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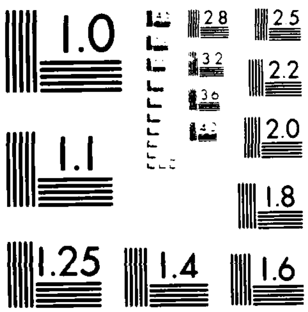

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A MODEL FOR DETERMINING ANNUAL QUOTAS TO FILL ADVANCED ACADEMIC DEGREE REQUIREMENTS WITHIN THE CIVIL ENGINEERING CAREER FIELD

James C. Rish, Captain, USAF

LSSR 52-82

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY (ATC)
AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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To date, an accurate estimating technique or forecasting model has not been developed to determine the number of engineers needed for entry into AFIT Master of Science degree programs in order to fill validated requirements within the Civil Engineering career field, Air Force Specialty Code (AFSC) 55XX. This thesis identifies important variables such as requirements, inputs, demand, and retention which affect AFIT MS degree quotas. The variables were used to develop a model that can determine quotas for officers entering MS degree programs. An accuracy rating of better than 97 percent was obtained on the model. In addition, it was determined through statistical tests that obtaining an MS degree enhanced the retainability of Civil Engineering officers. The model and retention data can be used by personnel in planning and managing the Air Force Civil Engineering career field.

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A MODEL FOR DETERMINING ANNUAL QUOTAS TO FILL ADVANCED ACADEMIC DEGREE REQUIREMENTS WITHIN THE CIVIL ENGINEERING CAREER FIELD

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Engineering Management

By

James C. Rish, BS
Captain, USAF

September 1982

This thesis, written by

Captain James C. Rish

has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment of the requirements for the degree of

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Statement of the Problem

The Air Force presently has approximately 83,500 line officers on active duty, of which about 33,000 or 39 percent have advanced academic degrees (2:161-166). At the same time, the Air Force has about 8,500 officer positions validated as requiring graduate degrees for adequate performance (15:607). This presents a paradoxical situation in which the number of line officers with advanced degrees (33,000) is 388 percent of the number of validated requirements (8,500). However, most of these officers do not have advanced academic degrees in areas (scientific and engineering) required to fill the majority of the validated positions.

Thus, the Air Force is forced to ask Congress for increased quotas in programs leading to advanced engineering degrees. Neither the Air Force nor Congress is satisfied with this situation. The Congress sees evidence in these figures that the Air Force is not effectively using current resources. Also, Congress is not convinced that all of the present advanced degree requirements are valid (15:219-220). The Air Force, in turn, sees evidence in these figures that there is a real and present danger that its ability to perform its mission could be adversely affected if the situation is allowed to continue (15:607).

The Civil Engineering career field (AFSC 55XX) is a specific career field within the Air Force which follows this pattern of not enough advanced degree holders in specific disciplines to fill the validated positions. Requirements for advanced academic degrees (grades 01-06) number 605, while the number of individuals with advanced academic degrees number 778, or 130 percent of the requirements (see Table 1). However, when degree holders are matched against specific degree disciplines, the number of matching advanced academic degrees is reduced to 391, or only 65 percent of the requirement (see Table 2). If the specific degree disciplines and grade requirements are then matched against the validated requirements, the number of advanced degree holders are further reduced to 235, or only 44 percent of the requirements can be satisfied (see Table 3).

TABLE 1

Validated Master Degree Requirements
and Degree Holders by Grade

Grade	Requirement	Inventory
01	0	5
02	28	30
03	211	281
04	131	200
05	163	170
06	72	92
TOTALS	605	778
INV/REQ: 1.3		
Ref: (1)		

TABLE 2

Validated Master Degree Requirements
and Degree Holders by Discipline

Grade	Requirements	Inventory
01	0	5
02	28	22
03	211	174
04	131	82
05	163	71
06	72	37
TOTALS	605	391
INV/REQ: .65		
Ref: (1)		

TABLE 3

Validated Master Degree Requirements
and Degree Holders by Discipline and Grade

Grade	Requirements	Inventory
01	0	0
02	28	14
03	211	109
04	131	61
05	163	51
06	72	17
TOTALS	605	235
INV/REQ: .44		
Ref: (1)		

To date, an accurate estimating technique or model has not been developed to determine the number of annual quotas for Master of Science degree programs in order to fill validated requirements within the Civil Engineering career field. This thesis develops a technique/model and evaluates its ability to determine quotas for officers educated at the Master level.

Definitions

To provide a common frame of reference, the following terms are defined as they are used in this thesis.

Management: Management is the effective and economical allocation, utilization, and/or control of resources to accomplish predetermined objectives. The functions of management are defined in Air Force Manual (AFM) 25-1, USAF Management Process, and includes the following: planning, organizing, coordinating, directing and controlling (19:10).

Engineering: As defined in the Model Law prepared by the National Council of Engineering Examiners:

> "engineering" . . . shall mean any service or creative work, the adequate performance of which requires engineering education, training, and experience in the application of special knowledge of the mathematical, physical, and engineering sciences. . . [10:237].

Advanced Academic Degree (AAD): An academic degree at the Master's or PhD level (17:1).

Academic Specialty Code: A four-character code which defined the academic field of study (17:1).

Civil Engineering Career Field: The Civil Engineering career field includes the following Air Force Specialty Codes (AFSCs) and utilization fields (17:12-1).

AFSC	Utilization Field
5525A	Architect/Architect Engineer
5525C	Civil Engineer

AFSC	Utilization Field
5525D	Industrial Engineer
5525E	Electrical Engineer
5525F	Mechanical Engineer
5525G	General Engineer
5516	Engineering Staff Officer
5596	Engineer Director

Background

The officer force has historically reflected an increase in levels of education corresponding to the education levels of the general population. In 1900, 30 percent of the leading business executives had some college education; in 1925, 51 percent; and in 1950, 75 percent. In the latter year, 20 percent also had some graduate education (13:261-262). The proportion of officers with college degrees rose from 47 percent in 1952 to 76 percent in 1971. A college degree is now accepted as the minimal basic education qualification for officers entering the Air Force.

The number of graduate degree holders has also increased, rising from 15 percent in 1973 to 39 percent in 1980 (14:87). However, while overall graduate degree holders have increased over the last decade, recent years have seen cutbacks in graduate degree programs. In passing the FY 1979 Defense Appropriations Bill, the Congress criticized the Department of Defense (DoD) for its management of officer professional development and educational programs, and reduced the FY 79 student input by 15 percent. This, coupled with a

7 percent reduction in FY 78, reduced the net FY 79 graduate educational input from FY 78 by approximately 17.5 percent.

In reviewing the Defense Appropriations Bill for FY 1980, the House compared education attainment in industry to the military, using a study recently published by the RAND Corporation. The study indicates that 56 percent of the officers in the rank of lieutenant colonel and above (analogous to senior executives) hold advanced academic degrees, compared to 40 percent of their civilian counterparts (16:62). The RAND study, coupled with the figures showing advanced degree holders 388 percent over requirements, triggered further reduction by the House to the Service's inputs to graduate degree programs (15:218). The Senate Committee on Appropriations disagreed with the House and restored the reductions to the FY 1980 Bill, keeping the requirements for advanced degrees the same as imposed by the FY 1979 Defense Appropriations Act.

While the RAND Corporation study shows more personnel with advanced academic degrees in the military than in the civilian sector, industry's advanced degrees are mostly technical, whereas less than 11 percent of the Air Force degrees are in technical fields (5:13).

Justification

The primary mission of the Air Force is to "organize, train, and equip Air Forces for the conduct of prompt and sustained combat operations in the air [20:11]." To accomplish this mission, the Air Force requires the services of many highly trained and dedicated professional military officers. Advanced graduate training is needed in the physical, mathematical, and engineering sciences underlying the development and operation of highly advanced and constantly changing weapons, transportation and communication systems, and associated Air Force technologies (12:II-2).

The current demand for scientific and engineering personnel in almost all fields is being pushed beyond the current supply. As a result, recruiting alone will fail to supply the demand in the 1980's. A survey of personnel executives by Deutach, Shea and Evans showed that 33 percent of 198 U.S. companies expected hiring of engineers and scientists to increase in the 1980's (7:14).

High starting salaries in industry leave little inducement to continue science and engineering studies past the undergraduate level. The results are that fewer and fewer candidates are entering PhD programs or filling the numerous new teaching jobs created by the boom in undergraduate enrollment. Thus, during the 1980's increased demand for engineers and scientists will be met by our declining ability to educate large numbers of undergraduates, further reducing the number of people available for advanced academic degree programs (3:732).

Unlike industrial and civilian government organizations, the Air Force is largely a closed system, promoting from within their ranks and providing almost no lateral entry into senior levels. Therefore, advanced education for officers can be obtained only by providing opportunities for mid-career education or by raising the educational and age requirements for entrance to the Air Force to unrealistic and undesirable levels (12:II-4).

The Air Force Civil Engineering Officer is the professional officer responsible for the operation and maintenance of Air Force real property and equipment necessary to support the Air Force mission. The Civil Engineering Panel of the Air Force Educational Requirements Board made the following comment on the subject of advanced degrees for engineers:

> The explosion of engineering technology and the changing demands of society, the Air Force, and the combat forces demand professional engineering competence. To accommodate this almost constant change, education must be a way of life to the engineer and engineer-manager. Much updating can be accomplished through part-time study, professional military schools and AFIT short courses. However, the Panel feels strongly that only full-time graduate study will provide officers with a high degree of professional engineering competence in complex engineering disciplines [18:18].

Today's complex weapon systems also breed complex support problems. Adequate numbers of graduate degree holders in the civil engineering career field is necessary to insure our scientific, engineering and technical abilities to maintain the complex support properties associated with research, development, and operation of these weapon systems. It is to this end of insuring adequate numbers of civil engineering graduate degree holders this study is conducted.

Objectives of the Research

The main objective of this thesis was to develop a technique or model to determine the number of engineers needed for continual student pipeline entry into AFIT MS degree programs in various engineering disciplines. This model can then be used by personnel in managing advanced academic education within the AFCE career field.

A secondary objective was to determine if advanced academic degrees are a significant contributor to retention of officers within the AFCE career field.

Research Questions

Research questions associated with the research objectives are:

1. What are the most important factors involved in developing the model?

2. Which modeling technique is the most appropriate for determining and managing student input to MS degree programs in order to fill validated graduate degree requirements?

3. Does obtaining an advanced academic degree enhance the retainability of officers within the AFCE career field?

CHAPTER II

LITERATURE REVIEW

Introduction

This thesis is a study of the civil engineering career field requirements for advanced education at the Master's degree level. The majority of related research in this general area has been accomplished by personnel in AFIT (PhD programs, Master's programs). A review of these prior research studies is provided in order to become familiar with other approaches to the subject.

Previous Studies

In August 1974, Majors Meri-Akri and Walton (11) wrote a thesis analyzing advanced degree requirements in the Air Force Civil Engineering Officer career field. Their problem statement alluded to considerable confusion as to the actual type of work done by civil engineering officers with Air Force Specialty Code (AFSC) 55XX. They also stated that 85 percent of the civil engineering officers, at that time, possessed an undergraduate degree in engineering; however, many of the activities of the career field were of a managerial rather than classical engineering nature (11:1).

Their purpose was to determine whether the predominant type of advanced degree required by Air Force Civil Engineers is management or engineering and to compare those findings to the type of advanced degrees provided to those engineers (11: 9). The data analyzed were primarily obtained through a job survey of 988 officers representing 44 percent of the parent population of 2271 Air Force civil engineering officers. The survey was conducted by the firm of Lifson, Wilson, Ferguson, and Winick, Inc. of Dallas, Texas in August 1971 under contract from the Air Force Human Resources Laboratory (AFHRL). Results of the survey showed that 66.3 percent of the Air Force engineering officer's working time was spent in performing management-type work, and the remaining 33.7 percent was spent performing engineering tasks (11:24). They concluded:

> There is a significant difference between the type of work performed by Air Force civil engineer officers and the type of advanced degrees provided to these officers. . . .
>
> Further research is recommended to identify those positions that actually require an advanced academic degree in an engineering specialty. . . . All other advanced academic degrees for civil engineering officers should be management type degrees [11:26].

In August 1975, Captain Julich and First Lieutenant O'Connell (9) wrote a student thesis on the Advanced Academic Degree Management System (AADMS). Their purpose was to determine if the AADMS, as it existed, was providing an adequate method of identifying and establishing advanced academic degree (AAD) requirements that were needed to accomplish the Air Force mission. Data were collected through an educational requirement survey of officers within Air Force Logistics Command that were manning positions requiring validated graduate degrees. The results of their study indicated only

55 percent of the positions validated under the AADMS were, in fact, valid according to Air Force criteria as tested by the Educational Requirements Survey (ERS). From this they concluded that the present AADMS does not appear to be an effective method of managing AAD positions.

They also observed that incumbents in validated positions have valuable information to offer the AADMS through an Educational Requirements Survey, and recommended that the AADMS include this additional source of information in its validation process (9:63-65).

In September 1977, Captains Gauntt and Stann completed a student thesis in the area of evaluating civil engineering educational needs (6). The data collected for this thesis consisted of a survey of 486 civil engineering base-level managers in order to obtain their opinions on the type of degree and level of education they thought necessary to accomplish their jobs. Survey results showed that 66.7 percent of civil engineering managers needing a bachelor's degree felt that their degree should be in an engineering discipline. The remaining 36.3 percent felt that a degree in management or some other area would be sufficient to accomplish their jobs (6:37).

From this they concluded that most, but not all, individuals entering the Air Force Civil Engineering career field should have at least a bachelor's degree in an engineering discipline.

The survey also showed that the percentage of individuals recommending a Master's degree to do their job was 23.4 percent. Recommended disciplines for these Master's degrees were: 48.3 percent engineering degrees, 42.1 percent management degrees. From this they recommended that base-level positions needing Master's level education need as many non-technical as technical degrees (6:42).

In June 1980, Major Johns and Captain Ray completed a student thesis comparing the usefulness of the Facilities Management Program in the graduate School of Systems and Logistics to similar programs in civilian institutions as perceived by former students (8). In their problem statement, they stated:

> Since it appears that Congress doubts the need for the amount of graduate education by military managers, it is extremely vital for the Air Force Institute of Technology (AFIT) to evaluate the relavancy of all programs, both at the resident school and civilian institutions, to insure the need for these graduate programs in the Air Force [8:1-2].

The data collected for this thesis consisted of a survey of officers from the AFIT Facilities Management Program and officers from similar programs at civilian universities. The five basic research questions and the conclusion of each follow (8:55-57):

> Question 1: Is there a need for graduate management education in the Air Force for civil engineers?
>
> Conclusion: There does appear to be a need for graduate management education in the Air Force for civil engineers since the majority of the graduates believe the programs to be useful. However, there does appear to be a need for further investigation into the area of Advanced Academic's Degree Code (AADC) validation.

Question 2: Are the similar programs offered through civilian institutions providing equivalent education?

Conclusion: Civil institutions do appear to be providing an equivalent education in the context of the course content. But their single disadvantage is the absence of the USAF orientation.

Question 3: Are the courses offered in the AFIT Facilities Management Program current and relevant?

Conclusion: The current Facilities Management Program does appear to be current and relevant according to the perceptions of the former graduates.

Question 4: Are the courses offered by civilian universities in Engineering Management or similar programs useful?

Conclusion: The civilian university programs are useful. However, their most singular disadvantage lies in their non-USAF orientation.

Question 5: Does the Facilities Management Program need to be changed to meet the demand of today's civil engineering manager?

Conclusion: In one word, yes. Throughout this effort, the analysis has shown that the present Facilities Management Program is needed and useful, but it has also shown the need for improvements to the existing program.

In 1980, Lieutenant Colonel Compton completed a study of the Air Force Civil Engineering career field requirements for officers educated at the doctoral level (4). His purpose was to establish guidelines for validating PhD job requirements, review and establish selection and utilization criteria, establish requirements necessary to provide the necessary technical capability to meet existing and projected requirements for research, development, and educational programs, and finally to propose a long-range career management program for obtaining and utilizing the officers holding a doctorate level education (4:1).

A working group was formulated to establish basic criteria for evaluation of the doctorate level of educational requirements to meet changes in missions and technologies. Three primary functions, Research and Development and Systems Acquisition, Educational Programs at the AFA and AFIT, and the area of High Technology were looked at. Interfaces at MAJCOM, Air Staff, and R&D activities were identified that may have valid requirements for the PhD level of education. The working group concluded that:

> There is, and will continue to be, a requirement for PhD-educated officers in Air Force Civil Engineering (AFCE). The total AFCE requirement for PhD's is 38 but only 11 of these positions must be filled by officers directly from graduate school. The remaining 27 positions should be filled by officers who have previously served in the 11 direct fill positions and have progressed in grade and experience. . . . Successful implementation and administration of a PhD resource plan is heavily dependent upon a modest but steady annual input of officers into graduate school. Advanced academic degree programs in AFCE are important recruitment and retention factors for young officers [4:37].

Summary

This literature review has presented the most pertinent material in the same general topical area as this research effort. While these efforts are useful as background information, none deal precisely with AFCE Master degree requirements, development of a model for predicting school quotas to fill validated requirements, and using the model in planning and managing the Air Force Civil Engineering career field.

CHAPTER III

METHODOLOGY

Overview of Research Design

Having stated the basic problem and objectives of this thesis, attention is now focused on the procedures that were used to answer the research questions.

The first step towards answering the research questions was a review of current advanced academic degree (AAD) requirements and procedures for entering personnel into MS degrees programs. The review was necessary to determine the status of the civil engineering AAD program, i.e., how many positions currently validated, number of personnel currently in inventory, short fall between requirements and inventory. Advanced academic degrees by discipline were then reviewed to determine if the current AFCE program was consistent with Air Force criteria established in AFM 36-19 and guidelines established by the Civil Engineering Panel of the Air Force Education Requirements Board. Specific results of this review are in Appendix A.

Population

The population consists of all validated requirements for Master's degrees within the Civil Engineering career field (AFSC 55XX, grades 01 through 06). Data were acquired from the Advanced Degree Requirements Information System (ADRIS) and the Atlas Variable Inquiries System (AVIS).

Method of Analysis

Research Question 1

The analysis for this research effort begins by answering Research Question 1: What are the most important factors involved in developing the model? The review of the current AAD program for the AFCE career field provided seven factors which could affect student inputs into the system. They are:

1. Educational Facilities - Can the physical plant accommodate the numbers of students needed to fill validated positions?

2. Career Progression - Does the career progression of individual officers as outlined in Part II of AFM 36-23, Officer's Career Management, affect student inputs?

3. Retention - How does retention affect student inputs?

4. Inputs - Are adequate numbers of officers available for student input?

5. Funding - Will funds be available for student inputs?

6. Requirements - What are the needs?

7. Demand - Are requirements being met?

Educational Facilities, Career Progression, and Funding were eliminated as variables in the model. Educational Facilities was eliminated because the Air Force utilizes civilian institutions to educate its personnel and it is capable of handling fluctuating inputs. Career Progression was eliminated because the individual officer may remain in the system as an AAD holder even if he doesn't make his career progression gates. Funding was eliminated from the model through the assumption that money for graduate education will be available. However, it is realized that funding will affect the number of officers that the Air Force could afford to put into graduate school in any given year.

The variables considered for the purpose of this model were Retention, Inputs, Requirements, and Demand. In addition, the AAD holder will remain in the system as an asset until separated from the service.

Research Question 2

Research Question 2 was: Which modeling technique is the most appropriate for determining and managing student quota input requirements to MS degree programs? Many modeling techniques exist which could be used to solve the same problem; however, the field was narrowed to two in order to facilitate the researcher's ability to develop a useful model.

The two modeling techniques considered were multiple linear regression (MLR) and an inventory model. It was felt that MLR would be appropriate in determining the number of validated requirements needed based on many variables associated with each discipline. However, it tended to become cumbersome as a simple tool for determining inputs. Therefore, it was felt that an inventory type model would be more conducive to the goal of providing a simple modeling technique for personnel managing inputs into AAD programs.

Assumptions for Model Development. Basic assumptions for the model development were:

1. All requirements at the lowest grade would be maximized or filled first, and the process would then proceed to the next higher grade. Grades are defined as: 01-Second Lieutenant; 02-First Lieutenant; 03-Captain; 04-Major; 05-Lieutenant Colonel; and 06-Colonel. Since there were no requirements at the 01 level, and it was assumed requirements at the 05 and 06 level would be met by career progression from the lower grades, inputs were restricted to the 02, 03, and 04 grades.

2. Inputs into grade 02 were at the second year of Total Active Federal Commissioned Service (TAFCS).

3. Inputs into grade 03 were from the fourth year to the eleventh year. To make the model more responsive, an average TAFCS of seven years was assumed. The seventh year was based on the average TAFCS date of 03's input into AFIT AAD programs and assigned to the Civil Engineering career field over the last 20 years.

4. Inputs at the 04 grade were at the twelfth year of service.

5. Inputs into the system at any point would progress through the system as normal career progression would allow, i.e., 03 at year 4, 04 at year 11, 05 at year 16, and 06 at year 21.

6. The maximum number of inputs into the system at any one time in order to satisfy requirements should not exceed

one-half the demand at grade 02 on the first run, and one-fourth the demand at grade 03 on the second run.

7. Retention factors were established at 100 percent for grades 01-02, 95 percent for grades 03-05, and 86 percent for grade 06. These figures were based on actual retention data obtained from the Atlas Variable Inquiry System (AVIS), run dated 3 August 1982.

Model Development. Based on the above assumptions, the actual inventory model was developed. The variables in the model were:

1. R1,R2,R3,R4,R5,R6 = Requirements for grades 01-06.
2. P1,P2,P3,P4,P5,P6 = New inputs for grades 01-06.
3. U1,U2,U3,U4,U5,U6 = Retention factor for grades 01-06.
4. X1,X2,X3,X4,X5,X6 = Demands for grades 01-06.

The basic equation for the model was:

$$X(\text{demand}) = R(\text{requirement}) - P[(\text{input}) \cdot U(\text{retention})]$$

The model functions and results are discussed in Chapter IV. The entire computer program for the model is contained in Appendix B, and a flowchart of the model is in Figure 1.

Research Question 3

Statistical analysis was performed on additional data to answer the third research question: Does obtaining an AAD enhance the retainability of officers with the AFCE career field?

Population. The population consists of total population and total losses by Total Active Federal Commissioned Service

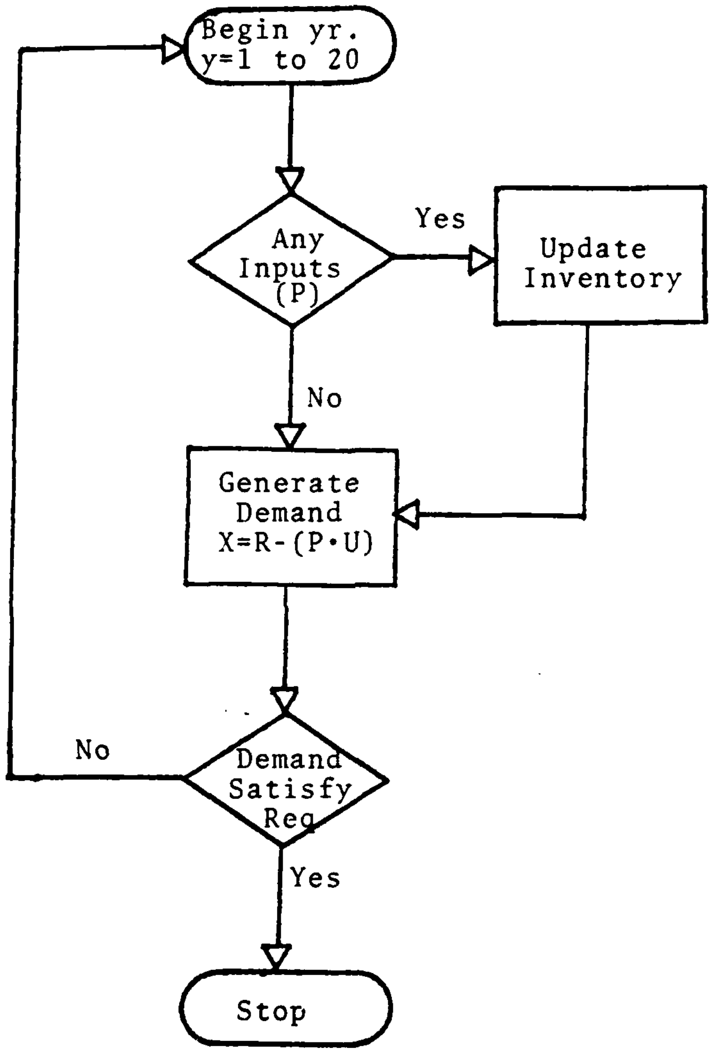

Fig 1. Flowchart of Model to Determine Inputs for AAD Programs Within AFCE Career Field

(TAFCS) date for all Air Force officers, Civil Engineering officers Air Force Specialty Code (AFSC) 55XX, and Civil Engineering officers with Master's degrees. The sample covered the years FY 77 through FY 81. The data for the Air Force and the Civil Engineering career field were provided by Major Jay Schuman from the office of Officer Retention, Military Personnel Center (MPC), Randolph AFB, Texas. The data for Civil Engineering officers with advanced academic degrees were obtained from the Atlas Variable Inquiry System (AVIS), run dated 23 August 1982.

Data Analysis. The data were correlated by group and year. The total losses of each group was divided by the total population of each group and multiplied by 100 to determine a percentage of losses by year. The results are shown in Table 4.

Statistical Test. The nonparametric Friedman F_r Test for a randomized block design was used to determine whether evidence exists to indicate that the loss percentages are significantly different between groups. The null and alternate hypotheses were:

H_0: The probability distribution of the three groups of loss rates are equal ($\mu_1 = \mu_2 = \mu_3$)

H_A: At least one μ is not equal.

The Friedman F_r test statistic is based on the rank sums:

$$F_r = \frac{12}{bk(k+1)} \sum_{j=1}^{k} R_j^2 - 3b(k+1)$$

where:

TABLE 4

Percentage of AAD Holders Losses by Year

Group	POP	LOSS	%
FY 77			
AF	45,190	3,745	8.28
CE	1,849	171	9.25
CE/AAD	507	37	7.30
FY 78			
AF	44,039	2,905	6.60
CE	1,788	128	7.16
CE/AAD	518	32	6.18
FY 79			
AF	43,585	3,837	8.80
CE	1,786	190	10.64
CE/AAD	546	22	4.03
FY 80			
AF	44,624	2,727	6.11
CE	1,716	100	5.83
CE/AAD	563	28	4.97
FY 81			
AF	45,949	2,504	5.45
CE	1,727	122	7.06
CE/AAD	575	22	3.83

b = number of blocks

k = number of treatments

R_j = Rank sum of the j^{th} treatment, where the rank of each measurement is computed relative to its position within its own block

α = the confidence level for each test of significance

Rejection region: $F_r < \alpha$ with (k-1) degrees of freedom. The Wilcoxon Rank Sum Test was then used to compare the pairs of groups if the F_r statistic supported the research hypothesis that some of the probability distributions differed.

With the Wilcoxon Rank Sum Test for a paired difference experiment (two-tailed), the null and alternate hypotheses were:

> H_0: The probability distribution corresponding to the loss rates of any two groups are equal ($\mu_1 = \mu_2$).
>
> H_A: The probability distribution corresponding to the loss rates of any two groups differ ($\mu_1 \neq \mu_2$).

The Wilcoxon Rank Sum Test statistic is:

> T, the smaller of the positive and negative rank sums, T_a and T_b.
>
> Rejection region: $T \leq T_0$, when T_0 is found for the significance level of α.

Assumptions. A basic assumption pertinent to the validity of this thesis is that all information obtained from valid official Air Force sources is accurate and reflect the current real world. An additional assumption is that all AAD requirements are valid and reflect the current need for graduate education within the AFCE career field.

CHAPTER IV

RESULTS

Introduction

The main objective of this research effort was to develop a model to determine the number of students who should enter Master of Science degree programs in Engineering on an annual basis. Achieving this objective was accomplished by subjective examination of the current AFCE advanced academic degree program to identify variables contributing to the modeling technique and the development and use of the model.

The second objective was to determine if advanced academic degrees are a significant contributor towards retaining officers in the civil engineering career field. This objective was accomplished by the examination of statistical significance of the probability distribution of the loss percentages between Air Force officers, Civil Engineering officers, and Civil Engineering officers with Master's degrees.

These analyses and their results are presented in detail in this chapter.

Analysis

Objective 1

Objective 1 was satisfied by determining the variables needed for the model and then selecting four significant variables to develop the model. The model functions and validation process are now presented.

Model Functions. As explained in Chapter III, the variables for the model were R(requirements grades 01-06), P(inputs grades 01-06), U(retention factor grades 01-06), and X(demand grades 01-06). The basic equation was:

$$X(\text{demand}) = R(\text{requirement}) - [P(\text{input}) \cdot U(\text{retention})]$$

The model was designed to run a maximum of 20 years or until the demand was satisfied ($X1+X2+X3+X4+X5+X6 = 0$) for any given year. While the parameters of the model can be changed, i.e., different requirements, inputs, and retention factors, the basic condition that entry into a Master's program must occur in the 02, 03, or 04 grades is fixed.

First run inputs are entered for the lowest grade only. This will maximize that grade and determine the demand needed for the next higher grade. For example, on the first run for total AAD requirements, the input for grade 02 was 14. At the ninth year, grade 03 reached a steady state (the flow of 02's into 03 equals the flow of 03's into 04) with the following remaining requirements (see Appendix C):

Grade:	01	02	03	04	05	06
Remaining Requirements	0	0	131	118	163	72

Second run inputs are entered for the lowest grade and the next higher grade. For example, on the second run for the total AAD requirements, the inputs were 14 for grade 02, and 33 (131/4 = 32.75) for grade 03. At the ninth year, grade

03 again reaches steady state with the following remaining requirements (see Appendix D) (overages at any rank are shown as a negative value):

Grade	01	02	03	04	05	06
Remaining Requirements	0	0	6	-8	132	72

This shows a demand for six additional 03's and is attributed to losses due to the retention factor.

A third run was made with inputs of 14 for grade 02, and 35 for grade 03 (see Appendix E). At the ninth year the remaining requirements were:

Grade	01	02	03	04	05	06
Remaining Requirements	0	0	-2	-15	130	72

The demand for grades 02 and 03 were maximized at this point, and the program was allowed to continue to determine how these inputs would affect grades 04 through 06. At year 14 the program stopped with the following remaining requirements:

Grade	01	02	03	04	05	06
Remaining Requirements	0	0	-2	-55	3	12

This shows an overage of 55 people at the 04 grade and a small shortfall in grades 05 and 06. Since the requirements (131) for grade 04 are less than the requirements (163) for grade 05, overages of MS degree holders in grade 04 will be a fact of life if the requirements at grade 05 are to be satisfied. A mix to lessen the demand for grades 05 and 06 and to shorten the total time to meet the requirements would be 14 02's, 35 03's, and 3 04's.

Model Validation. To determine if the model was a useful tool in determining inputs into AAD programs and in some way validate the model, runs were made to determine inputs for all of the disciplines within the AFCE career field. A run was also made to determine inputs for the total requirements for all engineering disciplines within the career field. An assumption was made at this time that personnel at grades 05 and 06 could fill an AAD MS in management requirement. If the sum of the inputs for each individual technical discipline was within 90 percent of the inputs for the total requirements for all technical engineering disciplines, the model would be considered useful in determining inputs into AAD programs. The results of the model are shown in Table 5, indicating the number of annual inputs by engineering discipline to satisfy existing validated AAD requirements.

TABLE 5

Inputs to Fill AAD Requirements
by Engineering Discipline

Discipline		Inputs	Appendix where shown
Electrical		4	G
Industrial		15	H
Mechanical		3	I
Civil		17	J
Architectural		3	K
	TOTAL	42	

The number of technical MS degree inputs overall was 41 modeling total requirements (see Appendix F), while the sum of the individual technical input was 42, giving a prediction percentage of 97.6 ($41/42 \cdot 100 = 97.6$). Therefore, the model is useful in determining the number of inputs needed to fill validated positions by individual discipline. The difference between the total inputs for technical degrees (41) and inputs for all validated AAD requirements (52) would be the number of quotas (11) needed for input into the engineering management program.

Summary. The model developed appears to be a useful tool in determining the inputs of engineers needed into AAD programs, and as such it should be used by the personnel responsible for managing the civil engineering career field advanced degree requirements.

Objective 2

Objective 2 was satisfied by testing the hypothesis concerning the probability distributions of the loss percentages of officers within the Air Force, Civil Engineering and Civil Engineering with Master's degrees. The null and alternate hypotheses were:

H_0: The probability distribution of the three groups of loss rates are equal ($\mu_1 = \mu_2 = \mu_3$).

H_A: At least one μ is not equal.

The Friedman F_r Test was used with an $\alpha = .1$, and a rejection region of $F_r < \alpha$. The results of the test were:

$F_r(.015) < (.1)$

Therefore, H_0 was rejected and the conclusion that evidence exists to indicate that the distributions of the loss rates are significantly different between groups was made.

The Wilcoxon Rank Sum Test was then used to compare the pairs of loss rates. The null and alternate hypotheses were:

H_0: The probability distributions corresponding to the loss rate of any two groups are equal ($\mu_1 = \mu_2$).

H_A: The probability distributions corresponding to the loss rate of any two groups differ ($\mu_1 = \mu_2$).

The tests were conducted with an $\alpha = .1$ and a rejection region of $T \leq T_0$, where T_0 is found for the significance level of .1. The results of these tests are presented in Table 6.

TABLE 6

Wilcoxon Rank Sum Test Results

Group	Test	Decision
AF vs CE	$.4206 > .1$	Fail to reject H_0
AF vs CE/AADs	$.1508 > .1$	Fail to reject H_0
CE vs CE/AADs	$.0952 < .1$	Reject H_0

From the above table, H_0 was rejected for the group CE vs CE's with degrees, and a conclusion that the probability distribution corresponding to the loss rate between CE's and CE's with degrees differ. The mean rank of loss percentages for CE's was 7.20, compared to 3.80 for CE's with degrees. This indicates that the losses for CE's with degrees is less than CE's without degrees, thus the retainability of CE's with degrees is enhanced.

Summary. Statistical evidence exists to show that the probability distributions of the three groups' loss rates differ. This was narrowed down specifically to CE's with degrees and CE's without degrees. By using the mean rank of the loss percentages of these two groups, it was determined that the losses in the group with degrees were less than the group without degrees. Hence, obtaining an advanced academic degree enhances the retainability of Civil Engineering officers, and as such should be considered by personnel in the management of the career field.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

There is no doubt as to the importance of advanced academic education in today's modern Air Force. Today's complex weapon systems demand it. In addition, complex weapon systems breed complex support systems and the associated problems that go with them.

Within the bounds of a highly educated society, the Air Force officer must deal not only with the complexities of his/her job, he/she must also be capable of interrelating with his/her civilian counterparts. A narrow technical skill can be ineffective without the broad judgment necessary for its measured use. Advanced education is one way officers can acquire such judgment.

The Air Force Civil Engineering officer is the professional to whom the responsibility falls for the development and maintenance of the complex support systems necessary for mission accomplishment. To meet the challenges of these systems and the future, he/she must be equipped with current knowledge in the proper academic disciplines.

In view of the above, the first objective was to develop a model that would determine the number of engineers needed for entry into MS degree programs to fill validated requirements within the civil engineering career field. Objective 1 was accomplished. Variables were identified and a model developed that provided better than 97 percent accuracy in determining quotas for the different engineering academic disciplines.

Objective 2 was to determine if advanced academic degrees enhanced the retainability of civil engineering officers. This objective was accomplished through the use of nonparametric statistics to analyze loss rate percentages from three groups: officers Air Force-wide; officers within the civil engineering career field; and officers within the civil engineering career field with MS degrees.

Conclusions

From the overall analysis and research conducted throughout this study, several conclusions can be drawn.

Objective 1

The model developed can determine the number of quotas for entry into MS degree programs. Validation of the model shows an accuracy of better than 97 percent. The model developed is not all-inclusive. As in any model, it can be continually refined and updated. Like most models, its output will only be as accurate as the information supplied into it. Current information regarding requirements, retention factors, and length of time available to fill valid requirements is essential if the model is expected to be an effective management tool.

Objective 2

The statistical analysis provided in this research showed that the loss rate for officers within the civil engineering career field holding advanced degrees was less than officers within the career field without advanced degrees. Hence, the retention of officers within the civil engineering career field appear to be enhanced by obtaining an advanced academic degree.

Supplementary Discussion

During the validation process of the model, many computer runs were made on the different academic disciplines. These products showed the number of inputs needed on an annual basis to fill validated AAD requirements for the civil engineering career field. More quotas were needed for degrees in technical disciplies at grades 02, 03, and 04. This is logical, for most of the validated requirements at these grades are in technical disciplines. However, during the review of the present AAD program for the civil engineering career field, it was found that the majority of the degree program entries were in the management area. For example, over the last five years, an average of 29 officers have obtained advanced degrees in engineering management, while an average of only 13 officers have obtained advanced degrees in technical engineering disciplines. With more than 80 percent of the degrees in grades 02 to 04 in the technical areas, inputing 70 percent of the overall annual input into management programs will continually fail to fill the majority of the validated requirements.

Recommendations

The research effort surfaced some issues related to the subject that need further research. In the area of developing a more dynamic and responsive model, further research is needed to determine the effects (if any) on the promotability of officers with advanced degrees and officers without advanced degrees. Also, some knowledge of systems dynamics should be obtained so that the present model can be expanded to account for the effect variables have on the AAD system over a period of time.

The author recommends that the model presented in this study be used by personnel in managing the civil engineering career field. Further, it is recommended that it be used by personnel managers in any career field for the purpose of determining quotas to MS degree programs.

If is further recommended that personnel managing the civil engineering career field look at the validated requirements vs the present inputs into various degree programs. One of the two must be changed if the AAD system is ever going to be balanced.

And finally, the author recommends that the opportunity for advanced degrees continue to be offered to officers in grades 02 to 04. The broader knowledge attained from an advanced degree, coupled with increased retention, will insure the Air Force Civil Engineering force the numbers of highly educated officers it needs to meet the challenges of the future.

APPENDIX A

REVIEW OF AAD'S FOR AFCE CAREER FIELD

Introduction

A complete review of the AAD's for the Air Force Civil Engineering career field was conducted as background information and to determine factors that could be used in the development of a model to determine inputs into the student pipeline. The results of the review are presented below.

AAD's Distribution

The distribution of graduate academic disciplines within the civil engineering career field, as contained in AFM 36-19, is provided in Table 7.

TABLE 7

Desired Advanced Academic Degree Requirements for Air Force Civil Engineering Officers

Discipline	Advanced Degree Requirement in Percent of Total C.E. Officer Force (%)
Architect/Architectural Engineering	2
Civil Engineering	9
Environmental Engineering	5
Electrical Engineering	5
Mechanical Engineering	5
Industrial Engineering	5
Facilities Management	4
Engineering Management	5
Total	40

Source: (17)

The actual distribution of validated advanced academic degree disciplines in the civil engineering career field is shown in

Table 8.

TABLE 8

Actual Advanced Academic Degree Requirements for Air Force Civil Engineering Officers

Discipline	Advanced Degree Requirement in Percent of Total C.E. Officer Force (%)
Architect/Architectural Engineering	1.02
Civil Engineering	7.35
Electrical Engineering	.97
Mechanical Engineering	1.25
Industrial Engineering	4.72
Engineering Management	17.26
Total	32.57

As shown, there is some disparity between the desired distribution in AFR 36-19, and the current validated requirements. For instance, the actual distribution no longer shows a need for degrees in the environmental and facilities management disciplines. Also, the percentage of personnel in engineering management is quite higher than the percentages of facilities and engineering management combined. However, the overall actual percentage of 32.57 of the total force is lower than the desired level of 40 percent. A conclusion can be made that the number of requirements today are below the desired level of 40 percent, and that the inputs are not balanced between the various disciplines.

Table 9 shows the percent of the total force by AFSC vs the percent of that AFSC authorized Master's degrees. From this table, it is possible to see the number of Master's degrees authorized by AFSC as compared to the size of that

TABLE 9

Percent of Total Force by AFSC vs Percent of AFSC Authorized Master's Degrees

AFSC	% Total Force	% Authorized Master's
Arch. - 5525A	5.5	19.2
Civil - 5525C	15.4	43.0
Elect. - 5525E	5.8	17.1
Mech. - 5525F	7.2	16.7
Indus. - 5525D	5.4	80.6
General - 5525G	33.0	18.6
Staff - 5516	27.7	49.6
Total	100.0	

Source: Ref (1)

AFSC with the total force. For example, Industrial Engineers make up only 5.4 percent of the total civil engineering career field; however, 80.6 percent of the Industrial Engineers have validated Master's degree positions. Compare that to Civil Engineers who comprise 15.4 percent of the total civil engineering force; however, they only have 43 percent of the positions validated at the Master's degree level.

Technical vs Management Degrees

Another area of concern is technical degrees vs management degrees. Table 10 shows the breakdown between Technical vs Management validated degree requirements in grades 01-03 and 04-06.

The majority of the technical degree requirements are at grades 01-03. This appears logical as the majority of management positions would occur at the senior grades. It is

TABLE 10

Technical vs Management Degrees

Discipline	01-03	04-06	Total
Management	41	261	302
Technical	199	104	303
		Total	605
Source: Ref (1)			

apparent that in order to fill the number of management positions in the senior grades, personnel holding MS technical degrees could be used. By the time an officer reaches the senior grades, his professional military education (PME), coupled with the experience and knowledge acquired from any advanced academic degree would allow him to fill a management AAD position.

Approximately 25 officers are input into the Graduate of Engineering Management Program on an annual basis. A run was made of the total validated management requirements to see if an average input of 25 per year would fill requirements. The results show that after 16 years, overages would occur in all grades except 05 (see Appendix L).

Summary

Some disparities exist between the stated Air Force distribution for graduate degrees within the civil engineering career area and the current requirements. Also, there may be some disparity between the number of Master's degrees validated by AFSC. Over the last five years, an average of 29 officers have obtained degrees in engineering management programs, while an average of only 13 officers have obtained degrees in technical engineering disciplines. With 199 positions available for degree holders with technical engineering degrees vs 41 positions available for degree holders with management degrees, it is unlikely that the technical degree requirements can be filled under current distribution of AAD quotas.

Many variables can be associated with the AAD program for the civil engineering career field. Among them are costs, retention, requirements, force size, demand, inputs, and ability to educate engineers. This list is by no means inclusive. While not all of these variables can be classified as direct contributors, they do interrelate to some degree and could influence decisions relating to the management of the Air Force Civil Engineering career field.

APPENDIX B

MODEL'S COMPUTER PROGRAM

```
LIST
100 REM***01,02,03,04,05,06 VARIABLES LISTED UNDER GRADE CORRESPONDS TO GRADE
102 REM***R1,R2,R3,R4,R5,R6 = REQUIREMENTS GRADE 01-06
106 REM***P1,P2,P3,P4,P5,P6 = NEW INPUTS GRADE 01-06
108 REM***X1,X2,X3,X4,X5,X6 = DEMANDS BY GRADE 01-06
110 REM***U1,U2,U3,U4,U5,U6 = RETENTION FACTOR GRADE 01-06
112 PRINT
114 PRINT
116 INPUT R1,R2,R3,R4,R5,R6,P1,P2,P3,P4,P5,P6,U1,U2,U3,U4,U5,U6
118 PRINT
119 PRINT
120 PRINT
122 PRINT
124 PRINT 'CIVIL ENGINEERING MASTER DEGREES'
126 PRINT
128 PRINT
130 PRINT '- INDICATES OVERMANNING'
132 PRINT '+ INDICATES UNDERMANNING'
134 PRINT '0 INDICATES NO REQUIREMENTS'
136 PRINT
138 PRINT
140 PRINT 'YEAR',1
142 PRINT
144 PRINT
146 PRINT 'GRADE',1,2,3,4,5,6
148 PRINT
150 X1 = R1-(P1 * U1)
152 X2 = R2-(P2 *U2)
154 X3 = R3-(P3 * U3)
156 X4 = R4-(P4 * U4)
158 X5 = R5-(P5 * U5)
160 X6 = R6-(P6 *U6)
162 PRINT
164 PRINT 'DEMAND',X1,X2,X3,X4,X5,X6
166 IF X1+X2+X3+X4+X5+X6 < 0 GOTO 900
168 PRINT
170 PRINT
172 PRINT 'YEAR',2
174 PRINT
176 PRINT
178 PRINT 'GRADE',1,2,3,4,5,6
180 PRINT
182 PRINT
184 X1 = R1-(2*P1)*U1
186 X2 = R2-(2*P2)*U2
188 X3 = R3-(2*P3)*U3
190 X4 = R4-(2*P4)*U4
192 X5 = R5-(2*P5)*U5
194 X6 = R6-(2*P6)*U6
196 PRINT'DEMAND',X1,X2,X3,X4,X5,X6
198 IF X1+X2+X3+X4+X5+X6 < 0 GOTO 900
```

```
200 PRINT
202 PRINT
204 PRINT 'YEAR',3
206 PRINT
208 PRINT
210 PRINT 'GRADE',1,2,3,4,5,6
212 PRINT
214 C1 = R1-(2*P1)*U1
216 X1 = C1
218 X2 = R2-(2*P2 + P1)*U2
220 X3 = R3-(3*P3 + P2)*U3
222 X4 = R4-(3*P4)*U4
224 X5 = R5-(3*P5)*U5
226 X6 = R6-(3*P6)*U6
228 PRINT
230 PRINT 'DEMAND',X1,X2,X3,X4,X5,X6
232 IF X1+X2+X3+X4+X5+X6 < 0 GOTO 900
233 PRINT
234 PRINT
235 PRINT 'YEAR',4
236 PRINT
238 PRINT
240 PRINT 'GRADE',1,2,3,4,5,6
242 PRINT
244 C2 = R2-(2*P2 + 2*P1)*U2
246 X1 = C1
248 X2 = C2
250 X3 = R3-(4*P3 + 2*P2)*U3
252 X4 = R4-(4*P4)*U4
254 X5 = R5-(4*P5)*U5
256 X6 = R6-(4*P6)*U6
258 PRINT
260 PRINT 'DEMAND',X1,X2,X3,X4,X5,X6
262 IF X1+X2+X3+X4+X5+X6 <0 GOTO 900
264 PRINT
266 PRINT
268 PRINT 'YEAR',5
270 PRINT
272 PRINT
274 PRINT 'GRADE',1,2,3,4,5,6
276 PRINT
278 X1 = C1
280 X2 = C2
282 X3 = R3-(4*P3 + 3*P2 + P1)*U3
284 X4 = R4-(4*P4 + P3)*U4
286 X5 = R5-(4*P5 + P4)*U5
288 X6 = R6-(5*P6 + P5)*U6
290 PRINT
292 PRINT 'DEMAND',X1,X2,X3,X4,X5,X6
```

```
294 IF X1+X2+X3+X4+X5+X6 < 0 GOTO 900
296 PRINT
298 PRINT
300 PRINT 'YEAR',6
302 PRINT
304 PRINT
306 PRINT 'GRADE',1,2,3,4,5,6
308 PRINT
310 X1 = C1
312 X2 = C2
314 X3 = R3-(4*P3 + 4*P2 + 2*P1)*U3
316 X4 = R4-(4*P4 + 2*P3)*U4
318 X5 = R5-(4*P5 + 2*P4)*U5
320 X6 = R6-(6*P6 + 2*P5)*U6
322 PRINT
324 PRINT 'DEMAND',X1,X2,X3,X4,X5,X6
326 IF X1+X2+X3+X4+X5+X6 < 0 GOTO 900
328 PRINT
330 PRINT
332 PRINT 'YEAR',7
334 PRINT
336 PRINT
338 PRINT 'GRADE',1,2,3,4,5,6
340 PRINT
342 X1 = C1
344 X2 = C2
348 X3 = R3-(4*P3 + 5*P2 + 3*P1)*U3
350 X4 = R4-(4*P4 + 3*P3)*U4
352 X5 = R5-(4*P5 + 3*P4)*U5
354 X6 = R6-(7*P6 + 3*P5)*U6
356 PRINT
358 PRINT 'DEMAND',X1,X2,X3,X4,X5,X6
360 IF X1+X2+X3+X4+X5+X6 < 0 GOTO 900
362 PRINT
364 PRINT
366 PRINT 'YEAR',8
368 PRINT
370 PRINT
372 PRINT 'GRADE',1,2,3,4,5,6
374 PRINT
376 X1 = C1
378 X2 = C2
380 X3 = R3-(4*P3 + 6*P2 + 4*P1)*U3
382 X4 = R4-(4*P4 + 4*P3)*U4
384 X5 = R5-(4*P5 + 4*P4)*U5
386 X6 = R6-(8*P6 + 4*P5)*U6
388 PRINT
390 PRINT 'DEMAND',X1,X2,X3,X4,X5,X6
392 IF X1+X2+X3+X4+X5+X6 < 0 GOTO 900
```

```
394 PRINT
396 PRINT
398 PRINT 'YEAR',9
400 PRINT
402 PRINT
404 PRINT 'GRADE',1,2,3,4,5,6
406 PRINT
408 X1 = C1
410 X2 = C2
412 X3 = R3-(4*P3 + 6*P2 + 5*P1)*U3
414 X4 = R4-(4*P4 + 4*P3 + P2)*U4
416 X5 = R5-(4*P5 + 4*P4 + P3)*U5
418 X6 = R6-(9*P6 + 5*P5 + P4)*U6
420 PRINT
422 PRINT 'DEMAND',X1,X2,X3,X4,X5,X6
424 IF X1+X2+X3+X4+X5+X6 < 0 GOTO 900
426 PRINT
428 PRINT
430 PRINT 'YEAR',10
432 PRINT
434 PRINT
436 PRINT 'GRADE',1,2,3,4,5,6
438 PRINT
440 X1 = C1
442 X2 = C2
443 C3 = R3-(4*P3 + 6*P2 + 6*P1)*U3
444 X3 = C3
446 X4 = R4-(4*P4 + 4*P3 + 2*P2)*U4
448 X5 = R5-(4*P5 + 4*P4 + 2*P3)*U5
450 X6 = R6-(10*P6 + 6*P5 + 2*P4)*U6
452 PRINT
454 PRINT 'DEMAND',X1,X2,X3,X4,X5,X6
456 IF X1+X2+X3+X4+X5+X6 < 0 GOTO 900
458 PRINT
460 PRINT
462 PRINT 'YEAR',11
464 PRINT
466 PRINT
468 PRINT 'GRADE',1,2,3,4,5,6
470 PRINT
474 X1 = C1
476 X2 = C2
478 X3 = C3
480 X4 = R4-(4*P4 + 4*P3 + 3*P2 + P1)*U4
482 X5 = R5-(4*P5 + 4*P4 + 3*P3)*U5
484 X6 = R6-(11*P6 + 7*P5 + 3*P4)*U6
486 PRINT
488 PRINT 'DEMAND',X1,X2,X3,X4,X5,X6
490 IF X1+X2+X3+X4+X5+X6 < 0 GOTO 900
500 PRINT
```

```
502 PRINT
504 PRINT 'YEAR',12
506 PRINT
508 PRINT
510 PRINT 'GRADE',1,2,3,4,5,6
512 PRINT
514 X1 = C1
516 X2 = C2
518 X3 = C3
520 X4 = R4-(4*P4 + 4*P3 + 4*P2 + 2*P1)*U4
522 X5 = R5-(4*P5 + 4*P4 + 4*P3)*U5
524 X6 = R6-(12*P6 + 8*P5 + 4*P4)*U6
526 PRINT
528 PRINT 'DEMAND',X1,X2,X3,X4,X5,X6
530 IF X1+X2X3+X4+X5+X6 < 0 GOTO 900
532 PRINT
534 PRINT
536 PRINT 'YEAR',13
538 PRINT
540 PRINT
542 PRINT 'GRADE',1,2,3,4,5,6
544 PRINT
546 X1 = C1
548 X2 = C2
550 X3 = C3
552 X4 = R4-(4*P4 + 4*P3 + 4*P2 + 3*P1)*U4
554 X5 = R5-(4*P5 + 4*P4 + 4*P3 + P2)*U5
556 X6 = R6-(13*P6 + 9*P5 + 5*P4 + P3)*U6
559 PRINT
560 PRINT 'DEMAND',X1,X2,X3,X4,X5,X6
562 IF X1+X2+X3+X4+X5+X6 < 0 GOTO 900
564 PRINT
566 PRINT
568 PRINT 'YEAR',14
570 PRINT
572 PRINT
574 PRINT 'GRADE',1,2,3,4,5,6
576 PRINT
578 X1 = C1
580 X2 = C2
582 X3 = C3
584 X4 = R4-(4*P4 + 4*P3 + 4*P2 + 4*P1)*U4
586 X5 = R5-(4*P5 + 4*P4 + 4*P3 + 2*P2)*U5
588 X6 = R6-(14*P6 + 10*P5 + 6*P4 + 2*P3)*U6
590 PRINT
592 PRINT 'DEMAND',X1,X2,X3,X4,X5,X6
594 IF X1+X2+X3+X4+X5+X6 < 0 GOTO 900
596 PRINT
598 PRINT
```

```
600 PRINT 'YEAR',15
602 PRINT
604 PRINT
606 PRINT 'GRADE',1,2,3,4,5,6
608 PRINT
610 X1 = C1
612 X2 = C2
614 X3 = C3
616 X4 = R4-(4*P4 + 4*P3 + 4*P2 + 5*P1)*U4
618 X5 = R5-(4*P5 + 4*P4 + 4*P3 + 3*P2)*U5
620 X6 = R6-(15*P6 + 11*P5 + 7*P4 + 3*P3)*U6
622 PRINT
624 PRINT 'DEMAND',X1,X2,X3,X4,X5,X6
626 IF X1+X2+X3+X4+X5+X6 < 0 GOTO 900
628 PRINT
630 PRINT
632 PRINT 'YEAR',16
634 PRINT
636 PRINT
638 PRINT 'GRADE',1,2,3,4,5,6
640 PRINT
642 X1 = C1
644 X2 = C2
646 X3 = C3
648 C4 = R4-(4*P4 + 4*P3 + 4*P2 + 6*P1)*U4
650 X4 = C4
652 X5 = R5-(4*P5 + 4*P4 + 4*P3 + 4*P2)*U5
654 X6 = R6-(16*P6 + 12*P5 + 8*P4 + 4*P3)*U6
656 PRINT
658 PRINT 'DEMAND',X1,X2,X3,X4,X5,X6
660 IF X1+X2+X3+X4+X5+X6 = 0 GOTO 900
662 PRINT
664 PRINT
666 PRINT 'YEAR',17
668 PRINT
670 PRINT
672 PRINT 'GRADE',1,2,3,4,5,6
674 PRINT
676 X1 = C1
678 X2 = C2
680 X3 = C3
682 X4 = C4
684 X5 = R5-(4*P5 + 4*P4 + 4*P3 + 4*P2 + P1)*U5
686 X6 = R6-(17*P6 + 13*P5 + 9*P4 + 5*P3 + P2)*U6
688 PRINT
690 PRINT 'DEMAND',X1,X2,X3,X4,X5,X6
692 IF X1+X2+X3+X4+X5+X6 < 0 GOTO 900
694 PRINT
696 PRINT
698 PRINT 'YEAR',18
700 PRINT
```

```
702 PRINT
704 PRINT 'GRADE',1,2,3,4,5,6
706 PRINT
708 X1 = C1
710 X2 = C2
712 X3 = C3
714 X4 = C4
716 X5 = R5-(4*P5 + 4*P4 + 4*P3 + 4*P2 + 2*P1)*U5
718 X6 = R6-(18*P6 + 14*P5 + 10*P4 + 6*P3 + 2*P2)*U6
720 PRINT
722 PRINT 'DEMAND',X1,X2,X3,X4,X5,X6
724 IF X1+X2+X3+X4+X5+X6 < 0 GOTO 900
726 PRINT
728 PRINT
730 PRINT 'YEAR',19
732 PRINT
734 PRINT
736 PRINT 'GRADE',1,2,3,4,5,6
738 PRINT
740 X1 = C1
742 X2 = C2
744 X3 = C3
746 X4 = C4
748 X5 = R5-(4*P5 + 4*P4 + 4*P3 + 4*P2 + 3*P1)*U5
750 X6 = R6-(19*P6 + 15*P5 + 11*P4 + 7*P3 + 3*P2)*U6
752 PRINT
754 PRINT 'DEMAND',X1,X2,X3,X4,X5,X6
756 IF X1+X2+X3+X4+X5+X6 < 0 GOTO 900
758 PRINT
760 PRINT
762 PRINT 'YEAR',20
764 PRINT
766 PRINT
768 PRINT 'GRADE',1,2,3,4,5,6
770 PRINT
772 X1 = C1
774 X2 = C2
776 X3 = C3
778 X4 = C4
780 X5 = R5-(4*P5 + 4*P4 + 4*P3 + 4*P2 + 4*P1)*U5
782 X6 = R6-(20*P6 + 16*P5 + 12*P4 + 8*P3 + 4*P2)*U6
784 PRINT
786 PRINT 'DEMAND',X1,X2,X,X4,X5.X6
788 IF X1+X2+X3+X4+X5+X6 < 0 GOTO 900
900 STOP
999 END
```

APPENDIX C

FIRST RUN OF TOTAL AAD REQUIREMENTS AFCE

```
RUN

?0,28,211,131,163,72,0,14,0,0,0,0,1,1,.95,.95,.95,.86
```

CIVIL ENGINEERING MASTER DEGREES

- INDICATES OVERMANNING
+ INDICATES UNDERMANNING
0 INDICATES NO REQUIREMENTS

YEAR	1					
GRADE	1	2	3	4	5	6
DEMAND	0	14	211	131	163	72
YEAR	2					
GRADE	1	2	3	4	5	6
DEMAND	0	0	211	131	163	72

YEAR	3					
GRADE	1	2	3	4	5	6
DEMAND	0	0	197.7	131	163	72
YEAR	4					
GRADE	1	2	3	4	5	6
DEMAND	0	0	184.4	131	163	72
YEAR	5					
GRADE	1	2	3	4	5	6
DEMAND	0	0	171.1	131	163	72

YEAR	6					
GRADE	1	2	3	4	5	6
DEMAND	0	0	157.8	131	163	72
YEAR	7					
GRADE	1	2	3	4	5	6
DEMAND	0	0	144.5	131	163	72
YEAR	8					
GRADE	1	2	3	4	5	6
DEMAND	0	0	131.2	131	163	72
YEAR	9					
GRADE	1	2	3	4	5	6
DEMAND	0	0	131.2	117.7	163	72

APPENDIX D

SECOND RUN OF TOTAL AAD REQUIREMENTS AFCE

?0,28,211,131,163,72,0,14,33,0,0,0,1,1,.95,.95,.95,.86

CIVIL ENGINEERING MASTER DEGREES

- INDICATES OVERMANNING
+ INDICATES UNDERMANNING
0 INDICATES NO REQUIREMENTS

YEAR	1					
GRADE	1	2	3	4	5	6
DEMAND	0	14	179.65	131	163	72
YEAR	2					
GRADE	1	2	3	4	5	6
DEMAND	0	0	148.3	131	163	72

YEAR	3					
GRADE	1	2	3	4	5	6
DEMAND	0	0	103.65	131	163	72
YEAR	4					
GRADE	1	2	3	4	5	6
DEMAND	0	0	59	131	163	72
YEAR	5					
GRADE	1	2	3	4	5	6
DEMAND	0	0	45.7	99.65	163	72
YEAR	6					
GRADE	1	2	3	4	5	6
DEMAND	0	0	32.4	68.3	163	72

YEAR	7					
GRADE	1	2	3	4	5	6
DEMAND	0	0	19.1	36.95	163	72
YEAR	8					
GRADE	1	2	3	4	5	6
DEMAND	0	0	5.800000001	5.600000001	163	72
YEAR	9					
GRADE	1	2	3	4	5	6
DEMAND	0	0	5.800000001	-7.699999999	131.65	72

APPENDIX E

THIRD RUN OF TOTAL AAD REQUIREMENTS AFCE

?0,28,211,131,163,72,0,14,35,0,0,0,1,1,.95,.95,.95,.86

CIVIL ENGINEERING MASTER DEGREES

- INDICATES OVERMANNING
+ INDICATES UNDERMANNING
0 INDICATES NO REQUIREMENTS

YEAR	1					
GRADE	1	2	3	4	5	6
DEMAND	0	14	177.75	131	163	72
YEAR	2					
GRADE	1	2	3	4	5	6
DEMAND	0	0	144.5	131	163	72
YEAR	3					
GRADE	1	2	3	4	5	6
DEMAND	0	0	97.95	131	163	72

YEAR	4					
GRADE	1	2	3	4	5	6
DEMAND	0	0	51.4	131	163	72
YEAR	5					
GRADE	1	2	3	4	5	6
DEMAND	0	0	38.1	97.75	163	72
YEAR	6					
GRADE	1	2	3	4	5	6
DEMAND	0	0	24.8	64.5	163	72
YEAR	7					
GRADE	1	2	3	4	5	6
DEMAND	0	0	11.5	31.25	163	72

YEAR	8					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-1.8	-2	163	72
YEAR	9					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-1.8	-15.3	129.75	72
YEAR	10					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-1.8	-28.6	96.5	72
YEAR	11					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-1.8	-41.9	63.25	72

YEAR	12					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-1.8	-55.2	30	72
YEAR	13					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-1.8	-55.2	16.7	41.9
YEAR	14					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-1.8	-55.2	3.4	11.8

STOP @ 900

APPENDIX F

RUN OF TOTAL TECHNICAL ENGINEERING DISCIPLINES

70,21,177,43,38,24,0,11,30,1,0,0,1,1,.95,.95,.95,.86

CIVIL ENGINEERING MASTER DEGREES

- INDICATES OVERMANNING
+ INDICATES UNDERMANNING
0 INDICATES NO REQUIREMENTS

YEAR	1					
GRADE	1	2	3	4	5	6
DEMAND	0	10	148.5	42.05	38	24
YEAR	2					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	120	41.1	38	24

YEAR	3					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	81.05	40.15	38	24
YEAR	4					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	42.1	39.2	38	24
YEAR	5					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	31.65	10.7	37.05	24
YEAR	6					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	21.2	-17.8	36.1	24

YEAR	7					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	10.75	-46.3	35.15	24
YEAR	8					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	.3000000007	-74.8	34.2	24
YEAR	9					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	.3000000007	-85.25	5.7	23.14
YEAR	10					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	.3000000007	-95.7	-22.8	22.28

YEAR	11					
GRADE	1	2	3	[illegible]	5	6
DEMAND	0	-1	.3000000007	-106.15	-51.3	21.42
YEAR	12					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	.3000000007	-116.6	-79.8	20.56
YEAR	13					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	.3000000007	-116.6	-90.25	-6.1

APPENDIX G

RUN OF ELECTRICAL ENGINEERING DISCIPLINE

?0,3,17,0,2,0,0,2,2,0,0,0,1,1,.95,.95,.95,.86

CIVIL ENGINEERING MASTER DEGREES

- INDICATES OVERMANNING
+ INDICATES UNDERMANNING
0 INDICATES NO REQUIREMENTS

YEAR	1					
GRADE	1	2	3	4	5	6
DEMAND	0	1	15.1	0	2	0
YEAR	2					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	13.2	0	2	0

YEAR	3					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	9.4	0	2	0
YEAR	4					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	5.6	0	2	0
YEAR	5					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	3.7	-1.9	2	0
YEAR	6					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	1.8	-3.8	2	0

YEAR	7					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-.1	-5.7	2	0
YEAR	8					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-2	-7.6	2	0
YEAR	9					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-2	-9.5	.1	0

APPENDIX H

RUN OF INDUSTRIAL ENGINEERING DISCIPLINE

?0,5,62,8,7,1,0,3,12,0,0,0,1,1,.95,.95,.95,.86

CIVIL ENGINEERING MASTER DEGREES

- INDICATES OVERMANNING
+ INDICATES UNDERMANNING
0 INDICATES NO REQUIREMENTS

YEAR	1					
GRADE	1	2	3	4	5	6
DEMAND	0	2	50.6	8	7	1
YEAR	2					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	39.2	8	7	1

YEAR	3					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	24.95	8	7	1
YEAR	4					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	10.7	8	7	1
YEAR	5					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	7.85	-3.4	7	1
YEAR	6					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	5	-14.8	7	1

YEAR	7					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	2.15	-26.2	7	1
YEAR	8					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-.7	-37.6	7	1
YEAR	9					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-.7	-40.45	-4.4	1
YEAR	10					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-.7	-43.3	-15.8	1

YEAR	11					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-.7	-46.15	-27.2	1
YEAR	12					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-.7	-49	-38.6	1
YEAR	13					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-.7	-49	-41.45	-9.32

APPENDIX I

RUN OF MECHANICAL ENGINEERING DISCIPLINE

?0,0,13,6,1,0,0,0,4,0,0,0,1,1,.95,.95,.95,.86

CIVIL ENGINEERING MASTER DEGREES

- INDICATES OVERMANNING
+ INDICATES UNDERMANNING
0 INDICATES NO REQUIREMENTS

YEAR	1					
GRADE	1	2	3	4	5	6
DEMAND	0	0	9.2	6	1	0
YEAR	2					
GRADE	1	2	3	4	5	6
DEMAND	0	0	5.4	6	1	0

YEAR	3					
GRADE	1	2	3	4	5	6
DEMAND	0	0	1.6	6	1	0
YEAR	4					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-2.2	6	1	0
YEAR	5					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-2.2	2.2	1	0
YEAR	6					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-2.2	-1.6	1	0

YEAR	7					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-2.2	-5.4	1	0
YEAR	8					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-2.2	-9.2	1	0
YEAR	9					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-2.2	-9.2	-2.8	0

AD-A123 004 A MODEL FOR DETERMINING ANNUAL QUOTAS TO FILL ADVANCED ACADEMIC DEGREE RE..(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYST.. J C RISH 2/2

UNCLASSIFIED SEP 82 AFIT-LSSR-52-82 F/G 5/9 NL

END
1-83
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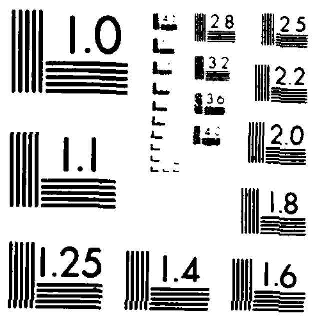

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

APPENDIX J

RUN OF CIVIL ENGINEERING DISCIPLINE

70,8,72,25,20,6,0,4,13,0,0,0,1,1,.95,.95,.95,.86

CIVIL ENGINEERING MASTER DEGREES

- INDICATES OVERMANNING
+ INDICATES UNDERMANNING
0 INDICATES NO REQUIREMENTS

YEAR	1					
GRADE	1	2	3	4	5	6
DEMAND	0	4	59.65	25	20	6
YEAR	2					
GRADE	1	2	3	4	5	6
DEMAND	0	0	47.3	25	20	6

YEAR	3					
GRADE	1	2	3	4	5	6
DEMAND	0	0	31.15	25	20	6
YEAR	4					
GRADE	1	2	3	4	5	6
DEMAND	0	0	15	25	20	6
YEAR	5					
GRADE	1	2	3	4	5	6
DEMAND	0	0	11.2	12.65	20	6
YEAR	6					
GRADE	1	2	3	4	5	6
DEMAND	0	0	7.4	.3	20	6

YEAR	7					
GRADE	1	2	3	4	5	6
DEMAND	0	0	3.6	-12.05	20	6
YEAR	8					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-.1999999997	-24.4	20	6
YEAR	9					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-.1999999997	-28.2	7.65	6
YEAR	10					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-.1999999997	-32	-4.7	6

YEAR	11					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-.1999999997	-35.8	-17.05	6
YEAR	12					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-.1999999997	-39.6	-29.4	6
YEAR	13					
GRADE	1	2	3	4	5	6
DEMAND	0	0	-.1999999997	-39.6	-33.2	-5.18

APPENDIX K

RUN OF ARCHITECTURAL ENGINEERING DISCIPLINE

?0,3,16,2,1,0,0,2,1,0,0,0,1,1,.95,.95,.95,.86

CIVIL ENGINEERING MASTER DEGREES

- INDICATES OVERMANNING
+ INDICATES UNDERMANNING
0 INDICATES NO REQUIREMENTS

YEAR	1					
GRADE	1	2	3	4	5	6
DEMAND	0	1	15.05	2	1	0
YEAR	2					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	14.1	2	1	0

YEAR	3					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	11.25	2	1	0
YEAR	4					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	8.4	2	1	0
YEAR	5					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	6.5	1.05	1	0
YEAR	6					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	4.6	.1	1	0

YEAR	7					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	2.7	-.85	1	0
YEAR	8					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	.8	-1.8	1	0
YEAR	9					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	.8	-3.7	.05	0
YEAR	10					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	.8	-5.6	-.9	0

APPENDIX L

RUN OF MANAGEMENT ENGINEERING DISCIPLINE

?0,7,34,88,125,48,0,4,20,1,0,0,1,1..95,.95,.95,.86

CIVIL ENGINEERING MASTER DEGREES

- INDICATES OVERMANNING
+ INDICATES UNDERMANNING
0 INDICATES NO REQUIREMENTS

YEAR	1					
GRADE	1	2	3	4	5	6
DEMAND	0	3	15	87.05	125	48
YEAR	2					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-4	86.1	125	48

YEAR	3					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-26.8	85.15	125	48
YEAR	4					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-49.6	84.2	125	48
YEAR	5					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-53.4	65.2	124.05	48
YEAR	6					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-57.2	46.2	123.1	48

YEAR	7					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-61	27.2	122.15	48
YEAR	8					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-64.8	8.2	121.2	48
YEAR	9					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-64.8	4.4	102.2	47.14
YEAR	10					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-64.8	.6000000001	83.2	46.28

YEAR	11					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-64.8	-3.2	64.2	45.42
YEAR	12					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-64.8	-7	45.2	44.56
YEAR	13					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-64.8	-7	41.4	26.5
YEAR	14					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-64.8	-7	37.6	8.44

YEAR	15					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-64.8	-7	33.8	-9.62
YEAR	16					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-64.8	-7	30	-27.68
YEAR	17					
GRADE	1	2	3	4	5	6
DEMAND	0	-1	-64.8	-7	30	-49.18

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83