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The Impact of Reducing Full Time Support Positions in the U.S. Army National Guard and Reserves

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THE IMPACT OF REDUCING FULL TIME SUPPORT POSITIONS IN THE U.S. ARMY NATIONAL GUARD AND RESERVES

THESIS

Lucas J. Lease, Major, U.S. Army

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ARMY NATIONAL GUARD AND RESERVES

THESIS

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ARMY NATIONAL GUARD AND RESERVES

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Abstract

   The United States Army is at a point in its history in which it, along with the other branches of the military, are experiencing cuts, constraints and a tightening of resources. The days of seemingly large budgets, abundant financial resources and high amounts of manpower are becoming a thing of the past. As the government reduces the allocations to the military, it is examining ways to reduce costs and improve its financial prospects. One of the positions examined for reduction or outright elimination is the full time support position in the U.S. Army National Guard (ARNG) and Reserves (USAR). The purpose of this research endeavor is to quantify the impact that these positions have on the ARNG and the USAR and determine the amount of risk associated with either reducing or eliminating them.

To my wife and two boys, for their love and support throughout my career and this endeavor.

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THE IMPACT OF REDUCING FULL TIME SUPPORT POSITIONS IN THE U.S. ARMY NATIONAL GUARD AND RESERVES

Chapter 1: Introduction

Throughout history, pinpointing the exact number of workers needed to perform the tasks and functions associated with a business or organization has been a challenge. Many organizations have experienced failure as a result of either being overstaffed and paying too much for labor or being understaffed and lacking the force to produce sufficient quantities of product to make a profit. In either case, mistakes have been made in terms of manpower estimation and the affected entity suffered greatly as a result. While the military is not concerned about generating a profit, it faces its own manpower questions and experiences successes and shortcomings due to the way it manages its people.

In the military, the amount of manpower available almost always impacts a unit's capacity for mission accomplishment. The number of men and women working during a specific mission influences several factors. Some of these factors include: time spent completing the mission, fully-mission capable rates of vehicles or equipment, the number of tactically or strategically important buildings constructed in an area over time, and ultimately the ability to neutralize the enemy (or the effects of the enemy's actions) during a fight. In other words, the number of people in a unit affect that unit's ability to do everything under its purview, including meeting the mandates of its warfighting missions.

In an effort to accurately predict the amount of workers required to conduct a mission and meet a goal, manpower models are developed and examined with a high level of interest by decision makers. Taking a "wild guess" at the amount of workers needed rarely ends with

positive results, so organizations today emphasize and welcome the process of manpower modeling. Manpower models rely heavily on statistically based analysis to derive the work structure that is appropriate for business operations of all varieties.

Manpower models come in all shapes and sizes and there is no "one size fits all" solution or equation that universally applies to multiple industries across the board. Even within organizations, the model used to generate the amount of workers, or "requirements," for one department or section may not be valid for any other section. For example, the model developed for most administrative sections of an agency will generally differ from the one used for the production section. The differences between the workload generated by the two sections as well as the variations in their roles and responsibilities necessitate the development of separate models to accurately capture work requirements.

The type of model used to derive the requirements in any organization depends largely upon two factors: the data and time available. In general, when data and time are in short supply, subject matter experts (SMEs) are used to generate the information needed to build and analyze a model. Most SMEs are able to draw from their years of experience to quickly convey the time needed to complete the unit's mandated tasks and address idiosyncrasies that may influence the model build. Conversely, when data and time are in abundance, the modeler can resort to a number of methods, including the use of regression, confidence intervals, distribution fitting and p-value analysis to ensure that a model accurately depicts the needs of the modeled organization.

Within our own government, we are at a place in time where the fiscal constraints emplaced upon the military are tightening due to a growing national debt, a decreasing size of the military force and myriad political considerations. In order to reach a workforce commensurate with current monetary allocations, the federal government is using manpower

models to see where savings can be gained or cuts can be made. One area that is currently being discussed for cuts is the full-time support (FTS) positions within the U.S. Army National Guard (ARNG) and Reserves. This thesis will examine manpower modeling from a conceptual standpoint, discuss the linkage between manpower and readiness, demonstrate various methodologies for generating a manpower model and use an appropriate methodology for determining the risk associated with taking FTS positions from the ARNG and Reserves.

Chapter 2: Background

Chapter Overview

This chapter defines and conceptually outlines the issue of manpower from both the general and military point of view. It reviews the manner in which manpower affects unit readiness and impacts a unit or organization and its capacity for carrying out its assigned missions. The chapter concludes with a review of the current fiscal climate and the arrival at the question that ultimately dominates the thesis: what would be the effect of reducing the number of full-time support positions in the U.S. Army National Guard and Reserves?

A Conceptual Look at Manpower

In general, manpower is defined as the total supply of personnel available or engaged for a specific task (BusinessDictionary.com, 2015). Any organization, whether public or private, must ponder and constantly evaluate the amount of manpower it needs to complete the work required to reach its goals. Striking a balance between having insufficient manpower and excess manpower is critical to the success of any organization. Having too many people results in wasted resources and the expenditure of monetary allocations that could have otherwise been used in alternative areas. Having insufficient manpower results in a backlog of tasks, required work remaining unfinished or the need to pay higher overtime rates to complete the jobs that cause a business to survive financially or in principle.

Having the right type of worker or identifying particular attributes for employees is a critical piece to the manpower process. Organizations need to develop screening tools to identify the experience levels and trainability in their potential employees, so as to maximize the returns from their subsequent investments in firm-specific training (Ngin, 2005). Because human capital

in these organizations is largely firm-specific and developed in-house, the ability to optimally allocate this human capital is critical to the success of these organizations (Ngin, 2005).

In terms of finding the proper balance of manpower, the United States Army is no different from the organizations in the business sector, but has the primary mission of fighting and winning the nation's wars as well as providing for the common defense of its citizens. In order to accomplish this mission, the Army must have highly-capable, flexible and intelligent soldiers with the capacity to deploy and fight in ever-changing environments. These soldiers must be willing to confront enemies who have become increasingly clandestine, unaffiliated with state governments and who have intentions dominated by ideologies rather than expanding previously established borders.

In addition to the soldiers who provide the "boots on the ground" and directly confront the enemy in combat operations, support personnel are necessary to prepare the warfighters for their combat engagements. These support workers conduct administrative training, assist in completing pre-deployment requirements, and perform other support-level jobs with a level of continuity that the military cannot match due to the rotation of assignments, permanent changes of station (PCS), expirations of terms of service (ETS), as well as a number of other factors. The soldiers and civilians required to set the conditions for meeting the overarching defense mission combine to form the manpower assets that the Army needs to conduct its primary mission.

The military has a unique problem not found in most other industries; its primary mission is far different from those of private sector companies. "The military is a clear example of an organization which pays at least part of training costs and does not pay market wages to skilled personnel. Implicit in this view is the prediction that the military will have an abundance of 'students' and heavy losses of 'graduates'" (Albrecht, 1976). Although the military understands

the numerical trends of one-term service members, it often wrestles with the issue of continuity in certain positions that emphasize a steady-state or historical knowledge of a process. It also understands that human capital (manpower) is founded on three basic assumptions:

1. Labor skills are durable and malleable.

2. Current productivity both contributes to current earnings and affects future productivity.

3. There is a positive association between the amount of schooling and the individual earnings.

Education in the form of on-the-job or formal training is viewed like any other capital investment process with investments justified to the point where the present discounted value of costs equals the present discounted value of returns (Albrecht, 1976). Although special in function and mission, the Army recognizes these manpower principles and desires to find the right people, at the right time, for the right position. In concert with finding the proper fit of an individual for a vacancy is determining the amount of people required to perform the mandated functions that contribute towards meeting an overall end state.

The Army attempts to answer a few key questions when discerning the number of employees needed to perform the functions of a certain job or position:

1. What type of person/what set of skills are required for a specific position?

2. How many people are required to complete the tasks pertaining to a particular position?

3. What kind of budget does the organization have to hire additional personnel or fill the allocated authorizations?

To answer question number 1, the Army details the management of manpower as focusing on the "accurate identification of human resources requirements (in terms of both

quality and quantity) necessary to perform specific tasks and upon the organization in which they will be most efficiently and economically used." (Headquarters Department of the Army, 8 February 2006). There exists an onus on the leadership and executive portion of each organization to employ personnel with the proper skillsets, knowledge levels, and attributes for performing the tasks unique to that unit in a manner that minimizes the cost and resources allocated by the government. The Army outlines the number of manpower requirements for each organization in its various authorization documents which "provide organization structures supported by Army resources against which units will be organized in the current, budget and first programs years. Authorization documents provide a record of approved organizational structure, mission, and capabilities (Section I), personnel requirements and authorizations (Section II), and equipment requirements and authorizations (Section III)" (Headquarters Department of the Army, 8 February 2006).

After describing the numbers and types of personnel each unit is allowed to have, the Army goes further in prescribing the utilization of these requirements. It analyzes and evaluates how organizations conduct activities as they receive or hand-off workload commensurate with prescribed missions. In terms of utilization, "manpower requirements are composed of military and civilian personnel as well as contractor support required to execute the mission of the organization. How these different types of personnel may be used in the best interests of national defense forms the basis for utilization policies" (Headquarters Department of the Army, 8 February 2006).

As far as additional analysis and evaluation is concerned, an organization cannot rely upon a steady state or status quo of manpower for the unforeseen future. They must make adjustments based upon the arrival of new missions or changing priorities based upon developing

national security concerns. In the words of AR 570-4, "The continual analysis and evaluation of missions, priorities, guidance, constraints and available resources form the basis of manpower assessments and validation. Analysts and managers at all levels review current military and civilian personnel data and budget performance in order to analyze manpower utilization" (Headquarters Department of the Army, 8 February 2006).

The Army answers various pieces of question 1 and then uses those answers to direct agencies towards proper hiring practices. These practices aim to meet the intent of the position while considering the financial implications of employing the right person. This simply does not translate into hiring a person with a small amount of experience in a specific area as the "one size fits all" perception cannot apply to this process. Instead, the leadership deliberately evaluates the balance between obtaining the proper skills and working within the budget granted. This issue can manifest itself in a couple of different ways. For example, a transportation unit has a position available for a mid-level supervisor for its maintenance division. In theory, management could employ someone who has a year or two of mechanic experience and pay them slightly more than they were making as a prior E3 Private First Class (PFC). While this would give the organization a person to fill their vacancy (who has experience as a mechanic) and initially maximize benefit to their budget, the person who was a PFC just a short time ago may not have the leadership experience or qualities necessary to make the operation run efficiently. Over time, the organization may have to expend resources either correcting this new hire's mistakes or getting him the training he lacked in the first place. In the end, this mistake could cause previously unrealized second and third-order effects, (i.e., more experienced workers abruptly quitting, unfounded negative perceptions, etc.), that costs the unit dearly, all in the name of saving a few dollars with the original decision. Thus, giving the position to someone with the

proper work experience and leadership qualifications (if required) is paramount to striking the right balance for employment by management.

While identification of the right experience is necessary, putting someone in a position who is overqualified could also create multiple issues. Staying with the mid-level supervisor example, the position would be best suited by hiring someone who was a prior E5 Sergeant or E6 Staff Sergeant or civilian General Schedule (GS) with comparable experience. In many instances in life, more leadership is better, but budget constraints alone would make hiring a prior maintenance company First Sergeant or even a prior maintenance company commander (former Captain or Major) cost prohibitive, especially if each one of those respective people/ranks expected to receive compensation in line with their previous military pay grade. Moreover, when discussing previous leadership experience, personalities may clash or conflict by those who feel that they are due the same level of responsibility that they held with other positions when the job they are applying for does not entail it. This is not intended to generalize all senior level Non-Commissioned Officers or Field Grade Officers (or higher) as incapable of working in a position that carries less responsibility or respect level than what they are accustomed; It is a detail that management must recognize when filling vacancies for particular jobs. Thus, organizational executives must ensure that they have the right experience for a requirement and also understand the ramifications towards the organization's overall budget and the issues that could arise by employing someone who lacks qualification or may even be overqualified for a certain spot.

Conceptually, the Army also addresses manpower by satisfying questions 2 and 3 (how many workers are required to complete the required tasks and what kind of budget an organization has to fill vacancies, respectfully) through other agencies or systems. The question

of budget is covered within a system called the Army's Programming, Planning, Budget and

Execution System (PPBES). The PPBES process starts by translating national security

objectives into military requirements, which drive the creation of programs, which in turn drives

the creation of budgets. The objective of the planning phase of PPBES is to identify the Army

capabilities that are required to support the national military strategy. These capabilities are

defined in terms of force size and structure, manning requirements, materiel capabilities, training

requirements, and sustainment needs (Defense Finance and Accounting Service - Indianapolis,

2014). The method for determining manpower is discussed in detail in the coming sections.

The Effect of Reducing Full-Time Support Positions

The Army National Guard (ARNG) is a valuable asset to our nation's defense serving

myriad purposes both on home soil and abroad. However, with the current fiscal situation and

the renewed focus on downsizing post Operation Iraqi Freedom and (the pending reduction of)

Operation Enduring Freedom, the government is striving to reduce expenditures in numerous

areas. Within the ARNG, the government has presented the idea of potentially reducing the

number of Full Time Support (FTS) positions in order save millions of dollars over the long

term. Specifically, the Army has highlighted that the FTS component has grown by 20 percent

since 2001 and that there may be an opportunity to achieve a potential savings of $1.5 billion in

FTS to offset shortfalls in ARNG training funds elsewhere in the program (Army Management

Action Group, 2014).

Most soldiers and personnel within the National Guard perform their duty one weekend

per month, two weeks a year (and deploy for longer extents when required), but do not engage in

daily military operations like Active Component soldiers. In order to ensure that the proper level

of continuity exists within the Reserve Component (RC), especially at the Brigade-level and below, the organization employs FTS personnel. According to Army Regulation 135-2, the FTS program

> "…encompasses personnel assigned as a full-time basis for the purposes of organizing, administering, recruiting, instructing, or training the Army National Guard and the U.S. Army Reserve. These personnel include civilian personnel, members of the Active Army, and personnel serving on Active Guard Reserve status. The Active Guard Program is a component of the Full-Time Support Program" (Headquarters Department of the Army, 1 June 1990)

An FTS person is one that supports the day-to-day foundational readiness activities of the organization (G-37/FMP, 2014). FTS personnel effectively manage the foundational readiness system and, in particular, impact the four months of post-mobilization training and cross-leveling from across the Reserve forces (Army Management Action Group, 2014). In the eyes of the ARNG, FTS personnel are "essential…for RC formations to meet Combatant Commander requirements including: theater security cooperation, short notice surge requirements and short term operational missions" (U.S. Army National Guard, 2014). To summarize, FTS personnel conduct the day-to-day process that provide the means for an ARNG unit to prepare for and execute its missions with a concentration on pre-mobilization and post-mobilization tasks.

Given the implications of the nation's current fiscal situation, many agencies and organizations will likely be examined for either cuts, reductions, or adjustments to the strength of their manpower. To gauge the effect of reductions to the ARNG's FTS system, this thesis analyzes and presents a new model to quantify the risk in terms of the potential for workload dropped, backlog accumulated and ultimately if the readiness of the affected units will suffer significantly as a result.

Chapter 3: Literature Review

Chapter Overview

This chapter begins with a review of the way that manpower is evaluated (through the U.S. Army proponent agencies) and the methods for determining manning requirements. It outlines the overall methodology used for most models and discusses the details behind each step used therein. This chapter concludes with a discussion of the most recent model methodologies as applied to specific instances and leads into the methodology used for the FTS model.

How Manpower is Evaluated

In general, most models for macro-planning are simple linear algebraic models. They are aggregate models with a simplicity necessitated by both considerations for mathematical tractability and data limitations (Johnson, 1975). While the argument may exist that the fundamental structure in a linear model is overly simplistic in its representation of the actual system involved, a model in the form of a non-linear relationship usually comes at the expense of the property of consistent aggregation. Thus, where analysts and managers do not have adequate knowledge concerning the nature of a non-linear relationship, the linear relationship is usually desirable (Johnson, 1975).

Johnson's (1975) concept of manpower models is one of general applicability. The Army component for manpower evaluation, the United States Army Manpower Analysis Agency (USAMAA), examines the construction of these models in similar fashion. USAMAA views manpower models as "decision support tools that are typically used to calculate the expected level of manpower that will be required to generate an estimated level of workload in the future. They are meant to represent the system under consideration in terms of its logical and

quantitative relationships. By understanding these relationships, one can better understand the interactions between manpower and workload, as well as gain insight into the systems sensitivities. This information gives decision makers insight into the intended and unintended consequences of potential resourcing and policy decisions" (USAMAA, 2008). As a result, an accurate model can provide a wealth of information to a decision maker about the inner workings of their organization.

To develop a manpower model involving the aggregation of linear components, USAMAA recommends analyzing a list of process drivers along with the workload generated by each driver and establishing a relationship between those elements. A workload driver is the item, document, or entity that enters a system to begin a process that an organization must perform to meet the assigned mandates outlined within the authoritative sources from the U.S. Army. Appropriate drivers should have a logical linkage to the process under consideration and should be available from those authoritative sources (USAMAA, 2008). Once the workload driver has been identified, business process maps (BPMs) are created with times assigned to each task necessary to accomplish the overarching task or process established by mandate. After those BPMs are refined and finished, data are collected either by entire organizations or subject matter experts (SMEs) to define the amount of time each process takes. As the data are scrubbed and matched with the applicable steps in each process, the overall times from the tasks generated by the BPMs are aggregated and then divided by a factor to determine the requirements needed to perform each mandated function. The finalized model is one that "determines the minimum essential manpower requirements necessary to accomplish specific mandated functions (i.e. what is needed). The models do not take affordability into account; they are decision support tools" (Free, 2014). The steps for this overall methodology are discussed in depth in the next section.

General Modeling Methodology

When creating and evaluating a model, the organizations and agencies involved should

establish a relationship and follow a general methodology that focuses on the modeled

organization's processes. While these models are numerically based in principle, those

developing the model and those performing the validation and verification of the model must

have a common comprehension of the business processes and missions they are modeling. A

good working relationship between organizations is essential as positive attitudes and an

understanding of each agency's mission provides the means for all parties to collectively produce

a model that meets the intents of everyone involved. Moreover, the presence of a positive

professional relationship enhances the quality of the model and may lead to fewer modifications

when conducting model verification and validation. The absence or non-existence of a positive

relationship limits the ability of the modeler to accurately capture the priorities of the affected

organization. As a result, major details may be withheld from the modeling process which may

endanger the endeavor in terms of reaching complete verification and validation. Thus, a

positive relationship is paramount when developing, validating and verifying any model.

As far as the model underpinnings go, the methodology needs to follow the systems

engineering process. The process also must be consistent with generally accepted modeling

methods and conform to the principles outlined in current Army regulations. Once the basis for

the model is created, the modeler should follow a generalized 5-step process (listed in Figure 1)

as the model development progresses. Before advancing to any subsequent steps, the analysis

team should verify that the decisions made during the current step of the process have adequately

addressed the questions created in the previous step, reaffirming that they have not diverged too

far from the original intent. This continuous verification leads to continuous learning, a superior

product, and a streamlined validation process (USAMAA, 2008). The result is a model or suite

of models that are credible, flexible, adaptable, transparent, and based on reliable data. The

model can then be used to provide the analytical justification for manpower requirements, and

also be available for follow-on uses. Figure 1 provides a graphical depiction of the methodology

(USAMAA, 2012):
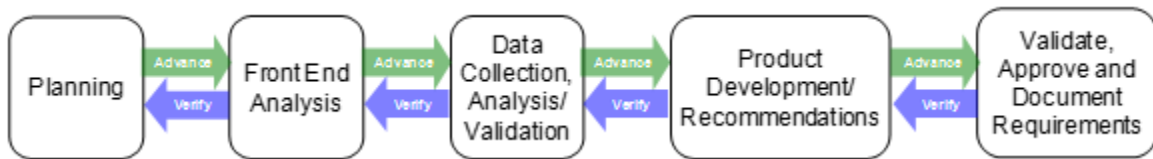
Figure 1: Manpower Model Development Methodology (USAMAA, 2012)

In the Manpower Model Development Methodology (MMDM), the process steps are not

mutually exclusive and one step may affect the next step or all the steps. In fact, the process may

continually retreat or advance within the process depending upon the particular situation. The

next section describes the intent of each step in detail and how it affects the overall process.

Step 1 – Planning

The first step in the MDMM is to formulate the problem by selecting the type of function

to analyze, and then selecting the level of the organization at which that function is executed.

For the purposes of standardization, a function is defined as a portion of an organization where

necessary and critical tasks are performed. For example, one of the many functions of a hospital

is a pharmacy. The pharmacy may have its own individual tasks to complete within this

purview, but the actual function for the overall purpose of the hospital is to distribute

medications under the heading of a "pharmacy." While this step may seem obvious, it is critical

to the rest of the process because it establishes a foundational baseline and is critical to defining

the functions under consideration. For a single function or a collection of adjacent functions, the

team must clearly define the processes and the boundaries between them. If the modelers

attempt to evaluate two adjacent processes, but are unable to determine where one ends and the

other begins, they can only accurately model the single aggregate function (USAMAA, 2008).

Step 2 – Front End Analysis (a.k.a. Business Process Analysis)

Analyzing the business processes requires close coordination between the analysis team

and the SMEs who have in-depth knowledge of the business processes of the function being

studied. This step begins with an initial development of a business process model, which is

commonly outlined using a flow chart or process map. The analysis or "scrubbing" of each

process map presents the opportunity for the owning organization to gain efficiencies and the

analyzing organization to see where efficiencies were made.   The analysis team does not

account for every minute of every day of every employee within an organization. Instead, the

analysis team focuses on the functions and processes that have the greatest impact on the

manpower–workload relationship, and thus have the biggest influence on the information

provided to decision makers (USAMAA, 2012).

When building the process model, the analysis team considers a set of basic questions for

example:

- What takes place inside this function?
- Why does this function exist in this organization?
- Is the function conducted elsewhere within the command, or across the Army?
- Is this function mandated by a law, regulation, or policy?
- What creates the demand for the output generated by these processes?
- Is the demand driven by internal or external forces? (USAMAA, 2008).

By answering these questions and others like them, the team gains a better understanding of the process functions, and can begin to develop a candidate list of workload and process drivers. A workload driver is the action or initial component that begins a process and the workload is the amount of work generated from the output (in terms of time). In the pharmacy example, the workload driver is the number of scripts the pharmacy receives as it begins the process and workers cannot proceed without it. A process driver is any action that has a significant influence on the sequence of tasks needed to complete a process and the overall process completion time. For example, when a pharmacy receives a script, the workers must identify if the script includes a prescription for a controlled substance. If the script does not have a controlled substance on it, then the process involves a sequence of tasks that progresses without requiring additional supervisory tasks associated with a controlled substance. If a controlled substance is present, then the sequence of tasks incorporates additional checks required for each controlled substance. Thus, the process driver influences the amount of time a process requires for completion and plays a significant role in the amount of manpower needed.

Those involved in the modeling need to analyze the list of workload and process drivers to determine which are the most appropriate to use for modeling. Appropriate workload drivers should have a logical linkage to the process under consideration, and should have historically available data from authoritative data sources. These drivers should also be available in a predictive sense in programmable, authoritative databases, either directly or derived (USAMAA, 2012). In the pharmacy example, the number of prescription slips the pharmacy receives meets the requirements for a workload driver as it starts the process and is documented for historical data purposes. The controlled substance question meets the criteria of a process driver as it

genuinely influences the sequence of steps (the path the process takes) and affects the time the process requires for completion (USAMAA, 2013).

Early on in the BPA process, the analysis is careful not to eliminate potential workload or process drivers, even if they appear initially to have no statistically significant effect on the process. The overarching goal of this methodology is to build models that have continued utility over a long period of time. If circumstances change, an initially insignificant driver could become more important. Retaining drivers for as long as is feasible is a good modeling practice, as it would be much more difficult to add the driver back in later (USAMAA, 2008).

To finish step 2, the analysis team confirms that the conceptual model provides a reasonable approximation of reality, and substantiates that the expected product provides information beneficial to the decision makers. This is the beginning of the overall verification and validation process that continues throughout the model development cycle (USAMAA, 2012).

Step 3 – Data Collection, Analysis/Validation

Data is the lifeblood of any modeling effort. There are four primary types of data used to support decision making: available, derived, proxy, and missing. Available data is singular data that resides in an authoritative source, is validated by the owner, and is accessible to the user. This is the most preferable kind of data to use in manpower modeling. An example of available data is the aforementioned total military population at an installation, housed in the Army Stationing and Installation Plan (ASIP) database. When there is no available data, the next best alternative is derived data. Derived data takes pieces of information, either from different sections of the same source or from different authoritative sources, and combines them into a

single piece of information. Derived data can be as valid as available data, but may be more

cumbersome to use because it depends on multiple sources, and involves extra calculations

(USAMAA, 2012).

Proxy data may substitute for available or derived data, when those are unobtainable.

Proxy (or "stand in") data is the least useful because it relies on an assumed relationship with the

desired data. This relationship is often tenuous, and difficult to validate; therefore, using proxy

data may decrement the model's overall credibility.

Missing data is information that is not available from an authoritative source. Often, data

appears to be available, but without a formal validation, approval, and storage process, the data

cannot be used to support official decisions. When data are required to support development of a

manpower model and is classified as missing, the community must decide if the value of

obtaining the data outweighs the cost (USAMAA, 2012).

If data are used in a validated manpower model to support the assumed value of a

workload driver, then that data must either be available or derived from one or more authoritative

sources. If data are used to support the assumed value of a process driver, then that data can be

available, derived, or proxy. The overall goal is to identify the data needed before embarking on

a data collection effort; data collection can be quite resource intensive (USAMAA, 2012).

In addition to the primary sources of data, there are a number of secondary sources of

data. One of the most common sources of data utilized today is from SMEs. Data sets from

SMEs are convenient as the data employ the resident knowledge base and actual real-world

experiences of the most seasoned workers in an organization. It is also usually the least time

consuming to gather as the modeler is normally gathering input from one person or a small group

rather than thousands. SME data is usually quite accurate, but can be subject to biases in terms of

task completion times or methods for completing individual tasks. Moreover, data from a group of SMEs could be biased by the opinion of the individual with the strongest personality, thereby failing to gain consensus as the true data point that is the most accurate.

Other forms of secondary data include surveys, data mining, ad hoc reports and standardized reports. Surveys have potential as they involve a larger sample size of data, but rely on individuals' memories. Data mining is the process of extracting hidden patterns from large data sets. Mined data involve a larger sample size, less biases, but can be unreliable. Ad hoc reports from authoritative sources are better, but rely on inferences. Standardized reports from authoritative sources are the best secondary data source, but are often unavailable for use. Using existing data has benefits including consistency and availability, but also could be detrimental since it was initially collected to answer a different question, and may not be suitable for this purpose. Regardless of the manner in which the data was collected, the analysts must check the data for accuracy and ensure that it makes sense when compared with questions being asked and processes being evaluated (USAMAA, 2012).

For many models, the primary factor used from the ASIP data is the population on the installation. The ASIP database contains historical data for a garrison's population, as well as other factors that have implications on future decisions (USAMAA, 2008). While the use of historical data is acceptable, the modeler employing this type of data should be aware of the risk associated with historical data. Historical data consist of information that is critical and convenient to collect. The risks occurs as great care is often taken in extracting the convenient information, but the essential information does not always receive the same attention. As a result, the accuracy of the historic data may be prone to outliers (Montgomery, Peck, & Vining,

2012). Naturally, historical data use is based on the current situation resembling the past

situation from which the data derives.

Data should be reliable and valid. Reliable data is evident when the same conditions

result in the same values. If the same environmental conditions can result in two distinct values,

or the same value results from disparate environmental conditions, then the data is not reliable.

Perfectly valid data exhibits a completely diagnostic relationship with the event that caused it, or

the event we are trying to predict. However, data is seldom perfectly valid, especially when

considered in isolation. In manpower model development, data validity should be addressed, and

sufficient enough to warrant its use in supporting a decision. If the analysis team develops a

valid model that is underpinned by invalid or unreliable data, the model cannot be validated or

approved for use in determining manpower requirements (USAMAA, 2008).

Once the analysis team has mapped out the business process and identified the modeling

drivers, they can begin to select candidate approaches. These approaches should logically fit the

business processes, and can utilize one or more analytical techniques. The team should start with

a simple solution, and embellish it as needed. In some cases, the simple, straightforward solution

is sufficient and will be the best approach. For example, in a basic function, the manpower

model might be a simple allocation rule. In other cases, such as in a medical clinic, the best fit

might be to use a discrete event queuing model. There are no real bounds placed on what is an

appropriate technique, as long as it conforms to generally accepted modeling methods, and as

approved for use by the stakeholder members of the analysis team. Regardless of the method the

team selects, the outcome is to strike a balance between creating a model that is useable and one

that is useful (USAMAA, 2008).

Traditionally, manpower models use mathematical regression to calculate single instance estimates of the manpower required at an installation to generate a set amount of workload. When using regression, the modeler is assuming that the current process is working at the proper efficiency level, and that the relationships among the drivers, manpower, and workload will not change. If the current process is flawed – under resourced and not completing the mission or over resourced and not operating efficiently – a regression approach reflects those flaws instead of eliminating them. Similarly, if the business process changes through the introduction of new technology or the emergence of new laws, policies, or regulations, the regression approach will not capture the effects of those changes. By taking a long term, strategic view and applying more flexible analytical approaches, the analysis team can potentially create models and simulations that can be leveraged for sensitivity analyses (USAMAA, 2008).

Step 4 – Product Development/Recommendations

In this step, the analysis team combines the standardized BPMs (or the results of the BPA), the data used and the modeling methodology to make a model. The result is a model, once populated with data, is useful and useable. When populating the model with data, the workload driver is at the forefront of the input for generating overall workload and the resultant requirements. Using the pharmacy example, the number of prescriptions or slips, (the workload driver for this scenario), generates an amount of time required to complete the task (the workload). The resulting workload is then divided by a factor of 1740 hours (the workload for one person in a year) to calculate the number of requirements for the pharmacy (or applicable organization). In some cases, a model may default to an allocation rule as a position may be mandated without having sufficient workload to generate 1740 hours of work in a year or some

other form of authoritative guidance may dictate the manpower allocation. Either way, the model should have a solid foundation that accurately reflects the hours required to perform tasks and generates the minimum number of requirements needed to complete the mission.

After initial model development, the analysis team determines the how much randomness exists in the system under study. If the resultant model is a static rule of allocation – e.g., one commander and one executive officer per command – then this step is complete. However, if a process is stochastic – e.g., a distribution of prescription fill times driving pharmacy performance – then the analysis team can develop a simulation to investigate the effects of the randomness (USAMAA, 2012). This piece is important as it helps solidify the underpinnings and foundation of the model prior to being presented to the decision makers. Upon achieving a degree of consensus and satisfaction between the model builder and the modeled organization, the model moves into validation and verification.

Step 5 – Validation

No model fully represents real the real world process. However, a well-developed model can provide insight into the areas of the process with the greatest impact on the overall performance, and can reflect reality to an extent sufficient enough to support decision making. Validation determines the degree to which the model and its corresponding simulations reflect reality.

Validation is defined as ensuring that the model represents the real world to a degree sufficient enough for the model to be useful. A model cannot address all contingencies or answer every possible question, but a model is useful and valid if it addresses the questions for which it was designed. There are several validation methods the analysis team can use. Methods

include expert consensus, comparison with historical results and test data, peer review, and independent review. If the validation process exposes limitations that make the models unfit for approval, the analysis team should adjust the model to mitigate those limitations (USAMAA, 2008).

A validation method compares results to actual data (e.g., recent past data). The intent is not to perpetuate the decisions of the past, but to provide insight into the thoroughness of the process analysis, and the reasonableness of the assumptions made during model development. If the results of a model run show the need for a significant increase in requirements, the model is not necessarily wrong. It is possible that there was workload not completed (backlog) or not completed to standard, or the organization may have been tasked with a new mission. It is also possible that the assumptions driving workload frequency and accomplishment times were too conservative. Conversely, if the results of the model show a significant decrease in requirements, the model is not necessarily correct either. It is possible that the process analysis missed an important function that should be included. The organization may also be executing workload that is not required, that is, it is mandated by a higher authority via a law, regulation, or policy. It is also possible that the assumptions driving workload frequency and accomplishment times were too optimistic (USAMAA, 2012).

While assessing the model, the analysis team evaluates the underpinning assumptions on the functions within the overall business process, especially the interrelationships between adjacent steps in the process. The model of the processes should be relatively transparent, (i.e., easily understood by those who intend to use the tool), as well as repeatable, generating reasonably similar results when subjected to the same inputs. This is a critical set of information that must be clearly articulated and understood before a model is applied to support a decision.

Otherwise, the model could be used inappropriately, resulting in an incorrect decision (USAMAA, 2008).

Once a thorough V&V of the model is complete, the model should be approved for use by the proper authorities. If the models are used to justify manpower requirements in the Table of Distribution and Allowances, the model must be approved by the Special Assistant for Manpower and Resources within the office of the Assistant Secretary of the Army (Manpower and Reserve Affairs). If a model employs workload or process drivers that were developed using subject matter expert opinion, and have not been statistically validated, then the model may be approved for up to one year. During that year, the drivers should be statistically validated using authoritative data, enabling a longer term of approval. If the model employs statistically validated drivers, the model may be approved for up to three years (USAMAA, 2008).

Model Application

Completing the previous five steps yields a model that is verified, validated, and approved for use. If the analysis team utilized enough foresight to make a flexible tool, then the tool can be used beyond the traditional manpower requirements determination. It can be used at many levels for sensitivity analyses, organizational efficiency assessments, and process improvement studies. The model and its commensurate simulations are tools that can have more than one use. However, these tools will not be universally applicable, so the community should be sure that the use is appropriate before applying it.

By the end of the modeling endeavor, the leadership within a unit should have an accurate depiction of the amount of workload (in hours) and manpower required to meet all missions established by the governing agency's authoritative documents. Conversely,

management should also be able to see the amount of work that is either dropped, backlogged or not completed due to the lack of appropriate manning. This process is not only useful for determining the actual times devoted to functions within an organization, but also presents an opportunity for an organization to improve their methods or processes for completing assignments. With all of these elements considered, the manpower model is a potentially powerful tool for improving organizational processes and efficiencies (USAMAA, 2008). The model has limitations, though, as it is approved for a specific use within a particular organization and not generally established as an "industry standard" to be applied across many agencies.

Most Recent FTS Model

The most recent model was validated according to its methodology and output in December of 2011 by USAMAA. The model was developed according to a system that emphasized the following functional areas: administration, training, other functions, medical and maintenance (ATOMM) (United States Army Manpower Analysis Agency, 2014). Throughout the creation of the ATOMM model, 106 BPMs were developed detailing the FTS functions leading to the quantitative accumulation of functional workload. Each BPM calculates the amount of time required to perform a function. The calculated time is then multiplied by the number of times a unit performs the function to derive the amount of hours generated for the specific function. The hours are then divided by the manpower factor of 1740 (work hours in a year) to yield the number of workers required to complete each mandated function. As far as the task and function time data is concerned, 3.5 million data points were collected and analyzed from over 20,000 respondents using data collection tools across both the ARNG and Reserve (USAR) components. The result was a model application that accounted for 31,773 (21,539

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ARNG & 10,234 USAR) FTS requirements at the Brigade and below level with a high degree of confidence (United States Army Manpower Analysis Agency, 2014).

This thesis uses regression as the primary methodology to develop the equations that aide decision makers in determining the amount of manpower for the National Guard FTS positions and answers the main question of "what would be the effect of reducing the number of full-time support positions in the U.S. Army National Guard and Reserves?" For the purpose of calculating and establishing the amount of manpower that each unit requires to complete the FTS mandates, the ATOMM model is the definitive model; however, the ATOMM model only provides information pertaining to the required amount of manpower but does not show the risks to mobility rates if the FTS positions are reduced or completely taken away. This thesis provides a methodology for determining the link between FTS positions and mobility rates. It then creates a table for decision makers to use to enhance their understanding of the risk/mobility trade-off. By understanding the impacts or concessions of various percentages of manpower against mobility rates, the final table provides the answers essential to decision makers making well-informed decisions pertaining to the welfare of their units.

Chapter 4: Methodology

This chapter outlines the various methodologies that are commonly used in manpower modeling, highlighting the ones that most agencies revert to when calculating manpower requirements. It first discusses the specific methodologies and ends by describing the one used for this project.

Specific Methodologies

Regression

One common methodology for generating manpower models is through linear regression. A simple linear regression model is one in which a single regressor x has a linear relationship with a response y according to the following equation:

$$y = \beta_0 + \beta_1 x + \varepsilon \qquad\qquad (\text{Eq. 1})$$

where the intercept β_0 and the slope β_1 are unknown constants and ε is a random error component. For simple linear regression, the errors are assumed to have a mean of zero, unknown variance, σ^2, are uncorrelated and normally distributed (Montgomery, Peck, & Vining, 2012). For a manpower model, the response variable, y, is the output of time (usually in hours or minutes) generated from the workload driver, x. The workload driver, (i.e., the number of prescription slips given to a pharmacists to begin the process), results in y hours of workload.

Prior to deriving the number of hours required to perform a function, an organization examines the unit BPMs. This examination ensures that every task within the function is mandated by an authoritative government document. Additionally, the modeled organization ensures that their BPMs for all functions and tasks are standardized so that all of their

subordinate units are conducting operations in the same way. The modeled organization will only

receive credit for tasks mandated by the Army or Congress and will not get more workers

because one of their units operates differently (unless they are authorized to do so). They cannot

aggregate time for a task they perceive as "nice to have" instead of "need to have."

As analysts receive BPM task times from an organization (or several organizations

underneath a headquarters unit), they can conduct regression diagnostics to check the task times

for influence and leverage points to ensure that no point adversely affects the model. A leverage

point is defined as a data point that has an unusual x value that may control certain model

properties and dramatically affects the R^2 value and the standard errors of the regression

coefficients (Montgomery, Peck, & Vining, 2012). An influence point is one that has a

noticeable impact on the model coefficients in that it "pulls" the regression model in its direction

(Montgomery, Peck, & Vining, 2012). In evaluating the various data points, the modelers help

ensure that a potential equation or correlation value is as accurate as possible under the given

conditions. There are a few methods that analysts and modelers can use to look for these

particular points.

To check for influential points, modelers can use Cook's D analysis and *DFFITS*

analysis. Cook's D measures the squared distance between the least squares estimate based on

all n points and the estimate obtained by deleting the ith point, and is denoted by the variable, D_i.

The magnitude of D_i is assessed by comparing it to an F-statistic of $F_{\alpha,p,n-p}$, where α is the level

of confidence, p is the number of parameters, and n is the number of data points considered.

Points with large values of D_i have considerable influence on the least squares estimate.

If $D_i > 1$, it is considered to have a large value and is thus influential (Montgomery, Peck, &

Vining, 2012).

A second method for measuring influence is *DFFITS*, a statistic that investigates the deletion influence of the ith observation on the predicted or fitted value. It measures the number of standard deviations that the fitted value changes if observation *i* is removed. It is found through the equation:

$$DFFITS_i = (h_{ii} / (1-h_{ii}))^{1/2} * t_i$$ (Equation 2)

where h_{ii} is the diagonal x'(x'x)$^{-1}$ x or the "hat" value and t_i is the r-student statistic. The *DFFITS$_i$* value is then measured against the equation

$$\left| DFFITS_i \right| > 2\sqrt{p/n}$$ (Equation 3)

Any point that exceeds this threshold is affected by both leverage and prediction error and warrants attention as a potential influential point in the data set (Montgomery, Peck, & Vining, 2012).

After checking for influential points and outliers, modelers can perform additional regressions to find a more accurate model for each function outlined by the modeled organization. Once the modeler has completed the appropriate analysis, then the proper equations can be derived, the number of workload drivers can be put into the new equations and the overall workload for the particular functional area totaled. Using the aggregated hours from all of the functions, the total number of manpower required can be determined by taking the total hours divided by 1740, the total number of work hours in a year for one manpower requirement.

Triangular Methodology

In today's time and resource-constrained environment, collecting hundreds, thousands or even millions of data points is not always possible. In cases that require a short timeline or do not allow for an exhaustive data collection effort, an SME-based triangular distribution is used to derive manpower required. Subject matter experts are quite adept at predicting system or process parameter values. In general, they are not so adept at defining distributions. A compromise is to obtain input regarding best case (max), worst case (min) and average performance and use the values as the parameters for the distribution. The triangular method is easy to define, easy to implement in a model and provides robust results in practice. However, this triangular methodology is not necessarily equivalent to the traditional equations generated from the triangular distribution often seen in statistical analysis. The traditional triangular method has a minimum point, a maximum point and a mean for its calculations. A graph of the traditional triangular distribution is in Figure 2:
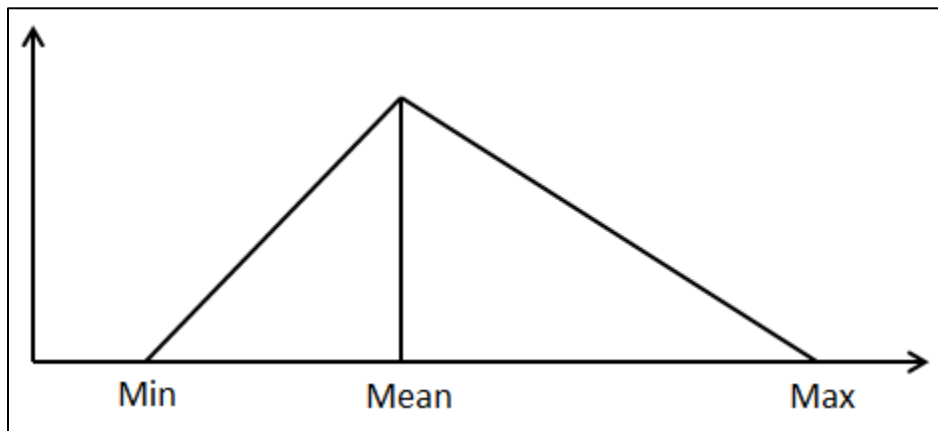

Figure 2: Traditional Triangular Distribution

Instead, the SME-based triangular distribution takes an SME's estimates of task times, adds weights and averages them to determine the amount of time a single task would take an average worker. For example, if an SME estimates that filling a prescription takes 5 minutes 15 percent of the time, 10 minutes 75 percent of the time and 15 minutes 10 percent of the time, then the total time for that task will be 5*.15+10*.75+15*.10= 9.75 minutes. If the pharmacy workers perform the task 8500 times per year, then those 8500 performance times are multiplied by 9.75 minutes per tasks to equal 82,875 minutes total. The minutes are then converted to hours (82,875/60 = 1381.25 hours) and the analyst divides those total hours by the manpower factor of 1740 work hours per year. The total number, in this case, 0.794 workers is aggregated with the other tasks on the BPM to determine the overall number of workers needed for the larger function. Figure 3 provides a pictorial representation for the pharmacy example:

Time Per Task: 5/10/15

Percentages: 15/75/10

Task
Find medicine and
fill prescription

Avg. Time Per Task: (5 x 0.15) + (10 x 0.75) + (15 x 0.10) = 9.75

Number of times task performed per year: 8500

Total Time Generated: 9.75 x 8500 = 82875 minutes;
(82875 minutes)/(60 min/hour)= 1381.25 hours

Total Manpower Generated = 1381.25/1740 = 0.794 manpower requirements for this task
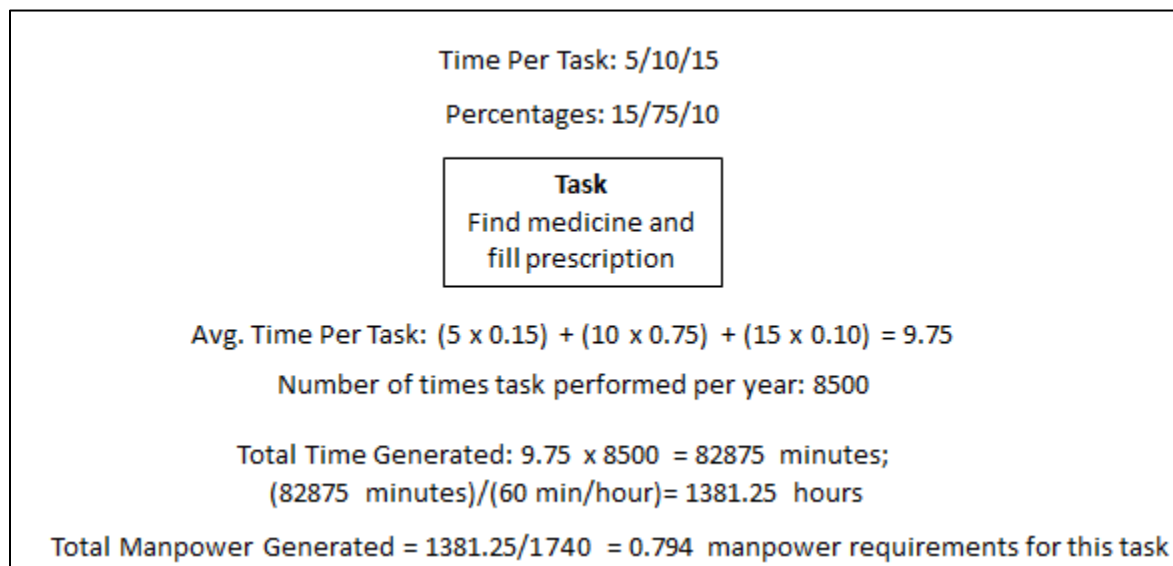
Figure 3: SME-Based Triangular Distribution Example

After all tasks times are calculated, the total times for all tasks are then aggregated across all process maps. The total number of hours is then summed up to determine the hours required for an organization to complete all functions. That total number of hours is then divided by 1740 to calculate the number of manpower requirements needed for the organization to operate. This method is one of the most widely used as it requires workers with experience, but does not need a large amount of data that requires a great deal of time to collect.

Deterministic Method

In some positions, regulations require that an organization operate for a specified amount of time instead of using a standard workload driver to determine workload times. In these cases, total hours is the hours of operation times the minimum number of positions required. For example, regulations may specify that an airfield requires two air traffic controllers (ATC) on duty at all times. If the airfield operates from 0800-1800 daily, then the modeler uses the number of hours of operation times the number of days open (per month or year), times the number of positions mandated by regulations, and divides by the number of work hours in a month (145) or year (1740). In this case of the ATC workers (which regulations mandate two workers per shift), the number of workers would be $(2*10*30)/145$ (per month) $= 4.13$ or 4 with rounding. This method does not require an examination or creation of BPMs as it is predominately based on mandated times of operation instead of number of tasks completed or number of customers served.

FTS Model Methodology

For any project, the end state or goal drives the methodology and the data or the availability of data may drive the way the particular methodology is used and adapted. For the FTS model, the only data given by the organizations involved are the number of manpower requirements authorized and the number of positions filled for each unit. As the primary focus for this study is finding the effect of reducing the number of FTS positions, it is necessary to draw a relationship between the number of FTS positions and the readiness rates of each unit prior to a deployment. This linkage creates the foundation needed to tailor the methodology and perform the calculations required to answer the question.

The lack of data and information limits the number methods available to develop the FTS model. FTS BPMs were not provided and neither were listings of mandated tasks required by manpower requirements in those position. Moreover, there are no times associated with the tasks or functions. Thus, it is not possible to standardize the times or BPMs that help derive the requirements needed for each unit. As a result, the triangular distribution or SME-influenced triangular distribution do not apply. Additionally, a strictly deterministic method cannot be used because the FTS positions are not allocated according to a regulation, (e.g., an air traffic controller position must have two workers on shift at all times), and the hours of operation are not set by some other authority. Therefore, regression is used and provides the means to determine the number of FTS requirements needed by each unit. After calculating the number of requirements, the risk associated with eliminating FTS positions is realized.

For this model, the ARNG data is the basis for the regression since the actual mobility rates (the dependent variable) are not available and describing the same methodology for both the ARNG and USAR sets of data is redundant. Additionally, a few assumptions must be made:

1. Personnel hired for FTS positions will perform similar tasks with the same method, purpose and goal regardless of the unit they are affiliated with.

2. The times associated with each tasks are normally distributed.

3. FTS workers perform tasks at an average rate (i.e. numbers of manpower requirements are not based off of the "superstar" or subpar performers).

4. All positions and tasks performed are mandated by the government and listed on the TDA or MTOE for each unit.

5. The hypothesis test for significance of a model is:
H_0: The model is not adequate for the data
H_A: The model is adequate for the data

6. The hypothesis test for significance of independent variables is:
H_0: The variable is not significant to the model
H_A: The variable is significant to the model

These assumptions provide the means to develop the correct model correctly to fulfill the verification and validation requirements.

The first step in many modeling endeavors is ensuring that the data is "cleaned" or checked for errors and discrepancies. The likelihood of receiving data that is free of errors is very small and modelers must ensure that the given data is appropriate and reasonable for incorporation into the analysis and model. Even if the data was rigorously scrutinized prior to distribution to the modeling agency, it must be examined closely by the modeling analyst before progressing with the remainder of the effort. For the ARNG FTS data set, there are 2894 units presenting data for 14 years from 2001-2014 (using 60 columns in Microsoft Excel) for a total of more than 173,640 data points. Moreover, the data spreadsheet included several tabs, of which this model measures the ratios developed by comparing the "FTS ARNG Authorized FY01-FY14" to the "FTS ARNG Assigned FY01-FY14" tabs. Each tab includes the unit identification

codes (UICs) and data for the 2894 units involved. These UICs must be consistent and accurate. A mismatch of UICs results in inaccurate ratios and a model that does not truly reflect reality. This step is critical to the model as it prepares the way for a model that is made correctly. In other words, if this step is wrong, the remainder of the process will be wrong.

Upon matching the appropriate UICs and data in each row, the ratio of number of manpower requirements authorized to each unit and the number of manpower assigned to each unit is calculated. It acts as the independent variable as it positively influences the mobility rates of each unit in both theory and in reality. The ratio calculation is performed for all 2894 ARNG units. For data cleaning purposes, any ratio that results in a value with zero in the denominator is eliminated.

Completing the calculation of the authorized/assigned manpower ratio leads to incorporating the mobility rates into the model as the dependent variable. Since the actual mobility rates for each unit are not provided, simulated mobility rates are generated using a normal distribution. A normal distribution is appropriate because most activities involving humans are normally distributed when plotted. The authorized/assigned manpower ratio and the simulated mobility rates are then regressed with the manpower ratio as the independent variable and the mobility rate as the dependent variable. As part of the regression, an analysis of variance (ANOVA) table, regression plots and normal plots are developed. The ANOVA table test the significance of the regression through F-test and p-value analysis. The regression plots show trends and correlation within the data and the leverage plots show points that may be exerting influence on the model. The normal plot helps to validate the assumption of normality required by the various statistics emanating from the regression analysis.

For swift and accurate computations, the data are transferred to the JMP computer program to conduct the regression and calculate the h_{ii} "hat values" and the values for the Cook's D analysis. The results of the h_{ii} diagonal values and Cook's D are then moved back to Microsoft Excel for outlier evaluation as the data directly transfers from JMP and the calculations are easily computed in Excel. The h_{ii} values provide the means to calculate the numbers needed for the *DFFITS* analysis as they are part of the *DFFITS* calculation in Equation 2 and subsequently contribute to the leverage check in Equation 3. The h_{ii} value, Cook's D and *DFFITS* analysis methods identify outliers and aide in making the model more accurate. If outliers exists, the analyst or modeler must determine if eliminating those points will improve the model or cause it to artificially appear more accurate.

If the analysts chooses to remove any of the outliers, then the regression must be completed again to determine if the deletion of those points has benefitted the model. This process includes producing the new ANOVA table, regression plots, and normality plots for the same purposes as the original regression. After creating and analyzing the charts and data from the most recent regression, the modeler may decide to accept the results of the current regression or experiment with more iterations of variations in data until the model appears to be sufficient.

Chapter Overview

This chapter discusses the output and results using the methodology described in the previous chapter. It then explores the implications of the results and sets a framework for future studies.

Initial Regression

In the ARNG data set, there are 2894 units presenting data for 14 years from 2001-2014 (using 60 columns in Microsoft Excel) for a total of more than 173,640 data points. After the data are scrubbed, the assigned/authorized manpower ratio and the simulated readiness rates calculated. The regression uses the ratios and rates for 26668 individual points. The JMP computer program produces the initial regression plot in Figure 2 (below) and the initial summary of fit and ANOVA in Figure 3:
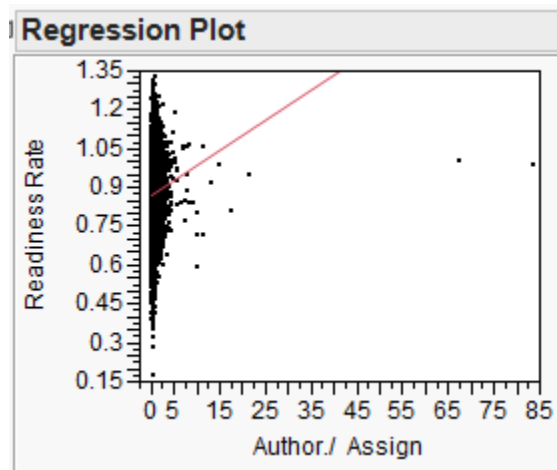

Figure 4: Initial Regression Plot

Summary of Fit		Analysis of Variance				
				Sum of		
RSquare	0.006391	Source	DF	Squares	Mean Square	F Ratio
RSquare Adj	0.006353	Model	1	2.32341	2.32341	171.5115
Root Mean Square Error	0.11639	Error	26666	361.23504	0.01355	Prob > F
Mean of Response	0.882689	C. Total	26667	363.55845		<.0001*
Observations (or Sum Wgts)	26668					

Figure 5: Initial Summary of Fit and ANOVA

Figure 2 includes all 26,668 points and indicates where outliers may exists in relation to the remainder of the data. It accomplishes this by showing that a small percentage of the points are not located close to the larger cluster of points on the graph. The most extreme example is the point that is located at (84, .98). For this particular point, an assigned/authorized manpower ratio of approximately 84/1 or 8400% generates a simulated readiness level of .98 or 98%. Compared to the rest of the data, this point certainly appears to be a potential outlier. Further inspection of the regression plot indicates the potential for additional outliers.

Figure 3 includes both the summary of fit and ANOVA tables and provides information about the initial regression. The summary of fit shows an R^2_{ADJ} value of .0064 or 0.64% (less than 1%) correlation between the assigned/authorized manpower ratio and the readiness rate. This means that virtually no correlation is established between the dependent and independent variable or that there is almost no relation between the two, which is counterintuitive to our assumption that the two are correlated. The lack of correlation, however, might be misrepresented or artificially influenced by the outliers in the data and the fact that the mobility rates are simulated instead of actual percentages. The ANOVA table in Figure 3 contains a very high F-statistic of 171.5 and a very low p-value of $< .0001$ to reject the null hypothesis from assumption number five and conclude that the possibility exist that the model is significant.

The high F-statistic and low p-value are partially the result of the large number of degrees of freedom. The model is also significant at least in part to the low mean square error value, 0.1355.

To improve the accuracy of the model, outliers are further examined. Outliers are then determined using *DFFITS* and a threshold of 0.01731975. For the h_{ii} outliers, 2p/n is used as a threshold, where p is the number of parameters (y-intercept + independent variables) and n is the number of points of comparison. For this data, 2p/n = 0.000149987 as p=2 (1 variable + 1 intercept) and n=26668. Any value exceeding the h_{ii} threshold of 0.000149987 is deemed a potential outlier. For Cook's D analysis, if $D_i > 1$, then it is considered to have a large value and is thus influential. Table 1 shows a sample of the outlier calculations with two of the *DFFITS* outliers highlighted in red:

Table 1: Outlier Calculations

Author./Assgn. Ratio	Readiness Rate	Studentized Res. (ri)	Hat Values (hii)	Residuals (ei)	Cook's D	t(i): R-Student	S^2i	DFFITS
0.799	0.688643037	-1.642306438	4.11227E-05	-0.191144262	5.54597E-05	-1.65E+00	1.34E-02	1.06E-02
0.877	0.746890918	-1.149641199	3.92096E-05	-0.133804218	2.59122E-05	-1.16E+00	1.34E-02	7.24E-03
0.887	0.827525448	-0.457832084	3.90156E-05	-0.053286077	4.09E-06	-4.60E-01	1.34E-02	2.88E-03
1.029	0.901296115	0.161802557	3.75199E-05	0.018831861	4.91E-07	1.63E-01	1.34E-02	9.96E-04
0.906	0.753207779	-1.098266696	3.86792E-05	-0.127824886	2.33282E-05	-1.10E+00	1.34E-02	6.87E-03
1.356	1.024437752	1.187133189	4.30173E-05	0.138167566	3.03131E-05	1.19E+00	1.34E-02	7.83E-03
1.107	0.880153075	-0.027657656	3.76988E-05	-0.003219016	1.44E-08	-2.78E-02	1.34E-02	1.71E-04
0.988	0.890781393	0.075560565	3.77103E-05	0.008794335	1.08E-07	7.60E-02	1.34E-02	4.66E-04
0.623	1.016374914	1.191161547	4.80457E-05	0.138636068	3.40869E-05	1.20E+00	1.34E-02	8.30E-03
0.813	1.025198652	1.247970228	0.000040727	0.145248408	0.000031716	1.25E+00	1.34E-02	8.01E-03
0.82	0.780756227	-0.852972129	4.05378E-05	-0.09927549	1.47475E-05	-8.58E-01	1.34E-02	5.46E-03
0.535	0.741290167	-1.163570143	5.28618E-05	-0.135424453	3.57866E-05	-1.17E+00	1.34E-02	8.51E-03
0.905	0.767796524	-0.972820745	3.86959E-05	-0.113224502	1.83112E-05	-9.78E-01	1.34E-02	6.08E-03
0.941	0.937432736	0.481087155	3.81698E-05	0.055992708	4.42E-06	4.84E-01	1.34E-02	2.99E-03
0.844	0.822417656	-0.497418222	3.99324E-05	-0.057893395	4.94E-06	-5.00E-01	1.34E-02	3.16E-03
0.788	0.479593317	-3.437356643	4.14495E-05	-0.400065954	0.000244882	-3.46E+00	1.34E-02	2.23E-02
0.973	0.957886969	0.653628971	0.000037829	0.076074495	8.08E-06	6.57E-01	1.34E-02	4.04E-03
0.505	0.637292854	-2.054119386	0.00005471	-0.239072598	0.000115428	-2.07E+00	1.34E-02	1.53E-02
0.873	0.90406584	0.201200291	3.92904E-05	0.02341726	7.95E-07	2.02E-01	1.34E-02	1.27E-03
0.773	0.529662068	-3.005667873	0.000041918	-0.349822619	0.000189352	-3.02E+00	1.34E-02	1.96E-02

For ease of analysis, the outliers are then consolidated and examined. Each point marked as an outlier is examined to see if it has true potential for leverage and influence. If an individual point appears to exert influence, the modeler may choose to either remove it from the model or keep it with the non-outlier data. Although the h_{ii} and *DFFITS* analysis produced outliers, the Cook's D analysis did not reveal any outliers for this project. A sample of the outlier consolidation is shown in Table 2 below:

Table 2: Consolidated Outliers

Author./Assgn. Ratio	Readiness Rate	Hat Values (hii)	DFFITS
2.494	0.737474326	0.000159352	1.77E-02
2.5	0.837459993	0.000160366	6.80E-03
2.551	1.009690097	0.00016915	1.23E-02
2.572	0.938636233	0.000172856	4.34E-03
2.604	0.79639708	0.000178601	1.21E-02
2.621	0.595271755	0.000181702	3.56E-02
2.626	0.82617559	0.00018262	8.74E-03
2.649	0.760420594	0.000186882	1.66E-02
2.671	0.877506672	0.000191017	2.87E-03
2.694	0.887581129	0.0001954	1.72E-03
2.745	0.78742677	0.000205338	1.42E-02
2.751	0.861887064	0.000206528	5.04E-03
2.909	0.807436849	0.000239353	1.30E-02
3.017	0.96410489	0.000263466	8.20E-03
3.056	1.028589425	0.000272508	1.75E-02
3.066	0.891495567	0.000274855	2.10E-03
3.122	0.866515249	0.000288213	5.91E-03
3.194	1.09449936	0.000305926	2.82E-02
3.266	0.794884468	0.000324243	1.77E-02

. In Table 2, a ratio above 2.49 (where a unit has 249% of their authorized manpower on hand), produces outlier conditions to some degree. After examining each outlier for this data set, 1,846 points were determined to have some type of leverage on the regression and taken out of the set.

While 1,846 points may sound like a large amount of to eliminate, it only comprises 6.921% of the total points in the entire data set.

A new regression based on the reduced data set yields the results in Figure 4:

Regression Statistics					
Multiple R	0.137044675				
R Square	0.018781243				
Adjusted R Square	0.01874171				
Standard Error	0.096309352				
Observations	24822				

ANOVA

	df	SS	MS	F	Significance F
Regression	1	4.406534636	4.406535	475.072909	2.4036E-104
Residual	24820	230.2176942	0.009275		
Total	24821	234.6242288			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0.838377423	0.002194519	382.0324	0	0.834076035	0.84267881
Author./Assgn. Ratio	0.044960457	0.002062769	21.79617	2.404E-104	0.040917307	0.04900361

Figure 6: 2nd Regression Statistics and ANOVA

By identifying and eliminating outliers through h_{ii}, *DFFITS* and Cook's D analysis, the second iteration of the model is an improvement over the first one. While the new R^2_{ADJ} value is still not high at only .0188, it is almost a 200% improvement compared to the R^2_{ADJ} of .006353 of the initial iteration. In this case, the R^2_{ADJ} value and correlation may improve once the actual data is used. The simulation, combined with a small range of percentages may be detracting from the R^2_{ADJ} value. With regards to model significance, an F-statistic of 475.1 provides the information necessary to reject the null hypothesis from assumption five so that one could conclude that the second regression model is adequate. Moreover, the independent variable in the model, the assigned/authorized manpower ratio, has a t-statistic of 21.77 to go along with a p-value of 2.404 x 10^{-104} (or basically zero). The high t-statistic combined with the extremely low p-value (at a

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confidence level of .95) makes it possible to reject the null hypothesis from assumption number six and conclude that the independent variable may be significant in this model.

Since the null hypothesis has been rejected for both the model and independent variable significance, a normal probability plot provides a check for the adequacy of the model. It gives modelers a tool for validating the normality assumption by graphing the R-student residuals generated from the data. Ideally, the graph is designed so that the cumulative normal distribution is a straight line (Montgomery, Peck, & Vining, 2012). Figure 5 below shows that the data appear to be normal as the R-student residuals do not deviate far from a straight line:
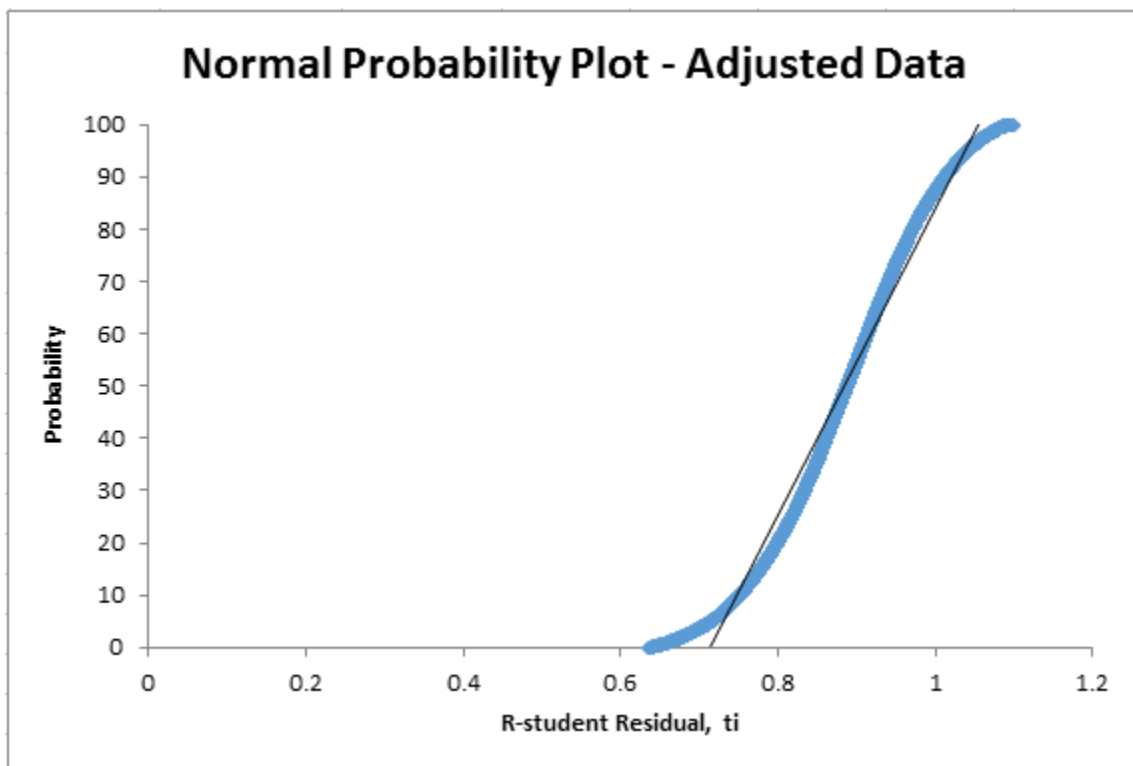

Figure 7: Normal Probability Plot for the 2nd Regression

Figure 5 indicates the data appears to have a slightly heavy tailed distribution. A

histogram of the residuals shows that the R-student residuals are normally distributed in Figure
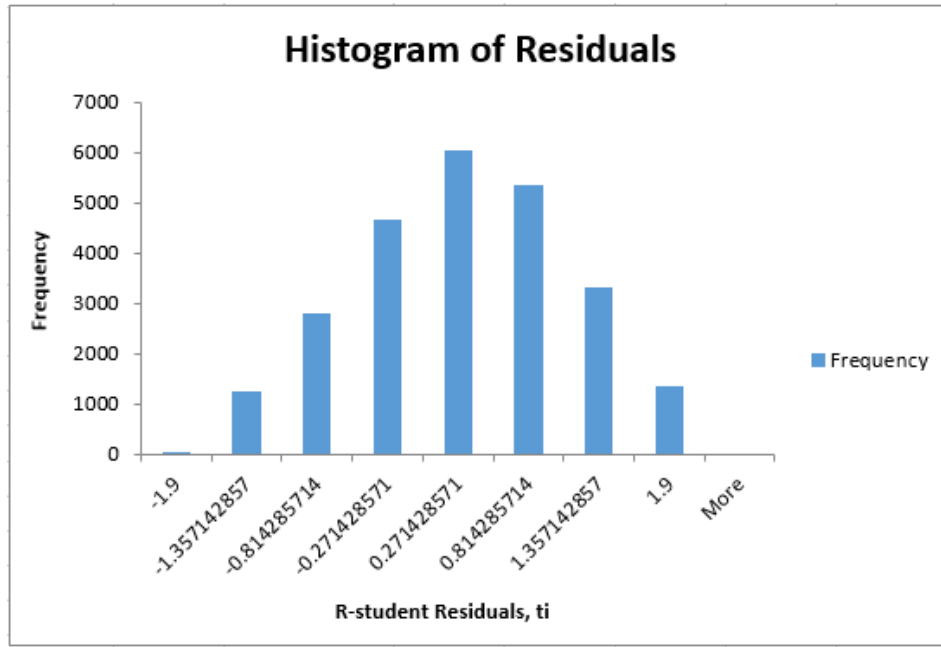
6:

Figure 8: Histogram of the Residuals

Prior to the using the equation from the most recent regression, we check a plot of the

data points to determine the range for implementation. The graph gives the modeler an idea of

which x-values to use by showing where the preponderance of the data lie. By doing this, we

narrow the focus of the application and ensure that the equation is not applied to points beyond

the bounds of the established range. Figure 7 provides a means for determining this range.
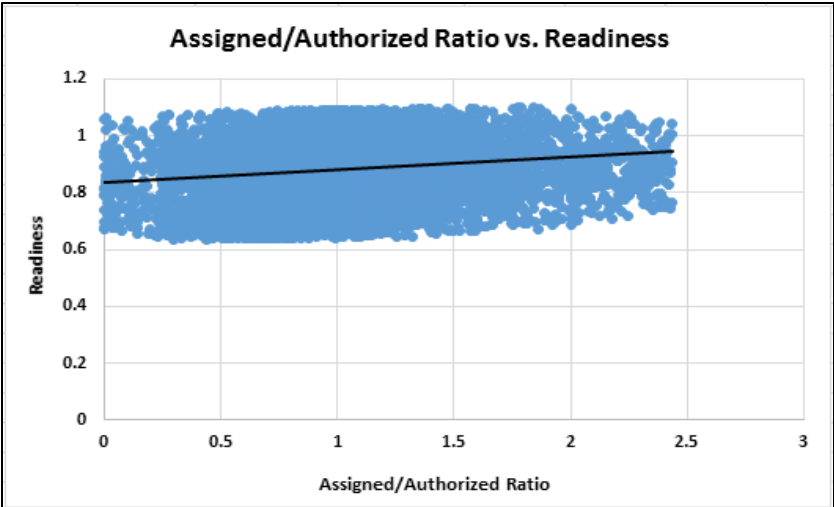
Figure 9: Assigned/Authorized Ratio vs. Readiness Plot

For the implementation of the model, the equation y = 0.04496x + 0.8384 is applied to a range of x-values between zero (or no FTS on-hand) and 2.5 (250% of authorized FTS on-hand). The bounds reflect that the data begins at zero FTS workers on-hand and ends at approximately 2.49 or 249% of authorized FTS on-hand. Rounding the lower bound of 0.25 down to 0.2 and the upper bound of 1.88 up to 1.9 creates intervals of 0.1 that most decision makers can easily work with. Table 3 shows the results of substituting various ratios into the new regression equation:

Table 3: Predicted Mobility Rates

Assigned/Authorized Ratio	Mobility Rate
0%	84%
20%	85%
50%	86%
80%	87%
100%	88%
120%	89%
140%	90%
160%	91%
190%	92%
210%	93%
230%	94%
250%	95%

Implementing the regression equation for this model produces a range of mobility rates from a low of 84% to a high of 95%. Table 3 gives the decision maker an idea of the ratio needed to generate the desired mobility rate or at least exceed the threshold for reaching a mobility rate goal. Once the decision maker has decided on a mobility goal, he or she can use the corresponding assigned/authorized manpower ratio necessary to attain that desired mobility rate. For example, if the threshold for mobility for a unit is 87%, then the unit needs to have 80% of the authorized FTS manpower assigned. For a unit that has 500 FTS positions authorized, that organization needs to fill 400 positions to reach the goal of 87%. If the unit fills less than 400 positions, then they risks falling short of the goal or making their current staff compensate for the unfinished work. If they hire more than 400, then they may be detracting from their budget in an environment that is already fiscally constrained.

In terms of savings, the average cost of a manpower requirement is $109,000. If an organization fills only 400 positions out of the 500 positions authorized, it would save $10.9 million. In doing this, however, the decision maker assumes the responsibility for risking at least one percent lower mobility rate, according to Table 3. Using the model developed through the methodology of this project and the figures in Table 3, decision makers have a valuable tool in making an informed decision that is in the best interest of their organization financially and in terms of meeting their assigned mission.

Chapter 6: Conclusion

In today's environment, where resources are constantly scrutinized, constrained and evaluated for future distribution and use, modeling is as important as it has ever been. Manpower modeling, in particular, can be the deciding factor in determining if organizations succeed or fail as the amount of work and the number of workers must be in balance to ensure success. While the right model can make or break and organization, the procedure that an organization follows to evaluate manpower requirements and build a model is just as important as the resulting model. From establishing mandates for each task to the data collection effort for each BPM, the foundation of the model must be solid in order to develop a defendable model that produces results that are accurate and unbiased.

Modelers and analyst must remember that in all modeling efforts, the data drives the manner in which the model methodology is realized. The type of methodology, the type of analysis available, the types of model adequacy checks and several other options are all driven by the amount and type of data provided to the modeler. In the FTS model, the authorized/assigned manpower ratios were the key pieces of data provided. In the future, additional data such as the actual mobility rates will give modelers an asset to make a stronger model. With these results, the leaders of an organization can use an effective, data driven model to make decisions that will increase the likelihood of success for their agency, unit or organization.

Bibliography

(2015, May 17). Retrieved from BusinessDictionary.com: http://www.businessdictionary.com/definition/manpower.html

Albrecht, M. (1976). A Discussion of Some Applications of Human Capital Theory to Military Manpower Issues. In M. Albrecht, *A Discussion of Some Applications of Human Capital Theory to Military Manpower Issues* (pp. 1-22). Santa Monica, California: The Rand Corporation.

Army Management Action Group. (2014, November 21). Executive Summary. Washington, D.C.: U.S. Army.

Defense Finance and Accounting Service - Indianapolis. (2014). DFAS-IN Regulation 37-1: Finance and Accounting. Indianapolis, Indiana: Defense Finance and Accounting Service.

Free, E. (2014, November 20). Information Paper: USAMAA Response to Requirements Determination Questions Raised in the PA&E Amicus Brief. *Information Paper*. Fort Belvoir, Virginia: USAMAA.

G-37/FMP. (2014, November 21). Full Time Support (FTS) Review. Washington D.C. : U.S. Army G-3/5/7.

Headquarters Department of the Army. (1 June 1990). *Army Regulation 135-2: Army National Guard and Army Reserve Full-Time Support Program.* Washington, D.C.: Headquarters Department of the Army.

Headquarters Department of the Army. (8 February 2006). AR 570-4: Manpower Management. In *Army Regulation 570-4: Manpower and Equipment Control - Manpower Management* (pp. Section 1-4b, Page 1). Washington D.C.: Headquarters Department of the Army.

Johnson, G. C. (1975). Toward a Theory on High-Level Manpower Planning: Alternatives and Suggestions. In G. C. Johnson, *Toward a Theory on High-Level Manpower Planning: Alternatives and Suggestions* (pp. 4-5). Cambridge, MA: Massachusetts Institute of Technology.

Montgomery, D. C., Peck, E. A., & Vining, G. G. (2012). *Introduction to Linear Regression Analysis, Fifth Edition.* Hoboken, New Jersey: John Wiley & Sons.

Ngin, P. C. (2005). *Applying Human Capital Management to Model Manpower Readiness: A Conceptual Framework.* Monterey, California: Naval Postgraduate School.

U.S. Army National Guard. (2014). ARNG Input into AMAG Tasker for Full Time Support.

United States Army Manpower Analysis Agency. (2014, September 2). FTS ATOMM Model Overview Brief. Fort Belvoir, Virginia.

USAMAA. (2008). *Manpower Model Development Methodology.* Fort Belvoir, VA: U.S. Army.

USAMAA. (2012). *Standard Operating Procedure for Manpower Modeling* . Fort Belvoir, VA: U.S. Army Manpower Analysis Agency.

USAMAA. (2013, December 13). Process Map Development Training (Phase I & II). Fort Belvoir, VA.

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14. ABSTRACT
The United States Army is at a point in its history in which it, along with the other branches of the military, are experiencing cuts, constraints and a tightening of resources. The days of seemingly large budgets, abundant financial resources and high amounts of manpower are becoming a thing of the past. As the government reduces the allocations to the military, it is examining ways to reduce costs and improve its financial prospects. One of the positions examined for reduction or outright elimination is the full time support position in the U.S. Army National Guard (ARNG) and Reserves (USAR). The purpose of this research endeavor is to quantify the impact that these positions have on the ARNG and the USAR and determine the amount of risk associated with either reducing or eliminating them.

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