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ABSTRACT

Beginning January 1, 1969, Systems Research Group (SRG) undertook a project to develop operational cost simulation models of three of the colleges of applied arts and technology in Ontario. These models, and the data needed to feed them, have been developed and are now operating. SRG describes their progress to date and identifies the remaining activities they have undertaken. A computer aided information system has been designed and set up in the colleges. It includes procedures and forms for gathering and preparing the data needed as well as for reporting on the results of a simulation. (TC)

THE CAMPUS (CAATS) ^{2} PROJECT

VOLUME I

A PROGRESS REPORT ON THE DEVELOPMENT OF COST SIMULATION MODELS FOR THREE ONTARIO COLLEGES OF APPLIED ARTS AND TECHNOLOGY

S R G

SYSTEMS RESEARCH GROUP

November 1969

130 Bloor Street West
Toronto 5, Ontario
Tel: (416) 964-8411

501 Fifth Avenue
New York, N.Y. 10036
Tel: (212) 682-1287

CAMPUS (CAATS)^2

An Explanation of the Acronym

CAMPUS – Stands for Comprehensive Analytical Methods for Planning in University Systems. The CAMPUS model was first developed for universities and health sciences complexes and provided the basic technology that has been adapted for the community colleges.

CAATS^2 – Stands for Computerized Analysis Adapting the Techniques of Simulation to Colleges of Applied Arts and Technology. This acronym was contributed by Dr. Bowen, the president of Niagara College to describe the adaptation of the basic CAMPUS methodology.

Thus, the combined acronym CAMPUS (CAATS)^2 stands for the present system that has been developed to simulate the operations of the colleges of applied arts and technology.

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SUMMARY

In this report we have described our progress to date and some of our initial findings. More detailed information on the project is available in other reports that are either in draft form or still in preparation as shown in Table I.

Simulation models for each of the three pilot colleges are now operational on data gathered from the colleges. We are presently carrying out the first simulation experiments for them and thus beginning the evaluation phase of the project. An information system has been designed and set up in the colleges. It includes procedures and forms for gathering and preparing the data needed as well as for reporting on the results of a simulation. A computer terminal has been installed in each college to allow it to communicate with its simulation model and data that have been stored on an IBM 360-65 computer in Ottawa. The economic reason for using the large computer is shown in Table II. In the appendices of this report we have described the kinds of problems that can be addressed with CAMPUS (CAATS) ^{2} and some sample analyses.

Preliminary estimates incidate that the cost and time required to implement CAMPUS (CAATS) ^{2} in the other CAATs will vary with the size of the institution and the number of colleges that proceed together. The elapsed time needed to develop an operational model of one of the other

colleges will be no less than 4 months and no more than 6 months at a cost of between $15,000. and $36,000. The annual operating cost, including time of internal personnel, external technical assistance and computer time, will be between $10,000. and $20,000. per year.

The pilot phase of this project will be completed before the end of January. The initial results thus far have been most encouraging and we are confident that the final assessment will demonstrate clearly the benefits of the system that has been developed.

TABLE I

PROJECT REPORTS

Volume I – The CAMPUS (CAATS) ^{2} Project:
A progress report on the development of cost simulation models for three Ontario colleges of applied arts and technology, November 196[illegible]

Volume II – CAMPUS (CAATS) ^{2} Input Documents

Volume III – CAMPUS (CAATS) ^{2} System:
1. Information requirements and reporting Structure
2. Output reporting structure
3. User command language
4. Remote CAMPUS

Volume IV – CAMPUS (CAATS) ^{2}
Sample Input and Output Reports

Volume V – CAMPUS (CAATS) ^{2}
The Pros and Cons of existing formula financing systems and a suggested new approach

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The following documents are in preparation:

CAMPUS (CAATS) ^{2} – Its use in planning physical facilities

CAMPUS (CAATS) ^{2} – Its use in evaluating changes in academic plans and policies

CAMPUS (CAATS) ^{2} – Its use in evaluating changes in administrative plans and policies

CAMPUS (CAATS) ^{2} – Its information requirements and a design of general information systems for operating control and reporting

CAMPUS (CAATS) ^{2} – Users Manual

CAMPUS (CAATS) ^{2} – What it is; how to use it; what it costs

CAMPUS (CAATS) ^{2} – A cost benefit evaluation and recommendations on its future

TABLE II

The Cost and Time of Simulating the Operations of a College of Applied Arts and Technology for 10 Years using CAMPUS (CAATS) [2]

Calculations Done By *1	IBM 360-85 Computer	IBM 360-65 Computer	IBM 360-40 Computer *2	Man and a Calculator *3
Time Needed	30 seconds	3 minutes	12 hours	6 months
Cost	$30.00	$40.00	$1,200.00	$4,000.

*1 Estimated number of calculations and steps to be followed 150,000,000.

*2 An estimate only it may not be technically feasible run on this size machine.

*3 Assuming no errors in calculations or procedure.

A. INTRODUCTION

Beginning January 1st 1969, Systems Research Group undertook a project to develop operational cost simulation models of three of the Colleges of Applied Arts and Technology in Ontario. These models, and the data needed to feed them, have been developed and are now operating. This report describes our progress to date and identifies the remaining activities in the study and from the initial results thus far suggests alternative ways of proceeding beyond the present undertaking.

B. A REVIEW OF COMPLETED PROJECT ACTIVITIES

The following is a list of the major project activities that were identified in the original proposal of September 4th 1968:

" a) Meet with the full committee of presidents, their administrative representatives, planners and architects to define the range of planning problems facing the CAATS. The scope of the model in terms of the analyses that it would be able to perform and the kind of information that it could supply would be identified at this time. While the pilot model would not be designed necessarily to handle all the specific problems of each of the colleges it would be built in such a way that it could be expanded to do so in the event that the pilot project proved its worth.

b) Prepare the technical systems design specifications of the model including its data requirements and the form and substance of reports that it would generate.

c) Assess in detail the proposed model and its ability to cope with specific planning problems of the three sample colleges. Make whatever modifications are necessary in order to accomplish this.

d) Develop with the three colleges the information requirements of the model and help them to formulate the kinds of planning analysis that they will carry out using the model when it is completed.

e) Carry out all computer programming to have the model working on a computer that is made available to the colleges, thoroughly test the programs and prepare them for use by the pilot colleges.

f) Work with the colleges in helping them to use the new tools on a variety of planning problems and iron out any remaining computer programming or model design problems.

g) Consider the following with respect to the pilot model and its wider use by the other colleges:

- The cost of implementing the model in the other colleges broken down as to initial cost and its ongoing operational costs.

- The potential benefits from its use to various types and sizes of colleges.

- The organizational questions of how the model would be made available to the colleges and the role of their own personnel in using it.

- The means by which the colleges would physically communicate with the model and perform analyses on it. This would include the question of confidential data.

- The question of training administrators in understanding the full potential and usefulness of the new tools and exactly how they can be used by them on their problems.

- The information needs of the model and their implications in a wider sense for information systems design within the colleges, including an assessment

of the costs and benefits of computerized and manual information systems on staff, students, space, finance and so on to be integrated with the model and its communications network.

h) Present the results as steps (g) and (f) to those who were involved in step (a) for their comments and criticisms and discuss in particular the relevance of results of step (f) to the problems of the wider group of colleges.

i) Consider the technical requirements, the cost and benefits, the information requirements, and the compatability problems involved in developing a 'systems level' model of all of the colleges.

j) Prepare a report summarizing the results of the project and make recommendations on any next steps deemed to be desirable. "

Steps a, b, c, d and e have all been completed. Step f is in progress; step g is in progress and our initial findings in this area are reported on in this document; step h has yet to be undertaken and will probably take place in the first part of January; step i is in progress and our initial findings are reported on in this document; and step j has been begun as demonstrated by the reports that accompany this summary.

C. INFORMATION SYSTEMS DESIGN

A complete system for gathering information needed by the model has been devised. Forms and coding sheets that describe information on staff, students, space, finance, programs and curricula, and general policy have been prepared, tested and used in the colleges. The document entitled "CAMPUS (CAATS)^2 Input Documents" contains a set

of each one of the coding sheets that has been used. This information is not only useful to the model directly, but also indirectly to the colleges themselves. A computer program has been written as an adjunct to the main model that analyses this information and puts it into readable report formats that can be used by the administration. Samples of these reports are contained in section A of the document "CAMPUS (CAATS) ^{2} Sample Input and Output Reports".

The document entitled "CAMPUS (CAATS) ^{2} Systems" describes the way in which data are gathered, how they are processed and analyzed and the relationship of the reporting system to the basic data contained in the files.

In addition to the design of this system to meet the needs of the computer model we have begun a study to analyze the broader information needs of the colleges for purposes of internal control and day-to-day information requirements. An initial design of this information is currently being prepared and should be ready for discussion by the first week in December. We hope to produce, as a result of this study, general recommendations on the kind of information that should be maintained, the form in which it should be maintained, and the integration of this data with the operating needs of the colleges and the Department of Education. Included in our final report on this area will be estimates of the costs and benefits to be derived from

developing this system in a number of ways including computerized extensions of the existing model information system as well as manual extensions of it.

D. MANAGEMENT AND PLANNING REPORTS

An extensive set of reports has been developed for the model. These can provide concise summaries or very detailed elaborations depending on the needs of the user. Information can be provided on one particular simulation period, or summarized over a number of periods into the future. The selection of reports is at the complete control of the user and he may ask for or delete any or all of the reports available. Information can be produced in both tabular and graphical form. The graphs are generated by a Calcomp plotter that produces continuous line graphs from the output of the model. The document entitled "CAMPUS (CAATS)^2 Systems" has a detailed section describing all of the reports that are available and the document entitled "CAMPUS (CAATS)^2 Sample Input and Output Reports" contains examples of each of the reports that are available.

An additional feature of the reporting system is that it has been developed so that it can function not only on simulated data from the model, but also on historical data that is gathered to describe what has actually taken place in a particular semester or year.

Thus these reports, or rather the reporting system from the model, can be combined to produce an information system that supplies continuous information over time in the same format. In other words, should a person in one of the colleges want to get information on the costs of a particular educational program he would select a report number that gave him the amount of detail he wanted. If he were interested in information on what had happened in 1967, then he would go to the information system and receive an historical summary. If he wanted information on what would likely take place in 1972 he would ask for a report from the simulation model. The only difference in the two reports would be that one report would be entitled "simulated", the other "historical", but the format and presentation of data would be the same. This concept helps to develop confidence in the use of the system and make it easy for people to recognize the data as presented and get the maximum amount of meaningful information from it. It should be emphasized, however, that these reports are for management and planning purposes and are not intended to include the detailed control functions, in particular of the accounting departments of the colleges.

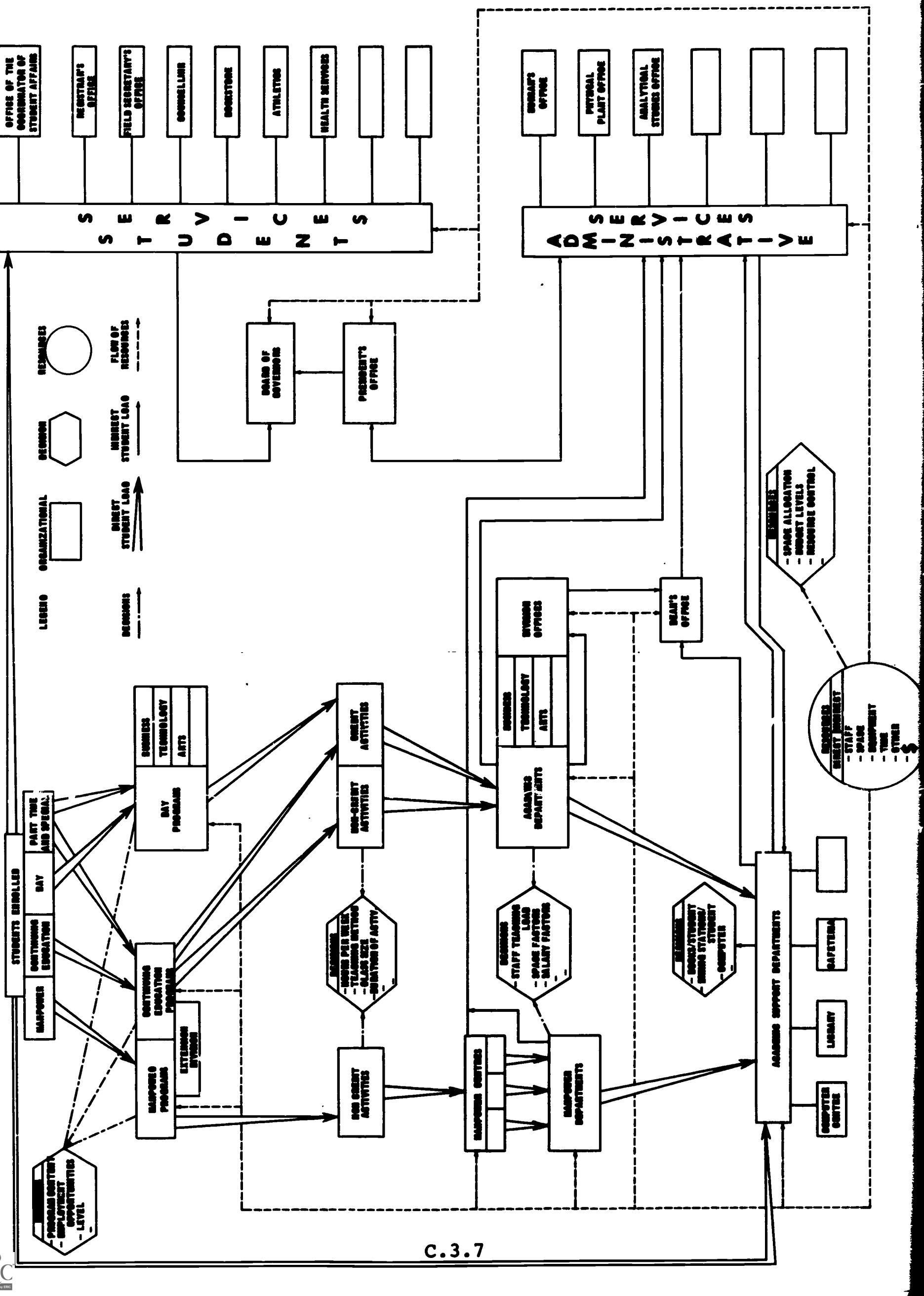
The reports that are available from the model are structured not only on an organizational basis, that is, by division, department, etc., but also on a program basis. Thus the colleges can be looked at from

one of two different viewpoints and the cost of its operation analyzed from both with respect to determining the impact of making changes in curriculum, administrative policy, teaching methods, etc. The program oriented reports also provide a useful adjunct to a formula financing or program budgeting system as will be pointed out later on in this report.

E. THE CAMPUS (CAATS)^2 SIMULATION MODEL

At present we have developed a fully operational and tested computer model which can represent each of the three colleges we are dealing with in the pilot study. This model can be adapted with relatively minor modifications to the other colleges in the system. The computer program presently consists of 15,000 Fortran language statements, and is being operated on an IBM 360-65 computer. Some twelve programmers and systems designers were involved in the model development effort, and while the system is now operational, they are continuing to modify and add improvements to it. The figure entitled "Colleges of Applied Arts and Technology Schematic and Resource Loading" describes the basic logical structure of the model. In essence the model accepts descriptions of the academic programs being offered in the college, the way in which they are being carried out, combines this with quantitative descriptions of administrative policies, and simulates the operations of the institution under these conditions.

Figure 1


COLLEGES OF APPLIED ARTS AND TECHNOLOGY
SCHEMATIC OF RESOURCE LOADING
STUDENTS
ADMINISTRATIVE
OFFICE OF THE COORDINATOR OF STUDENT AFFAIRS
REGISTRAR'S OFFICE
FIELD SECRETARY'S OFFICE
COUNSELLING
BOOKSTORE
ATHLETICS
HEALTH SERVICES
BURSAR'S OFFICE
PHYSICAL PLANT OFFICE
ANALYTICAL STUDIES OFFICE
BOARD OF GOVERNORS
PRESIDENT'S OFFICE
LEGEND
RESOURCES
FLOW OF RESOURCES
ORGANIZATIONAL
DECISION
NEAREST STUDENT LOAD
DIRECT STUDENT LOAD
DECISIONS
STUDENTS ENROLLED
MANPOWER
CONTINUING EDUCATION
DAY
PART TIME AND SPECIAL
DAY PROGRAMS
BUSINESS
TECHNOLOGY
ARTS
CONTINUING EDUCATION PROGRAMS
MANPOWER PROGRAMS
LITERACY DIVISION
ORIENT ACTIVITIES
NON-ORIENT ACTIVITIES
NON ORIENT ACTIVITIES
ACADEMIC DEPARTMENTS
DIVISION OFFICES
DEAN'S OFFICE
MANPOWER COURSES
MANPOWER DEPARTMENTS
ACADEMIC SUPPORT DEPARTMENTS
LIBRARY
CAFETERIA
COMPUTER CENTRE
- SPACE ALLOCATION
- BUDGET LEVELS
- RESOURCE CONTROL
- STAFF
- SPACE
- EQUIPMENT
- TIME
- OTHER
- $

It seems apparent now that the model is too large to be operated on any of the computers that the colleges are likely to have on their own premises. This means that they will have to communicate with some kind of outside service, either by taking advantage of a university's computer or one of the commercial computer utilities that has grown up in the province.

F. THE USE OF THE MODEL

The staff support required to operate the model once it has been established can be broken into two types of personnel. The first involving a person or persons who can help the decision-makers in the colleges to formulate their problems for analysis and then interpret the results of these analyses back to them. The problem formulator will probably only have to be a part time person in the college who will have working with him a couple of part time assistants to aid in particular with the data preparation. These people should, in our opinion, reside within the colleges, and probably be drawn from existing staff. On the other hand, there is a need for a technical capability to maintain the models and information systems to insure that they function properly and to adapt them to the changing needs of the colleges. This capability we feel should be provided from some central technical body so as to lower the cost to the participating colleges. We do not feel, however, that the problem formulator type of staff can be drawn from a central group. These people must

be part of the ongoing organization of the institution if the use of the model is ever to have a real impact on decision making.

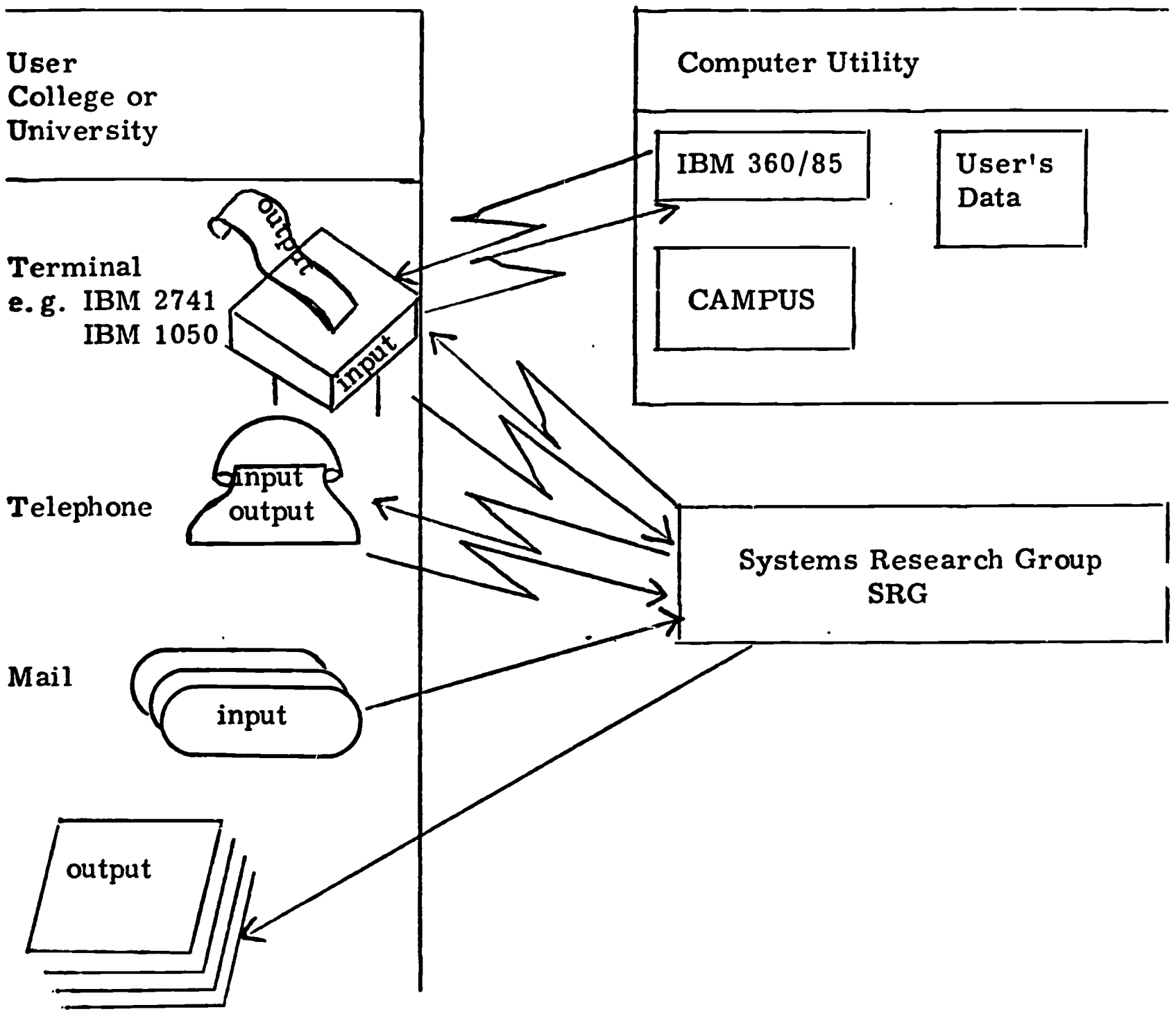
While Systems Research Group personnel are at present functioning as the internal staff and problem formulators, we see no problem in transferring this role to the college staff once the study has been completed, and if the colleges and the department decide to proceed in an onging way. In fact, in some of the pilot colleges, this transfer has already taken place.

In order to test the concept of the central technical facility, we have incorporated the simulation models of the colleges into a new system that has been developed by SRG called Remote CAMPUS. Under Remote CAMPUS a college using the CAMPUS model is not required to have any technical staff nor any major computer facilities. The simulation model that represents the participating college and the basic information base of that college are stored on a large central computer. A number of alternative means of communicating with the central facility are established and SRG functions as a technical support to the colleges. See Figure 2.

In the case of the community colleges, the three models and associated data bases for the pilot institution are stored on an IBM 360-65 computer operated by Systems Dimensions Limited in Ottawa, Ontario.

Figure 2

Possible Modes of Remote CAMPUS



In each of the colleges we have installed an IBM 2741 terminal. This is a low speed terminal that looks much like a typewriter on a small stand. The colleges can carry out their simulation by keying into the Ottawa computer via their terminal. They provide to begin with appropriate security codes so as to be able to access their information and their version of the model, and they then describe via a verbal command language (see the document "CAMPUS (CAATS)[2] System" for details) the kind of experiment that they wish to have run. They also indicate the kinds of reports they would like to have transmitted to them via their terminal, and which reports they would like to have printed at the computer center and mailed to them. This system essentially brings to the colleges the power of a very large computer and enables them to get rapid response to questions they want to ask. This response is usually in the form of summary reports that are transmitted by the terminal and any more detailed reports that the colleges are interested in are printed at the computer center and mailed to them immediately.

During the course of this study we will evaluate this communications link with regard to its cost and benefits, as well as looking into other possibilities, such as using the mails or the phone for communications in both directions or perhaps a more expensive and faster terminal system. The terminals that are presently being tested are inexpensive and rent for about $120.00 per month.

G. PRELIMINARY ESTIMATES OF THE COST OF SETTING UP AND OPERATING CAMPUS (CAATS) ^{2}

In this section we have put together our best estimates of the cost and time considerations involved in setting up and using the CAMPUS (CAATS) ^{2} system. These estimates are preliminary only, but do indicate the order of magnitude of expenditures involved. The figures are set up in a range that, in our estimation, would cover any of the colleges within the system in Ontario.

1. The Implementation of CAMPUS (CAATS) ^{2}

Elapsed time to obtain operational results --- 4 to 6 months

The following is a list of the major activities that have to be undertaken in order to implement the system:

I Education of the personnel within the colleges, interviews with senior staff to determine modifications needed to the model, design modifications to the model, design data collection system --- $3,000 - $ 6,000.

II Carry out programming changes to the model and set up operating communication system to it from the college --- $4,000 - $10,000.

III Collect and analyze necessary data and establish system for maintaining currency of the information --- $4,000 - $10,000.

IV Carry out pilot use of the model to insure that the model is operational and that the data are representative. Finalize training of college staff and insure that those who are using the system understand how to operate it and how to interpret the results	$ 4,000 - $10,000.
TOTALS:	$15,000 - $36,000.

These cost estimates represent the full cost to the colleges of having an organization like SRG adapt and install the system. The costs include time, materials, miscellaneous expenses and computer time.

2. The Operation of CAMPUS (CAATS)[2]

College staff requirements in full time equivalents	1/3 f.t.e. - 1 1/2 f.t.e.
Annual fee to central technical group for maintenance, minor modifications, consultative advice, program improvements and detailed user instructions	$10,000 - $15,000 per year
Cost of slow speed terminal for direct hook-up	$1,500. per year
Cost of computer time to simulate the college for one year (assuming IBM 360-65)	$2.00 - $4.00 (i.e. a simulation of the operation of the college for ten years into the future would cost between $20.00 and $40.00)

The cost of communications hook-up for transmitting instructions for the experiment and receiving a summary report	10 minutes (the cost would vary from $0.00 to $5.00 depending on the location of the college)

APPENDIX I

THE PROBLEMS OF THE CAATS THAT CAN AND CANNOT BE ANALYZED WITH CAMPUS (CAATS) [2]

IN GENERAL

MODEL CAN'T

- Forecast exogenous inputs -- e.g. data on enrolment or rules on staff workloads.
- Predict community needs.
- Evaluate the quality of education.
- Create alternatives, but does analyze them in economic terms.

MODEL CAN

- Calculate the resource requirements of alternative educational programs.
- Compare the costs of different administrative rules on staff, space, equipment, enrolment.
- Enable the administrator to manage and plan the institution in the future.

FINANCE

MODEL CAN'T

- Predict operating and capital allocations from outside sources (except under formula financing).
- Control expenditures.

MODEL CAN

- Provide detailed cost estimates for the college, division, department, program or activity.
- Be used under different assumed funding levels to indicate what courses, enrolments and methods can be supported.
- Be the analytical mechanism of a Planning-Programming-Budgeting System.
- Facilitate preparation of annual budgets and long-term growth plans for review by senior authorities.
- Provide detailed justification of requests for funds, either under present procedures or as a supplement to formula financing.

SPACE PLANNING

MODEL CAN'T

- Say what kind of space should be used in a given program, or set class size.
- Prescribe certain sizes of offices, etc. for academic and support staff.
- Lay down policies on ancillary facilities such as libraries, residences, lounges.

MODEL CAN

- Forecast detailed space requirements under alternative situations.
- Assess the impact on space of changes in teaching methods, enrolment, etc.
- Pinpoint overages, shortages and % utilization of different kinds of space at different future times.
- Assess the impact of alternatives in future construction.
- Evaluate the effect, on space needs, of changes in length of eaching week, computerized scheduling, etc.
- Assess the economics of flexibility.
- Produce information for architects on the affinity of one type of space for others.

ENROLMENT

MODEL CAN'T

- Predict enrolment (total or by course).
- Predict student choice.
- Assess promotional effectiveness.
- Tell about community needs.
- Forecast success of students.

MODEL CAN

- Calculate resources needed for different enrolments.
- Assess different mixes of courses.
- Help cope with uncertainty and variations in actual enrolment.
- Evaluate the economies of scale.
- Help set timing of acquisition of new resources.
- Operate in long and short run context.

ACADEMIC PLANNING

MODEL CAN'T

- Decide what courses should be offered.
- Balance academic vs. professional subjects.
- Say much about community role.
- Design course content.

MODEL CAN

- Compare the resources (staff, space, equipment, etc.) needed for different mixes of program.
- Analyze the resource requirements for changing course content.
- Compare costs of educating different kinds of students (day, extension, industrial, manpower).

TEACHING METHODS

MODEL CAN'T

- Say which methods are pedagogically best.
- Generate new teaching ideas.
- Measure student reactions.

MODEL CAN

- Help make trade-off analyses of different teaching methods.
- Highlight the costs of introducing new methods.
- Calculate how college costs will rise with enrolment given possible changes in methods.
- Help tie together enrolment, program decisions and available resources into a coherent plan.

STAFF PLANNING

MODEL CAN'T

- Say what kinds of staff should be used.
- Help recruit staff directly.
- Evaluate teacher performance.
- Determine staffing policy.

MODEL CAN

- Calculate the requirements for various staff.
- Take into account alternative staffing policies -- load, tenure, etc.
- Analyze the cost of different mixes of staff.
- Predict future staff work requirements under alternative educational and administrative policies.
- Calculate future operating costs under different staffing policies and salary scales.

APPENDIX II

SAMPLE ANALYSES OF PROBLEMS USING CAMPUS (CAATS) 2

SAMPLE ANALYSES OF PROBLEMS USING CAMPUS (CAATS) [2]

During the course of the community colleges study, SRG analysts have gathered data on, and created, a representative community college for demonstration purposes. Although CAMPUS college is imaginary, its organizational and educational structure is realistic, and it is an ideal vehicle for carrying out experimentation and testing without revealing confidential data. A base case and three experimental cases and been run through Remote CAMPUS to illustrate the experimental capabilities of the CAMPUS system.

Base Case

CAMPUS college began operations in the Fall of 1967, and after two years of operations, administrative and academic personnel evolved a ten year plan with enrolment increasing from 1148 students in 1969 to 3591 students in 1978. The forecasted input data and policy parameters are stored on CAMPUS college's data files at a large computer center, and a ten year run was made.

Figure 1 is a summary report for the total operations of the college over this ten year period. Academic staff costs have risen from $1,566,000. to $3,307,000.; total operating costs have risen from $2,147,000. to $4,800,000.; Space requirements have risen from 120,000 sq. ft. to almost 284,000 sq. ft. Capital costs were calculated on the basis that deficiencies in space were rectified each year through new construction.

As enrolment has increased, cost per student has dropped from $1870. in 1969 to $1336 in 1978, and space per student from 104 sq. ft. to 79 sq. ft.

Case 1

Due to increased enrolment in area high schools and expected popularity of new programs being offered at CAMPUS College, the registrar has changed his enrolment forecast. It is now expected that total enrolment will reach approximately 5,500 students by 1978. Case 1 is a ten year run with no data or policy changes except the above mentioned increase in enrolment. College costs are reflected in figure 2, and costs for one division or faculty are shown in figure 3. Total operating costs are considerably higher with the increased enrolment, moving to $6,647,000. in 1978 while space requirements have risen to 408,000 sq. ft. in 1978. Although total costs have increased, economies of scale are evident since cost per student and space per student in Case 1 are lower than in the base case.

Case 2

College personnel have decided that the enrolment estimates postulated in Case 1 are realistic, but the college is faced with a stringent operating budget. In order to reduce academic staff costs (the largest single element in the operating budget) administrators have decided to analyze an increase in teaching duties by 15% and an increase in class size by 15% over the

ten year period. Figure 4 contains a college summary report which reflects these changes, while figure 5 contains the same report but for the Arts faculty. Academic staff costs and therefore total operating costs have been reduced considerably as is shown in figures 4 and 5. Cost per student has also been reduced from $1,778. to $1,643. in 1969 and to $1,051. from $1,211 in 1978. Since overhead costs have remained fairly constant, the drop in cost per student is most evident at the teaching level: This can be seen by a comparison between figures 3 and 5.

Case 3

Although operating costs for the first five years have been reduced to a reasonable level, it is deemed necessary to reduce space requirements and hence capital costs below the forecasted level. Thus teaching space policy has been altered by changing the length of the teaching week for all teaching space from 35 hours per week to 45 hours per week. The resultant changes in space requirements and capital costs are illustrated in figure 6. The results show that there has been a small decrease in total space requirements and capital costs; space per student has dropped from 104 sq. ft. to 99 sq. ft. in 1969 and from 74 sq. ft. to 68 sq. ft. in 1978. The drop in space requirements is not proportional to the increase in the length of the teaching week: This is due to the fact that a large proportion of the space is devoted to service departments and is not effected by changes in academic policy, and some types of teaching space were not

used fully in earlier years and therefore were not effected by increased availability.

Summary

Figures 7 and 8 illustrate comparisons for total costs and operating costs per student between four runs. In addition graphical output of summary values would be available although it was not requested in this case. Figure 9 illustrates one such graph.

The above cases are somewhat simplified with respect to the real world, but are meant to illustrate the ease by which problem analysis can be carried out by college personnel with a CAMPUS model replacing the drudgery and inaccuracy of manual calculations, and greatly reducing the response time once the user has defined his problem or changes.

COST CENTRE
COLLEGE

C A M P U S C O L L E G E

OVER TIME REPORT 1.5
SESSION AVERAGES

SUMMARY REPORT

FIGURE 1

	SESSION									
	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79
STAFF										
ACADEMIC	1178	1498	1685	1748	1786	1912	2039	2189	2412	2642
ACADEMIC SUPPORT	33	46	52	52	52	59	59	59	65	72
NON-ACADEMIC	81	96	101	101	111	116	116	126	136	141
SERVICE	274	300	326	342	342	368	368	394	426	452
TOTAL	1566	1940	2164	2243	2291	2455	2582	2768	3039	3307
TOTAL EQUIPMENT COST	352	467	529	566	583	636	694	758	851	948
MISCELLANEOUS	221	319	352	364	371	395	414	442	483	523
MAINTENANCE	8	11	12	13	13	15	16	18	20	22
TOTAL AGGREGATE COST (THOUSANDS OF DOLLARS)	2147	2737	3057	3186	3258	3501	3706	3986	4393	4800
SPACE										
OFFICE	15350	18670	20660	21330	21810	23280	24320	26040	28410	30790
CLASSROOM	17740	23870	26130	27480	27630	30160	33860	36060	39430	41890
INSTRUCTIONAL LABORATORY	1915	3270	3895	3845	4345	4445	4360	5260	5765	5980
SPECIAL LABORATORY	30900	41750	48050	46400	50250	50450	51250	53400	62750	63750
SERVICE DEPARTMENT	54287	71441	80744	85247	87825	95614	104271	113813	127710	142091
TOTAL SPACE (SQUARE FEET)	120192	159001	179479	184302	191860	203949	218061	234573	264065	284501
CAPITAL COSTS SPACE - (ACTUAL DOLLARS)	70450	480275	313200	142300	92800	255550	297400	401775	806925	573625
AFFILIATED STUDENTS										
AT THIS COST CENTRE	0	0	0	0	0	0	0	0	0	0
AT AFFILIATED COST CENTRES										
ARTS	277	405	461	490	504	563	626	688	790	890
BUSINESS	434	571	643	682	707	787	868	956	1087	1225
ENGINEERING	437	647	776	834	867	945	1043	1159	1313	1476
CONTINUING EDUC	0	0	0	0	0	0	0	0	0	0
TOTAL	1148	1623	1880	2006	2078	2295	2537	2803	3190	3591
REVENUE										
TOTAL REVENUE FUNDS	0	0	0	0	0	0	0	0	0	0
INDICATORS										
COST PER STUDENT (ACTUAL DOLLARS)	1870	1686	1626	1588	1567	1525	1460	1422	1377	1336
SPACE PER STUDENT SQ.FT.	104	97	95	91	92	98	85	83	82	79

COST CENTRE 00 CAMPUS (CAATS)2 - CASE ONE - NOV 1969
COLLEGE

C A M P U S C O L L E G E

OVER TIME REPORT 1.5
SESSION AVERAGES

SUMMARY REPORT

FIGURE 2

	SESSION									
	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79
STAFF										
ACADEMIC	1190	1599	1836	2012	2213	2476	2806	3102	3421	3644
ACADEMIC SUPPORT	39	52	52	59	59	65	72	72	78	78
NON-ACADEMIC	86	101	111	116	126	141	156	171	181	191
SERVICE	274	326	342	368	394	436	478	520	562	588
TOTAL	1589	2078	2341	2555	2792	3118	3512	3865	4242	4501
TOTAL EQUIPMENT COST	371	506	598	683	761	878	1023	1181	1308	1413
MISCELLANEOUS	225	338	377	410	445	494	553	605	662	702
MAINTENANCE	9	11	15	16	18	21	23	27	29	31
TOTAL AGGREGATE COST (THOUSANDS OF DOLLARS)	2194	2933	3331	3664	4016	4511	5111	5678	6241	6647
SPACE										
OFFICE	15580	19940	22230	24100	26240	29230	32670	35840	39120	41510
CLASSROOM	18030	24900	29440	33110	36040	40750	46370	51960	57420	61270
INSTRUCTIONAL LABORATORY	1715	3410	4445	4360	5260	5765	5915	6960	7375	7600
SPECIAL LABORATORY	32500	41550	51550	49550	55650	63900	68550	79550	85100	88000
SERVICE DEPARTMENT	57059	77339	91086	102554	114210	131691	153153	175503	194437	209965
TOTAL SPACE (SQUARE FEET)	124884	167139	198751	213674	237400	271336	306658	349813	383452	408345
CAPITAL COSTS SPACE - (ACTUAL DOLLARS)	118425	626300	459025	371175	510950	981125	1010375	1263575	962775	712575
AFFILIATED STUDENTS										
AT THIS COST CENTRE	0	0	0	0	0	0	0	0	0	0
AT AFFILIATED COST CENTRES										
ARTS	300	451	540	615	691	818	972	1129	1255	1359
BUSINESS	463	629	743	853	962	1129	1330	1542	1716	1860
ENGINEERING	464	707	886	1021	1160	1354	1598	1855	2082	2268
CONTINUING EDUC	0	0	0	0	0	0	0	0	0	0
TOTAL	1227	1787	2169	2489	2813	3301	3900	4526	5053	5487
REVENUE										
TOTAL REVENUE FUNDS	0	0	0	0	0	0	0	0	0	0
INDICATORS										
COST PER STUDENT (ACTUAL DOLLARS)	1788	1641	1535	1472	1427	1366	1310	1254	1235	1211
SPACE PER STUDENT SQ.FT.	101	93	91	85	94	82	78	77	75	74

OST CENTRE 00 CAMPUS (CAATS)2 - CASE ONE - NOV 1969
ARTS

OVER TIME REPORT 1.5
SESSION AVERAGES

C A M P U S C O L L E G E

SUMMARY REPORT

FIGURE 3

	SESSION									
	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79
STAFF										
ACADEMIC	244	375	436	472	521	584	658	731	805	855
ACADEMIC SUPPORT	39	52	52	59	59	65	72	72	78	78
NON-ACADEMIC	24	24	29	29	29	34	39	44	44	49
SERVICE	0	0	0	0	0	0	0	0	0	0
TOTAL	307	451	517	560	609	683	769	847	927	982
TOTAL EQUIPMENT COST	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	35	65	74	81	88	99	111	123	135	143
MAINTENANCE	0	0	0	0	0	0	0	1	1	1
TOTAL AGGREGATE COST (THOUSANDS OF DOLLARS)	342	516	591	641	697	782	880	971	1063	1126
SPACE										
OFFICE	2920	4080	4660	5010	5410	6110	6840	7520	8170	8720
CLASSROOM	0	0	0	0	0	0	0	0	0	0
INSTRUCTIONAL LABORATORY	0	0	0	0	0	0	0	0	0	0
SPECIAL LABORATORY	0	0	0	0	0	0	0	0	0	0
SERVICE DEPARTMENT	0	0	0	0	0	0	0	0	0	0
TOTAL SPACE (SQUARE FEET)	2920	4080	4660	5010	5410	6110	6840	7520	8170	8720
CAPITAL COSTS SPACE - (ACTUAL DOLLARS)	0	30625	18125	10925	12500	21875	22800	21250	20300	17175
AFFILIATED STUDENTS AT THIS COST CENTRE	300	451	540	615	691	818	972	1129	1255	1359
TOTAL	300	451	540	615	691	818	972	1129	1255	1359
REVENUE										
TOTAL REVENUE FUNDS	133	200	240	272	306	362	431	501	557	602
INDICATORS COST PER STUDENT (ACTUAL DOLLARS)	1140	1144	1094	1042	1008	955	905	860	847	828

ST CENTRE
COLLEGE

00 CAMPUS (CAATS)2 CASE TWO - NOV 1969

C A M P U S C O L L E G E

SUMMARY REPORT

OVER TIME REPORT 1.5
SESSION AVERAGES

FIGURE 4

	SESSION									
	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79
STAFF										
ACADEMIC	1044	1299	1485	1587	1748	1936	2216	2462	2654	2892
ACADEMIC SUPPORT	33	39	46	52	59	59	65	65	72	72
NON-ACADEMIC	86	101	111	116	126	141	156	171	181	191
SERVICE	274	326	342	368	394	436	478	520	562	588
TOTAL	1437	1765	1984	2123	2327	2572	2915	3218	3469	3743
TOTAL EQUIPMENT COST	371	506	598	683	761	878	1023	1173	1308	1413
MISCELLANEOUS	200	290	322	342	371	407	458	504	540	582
MAINTENANCE	9	12	14	15	16	19	23	26	29	32
TOTAL AGGREGATE COST (THOUSANDS OF DOLLARS)	2017	2573	2918	3163	3475	3876	4419	4921	5346	5770
SPACE										
OFFICE	14240	17360	19260	20530	22380	24630	27740	30490	32730	35150
CLASSROOM	18720	24560	28590	31520	34920	39330	44230	49640	56100	60990
INSTRUCTIONAL LABORATORY	1715	3410	4070	4485	4760	5530	5790	6660	6315	7930
SPECIAL LABORATORY	35000	42750	51650	52650	56250	63500	73900	79400	89300	94800
SERVICE DEPARTMENT	56786	76744	90392	101712	113295	130626	151989	174240	192926	208479
TOTAL SPACE (SQUARE FEET)	126461	164824	193962	210897	231605	263616	303649	340430	377371	407349
CAPITAL COSTS SPACE - (ACTUAL DOLLARS)	111550	615175	443625	376075	479000	944075	1167900	1077525	1109250	859775
AFFILIATED STUDENTS										
AT THIS COST CENTRE	0	0	0	0	0	0	0	0	0	0
AT AFFILIATED COST CENTRES										
ARTS	300	451	540	615	691	818	972	1129	1255	1359
BUSINESS	463	629	743	853	962	1129	1330	1542	1716	1860
ENGINEERING	464	707	886	1021	1160	1354	1598	1855	2082	2268
CONTINUING EDUC	0	0	0	0	0	0	0	0	0	0
TOTAL	1227	1787	2169	2489	2813	3301	3900	4526	5053	5487
REVENUE										
TOTAL REVENUE FUNDS	0	0	0	0	0	0	0	0	0	0
INDICATORS										
COST PER STUDENT (ACTUAL DOLLARS)	1643	1439	1345	1270	1235	1174	1133	1087	1057	1051
SPACE PER STUDENT SQ.FT.	103	92	89	84	82	79	77	75	74	74

COST CENTRE 0C CAMPUS (CAATS)2 CASE TWO - NOV 1969
1 ARTS

C A M P U S C O L L E G E

OVER TIME REPORT 1.5
SESSION AVERAGES

SUMMARY REPORT

FIGURE 5

	SESSION									
	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79
STAFF										
ACADEMIC	219	301	349	375	412	460	523	584	621	683
ACADEMIC SUPPORT	33	39	46	52	59	59	65	65	72	72
NON-ACADEMIC	24	24	29	29	29	34	39	44	44	49
SERVICE	0	0	0	0	0	0	0	0	0	0
TOTAL	276	364	424	456	500	553	627	693	737	804
TOTAL EQUIPMENT COST	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS	30	52	61	65	71	79	90	100	106	116
MAINTENANCE	0	0	0	0	0	0	0	0	0	1
TOTAL AGGREGATE COST (THOUSANDS OF DOLLARS)	306	416	485	521	571	632	717	793	843	921
SPACE										
OFFICE	2620	3380	3910	4160	4510	4990	5690	6270	6620	7200
CLASSROOM	0	0	0	0	0	0	0	0	0	0
INSTRUCTIONAL LABORATORY	0	0	0	0	0	0	0	0	0	0
SPECIAL LABORATORY	0	0	0	0	0	0	0	0	0	0
SERVICE DEPARTMENT	0	0	0	0	0	0	0	0	0	0
TOTAL SPACE (SQUARE FEET)	2620	3380	3910	4160	4510	4990	5690	6270	6620	7200
CAPITAL COSTS SPACE - (ACTUAL DOLLARS)	0	8750	16550	7800	10925	15000	21875	18125	10925	18125
AFFILIATED STUDENTS AT THIS COST CENTRE	300	451	540	615	691	818	972	1129	1255	1359
TOTAL	300	451	540	615	691	818	972	1129	1255	1359
REVENUE										
TOTAL REVENUE FUNDS	133	200	240	272	306	362	431	501	557	602
INDICATORS COST PER STUDENT (ACTUAL DOLLARS)	1020	922	898	847	826	772	737	702	671	677

OST CENTRE 00 CAMPUS (CAATS)2 - CASE THREE - NOV 1969
5 COLLEGE

OVER TIME REPORT 1.5
SESSION AVERAGES

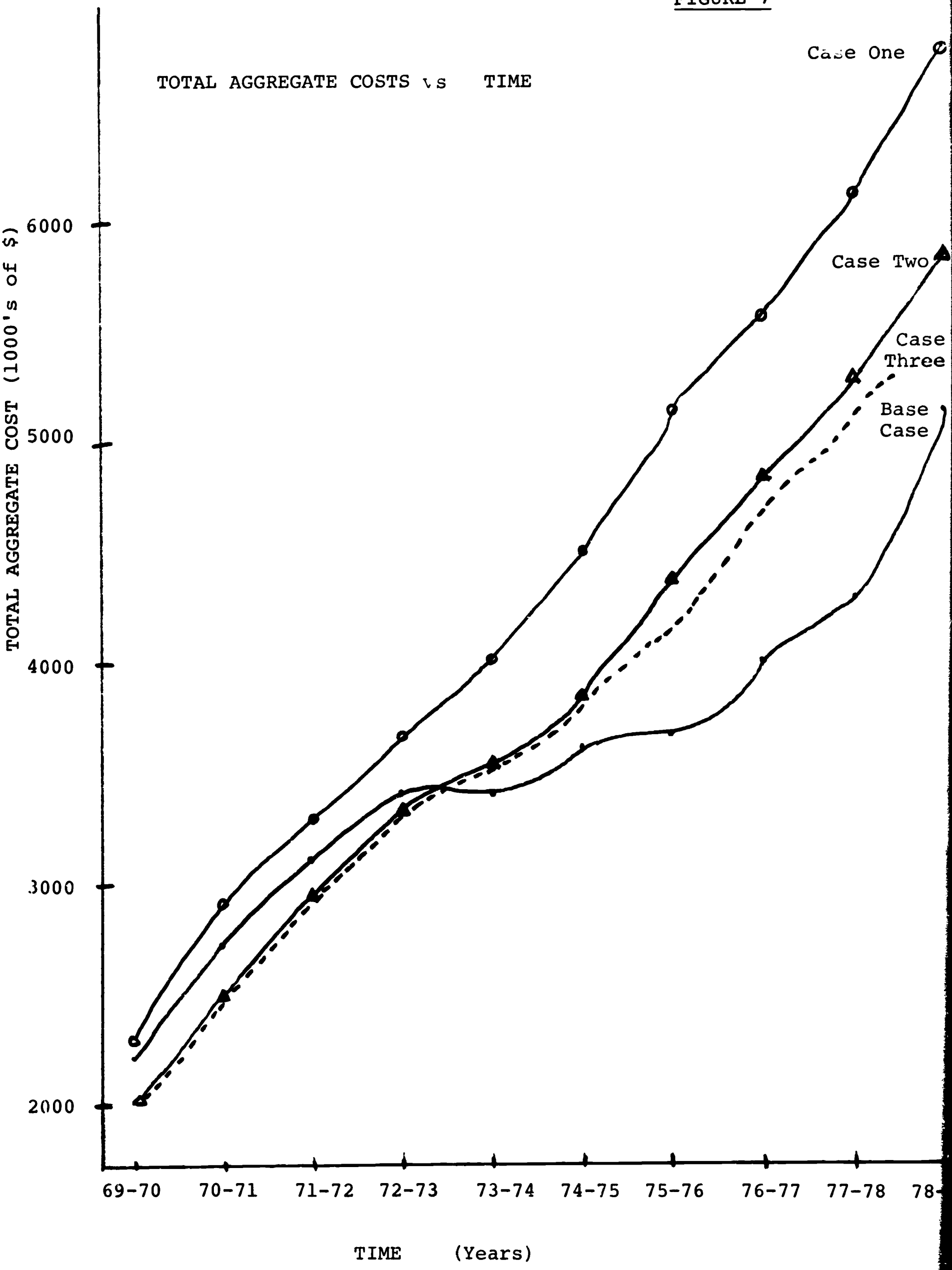
C A M P U S C O L L E G E

SUMMARY REPORT

FIGURE 6

	SESSION									
	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79
STAFF										
ACADEMIC	1044	1299	1485	1587	1748	1936	2016	2302	2514	2667
ACADEMIC SUPPORT	33	39	46	52	59	59	65	65	65	72
NON-ACADEMIC	86	101	111	116	126	141	156	171	181	191
SERVICE	274	326	342	368	394	436	478	520	562	588
TOTAL	1437	1765	1984	2123	2327	2572	2715	3058	3322	3518
TOTAL EQUIPMENT COST	371	506	598	683	761	878	1023	1173	1300	1413
MISCELLANEOUS	200	290	322	342	371	407	428	478	517	546
MAINTENANCE	8	11	13	14	15	18	22	24	27	28
TOTAL AGGREGATE COST (THOUSANDS OF DOLLARS)	2016	2572	2917	3162	3474	3875	4188	4733	5166	5505
SPACE										
OFFICE	14240	17360	19260	20530	22380	24630	26080	29150	31540	33290
CLASSROOM	16030	18800	21840	25350	28480	31730	34330	39700	45190	47240
INSTRUCTIONAL LABORATORY	1715	3110	3695	4110	4085	4150	4375	5455	5835	5995
SPECIAL LABORATORY	32900	41400	46850	50250	50400	54000	68600	68800	78800	78950
SERVICE DEPARTMENT	56786	76744	90392	101712	113295	130626	151593	173918	192653	208034
TOTAL SPACE (SQUARE FEET)	121671	157414	182037	201952	218640	245136	284978	317023	354018	373509
CAPITAL COSTS SPACE - (ACTUAL DOLLARS)	111550	605800	441275	376075	371325	556900	1142875	919525	1095450	563775
AFFILIATED STUDENTS										
AT THIS COST CENTRE	0	0	0	0	0	0	0	0	0	0
AT AFFILIATED COST CENTRES										
ARTS	300	451	540	615	691	818	972	1129	1255	1359
BUSINESS	463	629	743	853	962	1129	1330	1542	1716	1860
ENGINEERING	464	707	886	1021	1160	1354	1598	1855	2082	2268
CONTINUING EDUC	0	0	0	0	0	0	0	0	0	0
TOTAL	1227	1787	2169	2489	2813	3301	3900	4526	5053	5487
REVENUE										
TOTAL REVENUE FUNDS	0	0	0	0	0	0	0	0	0	0
INDICATORS										
COST PER STUDENT (ACTUAL DOLLARS)	1643	1439	1344	1270	1234	1173	1073	1045	1022	1003
SPACE PER STUDENT SQ.FT.	99	88	83	81	77	74	73	70	70	68

FIGURE 7


TOTAL AGGREGATE COSTS vs TIME
Case One
Case Two
Case Three
Base Case
TOTAL AGGREGATE COST (1000's of $)
6000
5000
4000
3000
2000
69-70
70-71
71-72
72-73
73-74
74-75
75-76
76-77
77-78
78-
TIME (Years)

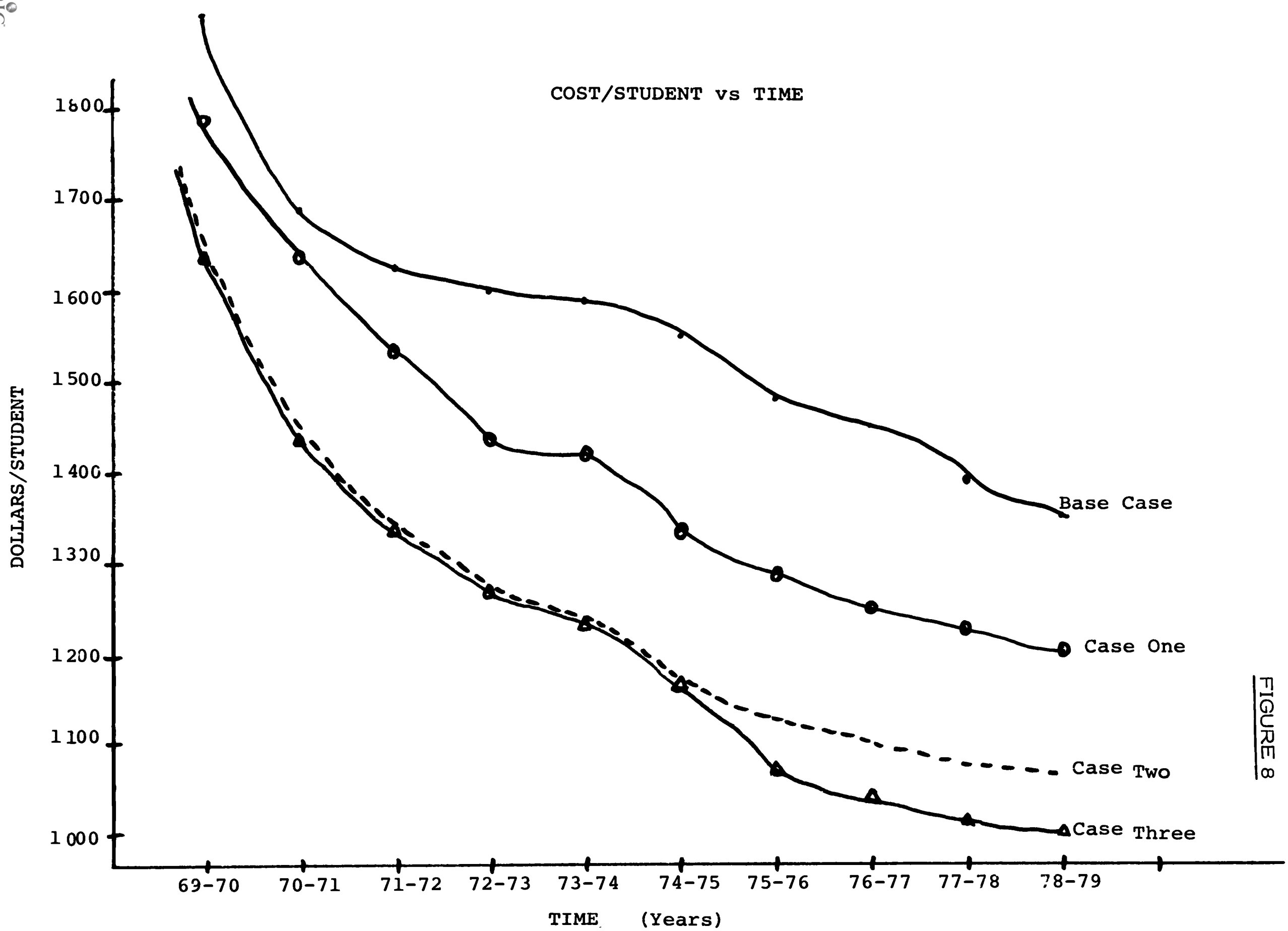
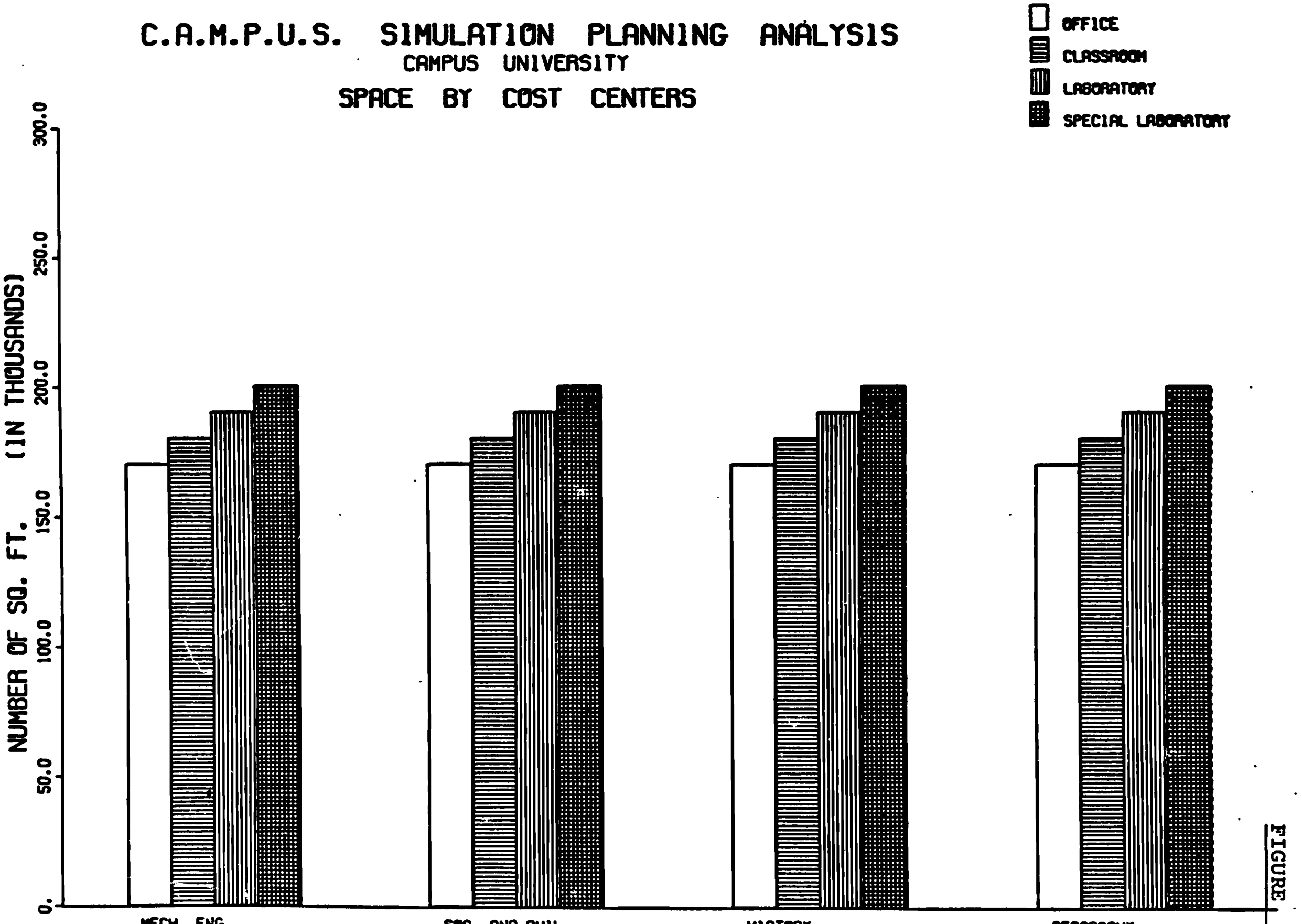

COST/STUDENT vs TIME
DOLLARS/STUDENT
1800
1700
1600
1500
1400
1300
1200
1100
1000
69-70
70-71
71-72
72-73
73-74
74-75
75-76
76-77
77-78
78-79
TIME (Years)
Base Case
Case One
Case Two
Case Three

FIGURE 8

C.A.M.P.U.S. SIMULATION PLANNING ANALYSIS

CAMPUS UNIVERSITY

SPACE BY COST CENTERS



FIGURE

APPENDIX III

A NEW APPROACH TO FORMULA FINANCING

A NEW APPROACH TO FORMULA FINANCING

During the course of our project we have become increasingly aware of the difficulties that the government has been having in attempting to arrive at a scheme for financing the colleges on some formula basis. In a document entitled "The Pros and Cons of Existing Formula Financing Systems and a Suggested New Approach" we have reviewed the various types of formulas that are being used throughout North America. We have then outlined an approach to developing a system of formula financing by taking advantage of the CAMPUS (CAATS)^2 model. This approach enables the government to develop, in cooperation with the colleges, a set of weights that meets the criteria of equity, and ease of understanding that are required for formula financing. On the other hand, the scheme is so structured as to take into account the individual differences of colleges and the effect on costs of scale of operations, mix of programs and various other key factors. The system is not so loose as to defeat the primary purpose of the formula scheme, that of having a well understood and predictable means of funding the institutions, and yet it is flexible enough so as to allow a great deal of individuality within the colleges.

The approach and the steps needed to develop such a system are outlined in detail in the above mentioned document.

APPENDIX IV

EXTENSIONS OF CAMPUS TO AID IN THE DESIGN OF PHYSICAL FACILITIES

[1] Judy, R. W., and Levine, J. B.; *A New Tool for Educational Administrators*, University of Toronto Press, 1966.
[2] Judy, R. W., Levine, J. B., and Wilson, R.; "Systems Analysis of Alternative Designs of a Faculty", a paper presented at the Organization for Economic Cooperation and Development meeting, Paris, 3-5 April, 1968.
[3] Levine, J. B.; "Application of the CAMPUS Simulation Models to the Major Planning Decisions of a Large University", a paper presented at the Second Conference on the Applications of Simulation, New York, December 2-3, 1968.
[4] Levine, J. B.; *A University Planning and Budgeting System Incorporating a Micro-analytical Model of the Institution*, Unpublished Ph.D. dissertation, University of Toronto, 1969.
[5] Levine, J. B. and Judy, R. W.; "The Integration of Simulation Models and Program Budgeting in University Planning and Administration", a paper presented at the Joint ORSA-TIMS Meeting, San Francisco, May, 1968.

Universities in the early growth stage stand to profit greatly from the use of simulation models. The range of decision variables is so broad and the importance of early decisions so great that the planners deserve all the assistance they can get. The design and use of a simulation model in the formative stages of university planning may avoid costly errors and raise the returns from new educational investment.

It has been demonstrated by four years of research and implementation that it is possible, with the present CAMPUS technology, to make pronounced improvements in the quality of decision-making in higher education, thus insuring more efficient utilization of the resources that unversities have at their disposal. □

Stage	Techniques Used	University's Role	Architect's Role
1. Preliminary Review	Non-computerized analysis of broad aims and budgets to establish guidelines for the planning process.	Consider and evaluate the following: general objectives • general availability of funds (timing) • capital and operating budget constraints • addition to existing facilities or new buildings • simple or elaborate design, aesthetics.	Supply general cost and other information with respect to type and size of physical plant needed.
2. Planning	CAMPUS simulates the aggregate description of the expansion. Alternative plans are explored to achieve a desired and feasible set.	More specific definition of objectives: enrolments by major programs • level of research • general space indices • non-space requirements.	Assist university in developing planning ratios related to space.
3. Programming	CAMPUS simulates alternative means of programming the planning objectives and estimates, facilities and operating cost requirements. Alternative architectural designs are assessed for their ability to cope with possible future events. Operating and capital costs of various plans are evaluated and a few plans are selected after an iterative process.	Proposed alternative means of carrying out objectives with respect to: teaching method • possible innovations at some future time • administrative and staffing policies • performance criteria of space type needed.	Create preliminary schematic designs that can be costed and evaluated.
4. Initial Design	CAMPUS simulates the operation of the university under various programming arrangements and produces space relationship information showing the affinity of one space to another based on: student movement • staff movement • electro-mechanical support system • provision for expansion • load bearing needs • miscellaneous support systems.	Factors that affect the placement of space in three dimensions are considered: department that should be close • facilities that should be close • importance of minimum staff movement • importance of minimum student movement • possible expansion by department.	Weigh the results of the model's analysis, the university's desires, aesthetic and other design factors to create a space position plan and design.
5. Detailed Architectural Plans	CAMPUS develops a detailed set of operating and capital resources requirements for the plan that has been chosen.	Plans are reviewed and approved.	Detailed plans are prepared for letting construction contracts.
6. Construction		Overseeing	Supervision
7. Master Plan	Information in CAMPUS is updated and forms the basis for a master plan that incorporates academic and administrative plans but no specific building plans. The plan may be experimented with and updated as new situations arise.	The new directions that might be pursued by the institution are continuously evaluated and explored with the CAMPUS master plan incorporating the latest thinking of the university.	A general flow system for people and mechanical systems provides the architectural skeleton for the CAMPUS master plan but no detail beyond this is supplied for future changes. Changes made to CAMPUS, not architectural drawings. When decision is made to build steps 1 to 6 are repeated.

Fig. 2.
Planning and Programming New Facilities with CAMPUS as the Master Plan

Campus Planning

Dalhousie University Master Plan

Evan H. Walker Consultants, Architects

Mechanical and Electrical Consultants:
R. E. Crossey & Associates and Engineering Services Company Limited

Dalhousie University is housed on two campuses, in the residential southern end of the Halifax peninsula. The main campus lies on a slight rise at the head of a long formal boulevard axis. The main buildings are placed symmetrically about a courtyard which is the visual and activity focus of the university. The campuses are separated by a quarter mile of residential grid, with the boulevard linking the two.

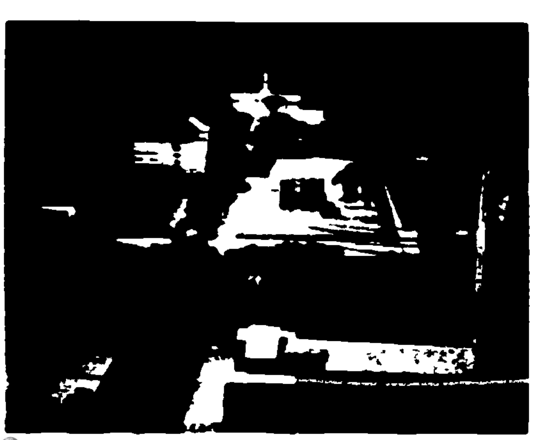
The Problem

The chief factors of concern in the formulation of the 50-million dollar development plan, apart from that of competition for funds, are:

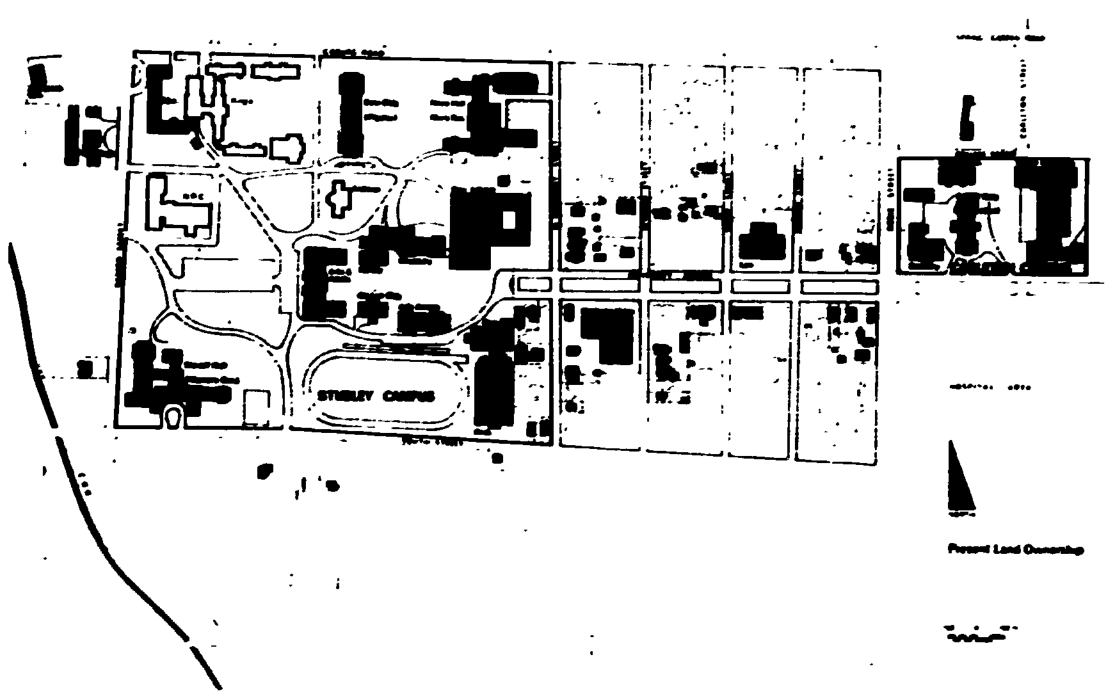
A projected enrolment double the present figure of 4,000 within the next decade.
Limited space to expand, both on the existing campuses and in the surrounding urban area.
A lack of expropriation powers aggravated by consequently inflated property values in the vicinity.
Building stock and recreational space, which even at present enrolment is over-strained.
A rapidly increasing student housing requirement coupled with a static and saturated rental market.
Separation of the main and medical campuses.

Objectives

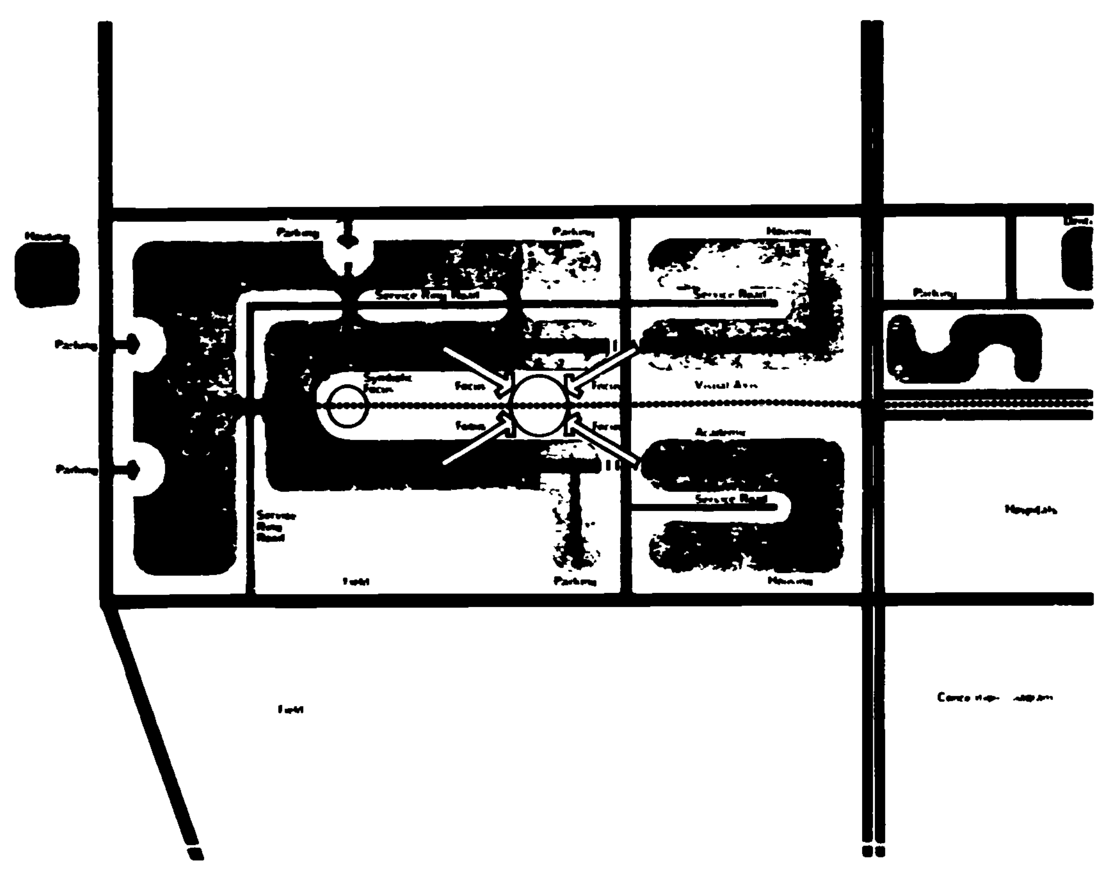
The major objectives of the plan are to achieve rational growth; increased density; unification of the two campuses; and a diverse but concentrated environment for working, living and recreation. Dispersal



1 Present land ownership. The university uses properties it has acquired for parking or academic purposes until sufficient are assembled in a block to make a development possible. Implementation along the boulevard open space spine has begun.
Terrain actuel. Acquises séparément les propriétés servent au stationnement avant qu'un bloc se développe.
2 The Concept. New buildings housing heavy student uses move the activity center from the present "visual Focus" to a central position on campus. The existing traffic pattern is rationalized to absorb all non-essential vehicles at the perimeter and to make use of land space offered by existing streets and roads. The formal existing focus is maintained. Development is "hung" on a movement and utilities framework as changing needs dictate over time.
Concept. Nouveaux bâtiments déplaçant le centre visuel et voitures amenée à la périphérie suivant disposition de viabilités.



1



2

The following description relates to Figure IV - 1 and describes in a general way some of the additional analyses that can be carried out using CAMPUS (CAATS) [2] generated space requirements.

STEP 1 Space requirements are generated. This can most easily be done using the CAMPUS simulation technique, but could be done in a large institution by the traditional means, or in a small institution by a study of courses offered and recommended class sizes etc.

STEP 2 An inventory of available space could be drawn from CAMPUS data or measured by traditional means.

STEP 3 The fit of required spaces into available is not a simple problem for the following reasons 1) small classes can use large rooms, 2) some room types are compatible to several activities, 3) some rooms are "owned" by departments or colleges, 4) migration distances about the university become quite important as size increases, and 5) capital building costs, renovation costs and maintenance costs are not easy to evaluate.

STEP 4 It is possible using linear programming to "best match" available and required. Depending on the detail required one may suppress the following information: 1) location (i.e. consider everything to be at one place), 2) college and department

(i.e. consider everything to be "owned" by one college or department, 3) type (i.e. all classrooms are of the same type - theatre and moveable seating are identical). It is possible to study one college in isolation or one category of space without conflict with others. A complete analysis for an institution like the University of Toronto is impossible even on modern machinery.

STEP 5 Having discovered gross averages and underages of space is it possible or desirable to alter activity loading and room requirements.

STEP 6 If one desires detailed information about corridor and partition (gross) it is possible to quickly calculate these based on number and type, and size of rooms required.

STEP 7 Using the above one knows a) how many rooms of each size and type he needs, and b) the mechanical and service spaces (like libraries and common rooms) that are required at this point in time. Unit costs can be applied and a "continuous capital cost" estimate built up. This would be the cost, for example, to build as required two classrooms, three labs, one thousand sq. ft. of offices and four hundred sq. ft. of mechanical space.

STEP 8 The above figures would be at best inaccurate but further study would determine feasible building amounts. For example if the requirements were for one hundred thousand sq. ft. of offices, and thirteen thousand sq. ft. of classrooms one might have a "feasible building project".

STEP 9 It is possible to study the increased utilization factors which one would have to employ to stall off additional building. One might explore these and increasing space needs with an "optimal building start time model".

STEP 10 Throughout this process one must experiment by testing alternatives further back in the chain. It may always be possible to change student loadings, or renovation or department ownership policies to obtain a "lower cost" or a "higher benefit" solution.

STEP 11 With unusual buildings like a medical science complex one will have to start gathering information on user needs very early. A more simply conceived building like an "arts addition" may require that limited information be gathered. Techniques are under investigation for determining user needs - primarily the use of questionnaires by personnel, users, and administrators about communication and such space requirements as staff workspace and common rooms.

STEP 12 Grouping theory can be used to determine which needs or objectives depend on which others. It is infeasible to build a theatre without dressing rooms and browsing through library stacks may conflict with certain security precautions. Several methods have been identified to group relevant problems together for study in total; one particular study clearly displayed the relationship between individuals in a building (i.e. who should have offices nearest).

STEP 13 As spaces are defined as needed and quantities are assigned an inventory of rooms and equipment is built up for study. Such figures as number of toilets and the amounts of mechanical space can be determined in more detail.

STEP 14 Preliminary cost estimates are prepared using "sketchy" data. The partition area and proportions of exterior wall to volume for example can be used in conjunction with square feet by space category to experiment with hypothetical structures before and during the period in which early drawings are done.

STEP 15 Sites can be selected for "least migration", and corridor patterns can be arranged to minimize the amount of corridor space required. The important thing to note is the speed

with which many alternatives can be displayed and roughly evaluated. Probably at least four or five sketch plans could be displayed and costed in a day by an experienced operator once the systems was understood. Using traditional methods each such plan would take at least a day with as detailed costing. It will of course always be necessary to evaluate social and psychological intangibles by hand.

Figure IV - 1

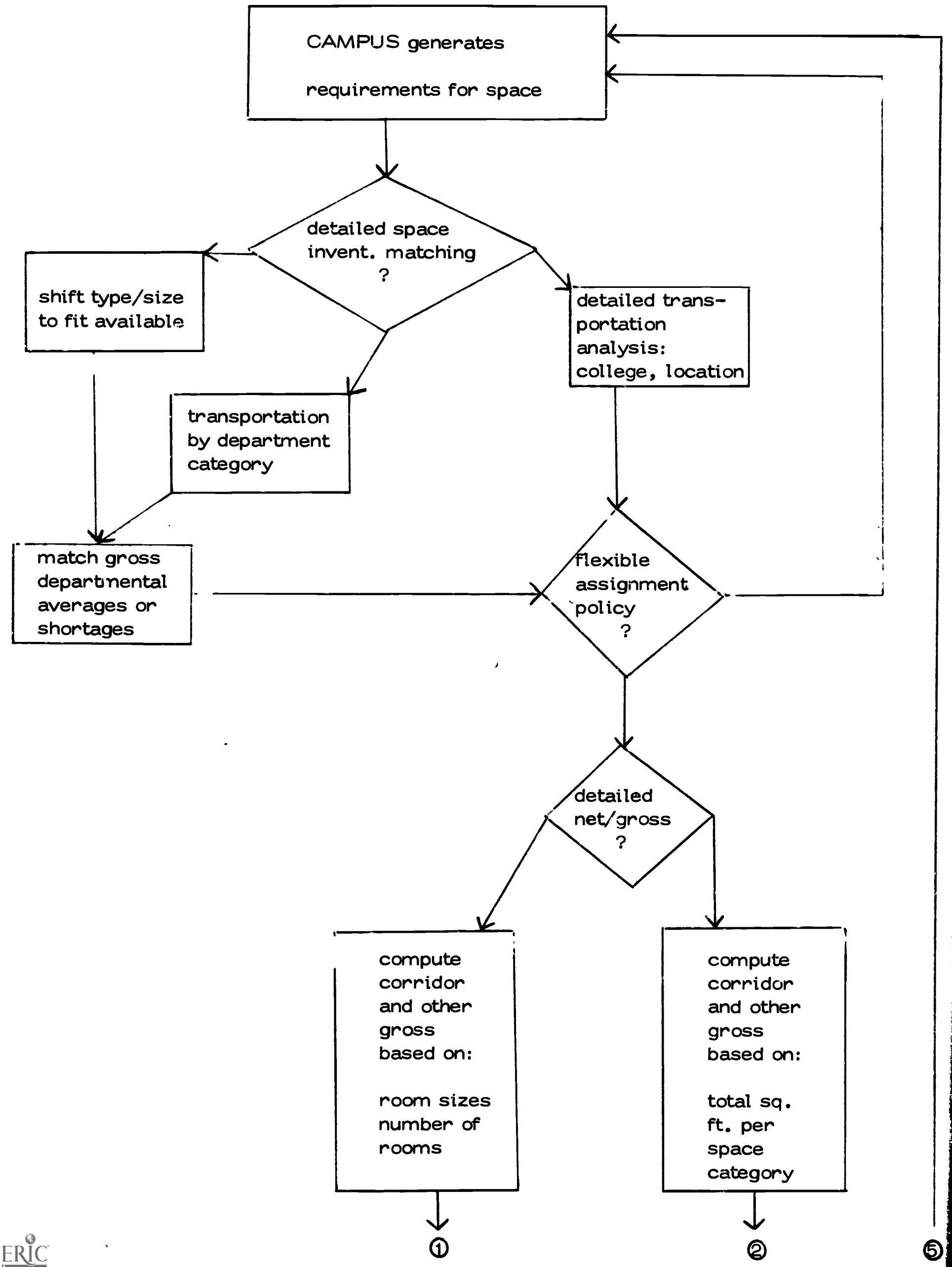

CAMPUS generates requirements for space
detailed space invent. matching ?
shift type/size to fit available
transportation by department category
match gross departmental averages or shortages
detailed trans-portation analysis: college, location
flexible assignment policy ?
detailed net/gross ?
compute corridor and other gross based on:
room sizes number of rooms
compute corridor and other gross based on:
total sq. ft. per space category
①
②
⑤

Figure IV - 1b

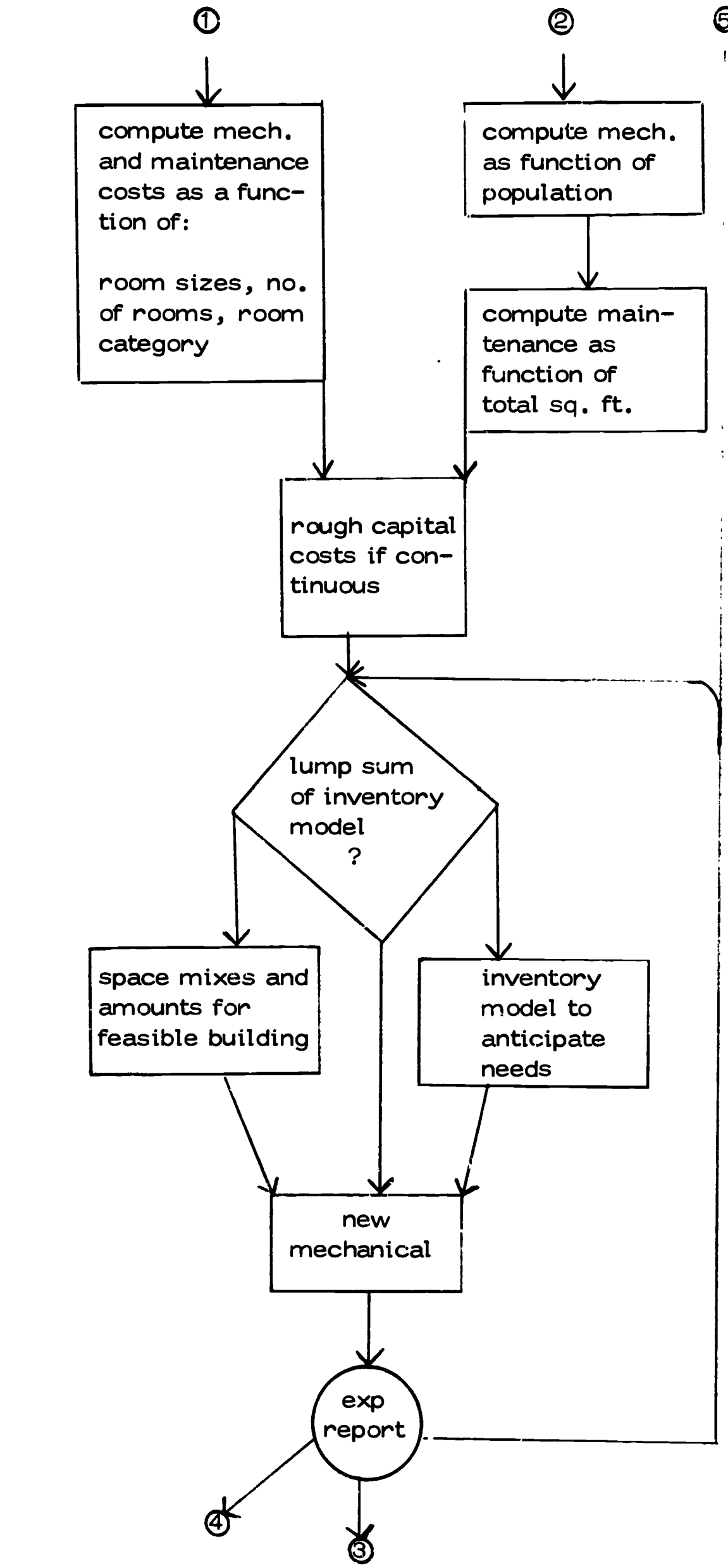
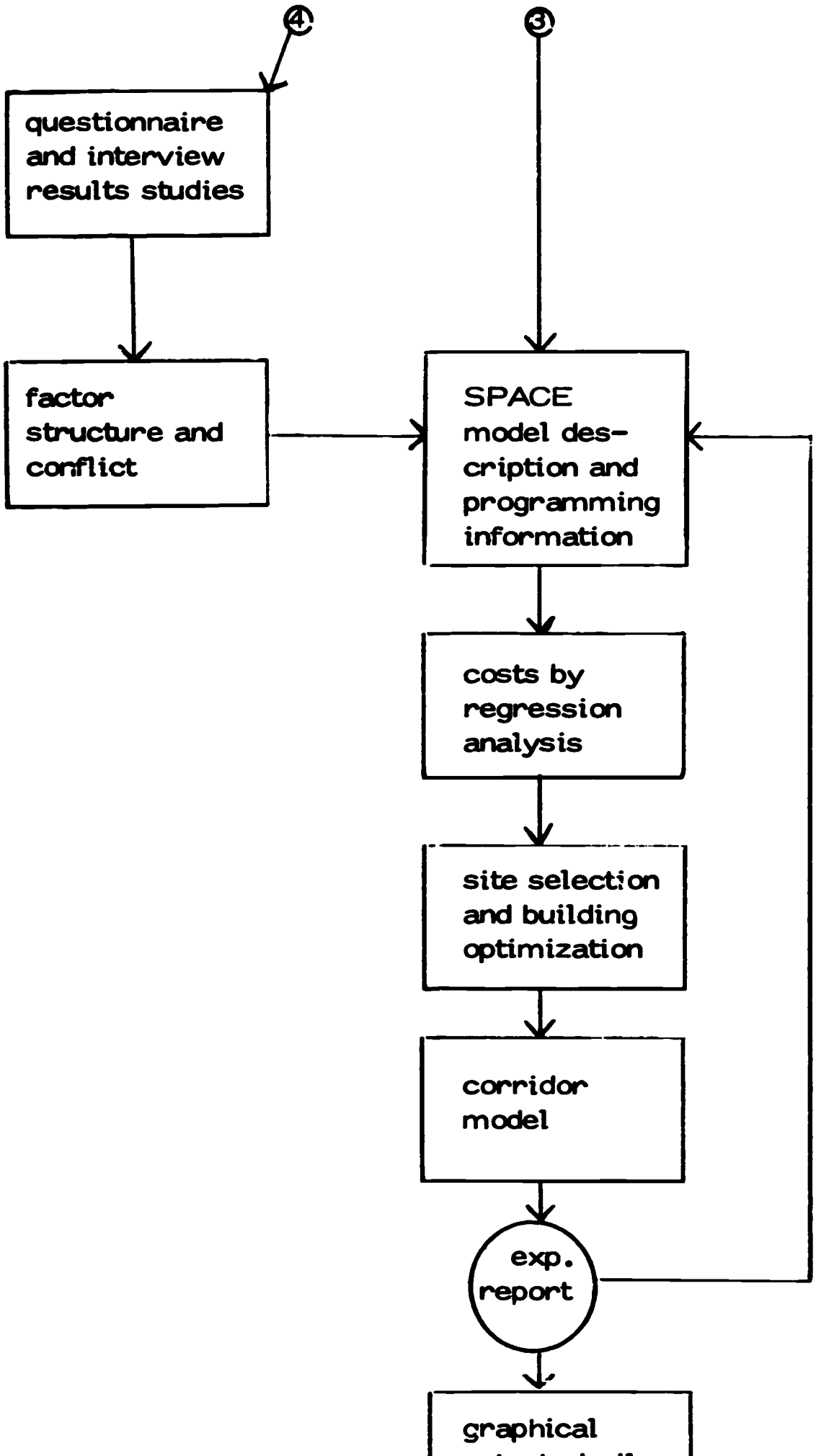

①
②
⑤
compute mech. and maintenance costs as a function of:
room sizes, no. of rooms, room category
compute mech. as function of population
compute maintenance as function of total sq. ft.
rough capital costs if continuous
lump sum of inventory model ?
space mixes and amounts for feasible building
inventory model to anticipate needs
new mechanical
exp report
④
③

Figure IV - 1c


④
③
questionnaire and interview results studies
factor structure and conflict
SPACE model description and programming information
costs by regression analysis
site selection and building optimization
corridor model
exp. report
graphical output similar to Craft/Aldep