A GOAL-PROGRAMMING MODEL FOR TURKISH ARMY PROMOTION AND MANPOWER PLANNING SYSTEM

A THESIS
SUBMITTED TO THE DEPARTMENT OF INDUSTRIAL ENGINEERING
AND THE INSTITUTE OF ENGINEERING AND SCIENCES
OF BILKENT UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF SCIENCE

By

B. Olcaytо Çandar

JULY, 2000

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I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

Assoc. Prof. Dr. Osman Oğuz (principal Adviser)

I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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ABSTRACT

A GOAL PROGRAMMING MODEL FOR TURKISH ARMY PROMOTION AND MANPOWER SYSTEM

Bekir Olcayto Çandar

M.S. in Industrial Engineering

Supervisor: Assoc. Prof. Dr. Osman Oğuz

July 2000

In the Turkish Army, officers are promoted to a higher rank automatically after they complete the period specified for their ranks. Currently, the number of officers on duty is sufficient to fill approximately 70 % of the available positions in the army. This shows the gap between personnel availability and requirements in the land forces at present. It is the main reason why automatic promotion procedures are practised in which no consideration is given to the individual performance of the officers when they are promoted.

In this thesis, an alternative system is proposed with the purpose of incorporating performance criteria in to the promotion process. This system is developed and analyzed for tank officers only, as a first stage. The feasibility of a system, which allows some individual officers to stay in the same rank longer than some normal duration if they do not meet certain performance criteria, is tested using a goal-programming model.

Keywords: Manpower Planning, Human Resource Planning, and Goal-Programming.

ÖZET

TÜRK SİLAHLI KUVVETLERİ TERFİ SİSTEMİ VE İNSAN KAYNAKLARI PLANLAMASI İÇİN BİR HEDEF PROGRAMLAMA MODELİ

Bekir Olcayto Çandar

Endüstri Mühendisliği Bölümü Yüksek Lisans

Tez Yöneticisi: Doç. Dr. Osman Oğuz

Temmuz 2000

Türk Ordusun'da subaylar rütbelerinin gerektirdiği süreleri tamamladıktan sonra bir üst rütbeye otomatik olarak geçmektedirler. Halihazırda görev yapmakta olan subay sayısı, mevcut kadroların % 70'ı için yeterli durumdadır. Bu, Silahlı Kuvetler'deki mevcut subay sayısıyla, ihtiyaç arasında açık fark olduğunu göstermektedir. Subayların terfi ederken şahsi performansları göz önüne alınmadan otomatik terfi etmelerinin ana sebebi budur.

Bu tezde performans kriterini terfi sistemine entegre eden alternatif bir sistem incelenmiştir. Alternatif sistem ilk safhada sadece tank subayları için geliştirilmiş ve uygulanmıştır. Performans kriterlerini karşılayamayan subayların, bir bölümünün aynı rütbede terfi etmeden normal süreden daha fazla beklemesini öngören sistemin fizibilitesi, hedef programlama metodu kullanılarak test edilmiştir.

Anahtar Kelimeler: İnsan Gücü Planlaması, İnsan Kaynakları Planlaması, Hedef Programlama.

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To my family...

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GLOSSARY

Military Terms and their Translations

Army: **Ordu**, involves approximately 9 brigades. Its commander is a full-general.

Corps: **Kolordu**, involves approximately 3 brigades. Its commander is a lieutenant general.

Brigade: **Tugay**, involves approximately 3 battalion task forces and 6000 soldiers. Its commander is a brigadier general.

Battalion: **Tabur**, involves approximately 3 company teams. Its commander is a lieutenant colonel.

Company: **Bölük**, involves approximately 4 platoons. Its commander is a captain.

Platoon: **Takım**, involves approximately 50 people. Its commander is a first lieutenant or second lieutenant.

CHAPTER 1

Introduction

1.1 Scope of the Study

Changing conditions, both inside organizations and the business environment in which they operate, have prompted the increased interest in better planning for manpower. Much interest in manpower planning has centred on finding techniques for forecasting manpower needs and supplies for long-range future.

Stainer [1], defines manpower planning as "manpower planning aims to maintain and improve the ability of the organization to achieve corporate objectives, through the development of strategies designed to enhance the contribution of manpower at all times in the foreseeable future".

People, jobs, and time are the basic ingredients of a manpower system. A decision-maker must be aware of the interactions among these three ingredients in order to formulate and evaluate manpower policy.

An organization must be informed about its internal dynamics and about the dynamics of its environment to manage its manpower. This involves the monitoring of internal personnel movements and the analysis of external supplies. The internal situation can largely be controlled through hiring, promotions, internal transfers, redundancies, and retirement planning. The problem is to plan and control these interrelated activities precisely in order to achieve a stable organization capable of meeting its objectives.

CHAPTER 1. Introduction

Manpower planning has been commonly described as a process consisting of three elements:

(a) Predicting the future demand for manpower.

(b) Predicting the future supply of manpower.

(c) Looking at policies to reconcile any difference between the results of (a) and (b), in other words, "closing the gap".

In this thesis, we will analyze the current Turkish Army Promotion System and the Flexible Promotion System that the Army is planning to use in the future.

1.2 The Literature Review:

Manpower and manpower behaviour have been studied in increasing depth since the turn of the century. Beginning with attempts to improve manpower productivity by time study, moving through the period of techniques for recording motion patterns leading to work simplification on assembly lines of the 1930s.

The establishment of organization and methods in the 1960s moved the study of work into the office and clerical systems. The late 1960s saw the formulation into a coherent and systematic framework of many of these different approaches and added the techniques of quantification developed by operational researchers and staticians.

The following studies are taken from the NATO Conference in 1969. Groover [2] developed a generalized entity simulation of a military personnel system, called "PERSYM". PERSYM is the set of interrelated renewal activities intended to maintain a balance between personnel assets and ever-changing requirements to meet the need for a policy evaluation instrument. The primary renewal activities with which he was concerned were personnel procurement, training, assignment, promotion, reassignment, retraining, and loss of retirement.

Lindsay [3], developed a computerized system for projection of long-range military manpower accession requirements and manpower supply. The system permitted alternative manpower policies to be evaluated very quickly, such as requirements, estimated gains, and losses. In addition, the system provided annual projections for ten years of officer and enlisted gains, losses, personnel costs, and new civilian accession for each of the four armed services in the U. S. (Army, Navy, Marine Corps, and Air Force).

Cotterill [4], developed a simple static model for forecasting officer requirements. The model made it possible for the personnel manager to examine more sets of policy options under more sets of assumed conditions. He calculated the structure at the beginning of each year. He assumed an input at the rank of lieutenant, from this he calculated the number of lieutenants with one year of service, then the number of officers with two years of service, until finally by a step-by-step procedure he calculated the number of officers of each rank having 35 years of service.

Caputo [5], worked on a mathematical approach to measure manpower requirements. He developed a computer model, which computes the maximum number of tactical aircraft that can be sustained in combat given an approved total aircraft inventory. This was important, because it was planned to limit the combat exposure of pilots. Therefore, the planers provided aircraft outside the combat zone for replacement pilot training. He simulated the activity of the aviation community in war and peace. Therefore, he could measure the impact on the total pilot system of alternative manning proposals for specific weapons system.

Charnes, Cooper, Niehaus, Sholtz [6], adapted a model for civilian manpower management and planning for the U. S. Navy by means of computer assisted mathematical models. They modelled manpower planning by combining the ideas of goal programming and Markov transition processes and utilizing multiple objectives along with other constraints.

Purkiss [7], designed models to be of practical use to a particular organisation in a specific industry (the Iron and Steel Industry). He used mathematical models to represent the relationship between manpower requirements and the technology of industry, and evaluate alternative ways of meeting these requirements.

Morgan [8], made a study of the manpower planning methods of the Royal Air Force in UK. He suggested that the best method of analysis was to abandon descriptive mathematical models and use linear programming based on an economic objective function and he gave an exercise in linear programming.

Stolley [9], developed models of a manpower selection procedure in the armed forces. He thought that the delicacy of modern weapon systems and the consequent variety of different tasks required better methods in selecting and assigning the man to the different jobs. In order to illustrate the difficulty of this task, he constructed a hypothetical schematic model showing how this problem could be tackled under fairly ideal circumstances.

Forbes [10], studied on the promotion and recruitment policies for the control of Quasi-stationary Hierarchical Systems. He considered a mathematical model, which was a Markov chain model with classes corresponding to the grade or age classes of a manpower system.

In 1976, Grinold [11] developed an equilibrium model of a manpower system based on the notion of a career flow. He formulated an optimal design problem and developed a solution procedure. The optimization problem was a generalized linear program in which columns were generated by solving a shortest path problem. The solution procedure was a column generation algorithm. The model could be used with several objectives. The effectiveness objective could be maximized, or the cost objective could be minimized, or the effectiveness - cost ratio could be maximized.

In 1979, Morgan [12] described a model for a hierarchical manpower system. Then he extended the model to a system with several grades and then to a system with several types of entrants or in which type of entrants has changed over time. Finally he described a method which can be used to determine the best mix of qualifications among the entrants.

In 1980, Bres et al. [13] developed a goal programming model for planning officer accession to the U. S. Navy from various commisioning sources. They considered the present and future requirements for different career specialty areas in the Navy in terms of years of commisioned service and related to various bottlenecks where inventories fall short of requirements in officer force structure.

Price et al. [14] reviewed the mathematical models in human resource planning in 1980. They investigated which type of model is most appropriate in which situation. They conclude that the fractional-flow or Markov models would seem to be most appropriate for system in which personnel movements between states are generated largely by the individuals and as such are not specifically controlled. Renewal-type models are most appropriate where grade size is closely controlled within the organization and where promotion and hiring decision are made only to fill vacant position. Finally they emphisize that in organizations where costs are an overriding factor or where conflicting objectives must be resolved optimization models (linear programming, the goal-programming, etc.) are possibly the best approach.

In 1983, Edwards [15] rewiewed the models which have been developed, concentrating on their assumptions and applications rather than on mathematical or statistical details. His intention is to look at the problems of using the various types of models in practice, the assumptions involved and the contribution which these models can make to the manpower planning proces in organizations.

Collins et al. [16] developed a model to evaluate the accession needs of all armed forces to reach or maintain a given strength and optimize the qualitative mix of new reqruits in 1986. They called the model as "The Accession Supply Costing and Requirements Model (ASCAR)". The model used goal programming for evaluation and allowed military manpower analysts to simulate and analyze the effects of manpower policy and program changes or the size and composition of the enlisted active duty forces.

In 1987, Collins-Merinhardt-Lemon & Gillette [17] developed a model called "The Army Manpower Long-Range Planning System (MLRPS)" that provides the analytical capability to project the strength of active U. S. Army for 20 years, thus allowing for the development of longe-range manpower plans. The model could simulate the interaction of gains, losses, promotions and reclassifications to enable the analyst to determine the impact of existing policies over the long term, and to determine changes that might be required to reach a desired force.

In addition to these works Lewis [18], prepared a bibliography to meet the need for a standart reference on manpower planning. The bibliography can be used by those working at either national, industry, or company level.

The work in thesis was largely inspired by the works of Grinold [11], Collins et al. [17], Collins et al. [16], Morgan [12], and Bres et al. [13]. Our main model is based on the models developed by Collins et al. [17] and Collins, Gass & Roshendahl [16].

CHAPTER 2

The Turkish Army Administrative System

2.1 General

The Turkish Army has a hierarchical administrative system similar to that of most of the armies in the world. Turkish General Staff is at the top of the Army. There are four main services in the Turkish Military: Land Forces, Airforce, Navy and Gendarmerie. Turkish General Staff coordinates these four services. Each of these services has varying numbers of armies, army corps, divisions, and brigades or their sub-units. In this thesis, we are mainly interested in Turkish Land Forces and its promotion system. The organization of Turkish Land Forces and one of its armies is shown in Figure-2.1 and Figure-2.2.

The smallest unit is the platoon in the organization of Land Forces. The larger units are, in hierarchical order: company, battalion, regiment, brigade, division, army corps, and army.

This hierarchical structure is managed with a hierarchical rank system. In the Turkish Army the ranks are, from lower to higher, Second Lieutenant, First Lieutenant, Captain, Major, Lieutenant Colonel, Colonel, Brigadier General, Major General, Lieutenant General and Full-General (shown in Figure-2.3). Since a different promotion system is in use for Generals, in this thesis, we are interested in the ranks from Second Lieutenant to Colonel,

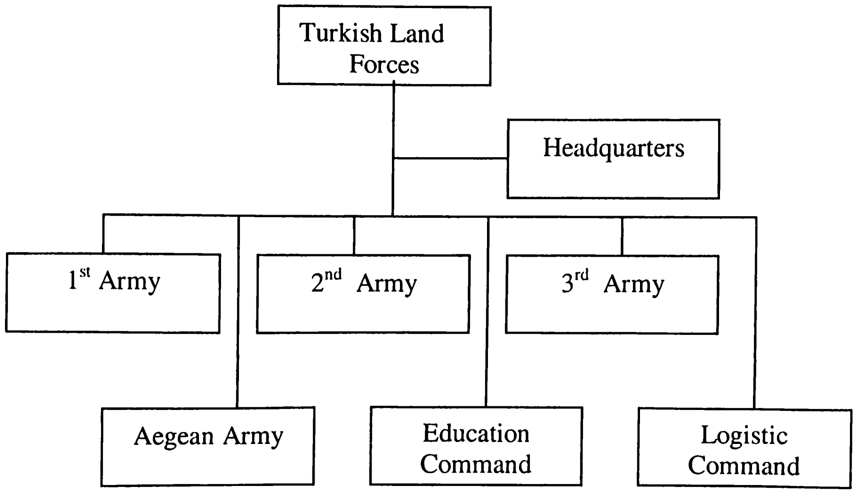

Figure-2.1 Organization chart of Turkish Land Forces

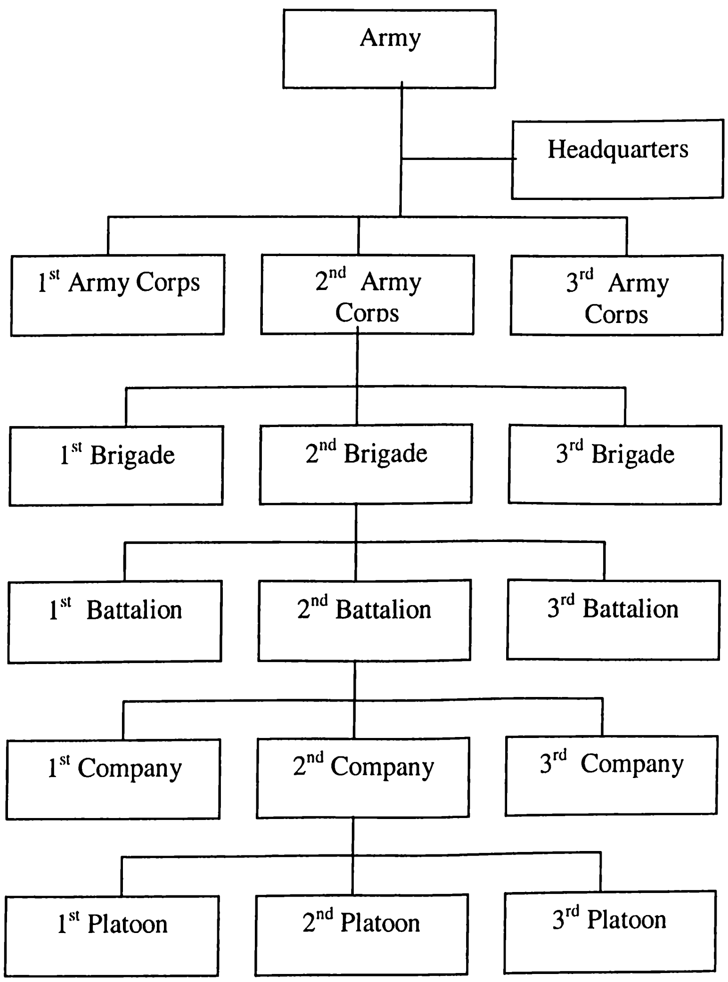

Figure-2.2 Organization chart of an army

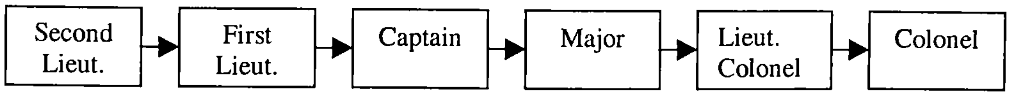

Figure-2.3 Ranks up to General

2.2 The Turkish Army Promotion System (The Current System)

Theoretically, every rank has a period to be completed. When an officer completes the period related with his or her rank, his or her past activities, performance, and success grade is evaluated by his or her superiors. If there is a need of officers with the next rank and if the officer has enough success grade, he or she is promoted to the higher rank. The periods of ranks are shown in Table-2.1

Rank	Period
Second Lieutenant	3 years
First Lieutenant	6 years
Captain	6 years
Major	5 years
Liutenant Col.	3 years
Colonel	5 years

Table-2.1, The periods of ranks

The Army has a fixed manpower requirement determined with positions and the promotion system works according to this requirement. If there are no positions for a higher rank, officers have to wait in the same rank until the positions are available, otherwise, they are retired. The periods that the officers can wait in the same rank are shown in Table-2.2.

Rank	Period
Second Lieutenant	Maximum age determined by law
First Lieutenant	Maximum age determined by law
Captain	21st year of his tenure
Major	22nd year of his tenure
Liutenant Col.	25th year of his tenure

Table-2.2, The maximum periods that the officers can wait in the same rank

If they cannot be promoted within these time limitations, they would have to retired.

2.3 The Problem:

In practice, every officer is promoted to a higher rank automatically after they complete the period related with their rank. The number of officers that the army has, is less than the number of officers required. The number of officers is 70 % of the number of required officers. Therefore, the officers are promoted to a higher rank automatically without considering their performance. The current and required number of tank officers is shown in Table-2.3. The data of tank officers is used during the application phase in the thesis and the data used in this thesis.

	Current Inventory	Needed Number	Requirement
Second Lieutenant	185	220	35
First Lieutenant	369	550	181
Captain	372	500	128
Major	210	245	35
Lieutenant Colonel	79	78	0
Colonel	138	160	22
Total	1353	1753	401

Table-2.3, The current and needed number of tank officers

As seen from Table-2.3 there is a gap between the current inventory and needed number of officers (positions) and this gap is the main cause of the problem. The gaps in ranks First Lieutenant and Captain are the most critical parts of the problem.

This problem causes another problem: Because every officer is promoted when he or she completes the period related with his or her rank, the performance of the officers looses its importance. So every officer is promoted whether his or her performance is good enough or not. The result is decreased motivation of the officers.

2.4 Some Possible Solutions:

(1) To increase the number of officers: In order to achieve this, the sources that provides officers to the army should increase the number of Second Lieutenants. However, this seems very difficult in terms of resources (because there is only one source (Military Academy) providing officers to the army) and cost.

(2) To reduce the number of the positions in the Army about 30 %. This means that the army looses approximately 15 brigades. It would be dangerous for the defence of Turkey in the existing circumstances.

The current system cannot solve the problem. The Army needs to increase the number of officers to a number that would meet the requirements. In addition to this it is needed to motivate the personnel to work more efficiently and to make them improve themselves. Moreover the officers that have a better performance and success have to be promoted earlier than the others do. Consequently, the system has to stop the practice of automatic promotion. As a result the Army needs a new system to solve these problems. The Army is planning to use an alternative system.

2.5 An Alternative System (The Flexible System):

(1) The Aim of the System:

a) To motivate the officers by promoting successful personnel earlier than the others.

b) To balance the number of officers related with the ranks.

(2) The Properties of the System:

a) The opportunity of being promoted to higher ranks in younger ages.

b) Establishing minimum and maximum waiting time for the ranks.

In the current system, the officers have to complete the full periods of the related ranks. The flexible system enables the officers, to be promoted between the minimum and maximum waiting time of related rank. In the current system, an officer with the rank of Second Lieutenant can be promoted to the rank Colonel after completing 23 years of service and to the rank One-Star-General after completing 28 years of service. However with Flexible System, this time decreases to 19 years for rank Colonel and 23 years for One-Star-General (assuming the officer is promoted after completing the minimum waiting time for all ranks). The retirements would also be changed by the Flexible System. In the current system the officers with the rank Captain would retire after 21 years of service, the Majors after 22 and the Lieutenant Colonels after 25 years of service. But in Flexible Promotion System the majors would be retired in between 18 and 24 years of service and the Lieutenant Colonels in between 22 and 31 years of service. So the new system will provide flexibility for the promotions and retirements of the officers.

Flexible system changes the periods of ranks and makes them flexible. The maximum and minimum periods for the ranks are shown in Table-2.4.

Rank	Minimum	Maximum
Second Lieutenant	3 years (fixed)	3 years (fixed)
First Lieutenant	4 years	7 years
Captain	4 years	7 years
Major	4 years	7 years
Liutenant Col.	4 years	7 years
Colonel	4 years	13 years

Table-2.4, The minimum and maximum periods for the ranks

For example, a First Lieutenant would be promoted after 4 years if he or she has a good performance. Otherwise, he or she would wait for the fifth, sixth or seventh year for promotion. After seventh year, a Second Lieutenant would be promoted if and only if there is a need of captains. (If there are positions).

In this thesis, the feasibility of the new system is tested by using a goal-programming model discussed in Chapter 3.

CHAPTER 3

Construction of Model

Our problem is to analyze if the new promotion system is feasible and has the capability of balancing the number of officers in each rank. We will employ an optimization model to find optimum promotion rates per rank, per year.

Collins-Gass & Roshendahl [6] used goal programming for evaluation of military manpower and they allowed military manpower analysts to simulate and analyze the effects of manpower policy .

We think that in organizations where conflicting objectives must be resolved, optimization models such as linear programming, goal-programming, etc. are possibly the best approach.

The only source is the Military Academy that provides officers to the army. We assumed 75 officers are graduated per year due to the capacity of the Military Academy. In our model the only supply is the Second Lieutenants graduating from the Military Academy each year. We represented the ranks by numbers from 1 through 6 corresponding to Second Lieutenant through Colonel. The initial inventory per rank and years of service are taken from the Army Manpower Planning Section and approximate numbers are used. The data is given in Appendix-A.

An officer can serve maximum 31 years if he or she is not a General. It is obligatory to serve at least 15 years. An officer can leave the Army after completing a minimum of 15 years of service.

We included separations, retirements, and deaths under the single name: casualties. The rates of casualties, *(RC (r))*, are taken from the Army Personnel Section. These rates are obtained by using the data of separations, retirements, and deaths per rank collected in past the 30 years. It is calculated by taking the ratio of the average of casualties to the average of total number of officers for each rank in the past 30 years.

For example, suppose;

$X_t =$ the number of captains in year t and;

$$X = \sum_{t=1}^{30} X_t$$

Then the average of captain is;

$$x = \frac{X}{30}$$

C_t = the summation of deaths, separations and retirements for the rank captain in year t and ;

$$C = \sum_{t=1}^{30} C_t$$

The average of casualties is;

$$c = \frac{C}{30}$$

Then the rate of casualties is;

$$RC = \frac{c}{x}$$

We used the same rates in order to be able to project the results so that the Army can evaluate the new promotion system. These rates are shown in Table-3.1.

Rank	Casualty Rates (%)
Second LIeutenant	0.035
First Lieutenant	0.058
Captain	0.041
Major	0.012
Lieutenant Colonel	0.007
Colonel	0.006

Table-3.1 Casualty Rates per Rank

The force inventory, $IX(t, r, y)$, with the rank r and years of service y, at the end of year t is equal to the previous year's ending inventory $(IX(t\text{-}1, r, y\text{-}1))$, minus casualties (including retirements, separations, and deaths) $(RC(r) \times IX(t\text{-}1, r, y\text{-}1))$, and promotions from rank r (out) $(PX(t\text{-}1, r, y\text{-}1))$, plus promotions from rank $r\text{-}1$ to rank r (in) $(PX(t\text{-}1, r\text{-}1, y\text{-}1))$.

$$IX(t, r, y) = IX(t\text{-}1, r, y\text{-}1) - (RC(r) \times IX(t\text{-}1, r, y\text{-}1)) - PX(t\text{-}1, r, y\text{-}1) + PX(t\text{-}1, r\text{-}1, y\text{-}1) + AX(t)$$

The inventory with first rank and one year of service is the number of officers that are graduated from the Military Academy.

The inventory for each rank is equal to the sum of inventories with rank r and represented as $TXr(t, r)$. The Army needs some fixed number of officers for each rank related with its organisation and jobs. This required number of officers is target inventory and represented as $TX(t, r)$. We used initial inventories as lower bounds in order to force the program reach the target inventories. We saw that the result is infeasible. So we used lower bounds, lower than the initial inventories. The lower bounds are shown in Table-3.2.

Rank	Lower Bounds
Second Lieutenant	185
First Lieutenant	350
Captain	340
Major	200
Lieutenant Colonel	78
Colonel	120

Table-3.2 Lower bounds for *TXr (t, r)*

The total force is equal to the sum of all inventories in all ranks and is represented as *TFXr (t)*. The total required number of officers is target inventory for total force and represented *as TFX (t)*.

The Army is planning to apply some fixed promotion rates to those officers who complete the 4^{th}, 5^{th} ,6^{th} and 7^{th} years of service of a rank. These rates are shown in Table-3.3.

Years of service	Promotion rate
4th year	.05
5th year	.15
6th year	.35
7th year	varying according to available positions

Table-3.3 Promotion rates that the Army is planning to use

The promotion rate for the officers in rank 1 is fixed. After serving three years the officers that have rank 1 are promoted to rank 2. The promotion rate is 1 for only rank 1. For the other ranks the Army is planning to use the promotion rates given in Table-3.3. After four years of service in a rank, % 5 of the force inventory is promoted to a higher rank. After five years of service in a rank, %15 of the remaining force inventory is promoted to a higher rank. After six years of service in a rank, %35 of the remaining force inventory is promoted to a higher rank. After seven years of service in a rank the number of officers that are promoted changes according to position availability. The entire remaining inventory is promoted to a higher rank if the positions are available after completing seven years of service.

In our model we did not use these fixed promotion rates. We tried to find the optimal number of officers that must be promoted each year, *PX (t, r, y)*, in order to reach the required force inventory per rank. We used the rates that the Army is planning to use as lower bounds for *PX (t, r, y)*. We used % 10 addition as upper bound with the agreement of the Army Manpower Planning Section.

The Army has fixed objectives for rank inventories. As we mentioned before the Army needs fixed number of officers, related with the positions, in all ranks that changes according to organization of Army. Our aim is to reach these objectives as soon as possible without changing the number of officers suplied.

We put goal variables for rank target *(TX (t, r))*. These goal variables are;

Tp (t, r) : The amount under the rank target.

Tn (t, r) : The amount over the rank target.

So the objective function is minimizing the sum of deviations *Tp (t, r)* and *Tn (t, r)*.

Consider the following formulation;

a) Indices:

Rank : $r = 1, 2, \ldots\ldots, 6$

Years of service: $y = 1, 2, \ldots\ldots, 31$

Time (year) : $t = 0, 1, \ldots\ldots, T$

b) Initial Data and Parameters:

AX (t) : Accession in year *t*. (Accession is made only to the first rank and we assume 75 officers graduate per year from the Military Academy)

RC (r) : Rate of casualties from rank *r*, with years of service *y*, in year *t*. (The rates are taken from Turkish Land Forces Personnel Section and shown in Table-3.1)

TFX (t) : Target inventory for total force at the end of year *t*.

$TX(t, r)$: Target inventory for rank r at the end of year t.

c)Variables:

z :The value of objective function

$IX(t, r, y)$: Force inventory at the end of year t, for rank r, with years of service y

$TXr(t, r)$: Total force for rank r in year t

$TFXr(t)$: Total force in year t

$PX(t, r, y)$: Number of officers that are promoted from rank r and years of service y to rank $r+1$ and years of service $y+1$

$CX(t, r, y)$: Casualties including separations, retirements and deaths for rank r, with years of service y and in year t

d) Constraints:

(1) Inventory:

$IX(t, 1, 1) = AX(t)$ and $AX(t) = 75$.

The force inventory that has only one year of service is equal to the accessions made during year t and it equals to the number of officers graduated from Military Academy.

$IX(t, r, y) \geq 0$

$$IX(t, r, y) = IX(t\text{-}1, r, y\text{-}1) - (RC(r) \times IX(t\text{-}1, r, y\text{-}1)) - PX(t\text{-}1, r, y\text{-}1) \\ + PX(t\text{-}1, r\text{-}1, y\text{-}1) + AX(t).$$

The force inventory at the end of year t for rank r is equal to the previous year's ending inventory minus casualties (including retirements, seperations and death), promotions from rank r (out), plus promotions from $r\text{-}1$ (in).

(2) Promotion:

$PX(t, r, y) \geq 0$

For $r = 2$:

$(.05 \times IX(t, 2, 7)) \leq PX(t, 2, 7) \leq (.15 \times IX(t, 2, 7))$

$(.15 \times IX(t, 2, 8)) \leq PX(t, 2, 8) \leq (.25 \times IX(t, 2, 8))$

$(.35 \times IX(t, 2, 9)) \leq PX(t, 2, 9) \leq (.45 \times IX(t, 2, 9))$

$0 \leq PX(t, r, y) \leq IX(t, r, y)$ for $r = 2$ and $y \geq 10$.

Promotions have different lower and upper bounds for 4^{th}, 5^{th} and 6^{th} years of service for rank r =2. (This means the officers that has rank r = 2 and completes 4^{th}, 5^{th} and 6^{th} years of service). After completing 7^{th} year of service the promotions can change between zero and the number of inventory of officers that completes 7^{th} year. The number of officers that would be promoted would change according to available positions.

To make the model and its results more accurate, the cumulative effective promotion must be taken into account for the numbers in the later years. In the current study, these effects have been ignored with view that their magnitude would have negligible effect on our numerical results, because the number of officers in the analysis are relatively small. Their inclusion woud increase the complexity of the model somewhat, but in no way make it unsolvable. The model can be easily revised to make room for this inclusion. However, considering the scope and the time limit for this study, we have chosen to ignore these effects. In a more general implementation of the model for the Army, this fact should be taken into consideration.

The lower and upper bounds for 4^{th}, 5^{th} and 6^{th} years of service for ranks 3, 4, 5 are shown

below.

For $r = 3$:

$(.05 \times IX(t, 3, 13)) \leq PX(t, 3, 13) \leq (.15 \times IX(t, 3, 13))$

$(.15 \times IX(t, 3, 14)) \leq PX(t, 3, 14) \leq (.25 \times IX(t, 3, 14))$

$(.35 \times IX(t, 3, 15)) \leq PX(t, 3, 15) \leq (.45 \times IX(t, 3, 15))$

$0 \leq PX(t, r, y) \leq IX(t, r, y)$ for $r = 3$ and $y \geq 16$.

For $r = 4$:

$(.05 \times IX(t, 4, 19)) \leq PX(t, 4, 19) \leq (.15 \times IX(t, 4, 19))$

$(.15 \times IX(t, 4, 20)) \leq PX(t, 4, 20) \leq (.25 \times IX(t, 4, 20))$

$(.35 \times IX(t, 4, 21)) \leq PX(t, 4, 21) \leq (.45 \times IX(t, 4, 21))$

$0 \leq PX(t, r, y) \leq IX(t, r, y)$ for $r = 4$ and $y \geq 22$.

For $r = 5$:

$(.05 \times IX(t, 5, 23)) \leq PX(t, 5, 23) \leq (.15 \times IX(t, 5, 23))$

$(.15 \times IX(t, 5, 24)) \leq PX(t, 5, 24) \leq (.25 \times IX(t, 5, 24))$

$(.35 \times IX(t, 5, 25)) \leq PX(t, 5, 25) \leq (.45 \times IX(t, 5, 25))$

$0 \leq PX(t, r, y) \leq IX(t, r, y)$ for $r = 5$ and $y \geq 26$.

(3) Casualities:

$CX(t, r, y) = (RC(r) \times IX(t\text{-}1, r, y\text{-}1))$

Casualties left to service at the and of the year t in rank r and years of service y is equal to the percent of casualties times inventory at the end of year t-1, in rank r, and years of service y-1.

(4) Rank Target Constraints:

$$TXr(t, r) = \sum_{y=1}^{31} IX(t, r, y)$$

The force inventory for a rank is equal to the sum of inventories with rank r.

(5) Total Force Target Constraint:

$$TFXr(t) = \sum_{r=1}^{6} \sum_{y=1}^{31} IX(t,r,y)$$

The total force inventory is the sum of inventories in all ranks.

Formulation of the problem is;

$$Minimize \ldots z = \sum_{t=0}^{T} \sum_{r=1}^{6} Tp(t,r) + \sum_{t=0}^{T} \sum_{r=1}^{6} Tn(t,r)$$

Subject to:

$$IX(t, r, y) = IX(t\text{-}1, r, y\text{-}1) - (RC(r) \times IX(t\text{-}1, r, y\text{-}1)) - PX(t\text{-}1, r, y\text{-}1) + PX(t\text{-}1, r\text{-}1, y\text{-}1) + AX(t)$$

For $r = 2$:

$$(.05 \times IX(t, 2, 4)) \leq PX(t, 2, 4) \leq (.15 \times IX(t, 2, 4))$$

$$(.15 \times IX(t, 2, 5)) \leq PX(t, 2, 5) \leq (.25 \times IX(t, 2, 5))$$

$$(.35 \times IX(t, 2, 6)) \leq PX(t, 2, 6) \leq (.45 \times IX(t, 2, 6))$$

$0 \leq PX(t, r, y) \leq IX(t, r, y)$ for $r = 2$ and $y \geq 7$.

For $r = 3$:

$$(.05 \times IX(t, 3, 13)) \leq PX(t, 3, 13) \leq (.15 \times IX(t, 3, 13))$$

$$(.15 \times IX(t, 3, 14)) \leq PX(t, 3, 14) \leq (.25 \times IX(t, 3, 14))$$

$$(.35 \times IX(t, 3, 15)) \leq PX(t, 3, 15) \leq (.45 \times IX(t, 3, 15))$$

$0 \leq PX(t, r, y) \leq IX(t, r, y)$ for $r = 3$ and $y \geq 16$.

For $r = 4$:

$$(.05 \times IX(t, 4, 19)) \leq PX(t, 4, 19) \leq (.15 \times IX(t, 4, 19))$$

$$(.15 \times IX(t, 4, 20)) \leq PX(t, 4, 20) \leq (.25 \times IX(t, 4, 20))$$

$(.35 \times IX(t, 4, 21)) \leq PX(t, 4, 21) \leq (.45 \times IX(t, 4, 21))$

$0 \leq PX(t, r, y) \leq IX(t, r, y)$ for $r = 4$ and $y \geq 22$.

For $r = 5$:

$(.05 \times IX(t, 5, 23)) \leq PX(t, 5, 23) \leq (.15 \times IX(t, 5, 23))$

$(.15 \times IX(t, 5, 24)) \leq PX(t, 5, 24) \leq (.25 \times IX(t, 5, 24))$

$(.35 \times IX(t, 5, 25)) \leq PX(t, 5, 25) \leq (.45 \times IX(t, 5, 25))$

$0 \leq PX(t, r, y) \leq IX(t, r, y)$ for $r = 5$ and $y \geq 26$.

$CX(t, r, y) = (RC(r) \times IX(t-1, r, y-1))$

$$TXr(t, r) = \sum_{y=1}^{31} IX(t, r, y)$$

$TX(r) = TXr(t, r) + Tp(t, r) - Tn(t, r)$

$IX(t, r, y) \geq 0$

$PX(t, r, y) \geq 0$

$$TFXr(t) = \sum_{r=1}^{6} \sum_{y=1}^{Y} IX(t, r, y)$$

$TXr(t, r, y) \geq 0$

$TFXr(t, r, y) \geq 0$

$0 \leq t \leq T,$

$0 \leq r \leq 6,$

$0 \leq y \leq 31.$

CHAPTER 4

Model Solutions

In this chapter we discuss the solutions of the goal programing model. We wrote a GAMS code of the model and ran the model for 10, 15, 31, and 40 years. The results are analyzed in the order of 10, 15, 31, and 40 years runs.

4.1 The Target Achievements

By using the goal-programming model, the Army can reach the required inventory for the rank Second Lieutenant and almost reach the required inventory for the rank First Lieutenant in 10 years. The inventory for the rank Colonel exceeds the required number. This means that the exceeding part will be retired. The number of officers with rank Captain increased approximately 12 %. And the number of Lieutenant Colonel didn't change and it is the same as the target inventory. The result of 10-year run is shown in Table-4.1. The full result of 10-year run is given in Appendix-B.

Ranks	Current Inventory	After 10 years	Target Inventory
Second Lieutenant	185	223	220
First Lieutenant	369	549	550
Captain	372	429	500
Major	210	200	245
Lieutenant Colonel	79	78	78
Colonel	138	180	150

Table-4.1, Results of 10-year run with the goal-programming model

The 15-year run with goal programming model gave us more optimistic results. We saw that the model reached the target inventory for rank 1, 2, 5, and 6. The number of officers with rank 3 increased approximately 19 % of current inventory. The inventory with rank 4 decreased 5 % of current inventory. The results of 15-year run are shown in Table-4.2 and the full results are shown in Appendix-C.

Ranks	Current Inventory	After 15 years	Target Inventory
Second Lieutenant	185	223	220
First Lieutenant	369	550	550
Captain	372	458	500
Major	210	200	245
Lieutenant Colonel	79	78	78
Colonel	138	245	150

Table-4.2, Results of 15-year run with the goal-programming model

The inventory has reached the target inventory for all ranks after 31 years with the goal-programming model. The results of 31-year run are shown in Table-4.3 and full results are shown in Appendix-D.

Ranks	Current Inventory	After 31 years	Target Inventory
Second Lieutenant	185	223	220
First Lieutenant	369	550	550
Captain	372	500	500
Major	210	245	245
Lieutenant Colonel	79	78	78
Colonel	138	265	150

Table-4.3, Results of 31-year run with the goal-programming model

The result of 40-year run is the same as 31-year run. Because all the ranks has reached the target inventories and the model preserve the force inventories at the level of target inventories. The results of 40-year run are shown in Table-4.4 and full results are shown in Appendix-E.

Ranks	Current Inventory	After 40 years	Target Inventory
Second Lieutenant	185	223	220
First Lieutenant	369	550	550
Captain	372	500	500
Major	210	245	245
Lieutenant Colonel	79	78	78
Colonel	138	265	150

Table-4.4, results of 40-year run with the goal-programming model

4.2 Promotion Rates

The goal-programming model gives the number of officers that will be promoted from a rank to a higher rank per year and the results of 10-year run is shown rank by rank Table-4.5 and following tables.

Year	Number of Officers Promoted
1	30
2	56
3	53
4	58
5	4
6	7
7	71
8	61
9	42
10	70

Table-4.5, promotions from rank 2 to rank 3 for 10-year run

Year	Number of Officers Promoted
1	30
2	55
3	68
4	57
5	0
6	0
7	35
8	8
9	51
10	44

Table-4.6, promotions from rank 3 to rank 4 for 10-year run

Year	Number of Officers Promoted
1	4
2	25
3	26
4	44
5	14
6	50
7	38
8	0
9	43
10	36

Table-4.7, promotions from rank 4 to rank 5 for 10-year run

Year	Number of Officers Promoted
1	0
2	22
3	24
4	0
5	19
6	18
7	28
8	36
9	42
10	32

Table-4.8, promotions from rank 5 to rank 6 for 10-year run

The number of officers that are promoted for the 15, 31, and 40-year runs are shown in appendices F, G, and H.

The number of officers for 10 and 31 year period with the Current Promotion System are shown in appendices I and J.

CHAPTER 5

Conclusions

5.1 General:

In this thesis, a goal-programming model is proposed which will help the Turkish Army to decide whether or not to use the Flexible Promotion System. The objective of Army is to balance the manpower between the ranks and close the gap between current inventory and required inventory without increasing the supply.

After analyzing results we saw that the Flexible Promotion System can solve the problem in a logical time span.

As a result, it will be beneficial to use this promotion system rather than the current one. The goal-programming model gives the number of officers that has to be promoted from a rank to a higher rank per year. These numbers differ from year to year. It would be better to adjust the promotions according to these numbers for the Army.

5.2 Recommendations:

It is obvious that the Flexible Promotion System will bring an extra motivation and create a competitive atmosphere among the officers. Besides, it seems that the Army can achieve its target inventories in at most 30 years without increasing supply or decreasing the positions. The Army needs to shorten this period.

Because of the importance for the defence of Turkey, decreasing the number of positions cannot be a solution. We think that the best approach to the problem is to increase the supply or provide manpower from the external sources such as related faculties of universities, besides Military Academy.

Before starting to implement this system, the Army needs to have an effective evaluation system to evaluate the officers that would be promoted early or late. It is crucial to develop an effective evaluation system and start to use the new promotion system and the evaluation system at the same time.

Another alternative is to let the promotion rates vary within each rank for different tenure lengths. Then of course, the number of trial runs to find the best rates may increase considerably, which may make the use of the model rather difficult.

As a further research avenue, incorporating stochastic considerations into the model may be considered. For example, casualty and promotion rates may assumed to be random variables. However finding data and obtaining realistic solution from a more complex model can be a problem.

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Appendix-A

The initial (current) inventories per rank and years of service.

Rank	Years of Service	Initial (Current) Inventory
1	1	45
1	2	65
1	3	75
2	4	75
2	5	60
2	6	60
2	7	57
2	8	67
2	9	50
3	10	65
3	11	55
3	12	60
3	13	75
3	14	67
3	15	50
4	16	65
4	17	55
4	18	40
4	19	25
4	20	25
5	21	25
5	22	29
5	23	25
6	24	18
6	25	15
6	26	22
6	27	25
6	28	24
6	29	20
6	30	9
6	31	5

Appendix-B

The full results of the goal-programming model for 10-year run.

Year	Rank	Total Force Inv. (TXr)
0	1	185
0	2	369
0	3	372
0	4	210
0	5	79
0	6	138
1	1	185
1	2	378
1	3	366
1	4	259
1	5	79
1	6	128
2	1	194
2	2	384
2	3	362
2	4	279
2	5	78
2	6	137
3	1	223
3	2	372
3	3	342
3	4	300
3	5	85
3	6	139
4	1	223
4	2	385
4	3	340
4	4	300
4	5	105
4	6	133
5	1	223
5	2	452
5	3	340
5	4	273
5	5	95
5	6	126

Year	Rank	Total Force Inv. (TXr)
6	1	223
6	2	515
6	3	343
6	4	211
6	5	121
6	6	122
7	1	223
7	2	514
7	3	385
7	4	190
7	5	125
7	6	135
8	1	223
8	2	522
8	3	433
8	4	190
8	5	81
8	6	153
9	1	223
9	2	550
9	3	419
9	4	190
9	5	78
9	6	173
10	1	223
10	2	549
10	3	440
10	4	190
10	5	78
10	6	180

Appendix-C

The full results of goal-programming model for 15-year run.

Year	Rank	Total Force Inv. (TXr)
0	1	185
0	2	369
0	3	372
0	4	210
0	5	79
0	6	138
1	1	185
1	2	365
1	3	383
1	4	256
1	5	79
1	6	128
2	1	194
2	2	381
2	3	365
2	4	279
2	5	78
2	6	137
3	1	223
3	2	372
3	3	342
3	4	300
3	5	85
3	6	139
4	1	223
4	2	385
4	3	340
4	4	300
4	5	105
4	6	133
5	1	223
5	2	400
5	3	340
5	4	300
5	5	120
5	6	126

Year	Rank	Total Force Inv. (TXr)
6	1	223
6	2	406
6	3	340
6	4	300
6	5	142
6	6	122
7	1	223
7	2	409
7	3	357
7	4	300
7	5	140
7	6	134
8	1	223
8	2	418
8	3	353
8	4	300
8	5	144
8	6	153
9	1	223
9	2	446
9	3	340
9	4	296
9	5	136
9	6	172
10	1	223
10	2	513
10	3	340
10	4	240
10	5	141
10	6	179

Year	Rank	Total Force Inv. (TXr)
11	1	223
11	2	550
11	3	359
11	4	200
11	5	131
11	6	200
12	1	223
12	2	550
12	3	369
12	4	200
12	5	124
12	6	224
13	1	223
13	2	550
13	3	26
13	4	200
13	5	80
13	6	239
14	1	223
14	2	550
14	3	433
14	4	213
14	5	78
14	6	243
15	1	223
15	2	550
15	3	458
15	4	200
15	5	78
15	6	245

Appendix-D

The full results of the goal-programming model for 31-year run.

Year	Rank	Total Force Inv. (TXr)
0	1	185
0	2	369
0	3	372
0	4	210
0	5	79
0	6	138
1	1	184
1	2	365
1	3	383
1	4	256
1	5	79
1	6	128
2	1	194
2	2	381
2	3	365
2	4	279
2	5	78
2	6	137
3	1	223
3	2	372
3	3	342
3	4	300
3	5	85
3	6	139
4	1	223
4	2	385
4	3	340
4	4	300
4	5	105
4	6	133
5	1	223
5	2	398
5	3	342
5	4	300
5	5	120
5	6	126
6	1	223
6	2	397
6	3	349
6	4	300
6	5	142
6	6	122
7	1	223
7	2	396
7	3	370
7	4	300
7	5	140
7	6	134
8	1	223
8	2	405
8	3	366
8	4	300
8	5	144
8	6	153
9	1	223
9	2	434
9	3	352
9	4	296
9	5	137
9	6	172
10	1	223
10	2	434
10	3	364
10	4	294
10	5	141
10	6	179

Year	Rank	Total Force Inv. (TXr)
11	1	223
11	2	434
11	3	376
11	4	295
11	5	131
11	6	200
12	1	223
12	2	434
12	3	376
12	4	300
12	5	127
12	6	224
13	1	223
13	2	434
13	3	375
13	4	300
13	5	137
13	6	239
14	1	223
14	2	434
14	3	384
14	4	300
14	5	140
14	6	243
15	1	223
15	2	434
15	3	411
15	4	300
15	5	120
15	6	245
16	1	223
16	2	434
16	3	411
16	4	300
16	5	136
16	6	234

Year	Rank	Total Force Inv. (TXr)
17	1	223
17	2	434
17	3	411
17	4	300
17	5	142
17	6	240
18	1	223
18	2	434
18	3	411
18	4	300
18	5	154
18	6	232
19	1	223
19	2	434
19	3	411
19	4	300
19	5	163
19	6	223
20	1	223
20	2	504
20	3	340
20	4	300
20	5	172
20	6	221
21	1	223
21	2	505
21	3	340
21	4	300
21	5	141
21	6	230

Year	Rank	Total Force Inv. (TXr)
22	1	223
22	2	506
22	3	340
22	4	300
22	5	173
22	6	234
23	1	223
23	2	506
23	3	340
23	4	300
23	5	179
23	6	240
24	1	223
24	2	506
24	3	340
24	4	300
24	5	197
24	6	226
25	1	223
25	2	507
25	3	340
25	4	300
25	5	196
25	6	234
26	1	223
26	2	550
26	3	363
26	4	287
26	5	144
26	6	240

Year	Rank	Total Force Inv. (TXr)
27	1	223
27	2	550
27	3	428
27	4	227
27	5	142
27	6	247
28	1	223
28	2	550
28	3	460
28	4	200
28	5	143
28	6	246
29	1	223
29	2	550
29	3	500
29	4	216
29	5	93
29	6	246
30	1	223
30	2	550
30	3	500
30	4	216
30	5	78
30	6	251
31	1	223
31	2	550
31	3	500
31	4	245
31	5	78
31	6	265

Appendix-E

The full results of the goal-programming model for 40-year run.

Year	Rank	Total Force Inv. (TXr)
1	1	184
1	2	378
1	3	366
1	4	259
1	5	78
1	6	128
2	1	194
2	2	384
2	3	362
2	4	279
2	5	78
2	6	137
3	1	223
3	2	372
3	3	342
3	4	300
3	5	85
3	6	135
4	1	223
4	2	385
4	3	340
4	4	300
4	5	105
4	6	133
5	1	223
5	2	452
5	3	340
5	4	273
5	5	95
5	6	126

Year	Rank	Total Force Inv. (TXr)
6	1	223
6	2	515
6	3	343
6	4	211
6	5	121
6	6	122
7	1	223
7	2	513
7	3	374
7	4	200
7	5	124
7	6	135
8	1	223
8	2	522
8	3	423
8	4	200
8	5	81
8	6	153
9	1	223
9	2	550
9	3	408
9	4	200
9	5	78
9	6	173
10	1	223
10	2	549
10	3	429
10	4	200
10	5	78
10	6	180

Year	Rank	Total Force Inv. (TXr)
11	1	223
11	2	434
11	3	376
11	4	295
11	5	131
11	6	200
12	1	223
12	2	434
12	3	376
12	4	300
12	5	127
12	6	224
13	1	223
13	2	434
13	3	375
13	4	300
13	5	137
13	6	239
14	1	223
14	2	434
14	3	384
14	4	300
14	5	140
14	6	243
15	1	223
15	2	434
15	3	411
15	4	300
15	5	142
15	6	240
16	1	223
16	2	434
16	3	411
16	4	300
16	5	136
16	6	234

Year	Rank	Total Force Inv. (TXr)
17	1	223
17	2	434
17	3	411
17	4	300
17	5	142
17	6	240
18	1	223
18	2	434
18	3	411
18	4	300
18	5	154
18	6	232
19	1	223
19	2	434
19	3	411
19	4	300
19	5	163
19	6	223
20	1	223
20	2	434
20	3	411
20	4	300
20	5	172
20	6	221
21	1	223
21	2	434
21	3	411
21	4	300
21	5	172
21	6	240

Year	Rank	Total Force Inv. (TXr)
22	1	223
22	2	434
22	3	411
22	4	300
22	5	172
22	6	223
23	1	223
23	2	434
23	3	411
23	4	300
23	5	173
23	6	240
24	1	223
24	2	434
24	3	411
24	4	300
24	5	197
24	6	226
25	1	223
25	2	434
25	3	411
25	4	300
25	5	197
25	6	240
26	1	223
26	2	434
26	3	411
26	4	300
26	5	197
26	6	246

Year	Rank	Total Force Inv. (TXr)
27	1	223
27	2	434
27	3	411
27	4	300
27	5	197
27	6	240
28	1	223
28	2	434
28	3	411
28	4	300
28	5	197
28	6	246
29	1	223
29	2	504
29	3	340
29	4	300
29	5	197
29	6	246
30	1	223
30	2	505
30	3	340
30	4	300
30	5	197
30	6	253
31	1	223
31	2	506
31	3	340
31	4	300
31	5	197
31	6	264

Year	Rank	Total Force Inv. (TXr)
32	1	223
32	2	506
32	3	340
32	4	300
32	5	197
32	6	264
33	1	223
33	2	506
33	3	340
33	4	300
33	5	197
33	6	264
34	1	223
34	2	507
34	3	340
34	4	300
34	5	196
34	6	165
35	1	223
35	2	550
35	3	363
35	4	287
35	5	144
35	6	265
36	1	223
36	2	550
36	3	428
36	4	227
36	5	142
36	6	265

Year	Rank	Total Force Inv. (TXr)
37	1	223
37	2	550
37	3	460
37	4	200
37	5	143
37	6	264
38	1	223
38	2	550
38	3	500
38	4	216
38	5	93
38	6	264
39	1	223
39	2	550
39	3	500
39	4	239
39	5	78
39	6	265
40	1	223
40	2	550
40	3	500
40	4	245
40	5	78
40	6	265

Appendix-F

Promotions for 15-year run:

	Promotions from rank 2 to 3
Year	Number of Officers Promoted
1	50
2	46
3	50
4	58
5	55
6	64
7	68
8	61
9	42
10	14
11	33
12	70
13	70
14	70
15	70

	Promotions from rank 3 to 4
Year	Number of Officers Promoted
1	24
2	58
3	68
4	57
5	51
6	60
7	46
8	61
9	51
10	12
11	10
12	55
13	18
14	57
15	39

	Promotions from rank 4 to 5
Year	Number of Officers Promoted
1	4
2	25
3	36
4	44
5	38
6	48
7	32
8	49
9	42
10	44
11	40
12	47
13	32
14	36
15	43

	Promotions from rank 5 to 6
Year	Number of Officers Promoted
1	17
2	22
3	24
4	19
5	19
6	18
7	27
8	36
9	42
10	31
11	42
12	46
13	37
14	33
15	39

Appendix-G

Promotions per year for 31-year run

	Promotions from rank 2 to 3
Year	Number of Officers Promoted
1	50
2	46
3	50
4	58
5	57
6	71
7	71
8	61
9	42
10	70
11	70
12	70
13	70
14	70
15	70
16	70
17	70
18	70
19	70
20	70
21	70
22	70
23	70
24	70
25	70
26	67
27	70
28	70
29	70
30	70
31	70

	Promotions from rank 3 to 4
Year	Number of Officers Promoted
1	24
2	58
3	68
4	57
5	51
6	60
7	46
8	61
9	51
10	54
11	53
12	66
13	66
14	57
15	39
16	65
17	65
18	65
19	65
20	65
21	65
22	65
23	65
24	65
25	65
26	36
27	34
28	33
29	24
30	64
31	64

	Promotions from rank 4 to 5
Year	Number of Officers Promoted
1	4
2	24
3	36
4	44
5	38
6	47
7	33
8	48
9	42
10	44
11	40
12	50
13	53
14	44
15	27
16	53
17	52
18	52
19	52
20	51
21	53
22	52
23	52
24	52
25	52
26	48
27	48
28	51
29	42
30	33
31	47

	Promotions from rank 5 to 6
Year	Number of Officers Promoted
1	18
2	22
3	24
4	19
5	19
6	18
7	27
8	36
9	41
10	31
11	42
12	46
13	37
14	33
15	39
16	29
17	39
18	33
19	35
20	34
21	43
22	42
23	36
24	25
25	42
26	41
27	42
28	41
29	42
30	43
31	42

Appendix-H

Promotions per year for 40-year run

	Promotions from rank 2 to 3
Year	Number of Officers Promoted
1	50
2	46
3	50
4	58
5	57
6	72
7	71
8	61
9	42
10	71
11	71
12	71
13	71
14	71
15	71
16	71
17	71
18	71
19	71
20	71
21	71
22	71
23	71
24	71
25	71
26	71
27	71
28	70
29	69
30	70
31	70
32	70
33	70
34	27
35	70
36	70
37	70
38	70
39	70
40	70

	Promotions from rank 3 to 4
Year	Number of Officers Promoted
1	58
2	58
3	69
4	57
5	52
6	60
7	46
8	61
9	51
10	54
11	54
12	67
13	66
14	57
15	39
16	66
17	66
18	66
19	66
20	66
21	66
22	66
23	66
24	66
25	66
26	66
27	66
28	66
29	66
30	66
31	66
32	66
33	66
34	33
35	32
36	33
37	33
38	24
39	64
40	64

	Promotions from rank 4 to 5
Year	Number of Officers Promoted
1	4
2	25
3	36
4	44
5	40
6	48
7	34
8	49
9	43
10	44
11	40
12	50
13	54
14	45
15	27
16	53
17	53
18	53
19	53
20	52
21	53
22	53
23	53
24	53
25	53
26	53
27	53
28	53
29	53
30	53
31	53
32	53
33	53
34	43
35	36
36	39
37	41
38	45
39	32
40	47

	Promotions from rank 5 to 6
Year	Number of Officers Promoted
1	18
2	22
3	24
4	19
5	19
6	18
7	28
8	37
9	42
10	32
11	42
12	47
13	37
14	34
15	39
16	30
17	40
18	33
19	35
20	35
21	43
22	43
23	37
24	25
25	42
26	42
27	42
28	42
29	42
30	42
31	42
32	42
33	42
34	43
35	41
36	42
37	41
38	42
39	42
40	43

Appendix-I

Full results of the Current System for 10 years.

Year	Rank	Total Force Inv. (TXr)
1	1	185
1	2	369
1	3	372
1	4	210
1	5	79
1	6	138
2	1	185
2	2	391
2	3	367
2	4	226
2	5	74
2	6	153
3	1	223
3	2	386
3	3	363
3	4	259
3	5	76
3	6	166
4	1	223
4	2	372
4	3	342
4	4	285
4	5	77
4	6	165
5	1	223
5	2	385
5	3	338
5	4	282
5	5	99
5	6	160
6	1	223
6	2	382
6	3	334
6	4	271
6	5	93
6	6	134

Year	Rank	Total Force Inv. (TXr)
7	1	223
7	2	381
7	3	342
7	4	278
7	5	97
7	6	144
8	1	223
8	2	380
8	3	363
8	4	258
8	5	105
8	6	170
9	1	223
9	2	389
9	3	358
9	4	248
9	5	160
9	6	151
10	1	223
10	2	417
10	3	356
10	4	287
10	5	105
10	6	188

Appendix-J

Full results of the Current System for 31 years.

Year	Rank	Total Force Inv. (TXr)
1	1	184
1	2	378
1	3	366
1	4	259
1	5	78
1	6	128
2	1	194
2	2	384
2	3	362
2	4	279
2	5	78
2	6	137
3	1	223
3	2	372
3	3	342
3	4	300
3	5	85
3	6	135
4	1	223
4	2	385
4	3	340
4	4	300
4	5	105
4	6	133
5	1	223
5	2	452
5	3	340
5	4	273
5	5	95
5	6	126

Year	Rank	Total Force Inv. (TXr)
6	1	223
6	2	381
6	3	342
6	4	278
6	5	97
6	6	144
7	1	223
7	2	380
7	3	363
7	4	258
7	5	105
7	6	170
8	1	223
8	2	389
8	3	358
8	4	248
8	5	160
8	6	151
9	1	223
9	2	417
9	3	356
9	4	287
9	5	105
9	6	188
10	1	223
10	2	417
10	3	356
10	4	287
10	5	105
10	6	188

Year	Rank	Total Force Inv. (TXr)
11	1	223
11	2	488
11	3	352
11	4	224
11	5	97
11	6	219
12	1	223
12	2	487
12	3	351
12	4	244
12	5	88
12	6	238
13	1	223
13	2	486
13	3	350
13	4	249
13	5	124
13	6	230
14	1	223
14	2	486
14	3	359
14	4	254
14	5	116
14	6	243
15	1	223
15	2	485
15	3	385
15	4	239
15	5	123
15	6	238
16	1	223
16	2	484
16	3	385
16	4	263
16	5	68
16	6	276

Year	Rank	Total Force Inv. (TXr)
17	1	223
17	2	483
17	3	452
17	4	195
17	5	84
17	6	278
18	1	223
18	2	482
18	3	452
18	4	199
18	5	97
18	6	273
19	1	223
19	2	481
19	3	451
19	4	210
19	5	143
19	6	222
20	1	223
20	2	481
20	3	451
20	4	236
20	5	119
20	6	232
21	1	223
21	2	480
21	3	407
21	4	236
21	5	118
21	6	275

Year	Rank	Total Force Inv. (TXr)
22	1	223
22	2	479
22	3	407
22	4	293
22	5	69
22	6	275
23	1	223
23	2	479
23	3	406
23	4	295
23	5	93
23	6	269
24	1	223
24	2	478
24	3	406
24	4	294
24	5	95
24	6	275
25	1	223
25	2	478
25	3	406
25	4	294
25	5	148
25	6	236
26	1	223
26	2	477
26	3	406
26	4	293
26	5	147
26	6	247

Year	Rank	Total Force Inv. (TXr)
27	1	223
27	2	427
27	3	405
27	4	292
27	5	145
27	6	289
28	1	223
28	2	427
28	3	405
28	4	291
28	5	144
28	6	291
29	1	223
29	2	427
29	3	405
29	4	291
29	5	145
29	6	212
30	1	223
30	2	427
30	3	405
30	4	291
30	5	145
30	6	300
31	1	223
31	2	427
31	3	405
31	4	291
31	5	144
31	6	317

VITA

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