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**AIR FORCE RESERVE FORCE STRUCTURE POLICY**

**EVAULATION MODEL**

**THESIS**

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AFIT/GOR/ENS/03-17

**DEPARTMENT OF THE AIR FORCE  
AIR UNIVERSITY**

**AIR FORCE INSTITUTE OF TECHNOLOGY**

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Wright-Patterson Air Force Base, Ohio

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AFIT/GOR/ENS/03-17

AIR FORCE RESERVE FORCE STRUCTURE POLICY EVALUATION MODEL

THESIS

Presented to the Faculty

Department of Operational Sciences

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the  
Degree of Master of Science in Operations Research

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March 2003

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## **Acknowledgements**

I would like to recognize my thesis advisor, Major Paul McAree, for his help and support throughout the course of this thesis effort. I would also like to express my thanks to my reader Dr. James Moore, for his direction and assistance. My sponsor, AF/REAMO, also deserves recognition for the support and assistance they provided during the entire thesis process.

I would be remiss if I failed to mention the endless support and encouragement my fiancé has given me throughout this process. The example she set with her own dedication to her studies and the support she gave me throughout my thesis allowed me to achieve my goals as a master's student.

## Table of Contents

	Page
<b>Acknowledgements</b> .....	iv
<b>List of Figures</b> .....	vii
<b>List of Tables</b> .....	ix
<b>Abstract</b> .....	x
<b>1. Introduction</b> .....	1
1.1 Overview.....	1
1.2 Background.....	2
1.3 Problem Statement.....	5
1.4 Thesis Overview .....	6
<b>2. Literature Review</b> .....	7
2.1 Chapter Overview .....	7
2.2 Management of the AGR.....	7
2.2.1 Accessions.....	7
2.2.2 Promotion.....	8
2.2.3 Separations.....	9
2.3 Markov Process.....	9
2.4 Personnel Planning Models.....	11
2.5 Summary .....	16
<b>3. Methodology</b> .....	17
3.1 Chapter Overview .....	17
3.2 Model Development.....	17
3.3 Assumptions.....	18
3.4 Model Formulation .....	20
3.4.1 Mathematical Formulation.....	21
3.4.2 Constraints .....	24
3.4.3 Objectives .....	24
3.5 Model Example.....	26
3.6 Model Implementation.....	28
3.7 Summary .....	28

	Page
<b>4. Analysis of Results</b> .....	30
4.1 Chapter Overview .....	30
4.2 Alteration of the Model.....	30
4.3 Scenario Analysis.....	31
4.4 Scenario Results.....	32
4.4.1 Minimizing Accessions.....	34
4.4.2 Minimizing Weighted Accessions .....	40
4.4.3 Maximizing Average Number of Years in the AGR .....	46
4.5 Summary of Results.....	52
4.6 Summary .....	54
<b>5. Contributions and Conclusions</b> .....	55
5.1 Research Contributions.....	55
5.2 Limitations .....	55
5.3 Future Research .....	56
5.4 Conclusions.....	56
<b>Bibliography</b> .....	58

## List of Figures

Figure	Page
Figure 1.1: Individual Reserve Guide, Attachment (IRG 02).....	4
Figure 2.1: Personnel Cycle for the AGR.....	7
Figure 2.2: Example DTMC .....	10
Figure 2.3: Military DTMC .....	10
Figure 2.4: Example College Student Flow Diagram (Grinold 78).....	14
Figure 2.5: N-Period Dyadic Format (Charnes 78) .....	15
Figure 3.1: Model Development Flow Chart.....	17
Figure 3.2: Sample Manpower Planning Model.....	26
Figure 3.3: Model Implementation in the Management of the AGR.....	28
Figure 4.1: The Path through the AGR.....	33
Figure 4.2: Personnel By Grade.....	34
Figure 4.3: Minimize Accessions Personnel Chart (D=0).....	35
Figure 4.4: Minimize Accessions Personnel Path Chart (D=0).....	36
Figure 4.5: Minimize Accessions Personnel Chart (D=0.25).....	37
Figure 4.6: Minimize Accessions Personnel Path Chart (D=0.25).....	38
Figure 4.7: Minimize Accessions Personnel Chart (D=0.50).....	39
Figure 4.8: Minimize Accessions Personnel Path Chart (D=0.50).....	40
Figure 4.9: Minimization of Weighted Accession Personnel Chart (D=0) .....	41
Figure 4.10: Minimization of Weighted Accession Personnel Path Chart (D=0) .....	42
Figure 4.11: Minimization of Weighted Accession Personnel Chart (D=0.25) .....	43
Figure 4.12: Minimization of Weighted Accession Personnel Path Chart (D=0.25) .....	44

Figure	Page
Figure 4.13: Minimization of Weighted Accession Personnel Chart (D=0.50) .....	45
Figure 4.14: Minimization of Weighted Accession Personnel Path Chart (D=0.50) .....	46
Figure 4.15: Maximize Average Number of Years Personnel Chart (D=0).....	47
Figure 4.16: Maximize Average Number of Years Personnel Path Chart (D=0).....	48
Figure 4.17: Maximize Average Number of Years Personnel Chart (D=0.25).....	49
Figure 4.18: Maximize Average Number of Years Personnel Path Chart (D=0.25).....	50
Figure 4.19: Maximize Average Number of Years Personnel Chart (D=0.50).....	51
Figure 4.20: Maximize Average Number of Years Personnel Path Chart (D=0.50).....	52

## List of Tables

Table	Page
Table 1.1: Authorized Strengths of the USAF Reserves for FY2000 (Vreeland 02) .....	3
Table 2.1: AGR Officer Promotion Requirements (CY0 02).....	8
Table 3.1: Assumptions pertaining to Accession and Modeling of Year Groups .....	19
Table 3.2: Sample Model Output.....	27
Table 4.1: Accession by Grade by YOS .....	35
Table 4.2: Weighting Scheme for Scenarios 4,5,6.....	41
Table 4.3: Scenario Summary of Accession.....	53
Table 4.4: Scenario UMD Differences .....	54

### **Abstract**

The United States Air Force Reserve is a constantly changing force. In response to these changes, the Active Guard Reserve (AGR), a small organization within the Reserve, is seeking to create a career track for Unit and Headquarters' Officers. It is necessary for the AGR policy division to be able to evaluate the availability of career paths to accomplish this goal.

The Air Force Reserve Force Structure Evaluation Model provides the AGR management with a tool to aid them in evaluating policy impact. This model allows the AGR management to identify the impact policy changes may have on the resulting force structure and is to be used as part of an iterative policy driven management cycle.

This study implements a Markov Chain model providing the user with several advantages to aid them in their decision process. The study evaluates several different objective functions in order to illustrate the impact a policy may have on the force structure. The conclusion of the study is that the current UMD requirements for the AGR do not allow for a viable career path for officers regardless of the policy implemented.

# AIR FORCE RESERVE FORCE STRUCTURE POLICY EVALUATION MODEL

## 1. Introduction

### 1.1 Overview

The United States Air Force (USAF) is evolving to meet new challenges in the post Cold War, post 9-11 world through changes in doctrine, strategy, and force structure. The doctrine of the USAF altered from a battle for the largest, most powerful, best-equipped standing Air Force to a small, active, and efficient fighting force (AFH 99). In response to budget cuts and changing requirements, the Air Force reduced their active duty component by over 40% from its peak in the late 1980s (AFH 99). Coupled with the downsizing of a permanent fighting force was an increase in the reserve force component. The USAF Active Duty, USAF Reserve, and Air National Guard are the elements of the Total Air Force.

In the Total Force, the Air Force Reserve and Air National Guard are fully integrated with the Active component in many areas (e.g. programming, planning, equipping, training) (Cantwell 97). A National Defense University study in 1985 determined the employment and integration of the Air Force Reserve and Air National Guard as the epitome of the Total Force Policy in action (Cantwell 97). The Total Force Policy specifies the mission of the USAF Reserve as providing:

combat units, combat support units, and qualified personnel for active duty in the Air Force to support augmentation requirements and to perform such peacetime missions as are compatible with the ARF training requirements and the maintenance of mobilization readiness. (Cantwell 97)

This policy calls for an annual review of the Air Reserve Forces programs and structure to ensure the proper composition of the Total Air Force (Cantwell 97). The active duty component aided the reserve component in developing their role in the total force structure by delegating management structure and equipment for performing real-world missions (Cantwell 97). Management of the Air Force Reserve is established from Public Law 90-168, which gives the Air Force Reserve the right to “manage itself and command its forces in peace time” (Cantwell 97).

The Air Force Reserve currently makes up 14% of the Total Air Force and supplies 20% of the Total Force capability (Sherrard 01). Unit Reservists contribute 67% of the 74,700 Air Force Reservists (Sherrard 01). The remainder of the Reserve force is 15% Individual Mobilization Augmentees, 11% Air Reserve Technicians, 5% civilian, and 2% in the Active Guard and Reserve (AGR). In 1997, the AGR had 650 personnel. In 2002, the entire AGR had 1,437 personnel with a projection to grow to 1,616 by the year 2007 (Vreeland 02). The focus of this paper is the personnel management of the AGR force.

## **1.2 Background**

The autonomy provided to the Air Force Reserve by Public Law 90-168 allows the Air Force Reserve to manage itself under a Reserve General. This allows the reserve to make policy and implement doctrine. The Air Reserve component is divided into two parts, the United States Air Force Reserve (USAFR) and the Air National Guard

(ANGUS). The ANGUS has three roles in providing ready units to the states and the nation. These three roles are:

- (1) to support national security objectives
- (2) to protect life and property, and to preserve peace, order, and public safety
- (3) to participate in local, state, and national programs that add value to America.

The USAFR role is to support the Air Force mission in defending the United States through control and exploitation of air and space (ANG 02).

The USAFR is divided into three categories: Standby Reserve, Ready Reserve, and Retired Reserve. The three categories identify the status of an individual and correlate to the level of participation required of the individual in the military. Retired and Standby Reservists do not directly participate in the full time reserve and are considered inactive. Under certain circumstances, standby and retired personnel can be activated.

**Table 1.1: Authorized Strengths of the USAF Reserves for Fiscal Year 2000 (Vreeland 02)**

<b>Authorized Strength</b>	<b>Officer</b>	<b>Enlisted</b>
Selected Reserve	16,664	55,676
<i>AGR-HQ</i>	257	553
<i>AGR Units</i>	137	198
<i>Individual Mobilization Augmentees (IMAs)</i>	7,016	5,581
<i>Unit</i>	9,254	47,983
Individual Ready Reserve	10,171	40,133
<b>Total Ready Reserve</b>	<b>26,835</b>	<b>95,809</b>

The Ready Reserve can be further broken down into Individual Ready Reservists (IRR) and Selected Reservists. The IRR consists of individuals responsible for ensuring their readiness for mobilization in non-pay positions. These individuals are still able to earn point credits toward retirement (IRG 02). The Selected Reserve is divided into four

areas: Individual Mobilization Augmentees (IMAs), Air Force Reserve Component (AFRC) NP's trainees, the Active Guard Reserve Headquarters (AGR-H), and Active Guard Reserves Units (AGR-U).

In 2000, the authorized strength of the Ready Reserve was 122,644, (72,340 Selected Reserve, 50,304 Individual Ready Reserve). The AGR-H and AGR-U are approximately 1.6% of the selected reserve force. (Table 1.1) This research concentrates on the AGR portion of the Ready Reserve. Although the AGR is a small part of the Ready Reserve, it serves a unique role, and the management of this force is extremely important. Figure 1.1 identifies the organizational structure of the Reserve Force and the shaded areas indicate where the AGR falls within this structure.

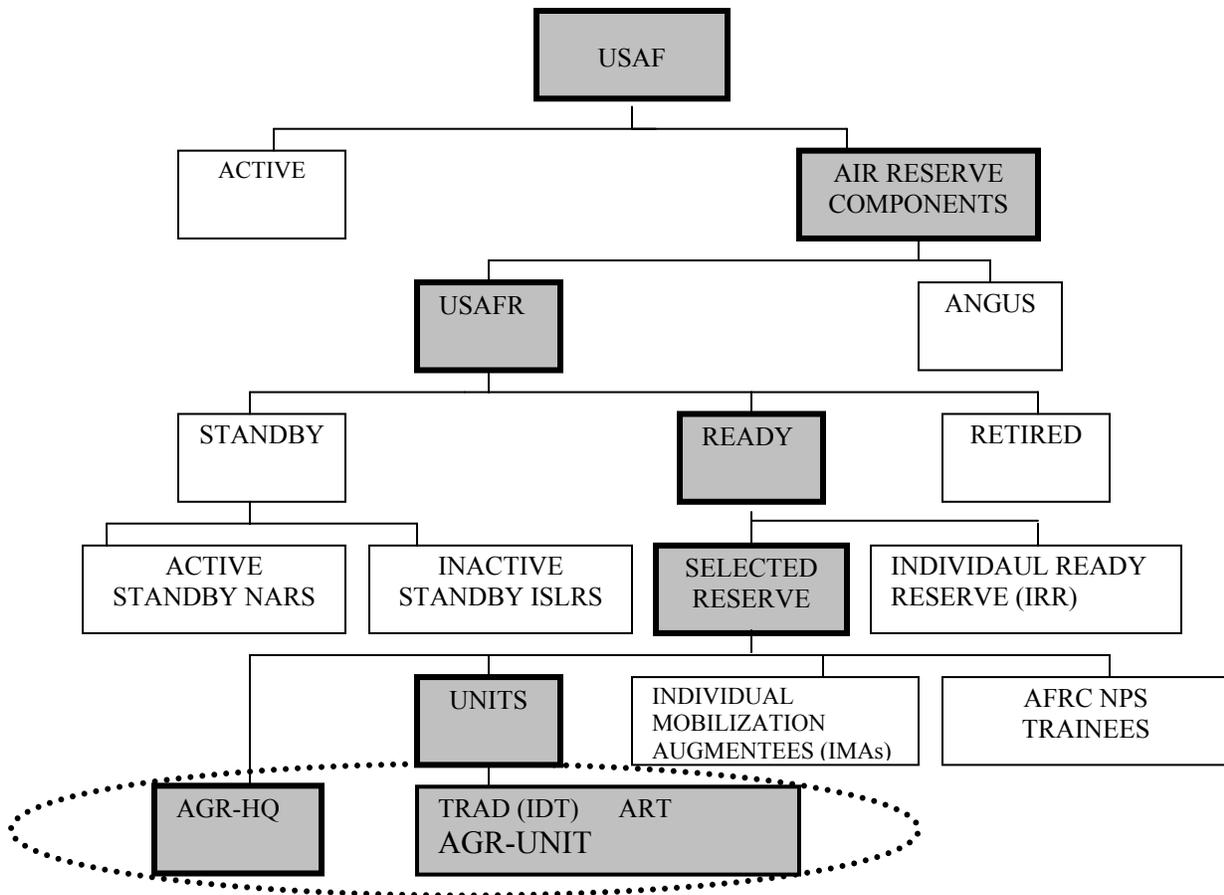


Figure 1.1: Individual Reserve Guide, Attachment (IRG 02)

The Headquarters Active Guard Reserve is made up of Air Force Reserve members who are ordered to active duty under the provisions of Title 10 U.S.C and those who are serving full-time active duty with, or in support of the Air Force Reserve at MAJCOM or higher level (AFI 36-2132 00). The distinction between the AGR-H and the AGR-U is simply the level at which the personnel are assigned. AGR Unit personnel are assigned to the AFRC mission to aid in the organizing, administration, recruiting, and instructing of training Reserve component units (AFI 36-2132 00). AGR-H personnel are those who work at headquarters and are not assigned to a specific Unit. The AGR, both Unit and Headquarters, is being changed in order to provide a career track within the organization. The AGR-H and AGR-U are combining and are analyzed as one entity in the development of a force structure model.

### **1.3 Problem Statement**

It is necessary to develop a well-organized and well-trained Reserve Component that can seamlessly integrate into the Total Force. The development of senior officers in the AGR is a necessity to ensure the success of the Total Force concept. The AGR programs will be administered as a career program that may lead to a military retirement (DoD 00). In 2000, 120 of the 257 officers in the AGR-H positions had less than 2 years AGR-H experience. These personnel are responsible for organizational and administrative support to the AFR (AFI 36-2132 00). In converting AGR programs into career programs, it is necessary to take into account the proposed manpower requirements as well as the historical retention and promotion rates associated with the AGR. The most important aspect of the career program is the ability to provide a career

path for military officers in the AGR that will lead them to retirement. These necessities create a need to analyze the current and future force structure of the AGR.

#### **1.4 Thesis Overview**

In Chapter Two, a review of pertinent literature is presented. The first half of the chapter discusses the relevant management policy and procedures within the AGR. The second half of the chapter gives an overview of past research accomplished with respect to manpower modeling and Markov Chains.

Chapter Three provides an in depth description on the development of the model. This chapter also includes a description of the underlying equations and structure of the model. In addition to the description of the model, an application of the model is illustrated through the use of a small example problem.

In Chapter Four, a summary of results is provided. These results relate the purpose of the model to the output the model yields. The results from the model are a function of a given goal or objective. The ability to explore different goals and objectives to provide the AGR with the flexibility to use the model for a variety of policy decisions is also demonstrated.

Chapter Five concludes with a summary of the work presented. A discussion of the practical uses and implementation of the model and insights into improvements that may be made is discussed. An outline of the limitations in the development of the model and a recommendation for future work in this area is then addressed.

## 2. Literature Review

### 2.1 Chapter Overview

The focus of this research is to develop a tool to help manage the AGR Career Program. An overview of the AGR and how it is managed is described in Section 2.2. This forms the basis for our understanding of AGR policy and management. This understanding is essential in the development of the model. The model developed in this thesis is based on the manpower allocation model efforts found in the literature and presented in Section 2.3.

### 2.2 Management of the AGR

A simplified personnel cycle for officers in the AGR is depicted in Figure 2.1. An individual enters the AGR as an accession. Once in the system, the individual can move within the AGR through promotions or leave the AGR by separation or retirement.

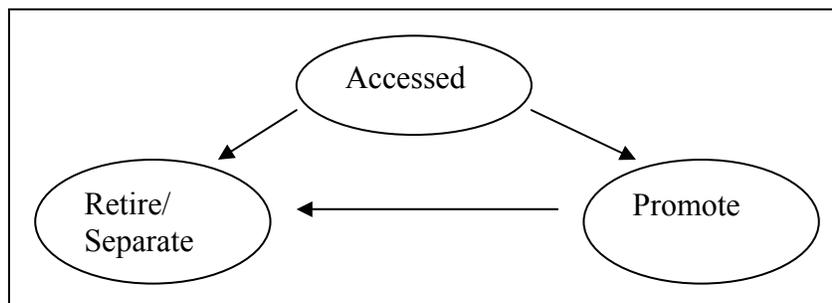


Figure 2.1: Personnel Cycle for the AGR

#### 2.2.1 Accessions

There are two types of accessions into the AGR. The first type of officer accessions is a 2<sup>nd</sup> Lieutenant with zero years of experience. The second type is as a “cross flow” from Active Duty or other components of the Ready Reserve (Percich 02).

The officer may have any number of years of experience and hold any grade from 2<sup>nd</sup> Lieutenant to Colonel.

### 2.2.2 Promotion

There are two means by which an officer in the reserves can be promoted: through a traditional promotion board or a vacancy promotion (AFI 36-2504 02). A traditional promotion board occurs at a specific point in an individual’s career based on total years of experience in their current rank. Table 2.1 identifies the time in grade requirements for promotion within the Air Force Reserve for fiscal year 2003.

**Table 2.1: AGR Officer Promotion Requirements (CY0 02)**

FY03 Promotion to:	Board		Vacancy	
	DOR	TIG	DOR	TIG
Captain	30-Sep-01	2 yrs	Does Not Apply	
Major	30-Sep-96	7 yrs	30-Sep-96	4 yrs
Lieutenant Colonel	30-Sep-96	7 yrs	30-Sep-96	4 yrs
Colonel	30-Sep-99	3 yrs		

If a member meets the board and is promoted during this time period, it is termed an “in the zone” promotion (AFI 36-2504 02). When an officer is not promoted, declines a promotion, or is removed from the promotion list during this period, then this person is now considered to be “above the zone.” Despite being “above the zone”, the officer is still eligible for promotion (AFI 36-2504 02).

The second method of promotion occurs out of cycle or before the individual has met the required years of service and experience. This occurs when an individual fills a position vacancy that requires one grade higher than the grade they currently possess. A vacancy promotion board convenes to select officers from this group to be promoted in

order to match the grade their job requires (AFI 36-2504 02). In order for this to occur, the individual must already be eligible for promotion, whether below, in, or above the zone, and the position being filled must have an authorization of a grade higher than the entering individual's current grade (AFI 36-2504 02). This type of promotion is subject to the TIG requirements referred to in Table 2.1.

### **2.2.3 Separations**

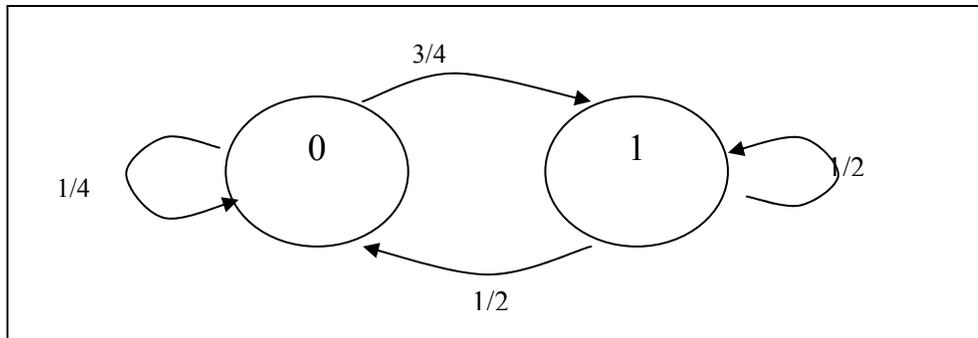
There are two methods by which an individual may leave the AGR: separation or retirement. A separation can be a transfer to active duty, another area of the reserves, or civilian life (Vreeland 02). All are considered the same with respect to policy in AGR. A retirement occurs when the member leaving the AGR for civilian life has 20 years or more of active duty/reserve service. Retirement and separations are both viewed as losses to the AGR with respect to the model developed.

### **2.3 Markov Process**

The model produced in this thesis is based on a Markov process. A Markov process is often used to describe the movement of individuals through time as they are promoted or change jobs within a company. A Markov Chain, a specific type of Markov process, is a stochastic process that has the Markov property. A valid description of the Markov process is that the probability of any future event, given any past event and the present state, is independent of the past event and only depends on the present state. Every individual in a given system, or company, is in a state which is defined by the characteristics the individual possesses at a given period in time (Hillier 95). A special type of Markov Chain is known as a Discrete Time Markov Chain (DTMC). In a DTMC, individuals have only a finite number of states in which they can transition to in a

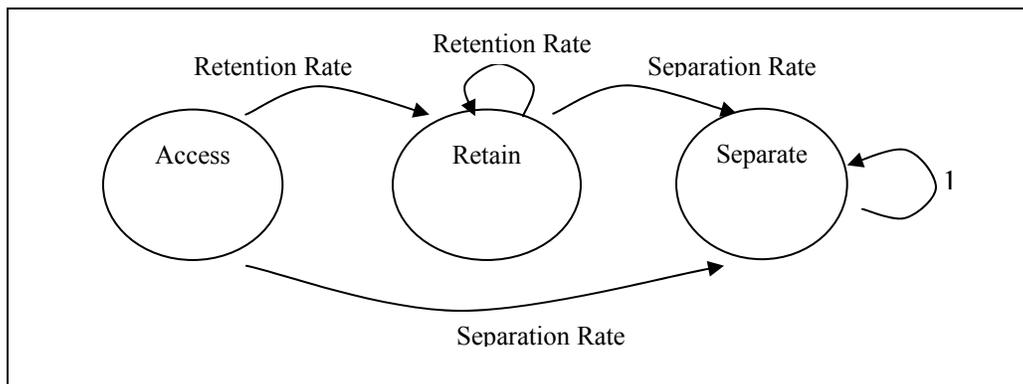
subsequent time period with an associated probability for each transition (Kulkarni 95).

Figure 2.2 is an illustration of a basic DTMC.



**Figure 2.2: Example DTMC**

In this example, there are two states. If an individual is in state zero in the first time period, then the probability they will be in state one in the next time period is 0.75. The probability the individual will remain in state zero is 0.25. The probability an individual will transition to state zero from state one in one time period is 0.50. The probability the individual will remain in state one is also 0.50. This small DTMC demonstrates the Markov property: the behavior of an individual is dependent only on the individual's current state. In Figure 2.3, a slightly more complex DTMC is presented.



**Figure 2.3: Military DTMC**

In this DTMC, there are three states: Access, Retain, and Separate. An individual in the Access state may transition to the Retain or Separate states. If an individual is in the Retain state, they will remain there or separate. Once an individual transitions into the Separate state, they remain there indefinitely. In the case where an individual leaves the AGR to go to a different area of the reserves and then returns, they will return as a new individual. This is a valid assumption because the individual will be returning to a new position within the AGR and be surrounded by different people and policy.

There are three assumptions associated with individuals in a Markov Chain model of personnel behavior. First, all individuals in the system behave and transition from state to state independently. Second, all individuals in the system are subject to these Markovian assumptions. Finally, an individual's rate of transition from one state to another is based solely on the individual's current state (Winston 94).

## **2.4 Personnel Planning Models**

There have been several approaches to personnel planning models. Some models in the literature have taken an inventory model approach to manpower modeling. Hu and Fu in their "Operations Research Letters On the Relationship of Capacitated Production/Inventory Models to Manufacturing Flow Control Models," draw the similarity between producing too many items and acquiring too many individuals into an organization (Hu Fu 95). This similarity allows for the modeling of personnel using known inventory models. Hornestay, in his "The People Problem", discusses the importance of considering multiple attributes in trying to match individuals to jobs that best suit their expertise and abilities (Hornestay 97). His approach aims to increase an individual's desire to stay in their respective positions for a long period of time

(Hornestay 97). This type of multi-attribute methodology is easily incorporated into a Markov Chain model.

The manpower allocation model developed in this thesis integrates the current accession, promotion, and separation/retirement policies providing a tool to be used in creating and implementing management policy. The goals of this manpower model are ease of use, ease of interpretation and flexibility. A model using a Markov Chain as its underlying structure enables us to meet these goals. The advantages of using a Markov Chain are independence, visual simplicity, and robustness. There are several uses for Markov Chains in the literature that illustrates these advantages (Kulkarni 95).

#### **2.4.1 Independence**

A most appealing attribute in using a Markov Chain is the assumption of independence. For the model developed in this research, this assumption applies to the independence of attributes of groups of individuals. One example of a model that exhibits this independence is the Army Planning Model.

The Army developed a manpower-planning model to determine the number of personnel and their skills that best meet future operational requirements (Gass 91). The model categorizes an individual based on four traits: seniority, skill, function, and job title. These four characteristics of an individual are used to identify the state of each individual. Independence is a necessary assumption because every individual acquires these traits at different rates.

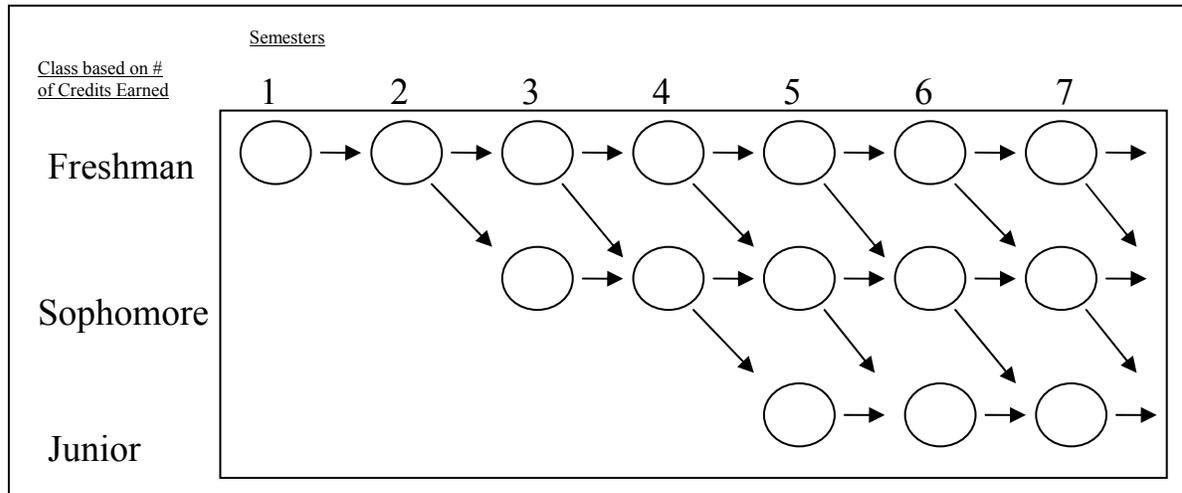
The model in this thesis is concerned with individuals as part of a group. For example, if an individual has the same attributes as another individual, they are in the same group and state. The path each individual took to get to this state may be different,

but this individuality is not the primary focus when modeling group movement through an organization. Brown, in his Quota Allocation model, demonstrates the benefit that can be gained despite the loss of an individual's history (Brown 99). The objective of Brown's model was to provide the minimum number of officers by grade that needed to have Advanced Academic Degrees (AAD) in order to meet the Air Force's requirements. Individuals may achieve an AAD in different ways, but regardless of how they earn their degree, the importance is placed on whether or not they have one (Brown 99). It is the Markov principle that allows this model to function without requiring the ability to follow a single individual's career path.

#### **2.4.2 Visual Advantages**

A Markov Chain also provides the advantage of a visual representation of a model. Through the use of nodes and arcs, the possible avenues of movement through a system from state to state can be graphically displayed. A Semi-Markov Flow Model presented by Grinold and Kneale in 1977 demonstrates this with a probabilistic approach to manpower modeling. Grinold and Kneale used a Markovian based model to explain the flow of a student through a college where there is uncertainty in reference to the time it takes a student to complete a year's worth of credits (Grinold 78). By using a diagram similar to the one in Figure 2.4, Grinold and Kneale were able to visually display all the possible paths an individual student may take. This figure outlines several pathways an individual may take while accumulating enough credits to elevate the grade status from freshman to sophomore, junior and senior. Although the senior grade is not displayed, it follows a similar structure. As seen, every individual starts as a freshman in his or her first semester. After one semester, it is assumed that a student would not have enough

credits to become a sophomore, so they must transition into being a freshman in their second semester. From there an individual may start their third semester as a sophomore, or if not enough credits were earned, they may still be a freshman for their third semester.



**Figure 2.4: Example College Student Flow Diagram (Grinold 78)**

A visual representation of a model can also be used to monitor or track movements of groups through a system. The Army Manpower Planning Model was used to decide how an initial force, given by grade and years of service indices, could best be modified to meet the desired force requirements for each year of a 20-year horizon (Gass 88). This model's focus was groups of individuals with common attributes, which are members of one state. The results from the model indicated that an increase of 16% in reenlistments during the 1990s is necessary to maintain the Army's current end strength. This end strength is divided up into grade and year groups. These groups can be displayed easily on an output chart revealing increases and decreases from current levels.

A Markov Chain was also used as an underlying process in the development of the Flexible Equal Employment Model (FEEO) presented by Charnes, Lewis, and Niehaus in 1976. The FEEO was used to balance a company's force structure with

respect to gender when applied to four areas or “jobs” within the company (Charnes 78). The goal of the model was to transform the male to female ratios of a given company to make them match predetermined quotas. One of the principle contributions of the research effort to that of this thesis was the development of the general dyadic format (Charnes 78). The format provides an easy way to visually relate the starting conditions to the end goals and the steps that were taken to achieve those goals. Figure 2.5 below

<b>TO</b> <b>FROM</b>	<b>t=1</b>	<b>t=2</b>	<b>. . .</b>	<b>t=N-1</b>	<b>t=N</b>	
<b>t=0</b>	$X_{ij}(0,1)$		<b>. . .</b>			$p_i a_i(0)$
<b>t=1</b>	$X_{ij}(1,1)$	$X_{ij}(1,2)$	<b>. . .</b>			$p_i a_i(1)$
<b>.</b>	<b>.</b>	<b>.</b>	<b>.</b>	<b>.</b>	<b>.</b>	<b>.</b>
<b>.</b>	<b>.</b>	<b>.</b>	<b>. . .</b>	<b>.</b>	<b>.</b>	<b>.</b>
<b>.</b>	<b>.</b>	<b>.</b>	<b>.</b>	<b>.</b>	<b>.</b>	<b>.</b>
<b>t=N-2</b>			<b>. . .</b>	$X_{ij}(N-2,N-1)$	$X_{ij}(N-2,N-1)$	$p_i a_i(N-2)$
<b>t=N-1</b>			<b>. . .</b>	$X_{ij}(N-2,N-1)$	$X_{ij}(N-2,N-1)$	$p_i a_i(N-1)$
	$p_i a_i(1)$	$p_i a_i(2)$	<b>. . .</b>	$p_i a_i(N-1)$	$p_i a_i(N)$	

shows this format.

**Figure 2.5: N-Period Dyadic Format (Charnes 78)**

This format allows the decision maker to see the number of individuals in each state at the same time. This decreases confusion while allowing for a neat and orderly display of most of the output from the model.

## **2.5 Summary**

The Air Force Reserve has determined that there is a need for a career path in the AGR. To aid them in this goal, this thesis develops a model that demonstrates the proper force structure needed to accomplish their objectives. The model developed is based on a Markov Chain. It is this underlying structure that offers several advantages to the management of the AGR. The advantages of flexibility and ease of use were discussed in this chapter. Chapter Three focuses on the development and implementation of the model.

### 3. Methodology

#### 3.1 Chapter Overview

The manpower planning model developed can be used as a tool by AF/RE in managing the AGR career program. In this chapter the methodology behind the model is discussed. In Section 3.1, a thorough examination of the development and underlying formulation of the model is presented. Section 3.2 discusses the formulation of the model and Section 3.3 illustrates how the model is implemented with a small example.

#### 3.2 Model Development

The development of the model followed the multi-step process shown in Figure 3.1. The first step in developing a model is identifying the goals and purpose of the model. The second step is to select the proper model. To accomplish this step, a review of existing models in the literature related to the purpose of this research was accomplished. This research, discussed in Chapter Two, led us to the selection of a Markov Chain as the appropriate underlying process in the model. After determining the type of model, the third step was to identify the scope of the model.

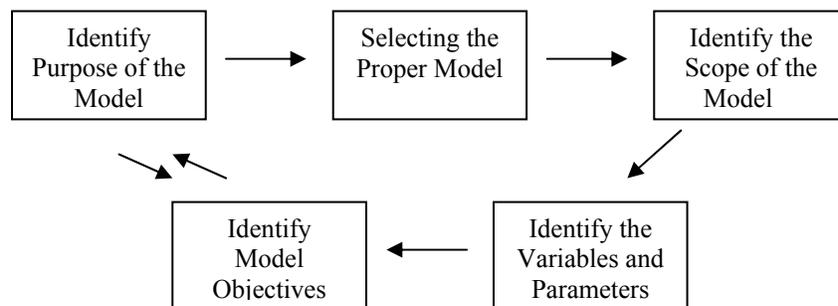


Figure 3.1: Model Development Flow Chart

Through discussion with AF/RE and time limitations on this research, it was determined to model the officer corps of the AGR. It stands to reason if the resultant model is successful for analysis of the officer corps of the AGR, it can be easily modified to incorporate and meet the needs of enlisted corps analysis.

Step four involves identifying the variables and parameters of the model. Each officer is an individual entity in the model, transferring from state to state, based on characteristics monitored in the model. The characteristics modeled include an individual's total years of commissioned service, grade, and the number of consecutive years the individual has served in the AGR. These characteristics provide information needed to define where an individual is in their career.

The final step of the development process is identifying an objective for the model that accurately drives the model to achieve the goals or purpose the model was intended to accomplish. Although the model only applies a single objective function in implementation, multiple objective functions may be substituted. The specific function and their uses is discussed in Section 3.43. The reason to use different objective functions is to allow the user to compare force structures resulting from different policies. This follows from discussion with AF/RE. We decided the model should be able to aid in the evaluation of the potential impact policy decisions may have on the force structure of the AGR.

### **3.3 Assumptions**

In addition to identifying objectives of the model, assumptions of the model must also be explicitly identified. Each grade has given limitations on the first and last year an

individual can be accessed. In addition to a limit on accessions, there are also limitations on the scope of the model in terms of what year groups to include in the model.

The assumptions pertaining to the year limitations are summarized in Table 3.1. These values are based on discussion with AF/RE and military requirements dictating availability of individuals. The Minimum YOS (years of service) for Accession refers to the number of years an individual has prior to entering into the AGR. For example a 2<sup>nd</sup> Lieutenant can be accessed without having any years of experience. Likewise, a Lieutenant Colonel can be accessed into the AGR at the beginning of their 15<sup>th</sup> year of service; thus a minimum of 14 years of service is required. The Maximum YOS for Accession column refers to the last allowable year group that can be accessed into the AGR. The values of this assumption are based primarily on military requirements. The values for Major, Lieutenant Colonel, and Colonel are less than they could be based on military allotments but are limited due to modeling restrictions.

**Table 3.1: Assumptions pertaining to Accession and Modeling of Year Groups**

<b>Grade</b>	<b>Minimum YOS for Accession</b>	<b>Maximum YOS for Accession</b>	<b>Minimum YOS to be Modeled</b>	<b>Maximum YOS to be Modeled</b>
2Lt	0	1	1	2
1Lt	2	3	3	4
Captain	4	13	5	14
Major	10	18	11	20
Lieutenant Colonel	14	26	13	26
Colonel	18	30	16	30

The Minimum YOS to be Modeled refers to the number of years the individual has been in the AGR. For example, a 2<sup>nd</sup> Lieutenant can only be in his/her first or second year of AGR service; anything greater would indicate the individual would have been promoted to 1<sup>st</sup> Lieutenant. Likewise, a Lieutenant Colonel will only be modeled if he or

she has at least 13 years of commissioned service before entering into the AGR. This number is based on the first allowable opportunity to achieve the rank of Lieutenant Colonel. This number reflects the TIG requirements found in Figure 2.2.

The Maximum YOS to be Modeled column refers to the last allowable year a group can be modeled. The values of this assumption are based primarily on the most common career paths experienced by military officers. The values for Major, Lieutenant Colonel, and Colonel are less than they could be based on military allotments but are limited due to their perceived impact on the model past the years shown. For example, after the 19<sup>th</sup> year of service a Major that is not promoted will be considered as a retirement or some other form of separation. Lieutenant Colonels and Colonels who have not separated prior to their 26<sup>th</sup> and 30<sup>th</sup> year of commissioned service, respectively, are also considered a separation or retirement. The main reason for these three restrictions is to simplify the model. There are very few individuals that would still be in the system after the maximum years of their commissioned service, and those who are still in the AGR are not in a position to further their career path beyond the focus of this research.

### **3.4 Model Formulation**

A necessary step in the formulation of a Markov Chain model is defining the states of the system being modeled. A state in this model is defined by an officer's characteristics: total years of commissioned service, grade, and total years of AGR service. A variable in the model represents the number of individuals in a particular state. There will be a variable for every combination of grade (2<sup>nd</sup> Lieutenant to Colonel), years of commissioned service (1-30), and years of experience in the AGR (1-30). The final step in the formulation of the Markov Chain model is the identification

and implementation of the transition probabilities. The method used to find these values, which for the purpose of this model are assumed to be constants, is discussed later in this section. Section 3.4.1 presents the mathematical formulation for the model.

### 3.4.1 Mathematical Formulation

In order to present the formulation properly, a working definition of the variables and parameters are as follows:

Variables:

$X_{i,j,k}^t$  = The number of individuals in the  $i^{th}$  year of experience, in grade  $j$ , in the  $k^{th}$  year of experience in the AGR in year  $t$

$A_{i,j}^t$  = The number of individuals in the  $i^{th}$  year of experience, in grade  $j$ , being accessed into the AGR in year  $t$

$P_{i,j,k}^t$  = The number of individuals in the  $i^{th}$  year of experience, in grade  $j$ , in the  $k^{th}$  year of experience in the AGR in year  $t$  being promoted within the AGR in year  $t+1$

$NP_{i,j,k}^t$  = The number of individuals in the  $i^{th}$  year of experience, in grade  $j$ , in the  $k^{th}$  year of experience in the AGR in year  $t$  not being promoted within the AGR in year  $t+1$

$S_{i,j,k}^t$  = The number of individuals in the  $i^{th}$  year of experience, in grade  $j$ , in the  $k^{th}$  year of experience in the AGR in year  $t$  separating from the AGR in year  $t+1$

Parameters:

$\%p_{i,j,k}^t$  = Promotion Rate for individuals in the  $i^{th}$  year of experience, in grade  $j$ , in the  $k^{th}$  year of experience in the AGR in year  $t$

$\%s_{i,j,k}^t$  = Loss Rate for individuals in the  $i^{th}$  year of experience, in grade  $j$ , in the  $k^{th}$  year of experience in the AGR in year  $t$

The following ranges on the variable and parameter exist:

- $t \in \{0,1,\dots\}$  representing all ranges of time
- $i \in \{1,2,\dots,30\}$  representing years of service and is used to represent total experience
- $j \in \{1,2,\dots,6\}$  representing 2Lt,1Lt,...,Col
- $k \in \{1,2,\dots,30\}$  representing number of years of AGR experience

Equations (3.1) through (3.5) represent the states in the model. All accessions, individuals entering into the AGR from another part of the military or from a commissioning source, are treated by the model as entering into their 1<sup>st</sup> year of AGR service. Therefore, Accessions entering into the AGR have two distinct characteristics: Years of Commissioned Service and Grade. Equation (3.1) demonstrates the total number of people in the system in their  $i^{th}$  year of commissioned service in grade  $j$ , in their 1<sup>st</sup> year of AGR duty is equal to the accession flow as described above.

$$X_{i,j,1}^t = A_{i,j}^t \quad \forall \begin{matrix} t \in \{0,1,\dots\} \\ i \in \{1,2,\dots,30\} \\ j \in \{1,2,\dots,6\} \\ k \in \{1,2,\dots,30\} \end{matrix} \quad (3.1)$$

The behavior of the group of individuals not accessed in the system (i.e.  $k > 1$ ) categorized by  $X_{i,j,k}^t$  is represented with Equation (3.2). All individuals who are not accessed must be at least in their second year of AGR service. The total number of individuals in their  $i^{th}$  year of commissioned service, in grade  $j$ , in their  $k^{th}$  year of the AGR in year  $t$  equals the number of individuals being promoted from the  $j-1$  grade in year  $t-1$  and the number of individuals in grade  $j$  in year  $t-1$  not being promoted.

$$X_{i,j,k}^t = P_{i-1,j-1,k-1}^{t-1} + NP_{i-1,j,k-1}^t \quad \forall \begin{matrix} t \in \{0,1,\dots\} \\ i \in \{1,2,\dots,30\} \\ j \in \{1,2,\dots,6\} \\ k \in \{2,\dots,30\} \end{matrix} \quad (3.2)$$

The number of individuals separating at the end of year  $t$  in their  $i^{th}$  year of commissioned service, in grade  $j$ , and in their  $k^{th}$  year of AGR service depends on the total number of people in that state in year  $t$  and the separation parameter specific to that state. This is represented mathematically in Equation (3.3).

$$S_{i,j,k}^t = (\%s_{i,j,k})X_{i,j,k}^t \quad \forall \begin{matrix} t \in \{0,1,\dots\} \\ i \in \{1,2,\dots,30\} \\ j \in \{1,2,\dots,6\} \\ k \in \{1,2,\dots,30\} \end{matrix} \quad (3.3)$$

The number of individuals being promoted at the end of year  $t$  in their  $i^{th}$  year of commissioned service, in grade  $j$ , and in their  $k^{th}$  year of AGR service depends on the total number of people in that state in year  $t$ , the number of individuals separating at the end of year  $t$ , and the promotion parameter specific to that state. This is represented mathematically in Equation (3.4).

$$P_{i,j,k}^t = (\%p_{i,j,k})(X_{i,j,k}^t - S_{i,j,k}^t) \quad \forall \begin{matrix} t \in \{0,1,\dots\} \\ i \in \{1,2,\dots,30\} \\ j \in \{1,2,\dots,6\} \\ k \in \{1,2,\dots,30\} \end{matrix} \quad (3.4)$$

The number of individuals not being promoted at the end of year  $t$  in their  $i^{th}$  year of commissioned service, in grade  $j$ , and in their  $k^{th}$  year of AGR service also equals the total number of people in that state in year  $t$ , the number of individuals separating at the end of year  $t$ , and the promotion parameter specific to that state. This is represented mathematically in Equation (3.5).

$$NP_{i,j,k}^t = (1 - \%p_{i,j,k})(X_{i,j,k}^t - S_{i,j,k}^t) = X_{i,j,k}^t - S_{i,j,k}^t - P_{i,j,k}^t \quad \forall \begin{matrix} t \in \{0,1,\dots\} \\ i \in \{1,2,\dots,30\} \\ j \in \{1,2,\dots,6\} \\ k \in \{1,2,\dots,30\} \end{matrix} \quad (3.5)$$

The two parameters in the model,  $\%s_{i,j,k}^t$  and  $\%p_{i,j,k}^t$  are point estimates based on historical data.

### 3.4.2 Constraints

The only constraints in the model represent the Unit Manpower Document (UMD) requirements. These requirements mandate the number of positions that a unit is allowed to fill. The requirements are given according to grade and are specific to a given unit. The AGR's UMD requirements by grade are incorporated in the model according to Equation (3.6).

$$\sum_i \sum_k X_{i,j,k}^t = UMD_j^t \quad \forall j,t \quad (3.6)$$

The difficulty caused by the equality constraint in Equation (3.6) is discussed in Chapter 4, Section 4.1. Additional constraints, (e.g. not allowing an individual to become a captain until his or her fifth year of service) are allowable and simple to add to the model.

### 3.4.3 Objectives

In this study, three objective functions are evaluated with respect to the model. Each objective function is evaluated separately to represent the resulting force structure based on the policy captured by the objective. The optimization of the different objective functions provides insight in evaluating the effect management policy can have on force structure for a given year  $t$ .

The first objective function minimizes the total number of accessions into the AGR over all years of commissioned service and all grades. This minimization is illustrated in Equation (3.7). The goal of this objective is to minimize the number of new individuals brought into the AGR. By minimizing this number, the AGR is forced to access individuals earlier in their careers and fill their manpower requirements from

within. This will allow for longer careers to be experienced by the individuals within the organization.

$$\text{Minimize } \sum_j \sum_i A_{i,j}^t \quad (3.7)$$

The second objective function is very similar to first in that it is minimizing accession. The difference is that the second objective function penalizes the accessing of individuals in the higher grades. The goal is to force accession to be made at the Captain and Major grade levels instead of at the Lieutenant Colonel and Colonel grade levels.

Equation 3.8 is:

$$\text{Minimize } \sum_j \sum_i W_j * A_{i,j}^t \quad (3.8)$$

Where  $W_j$  is the penalty associated with accessing an individual from grade  $j$ .

The third objective function seeks to maximize the total length of served time in the AGR. This is accomplished by multiplying the number of individuals in a state by their current number of years in the AGR and sum all those across all the grades and commissioned years of service. This is represented in Equation (3.9).

$$\text{Maximize } \frac{\sum_k \sum_j \sum_i k * X_{i,j,k}^t}{\sum_k \sum_j \sum_i X_{i,j,k}^t} \quad (3.9)$$

The goal of this objective is to force the model to maximize the average number of years of AGR experience, which will also maximize the numbers of years in an individual's career within the AGR.

### 3.5 Model Example

This section illustrates the model on a small sample problem. The parameters of the model are as follows: capacity for two grades and five years of total service. Figure 3.2 is a sample of the model where an arrow indicates movement through the model, and each group of squares represent a state.

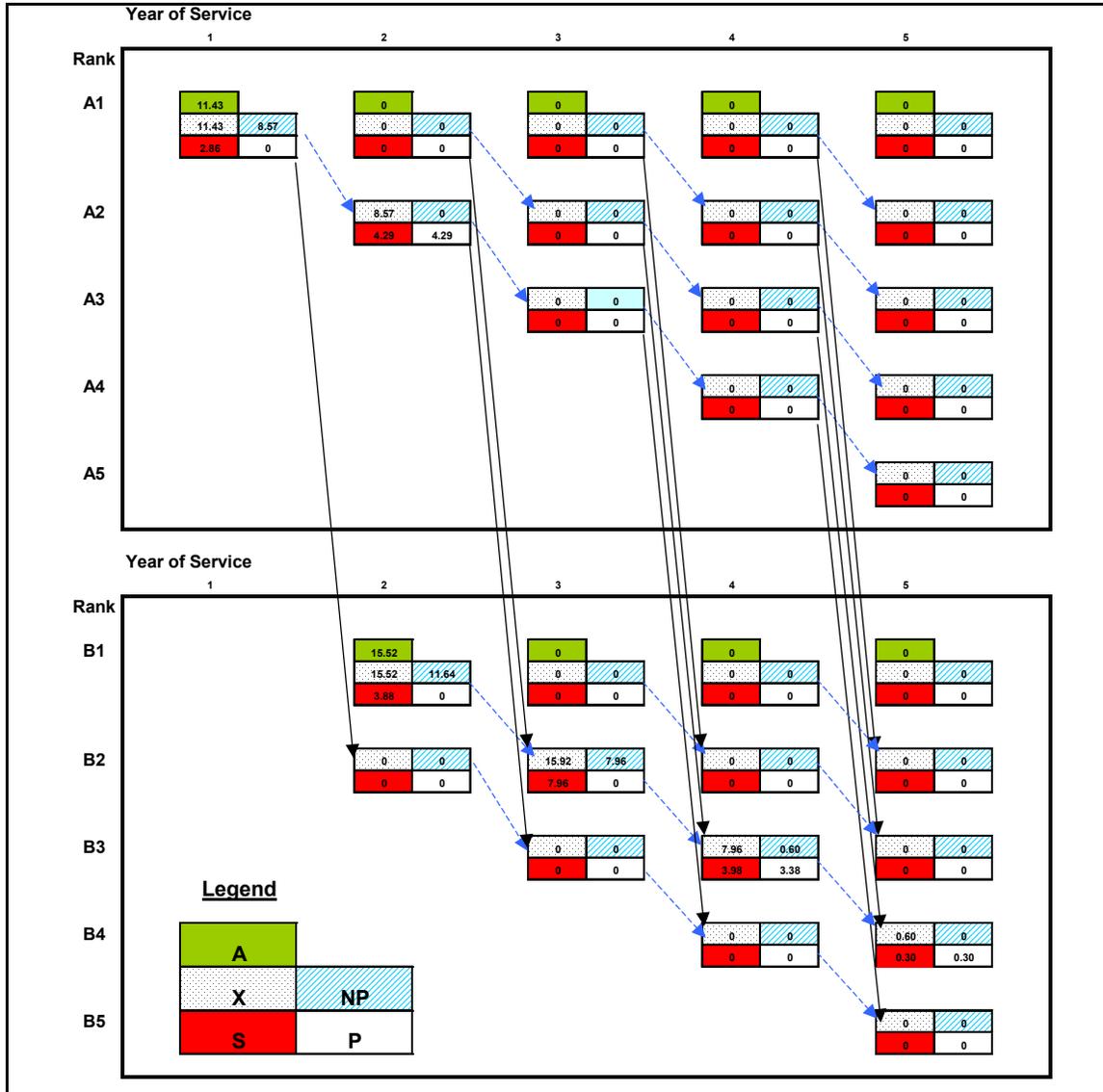


Figure 3.2: Sample Manpower Planning Model

The solid and dashed arrows represent  $P_{i-1,j,k-1}^t$  and  $NP_{i-1,j,k-1}^t$  in Equation (3.5), respectively. Each of the boxes represents a variable specific to that state. All states have at least four boxes, one representing each of the following: total number of individuals (X), total number of individuals being promoted in the next year (P), total number of individuals not being promoted in the next year (NP), and the total number of people separating from the AGR in the next year. The states with five boxes are accession states with the fifth boxes representing the total number of individuals accessed at the beginning of the year. As shown in Figure 3.2, the only opportunity for accession is to access into the first year of the AGR.

This particular model’s objective is to minimize total accessions. The output from this model identifies the number of individuals by grade and year of service to access to meet the UMD requirements of 20 individual in grade A and 40 individuals in grade B. Table 3.2 displays these results.

**Table 3.2: Sample Model Output**

Grade	Years of Commissioned Service				
	1	2	3	4	5
A	11.4	0	0	0	0
B	0	15.5	0	0	0

Note that the values output from the model are not integers. For the purpose of our modeling, the results are going to be representative of a continuous policy. This assumption allows for the accessions that are non-integer. The result can be achieved in the following manner: on average over the course of several years, 26.9 individuals should be accessed. Of these 26.9 individuals, 11.4 of them should be accessed into the A grade in their first year of service while 15.5 people should be accessed into grade B in

their second year of total service. Other types of output and statistics for the model are discussed in Chapter Four.

### 3.6 Model Implementation

The model developed in this thesis is not a stand-alone model; it should be an integral part of the AGR management process. Figure 3.3 illustrates one process in which the model can be used in developing policy to help manage personnel within the AGR. As with any other model, it is very dependent on the inputs. If the promotion and separation rates are not valid for future years, then the outputs from the model may not provide accurate evaluation on the impact of new policy. Used properly, the model does provide an objective way to quantify the affect policy has on the future force structures of the AGR.

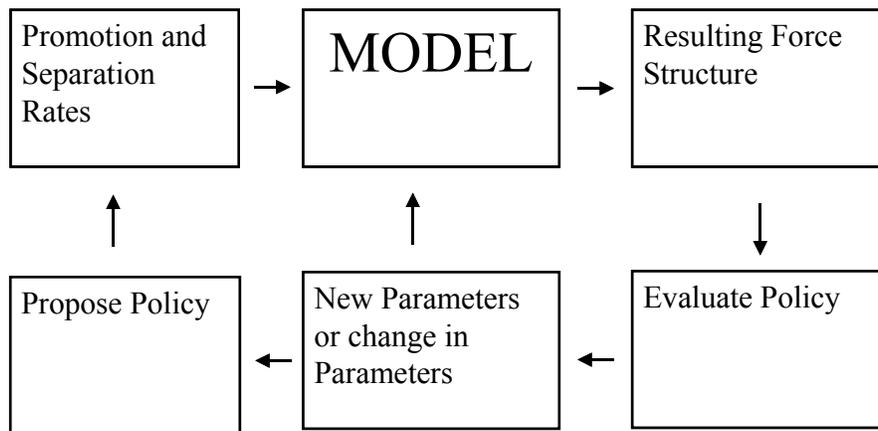


Figure 3.3: Model Implementation in the Management of the AGR

### 3.7 Summary

The model developed in this thesis is a tool that can be used to explore many facets of an organization's force structure. The purpose of the model is to show how a career path in the AGR can be achieved. By implementing three different objective

functions, the model can be driven to achieve this goal. The methodology behind the model is simple and few assumptions were necessary in its development.

Chapter Four provides and interprets results from the model.

## 4. Analysis of Results

### 4.1 Chapter Overview

This chapter presents results and analysis from several runs of the model. Several scenarios are presented to illustrate the impact changes in management policy may have on the resulting force structure. These scenarios include meeting current UMD requirements and allowing for different levels of UMD requirement relaxations.

### 4.2 Alteration of the Model

In the implementation of the model with current promotion and separation rates as inputs, we found only one solution existed that matched the requirements exactly. The stringent requirements did not allow for overages or shortages. Regardless of the objective, only one feasible solution exists. Although it is desirable for the UMD requirements to match the assigned personnel, the model needs to allow for deviations. This deviation from the requirements provides insight about the impact policy, which affects promotion and separation rates, has on the force structure. If an infeasible solution or an undesirable force structure is the outcome of a proposed policy, then it can be concluded the policy is not desirable.

To allow for deviation from the UMD requirements, a controlled variation ( $\lambda_j$ ) is allowed in the right hand side of the constraints. The limit on the deviation from the UMD requirements is plus or minus ten. This method changed the equality constraint into two inequality constraints. The implementation of the variation is mathematically represented in Equations (4.1) and (4.2).

$$\sum_i \sum_k X_{i,j,k}^t \leq UMD_j + \lambda_j \quad \forall j,t \quad (4.1)$$

$$\sum_i \sum_k X_{i,j,k}^t \geq UMD_j - \lambda_j \quad \forall j,t \quad (4.2)$$

To minimize the variation, a penalty is assessed in the objective function. This penalty,  $M_j$ , is represented in Equations (4.3) and (4.4) for the two accession based objective functions.

$$\text{Minimize } \sum_j \sum_i A_{i,j}^t + \sum_j M_j * \lambda_j \quad (4.3)$$

$$\text{Minimize } \sum_j \sum_i W_j * A_{i,j}^t + \sum_j M_j * \lambda_j \quad (4.4)$$

For the maximization of time in the AGR objective function, the numerator is amended by subtracting a large multiplicative of the variation.

$$\text{Maximize } \frac{\sum_k \sum_j \sum_i k * X_{i,j,k}^t - \sum_j M_j * \lambda_j}{\sum_k \sum_j \sum_i X_{i,j,k}^t} \quad (4.5)$$

### 4.3 Scenario Analysis

The goal of the AGR is to develop a career path for individuals in the AGR. Under current UMD requirements, the longest career possible before becoming retirement eligible in the AGR is 16 years. This is for a Captain entering the AGR with four years of service. Only a few officers can have such a career because there are so few AGR Captain requirements. The next longest and substantially more available career length in the AGR is 11 years; a Major entering the AGR with nine years of service.

To increase the availability of longer careers, several constraints are introduced to the model to represent possible changes in policy. These constraints are driven by new policy or stem from new apportionment of the UMD Requirements. For example, if the UMD requirements are relaxed to allow Captains to fill a certain percentage of Major positions, then there is more opportunity for an officer to enter the AGR as a Captain. Equations (4.6), (4.7), (4.8), and (4.9) mathematically represent how the constraints allow a portion,  $0 \leq D \leq 1$ , of the Major jobs to be filled by Captains. Equations (4.6) and (4.7) illustrate the decrease in the number of Major jobs and also allow for the deviation.

$$\sum_i \sum_k X'_{i,4,k} \geq UMD_4 - (D * UMD_4) - \lambda_4 \quad (4.6)$$

$$\sum_i \sum_k X'_{i,4,k} \leq UMD_4 - (D * UMD_4) + \lambda_4 \quad (4.7)$$

Equations (4.8) and (4.9) illustrate the increase in the number of Captain jobs. They also allow for the deviation from UMD requirements.

$$\sum_i \sum_k X'_{i,3,k} \geq UMD_3 + (D * UMD_4) - \lambda_4 \quad (4.8)$$

$$\sum_i \sum_k X'_{i,3,k} \leq UMD_3 + (D * UMD_4) + \lambda_4 \quad (4.9)$$

This technique, coupled with the objective of minimizing the average number of years in the AGR, allows reapportionment to be quantified. Results of this analysis are provided later in this chapter.

#### 4.4 Scenario Results

The output from the model using the current policies, promotion rates, separation rates, and the alterations discussed in Sections 4.2 and 4.3 produced a force structure that meets the UMD requirements exactly. Multiple scenarios were modeled with random

separation rates based on historical values. Figures 4.1 and 4.2 display the output from a modeled scenario. This output is broken into two categories: a Path through the AGR chart and a Personnel By Grade chart.

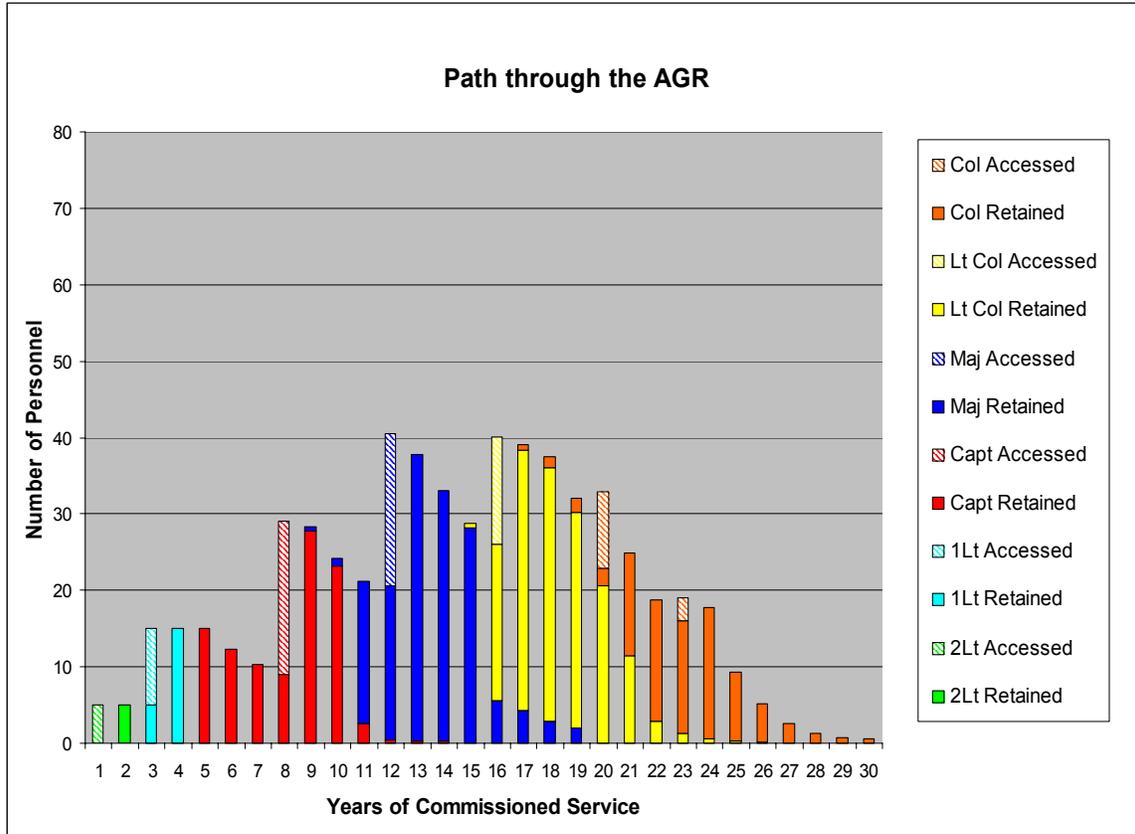
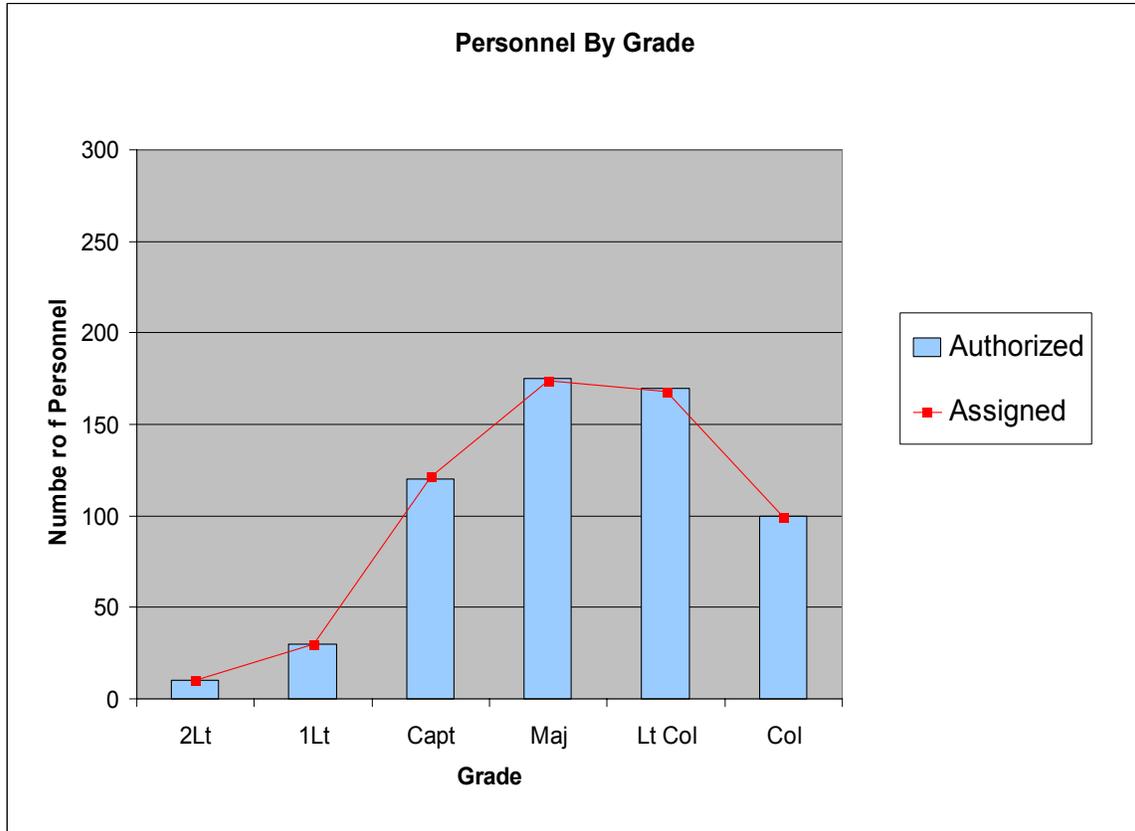


Figure 4.1: The Path through the AGR

The Path through the AGR chart provides a visual representation of the accessions, retentions, and promotions within the AGR. Figure 4.2, The Personnel Grade Chart, provides the decision maker with a simple display for identifying shortages or overages.



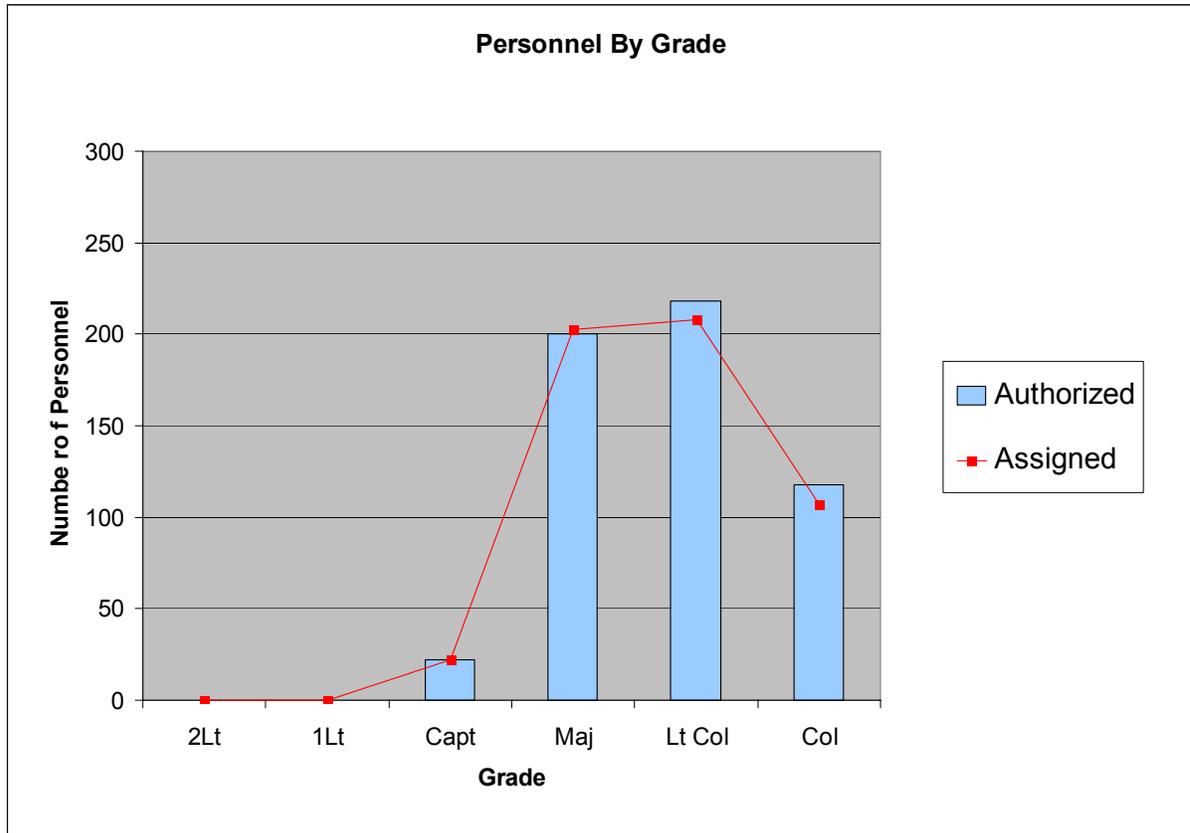
**Figure 4.2: Personnel By Grade**

These two graphs along with the values of the objective functions serve as the main measure of performance for the outcomes of the model. These outputs are used in the evaluation of the next nine scenarios.

#### **4.4.1 Minimizing Accessions**

The objective of this model is to minimize the total number of accessions into the AGR. This model was run under three different levels of reapportionment with respect to job requirement scenarios. The results from the model using this objective function provide valuable information pertaining to the feasibility of the requirements. Under scenario one, no grade mismatches are allowed (e.g. Captains are not allowed to serve in

Major billets). All UMD requirements were met within the allowed deviation parameter  $\lambda_j$ . This is shown in Figure 4.3.



**Figure 4.3: Minimize Accessions Personnel Chart (D=0)**

Figure 4.4 illustrates the ideal accession flow under this policy. Individuals are accessed at the first opportunity for all grades. This force structure allows 79 accessions per year broken up into the grades shown in Table 4.1.

**Table 4.1: Accessions by Grade by YOS**

Grade	Lt	Capt	Maj	LtCol	Col
Accessions	0	8	43	17	11
YOS of Accessions	N/A	8	12	16	20

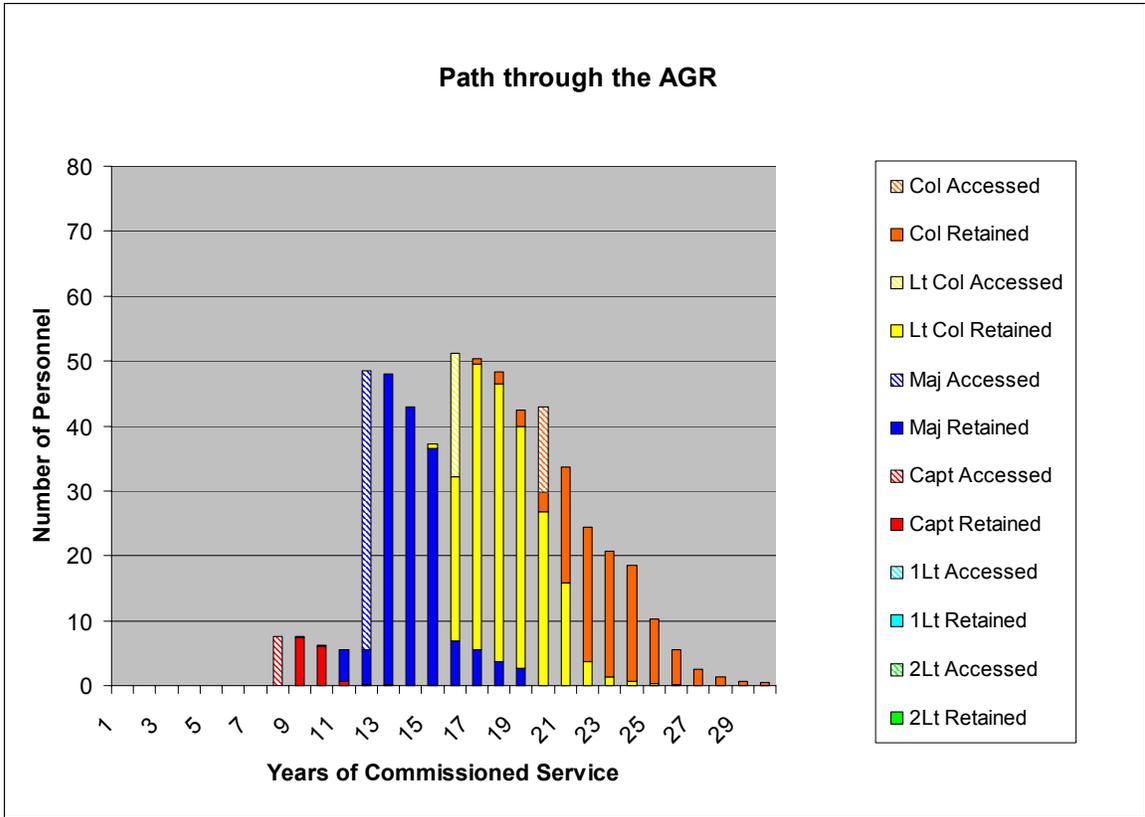


Figure 4.4: Minimize Accessions Personnel Path Chart (D=0)

The average number of years of AGR experience of the individuals for this scenario is 4.77 years.

A second scenario for the minimization of accessions objective is accomplished where 25 percent of the requirements in a specific grade can be filled by an individual one grade lower (e.g. 25% of Major billets may be filled Captains). This scenario produced slightly different results. Figures 4.5 and 4.6 display the results of this scenario.

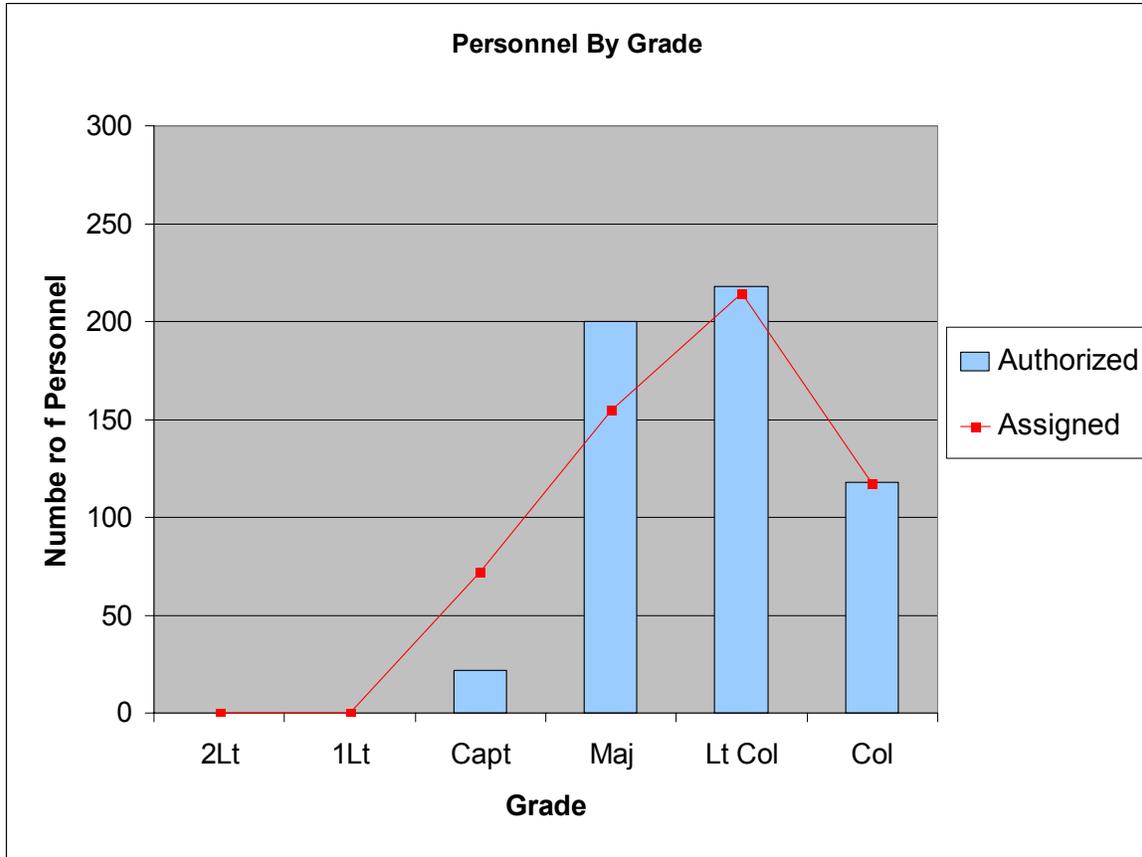


Figure 4.5: Minimize Accessions Personnel Chart (D=0.25)

By allowing grade mismatches, the number of personnel assigned does not equal the UMD requirements by grade. Figure 4.5 illustrates an increase in the number of Captains when compared to the previous scenario. This increase in Captains is reflected in a large decrease in Majors and a slight decrease in Lieutenant Colonels. The differences from the UMD requirements indicate that about 50 Captains are assigned to Major's billets. Figure 4.6 shows the results of this change to the steady-state force structure. This scenario results in a decrease of total accessions from 79 in the first scenario to 74 and average number of years of experience increased to 5.01 years.

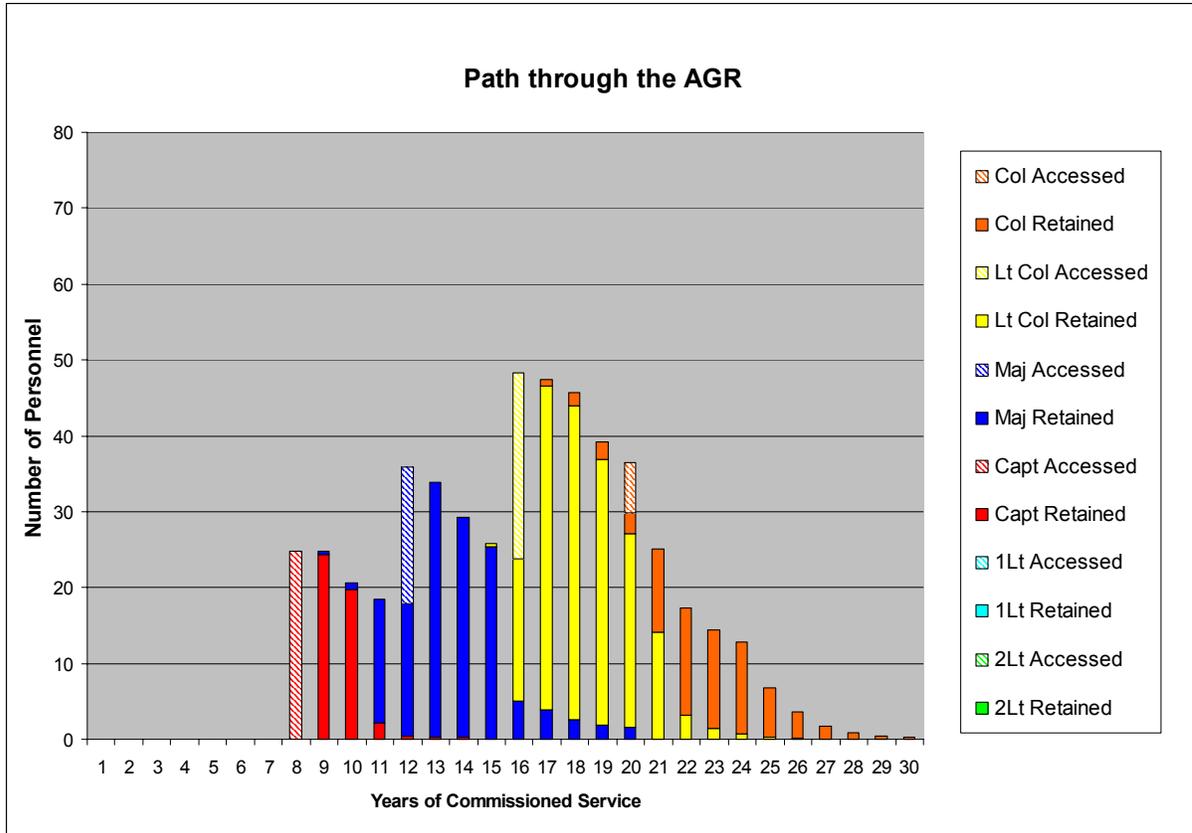


Figure 4.6: Minimize Accessions Personnel Path Chart (D=0.25)

A third scenario for the minimization of accessions objective is accomplished where 50% of all positions in grades Major through Colonel are allowed to be filled by an individual one grade lower. Figures 4.7 and 4.8 display the results of this scenario.

Figure 4.7 illustrates an even larger increase in the number of Captains when compared to the previous scenarios. As in scenario two, this increase is due to the decrease in Majors and Lieutenant Colonels in the organization. Figure 4.8 reflects this change in the steady-state force structure.

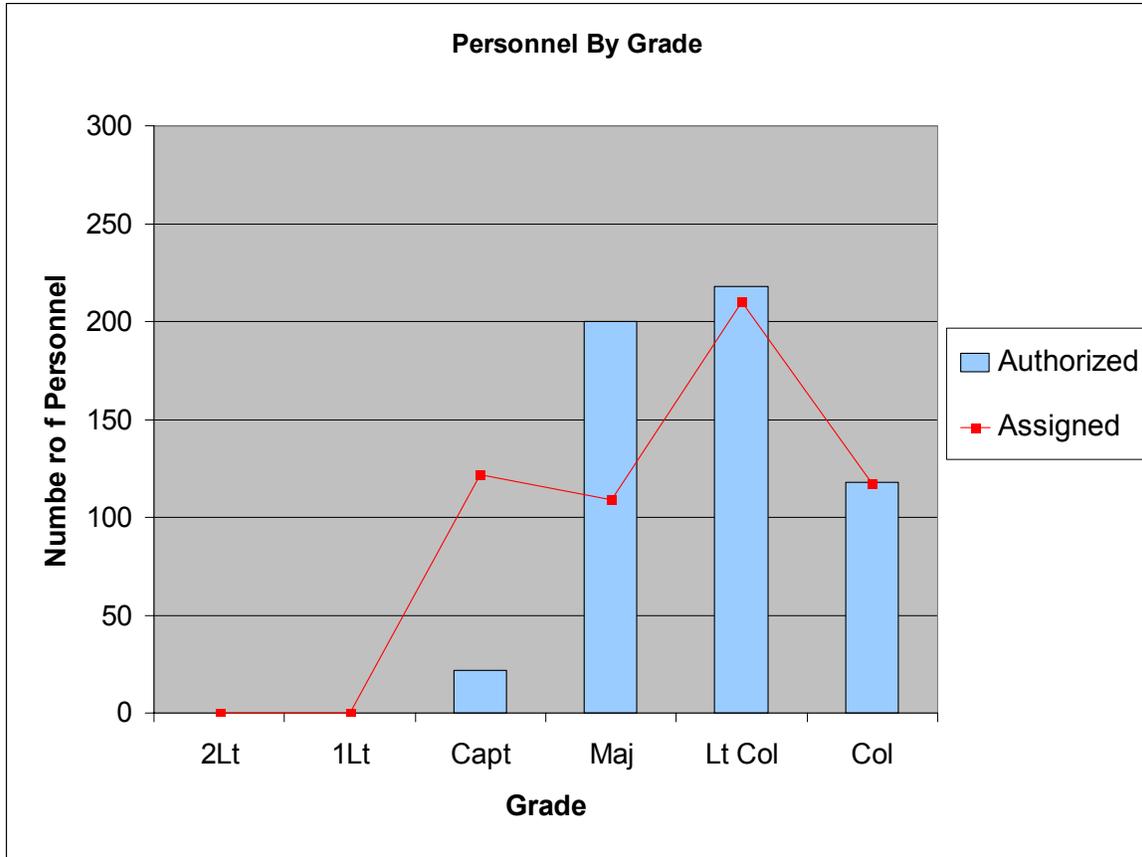


Figure 4.7: Minimize Accessions Personnel Chart (D=0.50)

The resulting average number of years of AGR experience rose to over 5.11 years by accessing only 72 individuals. Despite having a higher average numbers of years of experience in the AGR, the third model's output identifies a policy that accesses Lieutenant Colonels very late in their careers. The ability to identify the increase in the average number of years in the AGR gives the decision maker the ability to identify how beneficial accessing an individual so late in their career can be. In this situation the decision maker may choose against the policy of the third scenario and choose the policy implemented in the second scenario.

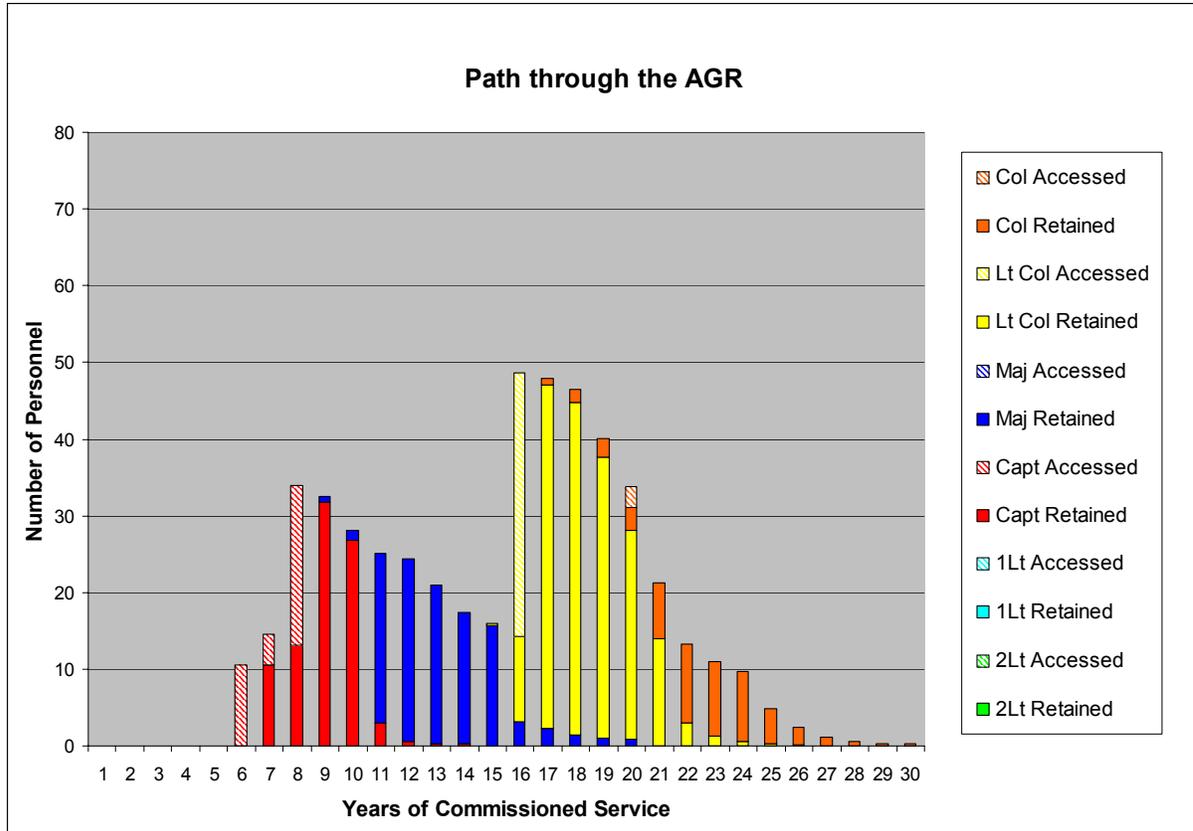


Figure 4.8: Minimize Accessions Personnel Path Chart (D=0.50)

The three results from the scenarios using the minimization of accession objective function give the decision maker insight into the types of implementation and benefit that this model can provide. The most glaring result for these scenarios is that in order to increase the career opportunities in the AGR, UMD requirements need to more closely reflect the assignments in Figure 4.7.

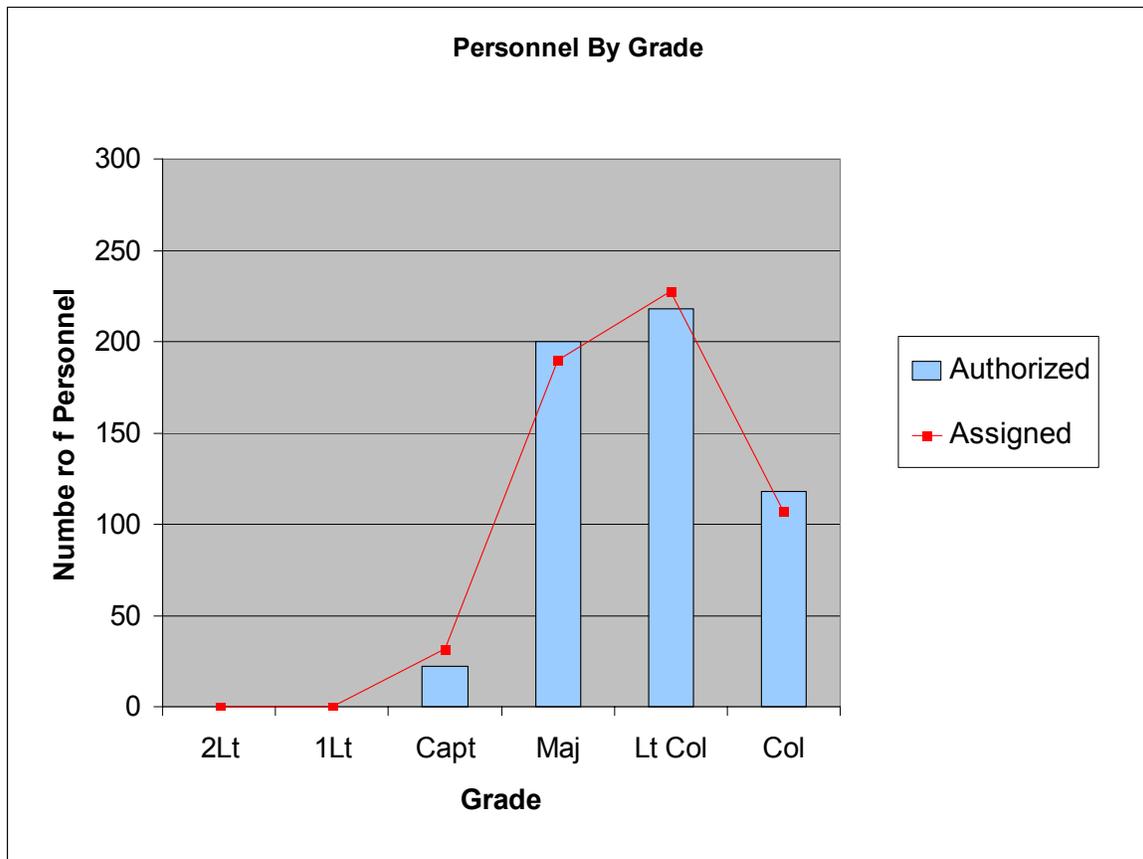
#### 4.4.2 Minimizing Weighted Accessions

The objective of the second three scenarios is to minimize the total number of late accessions into the AGR. To do this, the weighting scheme found in Table 4.2 is used.

**Table 4.2: Weighting Scheme for Scenarios 4,5,6**

Grade	Lt	Capt	Maj	LtCol	Col
Weight	0	1	10	1000	1000

This model was also run under the three different levels of adjustment in UMD requirements with respect to the three scenarios. Again, no grade mismatches are allowed in the first scenario. The deviations for the UMD requirements shown in Figure 4.9 indicate that  $\lambda_j$  was maximized at ten allowing for the most deviation possible on both extremes.



**Figure 4.9: Minimization of Weighted Accession Personnel Chart (D=0)**

Figure 4.10 illustrates the ideal accession policy for this scenario. As seen in Figure 4.10 the highest grade being accessed is Lieutenant Colonels. In addition, accessions are not

being made as early in their respective grades, but this type of force structure could be implemented if it is desirable to the decision maker.

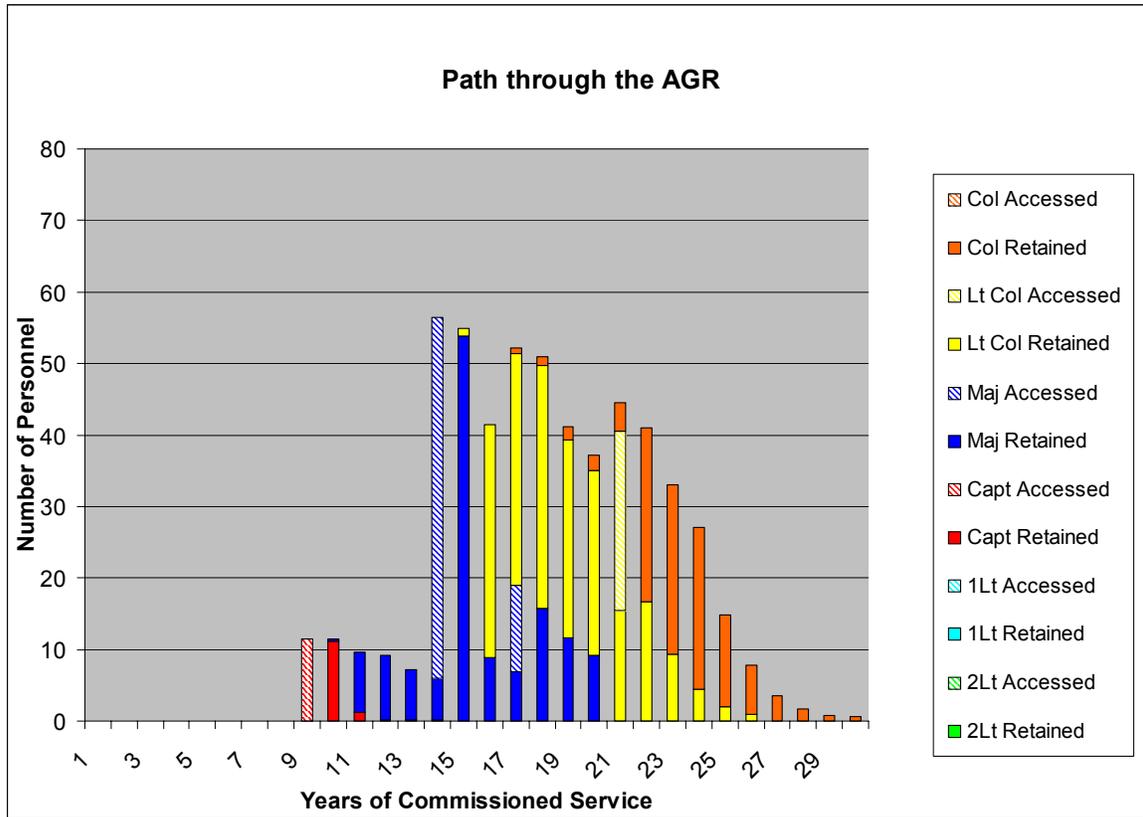


Figure 4.10: Minimization of Weighted Accession Personnel Path Chart (D=0)

The average number of years of AGR experience of the individuals in the AGR under this scenario is 4.22 years with 99 accessions distributed only amongst Captain, Major and Lieutenant Colonels.

Figures 4.11 and 4.12 display the results from the second scenario of the minimization of weighted accessions objective represented in Equation (4.4). The increase in the number of Captains in the organization is again due to the decrease in the number of Major and Lieutenant Colonels.

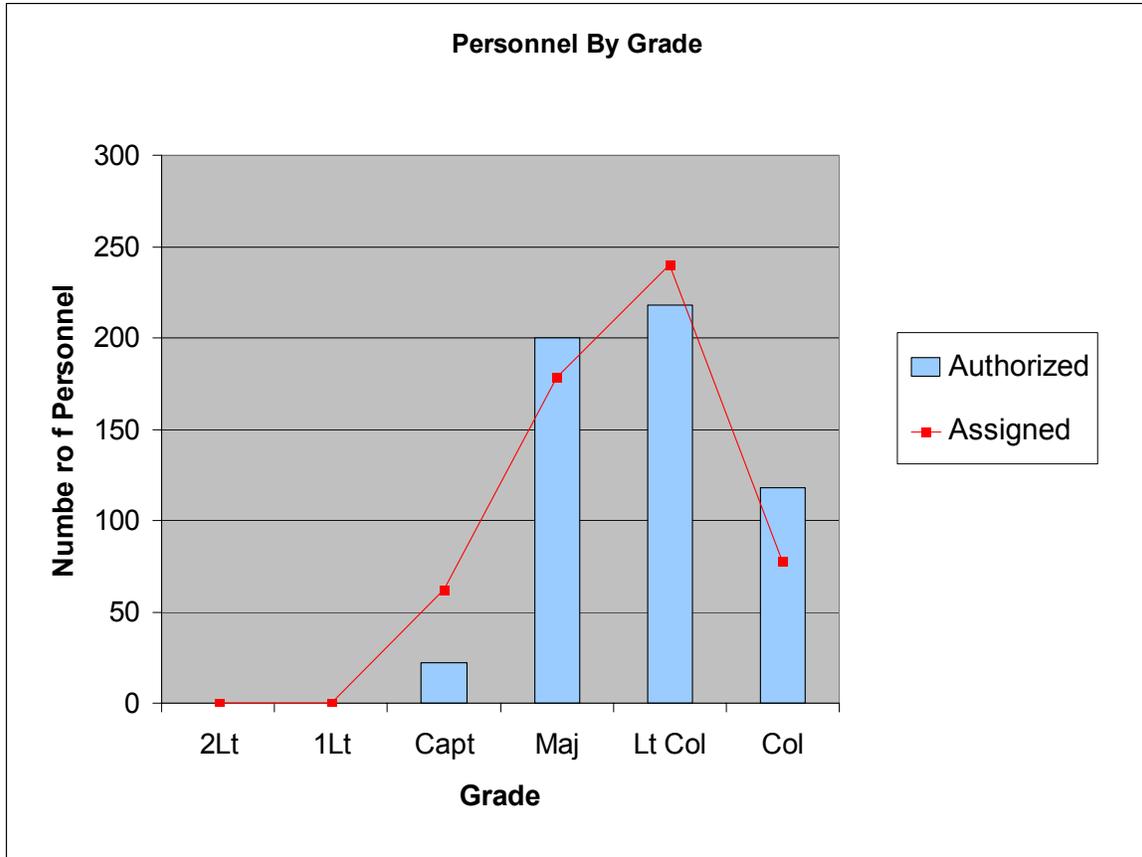
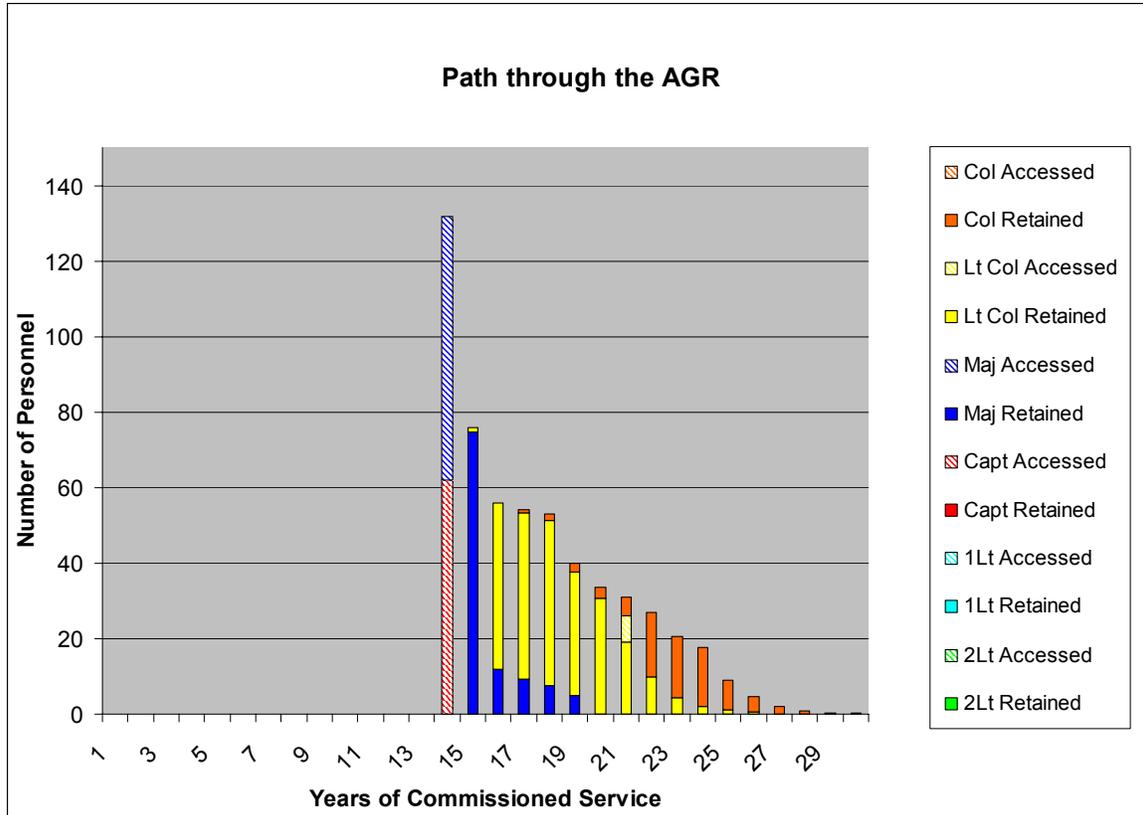


Figure 4.11: Minimization of Weighted Accession Personnel Chart (D=0.25)

Figure 4.12 identifies that individuals are accessed at different times in their respective grades. For example, the accession of Captains happens in the year that they will be in the zone for promotion to Major as opposed to earlier in their career as seen in the first three scenarios. This result is not practical and other policy options should be employed.

The average number of years of AGR experience for this scenario decreased to 4.10 years and there were 138 accessions.



**Figure 4.12: Minimization of Weighted Accession Personnel Path Chart (D=0.25)**

Figures 4.13 and 4.14 are the results from the third scenario of the minimization of late accessions. The large increase in Captains in this scenario is due not only to the decrease in the number of Majors and Lieutenant Colonels but also a decrease in the number of Colonels as well.

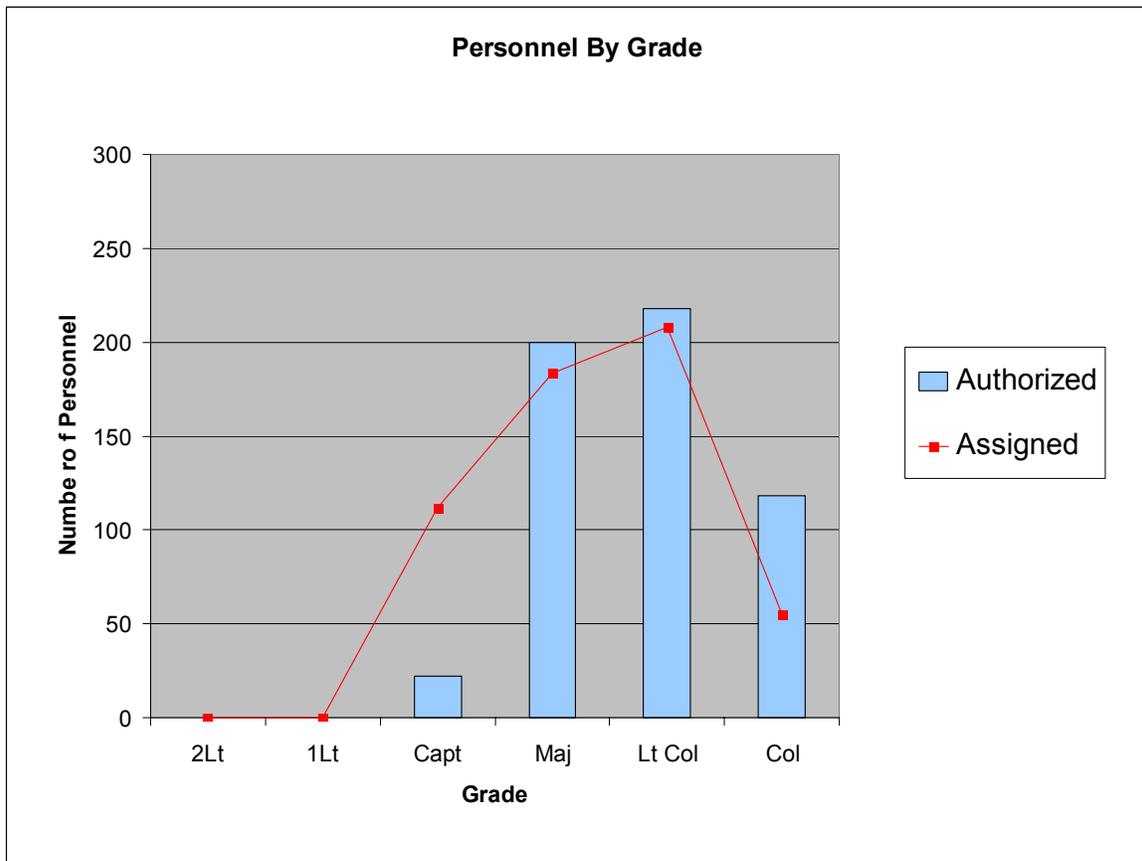


Figure 4.13: Minimization of Weighted Accession Personnel Chart (D=0.50)

Figure 4.14 displays the large number of Captain accessions in their 12<sup>th</sup> year of service, which provides for a very stable force structure. One of the most beneficial aspects to this force structures is that all the Colonels in the AGR were also Lieutenant Colonels in the AGR. This scenario produces a slight increase in the average number of years of AGR experience from 4.10 years to 4.29 years. In addition, the total number of accessions decreased to 104.

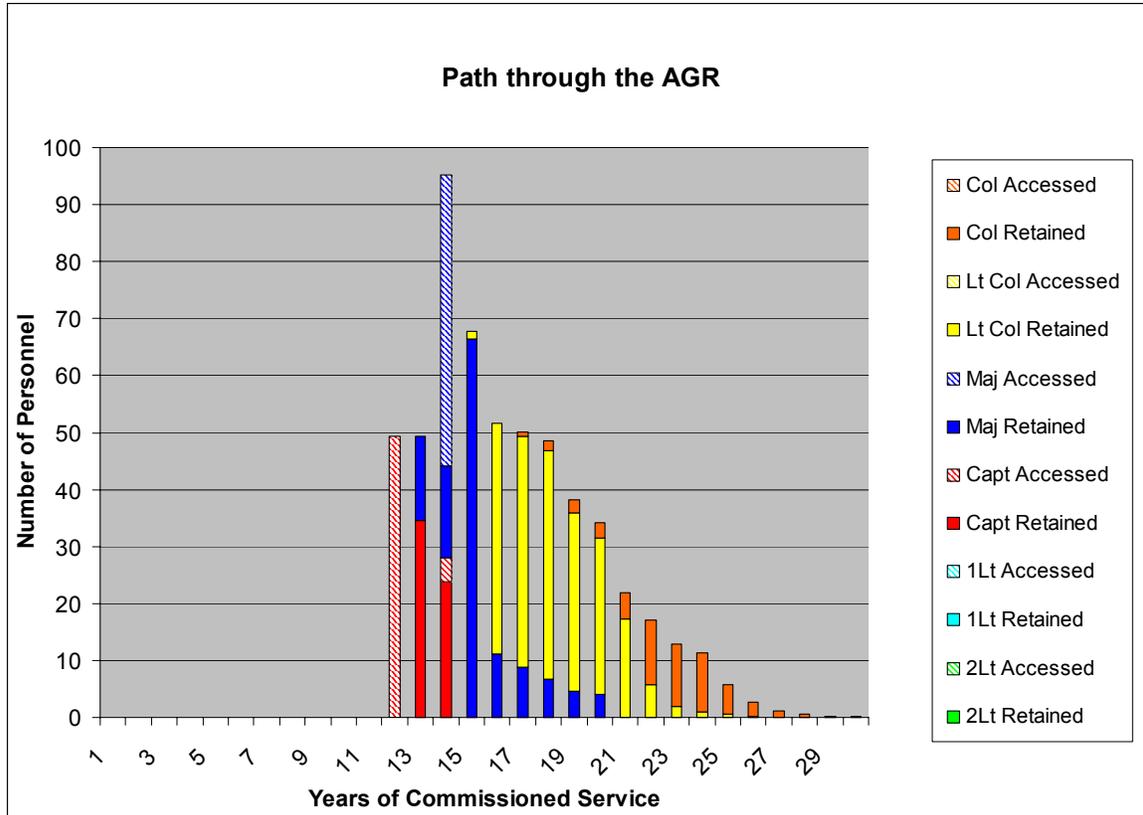
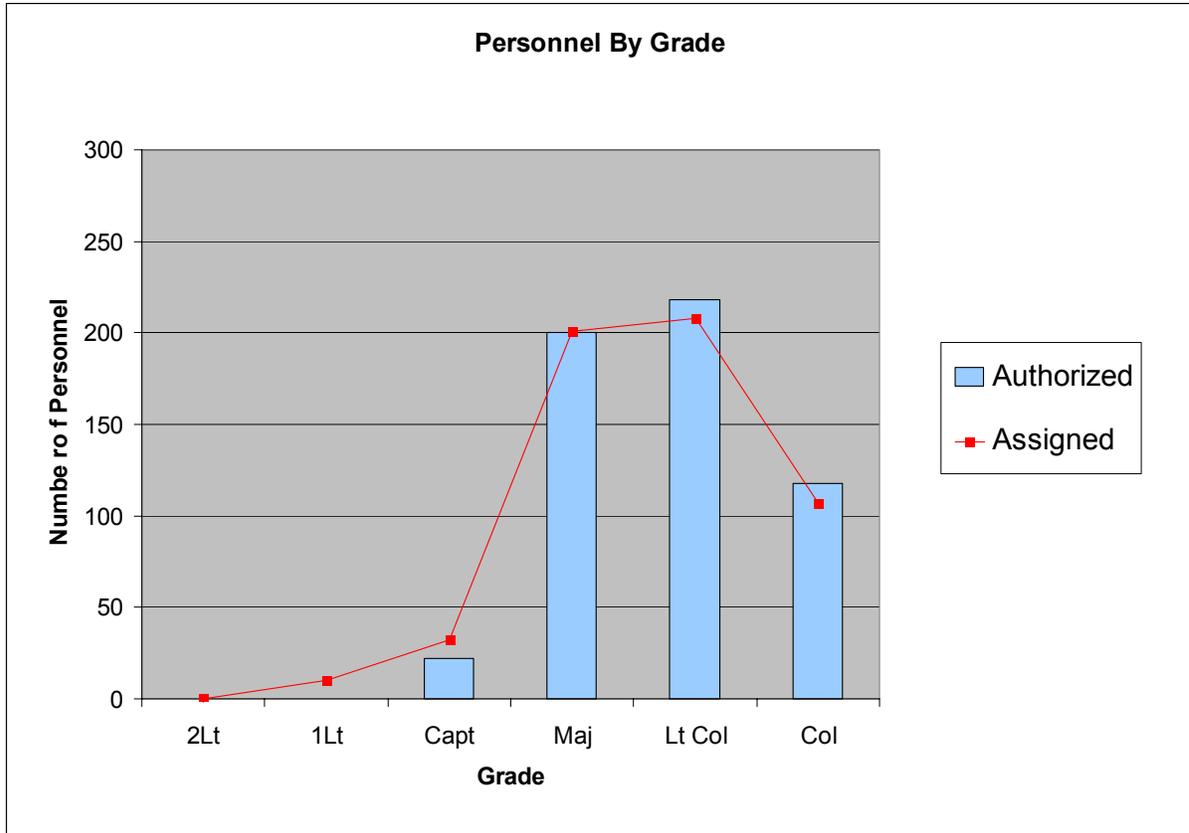


Figure 4.14: Minimization of Weighted Accession Personnel Path Chart (D=0.50)

#### 4.4.3 Maximizing Average Number of Years in the AGR

The objective of the last three scenarios is to maximize the average number of years an individual has in the AGR. The results from the first scenario using this objective function provide valuable information pertaining to the role 1<sup>st</sup> Lieutenants can have with in the AGR. The results of this scenario maximize the amount of accessions from the 1<sup>st</sup> Lieutenant grade within the allowable deviation of  $\lambda$ .



**Figure 4.15: Maximize Average Number of Years Personnel Chart (D=0)**

Figures 4.15 and 4.16 illustrate the accession of 1<sup>st</sup> Lieutenants under this policy. The average number of years of AGR experience of the individuals in the AGR under this scenario is 4.88 years and the total number of accessions is 81. Both these measures are the best values (highest average number of years in the AGR and lowest number of accessions) of all three objective function values under the first scenario policies.

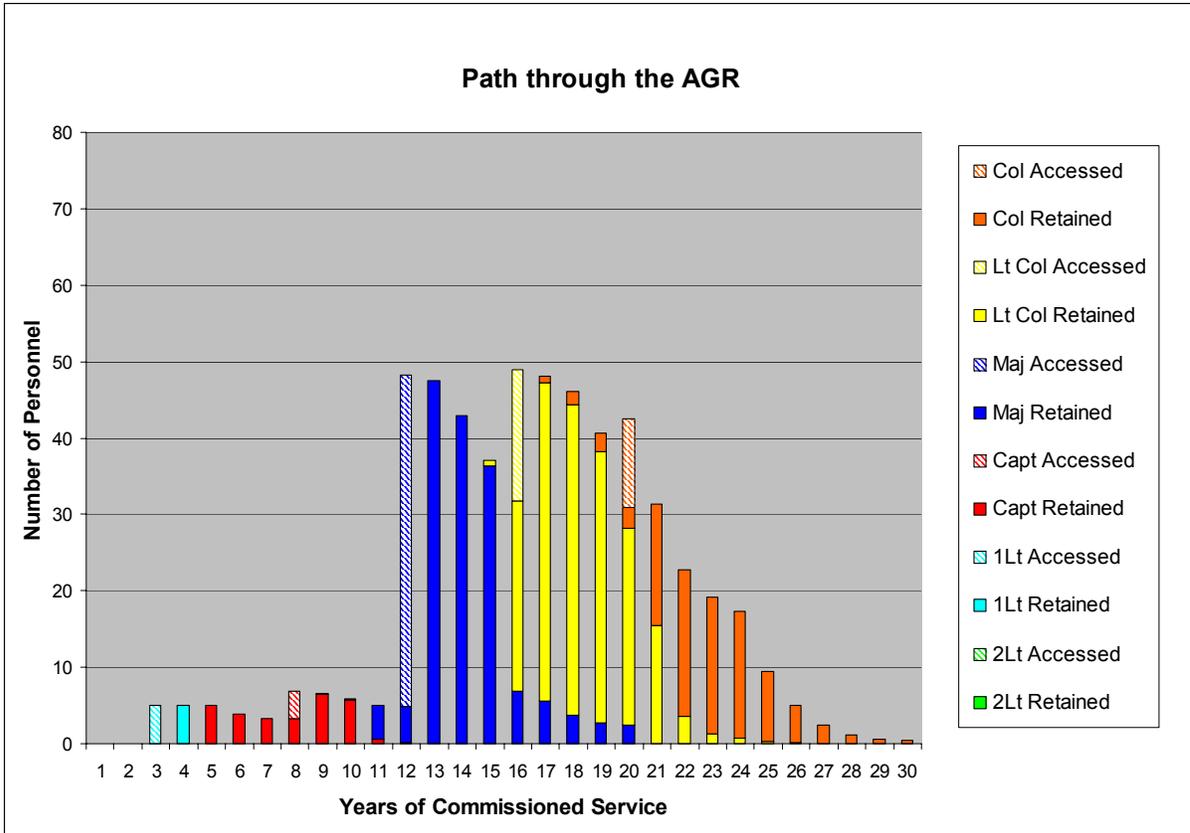


Figure 4.16: Maximize Average Number of Years Personnel Path Chart (D=0)

Figures 4.17 and 4.18 display the results from the second scenario of the minimization of weighted accession model. This scenario produced very similar results to the first scenario. All grade levels from 1<sup>st</sup> Lieutenant through Lieutenant Colonels are allowed to fill positions one grade above their own.

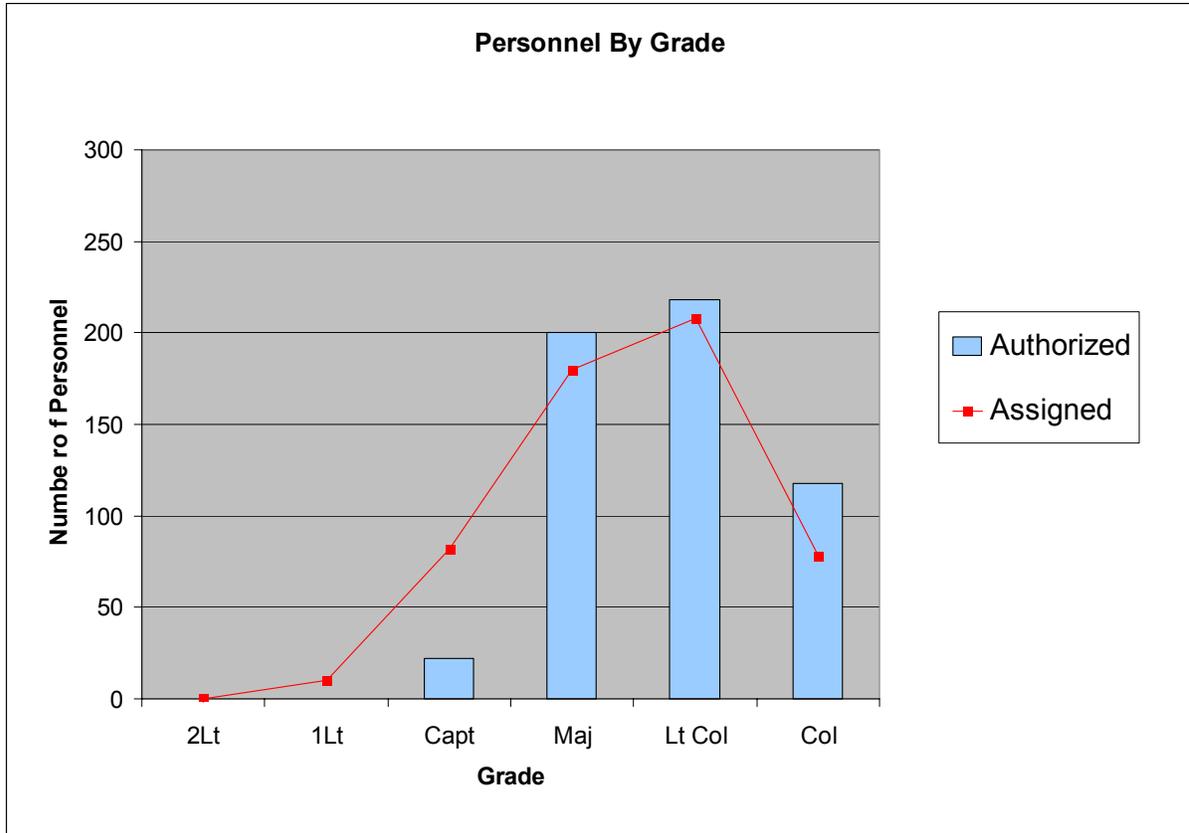
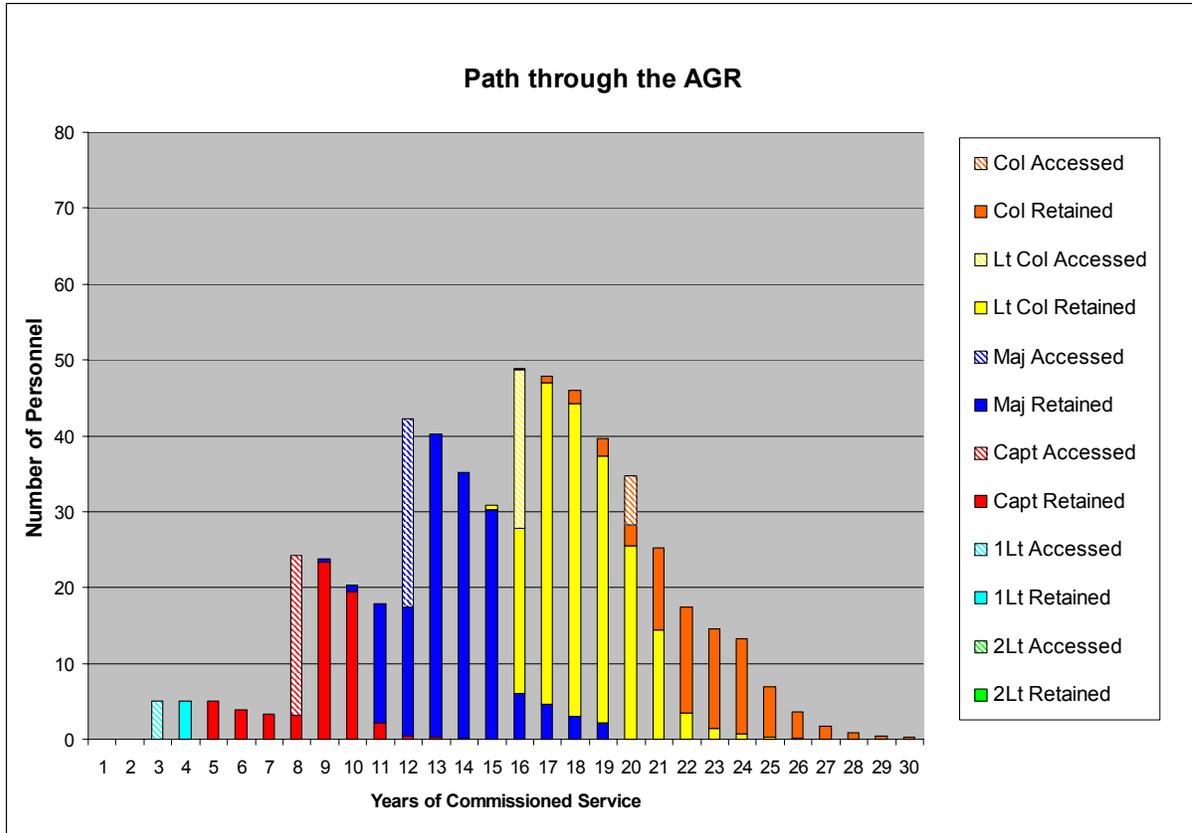


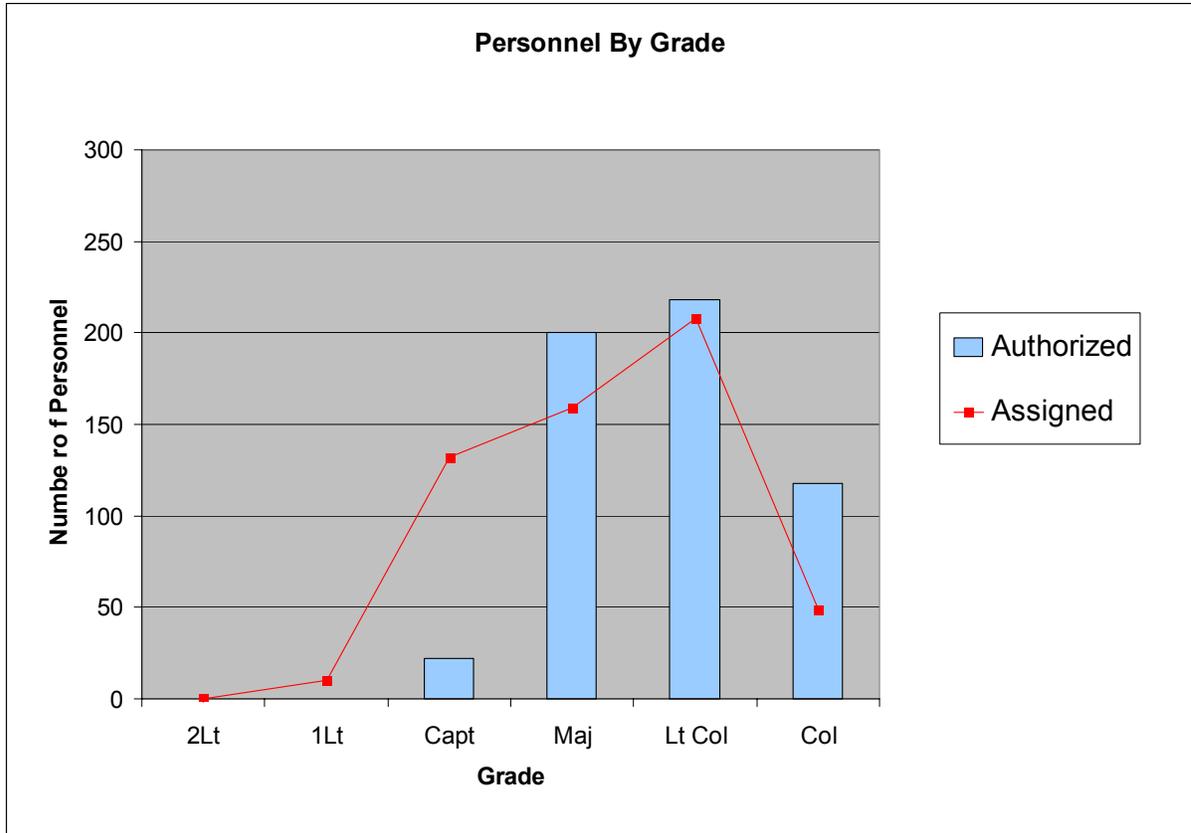
Figure 4.17: Maximize Average Number of Years Personnel Chart (D=0.25)

Figure 4.18 reflects the impact of utilizing lower grades in the filling of the UMD position requirements. The force structure is not as heavily centered on Lieutenant Colonels but rather centers around Majors. The resulting force structure allows for a steady advancement through all levels within the AGR. In addition to the more balanced force structure layout, the average number of years of experience was increased to 5.16 years and the total accession is 79 individuals distributed among all grades except 2<sup>nd</sup> Lieutenants.



**Figure 4.18: Maximize Average Number of Years Personnel Path Chart (D=0.25)**

Figures 4.19 and 4.20 display the results from the third scenario allowing mismatches of 50% while maximizing average number of years in the AGR. This scenario provides the best results of all nine scenarios with respect to the average number of years in the AGR. This model accesses a very large number of 1<sup>st</sup> Lieutenants and Captains while taking full advantage of the ability to mismatch positions at all levels within the organization.



**Figure 4.19: Maximize Average Number of Years Personnel Chart (D=0.50)**

Figure 4.20 shows the years of service distribution of this proposed policy. Although only a slight increase, the resulting average number of years of AGR experience is the highest of all the scenarios at 5.44 years. With 76 individuals, this scenario produces the second lowest number of accessions among all nine scenarios.

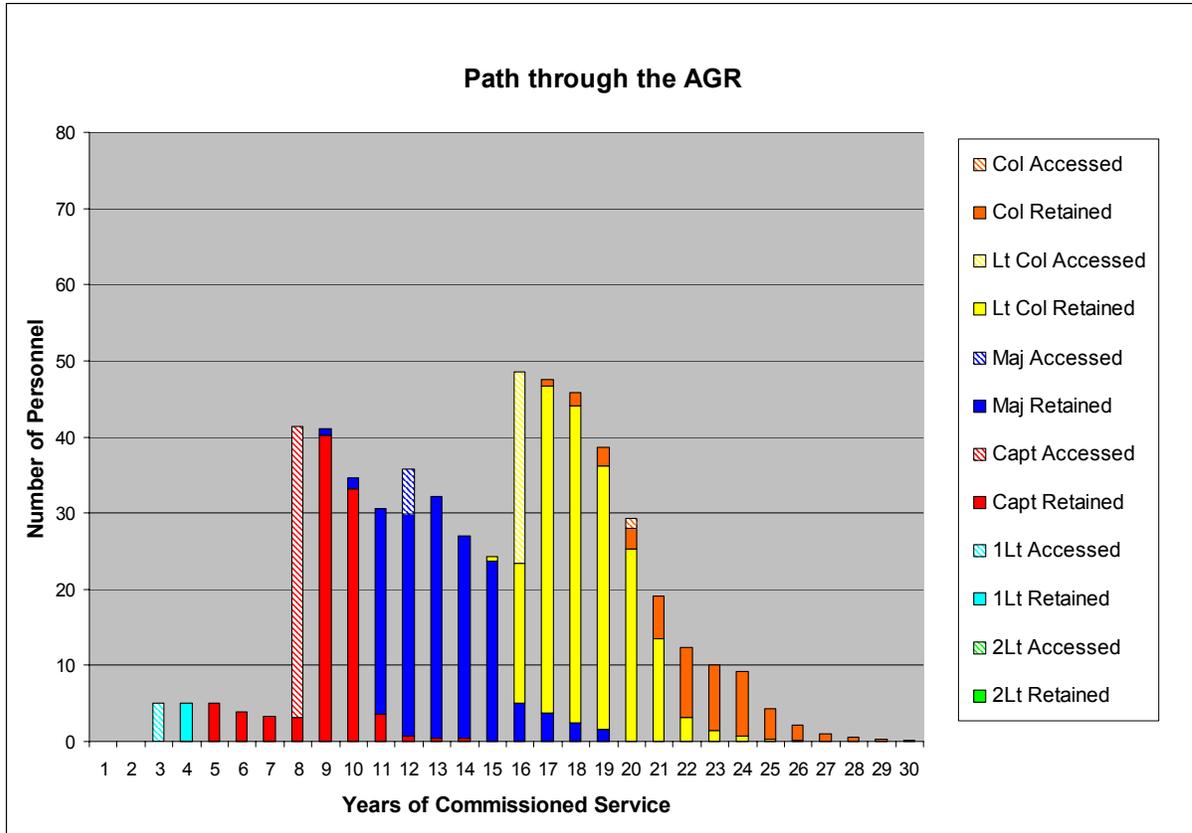


Figure 4.20: Maximize Average Number of Years Personnel Path Chart (D=0.50)

#### 4.5 Summary of Results

Tables 4.3 and 4.4 give a summary of all nine scenarios. Table 4.3 gives the total number of accessions by grade for all nine scenarios. In addition, Table 4.3 also displays the average number of years of AGR experience resulting from each scenario.

**Table 4.3: Scenario Summary of Accession**

Scenario	Accessions						Average AGR Experience (yrs)
	1Lt	Capt	Maj	LtCol	Col	Total	
MA-0	0	8	43	17	11	79	4.77
MA-25	0	25	18	25	6	74	5.01
MA-50	0	35	0	34	3	72	5.11
MW-0	0	12	62	25	0	99	4.22
MW-25	0	62	69	7	0	138	4.10
MW-50	0	53	51	0	0	104	4.29
MYrs-0	5	1	46	18	11	81	4.88
MYrs-25	5	18	27	22	6	79	5.16
MYrs-50	5	35	8	27	1	76	5.44

This table demonstrates that the optimal scenario for minimizing total accessions is MA-50, or the third scenario under the minimization of accession objective. This means that under the limitations of the model, the minimum number of accessions is 72 individuals from the grades given in Table 4.3. The optimal scenario with reference to average number of years within the AGR is MYrs-50. This third scenario of the maximization of AGR experience objective yields an average of 5.44 years of AGR experience.

Table 4.4 summarizes the impact each scenario has on the UMD requirements. The total column identifies that none of the total UMD requirements have been exceeded. Some of them have not been met which indicates that the optimal policy for these scenarios may not be implementable.

**Table 4.4: Scenario UMD Differences**

<b>Scenario</b>	<b>Difference from UMD requirements</b>					
	<b>1Lt</b>	<b>Capt</b>	<b>Maj</b>	<b>LtCol</b>	<b>Col</b>	<b>Total</b>
MA-0	0	0	2	-10	-10	-18
MA-25	0	50	-44	-10	-40	-44
MA-50	0	100	-90	1	-61	-52
MW-0	0	2	-1	10	-11	0
MW-25	0	40	-19	19	-40	0
MW-50	0	90	-16	-10	-63	0
MYrs-0	10	0	2	-2	-10	0
MYrs-25	10	50	-20	0	-40	0
MYrs-50	10	100	-41	0	-69	0

The results in Table 4.4 illustrate that all the shortages (i.e. below UMD requirements) are in the higher grades and all the extra positions (i.e. above UMD requirements) are in the lower grades.

#### **4.6 Summary**

The model developed in this thesis was run with three scenarios incorporating three different objective functions. The results for all nine runs point to the same conclusion. In order to provide a career path within the AGR, the indicated policy change is a change in the UMD requirements. Chapter Five provides further conclusions as well as ideas for improvement and continuance of this research.

## **5. Contributions and Conclusions**

### **5.1 Research Contributions**

The results from this research should help the Air Force Reserve evaluate the impact that management policies have on the resulting force structure. This in turn allows the USAF Reserves to offer a career path that leads to retirement from the AGR. By making changes to the current policies governing the management of the AGR, a resulting force structure can be evaluated as to its ability to offer a sufficient career path. The model developed in this thesis allows the management of the AGR to do this as part of an iterative process discussed in Chapter Three.

### **5.2 Limitations**

There were several limitations on the modeling efforts in this thesis. The most limiting factor in this research was the availability of information. Without a strong understanding of the inner workings of the USAF Reserves, it is extremely difficult for an analyst to develop a model that incorporates enough policies and restrictions in the model. The limitation of not being able to learn all the policies which apply to the AGR stems from the underlying variances in the Reserves. The amount of variance in a career from one officer to the next greatly limits the ability to model the behaviors of groups within the Reserves. This result has limited the model by only being able to model the majority of the force and not account for every possible career path that may actually exist.

Another limitation that all analysts encounter is the communication barrier between decision makers and the modelers. There are limitations on the model that result from the

inability to communicate. The need for ease of use by the decision maker restricts the ability of the model to be complex enough to model the problem accurately. The limitation on the complexity of the model may need to be addressed in future research.

### **5.3 Future Research**

Future thesis efforts should concentrate on the acquisition of better inputs and the development of more attributes. There are several characteristics that were not modeled in this research including competitive category and whether or not an individual is serving at the unit or headquarters level within the AGR. Future research could also focus on how adjustments to specific promotion and separation rates could impact force structure. This type of study would result in identifying the most influential states of the model and in turn provide the decision maker with a hierarchy of importance for how and at which levels policy changes should be implemented.

Future research might involve analyzing the enlisted corps of the AGR. This may prove to be just as beneficial. In this research, the cross flow between enlisted and officer could also be modeled. Policy pertaining to the acquisition of officers from the enlisted troops within the AGR could be evaluated. In addition, future work in the area on modeling more aspects of existing policies may provide further insight into the manipulation of the AGR into a career force structure.

### **5.4 Conclusions**

The results and conclusions drawn from this research effort are intended to provide AF/RE with insight into how to properly manage the AGR. In order to develop a career path within the AGR, the UMD requirements need to be altered to allow for more Captain and Lieutenant positions. The current force structure with the UMD

requirements do not allow for a career longer than 14 years in the AGR. The limitations due to these requirements are so severe that any policy changes that can affect promotion and separation rates have little affect. The most significant conclusion from this research is that the UMD requirements that are currently in place do not support the career goals of the AGR.

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<b>1. REPORT DATE (DD-MM-YYYY)</b> 06-09-2002	<b>2. REPORT TYPE</b> Master's Thesis	<b>3. DATES COVERED (From - To)</b> Jun 2002 - Mar 2003
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<b>4. TITLE AND SUBTITLE</b>  <b>AIR FORCE RESERVE FORCE STRUCTURE POLICY EVAULATION MODEL</b>	<table border="1" style="width:100%; border-collapse: collapse;"> <tr><td><b>5a. CONTRACT NUMBER</b></td></tr> <tr><td><b>5b. GRANT NUMBER</b></td></tr> <tr><td><b>5c. PROGRAM ELEMENT NUMBER</b></td></tr> </table>	<b>5a. CONTRACT NUMBER</b>	<b>5b. GRANT NUMBER</b>	<b>5c. PROGRAM ELEMENT NUMBER</b>
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<b>5b. GRANT NUMBER</b>				
<b>5c. PROGRAM ELEMENT NUMBER</b>				

<b>6. AUTHOR(S)</b>  Percival, Scott A., 2d Lt, USAF	<table border="1" style="width:100%; border-collapse: collapse;"> <tr><td><b>5d. PROJECT NUMBER</b></td></tr> <tr><td><b>5e. TASK NUMBER</b></td></tr> <tr><td><b>5f. WORK UNIT NUMBER</b></td></tr> </table>	<b>5d. PROJECT NUMBER</b>	<b>5e. TASK NUMBER</b>	<b>5f. WORK UNIT NUMBER</b>
<b>5d. PROJECT NUMBER</b>				
<b>5e. TASK NUMBER</b>				
<b>5f. WORK UNIT NUMBER</b>				

<b>7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S)</b> Air Force Institute of Technology Graduate School of Engineering and Management (AFIT/EN) 2950 P Street, Building 640 WPAFB OH 45433-7765	<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b>  AFIT/GOR/ENS/03-17
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<b>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b> Ann C. Shippy, Lt Col, USAF Chief, AGR Management Office 2211 S. Clark Place, Ste 924 Arlington, VA 22202 (703) 604-4004 DSN: 664-4004	<table border="1" style="width:100%; border-collapse: collapse;"> <tr><td><b>10. SPONSOR/MONITOR'S ACRONYM(S)</b> AF/REAMO</td></tr> <tr><td><b>11. SPONSOR/MONITOR'S REPORT NUMBER(S)</b></td></tr> </table>	<b>10. SPONSOR/MONITOR'S ACRONYM(S)</b> AF/REAMO	<b>11. SPONSOR/MONITOR'S REPORT NUMBER(S)</b>
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<b>11. SPONSOR/MONITOR'S REPORT NUMBER(S)</b>			

**12. DISTRIBUTION/AVAILABILITY STATEMENT**  
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

**13. SUPPLEMENTARY NOTES**

**14. ABSTRACT**

The United States Air Force Reserve is a constantly changing force. In response to these changes, the Active Guard Reserve (AGR), a small organization within the Reserve, is seeking to create a career track for Unit and Headquarters' Officers. It is necessary for the AGR policy division to be able to evaluate the availability of career paths to accomplish this goal.

The Air Force Reserve Force Structure Evaluation Model provides the AGR management with a tool to aid them in evaluating policy impact. This model allows the AGR management to identify the impact policy changes may have on the resulting force structure and is to be used as part of an iterative policy driven management cycle.

This study implements a Markov Chain model providing the user with several advantages to aid them in their decision process. The study evaluates several different objective functions in order to illustrate the impact a policy may have on the force structure. The conclusion of the study is that the current UMD requirements for the AGR do not allow for a viable career path for officers regardless of the policy implemented.

**15. SUBJECT TERMS**  
Personnel Planning, Manpower Modeling

<b>16. SECURITY CLASSIFICATION OF:</b>			<b>17. LIMITATION OF ABSTRACT</b>	<b>18. NUMBER OF PAGES</b>	<b>19a. NAME OF RESPONSIBLE PERSON</b> Dr. James T. Moore, (ENS)
a. REPORT	b. ABSTRACT	c. THIS PAGE			<b>19b. TELEPHONE NUMBER (Include area code)</b> (937) 255-6565, ext 4337; e-mail: James.Moore@afit.edu
U	U	U	UU	72	