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ABSTRACT

The authors investigated the feasibility of desiging cost/benefit, or cost effectiveness models for two alternative organizations within United States Air Force: the United States Air Force Academy and the Reserve Officer Training Corps of Air University. On the basis of the situation analyses, two cost simulation models for both institutions were developed to enhance their management planning and analysis capabilities. Preliminary efforts at analyzing the benefit side of the cost/benefit equation proved unrewarding and concentration was placed on the development of conceptual designs of cost simulation models; futher resources are necessary to implement the proposed models. (Author/CH)

AFHRL-TR-72-2

AIR FORCE

HUMAN RESOURCES

ED 084884

A CONCEPTUAL DESIGN FOR THE COST EVALUATION OF ALTERNATIVE EDUCATIONAL SYSTEMS IN MANAGING THE AIR FORCE ACADEMY AND AIR FORCE ROTC

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September 1973

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LABORATORY

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This report has been reviewed and is approved.

James E. Wade, Major, USAF
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13. ABSTRACT

This document contains detailed designs of two models customized to the management needs of the U.S. Air Force Academy and the Air Force ROTC. The model, upon implementation, would permit administrators to obtain answers to various "what if . . . ." management questions. The design of these models was based on a situation analysis of the U. S. Air Force Academy and the Air Force ROTC and a state-of-the-art analysis of existing educational cost models. No solution was attempted for the difficult problem of obtaining good measures of the effectiveness of educational systems: these are resource requirements prediction models. This effort has produced customer participation and acceptance; implementation is for the future.

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ROTC						
planning						
budgeting						
PPBS						
system						

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PREFACE

This document reports the work of Canadian Commercial Corporation in developing a conceptual system design for the simulation and evaluation of the cost-effectiveness of alternative educational systems.

The Canadian Commerical Corporation's principal investigators were Professor Richard W. Judy, Dr. Jack B. Levine, Mr. R. Stephen Russell, Mr. Alfons Van Wijk and Mr. William G. Wolfson.

Many individuals, in and out of the Air Force, contributed. The monitors are indebted to a variety of educational and research institutions in North America. The contractors enjoyed excellent support from personnel at the Air Force Academy and ROTC at Air University.

This report contains a general overview or explanation of the effort; a review of the state-of-the-art of the modelling and simulation of educational systems; an overview of the conceptual model for the Academy; and an overview of the model designed for ROTC.

At this time no formal request has been received to implement these models, but the work has received favorable consideration at both Air Force institutions.

SUMMARY

Problem

The problem was to investigate the feasibility of designing cost/benefit, or cost/effectiveness models for two pre-commissioning organizations within the United States Air Force: the United States Air Force Academy (USAFA) and the Reserve Officer Training Corps (ROTC) of Air University.

Approach

Interviews were held with numerous officers and civilians at both institutions in order to identify management problems being faced by administrators, identify sources of data, understand existing planning and modelling capabilities, and in general to prepare situation analyses from which customized models could be designed.

Results

Two cost simulation models were developed, one for the United States Air Force Academy (bearing the acronym ASTRA - Academy's Simulation Technique for Resource Allocation) and one for ROTC. The models are based on the situation analyses, are customized to the needs of USAFA and ROTC administrators, and enhance their management planning and analysis capabilities.

Preliminary efforts at analyzing the benefit side of the cost/benefit equation proved unrewarding, and, at the direction of the Project Monitor, concentration was placed on the development of conceptual designs of cost simulation models.

Conclusions

Conceptual models of USAFA and ROTC have been successfully designed. However, the conceptual designs are blueprints only; further resources and efforts are necessary to build and implement the proposed models.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd.)

PAGE NO.

TABLE OF CONTENTS (Cont'd.)

PAGE NO.

TABLE OF CONTENTS (Cont'd.)

PAGE NO.

OVERVIEW OF MODEL DESIGNS

TABLE OF CONTENTS (Cont'd.)

TABLE OF CONTENTS (Cont'd.)

APPENDICES

LIST OF TABLES

PROJECT OVERVIEW

1. PROJECT ACTIVITIES

The Canadian Commercial Corporation has been under contract to the Human Resources Laboratory to design cost/effectiveness models customized to the needs of the United States Air Force Academy (USAFA) and to the needs of the Reserve Officer Training Corps (ROTC) of Air University. The major project activities are described below.

1.1 Interviews Were Conducted

Interviews were conducted at USAFA and ROTC in 1971 and 1972 in order to identify the management problems being faced by administrators, to secure relevant documents, to identify existing management information systems, and in general to understand the inner workings of these Air Force institutions. Considerable written materials were secured including Faculty Operating Instructions, Management Engineering Division Studies, Organization Manuals, Curriculum Handbooks and Catalogues, ~~etc.~~ These describe the operations and policies of the two Air Force institutions.

1.2 The State-of-the-Art Was Reviewed

A search of current literature on educational cost models and related systems was carried out. Ten operational systems were selected for further study. Features to be incorporated into the design of the models for USAFA and ROTC were identified.

1.3 Two Models Have Been Designed

Conceptual designs for two cost simulation models have been developed: one bearing the acronym ASTRA (Academy's Simulation Technique for Resource Allocation) for USAFA and another for ROTC. The two models are based on situation analyses carried out at the Academy and at the Air University.

2. SOME MANAGEMENT PROBLEMS HAVE BEEN IDENTIFIED

A number of management problems being faced currently by Air Force administrators were identified as the result of our interviews. They are described here in general terms only. The specific problem areas applicable to USAFA or ROTC can be found in Section III of this document.

2.1 The Allocation of Resources

Allocations of men, dollars, and facilities among and within the major organizational units of each institution must be made in order to provide the resources necessary to support their educational programs. Air Force administrators agreed that alternatives should be explored and priced out before compiling any final multi-year master plan. At present the procedures (essentially manual) for exploring the alternatives are too cumbersome and hence are not used.

2.2 Means of Assessing Alternatives

A large number of alternative policies and plans were identified as potential courses of action, but no present capability exists to analyze the implications of these alternatives efficiently. The alternatives include:

- Changing staffing policies (the manning formula, wage rates)
- Changing facilities utilization policies (length of the teaching week, section size policy)
- Changing equipment policies (authorization limits, replacement rates)
- Changing other resource policies (TDY per officer)
- Introduction of new teaching methods (team teaching, computer assisted instruction, self-paced learning)
- Change program design (different graduation policies)
- New enrollment projections (by program, over time)

2.3 Measurement of Output

It was agreed that an Air Force educational institution, in the ideal situation, would be able to define its desired output; that is, the desired qualities of an officer. Those qualities having been defined, a method for measuring them perhaps could be developed. More than that, a relationship could be struck between the output produced and the educational process so that the latter could be fine-tuned in order to produce the desired output.

The problem of output measurement is a difficult one, not yet surmounted by the current State-of-the-Art. At the direction of the Project Monitor, no extensive effort was expended attempting to define output and strike up the interrelationships.

3. THE STATE-OF-THE-ART REVIEW

3.1 The Systems Examined

The systems included in the State-of-the-Art Review are:

CAMPUS VI (Canadian Commercial Corporation)

CAMPUS VII (Canadian Commercial Corporation)

RRPM (NCHEMS/WICHE)

HELP/PLANTRAN (Midwest Research Institute)

SEARCH (Peat, Marwick, Mitchell & Co.)

CAMPUS/HEALTH (Canadian Commercial Corporation)

Michigan State University Model

Tulane University Model

FACSIM (U.S.A.F. Academy)

Resources and Cost Model (RAND Corp.)

Each of these systems is described. The bibliography refers to additional systems which are currently at various stages of development.

3.2 Assessment

In order to compare the major systems criteria have been established.

Administrative Criteria refer to the administrative use of these systems in:

Enrollment Forecasting
Academic Planning and Curricula Design
Facilities Planning
Staffing
Financial Planning and Budgeting

Technical Criteria refer to four aspects of the systems:

System Dimensions
Adaptability
Reporting Capabilities
Operating Mode

Implementation Criteria refer to practical aspects:

Extent of Use
Cost and Time to Implement

4. GENERAL DESIGN OF THE AIR FORCE MODELS

4.1 Two Cost Simulation Models Have Been Developed

The conceptual designs for two cost simulation models have been developed, one for USAFA and one for ROTC. The models are based on the situation analysis, are customized to the Air Force organizational structure, and address many of the problem areas currently of interest to Air Force administrators. Cost simulation models describe the relationships between the inputs to the educational system (cadets), the process through which the cadets are educated (using staff, space, equipment, other resources/ requiring overhead items such as a Commandant, a division of physical plant, etc.), and the outputs of the educational system (graduates, dropouts, etc.). They do not say anything about the quantity of the output. The focus is on the level of resources necessary to transform the inputs into the outputs by means of a specified process. With the model, it is possible to "simulate" the behaviour of the real system and thereby estimate the effects of changes in alternative policies or other variables. Indeed the primary purpose of a cost simulation model is to aid decision-makers in predicting the future for an institution, under various alternatives.

4.2 The models are described in detail.

4.3 The Models Draw on the State-of-the-Art Review

The models designed for the USAFA and ROTC certainly bear a family resemblance to existing CAMPUS models developed by the Canadian Commercial Corporation. The resemblance is particularly strong in terms of basic design: the feature of a modelling language by which the user builds a representation of his institution, constrained in no way by predetermined relationships.

With that basic philosophy in mind, models have been designed to suit the particular needs and characteristics of USAFA and ROTC. In doing so, we have drawn upon our study of the state-of-the-art and have included in the design certain capabilities which do not exist in the CAMPUS VI and VII models:

- The ability to specify an external planning factor upon which resource requirements will depend (source: SEARCH)

- The ability to constrain statements of resource requirements by a logical IF statement (source: HELP/PLANTRAN)

- The ability to specify a goal value of an experimental change, to be achieved in equal increments over the planning horizon (source: HELP/PLANTRAN)

- The concept of an enrollment multiplier used to scale down enrollment predictions (source: FACSIM)

- A sophisticated equipment procurement routine (source: FACSIM)

- A comprehensive data editor (source: CAMPUS/HEALTH and RRPM)

- A clear indication on output of the steps used in calculating resource requirements (source: RRMP)

- The production of numerous cost/effectiveness measures (source: RAND model and USAFA handbooks)

4.4 The ASTRA Model

The ASTRA model developed for USAFA is chosen here for illustrative purposes. The model designed for ROTC is similar in overall design.

The ASTRA model is comprised of ten interrelated subsystems. These are:

STRUCTURAL DEFINITIONS (DF):	The Model Language
CADET FLOW (CF):	Cadet Program Enrollment
CADET COURSE (CC):	Course and Sections Enrollment
CONTACT HOURS (CH):	Academic Cost Center Loads
RESOURCE REQUIREMENTS (RR):	Cost Center Resource Requirements
PROGRAM COSTING (PC):	Individual Course and Program Costs

MULTI-YEAR (MY):	Overtime Reporting Capability
DATA EDITOR (DE):	Error checking and listing of input date
MONITOR (MO):	Controlling the Model Operation
INTERACTIVE PROMPTER (IP):	Computer Assisted Operating Instructions

4.5 Reporting Capabilities are Extensive

The reporting capabilities of the models designed for the Air Force are quite extensive. The user has considerable control over the nature and number of reports produced. The reporting structure facilitates the dissemination of summary reports to senior administrators, department reports to departmental chairmen, and program reports to program co-ordinators. The reports are interrelated permitting the user to trace back from one item on an aggregate multi-year report through more and more levels of detail until he reaches all the supportive data which underlie the original item.

4.6 The Experimental Capabilities are Sophisticated

The experimental capability allows the user to make temporary changes to the data base in order to analyse the implications of alternative formulations of educational planning problems. These problems are the usual "What if...?" type questions that require quantitative answers to bolster management decision making.

The experimental capabilities are sophisticated and provide the following:

- The ability to experiment with an individual data element or a group of elements.
- The ability to analyze changes to individual cost centers (detachments), programs, or courses, or aggregations of these.
- The ability to start and stop the experimentation at any point in the time horizon.
- The ability to change a data element by an absolute or percentage amount.
- The ability to replace a data element by a new value or to set an old value to be reached over the planning horizon.

4.7 The Models Can be Used in an Interactive Mode

One subsystem for each model, the Interactive Prompter, has been designed to act as an efficient, informative, and easily understandable interface between a model user and the model itself. The user is connected to the computerized model via a terminal similar to a typewriter, and can "converse" with the system in an English language conversational mode. If the user has a general understanding of the system, the conversation takes the form of an interchange in which the user is informed of the capabilities available, and how they can be activated. The more experienced user can quickly access and execute the specific portion of the modelling system he wishes, avoiding as much explanatory information as he desires.

The Interactive Prompter is not an integral part of the model design; no other subsystem is dependent on it. Air Force computer hardware, the desires of Air Force administrators, etc. will dictate whether this subsystem will be built.

4.8 The Data Requirements have Been Identified

The data necessary to fuel the proposed models have in most cases already been collected and can be found in Air Force information systems, Air Force catalogues, Air Force budget documents, Management Engineering Division standards, etc.

5. WHAT THE MODELS CAN DO

5.1 Sample Problems

A series of problems given below illustrate the kind of questions which can be addressed with the proposed models. The sample problems are not meant to be exhaustive; they are intended only to indicate the diverse kinds of problems that can be addressed. Where a problem is of particular importance at one of the two Air Force Institutions, it is indicated in brackets after the heading.

Academic Policy (USAFA)

What would be the impact on a particular department of moving towards individualized instruction and self-paced learning?

Administrative Policy (ROTC)

What would be the resource requirements of introducing a new recruitment program involving more liaison officers and TDY expenses? What are the implications if the recruitment program is completely successful in attracting cadets?

Staffing Policy (USAFA, ROTC)

Which academic departments (detachments) would gain additional staff and which would lose staff if manning allocation standards were changed from "Plan Blue" to "Plan Orange"? Under which of the two schemes is total manning the less?

Space Policy (USAFA)

What would be the impact on shortages and surpluses of teaching space, by category, subcategory and size range, of offering most first and second year courses in section sizes of 76 cadets?

Reorganization (ROTC)

What savings can be realized by disestablishing certain detachments which presently have low enrollments? What is the shadow cost (savings foregone) if the Department of Defense will not permit the disestablishment?

Enrollment (ROTC)

What would be the impact on total annual operating budgets for the next five years of a Department of Defense decision to increase ROTC production to 4500 cadets, 3000 flying and 1500 non-flying?

Environmental (ROTC, USAFA)

What would be the impact on operating budgets of a specified change in the officer pay schedule, together with certain levels of inflation for civilian manpower and other items in the O&M budget?

Long Term Budget (ROTC, USAFA)

What will the budget be in FY77 if current policies and plans are maintained?

Selection (ROTC)

What is the effect of a number of graduates produced, and on the cost per graduate of admitting more minority group cadets?

5.2 Other Benefits

In addition to being of assistance in determing the economic implications of alternative decision policies, a cost model may provide benefits in any one or more of the following areas:

- It may force decision-makers to be explicit in formulating the characteristics of any alternative policy.
- It may aid in identifying or suggesting alternative decision policies to be explored.
- It may be a convenient device around which much of an institution's data can be organized.
- It may point out weaknesses or inefficiencies in existing policies and plans.
- It may enable managers to be better prepared for

certain "uncontrollable" eventualities (for example, changing cadet program preferences).

- It may be the focal point around which a set of formal planning and budgetary procedures can be built.

6. AN ILLUSTRATIVE PROBLEM IS FORMULATED AND ANALYZED

An example of how the Air Force models can be used to shed light on a particular problem follows. The problem and its data are illustrative only, and in no way are meant to reflect any real situation. The example is taken verbatim from the USAFA Technical Report.

6.1 Description

Suppose that the Academy is considering a new teaching method and a reorganization of its curriculum. The new teaching method involves self-paced instruction in which cadets make much greater use of programmed texts, audio visual aids, etc. At the same time the curriculum is reorganized so that those activities for which greater emphasis is placed on self-paced instruction meet formally only once per week in section sizes of 76 cadets rather than in 20 cadet sections once per cycle. The self-paced activity involves no staff time.

6.2 Analysis

Report MY02 - Resource Requirements shows the effect on the faculty. Requirements for faculty slots are affected in the following way: 12 teaching officers slots are saved; two more support officers are required; and one more civilian slot is required; for a total of 9 slots.

The same report shows the total implications for the faculty in terms of manning (a saving of $146,000) in terms of faculties (a requirement for an additional 2840 sq. ft.) in terms of equipment (an addition of $10,000), and other O&M Budget items (an addition of $13,000).

More detailed information is available at the division level. For the basic Science Division, space requirements are altered by the reorganized curriculum and new teaching method in the following way: a surplus of one classroom of size 20 is produced but a shortage of one classroom of size 76 is produced. Report RR03 - Teaching Space Requirements illustrates the effect.

At the department level, manning at the Aeronautics Department for example, is reduced by one slot. This is illustrated by Report RR02 - Teaching Staff Requirements.

6.3 Decision

The question of whether or not the new teaching method and altered curricula should be introduced at the Academy is not answered by merely having the cost data illustrated above. Decision makers must ponder the pedagogical effectiveness of the proposed change, balancing this off against the cost date provided from the ASTRA model.

Sample Report: Base

UNITED STATES AIR FORCE
INSTITUTION: USAFA

REPORT: MY02
PLAN: BASE
PAGE:

RESOURCE REQUIREMENTS

COST CENTER: FACULTY

RESOURCE TYPE	CATEGORY	FY72		FY73	
		NO.	COST	NO.	COST
STAFF (MEN)	1 - TEACHING OFF	378	5670	382	5730
	2 - SUPPORT OFF	67	938	68	950
	3 - SUPPORT	39	390	40	400
	TOTAL	484	6998	490	7080
		NET	SOS	NET	SOS
SPACE (SQ. FT.)	1 - CLASSROOM	48720	0	48720	0
	2 - LABORATORY	89970	0	89970	0
	3 - SUPPORT	20010	0	20010	0
	TOTAL	158700	0	158700	0
		INV.	PROC'D	INV.	PROC'D
EQUIPMENT (DOLLARS)	1 - EXPENSE	3870	160	3774	170
	2 - INVESTMENT	4606	156	4489	173
		INV.	PROC'D	INV.	PROC'D
OTHER	1 - OPERATING (O & M)	1000	1011	975	987

Sample Report: Experiment

UNITED STATES AIR FORCE
INSTITUTION: USAFA

REPORT: MY02
PLAN: EXP.
PAGE:

RESOURCE REQUIREMENTS

COST CENTER: FACULTY

RESOURCE TYPE	CATEGORY	FY72		FY73	
		NO.	COST	NO.	COST
STAFF (MEN)	1 - TEACHING OFF	378	5670	370	5550
	2 - SUPPORT OFF	67	938	70	974
	3 - SUPPORT	39	390	41	410
	TOTAL	484	6998	481	6934
		NET	SOS	NET	SOS
SPACE (SQ. FT.)	1 - CLASSROOM	48720	0	51120	- 2400
	2 - LABORATORY	89970	0	90410	- 440
	3 - SUPPORT	20010	0	20010	0
	TOTAL	158700	0	161540	- 2840
		INV.	PROC'D	INV.	PROC'D
EQUIPMENT (DOLLARS)	1 - EXPENSE	3870	160	3784	180
	2 - INVESTMENT	4606	156	4489	173
		INV.	PROC'D	INV.	PROC'D
OTHER	1 - OPERATING (O & M)	1000	1011	975	1000

Sample Report: Base

UNITED STATES AIR FORCE

YEAR: INSTITUTION: REPORT: RRO3
SEMESTER: PLAN: BASI
DATE: PAGE:

TEACHING SPACE REQUIREMENTS

COST CENTER: BASIC SC.

TEACHING SPACE CATEGORY	SIZE (STAT)	BEFORE ROOMS REQUIRED	BEFORE ROOMS AVAILABLE	BEFORE SHORTAGE OR SURPLUS (RM
1 CLASSROOM	20	10	10	0
	40	3	3	0
	76	1	1	0
SUBTOTAL		14	14	0

Sample Report: Experiment

UNITED STATES AIR FORCE

YEAR: INSTITUTION: REPORT: RRO3
SEMESTER: PLAN: EXP
DATE: PAGE:

TEACHING SPACE REQUIREMENTS

COST CENTER: BASIC SC.

TEACHING SPACE CATEGORY	SIZE (STAT)	BEFORE ROOMS REQUIRED	BEFORE ROOMS AVAILABLE	BEFORE SHORTAGE OR SURPLUS (RM)
1 CLASSROOM	20	9	10	+ 1
	40	3	3	0
	76	2	1	- 1
SUBTOTAL		14	14	0

Sample Report: Base

UNITED STATES AIR FORCE

YEAR: INSTITUTION: REPORT: RR02
SEMESTER: PLAN: BASE
DATE: PAGE:

TEACHING STAFF REQUIREMENTS

COST CENTER: AERO
PART ONE: STAFF AND COST

TEACHING STAFF SUBCATEGORY	PREVIOUS INVENTORY	DESIRED DISTRIBUTION	STAFF REQUIRED	AUTHORIZATION	(AUTH.-REQ'D)	(REQUIRED PRE INV)	ANNUAL SALARY	TOTAL SEMESTER COST
PROFESSOR	1	10	1	1	0	0	20,000	10,000
ASSOCIATE PROFESSOR	3	15	3	4	1	0	17,000	25,500
ASSISTANT PROFESSOR	4	35	5	5	0	+1	15,000	37,500
LECTURER	5	40	5	6	1	0	12,000	30,000
TOTAL	13		14	16	2	1		103,000

Sample Report: Experiment

UNITED STATES AIR FORCE

YEAR: INSTITUTION: REPORT: RR02
SEMESTER: PLAN:
DATE: PAGE:

TEACHING STAFF REQUIREMENTS

COST CENTER: AERO
PART ONE: STAFF AND COST

TEACHING STAFF SUBCATEGORY	PREVIOUS INVENTORY	DESIRED DISTRIBUTION	STAFF REQUIRED	AUTHORIZATION	(AUTH.-REQ'D	(REQUIRED PRE INV)	ANNUAL SALARY	TOTAL SEMESTER COST
PROFESSOR	1	10	1	1	0	0	20,000	10,000
ASSOCIATE PROFESSOR	3	15	3	4	1	0	17,000	25,500
ASSISTANT PROFESSOR	4	35	5	5	0	+1	15,000	37,500
LECTURER	5	40	4	6	2	-1	12,000	24,000
TOTAL	13		13	16	3	0		97,000

7. THE MODELS ARE READY TO BE IMPLEMENTED

The conceptual designs of the ASTRA and ROTC models are complete. They have been presented to the administrators at each of these institutions, and to personnel at Headquarters Air Staff, and have been accepted in principle by all.

The next step is the implementation of the conceptual model designs. The following major activities are involved, both for ASTRA and for the ROTC model:

System Activities

- Review system alternatives (which subsystems to build)
- Build computer software
- Build software interfaces with existing information systems

Implementation Activities

- Review implementation alternatives (which aspects to implement)
- Data collection and verification
- Education of users, including development of users' manual
- Problem formulation and analysis.

II

STATE-OF-THE-ART REVIEW

1. INTRODUCTION

Educational administrators are being asked to demonstrate that they are making the best use of the resources at their disposal. They are being called upon to outline the goals and objectives of their institutions, and to relate these to the level of resources allocated to them. As a result, decision-makers in higher education have, with increasing frequency, looked to new tools such as Planning Programming Budgeting Systems and to simulation models in order to manage their complex institutions with greater skill. This document describes and compares the most advanced generalized cost simulation models.

The models to be compared are all "economic" models - or, to use the term popularized by WICHE*, "Resource Requirement Prediction Models". These devices are specifically designed to estimate the staff, space and financial requirements of an institution to provide educational programs to students over a period of years. They also compute the cost for the provision of other related educational services such as research, public service programs, academic support, etc.

A very important quality of all general simulation models is their ability to answer "what if" questions. For example, what are the cost implications of increasing enrollment in certain programs" What are the cost implications of new staff workload or hiring policies? If current trends continue when should additional teaching space be built? In short, these models help us visualize and explore the resource and budgetary implications of alternative futures (capital and/or operating).

Why should an institution bother to acquire and use a simulation model? Models are abstractions of the educational system that are used when it is too costly, too difficult or impossible to experiment with the real system. With a model, it is possible to simulate the behaviour of the real system and thereby estimate the effects of changes in alternative decision policies. In addition to being of assistance in determining the economic implications of alternative decision policies, a cost model may provide benefits in one or more of the following areas:

- force decision-makers to be explicit in formulating the characteristics of possible alternative policies;

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* WICHE: Western Interstate Commission for Higher Education

- aid in identifying alternative decision-policies to be explored;

- be a convenient framework on which much of the institution's data can be organized for management purposes;

- point out weaknesses or inefficiencies in existing policies and plans thereby stimulate the search for alternatives;

- enable managers to be better prepared for certain uncontrollable eventualities (for example, decreased enrollment, change in student program preferences);

- be the focal point around which a set of formal planning and budgeting procedures may be developed; and

- assist managers in gaining an understanding of the dynamics of his institution.

The purpose of this section is to discuss the similarities and differences of educational simulation models - their practical value in educational administration and their technical characteristics.

2. CRITERIA FOR ASSESSMENT

2.1 Introduction

Educational simulation models are computer programs which are developed to assist educational administrators in computing the staff, space and finances that will be needed to meet predicted demands. Each set of computations is made under certain assumptions about the ways in which the institution's resource management centers, usually departments, are visualized as responding to the educational demands of future generations of students. The models provide a framework for thinking about the future of education in economic terms.

This means, among other things, that none of the models has anything to say explicitly about the quality of education, the value of education, the academic content of curricula, or what is the 'best' course of action to follow. Implicitly, however, the models draw attention to the value of cost/benefit analysis and to the importance of better instructional methods and policies. In economic terms, the models do not even automatically indicate what is the least expensive course or action to follow; the user has to select his own assumptions and evaluate the answer for himself. The simulation models described in this study are not optimization models. The best plan has to be sought through iterative procedures.

In order to describe and compare the major models a number of criteria have been established. These fall into three main areas:

- User oriented criteria
- Technical criteria
- Implementation criteria

An explicit definition for each of the criteria established within the three major headings is given below:

2.2 User Oriented Criteria

The most important criteria to be used in the assessment of any analytical system are those related to the administrative uses to which these systems can be put. Five uses have been identified.

2.2.1 Enrollment Forecasting

All education simulation models are driven by enrollment. The models display costs and resource requirements primarily on the basis of analysis of the expected number of students to be served. Therefore, the extent to which the models contribute to the enrollment forecasting process is an important consideration in the assessment of the relative merits of the various models.

2.2.2 Academic Planning and Curriculum Design

Decisions about programs to be offered and teaching methodologies to be employed shape the academic character of an institution. In order to evaluate various models it is important to understand in what way these models can contribute to the academic planning and curriculum design process.

2.2.3 Facilities Planning

The determination of future space requirements as well as capital fund requirements is an important institutional planning function. The assessment will include the description of what each of the major models has to contribute in this area.

2.2.4 Staffing

About fifty per cent of the operating budgets of most educational institutions is devoted to faculty salaries. Given the current policies on tenure, past staffing patterns may impose constraints on the future plans of an institution. It will be of specific interest to see how various systems handle the faculty flow problem and the calculation of future staff requirements.

2.2.5 Financial Planning and Budgeting

The calculation of total revenues and expenditures for any one year provides the ultimate test for the economic feasibility of proposed plans of an institution. What is of particular importance are the ways in which the models deal with revenue calculations, cost projections and budget allocations.

2.3 Technical Criteria

2.3.1 System Dimensions

The level of detail to which a model delves has an impact on the administrative uses of the model as well as on the size of the computer necessary to support the system. The system dimensions are an indication of the amount of detail a system can deal with.

2.3.2 Adaptability

The usefulness of a model to a particular institution depends in part on the adaptability of that model to that institution. At one extreme the model may be completely adaptable to any particular institution, but be inefficient and at the other extreme, a very efficient system may have to be almost completely rewritten for each institution.

3.3.3 Reporting Capabilities

In order to assess the relative merits of various systems, the user must have information regarding the output that may be obtained from it. A complete description of the reporting capabilities of the major models, therefore, is required.

2.3.4 Operating Mode

The interface between the user and the operation of the model can be accomplished in either the time-shared or batch-operating mode. The models that run in a time-sharing environment, via low-speed computer terminals, usually are interested in reaching the non-technical users with computer assisted instruction packages, automated experimental capabilities, and/or on-line report generation.

The traditional batch mode of operation is one in which the user submits his problem to the computer which then processes the data and produces the output without any intervention of the user.

2.4 Implementation Criteria

2.4.1 Extent of Use

Institutions interested in implementing a simulation model will want to know whether the system has been implemented in other institutions. The extent of use will be described in terms of the number and type of institutions that are actively using the various modelling systems.

2.4.2 Cost and Time for Implementation

As in so many things, the ultimate cost plays an important part in the decision to proceed with any particular project. The time and resources required to implement the systems should be clearly understood by any institution wishing to use a model for institutional planning.

3. DESCRIPTION OF EDUCATIONAL MODELLING SYSTEMS

Over the years many efforts have been made to build models of educational systems. Broadly speaking we can identify several basic features common to most resource prediction planning models:

- The models are driven by enrollment. The models display cost and other resource requirements primarily based on an analysis of the expected number of students to be served. (In larger institutions sponsored research projects may constitute an additional significant demand for institutional resources.)

- The models estimate staff requirements. From enrollment figures and teaching loads the models calculate future staff requirements in terms of numbers of people and payroll dollars required to employ them.

- The models estimate future facilities needs. In greater or lesser detail, the models address themselves to the physical facilities required as a result of the academic programs and their projected enrollments. Outputs from the models vary from gross square feet to actual number of rooms by size and type, depending on the model.

- The models deal with resources required to support the instructional program. The support resources required as represented by the library, cafeteria, business office, registrar's office, etc. are estimated on the basis of the number of students, staff, or square feet previously calculated. The models, therefore, deal with all operational aspects of educational institutions.

- The models provide program costing information. To provide information for program analysis the models usually allocate the computed resource cost back to programs. This in turn permits the models to calculate average course cost, cost per student, cost per student credit hours and other similar measures that may be of use in cost analysis.

The models calculate expected operating and capital revenues.

From a thorough search of available literature, it appears that there are only a few modelling systems which have reached a sufficient level of maturity to be called operational.

Following is a list of systems considered in this State-of-the-Art Review (in alphabetical order).

SYSTEM	ORGANIZATION
CAMPUS VI	(Canadian Commercial Corporation)
CAMPUS VII	"
CAMPUS/HEALTH	"
Cost Simulation Model (CSM)	(University of California)
FACSIM	(U.S.A.F. Academy)
HELP/PLANTRAN	(Midwest Research Institute)
Michigan State University Model	(M.S.U.)
Resource and Cost Model (RCM)	(RAND Corp. for U.S.A.F.)
RRPM	(NCHEMS/WICHE)
SEARCH	(Peat, Marwick, Mitchell & Co.)
Tulane University Model	(T.U.)

Each of these eleven planning systems is described. The annotated bibliography refers to additional modelling systems which are currently at various stages of development.

Three of the eleven systems have been selected for a more intensive treatment in this review: CAMPUS VI and CAMPUS VII developed by the Canadian Commercial Corporation and RRPM developed by the National Center for Higher Education Management Systems (NCHEMS) at WICHE. The reason for this selection is that these three systems are the most generalized and comprehensive in dealing with all sectors of resource consumption in educational institutions.

CAMPUS/HEALTH, the Michigan State University Model, the Tulane University Model, the Cost Simulation Model and the two USAF models are all interesting and worthwhile applications of the concepts of simulation to management problems, but each of these is currently operational in only one institution or for one type of post secondary education and additional work would be required to generalize the design of these models to the point where they could easily be implemented in any other institution.

Two other systems which are generally available have been excluded from the detailed examination. These are HELP/PLANTRAN developed by the Midwest Research Institute and SEARCH which was developed by Peat, Marwick, Mitchell & Co. The reason that these two systems have not been included in detail is that they belong to a different class of systems. By design, they are not intended to be used as general educational simulation models. Rather, they might more accurately be described as budget simulators. Each line item in the budget is functionally related to another line or set of lines in the budget. Although the term budget simulator is used to describe them, this does not mean that either SEARCH or HELP/PLANTRAN is restricted to financial information. HELP/PLANTRAN may have as many as several thousand lines. Both HELP/PLANTRAN and SEARCH are designed to serve as very aggregate models of an educational unit whether this be a department, faculty or college or university. The CAMPUS models and RRPM on the other hand, have been specifically designed to serve as comprehensive models of complex institutions. In varying degrees, they provide a general framework for planning activities in educational institutions.

By excluding the SEARCH and HELP/PLANTRAN systems, we do not wish to imply any judgment about their usefulness - merely that they are of a type so different from the three major models that comparisons would tend to be meaningless.

The description and assessment of educational modelling systems will, therefore, be divided into three sections:

- Major Education Simulation Models
  - CAMPUS VI
  - CAMPUS VII
  - RRPM

- Other Systems

  - HELP/PLANTRAN
  - SEARCH
  - CAMPUS/HEALTH
  - MICHIGAN STATE UNIVERSITY
  - TULANE
  - COST SIMULATION MODEL

- USAF Models

  - FACSIM
  - Resource and Cost Model

3.1 Major Education Simulation Models

3.1.1 CAMPUS VI*

CAMPUS (Comprehensive Analytical Methods for Planning in University Systems) is a set of computer programs and related procedures which are designed to assist educational administrators in decision-making. CAMPUS consists of:

- an information system oriented towards planning and budgeting decisions

- a simulation model which enables educational administrator to determine the resource implications in terms of staff, space, and finances of alternative academic program and administrative policies.

- a planning and budgeting manual which sets out the forms and procedures that may be used in conjunction with the information system and the simulation model in the development of multi-year plans and annual budgets

- a physical facility planning manual for the development of detailed specifications for a physical facilities master plan.

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* See also: Van Wijk, A.P., Russell, R.S., and Atcheson, R.M., "The Use of Simulation Models in Educational Planning" a paper presented at the Canadian Operational Research Association Conference, Ottawa, June, 1971. (See Bibliography for additional references).

NOTE: After this report was written, CAMPUS VIII replaced CAMPUS VI as the most advanced of the CAMPUS models. CAMPUS VIII is similar to CAMPUS VI in design but provides additional flexibility. Since CAMPUS VIII is also more modular it is possible to implement it on smaller computers.

CAMPUS VI is the most detailed and comprehensive simulation model in the CAMPUS series. CAMPUS VI is, in a sense, a language by which the user is able to describe the entire structure of his institution. On input, the user provides information about:

- the names, and interrelationships among organizational units (cost centers) which are responsible for the expenditure of resources;
- the names, codes, timing and curricula content of academic programs;
- the names of categories and subcategories of staff, space and other financial resources;
- the format of the budget;
- timing information on fiscal years, semesters, and academic years; and
- miscellaneous other structural definitions.

Following is a brief description of the ways in which the CAMPUS VI model makes its calculations.

a) Enrollment Forecast

The front end of the CAMPUS VI system consists of a student flow module. The purpose of the student flow module is to calculate the number of students that will likely be enrolled at each level of each program for each semester of each year to be simulated. Future enrollments are calculated on the basis of an initial inventory of students and the percent of students who pass on to the next level, repeat the same level, drop out of the institution, transfer to another program or graduate from a program. The student flow module also requires input regarding new freshman entrants as well as any possible advanced entrants. With CAMPUS VI, the user has the option to bypass the student flow module completely and to specify directly the number of students to be enrolled at each level of each program in each semester of each year to be simulated.

b) Computation of Instructional Workloads

CAMPUS VI calculates the instructional workloads placed by students on academic departments in terms of detailed course enrollments, the number of sections for each course, the number of section hours, the number of student credit hours, the number of staff contact hours differentiated by staff rank, activity levels and activity disciplines and the number of space contact hours differentiated by type and size of room required. Course enrollments are calculated on the basis of the number of students from each program that are expected to take that particular course in the semester to be simulated. The distribution patterns of program enrollments to specific courses can, of course, be changed for each semester to be simulated.

The course of activity is a key concept in the CAMPUS VI model. Basically an activity is an event that demands physical resources in terms of teaching staff or teaching space on a scheduled basis. In most cases, there is a one-to-one relationship between an instructional activity and what is usually termed a course. The exception to this is a course, for example, Physics 101, which consists of both a lecture and a laboratory. In this case, the course consists of two distinct activities. Activities are the responsibility of academic departments (or cost centers) and one specific activity may be part of a number of different programs.

Programs are defined in terms of the activities which constitute it. The program may be a degree program such as a baccalaureate degree in arts or it may be a degree program differentiated by the major of the student as a baccalaureate degree in arts majoring in history. On the other hand the programs in CAMPUS VI might be defined as discipline programs; that is to say, all history courses might be said to constitute the history program which may make a "program" simply the sum total of the offerings of a teaching "department".

The user, therefore, has wide latitude in the definition of activities according to his own perceived needs. Some institutions may choose to define activities as individual courses or the way they are listed in the catalogue of the institution. Others may choose to define representative activities; that is to say, instead of defining specific activities, the institution might choose to define one activity to represent many similar activities -- for example, all lecture activities, all seminar activities, etc.

Each activity, or representative activity, is defined in terms of a name, type (lecture lab, seminar, individualized instruction, etc.), location, staff discipline, credits, level (lower division, upper division, graduate, etc.), section size policy, hours per week, duration in weeks, teaching staff required by rank, teaching space required by type and size of room, maximum number of sections to be offered, and minimum enrollment below which the course will be cancelled. On the basis of enrollment information and the specific description of each specific activity (or type of activity), the model can calculate the instructional workloads of each department.

c) Computation of Teaching Staff Requirements

CAMPUS VI calculates the teaching staff requirements to meet both the instructional workload and the non-instructional workload placed on each department. The calculation of the instructional workload was explained in the preceding section. The non-instructional workload (administration, research, public service, counselling, etc.) is calculated on the basis of specific planning policies provided by the institution as input to the model, for example: one half hour of counselling per week for each student. Total teaching staff contact hours required to meet both the instructional and non-instructional loads of each department are converted into FTE's by applying, for each cost center, a specific policy dictating how many hours per week teaching staff are required to put in for teaching and other activities.

CAMPUS VI also includes a faculty flow module. On the basis of an initial inventory and transition information in terms of the per cent of staff promoted to the next rank each year and the per cent of staff expected to leave the institution each year, the module calculates the number of staff that will be available for each academic department for each of the years to be simulated. The number required is compared to the number that will be available in each year. If additional staff are required the model adds new staff to the inventory on the basis of a specific percentage distribution policy by rank and on the basis of whether the institution wants to minimize the number of staff or minimize the cost of staff. Finally, an average salary figure is applied to each rank of staff to calculate the total teaching staff budget of each cost center. The costs of teaching staff are then assigned to a specific line item and budget function in order to reflect the established budget format of the institution.

d) Computation of Teaching Space Requirements

The conversion of teaching space contact hour requirements by type and size into specific number of rooms required is carried out on the basis of two policies specified by the institution: the length of the teaching week (expressed as the number of hours per week teaching rooms are available) and a factor expressing the maximum utilization of space to be achieved for each type of space in view of normal scheduling problems (expressed as a percentage of the teaching week). The number of rooms required by type and size are then compared with a current inventory of space available, or likely to be available in each of the years to be simulated, to arrive at shortages or surpluses of specific types and sizes of rooms. Room area planning factors are applied to indicate the additional square feet of each type of space that is required. In addition, the capital construction cost and capital equipment cost are indicated for the additional space required over and above that which is available in the inventory. The capital construction cost and capital equipment cost are assigned to specific line items and budget functions of the institution's capital budget.

e) <u>Computation of Supportive Resource Requirements</u>

Requirements for Supportive Resources (non-teaching staff, non-teaching space, other resources such as instructional supplies, fringe benefits, etc.) are calculated on the basis of specific planning factors provided by the institution. The planning factors consist of statements of the functional relationships that exist between the supportive resources and the number of students, the number of teaching staff, the square feet of teaching space, or any other variable, computed earlier by the model. For example, on input it might be specified that the library requires a basic complement of 10 staff plus an additional staff member for every three hundred students at the institution. Office space requirements could be calculated on the basis of the number of teaching and non-teaching staff required by the institution. Maintenance costs could be calculated on the basis of the total square feet required by the institution. CAMPUS VI allows the user to specify several thousand functional relationships. At each cost center, there may be anywhere from 15 to 35 different bases on which indirect resources may be calculated.

f). <u>Computation of Program Cost</u>

The program costing model in CAMPUS VI calculates the direct and indirect costs of each course and each program. It also indicates the cost per student, per student contact hour, and per student credit hour in each course and each program. Course costs are aggregated by level and activity type. Program costs are aggregated by program subcategory and program category as well as by program level. Program categories and subcategories typically correspond to HEGIS* discipline divisions and specialties.**

g) <u>Computation of Revenues</u>

CAMPUS VI deals with different types of revenue, such as tuition, state funding, gifts and grants. Revenue calculations are based either on the number of students in varying programs or on an absolute basis.

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* HEGIS: Higher Education General Information Survey.

** (In CAMPUS VIII costs are also allocated to the programs and sub-programs of the Program Classification Structure developed by NCHEMS. Subsequently, support program costs are allocated to primary programs.

3.1.2 CAMPUS VII

CAMPUS VII is a basic version of CAMPUS VI developed by the Canadian Commercial Corporation to run on a small computer. The conceptual difference between CAMPUS VI and CAMPUS VII is that CAMPUS VI is designed to calculate detailed course enrollments, the number of sections in each course on the basis of a section size policy that is specific to that course, resource requirements for each course, and direct and indirect costs of specific courses. CAMPUS VII can deal with only a few types of courses at each department. It has been developed to provide a planning capability to institutions with limited manpower, computer power, or developed information systems.

Like CAMPUS VI, CAMPUS VII is quite flexible. The user is able to describe the structure of his institution in terms of the following:

- faculty rank and support staff types
- classroom laboratory and support facility type
- program names, department names and course types
- revenue and other miscellaneous resource types.

Following is a brief description of the way in which calculations are made in the CAMPUS VII model.

a) Enrollment Forecast

The first part of CAMPUS VII consists of a student flow module that calculates the number of students to be enrolled at each level of each program for each year to be simulated on the basis of initial enrollment, and the percentage of students to be promoted to the subsequent level of the program in the next year to be simulated. In addition, new freshmen enrollments must be supplied for each year to be simulated, as in CAMPUS VI.

b) Computation of Instructional Workloads

In CAMPUS VII the instructional workloads are calculated on the basis of input data regarding the average number of courses taken by each student at each level of each program. The average course load is multiplied by the forecasted enrollment to produce the number of student courses generated by each program for each of the years to be simulated.

The user specifies how the total student course load generated by each level of each program is distributed over the various academic department of the institution. For example, the user may specify that first year history majors take 30 per-cent of their courses from the History department, 10 per cent of their courses from the English department, 10 per cent of their courses from the Sociology department, 15 per cent of their courses from the Philosophy department, etc.

The student course load on each academic department is broken down by course types defined by the user (lecture, laboratory). This is done on the basis of input data supplied regarding the percentage of student courses that are of one type or the other. For each type of course, the user is asked to specify the number of courses of that type that are offered, the average section size, average credits, average hours per week, average student contact hours per week, average faculty per section and average classrooms or laboratories per section. The basic instructional workload, therefore, is calculated in terms of the number of courses offered of each type, average course enrollments, total number of sections, the number of section hours, the number of student contact hours, the number of student credit hours, the number of faculty hours, the number of classroom hours and the number of laboratory hours.

c) <u>Computation of Teaching Staff Requirements</u>

The number of teaching staff requirements may be calculated in one of two ways.

- by dividing the faculty contact hour requirements by a workload policy expressed in hours per week, or

- by dividing the number of students enrolled in courses by a student/staff ratio expressed in persons or contact hours.

Once the total number of faculty is calculated for a department, the number required by rank is determined by applying a percentage distribution of total faculty requirements to each rank. Subsequently, average salaries for each rank are input in order to calculate the total teaching staff salary budget for each academic department.

d) <u>Computation of Teaching Space Requirements</u>

The contact hour requirements for classrooms and laboratory are converted directly to the number of stations and total square feet required by each department by taking into account user-defined information on station occupancy rates, the length of the teaching week, the maximum expected room utilization rate, and the square feet per station, for each type of classroom or laboratory.

e) Computation of Supportive Resource Requirements

In CAMPUS VII, supportive resource requirements are calculated on the basis of the number of students in a particular program, the teaching staff requirements, teaching space requirements, and non-teaching resource requirements. The model accepts functional relationships which are used to calculate requirements for non-teaching staff, non-teaching space and other financial resources which are not calculated on a contact hour basis as described in the above section.

f) Program Costing

Following are some of the costs displayed by the program costing module for each simulation period: total program cost by level, cost per student by level, total direct and indirect cost of the program, the average cost per student in the program, the cost to graduate in a program, classroom and laboratory space required by program, allotted space required by program, average space required per student in each program.

g) Multi-Year Costing of Academic Departments (disciplines)

CAMPUS VII displays organizationally defined future-year costs in any configuration predicated by the user's institution: total costs (faculty salaries, support staff salaries, other costs), number of faculty and support staff needed, square feet of space by type, total cost per student, faculty cost per student, total square feet of space per student, and total cost per student for each of the four years of the curriculum.

h) Multi-Year Costing of Administrative Units

"Administrative units" include overhead departments such as president's office, student affairs, and also all other non-academic functions such as dormitories, recruiting, etc. Costing outputs are less detailed than on academic activities: total costs (salaries and other resources), number of staff, office and support space in square feet, total space, total cost per student.

i) Computation of Revenue in Future Years

Revenues are simulated on three bases: absolute or percentage changes from year to year in any or all of five revenue categories; and as a function of tuition rates and projected enrollment. Grants, endowments, special revenue sources can also be included.

3.1.3 Resource Requirements Prediction Model RRPM

RRPM is the "Resource Requirements Prediction Model" of the National Center for Higher Education Management Systems at the Western Interstate Commission on Higher Education (WICHE)*. The RRPM system is a long-range planning model designed to enable higher level management to determine the resource implications of alternative policy and planning changes. RRPM was developed for large universities as well as small colleges. It is based on the assumption that user institutions would adopt an outlook exemplified by the program classification structure developed by NCHEMS at WICHE, although the user is not constrained to use only the NCHEMS program classification structure. The RRPM system, together with appropriate documentation, is available to any institution at a nominal cost. The assumption is that institutions with medium to large-size computers will take this material and organize both the implementation of the model and the informational taxonomy needed as its operational environment.

Following is a brief description** of the way the RRPM system operates:

a) Enrollment Forecast

The RRPM system does not include a student flow module. However, NCHEMS has developed an independent student flow module that can be used in conjunction with the RRPM system.

b) Computation of Instructional Workloads

The basis of the RRPM model is the "induced course load matrix" (ICLM). The induced course load matrix indicates the number of credit hours or proportion of average load induced by the average student at a certain level within a field of study, upon each course level within a discipline/department. The induced course load matrix may be changed for each of the years to be simulated. The ICLM is normally derived from the institution's student data system. From this information, the total number of student credit hours generated by each student level within each major and every course level in each discipline/department should be divided by the number of students within each major/student level category. If a percentage of average load is chosen then the entry is in proportion.

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* See also: Gulko, W.W., "The Resource Requirements Prediction Model, RRPM-1; An Overview". WICHE, Technical Report 16, Boulder, Colorado, January 1971.

** The system described here is RRPM 1.3. NCHEMS will release a new improved version (RRPM 1.6) in December 1972. The new version provided additional flexibilities and requires less computer storage.

e) Computation of Supportive Resource Requirements

The RRPM system identifies two types of supportive resource requirements: four ranks of non-academic staff and three types of other financial resources (supply, travel and equipment). Supportive Resource requirements can be calculated only on the basis of the costs, FTE faculty, the log of FTE faculty, (Full Time Equivalent) on academic staff, the log of FTE academic staff, student credit hours or the log of the student credit hours. Supportive resource requirement calculations can be differentiated by discipline and programs and subprograms of the program classification structure. The RRPM system also allows the user to calculate office space requirements on the basis of the number of staff, library space on the basis of specific planning factors, and an over-all proportion of "other" space on the basis of the sum of teaching, office and library space.

f) Program Costing

The RRPM system calculates the cost per credit hour differentiated by discipline and course level. Costs are differentiated in terms of direct and allocated costs. It also calculates the cost per student in programs, in terms of direct costs, allocated costs, indirect costs and total costs.

g) Computation of Revenue

The RRPM system, as it stands now, does not allow for revenue calculations.

3.2 Other Systems

3.2.1 HELP/PLANTRAN

HELP/PLANTRAN is a modelling system for educational planning developed by the Economics and Management Science Division of the Midwest Research Institute (MRI).* HELP is an acronym standing for Higher Education Long Range Planning service program; PLANTRAN refers to the planning translation feature which "translates plans into computer operations".

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* See also: Richard Salmon et al, "A Computer Simulation Modelling Tool to Assist Colleges in Long Range Planning", Final Report MRI Project Number 3279-D, July 1969. For a more recent report, see "HELP/PLANTRAN: A Simulation Modelling system for Planning", developed by Economics and Management Science Division, Midwest Research Institute, (1970).

The HELP/PLANTRAN system accepts almost any resource or cost item in the budget and then "simulates" budget calculations, line item by line item, from instructions which direct the model to calculate each and every line item of the budget for each of the years of the planning horizon. The number of line items usually falls between a few dozen and several thousand.

There are two kinds of instructions which can be given to the system in order to manipulate the various budget line items: Instructions for independent variables and instructions for dependent variables. The independent variables are those line items for which the user can directly specify projections or a projection equation. The dependent variables are those line items which are calculated from the interrelationship of two or more previously calculated line items.

There are four methods of calculating dependent variables:

- The most direct method of creating a line is to insert the data for each of the years being studied in the planning exercise;

- The second method is providing on input the current value of the line item and then instructing that this item be modified by a given percentage (positive or negative) in each planning;

- The third method is providing the current value and then instructing that it be modified by a given absolute amount (positive or negative) for each future year; and

- The fourth method is specifying a goal value which is to be held constant once it is attained.

The dependent variable instructions allow the user to specify the interrelationships of two or more lines. The operations which can be performed are:

- One line can be calculated as a linear function of other lines previously calculated (addition, subtraction, multiplication or division);

- A new line can be calculated as the maximum or the minimum of up to four previously calculated lines;

- Line items from different years can be added in order to produce a total;
- A one period shift can be accommodated in which "last year's" value is shifted to "this year"; and
- Finally, there is a procedure by which a previous year's information can be shifted to the next year but with a modification. For example, 100 freshmen in year 1 may turn into 90 sophomores in year 2.

3.2.2 SEARCH*

The System for Exploring Alternative Resource Commitments in Higher Education (SEARCH) has been developed by Peat Marwick Mitchell & Co. The SEARCH System is the most recent version of other computer-based planning systems, developed by the same firm over the past few years. For example, the Remote Access Planning for Institutional Development (RAPID) and the Computer Assisted Planning for Small Colleges (CAP:SC) are all conceptually the same system. The RAPID model was primarily developed for demonstration and seminar purposes. The CAP:SC model was developed to aid in the planning of small colleges, and SEARCH is most suited for use by small private liberal arts colleges.

The basic approach in SEARCH is one of simulating the utilization of each resource category (for example, classrooms, faculty members) in each area of the institution (example, students, physical plant) over each of a specified number of future years. The simulation takes into account initial values for a host of data items which describe the beginning state of the institution in the first year of the planning horizon (state variables), the modifications to these state variables through the application of explicitly stated values for decision possibilities (decision variables) and assumed values for non-controllable environmental chracteristics (environmental variables).

The initial values include enrollment by program and level, number of courses offered by instructional area, student-to-faculty ratio by instructional area, average class size by instructional area, inventories of staff and space, current expenditures in the non-academic areas, current income by category (tuition, endowment, sponsored research, auxiliary enterprises).

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* See also: Casasco, "Systems for Exploring Alternative Resource Commitments in Higher Education (SEARCH)", Peat Marwick Mitchell & Co.

The decision variables (to be supplied for each year) include the amount of salary and benefit increases, change in the number of courses being offered, change in the number of sections by instructional area, the number of lecture halls, classrooms, seminar rooms, offices, dormitory units, library stations, laboratory stations, etc., to be built, the number of library volumes to be purchased, and other similar changes.

The environmental variables include gift income, interest rates, index of construction costs, student and faculty attrition rates, average country-wide faculty salaries by rank.

The model begins with the following information:

- Initial values for each of the state variables;
- Values for the decision variables for each of the years of the planning horizon; and
- Values of the environmental, variables for each of the years of the planning horizon.

Each year new values are calculated based on defined changes from the base year as described by the state and environmental variables.

The model then proceeds to calculate the number of students by program and level enrolled in each year of the planning horizon. Students are promoted, degrees are awarded, freshmen are enrolled, and their attrition rates are calculated by the model. Then the model determines classroom utilization and faculty loads from input data on the number of sections, desired section size, distributions, and average loads. The model has a teaching staff calculation routine which produces the faculty "available" each year from reducing or increasing the existing inventory by use of the appropriate decision variables for change in the number of faculty. Changes in support staff are calculated on the basis of a fixed student to staff and faculty to staff ratio plus a core number of administrative staff. Staff costs are calculated by multiplying the number of staff times an average salary figure, adjusted for cost of living index changes.

A special library routine calculates the number of new books required for the library and computes the operating cost of the library based on the previous year's cost changes, the size of the collection and changes in the cost of living.

A special dormitory routine computes the number of persons housed in dormitories based on an input assumption about the percentage of students who desire dormitory accommodations. Room and board expenditures are calculated on per student cost basis.

The model contains a capital cost section in which construction costs are computed based on a two year building time, and construction cost indices. The amount of space to be built in any year of the planning horizon is not calculated by the model but rather is a user decision variable input.

The SEARCH model replicates the financial statement of a private college, indicating endowment and current fund financial projections expenditure by the plant fund, for instructional programs, etc. Reports are available either for a single year or for all years of the planning horizon. The user can also request the display of any or all of the variable values.

3.2.3 CAMPUS/HEALTH (HSEPS)*

The fundamental purpose of the Health Sciences Education Planning System (HSEPS) is to aid the administrator in his resource planning: to estimate the staff, space, patients and other resources required to support future educational plans and expected enrollments. The system reports on the resource implications of alternative program and enrollment plans, leaving the administrator free to make the necessary judgmental decisions.

An understanding of current operations is a necessary prerequisite to future planning. For this reason, the first part of the planning system is an Educational Activity Analyzer (EAA) which produces reports on current resource usage based on detailed activity files. Among the statistics derived by the EAA are aggregate resource usage functions. These may be input to the Educational Planning Model (EPM), the second part of the planning system, to produce reports on the long-range implications of the current operating policies. Changes to these functions or planning parameters allow the administrator to investigate alternative future plans.

The Educational Activity Analyzer analyzes the educational or activity content of health education programs. It accepts as input an activity file containing detailed information on the enrollments and the resources used in each course and definitional data regarding the institution's organizational structure, program offerings and resource classification.

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* Systems Research Group "Health Sciences Education Planning Systems", Toronto, December 1971.

NOTE: CAMPUS/HEALTH is a special version of CAMPUS VI adapted for Medical Schools.

The EAA simulates the direct activity portion of health sciences education. Enrollments are specified by program and phase (level within a program). Students from each program and phase are enrolled in courses consisting of one or more activities offered by cost centers or departments. A course may be offered to one program or may be shared by more than one program. A course can vary from a formal lecture, to rounds, to individual patient care. Direct resource loads are built up as a function of student enrollments in courses. These resource loads represent the demand which each department must meet.

The data which are input to the EAA are analyzed to show resource usage at each teaching cost center in terms of hours of staff, teaching space and other resources, and numbers of patients seen.

From the detailed resource usage figures generated for the analytical reports, the EAA produces more aggregate planning factors which are used as input data for the Planning Model. These numbers can be easily changed to examine the implications of modifying the current operations.

The resource usage functions (planning parameters) produced by the EAA are used to make requirement projections based on expected enrollments. Policy definitions modify requirements such as 1000 faculty hours into "10 Faculty", and further into "4 Professors, 5 Associate Professors and 1 Assistant Professor". Policies and planning parameters are data which can be easily changed to examine the implications of modifying the current operations at the institution.

The EPM is designed to produce resource usage analyses for up to ten years. Departmental requirements expressed in hours can be examined for a program phase (level), a program or for all programs. Reports showing requirements expressed in numbers of people, dollars and square feet are available for all programs at a department or institution summaries.

3.2.4 The Michigan State Model*

Another system entitled "Systems Model for Management Planning and Resource Allocation in Institutions of Higher Education:, has been developed at the Michigan State University and will be referred to as the MSU model. It includes student flow

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* 6 M. G. Keeney, H. E. Koenig, and R. Zemach, "State - Space Models of Educational Institutions", Division of Engineering Research, Michigan State University, (1968).
Koenig, H., "A Systems Model for Management, Planning, and Resource Allocation in Institutions of Higher Education", Management Information Systems, Their Development and Use in the Administration of Higher Education, WICHE, October, 1969.

projection, and calculations of concomitant faculty, personnel, space, and budgetary requirements.

The MSU Model has five main sectors which transform input resources (manpower and physical facilities) into outputs (developed manpower, research, and public service). These are:

- student section
- academic production section
- non-academic production section
- personnel section
- physical facilities section.

The student section predicts future student enrollment by program and level from present enrollment figures, available assistantships and fellowships, and the incoming student population. It predicts from these student enrollment figures the student credit hours of classroom work and teaching research work that will be "requested" by the students. The student credit hour information comes from definitions of curricula requirements and student electives. It also predicts the number of students leaving the institution by field and level and inputs to them a "cost of development" as determined by the input resources which they utilized.

The academic production section is viewed as producing student credit hours, teaching research, and academic services to the outside community (sponsored research, continuing education, special programs). A relationship between the level of output of each of these items and the cost and number of resources necessary to produce the level of output is generated. The resources include faculty by field and rank, graduate assistants by field and level, educational equipment, and physical facilities.

The non-academic production section is handled by a similar input/output procedure. The outputs include such items as housing, registration, counselling, medical services. The resource definitions depend upon the level of aggregation at which analysis is to be made, but they do fall into the general category of personnel services and physical facilities.

The personnel and physical facilities section indicate the quantity of each supportive resource necessary to produce a given level of output. For example, in order to produce a particular level of faculty teaching effort, the university must utilize not only the labour of academic employees themselves, but also the labour of secretaries and facilities required to maintain the academic staff on the campus. The personnel section indicates the quantity of each of these resources used to produce the given level of faculty teaching effort. In addition, these sections apply average faculty salaries, average unit cost of office space, average unit cost of equipment, and other secondary costs to the levels of production.

The experimental capabilities of the Michigan State Model seem to be rather extensive and indeed the model builders have set up the model in such a way that it can be used to determine the set of "production policies" that result in a total minimum cost of education, although they do recognize the difficulties inherent in determining the objectives of higher education in terms of a mathematical function only.

3.2.5 The TULANE Model*

The TULANE model has been designed specifically to cover a nine-year planning period. Of these nine years, five encompass past data and four cover future years (the planning horizon). Historical data on student enrollment, faculty by rank, pay scale, teaching loads, etc. are used to determine projections for future years.

The model first determines enrollment by program and level for each of the predicted periods covered by the simulation, normally the full four years. This is calculated from historical patterns of enrollment (based on weighted average of past enrollment) or can be directly specified by the user. Once this prediction is made, the enrollment figures are used to determine credit hour demand by department. This is done by multiplying an input specified average student credit load by level times the number of students enrolled at each level.

The total faculty available for each and every year of the planning horizon is an input. The number of faculty required is determined by applying an average rank distribution as reflected in five years of historical data.

After this initial estimate of faculty requirements by rank is obtained, it is applied against faculty teaching workloads by rank (input defined) to determine the total number of instructor hours available. This number is then divided into the total number of student credit hours demanded, as calculated above, to determine the section size predicted by the model. This section size is then compared to an input-specified maximum and minimum allowable standards. If the calculated values do not lie between these constraints, some (unspecified) adjustments are made to faculty requirements to bring the section size in the range desired. The faculty requirements are then totalled by rank, for each of the planning periods (by division and for the total university). Alternatively, if the total number of faculty members in the planning horizon has not been entered by the user, the model will calculate it on the basis of average faculty workloads, given the total student demand.

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* P.A. Firmin and others, "University Cost Structure and Behaviour Cost Simulation Model", Tulane University, New Orleans, Louisiana (1967).

Once total faculty requirements have been determined, the total faculty salary wage bill by division is calculated by applying an input-specified faculty schedule.

Total faculty salaries are then distributed to seven areas according to an input specified distribution pattern calculated from historical data:

- academic instruction
- research supporting
- supporting activities
- community service
- professional activities
- administration
- other.

After the faculty costs have been calculated, the model calculates costs for non-instructional departments, based on simple relationships determined by historical data.

3.2.6 Cost Simulation Model (CSM)*

The Cost Simulation Model was developed by G.B. Weathersly and associates at the Office of Analytical Studies of the University of California. The development of the Cost Simulation Model was part of a larger program of developing a set of facts to be used by the Office of Analytical Studies.

The basic inputs of the model are numbers of students by level and discipline. The outputs are:

(a) personnel required -- academic and non-academic by type.

(b) physical facilities -- square feet by function and associated capital costs.

(c) operating budget in all of the usual categories; i.e., instruction, instructional support (supplies, equipment, support personnel), organized research, organized activities, general administration, libraries, student aid, maintenance and operation of plant, etc.

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*See also: Weathersly, G.B., "The Development and Applications of a University Cost Simulation Model", University of California, Berkely, California, 1967.

Weathersly, G.B., and B.T. Wolfman, S.A. Hoenack, J.E. Keller, "The Use of Models in Planning and Budgeting at the University of California", Office of Analytical Studies, University of California, 1970.

The model operates in one of two modes:

(a) On the basis of empirically determined historic parameter values. These parameter values and the forms of the relationships are derived from a large number of regression analyses which examined all of the reasonable relationships and selected those with the highest correlation coefficients. (It should be noted that the model incorporates a number of non-linear functions).

(b) On the basis of specific changes in any of the input parameters. For example: Mix of students by number, level, and area of concentration; mean class size; faculty contact hours; distribution of rank of instructors for each discipline and level of instruction; credit hours per course; rate of increase in faculty salaries; proportion of support per faculty member; assignable square feet per weekly student hour by level, by discipline, and by form of instruction, and so forth.

A key feature of the model is the induced course load matrix. Given the level and discipline of a student, this matrix enables statistical predictions to be made of the course workload induced by this student in all departments at all levels throughout his college career.

The model is not an optimizing one; nor are there measurements of benefits. Benefit estimation is left in the hands of the professionals -- academicians and academic planners. The model merely tells them the direct and opportunity costs of their preferences. But, even this relatively crude and incomplete analysis helps lead to much improved choices.

The model also makes feasible a detailed program budget. It does so by providing a mechanism for a rapid price-out, up-date, and projection of detailed program element costs throughout a campus as a result of an approved change. In addition, the model greatly speeds up and simplifies preliminary budget making and campus allocations.

3.3 USAF Academy Models

3.3.1 FACSIM at USAFA*

FACSIM is an acronym for the Faculty Simulation Model developed at the U.S. Air Force Academy (USAFA). The FACSIM modelling effort was initiated because of impending budget constraints that are expected to develop in the next few years. FACSIM is, therefore, a special purpose application of a cost simulation model, designed to meet particular management problems of the faculty at the USAFA.

The model analyzes three aspects of resource requirements and allocation within the faculty: manning requirements, operating and maintenance (O&M) budget, and equipment budget.

Cadet course enrollment projections over a ten-semester planning horizon are explicitly required in order to determine the manpower requirement. For the teaching departments, there are special conversion rules to determine the number of faculty required from information on the number of cadets enrolled in the department, the number of sections of various sizes (an authorized section size for each course in an input), the number of courses with a certain credit value, etc. More than one set of conversion rules have been explored. For the non-teaching departments (such as the Library, and the Instructional Technology Department) there is another set of special purpose conversion rules based on the United States Air Force Management Engineering Division Studies. These conversion rules accept measures of the "work" required by the department, and compute the manpower necessary to perform the work.

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* A computer listing of FACSIM was provided by Colonel Roger Bate, Vice Dean of Faculty.

For both types of departments, the manpower requirements are expressed first in terms of the number of men. Thereafter they are converted into dollar requirements by applying an Air Force-wide average salary figure.

The O&M budget items (for example, temporary duty, expendable supplies, periodicals) are based on specific indirect resource relationships. The formulae which are used to compute the O&M budget items are fixed in the model and estimates of the value of the coefficients are supplied in many cases from an analysis of historical data.

The third distinct process in the model involves the equipment area. Equipment is divided into expense items (less than $1,000) and investment items (greater than $1,000). In addition there is the distinction between a non-depot purchase of equipment which comes out of the faculty's funds and a depot purchase which comes from the Air Academy's funds. For ease of exposition, these distinctions are ignored henceforth.

The objective of the equipment routine is to control both the level of the equipment inventory and the procurement of equipment to insure that the equipment inventory will always be sufficiently maintained and up to date.

Each department is given as input an annual procurement limit, an authorized level of inventory, and a specified amount of equipment to be turned in (in other words, removed from the inventory). The first calculation is the amount of equipment to be removed from the existing inventory and replaced, called replacement equipment. The latter is computed as a percentage (input defined) of the current inventory less turn-ins. The first estimate of the amount of equipment that the department will actually be allowed to procure is computed as the product of the inventory authorization limit times an input specified replacement rate. If, after taking into account the amount of equipment turned in and the amount of replacement equipment calculated above, the inventory is greater than the authorization limit, then a penalty is applied which scales the turn-in equipment up and the procurement down by a factor which is in proportion to the ratio of the inventory to the procurement limit. The equipment routine in FACSIM illustrates a method of simulating alternative equipment inventory levels and procurement levels and provides a management tool for equipment control.

The FACSIM covers all resources necessary to sustain the faculty at the United States Air Force Air Academy except space requirements. It is operating at a developmental stage in the Dean of the Faculty's office and is now ready to be implemented at the department level.

3.3.2 The Resource and Cost Model*

A resource and cost modelling system is being developed at Rand under project number 1476, "Analysis of Systems for Air Force Education Training". The goal of this project is to aid the Air Force in managing the technical training program by calculating, under various alternatives, the costs (manpower, supplies) of technical training.

RCM used here will refer to the Resource and Cost Model developed at the Rand Corporation to estimate the resources and costs of an Air Force resident technical training course. The RCM model has been designed to interface with two "feeder" models, the "media model", and the "Airmen's technical training flow model". The "media model" will calculate costs of communication media for any given course. The "Airmen's technical technical training flow model" is being developed to predict the flow of Airmen to training courses based on the number of Airmen by specialty and skill in the Air Force, future Airman requirements, and loss rates, etc.

There are 5 segments to the model:

- course length
- student load
- manpower requirements
- facility additions
- estimated costs

The length of time in days a student spends at the Training Center is determined in segment one. This is the sum of the course length, the time spent waiting to begin the training course for other assignments. The first of these can be computed within the model or specified by the user; the last two must be specified on input. If the course length is to be computed by the model, it is done on the basis of the total number of hours required (the sum of hours of training by type of training) and the number of hours per day during which training can take place.

The next calculation involves the average number of students in the training course. This is done on the basis of input-specified data on elimination rates, advanced proficiency rates, and washback rates. The student load is measured on a daily basis.

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*See also: S.L. Allison, "A Computer Model for Estimating Resources and Costs of an Air Force Resident Technical Training Course", Rand, WN-7044-PR (October 1970).

In the third segment, the manpower requirements associated with the technical training course are computed. Included are instructors and course supervisors, curriculum manpower, training aid maintenance manpower, training aid maintenance manpower, medium manpower, and other forms of indirect manpower. The first step in the calculation involves determining the number of groups on the basis of total class enrollment and a desired class size. (Alternatively the number of entry groups can be specified as input). Once the number of groups has been calculated, the number of instructors, support instructors, and remedial instructurs can be calculated on the basis of fixed formulae depending upon the number of hours of academic training per group, the number of hours of remedial instruction per group, the number of groups, etc. Other support staff are calculated on the basis of specific formulae which in many cases reflect simply a cost allocation of existing overhead items such as curriculum manpower, training aides, maintenance manpower, and administration manpower. In some cases, however, the model distinguishes between the allocation of a fixed amount of overhead and the calculation of an incremental or variable amount (e.g. departmental administration) being based on the number of groups.

The fourth segment is not computational in any way, but rather displays input values representing user-specified amounts of additional facilities required to carry out the resident training.

The fifth segment calculates costs of two types:

- non-recurring costs (one time costs incurred for the procurement of equipment or the construction of facilities); and

- recurring costs (incurred continuously for such items as personnel pay, student travel, instructor training, and operation and maintenance of equipment).

The non-recurring costs are estimated to be the sum of the cost classrooms added plus the cost of laboratories added plus the cost of other facilities added. The amounts of these additions are all input-specified, together with the cost per square foot of construction of each type. Simple arithmetic is necessary to arrive at the total amount of non-recurring costs.

Recurring costs include student temporary duty pay (based on the course length calculated in setment one) plus manpower costs for all the manpower items computed earlier. The cost of instructional media is not considered in the October 1970 version of the model, the a mention is made of the fact that this will be passed over from the "media model".

The RCM model has been designed specifically for estimating the resources and cost necessary to support an Air Force resident technical training course.

4. COMPARISON OF THREE MAJOR EDUCATIONAL MODELLING SYSTEMS

This section is divided into four sub-sections. Sub-section 4.1, 4.2 and 4.3 provide a detailed comparative analysis of the three major educational simulation models under the following general headings: Administrative Criteria, Technical Criteria, and Implementation Criteria. Section 5 provides a brief summary assessment of each of the ten systems considered.

4.1 Administrative Criteria

CAMPUS VI, CAMPUS VII and RRPM are conceptually very similar. However, there are a number of significant differences. Table 1 attempts to summarize the capabilities of the three models.

4.1.1 Enrollment Forecasting

Each of the three models is based upon enrollment. However, the models differ in the way they deal with enrollment projections. RRPM does not have a student flow module incorporated in the system.* Both CAMPUS VI and CAMPUS VII have a student flow module which gives the user assistance in the development of enrollment forecasts. CAMPUS VII enables the user to calculate future enrollments by the application of transition rates to program enrollments by level. CAMPUS VI is a bit more sophisticated than CAMPUS VII in that it allows the user to apply five different types of transition rates: pass, repeat, transfer, dropout and graduate. Through the use of student transition rates and/or direct enrollment it is possible with both CAMPUS VI and CAMPUS VII to represent any probable future enrollment pattern.

4.1.2 Academic Planning and Curriculum Design

The three models differ in the extent to which they can be used in the academic planning process. Conceptually, RRPM and CAMPUS VII are basically the same, and operate at the program level with an induced course load matrix as an input. CAMPUS VI is different in that it allows the institution to define individual courses or activities in instruction, research and public service. This capability in CAMPUS VI makes it a very useful tool at the departmental level for academic planning and curriculum design. High level long-range planning can be done quite adequately with the use of CAMPUS VII or RRPM. However, at some point in time, institutional plans must be translated into specific instructional activities to be undertaken by individual departments. CAMPUS VI is the only model available which allows detailed academic planning at the department/program level.

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*NCHEMS does have a separate program to deal with student flow.

TABLE 1

COMPARISON OF CAMPUS VI, CAMPUS VII, RRPM

Administrative Criteria	VI	VII	RRPM
Enrollment Forecasts			
student flow module	yes	yes	no
Academic Program/Curriculum			
individual course data	yes	no	no
program/discipline data	yes	yes	yes
Facilities Planning			
space contact hours	yes	yes	no
number of stations	yes	yes	yes
number of rooms	yes	no	no
number of square feet	yes	yes	yes
inventory of space	yes	no	no
net future requirements	yes	no	no
Staffing			
staff contact hours	yes	yes	no
number of staff by rank	yes	yes	yes
staff salaries	yes	yes	yes
faculty flow module	yes	no	no
Financial			
operating costs	yes	yes	yes
capital costs	yes	no	no
revenue	yes	yes	no

Since CAMPUS VI deals with individual activities it becomes a useful tool in curriculum design. Curriculum design consists primarily of specifying the activities that are to constitute a program. Each activity needs to be defined in terms of its teaching methodology (lecture, laboratory, seminar, individualized instruction, etc.) and resource requirements (graduate assistant, special laboratories or workshops, etc.). Only CAMPUS VI can contribute to detailed curriculum design or to comparative course costing.

Since both CAMPUS VII and RRPM deal consistently with averages (average section sizes, average contact hour loads), their usefulness at the department/program level is limited. However, this level of aggregation in no way limits the usefulness of these models to higher levels of management.

A unique quality of CAMPUS VI is precisely its capability to serve effectively various managerial levels at an institution. It provides full detail to departmental chairmen and aggregates relevant data for higher levels of management. It is not necessary for university presidents or faculty deans to concern themselves with the full detail available at the departmental level, although from time to time special problems may make this desirable.

4.1.3 Facilities Planning

The models differ significantly in the area of facilities planning. RRPM calculates the square feet required for three types of teaching space and five other space types. CAMPUS VII calculates the number of stations and square feet required for eight teaching space types and ten other space types. CAMPUS VI calculates the contact hour requirements for up to nine sizes of up to 125 different teaching space types; the number of rooms required by size and type; and the square feet required for each type of teaching and non-teaching space (up to 110 non-teaching space types). CAMPUS VI also carries an inventory of available rooms by size and type and total square feet. It is able to show for each year the utilization of teaching space and the net shortage of surplus space. The facilities planning capabilities of CAMPUS VI are not found in any other model.

CAMPUS VII and RRPM are both capable of providing a general indication as to how much space is required by an institution. However, neither of the two models indicate the number of rooms required by size and type. This is unique to CAMPUS VI.

4.1.4 Staffing

The three models differs somewhat in the way they deal with the difficult problem of staffing institutions of higher learning. The RRPM system applies a faculty distribution policy differentiated by discipline, course level and instruction type to the student contact hours generated within each one of those categories. It then applies workload policies in terms of hours for faculty, differentiated by discipline course leve and instruction type, to calculate the number of FTE's required in each discipline/department. CAMPUS VII provides the user with the option of using either faculty workload policies or more traditional student-staff ratios for the calculation of FTE faculty requirements. CAMPUS VI also allows the user to apply either faculty workload policies or student-staff ratios to calculate FTE's. One important difference between CAMPUS VI and CAMPUS VII and RRPM is that CAMPUS VI has a faculty flow model which applies annual promotion rates and termination rates to annually updated inventories of faculty members. It is, therefore, able to show for each year of the planning period how many additional staff members are required to meet either the instructional or non-instructional load; i.e., research, public service, administration, counselling, etc.

4.1.5 Financial Planning and Budgeting

Financial Planning and Budgeting is a very important function within each institution. Unless funds are available to support academic and non-academic programs, no amount of planning is going to help. The three models differ in the way they can assist the financial planner. As in the other areas CAMPUS VI has the most extensive capabilities. Not only does CAMPUS VI cost out resource requirements of courses, degree programs and departments, but it also aggregates costs by budget function and object of expenditure. CAMPUS VII and RRPM show cost by program as well as academic and support departments. RRPM also aggregates cost by primary and support programs and subprograms. Neither CAMPUS VII nor RRPM aggregates cost by budget function or object of expenditure. CAMPUS VI also has the capability to aggregate costs in other ways:

- by cost center category;
- by degree program category (i.e. discipline division);
- by degree program subcategory (i.e. discipline specialty); and

CAMPUS VI and VII also have revenue modules. In addition to tuition fees, the CAMPUS models can deal with gifts, grants, formula income from state agencies, endowment income. SRG's experience has been that a certain amount of "customization" of the basic revenue model is invariably required for each institution. Each type of user institution tends to have unique requirements for revenue analysis and simulation of future revenue patterns. A number of state systems have very specific formula which govern the distribution of operating and/or capital grants. In these cases, SRG has customized the revenue modules for client institutions.

While CAMPUS VII and RRPM are primarily long-range planning models, CAMPUS VI is able to provide significant assistance not only in the development of multi-year plans but also in the translation of these multi-year plans into annual budgets. CAMPUS VI has the capability of reproducing the traditional line-item budget used in most institutions today (as well as program budgets). While program budgets are the most useful in the analysis of academic program decisions, line-item budgets are necessary for financial control.

4.2 Technical Criteria

4.2.1 Systems Dimensions

The parameters or dimensions of a simulation model indicate the level of detail of input and output handled by the system. In the preceding chapters many references were made to the level of detail that could be handled by each of the three models. Table 2 provides a comparison of some key dimensions of the three models.

Technically knowledgeable people realize that the parameters of any system can be changed within certain constraints imposed by either the logic of the model or the type, core size and peripherals of the computer. RRPM and CAMPUS VII are designed to be aggregate models of educational institutions and CAMPUS VI is designed to be both. CAMPUS VII has been designed to run on a very small computer such as an IBM 1130-16K. Obviously, if the system were implemented on a larger computer such as an IBM 360-50 or so, its parameters could be increased significantly.

TABLE 2

COMPARISON OF TYPICAL SYSTEM DIMENSIONS

RRPM 1.3	CAMPUS VII	CAMPUS VI
(IBM 360/50 Version)	(IBM 1130 Version)	(CDC 6400 or IBM 360/67 versions)
(no information about individual courses)	(no information about individual courses)	4000 courses or instructional activities
5 faculty ranks	5 faculty ranks	10 faculty ranks
4 non-academic ranks	7 non-academic ranks	150 non-academic ranks
3 other resource types	7 other resource types	120 other resource types
90 academic depts/disciplines	20 academic depts. 10 non-academic depts.	75 academic depts. 25 non-academic depts.
90 programs	20 programs	350 programs
4 instruction types	3 instruction types	9 instruction types
3 teaching space types	8 teaching space types	125 teaching space types
17 other space types	10 other space types	110 other space types
7 student levels	4 student levels	8 student levels

4.2.2 Adaptability

The ability of an institution to use its own terminology and classification schemes (for example, program classification schemes, organizational structure, resource classifications and budget), is important in making a model relevant to a particular institution. By allowing the institution to define its own structure and terminology through the input, a model can be made to reflect more accurately the situation at that institution. Table 3 provides a listing of the terminology that can be defined through the input of each of the simulation models.

It should be noted that RRPM 1.3 is limited in its adaptability to the terminology of a specific institution. The CAMPUS models on the other hand have been designed to provide flexibility in this area. CAMPUS VI has been designed with a greater flexibility than CAMPUS VII.

4.2.3 Reporting Capabilities of the Models

A thorough understanding of the reporting capabilities of each of the three systems is important in an assessment of which model most accurately reflects the needs of a particular institution.

4.2.3.1 RRPM Reports

The RRPM system produces a total of nine reports, five reports for instruction and four reports for non-instructional areas. Following is a brief description of each of the reports. The first five are instruction reports and the last four are other reports:

1. Personnel by FTE and salary costs for each of five faculty ranks and four non-academic ranks, including supply, travel and equipment expense.

2. Student load by four course levels and four types of instruction.

3. Faculty load by four course levels and four types of instruction.

4. Space requirements for five types of instruction facilities including office space.

5. Cost per credit hour by course level and cost per student by level of student.

TABLE 3

ADAPTABILITY OF THE MODELS TO SPECIFIC INSTITUTIONS AND THEIR TERMINOLOGY

RRPM	CAMPUS VII	CAMPUS VI
Terminology that can be defined through the input: discipline names course levels	Terminology that can be defined through the input: Institution name and location Classroom types Laboratory types Support facility types Faculty ranks Support staff types Other resource types Programs Department names Course types Support departments Revenue types	Terminology that can be defined through the input Institution name and location Teaching space categories and subcategories Support facility categories and subcategories Faculty ranks Support staff categories and subcategories Cost centers Cost center categories Programs, subprograms, program categories and degree programs Course names Course types Course locations Course disciplines Teaching duties Non-teaching duties Student categories Budget Functions Object of expenditure categories Revenue types

NOTE: All other terminology is either defined by the system or only code numbers are used.

In RRPM 1.3 most report headings were predefined through the program. In RRPM 1.6 the user has full flexibility in defining terminology through input data.

6. Total construction cost required by space type.

7. Total enrollment aggregated to four student levels.

8. FTE and cost for academic and non-academic personnel including supply, equipment and travel expenses.

9. Space requirements for seventeen types of non-instructional facilities plus office space.

These reports are produced for each program and subprogram of the Program Classification Structure. Some of these reports can be aggregated by discipline, department, division, school, college, and campus.

4.2.3.2. CAMPUS VII Reports

The CAMPUS VII system produces thirteen reports.

1. Average course loads per student and student course loads, by program and level.

2. Program loading on disciplines in terms of student courses by level.

3. For each discipline/department, the number of courses offered, the average course enrollment, the number of sections and average section size, section credit hours, section hours, student contact hours, faculty contact hours, classroom contact hours and laboratory contact hours.

4. Teaching staff requirements by discipline, by faculty type; total salary and office space requirements of teaching staff.

5. Teaching space requirements in terms of classrooms and laboratories, by type, the number of stations, and the square feet required for each discipline.

6. Supportive resource requirements in terms of staff, space and other resources, by discipline, in terms of units and dollars.

7. The supportive resource requirements of administrative programs in terms of staff, space and other resources in terms of units and dollars.

8. Enrollment and resource requirements for each program in terms of total costs and cost per student, direct and allocated cost, cost to graduate and space requirements per student in each program.

9. The summary of resource requirements in terms of staff space and other resources as well as revenue for each discipline. Also included in this report are the total costs by level of student, total cost per student, faculty cost per student, total space per student, teaching space per student and student/faculty ratio.

10. Resource requirements of individual administrative programs in terms of staff space and other resources, revenue expected, and total cost per student.

11. Summary of all resource requirements for all disciplines in terms of operating costs for salaries and other financial resources, revenue expected, faculty and support staff requirements, space requirements, total cost per student, faculty cost per student, total space per student, teaching space per student and student faculty ratio as well as total cost per level student for the whole institution.

12. The summary of all resource requirements of all administrative programs.

13. A summary of total resource requirements of the institution. In terms of staff, space and other financial resources, Included in this report is information regarding enrollment in

terms of FTE's and student courses, total credit hours generated, faculty credit hours, cost per student, space per student, student/staff ratio, cost per student contact hour and ratio of student contact hours over faculty contact hours.

4.2.3.3 CAMPUS VI Reports

CAMPUS VI has a comprehensive set of reports consisting of six input data reports and 30 output reports. Following is a brief description of the six input data reports:

1. A description of the courses offered by each department of the institution.

2. Description of the programs in terms of the activities that make up each of the programs.

3. A description of the electives from which students may choose optional courses.

4. Initial enrollment information.

5. A complete description of a six-level hierarchical cost center structure to represent the organizational make-up of the institution.

6. An inventory of teaching space in terms of number of rooms by size and type and non-teaching space in square feet.

Following is a brief description of the output reports available from CAMPUS VI:

1. Enrollment data by program and level for each of the years to be simulated.

2. A listing of courses, enrollment in courses, the number of sections in each course, section hours, and student contact hours for each department for each year simulated.

4. A summary of the induced-course-load matrix at the program/department level of the institution. (This is an output from CAMPUS VI and an input to CAMPUS VII and RRPM).

5. A summary of course contact hours by discipline, instruction type, course level, and location.

6. A summary at each cost center of the teaching-space contact hours required, differentiated by size and type of room.

7. A summary at each cost center of the contact hours required for teaching staff differentiated by instruction type and level.

8. A summary of the weekly fluctuations of instructional workloads at each of the cost centers within the institution.

9. Enrollment at each level at each program for each period simulated.

10. A summary of section hours, student contact hours and staff contact hours generated at each cost center of the institution.

11. Information on teaching staff requirements by rank at each cost center.

12. Information on teaching space requirements by size and type at each teaching space control center.

13. Detailed information on the supportive resource requirements at each cost center.

14. A summary of operating costs at each cost center.

15. A summary of total operating costs by term for the institution.

16. Information on the direct and indirect cost of each individual course for each of the simulation periods.

17. A breakdown of the direct and indirect costs of degree programs.

18. A summary of the cost of individual programs in terms of total cost and cost per student contact hours for each term.

19. Cost by student category in each program.

20. A multi-year summary of operating costs at each cost center.

21. A multi-year summary of teaching and non-teaching space requirements at each space control center.

22. A multi-year summary of total teaching and non-teaching space requirements at the institution.

23. A multi-year summary of program enrollment information.

24. A multi-year summary of program costs.

25. A budgetary report showing budgetary costs by budget function and object of expenditure category.

26. A multi-year summary of operating costs by budget function and object of expenditures.

27. The fiscal year equivalent of report in 25.

28. A fiscal year equivalent of report 20.

29. A summary of operating costs by cost center category.

In addition to the above-named 35 reports, one additional multi-year report contains 20 administrative indices regarding space requirements, 25 administrative indices regarding operating costs, and 10 administrative indices for each program category. The administrative indices report is designed to give senior administrators a one page summary of the implications of any simulation.

4.2.4 Operating Mode

CAMPUS VI, CAMPUS VII and RRPM can be operated either in time-shared or batch mode. This means that the three models can be installed on computers which ~~have~~ an interactive capability as well as on machines which do not.

Only CAMPUS VI and CAMPUS VII have computer-assisted instruction packages (CAI) available which guide the user in the specification of alternative enrollment levels and alternative academic and administrative policies. RRPM does not have such an automated experimental procedure, although such a capability is reported to be under development.

Of the three models, only CAMPUS VII can be run on a small computer. CAMPUS VI and RRPM can be installed on either a medium or large computer. The minimum computer storage requirements of any modelling system depends on the size and complexity of the institution to be modelled. If the parameters listed on Table 2 are used, the core requirements are as follows:

CAMPUS VII	16K (IBM-1130)
CAMPUS VI	256K (IBM-360/50)
RRPM 1.3*	240K (IBM-360/50)

4.3 Implementation Criteria

4.3.1 Extent of Use

CAMPUS VI has been or is being implemented in five universities, 29 colleges and two school boards, and two state level co-ordinating agencies. CAMPUS VII, a fairly recent product, is being implemented only at three colleges. RRPM has been implemented in a significant number of universities and colleges**. The implementation of these models in many institutions indicates that simulation models represent a viable planning methodology in educational institutions.

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* RRPM 1.6 only requires 50K.

** The precise number of institutions that have implemented RRPM is not known to the authors.

4.3.2 Cost and Time for Implementation

The cost to purchase the CAMPUS VI software is $25,000 or a leasing arrangement of $6,000 down plus $700 per month for three years. This includes the right to use the software and technical training to assist the institution to make the model operational on a particular hardware configuration. In addition to providing the basic software, the Systems Research Group provides consulting services for the education of senior administrative staff, overall management of the implementation project and the adaptation of CAMPUS Planning and Budgeting Manuals and CAMPUS Facilities Planning Manuals.

The CAMPUS VII system may be purchased for $12,500 or leased for a down payment of $3,000 plus $350 per month for three years. At the end of three years the system would become the property of the institution. The purchase price for CAMPUS VII includes:

- A seminar on planning with CAMPUS VII
- A workshop on data structure and model operations
- Guidance in data collection and coding
- Individual training sessions with Senior Administrators and College
- Assistance in running the first planning exercises
- System installation and technical documentation.

Because of the relative simplicity of the CAMPUS VII system as compared with CAMPUS VI system, it is expected that an institution would not require significant amounts of additional consulting services.

RRPM may be obtained for a cost of $50. This includes the program and appropriate documentation. Unlike the Systems Research Group, NCHEMS is not prepared to take responsibility for the actual implementation of RRPM. The implementation is fully the responsibility of the institution. The Systems Research Group, on the other hand, assumes complete responsibility for the initial technical implementation as well as the training of the technical and an administrative staff in the operation and use of the model.

The cost of the initial implementation of CAMPUS is included in the basic purchase price.

In order to calculate the cost of implementing a simulation model, an institution should ask itself a number of questions:

1. Who will take an overall responsibility for planning?

2. What computer will we use? Is it big enough?

3. Do we have adequate technical staff for the initial implementation, for ongoing operation and maintenance?

4. Are our current information systems adequate? Who will be responsible for data collection?

5. What is the cost of acquiring the software?

6. To what extent can the organization provide technical support? at what cost?

7. Will the existing management of the institution use the model?

The total cost and time to implement a model will vary according to the answers provided to each of the questions above.

5. SUMMARY EVALUATION OF THE TEN MODELLING SYSTEMS

5.1 Introduction

Since every educational institution is in some respect unique, models should be selected (if they are to be used at all) to meet the user's own perception of his needs. This means that the available simulation models are to be compared and selected on the basis of how they dovetail with the modus operandi of the user. Data collection and pre-processing of inputs may be fairly easy in small, reasonably well organized institutions where one or two key people literally know all about the school. Such institutions will, therefore, be inclined to use the simpler models such as CAMPUS VII and RRPM. Experienced planners, on the other hand, may prefer the depth to be achieved in planning and budgeting with CAMPUS VI.

5.2 CAMPUS VI

CAMPUS VI is the most detailed and comprehensive system presently available. It has the most extensive capabilities and it is very flexible in terms of the structural definitions by which a user is able to describe his institution.

CAMPUS VI is the only system that allows the user to define the academic program of the institution, either in a disaggregate mode down to the individual course level or in a more aggregate mode at the discipline level. CAMPUS VI has the widest spectrum of reports, in terms of both number and content.

CAMPUS VI provides the user with the capability of analyzing all aspects of an educational institution including its structure and all of its resources. It produces operating budgets, capital budgets and revenue projections. Projections of resource requirements can be made either on a net or a gross basis, depending upon whether the user chooses to input an existing inventory of the staff and space. If he does, the gross requirements will be calculated and the inventory subtracted to produce net requirement figures. CAMPUS VI has extensive experimentation procedures which include the option of a computer assisted instruction package.

CAMPUS VI is widely used by a number of institutions of various sizes and types. In addition to simulating individual institutions, it is also capable of simulating system of colleges and school boards.

5.3 CAMPUS VII

CAMPUS VII is conceptually very similar to CAMPUS VI except that it has been designed to be used by small institutions and to be run on a small computer. CAMPUS VII cannot go to the level of detail of CAMPUS VI. It does not provide a capability of specifying individual courses or activities.

CAMPUS VII provides only gross projections of resource requirements. The system produces 13 reports which provide a comprehensive picture of the resource requirements of an institution.

CAMPUS VII covers all aspects of an institution. Experimentation can be accomplished by a non-technical user through a computer-assisted instruction package.

5.4 RRPM

RRPM is an aggregate comprehensive cost modelling system. RRPM does not have a student flow component. It is not able to go down to the level of individual courses. The experimental capabilities of RRPM are automated to the point where they are able to accept simultaneously several experimental cases and report the impact all on one page. In fact, this multi-case capability is more or less unique to RRPM (a similar capability can be programmed into the HELP/PLANTRAN system). The reporting capabilities of RRPM are comprehensive, with control both on the input and the output side of the model.

RRPM covers extensively all subjects of analysis in the resource and financial area. However, inventories of staff and space are not included and as a result only gross predictions are provided.

The National Center for Higher Education Management Systems at WICHE has recently published extensive information on the operations of the RRPM model in eight pilot institutions. It should be noted that the present version will not run on a small computer.

5.5 HELP/PLANTRAN

HELP/PLANTRAN is basically a computer language which allows the user to develop a relatively unsophisticated cost model which concentrates on producing resource and cost predictions on a line-item-by-line-item basis. The HELP/PLANTRAN system allows the user to develop a model that is comprehensive in the sense that it can be programmed to accept almost any resource or cost item in the budget. It is impractical to attempt a detailed analysis of the demand for educational resources in terms of courses being offered by the institution with the HELP/PLANTRAN system. There is no automatic program costing capability in the HELP/PLANTRAN system. Again, this type of capability would have to be programmed by the user using the high-level language of the system.

In summary, the HELP/PLANTRAN system is not an educational simulation model but an English-language-type programming language that allows the user to develop models of any situation in which resource consumption may be related to patterns of demand. In other words, the system can be used to develop aggregate models for educational institutions as well as many industrial situations. Although the program to date has been used primarily by educational institutions, it is not an educational simulation model per se.

5.6 SEARCH

SEARCH contains a student-flow component producing enrollment data for resource and cost calculations. The calculations are based on status, environmental and decision variables (with the user supplying the values for each). Values are required on input for decision variables that other models can provide as output: for example, the number of staff to be hired, or the number of square feet to be built. The explicit recognition and grouping of non-controllable variables under the heading "environmental" is a useful technique.

Detailed information at the course level is not used since the variables are fixed at an aggregate level. The SEARCH system basically operates on combinations of specified future planning information. The system is capable of analyzing almost any subject from the structure to the resources as well as the financial aspects of an institution provided the information can be couched in the SEARCH terminology of state, environmental and decision variables. The model is fixed in so far as computations of various resources are directly linked to specific variables. In most of the other models, these relationships can be built up through the input. The SEARCH model also has fixed terminology.

5.7 CAMPUS/HEALTH

The basic objective of CAMPUS/HEALTH, the health sciences educational planning system developed by the Systems Research Group is to provide university medical schools with a planning and analytical capability. This system is unique because it consists of two separate but related systems: the educational activity analyzer and the educational planning model. The educational activity analyzer is basically an information system regarding the academic program, enrollments and associated resource requirements of the university medical school. In addition to the analytical reports produced by the educational activity analyzer, planning parameter reports are produced which provide the input to the educational planning model.

CAMPUS/HEALTH is a comprehensive planning system. In addition to the more traditional resource requirements such as academic staff and teaching space, the system deals with the number and type of patients and associated medical facilities required for various phases of the academic program. The system has a complete range of reports for management and planning purposes.

Currently, the system is operational only at the Duke University Medical Center. But is has reached the state of development where applications of the same type of planning system in other institutions is feasible and economic.

5.8 MSU

The university-based cost modelling routines of the MSU model at Michigan State University are the most comprehensive, covering all resource requirements. The model relies heavily on input-output coefficients to describe its different sectors (student, academic, non-academic, etc.). The model includes a student flow component and a component which calculates resource and cost requirements.

The ability to analyze the structural aspects of the institution is limited since the model does not deal effectively with organizational units such as departments. However, all other resource and financial subjects are capable of being analyzed, but only in terms of their operating cost. Only gross projections are provided.

Since the MSU model has remained at Michigan State University, except for one outside user on a test basis, it is premature to make any assessment about its possible implementation elsewhere.

5.9 TULANE

The TULANE model does not appear to be general enough to be used by more than one institution, and is not comprehensive as it ignores the space resource. The original work at Tulane University is now part of the modelling effort RELCV and no current information is available on the operational status of the system.

The basic components of the TULANE system are a student-flow module that feeds a faculty resource conversion routine. Thereafter, other costs are based on fixed ratios of faculty costs. The academic program is described in terms of average course loads per student. Explicit analysis of the structural components such as programs, disciplines or courses is not evident since all of these must remain fixed. Staff and other resource costs can be analyzed but the physical facilities aspect is notably absent. Consequently only operating costs are produced and on a gross projection basis.

The TULANE model has not been implemented at any other institution to our knowledge and, therefore, information on cost and time to implement this system is not available.

5.10 Cost Simulation Model

The cost simulation model was the immediate fore-runner of RRPM. NCHEMS patterned its model after the Cost Simulation Model developed and used at the University of California.

CSM was used effectively in a number of institutions for example: an analysis of the minimum course size rule; an analysis of summer quarter operations; and an analysis of unit costs of educational programs.

CSM was specifically developed for the University of California. No attempt was made to develop a version that could be implemented by other institutions. The people involved with CSM instead contributed significantly to the development of RRPM.

5.11 FACSIM

The FACSIM model is under development for use only at the United States Air Force Academy. At this stage in its development it is not considered generalized enough to be applicable enough to other institutions, nor is it comprehensive since the physical facilities are not considered. The FACSIM model is a specialized model with Academy-specific information built into the system. The analysis of the individual activities or courses and the calculation of the resources and costs associated with these courses is the heart of the model. The reporting capability is concise, with a small menu of fixed-format input as well as output reports covering the five-year planning horizon.

Programs are not identified. Consequently, structural subjects of analysis include only the departments and courses. In the resource area both teaching and non-teaching personnel are covered exhaustively. However, as previously mentioned, the space requirements are ignored. By far the most elaborate and sophisticated technique is used for the equipment resource. Other resource costs in the budget are functionally related to indogenous and exogenous variables. The operating budget and equipment capital budget for the faculty can be produced. Revenue generation is not part of the system.

Inventories of staff are provided as initial conditions but only gross staff requirements are projected. Since this is a specific modelling effort at the United States Air Force Academy, it is impossible to say what the cost and time required would be for implementation.

5.12 <u>RCM</u>

The Rand Corporation has made two computer modelling efforts to estimate resource requirements for the USAF Academy, one for pilot training and the other for the resident technical training course. The most recent modelling effort is the latter, to which this assessment is directed.

The RAND model is a very specialized development for one type of educational process. It is not considered generalized enough to handle any other similar institution nor is it operational in another institution. The model is comprehensive. It includes student flow, activity or course analysis, resource and cost calculations, and program costing. Program costing is included only because course and program are synonymous in the RAND model.

With regard to reporting, input is not displayed and there is a small set of output reports. All subjects of analysis in the resource and financial area are considered except revenue. Only gross, resource and cost estimates are projected.

The model was developed to assist one technical program within the Air Force, hence, information on other possible implementations is not available.

OVERVIEW OF MODEL DESIGNS

The Canadian Commercial Corporation has been under contract to the Human Resources Laboratory to design a cost/effectiveness model customized to the needs of the United States Air Force Academy (USAFA) and the United States Air Force Reserve Officers Training Corps (ROTC). Interviews were held with numerous officers and civilians at the Academy and at the Air University in order to identify the management problems being faced by administrators, identify sources of data, understand existing planning and modelling capabilities, and in general to prepare a "Situation Analysis" from which a customized model could be designed.

1. THE SITUATION HAS BEEN ANALYZED

Interviews were conducted at the United States Air Force Academy (USAFA) and at the Air University, ROTC branch, during 1971 and 1972 in order to identify the management problems being faced by Academy and ROTC administrators, to secure relevant documents, to identify existing management information systems and in general to understand the inner workings of the two institutions. Interviews were conducted in each of the major subdivisions:

at the Academy

- Dean of Faculty
- Chief of Staff
- Commandant of Cadets
- Department of Athletics

Appendix 1 lists the military and civilian personnel who were interviewed at the academy.

at ROTC

- Vice Commandant
- AFROTC (Senior)
- AFJROTC (Junior)
- Director of Education
- Director of Operations
- Director of Financial Management
- Director of Administration
- Director of Information.

Appendix 2 lists the military and civilian personnel who were interviewed at the Air University.

Considerable written materials were received from the Academy and Air University including Faculty Operating Instructions, Management Engineering Division Studies, Organization Manuals, the Academy's Curriculum Handbook and Catalogue, and a proposed Academy model design by Colonel R. Thomas entitled "Partial Cost/Allocation Model for the Faculty", Headquarters Operating Instructions, AFROTC Education Program Descriptions, Organization Manuals, ROTC Cost and Enrollment Reports, Air University Catalogue. Appendix 3 lists all documents received from the Academy. Appendix 4 lists all documents received from the Air University.

It is clear that the present capabilities of USAFA and ROTC are well advanced, especially in comparison to civilian institutions. Both institutions maintain extensive management information systems on their operations (cadets, staff, other resources).

The Academy's management structure is well defined, with the Curriculum and Equipment Review Committees at the Dean of Faculty level, and the Budget and Real Property Review Committees at the Academy level.

The Academy's planning capabilities are far advanced, as evidenced by both manual and computerized systems. A computer model, entitled "FACSIM" for Faculty Simulation Model, has been developed by the Vice Dean, Colonel Bate, based in part on the conceptual model developed by Colonel Thomas.

Following is a list of existing information systems at the Academy:

1. CADETAIDS (Cadet Administrative Information Data System)
2. Staff Unit Detail Listing
3. Space Civil Engineering System
4. Equipment Custodial Authorization Receipt List

Senior administrators and the Management Engineering Division at the Air University have gone to considerable lengths in establishing administrative policies and planning factors for ROTC.

2. SOME MANAGEMENT PROBLEMS HAVE BEEN IDENTIFIED

2.1 At USAFA

A number of management problems being faced currently by the Academy's administrators were identified as a result of our interviews:

2.1.1 Resource Allocations to the Major Subdivisions

The allocation of men, dollars and space among the major organizational units (Faculty, Commandant of Cadets, Physical Education, Chief of Staff) must be made in order to provide the resources necessary to support the programs being run by the Academy. This is accomplished by specified procedures under the direction of the Superintendent by the Budget Review Committee. The ultimate goal of the committee is the production of a comprehensive five year master plan for the Academy. It was agreed that alternatives should be explored and priced out before compiling a final master plan for submission to the Department of Defense. At present the procedures (essentially manual) for pricing out the alternatives are too cumbersome and hence are not used.

A number of officers pointed out the importance of long range planning and the exploration of alternatives. The general consensus is that the Academy's budget will be much more severely constrained in future years. The most severe constraint will be felt in the area of O&M (Operations and Maintenance) monies. The latter includes civilian pay and it is expected that the O&M budget itself will not increase as fast as civilian pay. Hence, the non-civilian items included in O&M will be heavily squeezed if the existing civilian work force is to be maintained.

There is not the same consensus on what the future will bring with regard to the Academy's allotment of officers; however, all agreed on the importance of exploring alternatives in non-civilian manning as well.

2.1.2 Resource Allocations within Organizational Units

Within each of the Organizational Units men, dollars, and space must be allocated to the various departments in order to support their programs. The manpower allocation is handled to some extent by the Department of Manpower and Organization which is responsible for, among other things, the establishment of manpower requirements and manning standards. At the moment, there do not seem to be any similar rules for the allocation of non-manpower items, except for those developed by Colonel Bate and Colonel Thomas for the Faculty.

Except for the FACSIM model, the allocation procedures are manual, making it difficult and cumbersome to test out alternative allocation rules.

2.1.3 Prediction of Enrollments

Cadet enrollment must be projected by program and course, for a number of years into the future in order to provide background information necessary for determining resource requirements. This task is not an easy one for a number of reasons:

- There is a wide range of electives from which cadets can choose.
- Cadets are allowed complete freedom in changing majors and choosing courses.
- The curriculum varies over time, with new courses being added and others being deleted.
- Enrollment projections are usually based on "first day attendance" at the Academy; however, there is considerable attrition over the academic year.
- Total academic course enrollment projections compiled by the Counselling and Scheduling Department from submissions by each of the individual departments do not coincide with expected total course enrollments computed by multiplying actual numbers of cadets enrolled by class, times actual average course loads per cadet.

2.1.4 Resource Implications of Alternative Teaching Methods

A number of officers within the Faculty were desirous of a tool which could explore the resource implications of alternative teaching methods such as team teaching, computer assisted instruction, educational television, self-paced learning, etc. Informal guesswork might be used to assess the implications of these changes; more exact methods were seen as desirable.

2.1.5 Resource Implications of Alternative Program Designs

These same officers were desirous of a tool which could explore the implications of altering academic program design specifications such as changing the graduation policy, changing average course loads, introducing graduate programs in co-operation with other governmental agencies, etc.

2.1.6 Control of Staff Resource

Except for the FACSIM computer model, the Academy has no efficient method for exploring the effects of alternative policies regarding the staff resource such as alternative manning formula, or the merging of two departments.

2.1.7 Control of Space Resource

Although space inventory systems exist, there is no present capability for the Academy to measure the existing utilization of teaching and/or non-teaching space, nor is there the capability to test out the effect of changing space policies such as authorized section sizes on academic space requirements, by size of room.

2.1.8 Control of Equipment Resource

The FACSIM Computer Model is the first step towards controlling a major item of expenditure of the Academy's funds within the academic areas, namely equipment. The objective is to control the equipment procurement and inventory levels, and to control the multiplier effect of adding new equipment on additional resources requirements. Balancing the downward pressure on equipment procurements is the desire to avoid technological obsolescence.

2.1.9 The Imposition of Department of Defense Constraints

Most officers with whom we spoke indicated that they expected budgetary constraints to be imposed by the Department of Defense. For this reason, the Academy must continually be exploring alternative ways of achieving their program objectives.

Currently, the Department of Defense does not permit substitution of O&M dollars for military pay. It is stated that this is an operative constraint on the operations of the Academy; at the moment there is no tool for calculating the opportunity costs (savings foregone) resulting from the imposition of this ruling.

2.1.10 Measurement of Output

It was agreed that the Academy, in the ideal situation would be able to define its desired output - the desired qualities of an officer. Those qualities having been defined, a method for measuring them could be developed. More than that, a relationship could be struck between the output produced by the Academy and the Academy's educational process so that the latter could be fine tuned in order to produce the desired output.

The problem of output measurement is a difficult one, not yet surmounted by the current state-of-the-art. At the Academy the problem is exacerbated by:

- An inability to define exactly the desired output at the Academy or the desired qualities for Air Force Officers.
- The present Officers Effectiveness Report is non-discriminatory and therefore it cannot be used to measure output.
- The Academy has only 12 years of history, an insufficient period of time from which to draw any conclusions.

2.2 <u>At ROTC</u>

A number of management problems being faced by ROTC administrators have been identified.

2.2.1 <u>Resource Allocation</u>

The allocation of men and dollars to detachments must be made in order to provide the resources necessary to support the Junior and Senior ROTC programs. Manning is determined by specified regulations. Other resources are calculated according to other <u>ad hoc</u> rules.

One of the ultimate goals of ROTC is to have more detachments equitably distributed over the United States. Achieving this goal requires a comprehensive multi-year planning exercise, exploring various alternatives, and compiling a master plan for future actions. The alternatives might include various resource allocation rules that not only take into account the allocation of men to various detachments but also other exogenous variables such as the distance of detachments from supply bases or the number of site visits per year. At present, multi-year planning procedures are essentially manual with little opportunity for the exploration of alternatives.

The individual detachments are also faced with resource allocation alternatives. The use of host institution staff, for instance, was suggested as an alternative. In fact, other host institution resources could be brought into the ROTC curriculum, for example equipment, computers, etc.

2.2.2 <u>Prediction of Enrollments and Quotas</u>

Enrollment must be projected for each year of the junior and senior ROTC program for a number of years into the future in order to provide not only information necessary to determine resource requirements but also data necessary to meet graduation quotas for rated and non-rated officers. This task is not an easy one for a number of reasons:

- The assignment of quotas to individual detachments is constrained by geography, by political considerations, by the existence of compulsory institutions, etc.
- The characteristics of cadets, and the selection criteria for ROTC programs, seem to vary across individual detachments.
- Retention and persistence rates are available by detachment, but are not analyzed for protecting enrollments.
- The curriculum can vary over time, with ROTC and host institution courses being added or deleted.

2.2.3 Resource Implications of Alternative Recruitment Programs

Various programs are being considered to enhance the recruitment and retention of cadets in ROTC programs. A vehicle is needed to explore the resource implications of, for example, increased subsistance pay, more scholarships, increased number of liaison officers or cadet recruiters, etc. The effectiveness of each of the alternative programs in terms of recruitment and retention obviously requires exploration as well.

2.2.4 The Implications of the Reorganizing Detachments

Measuring the savings that could be realized by disestablishing certain detachments which presently have low enrollment, or measuring the shadow costs (savings foregone) if the disestablishments are not allowed is presently a manual exercise. Similarly the implications of creating new detachments in order to meet increased production quotas is a manual procedure with limited flexibility for the exploration of alternative policies.

2.2.5 The Imposition of the Department of Defense Constraints

There was ample evidence from discussions with several ROTC officers that the Department of Defense imposes constraints on the operation of the ROTC programs. For this reason it was indicated that ROTC administrators would welcome a tool that would enhance their planning procedures and allow them to respond to the Department having explored all of the alternative ways of achieving their program objectives within the Department's constraints.

2.2.6 The Implications of Alternative Teaching Methods

A tool which could explore the resources implications of alternative teaching methods such as team teaching, computer assisted instruction, educational television, self-paced learning, or some other innovative technique was discussed with a number of ROTC officers. Although none of these teaching methods are presently being contemplated, it was agreed that a more exact method of assessing the implications of these changes would be desirable.

2.2.7 The Implications of Alternative Program Designs

Certain ROTC officers were interested in a tool which could explore the implications of altering the ROTC curriculum design specifications such as changing the mix of ROTC and host institution courses, changing the number of ROTC courses required for graduation, and in general having a tool to look at alternative curricula.

2.2.8 Control of Staff Resource

ROTC does not have an efficient method for exploring the effects of alternative manning formulae, greater use of host institution staff, varying the mixture of active and retired teaching officers, etc.

2.2.9 Control of Space Resource

There is at present no capability to measure the existing loads placed by ROTC programs on the host institution's space, nor is there the capability to test out the effects of changing policies such as authorized section sizes on the host institution's space.

3. DESCRIPTION OF THE MODELS

Two cost simulation models have been developed: one for the Academy bearing the acronym ASTRA (Academy's Simulation Technique for Resource Allocation) and one for AFROTC. The models are based on the situation analyses, are customized to the two organizational structures, and address many of the problem areas.

The models both consider all resources used in the educational process:

- staff (teaching, nonteaching)
- staff (military, civilian)
- space (teaching, support)
- equipment (expense, investment)
- other (TDY, supplies, etc.)

The capabilities of the models are based, in part, on the information gleaned from a review of State-Of-The-Art, and include the best features of the systems currently available.

3.1 The ASTRA Model

The ASTRA model is comprised of ten interrelated subsystems. These are:

- STRUCTURAL DEFINITIONS (DF): The Model Language
- CADET FLOW (CF): Cadet Program Enrollments
- CADET COURSE (CC): Course and Section Enrollments
- CONTACT HOURS (CH): Academic Cost Center Loads
- RESOURCE REQUIREMENTS (RR): Cost Center Resource Requirements
- PROGRAM COSTING (PC): Individual Course and Program Costs
- MULTI-YEAR (MY): Overtime Reporting Capability
- DATA EDITOR (DE): Error Checking and Listing of Input Data
- MONITOR (MO): Controls the Model Operation
- INTERACTIVE PROMPTER (IP): Computer Assisted Operating Instructions

Two flowcharts illustrate the subsystem interrelationships.

- Overview Flowchart: describes the interactions of the ten subsystems.

- Descriptive Flowchart: describes the inputs and outputs of the individual subsystems, in verbal terms.

3.1.1 Structural Definitions

The specific organizational, program, timing, resource, and budget structure of the United States Air Force Academy is input in this subsystem. At any moment in time, the structural description of the Academy is fixed. However, the input to this subsystem is flexible and hence alternative structural descriptions can be tested out.

3.1.2 Cadet Flow

The Cadet Flow subsystem accepts data on class enrollments, program distributions, cadet transition rates, and produces cadet enrollments by program and level.

3.1.3 Cadet Course

The Cadet Course subsystem accepts as input the output of the Cadet Flow subsystem, and produces as output the number of cadets enrolled in each course.

3.1.4 Contact Hour

Taking as input the output of the Cadet Course subsystem and given course scheduling information, the Contact Hour subsystem calculates cadet, section, staff, and space contact hours (minimum weekly, average weekly, maximum weekly, total over semester) for each academic cost center (department).

3.1.5 Resource Requirements

The number of staff required by category and subcategory, teaching space required by category, subcategory, and size range (measured in numbers of rooms and in square feet), other space requirements (measured in square feet), equipment procurements, and other resource requirements (for example, O&M dollars) are calculated in this subsystem for each cost center, according to relationships specified by the user.

3.1.6 Program Costing

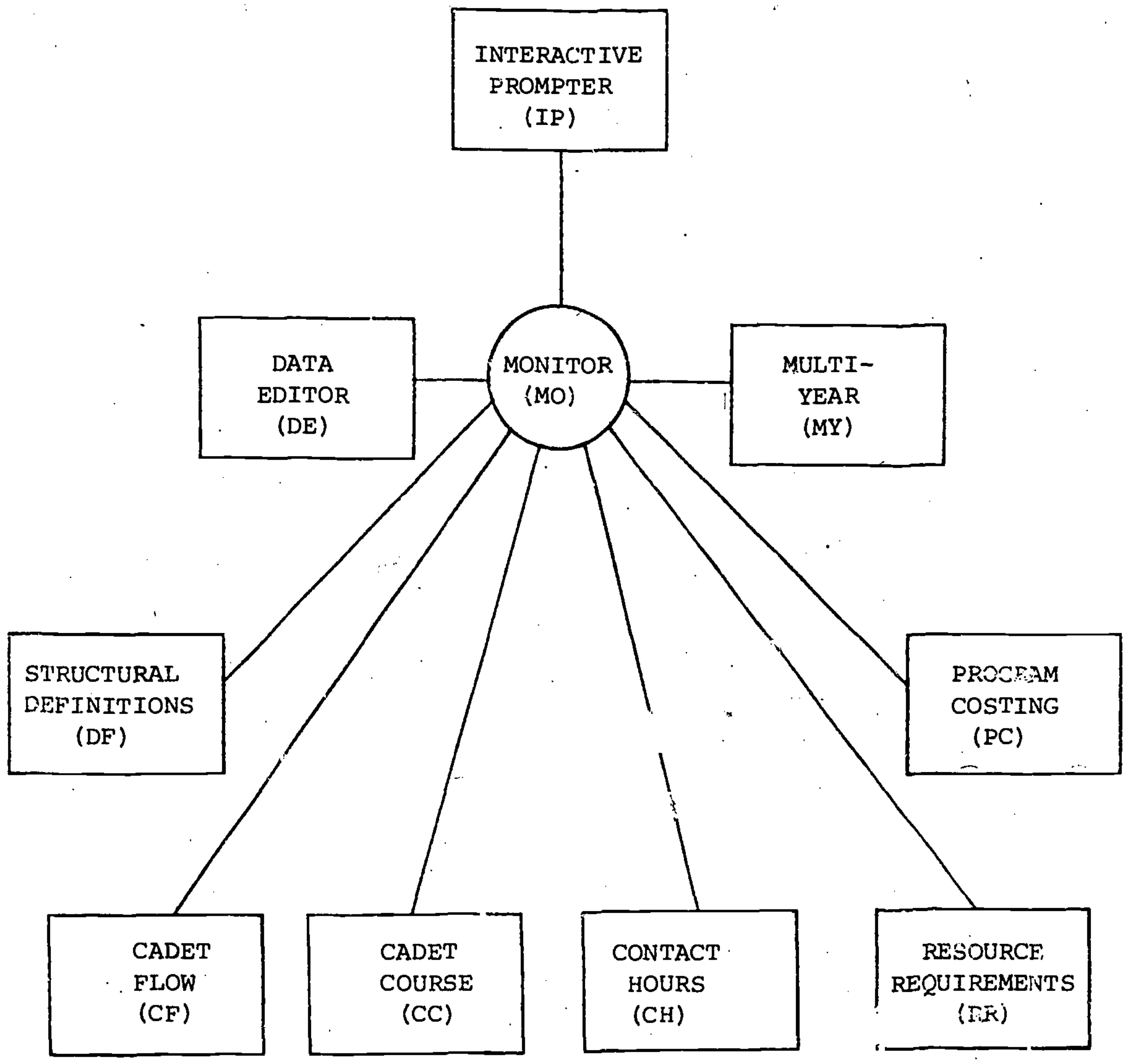
According to a specific costing methodology, the Program Costing subsystem prorates institutional costs to instructional programs in order to generate true program costs.

UNITED STATES AIR FORCE
ASTRA MODEL DESIGN

PROCESS CALCULATION FORM

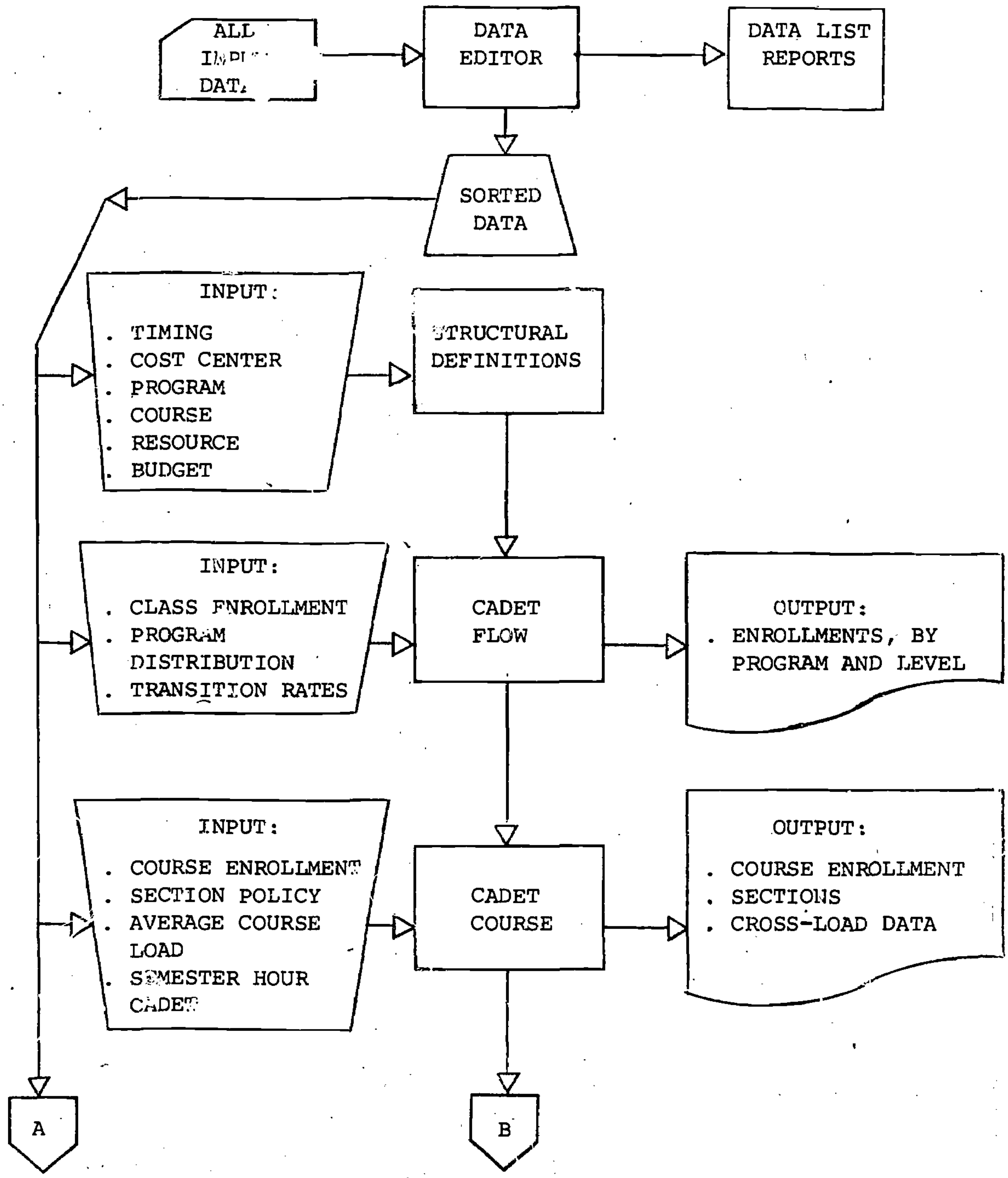
~~FLOWCHART~~

OVERVIEW



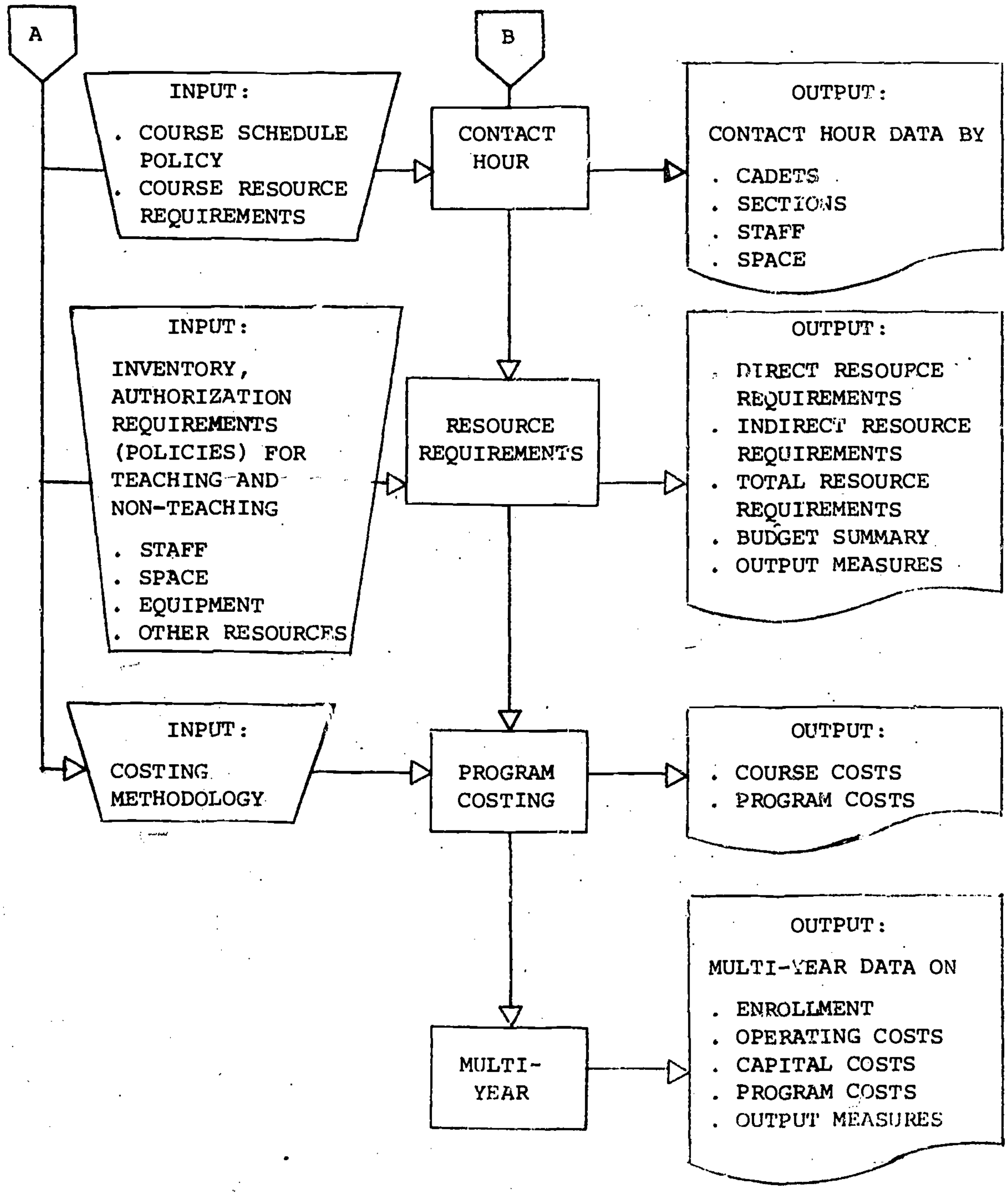
UNITED STATES AIR FORCE
ASTRA MODEL DESIGN
PROCESS CALCULATION FORM

~~FLOWCHART~~
~~Descriptive~~



UNITED STATES AIR FORCE
ASTRA MODEL DESIGN
PROCESS CALCULATION FORM

FLOWCHART
Descriptive



3.1.7 Multi-Year

The Multi-Year subsystem accepts annual resource requirement data and displays it in a multi-year format with up to five years of requirements on one report.

3.1.8 Data Editor

The Data Editor subsystem accepts input defined constraints about the information which is to appear on each input document for each of the other subsystems. Error messages signal unsatisfactory data. Formatted data reports are produced to allow for analytical scrutiny.

3.1.9 Monitor

The Monitor Subsystem controls the operation of the model, indicating which subsystems are to be activated for how many time periods, what experimental changes are to be made, which reports are to be produced, etc.

3.1.10 Interactive Prompter

The interactive prompter subsystem allows the user, after he has passed a security check, to interact over a computer terminal with the modelling system in order to specify experiments, run simulations, produce reports, etc. The prompter is designed to interact at two levels: a very sparse dialogue for the experienced user; a very detailed dialogue to assist the inexperienced user in specifying his tasks.

3.2 The ROTC Model

The model is comprised of nine interrelated subsystems. These are:

- STRUCTURAL DEFINITIONS (DF): The Model Language
- CADET FLOW (CF): Cadet Program Enrollment
- CONTACT HOURS (CH): Contact Hour Loads
- RESOURCE REQUIREMENTS (RR): Detachment Resource Requirements
- UNIT COSTING (UC): Individual Course and Program Costs
- MULTI-YEAR (MY): Overtime Reporting Capabilities
- DATA EDITOR (DE): Error Checking and Listing of Input Data

- **MONITOR (MO):** Controls Model's Operation

- **INTERACTIVE PROMPTER (IP):** Computer Assisted Operating Instructions

Two flowcharts illustrate the **subsystem interrelationships.**

- Overview Flowchart: Describes the interactions of the nine subsystems.

- Descriptive Flowchart: Describes the inputs and outputs of the individual subsystems, in verbal terms.

3.2.1 Structural Definitions

The specific organizational, program, cadet, resource, and budget structure of ROTC is input in this subsystem. At any moment in time, the structural description is fixed; however, the input to this subsystem is flexible and, hence, alternative structural descriptions can be tested out.

3.2.2 Cadet Flow

The Cadet Flow subsystem accepts data on host enrollments, ROTC program distributions, cadet transition rates, and produces cadet enrollments by program and level and by cadet category and subcategory for each year of the planning horizon. Alternatively quotas can be set and this subsystem will compute the prerequisite enrollments.

3.2.3 Contact Hour

Taking as input the output of the Cadet Flow subsystem, and given course scheduling information and section size information, the Contact Hour subsystem calculates cadet and staff contact hours for each detachment.

3.2.4 Resource Requirements

The number of staff required by category and subcategory, and other resource requirements (for example, O&M dollars) are calculated in this subsystem for each detachment according to relationships specified by the user.

3.2.5 Unit Costing

According to a specific costing methodology, the Unit Costing subsystem accumulates costs by course, by program, and by cadet category and subcategory.

3.2.6 Multi-Year

The Multi-Year subsystem accepts annual resource requirement data and displays it in a multi-year format with up to five years of requirements on one report.

3.2.7 Data Editor

The Data Editor subsystem accepts input defined constraints about the information which is to appear on each input document for each of the other subsystems. Error messages signal unsatisfactory data. Formatted data reports are produced to allow for analytical scrutiny.

3.2.8 Monitor

The Monitor Subsystem controls the operation of the model, indicating which subsystems are to be activated, for how many time periods, what experimental changes are to be made, which reports are to be produced, etc.

3.2.9 Interactive Prompter

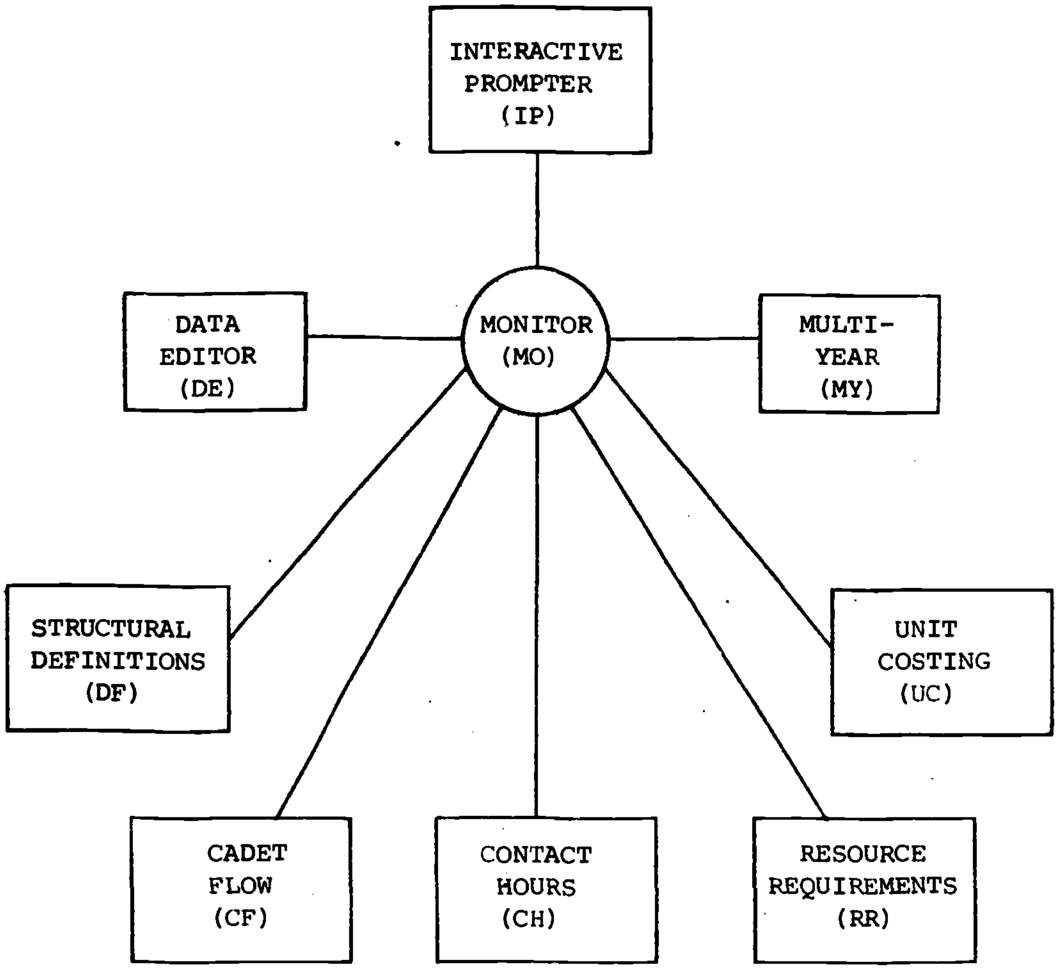
The interactive prompter subsystem allows the user, after he has passed a security check, to interact over a computer terminal with the modelling system in order to specify experiments, run simulations, produce reports, etc. The prompter is designed to interact at two levels: a very sparse dialogue for the experienced user; a very detailed dialogue to assist the inexperienced user in specifying his tasks.

UNITED STATES AIR FORCE
ROTC MODEL DESIGN

PROCESS CALCULATION FORM

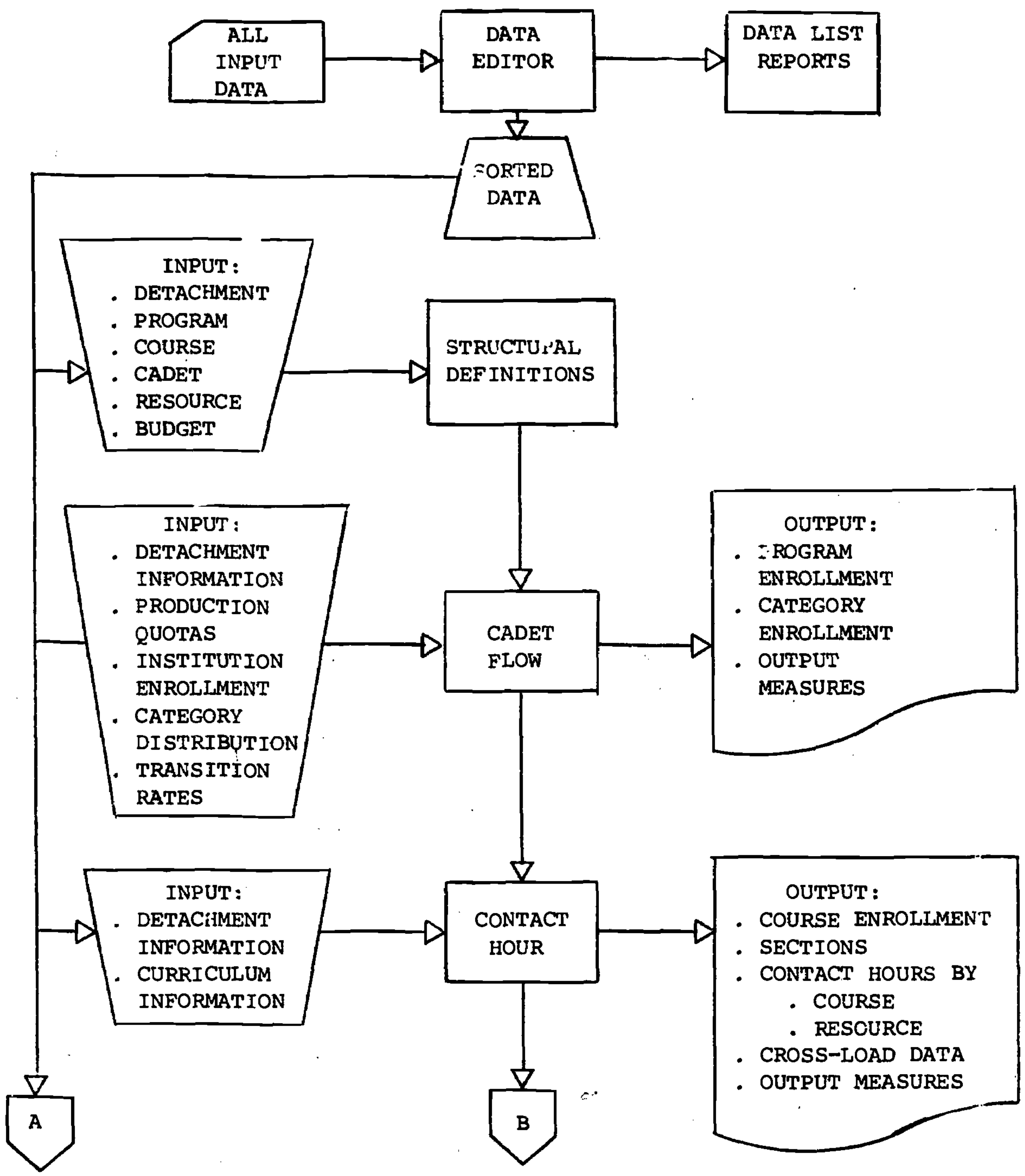
FLOWCHART

OVERVIEW



UNITED STATES AIR FORCE
ROTC MODEL DESIGN
PROCESS CALCULATION FORM

FLOWCHART
Descriptive

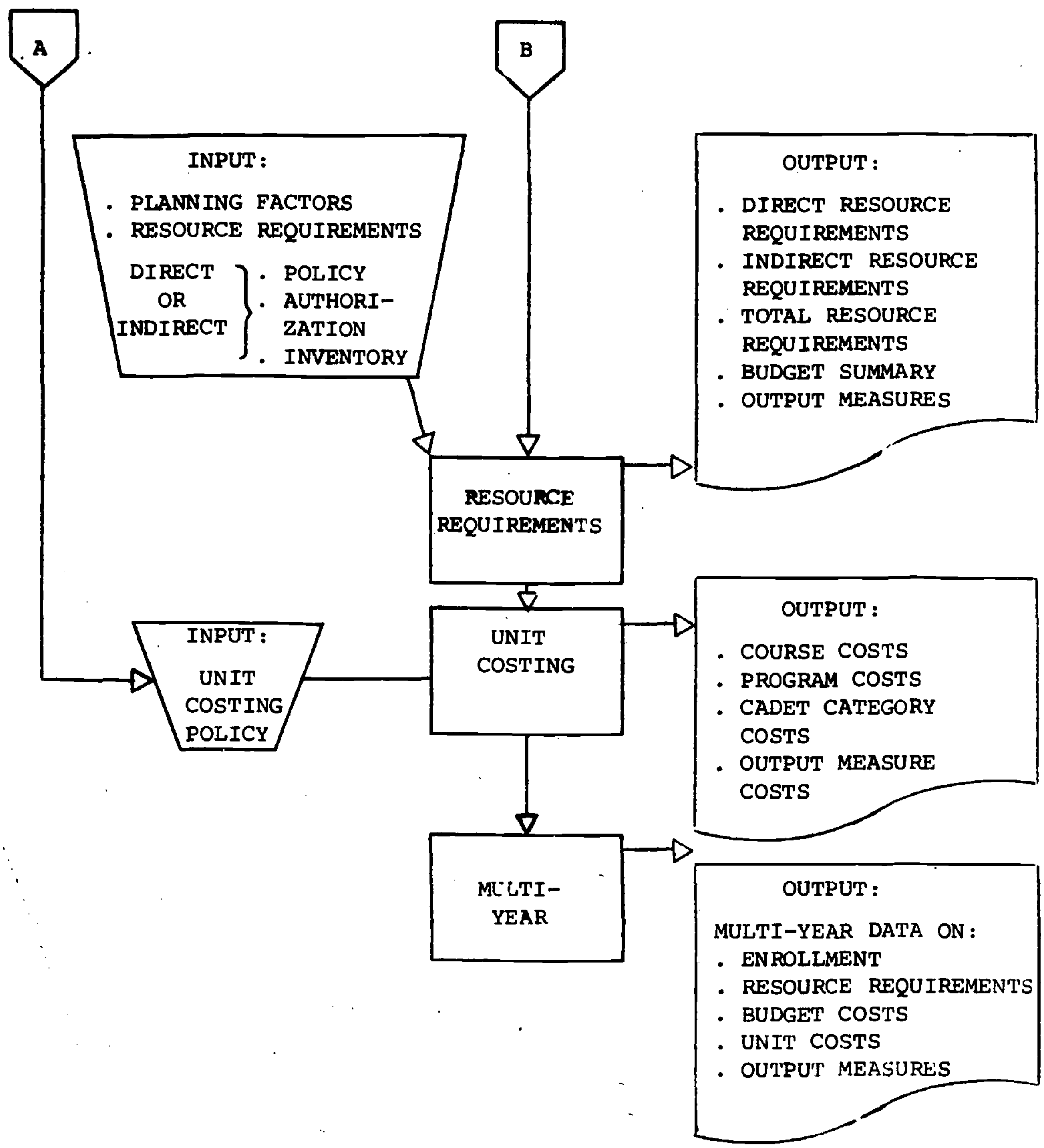


UNITED STATES AIR FORCE
ROTC MODEL DESIGN

PROCESS CALCULATION FORM

FLOWCHART

Descriptive



4. THERE ARE TWO DESIGN DOCUMENTS

There are two portions to the design documents for each model: a main text which gives concise design descriptions and a set of related appendices which contain extremely detailed design descriptions, including array and variable names, algebraic statements, etc.

Each subsystem is described in the main text under these headings:

1. Introduction
2. Input Phase
3. Process Phase
4. Example
5. Output Phase
6. Experiment Phase

The related appendices are entitled:

I Input Phase
II Process Phase
III Flowchart
IV Report Descriptions
V Experiment Phase

The contents of each of these is described below.

4.1 Introduction

The introductory paragraphs give the objectives of the subsystem and any basic concepts or assumptions which underlie the computational steps carried out in order to meet those objectives.

4.2 Input Phase

The Input Phase describes the inputs to the subsystem. The inputs are organized into input commands, each of which is explained fully in the body of the text, with further detail included in Appendix I.

4.3 Process Phase

The manner in which the subsystem brings information together, performs calculations, and organizes results for output display is described verbally in the Process Phase subsection. More detail, including a description of the calculation steps in algebraic terms, and a flowchart can be found in Appendices II and III.

4.4 Example

Simple numeric examples are chosen to illustrate the concepts and calculations involved in each subsystem. In most cases the information used in the numeric example appears on the output reports; in this way the relationship between the inputs, processing steps, outputs, and output reports is highlighted.

4.5 Output Phase

The results of the information processed and the calculations performed in each subsystem are displayed on output reports. Sample output reports are given for each subsystem, with detailed descriptions in Appendix IV.

4.6 Experimental Phase

The information in each subsystem can be experimentally altered in order to generate answers to questions of the "what if...?" type. Essentially an experiment consists of temporarily altering the input data to reflect the experimental change, and proceeding through the Process Phase to produce new results (output reports). The variables which can be experimentally altered are listed in the text. Again, more detailed information on these variables is given in Appendix V.

5. WHAT THE MODELS CAN DO

The problems that can be analyzed with the proposed ASTRA model can be classified in many ways. The classifications given below are not meant to be exclusive, nor are the sample problems meant to be exhaustive. They are intended only to indicate the diverse kinds of problems which can be addressed. Some are certainly of concern to management (having been identified in the Situation Analysis); others may be of no present concern at all.

5.1 For USAFA

5.1.1 By Time Horizon

Short Term

- What changes in authorized section size, manning standards, and facilities allocation can be made to accommodate the predicted shift in student program and course selection patterns as the result of permitting cadet complete freedom in the selection of majors and courses?

- What three plans can be developed in order to cut back the operating budget by ten per cent as dictated by the Department of Defense?

Long Term

- What would be the impact on operating and capital budgets if educational television (or computer assisted instruction, or some combination) is gradually introduced for the first two years of all programs?

- What will the Academy's budget be in 1976 if current policies are maintained?

5.1.2 By Organizational Level

Dean of Faculty

- What value of the equipment penalty policy will bring inventories of equipment for all academic departments in line with authorization limits by 1974?

- Which academic departments would gain additional staff and which would lose staff if manning allocation standards were changed from Plan "Blue" to Plan "Orange"? Under which of the two schemes is total manning the lesser?

Individual Department

- What average staff loads can be expected if all lecture courses are reduced by 1 hour per lesson, all seminar courses are increased 1 hour per lesson, all individual study cadets meet an extra 2 hours per week with an instructor, etc.?

- What would be the impacts on the individual academic departments of increasing enrollments in Science programs over time while reducing enrollments in the Humanities programs?

Individual Program

- What would be the impact on total program costs of relaxing (or reducing) first and second year passing requirements?

- What would be the effect on the cost per graduate by lightening the average course load per semester for the last four semesters of a particular program?

5.1.3 By Level of Detail

Summary

- What would be the impact on the total annual operating budget for the next five years if the rate of inflation on civilian payroll is 6 per cent per year and on other resources is 5 per cent per year?

- What would be the impact of a Congressional decision to increase total enrollment at the Academy from 4417 cadets to 5000 cadets over that time period on the total annual operating and capital budgets for the next six years?

Detailed

- What would be the impact of a change in the manning formula for all activities involving 20 cadets or more on moving in each department?

- What would be the effect of manning, by category and subcategory, for the Library if either the Management Engineering Division planning factors are altered, or if a revised set of Library workload estimates are made?

5.1.4 By Resource Type

Staff

- What would be the effect on the number of staff required, by category and subcategory, of combining three particular instructional departments into one?

- What change in staff complement would be required, under existing manning formula, to accommodate a 25 per cent decrease in authorized section sizes?

Space

- Under present plans and programs, where is there excess space in the system and what can it be used for?

- What would be the impact of offering most first and second year courses in section sizes of 76 cadets on shortages and surpluses of teaching space, by category and subcategory?

Equipment

- What would be the effect of increasing the general replacement rate by 3 percentage points on equipment procurements, department by department?

- In what year would the equipment inventory equal the authorization limit if turnins for each department are increased by 10 per cent?

Operating Budget

- What is the shadow price (savings fore-gone) resulting from the Department of Defense's ruling that military pay and O&M items cannot be substituted one for the other in the operating budget?

- What would be the impact of a change in the desired distribution of academic staff members towards the lower ranks on the military payroll portion of the total operating budget?

5.1.5 By Problem Type

Enrollments

- What is the impact of using end-of-semester enrollment levels in all resource requirement statements, rather than first-day-of-semester enrollments on resource requirements?

- Which program shows the greatest economies of scale from increased enrollments? Which programs show the greatest diseconomies of scale from increased enrollments?

Academic Policy

- What would be the impact of adding one new program in fiscal year 73 and two new programs in fiscal year 74 on operating budgets?

- What would be the impact of moving towards individualized instruction and self-paced learning on a particular department?

Administrative Policy

- What would be the impact of instituting a trimester system at the Academy on operating budgets?

- What would be the impact on resource requirements if the Academy's manning policies with regard to civilian and officer support staff were changed?

Environmental Factors

- What would be the impact of a specified change in the officer pay schedule, together with certain levels of inflation for civilian manpower, supplies, etc. on operating budgets?

- What plans can be developed in anticipation of the fact that a sufficient number of staff in a particular academic discipline will not be available over the planning horizon?

5.2 For ROTC

5.2.1 By Time Horizon

Short Term

- What changes in the authorized section size policy and manning standards can be made to accommodate the projected change in ROTC enrollments in specified detachments in order to stay within last year's budget?

- What plans can be developed in order to cut back the operating budget by 10 percent as dictated by the Department of Defense?

Long Term

- How many years will it take to move from graduating 1 flying officer for every 1 non-flying officer to a 2 to 1 ratio?

- What will the ROTC budget be in 1976 if current policies are maintained?

5.2.2 By Organization Level

Geographic Region

- Within "Project Access" the objective is to achieve an equitable distribution of Junior Units throughout the entire nation. Given the present successful application rate from schools visited, what are the manning and other resource implications of meeting the full quota?

Individual Detachment

- What savings can be realized by disestablishing certain detachments which presently have low enrollments?

- What is the shadow cost (savings foregone) if the Department of Defense will not permit the disestablishment?

Individual Program

- What would be the effect of admitting more minority group cadets into the senior programs on the number of graduates, on the cost per graduate, on cost per retained officer?

- What are the resource requirements of introducing a totally new program, for example flight instruction, where it does not presently exist, or in breaking up the Junior ROTC program into two and four year efforts?

5.2.3 By Level of Detail

Summary

- What would be the impact on the total annual operating budget for ROTC in the next five years if the rate of inflation on civilian payroll were 6 per cent per year and on other resources it is 5 per cent?

- What would be the impact of a Department of Defense decision to increase ROTC production to 4500, 3000 flying and 1500 non-flying on total annual operating budgets for the next five years?

Detail

- What would be the impact of a change in the manning formula for all AS100 from one instructor per ten hours to one instructor per eight hours in each department on manning?

- What would be the cost implications of alternative designs for curricula including self-paced instruction, computer assisted instruction, team teaching?

5.2.4 By Resource Type

Staff

- What are the implications of changing the manning formula on staff requirements, both military and civilian?

- What are the implications of using the host institution staff to teach certain portions of the curricula at selected detachments?

Space

- What is the impact of the ROTC programs on the space resource of the host institution?

- What would be the implications for host institution space requirements, of altering authorized section sizes?

Operating Budget

- What is the shadow price (savings foregone) as a result of the Department of Defense ruling that military pay and O&M items can not be substituted one for the other in the operating budget?

- What is the effect on the O&M budget of changing the cadet pay and/or changing the number of scholarships and/or changing the value of scholarships?

5.2.5 By Problem Type

Enrollment

- Given a change in the enrollment projections of the host institution, what is the likely effect on ROTC program enrollments?

- Which detachments show the greatest economies of scale for increased enrollments? Which detachments show the greatest diseconomies of scale for increased enrollments?

Academic Policy

- What would be the impact on teaching staff workloads if the duration of the ROTC courses were increased by 25%?

- What would be the impact on a particular detachment's teaching officers of moving back to the regular ROTC curriculum from an alternative curriculum involving host institution staff?

Administrative Policy

- What would be the resource requirements of introducing a new recruitment program involving more liaison officers and TDY expenses?

- What is the effect on the O&M budget, detachment-by-detachment, and across all detachments, of altering policies regarding expendible supplies, TDY etc.?

Environmental Factors

- What would be the impact on operating budgets, of a specific change in the officer pay schedule, together with certain levels of inflation for civilian and other items in the budget?

C. REPORTING CAPABILITIES ARE EXTENSIVE

The reporting capabilities of the two models are quite extensive. The user has complete control over the nature and number of reports produced. The following pages list all reports, grouped by subsystem, and indicate for each report the extent of the user's control.

This reporting structure facilitates the dissemination of summary reports to senior administrators, department reports to departmental chairmen, and program reports to program co-ordinators.

The reports are interrelated permitting the user to trace back from one item on an aggregate multi-year report through more and more levels of detail (e.g. from Institution to Faculty, to group of departments, to individual department; from multi-year to year to semester) until he reaches all the supportive data which underlie the original item.

The structure is given below:

TIMING

- single semester
- academic year
- multi-year

FOCUS

- individual activity
- academic department/detachment
- support department
- groups of detachments
- program
- institution

RESOURCES

- direct (teaching staff, teaching space, equipment)
- indirect (non-teaching staff, non-teaching space, other resources)

FORMAT

- resource type, category, subcategory
- traditional line-item budget

TYPE

- Input and Error Checking
- Output and Output Measures

Sample reports are provided in Appendix [illegible] for the Academy and in Appendix G for ROTC.

LIST OF REPORTS FROM THE ASTRA MODEL

Subsystem	Report No.	Report Name	Individual Control	Group Control
Cadet Flow	CF01	Cadet Flow Summary	Program Category	-
Cadet Course	CC01	Courses	Cost Center	Cost Center Category, Subcategory
	CC02	Programs	Program	Program, Category, Subcategory
	CC03	Load Summary	Program Category	-
Contact Hours	CH01	Course Contact Hours	Cost Center	Cost Center Category, Subcategory
	CH02	Resource Contact Hours	Cost Center	Cost Center Category, Subcategory
	CH03	Contact Hour Summary	Cost Center	Cost Center Category, Subcategory
Resource Requirements	RR01	Direct Resource Requirements	Cost Center	Cost Center Category, Subcategory
	RR02	Teaching Staff Requirements	Cost Center	Cost Center Category, Subcategory
	RR03	Teaching Space Requirements	Cost Center	Cost Center Category, Subcategory
	RR04	Equipment Resource Requirements	Cost Center	Cost Center Category, Subcategory
	RR05	Indirect Resource Requirements	Cost Center	Cost Center Category, Subcategory
	RR06	Resource Requirements Summary	Cost Center	Cost Center Category, Subcategory
	RR07	Budget Summary	Cost Center	Cost Center Category, Subcategory
	RR08	Output Measure Summary	Cost Center Category	-

LIST OF REPORTS FROM THE ASTRA MODEL

Subsystem	Report No.	Report Name	Individual Control	Group Control
Program Costing	PC01	Cost Center Summary	Cost Center	Cost Center Category, Subcategory
	PC02	Course Costing	Cost Center	Cost Center Category, Subcategory
	PC03	Program Costingl	Program Category	-
	PC04	Program Costing Summary	Program Category	-
Multi-Year	MY01	Program Enrollment	Program Category	-
	MY02	Resource Requirements	Cost Center	Cost Center Category, Subcategory
	MY03	Operating Costs	Cost Center Category	-
	MY04	Capital Costs	Cost Center Category	-
	MY05	Budget Costs	Budget Function	-
	MY06	Program Costs	Program Category	-
	MY07	Output Measures	Output Indices	-
Data Editor		One report for each input file		

LIST OF OUTPUT REPORTS FROM THE ROTC MODEL

Subsystem	Report No.	Report Name	Individual Control	Group Control
Cadet Flow	CF01	Cadet Program Enrollment	Detachment	Category Subcategory
	CF02	Cadet Category Enrollment	Detachment	Category Subcategory
Contact Hours	CH01	Course Contact Hours	Detachment	Category Subcategory
	CH02	Resource Contact Hours	Detachment	Category Subcategory
Resource Requirements	RR01	Direct Resource Requirements	Detachment	Category Subcategory
	RR02	Indirect Resource Requirements	Detachment	Category Subcategory
	RR03	Resource Requirements Summary	Detachment	Category Subcategory
	RR04	Budget Summary	Detachment	Category Subcategory
Unit Costing	UC01	Course Cost	Detachment	Category Subcategory
	UC02	Program Cost	Detachment	Category Subcategory
	UC03	Cadet Category Cost	Detachment	Category Subcategory
	UC04	Unit Costing Summary		Category Subcategory
Multi-Year	MY01	Enrollment		Category Subcategory
	MY02	Resource Requirements		Category Subcategory
	MY03	Budget Costs		Category Subcategory
	MY04	Unit Costs		Category Subcategory
	MY05	Output Measures		Category Subcategory
Data Editor		One report for each input file		

7. THE EXPERIMENTAL CAPABILITIES ARE SOPHISTICATED

The experimental capability allows the user to make temporary changes to the data base in order to analyze the implications of alternative formulations of educational planning problems. These problems are the usual "What if...?" type questions that require quantitative answers to bolster management decision-making.

The experimental capabilities are sophisticated and provide the following:

- The ability to experiment with an individual data element or a group of elements.
- The ability to analyze individual cost centers, detachments, programs or courses or aggregations of these.
- The ability to start and stop the experimentation at any point in the time horizon.
- The ability to change a data element by an absolute or percentage amount.
- The ability to replace a data element with a new value or to set a goal value over the planning horizon.
- The ability to operate in either an interactive or batch mode.

The experiments are catalogued by a key grouping for each subsystem and sequentially numbered for easy reference and use.

3. THE DATA REQUIREMENTS HAVE BEEN IDENTIFIED

The data necessary to fuel the proposed models has in most cases already been collected and can be found in information systems, catalogues, documents, and Engineering Division Standards, etc.

3.1 The Data Requirement Table

For both USAFA and ROTC, a data requirement table is displayed. This table shows the requirements for input information for each subsystem on the following headings:

Data Type

A descriptor of the data required (for example, transition rates).

Level of Detail

The user has the option of specifying almost all input data at more than one level of detail. The volume of input data required is a direct function of the level of disaggregation chosen. For each type of data, the table shows the most aggregate definition possible and the least aggregate definition possible. It is to be noted that in many cases the user may choose a level of detail which lies between these two extremes.

Time Dimension

Some data must be specified for each year and semester of the planning horizon (for example, enrollments); other types of data must be specified once only (for example, descriptions of the structural organization); other data are specified for the base period only (for example, transition rates) and need be specified for other periods only if the information changes.

Of course, in all cases, the user may experimentally alter the data at any date in the planning horizon in order to determine results of the change.

Source

The sources of the data necessary to fuel the models fall into a number of distinct categories:

- USAFA or ROTC catalogue
- USAFA or ROTC budget documents
- USAFA or ROTC automated information systems

- Management Engineering Division Standards
- Published papers, policies, and operating instructions
- Interviews
- Manual of Instructions, prepared for model users.

Frequency of Collection and Update

Although the user can experimentally alter any data element, a general guideline to the frequency of collection and permanent updating of information can be given. The descriptors are:

- "Once" (for example, structural definitions need by input only once).
- "Each planning cycle" (the information should be updated after each planning cycle).

The data requirements for the Academy are presented in Table 4 and for ROTC in Table 5. The entries in the Tables indicate that users have quite a wide latitude in defining the data required at various levels of detail. Most data are available from existing sources. Except for experimental changes, permanent updates occur once in each planning cycle.

8.2 Data Input Commands

The model is controlled through its input commands. The list of input commands for the ASTRA model is displayed in Table 6 and for the ROTC model in Table 7. The data must be transferred from their source to the appropriate input command either manually or automatically from a computer based information system.

8.3 Model Size

The size of the model can be varied to accommodate various data bases. Table 8 gives estimates of maximum values required of certain parameters in order to accommodate the Academy's data base whereas Table 9 does the same for the ROTC.

TABLE 4

USAFA ASTRA MODEL

DATA REQUIREMENTS

SUBSYSTEM	DATA TYPE	LEVEL OF DETAIL AGGREGATE	LEVEL OF DETAIL DISAGGREGATE	TIME DIMENSION	SOURCE	SUGGESTED FREQUENCY OF COLLECTION AND UPDATE
STRUCTURAL DEFINITIONS	Timing	Year	Semester	once	USAFA Catalogue	once
	Cost Center	Categories	Individual	once	USAFA Catalogue	once
	Program	Categories	Individual	once	USAFA Catalogue	once
	Course	Categories	Individual	once	USAFA Catalogue	once
	Resource	Type	Subcategory	once	Budget Documents	once
	Budget	Major Functions, Categories	Subfunctions, Subcategories	once	Budget Documents	once
CADET FLOW	Class Enrollment	Class	-	year, semester	Policy (Congress)	once
	Program Distributions	Program Category	Individual Programs	base period	Historical (CADETAIDS)	each planning cycle
	Transition Rates	Program Category	Individual Programs	base period	Historical (CADETAIDS)	each planning cycle
CADET COURSE	Course Policies	Categories	Individual	base period	CADETAIDS	each planning cycle
	Average Course Load	Program Category	Individual Programs	base period	Historical data (CADETAIDS)	each planning cycle
CONTACT HOUR	Course Policies	Categories	Individual	base period	CADETAIDS	each planning cycle
RESOURCE REQUIREMENTS	Teaching Staff	Category	Subcategory			
	-inventory			base period	USAFA Information System	each planning cycle
	-authorization			year, semester	USAFA Information System	each planning cycle
	-requirements			base period	FACSIM and/or other policy rules	once
	Teaching Space	Category	Subcategory			
	-inventory			base period	USAFA Information System	each planning cycle
	-authorization			year, semester	USAFA Information System	each planning cycle
	-requirements			base period	FACSIM and/or other policy rules	once

SUBSYSTEM	DATA TYPE	LEVEL OF DETAIL AGGREGATE	DIS`REGATE	TIME DIMENSION	SOURCE	SUGGESTED FREQUENCY OF COLLECTION AND UPDATE
RESOURCE REQUIREMENTS (Cont'd)	Equipment	Category	Subcategory			
	-inventory			base period	USAFA Information System	each planning cycle
	-authorization			year, semester	USAFA Information System	each planning cycle
	-requirements			base period	FACSIM and/or other policy rules	once
	Non-Teaching Staff	Category	Subcategory			
	-inventory			base period	USAFA Information System	each planning cycle
	-authorization			year semester	USAFA Information System	each planning cycle
	-requirements			base period	Policy rules	once
	Non-Teaching Space	Category	Subcategory			
	-inventory			base period	USAFA Information System	each planning cycle
	-authorization			year, semester	USAFA Information System	each planning cycle
	-requirements			base period	Policy rules	once
	Other Resources	Category	Subcategory			
	-inventory			base period	Budget Documents	each planning cycle
	-authorization			year, semester	Budget Documents	each planning cycle
	-requirements			base period	FACSIM and/or other policy rules	once
PROGRAM COSTING	Costing	Main Functions	Subfunctions	base period	Interview	once
	Methodology	Objects	Subcategories			
MULTI-YEAR	-	-	-	-	-	-
DATA EDITOR	Edit Information	-	-	once	USAFA Catalogue, model design documentation	once, unless model is to be changed
MONITOR	Simulation Control	-	-	-	Manual of Instructions	each run
	Experiment Control	-	-	-	Manual of Instructions	each experiment
	Report Control	-	-	-	Manual of Instructions	each report

Page 2 of 2

TABLE 5

ROTC MODEL

DATA REQUIREMENTS

SUBSYSTEM	DATA TYPE	LEVEL OF DETAIL AGGREGATE	LEVEL OF DETAIL DISAGGREGATE	TIME DIMENSION	SOURCE	FREQUENCY OF COLLECTION OR UPDATE
STRUCTURAL DEFINITIONS	Detachment	Categories	Individual	Once	AFROTC Documents	Once
	Program	Categories	Individual	Once	AFROTC Documents	Once
	Course	Categories	Individual	Once	AFROTC Documents	Once
	Cadet	Type	Categories	Once	AFROTC Documents	Once
	Resource	Type	Categories	Once	AFROTC Documents	Once
	Budget	Functions Categories	Sub-Functions Subcategories	Once	AFROTC Documents	Once
CADET FLOW	Detachment	Categories	Individual	Year	AFROTC Documents and Policy	Planning Cycle
	Production Quotas	Categories	Individual	Year	Policy	Planning Cycle
	Institution Enrollment	Type	Categories	Year	Institution	Planning Cycle
	Distributions	Category	Subcategory	Year	Tupes, Madden	Planning Cycle
	Transition Rates	Category	Subcategory	Year	Tupes, Madden	Planning Cycle
CONTACT HOUR	Detachment	Category	Individual	Year	Policy	Planning Cycle
	Curriculum	Category	Individual	Year	AFROTC Documents and Policy	Planning Cycle
RESOURCE REQUIREMENTS	Teaching Resource	Category	Subcategory			
	-Inventory			Base Year	AFROTC Information	Planning Cycle
	-Authorized			Year	AFROTC Information	Planning Cycle
	-Required			Base Year	Policy AFROTC REG 26-1	Once
	Non-Teaching Resource	Category	Subcategory			
	-Inventory			Base Year	AFROTC Information	Planning Cycle
	-Authorized			Year	AFROTC Information	Planning Cycle
	-Required			Base Year	Policy HQ-OI172-1	Once
UNIT COSTING	Cost Policy	Function	Object - Category	Base Year	Policy	Once
MULTI-YEAR	Report Control	-	-	By run	Manual of Instruction	Each run
DATA EDITOR	Edit Information	-	-	Once per Data Base	Model Design Documentation	Once, unless model is modified
MONITOR	Simulator Control	-	-	By run	Manual of Instruction	[illegible]
	Experimental Control	-	-	By run	Manual of Instruction	Each experiment
	Report Control	-	-	By run	Manual of Instruction	Each report

TABLE 6

LIST OF INPUT COMMANDS

STRUCTURAL DEFINITIONS SUBSYSTEM

DF1	Timing structural definitions
DF2	Cost Center structural definitions
DF3	Program structural definitions
DF4	Course structural definitions
DF5	Resource structural definitions
DF6	Budget structural definitions

CADET FLOW SUBSYSTEM

CEN	Cadet Enrollment
CCE	Cadet Class Enrollments
CCD	Cadet Class Distribution
CTR	Cadet Transition Rate

CADET COURSE SUBSYSTEM

CAC	Cadet Course
COU	Course
ACL	Average Course Load
SHC	Semester Hour Credit

CONTACT HOUR SUBSYSTEM

COU	Course

RESOURCE REQUIREMENT SUBSYSTEM

PFN	Planning Factor Size Range
PFD	Planning Factor Definition
PFE	Planning Factor External
RRQ	Resource Requirements
TSF	Teaching Staff Policy
TSP	Teaching Space Policy
EQP	Equipment Policy
NSF	Non-teaching Staff Policy
NSP	Non-teaching Space Policy
ORP	Other Resource Policy
SFI	Staff Inventory
SPI	Space Inventory
EQI	Equipment Inventory
ORI	Other Resource Inventory

PROGRAM COSTING SUBSYSTEM

PCP	Program Costing Policy

MONITOR SUBSYSTEM

SIM	Simulation Control
BXP	Experiment Control
RPT	Report Control

TABLE 7

LIST OF INPUT COMMANDS

STRUCTURAL DEFINITIONS SUBSYSTEM

DF1	Detachment or Unit Definitions
DF2	Program Definitions
DF3	Course Definitions
DF4	Cadet Definitions
DF5	Resource Definitions
DF6	Budget Definitions

CADET FLOW SUBSYSTEM

DET	Detachment Information
CPQ	Cadet Production Quotas
IEN	Institution Enrollment
CCD	Cadet Category Distributions
CTR	Cadet Transition Rates

CONTACT HOURS SUBSYSTEM

DET	Detachment Information
CUR	Curriculum Information

RESOURCE REQUIREMENTS SUBSYSTEM

PFS	Planning Factor Sizes
PFD	Planning Factor Definition
PFE	Planning Factor External
PRQ	Resource Requirements
DRP	Direct Resource Policy
IRP	Indirect Resource Policy
RSI	Resource Inventory

UNIT COSTING SUBSYSTEM

UCP	Unit Costing Policy

MONITOR SUBSYSTEM

SIM	Simulator Control
EXP	Experimental Control
RPT	Report Control

TABLE 8

ESTIMATED PARAMETER VALUES
FOR UNITED STATES AIR FORCE ACADEMY

Data Element	Estimated Maximum Value	Description
Timing		
Year	5	Number of years to be simulated
Semester	3	Number of semesters or terms per year
Cost Center	50	Number of cost centers
Category	9	Number of cost center categories
Subcategory	9	Number of cost center subcategories
Program	50	Number of programs
Category	9	Number of program categories
Subcategory	9	Number of program subcategories
Level	4	Number of program levels
Course	500	Number of courses
Category	9	Number of course categories
Subcategory	9	Number of course subcategories
Units	9	Number of course unit weights
Time	9	Number of course time of day ranges
Resource		
Types	4	Number of resource types
Category	9	Number of resource categories
Subcategory	9	Number of resource subcategories
Combinations	9	Number of resource combinations per course
Size Ranges	9	Number of resource size ranges
Budget		
Function	9	Number of budget function
Subfunction	9	Number of budget subfunction
Object		
Category	20	Number of budget object categories
Subcategory	20	Number of budget object subcategories

TABLE 9

ESTIMATED PARAMETER VALUES
FOR THE ROTC - AIR UNIVERSITY

Data Element	Estimated Maximum Value	Description
Timing		
Years	5	Number of years to be simulated
Detachment	500	Number of detachments
Category	2	Number of detachment categories
Subcategory	9	Number of detachment subcategories
Characters	9	Number of detachment characteristics
Program	10	Number of programs
Category	9	Number of program categories
Subcategory	9	Number of program subcategories
Course	50	Number of courses
Category	9	Number of course categories
Subcategory	9	Number of course subcategories
Descriptions	9	Number of course descriptions
Cadet		
Type	2	Number of cadet types
Category	9	Number of cadet categories
Subcategory	9	Number of cadet subcategories
Resource		
Type	4	Number of resource types
Category	9	Number of resource categories
Subcategory	9	Number of resource subcategories
Combinations	9	Number of resource combinations per course
Budget		
Functions	9	Number of budget functions
Objects	9	Number of object categories

9. THE MODEL CAN BE USED IN AN INTERACTIVE MODE

One subsystem, the Interactive Prompter, has been designed to act as an efficient, informative, and easily understandable interface between model user and the model itself. The user is connected to the computerized model via a terminal similar to a typewriter, and can "converse" with the system in an English language conversational mode. If the user has a general understanding of the system, the conversation takes the form of an interchange in which the user is informed of the capabilities available, and how they can be activated. The more experienced user can quickly access and execute the specific portion of the modelling system he wishes, avoiding as much explanatory information as he desires.

The Interactive Prompter is not an integral part of the model design; no other subsystem is dependent on it. The computer hardware, the desires of the administrators, etc. will dictate whether this subsystem will be built.

The Modes of Operation Flowchart displays the model operating in both an interactive and batch mode.

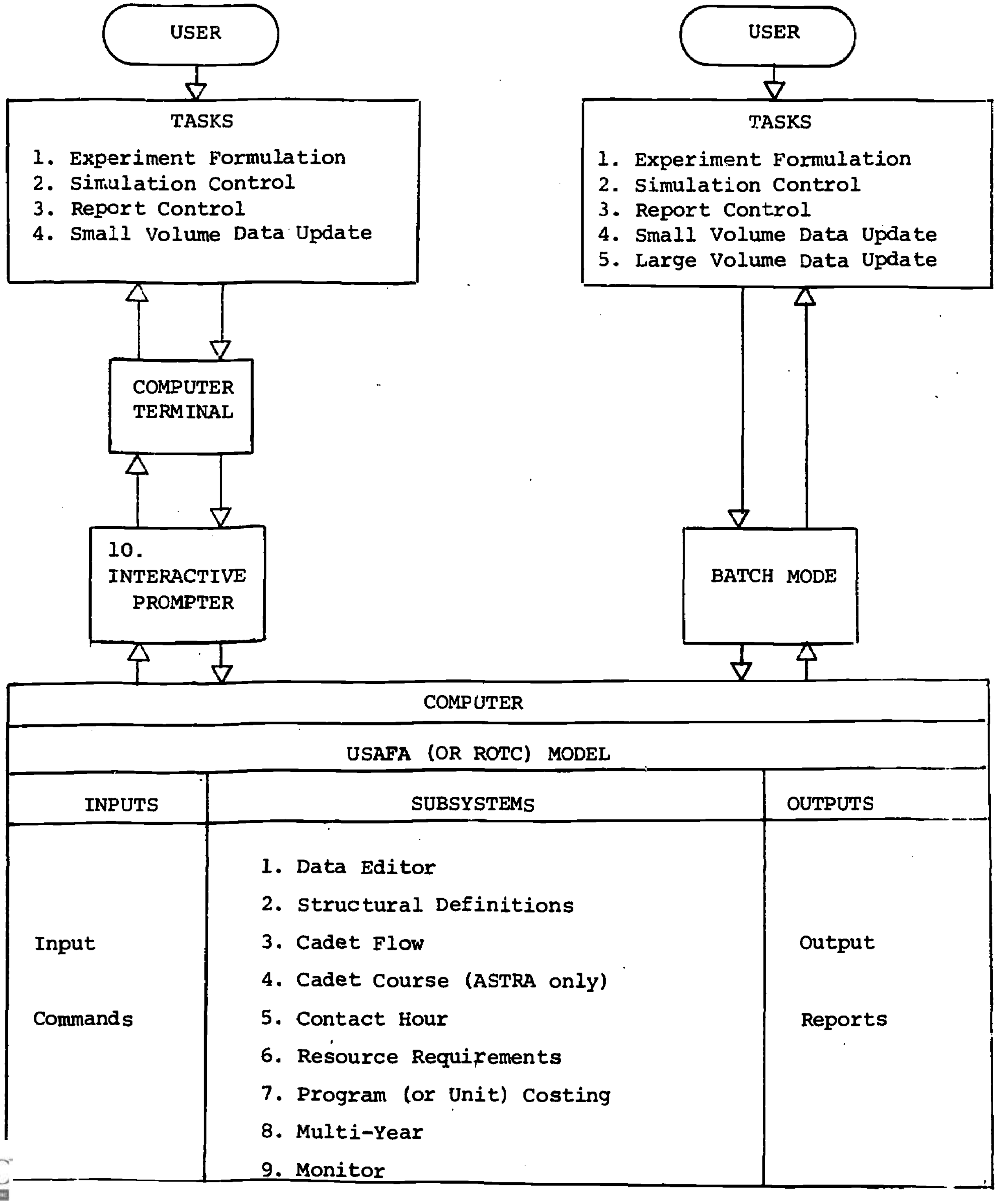
Samples of the dialogue for both experienced and inexperienced users may be found in Appendix 7.

UNITED STATES AIR FORCE

ASTRA AND ROTC MODELS

MODES OF OPERATION

FLOWCHART



APPENDIX 1

MILITARY AND CIVILIAN PERSONNEL INTERVIEWED AT THE UNITED STATES AIR FORCE ACADEMY	
MILITARY	
Lt. Colonel J.E. Arnet	Director, Counselling and Scheduling
Colonel R.R. Bate	Vice Dean of Faculty
Colonel D.H. Brockett	Director of Cadet Logistics
Captain G. Clouse	Budget Office
Captain B. DeMichaels	Counselling and Scheduling
Colonel W.E. Fluhr	Head Civil Engineering Dept.
Major H.W. Frank	Chief, Management Engineering Division
Lt. Colonel H.L. Gilster	Assoc. Prof. Economics and Management
Captain M.P. Gyauch	Computer Science Dept.Instructor
Captain G. Lewis	Athletics Dept.Budget Office
Lt. Colonel M.S. Majesty	Director of Professional Education Division, Human Resources Laboratory
Lt. Colonel R.E. Mazurowski	Director of Manpower and Organization
Captain J.H. Nolen	Associate Professor Computer Science
Major R.J. Penick	Cadet Records
Lt. Colonel J. Sheen	Director of Budget
Lt. Colonel T. Sherman	Budget Office
Major W. Summerhill	Athletics Department Business Manager
Colonel R.E. Thomas	Head of the Department of Electrical Engineering
Captain F.H. Williamson	Counselling and Scheduling
Colonel M.E. Wilt	Deputy Chief Staff and Comptroller
CIVILIAN	
Mr. Drummond	Base Data Automation
Mr. Goodson	Base Data Automation

APPENDIX

MILITARY AND CIVILIAN PERSONNEL INTERVIEWED AT AIR UNIVERSITY - ROTC	
MILITARY	
Lt. Colonel Alker	Directorate of Operations, AFROTC plans
Lt. Colonel Cohn	Educational Directorate ROTC
Lt. Colonel Dahle	Directorate of AFJROTC
Lt. Colonel J.C. Engle	Executive Officer for AFJROTC
Captain Flinn	Educational Directorate ROTC
Major Gibson	Director of Operations
Major E. Kerby	Chief, Cadet Statistics Branch, Directorate of Operations, AFROTC
Captain Kleid	Chief, Plans & Programs Branch, Office of Information AFROTC
Captain McFarland	Directorate of AFJROTC
Major E.F. Oldnettle	Data Automation Center, Air University
Captain P. Slattery	Educational Directorate ROTC
Colonel Sproule	Director of Operations AFROTC
Major R.M. Stimac	Director of Administration, AFROTC
Colonel J.L. Watkins	Vice Commandant, AFROTC
Captain Zitrick	Cadet Statistics Branch Directorate of Operations Plans
CIVILIAN	
Mr. M. Gordon	Chief, Evaluation and Research Division, Directorate of Education, AFROTC
Dr. K.J. Groves	Director of Research and Evaluation, Headquarters Air University
Mr. O.C. Wiley	Director of Financial Management, AFROTC

APPENDIX 3

LIST OF DOCUMENTS SECURED FROM THE UNITED STATES AIR FORCE ACADEMY	
1.	United States Air Force Academy Catalogue 1971/72
2.	Organization Chart, Air Force Human Resources Laboratory
3.	United States Air Force Management Information Summary, 17th August, 1970
4.	United States Air Force Managers' Handbook of Information 1971.
5.	United States Air Force Academy Curriculum Handbook, 1971/72
6.	Manpower: United States Air Force Academy Manpower Determinents, USAF - 26-3, 22nd July, 1970
7.	Air Force Data Automation 1969/78, AFM-300-1, 2nd January, 1969
8.	Organization and Functions, Headquarters, United States Air Force Academy and Signed Units, USAFAM-23-1, 15th June, 1971
9.	ALGOL Listing of the FACSIM Model
10.	Faculty Resource Management Program, Faculty Operating Instruction 178-1
11.	S.L. Allison, "A Computer Model for Estimating Resources and Costs of an Air Force Resident Technical Training Course", WN-7044-PR, RAND, October, 1970
12.	Chapter V from a Report on the New Academy Faculty Computer Specification, entitled "Specific Conditions".
13.	Attachment #2, Data Element Title for the USAFAM Manual 300-1
14.	Flowchart of the CADETAIDS Immediate Access Data Bank
15.	A list of the 16 users of the CADETAIDS System
16.	Academic Program Change USAF From 25B, November, 1970
17.	Initial Operations Operating Budget, Fiscal Year 1970, March 22, 1971, pages 1-77
18.	USAF Academy "Call" from the FY-72 Operating Budget, Budget Letter #1 from J.W. Sheen, with attachments: General Guidelines, FY72 Tensive Operating Budget, Instructions and Format
19.	Table of Contents, Organization and Functions, Headquarters, United States Air Force Academy, USAFA Manual 23-1 15th August, 1969

APPENDIX 3 (cont'd)

20.	"A Partial Cost/Allocation Model for the Faculty", Colonel R.E. Thomas, Professor and Head of Electrical Engineering, USAFA
21.	Academic Library System, Management Engineering Program, USAFA, FC4562, 1st November, 1970
22.	Director of Instructional Technology, Management Engineering Program, USAFA, FC392X, 21st April, 1970
23.	Manpower Requirements, FOI26-1, 10th September, 1970
24.	Field Grade Officer Effectiveness Report, AF Form 707 February, 1969
25.	Company Grade Officer Effectiveness Report, AF Form 77, June, 1969

APPENDIX 4

LIST OF DOCUMENTS SECURED FROM UNITED STATES AIR FORCE AIR UNIVERSITY - ROTC	
1.	Financial Management, Headquarters Operating Instruction 172-1, September, 1971
2.	Organization and Functions Chart Book, AUP23-1, Part V, November 1, 1971
3.	AFROTC Cost Report FY71
4.	The AFROTC Membership Report, AFROTCR45-1, September 1971
5.	Historically Speaking on Air Force ROTC, AU, September, 1971
6.	Air Force ROTC Education Program, AFROTCM 53-3, July, 1971
7.	Application and Agreement for the Establishment of Senior Air Force Reserve Officers Training Corps Unit, Air Force Form 1268, March, 1967
8.	Allocation and Utilization of Manpower Resources, AFROTC Regulation 26-1, January, 1971
9.	Call for FY 1973 Operating Budget, AFROTC, AU, November, 1971
10.	List of AFROTC Cadet Reports from Cadet Statistics Branch Cadet Information System
11.	Various reports on Enrollment and Production of Graduates from AFROTC Units, June, 1971
12.	General promotional literature from ROTC Programs
13.	Development of a Data Base for an AFROTC Management Control System, By E.C. Tupes, Captain D.L. Dieterly, Lieutenant Colonel A.L. Fortuna, and H.L. Madden AFHRL-TR-68-118, December, 1968
14.	Prediction of Officer Performance and Retention from Selected Characteristics of the College Attended by E.C. Tupes, and H.L. Madden, AFHRL-TR-68-119, December, 1968

APPENDIX 5: SAMPLE REPORTS FROM THE ASTRA MODEL

YEAR: FY72
SEMESTER: FALL

REPORT: CF01
DATE:
PAGE:

CADET FLOW OUTPUT SUMMARY

PROGRAM CODE	PROGRAM NAME	CLASS ENROLLMENT 4	3	2	1	OUTPUT MEASURES PASS	TURNBACKS	DROPOUTS	GRADUATE
1	AERO	100	60	50	40	147	18	49	36
2	ASTRØ	50	40	32	26	97	8	20	23

REPORT EXPLANATION	
SUBSYSTEM:	Cadet Flow
TIMING:	Year and Semester
FOCUS:	Program
COMMENTS:	The Cadet Flow subsystem shows the movement of cadets through academic levels. This report shows total program enrollment by cadet class for each program at the Academy. The output measures are the forecasted transitions of cadets by program.

UNITED
INSTITUTION

YEAR: FY73
SEMESTER: FALL

REPORT: CC03
DATE:
PAGE:

LOAD SUMMARY

PROGRAM CODE	PROGRAM NAME	COST CENTER CODE	COST CENTER NAME	4th CLASS CADET COURSES	4th CLASS % PROG LOAD	4th CLASS % C.C. LOAD	3rd CLASS CADET COURSES	3rd CLASS % PROG LOAD	3rd CLASS % C.C. LOAD	2nd CLASS CADET COURSES	2nd CLASS % PROG LOAD	2nd CLASS % C.C. LOAD	1st CLASS CADET COURSES	1st CLASS % PROG LOAD	1st CLASS % C.C. LOAD	ALL CLASSES CADET COURSES	ALL CLASSES % PROG LOAD	ALL CLASSES % C.C. LOAD
1	AERO	1	AERO	300	100	75												
		2	ASTRO	0	0	0												
			TOTAL	300	100													
2	ASTRO	1	AERO	100	100	25												
		2	ASTRO	0	0	0												
			TOTAL	100	100													

REPORT EXPLANATION	
SUBSYSTEM:	Cadet Course
TIMING:	Year and Semester
FOCUS:	Program and Academic Department
COMMENTS:	The Cadet Course subsystem provides course load information by program and cost center. This report shows the cadet course load on cost centers generated by each program, giving percentage of the program load borne by each cost center and the percentage of the cost center load generated by each program.

UNITED STATES AIR FORCE
INSTITUTION:

YEAR FY
SEMESTER: SM

REPORT: CH02
DATE:
PAGE:

RESOURCE CONTACT HOURS

COST CENTER: AERONAUTICS

TYPE	RESOURCE CATEGORY	SUBCATEGORY	SIZE	MINIMUM	AVERAGE	MAXIMUM
				CONTACT HOURS PER WEEK		
STAFF 1	TEACHING OFFICERS	AERO				
2	SUPPORT					
	TOTAL STAFF					
			SIZE	MINIMUM	AVERAGE	MAXIMUM
SPACE 1	CLASS-ROOMS	1 TABLE & CHAIRS	20 40			
	SUBTOTAL CLASSROOM					
2	LABORATORY	1 CHEMISTRY	16 20			
		2 PHYSICS	16 20			
	SUBTOTAL LAB					
	TOTAL SPACE					

REPORT EXPLANATION

SUBSYSTEM: Contact Hours
TIMING: Year and Semester
FOCUS: Academic Department
RESOURCES: Direct
COMMENTS: The Contact Hour subsystem gives contact hour information for all academic departments. This report shows weekly contact hour loads by resource type, category and subcategory.

YEAR:
SEMESTER:
DATE:

REPORT: RR01
PLAN:
PAGE: 1 of ?

DIRECT RESOURCE REQUIREMENTS

COST CENTER: AERO

RESOURCE TYPE, CATEGORY AND SUBCATEGORY	INPUT INVENTORY	ELEMENT	COMPUTATION BASIS	NAME AND VALUE	OUTPUT VALUE	OUTPUT UNITS
STAFF (MEN)						
1 - TEACHING OFFICERS		1	.2 + .2 *B SEC L5	5	1.2	MEN
		2	.4 + .2 *B SEC L15	60	12.4	MEN
		3	B + B*.05 MEN	13.6	.7	MEN
TOTAL	13					
SPACE (ROOM)						
1 - TEACHING SPACE						
1.1 CLASSROOM	8	1				
	4	2				
	2	3				
TOTAL	14					
2.1 LABORATORY	5	1				
TOTAL	5					

REPORT EXPLANATION

SUBSYSTEM: Resource Requirements
TIMING: Year and Semester
FOCUS: Academic Department and Support Department
RESOURCES: Direct
COMMENTS: The Resource Requirements subsystem gives direct and indirect resource requirements by cost center. This report shows direct resource requirements by resource type, category and subcategory. The planning factor for each resource is defined and the output values are given.

UNITED STATES AIRFORCE
INSTITUTION:

REPORT: MY02
PLAN:
PAGE:

RESOURCE REQUIREMENTS

COST CENTER: FACULTY

RESOURCE TYPE	CATEGORY	FY72		FY73		FY74		FY75		FY76	
		NO.	COST	NO.	COST	NO.	COST	NO.	COST	NO.	COST
STAFF (MEN)	1-TEACHING OFF	378	5670000								
	2-SUPPORT OFF	67	938000								
	3-SUPPORT	39	390000								
	TOTAL	484	6998000								
		NET	SOS	NET	SOS	NET	SOS	NET	SOS	NET	SOS
SPACE (SQ.FT.)	1-CLASSROOM	16240	0								
	2-LABORATORY	29990	0								
	3-SUPPORT	6670	0								
	TOTAL	52900	0								
		INV.	PROC'D								
EQUIPMENT (DOLLARS)	1-EXPENSE										
	2-INVESTMENT										
		INV.	PROC'D								
OTHER	1-OPERATING (O&M)										
	2-CAPITAL										
	3-REVENUE										

REPORT EXPLANATION

SUBSYSTEM: Multi-Year
TIMING: Multi-Year
FOCUS: Academic and Support Departments
RESOURCES: Direct and Indirect
COMMENTS: The Multi-Year subsystem gives information for the entire five year planning period. This report shows resource requirements, costs etc. by resource type and category.

REPORT: MY03
PLAN:
PAGE:

OPERATING COSTS

COST CENTER CATEGORY
COST CENTER SUBCATEGORY

RESOURCE TYPE	CATEGORY	FY72	FY73	FY74	FY75	FY76
STAFF	1-TEACHING OFF					
	2-SUPPORT OFF					
	3-SUPPORT					
EQUIPMENT	1 - EXPENSE					
OTHER	2 - O + M					
TOTAL						

REPORT EXPLANATION

SUBSYSTEM: Multi-Year
TIMING: Multi-Year
CONTROL: Cost Center Category and Sub-Category
RESOURCES: Direct and Indirect
COMMENTS: The Multi-Year subsystem gives information for the entire five year planning period. This report shows operating costs by resource type and category for each cost center category and sub-category.

34

UNITED STATES AIRFORCE
INSTITUTION:

REPORT: MY06
PLAN:
PAGE:

PROGRAM COSTS

PROGRAM CATEGORY
PROGRAM SUBCATEGORY

PROGRAM	CLASS	FY72 COST	FY72 COST/CH	FY73 COST	FY73 COST/CH	FY74 COST	FY74 COST/CH	FY75 COST	FY75 COST/CH	FY76 COST	FY76 COST/CH
1 AERO	4th										
	3rd										
	2nd										
	1st										
2 ASTRO	4th										
	3rd										
	2nd										
	1st										
	TOTAL										

REPORT EXPLANATION

SUBSYSTEM: Multi-Year
TIMING: Multi-Year
FOCUS: Program
COMMENTS: The Multi-Year subsystem shows information for a five year planning period. This report shows total and hourly program costs by cadet class within each program. Information is given by program category and sub-category.

UNITED STATES AIRFORCE
INSTITUTION:

REPORT: MY07
PLAN:
PAGE: 1 of 4

OUTPUT MEASURES

OUTPUT INDICES	FY72	FY73	FY74	FY75	FY76
PROGRAM CATEGORY					
TOTAL OPERATING COST					
TOTAL CADET CONTACT HOURS					
COST PER CADET CONTACT HOUR					
COST AS PERCENTAGE OF TOTAL					
AVERAGE CADET CONTACT LOAD PER WEEK					
TOTAL CADETS					
COST CENTER CATEGORY					
TOTAL OPERATING COST					
TOTAL CADETS					
TOTAL CADET CONTACT HOURS					
TOTAL STAFF CONTACT HOURS					
TOTAL COST PER CADET					
TOTAL COST PER CADET CONTACT HOUR					
TOTAL TEACHING COST					
TEACHING COST PER CADET					
TEACHING COST PER CADET CONTACT HOUR					
TEACHING COST PER STAFF CONTACT HOUR					
AVERAGE SECTION SIZE					
CADET TO STAFF CONTACT HOUR RATIO					

REPORT EXPLANATION

SUBSYSTEM: Multi-Year
TIMING: Multi-Year
FOCUS: Cost Center Category, Program Category
RESOURCES: Direct and Indirect
COMMENTS: Five years of information are given in the Multi-Year subsystem. This report shows several sets of output indices which give summary and unit cost information.

35

UNITED STATES AIR FORCE
INSTITUTION:

YEAR:
SEMESTER:
DATE:

RESOURCE REQUIREMENTS SUMMARY

REPORT: RR06
PLAN:
PAGE: 1 of 4

COST CENTER: FACULTY

RESOURCE TYPE, CATEGORY AND SUBCATEGORY	FALL SEMESTER NO. REQ'D	FALL SEMESTER NO. AUT'D	FALL SEMESTER COST REQ'D	SPRING SEMESTER NO. REQ'D	SPRING SEMESTER NO. AUT'D	SPRING SEMESTER COST REQ'D	TOTAL OVER YEAR NO. REQ'D	TOTAL OVER YEAR NO. AUT'D	TOTAL OVER YEAR COST REQ'D	TOTAL OVER YEAR COST AUT'D	TOTAL OVER YEAR COST DIFF	PERC. DIS.
STAFF (MEN												
1 - TEACHING OFFICERS												
1.1 PROFESSOR	18	20	135,000	18	20	135,000	18	20	270,000	300,000	30,000	8
1.2 ASSOC. PROF.	90	95	675,000	90	95	675,000	90	95	1,350,000	1,425,000	75,000	24
1.3 ASSI. PROF.	120	130	900,000	120	130	900,000	120	130	1,800,000	1,950,000	150,000	32
1.4 LECTURER	150	170	1,125,000	150	170	1,125,000	150	170	2,250,000	2,550,000	250,000	39
TOTAL	378	415										
2 - OTHER OFFICERS												
2.1 ADMINISTRATION	67	73	469,000	67	73							
2.2 OTHER ACAD. AG.												
2.3 RES. & PROF. DEV.												
3.4 LABORATORY												
3.5 MISCELLANEOUS												
TOTAL												
3 - SUPPORT												
3.1 TEACHING	39	42	195,000	39	42							
3.2 ADMINISTRATION												
3.3 OTHER ACAD. AG.												
3.4 RES. & PROF. DEV.												
3.5 LABORATORY												
3.6 MISCELLANEOUS												

REPORT EXPLANATION

SUBSYSTEM:	Resource Requirements
TIMING:	Year and Semester
FOCUS:	Academic Department and Support Dept.
RESOURCES:	Direct and Indirect
COMMENTS:	The Resource Requirements subsystem gives direct and indirect resource requirements by cost center. This report shows a summary of requirements by resource type, category and subcategory. Resource authorizations, requirements and the cost of these requirements are given.

YEAR:
SEMESTER:
DATE:

PROGRAM COSTING

REPORT: PC03
PLAN:
PAGE:

PROGRAM CATEGORY: ACADEMIC

PART ONE: COSTS

PROGRAM CODE	PROGRAM NAME	PROGRAM LEVEL	PROGRAM ENROL	COSTS DIRECT	COSTS INDIRECT	COSTS TOTAL	COST PER CADET
1	AERO	1 2	100	91,965	15,512	107,477	1,075
TOTAL PROGRAM							

PART TWO: OUTPUT MEASURES

AVERAGE COST PER CADET

AVERAGE COST PER - TURNBACK
- DROPOUT
- GRADUATE

REPORT EXPLANATION

SUBSYSTEM:	Program Costing
TIMING:	Year and Semester
FOCUS:	Program
COMMENTS:	The Program Costing subsystem gives cost information for each program offered at the Academy. This report gives direct costs, indirect costs, and unit costs for each program within the program category.

UNITED STATES AIR FORCE

INSTITUTION:

FORMATTED
INPUT
LISTING

REPORT: CH
DATE:
PAGE:

		COURSE							COURSE SCHEDULE						RESOURCES							
YEAR	SEM.	CODE	NAME	SECT. SIZE	CAT.	SUBC.	UNIT	SM HR CR	COST CENTER CODE	COST CENTER NAME	START	H/L	L/S	DAY	TYPE	CAT. CODE	CAT. NAME	SUBC. CODE	SUBC. NAME	CC	BASIS	QUANT
FY72	Fall	1	B131	21.4	1	2	3		1	AERO	1	2.0	40	DAY	1	1	TEACH	-	-	AERO	SECT.	1.0
															2	2	LAB.	1	AERO	AERO	SECT.	2.0
		2	B132	20.0	1	2	3		1		1	3.0	40	DAY	1	1	TEACH	-	-	AERO	SECT.	[illegible]
															2	2	LAB.	1	AERO	AERO	SECT.	1.0

COURSE CODE	CATEGORY NAME
1	UNDERGRADUATE
2	GRADUATE
3	RESEARCH
4	PUBLIC SERVICE
5	MILITARY
6	ATHLETIC

COURSE SUBC. CODE	NAME
1	LECTURE
2	LABORATORY
3	SEMINAR
4	INDIVIDUAL
5	DRILL

RESOURCE TYPE CODE	NAME
1	STAFF
2	SPACE
3	EQUIPMENT
4	OTHER

REPORT EXPLANATION

SUBSYSTEM: Data Editor

COMMENTS: In this subsystem data is checked for logical inconsistencies. This report shows the data contained on the COURSE input form. Information is given on number and size of course sections as well as scheduling and resource requirements information for each course.

YEAR: FY73
DATE:

REPORT: CF02
PLAN:
PAGE:

CADET CATEGORY ENROLLMENTS

DETACHMENT: 005 AUBURN UN.
CATEGORY: SENIOR
SUBCATEGORY: SOUTHEAST
CHARACTERISTICS: LG:Q:A-N

CADET TYPE	CADET CATEGORY	ENROLLMENT DIST.	ENROLLMENT AUTH.	ENROLLMENT ACTUAL	CADET SUBCATEGORY	ENROLLMENT DIST.	ENROLLMENT AUTH.	ENROLLMENT ACTUAL	OUTPUT MEASURES DROP-OUTS	OUTPUT MEASURES GRADU-ATE	OUTPUT MEASURES RETAINED
MALE	I-PILOT	40	240	220	REGULAR	60	144	132	13	46	31
					MINORITY	40	96	88	9	31	20
					SUBCATEGORY TOTAL		240	220	22	77	51
					CATEGORY TOTAL		240	220	22	77	51
					TYPE TOTAL		240	220	22	77	51

REPORT EXPLANATION

SUBSYSTEM: Cadet Flow
TIMING: Year
CONTROL: Detachment, Category, Subcategory
COMMENTS: This report shows the number and distribution of cadets by type, category and subcategory. Projected numbers of dropouts, graduates and retained cadets are shown.

UNITED STATES AIR FORCE
INSTITUTION:

YEAR: FY73
DATE:

REPORT: CH02
PLAN:
PAGE:

RESOURCE CONTACT HOURS

(HOURS/YEAR)

DETACHMENT: 005 AUBURN UN.
CATEGORY: SENIOR
SUBCATEGORY: SOUTHEAST
CHARACTERISTICS: LG:Q:A-N

RESOURCE TYPE	RESOURCE CATEGORY	SUB-CATEGORY	REQUIREMENTS BASIS NAME	REQUIREMENTS BASIS NUMBER	OUTPUT VALUE	RESOURCE SCHEDULE	CONTACT HOURS ROTC	CONTACT HOURS HOST
STAFF	OFFICER	TEACHING	SECTIONS	11	11	15	165	
STAFF	CIVILIAN	TEACHING	SECTIONS	11	11	15		165
STAFF	OFFICER	TEACHING	SECTIONS	16	16	30	480	

REPORT EXPLANATION

SUBSYSTEM: Contact Hours
TIMING: Year
CONTROL: Detachment, Category, Subcategory
COMMENTS: The Contact Hour subsystem calculates contact hour load information. This report gives the contact hour load on ROTC and host resources by resource type, category, and subcategory. The underlying computational steps are displayed (e.g. scheduling).

UNITED STATES AIR FORCE
INSTITUTION: AU-ROTC

YEAR: FY73
DATE:

REPORT: RR01
PLAN:
PAGE:

DETACHMENT: 005 AUBURN UN
CATEGORY: SENIOR
SUBCATEGORY: SOUTHEAST
CHARACTERISTICS: LG:Q:A-N

RESOURCE TYPE, CATEGORY AND SUBCATEGORY	INPUT INVENTORY	ELEMENT	PLANNING FACTOR COMPUTATION	BASIS	NAME	VALUE	OUTPUT VALUE	UNITS
STAFF								
1 OFFICER								
1 TEACHING	2	1	B/300	CH	GMC	375	1	MEN
		2	B/270	CH	POC	270	1	MEN

REPORT EXPLANATION

SUBSYSTEM: Resource Requirements
TIMING: Year
CONTROL: Detachment
COMMENTS: The Resource Requirements subsystem computes direct and indirect resource requirements for each detachment. This report shows direct resource requirements by category and subcategory and the planning factors which are used in the calculation process.

YEAR: FY73
DATE:

INDIRECT RESOURCE REQUIREMENTS

REPORT: RR02
PLAN:
PAGE:

DETACHMENT: 005 AUBURN UN
CATEGORY: SENIOR
SUBCATEGORY: SOUTHEAST
CHARACTERISTICS: LG:Q:A-N

RESOURCE TYPE CATEGORY AND SUBCATEGORY	INPUT INVENTORY	INPUT UNIT FACTOR	ELEMENT	PLANNING FACTOR BASIS COMPUTATION	NAME	VALUE	OUTPUT INTERMEDIATE (UNITS)	OUTPUT FINAL (DOLLARS)
STAFF								
1 SUPPORT	1	10,000	1	B/2	MEN	2	1	10,000
OTHER								
1-TDY	10,000		1	B				

REPORT EXPLANATION

SUBSYSTEM: Resource Requirements
TIMING: Year
CONTROL: Detachment
COMMENTS: The resource requirements subsystem computes direct and indirect resource requirements for each detachment. This report shows indirect resource requirements by category and subcategory and the planning factors which are used in the calculation process.

UNITED STATES AIR FORCE
INSTITUTION: AU-ROTC

YEAR: FY73
DATE:

REPORT: UC01
PLAN:
PAGE:

COURSE COST

DETACHMENT: 005 AUBURN UN
CATEGORY: SENIOR
SUBCATEGORY: SOUTHEAST
CHARACTERISTICS: LG:Q:A-N

COURSE CATEGORY	COURSE SUBCATEGORY	COURSE NAME	COURSE ENROLLMENT	CADET CONTACT HOURS	COURSE COST	COST PER CADET CONTACT HOUR
GMC	LECTURE	1 US MILITARY	230	6900	16,194	$2.35

REPORT EXPLANATION	
SUBSYSTEM:	Unit Cost
TIMING:	Year
CONTROL:	Detachment, Category, Subcategory
COMMENTS:	The unit cost subsystem produces cost data by course, by program, and by cadet category. This report shows course enrollments, cadet contact hours, and costs.

YEAR: FY73
DATE:

PROGRAM COST

REPORT: UC02
PLAN:
PAGE:

DETACHMENT: 005 AUBURN UN
CATEGORY: SENIOR
SUBCATEGORY: SOUTHEAST
CHARACTERISTICS: LG:Q:A-N

PROGRAM CATEGORY	COURSE LEVEL	PROGRAM ENROLLMENT	CADET CONTACT HOURS	PROGRAM LEVEL COST	COST PER CADET	COST/CADET CONTACT HOUR
SENIOR	AS100	230	6900	16,194	70.41	2.35
	AS200	144	4320	15,472	107.44	3.58
	AS300	92				
	AS400	84				
		550				

REPORT EXPLANATION	
SUBSYSTEM:	Unit Cost
TIMING:	Year
CONTROL:	Detachment, Category, Subcategory
COMMENTS:	The unit cost subsystem produces cost data by course, by program, and by cadet category. This report shows program enrollments, cadet contact hours and costs.

UNITED STATES AIR FORCE
INSTITUTION: AU-ROTC

REPORT: MY05
PLAN:
PAGE: 1 of 2

OUTPUT MEASURES

OUTPUT INDICES	FY73	FY74	YEARS FY75	FY76	FY77

<u>PROGRAM CATEGORY</u>

(Junior or Senior)

TOTAL COST
TOTAL CADET CONTACT HOURS
COST PER CADET CONTACT HOUR
COST AS PERCENTAGE OF TOTAL
TOTAL CADETS
COST PER CADET

<u>CADET CATEGORY</u>

(Pilot, Navigator, etc.)

TOTAL COST
TOTAL CADET CONTACT HOURS
COST PER CADET CONTACT HOUR
COST AS PERCENTAGE OF TOTAL
TOTAL CADETS
COST PER CADET
TOTAL GRADUATES
COST PER GRADUATE
TOTAL DROPOUT
COST PER DROPOUT
TOTAL RETAINED
COST PER RETAINED

<u>DETACHMENT CATEGORY</u>

(regional, areas)

TOTAL COST
TOTAL CADETS
TOTAL MEN
TOTAL CADET CONTACT HOURS
TOTAL STAFF CONTACT HOURS
COST PER CADET
COST PER MAN
COST PER CADET CONTACT HOUR
COST PER STAFF CONTACT HOUR
TOTAL SECTIONS
AVERAGE SECTION SIZE
CADET TO STAFF CONTACT HOUR RATIO

<u>RESOURCE CATEGORY</u>

(staff, other)

TOTAL COST
TOTAL RESOURCE CONTACT HOURS
COST PER RESOURCE CONTACT HOUR

<u>BUDGET FUNCTION</u>

TOTAL COST
PERCENTAGE OF TOTAL

REPORT EXPLANATION	
SUBSYSTEM:	Multi-Year
TIMING:	Multi-Year
CONTROL:	Program, Cadet, Detachments or Resource Category
COMMENTS:	Five years of information are displayed by the Multi-Year subsystem. This report shows several sets of output indices what gives summary and unit cost information by program category, by cadet category, by detachment category and by budget functions

FORMATTED
INPUT
LISTING

REPORT: DF01
PAGE:

STRUCTURAL DEFINITIONS

DETACHMENT CODE	CATEGORY NAME
1	JUNIOR
2	SENIOR

DETACHMENT CODE	SUBCATEGORY NAME
1	NEW ENGLAND
2	MID EAST
3	GREAT LAKES
4	PLAINS
5	SOUTH EAST

TYPE INSTITUTION

CODE	NAME
LG	LAND GRANT
ST	STATE
P	PRIVATE
CA	CHURCH AFFILIATED
MG	MUNICIPAL GOV'T
N	NATIONAL
MGST	MILITARY-STATE

CO-LOCATED ROTC

CODE
AF
AFAN
AFA
AFN

TYPE SYSTEM

REPORT EXPLANATION	
SUBSYSTEM:	Data Editor
COMMENTS:	In this subsystem data is checked for logical inconsistencies. This report shows the data contained on the detachment definition report form. Information is given on detachment categories and subcategories, the types of systems and institutions which have ROTC detachments and co-located ROTC detachments.

INTERACTIVE PROMPTER DIALOGUE

EXPERIMENT CONTROL

(Inexperienced User)

EXPERIMENT CONTROL SECTION

DO YOU WISH AN EXPLANATION OF EXPERIMENTAL CAPABILITIES?

ANSWER "YES" OR "NO"

YES

EXPERIMENTS ARE PERFORMED BY TEMPORARILY ALTERING THE BASE CASE DATA, AND ACTIVATING THE USAFA ASTRA MODEL

THE EXPERIMENTS HAVE BEEN CONVENIENTLY GROUPED AND NUMBERED BY SUBSYSTEM

FOR EACH EXPERIMENT, CERTAIN KEY DATA MUST ALWAYS BE SPECIFIED:

YEAR/SEMESTER INDICATOR START	- THIS INDICATES THE ACADEMIC YEAR AND TERM IN WHICH THE EXPERIMENTAL CHANGE FIRST TAKES EFFECT.
YEAR/SEMESTER INDICATOR STOP	- THIS INDICATES THE ACADEMIC YEAR AND TERM IN WHICH THE EXPERIMENTAL CHANGE IS TO BE TERMINATED.
OPERATOR	- THE KIND OF EXPERIMENTAL CHANGE: AC - ABSOLUTE CHANGE PC - PERCENTAGE CHANGE RE - REPLACE GL - GOAL VALUE
EXPERIMENT VALUE	- THE VALUE OF THE EXPERIMENTAL CHANGE. DEPENDING ON THE SPECIFIC EXPERIMENT ADDITIONAL INFORMATION MUST BE SPECIFIED TO INDICATE, FOR EXAMPLE, WHICH COST CENTERS ARE AFFECTED. IN ALL CASES, A DETAILED EXPLANATION IS AVAILABLE.

EXPERIMENT CONTROL

(Inexperienced User)
(Cont'd)

DO YOU WISH A LIST OF EXPERIMENTS AVAILABLE? ANSWER "YES" OR "NO".

YES

FOR WHICH SUBSYSTEM? ANSWER CF, CC, CH, RR, PC, WC, NONE

cc

LIST OF EXPERIMENTS

SUBSYSTEM CADET COURSE (CC)

KEY	SEQUENCE NUMBER	EXPERIMENT
2	01	COURSE ENROLLMENT
2	02	AVERAGE COURSE LOAD
2	03	SECTION SIZE POLICY
.	.	.
.	.	.
.	.	.

DO YOU WISH ANY MORE LISTS? ANSWER "YES" OR "NO"

NO

WHICH EXPERIMENT DO YOU WISH TO PERFORM?

KEY	SEQUENCE
I	II
2	03

DO YOU WISH A DETAILED DESCRIPTION OF THE TERMS USED IN FORMULATING THIS EXPERIMENT? ANSWER "YES" OR "NO".

YES

EXPERIMENT CONTROL

(Inexperienced User)
(Cont'd)

YEAR/SEMESTER INDICATOR START	-	THIS INDICATES THE ACADEMIC YEAR AND TERM IN WHICH THE EXPERIMENTAL CHANGE FIRST TAKES EFFECT
YEAR/SEMESTER INDICATOR STOP	-	THIS INDICATES THE ACADEMIC YEAR AND TERM IN WHICH THE EXPERIMENTAL CHANGE IS TO BE TERMINATED.
OPERATOR	-	THE KIND OF EXPERIMENTAL CHANGE: AC - ABSOLUTE CHANGE PC - PERCENTAGE CHANGE RE - REPLACE GL - GOAL VALUE
EXPERIMENT VALUE	-	THE VALUE OF THE EXPERIMENTAL CHANGE
COST CENTER INDIVIDUAL	-	THE INDIVIDUAL COST CENTERS TO WHICH EXPERIMENT APPLIES
COST CENTER CATEGORY	-	THE COST CENTER CATEGORY TO WHICH EXPERIMENT APPLIES (LEAVE INDIVIDUAL COST CENTERS BLANK)

PLEASE GIVE THE EXPERIMENT CONTROL INFORMATION UNDER THE HEADINGS PROVIDED.

(ALL IS REPRESENTED BY 9'S).

YEAR	SEMESTER		
START	STOP	OPERATOR	VALUE
II I	II I	AA	DDDDDD
72 1	75 2	pc	10.0

COST CENTERS

INDIVIDUAL

II II II II II II II II

99

DO YOU WISH TO SPECIFY ANY MORE EXPERIMENTS? ANSWER "YES" OR "NO".

NO

EXPERIMENT CONTROL

(Experienced User)

EXPERIMENT CONTROL SECTION

EXPLANATION? "YES" OR "NO"

NO

LIST? "YES" OR "NO"

NO

EXPERIMENT

KEY	SEQUENCE
II	II
2	03

YEAR - SEMESTER

START	STOP	OPERATOR	VALUE
II I	II I	AA	DDDDDD
72 1	75 2	pc	10.0

COST CENTERS

INDIVIDUAL

II II II II II II II II

99

MORE EXPERIMENTS? "YES" OR "NO"

NO

(Inexperienced User)
INTERACTIVE PROMPTER DIALOGUE
REPORT CONTROL

REPORT CONTROL SECTION

DO YOU WISH A DETAILED EXPLANATION OF REPORT CONTROL SPECIFICATION? ANSWER "YES" OR "NO".

YES

REPORT CONTROL IS SPECIFIED BY:

1. THE REPORT NAME (CF01, CH02, ETC.)
2. REPORT TIMING. THE YEAR AND SEMESTER FOR WHICH THE REPORT IS DESIRED.
3. INDIVIDUAL REPORT CONTROL. YOU CAN ASK FOR SPECIFIC REPORTS BY:
    - COST CENTER
    - COST CENTER CATEGORY
    - PROGRAM
    - PROGRAM CATEGORY
4. GROUP REPORT CONTROL. YOU CAN ASK FOR ALL REPORTS AVAILABLE WITHIN A:
    - COST CENTER CATEGORY
    - COST CENTER SUBCATEGORY
    - PROGRAM CATEGORY
    - PROGRAM SUBCATEGORY

DO YOU WANT A LIST OF AVAILABLE REPORTS? ANSWER "YES" OR "NO".

YES

SPECIFY THE SUBSYSTEM FOR WHICH YOU WANT A LIST OF REPORTS.

CHOOSE ONE OF THE FOLLOWING: (CF, CC, CH, RR, PC, MY, NONE)

pc

REPORT CONTROL (Cont'd)

PROGRAM COSTING

REPORT NO.	REPORT NAME	INDIVIDUAL CONTROL	GROUP CONTROL
PC01	COST CENTER SUMMARY	COST CENTER	COST CENTER CATEGORY, SUBCATEGORY
PC02	COURSE COSTING	COST CENTER	COST CENTER CATEGORY, SUBCATEGORY
PC03	PROGRAM COSTING	PROGRAM CATEGORY	
PC04	PROGRAM COSTING SUMMARY	PROGRAM CATEGORY	

DO YOU WISH ANY OTHER LISTS OF AVAILABLE REPORTS? ANSWER "YES" OR "NO".

NO

YOU CAN NOW REQUEST THE REPORTS YOU WISH PRINTED. PLEASE ENTER THE NECESSARY INFORMATION UNDER THE HEADINGS PROVIDED.

REPORT CONTROL INFORMATION

REPORT NO.	TIMING	INDIVIDUAL CONTROL	GROUP CONTROL
AAII	III III III II	II II II	I I I I
pc02	712	99	

DO YOU WISH ANY OTHER REPORTS? ANSWER "YES" OR "NO".

NO

(Experienced User)

INTERACTIVE PROMPTER DIALOGUE

REPORT CONTROL

REPORT CONTROL SECTION

EXPLANATION? "YES" OR "NO"

NO

LIST? "YES" OR "NO"

NO

REPORT CONTROL INFORMATION

REPORT NO.	TIMING					INDIVIDUAL CONTROL					GROUP CONTROL			
AAII	III	III	III	III	III	II	II	II	II	II	III	III	III	III
pc02	712					99								

REPORTS? "YES" OR "NO"

NO

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Resource Prediction Model - CAMPUS

Organization SRG - Systems Research Group Inc.

Model CAMPUS VI and CAMPUS VII (Comprehensive Analytical Methods for Planning in University/ College Systems)

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Resource Prediction Model - HELP/PLANTRAN

Organization	MRI	- Midwest Research Institute
Model	HELP	- Higher Education Long-range Planning
	PLANTRAN	- Planning Translator
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Resource Prediction Model - RRPM

Organization	NCHEMS	- National Center for Higher Education Management Systems
	WICHE	- Western Interstate Commission on Higher Education
Model	RRPM-1	- Resource Requirements Prediction Model
Contacts	Ben Lawrence, Director NCHEMS at WICHE	
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Resource Prediction Model - SEARCH

Organization	PMM	- Peat, Marwick, Mitchell & Co.
	PML	- Peat, Marwick, Livingston & Co.
Model	RAPID	- Remote Access Planning for Institutional Development, 1967
	CAP:SC	- Computer-Assisted Planning for Small Colleges, 1969
	SEARCH	- System for Exploring Alternative Resource Commitments in Higher Education, 1970
Contact	George Keane and James Daniel at PMM & Co.	

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Resource Prediction Model - MSU

Organization — MSU - Michigan State University

Model — A Systems Model for Management, Planning and Resource Allocation in Institutions of Higher Education.

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Resource Prediction Model - TULANE

Organization	RELCV	- Regional Education Laboratory for the Carolinas and Virginia.
Model	TULANE	- Computerized Simulation Model for Relating College and University Cost Structure to Institutional Goals, Plans and Characteristics
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Resoruce Prediction Model - RAND

Organization — The Rand Corporation

Model
- Resources and Cost Model for an Air Force Resident Technical Training Course
- The Pilot Training Models

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Resource Prediction Model - YARDSTICK

Organization | The Yardstick Project
Model | The Growth Gauge and the Planning Model
Contacts | James Hardie, Chairman; Fred Pinkham, Director

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GLOSSARY OF TERMS

ACADEMIC (staff inventory, activities, duties, space)

- pertaining to the teaching and research body of the institution of higher education.

ACADEMIC YEAR

- that part of the calendar year during which instruction occurs.

ACTIVITY

- a basic element to describe the teaching of an activity (lecture, laboratory or seminar type) or alternatively non-academic pursuits such as athletics, field trips, etc.

Note: A course could be made up of more than one activity, such as a lecture plus a laboratory.

ADMINISTRATIVE (support staff, offices, duties)

- connected with the management or executive function of the institution.

AUDIO-VISUAL AIDS

- motion pictures, slides, phonograph records, educational television, computer assisted instruction, and other materials used as a teaching aid.

AUTOMATED EXPERIMENTATION

- submission of control instructions which trigger experimental operations. This temporarily overrides base data.

BASIS (resource allocation)

- one of several factors used to calculate resource allocations within a cost model, for example, functions, of the number of students, activities, sections, programs, classrooms, etc.

BATCH

- used to describe a computer system where the users queue up to use the computer facilities one at a time.

C.A.I. (Computer Assisted Instruction)

- a teaching method in which academic staff-student contact is replaced by support staff-student-equipment contact. The academic staff can design other (software) programs for the equipment (hardware).

CAPITAL (cost, expenditures)

- the cost of, or expenditures for, the acquisition of fixed assets such as buildings, other properties, and some types of equipment.

CLASSROOM

- the physical space required to hold a seminar, tutorial or lecture activity.

CLASS SIZE

- the number of students enrolled in one section of an activity. Note: Class size is equivalent to section size.

COMPREHENSIVE (model)

- dealing with all resources used in the educational process.

CONTACT HOUR

- time period of direct contact between students, staff, space, equipment and other resources.

CONTROL

- ability of the user to specify individual reports or sets of reports out of the whole menu of reports available.

CONVERSION

- the transformation of the units of the elements of a model. An example is the conversion of space contact periods per week to number of rooms.

COURSE

- a type of instructional activity (lecture, lab or seminar) in which a student may participate. A course may consist of more than one activity.

CREDIT (course unit weight)

- the value given for the successful completion of a unit of course-work.

CURRICULUM

- the set of courses that students take at each level of their program or major.

DATA (base, collection, sheets)

- facts and figures collected from historical records, extrapolation of future trends, or policy.

DATA EDITOR

- a series of steps through which input data is checked to ensure that it conforms to user specified constraints.

DEPARTMENT

- an organizational unit that performs a teaching or instructional function, supplies support services or provides a convenient point of aggregation.

DEPENDENT VARIABLES

- those line items calculated from the interrelationship of two or more previously calculated line items

DEVELOPMENTAL (model)

- in formative stages of conceptualization, programming, testing or validation.

DIRECT (costs, operating resources)

- are costs and resources built up at the course level and based on the number of contact periods.

DISCIPLINE

- a specific branch of knowledge or learning with which a department or program is concerned.

ENDOGENOUS (variable, array)

- an internally generated value of a variable or array in a model.

EXOGENOUS

- an externally supplied input value of a variable or array in a model.

EXPERIMENT

- alteration of base data in order to assess implications of the changed data.

FACILITIES

- the physical space and equipment resources of the institution.

FACTORS (planning, economic, failure)

- elements or constituents used as input planning values for a cost model.

FACULTY

- academic staff members in the institution.

FIXED DIMENSION

- a model which is constrained to an absolute maximum number of data elements.

FIXED FORMAT

- report format that is an integral part of the model and can not be changed by the user.

FORMAT

- the general make-up or arrangements of the computer prepared input/output reports and graphs.

GENERALIZED (model)

- having the ability to process information from more than one educational institution.

GROSS REQUIREMENTS

- requirement projection that does not take into account existing inventory.

INDEPENDENT VARIABLES

- those line items for which the user can directly specify projections.

INTERVENTION

- the ability of the model to allow the user to interrupt the processing order to modify numerical calculations or structural form prior to subsequent processing.

INVENTORY (students, staff, space)

- an itemized list or catalogue of the stock of students, staff or space.

LABORATORY (space)

- room or building space allocated to scientific experimentation or research and can be characterized by special equipment or service requirements.

LECTURE (rooms, halls)

- a room or space in which instruction is given.

MANAGEMENT INFORMATION SYSTEM (MIS)

- a system oriented to providing management with control and planning information by making readily available structured data characterizing the institution.

MANUAL EXPERIMENTATION

- change of cards in input deck - represents more permanent change in basic data.

MARGINAL COST

- the change in total cost that results from an increase or decrease in the output by one unit.

MODULAR

- a computer model having more than one segment, component or subroutine.

MULTI-CASE

- a model which allows comparison of numerous experiments with the base case, on one report.

MULTI-LEVEL (time)

- the ability to perform analysis for more than one unit of time.

MULTI-YEAR

- the capability of performing simulations across more than one year.

NET REQUIREMENTS

- requirement projection that is gross requirement minus the existing inventory.

NON-ACADEMIC (staff, activities, duties, space)

- pertaining to administration and management of an institution of higher education.

NON-TEACHING DUTY

- a job or task fulfilled by the academic staff besides their instructional duties, such as the chairman of the department.

OFFICE (space, cost)

- the rooms in which the administrative, academic and support staff are housed to carry out their duties.

OPERATIONAL (model)

- reliable software being exercised by knowledgeable decision-makers in the process of considering alternative decisions.

OTHER RESOURCES

- those resources or miscellaneous costs that cannot be categorized as staff or space.

PARTICIPATION RATES

- Program: the proportion or percentage of students enrolled at the institution selecting a certain program.

- Course: the proportion or percentage of students enrolled in a program selecting a particular course.

PORTABILITY

- the ability of the model to be run on more than one computer without extensive reprogramming.

PLANNING HORIZON

- the time span for which a plan is projected.

P.P.B.S. (Planning, Programming and Budgeting System)

- a management system whose purpose is to aid an institution in optimizing the effectiveness of resource allocations in terms of objectives. This is achieved primarily through the development, analysis and presentation of information regarding the significant costs and benefits of operational alternatives.

  The main elements of a PPB system are:

  1) Systematic analysis and evaluation of alternative programs using tools such as a cost model.

  2) Long-range planning.

  3) Information system to monitor progress and costs against the approved plan.

PROGRAM (major)

- a group of interdependent courses contributing to a common objective; usually for degree of diploma granting purposes.

PROGRAM COSTING

- allocation of total resource costs to instructional programs in order to evaluate the effectiveness of each program in view of its objectives.

SECTION SIZE

- number of students in a class group using space and staff.

SECTION CONTACT HOURS (per lesson)

- the number of hours per lesson times the number of sections.

SEMINAR (room)

- the room or space where a group of supervised students meet to discuss or do research or advanced study.

SPACE CONTACT HOURS (per lesson)

- the number of section hours (by size range) per lesson times the number of sections of the specified size. A measure of the load being generated on space.

STAFF CONTACT HOURS (per lesson)

- the number of hours per lesson, times the number of sections, times the number of staff members per section.
  A measure of the load being generated on staff.

STUDENT CONTACT HOURS (per lesson)

- the number of hours per lesson a course meets times the number of students enrolled in the course.

STUDENT FLOW (model)

- a model which accepts student inventory information at one point in time, then calculates the movement of students through programs and levels through a set of transition rates.

SUPPORT STAFF (academic, administrative)

- ancillary institutional employees which aid both academic and administrative staff (e.g. technician, secretary, etc.).

TEACHING DUTY

- the job or task fulfilled by the academic staff in giving teaching instruction in lectures, labs or seminars.

TEACHING METHOD

- the mix of resources (human, equipment, space, time) involved directly with a class in the teaching process.

TIME-SHARING

- used to describe a computer system where multiple users share and use the computer facilities simultaneously.

TRANSITIONS (students, staff)

- the act of changing states or remaining within a state, from one simulation period to the next. States may be characterized by academic levels, ranks, years, etc.

TRANSITION RATE

- the movement of students from one program level to another expressed as a percentage pass, turnback or dropout.

UTILIZATION (room, station, classroom, space)

- the ratio, something expressed as a percentage of the amount of resource used over the amount of resource available.

VARIABLE DIMENSION

- model size can be altered to accommodate user.

VARIABLE FORMAT

- the ability to allow the user to specify report format.