, the number of available SDP test administrator resources does not change when alternating between size categories of a MEPS.

The enlistment officer resource models the military commissioned officer staff at a MEPS. This resource is required for processing in the enlistment ceremony server and the sign enlistment contract server. This resource is assigned a Monday through Friday work schedule and is available during applicant processing hours. We assume that each MEPS would have at least two commissioned officers at each location, regardless of size categories.

The travel assistant resource models the travel assistant staff at a MEPS. This resource is required for processing in the travel brief server and is assigned a Monday through Friday work schedule. One travel assistant resource is required since entities are batched prior to their processing at the travel brief server. There is no variation in the number of travel assistant resources available when alternating between MEPS size categories.

The number of available HRA staff is modeled by two separate resource objects. First, the HRA OCD resource models the HRA staff manning the control desk at a MEPS. Typically, the HRA staff at a MEPS are crossed trained to perform every processing activity; however, during a simulation run, a proportion of HRA staff are permanently dedicated to processing entities at the OCD and operations in (OPSIn) servers. Modeling the staff in this manner reduces the total number of HRA staffing resources available for other processing activities elsewhere in the simulation. HRA OCD capacities are three, two, and one for a large, medium, and small MEPS, respectively.

The processing HRA resource object is the second HRA resource in the model. This resource models the pool of remaining applicant processing HRA staff at a MEPS. The processing HRA resources are required for processing at the Commander' brief, modified Commander's brief, PEI, PAI, fingerprints, and pre-oath servers. Both the HRA OCD and processing HRA resources are available for entity processing Monday through Friday. The daily work schedule for the processing HRA resource staggers the number of staff available throughout the simulation run, replicating the staggered shift start and end times for HRA employees at a MEPS. From 0600 to 0800, a small portion of processing HRA staff are available to process entities when they first arrive to the system. During the main processing window, from 0800 to 1430, the processing HRA staff is at maximum manning. Starting at 1430 the number of available processing HRA resources decreases until all staff conclude the workday shift at 1630. The number of maximum processing HRA available for a large MEPS is nine, four for a medium, and three for a small MEPS.

The number of available medical technicians is divided into three separate resource objects. First, the Med Desk resource object replicates the medical desk personnel required to process applicants checking in and checking out of the medical section of a MEPS. Unlike the HRA OCD resource, Med Desk resources are not assigned a permanent proportion of medical technicians for manning of the Med In and Med Out servers in the model. Instead, Med Desk resources may be seized by other servers within the medical section of the model. Modeling the medical resources in this manner allows our model to replicate the cross trained capability for all medical staff to perform all medical processing activities at a MEPS.

The remaining two medical technician resources modeled are the male and female medical technician resource objects. These resources model the male and female medical technician staff within the medical section at a MEPS. Technician staff gender is modeled to enable seizure of a specific gender to process entities of the same gender during the gender specific activities in the medical section. For example, a female medical technician resource will be seized during female entity processing in the female drug and pregnancy test servers. Non-gender-specific processing activities permit the seizure of a male or female medical technician for entity processing. The maximum number of available male and female medical technicians at a large MEPS is seven and six respectively. At a medium MEPS, four male and four female medical technicians are modeled. For a small MEPS, two male and two female medical technicians are modeled. Like the processing HRA resources, the medical technician resource daily schedule is staggered to model differences in shift start and end times. A small proportion of medical technician staff is available from 0530 to 0730. During the primary processing hours of

0730 to 1400, the maximum number of medical technician resources are available for entity processing. Beginning at 1400 the number of available medical technician resources decreases until all staff conclude the workday at 1600.

The medical provider and FBP resources model the remaining medical staff required for applicant processing at a MEPS. The provider resource simulates a chief medical officer and assistant chief medical officer typically available at MEPS locations. For modeling, a large and medium MEPS is assigned the availability of both a chief medical officer and an assistant chief medical officer. A small MEPS is assigned the availability of only the chief medical officer resource. FBP resources simulate the availability of fee-basis providers for applicant processing. Fee-basis providers typically augment the full-time provider staff according to the number of DEP and ship applicant arrivals hence influencing the number of FBP resources available. To accurately model the resulting number of FBP resources required for processing in response to shifting arrival ratios, the model allows for a user defined parameter altering the number of FBP resource availability for each day of the week.

The chaperone resource is the last resource object modeled. This resource is designed to simulate the augmentation of medical staff with non-medical MEPS staff for trivial medical processing activities during periods when medical staff are unavailable. Currently, the baseline model allows the seizure of a chaperone resource at the gender-specific exam server. However, as USMEPCOM seeks to make improvements to its processing operations, future consideration for using a chaperone for more processing activities has been discussed. The inclusion of the chaperone resource enables

USMEPCOM to examine potential policy changes and to analyze impacts with regards to its use of chaperones in a simulated environment prior to full scale implementation.

3.7 Model Assumptions

Modeling assumptions limit the scope of a simulation and provide a modeling simplification to a complex process. Assumptions include the decision to not model exception to workdays such as Holidays and non-processing days. We determined that inclusion of such instances would degrade the concept of a general-purpose model that could be utilized repeatedly from year to year. Our study makes no attempt at modeling differences of service times between size categories. We assumed that applicant processing times for a specific processing activity at a large MEPS takes the same amount of time at a medium or small MEPS. The exception to this assumption is the applicant processing time at the service liaison servers, where applicant processing is both service and size dependent. No attempt was made to measure or model the differences in service times between medical providers or between medical providers and FBPs. High fidelity medical instances such applicant fainting at the conclusion of providing a blood sample or an applicant's inability to provide a urine sample in a timely manner are not modeled. A lunch period was not modeled in our study. It was assumed that applicant lunch periods were indirectly captured during the waiting periods entities experience at the service liaison or travel brief servers. All assumptions were deemed either negligible or inconsequential by USMEPCOM and AFIT subject matter experts.

3.8 Data

The data used in this study was collected by the automated USMEPCOM Integrated Resource System (USMIRS) in fiscal year 2019 for all 65 MEPS operations. The timeframe captured by this data is 1 October 2018 to 30 September 2019. This data set contained 4,724,647 individual observations and tracks an applicant's flow from processing section to processing section. USMIRS data, while abundant, presented a distinct challenge for its use due to the lack of granularity within the data. USMIRS provides a timestamp to an individual applicant ID as the applicant arrives and exits a processing section, however, no data is collected on the intermediate activities between these events. Figure 3.3 is a sample of the cleaned USMIRS data capturing an applicant's medical processing times, sex, service, and next processing section. Data validity techniques during model construction were applied to ensure appropriate, accurate, and sufficient data was used for modeling.

MEPS_NAME	RECRUIT_ID	STATION	NEXT_STATION	SEX	SPF	SERVICE	DATE_IN	TIME_IN	TIME_OUT	TI
COLUMBUS	H1909463805	MED	SVC	M	DMR	MARINES REGULAR	03/29/2019	7:02:03 AM	10:40:30 AM	3:3
COLUMBUS	H1909464086	MED	SVC	M	DMR	MARINES REGULAR	03/22/2019	6:11:28 AM	9:45:16 AM	3:3
COLUMBUS	H1909464236	MED	SVC	M	DMR	MARINES REGULAR	03/27/2019	6:03:30 AM	9:08:12 AM	3:0
COLUMBUS	H1909464256	MED	SVC	M	DMV	MARINES RESERVE	03/22/2019	7:11:28 AM	10:57:02 AM	3:4
COLUMBUS	H1909465294	MED	SVC	F	DNR	NAVY REGULAR	03/26/2019	6:57:00 AM	11:38:11 AM	4:4

Figure 3.3. Sample of cleaned USMIRS data

3.9 Model Development Process

The model development methodology focuses on three main topics for model construction: input modeling, variance reduction techniques, and verification and validation. These techniques provide the framework for construction of a base model for

current MEPS processing operations across the three size categories. The base model is used as the de facto standard to which all system comparisons of alternative scenarios are made. Simio was chosen as the discrete event simulation software for computerized implementation of the model.

3.10 Input Modeling

A thorough network analysis of the USMIRS data was conducted before construction of the computerized model. Utilizing work completed in 2020 by USMPECOM SMEs, a common path analysis identified the most common applicant flows from processing section to processing section. An example of the MEPS common path analysis that was provided can be found in Figure 3.4. This analysis enabled the identification of primary MEPS processing sections and processing activities within these main sections. The identification of these activities led to the development of a list of modeling servers for conceptual and computerized implementation.

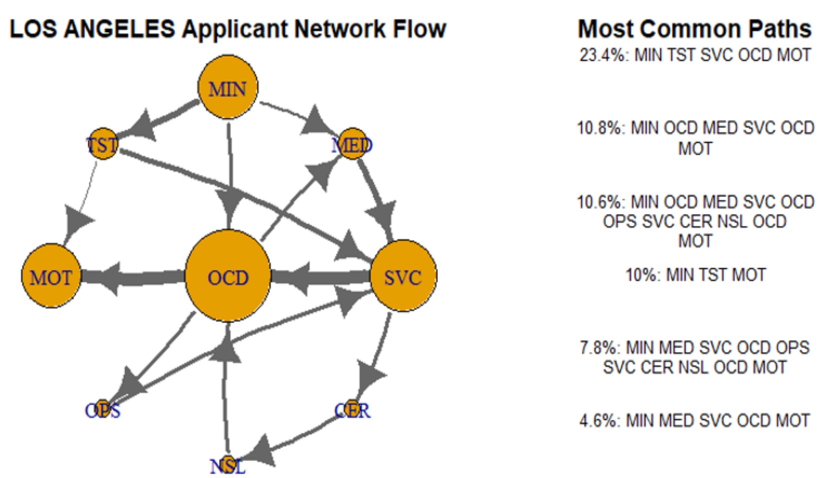


Figure 3.4. Common path analysis used to identify MEPS network flows

Service time distributions were required for the listed servers to define the processing times an applicant experiences during their visit. The primary focus was to use well-known theoretical probability distributions as candidate distributions to describe the various service times. The Arena Input Analyzer software was used to model distributions for the data. A systematic approach to include conducting Goodness of Fit tests to each candidate distribution was taken to assess the validity that the observed sample corresponded to a specific hypothesized distribution. Figure 3.5 illustrates an instance of fitting the data to a theoretical probability distribution in the Arena Input Analyzer.

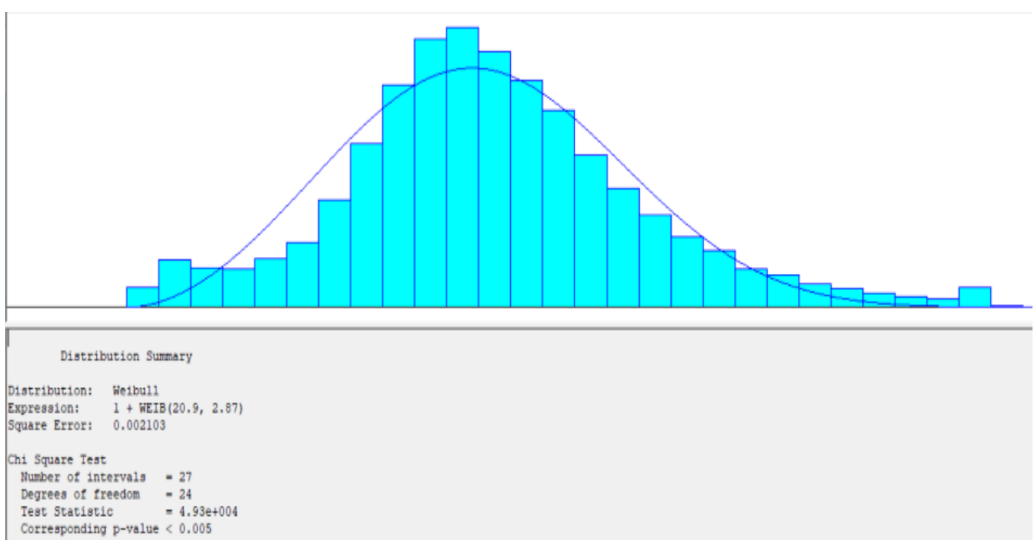


Figure 3.5. Theoretical distribution fitting in Arena Input Analyzer

From the output above, the corresponding p-value for the Chi-square hypothesis test using the Weibull distribution to fit our data was 0.005. This indicates a poor fit of this distribution to describe our data and should not be used as part of our input modeling. Furthermore, varying the number of bins to fit our data to the distribution did not yield any favorable results for any of the service times we attempted to fit to theoretical probability distributions. We concluded that many of the service times not captured in the USMEPCOM manpower models required empirical distributions to describe the data. The use of empirical distributions comes with an inherent risk, however, in that the distribution may not represent all possible occurrences such as rare events. The relative abundance of data available, though, makes the risk in these cases acceptable. The model applies two categories of empirical distributions to describe different processes in the system. For example, continuous empirical distributions such as Random.Continuous(1, .008, …, .998, 51.5, 1) were applied to processing time scenarios and allow for linear interpolation of time values while discrete empirical distributions such as Random.Discrete(0, .5, 1, .7, 2, 1) were applied to instances in which constant interpolation was needed such as modeling an applicant testing category.

To remedy the deficiencies in the USMIRS data, our study implemented validated model parameters used in previous studies such as USMEPCOM manpower models which capture mean processing times for some individual processing sections. These manpower models provided an avenue to model intermediate service activities, particularly in the medical and operations sections. Linton (2021), a Naval Postgraduate School (NPS) Master's thesis, was used to augment the USMEPCOM manpower models. The NPS study focused modeling efforts to the medical section at a single MEPS and

collected empirical service times for medical activities from which theoretical distributions were fit. These distributions were deemed more accurate than the mean service times provided in the USMEPCOM manpower models which were SME provided as opposed to time studied. USMEPCOM regulations 601-23 and 40-1, among others, were instrumental in identifying capacities and required resources for various processing activities such as the drug testing, orthopedic and neurological exam, and hearing servers. Figure 3.6 provides an instance of a combination of MEPS manpower model, NPS, and regulation capacities used as model input parameters for our study.

Hearing

- Resource = 1 Med Tech

PROCESS	Major	Sub-Function	Step or Dec Node #	Time (in	% YES	% NO	REMARKS
10	Medical Processing	Hearing Test	1	16			16 min for 4 man booth
			2	0.5			17 min for 6 man booth
			3				18 min for 8 man booth
			4				19 min for 10 man booth
			5				(Batch time increases by 0.5
			6				minutes for each seat above a
			7				
			8				Steps 8-10 and 14 - 17 capture ear
			9	1			exam and additional
			10				documentation
			11				
			12				
			13				
			14	1			Ear Exam by trained Med Tech
			15				by CMO
			16				by CMO
			17				by CMO
			18				
			19				
			Total Process Time (hours)	22443.87			16

- NPS: 11 mins 10 sec

Hearing	1	1	6	Gamma(53.22, 0.21)	70

Figure 3.6. USMEPCOM manpower model, NPS, and MEPS regulation input modeling

3.11 Model Limitations

Model limitations were identified during the conceptualization, construction, and testing phases of our study. Through the MEPS network analysis, it became evident that identifying common paths which capture the majority of applicant flows to represent all MEPS locations would be a challenge. Many factors have the potential to dictate applicant processing flows resulting in different permutations for an identical process. Further exacerbating the contrast of these permutations are factor differences between MEPS size categories. The goal of this research during model conceptualization was to capture the most common permutations between each MEPS and each size category to limit the degree of uncertainty. For this reason, the model simulates the general MEPS applicant processing operation and does not capture special processing nuances a MEPS may apply at a local level. Moreover, this idea can be extended further to incorporate resource availability, certain capacities, and staff scheduling. The model built for this research is limited to a general application of these modeling inputs and it is left for future studies to provide better fidelity in these areas.

The service liaison servers presents a unique limitation. An entity's total time in system is dependent on multiple visits to these servers, and small changes to the modeling inputs for processing times result in differing total times. While distributions to model applicant processing time are informed by the USMIRS data they are not verified or validated by operational SMEs.

Testing the combiner node objects used to model batch logic at certain servers identified a key model limitation. The combiner node relies on a state variable to track

the number of entities created from a source which dictates the entity batch size. During developmental testing of the model, a wide range of entity arrivals and time between arrival windows was evaluated. We discovered that a combination of random arrival numbers and minimal time between arrival windows results in incorrect batch sizes. Consequently, the incorrect batch sizes lead to less efficient processing for the remainder of the simulation run. To avoid this limitation, we recommend using deterministic arrival numbers when time between arrival windows is less than 30 minutes. If a random arrival scheme is desired, the time between arrival windows should exceed 30 minutes.

3.12 Variance Reduction

Common Random Numbers (CRN) were implemented in our model to induce correlated sampling using matching number streams. This variance reduction technique pays dividends during our comparison of multiple system configurations. The use of CRN in modeling is meant to produce similar realizations of uncertain events in each configuration and enables our team to identify differences in simulation outputs as a result from operational differences between the configurations as opposed to differences due to the stochastic nature of the system. Furthermore, extra programming effort was applied to dedicate different random number streams for each purpose such as process time distributions and medical qualifications resulting in synchronization between system configurations. The model contains 120 different random number streams for each of its random processes. No tests were conducted to evaluate the effect of the random numbers or whether they produce a positive correlation. Additionally, no tests were performed to

evaluate whether the output performance measures for different configurations react monotonically in the same direction.

3.13 Verification and Validation

Informed by techniques presented in Sargent (2013), we used a cyclic and continuous approach for verification and validation of the simulation model. To aid in the development of the conceptual models, two familiarization visits to separate MEPS locations were conducted. Structured walkthroughs of each conceptual model were conducted with AFIT and USMEPCOM SMEs. To verify the model's operational behavior was working as intended, animation was used to graphically display and differentiate between the entities, and operational graphics were developed to visually display the model's dynamic queuing behavior. Figure 3.7 displays an instance during model verification using animation and graphics to help determine correct or incorrect model logic. Trace runs follow entities through the model to determine whether the model's logic is correct and enable event verification analysis. After development of each module, structured walkthroughs of the computerized model were conducted with AFIT and USMEPCOM SMEs, and the process was repeated in a cyclic and continuous fashion, concluding with SME judgment that the model's input modeling, logic, and structure are valid.

Figure 3.7. Animation and graphics used for model verification

The next phase of model development is operational validation. USMEPCOM analysts provided measurements correlating to the performance metrics of interest contained in Table 3.4. This data was used as the standard against which we compared the simulation's output. USMEPCOM requested that operational validation runs be performed using instances when the MEPS systems and staff experienced the maximum values of DEP and ship applicant arrivals at each MEPS during FY 2019. This technique, referred to as extreme condition testing, examines the model's structure and outputs under extreme or unlikely combinations of factors.

Table 3.4. Performance metrics used to determine operational validity of model

Scenario: Maximum number of DEP arrivals (MAXDEP)	**Scenario: Maximum number of Ship arrivals (MAXShip)**
Average DEP time in system (TIS)	Average DEP TIS
Average Ship TIS	Average Ship TIS
Number of Holdovers	Number of Holdovers

Operational validity of the model was assessed using graphical displays of the simulation output and a series of associated statistical tests. Results and analysis were presented to stakeholders at HQ USMEPCOM, and the ensuing adjustments elicited

better model performance consisting of fewer statistically significant differences between model outputs and the benchmarks provided by USMEPCOM. While some performance metrics indicated statistical differences between the model's performance and the actual system, the differences were not substantial enough to indicate a practical significance. Subsequently, after presentation of results, the base model was considered operationally valid and deemed a sufficient surrogate for the actual system.

3.14 Experimentation: Alternative Applicant Arrival Scenarios

This section details the development of alternative applicant arrival scenarios. Scenario development attempted to achieve three objectives: identify better performing alternatives, develop insight into the processing operation across size categories, and demonstrate the model's capabilities and flexibility as a decision support tool.

Table 3.5 displays the performance metrics used to compare experimental alternatives. Experimental scenarios, similar to validation scenarios, simulate a single processing day for the DEP and Ship entity under both heavy DEP and heavy ship conditions for each MEPS size category. The column titled, "Scenario Name", indicates whether a scenario simulates an instance when either DEP entities outnumber Ship entities i.e., HeavyDEP or when Ship entities outnumber DEP entities i.e., HeavyShip. HeavyDEP and HeavyShip scenarios differ to those scenarios used for validation in that no extreme conditions are evaluated.

Table 3.5. Performance metrics used for experimentation

Number of holdovers	Average DEP time in medical section (Genders Combined)
Provider utilization	Average Ship time in medical section (Genders Combined)
Processing HRA utilization	Average TIS (DEP, Ship)
HRA OCD utilization	Total throughput (DEP,Ship)
Medical technician utilization (Male, Female, Average)	Number of medical prescreen packet holdovers
FBP utilization	Average time in queue (DEP, Ship)

Appendix C provides the alternatives developed for experimentation. Arrival windows are varied only for the DEP entities in this study. The column titled "Express Lane" indicates whether an alteration to the order of processing activities is modeled for a given scenario. Scenarios with three or more arrival windows always operate under baseline conditions. The alternatives, Alt6 through Alt9, simulate pure appointment scheduling techniques. Appointment blocks are scheduled using block scheduling techniques presented by Gupta and Denton (2008). Scenarios with one or two arrival windows enable the capability to create ELANE DEP entities and alter processing activities. This is accomplished via an express lane state variable using values of zero, one, or two. A zero indicates no change to processing activities and no creation of ELANE DEP entities, hence, this alternative simulates current policy operations. One arrival window with the express lane value set to one will prompt the creation of ELANE DEP entities. ELANE DEP entities bypass the CCBrief server and proceed directly to the medical section, while regular DEP entities process under normal operations. The alternative, Alt1, models this process which replicate those conditions entertained by USMEPCOM's HDHC ELANE initiative. One arrival window with the express lane

value set to two, vectors ELANE DEP entities to the medical section's BAT server bypassing the CCBrief and MedBrief servers. The two-arrival window, Alt3, models the express variable set to zero and simulates the split-shift alternative. Two arrival windows with the express lane variable set to one or two prompts identical processes as one arrival window alternatives with the exception that entity arrivals occur in two arrival windows. These alternative scenarios, denoted Alt4 and Alt5, simulate a mixture of block scheduling and express lane concepts and thus are referred to as Hybrid 1 and Hybrid 2.

The final three alternatives, denoted resource 1, 2, and 3 model variations in medical technician staffing. Base medical technician staffing incorporates a 50/50 ratio of morning and afternoon staff of both male and female medical technicians. These alternative scenarios simulate current policy operations but alter morning and afternoon resource availability. Resource 1 simulates a 10/90 ratio, while resource 2, and 3 simulate a 70/30 and 90/10 ratios respectively. All alternatives incorporate heuristic scheduling policies investigated during the literature review.

The small, medium, and large MEPS scenario compares model performance for BaseHeavyDEP and BaseHeavyShip to 12 and nine alternatives respectively. The number of Ship applicant arrivals remains constant over all scenarios. The number of DEP applicant arrivals varies according to the number of DEP arrival windows. Express lane values influence the number of regular DEP entities that are created. Alternatives where express lane values are a one or two have fewer regular DEP entities. This adjustment is made to account for the ELANE DEP entities that are created where these entities increase the original regular DEP proportion by 25%. By aggregating the number

of ELANE and regular DEP entity arrivals, each alternative is subjected to similar arrival numbers. This strategy is applied to all MEPS size categories. The number of arrival windows and number of arrivals by size category are captured in Appendices D-F.

IV. Results and Analysis

4.1 Chapter Overview

This chapter provides results and analysis for model validation and alternative applicant arrival scenarios. The results and analysis from this study's experimental phase are then synthesized to provide the recommendations and discussions presented in the ensuing chapter. Each MEPS size was modeled during operational validity and experimentation and results presented in two categories of analysis: graphical and statistical. Graphical analysis results are illustrated using a simulated Large MEPS, and statistical analysis results are illustrated using a simulated Medium MEPS for operational validity analysis in MAXDEP and MAXShip scenarios. During experimentation, each alternative's performance is compared to current policy operations. Graphical and statistical analysis results are presented for alternative applicant arrival analysis in HeavyDEP or HeavyShip scenarios.

4.2 Operational Validity: Graphical Analysis

Thirty initial replications were applied to begin the operational validation process. Once initial simulation output was generated, the number of additional replications required to obtain a relative error of 5% across all performance metrics was computed using equation (1),

$$n_r^*(\gamma) = min\left\{ i \geq 2: \frac{t_{\frac{\alpha}{2},\ i-1}\sqrt{\frac{S^2}{i}}}{|\bar{X}(n)|} \leq \gamma' \right\} \tag{1}$$

where n_r^* is *number of additional replications needed*, γ is *desired relative error*, i is

additional replication, $t_{\frac{\alpha}{2}}$ is *a two-tailed Student's t-distribution at significance level* α, $i-1$ is *degrees of freedom*, S^2 is *sample variance*, $\bar{X}(n)$ is *sample mean*, and γ' is $\frac{\gamma}{1+\gamma}$.

After each scenario received the correct number of additional replications, graphical output of model performance for each metric was generated and analyzed. The Simio Measure of Risk & Error (SMORE) plot is a modified Box and Whisker plot and displays point estimates and associated 95% confidence intervals for sample mean, 25th percentile, and 75th percentile. The SMORE plot in Figure 4.1 shows the average time in system (TIS) for a DEP entity at a Large MEPS in the MAXDEP and MAXShip scenarios. The output indicates that the mean TIS for a simulated DEP entity is slightly faster than the benchmark derived from historic data in the MAXDEP scenario but is statistically equivalent in the MAXShip scenario.

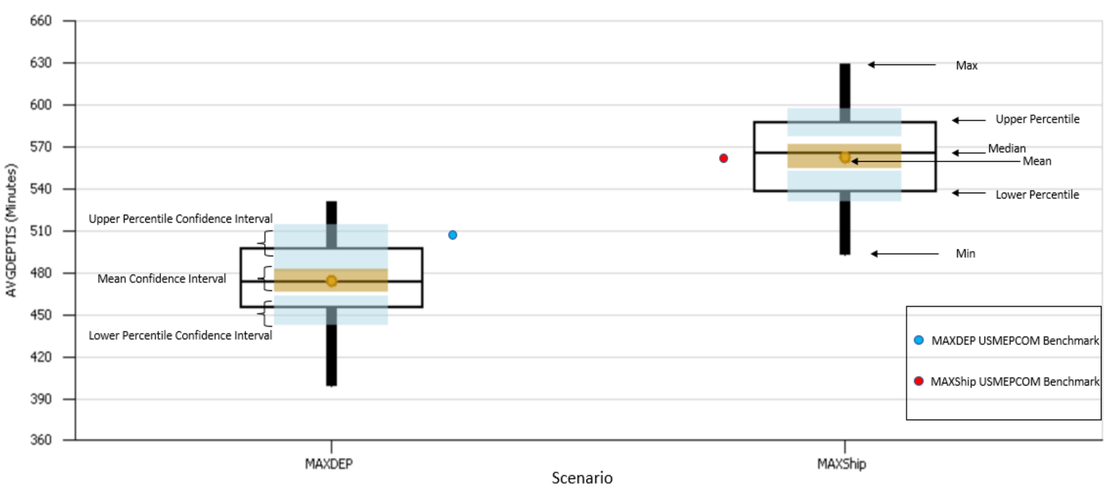


Figure 4.1. DEP entity average TIS SMORE plot in MAXDEP and MAXShip scenarios for Large MEPS

Evaluation of the Ship entity average TIS at a Large MEPS can be accomplished in similar fashion. The SMORE plot in Figure 4.2 shows that the model simulates Ship entity average TIS slower than the USMEPCOM benchmark in both scenarios.

The Ship entity TIS for the MAXDEP scenario is noteworthy in that it exhibits almost no variance whatsoever. This phenomenon occurs because the small number of Ship entities (eight) all attend the first travel brief at 1100, after which they exit the system. The gap between the USMEPCOM benchmark and the model output is likely explained by the programming of the travel brief at 1100 in the model, whereas individual MEPS have the latitude to adjust their travel brief times if applicants are ready.

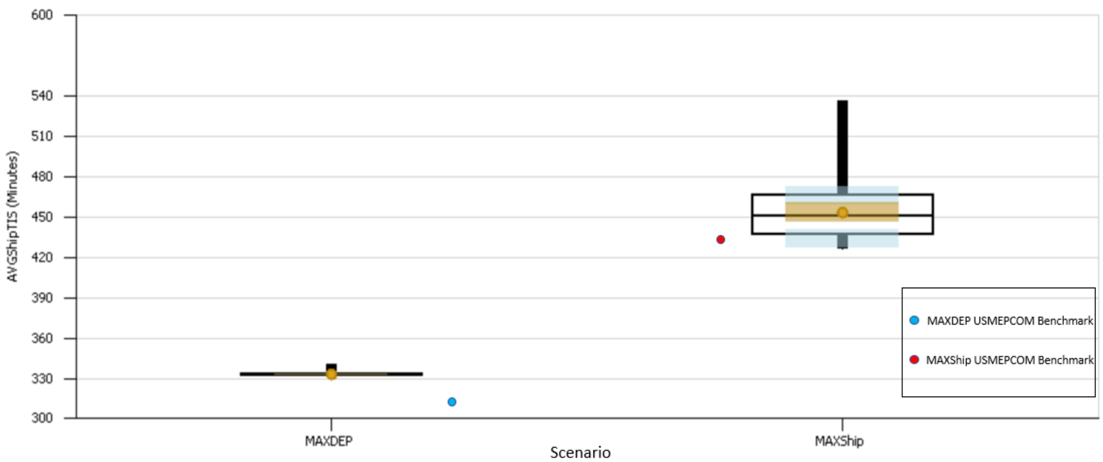


Figure 4.2. Ship entity average TIS SMORE plot in MAXDEP and MAXShip scenarios for Large MEPS

4.3 Operational Validity: Statistical Analysis

The second model validation approach was to compare simulation output to the benchmarks provided by USMEPCOM using two-tailed 95% confidence intervals calculated using equation (2),

$$\overline{(X}(n) - \mu) \pm t_{\frac{\alpha}{2},\ n-1}\sqrt{\frac{S^2}{n}} \qquad (2)$$

where $\bar{X}(n)$ is *sample mean*, μ is *USMEPCOM benchmark*, $t_{\frac{\alpha}{2}}$ is *a two-tailed Student's t-distribution at significance level* α, $n-1$ is *degrees of freedom*, S^2 is *sample variance*, and n is *number of replications.*

Table 4.1 summarizes the simulated Medium MEPS in the MAXDEP and MAXShip scenarios.

Table 4.1. 95% CI and summary of Medium size MEPS in the MAXDEP and MAXShip scenarios

MAXDEP Medium MEPS						
Performance Metric	**Simulation Mean**	**Actual Mean**	**95 % Lower**	**95% Upper**	**Conclusion**	**+/-**
AVG DEP TIS	488.2	501.866	-22.08856788	-5.243432123	Difference	-
AVG Ship TIS	333.6	337.72	-4.896119526	-3.343880474	Difference	-
Number Holdovers	0.02	0.33	-0.338419686	-0.281580314	Difference	-
MAXShip Medium MEPS						
Performance Metric	**Simulation Mean**	**Actual Mean**	**95 % Lower**	**95% Upper**	**Conclusion**	**+/-**
AVG DEP TIS	523.3	523.192	-9.326486241	9.542486241	No Difference	0
AVG Ship TIS	391.7	385.037	-1.740649042	15.06664904	No Difference	0
Number Holdovers	0	0.66	-0.66	-0.66	Difference	-

In the MAXDEP scenario, the simulation models both DEP and Ship entities slightly faster than their respective benchmarks, three to five minutes for Ship entities and five to 22 minutes for DEP entities. These values, in a 10-hour processing day, are sufficiently small that they present little concern with respect to the model's overall usefulness. In the MAXShip scenario, there is no statistically significant difference in either the DEP or Ship entity TIS. There is a statistical difference in the number of holdovers for each scenario, although this can be attributed to the way service liaison data was truncated to construct service time distributions in the model. USMIRS data includes instances of applicants spending excessive time with service liaisons, up to 12 hours in rare cases. Those instances were deemed sufficiently unlikely that they were not programmed into the model, which likely accounts for the reduced number of holdovers in the simulation output.

Table 4.2 provides an overall summary of model performance metrics during the operational validation phase. In general, the simulation models DEP entities faster than their associated benchmarks and Ship entities slower. A second observation is that MAXDEP results are generally faster than benchmark while MAXShip results are generally slower. In each case, however, the magnitude of the overestimation or underestimation is relatively small when contextualized with the 10-hour processing day and supports the conclusion that the simulation model is verified and operationally valid.

Table 4.2. Overall summary of model performance metrics during operational validation

	Scenario			
	MAXDEP	95% Confidence Interval (minutes)	MAXSHIP	95% Confidence Interval (minutes)
Conclusion				
Fast TIS	Large AVGDEP	[-42, -25]		
	Medium AVGDEP	[-22, -5]		
	Medium AVGShip	[-4, -3]		
	Small AVGDEP	[-40, -20]		
	Small AVGShip	[-7, -0.7]		
Slow TIS	Large AVGShip	[18, 19]	Large AVGShip	[3, 22]
			Small AVGDEP	[9, 36]
			Small AVGShip	[3, 18]
No Statistical Difference			Large AVGDEP	[-7.6, 10.9]
			Medium AVGDEP	[-9.3, 9.5]
			Medium AVGShip	[-1.7, 15.1]

4.4 Experimentation Results and Analysis

This section provides the results and analysis for the alternative arrival schemes examined in the HeavyDEP and HeavyShip scenarios. Fifteen initial replications were applied to all alternatives in each scenario and size category to begin the experimental process. Once initial simulation output was generated, we calculated the number of additional replications required to obtain a relative error of 5% across all performance metrics using equation (1). We decided to apply the same number of additional replications across all size category alternatives.

To compare alternatives, two classes of two-tailed 95% joint confidence intervals were calculated. The first class calculates an overall 95% joint confidence when considering all pairwise comparisons. The calculation for these intervals utilizes the standard confidence interval equation $\bar{X} \pm t_{critical}\sqrt{\frac{s^2}{n}}$. Calculation of the two-tailed

Student's t-distribution critical value requires the number of comparisons made, the degrees of freedom, and the equation $1 - \frac{\alpha}{2[\frac{c(c-1)}{2}]}$. For the HeavyDEP and HeavyShip scenarios the number of comparisons, *c*, equals 13 and 10 respectively with 31 degrees of freedom. The second class calculates the comparison of each alternative to the de facto standard of the current baseline policy. The calculation for these Bonferroni joint confidence intervals was straightforward, utilizing equation (2). Calculation of the two-tailed Student's t-distribution critical value requires the number of alternatives, the degrees of freedom, and the equation $1 - \frac{\alpha}{2[c]}$. For the HeavyDEP and HeavyShip scenarios, the number of alternatives, *c*, equals 12 and 9 respectively with 31 degrees of freedom. The interpretation of these Bonferroni joint confidence intervals is identical to those calculated in the statistical analysis for operational validation. All pairwise comparison intervals are used to develop the figures presented in this section while Bonferroni intervals are used to provide the analysis for all tables. Results and analysis of alternatives is presented in six subsections separated by performance metric category.

4.5 Performance Metric Results: Number of Holdovers

We examined alternative scheme impact on the number of holdovers to determine which ones maintain, reduce, or increase applicant holdover rates when compared to baseline operations. Figure 4.3 captures results for each HeavyDEP alternative and reveals three observations. First, implementation of a two-window arrival scheme in Alt3, Alt4, or Alt 5 results in a significant increase in the number of applicant holdovers across all size categories. Second, the single arrival window scheme utilizing the express lane alternatives, Alt1 and Alt2, result in lower holdover rates than any other alternative

across all size categories. Performance of these alternatives is superior to the current policy for a Large MEPS and is statistically no different than the baseline in a Medium or Small MEPS. This is attributed to the removal of the batch processing activities for 25% of the DEP applicant arrivals in the express lane options. Since a Large MEPS experiences higher volumes of arriving applicants, it follows that a higher number of DEP applicants would bypass these activities thus eroding the holdover probability. Third, results indicate that a Medium size MEPS is less robust to changes in medical technician resource availability. Where a Large and Small MEPS experienced little change to holdover rates for the 10/90, 70/30, and 90/10 MedTech Schedule alternatives, a Medium MEPS experienced increases in the number of holdovers. This is possibly explained by the default values for MedTech resources made available to in each size category of simulated MEPS.

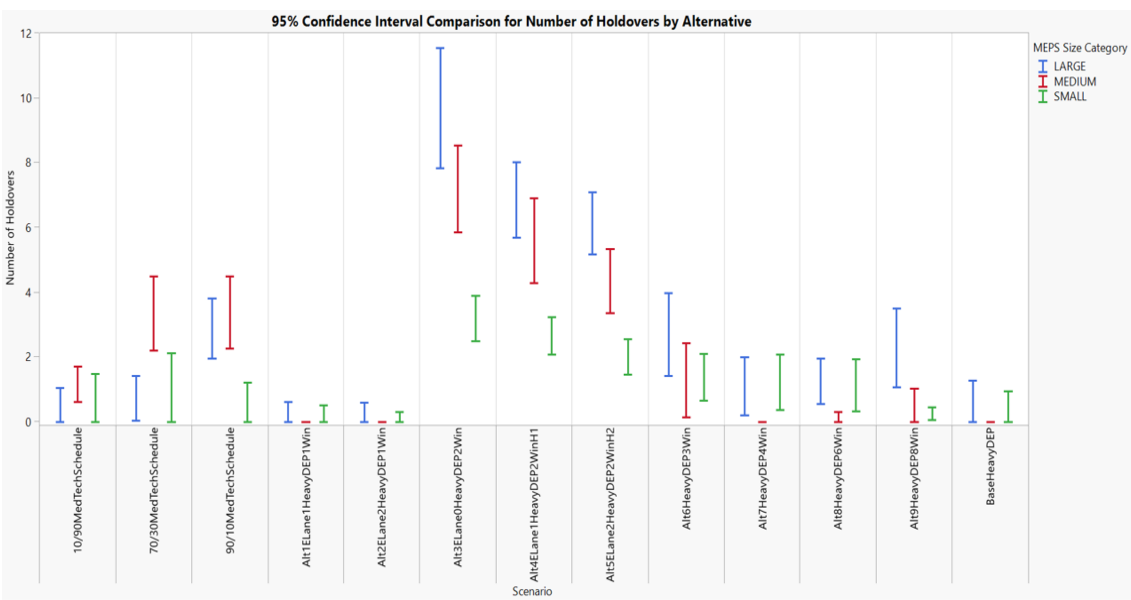


Figure 4.3. 95% pairwise confidence intervals for number of holdovers in the HeavyDEP scenario

Bonferroni confidence intervals provide the ability to identify granular differences and trends for the number of holdovers metric. The 95% joint confidence intervals in Table 4.3 indicate a significant time threshold trend and provide strong evidence for the best alternatives to reduce holdover rates at a MEPS. Table 4.3 indicates that each two-window arrival alternative demonstrates poor performance; however, knowledge of the time between arrival windows factor for these alternatives provides insight into a time threshold trend. During the two-window arrival alternatives, entities are created at 0600 and 1100. During the three-arrival window alternative, Alt6, the final entity arrival batch is created at 1000. In the four, six, and eight window arrival alternatives the final entity arrival batches are created at 0900, 0945, and 0930 respectively. The implication is that current MEPS operations cannot support appointment-based scheduling for applicant arrivals beyond 0900 without incurring a substantial increase in holdovers. The holdover rates decrease in the hybrid mix of express lane and split-shift schemes; however, a MEPS can expect to experience, on average, one to three more holdovers using these scenarios, assuming no other changes to MEPS processing operations.

Table 4.3. 95% Bonferroni confidence intervals for number of holdovers in the HeavyDEP scenario

HeavyDEP Performance Metric: Number of Holdovers						
	LARGE MEPS		MEDIUM MEPS		SMALL MEPS	
Bonferroni Baseline as Standard	95 % Lower	95% Upper	95 % Lower	95% Upper	95 % Lower	95% Upper
Alt1ELane1HeavyDEP1Win	-0.82	-0.12	0.00	0.00	-0.45	0.01
Alt2ELane2HeavyDEP1Win	-0.74	-0.14	0.00	0.00	-0.51	-0.18
Alt3ELane0HeavyDEP2Win	7.52	10.54	6.09	8.28	2.17	3.33
Alt4ELane1HeavyDEP2WinH1	5.23	7.14	4.53	6.66	1.75	2.69
Alt5ELane2HeavyDEP2WinH2	4.69	6.25	3.54	5.14	1.12	2.01
Alt6HeavyDEP3Win	0.99	3.07	0.35	2.22	0.35	1.52
Alt7HeavyDEP4Win	-0.29	1.16	0.00	0.00	0.09	1.47
Alt8HeavyDEP6Win	0.02	1.17	-0.13	0.26	0.04	1.34
Alt9HeavyDEP8Win	0.63	2.62	0.07	0.93	-0.35	-0.02
10/90MedTechSchedule	-0.60	0.28	0.71	1.60	-0.56	0.88
70/30MedTechSchedule	-0.50	0.62	2.42	4.27	0.50	1.56
90/10MedTechSchedule	1.47	2.97	2.47	4.28	-0.46	0.65

(Red) Indicates worse performance than current
(Green) Indicates better performance than current
No Fill Indicates no difference

The two alternatives that implement the express lane option in a single window arrival scheme result in equivalent or superior performance in all size categories when compared to the baseline policy. However, there is little practical difference in performance between these alternatives, suggesting that bypassing the Commander's brief and/or the medical brief will yield similar results.

4.6 Performance Metric Results: Total Throughput

No alternative, in either a HeavyDEP or HeavyShip scenario, impacted the total number of Ship applicants a MEPS processes. Figure 4.4 captures results for DEP entity processing in each HeavyDEP alternative. Implementing a two-window arrival scheme in a HeavyDEP and scenario drastically decreases the total number of DEP applicants a

MEPS can process by an average of eight to 12 applicants at a Large MEPS, seven to eight at a Medium MEPS, and two to three at a Small MEPS. Alt4 and Alt5, where mixtures of split-shift and express lane policies are implemented, alleviates some deficiencies in the HeavyDEP but not in the HeavyShip scenario. Analysis of time thresholds for applicant arrivals indicates identical patterns to those discussed in the holdovers section. Appointment-based alternatives with four, six, and eight arrival windows in the HeavyDEP scenario exhibit no statistical differences to the baseline policy at a Large and Medium MEPS but results in an average of one to two fewer DEP applicants processed at a Small MEPS.

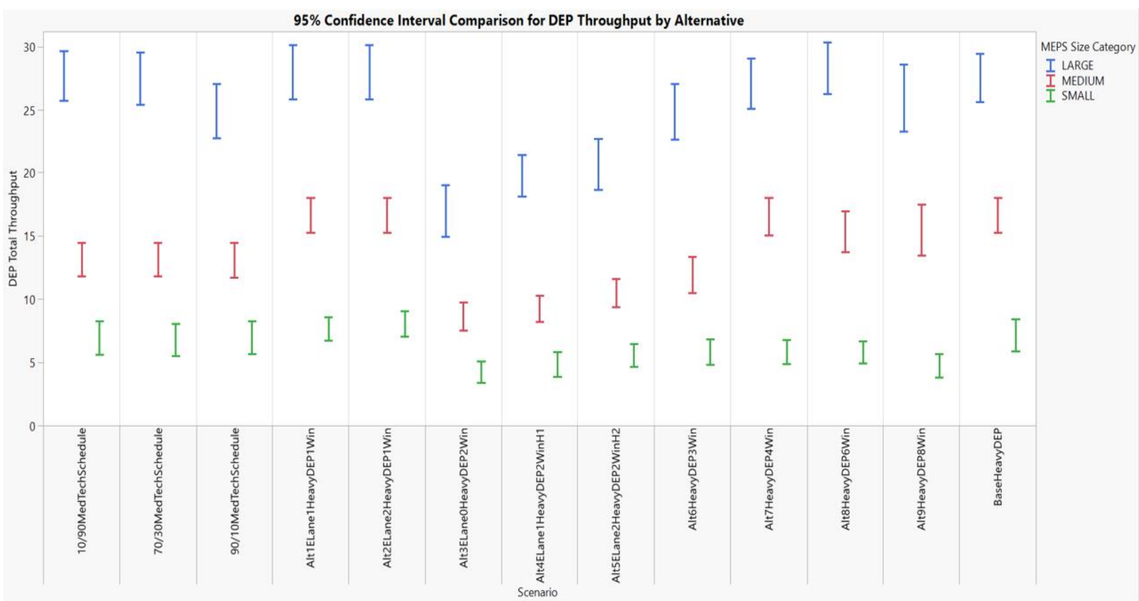


Figure 4.4. 95% pairwise confidence intervals for DEP applicant throughput in the HeavyDEP scenario

Alternatives with variations in medical technician scheduling impact a Large and Medium MEPS' ability to process applicants. In the HeavyDEP scenario, Bonferroni interval analysis indicates that applicant throughput decreases in the 90/10 alternative.

This result is not unexpected since the 90/10 alternative decreases the number of medical technicians during the main processing window for DEP entities in the medical section. The higher volume of entities in the medical section coupled with limited resources have a cascading effect that impacts throughput. This explains why a Small MEPS is not impacted by this alternative.

4.7 Performance Metric Results: Time in System (TIS)

No alternative, in either a HeavyDEP or HeavyShip scenario, impacted the Ship entity TIS. Figure 4.5 captures results for each HeavyDEP alternative and indicates that all alternative arrival schemes decrease DEP entity TIS, with the split-shift alternatives resulting in the largest reduction. However, this lower TIS is likely a byproduct of the increased holdovers for these alternatives. DEP entities spend less time in the system due to the 1100 arrival time of the second batch of entities and removal at 1630. This creates a false narrative of improved TIS when in actuality the decrease is attributed to the reneging of entities. Appointment-based scheduling options with three, four, six, and eight arrival windows also result in the highest savings in DEP TIS, but the same argument applies.

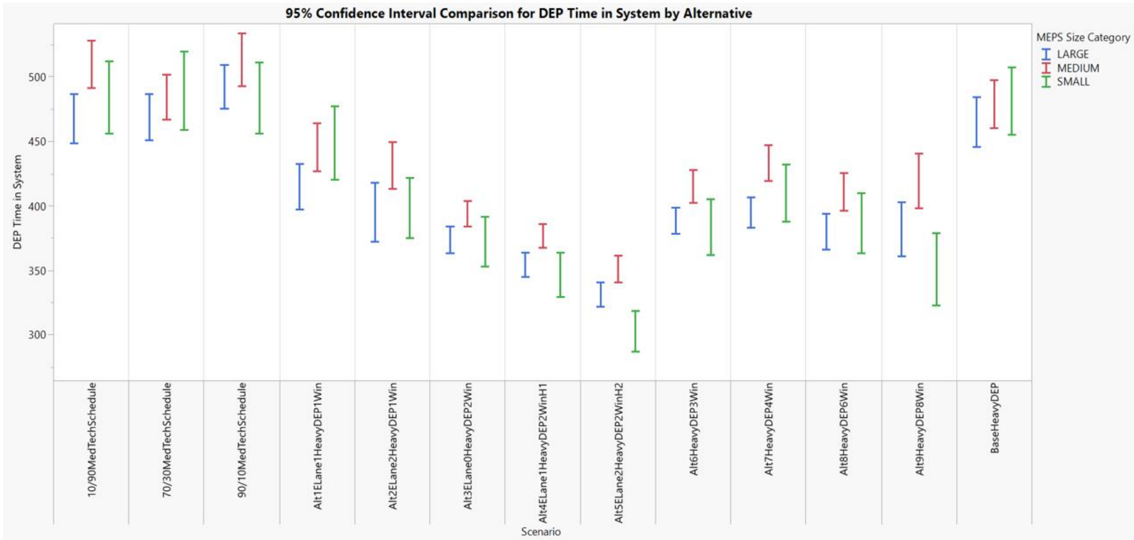


Figure 4.5. 95% pairwise joint confidence intervals for DEP applicant TIS in the HeavyDEP scenario

Express lane options with a single arrival window demonstrate the best performance, which is understandable when considering the lack of holdovers for these alternatives. The express lane one option, where entities bypass the Commander's brief, leads to average TIS savings of 35 to 64 minutes at a Large MEPS, 15 to 48 minutes, and nine to 55 minutes at a Medium and Small MEPS respectively. The express lane two option, where entities bypass the Commander's brief and medical brief, leads to average TIS savings of over an hour for all size categories. The better performance of these alternatives occurs when high volumes of DEP entities are present in the system. At a Medium and Small MEPS in the HeavyShip scenario, where DEP applicant volume is reduced, the performance of these alternatives is on par with current operations.

4.8 Performance Metric Results: Resource Utilization Rates

In the HeavyShip scenario, all appointment-based alternatives result in an increase in HRA utilization when operating under two or fewer arrival windows. Table 4.4 shows that each two-window arrival alternative results in decreases in HRA utilization rate, continuing the comparatively poor performance of these scenarios. This is, once again, due to the increased holdovers in these alternatives where DEP applicants are removed from the system prior to completing processing at the PEI, fingerprints, and pre-oath servers. Like the HeavyShip scenario, appointment-based alternatives exhibit higher processing HRA utilization due to the multiple entity arrival windows inducing multiple instances of processing HRA resource seizures in the Commander's brief server. A Medium MEPS is impacted by the cascading effect of frontloaded medical technician resources in the 70/30 and 90/10 alternatives, exhibiting the same correlation to performance with respect to holdovers. In these alternatives, there is an average decrease in processing HRA utilization of two to six percent.

Table 4.4. 95% Bonferroni confidence intervals for processing HRA utilization rates in the HeavyDEP scenario

HeavyDEP Performance Metric: Processing HRA Utilization Rate						
	LARGE MEPS		MEDIUM MEPS		SMALL MEPS	
Bonferroni Baseline as Standard	95 % Lower	95% Upper	95 % Lower	95% Upper	95 % Lower	95% Upper
Alt1ELane1HeavyDEP1Win	-1.46	1.44	-2.51	1.87	-1.97	2.50
Alt2ELane2HeavyDEP1Win	-1.11	1.68	-1.64	2.59	-1.84	3.05
Alt3ELane0HeavyDEP2Win	-5.05	-2.28	-7.01	-2.42	-5.80	-0.88
Alt4ELane1HeavyDEP2WinH1	-3.03	-0.53	-5.07	-0.99	-3.82	1.24
Alt5ELane2HeavyDEP2WinH2	-2.59	-0.23	-3.71	0.76	-2.98	1.51
Alt6HeavyDEP3Win	-0.40	2.33	1.03	5.15	0.83	5.65
Alt7HeavyDEP4Win	0.57	3.49	3.02	7.55	3.25	8.41
Alt8HeavyDEP6Win	2.23	5.20	5.37	9.98	6.41	11.16
Alt9HeavyDEP8Win	0.74	3.55	3.74	8.81	0.73	5.72
10/90MedTechSchedule	-1.10	1.86	-2.37	2.47	-2.47	2.34
70/30MedTechSchedule	-1.45	1.41	-6.46	-2.14	-4.08	0.73
90/10MedTechSchedule	-2.16	0.76	-6.41	-2.11	-2.46	2.37

Indicates worse performance than current
Indicates better performance than current
No Fill Indicates no difference

Provider utilization rates increase in all HeavyShip alternatives and decrease in multiple alternatives in the HeavyDEP scenario. Figure 4.6 reveals that provider utilization rates decrease in alternatives implementing two-arrival windows and resource variations. While Large MEPS provider utilization rates remain unaffected, they decrease on average of one to four and nine to 13 percent at Medium and Small MEPS, respectively. An increase in provider idle time can be attributed to lower volume of DEP entities and a five-hour gap between entity arrivals which leads to provider resources extinguishing their queues prior to the arrival of entities in the second batch. A Medium MEPS experiences a decrease in provider utilization when medical technician resources are limited during main processing windows for DEP applicants. Fewer medical technician resources creates a bottleneck for DEP entity processing resulting in longer idle times for providers. In the resource variation alternatives, provider utilization is expected to decrease on average by five to eight percent.

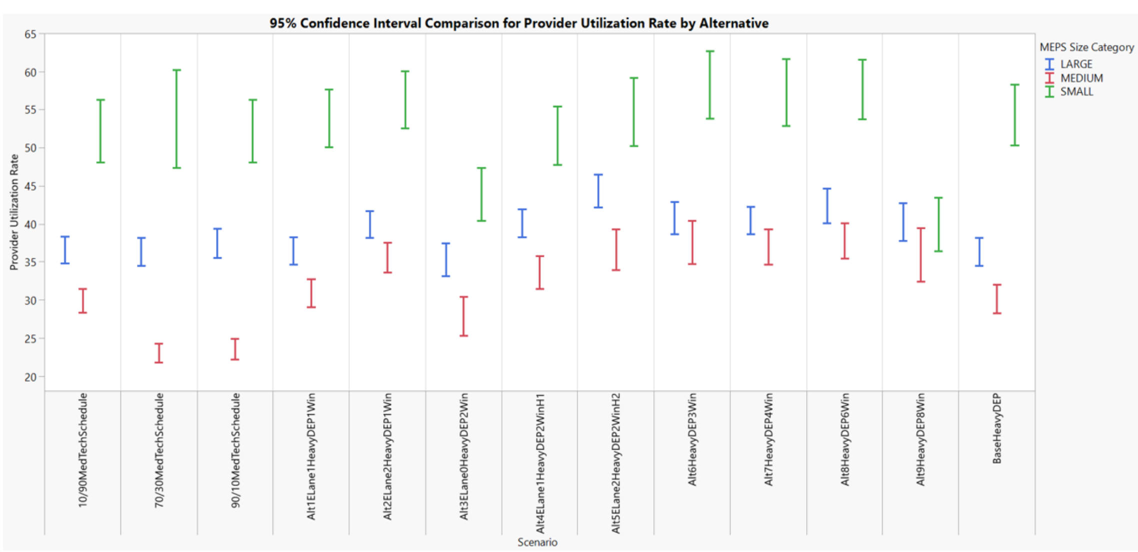


Figure 4.6. 95% pairwise confidence intervals for provider utilization rates in the HeavyDEP scenario

4.9 Performance Metric Results: Time in Medical Section

All alternative arrival schemes result in faster DEP entity time in the medical section in the HeavyDEP scenario. Additionally, for this scenario under the 10/90MedTechSchedule alternative, Ship entity time is slower than the baseline by an average of 13 minutes for Large and Medium MEPS. Typically, Ship entities process in the medical section upon arrival to a MEPS and since the 10/90 alternative reduces the number of medical technician resources earlier in the processing day this causes a bottleneck for Ship entity processing inducing slower medical processing times. The converse is true for the 70/30 and 90/10 alternatives where more medical technician resources are available for Ship entity processing. In these alternatives, Ship entity time

in medical is faster on average by seven to 11 minutes at a Medium MEPS and statistically no different to current policy operations at a Large and Small MEPS.

Figure 4.7 captures results for each HeavyShip alternative. DEP entity processing is slower under most alternatives, with split-shift alternatives exhibit better performances relative to the other alternatives when compared to the baseline. The poorest performance is exhibited under appointment-based scheduling alternatives. In these alternatives, DEP entity processing may be, at most, slower than the baseline by 43 minutes, and at best, slower than the baseline by 10.5 minutes.

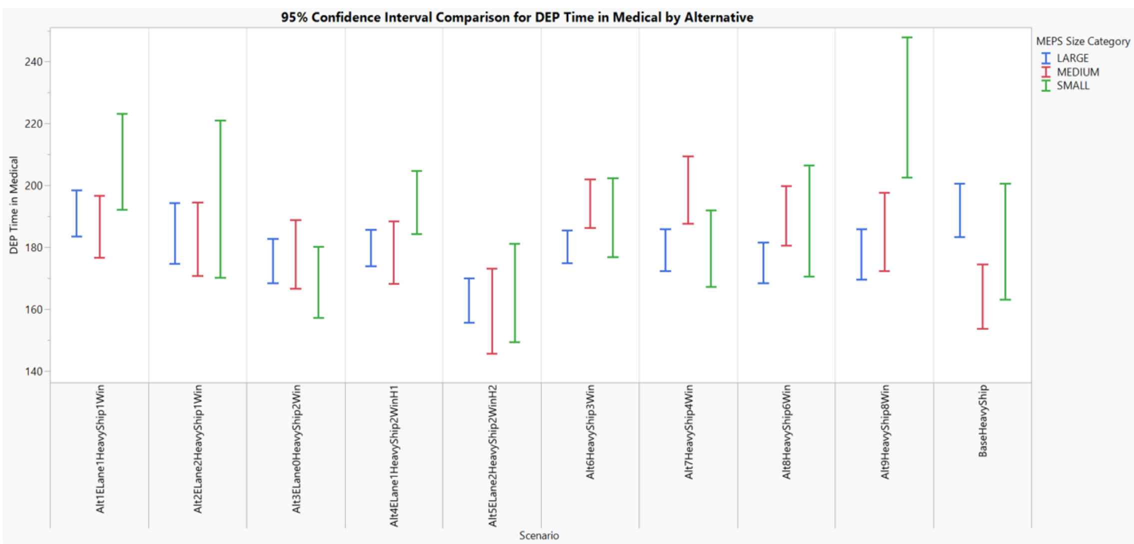


Figure 4.7. 95% pairwise confidence intervals for DEP applicant time in the medical section in the HeavyShip scenario

4.10 Performance Metric Results: Time Waiting in Queue

All alternative arrival scenarios lead to a reduction in wait time for both DEP and Ship entities in the HeavyDEP scenario, with the most improvement in alternatives with multiple arrival windows. However, due to the excess holdovers under these alternatives,

caution is advised when declaring the performances of these alternatives as superior to baseline operations. For this reason, single arrival window schemes employing express lane options exhibit better performance to the current policy in reducing DEP entity waiting times across all size categories. Under these alternatives, a Large MEPS experiences a reduction of DEP entity wait time of 64 to 78 minutes, and a Medium and Small MEPS experiences a reduction of 45 to 60 minutes and 90 and 107 minutes respectively. Ship entities under these alternatives experience no statistical differences in waiting times. Moreover, Ship entity wait times are not impacted by any alternative in the HeavyShip scenario.

Figure 4.8 captures results for each HeavyShip alternative and illustrates two themes captured by the DEP time in queue response. First, similar to the time in medical section metric, a Medium MEPS demonstrates inferior performance under most alternatives when compared to the current policy. DEP entity wait times are increased by 23 to 41 minutes and 18 to 36 minutes utilizing appointment-based scheduling schemes, Alt6 and Alt7, of three and four windows respectively.

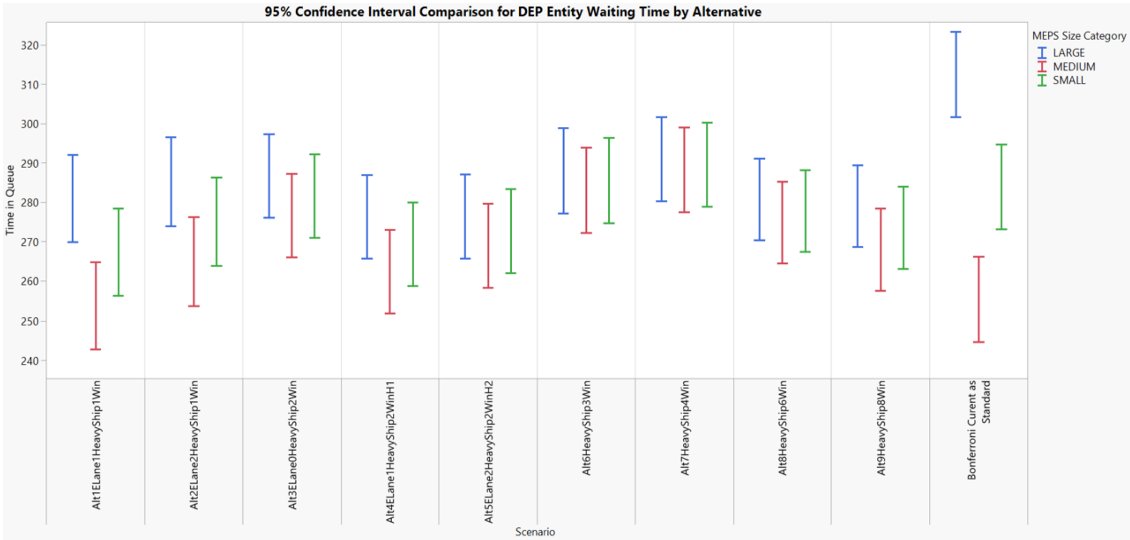


Figure 4.8. 95% pairwise confidence intervals for DEP applicant time waiting in queue in the HeavyShip scenario

4.11 Summary of Primary Insights

This section provides a list of primary insights gained from our analysis of each alternative. The insights are as follows:

- Single batch arrival policies exhibit the best performances for applicant processing; however, they may not always lead to best resource utilization rates or the lowest time statistics.
- Current MEPS operations require adjustment for split-shift or appointment-based scheduling to offset the disadvantages identified by our analysis.
- Express lane procedures implementing a single arrival window can be completed in one processing day with no adverse effects to overall applicant processing.
- Alternatives employing a final applicant arrival window beyond 0900 lead to higher holdover rates and decreased total throughput.
- Appointment-based alternatives increase resource utilization rates at a Large and Medium MEPS

V. Conclusions and Recommendations

In this research we analyze alternative applicant scheduling schemes, such as split-shift scheduling, appointment-based processing, and express lane options, for their viability as a proxy for current USMEPCOM operations. Pursuit of these alternatives had never progressed beyond the pilot state. One reason for this is because the Command lacked a general decision support model to evaluate the impacts on applicant processing operations from such policies. A discrete event simulation computer model of current MEPS operations, implemented in Simio, was created and applied to analyze alternative applicant scheduling schemes. Results were examined by multiple performance measurements for each alternative's efficacy compared to current policy operations. Insights were synthesized to provide basis for recommending best performing policies while presenting evidence for not recommending inferior schemes.

5.1 Conclusions

The analysis suggests that conducting operations under single batch arrival policies most consistently exhibits the best performances for applicant processing at a MEPS. In terms of maximizing total applicant throughput, no alternative outperforms the current policy. In a HeavyShip scenario, the current policy is superior to all alternatives in minimizing the number of holdovers. Implementation of express lane options with a single arrival window is a viable option but leads to no statistical differences in holdover numbers from the current policy. These results taken together lead to the conclusion that maintaining current policy operations is the most risk averse and best option. Express lane policies are a viable option, and should they be implemented, are recommended for

scenarios when significant numbers of DEP applicants require processing. Additionally, analysis suggest express lane procedures can be completed in one day with no adverse effects to overall applicant processing. The high demand high-capacity express lane initiative considered by HQ USMEPCOM proposes two-day express lane processing.

5.2 Recommendations

Express lane options are viable in that they appear not to have adverse effects on overall applicant processing but are generally not value added except perhaps for scenarios in which significant numbers of DEP applicants require processing. In a HeavyDEP scenario, both express lane options equivalently reduce holdover numbers and typically exhibit the same resource utilization rates as the current policy with modest gains at most. In a HeavyShip scenario, DEP applicant time in medical using express lanes are on average 30 minutes slower at small and medium MEPS.

Split shift scheduling with two arrival windows is not recommended under current applicant processing operations. Current MEPS operations require adjustment for split shift scheduling implementation, and the use of express lane options do not alleviate the poor performance of this scheme.

Appointment-based processing with three, four, six, and eight arrival windows are not recommended under current applicant processing operations. Each of these options increases MEPS manpower utilization rates and reduces DEP applicant time in the medical section but declines in terms of excessive holdover rates and lower throughput for any alternative with final applicant arrivals beyond 0900. Implementation of appointment-based processing, even with the inclusion of a time threshold, should be

carefully considered as it would likely require adjustment to MEPS processing operations to offset the disadvantages identified in the simulation runs.

5.3 Future Work

Future work should concentrate in areas of model refinement and application of a design of experiments to evaluate experimental scenarios. Combiner objects used for entity batch processing activities, particularly those used in the medical processing section, would benefit from refactoring efforts. Service time distributions, resource proportions, input probabilities, and staff scheduling patterns would be bolstered by means of multiple on-site studies in all MEPS size categories. Service liaison service time distributions and capacities for each service branch are prime candidates for on-site time studies. Conducting time studies in these areas will pay exponential dividends to improving accuracy and precision of simulation output. Application of a design of experiments to evaluate experimental scenarios would shed further insight to significant factors influencing performance metrics. Through development of screening designs or fractional factorial designs, the number of experimental alternatives, design points, and input factors needed for evaluation can be reduced while providing information toward construction of a metamodel. This model can then be employed to create linear regression equations to better communicate model characteristics, sensitivity analyses, and better aid in decision support analysis.

Future work may also explore feasibility criteria for the processing scenarios deemed nonviable under the current processing model. Even though this study finds appointment-based and split-shift scheduling not viable without adjustment to MEPS

operations, future work can identify what those required changes may be and quantify the subsequent order effects of implementing them.

APPENDIX A. MEPS APPLICANT PROCESSING

Our research examines USMEPCOM regulations to identify major applicant processing sections in a MEPS and the various processing activities within those sections. USMEPCOM regulations and Bell et al. (2016), detail the various activities each applicant must complete within these sections upon arrival to a MEPS. Our analysis of regulation and literature provide a general understanding of the typical trajectory, or flows, each applicant must follow while processing. This model is used to inform development of our own model as well as the construction of our computerized simulation presented in the methodology chapter of this paper. Understanding the purpose of each processing section and applicant category yields a better comprehension of applicant flow.

A MEPS can simultaneously process different types of applicants each requiring different process flows and resources. Shipping applicants or “shippers,” are those expecting to depart MEPS for basic training upon completing miscellaneous processing. Delayed Entry Program (DEP) applicants are those who are not immediately reporting for basic training upon completion of the enlistment process. A large proportion of the applicants entering the DEP follow a multi-day processing schedule and conduct aptitude tests the evening before a full medical examination; this is known as night testing. Same Day Processing (SDP) applicants are those who undergo enlistment aptitude testing, a full medical examination, and enlistment in one MEPS duty day (22:17). A walk-in is an applicant not projected for processing at or before the established MEPS projection cut-off time (22:17). Special-category processing applicants are those who deserve special treatment with respect to their expected position in military service. This applies to an

applicant for direct commission, such as a healthcare professional, chaplain, and attorney (22:17). Typically, these applicants arrive later in the duty and are given priority throughout the MEPS applicant process. A processing holdover applicant is an applicant that is unable to complete enlistment processing in a single day and is designated to return to the MEPS the following day to complete processing (22:17). Each applicant type may visit one or more processing sections during their enlistment process.

MEPS Maximum Daily Capacity/Allocation (MDC/A)

The MEPS MDC/A determines its maximum daily capacity based on the number of processing staff and medical department staffing (22:15). The MDC/A is an integral tool for establishing resource allocation for the various applicant processing sections in a MEPS. Resources, for purposes of this study, is anything required for the processing of applicants to include civilian and military personnel who operate the MEPS. In addition, the MDC/A provides each recruiting service a guaranteed minimum level of daily contract and full medical exams (22:15). Inclusion of the MDC/A in this study establishes a standard for the diverse applicant processing categories to be serviced, capacities, and staffing resources at MEPS. These standards are used extensively for developing assumptions, methodology, and analysis for this research.

The MEPS Applicant Processing Operation

Previous research examines USMEPCOM regulations to detail a U.S. Navy centric applicant process flow in a MEPS (Bell et al., 2016). Thorough review of previous research and USMEPCOM regulations enables our study to detail the MEPS applicant processing operation. The organization in which applicant flow is presented in our study borrows from the structure presented in Bell et al. (2016). Typically, a MEPS

will operate on a five-day workweek, excluding federal holidays, and avoid initiating the processing day prior to 0600 (22:5). A MEPS can offer Saturday processing for full physicals and new contracts at the discretion of MEPS Commanders; however, no attempt is made to model Saturday openings in our research (22:7). Prior to arrival each applicant will be projected in USMIRS for MEPS or SL/GC processing to align with MDC/A resource allocation (22:5,15). A minimum of one walk-in applicant per recruiting service per day is authorized and a MEPS will provide sufficient medical staffing to support processing of walk-ins as established by the MDC/A (22:17). When applicants arrive at a MEPS, they are separated by processing category, receive prioritization based on their category, and check-in by biometrically enrolling into USMIRS (22:29). Shipper applicants are given priority on their shipping day and are "front-loaded" when they arrive (3:46). After successfully establishing aptitude and medical qualifications, applicants are placed into the DEP and typically return to MEPS for shipping at the end of the DEP period (3:46). MEPS staff track applicant workflow via USMIRS and require applicants to biometrically check-in and out as they progress through each stage of their MEPS process (3:48).

USMEPCOM mandates all applicants unfamiliar with MEPS who are processing for Active, Reserve, or National Guard components receive a Commander's initial processing welcome brief. This briefing precedes as much of the MEPS processing day as possible and is presented to applicants in a group setting (22:29). Abbreviated versions of the initial welcome brief are given to shipping applicants or to night testing applicants (22:30). For purposes of this research, the modified versions of the initial welcome brief are not modeled.

Appendix B depicts a version of a MEPS applicant processing operation found in Bell et al. (2016). This conceptual model captures all the major processing sections and the associated processing activities. Entities are defined as the object of interest processing through the system. The entities for our study are the MEPS applicants. Resources modeled, as previously discussed, are the various MEPS staff that provide processing services to a MEPS applicant. The rectangles illustrated in the model are the processing activities an applicant completes while in the MEPS processing system. The diamonds indicate decision nodes, these nodes represent instances where applicant flows may diverge due to an occurrence of a probabilistic event. These events may include medical qualification decisions or whether an applicant may need to take a specialty test. The convex rectangles indicate a preparatory precursor event to a processing activity that significantly contributes to the service time of an applicant. For example, hearing screening preparations include applicants entering an audio booth as a prelude to the actual administration of the hearing screening. The inclusion of preparatory activities is essential to modeling a MEPS processing system for a high degree of realism. This allows our study to capture better estimates of service times and overall applicant time in the system. The model illustrates the different applicant flows through the system depending on the category and gender of the applicant (e.g., male shipper, DEP female, and night testing applicants). This clearly highlights the different activities an applicant must complete depending on an applicant's category. As illustrated, the multiple applicant types have a direct influence on the complexity of the MEPS applicant processing operation particularly in the medical processing section. This conceptual model establishes a better understanding and reference point for the subsequent

paragraphs that explain the processing activities illustrated in the model. Additionally, this model informs our research because it provides a baseline concept for applicant flows, activities, and resources from which we develop our own conceptual model.

The MEPS Testing Section

Prior to any other processing activity, an applicant must be evaluated based on his or her aptitude in the testing section. The testing section renders an aptitude qualification decision for an applicant upon completion of testing. Applicants scoring less than 10 on the Armed Forces Qualification Test (AFQT) are not permitted to proceed with the enlistment process (22:16). Under normal processing procedures, aptitude testing will precede all other MEPS applicant processing activities (22:16). A MEPS testing section Test Administrator (TA) administers the Computerized Adaptive Testing-Armed Services Vocational Aptitude Battery (CAT-ASVAB) to applicants in a dedicated computer room. Applicants are given three hours to complete the exam with the maximum applicant to TA ratio established at 40:1 (23:27, 28). To minimize applicant idle time associated with SDP, a MEPS offers the capability for applicants to test the night before they are projected for full medical examinations and enlistment processing activities. Night testing will be provided Monday through Thursday and at a minimum a MEPS must include the three-hour timeframe of 1500 to 1700 for applicants to test (23:27). Applicants who fail to meet aptitude qualification standards are not permitted to proceed with their enlistment processing until they can provide a valid qualification score.

The MEPS testing section administers special purpose tests when necessary to determine qualifications of applicants for specific occupational specialties (23:41). Special purpose testing can be administered on the same day the ASVAB is administered

given the stipulation that the ASVAB must be administered first (23:41). Applicants typically take special purpose tests in a separate testing room from where the ASVAB is administered. To streamline operations, a MEPS establishes a local schedule for the most common special purpose tests so the services can schedule their applicants in advance (23:41).

The MEPS Medical Section

The MEPS medical section provides and manages an array of medical services for applicants and is arguably the most complex processing section in a MEPS. The medical department staff conduct entry-level medical examinations to determine applicant's physical fitness to perform military duties (14:13). Rendering a medical qualification determination is a critical part of applicant processing and is applicable to all applicants medically processing for accession into the military services (24:8). A steady flow of full-physical medical examinations is required to align MEPS capabilities with the needs of the SL/GC office while each service branch is to provide the MEPS with a steady flow of applicants for processing (22:15). Under normal processing procedures, a medical examination will follow aptitude testing (22:16). When applicants biometrically check-in to the medical processing section they must complete a battery of full physical examination activities, some are gender specific. The MEPS medical examination activities, once started, should be followed through to completion unless an applicant refuses to participate in a medical examination activity (24:30). These activities include one or more of the following: a medical brief, Breath Alcohol Test (BAT), Blood Pressure (BP) and heart rate measurement, vision screening, hearing screening, drug testing, Human Immunodeficiency Virus (HIV) testing, height/weight measurement,

pregnancy test, Orthopedic/Neurological Examination (ONE), accession medical evaluation, and medical inspection. To administer these services, MEPS relies on a medical staff that consists of any of the following: Chief Medical Officers (CMOs), Assistant Chief Medical Officers (ACMOs), Medical Officers (MOs), an assortment of medical technicians, and Fee Basis Providers (FBPs) (24:111). FBPs are contracted medical providers who augment the MEPS medical department as necessary upon request (24:111).

Applicants scheduled to receive physical examinations receive a medical briefing to familiarize applicants with the medical processing for the day. This brief is administered to all applicants of the same category type in a group setting and is used to assist them in the review and completion of required medical documentation (24:38). The medical provider or medical technician gives the brief and ensures all applicant questions have been answered (24:38). All applicants must remain in the medical briefing room until all forms are completed (24:38).

The Breath Alcohol Test (BAT) is performed immediately after the medical briefing. Applicants are informed of eating and drinking restrictions at the beginning of the medical briefing and are administered the BAT where the medical briefing was conducted (26:35). Alcohol testing requires each applicant to open the breathalyzer tube wrapper in the presence of the technician and hand the tube to the technician for proper placement (26:35). Applicants who refuse alcohol testing will not continue any part of MEPS processing (26:8).

A blood pressure (BP) measurement will be obtained from all applicants. This measurement is taken after the applicant has been seated for a minimum of one minute

with their feet flat on the ground and legs uncrossed (24:53). During the BP measurement, a heart rate measurement will be obtained from the applicant (24:54). Failure to meet standards may result in the applicant being medically disqualified which terminates their enlistment processing until further evaluation can be completed (3:50). Furthermore, a single temperature measurement will be taken during the BP measurement activity on each shipping applicant (24:55).

Vision screening is performed by trained MEPS Medical Department personnel on all applicants undergoing an accession medical examination at the MEPS. The vision screening consists of several mandatory, service specific, and job specific tests (24:43). The vision screening examinations include the following: screening for undisclosed contact lenses, color vision testing, depth perception testing, visual acuity testing, and a non-contact tonometer test (24:43). Color vision testing is performed on all applicants for job selection and not administered for medical qualification determination for service (24:44). Repeat color vision testing is not authorized and results are annotated as pass or fail with failures requiring further evaluation (24:45). Like the color vision test, the depth perception testing activity will be conducted for job classification only (24:46). The MEPS medical department administer depth perception testing in accordance with service and job specific standards; failure of any test only impacts the qualification for that specific job (24:46). As with color vision testing, repeat depth perception testing is not authorized (24:46). All applicants have their uncorrected distance and near visual acuities tested for both corrected and uncorrected visual circumstances (24:46). MEPS medical personnel may perform a non-contact tonometer test to screen for glaucoma for applicants entering select career fields (24:48).

Hearing tests will be conducted by trained technicians in an environment that is as quiet as possible. Typically, the audiogram is conducted with small groups of applicants in an audio booth; use of an audio booth ensures that it is sufficiently quiet to perform hearing tests (24:127). If the applicant fails the initial hearing test, the ears are examined by authorized MEPS medical staff for the presence of cerumen obstruction (24:40). Only a certified medical provider who is specifically trained in cerumen removal procedures can conduct the removal (24:41). One audiogram retest is authorized if the applicant fails the initial hearing test and there is no evidence of cerumen obstruction (24:40).

All applicants are required to submit a urine sample as part of the Drug and Alcohol Testing (DAT) policy. Drug testing observers must be the same gender as the applicants and will escort applicants to the restrooms (26:39). A single observer will not escort and observe more than six male or two female applicants at a time (26:39). Applicants who cannot immediately provide a specimen have until the end of medical processing to provide it and those applicants who refuse are disqualified for military enlistment until they provide specimens for testing (26:11).

The excess urine that is collected during DAT activities is used to perform pregnancy tests (26:41). If the test is positive, the applicant will be escorted to the provider and informed that the test indicates that she might be pregnant (24:69). A positive test may result in applicant disqualification. Negative pregnancy tests are annotated in the applicants file and standard enlistment processing continues.

All applicants receiving medical examinations at the MEPS must provide a blood sample for Human Immunodeficiency Virus (HIV) antibody screening. Qualified medical technicians perform all portions of the HIV testing activity. Applicants who

refuse to test or who test positive or indeterminate on initial testing, and test positive or indeterminate on redraw are disqualified from military service (26:19). Shipping applicants are not permitted to ship to initial basic training facilities without a negative HIV result (26:21).

The height, weight, and body fat measurements of an applicant is performed by the medical staff and are considered the official measurements for accession (24:50). All standards are established by the respective services and if at any time during the DEP period a previously qualified applicant no longer meets the established standards the applicant is temporarily disqualified from military service (24:50). Male and female applicants are separated and complete these activities in separate facilities within the MEPS medical section. An applicant's height is measured without shoes or socks while the weight measurements are taken with the applicant in undergarments only (24:50). A trained MEPS representative will complete a body fat measurement and calculation should the applicant exceed the service-specific maximum allowable weight (24:50).

All applicants must demonstrate the ability to perform a series of maneuvers intended to identify orthopedic or neurological abnormalities during the Orthopedic/Neurological Examination (ONE). Applicants are given demonstrations of all maneuvers and since applicants must perform these maneuvers in their undergarments only, the demonstrator must be the same biological sex as the applicants being tested (24:83). This examination may be performed individually or in groups, and if done in groups, there will no more than eight applicants of the same gender per provider (24:84). The provider must be in the room while the maneuvers are being completed by the applicants (24:84). The blood pressure, heart rate, and a negative pregnancy test result

must be documented prior to the ONE (24:84). This is relevant because it provides an order of operations for applicant flow which informs the development of our conceptual model.

A medical provider delivers a qualification determination at the culmination of these medical processing activities. An integral examination to making this determination is the accession medical evaluation. This evaluation is a review of an applicant's medical history, a head-to-toe examination of an applicant by a licensed provider to ensure that individuals considered for appointment, enlistment, or induction into the military are qualified (24:64). Male and female applicants undergo different processes during this medical examination; female applicants require additional examination and consultation (24:66). Upon receiving their qualification determination, an applicant's medical packet is reviewed for completeness and applicants are biometrically checked out of the medical section (24:99).

Medical inspections are provided to applicants who have returned to MEPS with the intent of departing for initial basic training on that day. Additionally, medical inspections are required for applicants not currently in the DEP and who have had 30 days or greater elapse since their medical examination or last inspection (24:101). Inspection of a shipping applicant is required if more than 72 hours have elapsed since the full medical examination or last inspection (24:101). Medical inspections are a condensed form of the medical examination applicants receive on their initial processing visit to a MEPS and is used to identify any temporary disqualifying medical condition since the medical examination or last inspection. After male and female applicants are separated, a current height and weight check of each applicant is taken with clothing

removed except for authorized undergarments (24:101). Applicants' hands and feet are inspected by a provider for any lesions or abnormalities that may interfere with training and pregnancy tests for females are administered (24:102). If the test is positive, the applicant will be informed by the provider that the test indicates that she may be pregnant at which time the applicant is disqualified for accession (24:102).

The Six-Hour Applicant Processing Window

Applicants scheduled to receive a full medical examination and projected to enter the DEP are selected to establish the six-hour processing window (22:14). The goal is to give the recruiting services a processing window to process new contract applicants. The six-hour window begins when the first full physical applicant, per service, completes their physical and is released from the MEPS medical department to the sponsoring SL/GC office (22:14). This information is relevant because after medical and throughout the rest of the processing day, applicants are expected to visit the sponsoring SL/GC office for job selection, contract review, and final processing activities. These processing activities are choreographed to coincide with completion of applicant processing activities in the MEPS operations processing section. Consequently, an applicant transits to and from the sponsoring SL/GC office to the operations processing section several times to complete processing.

The MEPS Operations Processing Section

The operations processing section within the MEPS conducts miscellaneous accession processing functions. Applicants projected for enlistment into the DEP check-in to the processing section following completion of their qualifying medical examination and initial visit to the SL/GC office. While at the operations processing section,

applicants complete the following activities prior to entering the DEP: Pre-Enlistment Interview (PEI), fingerprinting, and the DEP Oath of Enlistment (3:54). Following completion of the DEP period a shipping applicant returns to MEPS to complete several shipping processes prior to departing for initial basic training. The shipping process involves the following: pre-accession interview (PAI), oath of enlistment, and travel guidance brief (3:59).

The PEI is a one-on-one interview conducted by a MEPS Human Resources Assistant (HRA) to all applicants before entering the DEP. An additional resource required to be available to conduct the interview is an enclosed workstation area, as far away as feasibly possible from traffic flow patterns (22:33). The purpose of the interview is to assist the sponsoring SL/GC in preventing fraudulent entry into the military (22:77). This interview is also used to verify the accuracy of the information provided by applicants on the enlistment documents (22:77). If a MEPS HRA determines that enlistment documents to be contradictory or fraudulent, applicant processing may be terminated (22:34).

Immediately following the PEI a MEPS HRA must digitally capture the applicants fingerprints on an Electronic Fingerprint Capture Station (EFCS). The capturing of applicant fingerprints, in accordance with Special Agreement Check (SAC) procedures, is an essential process in support of background investigations and ethical enlistment into the armed forces in (22:48). A MEPS submits the captured fingerprints no later than the close of business for the date of capture with investigation results typically posting within 72-hours (22:48, 49). Applicants cannot depart for initial basic

training until results of the background investigation have successfully been adjudicated and posted.

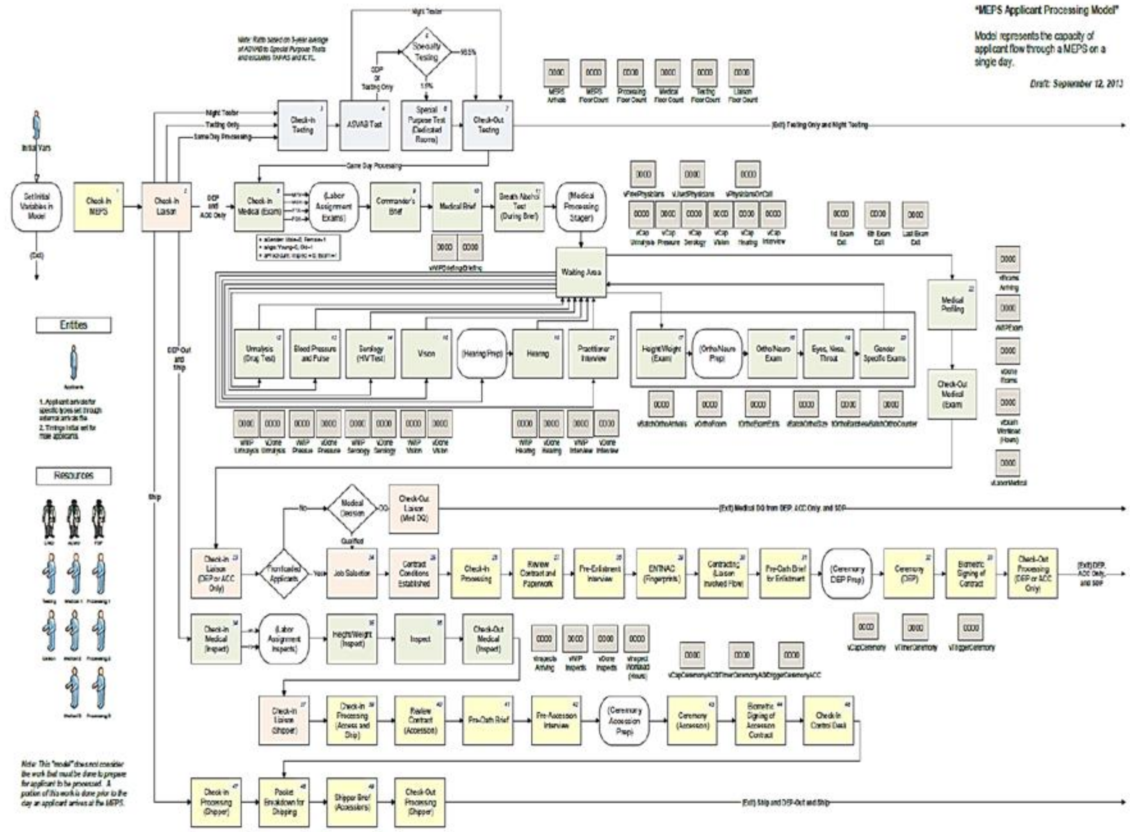
Prior to administering the oath of enlistment for entry into the DEP or accession to active duty, MEPS personnel must deliver the pre-oath briefing to applicants (22:39). The DEP oath of enlistment will take place immediately following the pre-oath briefing and is administered by the MEPS Commander or designated Enlistment Officer (EO) (22:40). An applicant may not enter the DEP until they have completed the oath of enlistment. After the oath of enlistment, the EO confirms the applicant's enlistment contract at which time the applicant becomes legally bound to depart for initial basic training at the completion of the DEP period (14:43).

Upon completion of the DEP period, an applicant must return to MEPS to complete several processing activities in the operations processing section prior to departing for initial basic training. The first of such processes is the PAI. The purpose of the interview is to provide another quality check after the medical inspection and before enlistment from the DEP (22:34). MEPS HRA staff will provide applicants with necessary documentation to disclose any changes that may impact their qualification for military service. The MEPS Commander may direct to have the PAI conducted on an individual basis or in a group session (22:34). For purposes of this research, the PAI is modeled to reflect an individual PAI process. The enlistment process may be terminated if the applicant discloses any fraudulent enlistment information.

Applicants must complete the accession oath of enlistment in a group setting prior to departing for initial basic training. As with the DEP oath of enlistment, applicants receive a pre-oath brief and complete the accession oath of enlistment administered by an

EO (22:40). After the oath of enlistment, the EO confirms the applicant's enlistment contract at which time the applicant becomes legally bound to depart for initial basic training on that day (14:43). After the oath of enlistment, applicants receive a travel guidance brief administered by MEPS HRA staff prior to departing a MEPS. Upon successful completion of the oath of enlistment and travel brief activities, the applicant completes the applicant processing operation at a MEPS

APPENDIX B. USMEPCOM DETAILED PROCESS MAP



(Source: Bell et al. (2016))

APPENDIX C. ALTERNATIVE APPLICANT ARRIVAL SCENARIOS

Scenario Name	Identifier	# of DEP Arrival Windows	Time Between Arrival Windows (Minutes)	Express Lane
BaseHeavyDEP	Current	1	N/A	0
BaseHeavyShip	Current	1	N/A	0
Alt1ELane1HeavyDEP	Current + ELane 1	1	N/A	1 Bypass CCBrief
Alt1ELane1HeavyShip	Current + ELane 1	1	N/A	1 Bypass CCBrief
Alt2ELane2HeavyDEP	Current + ELane 2	1	N/A	2 Bypass CCBrief and MedBrief
Alt2ELane2HeavyShip	Current + ELane 2	1	N/A	2 Bypass CCBrief and MedBrief
Alt3ELane0HeavyDEP	Split-Shift	2	300	0
Alt3ELane0HeavyShip	Split-Shift	2	300	0
Alt4ELane1HeavyDEP	Hybrid 1	2	300	1 Bypass CCBrief
Alt4ELane1HeavyShip	Hybrid 1	2	300	1 Bypass CCBrief
Alt5ELane2HeavyDEP	Hybrid 2	2	300	2 Bypass CCBrief and MedBrief
Alt5ELane2HeavyShip	Hybrid 2	2	300	2 Bypass CCBrief and MedBrief
Alt6HeavyDEP3Win	Pure Appt.	3	120	N/A
Alt6HeavyShip3Win	Pure Appt.	3	120	N/A
Alt7HeavyDEP4Win	Pure Appt.	4	60	N/A
Alt7HeavyShip4Win	Pure Appt.	4	60	N/A
Alt8HeavyDEP6Win	Pure Appt.	6	45	N/A

APPENDIX C. ALTERNATIVE APPLICANT ARRIVAL SCENARIOS (Cont.)

Alt8HeavyShip6Win	Pure Appt.	6	45	N/A
Alt9HeavyDEP8Win	Pure Appt.	8	*Random.Exponential(30)	N/A
Alt9HeavyShip8Win	Pure Appt.	8	Random.Exponential(30)	N/A
10/90MedTechSchedule	Resource 1	1	N/A	N/A
70/30MedTechSchedule	Resource 2	1	N/A	N/A
90/10MedTechSchedule	Resource 3	1	N/A	N/A
*Random.Exponential(mean)				

APPENDIX D. ALTERNATIVE APPLICANT ARRIVAL SCENARIOS FOR SMALL MEPS

Scenario Name	DEP Arrival Windows	Number of Arrivals (DEP, Ship) / ELane DEP Arrivals
BaseHeavyDEP	1	(12, 5) / 0
BaseHeavyShip	1	(4, 28) / 0
Alt1ELane1HeavyDEP	1	(9, 5) / 3
Alt1ELane1HeavyShip	1	(3, 28) / 1
Alt2ELane2HeavyDEP	1	(9, 5) / 3
Alt2ELane2HeavyShip	1	(3, 28) / 1
Alt3ELane0HeavyDEP	2	(6, 5) / 0
Alt3ELane0HeavyShip	2	(2, 28) / 0
Alt4ELane1HeavyDEP	2	(4, 5) / 2
Alt4ELane1HeavyShip	2	(2, 28) / 1
Alt5ELane2HeavyDEP	2	(4, 5) / 2
Alt5ELane2HeavyShip	2	(2, 28) / 1
Alt6HeavyDEP3Win	3	(4, 5)
Alt6HeavyShip3Win	3	(2, 28)
Alt7HeavyDEP4Win	4	(3, 5)
Alt7HeavyShip4Win	4	(1, 28)
Alt8HeavyDEP6Win	6	(2, 5)
Alt8HeavyShip6Win	6	(1, 28)
Alt9HeavyDEP8Win	8	(1, 5)
Alt9HeavyShip8Win	8	(1, 28)
10/90MedTechSchedule	1	(12, 5)
70/30MedTechSchedule	1	(12, 5)
90/10MedTechSchedule	1	(12, 5)

APPENDIX E. ALTERNATIVE APPLICANT ARRIVAL SCENARIOS FOR MEDIUM MEPS

Scenario Name	DEP Arrival Windows	Number of Arrivals (DEP, Ship) / ELane DEP Arrivals
BaseHeavyDEP	1	(24, 7) / 0
BaseHeavyShip	1	(8, 54) / 0
Alt1ELane1HeavyDEP	1	(18, 7) / 6
Alt1ELane1HeavyShip	1	(6, 54) / 2
Alt2ELane2HeavyDEP	1	(18, 7) / 6
Alt2ELane2HeavyShip	1	(6, 54) / 2
Alt3ELane0HeavyDEP	2	(12, 7) / 0
Alt3ELane0HeavyShip	2	(4, 54) / 0
Alt4ELane1HeavyDEP	2	(9, 7) / 3
Alt4ELane1HeavyShip	2	(3, 54) / 1
Alt5ELane2HeavyDEP	2	(9, 7) / 3
Alt5ELane2HeavyShip	2	(3, 54) / 1
Alt6HeavyDEP3Win	3	(8, 7)
Alt6HeavyShip3Win	3	(4, 54)
Alt7HeavyDEP4Win	4	(6, 7)
Alt7HeavyShip4Win	4	(3, 54)
Alt8HeavyDEP6Win	6	(4, 7)
Alt8HeavyShip6Win	6	(2, 54)
Alt9HeavyDEP8Win	8	(3, 7)
Alt9HeavyShip8Win	8	(1, 54)
10/90MedTechSchedule	1	(24, 7)
70/30MedTechSchedule	1	(24, 7)
90/10MedTechSchedule	1	(24, 7)

APPENDIX F. ALTERNATIVE APPLICANT ARRIVAL SCENARIOS FOR LARGE MEPS

Scenario Name	DEP Arrival Windows	Number of Arrivals (DEP, Ship) / ELane DEP Arrivals
BaseHeavyDEP	1	(40, 8) / 0
BaseHeavyShip	1	(16, 70) / 0
Alt1ELane1HeavyDEP	1	(30, 8) / 10
Alt1ELane1HeavyShip	1	(12, 70) / 4
Alt2ELane2HeavyDEP	1	(30, 8) / 10
Alt2ELane2HeavyShip	1	(12, 70) / 4
Alt3ELane0HeavyDEP	2	(20, 8) / 0
Alt3ELane0HeavyShip	2	(8, 70) / 0
Alt4ELane1HeavyDEP	2	(15, 8) / 5
Alt4ELane1HeavyShip	2	(6, 70) / 2
Alt5ELane2HeavyDEP	2	(15, 8) / 5
Alt5ELane2HeavyShip	2	(6, 70) / 2
Alt6HeavyDEP3Win	3	(13, 8)
Alt6HeavyShip3Win	3	(5, 70)
Alt7HeavyDEP4Win	4	(10, 8)
Alt7HeavyShip4Win	4	(4, 70)
Alt8HeavyDEP6Win	6	(7, 8)
Alt8HeavyShip6Win	6	(3, 70)
Alt9HeavyDEP8Win	8	(5, 8)
Alt9HeavyShip8Win	8	(2, 70)
10/90MedTechSchedule	1	(40, 8)
70/30MedTechSchedule	1	(40, 8)
90/10MedTechSchedule	1	(40, 8)

APPENDIX G. TESTING SECTION REFERENCE PROPERTIES

Tester Category and Service Branch	**Processing Time Reference Property**
Tester Category: 0 Service Branch: Coast Guard	ASVABTime
Tester Category: 0 Service Branch: Navy	ASVABTime + CyberTestTime + MentalCountersTestTime + CodingSpeedTestTime
Tester Category: 0 Service Branch: Army	ASVABTime + ArmyTAPASTestTime + CyberTestTime
Tester Category: 0 Service Branch: Air Force and Marines	ASVABTime + AFMarineTAPASTime + CyberTestTime
Tester Category: 1 Service Branch: Coast Guard	PiCATTestTime
Tester Category: 1 Service Branch: Navy	PiCATTestTime + CyberTestTime + MentalCountersTestTime + CodingSpeedTestTime
Tester Category: 1 Service Branch: Army	PiCATTestTime + ArmyTAPASTestTime + CyberTestTime
Tester Category: 1 Service Branch: Air Force and Marines	PiCATTestTime + AFMarineTAPASTime + CyberTestTime
Tester Category: 2	ASVABTime

APPENDIX H. TESTING SECTION PROCESSING TIMES

Exam	Processing Time Distribution (Minutes)
ASVABTime	Random.Continuous(21, .0001, 28.3, .0002, 35.6, .001, 42.9, .003, 50.2, .009, 57.5, .021, 64.8, .043, 72.1, .078, 79.4, .126, 86.7, .189, 94, .263, 101.3, .347, 108.6, .432, 115.9, .516, 123.2, .597, 130.5, .674, 137.8, .742, 145.1, .802, 152.4, .851, 159.7, .892, 167, .925, 174.3, .95, 181.6, .967, 188.9, .980, 196.2, .988, 203.5, .993, 210.8, .996, 218.1, .998, 225.4, .998, 232.7, .999, 240, 1)
CyberTestTime	Random.Continuous(1, .009, 3.6, .033, 6.2, .114, 8.8, .307, 11.4, .547, 14, .742, 16.6, .862, 19.2, .928, 21.8, .964, 24.4, .982, 27, .992, 29.6, .999, 34.8, 1)
MentalCountersTestTime	Random.Continuous(.5, .034, 1.5, .038, 2.5, .039, 3.5, .040, 4.5, .0401, 5.5, .041, 6.5, .0411, 7.5, .042, 8.5, .045, 9.5, .061, 10.5, .120, 11.5, .236, 12.5, .386, 13.5, .531, 14.5, .651, 15.5, .751, 16.5, .822, 17.5, .872, 18.5, .905, 19.5, .933, 20.5, .951, 21.5, .964, 22.5, .975, 23.5, .981, 24.5, .988, 25.5, .992, 26.5, .995, 27.5, .998, 28.5, .9995, 29.5, .9999, 30.5, 1)
CodingSpeedTestTime	Random.Continuous(2.6, .001, 4.3, .005, 6.7, .109, 9, .611, 11.3, .880, 13.7, .956, 16, .983, 18.3, .993, 20.7, .997, 23, .999, 25.3, .9991, 27.7, .9992, 30, .9993, 32.3, .9994, 34.7, .9999, 37, 1)
ArmyTAPASTestTime	Random.Continuous(1, .008, 2.7, .025, 4.3, .04, 6, .055, 7.7, .073, 9.3, .098, 11, .139, 12.7, .201, 14.3, .285, 16, .386, 17.7, .492, 19.3, .589, 21, .674, 22.7, .749, 24.3, .806, 26, .851, 27.7, .887, 29.3, .913, 31, .935, 32.7, .950, 34.3, .962, 36, .971, 37.7, .978, 39.3, .984, 41, .988, 42.7, .991, 44.3, .992, 46, .993, 47.7, .995, 49.3, .998, 51.5, 1)
AFMarineTAPASTime	Random.Continuous(1, .0001, 2.5, .002, 4, .005, 5.5, .009, 7.1, .017, 8.6, .029, 10.1, .055, 11.6, .103, 13.1, .176, 14.7, .277, 16.2, .395, 17.7, .509, 19.2, .616, 20.7, .709, 22.2, .785, 23.8, .842, 25.3, .885, 26.8, .917, 28.3, .940, 29.8, .958, 31.3, .969, 32.9, .978, 34.4, .983, 35.8, .988, 37.4, .991, 38.9, .993, 40.4, .995, 41.9, .997, 43.5, .998, 44.9, .999, 46.5, 1)
PiCATTestTime	Random.Discrete(*Random.Triangular(20, 25, 45), .95, ASVABTime, 1)
*Random.Triangular(minimum, mode, maximum)	

APPENDIX I. BASE MODEL MEDICAL SECTION APPLICANT PROCESSING

Server	Processing Time Distribution (Minutes)	Resource Seized	Capacity Value
MedIn	****Random.Gamma(12.53,0.32)	*Medical Technician	Small: 3 Medium: 3 Large: 4
MedOut	Random.Gamma(12.53, 0.32)	*Medical Technician	Small: 3 Medium: 3 Large: 4
MedBrief	*****Random.Triangular(57,59,60)	*Medical Technician	***1 Batch All sizes: 1
BAT	Random.Exponential(0.67)	*Medical Technician	All sizes: 1
BATWaiting	Random.Exponential(15)	*Medical Technician	Infinite
BP	Random.Exponential(1) + Random.Exponential(0.5)	*Medical Technician	Small: 1 Medium: 2 Large: 3
Vision	Random.Gamma(53.22, 0.21)	*Medical Technician	Small: 2 Medium: 3 Large: 4
Hearing	Random.Gamma(3.19, 3.27)	*Medical Technician	6 Various Sizes Available
HIVTest	Random.Triangular(2.25,2.5,3)	*Medical Technician	Small: 1 Medium: 2 Large: 3
FemaleDrugTest	Random.Exponential(4.8) (DEP) Random.Triangular(2.25,2.5,2.75) (Ship)	Female Medical Technician	***1 Batch Up to 2
FemaleDAT_Lab	Random.Exponential(1)	Female Medical Technician	1

APPENDIX I. BASE MODEL MEDICAL SECTION APPLICANT PROCESSING (Cont.)

MaleDrugTest	Random.Exponential(7)	Male Medical Technician	***1 Batch Up to 6
MaleDAT_Lab	Random.Exponential(1)	Male Medical Technician	1
ProviderInt	Random.Gamma(5.63, 1.23) (DEP) Random.Exponential(0.5) + Random.Gamma(5.63, 1.23) (Ship)	Provider or FBP	Small: 2 Medium: 3 Large: 4
OrthoNeuroMale	Random.Gamma(68.69, 0.27)	Provider or FBP **and Male Medical Technician	***1 Batch Up to 8
OrthoNeuroFemale	Random.Gamma(68.69, 0.27)	Provider or FBP **and Female Medical Technician	***1 Batch Up to 8
Fem_Height_Weight	Random.Exponential(1.5)	Provider or FBP **and Female Medical Technician	2
Male_Height_Weight	Random.Exponential(1.5)	Provider or FBP **and Male Medical Technician	2

APPENDIX I. BASE MODEL MEDICAL SECTION APPLICANT PROCESSING (Cont.)

DEPProviderEX	Random.Gamma(7.89, 0.76) (Male) Random.Gamma(9.53, 0.76) (Female)	Provider or FBP **and Medical Technician or Chaperone	2
* Male or female medical technician seized from list ** Simultaneous seizure of resources is required for processing *** Batch processing of entities is required ****Random.Gamma(shape α, scale β) where mean: $\mu = \alpha\beta$ *****Random.Triangular(minimum, mode, maximum)			

APPENDIX J. BASE MODEL OPERATIONS SECTION APPLICANT PROCESSING

Server	Processing Time Distribution (Minutes)	Resource Seized	Capacity Value
OPSIn	**Random.Triangular(.95,1,1.5)	HRA OCD	Small: 1 Medium: 2 Large: 3
PEI	***Random.Exponential(15)	Processing HRA	Small: 2 Medium: 3 Large: 4
Fingerprints	Random.Exponential(5)	Processing HRA	Small: 1 Medium: 2 Large: 3
PAI	Random.Exponential(20)	Processing HRA	*1 Batch
PreOath	Random.Triangular(12,15,15.5)	Processing HRA	*1 Batch Up to 16
OathCeremony	Random.Triangular(9, 10, 15)	Enlistment Officer	*1 Batch Up to 16
SignEnlistmentContract	Random.Triangular(1.25,1.5,1.75)	Enlistment Officer	1
* Batch processing of entities is required **Random.Triangular(minimum, mode, maximum) ***Random.Exponential(mean)			

APPENDIX K. BASE MODEL SERVICE LIAISON APPLICANT PROCESSING SMALL MEPS

Server	Processing Time Distribution (Minutes)
SCVAF 1st visit (DEP/SDP/MSN)	Random.Continuous(1, 0.314, 21.099, 0.460, 41.199, 0.619, 61.299, 0.717, 81.399, 0.781, 101.499, 0.843, 121.600, 0.888, 141.700, 0.936, 161.800, 0.960, 181.900, 0.969, 202.000, 0.974, 222.100, 0.986, 242.200, 0.988, 262.300, 0.993, 282.400, 1)
SVCAF 2nd visit (DEP/SDP/MSN)	Random.Triangular(.75,1,1.25)
SVCAF 3rd visit (DEP/SDP/MSN)	Random.Continuous(1, 0.832, 10.249, 0.947, 30.499, 1)
SCVAF 1st visit (Ship)	Random.Triangular(.5,1,1.25)
SVCAF 2nd visit (Ship)	Random.Triangular(.5,1,1.25)
SVCAF Medical Disqualification	Random.Continuous(1, 0.557, 17.024, 0.604, 33.049, 0.633, 49.074, 0.667, 65.099, 0.695, 81.124, 0.724, 97.149, 0.751, 113.174, 0.785, 129.199, 0.819, 145.224, 0.849, 161.249, 0.874, 177.275, 0.896, 193.300, 0.918, 209.325, 1)
SCVArmy 1st visit (DEP/SDP/MSN)	Random.Continuous(1, 0.092, 17.940, 0.437, 34.881, 0.500, 51.823, 0.582, 68.764, 0.642, 85.705, 0.700, 102.646, 0.743, 119.588, 0.777, 136.529, 0.815, 153.470, 0.849, 170.411, 0.873, 187.353, 0.888, 204.294, 0.905, 221.235, 0.919, 238.176, 0.943, 255.118, 0.960, 272.059, 0.974, 289.000, 0.978, 305.941, 0.984, 322.882, 0.987, 339.824, 0.995, 356.765, 0.997, 373.706, 0.998, 390.647, 1)
SVCArmy 2nd visit (DEP/SDP/MSN)	Random.Continuous(1, 0.213, 13.820, 0.751, 26.642, 0.781, 39.463, 0.807, 52.285, 0.837, 65.106, 0.850, 77.928, 0.881, 90.749, 0.907, 103.571, 0.928, 116.393, 0.943, 129.214, 0.952, 142.035, 0.959, 154.857, 0.969, 167.678, 0.976, 180.500, 0.981, 193.321, 0.988, 206.143, 0.990, 218.964, 0.990, 231.786, 0.990, 244.607, 0.991, 257.429, 0.993, 270.250, 0.994, 283.072, 0.995, 295.893, 0.999, 308.715, 1)
SVCArmy 3rd visit (DEP/SDP/MSN)	Random.Continuous(1, 0.058, 6.959, 0.763, 15.919, 0.821, 20.879, 1)

APPENDIX K. BASE MODEL SERVICE LIAISON APPLICANT PROCESSING SMALL MEPS (Cont.)

SCVArmy 1st visit (Ship)	Random.Triangular(1,5,5.25)
SVCArmy 2nd visit (Ship)	Random.Triangular(1,5,5.25)
SVCArmy Medical Disqualification	Random.Continuous(1, 0.663, 16.999, 0.724, 32.999, 0.742, 48.999, 0.759, 64.999, 0.775, 80.999, 0.792, 96.999, 0.811, 112.999, 0.831, 128.999, 0.855, 144.999, 0.876, 160.999, 0.898, 177.000, 0.917, 193.000, 1)
SCVCG 1st visit (DEP/SDP/MSN)	Random.Continuous(1, 0.619, 65.333, 0.857, 129.666, 0.881, 194.000, 0.952, 258.334, 0.976, 322.667, 0.990, 387.001,1)
SVCCG 2nd visit (DEP/SDP/MSN)	Random.Continuous(2, 0.182, 32.799, 0.455, 63.600, 0.773, 94.400, 0.955, 125.201, 0.990, 156.0, 1)
SVCCG 3rd visit (DEP/SDP/MSN)	Random.Triangular(7,9,10)
SCVCG 1st visit (Ship)	Random.Triangular(.5,1,1.25)
SVCCG 2nd visit (Ship)	Random.Triangular(.5,1,1.25)
SVCCG Medical Disqualification	Random.Continuous(1, 0.708, 29.285, 0.780, 57.571, 0.847, 85.857, 0.895, 114.142, 0.909, 142.428, 1)
SCVMarines 1st visit (DEP/SDP/MSN)	Random.Continuous(1, 0.027, 30.866, 0.504, 60.733, 0.557, 90.599, 0.689, 120.466, 0.783, 150.333, 0.843, 180.200, 0.911, 210.067, 0.974, 239.933, 0.987, 269.800, 0.991, 299.667, 0.996, 329.534,1)
SVCMarines 2nd visit (DEP/SDP/MSN)	Random.Continuous(1, 0.162, 33.444, 0.593, 65.888, 0.747, 98.333, 0.813, 130.778, 0.890, 163.222, 0.956, 195.667, 0.967, 228.112, 0.978, 260.556, 0.990, 293.001, 1)
SVCMarines 3rd visit (DEP/SDP/MSN)	Random.Continuous(1, 0.426, 10.166, 0.741, 59.333, 0.869, 88.499, 1)
SCVMarines 1st visit (Ship)	Random.Triangular(1,5,5.25)
SVCMarines 2nd visit (Ship)	Random.Triangular(1,4,4.25)

APPENDIX K. BASE MODEL SERVICE LIAISON APPLICANT PROCESSING SMALL MEPS (Cont.)

SVCMarines Medical Disqualification	Random.Continuous(1, 0.182, 23.032, 0.256, 45.066, 0.322, 67.099, 0.386, 89.133, 0.451, 111.166, 0.511, 133.199, 0.596, 155.233, 0.680, 177.266, 0.761, 199.300, 0.836, 221.333, 0.887, 243.366,1)
SCVNavy 1st visit (DEP/SDP/MSN)	Random.Continuous(1, 0.080, 21.624, 0.114, 42.249, 0.302, 62.874, 0.418, 83.499, 0.540, 104.124, 0.635, 124.750, 0.720, 145.375, 0.790, 166.000, 0.854, 186.625, 0.880, 207.250, 0.910, 227.875, 0.934, 248.500, 0.939, 269.125, 0.948, 289.750, 0.955, 310.375, 0.960, 331.000, 0.970, 351.625, 0.977, 372.251, 0.984, 392.876, 0.986, 413.501, 0.988, 434.126, 0.9885, 454.751, 0.990, 475.376, 0.995, 496.001, 1)
SVCNavy 2nd visit (DEP/SDP/MSN)	Random.Continuous(1, 0.162, 33.249, 0.607, 65.499, 0.738, 97.750, 0.807, 130.000, 0.876, 162.250, 0.924, 194.500, 0.945, 226.750, 0.966, 259.000, 0.972, 291.250, 0.972, 323.501, 0.993, 355.751, 0.999, 388.001, 1)
SVCNavy 3rd visit (DEP/SDP/MSN)	Random.Continuous(1, 0.674, 21.332, 0.789, 41.666, 0.842, 61.999, 1)
SCVNavy 1st visit (Ship)	Random.Triangular(1,5.75,6.25)
SVCNavy 2nd visit (Ship)	Random.Triangular(1,3,3.25)
SVCNavy Medical Disqualification	Random.Continuous(1, 0.581, 14.999, 0.602, 28.999, 0.622, 42.999, 0.641, 56.999, 0.664, 70.999, 0.681, 84.999, 0.710, 98.999, 0.733, 112.999, 0.759, 126.999, 0.782, 141.000, 0.809, 155.000, 0.833, 169.000, 0.863, 183.000, 0.881, 197.000, 1)

APPENDIX L. BASE MODEL SERVICE LIAISON APPLICANT PROCESSING MEDIUM MEPS

Server	Processing Time Distribution (Minutes)
SCVAF 1st visit (DEP/SDP/MSN)	Random.Continuous(1, 0.314, 21.099, 0.460, 41.199, 0.619, 61.299, 0.717, 81.399, 0.781, 101.499, 0.843, 121.600, 0.888, 141.700, 0.936, 161.800, 0.960, 181.900, 0.969, 202.000, 0.974, 222.100, 0.986, 242.200, 0.988, 262.300, 0.993, 282.400, 1)
SVCAF 2nd visit (DEP/SDP/MSN)	Random.Triangular(.75,1,1.25)
SVCAF 3rd visit (DEP/SDP/MSN)	Random.Continuous(1, 0.832, 10.249, 0.947, 30.499, 1)
SCVAF 1st visit (Ship)	Random.Triangular(.5,1,1.25)
SVCAF 2nd visit (Ship)	Random.Triangular(.5,1,1.25)
SVCAF Medical Disqualification	Random.Continuous(1, 0.557, 17.024, 0.604, 33.049, 0.633, 49.074, 0.667, 65.099, 0.695, 81.124, 0.724, 97.149, 0.751, 113.174, 0.785, 129.199, 0.819, 145.224, 0.849, 161.249, 0.874, 177.275, 0.896, 193.300, 0.918, 209.325, 1)
SCVArmy 1st visit (DEP/SDP/MSN)	Random.Continuous(1, 0.092, 17.940, 0.437, 34.881, 0.500, 51.823, 0.582, 68.764, 0.642, 85.705, 0.700, 102.646, 0.743, 119.588, 0.777, 136.529, 0.815, 153.470, 0.849, 170.411, 0.873, 187.353, 0.888, 204.294, 0.905, 221.235, 0.919, 238.176, 0.943, 255.118, 0.960, 272.059, 0.974, 289.000, 0.978, 305.941, 0.984, 322.882, 0.987, 339.824, 0.995, 356.765, 0.997, 373.706, 0.998, 390.647, 1)
SVCArmy 2nd visit (DEP/SDP/MSN)	Random.Continuous(1, 0.213, 13.820, 0.751, 26.642, 0.781, 39.463, 0.807, 52.285, 0.837, 65.106, 0.850, 77.928, 0.881, 90.749, 0.907, 103.571, 0.928, 116.393, 0.943, 129.214, 0.952, 142.035, 0.959, 154.857, 0.969, 167.678, 0.976, 180.500, 0.981, 193.321, 0.988, 206.143, 0.990, 218.964, 0.990, 231.786, 0.990, 244.607, 0.991, 257.429, 0.993, 270.250, 0.994, 283.072, 0.995, 295.893, 0.999, 308.715, 1)
SVCArmy 3rd visit (DEP/SDP/MSN)	Random.Continuous(1, 0.058, 6.959, 0.763, 15.919, 0.821, 20.879, 1)

APPENDIX L. BASE MODEL SERVICE LIAISON APPLICANT PROCESSING MEDIUM MEPS (Cont.)

SCVArmy 1st visit (Ship)	Random.Triangular(1,5,5.25)
SVCArmy 2nd visit (Ship)	Random.Triangular(1,5,5.25)
SVCArmy Medical Disqualification	Random.Continuous(1, 0.663, 16.999, 0.724, 32.999, 0.742, 48.999, 0.759, 64.999, 0.775, 80.999, 0.792, 96.999, 0.811, 112.999, 0.831, 128.999, 0.855, 144.999, 0.876, 160.999, 0.898, 177.000, 0.917, 193.000, 1)
SCVCG 1st visit (DEP/SDP/MSN)	Random.Continuous(1, 0.619, 65.333, 0.857, 129.666, 0.881, 194.000, 0.952, 258.334, 0.976, 322.667, 0.990, 387.001,1)
SVCCG 2nd visit (DEP/SDP/MSN)	Random.Continuous(2, 0.182, 32.799, 0.455, 63.600, 0.773, 94.400, 0.955, 125.201, 0.990, 156.0, 1)
SVCCG 3rd visit (DEP/SDP/MSN)	Random.Triangular(7,9,10)
SCVCG 1st visit (Ship)	Random.Triangular(.5,1,1.25)
SVCCG 2nd visit (Ship)	Random.Triangular(.5,1,1.25)
SVCCG Medical Disqualification	Random.Continuous(1, 0.708, 29.285, 0.780, 57.571, 0.847, 85.857, 0.895, 114.142, 0.909, 142.428, 1)
SCVMarines 1st visit (DEP/SDP/MSN)	Random.Continuous(1, 0.027, 30.866, 0.504, 60.733, 0.557, 90.599, 0.689, 120.466, 0.783, 150.333, 0.843, 180.200, 0.911, 210.067, 0.974, 239.933, 0.987, 269.800, 0.991, 299.667, 0.996, 329.534,1)
SVCMarines 2nd visit (DEP/SDP/MSN)	Random.Continuous(1, 0.162, 33.444, 0.593, 65.888, 0.747, 98.333, 0.813, 130.778, 0.890, 163.222, 0.956, 195.667, 0.967, 228.112, 0.978, 260.556, 0.990, 293.001, 1)
SVCMarines 3rd visit (DEP/SDP/MSN)	Random.Continuous(1, 0.426, 10.166, 0.741, 59.333, 0.869, 88.499, 1)
SCVMarines 1st visit (Ship)	Random.Triangular(1,5,5.25)
SVCMarines 2nd visit (Ship)	Random.Triangular(1,4,4.25)

APPENDIX L. BASE MODEL SERVICE LIAISON APPLICANT PROCESSING MEDIUM MEPS (Cont.)

SVCMarines Medical Disqualification	Random.Continuous(1, 0.182, 23.032, 0.256, 45.066, 0.322, 67.099, 0.386, 89.133, 0.451, 111.166, 0.511, 133.199, 0.596, 155.233, 0.680, 177.266, 0.761, 199.300, 0.836, 221.333, 0.887, 243.366,1)
SCVNavy 1st visit (DEP/SDP/MSN)	Random.Continuous(1, 0.080, 21.624, 0.114, 42.249, 0.302, 62.874, 0.418, 83.499, 0.540, 104.124, 0.635, 124.750, 0.720, 145.375, 0.790, 166.000, 0.854, 186.625, 0.880, 207.250, 0.910, 227.875, 0.934, 248.500, 0.939, 269.125, 0.948, 289.750, 0.955, 310.375, 0.960, 331.000, 0.970, 351.625, 0.977, 372.251, 0.984, 392.876, 0.986, 413.501, 0.988, 434.126, 0.9885, 454.751, 0.990, 475.376, 0.995, 496.001, 1)
SVCNavy 2nd visit (DEP/SDP/MSN)	Random.Continuous(1, 0.162, 33.249, 0.607, 65.499, 0.738, 97.750, 0.807, 130.000, 0.876, 162.250, 0.924, 194.500, 0.945, 226.750, 0.966, 259.000, 0.972, 291.250, 0.972, 323.501, 0.993, 355.751, 0.999, 388.001, 1)
SVCNavy 3rd visit (DEP/SDP/MSN)	Random.Continuous(1, 0.674, 21.332, 0.789, 41.666, 0.842, 61.999, 1)
SCVNavy 1st visit (Ship)	Random.Triangular(1,5.75,6.25)
SVCNavy 2nd visit (Ship)	Random.Triangular(1,3,3.25)
SVCNavy Medical Disqualification	Random.Continuous(1, 0.581, 14.999, 0.602, 28.999, 0.622, 42.999, 0.641, 56.999, 0.664, 70.999, 0.681, 84.999, 0.710, 98.999, 0.733, 112.999, 0.759, 126.999, 0.782, 141.000, 0.809, 155.000, 0.833, 169.000, 0.863, 183.000, 0.881, 197.000, 1)

APPENDIX M. BASE MODEL SERVICE LIAISON APPLICANT PROCESSING LARGE MEPS

Server	Processing Time Distribution (Minutes)
SCVAF 1st visit (DEP/SDP/MSN)	Random.Continuous(1,.168,5.89,.260,10.78,.312, 15.67,.356,20.56,.409,25.46,.443,30.35, .482,35.24,.529,40.13,.569,45.03,.591, 49.91,.620,54.81,.658,59.70,.677,64.59,.707, 69.49,.738,74.38,.763,79.27,.783,84.16,.813, 89.05,.828,93.95,.848,98.34,.864,103.73,.878, 108.622,.895,113.514,.902,118.406,.911,123.39, .924,128.190,.931,133.082,.939,137.97,.946, 142.86,.956,147.75,.965,152.65,.976,157.54,.984, 162.43,.987,167.32,.994,172.22,.997,182,1)
SVCAF 2nd visit (DEP/SDP/MSN)	Random.Triangular(.75,1,1.25)
SVCAF 3rd visit (DEP/SDP/MSN)	Random.Continuous(1, 0.245, 2.999, 0.343, 4.999, 0.415, 6.999, 0.455, 8.999, 0.499, 10.999, 0.542, 12.999, 1)
SCVAF 1st visit (Ship)	Random.Continuous(1, 0.072, 2.999, 0.161, 4.999, 0.234, 6.999, 0.277, 8.999, 0.319, 10.999, 0.348, 12.999, 0.370, 14.999, 0.396, 16.999, 0.415, 18.999,1)
SVCAF 2nd visit (Ship)	Random.Triangular(.75,1,1.25)
SVCAF Medical Disqualification	Random.Continuous(1, 0.557, 17.024, 0.604, 33.049, 0.633, 49.074, 0.667, 65.099, 0.695, 81.124, 0.724, 97.149, 0.751, 113.174, 0.785, 129.199, 0.819, 145.224, 0.849, 161.249, 0.874, 177.275, 0.896, 193.300, 0.918, 209.325, 1)
SCVArmy 1st visit (DEP/SDP/MSN)	Random.Continuous(1, 0.253, 6.824, 0.320, 12.649, 0.360, 18.474, 0.392, 24.299, 0.424, 30.124, 0.444, 35.949, 0.473, 41.774, 0.493, 47.599, 0.519, 53.424, 0.546, 59.249, 0.574, 65.075, 0.597, 70.900, 0.625, 76.725, 0.651, 82.550, 0.675, 88.375, 0.694, 94.200, 0.720, 100.025, 0.738, 105.850, 0.757, 111.675, 0.775, 117.500, 0.791, 123.325, 0.810, 129.150, 0.821, 134.975, 0.841, 140.800, 0.856, 146.625, 0.870, 152.450, 0.886, 158.275, 0.901, 164.100, 0.910, 169.925, 0.919, 175.751, 0.934, 181.576, 0.942, 187.401, 0.950, 193.226, 0.958, 199.051, 0.963, 204.876, 0.972, 210.701, 0.981, 216.526, 0.988, 222.351, 0.994, 228.176, 0.998, 234.001,1)

APPENDIX M. BASE MODEL SERVICE LIAISON APPLICANT PROCESSING LARGE MEPS (Cont.)

SVCArmy 2nd visit (DEP/SDP/MSN)	Random.Continuous(1,.338,7.17,.4,13.35,.446,19.52,.483, 25.7,.515,31.87,.547,38.05,.578,44.22,.605,50.4, .626,56.57,.646,62.75,.665,68.92,.684,75.1, .701,81.27,.720,87.45,.735,93.62,.751,99.8, .765,105.97,.784,112.15,.801,118.32,.817, 124.5,.829,130.67,.846,136.85,.859,143.03,.870, 149.2,.884,155.37,.894,161.55,.906,167.72,.918, 173.9,.931,180.08,.941,186.25,.948,192.43, .957,198.6,.962,204.78,.969,210.95,.975,217.13, .981,223.3,.987,229.48,.991, 235.65,.996,241.82,.999,248,1)
SVCArmy 3rd visit (DEP/SDP/MSN)	Random.Triangular(19.5,20,20.5)
SCVArmy 1st visit (Ship)	Random.Continuous(1, 0.206, 2.999, 0.283, 4.999, 0.356, 6.999, 0.400, 8.999, 0.427, 10.999, 0.450, 12.999, 0.70, 14.999,1)
SVCArmy 2nd visit (Ship)	Random.Continuous(1, 0.241, 2.999, 0.369, 4.999, 0.84, 6.999, 1)
SVCArmy Medical Disqualification	Random.Continuous(1, 0.663, 16.999, 0.724, 32.999, 0.742, 48.999, 0.759, 64.999, 0.775, 80.999, 0.792, 96.999, 0.811, 112.999, 0.831, 128.999, 0.855, 144.999, 0.876, 160.999, 0.898, 177.000, 0.917, 193.000, 1)
SCVCG 1st visit (DEP/SDP/MSN)	Random.Continuous(1,.322,17.4,.530,33.79,.635, 50.2,.730,66.6,.817,83,.861, 99.4, 0.922,115.8, .957,132.2,.974,148.6,.974,165,1)
SVCCG 2nd visit (DEP/SDP/MSN)	Random.Triangular(.75,1,1.25)
SVCCG 3rd visit (DEP/SDP/MSN)	Random.Continuous(1, 0.836, 8.499, 0.883, 15.999, 0.925, 23.499, 0.934, 31.000, 0.934, 38.500, 0.934, 46.000, 0.944, 53.500, 0.948, 61.000, 0.953, 68.500, 0.972, 76.000, 0.981, 83.501, 0.986, 91.001, 0.991, 98.501, 0.995, 106.001, 1)
SCVCG 1st visit (Ship)	Random.Continuous(1, 0.340, 9.999, 0.62, 15.999, 1,)
SVCCG 2nd visit (Ship)	Random.Triangular(.75,1,1.25)
SVCCG Medical Disqualification	Random.Continuous(1, 0.708, 29.285, 0.780, 57.571, 0.847, 85.857, 0.895, 114.142, 0.909, 142.428, 1)

APPENDIX M. BASE MODEL SERVICE LIAISON APPLICANT PROCESSING LARGE MEPS (Cont.)

SCVMarines 1st visit (DEP/SDP/MSN)	Random.Continuous(1,.178,8.10,.248,15.21,.294,22.32, .347,29.43,.403,36.54,.442,43.65,.489,50.76, .526,57.86,.570,64.97,.614,72.08,.640,79.19, .670,86.29,.696,93.41,.720,100.51,.747, 107.62,.779,114.73,.806,121.84,.824, 128.95,.841,136.05,.856,143.16,.872,150.27, .879,157.38,.894,164.49,.904,171.59, .912,178.70,.926,185.81,.937,192.92,.948, 200.03,.957,207.14,.971,214.24,.977 ,221.35,.983,228.46,.987,235.57,.991, 242.68,.993,256.89,.997,264,1)
SVCMarines 2nd visit (DEP/SDP/MSN)	Random.Continuous(1,.187,10.46,.287,19.92, .368,29.38,.413,38.84,.463,48.31,.541, 54.77,.605,67.23,.645,76.69,.683,86.15,.723, 95.61,.766,105.08,.784,114.54,.810,124,.821, 133.46,.839,142.92,.862,152.39,.886,161.85, .898,171.31,.913,180.77,.930,190.23,.949, 199.69,.956,209.15,.964,218.62,.982 ,228.08,.991,237.54,.995,247,1)
SVCMarines 3rd visit (DEP/SDP/MSN)	Random.Continuous(1, 0.259, 2.999, 0.334, 4.999, 0.390, 6.999, 0.431, 8.999, 0.460, 10.999, 0.490, 12.999, 0.520, 14.999, 0.541, 16.999, 0.568, 18.999, 0.596, 20.999, 0.623, 22.999, 0.640, 24.999, 0.672, 26.999, 0.696, 28.999, 0.712, 30.999, 0.729, 32.999, 0.748, 34.999, 0.762, 36.999, 0.769, 38.999, 0.782, 40.999, 0.795, 42.999, 0.807, 44.999, 0.815, 46.999, 0.833, 48.999, 0.842, 50.999, 0.849, 52.999, 0.855, 54.999, 0.864, 56.999, 0.878, 58.999, 0.895, 60.999, 0.918, 62.999, 0.928, 64.999, 0.937, 66.999, 0.945, 68.999, 0.956, 70.999, 0.965, 72.999, 0.974, 74.999, 0.986, 76.999, 0.990, 78.999, 0.998, 100.500, 1)
SCVMarines 1st visit (Ship)	Random.Continuous(1, 0.132, 2.999, 0.179, 4.999, 0.215, 6.999, 0.250, 8.999, 0.278, 10.999, 0.308, 12.999, 0.340, 14.999, 0.357, 16.999, 0.378, 18.999, 0.394, 20.999, 0.412, 22.999, 0.434, 24.999,1)
SVCMarines 2nd visit (Ship)	Random.Continuous(1, 0.115, 2.999, 0.162, 4.999, 0.202, 6.999, 0.230, 8.999, 0.256, 10.999, 0.303, 12.999, 0.333, 14.999, 0.356, 16.999, 0.384, 18.999, 0.401, 20.999, 0.431, 22.999, 0.454, 24.999, 1)

APPENDIX M. BASE MODEL SERVICE LIAISON APPLICANT PROCESSING LARGE MEPS (Cont.)

SVCMarines Medical Disqualification	Random.Continuous(1, 0.182, 23.032, 0.256, 45.066, 0.322, 67.099, 0.386, 89.133, 0.451, 111.166, 0.511, 133.199, 0.596, 155.233, 0.680, 177.266, 0.761, 199.300, 0.836, 221.333, 0.887, 243.366,1)
SCVNavy 1st visit (DEP/SDP/MSN)	Random.Continuous(1, 0.505, 7.024, 0.528, 13.049, 0.548, 19.074, 0.567, 25.099, 0.583, 31.124, 0.598, 37.149, 0.609, 43.174, 0.621, 49.199, 0.638, 55.224, 0.654, 61.249, 0.674, 67.275, 0.691, 73.300, 0.706, 79.325, 0.719, 85.350, 0.735, 91.375, 0.750, 97.400, 0.764, 103.425, 0.778, 109.450, 0.792, 115.475, 0.806, 121.500, 0.817, 127.525, 0.835, 133.550, 0.848, 139.575, 0.862, 145.600, 0.875, 151.625, 0.885, 157.650, 0.895, 163.675, 0.905, 169.700, 0.915, 175.725, 0.925, 181.750, 0.934, 187.776, 0.944, 193.801, 0.952, 199.826, 0.961, 205.851, 0.968, 211.876, 0.975, 217.901, 0.980, 223.926, 0.988, 229.951, 0.994, 235.976, 0.997, 242.001, 1)
SVCNavy 2nd visit (DEP/SDP/MSN)	Random.Continuous(1,.228,9.79,.357,18.59,.427, 27.38,.485,36.17,.523,44.97,.575,53.76, .602,62.55,.643,71.34,.671,80.14,.694,88.93, .727,97.72,.751,106.52,.772,115.31,.802,124 .10,.826,132.89,.844,141.69,.867,150.48, .882,159.28,.895,168.07,.908,176.86,.919, 185.66,.933,194.44,.942,203.24,.954,212.04, .968,220.83,.980,229.62,.992,238.415, .995,247.21,.997,256,1)
SVCNavy 3rd visit (DEP/SDP/MSN)	Random.Continuous(1, 0.446, 4.049, 0.501, 7.099, 0.537, 10.149, 0.575, 13.199, 0.600, 16.249, 0.627, 19.299, 0.645, 22.349, 0.662, 25.399, 0.680, 28.449, 0.693, 31.499, 0.706, 34.550, 0.724, 37.600, 0.737, 40.650, 0.749, 43.700, 0.764, 46.750, 0.775, 49.800, 0.787, 52.850, 0.798, 55.900, 0.811, 58.950, 0.820, 62.000, 0.831, 65.050, 0.836, 68.100, 0.844, 71.150, 0.851, 74.200, 0.860, 77.250, 0.872, 80.300, 0.880, 83.350, 0.887, 86.400, 0.897, 89.450, 0.903, 92.500, 0.910, 95.551, 0.919, 98.601, 0.929, 101.651, 0.938, 104.701, 0.945, 107.751, 0.953, 110.801, 0.962, 113.851, 0.973, 116.901, 0.985, 119.951, 0.985, 123.001, 1)
SCVNavy 1st visit (Ship)	Random.Continuous(1, 0.612, 2.999, 1)
SVCNavy 2nd visit (Ship)	Random.Continuous(1, 0.198, 4.999, 0.301, 8.999, 0.788, 12.999, 1)

APPENDIX M. BASE MODEL SERVICE LIAISON APPLICANT PROCESSING LARGE MEPS (Cont.)

SVCNavy Medical Disqualification	Random.Continuous(1, 0.581, 14.999, 0.602, 28.999, 0.622, 42.999, 0.641, 56.999, 0.664, 70.999, 0.681, 84.999, 0.710, 98.999, 0.733, 112.999, 0.759, 126.999, 0.782, 141.000, 0.809, 155.000, 0.833, 169.000, 0.863, 183.000, 0.881, 197.000, 1)

APPENDIX N. LIST OF MODEL RESOURCES AND VALUES

Resource	Value
Night Test Administrator	All Sizes: 1 Seat capacity small: 15 Seat capacity medium: 25 Seat capacity large: 41
SDP Test Administrator	All sizes: 1 Seat capacities: Same as Night Test
Enlistment Officer	All Sizes: 2
Travel Assistant	All Sizes: 1
HRA OCD	Small: 1 Medium: 2 Large: 3
Processing HRA	Small: 3 Total *(2, 3, 1) Medium: 4 Total *(2, 4, 2) Large: 9 Total *(4, 9, 5)
Med Desk	Small: 3 Medium: 3 Large: 4
Male Med Tech	Small: 2 Total **(1, 2, 1) Medium: 4 Total **(2, 4, 2) Large: 7 Total **(3, 7, 4)
Female Med Tech	Small: 2 Total **(1, 2, 1) Medium: 4 Total **(2, 4, 2) Large: 6 Total **(3, 6, 3)
Chaperone	User Defined
Provider	Small: 1 Medium: 2 Large: 2
FBP	User Defined
*Denotes (0600 to 0800, 0800 to 1430, 1430 to 1645) shift availability **Denotes (0530 to 0730, 0730 to 1400, 1400 to 1600) shift availability	

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14. ABSTRACT
Applicant processing at Military Entrance Processing Stations (MEPS) is conducted via a batch arrival process by which all applicants arrive at the beginning of the processing day. Pursuit of alternate processing scenarios has never progressed beyond the pilot stage, possibly because the Command lacks a general decision support model to evaluate the impacts of proposed policies on applicant processing operations. This research creates a discrete event simulation of MEPS applicant processing operations and applies the model to three alternative applicant processing scenarios: split-shift, appointment-based, and express-lane. Results are examined and compared to benchmarks using multiple performance measurements.

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