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ABSTRACT

This report presents the conceptual design of a computer-based linear programing model of the Air Force officer procurement system called TOPOPS. The TOPOPS model is an aggregate model which simulates officer accession and training and is directed at optimizing officer procurement in terms of either minimizing cost or maximizing accession quality over a five-year time frame. Optimization is constrained by total production requirements by officer type (e.g., pilot, navigator, etc.), a number of policy restrictions, and the specific characteristics of the various commissioning sources and training programs (including attrition rates and career turnover). The report also contains a simplified mathematical description and hypothetical sample problem. Completed data input forms and the five computer-generated reports for the sample problem are presented in the appendix. (Author)

AFHRL-TR-73-73

AIR FORCE HUMAN RESOURCES LABORATORY

A CONCEPTUAL VIEW OF THE OFFICER PROCUREMENT MODEL (TOPOPS)

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AIR FORCE SYSTEMS COMMAND
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This technical report has been reviewed and is approved.

THEODORE B. ALDRICH, Chief
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HAROLD E. FISCHER, Colonel, USAF
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The Air Force officer procurement system is defined to include three stages: the Supply of officer applicants, the Production of commissioned officers, and the Training of commissioned officers for various assignments.

This report presents the conceptual design of a computer-based linear programming model of the Air Force officer procurement system called TOPOPS. The TOPOPS model is an aggregate model which simulates officer accession and

Item 20. (Continued)

training and is directed at optimizing officer procurement in terms of either minimizing cost or maximizing accession quality over a five-year time frame. Optimization is constrained by total production requirements by officer type (e.g., pilot, navigator, etc.), a number of policy restrictions, and the specific characteristics of the various commissioning sources and training programs (including attrition rates and career turnover). The report also contains a simplified mathematical description and a hypothetical sample problem. Completed data input forms and the five computer-generated reports for the sample problem are presented in the Appendix.

PREFACE

This report is one of four reports prepared under a contract study entitled "Development of an Operational Model of the Officer Procurement System (TOPOPS)," #F41609-72-C-0042, conducted by System Automation Corporation, Silver Spring, Maryland. Mr. Allan Akman was the Principal Investigator for the study. Mr. Alfred Rubin and Mr. Mike Regardie, of System Automation Corporation, provided extensive support for this research effort. Lt James F. Roach, Manpower and Personnel Systems Division, made a major contribution to the revision of this report.

This research was conducted under Project 2077, Personnel and Manpower Management Systems Development, Task 207703, Computer-Based Models of the Air Force Personnel Subsystem. Maj Fred Nordhauser served as Contract Monitor for the Laboratory.

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INTRODUCTION - OVERVIEW OF THE TECHNICAL REPORT

A. Overview

This Technical Report has been prepared to document the conceptual design of the TOPOPS[1] model. The model was designed in response to a need by Air Force planners to have some analytical tools available to assess the impact of alternative procurement decisions on the costs of procurement as well as on the quality of officer candidates entering the Air Force.

This technical report consists of three sections and a set of appendices which describe the TOPOPS programming system and present sample TOPOPS input and output reports.

Chapter I highlights in summary form the principal features incorporated by the model.

Chapter II presents a detailed description of the conceptual framework used in developing TOPOPS. The concept was developed as a result of numerous discussions with Air Force personnel and reflects an effort to develop a systematic definition of the officer procurement process.

Chapter III describes in general terms the TOPOPS mathematical model. The description tends to be non-technical to the extent that describing a linear program can be. A detailed mathematical exposition is included in a second technical report, AFHRL TR73-76, "A Technical Description of the Officer Procurement Model (TOPOPS)".

B. Purpose of Project

The purpose of this effort was to design and develop an officer procurement model called TOPOPS which can be used in establishing optimal procurement schedules in terms of costs and entry-level quality.

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[1]The acronym TOPOPS stands for: Total Objective Plan for the Officer Procurement System

C. Basic System Concept

The fundamental concept which lies behind the design of TOPOPS is an overall systems concept of officer procurement. As reflected in the TOPOPS model design, the procurement system is viewed in terms of three major stages. These stages are the supply, production, and training stages.

The supply stage is the beginning point in the process. We consider that there are supply pools from which the commissioning sources can recruit men. The size and characteristics of the supply pools are influenced by any factors. Such factors as unemployment rates and the attitudes of youth are generally beyond the control of the Air Force. Air Force controlled factors include physical, mental, and moral standards, pay and allowances, fringe benefits, recruiting effort and advertising.

The production stage is the phase of the process in which officer candidates are prepared for commissioning. The major operating units composing the production stage are Air Force Reserve Officer Training Corps (AFROTC), Officer Training School (OTS), and the United States Air Force Academy (USAFA). These are referred to as commissioning sources.

The final stage in the procurement process is the post-commissioning training stage. The procurement requirements which Air Force planners attempt to fill are generally in terms of pilots, navigators, and non-rated officers. The officer commissioned in the production stage usually must enter undergraduate pilot/navigator training and various specialty schools in order to meet Air Force procurement requirements. However, some commissioned officers are assigned directly to duty and bypass this stage.

To complete the entire procurement program from initial recruitment to final training may take as long as five years. Therefore, as the model focuses on a five-year time horizon in order to meet the procurement requirements in any one year, a schedule over the five preceding years must then be determined.

D. Minimizing Production Costs

TOPOPS can be operated in the cost minimization mode. The cost which is being minimized is the total program cost to meet the five year procurement requirements.

Most simply stated, the total costs are determined as a function of pay and allowances and other costs during the production and training stages. Since these costs are significant in the short-run and the procurement decisions have long run effects on the officer force in terms of personnel replacement, the cost function used in the model is modified by the turnover rates (the number of times an officer must be replaced in a twenty year time frame) for the various commissioning sources. While this technique distorts the cost function as a measure of the short-term cost, it creates a more effective allocation mechanism. In particular, it assures us that certain commissioning sources having higher costs but lower long term turnover are competitive with lower cost sources.

E. Maximizing Entry-Level Officer Quality

TOPOPS can also be operated in a quality maximization mode. Definition of an operational concept of quality has been considerably more difficult than the development of a cost concept. We do not have any comprehensive definition but have developed a concept based on a number of existing practices used by Air Force planners in addressing quality.

The basic design objective in dealing with quality has been to identify a measure which would result in officers entering the force with a higher probability of success than otherwise would be the case. The following two features have been incorporated into the TOPOPS model for this research effort.

1. The basic measure of quality used in TOPOPS is the average AFOQT score. The objective then when maximizing quality is to maximize the average AFOQT score of the entering officer candidates. To allow candidates with lower scores to enter the force there are a series of constraints which result in a distribution of men by AFOQT scores.

2. To broaden the quality concept beyond AFOQT scores, the TOPOPS model allows for a number of other features which relate to other aspects of quality. These include minimum production requirements from all of the commissioning sources and the capability to define supply pools in terms of physical, mental, and educational standards which also have bearing on quality.

We have been careful to qualify our approach to quality in terms of what is known and what we could readily accomplish. The model is structured to use other operational concepts or measures of quality. When developed they can easily be integrated into the model.

F. Formulating TOPOPS as a Linear Program

TOPOPS has been formulated as a linear programming model. As indicated in D and E above, there is a choice of objective functions. The analyst can either minimize costs or maximize quality. In each case, a procurement schedule for officer candidate procurement is generated which achieves the objective while satisfying various operating constraints. There are basically five sets of constraints.

First, there is a set of quality distribution constraints. These constraints assure that men having a range of AFOQT scores are allowed to enter the force. This accounts for a design weakness in terms of our dependency on a test score to measure quality; it allows some portion of men with lower scores to enter the force on the assumption that there are other attributes not implied by the AFOQT score which result in a high quality force.

Second, there is a series of program budget constraints. These constraints limit the expenditures for procurement to budget levels which may exist as a result of Congressional action or internal Air Force policy.

Third, there are a set of supply constraints. With these constraints the analyst can specify from which supply pools the various procurement sources can draw their officer candidates.

Fourth, there is a set of requirements constraints which specify for each type of officer what the requirements are for each of the five years in the time horizon.

Fifth, there is a set of selective procurement and recruitment constraints which assures that each commissioning source will supply some minimal level of officers to meet the annual requirements and have the ability to draw candidates from certain supply pools.

The model has been formulated in the most general way so that the analyst is allowed considerable freedom in defining the nature of the commissioning sources and other operating characteristics. If he chooses he can assume the system operates as is today; in that case the data base reflects current operating policy and characteristics.

Alternatively, he can redefine the operating factors. In this regard, there are potentially twenty supply pools, five different types of officers, a five-year time horizon, and ten commissioning sources. The flow patterns between these factors are flexible as well; the analyst can indicate whatever patterns he wishes. In other words, TOPOPS is generalized so that many different procurement problems can be analyzed.

G. The TOPOPS Computer System

A convenient way to close this summary is to tie all these features together in the overall computer system framework which has been developed.

The logical structure of the TOPOPS programming section consists of three modules. Each module is a self-contained routine satisfying basic functional requirements of the computer program system.

The first module is labeled the Data Initializer (DI). The DI serves as the interface between the user and the system. It is designed to allow the user to specify his procurement problem in terms with which he is relatively familiar. The routine translates these specifications into a format which is consistent with the requirements of the UNIVAC 1108 linear programming package.

The second module is the linear program routine, which is based on the UNIVAC 1108 Linear Programming System.

The final module is a Report Processor. This module uses the linear program outputs to generate a series of five reports for use by the analyst. The Report Processor also reduces the necessity for the analyst to be familiar with the standard linear program output formats generated by the package. The reports which the system generates for each problem include the following:

Annual Procurement Schedule
Aggregate Cost Estimates
Cost Analysis
Officer Quality Profile
Procurement Policy Analysis

II.

OFFICER PROCUREMENT: A CONCEPTUAL FRAMEWORK

A. Introduction

The purpose of this section is to describe the concepts used in formulating the TOPOPS officer procurement model. These concepts were based on a review of Air Force officer procurement policy and are designed to represent the major features of the officer procurement system.

B. Conceptual Overview

The basic concept that is embodied in the model is that the Air Force has both quantitative and qualitative procurement requirements for line officers; in order to meet those requirements there is a training and screening system through which potential officers are processed. During the course of the processing, which may last as long as five years, there is a steady process of qualification and elimination. To meet the procurement requirements for rated and non-rated officers there are a series of intermediate requirements which must be met. The manpower pool is trimmed down to meet successively recruitment, training, and finally, procurement requirements (see Figure 1).

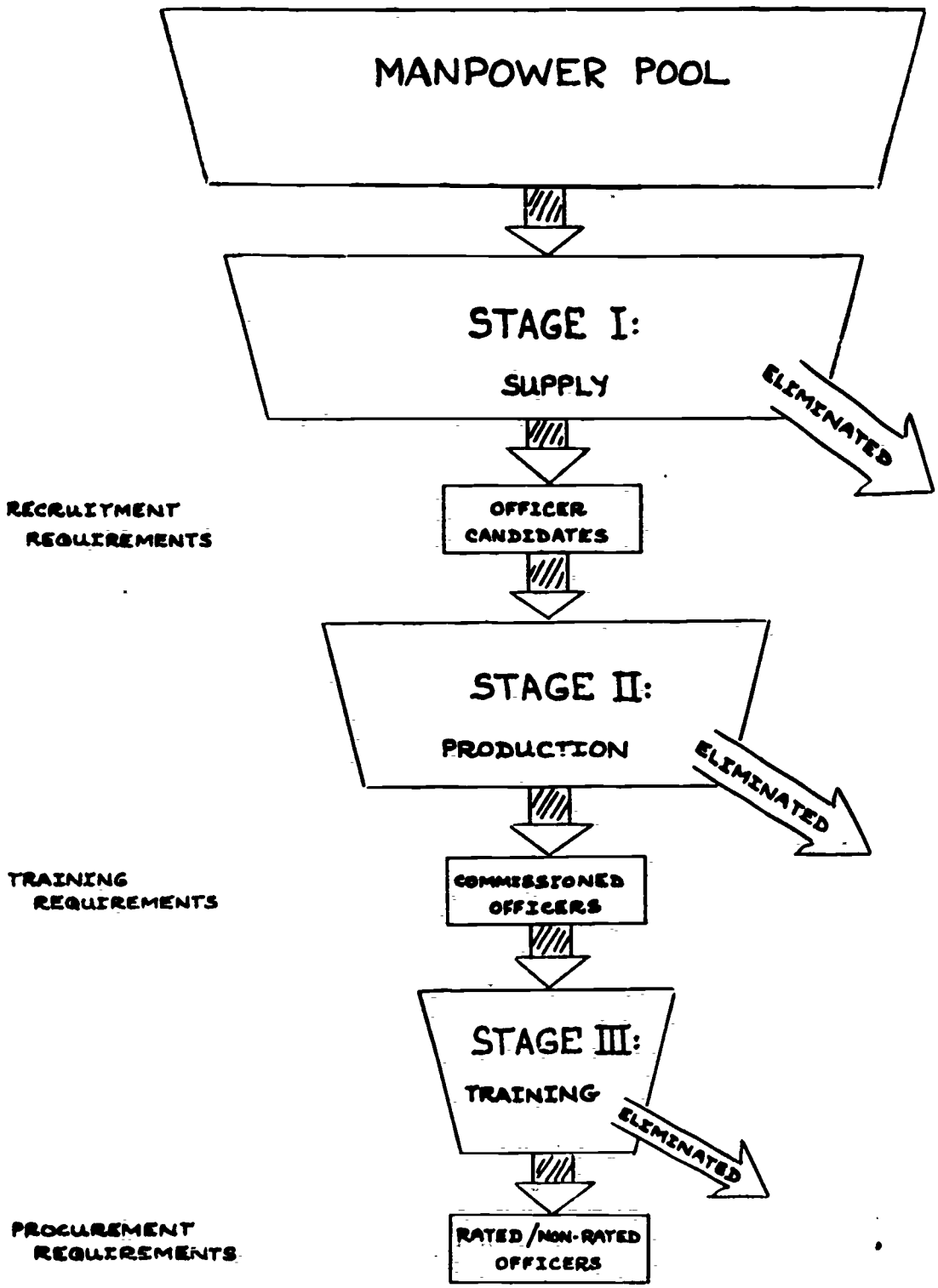
The conceptual framework, which reflects this qualification process and which is used in developing TOPOPS, involves three-stages. Figure 1 portrays the system concept and its three stages: supply, production, and training.

The first stage is the supply stage in which officer candidates are selected from a manpower pool. The manpower pool available to the Air Force depends on socio-economic characteristics of the general population, the Air Force entrance standards, and motivational factors such as incentive pay, subsistence and pay, and allowance. Recruitment requirements are the number of officer candidates which must enter the production stage at various times in order to meet eventually the procurement requirements.

Figure 1

OFFICER PROCUREMENT

- A Conceptual Framework -



The second stage is the production stage. Its purpose is to prepare officer candidates through the commissioning source programs. The major programs as already noted include AFROTC, OTS and the United Stages Air Force Academy (USAFA). During the time in which officer trainees are in these programs men are selected for pilot, navigator and non-rated training. The number of people entering this stage is generally greater than the number which quality to continue.

The production objective of this stage is to meet the training requirements. These are the numbers of officers which must enter the various training programs in order to fulfill procurement requirements.

In the last stage, the training stage, commissioned officers usually enter one of the three basic programs; undergraduate pilot training (UPT), undergraduate navigator training (UNT), or technical training schools, or direct duty assignments. As before, a certain number of officers do not successfully complete the programs that they begin; where possible, those officers who are not pilot or navigator-qualified are shifted into non-rated specialities to the extent that opportunities exist. Therefore, there is substantial cross-flow from UPT to UNT and the technical schools. The objective of this stage is to train sufficient officers to meet the procurement requirements, such as those specified by TOPLINE.

If effective planning has preceded the actual processing of candidates through the procurement system then the number of officers successfully trained should satisfy the procurement requirements. However, because the leadtime of the various commissioning sources ranges from twelve weeks to four years for those who enter two of the three basic programs (UPT and UNT) it is difficult in practice to meet the precise needs at any particular time. To provide some flexibility around the AFROTC and USAFA relatively long leadtimes, OTS, with its relatively short leadtime, is sometimes used as a shortfall commissioning source.

Figure 2 shows the estimated numbers of candidates and officers processed through the system in order to meet FY 1971 procurement requirements. The requirements imply specific levels of UPT/UNT training during the previous year. The diagram shows that the total number of commissioned officers receiving training is larger than the

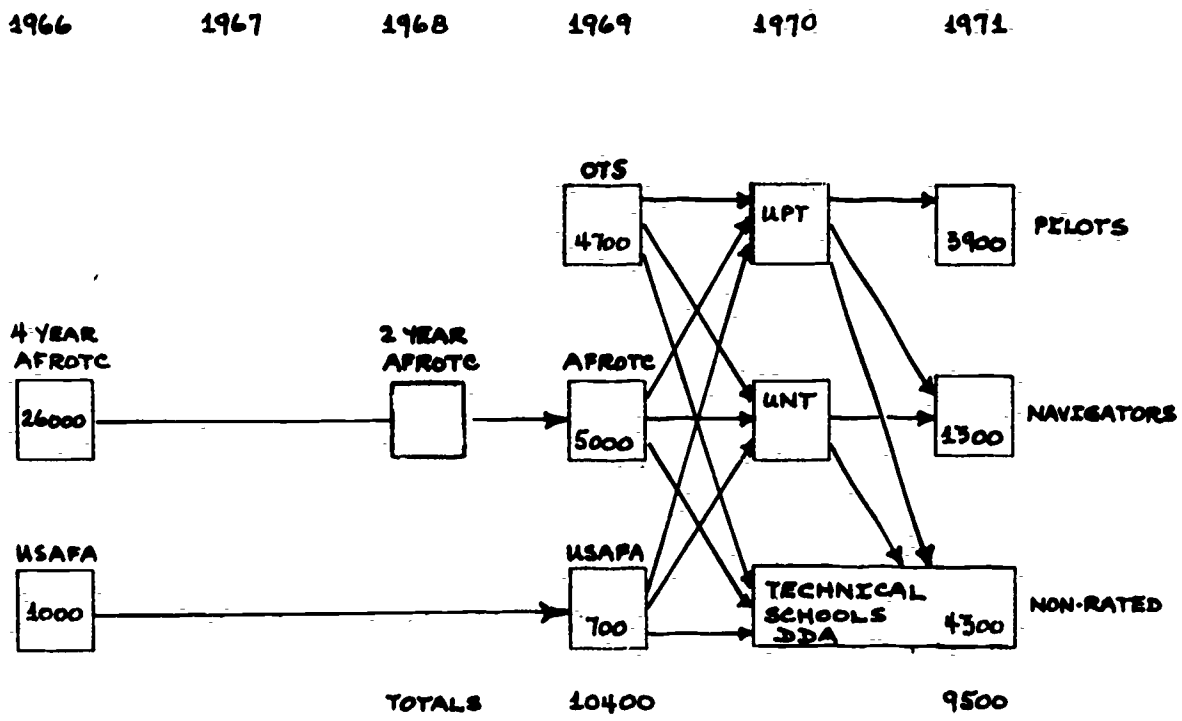
level of production significantly larger numbers of recruits must enter the system in prior years.

Let us now turn to a more detailed discussion of each of the stages and the problem of quality.

Figure 2

PROCUREMENT PATTERN

To produce 9500 line officers in FY 1971



C. Stage I: Supply

A basic concept adopted in the TOPOPS model is that the general manpower pool is divided into civilian and airmen components which are in turn decomposable into a set of eligibility pools from which the various commissioning sources draw. Their ability to attract officer candidates is dependent upon such factors as incentives, pay, and allowances. In terms of TOPOPS, the analyst specifies the size of the supply pools.

Figure 3 illustrates the composition of the general manpower pool as well as the relationship of the eligibility pools to the major commissioning sources. Following is a discussion of the general manpower pool, the eligibility pools, and supply.

1. General Manpower Pool. As indicated above, the general manpower pool consists of two components, civilian and airmen. With minor exceptions, the civilian manpower pool from which officer candidates are drawn in any year consists of males ages 18 to 26. In the past officer candidates might have been recruited from draft eligibles, deferred college students, and college graduates.

The airmen pool consists of the Air Force enlisted men who meet specific eligibility requirements of the different commissioning programs. These programs offer opportunity to enlisted men to earn baccalaureate degrees and become commissioned officers. Although this is a relatively specialized set of programs, it represents an important source of future officers particularly in view of the career commitment made by participants.

Table 1 shows the estimated size of these pools during the 1965-70 time period.

2. Supply Pools. The size of supply pools are dependent principally upon Air Force standards. At the present time, the general academic requirement for commissioned line officers is a baccalaureate degree. The pools are further restricted by physical, mental, moral and additional academic standards. The screening based on these various standards determines the size of supply pools.

Figure 3

Manpower Supply

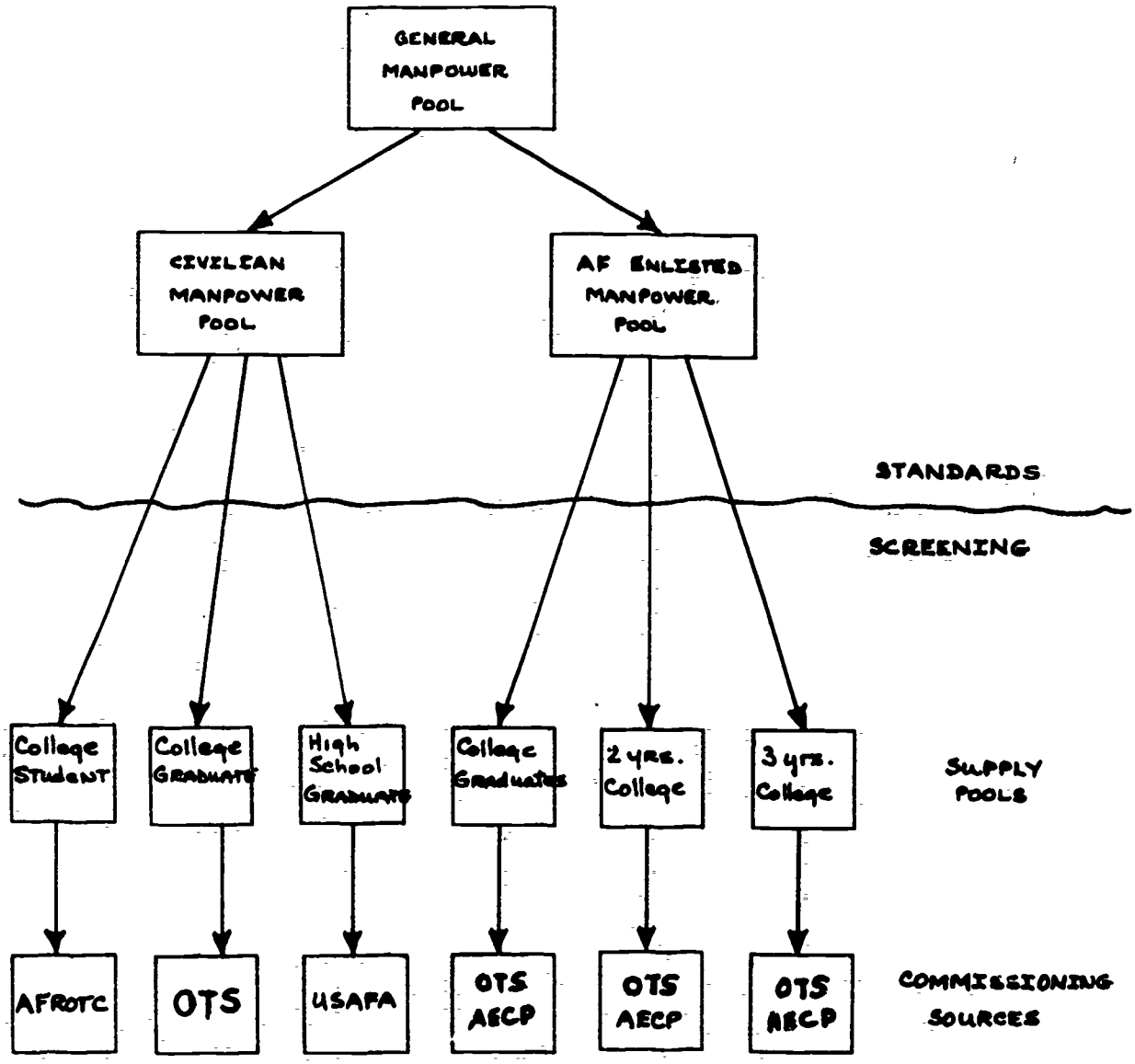


Table 1

THE GENERAL MANPOWER POOL
1965-1970

	Draft Eligible[1]	Student Deferred[1]	Earned Bachelor's Degree[2]	Air Force Enlisted[3]
1970	2,596	1,746	--	662
1969	1,468	2,261	447	727
1968	1,446	2,200	393	765
1967	1,412	2,221	355	762
1966	1,165	2,084	331	756
1965	1,485	2,212	320	692

(Numbers in Thousands)

Source:

1. U. S. Selective Service System, National Headquarters, unpublished data
2. U. S. Office of Education, Earned Degrees Conferred, 1965-1970
3. U. S. Office of Management and Budget, The Budget of the United States, 1965-1970.

Where a particular commissioning source has a specialized set of standards, its pool of available manpower is unique to it. It will be possible for the supply pools of several commissioning sources to overlap with one another.

3. Supply of Manpower. The ability of a particular commissioning source to attract a sufficient number of applicants from the supply pools to satisfy its entrance requirements is dependent upon numerous factors. Some are controllable by the Air Force while others are not.

With respect to the latter, the Air Force is one among many competitors for manpower out of the civilian manpower pool. Its ability to recruit is affected by such factors as the degree of national emergency, the unemployment rate among members of the supply pools, their income levels, and the prevailing attitudes of society toward military service.

Factors which the Air Force can more directly control and which also affect the ability to attract officers from the supply pools include such items as career and training opportunities, levels of pay, and fringe benefits.

4. Implications for TOPOPS Design. Regardless of the number of line officers which must be procured, the Air Force can potentially always fill its requirements. This could require modifying standards drastically and/or revising incentives to increase the size of the supply pools.

This means that the supply from the pool can potentially be made large enough to meet requirements. In terms of the TOPOPS model, however, the supply of officer applicants will be constrained to more closely conform to the existing procurement situation. The design of the model allows additional manpower to be drawn into the procurement process to preclude indeterminate solutions. This additional manpower is treated separately and costs are associated with these normally ineligible applicants.

An additional consideration with respect to future model development is that estimating relationships can be incorporated to specify supply constraints. Such techniques may result from the RAND officer procurement project or other research efforts now underway.

D. Stage II: Production

The Production Stage is the major phase of the procurement process modeled in the linear programming algorithm of TOPOPS. This stage models the commissioning process carried on by the various commissioning sources such as AFROTC, OTS, and USAFA. While TOPOPS has been generalized to handle up to ten commissioning sources, we are specifically dealing with seven[2] major sources which currently provide the bulk of the commissioned officers and encompass the present range of choices faced by Air Force personnel planners. These include the following:

AFROTC - 2 Year Program
AFROTC - 4 Year Program
OTS - Non-Prior Service (NPS)
OTS - Airman Education and Commissioning Program (AECP)
OTS - Airman Education and Commissioning Program (AECP)
OTS - Airman Education and Commissioning Program (AECP)
United States Air Force Academy - (USAFA)

The Production Stage is constrained both on the input and output side. The input constraints are the manpower supplies available to each commissioning source. On the output side, the constraint is the production requirements which the commissioning sources must meet in order to provide sufficient numbers of commissioned officers for advanced training.

Since there are basically seven commissioning sources feeding into the three requirements (i.e. pilot, navigator, and non-rated), Air Force personnel planners have a wide range of discretion with respect to how many candidates are drawn from which sources to satisfy the three requirements. Since procurement costs as well as the prospective quality of the officer force are dependent upon these allocation decisions, being able to estimate the impact both in the short-run and long-run is important. TOPOPS provides insight into the nature of these allocation decisions.

In the discussion that follows, we will focus attention on the flow of personnel through this stage, the structural and operating characteristics of the major commissioning sources, and the cost concepts which will be used in TOPOPS.

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[2] other delineations of the commissioning sources may be specified by the user.

1. Officer Flow. The principal operating units in the Production Stage are the commissioning sources. A commissioning source is an organization which acquires officer candidates based on various standards, admission criteria and production quotas, provides basic and general officer orientation and training, and at the conclusion of its programs provides commissioned officers for entry into the Training Stage.

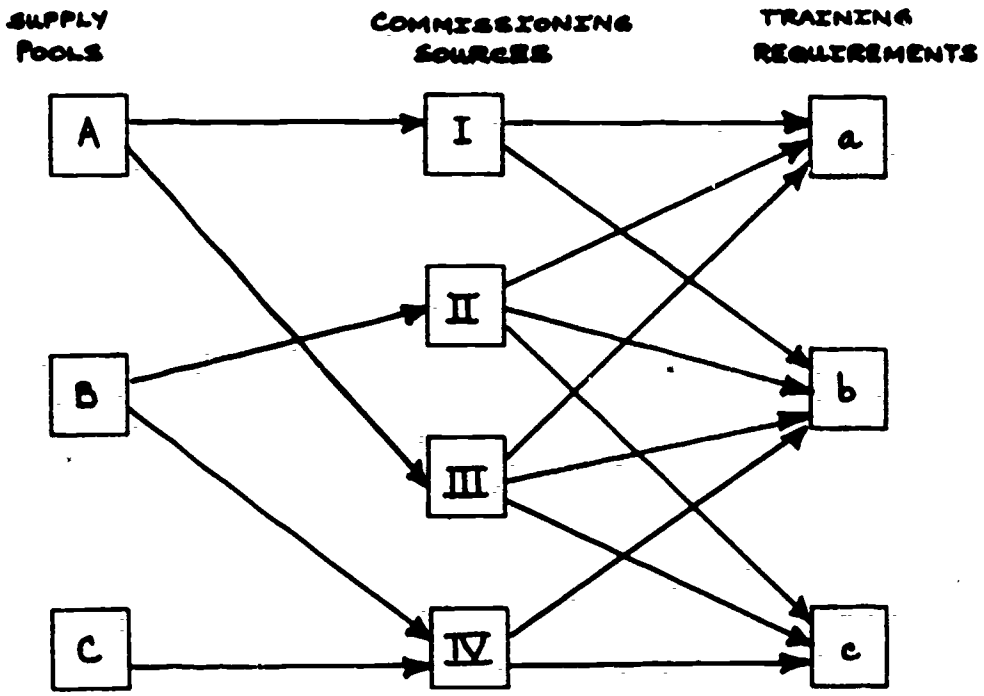
In its simplest form, the flow would involve one supply source feeding one commissioning source supplying one training requirement. However, in keeping with reality and the generalized approach to the TOPOPS design, the flow must be conceived in terms of multiple supply sources providing numerous commissioning sources officer candidates on an exclusive or joint basis. Further, the various commissioning sources produce commissioned officers to satisfy various training requirements.

Figure 4 illustrates the generalized officer flow in the Production Stage. TOPOPS will actually have the capacity to handle twenty supply pools, ten commissioning sources, and five officer type requirements.

2. Major Officer Commissioning Sources. While there are more than seven commissioning sources, we will concentrate only on those seven which represent the major sources of commissioned officers and provide the greatest range of discretion as far as personnel planners are concerned. Such sources as direct appointment, interservice transfers, and other military academies provide some officers but on such a limited basis and under such special circumstances that they do not in themselves represent a major alternative source of officers either on an individual or joint basis.

Figure 4

OFFICER FLOW



SAMPLE SCHEMATIC FORM

The seven major commissioning sources for which TOPOPS has been tested include the following:

AFROTC - 2 Year Program
AFROTC - 4 Year Program
OTS - NPS
OTS - AECP
OTS - AECP
OTS - AECP
USAFA

Again, because of the generalized nature of the model the analyst is in no way restricted to these specific commissioning sources.

3. Costing Concepts. The basic costing concept used in TOPOPS is program cost. This cost is incurred directly and indirectly from the time an officer candidate enters a commissioning source to the time he completes his technical training. "Cost per graduate" factors for the production and training stages are used to estimate program costs. These per-unit cost factors include both direct and indirect costs as well as account for an attrition rate.

Several extensions of the basic cost concept have to be made in order to achieve an appropriate program cost function for TOPOPS.

First, production cost by its very nature is not a comprehensive measure of the costs of a particular set of procurement decisions. Because these decisions have long-run implications which do not show up until years later, focusing strictly on production costs as an objective function in an optimization model can result in a suboptimization. While it is beyond the scope of this effort to delve extensively into the long-term effects of procurement decisions, the cost function can, however, be modified to reflect the costs of replacement at some point in the future. Therefore, if a commissioning source produces officers whose average career length is short, its cost function in the short run can be penalized to reflect this eventuality. We use twenty-year turnover rates for this purpose.

Table 2

OFFICER PRODUCTION COSTS
FY 1968

	OTS	AFROTC	USAFA
Operations and Maintenance	$14.0	$3.4	$21.9
Military Pay & Allowances	$5.1	$19.2	$21.3
Reserve Pay & Allowances		$9.2	
Other	$1.2	$2.5	
Total Cost	$20.3	$34.2	$43.2
Total Graduates	6700	5700	612
Cost Per Graduate	$3000	$6000	$70,000

(Millions of Dollars except 'Total Graduates' and 'Cost Per Graduate')

Source:

The RAND Corporation, "The Pilot Training Study", Memorandum RM-6082-PR, December 1969.

Second, as already noted in the description of officer flow, procurement for any one year involves decisions made and training programs conducted over the preceding four or five years. The production costs minimized by TOPOPS are the program costs incurred to meet procurement requirements. The cost function is not time-phased, however, to represent annual budget costs but aggregated to equal total program costs.

Turning to existing cost data, Table 2 shows costs for FY 1968. As can be seen the costs are broken down into three major appropriation categories: (1) Operations and Maintenance (O & M), (2) Military Pay and Allowances (MPA), and (3) Reserve Pay and Allowances (RPA). The first two apply to all three major procurement programs; however, the last (RPA) applies only to AFROTC which is a reserve program.

The major cost factors of interest to Air Force personnel analysts include military pay and allowances, scholarships, and subsistence. These are the controllable cost factors which most directly influence the supply of manpower to the commissioning sources.

The costs in Table 2 represent estimates of accounting or budget data. To develop an operational cost measure compatible with the TOPOPS cost concept, two modifications have to be made.

First, the model will be focusing on future years, not the past. Therefore, the existing data represent only basic benchmarks from which estimates must be made of the future costs. Second, the TOPOPS cost function involves several basic cost elements which will allow the analyst to reflect alterations in the incentive programs as well as changes in the operating characteristics of the commissioning sources.

4. Implications for TOPOPS. Figures 5a and 5b portray two important aspects of the TOPOPS model. First, the linear programming algorithm of TOPOPS focuses on the production stage (Figure 5a). Based on the procurement requirements, a set of training requirements are determined. These represent the total numbers of rated and non-rated officers that should be produced by the commissioning sources. The commissioning sources in turn acquire their candidates from the various supply pools. Then the optimization algorithm establishes the number of officer candidates for each commissioning source in the production stage. The specific supply constraints as well as the production and training requirements are determined by the user via the Data Initializer module.

Figure 5a

PRODUCTION STAGE

Linear Programming Algorithm

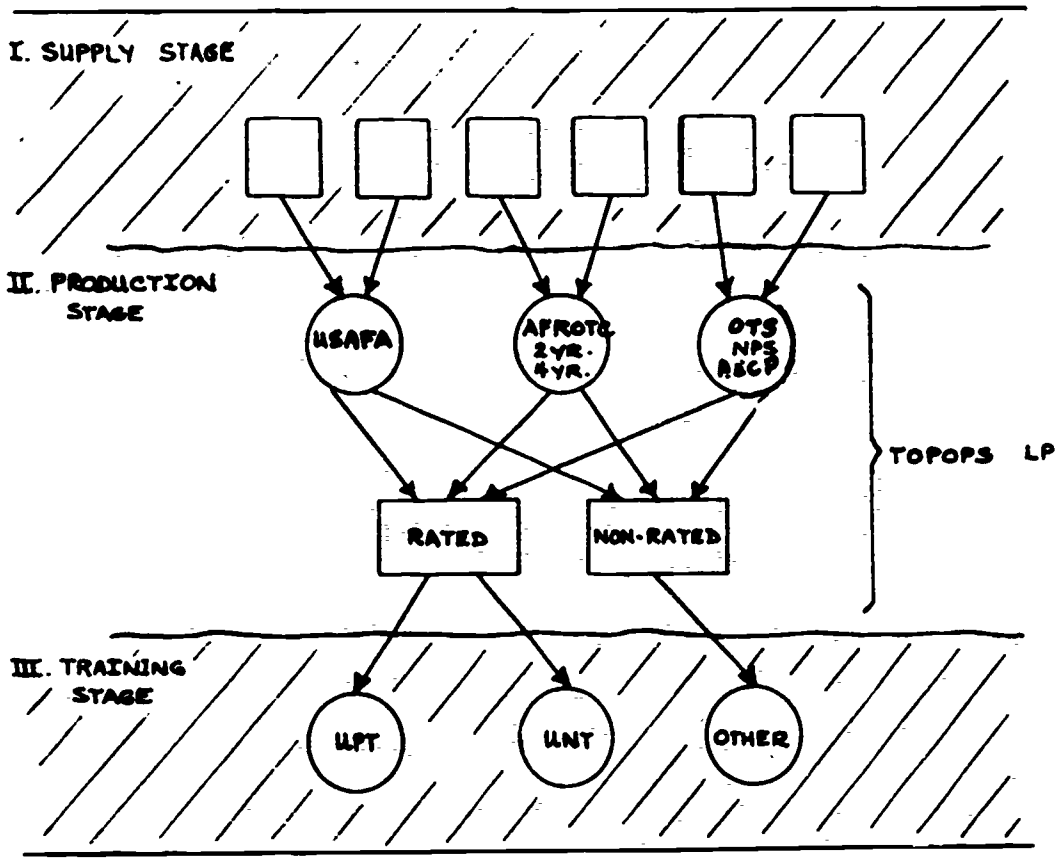
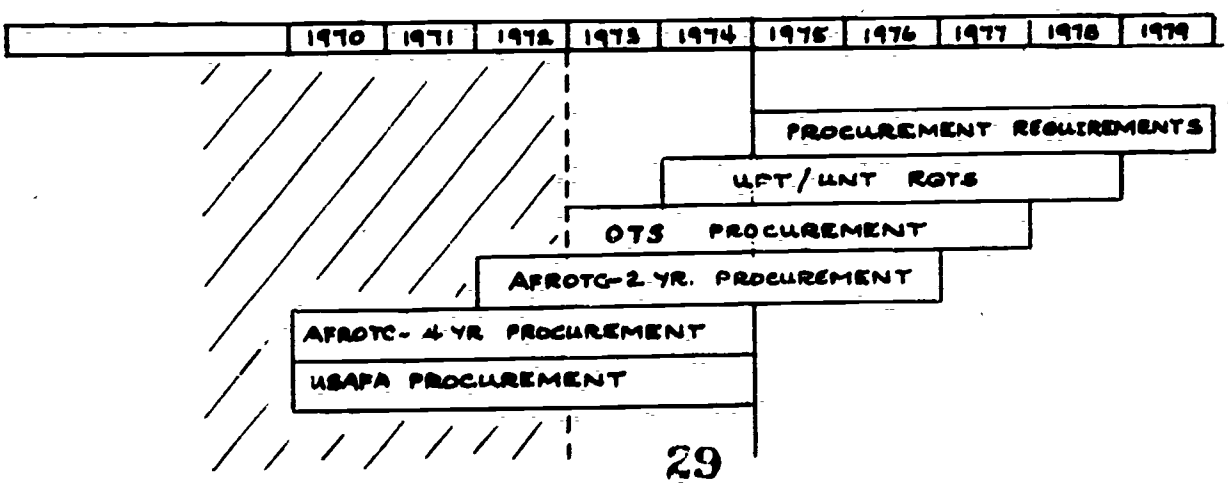


Figure 5b

PRODUCTION STAGE

Time-Phasing Pattern



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Second, Figure 5(b) shows that the procurement decisions for any one year are staggered over the five previous years. For example, if the model is to solve for procurement for the 1975-79 period, a series of procurement decisions stretching back to the year 1970 will result. For example, in 1973 the solution will be constrained by the decisions already made in the years 1970-72.

E. Stage III: Training Stage

This final stage in the procurement process trains commissioned officers within special skills such as pilots, navigators, meteorologists and computer scientists. The importance of this stage for TOPOPS lies in the operation of its training programs and their output of rated and non-rated officers which are directed at meeting the procurement requirements.

The procurement requirements, such as those specified by TOPLINE, for pilots, navigators and non-rated officers represent the final output of the procurement process. For purposes of TOPOPS, these numbers must be translated back into training requirements for rated and non-rated officers.

The significance of this interpretation is two-fold. First, the training programs such as UPT, UNT and others involve lead times. Therefore, to meet any requirements in one year implies that training had to begin the previous year. Second, as shown in Figure 6, there is a significant amount of crossflow between the schools. For example, those officers failing for various reasons in UPT leave the Air Force, or go to UNT and/or other schools, or are assigned to an Air Force position. Therefore, determining training requirements requires estimating this crossflow.

Figure 6
TRAINING CROSS-FLOW

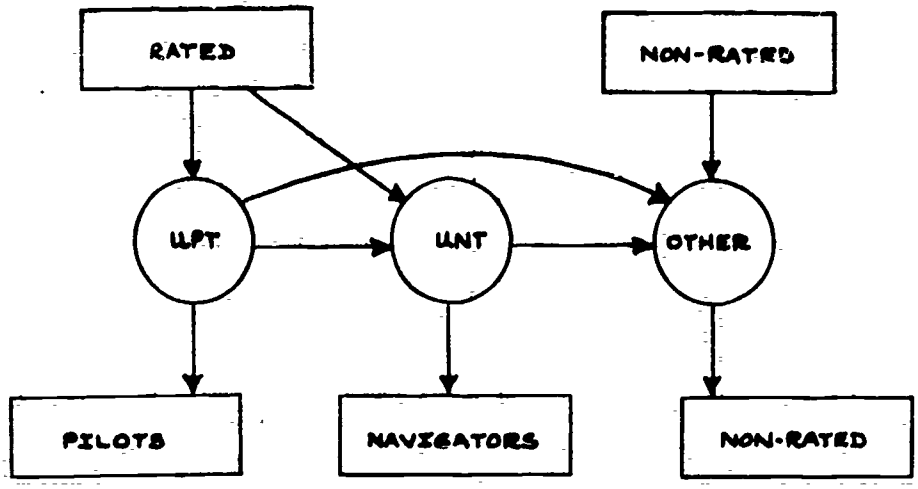


Table 3 also shows data for UPT and UNT in terms of their lead times, attrition rates, and production during the last two years. This type of data is required for determining training requirements as input to the linear programming algorithm.

Table 3

LEADTIME, ATTRITION RATES, AND PRODUCTION FOR UPT AND UNT, FY1971

	FY 1971	
	UPT	UNT
LENGTH (IN MONTHS)	12	9
ENTERED	5295	1496
GRADUATED	3801	1325
ATTRITION RATE	29%	13%

F. Obtaining High Quality in the Officer Force

Quality in the officer force was a major consideration in the development of TOPOPS. Historically, the various commissioning sources have acted quasi-independently in meeting their production goals. Generally, the availability of applicants from the various supply pools was not a major consideration in the establishment of these production goals. If a particular commissioning source did not meet its quota over a period of time, it could be expected that its quota would be adjusted on an ex-post basis.

During the time one particular commissioning source might be struggling to meet its quotas either by drawing supply close to its minimum standards or by adjusting its standards lower, another commissioning source may not even begin to draw from its more qualified manpower supplies. Because these commissioning sources traditionally have operated somewhat independently, the possibility of tradeoffs in procurement from one source to the next has not adequately been addressed.

A major purpose of the TOPOPS model is to provide an analytical framework in which cost and/or quality tradeoffs between commissioning sources can be assessed. One basic problem in accomplishing this is operationalizing the concept of "quality".

Listening to proponents of various operational definitions of quality it is apparent that there is limited consensus with respect to its meaning or its measurement. Nevertheless, the Air Force does address the quality issue in a number of ways; e.g. AFOQT scores, CLEP scores, standardized GPA's, and various selection boards. While we have not developed any alternative method of measuring quality, we provide a means with TOPOPS for personnel analysts to evaluate the effects of procurement decisions on the quality of the officer force at least in similar terms as the Air Force presently handles the problem.

Our approach to operationalizing the concept within TOPOPS involves the following assumptions:

1. Due to limited data, TOPOPS now addresses the measurement of officer candidate quality at the time of their entry into the various commissioning sources.

2. The present method for measuring quality in the TOPOPS context is through the use of AFOQT scores. Based on past research, it is generally believed that officer candidates with higher AFOQT scores will have a greater probability of success than candidates with lower scores.

3. We assume supply pools can be characterized by a distribution of AFOQT scores.

4. The AFOQT is no more than a partial measure of quality and hence, treatment of the quality concept should be extended beyond the use of AFOQT scores.

5. Two means for extending the quality concept used in TOPOPS are the inclusion of selective recruitment and selective procurement. Selective recruitment implies that we recruit officer candidates from different supply pools on the assumptions that some candidates with low scores will make successful officers. A distribution of AFOQT scores rather than simply selecting those with the highest scores will result in a more qualified officer force. Selective procurement is used to insure that all commissioning sources provide at least some minimum proportion of the requirements.

6. An additional means for extending the quality concept is to define the supply pools in terms of parameters other than AFOQT scores. These may include physical, mental, moral, and educational standards.

These, then, are the means for addressing the quality concept in TOPOPS. Although this is not a wholly satisfactory approach, it enables us to model some of the principal procedures used by personnel planners to achieve a quality force.

Until an improved operational concept of quality is developed, the approach mapped out here appears as satisfactory as is possible. We do not regard this approach as "optimizing quality" but as a set of techniques which if used judiciously, raise the probability of achieving a quality officer force.

III.

MATHEMATICAL FORMULATION OF THE TOPOPS MODEL

A. Introduction

The purpose of this chapter is to describe the mathematical formulation of the TOPOPS officer procurement model. This formulation is based on the conceptual framework developed in the preceding chapter and represents the basic mathematical structure of the TOPOPS model. A more detailed formal mathematical treatment is presented in a second technical report entitled "A Technical Description of the Officer Procurement Model (TOPOPS)", AFHRL TR 73-76.

B. Model Overview

The basic mathematical algorithm used for determining optimal procurement strategies takes the form of a linear program. Linear programming is a mathematical technique designed to determine optimal resource allocations by optimizing an objective function subject to various constraints. In this case, we have formulated a model which determines an optimal procurement schedule in terms of costs or entry-level quality subject to various policy and operating constraints.

The general structure of the model appears in Table 4. As shown, there are two objective functions and five sets of constraints. The analyst chooses among these to formulate his problem.

The model provides a choice between two objective functions. The first minimizes total program cost. The other maximizes entry-level quality of officers as measured by average AFOQT scores.

Five sets of constraints are considered. The first set is designed to represent a series of program budget constraints which assure that expenditures for procurement do not exceed specified levels. The second set consists of quality distribution constraints. These constraints are

Table 4

GENERAL STRUCTURE OF TOPOPS MODEL

Model Component	Description	Ref.
Objective	MINIMIZE: Total Production Costs MAXIMIZE: Overall quality of officers produced	III. 1 III. 2
Constraint	SUBJECT TO:	
	Quality Distribution	III. 3
	Annual Budgets	III. 4
	Supply of officer candidates:	
	1. to each commissioning source	III. 5
	2. from each supply pool	III. 6
	Training requirements	III. 7
	Policy and Operating characteristics	
	1. Commissioning Source restriction	III. 8-9
	2. Selective production	III. 10-11
	3. Selective recruitment	III. 12-13

designed to force procurement of officer candidates exhibiting a range of permissible AFOQT scores. The rationale for using this set of constraints is that some men may not score well on the AFOQT, or any other quality measure, but still make excellent officers in certain categories of Air Force skills, or be required to satisfy Air Force policy in given areas.

The other sets of constraints deal with supply, procurement requirements, and policy and operating characteristics of the procurement system. The third set of constraints, supply, reflect limitations on the production of officers resulting from the size of supply pools and the ability of different commissioning sources to recruit men from particular pools. A fourth set, the requirements constraints, specify minimum production levels which must be achieved in order to provide sufficient commissioned officers to meet the procurement requirements established by the Air Force. Finally, the policy and operating constraints reflect limitations in the production capacities of the various commissioning sources as well as explicit policies to assure that certain supply pools and certain commissioning sources provide either minimum or maximum numbers of officers.

TOPOPS solution variables specify optimal procurement schedules. The schedule indicates a mix of commissioned officers of different types produced by the various commissioning sources. The schedule either minimizes cost or maximizes quality while satisfying the various constraints.

C. Statement of the Problem

To describe the mathematical model, we will use a hypothetical problem designed to emphasize its basic structure. While TOPOPS is capable of dealing with officer procurement requirements for five years, five different types of officers, ten commissioning sources and twenty supply pools, the following simple hypothetical problem serves as a description of the model.

Based on long-term plans, the Air Force determines that in 1980, they require 3000 additional rated officers and 1500 non-rated officers. In addition, 4,500 non-rated officers will be needed to fulfill a special program created by a policy change. Thus, the total number of non-rated officers required in 1980 will be 6,000. For simplicity, only two commissioning sources are assumed. Each source may recruit from three supply pools. We want to determine how many officers each source should produce. Using TOPOPS we will formulate a model which will determine

values for:

$$x_{ij}$$

where for non-rated officers i=1 and rated officer i=2. Values for j are 1 and 2 corresponding to the two commissioning sources.

We will solve for four unknown quantities:

x_{11} = non-rated officers produced by source 1

x_{21} = rated officers produced by source 1

x_{12} = non-rated officers produced by source 2

x_{22} = rated officers produced by source 2

Characteristics for each commissioning source and training agency are exhibited in Table 5 and 6 respectively. For example, source 1 has an annual cost per graduate of $5,000.00. Also, ten percent are lost annually through attrition; the program requires two years; in a twenty-year period officers commissioned through this source must be replaced two times; and required minimum and maximum production is 2,000 and 6,000, respectively.

D. Formulating the Objective Function

The personnel analyst using TOPOPS can choose to optimize one of two objective functions. One minimizes total program cost and is formulated as follows:

(III.1)

BASIC TERM	NUMBER PROCURED X (COMMISSIONING COST + TRAINING COST) X TURNOVER
EXAMPLE	MINIMIZE $[X_{11} \times (5000+8000) \times 2] + [X_{21} \times (5000+37000) \times 2]$ + $[X_{12} \times (7500+8000) \times 4] + [X_{22} \times (7500+37000) \times 4]$ OR $26000X_{11} + 84000X_{21} + 62000X_{12} + 178000X_{22}$

Table 5

COMMISSIONING SOURCE CHARACTERISTICS

Characteristic	Commissioning Source	
	1	2
Procurement Cost per Graduate	$5000	$7500
Program Retention	.90	.75
Program Length (in years)	2	1
Twenty-year Turnover	2	4
Minimum Production	2000	1000
Maximum Production	6000	9000

Table 6

TRAINING AGENCY CHARACTERISTICS

Characteristic	Training Agency	
	1	2
Training Cost per Graduate	$8000	$37000
Program Length (in years)	1	1

In the example, each term within brackets (e.g. $\left[x_{11} \times (5000 + 8000) \times 2 \right]$) is called the basic term.[3] The basic term is defined for each solution variable (number procured on x_{ij}). The basic terms summed over all solution variables is the total program cost. Several aspects of the objective function require further explanation.

The cost factor is based on two components: COMMISSIONING COST and TRAINING COST. The COMMISSIONING COST is the cost per graduate of a commissioning source. It is determined based on the total costs incurred including pay and allowances and O & M from the time an officer candidate enters a commissioning source until he is ready for UPT/UNT, technical schools, or direct duty assignment. The total costs are divided by the number of graduates to determine COMMISSIONING COSTS, thereby reflecting attrition.

TRAINING COST is the cost of UPT/UNT or technical training schools per graduate. Since this factor also must account for attrition in the training programs, the cost has been adjusted by the attrition rate.

TURNOVER is a measure of the number of times an officer must be replaced in the Air Force over a twenty-year period. If, for example, officers coming from source 2 remain in the Air Force on the average five years, then in a twenty-year period, the turnover would be four times. We have adjusted the objective function in this way in order to reflect the fact that procurement from one source may in fact be less expensive in the long run due to fewer replacement requirements. While we recognize that this adjusted cost is misleading in terms of annual expenditures, it is considered appropriate to use in the context of the linear programming problem in a long term sense.

[3] This convention will be used throughout the following discussion.

An alternative to the cost objective function, is an objective function which maximizes the average quality of officers entering the commissioning sources. The TOPOPS objective function maximizing quality in terms of average AFOQT scores may be formulated as follows:

(III.2)

BASIC TERM	(AVERAGE AFOQT × NUMBER OF CANDIDATES FROM EACH SUPPLY POOL) / TOTAL REQUIREMENTS
EXAMPLE	$\left(\left[40\times(F_{111}+F_{121})\right]+\left[45\times(F_{212}+F_{222})\right]+\left[50\times F_{322}\right]\right)/9000$ OR $\underbrace{(40\times F_{111}+45\times F_{212})}_{\text{AGENCY 1}}+\underbrace{(40\times F_{121}+45\times F_{222}+50\times F_{322})}_{\text{AGENCY 2}}/9000$

As with the cost function, the basic term shows the functional form for one supply source supplying one type of candidate for one commissioning source. The sum of all these terms divided by the total number of men recruited determines the average quality level. The solution variables f_{kij} indicate the supply pool (k), the officer type (i) and the commissioning source (j). Table 7 lists the characteristics of the pools. Table 8 indicates the flow patterns between supply pools 1, 2, and 3 and commissioning sources 1 and 2 for officer type 1, non-rated and type 2, rated. For instance, non-rated officer candidates (type 1) may be recruited only from supply pool 1 by sources 1 and 2.

E. Defining the Constraints

When using the cost objective function, the analyst is provided the option of specifying other goals, for example, quality; for which a set of quality distribution constraints may be used. These insure that candidates from a wide distribution of AFOQT scores enter the force. The quality distribution constraints may be formulated as follows:

Table 7.

SUPPLY POOL CHARACTERISTICS

Characteristics	Supply Pool		
	1	2	3
Size	10000	6000	3000
Average AFOQT	40	45	50

Table 8

FLOW PATTERNS

Non-rated

SOURCE / SUPPLY	1	2
1	1	1
2	0	0
3	0	0

Rated

SOURCE / SUPPLY	1	2
1	0	0
2	1	1
3	0	1

(III.3)

BASIC TERM	NUMBER OF CANDIDATES FROM EACH SUPPLY POOL ≥ PORTION OF TOTAL RECRUITMENT REQUIREMENT
EXAMPLE	FOR SUPPLY POOL 1 : $r_{111} + r_{121} \geq .10\,(r_{11} + r_{21} + r_{12} + r_{22})$ FOR SUPPLY POOL 2 : $r_{212} + r_{222} \geq .25\,(r_{11} + r_{21} + r_{12} + r_{22})$ FOR SUPPLY POOL 3 : NO CONSTRAINT

In this case we are saying that supply pool 1 must provide at least ten percent of the candidates; supply pool 2 at least 25 percent. The r_{ij} terms indicate the number of entering candidates derived from the solution variables x_{ij}; their formulation is discussed later.

When using the quality objective function, there is a set of program budget constraints which can be used to limit the procurement costs. These budget constraints may be formulated as follows.

(III.4)

BASIC TERM	NUMBER PROCURED × (COMMISSIONING COST + TRAINING COST) × TURNOVER ≤ PROGRAM BUDGET
EXAMPLE	$[x_{11} \times (5000 + (8000)) \times 2] + [x_{21} \times (5000 + (37000)) \times 2] +$ $[x_{12} \times (7500 + (8000)) \times 4] + [x_{22} \times (7500 + (37000)) \times 4]$ $\leq 65{,}000{,}000$ OR $26000x_{11} + 84000x_{21} + 62000x_{12} + 178000x_{22} \leq 900{,}000{,}000$

This constraint focuses on program costs to fulfill procurement requirements in a given year. The user should recognize that these costs are not time-phased. There can be a program cost constraint for each year in the planning horizon.

In reality, regardless of the objective function, both sets of constraints can be used in formulating a procurement problem to be solved by TOPOPS. For the remainder of the presentation, however, we will focus only on a problem in which costs are minimized subject to quality distribution and other constraints.

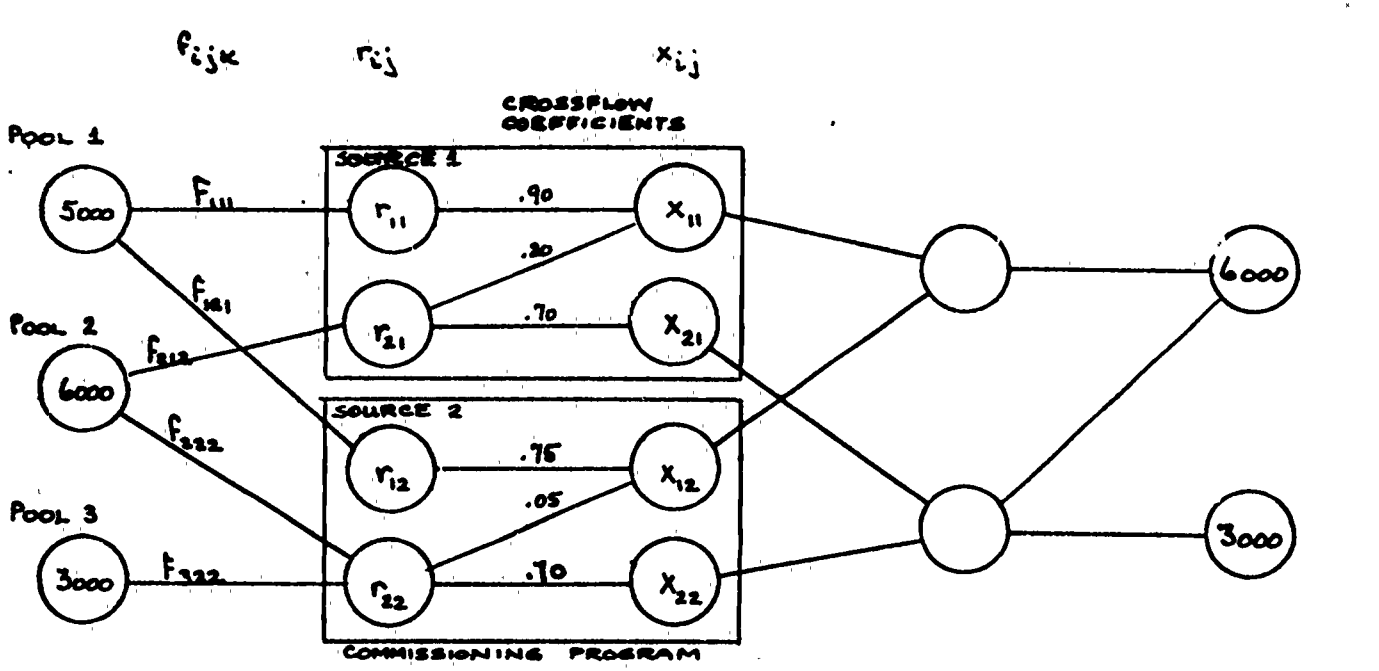
To illustrate the use of other constraints, the Air Force officer procurement system may be graphically portrayed as a network. Figure 7 portrays the relationships between supply pools, recruiting requirements, officer production and training and procurement requirements. Working from right to left, we see that procurement requirements determine the number of officers of each type who must enter training. Officer production (x_{ij}) satisfies training requirements and indicates recruiting levels (r_{ij}) for each commissioning source. Recruiting requirements (r_{ij}) are filled by selecting potential officer candidates from the supply pools (f_{kij}).

The system appearing in the figure illustrates the relationships included in the hypothetical sample problem; these also represent the most important features of the generalized TOPOPS model. Let us examine the segments of the procurement network with respect to the constraints they imply.

1. Supply Constraints. The number of individuals recruited by commissioning source is limited by the number of potential officer candidates in the supply pools available to that source. TOPOPS includes two types of supply constraints. One is an identity which specifies that the number of men recruited for a commissioning source from the various supply pools is exactly equal to the source's total recruiting requirements.

Figure 7

TOPOPS OFFICER PROCUREMENT SYSTEM



	SOLVING FOR RECRUITING REQUIREMENTS (r_{ij})	
AGENCY 1	$x_{11} = .9\,r_{11} + .2\,r_{21}$ $x_{21} = .7\,r_{21}$	$\Rightarrow$ $r_{11} = 1.1\,x_{11} - .3\,x_{21}$ $r_{21} = 1.4\,x_{21}$
AGENCY 2	$x_{12} = .75\,r_{12} + .05\,r_{22}$ $x_{22} = .7\,r_{22}$	$\Rightarrow$ $r_{12} = 1.3\,x_{12} - .1\,x_{22}$ $r_{22} = 1.4\,x_{22}$

Referring to Figure 7, it can be seen that the recruiting requirements differ from the officer production requirements because there is attrition and crossflow during the commissioning program. The crossflow coefficients are indicated within the commissioning program boxes on the lines connecting the r_{ij} and x_{ij}'s. Thus, 90% of the entrants from supply pool 2 graduate commissioned officers (i.e., 10% attrition). However, 20% will no longer be considered for pilot/navigator training, while 70% do remain qualified for rated training. The recruiting requirements, r_{ij}, must be stated in terms of the solution variables, x_{ij}. These relationships are shown in the lower portion of Figure 7.

The identity supply constraints may be derived from Figure 7 and specified as follows.

(III.5)

BASIC TERM	SUPPLY FLOW TO COMMISSIONING SOURCE = COMMISSIONING SOURCE RECRUITMENT REQUIREMENT
EXAMPLE	FOR r_{11} : $f_{111} = 1.1\,x_{11} - .3\,x_{21}$ FOR r_{21} : $f_{212} = 1.4\,x_{21}$ FOR r_{12} : $f_{121} = 1.3\,x_{12} - .1\,x_{22}$ FOR r_{22} : $f_{222} + f_{322} = 1.4\,x_{22}$

Both flow variables, f_{kij} and the procurement variables, x_{ij}, are solution variables. These constraints require the procurement to exactly equal the flows.

The need for the second set of supply constraints is straightforward. These constraints require the total flow from each supply pool not to exceed its size. They are formulated in the following manner:

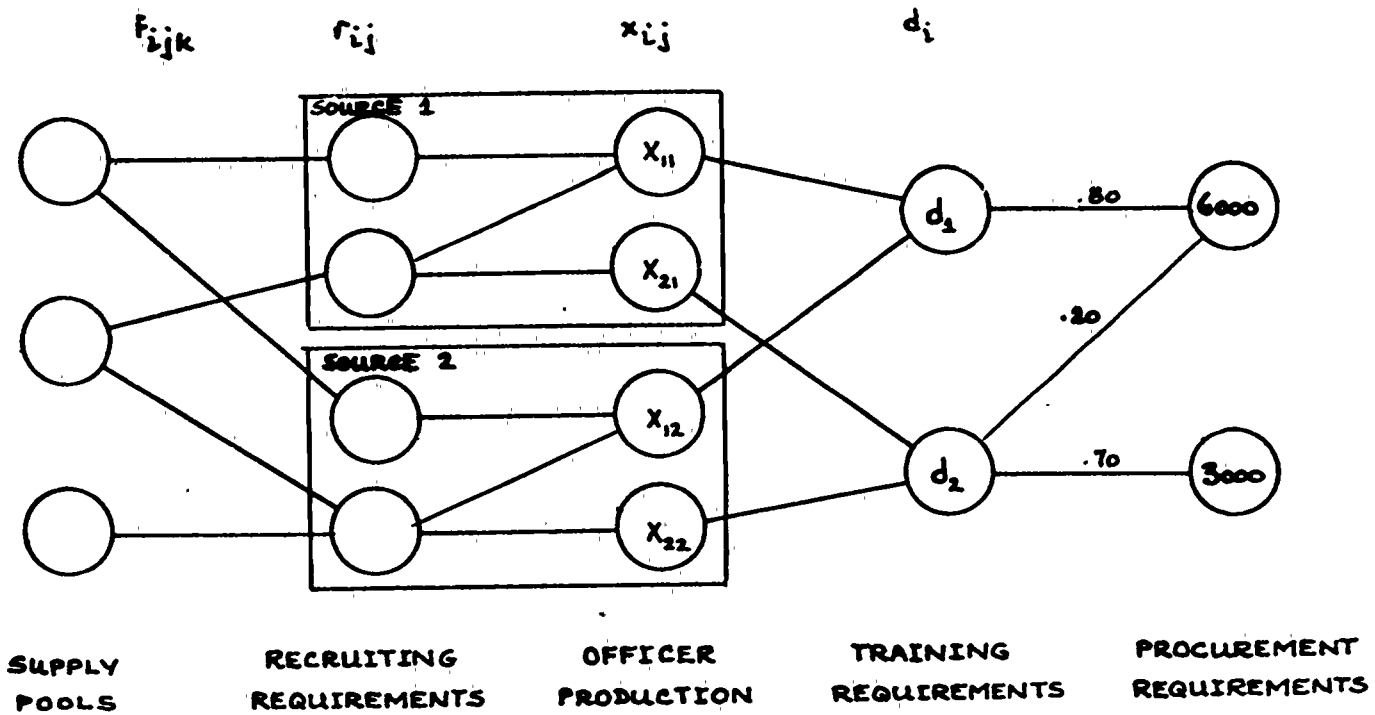
(III.6)

BASIC TERM	SUPPLY FLOW FROM SUPPLY POOL $\leq$ SUPPLY POOL SIZE
EXAMPLE	FOR SUPPLY POOL 1 : $F_{111} + F_{121} \leq 10000$ FOR SUPPLY POOL 2 : $F_{212} + F_{222} \leq 6000$ FOR SUPPLY POOL 3 : $F_{322} \leq 3000$

2. Training Requirements. On the demand side, TOPOPS must determine values for the solution variables so that the procurement requirements are met. As noted elsewhere, these requirements correspond to the output of the last phase, the training stage. The solution variables, x_{ij}, tell us the number of officers to be commissioned at the end of the second stage (production stage) in order to satisfy the training requirements. Consequently, the procurement requirements must be adjusted to reflect the attrition and crossflow occuring during training. Figure 8, shows the hypothetical rates and the calculations determining the training requirements, d_i, where again i refers to officer type.

Figure 8

TRAINING REQUIREMENTS CONSTRAINTS



SOLVING FOR TRAINING REQUIREMENTS (d_i)	
$6000 = .80d_1 + .20d_2$ $3000 = .70d_2$	$\Rightarrow$ $d_1 = 6400$ $d_2 = 4300$

The constraints are formulated as follows:

(III.7)

BASIC TERM	TOTAL PRODUCTION OF AN OFFICER TYPE = TRAINING REQUIREMENT
	FOR NON-RATED : $X_{11} + X_{12} = 6400$ FOR RATED : $X_{21} + X_{22} = 4300$

The constraints specify that production must exactly equal the requirements. As the procurement system has been defined, there is no benefit in producing more officers than required; on the other hand, to produce less would result in failing to meet the requirements. Therefore, these constraints are specified as equalities.

3. Policy and Operating Characterisitics. Three types of operating and policy constraints are incorporated in TOPOPS: production capacity, selective procurement, and selective recruitment.

As indicated earlier, the minimum production constraints insure that each procurement agency operates at a minimum level. At the same time, maximum constraints guarantee that production will not exceed some upper limit. Hence, using data from Table 5 we have:

(III.8)

(III.9)

BASIC TERMS	TOTAL PRODUCTION OF COMMISSIONING SOURCE $\geq$ MINIMUM PRODUCTION TOTAL PRODUCTION OF COMMISSIONING SOURCE $\leq$ PRODUCTION CAPACITY
EXAMPLE	COMMISSIONING SOURCE 1 : $r_{11} + r_{21} \geq 2000$ $r_{11} + r_{21} \leq 6000$ COMMISSIONING SOURCE 2 : $r_{12} + r_{22} \geq 1000$ $r_{12} + r_{22} \leq 9000$

If we want to fix production of a commissioning source at a specific level, the minimum production and production capacity would be set equal. Among reasons for doing this is the case where production is pre-determined based on prior decisions. Suppose, in the sample problem, the year 1973 rather than 1980. The output of commissioning source 1 would already be determined since its recruitment was completed the previous year.

"Selective production" refers to policies which insure that either a minimum or maximum number of officers from a specific commissioning source are used to meet a training requirement. In other words, a policy may exist that a source provide a minimum level of officers. These constraints allow us to spread production among any or all sources should policy dictate. They are formulated as follows:

(III.10)	BASIC TERMS	NUMBER PRODUCED BY SOURCE ≤ PROPORTION OF TRAINING REQUIREMENT
		OR
(III.11)		NUMBER PRODUCED BY SOURCE ≥ PROPORTION OF TRAINING REQUIREMENT
	EXAMPLE	$x_{11} \leq .40\, d_1$ (6400)
		$x_{22} \geq .50\, d_2$ (4300)

The first constraint says that production of commissioning source 1 to meet the requirement for non-rated officers cannot be greater than forty percent of the total requirement. The second constraint requires at least fifty percent of the rated officers to come from commissioning source 2. The use of these constraints, as true of other constraints, is optional.

The final set of constraints, termed "selective recruitment", permit a similar set of constraints to be specified on the supply side of the system. In this instance, we want to make certain that commissioning sources acquire their officer candidates from different supply pools. Selective recruitment constraints are specified in the following way:

(III.12) (III.13)	BASIC TERMS	SUPPLY FLOW ≤ PROPORTION OF RECRUITMENT REQUIREMENT OR SUPPLY FLOW ≥ PROPORTION OF RECRUITMENT REQUIREMENT
	EXAMPLE	$F_{222} \leq .50\,(1.4\,x_{22})$ $F_{322} \geq .60\,(1.4\,x_{22})$

These can be interpreted to mean that commissioning source 2 will recruit no more than fifty percent of its rated officer candidates from supply pool 2 and at least sixty percent from supply pool 3.

F. Summary: TOPOPS Mathematical Model

Taken together the objective functions and constraints can be used to formulate a procurement problem in terms of TOPOPS. Figure 9 shows the complete formulation for the hypothetical problem discussed in this chapter. Appendices B and C present TOPOPS input and output reports for this same problem.

The reader should recognize the wide range of discretion the potential user has in formulating a problem. First, there is a choice of objective functions. Second, he can choose from among five sets of constraints to specify supply and procurement requirements as well as policy and operating characteristics.

Figure 9

TOPOPS MODEL: SAMPLE PROBLEM

	F_{111}	F_{212}	F_{121}	F_{222}	F_{322}	X_{11}	X_{21}	X_{12}	X_{22}	
III. 1				MINIMIZE :		26000 X_{11}	+ 84000 X_{21}	+ 62400 X_{12}	+ 178000 X_{22}	
III. 3	F_{111}		+ F_{121}			− .10 (1.1 X_{11}	+ 1.1 X_{21}	+ 1.3 X_{12}	+ 1.3 X_{22})	≥ 0
		F_{212}		+ F_{222}		− .25 (1.1 X_{11}	+ 1.1 X_{21}	+ 1.3 X_{12}	+ 1.3 X_{22})	≥ 0
III. 5	F_{111}					− 1.1 X_{11}	+ .3 X_{21}			= 0
		F_{212}					− 1.4 X_{21}			= 0
			F_{121}					− 1.3 X_{12}	+ .1 X_{22}	= 0
				F_{222}	+ F_{322}				− 1.4 X_{22}	= 0
III. 6	F_{111}		+ F_{121}							≤ 10000
		F_{212}		+ F_{222}						≤ 6000
					F_{322}					≤ 3000
III. 7						X_{11}		+ X_{12}		= 6400
							X_{21}		+ X_{22}	= 4300
III. 8						1.1 X_{11}	+ 1.1 X_{21}			≥ 2000
								1.3 X_{12}	+ 1.3 X_{22}	≥ 1000
III. 9						1.1 X_{11}	+ 1.1 X_{21}			≤ 6000
								1.3 X_{12}	+ 1.3 X_{22}	≤ 9000
III. 10						X_{11}				≤ 2560
III. 11									X_{22}	≥ 2150
III. 12				F_{222}					− .7 X_{22}	≤ 0
III. 13					F_{322}				− .8 X_{22}	≥ 0

G. Extensions of the Sample Model

All the basic features of the TOPOPS mathematical model have been discussed in the previous example. To fully appreciate the scope of the mathematical design, however, several additional facets of the model should be made explicit, again.

First, as noted in the beginning, the mathematical design is in reality generalized. Using its complete capabilities, an analyst can formulate a problem dealing with the procurement of five different types of officers from ten commissioning sources which may draw their officer candidates from twenty supply pools.

Second, rather than being a one-year model as depicted, TOPOPS has been formulated as a five-year model. Procurement requirements can be specified for each year and procurement decisions can be determined for the entire time period.

APPENDIX A

OVERVIEW OF TOPOPS PROGRAMMING SYSTEM

The TOPOPS programming system is composed of three modules plus an executive routine that controls the operation of the modules, provides error recovery procedures, and establishes the interfaces for data transmission between the various system elements. Figure A1 illustrates the general model structure.

The Data Base Initializer is the first module. It performs a number of routine operations designed to collect and edit data from procurement requirements and other primary data sources and to structure the data inputs for the second phase. The major system inputs include:

Procurement Requirements
Operating Characteristics of Commissioning Sources
Procurement Policy Parameters
Current Status of Commissioning Sources

The procurement requirements (e.g. by TOPLINE) are specified on an annual basis. The operating characteristics specify source limitations and unit production costs. The current status data allows for the analyst to specify the initial status of the ten commissioning sources for officers. While the user specified policy parameters allow for policy analysis in terms of their impact on procurement strategy, their primary purpose is to permit the generation of procurement policies. The Initializer will generate as its major output a procurement data matrix which is used by the next phase to determine optimal procurement strategies.

The Procurement Policy Generator is the second module. The model has been formulated as a linear program in order to optimize officer procurement in terms of either quality or costs. The model is designed on an annual production basis and permits sequencing for a five-year period. The solution variables are subject to a variety of constraints. These include annual production of officers (such as pilot and navigator candidates, and non-rated), characteristics of the commissioning sources

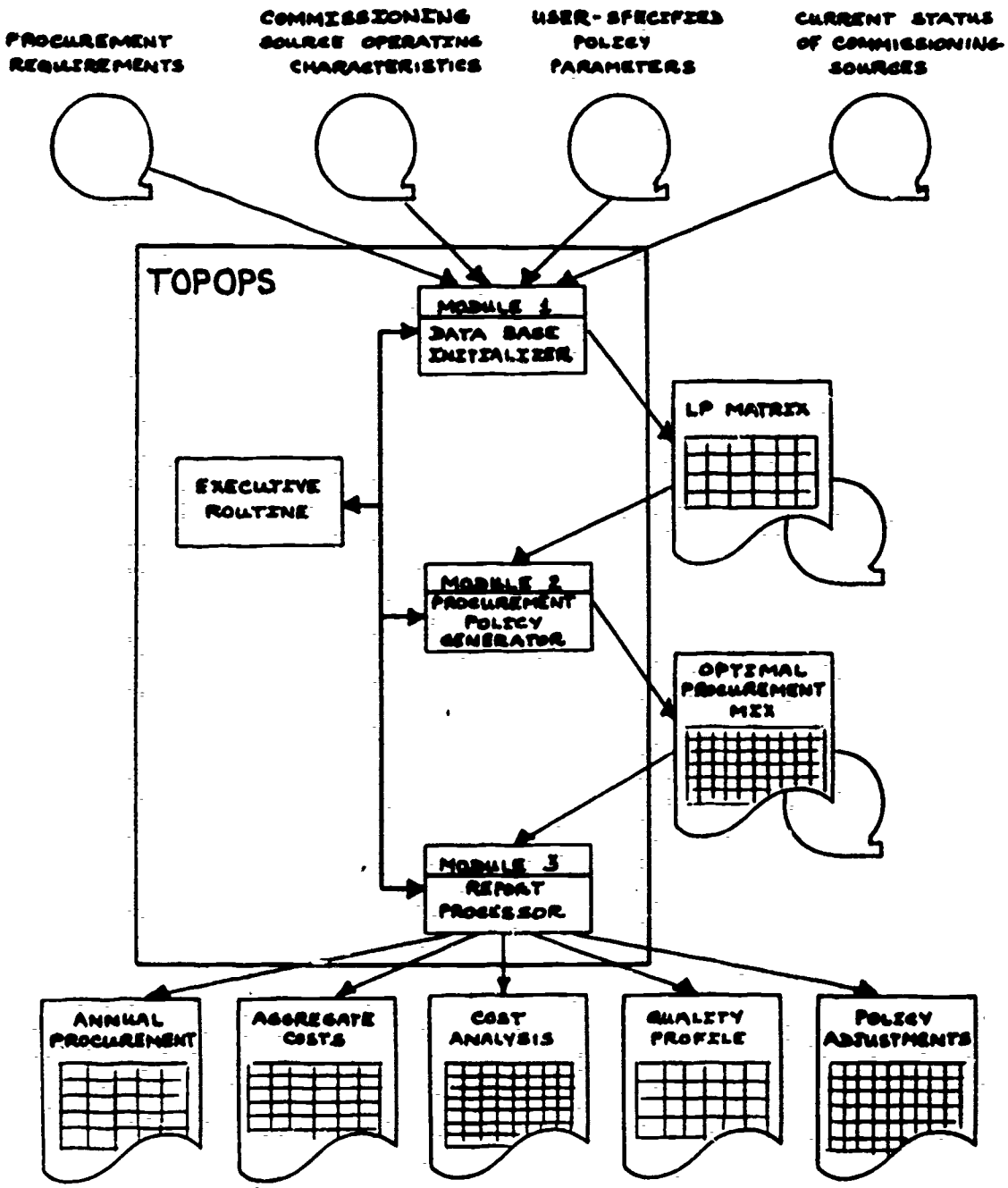


Figure A1

TOPOPS Program Structure

such as production lead time, legal maximum strength, flexibility, and existing policy. This module utilizes the UNIVAC 1108 Linear Programming System.

The final phase of the TOPOPS system is the Report Processor. The basic purpose of this segment is to generate the reports based on the data accumulated and developed from the previous phases. The reports generated by the system include: annual procurement schedule, aggregate cost estimates, cost analysis, officer quality profile, and procurement policy analysis. These reports represent a comprehensive set of data for analysis and evaluation. The procurement schedule shows possible allocations of officers across the various commissioning sources. The second report portrays the aggregate costs by commissioning source by major cost elements. The next two reports are more analytical in nature and show unit costs and force quality profiles based on the optimal procurement strategy. The final report documents potential changes in the results which would occur if policy constraints were relaxed.

APPENDIX B

SAMPLE TOPOPS DATA INPUT

Following are completed input forms for a TOPOPS run based on the hypothetical sample problem. Note, however, that the sample problem has been expanded to allow for procurement decisions that will be arrived at up to five years before the year of interest, 1980.

Form 1 contains the problem specification. It states the procurement requirements, the objective, and constraints.

Each Form 2 describes a commissioning source. Form 3 describes the supply pools and the flow networks. Training is specified on Form 4.

Form 5 specifies the minimum and maximum selective recruitment and selective production requirements.

TOPOPS SPECIFICATIONS

PROBLEM DEFINITION : PART I

PROCUREMENT REQUIREMENTS

TOPOPS FORM (1) [1]

BASE YEAR (76–79) [1 9 8 0]

RECORD SERIAL # (2–5)	RECORD TYPE (6)	OFFICER TYPE (7)	OFFICER DESCRIPTOR (11–28)
1 0	1	1	NON-RATED
2 0	1	2	RATED
	1	3	
	1	4	
	1	5	

RECORD SERIAL # (2–5)	RECORD TYPE (6)	PROCUREMENT REQUIREMENT (29–53)				
		BASE YEAR (29–34)	+1 (34–39)	+2 (39–44)	+3 (44–49)	+4 (49–53)
6 0 0 0						
3 0 0 0						

RECORD SERIAL # (2–5)	RECORD TYPE (6)	MODEL RUN OPTION
3 0	2	

MODEL RUN OPTION (29–39)

29										39
1	1	1	1	1	1	1	1	1	1	1
						10	11	12	13	

OBJECTIVE

RECORD SERIAL # (2–5)	RECORD TYPE (6)	OBJECTIVE (11–14)	
4 0	3	C O S T	ENTER 'COST' OR 'QUAL'

RECORD SERIAL # (2–5)	RECORD TYPE (6)	RECORD YEAR (8)	
	4	5	BASE YEAR
	4	6	+1
	4	7	+2
	4	8	+3
	4	9	+4

INFLATION RATE (31–33)

PROGRAM BUDGET IN $1000 (44–53)

TOPOPS FORM 1/2

TOPOPS SPECIFICATIONS

DATA BASE: PART I

BASE YEAR (76–79): 1980

COMMISSIONING SOURCE CHARACTERISTICS

RECORD SERIAL # (2–5)	RECORD TYPE (6)	SOURCE CODE (8)	SOURCE DESCRIPTOR (15–28)	P & A COST (29–33)	OTHER COST (34–38)	PROG LNGTH (57–59)
50	1	1	SOURCE 1	5000		2

RECORD SERIAL # (2–5)	OFFICER TYPE PRODUCED (6)	(7)	(8)
60	2	1	1
70	2	2	1
	2	3	
	2	4	
	2	5	

SOURCE CROSSFLOW ENTERING OFFICER TYPE

1 (54–56)	2 (57–59)	3 (60–62)	4 (63–65)	5 (66–68)	TURN OVER (72–74)
90	20				2.0
	70				2.0
					.
					.
					.

MINIMUM PRODUCTION LIMIT

RECORD SERIAL # (2–5)	PART (6)	(7)	(8)	-5 (29–33)	-4 (34–38)	-3 (39–43)	-2 (44–48)	-1 (49–53)
80	3	1	1	20000	20000	20000	20000	20000
90	3	2	1	BASE YEAR 20000	+1	+2	+3	+4

MAXIMUM PRODUCTION LIMIT

RECORD SERIAL # (2–5)	PART (6)	(7)	(8)	-5 (29–33)	-4 (34–38)	-3 (39–43)	-2 (44–48)	-1 (49–53)
100	4	1	1	60000	60000	60000	60000	60000
110	4	2	1	BASE YEAR 6000	+1	+2	+3	+4

TOPOPS FORM 1/2

TOPOPS SPECIFICATIONS

DATA BASE: PART I

BASE YEAR 1980

COMMISSIONING SOURCE CHARACTERISTICS

RECORD SERIAL # (2-5)	RECORD TYPE (6)	SOURCE CODE (8)	AGENCY DESCRIPTOR (11-28)	P$A COST (29-33)	OTHER COST (34-38)	PROG LNGTH (57-59)
120	1	2	SOURCE 2	7500		1

RECORD SERIAL # (2-5)	OFFICER TYPE PRODUCED (6)	(7)	(8)
130	2	1	2
140	2	2	2
	2	3	
	2	4	
	2	5	

SOURCE CROSSFLOW ENTERING OFFICER TYPE

(54)	1 (56-57)	2 (59-60)	3 (62-63)	4 (65-66)	5 (68)	TURN OVER (72-74)
75	5					4.0
	70					4.0
						.
						.
						.

MINIMUM PRODUCTION LIMIT

RECORD SERIAL # (2-5)	PART (6)	(7)	(8)	-5 (29-33)	-4 (34-38)	-3 (39-43)	-2 (44-48)	-1 (49-53)
150	3	1	2	1000	1000	1000	1000	1000
160	3	2	2	BASE YEAR 1000	+1	+2	+3	+4

MAXIMUM PRODUCTION LIMIT

RECORD SERIAL # (2-5)	PART (6)	(7)	(8)	-5 (29-33)	-4 (34-38)	-3 (39-43)	-2 (44-48)	-1 (49-53)
170	4	1	2	9000	9000	9000	9000	9000
180	4	2	2	BASE YEAR 9000	+1	+2	+3	+4

TOPOPS FORM 1 [3]

TOPOPS SPECIFICATIONS

DATA BASE : PART II

MANPOWER SUPPLY

BASE YEAR (76–79) [1 9 8 0]

RECORD SERIAL # (2–5)	RECORD TYPE (6)	SUPPLY POOL (9–10)	POOL DESCRIPTOR (11–28)	AFOQT (29–33)	TYPE OFFICERS FROM POOL 1 (34)	2 (59)	3 (62)	4 (65)	5 (68)
1 9 0	1	1	POOL NO. 1	4 0	1				

YEAR (2–5)	(6)	(8)		(9–10)
2 0 0	2	0	-5	1
2 1 0	2	1	-4	1
2 2 0	2	2	-3	1
2 3 0	2	3	-2	1
2 4 0	2	4	-1	1
2 5 0	2	5	BASE YR	1
	2	6	+1	
	2	7	+2	
	2	8	+3	
	2	9	+4	

QUANTITY AVAILABLE (29–33)
1 0 0 0 0
1 0 0 0 0
1 0 0 0 0
1 0 0 0 0
1 0 0 0 0
1 0 0 0 0

PROP. OF REQ. FROM THIS POOL (54–56)

1 0

RECORD SERIAL # (2–5)	RECORD TYPE (6)	POOL (9–10)	SOURCES SUPPLIED BY THIS POOL 1 (33)	2 (38)	3 (43)	4 (48)	5 (53)	6 (56)	7 (59)	8 (62)	9 (65)	0 (68)
2 6 0	3	1	1	1								

TOPOPS FORM 1/3

TOPOPS SPECIFICATIONS

DATA BASE : PART II

MANPOWER SUPPLY

BASE YEAR (76–79): 1980

RECORD SERIAL # (2–5)	RECORD TYPE (6)	SUPPLY POOL (9–10)	POOL DESCRIPTOR (11–28)	AFOQT (29–33)	TYPE OFFICERS FROM POOL 1 (56)	2 (59)	3 (62)	4 (65)	5 (68)
270	1	2	POOL NO. 2	45		1			

RECORD SERIAL # (2–5)	RECORD TYPE (6)	YEAR (8)		SUPPLY POOL (9–10)	QUANTITY AVAILABLE (29–33)	PROP. OF REQ. FROM THIS POOL (54–56)
280	2	0	-5	2	6000	25
290	2	1	-4	2	6000	
300	2	2	-3	2	6000	
310	2	3	-2	2	6000	
320	2	4	-1	2	6000	
330	2	5	BASE YR	2	6000	
	2	6	+1			
	2	7	+2			
	2	8	+3			
	2	9	+4			

RECORD SERIAL # (2–5)	RECORD TYPE (6)	POOL (9–10)	SOURCES SUPPLIED BY THIS POOL 1 (33)	2 (38)	3 (43)	4 (48)	5 (53)	6 (56)	7 (59)	8 (62)	9 (65)	0 (68)
340	3	2	1	1								

TOPOPS FORM 1 [3]

TOPOPS SPECIFICATIONS

DATA BASE : PART II

MANPOWER SUPPLY

BASE YEAR 76–79 [1980]

RECORD SERIAL # (2–5)	RECORD TYPE (6)	SUPPLY POOL (9–10)	POOL DESCRIPTOR (11–28)	AFOQT (29–33)	TYPE OFFICERS FROM POOL 1 (56)	2 (59)	3 (62)	4 (65)	5 (68)
350	1	3	POOL NO. 3	50		1			

RECORD SERIAL # (2–5)	RECORD TYPE (6)	YEAR (8)		QUANTITY AVAILABLE (29–33)	PROP. OF REQ. FROM THIS POOL (54–56)
360	2	0	-5	3000	
370	2	1	-4	3000	
380	2	2	-3	3000	
390	2	3	-2	3000	
400	2	4	-1	3000	
410	2	5	BASE YR	3000	
	2	6	+1		
	2	7	+2		
	2	8	+3		
	2	9	+4		

RECORD SERIAL # (2–5)	RECORD TYPE (6)	POOL (9–10)	SOURCES SUPPLIED BY THIS POOL 1 (33)	2 (38)	3 (43)	4 (48)	5 (53)	6 (56)	7 (59)	8 (62)	9 (65)	0 (68)
420	3	3		1								

TOPOPS FORM 4 (1)

TOPOPS SPECIFICATIONS

DATA BASE : PART III

TRAINING CHARACTERISTICS

BASE YEAR (76–79): 1980

RECORD SERIAL # (2–5)	RECORD TYPE (6)	OFFICER TYPE PRODUCED (7)	TRAINING AGENCY DESCRIPTOR (11–28)	TRAINING TIME (38)	COST (39–43)	SCHOOL TRAINING CROSSFLOW ENTERING OFFICER TYPE (54–68)
430	1	1	TECH SCHOOL	0	10000	80 20
440	1	2	PILOT TRAINING	1	50000	70
	1	3				
	1	4				
	1	5				

TOPOPS FORM 1 5 PAGE 1

TOPOPS SPECIFICATIONS

DATA BASE: PART IV

NETWORK DEFINITION

BASE YEAR 76–79: 1980

SOURCE

RECORD SERIAL # (2–5)	RECORD TYPE (6)	OFFICER TYPE (7)	8
4500	1	2	2
	1		
	1		
	1		
	1		
	1		
	1		
	1		
	1		
	1		

REQUIREMENTS

SELECTIVE PRODUCTION MINIMUMS

BASE YEAR (31)	+1 (36)	+2 (41)	+3 (46)	+4 (51)
50				

SELECTIVE PRODUCTION MAXIMUMS

BASE YEAR (31)	+1 (36)	+2 (41)	+3 (46)	+4 (51)
40				

2–5	6	7	8
4600	2	1	1
	2		
	2		
	2		
	2		
	2		
	2		
	2		
	2		
	2		

TOPOPS SPECIFICATIONS

DATA BASE : PART IV

NETWORK DEFINITION

TOPOPS FORM 5 (1) PAGE 2

BASE YEAR (76–79) 1980

SOURCE

SUPPLY

RECORD SERIAL # (2–5)	RECORD TYPE (6)	OFFICER TYPE (7)	(8)	SUPPLY POOL (9–10)
470	3	2	2	3
	3			
	3			
	3			
	3			
	3			
	3			
	3			
	3			

SELECTIVE RECRUITMENT MINIMUM

BASE YEAR (31–35)	+1 (36–40)	+2 (41–45)	+3 (46–50)	+4 (51–53)
60				

RECORD SERIAL # (2–5)	RECORD TYPE (6)	OFFICER TYPE (7)	(8)	SUPPLY POOL (9–10)
480	4	2	2	2
	4			
	4			
	4			
	4			
	4			
	4			
	4			
	4			

SELECTIVE RECRUITMENT MAXIMUM

BASE YEAR (31–35)	+1 (36–40)	+2 (41–45)	+3 (46–50)	+4 (51–53)
50				

APPENDIX C

TOPOPS OUTPUT

Following is a set of TOPOPS output based on the sample problem. The output consists of:

- Problem Statement
- Optimal Procurement Schedule
- Cost
- Cost Analysis
- Quality Profile
- Policy Analysis

AIR FORCE HUMAN RESOURCE LABORATORY

TOPOPS OFFICER PROCUREMENT
ANNUAL PROCUREMENT SCHEDULE

DATE OF REPORT: NOT GIVEN

OBJECTIVE: MINIMIZE COST

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
PROCUREMENT REQUIREMENTS										
NON-RATED						6000				
RATED						3000				
TOTAL						9000				
TRAINING REQUIREMENTS										
NON-RATED	0	0	0	0	6428					
RATED	0	0	0	0	4285					
TOTAL	0	0	0	0	10713					
RECRUITMENT REQUIREMENTS										
AGENCY 1										
NON-RATED	0	0	2176	0	0	0	0	0		
RATED	0	0	3861	0	0	0	0	0		
AGENCY 2										
NON-RATED	0	0	0	4938	0	0	0	0		
RATED	0	0	0	3861	0	0	0	0		
TOTAL										
NON-RATED	0	0	2176	4938	0	0	0	0		
RATED	0	0	3861	3861	0	0	0	0		

AIR FORCE HUMAN RESOURCE LABORATORY

TOPS OFFICER PROCUREMENT
AGGREGATE COST ESTIMATES
(IN MILLIONS)

DATE OF REPORT: NOT GIVEN

OBJECTIVE: MINIMIZE COST

PROGRAM COSTS	1980	1981	1982	1983	1984	TOTAL
AGENCY 1	123.4	.0	.0	.0	.0	123.4
AGENCY 2	155.1	.0	.0	.0	.0	155.1
TOTAL	278.6	.0	.0	.0	.0	278.6

PROGRAM COSTS (WITH TURNOVER)	1980	1981	1982	1983	1984	TOTAL
AGENCY 1	246.9	.0	.0	.0	.0	246.9
AGENCY 2	620.6	.0	.0	.0	.0	620.6
TOTAL	867.4	.0	.0	.0	.0	867.4

AIR FORCE HUMAN RESOURCE LABORATORY

TOPOPS OFFICER PROCUREMENT
COST ANALYSIS

DATE OF REPORT: NOT GIVEN

OBJECTIVE: MINIMIZE COST

I. COST PER OFFICER

	PAY AND ALLOWANCES	OTHER COSTS	TOTAL COSTS
AGENCY 1	5000	0	5000
AGENCY 2	7500	0	7500
AVERAGE	6400.	0.	6400.

II. COST PERCENTAGES

	1980	1981	1982	1983	1984	TOTAL
AGENCY 1	44.3	.0	.0	.0	.0	44.3
AGENCY 2	55.7	.0	.0	.0	.0	55.7
TOTAL	100.0	.0	.0	.0	.0	100.0

III. COST PERCENTAGES (WITH TURNOVER)

	1980	1981	1982	1983	1984	TOTAL
AGENCY 1	28.5	.0	.0	.0	.0	28.5
AGENCY 2	71.5	.0	.0	.0	.0	71.5
TOTAL	100.0	.0	.0	.0	.0	100.0

AIR FORCE HUMAN RESOURCE LABORATORY

TOPOPS OFFICER PROCUREMENT
OFFICER QUALITY PROFILE

DATE OF REPORT: NOT GIVEN

OBJECTIVE: MINIMIZE COST

I. AVERAGE QUALITY

	1980	1981	1982	1983	1984	AVERAGE
AGENCY 1	42.9	.0	.0	.0	.0	42.9
AGENCY 2	43.7	.0	.0	.0	.0	43.7
AVERAGE	43.4	.0	.0	.0	.0	43.4

II. SOURCE OF SUPPLY (1980-84)

	AGENCY 1	AGENCY 2							ADL REQ	TOTAL
POOL NO. 1	0	2177	4939	0	0	0	0	0	0	7115
POOL NO. 2	0	3861	248	0	0	0	0	0	0	3309
POOL NO. 3	0	0	2813	0	0	0	0	0	0	2813

III. OFFICERS BY PRODUCTION AGENCY

	1980	1981	1982	1983	1984	TOTAL
NON-RATED						
AGENCY 1	2485	0	0	0	0	2485
AGENCY 2	3524	0	0	0	0	3524
RATED						
AGENCY 1	1500	0	0	0	0	1500
AGENCY 2	1500	0	0	0	0	1500

AIR FORCE HUMAN RESOURCE LABORATORY

TOPOPS OFFICER PROCUREMENT
PROCUREMENT POLICY ANALYSIS

DATE OF REPORT: NOT GIVEN

OBJECTIVE: MINIMIZE COST

CONSTRAINT	MARGINAL IMPROVEMENT	RANGE		
A5A2	.#####	-927.	TC	107.
M522	94.###	-2893.	TC	-1976.
I511	36.###	-1821.	TC	3257.