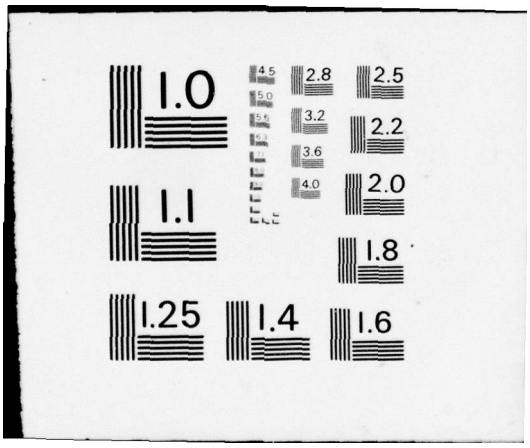
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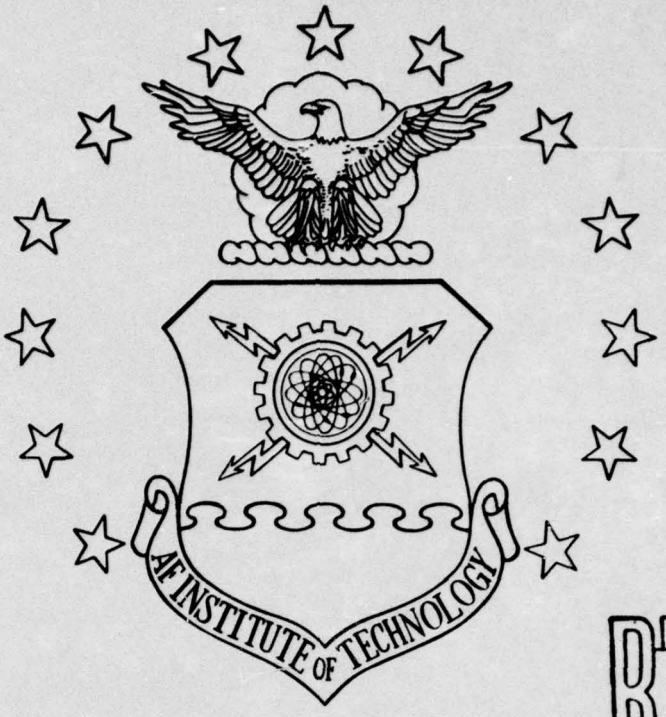
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This thesis analyzes the growth rate of usage of the Air Force Logistics Command CREATE computer system by the Air Force Institute of Technology. The analysis uses exponential smoothing in time series forecasting, linear regression to determine the effect of changes in the number of batch jobs or hours of time sharing on the amount of each parameter used such as Core, central processing unit and input-output, and interviews of the faculty and staff to determine curriculum and policy changes not reflected in the historical data base of computer usage. The data base for the analysis was the thirty-month period from January, 1974, to June, 1976. The forecast was for the twelve-month period from July, 1976, to June 1977. The results showed a slight increase in most parameters over the forecast period. An interruption in the start and stop times of the School of Systems and Logistics graduate 'A' class in early 1975 explained a relatively large cyclic error term. It was concluded that the time series forecast held promise for computer usage prediction and may have application in scheduling of computer systems.

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A MODEL TO FORECAST COMPUTER USAGE BY THE AIR FORCE INSTITUTE OF TECHNOLOGY

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 Logistics Management

By

Thomas E. Anderson, BS
Captain, USAF

Gerald A. Purnell, BS, MA
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September 1976

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This thesis, written by

Captain Thomas E. Anderson

and

Mr. Gerald A. Purnell

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

MASTER OF SCIENCE IN LOGISTICS MANAGEMENT

DATE: 7 September 1976

Eugene C. Jones

COMMITTEE CHAIRMAN

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CHAPTER I

INTRODUCTION

This chapter includes a discussion of the problem, the background of the problem, the significance of and reason for the research, and the research questions.

The Problem

The Air Force Institute of Technology (AFIT) located on Wright-Patterson Air Force Base, Ohio, performs its mission through the educational and training programs of three separate schools: the School of Engineering (AFIT/EN), the School of Civil Engineering (AFIT/DE), and the School of Systems and Logistics (AFIT/SL). Each of the schools has a unique computer capability to serve its own needs.

The School of Systems and Logistics (AFIT/SL) will relocate in 1977, from Building 288, Area A, Wright-Patterson Air Force Base, Ohio, to Building 641, Area B, Wright-Patterson Air Force Base (see Figure 1). AFIT/SL will, therefore, be located in Area B with the other AFIT schools, whereas it is now approximately three miles away. The new AFIT/SL facility is programmed to have the same capability and to remain tied to the same computer system as before.

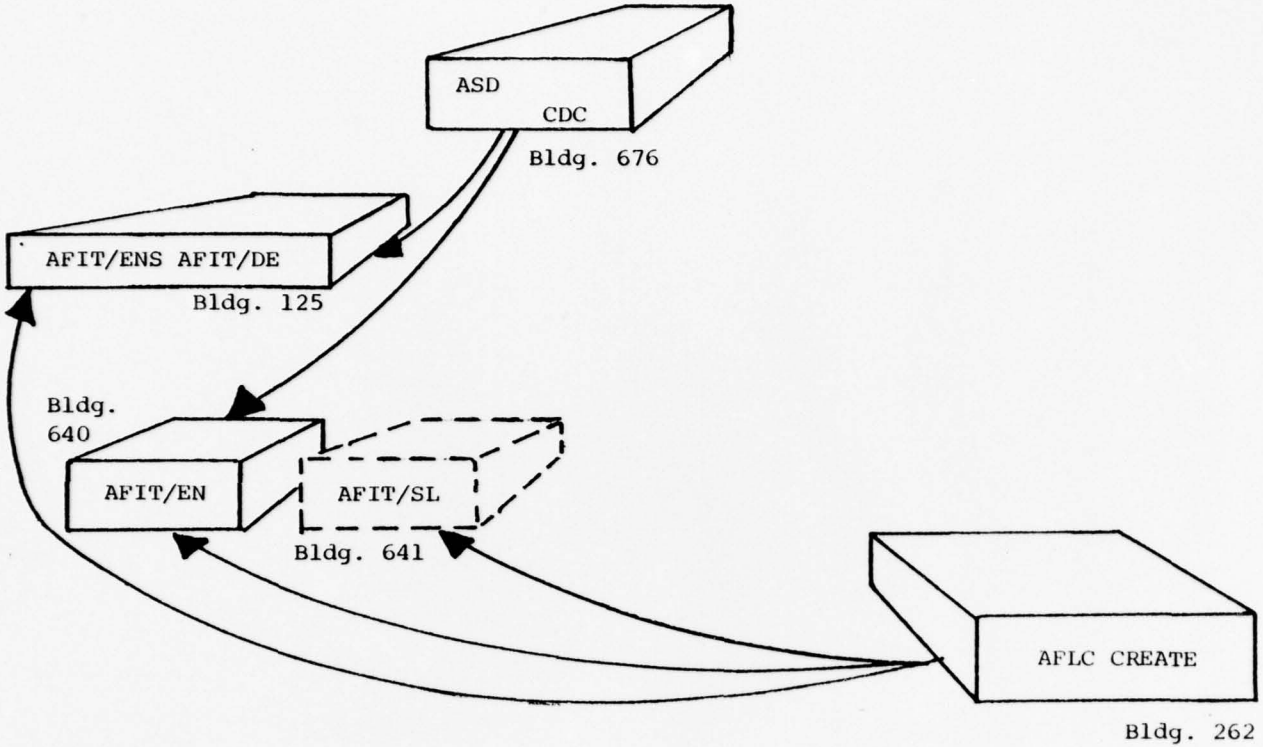


FIGURE 1. AFIT SCHOOLS AND LOCATIONS OF COMPUTER SYSTEMS AT WRIGHT-PATTERSON AFB, OHIO

The development of a model capable of predicting future AFIT usage of the Air Force Logistics Command (AFLC) Honeywell-635 *C*omputational *R*equirements for *E*ngineering *a*nd Simulation *T*raining and *E*ducation (CREATE) computer system is the purpose of this thesis. The effect of the relocation was considered to have a potential influence on the computer system but was not expected to be a central issue (1).

Background

A discussion of the mission and computer capability of each of the AFIT schools follows.

1. The School of Engineering offers graduate and undergraduate curricula designed to meet specific Air Force requirements in specialized fields of engineering and systems management. The school facility is located in Area B, Building 640, Wright-Patterson Air Force Base, Ohio.

The School of Engineering Computation Laboratory contains both analog and digital computer equipment. The analog equipment includes four Electronic Associates TR-48 computers and one mobile TR-10 computer. The digital equipment includes one CDC 1700 (Control Data Corporation) high-speed batch terminal, and seven timesharing remote keyboard terminals. The analog and digital computer equipment is connected to the Control Data Corporation

(Dual 6600s) computer system located at the Computer Science Center, Building 676, of the Aeronautical Systems Division (ASD). In addition, one terminal is connected to the AFLC CREATE computer system (3:26).

2. The Civil Engineering School conducts non-degree training and continuing education courses designed for the professional development of personnel in the Air Force civil engineering field. The school is located in Building 125.

The School of Civil Engineering computer facility consists of one Honeywell 115 remote batch unit which provides printer, punch and card reader capability. Also, there is one ADDS-900 graphics unit and three timesharing remote keyboard terminals. The batch unit, the terminals, the graphics unit, are all connected to the AFLC CREATE computer system (8).

3. The School of Systems and Logistics offers a twelve-month resident program leading to a Master's of Science in Logistics Management. The school also conducts a continuing education program which provides short courses in systems and logistics as required to meet the needs of the Department of Defense.

The AFIT/SL computer facility presently consists of one Honeywell 115 remote batch unit which provides printer, punch and card reader capability. Also, there are thirteen timesharing remote keyboard terminals, two

Honeywell terminets, and one ADDS-900 graphics unit. The batch unit and other remote devices are connected to the AFLC CREATE computer system (1).

The computer facilities located at the three schools are not true stand-alone computer systems but consist of time-sharing remote devices connected to a larger computer system. Future reference to any school's computer facility will be referred to as a "computer system" and is understood to mean those devices or units of equipment which are utilized by the school on a time-sharing basis to fulfill its computational requirements.

History of the AFIT/CREATE Computer Capability

According to the original equipment specification, the specific objectives of the installation and operation of the CREATE system were to:

> . . . enhance the achievement of mission accomplishment and increase the effectiveness of the respective organizations as in AFLC's logistics support of USAF operations, and AFIT's desired education goals [4:7].

The present computer system, CREATE, originated in November of 1966 when the Deputy Chief of Staff for Systems and Logistics instructed AFLC and AFIT to develop a joint computer support plan. Specifications for a time-sharing scientific computer system were forwarded to USAF/AFADA (data processing function) in November of 1967 and by a cost-effectiveness study in April, 1968. The Assistant Secretary of the Air Force

for Financial Management approved funding for the new CREATE computer system in November, 1968. The Request for Proposal (RFP) was released to the computer vendors on 28 February 1969. Subsequently, the General Electric (GE-600) computer system was selected and installed in early 1970.

The Honeywell Corporation acquired the contract from General Electric in 1971 and is now the prime contractor and all computer units were renamed (4:1-2). The Honeywell-600 computer is a modular solid state system which consists of three basic units arrangeable in a variety of configurations to provide the required storage, central processors for computational ability, and input-output controllers (IOC) required for the peripheral equipment being used. System growth is enhanced through modularity of basic units and peripheral devices. Through data communications equipment, remote locations are tied into the central computation system for remote inquiry and data process (10:1-1).

The Present CREATE System

1. *Workload.* The general workload applications for the present system are: (a) engineering computation, (b) logistics research, and (c) education. Specific workload criteria are further identified as statistical analysis, computational methods, simulation, computer

aided design, mathematical programming and education. Additional workloads not meeting the criteria above may be included upon approval of the CREATE Management (6:5).

2. *Management*. Management of the CREATE system is the responsibility of the AFLC Director of Data Automation (ADD) and is affected in accordance with Air Force Regulation 300-2 by the AFLC CREATE Management Branch (ADDRE). AFIT/SL participates in the management of the system through membership in the CREATE User Group. This group is established to provide a link between the users and CREATE management to help achieve the following objectives:

a. Identify short- and long-range requirements

b. Recommend modifications to the system

c. Promote effective utilization of the system

d. Reduce duplicate development efforts

e. Maintain active support of the vendor-user group (6:1).

As stated above, AFIT/SL will move to join the other AFIT schools. At the minimum, this move simply consists of transferring the existing equipment and extending the communication lines to the new area. However, other questions surface which are related to the future of the AFIT/SL computer system. Some of these

questions relate to the new location while others may be relevant even in the absence of a move. The questions fall into two general categories: growth and consolidation.

Growth

The future requirements for computer capability of AFIT are open to question. The past growth rate of the AFIT capability has continued, and the use of the CREATE system as a whole has continued to grow, to the extent that portions of the CREATE system are approaching saturation (2:2).

These undetermined future requirements may be explained in part by the natural growth of the computational capability within AFIT as past growth may show a gradual deterministic rate. The requirements may also be driven by departments within AFIT due to changes in curriculum design which impact upon computer use.

Consolidation

An area where impact upon the AFIT/SL computer system was questioned is the new location of the school itself. The availability of an added collecton of computer terminals could encourage use by one of the other schools and could therefore directly affect the workload of AFIT/SL computer systems (12).

The benefits of dual use of separate computer facilities by AFIT/EN and AFIT/SL raises the question of

equipment consolidation after the move of AFIT/SL was to be completed and the schools were in close proximity. The continued use of two separate computer facilities poses the following questions:

1. Can one of the present systems (CREATE or CDC) be expanded to accommodate all of AFIT's needs?

2. What significant differences between the needs of the two users would prohibit the co-use or consolidation of computer facilities?

3. What duplication of resources would be expended to maintain separate facilities?

4. Would consolidation of computer facilities provide cost savings large enought to justify a stand-alone computer system to support all of AFIT's needs?

The above questions were included because of the relevance of the topic of possible consolidaton to any study of growth despite the fact that they were recognized from the beginning to be beyond the scope of any design to test which could realistically be applied. The aspect of consolidation which *was* an actual input to the research was the attempt to measure projected changes in user demand within each existing school as new equipment would become available by moving into close proximity to potential users.

Justification for Research

Current DOD research does not include any study of an educational institution such as AFIT/SL as a computer user. The fact that the system had not been analyzed for growth and projected workload indicated that such an analysis could add to the existing knowledge needed by AFIT management. In addition, demands on the CREATE system had continued to increase which had caused a decline in the ability to respond to user demands in the preceeding year (2:2). The AFIT/SL demands upon the CREATE system as a result of any increase due to research, curriculum changes, or increased number of users, or the new location was not known. Therefore, any information which may be learned in this area would apply to an imminent management decision process and the question provided by this research was considered to have a potential benefit to AFIT.

Scope

This research was limited to an analysis of the past growth rate of the *AFIT portion* of the CREATE system and the development of a model capable of forecasting the usage rate for twelve months into the future.

Objective

The objective of this research was to develop a model capable of forecasting computer usage and expected capability in a future period of twelve months.

The relevant capabilities were identified in three steps:

1. The existing usage rate of the AFIT/CREATE system was determined. This AFIT/SL usage was compared to the total CREATE system and the individual schools within AFIT were compared to AFIT totals, in turn.

2. The AFIT/SL computer staff and potential users in other departments throughout AFIT were questioned to determine known future requirements. The resulting information was considered in the context of possible interaction with other potential users to identify probable growth areas for the system.

3. The determination was made within each parameter of capability measurement as to the amount of growth which may be predicted for specified periods in the future.

Research Questions

1. What type of growth model will fit the "AFIT/CREATE system?"

2. How do new user demands ultimately impact on the AFIT/CREATE system?

a. How will these demands be altered in the future?

b. Is data available to forecast the impact of relocation of AFIT/SL upon these user demands?

3. What level of use will the growth model project for a twelve month future period?

CHAPTER II

METHODOLOGY

Collection of Data

Overview

Data was obtained by two general methods. First, data was collected from accounting reports from CREATE Management, AFLC/ADD for analysis of the relationships between pertinent variables in the AFIT/CREATE computer usage. Then, a direct interview was administered, using a list of specific questions as the format (see Appendix C). The purpose of this interview was to obtain input to take into account known projected operational changes which could affect the output values of the prediction model.

Accounting Records

The AFLC/ADD reports of computer usage take several forms including a printout of monthly usage for each user of the system (see Figure 2). This printout contains the following disclaimer:

> This is not a bill. This identifies charges that would accrue if CREATE services were provided under industrial funding procedures [4:2].

The "costs" of the above mentioned charges are measured by parameters of computer usage. These parameters

are Central Processing Unit (CPU), CPU Time-Sharing, Core, Hours Logged on Terminals, and Central Site Input/Output (IOC). The hypothetical charges are futher broken down by prime or nonprime time as a prefix to each of the above categories.

AFIT/SL falls under six billing categories of the CREATE system. By name they are:

1. SLS, School of Systems and Logistics Support
2. SLG, Student Classroom Support
3. SLG, Student Thesis Support
4. SLG, Faculty Support
5. SLC, Student Classroom Support
6. SLC, Faculty Support

The largest AFIT users are within these six categories.[1]

A second accounting record maintained by AFLC/ADD was found to record the LOG ON time, Core hours resulting from the LOG ON time, CPU as a result of that LOG ON time and the "Average Core," (a round number used by AFLC/ADD for certain studies, but not a standardized measure), for each individual time-sharing terminal in the AFIT/CREATE system.

---

[1]As Appendix A illustrates, other large users within AFIT include ENS thesis support and Civil Engineering Simulation.

Both accounting records were manually entered into computer files. The result was the formation of two matrices which could be manipulated to determine patterns of time-dependent changes, the relationship between variables within a matrix, and as a result, forecast behavior of the variables within the matrix.

As Figure 2 illustrates, the columns in the monthly accounting record are "Problem, CPU Batch Prime, CPU Batch Nonprime, CPU T/S Prime, CPU T/S Nonprime, Core, Hrs Prime, Core Hrs Nonprime, Tape Hours Prime, Tape Hours Nonprime, Line/CD in 1000, TTY LOGON Hours, and Charges." The prime and nonprime distinction is simply to represent 0800 through 1700 hours Eastern Time, as described in AFLC Regulation 400-25. The "charges" are based upon the pricing algorithm contained in the same regulation (6:5).

It was determined that certain basic assumptions would hold for manipulation of the data contained in some of the particular columns such as Core would be influenced by certain other columns in the manner of dependent variables. The variables in the columns doing this influencing, such as batch jobs would behave as independent variables, it was assumed. Finally, it was assumed that linearity exists between the independent and dependent variables to the extent that the relationships

01 MAY 1976 TO 31 MAY 1976
USER'S IDENTIFICATION AFIT/EDUCATION

	CPU HOURS				MEMORY		
PROBLEM	BATCH PRIME	BATCH NONPRIME	TIME-SHARING PRIME	. . .	CORE HOURS PRIME	. . .	LOGON HOURS
WP0111	.6896	.0163	.2111	. . .	36.7317	. . .	47.53
WP0012	.0061	.0000	.0401	. . .	1.2145	. . .	20.64
WP0118	2.8700	.0483	.0521	. . .	73.2326	. . .	9.21
.	.	.	.		.		.
.	.	.	.		.		.
.	.	.	.		.		.
WP5505	6.5595	1.9165	1.3052	. . .	144.1031	. . .	278.48

FIGURE 2. CREATE ACCOUNTING RECORDS OF COMPUTER USAGE*

*Simulation of computer output.

would allow the independent variables to be capable of predicting dependent variable values within the model.

The dependent variables were reasoned to be the CPU parameters, including both batch and time-sharing CPU, Core hours, and IOC, measured in tape hours. The independent variables were those reasoned to drive the system. The way that the Core, CPU or IOC can be influenced is by running a time-sharing terminal or a batch job. Therefore, LOGON hours was assumed to be an independent variable. Similarly, the number of batch jobs would qualify as a measure of activity which drives the system usage. Therefore, an additional column was added to the matrix. From another source within the AFLC/ADD reports, the number of monthly batch jobs, by user or "problem number" was added to the matrix. Since the number of log-ons at time-sharing terminals was available, it was also added to the matrix, to accompany total log-on time which was already present. One final parameter, the number of students using the system, was determined to affect the usage rate of the computer system.

The variability in the student body of the AFIT schools was considered an independent variable worthy of a column in the matrix. In order to obtain these figures, the records were obtained of the number of graduates of

the graduate and continuing education students from each of the AFIT schools (see Appendix D).

The prime and nonprime distinction was removed from the three parameters of Core, CPU and IOC, and each was consolidated into a single column. This step was necessary to enhance the explanitory power of the model which would have been compromised by this arbitrary separation of data.

At this point, there existed a matrix of the independent variables which could reasonably drive computer usage and the dependent variables of Core, CPU and IOC, the resultant demands upon the computer system. The result was the historical data base which would be manipulated to form the prediction model.

Interviews

In order to explain the results of any prediction in the face of "real world" events which could be forecast, it was determined that interviews of certain individuals would be necessary in order to determine predictable changes from the pattern of past events contained in the data base. Such information would fill in areas which would change within the near future and which a model would not be reasonably expected to predict. The changes would be driven by new policies and by possible new interfaces in the system which could not be extracted from a historical data base.

Model Development

The model herein was designed to predict the growth rate of the AFIT/CREATE system based on:

1. The time-dependent growth of the system. The Honeywell Time Series Forecasting (TCAST) was used to analyze the effect of time on the growth and usage rates of the system (11:18).

2. The correlation between measurable user inputs to system demand in the form of time-sharing terminal and batch terminal usage and the resultant demands upon Core, CPU, and IOC. To investigate the relationships between user inputs and system demands, statistical analysis was performed using the BMD02R Stepwise Regression Program (9:232).

3. The forecast change in the above user inputs to the model, as measured by plans in the curriculum, research and administrative activity of AFIT, were used to estimate user input which was programmed to deviate markedly from the input which existed with the historical data base, that is, when a user had already programmed a change in policy which would vary the use of the system by a measured amount within the forecast period, the independent variables were altered to show that variation. The model, modified by this varied input could then be contrasted with the unaltered model based solely upon past patterns.

Time Series Forecasting

The Honeywell TCAST program follows four steps to provide predictions. They are: (1) Cyclic analysis of past data, (2) Trend analysis of past data, (3) An error analysis for comparing forecast with actual data, and (4) A synthesis of these three analyses determine a forecast (11:91).

The program can accept raw historical data and an optional base series point for each time period. The base series is a time series which "may represent human judgement, cyclic variations, the results of multiple regression correlation analysis or known phenomena [11:92]." The purpose of this base series data is to match the data against known types of fluctuation which is time-dependent, or against a similar a priori condition which can take some of the "noise" out of the program's search for time-dependent patterns.

The program seeks to explain the patterns of fluctuation in the data using a hierarchy of smoothing patterns, as illustrated below. The basic equation of exponential smoothing is:

$$Sl_t = \alpha x_t + (1-\alpha) Sl_{t-1}; \quad (t=1,2,3,\ldots,n.); \quad 0 \leq \alpha \leq 1$$

Sl_t represents the exponentially smoothed average of the observations through time t, and α is the smoothing constant. The data is weighted to give more or less

weight to older data by the alpha value, in an exponential manner where the data p periods ago is weighted by:

$$\alpha(1-\alpha)p$$

Single exponential, or type 1 smoothing follows the basic equation above, in simply comparing the raw data to a straight line of slope zero. Double smoothing, (or type 2) seeks a straight line with a positive or negative slope:

$$S2_t = (\alpha)S1_t + (1-\alpha)S2_{t-1}$$

Triple smoothing, or type 3 smoothing, applies the quadratic formula to the data:

$$S3_t = (\alpha)S2_t + (1-\alpha)S3_{t-1}$$

Finally, a best-fit formula is obtained to explain the behavior of the raw data. The cyclic residues are the amounts left over which are unexplained by the best fit curve and the mean absolute deviations are a measure of the absolute value of the unexplained variation of the actual values compared to the values forecast by the model (11:14).

The program will also show the cyclic error, based upon the residual variance for a cycle length determined to be the best-fit cycle which minimizes the mean absolute deviation:

$$\frac{1}{p}\sum_{i=1}^{p}|x_i-\bar{x}| \qquad (16:21)$$

The raw data residue from each period is subtracted from each succeeding type of smoothing and is added back to form a composite forecast along with base series data points plus the cyclic values. TCAST performs an error analysis on the raw data base itself, contrasting the data base with the forecast data for that time period. This forecast may begin with "time period one," or the first period in the data base. Finally, the program extends a forecast into the future for the lead time specified.

The multiple smoothing process of the time series begins by estimating the coefficient of the constant model were $E(X_t)=a_0$. This is the process of searching for the straight line of zero slope which most closely represents the data base. Next, the data is examined for a slope, and the function of time, $E(X_t)=a_0+a_1X_t$ forms the best linear approximation. Then, the quadratic model attempts to explain the residues or variations from the linear model by the application of a second order equation. Finally, a best fit is provided for the cycle component of the data and the user may

select the smoothing method which minimizes the mean absolute deviation (7:144).

The results of this time series forecast was a plot of the raw data points and the "composite points," the forecast for each of the time periods in the data base. Then the composite points were projected for twelve future time periods and their values plotted. The result was a plot of each of the variables of computer usage. Separately, the plots formed an estimate of the value of each parameter for each time period ahead.

At this point, the forecast was based entirely upon time-dependent behavior of the data. In order to refine the prediction, the relationships between individual parameters were examined next, followed by information on programmed changes to the independent variables which would cause them to deviate from the historical time patterns.

BMD02R Stepwise Regression Program

In order to identify relationships among the parameters of computer usage, regression analyses were run using the Biomedical Computer Program (BMD). The BMD02R Stepwise Regression Program was used. The output from the regression was needed to transform the interview data into the dependent variables of Core, CPU or IOC, so that the time series output could be modified to

reflect the programmed changes capability of taking in and removing variables based upon their statistical sigificance in the overall model. Each step adds the variable which adds the greatest explanatory power to be modeled by making the greatest reduction in the sum of squares of the error (9:232).

The model produced is in the form:

$$Y = B_0+B_1X_1+B_2X_2+B_nX_n$$

where B_0 is the intercept and $B_1,\ldots,B_n$ are the coefficients of the significant variables left in the model.

With the cause-and-effect relationships mentioned earlier, the regression model was tested for R^2, the coefficient of determination, which indicated the predictive ability of each model. The maximum obtainable value of R^2 is one and the minimum value is zero. R^2 can also be defined as the explained variation divided by the total variation.

To test the model for overall significance, the F test was used. The hypotheses, abbreviated H_1 and H_0 were computed as follows:

$$H_0: \quad R^2 = 0$$

$$H_1: \quad R^2 \neq 0$$

H_1 is stated simply "the value of R^2 is significant at the designated level." H_0 states that R^2 is not significant. The F of the observation is computed in the BMD program. The critical value of F is obtained from tables using the selected alpha value and upper and lower degrees of freedom corresponding to the number of parameters minus one and the number of observations minus the number of parameters respectively:

$$F_{n-1}^{p-1}, \quad \alpha$$

In order to imply significance in the model, the sample F must exceed the critical F indicating that the model has sufficient significance to serve as a linear model.

Individual tests were run to test the individual regression coefficients against the dependent variable Y.

The sample t's are computed as follows:

$$t_{b_i} = \frac{b_i}{s_{b_i}}$$

where s_{b_i} is the standard error of b_i.

Hypotheses for the t test are as follows:

$$H_0: \quad B_i = 0$$
$$H_1: \quad B_i \neq 0$$

Exceeding F critical will reject the null hypotheses.

At this point, the significant relationships between independent and dependent variables were determined. The regression process was applied to the overall model of the AFIT/CREATE data base, with a formula for each dependent variable. Each of the AFIT schools on the CREATE system were then separated and individual models were developed. Finally, the users determined to be "large," which included AFIT/SL and AFIT/ENS were separated and a model developed for each.

A complete model for the overall school usage and models for the selected subdivisions were now possible by entering time series forecasts into the matching regression models. For each time period forecast, the independent variables in the regression model yielded the estimate of the dependent variable for each future time period selected. However, the problem with this model as a solely time-dependent forecast was the lack of considering future changes in the system due to the addition or elimination of activities. The evolutionary nature of curriculum, the physical equipment and the resultant computer usage rates is apparent from past history. For example, in early 1971, the AFIT/SL student terminals numbered four. A few months later, there were six, and by late 1972 the number had incrementally

increased to sixteen. Although a time series analysis of such a period would perhaps be sensational in its growth, it would be invalidated by a failure to consider system start up (14:358). It was this line of reasoning which caused the selection of the time period of the data base, beginning with January, 1974. With such a change in equipment, it might be expected that the curriculum and resultant use of the computer system would also change. The data base had been a compromise between the need for a cycle which approached a steady-state condition and the desire for a large number of data points.

Interview Procedures

The structured interview was conducted with selected faculty and administrative personnel throughout AFIT (see Appendix C). The purpose was to sense any impending changes in the system which could affect the predictive ability of the model. The selection was based upon the control of use of the computer equipment. To determine who influences the system, the interviews began with AFIT/SLS, AFIT/ENS, and AFIT/DET. The managers of each problem number were contacted first because they were in a position to determine who the prime users were within each problem number. In the case of AFIT/SL, the identification of users confirmed and supplemented the writers' knowledge of course activity. In the other two schools, each interview led to other users of the system

and helped form an overall image of the set of users within each problem number.

The objective of each interview was to obtain one of two possible estimates of the use of each problem number. The first estimate would be "no change" if the person interviewed had programmed no change to the next period of his activity, such as the next offering of a course. The alternative would be a specific forecast change which was planned, such as the addition of a particular number of time-sharing or batch problems. For classroom support, the number of problems added times the estimated number of students provided an estimated difference to the total number of problems within a particular classroom support number.

Faculty support includes assisting students and faculty with research, independent research, and miscellaneous other activities (15). For faculty support, the inputs were less concise, since the workload is a related activity not structured in advance at the same level of detail as the classroom. Therefore, the same structure of the interview was not applicable and the effort was to determine any demands on the horizon which would represent a change to the workload (see Appendix C). The approach was similar to specialized studies. Again, the attempt was made to determine the quantity and type

of workload and to explain any forecast changes to the existing patterns of usage.

Quantifying the projected changes was accomplished by assigning the forecast change to a particular problem number, quantifying the change in terms of one or more of the dependent variables and assigning it to a time period. In the case of class work, the time period would correspond to the next offering of a course. In thesis work, the projected increase of a particular parameter was added to its problem number in proportion to the existing thesis workload forecast for the time period. For example, if the time series forecast workload under a thesis support problem number was 180 batch jobs, the projection of the interviews was added directly to 180.

Summary

The resulting values of each parameter modified by the programmed changes, were entered back into the model to replace the parameters which were an estimate based purely on the time-dependent model. The difference in each dependent variable was added as a correction to the pure TCAST of that dependent variable, resulting in the final predicted value for each time period. This difference, representing the programmed changes from the interviews, was obtained by adding the estimated changes to the independent variables, placing the new values into the regression model for each dependent

variable, and comparing the new value of the dependent variable to its value from an unaltered regression model. The difference between the two was the measured result of programmed changes. Adding the difference to the pure TCAST allowed the model to incorporate the programmed changes into the forecast. The result was a forecast model of future usage rates based upon time-dependent analysis, known relationships between the parameters, and programmed changes not represented in the historical data base. This model could serve as an alternative to a simple extrapolation of historical data.

CHAPTER III

RESULTS

Introduction

This chapter presents the results of the three forms of analysis used in the thesis. The first section describes the results of the multiple linear regressions. The second section presents the unaltered time series forecasts from the TCAST program. Finally, the results of interviews and the programmed changes to user demands are presented in the third section.

Relative Impact of Programmed Changes of AFIT and the Individual Schools Against Total CREATE Usage

The impact of AFIT upon the CREATE system is illustrated in Figure 3a through Figure 3g. The relative size of each parameter of computer usage appears in these figures for the historical data base which was used for the forecasting model. Figure 4a through Figure 4g show the comparison of the individual schools within AFIT to the AFIT totals.

The Regression Model

With the exception of time-sharing CPU, the dependent variables had R^2 values well above .5 and most were in the vicinity of .8 or higher as shown in Table 1

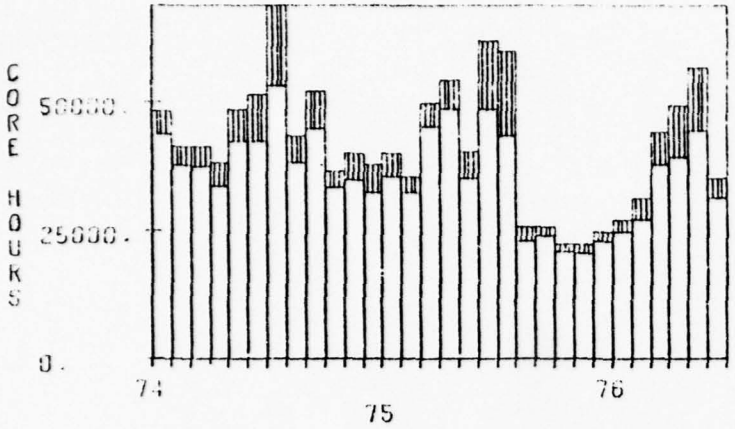


FIGURE 3B. CREATE VS. AFIT

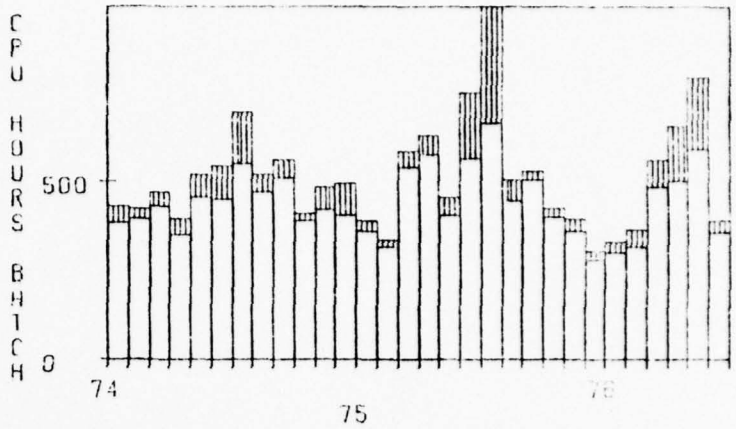


FIGURE 3C. CREATE VS AFIT

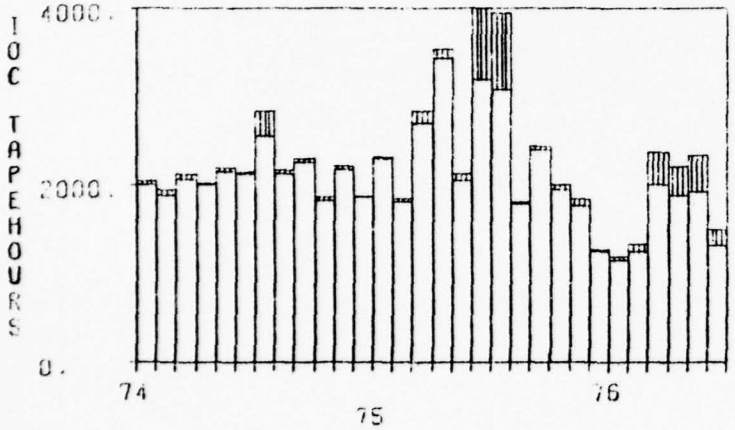


FIGURE 3A. CREATE VS. AFIT

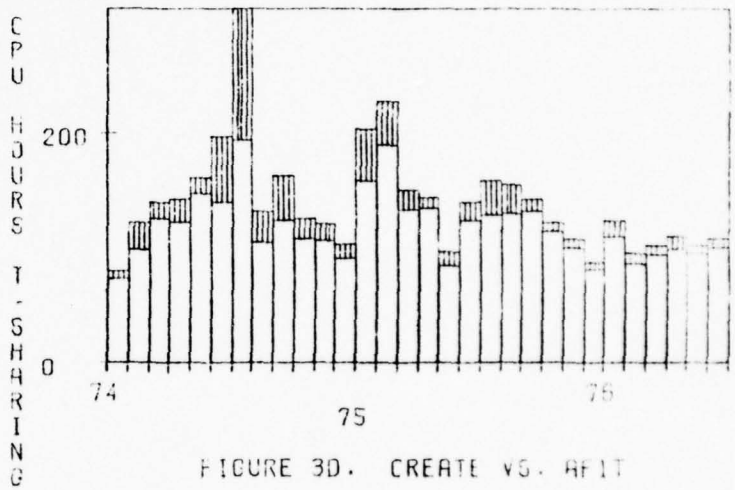


FIGURE 3D. CREATE VS. AFIT

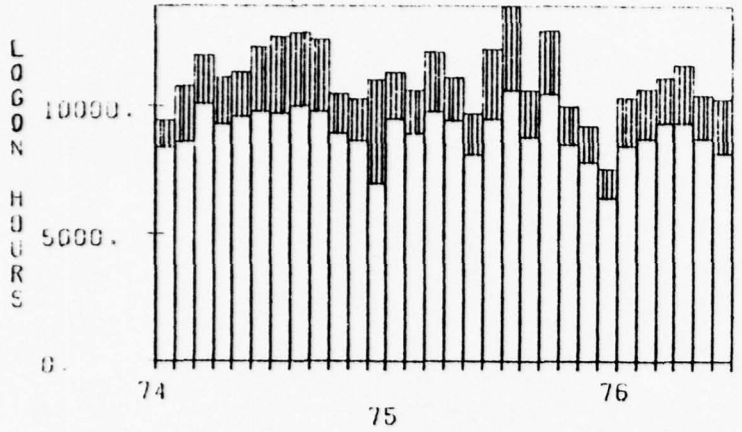


FIGURE 3F. CREATE VS. AFIT

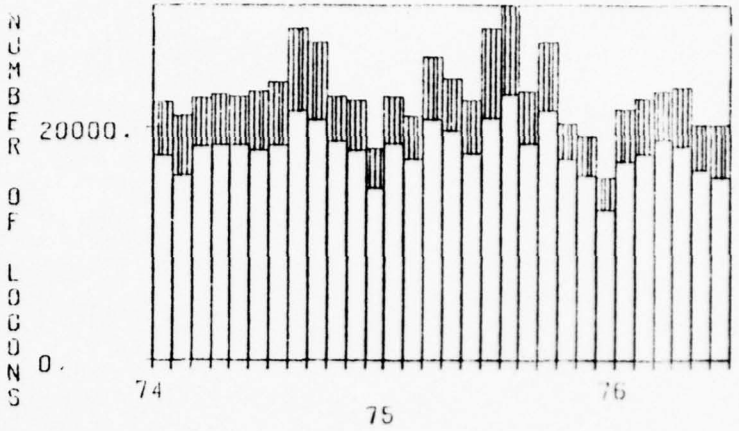


FIGURE 3G. CREATE VS. AFIT

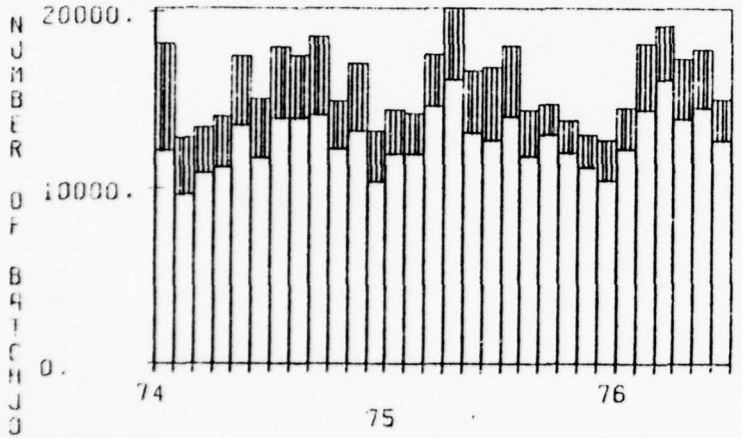


FIGURE 3E. CREATE VS. AFIT

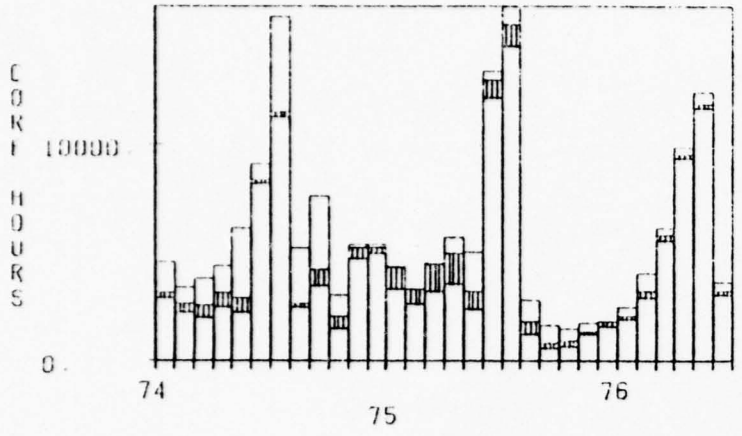


FIGURE 4B. AFIT/SL-DE-EN

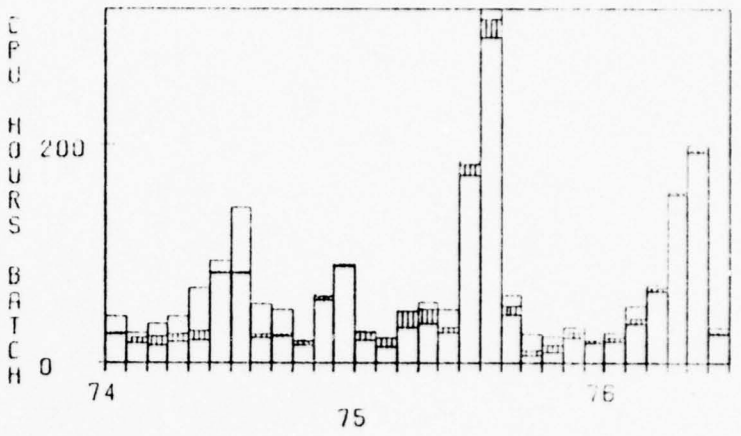


FIGURE 4C. AFIT/SL-DE-EN

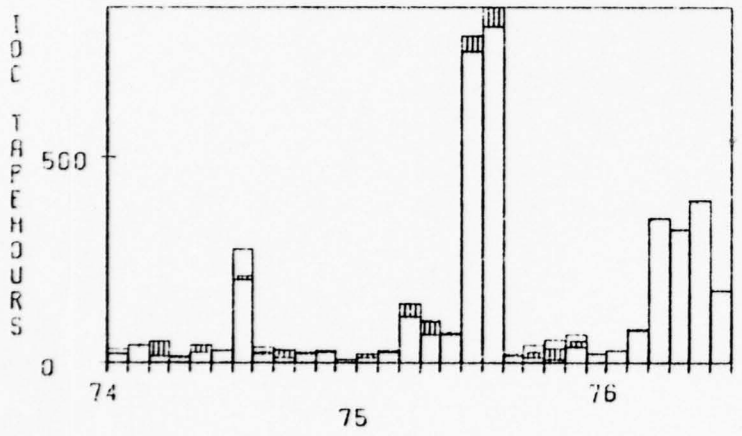


FIGURE 4A. AFIT/SL-DE-EN

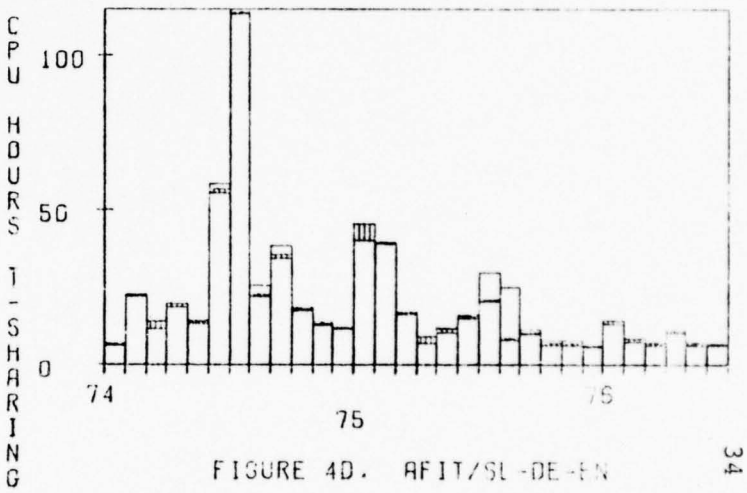


FIGURE 4D. AFIT/SL-DE-EN

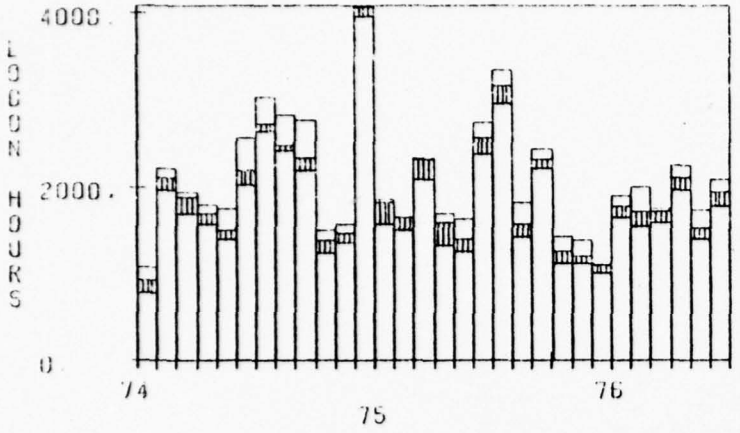


FIGURE 4F. AFIT/SL-DE-EN

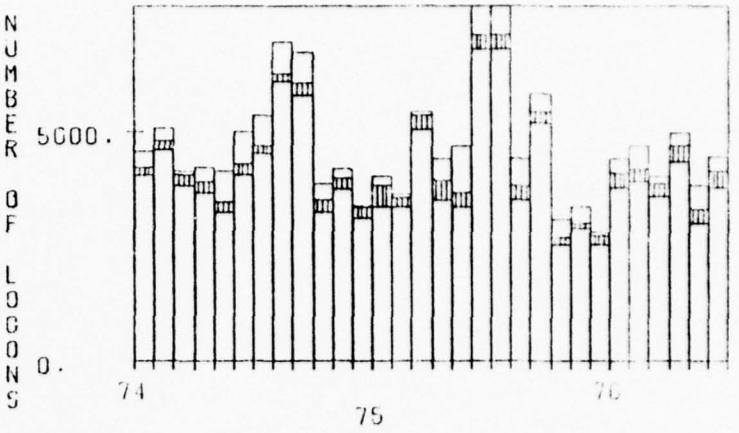


FIGURE 4G. AFIT/SL-DE-EN

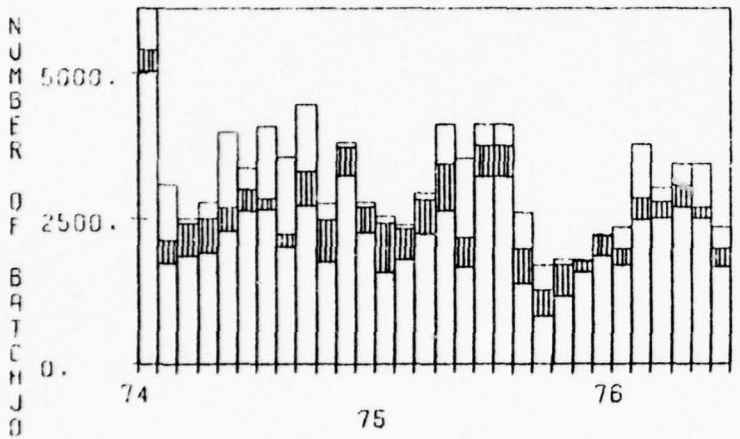


FIGURE 4E. AFIT/SL-DE-EN

TABLE 1

RESULTS OF *F* TESTS OF THE REGRESSIONS
ON PARAMETERS OF COMPUTER USAGE
AFIT TOTALS

Dependent Variables	R^2	F Sample	F Critical (.95)
IOC	.6108	$F^{7}_{22} = 4.933$	$F^{7}_{22} = 2.46$
Core Hours	.9586	$F^{7}_{22} = 72.825$	$F^{7}_{22} = 2.46$
Batch CPU	.8129	$F^{6}_{23} = 16.65$	$F^{6}_{23} = 2.53$
Time-Sharing CPU	.3804	$F^{7}_{22} = 1.93$	$F^{7}_{22} = 2.46$

and Table 2. The two tables represent AFIT totals and AFIT/SL. The two remaining schools are not shown because it turned out that the regressions were not needed. Due to the status quo results of the interviews, there was no occasion to translate the projected changes into alterations of the time series forecasts. The regression models had the standard form previously discussed. The variables retained their position in the data matrix, with the exception of the independent variable which was being tested. For example, Core for AFIT totals resulted in:

$$Y = -31.39+1.05X_1+29.77X_2+65.16X_3+5.49X_4+43X_5-.37X_6+2.92X_7$$

where:

X_1 = The number of batch jobs

X_2 = Batch CPU for the time period

X_3 = Time-sharing CPU for the time period

X_4 = IOC

X_5 = LOGON hours

X_6 = The number of LOGON hours

X_7 = The number of students

Similar results were obtained for each dependent variable and were applied to transforming the interview data as previously described. Of the parameters tested, it was noted that time-sharing CPU for overall AFIT failed the

TABLE 2

RESULTS OF *F* TESTS OF THE REGRESSIONS
ON PARAMETERS OF COMPUTER USAGE
AFIT/SL

Dependent Variable	R^2	F Sample	F Critical (.95)
IOC	.8974	$F^{6}_{23} = 33.526$	$F^{6}_{23} = 2.53$
Core Hours	.9703	$F^{7}_{22} = 102.69$	$F^{7}_{22} = 2.46$
Batch CPU	.9518	$F^{5}_{24} = 94.692$	$F^{5}_{24} = 2.62$
Time-Sharing CPU	.7834	$F^{6}_{23} = 13.865$	$F^{6}_{23} = 2.53$

F test for the test hypothesis of statistical significance. Therefore, time-sharing CPU was left unaltered in the TCAST of AFIT totals for the forecast use of CPU. All other dependent variables past the F test.

Time Series Forecasting

Validating the TCAST Model

It was determined that the TCAST model should be tested for its ability at fitting the time patterns of computer usage data prior to attempting to forecast with the model.

A new set of raw data was selected for the test. The total of CREATE usage was chosen for this purpose. It was assumed that the data base by virtue of its larger scale would be more stable, but otherwise similar since it was the larger set of the data base under examination.

The results of these TCASTs were encouraging with respect to the validity of the proposed research. As Figure 5a and Figure 5b illustrate, the fit of the forecast to the raw data is "very good." In addition, the error term was considered a suitably small fraction of the mean of the data points. Specifically, the poorest ratio of mean absolute deviation to mean of the data was .22, or allowed a .78 level of confidence in the forecast, which occurred in time-sharing CPU. Figure 5a and Figure 5b, IOC and Batch Jobs had .853 and .858

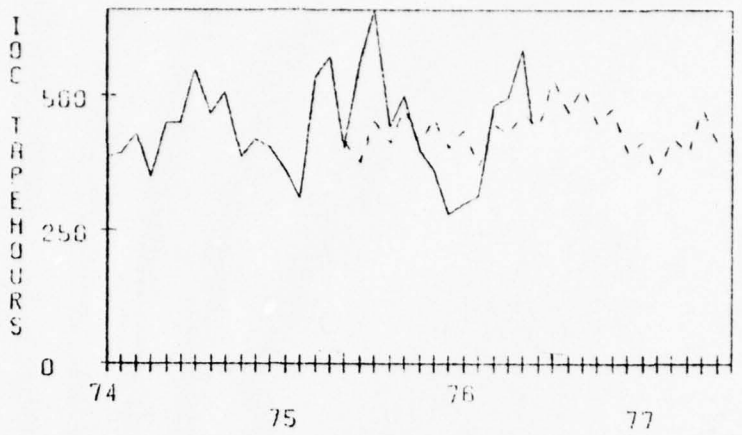


FIGURE 5A. FORECAST CREATE

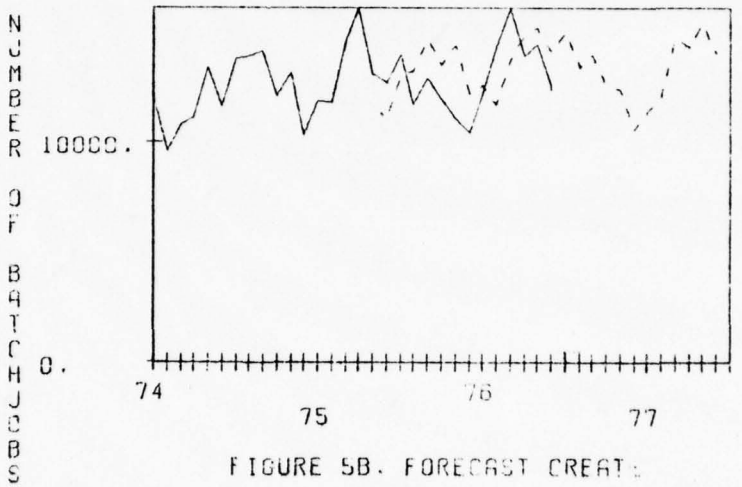


FIGURE 5B. FORECAST CREAT

respectively. It was thus concluded that, within the limits of each specified ratio of the mean error to the data mean, the TCAST model formed a dependable and appropriate means of forecasting the behavior of data over time.

Search for a Base Series

As previously discussed, the purpose of the base series is to extract known expected conditions so that the exponential smoothing process will be free to search for time dependent patterns other than the base series values, for example, a known growth in the gross national product of 6 percent. Cyclic values can also be represented in the base series. Examples include the thesis-related workload cycle and other seasonal fluctuations. It was also discussed that the pattern of AFIT use of CREATE following the natural steep increase of system startup in 1971 and 1972 left a period of about thirty months. Since there were three full seasons at the most, no attempt was made to infer an expected growth rate from previous knowledge of the system history.

An attempt was made to use the regressions for entering an expected value of a parameter into a base series. The actual values of each of the dependent variables was obtained by using the regression coefficients and the actual values of the other variables. This

revised set of values for the dependent variables was entered into the TCAST as a base series. The result was an increase each time in the mean absolute deviation, and further attempts were aborted.

It was considered that base series data may be contained in the historical data which could be extracted by the TCAST program itself. The cyclic residue, that data which remains after the program subtracts the optimum cycle from the raw data would logically: (1) be stochastic or (2) follow some pattern. The cyclic residues of two TCAST runs, with relatively low mean absolute deviations in relation to the mean value of the forecast data points, were run on a separate TCAST. Again, no meaningful results were obtained. Subsequent TCAST runs contained only the raw data. Analysis by TCAST was run on each of the AFIT schools and finally on AFIT totals. Results are shown below. The validity of the results will be discussed in Chapter IV.

AFIT/SL

The general trend in AFIT/SL was one of forecast increase in the usage of computer capability as shown in Figure 6a through Figure 6g. IOC, pictured in Figure 6a shows a dramatic increase in forecast use of IOC. The data was smoothed considerably using the optimal smoothing of Type 2 with an alpha of .02. Note that the

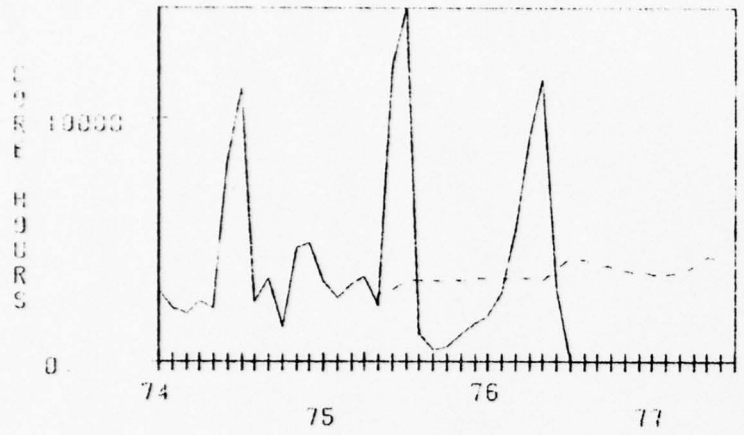


FIGURE 6B. FORECAST AFIT/SL

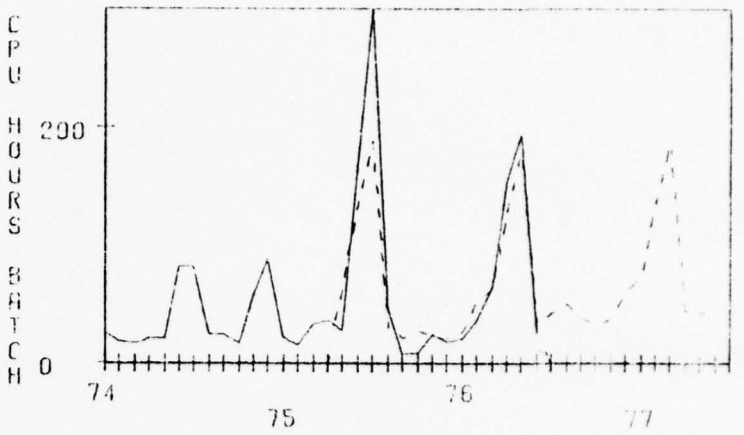


FIGURE 6C. FORECAST AFIT/SL

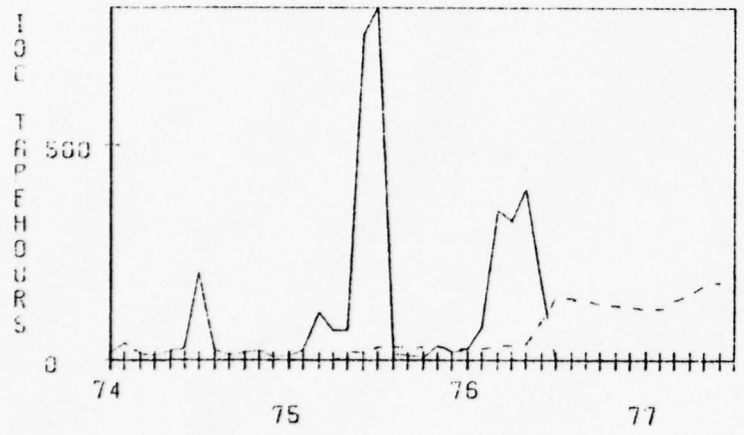


FIGURE 6A. FORECAST AFIT/SL

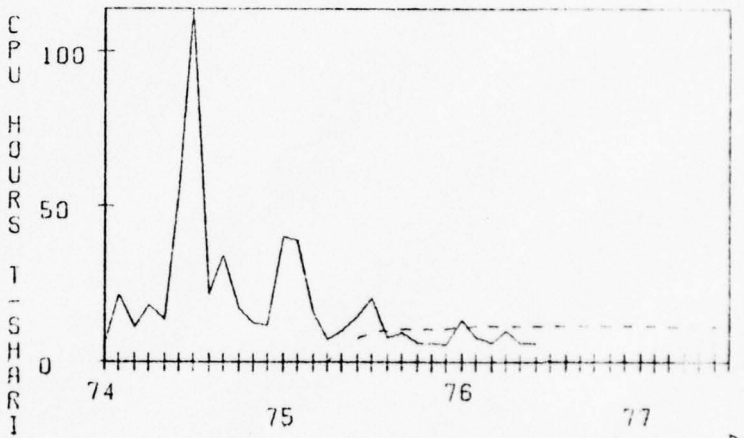


FIGURE 6D. FORECAST AFIT/SL

peak actual values occur during the periods just prior to August, 1974, December, 1974, August, 1975, and May, 1976.

Core hours for AFIT/SL in Figure 6b shows a steady increase with a smoothed cycle of period twelve. The mean values of the forecast calls for a monthly use of nearly 4,000 Core hours. Once again, the same peak periods appear in the actual data points.

Batch CPU shows a strong cyclic nature of period eleven, with a slight positive slope between peaks and troughs. Type 1 smoothing with an alpha of .01 resulted in a nearly flat projection for time-sharing CPU.

The number of Batch jobs on Figure 6e projects a negative slope with a pronounced cycle. LOGON hours shown in Figure 6f shows an increasing forecast with a smoothed cycle of three and forecast values peaking in excess of 2,500 hours per month. The number of LOGONS appears cyclic with period ten and a nearly flat slope between cycles. Once again, the four strong peak periods of August, 1974, December, 1974, August, 1975, and May, 1976, are apparent from the plot of actual data points.

AFIT/ENS

The usage rates for AFIT/ENS were also separated and analyzed using TCAST. Figure 7a, IOC, may allow speculation of a decline in the forecast, but,

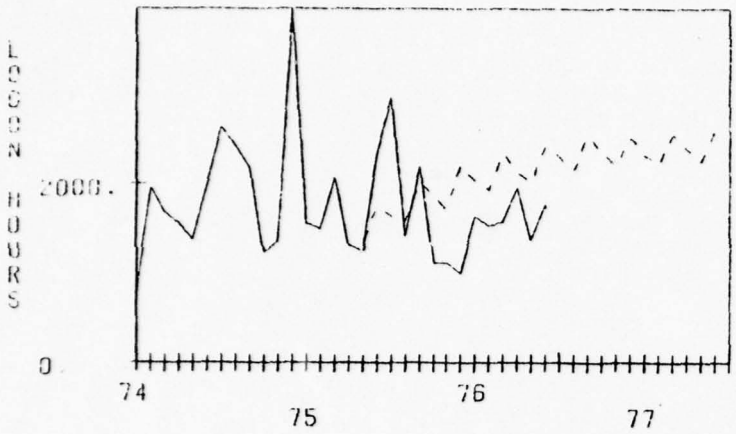


FIGURE 6F. FORECAST AFIT/SL

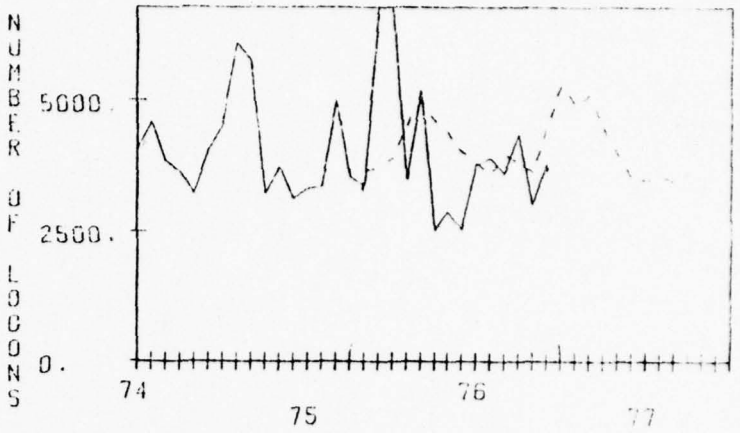


FIGURE 6G. FORECAST AFIT/SL

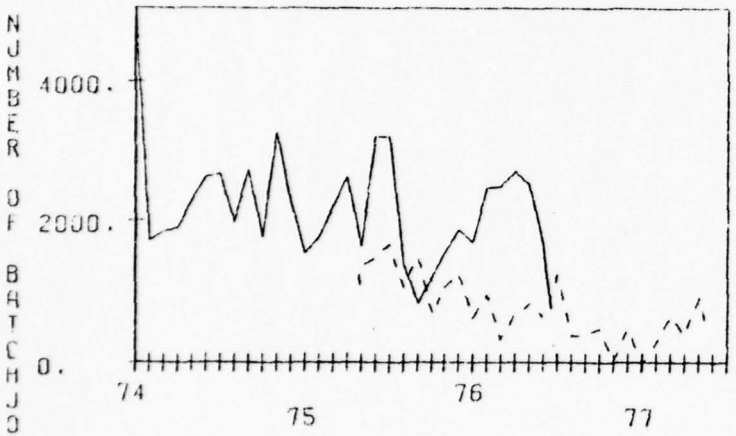


FIGURE 6E. FORECAST AFIT/SL

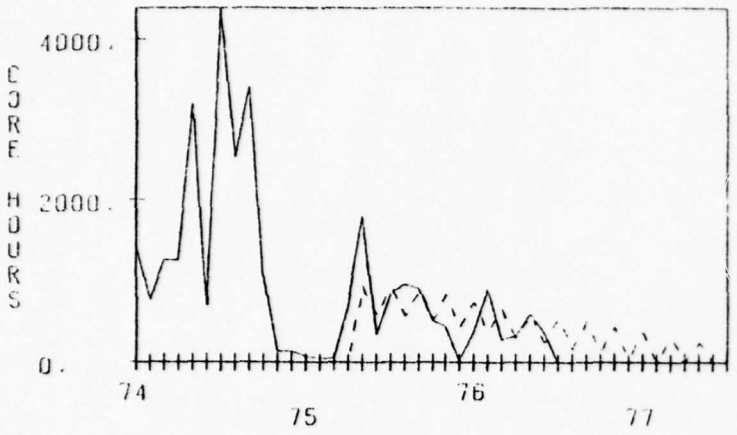


FIGURE 7B. FORECAST AFIT/EN

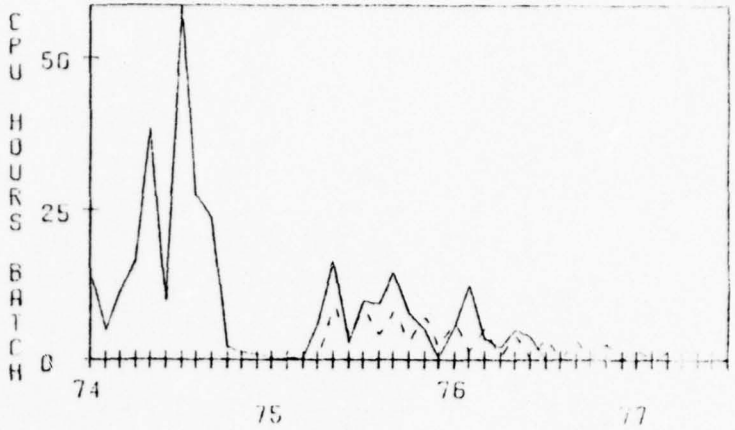


FIGURE 7C. FORECAST AFIT/EN

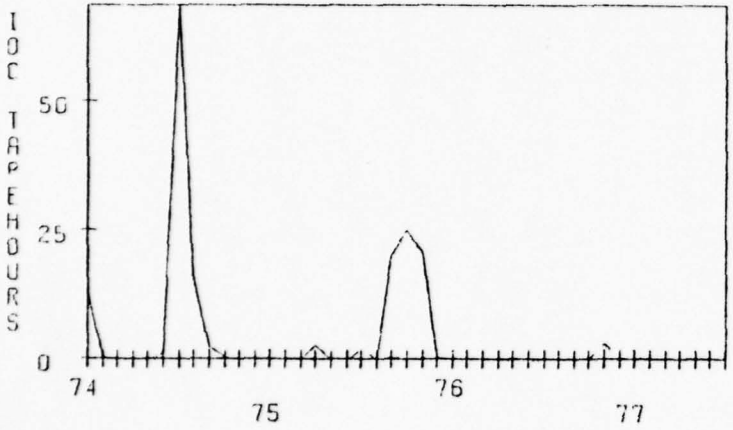


FIGURE 7A. FORECAST AFIT/EN

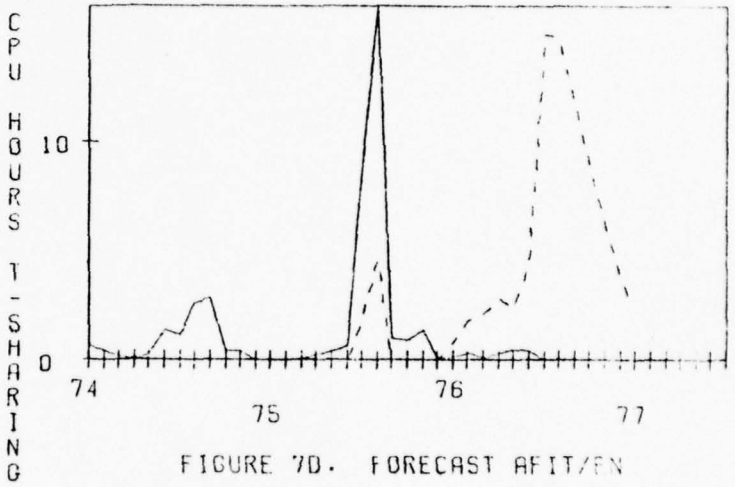


FIGURE 7D. FORECAST AFIT/EN

typical of the results for ENS, there was no clear pattern other than an apparent decline. Core, in Figure 7b, also shows a pattern of forecast decline in usage. Batch CPU and time sharing CPU both show low levels of use and projected declines in Figure 7c and Figure 7d. Batch jobs show a cyclic process of period twelve months with the values in a declining trend over each period. Finally, LOGON activity in Figure 7f and Figure 7g show a fairly constant forecast in each case.

AFIT/DE

The most striking feature of Figures 8a and 8g representing AFIT/DE is a steady increase in use until early 1975 followed by a steady decline. The exception to this pattern is the number of LOGONS in Figure 8g where an increase is projected. Time-sharing CPU and Core show a projection for nearly level usage, neglecting the pronounced cycle in Core in Figure 8d.

Overall AFIT

As Figure 9a shows, the TCAST Projected a cyclic increase of period four with the average value rising to over 200 tapehours of use per month. Batch CPU had a strong cycle of period ten, with peak values climbing slightly from period to period. Time-sharing CPU projected values relatively unchanged from period to period. The data was smoothed by Type 1 with an alpha of .02.

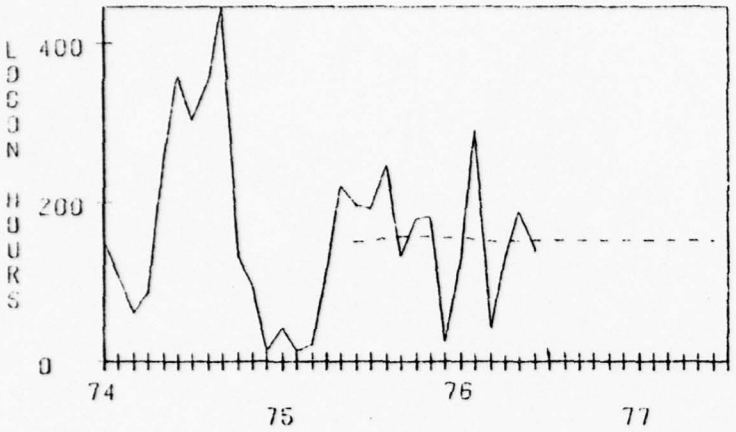


FIGURE 7F. FORECAST AFIT/EN

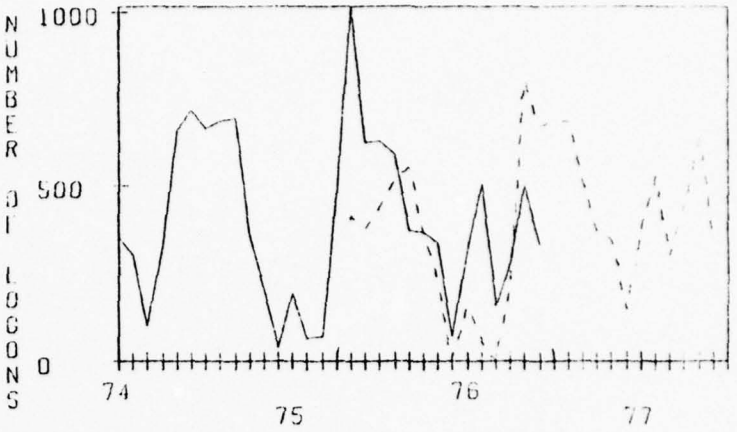


FIGURE 7G. FORECAST AFIT/EN

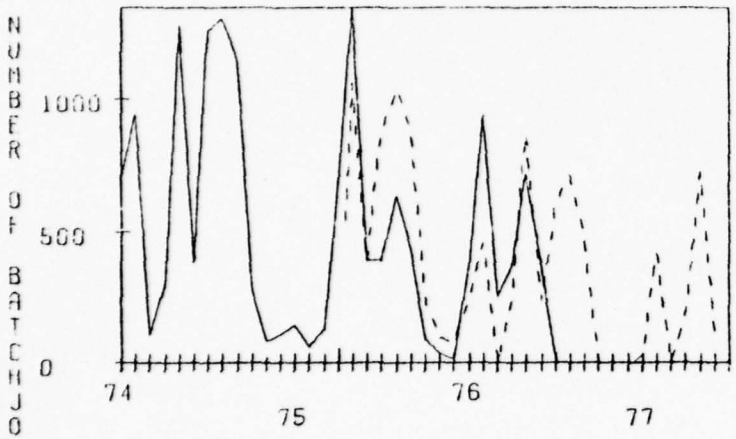


FIGURE 7E. FORECAST AFIT/EN

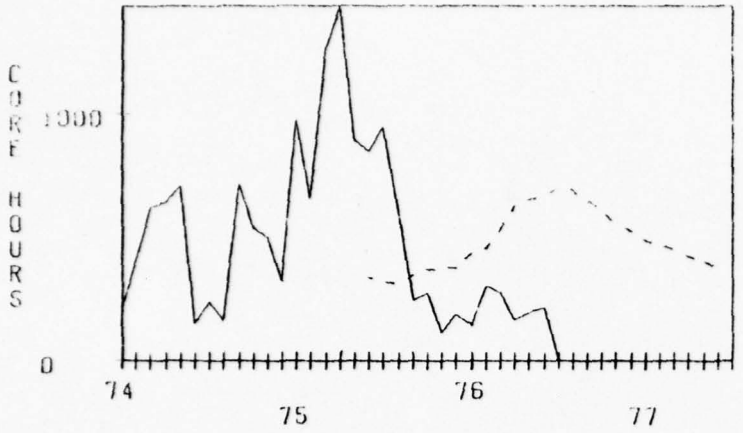


FIGURE 8B. FORECAST AFIT/DE

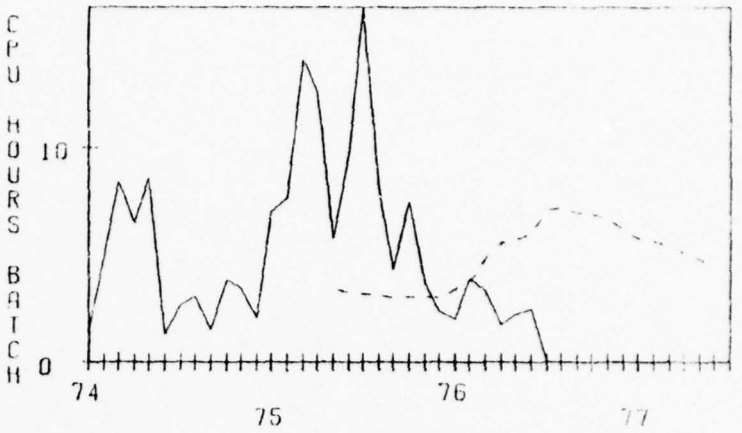


FIGURE 8C. FORECAST AFIT/DE

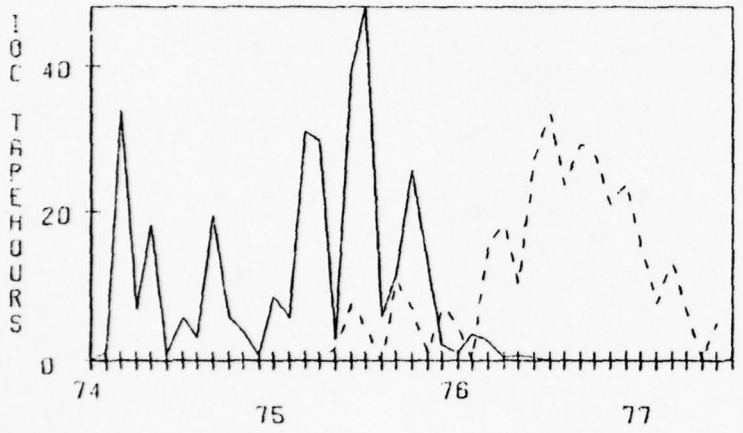


FIGURE 8A. FORECAST AFIT/DE

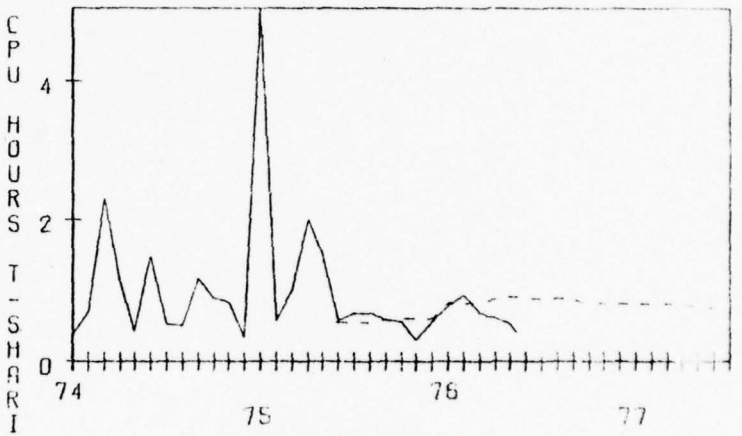


FIGURE 8D. FORECAST AFIT/DE

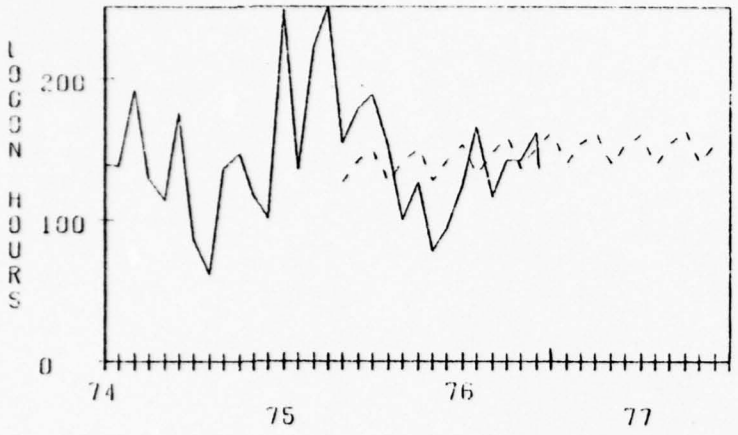


FIGURE 8F. FORECAST AFIT/DE

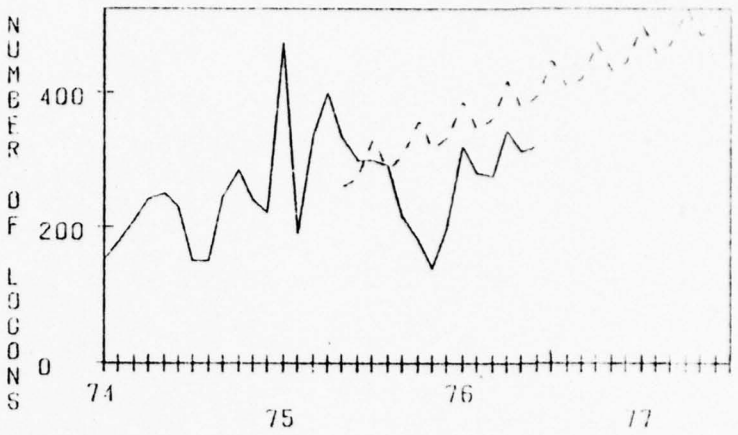


FIGURE 8G. FORECAST AFIT/DE

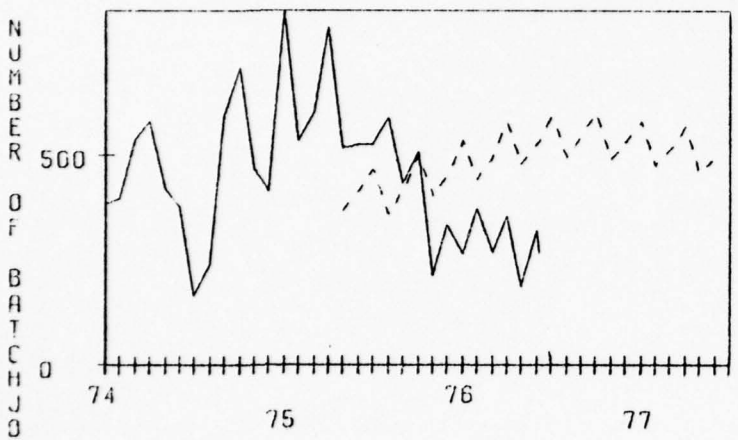


FIGURE 8E. FORECAST AFIT/DE

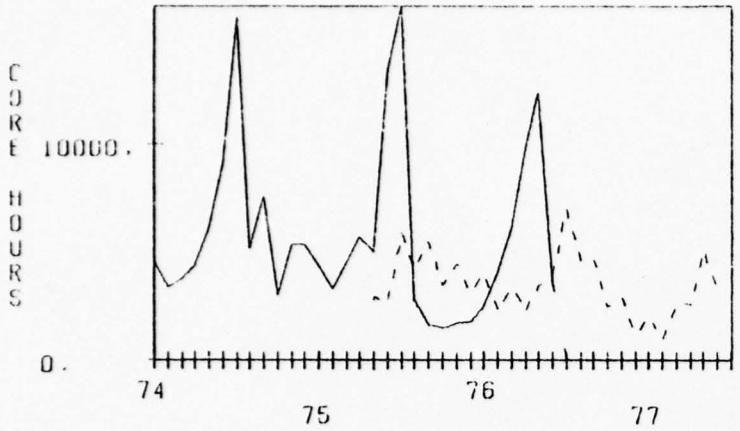


FIGURE 9B. FORECAST AFIT TOTALS

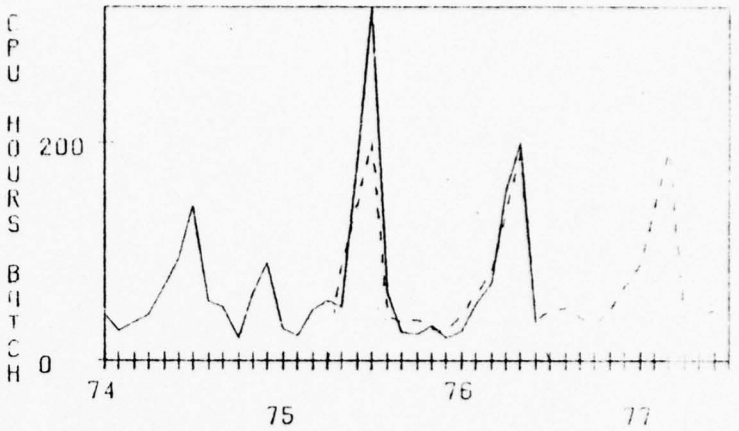


FIGURE 9C. FORECAST AFIT TOTALS

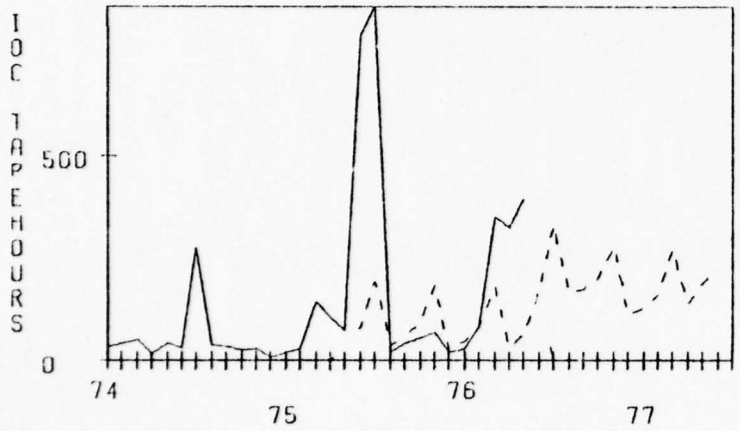


FIGURE 9A. FORECAST AFIT TOTALS

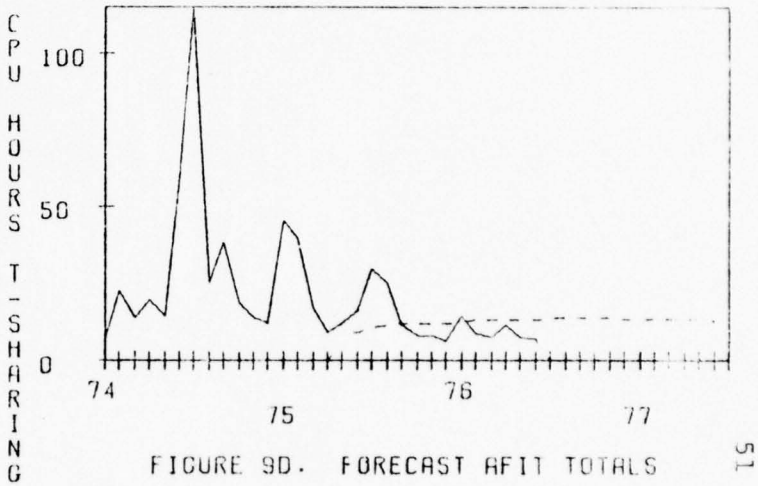


FIGURE 9D. FORECAST AFIT TOTALS

Core hours for AFIT totals showed a predominant cycle of two months with at least one additional cycle evident and roughly the same level of usage in the projection. Batch jobs required a smoothing Type 2 with a smoothing constant of .02. The program came closest to capturing the peak periods in this parameters where batch jobs are seen in Figure 9e to have pronounced periodic increases. Comparing Figures 9a through 9g to Figures 6a through 6g shows conclusively that the same four peak periods previously discussed are present in each parameter in almost the same relative degree as in the corresponding figure in the other group. This close similarity between overall AFIT and AFIT/SL will be discussed in Chapter IV.

The Interviews

The outline of the interviews appears in Appendix C. The results indicate a collective of seventeen faculty and staff members increased usage in the two AFIT/SL schools, based on programmed changes to course work and expert opinion on the probable effect of changed computer instructions upon computer techniques used in research. The other two schools, AFIT/ENS and AFIT/DE indicated through the interviews that no trends existed in either school to suggest a change from past patterns.

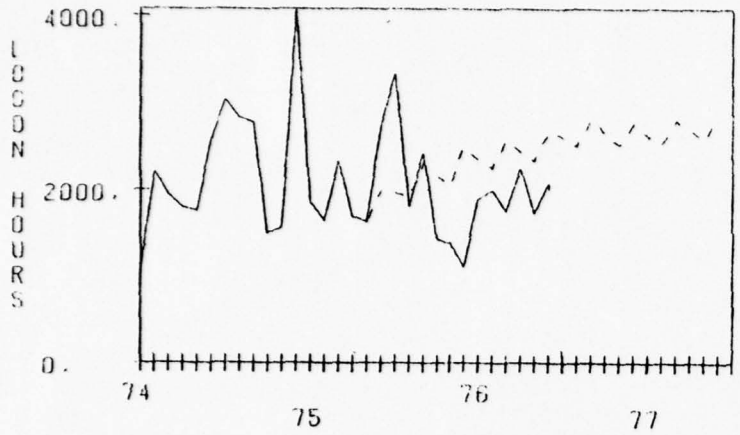


FIGURE 9I. FORECAST AFIT TOTALS

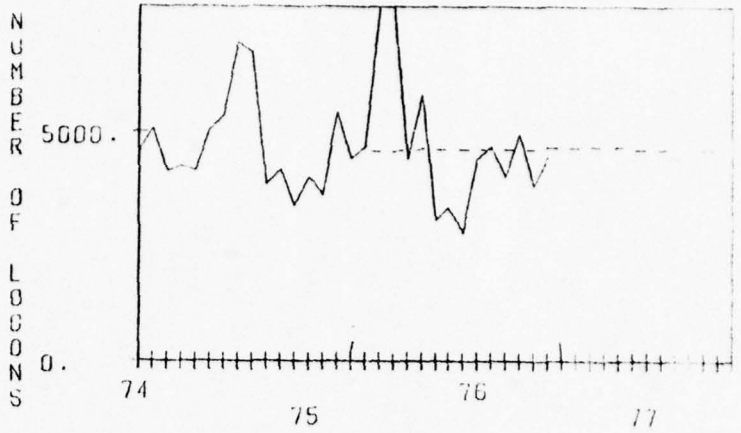


FIGURE 9G. FORECAST AFIT TOTALS

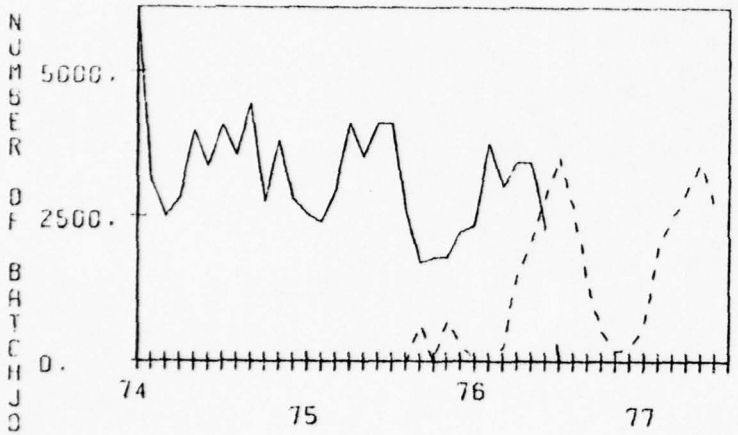


FIGURE 9E. FORECAST AFIT TOTALS

AFIT/SL

The interviews within AFIT/SL began with AFIT/SLS as the controller of the CREATE problem numbers within the school and were extended to include every computer course instructor and a representative from each course with a history of assigning computer problems or the possibility of adding computer-assisted instruction in the future.

The computer instruction curriculum had been expanded so that the next offering of each computer course in the Master's degree program would be changed. The first course was in progress for Class 77A and was unchanged. But the computer course had been expanded across three quarters total and would emphasize the use of large time-sharing and batch software programs such as simulation programs, time series analysis, and ANOVA programs. The increase in the use of batch jobs and LOGON time was estimated by consensus of all course instructors at 20 percent for each of these parameters. The change would apply to Class 77A from July through December, 1976, and to Class 77B from October, 1976, through March, 1977. The estimate of the effect of the increased computer activity in the thesis efforts was also put at 20 percent by consensus agreement for both time sharing and batch. This change would apply to both graduate Logistics classes from March, 1977, through the end of the forecast period.

The search for other potential changes within the Master's degree curriculum revealed [illegible]med changes. The computer preparation c[illegible] integrated with quantitative courses in the curriculum changes mentioned above and a census of other departments revealed a status quo in each case.

The Continuing Education Division, AFIT/SLC is constrained by a lack of scheduled terminal time. Therefore, the programmed changes are predictably small within each course. Eleven courses were programmed to have changes in the future for a total of 340 additional LOGON hours over the next year. This figure was determined by multiplying the increased hours to be scheduled by the number of terminals scheduled. This increase does not measure increased activity over the weekends which several instructors interviewed felt would result from increased instruction in the classes, but did not believe could be estimated. Increases in the Continuing Education Department were applied evenly through a year because of the multiple offerings of each course.

AFIT/ENS

AFIT/ENS uses computer support in the computer simulation instruction course and the economics course. These courses will not change their computer workload during the next offering. There are no programmed changes

to faculty research. Similar to AFIT/SL, the faculty research is not scheduled far in advance and the combination of demands are flattened out over the year. The thesis efforts comprise about 70 percent of the AFIT/ENS computer work during the winter and spring quarters.

Actually, there is a lack of audit trail for the actual purpose of each computer use record because of the tendency of some individuals to use the same problem number for any activity. This opinion has appeared in several interviews from unrelated sources throughout AFIT. A condition unique to AFIT/ENS, however, is the tendency for students to select the computer system based upon convenience. Since they have access to both the CREATE and the CDC computer systems, students tend to use the CDC system during periods when CREATE is busy and vice versa. This practice has a dampening effect on trends of increased use of one of the systems. Personal contact with students of AFIT/ENS has supported this fact of trading between systems. In summary, AFIT/ENS is projecting no changes in use of the CREATE system which could add explanatory power to the time-dependent model of usage.

AFIT/DE

AFIT/DE faculty members interface with the other engineering school as well as AFIT/ENS. There is a diversity of faculty members in different functional

areas which again is reflected in the crossover between the two computer systems. The use of CREATE is not forecast to have any cause for change in the period of interest of this thesis. The controllers for the simulation and engineering applications problem numbers were interviewed and indicated that no courses would have significant changes in the use of the system.

Throughout the interviews, an attempt was made to gather information relevant to the effect of the impending move of AFIT/SL to the same "campus" as the other schools; the availability between schools of more equipment in close proximity thereby allowing more potential flexibility in use, the potential of cooperation or consolidation between computer centers, or changes in policy pointing to the likelihood of a new configuration such as a stand-alone system, new data automation requests (DARS), or any written record of policy change. No written information was discovered which would add meaning to current speculations on the subject. Although, the interplay between schools may well have an effect upon usage rates and system growth, planning for the move was in progress during the time of the interviews and was still at the level of the individual school functions rather than the interfaces between schools. Forecast changes in equipment was limited to replacing older items with newer models of like type (1).

Summary

This chapter was limited to the results of the multiple linear regressions, the time series forecasts, and the interviews to sense curriculum and policy changes relating to computer usage. Synthesizing the results and interpreting the prediction models were specifically avoided in this chapter because it was determined that subjective judgement would be involved, particularly in dealing with the fit of particular TCAST models. Next, the three sources will be assembled and the result interpreted.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This chapter contains the forecast, which is the best fit to the patterns of past usage of each parameter and to the programmed changes to those patterns.

Importance of Parameters Forecast

The forecast of each parameter depicts the impact upon the CREATE system of the projected use of the particular computer resource. The fact that some parameters are closer to saturation in the total system makes the impact more significant in those parameters than in the others.

The most saturated parameter at the time of this thesis was IOC. The front-end processor on the CREATE system was a Datanet 355. The front-end processor itself was running out of Core due to difficulties in satisfying the diversified load, due to numerous large peripheral devices requiring dedicated Core. This situation was causing IOC to be the "choke point" for users of time-sharing terminals, particularly during hours of peak use. The second most saturated parameter measured was

Core. The total system had a capacity of 256,000 computer words. Core could become saturated if IOC were modified to increase capacity.

Next in order was CPU. The CPU was running at 70 to 80 percent of capacity. Storage area would need expansion within one year, it was estimated, but since storage was determined by allocation, the situation could be predicted and controlled by policy and therefore was not put into the model. The above description of the hierarchy of parameters indicates the order in which increased usage would be significant (13).

Impact of AFIT/SL Thesis Work on AFIT/CREATE Usage

Recall that in the previous chapter it was observed that both dependent and independent variables in the total AFIT forecasting models followed a common pattern of local peak values just prior to August, 1974, December, 1974, August, 1975, and May, 1976, and that the same patterns were presented in the AFIT/SL models. For example, comparing Figure 6d and Figure 9b shows that nearly the same peak periods exist for Core usage within the AFIT total and AFIT/SL usage. This similarity is not surprising when it is considered that during the four peak periods mentioned, AFIT/SL core was 70.8 percent, 90.7 percent, 76.1 percent and 93.5 percent respectively of AFIT totals. As Appendix D illustrates, the four peak periods

also occur just prior to the graduation of one of the graduate logistics classes. It was, therefore, concluded that the heavy usage rates are a function of the heavy use of large programs to complete thesis work during the period immediately prior to graduation of graduate AFIT/SL classes.

TCAST Results

The impact of the graduating classes also helps explain the difficulty experienced by the TCAST program in obtaining a "good" fit to the actual data points, and the numerous periods of the cycle which were computed as optimal in explaining the pattern of usage. It was common for the TCAST program to smooth the data points into a nearly straight line implying a nearly stochastic process. It was concluded, however, that the major difficulty in obtaining a close fit was the interruption in the scheduling of graduate logistics classes. Beginning in 1975, the "A" class ran from May to May whereas it had run from January to January. This interruption approximately in the middle of the data base by the driver of 80 percent of the cycle of most parameters caused the program to hunt for a period in the data, and to select the strongest of two or more apparent periods. The result of this compromise in the program was a high, mean absolute deviation in each of the parameters. For

example, the mean absolute deviation for AFIT total of batch jobs equals 19 percent of the highest value recorded or nearly 34 percent of the average value of the forecast.

In the case of batch CPU, the mean absolute deviation equals 8 percent of the peak value and 42 percent of the average value. Similarly, the mean absolute deviation was 24 percent of the peak value of Core and 42 percent of the average forecast value, 14 percent of the peak value of IOC and 48 percent of the average forecast value, 14 percent of the peak LOGON time and 26 percent of the average forecast value and 16 percent of the time-sharing CPU peak value with a full 95 percent of the average forecast value. Remembering that the higher alpha value will cause the TCAST to weigh recent events more strongly than older data points, the cycles were still salvaged in most cases, but with a mean absolute deviation allowing a lower level of confidence in the results. It was therefore concluded that with the exception of time sharing, the TCAST CPU, plots show an acceptable forecast of the general trend for the forecast period, although specific values were compromised by relatively high mean absolute deviations.

Impact of the Known Changes

To determine the result of the added LOGON time and batch jobs programmed to take place, each of the

original TCAST values were put into the regression model to which they applied. Then the changes were made in the independent variables which were to increase, and the new values obtained for each dependent variable. This difference for each period of each dependent variable was then added to the original TCAST value. This application to the TCAST projections is illustrated in Figures 10a through 10d. These projections were the final result of considering the time-dependent nature of the growth rate of the system, the dependence between parameters of the system and the changes forecast to take place in the system. They determined the best projection available from this model of the impact AFIT will have on the CREATE system during the coming twelve month period.

Answers to Research Questions

1. *What type of growth model will fit the AFIT/CREATE system?* A time series forecasting model capable of incorporating changes to the data base which are known to be programmed for the forecast period provides a very suitable forecast for computer usage, as evidenced in the validation of the model. Such a model can project both trends and cycle patterns of the data.

2. *How do new user demands ultimately impact on the AFIT/CREATE system?*

a. *How will these demands be altered in the future?* It was concluded that a linear relationship

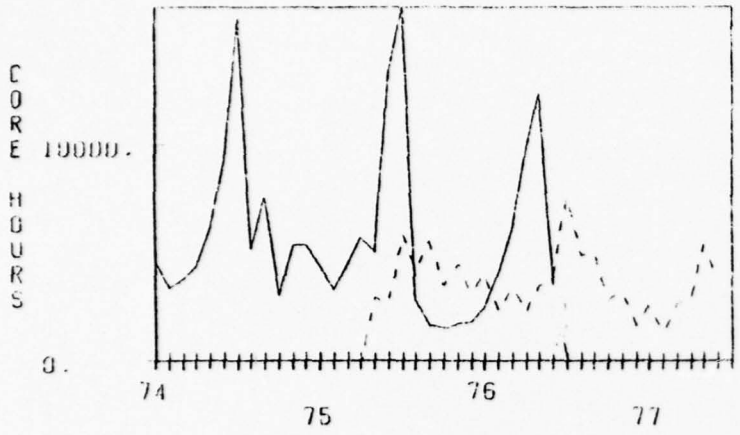


FIGURE 10B. ADJUSTED FORECAST AFIT

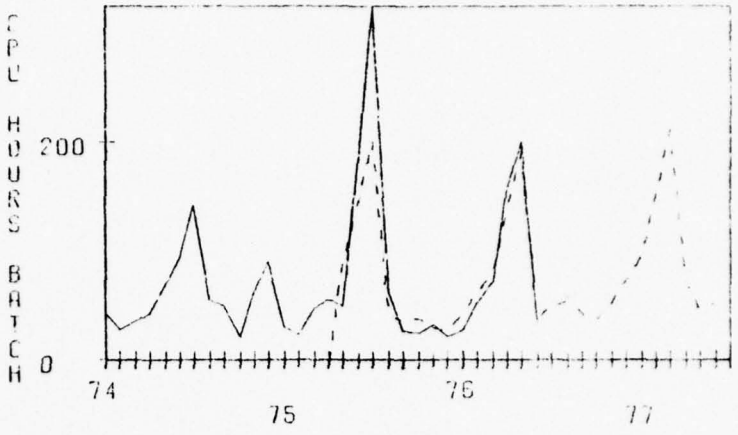


FIGURE 10C. ADJUSTED FORECAST AFIT

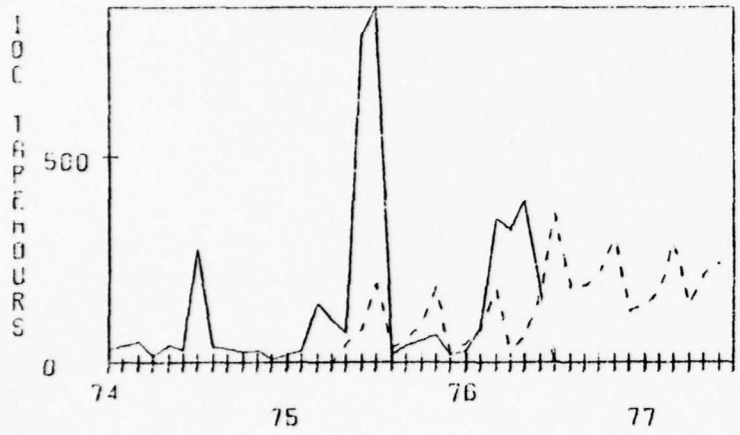


FIGURE 10A. ADJUSTED FORECAST AFIT

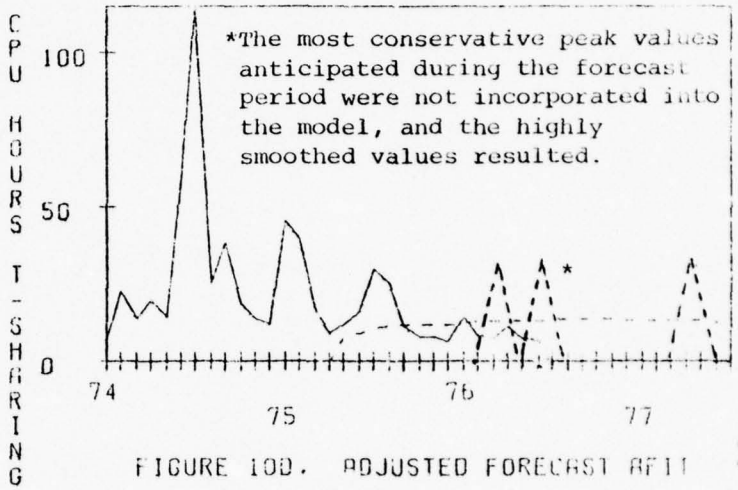


FIGURE 10D. ADJUSTED FORECAST AFIT

was a reasonable approximation of the effect of increased user activity upon the parameters of IOC, Core and batch CPU. The linear regressions provided coefficients which enabled the model to show the difference in the variables of computer usage resulting from specific changes in LOGON or batch activity. Due to the R^2 of only .38 and failure of the *F* test, time-sharing CPU could not be predicted in the same manner.

b. *Is data available to forecast the impact of relocation of AFIT/SL upon these user demands?* No written analysis was found on this subject, although much unwritten speculation is taking place. It was concluded that observing the usage rates in the new location for comparison with the old location would form a data base which could conclusively answer this question. Prior to actual use, as curriculum plans and schedules are written for the period following the move, estimates of any differences from the old location could be made.

3. *What level of use will the growth model project for a twelve-month future period?* It was concluded that the already saturated IOC will have an increased potential demand from AFIT in the future, as illustrated in Figure 10. Core hours, and batch CPU also show slight increases. Since the most conservative estimates of the programmed curriculum changes were placed

into the model, it is concluded that CREATE will receive a higher potential impact from AFIT in the coming twelve-month period.

A projected increase which will not affect CREATE directly is the forecast of increased number of LOGON hours, illustrated in Figure 9f. Realizing the projected trend in LOGON hours would further constrain the use of prime time-sharing by graduate students, the ability of AFIT/SL continuing education to schedule terminals, or both.

Recommendations

Techniques

It is felt that time series forecasting could be used exclusively to predict AFIT's computer usage. Since this method was able to fit the CREATE model with a low error term in every parameter, it was strongly concluded that the method had high promise. First, a longer data base which could incorporate two complete cycles of Graduate Logistics "A" and "B" classes without interruption could obtain a much better fit to the data. Then, a base series could be developed which could incorporate policy changes within the forecast period. This base series of data could enter these policy changes into the model in a manner more compatible to the TCAST methodology than the use of a regression formula.

Regression models can be used in time series forecasting to measure growth. Ths is done by simply regressing the data base against time, where time is expressed as a series of integers. Cyclic variation may be shown by cycling the number of the time periods. In this case, time could have been numbered from one to twelve in cycles representing the twelve months of each year. But, once again, the time series forecasting technique accomplishes the same analysis in a more sophisticated manner. Therefore, a longer data base would allow increased use of time series forecasting techniques and the elimination of linear regression methods.

Applications for Further Study

It is felt that a forecasting model could be used to study the potential of co-use of CREATE or CDC by all AFIT schools. Such a model could provide lead time in identifying serious problems of outgrowing either system. In the long term, a cost analysis would be necessary to determine the most cost-effective alternative to the present computer usage. A knowledge of cost versus capabilities of computer systems would be a part of such analysis.

On a wider scale, it is felt that other subsystems of CREATE could be analyzed using time series forecasting to determine growth and project future requirements of units within AFLC.

It is also felt that time series forecasting, and a knowledge of the behavior of large individual users could be applied in seeking the optimal periods to contract out computer workloads and could be used to influence users in their planning and scheduling of computer activity.

As the graphics features contained within this research indicate, the visual display of usage rates increases the power of explanation of any analysis. It is suggested that the printouts of computer usage could incorporate appropriate visual displays of the most frequently sought information such as the growth and cyclic behavior of an individual user's demands or the ratio of an individual user to the total CREATE system.

In summary, it is felt that the potential of this model to analyze variables collectively with regards to time makes it an appropriate tool in the effort of analyzing the usage of a computer system.

APPENDIXES

APPENDIX A

ACCOUNTING RECORDS OF COMPUTER USAGE

CREATE USER'S ACCOUNT SUMMARY FROM 01 MAR 76 TO 31 MAR 76.

USER'S IDENTIFICATION AFIT/EDUCATION

THIS IS NOT A BILL

THIS IDENTIFIES CHARGES THAT WOULD ACCRUE IF CREATE SERVICES WERE PROVIDED UNDER INDUSTRIAL FUNDING PROCEDURES.

CREATE SERVICE	CHARGES
REMOTE DEVICES	$ 4,620.97
TAPE & DISC STORAGE	$ 1,032.28
COMPUTER USE	16,362.05
TOTAL CHARGES	$ 22,015.30

CREATE PRICING POLICY

CREATE SERVICE	BILLING RATES
PRIME CPU	$140.00/CPU-HOUR
NON-PRIME CPU	$14.00/CPU-HOUR
PRIME CPU T/S	$280.00/CPU-HOUR
NON-PRIME CPU T/S	$28.00/CPU-HOUR
PRIME CORE	$1.60/CORE-HOUR
NON-PRIME CORE	$.16/CORE-HOUR
PRIME TAPE	$40.00/CONNECT-HOUR
NON-PRIME TAPE	$4.00/CONNECT-HOUR
CENTRAL SITE I/O	$.80/1000 CD/LINES

CREATE PROBLEM NUMBER MANAGEMENT DATA FROM 01 MAR 76 TO 31 MAR 76.

USER'S IDENTIFICATION AFIT/EDUCATION

PROBLM NUMBER	PROBLEM TITLE	OWNER	OPC	PHONE	TERMA	JOB#	LENS	CHARGES TO DATE	RESOURCES REMAINING	STS
WP0111	RESEARCH STUDIES DEPARTMENT PROGRAM DEVELOPMENT	C COTTER	DEE	787-3157	771031	144	176	$34,867,50		CAN
WP0112	BCE-X CIVIL ENGINEERING SIMULATION	C COTTER	DEE	787-3157	771031	21	65	$4,551,25	$34,838,	
WP0118	CIVIL ENGINEERING FORCE STUDY	C COTTER	DEE	787-3157	771031	61	2	$12,332,17	$36,307,	
WP0132	INDUSTRIAL ENGINEERING APPLICATIONS (FACULTY)	R FLUHARTY	DEE	787-3157	751031	0	0	$257,16	$1,756,742,	CAN
WP0132	INDUSTRIAL ENGINEERING APPLICATION (FACULTY)	R FLUHARTY	DEE	787-3157	760430	0	0	$257,00	$174,943,	CAN
WP0346	DFIT/ENS FACULTY RESEARCH	C MCNICHOLS	ENS	787-2589	760331	113	62	$4,407,48	$14,021,	CAN
WP0352	AFIT/ENS STUDENT THESIS	C MCNICHOLS	ENS	787-2589	760331	0	0	$311,176,53	$23,857,	CAN
WP0354	AFIT/ENS STUDENT PROBLEMS	C MCNICHOLS	ENS	787-2589	770731	140	97	$32,834,66	$24,561,	
WP0465	CIVIL ENGINEERING SCHOOL COURSE/STUDENT EVALUATION	C COTTER	DEE	787-3157	771031	7	0	$2,811,49	$9,467,	
WP0615	ELECTRICAL ENGINEERING DESIGN (STUDENT USE)	E BARTLETT	DET	787-5964	771031	0	0	$11,88	$14,139,	
WP0616	ELECTRICAL ENGINEERING DESIGN (FACULTY USE)	E BARTLETT	DET	787-5964	771031	0	4	$1,378,18	$62,871,	
WP0617	MECHANICAL ENGINEERING PROBLEMS (STUDENTS)	R DANT	DET	787-5964	771031	0	8	$337,49	$13,946,	
WP0618	MECHANICAL ENGINEERING PROBLEMS (STAFF)	R DANT	DET	787-5964	771031	36	47	$665,88	$12,837,	
WP1186	SLS SCHOOL OF SYSTEMS LOGISTICS SUPPORT	D THOMSON	SLSC	787-3366	771231	940	419	$13,272,88		CAN
WP1187	SLC FACULTY SUPPORT (CONTINUING EDUCATION)	D THOMSON	SLSC	787-3366	771231	32	113	$855,51	$159,	
WP1188	SLC STUDENT CLASSROM SUPPORT (CONTINUING EDUCATIO	D THOMSON	SLSC	787-3366	771231	14	883	$739,85	$54,260,	
WP1189	SLG FACULTY SUPPORT (GRAD LOG)	D THOMSON	SLSC	787-3366	771231	68	201	$1,102,85	$16,897,	
WP1190	SLG STUDENT THESIS SUPPORT (GRAD LOG)	D THOMSON	SLSC	787-3366	771231	736	918	$9,305,65	$57,894,	
WP1191	SL STUDENT CLASSROOM SUPPORT (GRAD LOG)	D THOMSON	SLSC	787-3366	771231	738	1076	$5,981,90	$12,918,	
WP5500	SLS SCHOOL OF SYSTEMS & LOGISTICS SUPPORT	D THOMSON	SLSC	787-4415	751231	0	0	$69,767,97	$21,641,	CAN
WP5501	SLG STUDENT CLASSROOM SUPPORT (GRAD LOG)	D THOMSON	SLSC	787-4415	751231	0	0	$111,297,36		CAN
WP5502	SLG STUDENT THESIS SUPPORT (GRAD LOG)	D THOMSON	SLSC	787-4415	751231	0	0	$97,127,88	$28,652,	CAN
WP5503	SLG FACULTY SUPPORT (GRAD LOG)	D THOMSON	SLSC	787-4415	751231	0	0	$14,812,39	$22,183,	CAN
WP5504	SLC STUDENT CLASSROOMSUPPORT (CONTINUING EDUCATION	D THOMSON	SLSC	787-4415	751231	0	0	$6,589,97	$103,410,	CAN
WP5505	SLC FACULTY SUPPORT (CONTINUING EDUCATION)	D THOMSON	SLSC	787-4415	751231	0	0	$1,158,54	$35,847,	CAN
TOTALS						3026	4044	$406,729,13	$2,531,978,	

CHARGES FOR CREATE COMPUTER USE FROM 01 MAR 76 TO 31 MAR 76.

USER'S IDENTIFICATION AFIT/EDUCATION

	CPU HOURS				MEMORY		INPUT-OUTPUT			TTY	
	BATCH	BATCH	T/S	T/S	CORE HRS	CORE HRS	TAPE HRS	TAPE HRS	LINE/CD	LOGON	
PROBLEM	PRIME	NONPR	PRIME	NONPR	PRIME	NONPR	PRIME	NONPR	IN 1000	HOURS	CHARGES
WP0111	1.5823	.3770	.2744	.0825	137.2369	35.6106	2.0798	.6049	115	81.82	$708.82
WP0112	.0362	.0255	.1296	.0270	5.6124	2.3051	.0000	.0265	16	15.05	$64.72
WP0118	1.0416	.0406	.0000	.0001	68.4089	1.8725	.0000	.0000	84	1.12	$323.34
WP0132	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	0	.00	$.00
WP0132	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	0	.00	$.00
WP0346	.2755	.3941	.0119	.0038	31.8555	33.2880	.0000	.0000	77	14.57	$165.42
WP0352	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	0	.00	$.00
WP0354	1.7509	1.2612	.0347	.0121	129.9778	94.8207	.0000	.0000	182	28.30	$641.57
WP0485	.0338	.0000	.0000	.0000	3.0399	.0000	.0000	.0000	11	.00	$18.39
WP0615	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	0	.00	$.00
WP0616	.0000	.0000	.0002	.0000	.0036	.0000	.0000	.0000	0	.27	$.06
WP0617	.0000	.0000	.0855	.0007	3.6613	.0062	.0000	.0000	0	4.50	$29.81
WP0618	.1519	.0204	.0364	.0559	14.3243	4.5536	.0000	.0000	38	14.19	$82.35
WP1186	12.3961	2.7382	.4906	.2134	816.9402	299.6731	32.0041	6.2789	24	200.10	$4,596.66
WP1187	.1375	.0055	.0839	.0051	7.2476	.3651	.0000	.0000	52	52.38	$96.29
WP1188	.0228	.0024	.6744	.7221	25.0903	25.1262	.0000	.0000	12	489.63	$266.04
WP1189	.1735	.0170	.3604	.0391	24.8466	2.2049	.0000	.0000	54	79.41	$209.84
WP1190	5.8270	37.2918	.9420	.7303	655.3517	2984.1021	54.9226	256.7992	728	365.98	$6,954.59
WP1191	3.4238	3.0950	1.3343	.9559	378.0776	296.1210	1.4744	.0113	706	399.61	$2,199.15
WP5500	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	0	.00	$.00
WP5501	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	0	.00	$.00
WP5502	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	0	.00	$.00
WP5503	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	0	.00	$.00
WP5504	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	0	.00	$.00
WP5505	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	0	.00	$.00
TOTALS	26.8529	45.2687	4.4583	2.8480	2301.7246	3780.0491	90.4809	263.7208	2099	1746.93	$16,362.05

APPENDIX B

COMPUTER PROGRAMS DEVELOPED FOR THE THESIS

```
1C THIS PROGRAM IS DESIGNED TO EXTRACT DATA FROM THE MASTER
2C FILE "TOTALS" AND PREPARE THE DATA FOR INPUT TO
3C EITHER A TIME-SERIES OR MULTIPLE REGRESSION PROGRAM IN ACCORDANCE
4C WITH THE DESIRES OF THE USER.
5C
6C
7C
20 CHARACTER FMT*80, PN*6(9),DEP*6,ANS*3,PROB*6,PN1*6/"TOTALS"/
30 CHARACTER DEPV*6(8)/"BAJOBS","CPUHRB","CPUHRT","COHRS","TAPEHR",
40&      "LOGHRS","LOGONS","STUDEN"/
50 DIMENSION ADD(8),A(8),IDX(7),COEF(8)
60 1 K=0; BIG=0; FINC=0.03; FDEL=0.05
70 CALL ATTACH(19, "76A64/REGSEL;",3,0,ISTAT,)
80 CALL ATTACH(14, "76A64/REGTSS;",3,0,ISTAT,)
90 CALL ATTACH(17, "76A64/TIMEIN;",2,0,ISTAT,)
100 CALL ATTACH(16, "76A64/REG;",3,0,ISTAT,)
110 CALL ATTACH(15, "76A64/TOTALS;",1,0,ISTAT,)
115 CALL STATUS(ISTAT,$998)
120 N=0; KNT=0; IT=0; IDEP=0; IR=0; CON=0
130 450 PRINT, "DO YOU WANT TO DO A REGRESSION YES OR NO///"
140 READ,ANS
150 IF(ANS.EQ."YES")IR=16
160 IF(ANS.NE."YES")IT=17
170 IF(IR.EQ.16)GO TO 493
171C
180 PRINT, "THIS IS TIMESERIES DO U HAVE COEFFICIENTS FROM REGRESSION"
190 READ,ANS
200 IF(ANS.EQ."YES")IR=1
210 IF(ANS.NE."YES")IR=0
220 IF(IR.NE.0)GO TO 200
```

```
221C
230 493 PRINT, " WHAT IS THE DEPENDENT VARIABLE ///????"
240 PRINT," BAJOBS CPUHRB CPUHRT COHRS TAPEHR LOGHRS LOGONS STUDEN ???
250 READ, DEP
260 DO 29 I =1,8
270 29 IF(DEP.EQ.DEPV(I))GO TO 489
280 489 IF(I.GT. 8)GO TO 450
290 480 IDEP=I
291C
300 PRINT, " HOW MANY PROBLEM NUMBERS DO YOU HAVE ???"
310 READ,N
320 IF(N.GT.9)PRINT, " THAT IS TOO MANY LIMIT IS NINE"
330 IF(N.GT.9)GO TO 480
340 PRINT, "WHAT IS THE PROBLEM NUMBER OR NUMBERS SEPERATED BY SPACE"
350 492 READ,(PN(I),I=1,N)
360 PRINT,(PN(I),I=1,N)
370 PRINT," IS THAT CORRECT "
380 READ,ANS
390 IF(ANS.NE."YES")GO TO 492
400 IF(IT.GT.2)GO TO 300
401C
410 PRINT, "  IS THIS TIME DEPENDENT REGRESSION YES OR NO???"
420 READ,ANS
430 IF(ANS.EQ."YES")IT=1
440 IF(ANS.NE."YES")IT=0
450 GO TO 300
451C
460 200 PRINT, " TYPE IN THE COEFFICIENTS SEPERATED BY A SPACE"
470 PRINT, " CONS C1 C2 C3 C4 C5 C6 C7 C8"
480 READ, CON,(COEF(K), K=1,8)
```

```
490 PRINT 121,CON, (COEF(I), I=1,8)
500 121 FORMAT(1X,6F10.4,/)
510 PRINT, " IS THIS CORRECT? YES OR NO? ? "
520 READ,ANS
530 IF(ANS.EQ."YES")GO TO 493
540 PRINT, " TRY AGAIN "
550 GO TO 200
551C
560 300 IF(IT.EQ.1)IDEP=1
570 DO 99 I=1,8
580 IF(IDEP.EQ.I)GO TO 99
590 K=K+1
600 IDX(K)=I
610 99 CONTINUE
620 123 FORMAT("TIMESERS")
630 106 FORMAT("12,12,0,0,",F10.4)
631C
632C
633C
634C
635C
640 481 DO 10 I=1,20000
650 READ(15,100,END=50)LN,PROB,(A(J),J=1,8)
660 100 FORMAT(I4,A6,F6.1,5F10.4,F7.1,F7.1)
670 IF(PROB.EQ.PN1.AND.N.GT.1)GO TO 7
680 DO 5 J=1,N
690 IF(PROB.NE.PN(J))GO TO 5
700 DO 6 K=1,8
710 6 ADD(K)=ADD(K)+A(K)
720 IF(IT.GT.2.AND.IR.LT.1)GO TO 12
```

```
730 DO 11 L=1,8
740 11 Y=Y+ADD(L)*COEF(L)
750 Y=Y+CON
760 12 IF(N.EQ.1)GO TO 7
770 5 CONTINUE
780 GO TO 10
790 7 KNT=KNT+1
800 IF(ADD(IDEP).GT.BIG)BIG=ADD(IDEP)
810 IF(IT.GT.2.AND.IR.EQ.1)WRITE(IT,105)ADD(IDEP),Y
820 IF(IT.GT.2.AND.IR.EQ.1)Y=0
830 IF(IT.GT.2.AND.IR.EQ.0)WRITE(IT,105)ADD(IDEP)
840 IF(IR.GT.2.AND.IT.EQ.1)WRITE(IR,103)KNT*10,PN(1),(ADD(IDEP)),KNT,K
850 IF(IR.GT.2.AND.IT.EQ.0)WRITE(IR,101)KNT*10,PN(1),(ADD(J),J=1,8)
860 101 FORMAT(I4,A6,1X,F6.1,5F10.4,F7.1,F7.1)
870 103 FORMAT(I4,A6,1X,F10.4,1X,I6,1X,I6)
880 105 FORMAT(F10.4,1X,F10.4)
890 DO 8 J=1,8
900 8 ADD(J)=0
910 10 CONTINUE
911C
912C
913C
920 50 IF(IR.GT.1)GO TO 25
930 ENDFILE IT
940 REWIND IT
950 WRITE(14,123)
960 WRITE(14,106)BIG+BIG*.2
970 DO 55 I=1,20000
980 IF(IR.EQ.1)GO TO 56
990 READ(IT,105,END=57)ADDER,Y
```

```
1000 WRITE(14,105)ADDER
1010 GO TO 55
1020 56 READ(IT,105,END=57)ADDER,Y
1030 WRITE(14,105)ADDER,Y
1040 55 CONTINUE
1050 57 REWIND  IT
1060 WRITE(14,107)
1070 107 FORMAT("99999999999999999, 99999999999999999")
1080 WRITE(14,108)
1090 108 FORMAT(".01 .02 .05 .10 .15 .20")
1100 ENDFILE 14
1110 REWIND 14
1111C
1112C
1113C
1120 PRINT, " END OF FILE GO TO TCAST PROGRAM NOW "
1130 PRINT, " THE NUMBER OF RECORDS IS ", KNT
1140 CALL CALLSS("REMO CLEARFILES#");CALL TCAST
1150 GO TO 999
1151C
1152C
1153C
1154C
1160 25 I=1
1170 IF(IT.EQ.1)NOV=3
1180 IF(IT.EQ.0)NOV=8
1190 ENDFILE IR
1200 REWIND IR
1210 WRITE(19,109)DEP,KNT,NOV,NOV
1220 109 FORMAT("PROBLM   ",A6,2I5,";;1",2X,I2," YES YES YES;;01")
```

```
1230 FMT="LABELS   1BAJOBS   2CPUHRB   3CPUHRT   4COHRS    5TAPEHR"
1240 IF(NOV.NE.3)WRITE(19,113)FMT
1250 IF(NOV.NE.3)FMT="LABELS   6LOGHRS   7LOGONS   8STUDEN"
1260 IF(NOV.NE.3)WRITE(19,113)FMT
1270 IF(NOV.EQ.3)FMT="LABELS   1PROBNO   2TIME     3TIMESQ"
1280 IF(NOV.EQ.3)WRITE(19,113)FMT
1290 FMT="(7X,F6.1,5F10.4,F7.1,F7.1)"
1300 IF(NOV.EQ.3)FMT="(7X,F10.4,1X,F6.0,1X,F6.0)"
1310 WRITE(19,113)FMT
1320 FMT="$:SELECTA:76A64/REG"
1330 WRITE(19,113)FMT
1340 113 FORMAT(A70)
1350 IF(IT.EQ.1)IDEP=1
1360 WRITE(19,115)IDEP,FINC,FDEL,NOV-1
1370 115 FORMAT("SUBPRO",I4,9X,F6.3,4X,F6.3,13X,I2,7X,"YES  YES")
1380 IF(IT.EQ.1)WRITE(19,117)NOV-1,NOV
1390 IF(IT.EQ.0)WRITE(19,117)(IDX(I),I=1,NOV-1)
1400 117 FORMAT("IDXPLT",7(I2))
1410 FMT="FINISH"
1420 WRITE(19,113)FMT
1430 FMT="$:ENDJOB"
1440 WRITE(19,113)FMT
1450 ENDFILE 19
1460 REWIND 19
1470 CALL CALLSS("REMO CLEARFILES#")
1480 CALL CALLSS("RUN REGSOR#","CDIN")
1490 GO TO 999
1491C
1492C
1493C
```

```
1500 998 PRINT, " THE FILE IS BUSY HOLD ON FOR A FEW SECONDS OK½ "
1510 999 PRINT, "  ARE YOU FINISHED ????? YES OR NO"
1520 REWIND 15
1530 READ, ANS
1540 IF(ANS.NE."YES")GO TO 1
1550 STOP " FINISHED"
1560 END
1570 SUBROUTINE TCAST
1580C THIS IS THE TIMESERIES FORECASTING PROGRAM AVAILABLE
1590C IN THE SL LIBRARY. DIRECTIONS FOR USE OF THIS PROGRAM ARE
1600C CONTAINED IN HONEYWELL MANUAL TIME SERIES FORECASTING
1610C (GCAST) SERIES 6000, DATED OCTOBER 1974.

*
```

```
10 CALL ATTACH(15, "76A64/TIMEIN;",3,0,,)
20 CALL ATTACH(19, "76A64/REG;",3,0,,)
30 CALL ATTACH(17, "76A64/REGTSS;",3,0,,)
40 CALL ATTACH(21, "76A64/REGSEL;",3,0,,)
50 DIMENSION A(8), B(8), C(8)
60 CHARACTER PROB*6, PRO*6
70 IA=0; IB=0; IC=0
80 READ, KK
90 DO 10 I=1,20000
100 IF(IA.EQ.0)READ(19,100,END=57)(A(J),J=1,8)
110 IF(IB.EQ.0)READ(17,100,END=58)(B(J),J=1,8)
115 IF(IC.EQ.0)READ(15,100,END=59)(C(J),J=1,8)
130 WRITE(21,103)KK*10,A(KK), B(KK), C(KK)
140 GO TO 10
150 57 IA=1; A(KK)=0; GO TO 1
160 58 IB=1; B(KK)=0; GO TO 1
162 59 IC=1; C(KK)=0
165 1 IF(IA.EQ.1.AND.IB.EQ.1.AND.IC.EQ.1)GO TO 999
170 10 CONTINUE
180 999 ENDFILE 21
190 REWIND 21
200 PRINT, "  NO OF RECORDS IS  ", I-1
210 100 FORMAT(11X,F6.1,5F10.4,F7.1,F7.1)
220 101 FORMAT(I4,A6,F8.1,5F10.4,F7.1,F4.1)
230 103 FORMAT(I4, 1X, 3F12.4)
240 STOP
250 END

ready

*
```

```
10 CALL ATTACH(15, "76A64/YR1974;",1,0,,)
20 CALL ATTACH(16, "76A64/AYEAR;",2,0,,)
30 CHARACTER A*6
40 DO 10 I=1,20000
50 READ(15,100,END=50)LN,A,B,C,D,E,F,G,H,AA,AB,AC,AD
60 100 FORMAT(V)
70 101 FORMAT(A6,1X,F6.1,9F10.4,F7.1)
80 WRITE(16,101)A,B,C,D,E,F,G,H,AA,AB,AC,AD
90 10 CONTINUE
100 50 PRINT," NO OF RECORDS IS ",I-1
110 ENDFILE 16
120 REWIND 16
130 STOP "SUCCESSFUL"
140 END

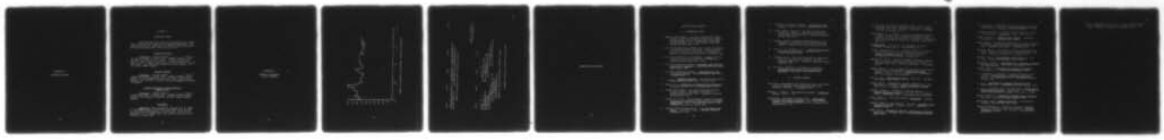
ready

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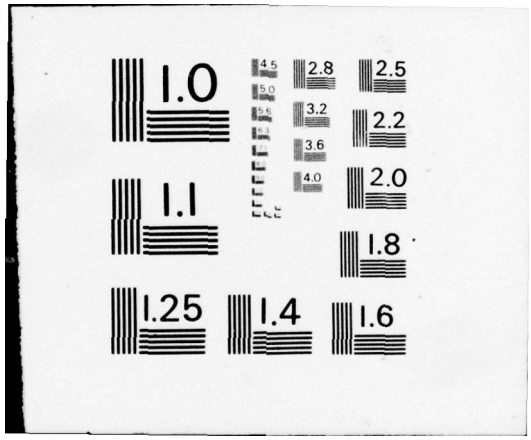
AD-A032 461 AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OHIO SCHO--ETC F/G 9/2
A MODEL TO FORECAST COMPUTER USAGE BY THE AIR FORCE INSTITUTE O--ETC(U)
SEP 76 T E ANDERSON, G A PURNELL

UNCLASSIFIED SLSR-21-76B NL

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APPENDIX C

INTERVIEW FORMAT

APPENDIX C

INTERVIEW FORMAT

Each question below was asked regarding the respondent's estimate of future use of computer resources. The questions were ask regarding each month within the twelve month period from June, 1976, to May, 1977.

Classroom Support

Questions: Problem number_____, "_____," used an average of (hours of LOGON time), (number of batch jobs). How many problems did you assign using time sharing? How will that number vary during the next course(s) of the same type? How many batch problems did you assign? How will that number change?

Faculty Support

Questions: Problem number_____, "_____," used an average of (hours of LOGON time), (number of batch jobs). Based on known research projects and other known system demands, for 1976-1977, how are the above numbers projected to change?

Student Evaluation, Administrative Support, Etc.

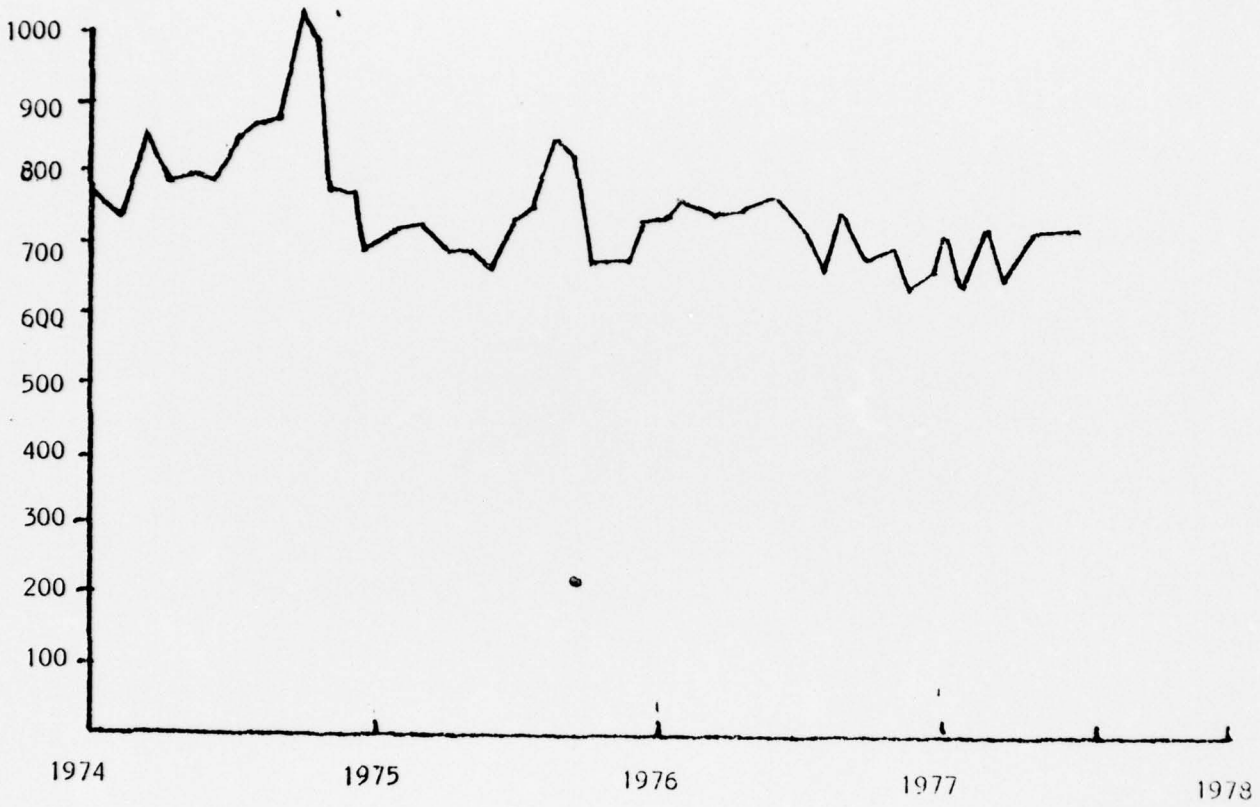
Questions: Problem number_____, "_____," used an average of (hours of LOGON time), (number of batch jobs). Based on the projected workload, how will these numbers change?

Equipment

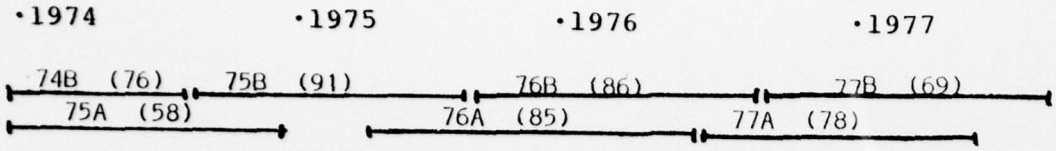
Questions: What peripheral devices will be added to the CREATE system within your area which will be used to add hours of time-sharing or batch jobs. What office equipment will be added which can replace the use of time sharing or batch jobs?

APPENDIX D

NUMBER OF STUDENTS IN AFIT SCHOOLS

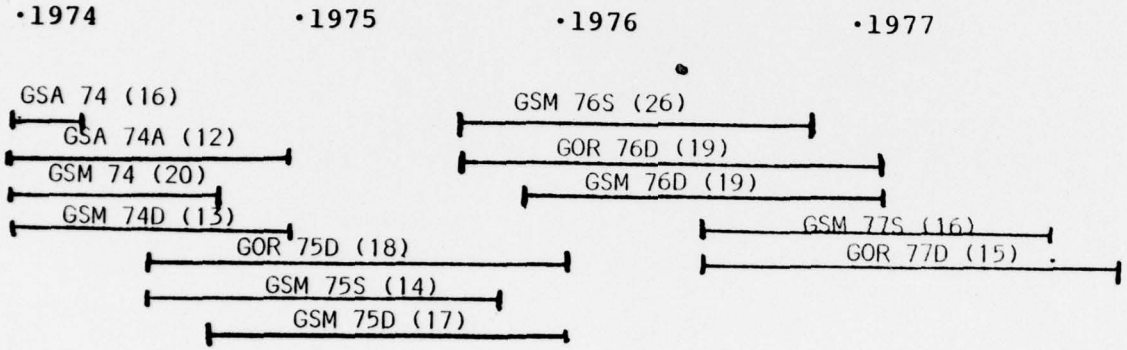


Number of Students in AFIT/ENS, AFIT/DE and AFIT/SL



School of Systems Graduate Logistics Classes

Number of Students
in Parentheses ()



School of Systems Management Graduate Classes

Graduate Classes in AFIT/SL and AFIT/ENS

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