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AUTHOR	Tallman, B. M.; Newton, R. D.
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ABSTRACT

This report is concerned with the development of a model for projecting the enrollments of The Pennsylvania State University by simulating the flow of students through the campuses and colleges of which the institution is composed. Because it concerns a twenty-two campus system of a single university, it not only constitutes an institutional application but also represents a prototype of a state-system of higher education. Markovian in concept, the model is based upon the premise that at a point in time a given group of students, possessing a set of institutionally-assigned characteristics distinguishing them as unique from all others, has an associated set of probabilities, which describe their distribution at the next point in time among similar sets of unique categorizations. When suitably classified enrollments at one point in time are provided as input to such a model and multiplied by appropriate sets of probability distributions, the output constitutes a projection of enrollments at the next point in time. (Author)

THE PENNSYLVANIA STATE UNIVERSITY

OFFICE
OF
BUDGET AND PLANNING
University Park, Pa. 16802

A STUDENT FLOW MODEL FOR PROJECTION OF ENROLLMENT IN A MULTI-CAMPUS UNIVERSITY

B. M. Tallman and R. D. Newton

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Operations Research
Office of Budget and Planning
The Pennsylvania State University
University Park, Pennsylvania 16802

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I: SUMMARY

The patterns of movement of students in a multi-campus institution of higher education have a significant impact upon the magnitude and major program composition of the enrollment at any one location. Inasmuch as the size and make-up of the student body are determinants of the demand for instructional services, it is of major importance that the institution be able to measure and predict these patterns of flow and to reflect them in their projections of enrollment.

This report is concerned with the development of a model - designated as SFM-1 - for projecting the enrollments of The Pennsylvania State University by simulating the flow of students through the campuses and colleges of which the institution is composed. Conceptually, it is based upon the premise that at a point in time a given group of students, possessing a set of institutionally-assigned characteristics distinguishing them as unique from all others, has an associated set of probabilities, which describe their distribution at the next point in time among similar sets of unique categorizations. When suitably classified enrollments at one point in time are provided as input to such a model and multiplied by appropriate sets of probability distributions, the output constitutes a projection of enrollments at the next point in time.

Models of this type are categorized as Markovian in formulation. Although conceptually accepted by the higher educational community as an improved methodology for projecting enrollments, applications are few in number and even fewer in those cases involving not only movement within a given location but among

different locations as well. The model described in this report bears a resemblance to two previously formulated models of state-systems of higher education encompassing the aspect of inter-campus flow, but it differs from both in that it provides a much higher level of disaggregation making it suitable for both system-wide as well as campus management. Because it concerns a twenty-two campus system of a single university, it not only constitutes an institutional application but also represents a prototype of a state-system of higher education.

The work was conducted principally between December 1971 and August 1972. It has resulted in a system, utilizing the existing records of the University and the facilities of the Computation Center, which is capable, given a forecast of admissions, of generating a ten-year projection of Fall term enrollment by campus, degree-level, student-level, college, and department at a computational cost of $35 with an annual updating expense of $110. The projections one year into the future are accurate within 0.5% when measured on a system-wide basis and within 4% when the sum of differences without regard for sign between the actual and projected enrollments by campus are expressed as a percent of total enrollment.

In practice the Student Flow Model may serve several purposes. First, in conjunction with the Admissions Model it provides an efficient way to project future enrollments. Secondly, the output from the model when employed as input to the Instructional Activity Model generates projections of the demand for instructional activity. And lastly, the model may ultimately serve as an essential part of a total simulation model of the University.

II: INTRODUCTION

The ways in which students move through and from a system of higher education - progressing in academic level, changing their fields of specialization, transferring to new locations, withdrawing, and graduating - are major determinants of both the magnitude and composition of the demand imposed upon the institution for instructional services. Within a college or university, the demand for instructional services can be related to the enrollment of students at various academic levels in different curricula. Consequently, projections of enrollment similarly disaggregated are requisite for providing adequate lead time to assure the allocation of resources in an efficient and effective manner.

Although an institution - and indeed the educational community at large - may influence the patterns of student movement, it does not control them. Once admitted, the initiative passes to the student and it is the institution which must respond to the varying patterns of movement during the period of attendance. Consequently, it is of major importance that the institution be able to measure and predict these patterns well in advance of their occurrence and to reflect them in their projections of enrollment.

For this reason considerable interest in recent years has been shown in the use of what is characterized as the Markov process for describing the flow of students through an educational system. The Markov process is based upon the premise that at a point in time a given group of individuals possessing a set of characteristics categorizing them as unique from all other groups - such as sophomore engineering students - has an associated set of transition probabilities, which in turn describes the status of the group at the next point in time - such as 80% will be junior engineering students, 5% will have transferred to another curriculum, 5% will have withdrawn, etc. Using historical data, it is possible to construct sets of transition probabilities, measuring the distribution of students in each origin state among all possible terminal states and to use these values as a vehicle for projecting enrollments from one point in time to the next.

Although conceptually accepted, there have been relatively few applications using a Markovian approach for projecting enrollments. With the exception of one by Gani (3) in 1963 concerning the projections of enrollment in the Australian system of higher education, all were reported around the turn between the last and current decades. Models for simulating aggregate enrollments at each major level of national systems of education were devised by Thonstad (15) and Zabrowski (16). Additionally, the technique was adopted to describe student-flows within the framework of resource simulation models for institutions of higher education by Koenig et al. (5) and Firmin (2) and to evaluate admission and enrollment options by Smith (12), Marshall (8), and Oliver et al. (10).

Of particular note, because they reflect the movement of students not only within an institution but also among different locations, are two other applications. The first is the HEEP model, designed and implemented by the Office of Program Planning and Fiscal Management (4) in the State of Washington to simulate the flows of undergraduate students by various academic levels within a state-wide system of higher education. The other, similar in concept but providing an additional dimension to the categorization of students, namely that of broadly defined disciplines of study, is a model developed and pilot-tested by Baisuck et al. (1) of the Rensselaer Research Corporation for the New York State Education Department. but apparently not implemented for routine application by its sponsors.

Of more recent origin, NCHEMS, recognizing the inherent importance of enrollment projections upon resource management, initiated a program to develop an institutional student-flow model (7). Availability of this model is currently anticipated by the beginning of 1974.

At The Pennsylvania State University, a model was developed in 1968 by Newton (9) employing a Markovian concept of student-flow for projecting system-wide enrollments by academic level and college, but its utility was limited by inadequate specification of inter-campus flows. Later research conducted by Richard (11) provided evidence that different sources of incoming students need not be categorized separately for establishing their subsequent patterns of behavior. Both of these investigations provided insight for defining the design specifications of the model described in this report.

The model described in this report is concerned with projecting the enrollments in an institution of higher education by simulating the flow of students within and from the institution. Explicit in its use is the availability for input of a forecast of admissions into the institution. It is principally Markovian in concept, although it has been necessary to rely on other techniques at least on a transitory basis in order to circumvent certain informational limitations. As such it is not methodologically unique. What is unique about the model, which has been designated as SFM-1, is that it depicts student-flow within as well as among the twenty-two campuses of The Pennsylvania State University. Consequently, it bears a resemblance to both the HEEP and Rensselaer models, but differs from both in that it is more highly disaggregated, making it suitable for institutional as well as campus management. Because it concerns a twenty-two campus system of a single university, it also represents a prototype application of a state-system of higher education.

Successful pursuit of efforts of this type are dependent upon the contributing roles played by a number of individuals and this project is not an exception. Several of these are of particular note. Even within an educational institution, acceptance of the need to break new ground can be a frustrating experience and for their support in nothing more tangible than a conceptualized goal we are indebted to both C. G. Norris and P. M. Etters. For their patient counsel and response to a myriad of questions in the process of design, recognition is due W. R. Haffner and A. W. Tyson. Lastly and of major significance is the contribution of C. A. Lindsay made years before work even began on the model; had he not taken the initiative in the middle 1960's in the development of what still must be regarded as a remarkable concept for maintenance of chronological records of student progression, the essential data for construction of the Student Flow Model would have been lacking.

III: CONCEPTUALIZATION

In the previous chapter, it was stated

> *that in a multi-campus institution of higher education, the patterns of student movement among academic levels, fields of specialization, and campuses have a significant impact upon the magnitude and major-program composition of the enrollment at any one location.*

In this chapter it will be shown how these flows of students may be conceptualized in a form analogous to what is characterized as a Markov process, which in turn may be used as the basis for development of a model for projecting enrollments in an institution of higher education.

MARKOV PROCESS

A Markov process is a discrete time system characterized by a set of probabilities, one for each of the transitions from each origin state to each of the possible terminal states at the next juncture in time. Between two states, the transition probabilities or rates are assumed to be dependent only upon the origin state. If these rates, as measured from historical observations, are constant over time, they may be employed as the basis for projecting the flow from an origin state to each of the possible states at the next point in time.

The flow of students within and from an educational institution is analogous to a Markovian process. At any point in time, such as the start of a term, semester, or academic year, students may be categorized into states or common groups in accord with some measure of their academic level - first year, second year, etc. and associate degree, baccalaureate degree, etc. - within their fields of specialization - liberal arts, law, engineering, etc. - within the institution. For a multi-campus institution, an additional element representing location is added to the dimensional characteristics of each category. For each group of students having a unique combination of these characteristics, there exists a set of probabilities which describe their distribution among all possible states at the next point in time. The utility of a Markov-type model for projecting student-flows lies in the fact that when enrollments, suitably categorized into common states at one point in time, are multiplied by the appropriate transition rates the result is a projection of the enrollments similarly categorized for the next point in time.

MODEL FORMULATION

In order to formulate a student-flow model in a form analogous to a Markov-type process, it is necessary to have available chronological records of students containing at calendar-identifiable points in time each student's academic level, field of study and, for a multi-campus institution, location. From such a record it is possible to determine

1: at some historical point in time, such as the start of the Fall term, the enrollment of students suitably categorized in accord with unique combinations of academic level, field of study, and location;

2: for the students categorized into each of these origin states, the enrollments at the next point in time, such as the following Fall term, in each suitably categorized terminal state; and

3: by dividing the enrollment in each terminal state by that appropriate to its origin state, to develop a set of transition rates.

The model operates on the assumption that the future enrollment is derived through the probabilities of students moving between two defined points in time from one state to other states. These probabilities are expressed by means of the transition rates. Once a student enters the system, there is a limited number of optional paths in which he can move from year to year. Once he is admitted to the institutional system, the individual either moves from state to state until he graduates or withdraws.

Transition Matrix

For illustrative purposes, a hypothetical example has been devised to show how data of the type described may be developed and used to compile the probability rates comprising a transition matrix. In order to simplify the discussion, the example is limited in scope to a single-campus institution. Let us assume that a hypothetical institution has students enrolled in two different fields of specialization - Letters and Applied Sciences - and at two student-levels - first and second year - within an associate degree-level program. Under such a structure, all returning and new students must be categorized within one of the following four origin states:

Letters - 1st year

Letters - 2nd year

Applied Sciences - 1st year

Applied Sciences - 2nd year

One year later, all of these students must be categorized within one of the following six terminal states:

Letters - 1st year

Letters - 2nd year

Applied Sciences - 1st year

Applied Sciences - 2nd year

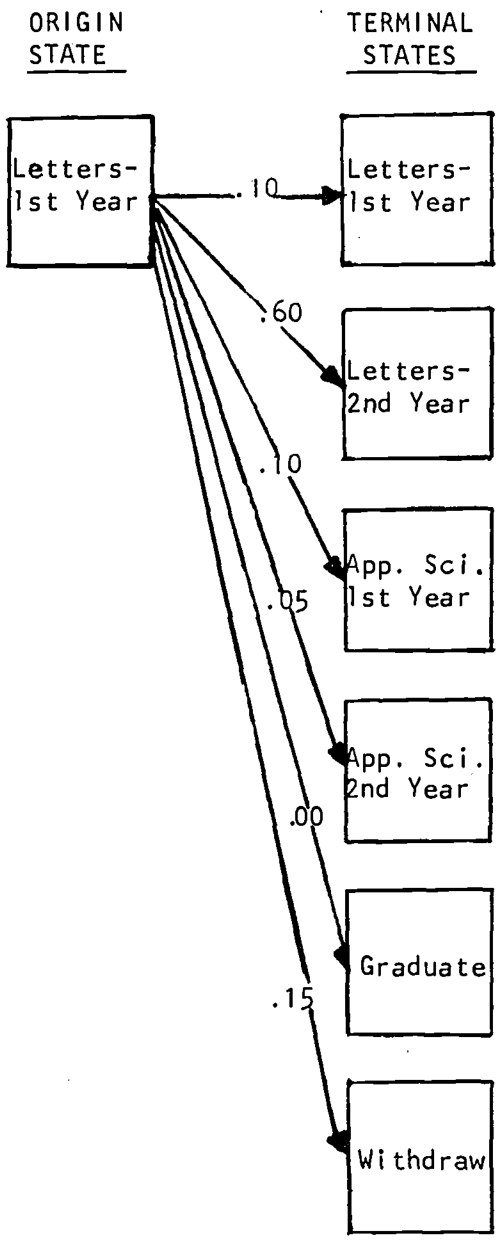
Graduated

Withdrawn

Let us furthermore assume that, from an appropriate record source, we can determine that at a point in time, such as the Fall term of 1970, there were 100 students enrolled as first-year students in Letters. One year later, in the Fall of 1971, these same students were distributed as follows: 10 in first-year Letters, 60 in second-year Letters, 10 in first-year Applied Sciences, and 5 in second-year Applied Sciences. In addition, 15 had withdrawn from attendance in the institution. The flow of students between the one origin state and all possible terminal states during these two points in time may be symbolically described as shown in Figure III-1. In order to determine the transition rates between the origin and terminal states, the enrollment in each terminal state is divided by the enrollment in their common origin state. For the case under consideration, the computed rates between each pair of states is shown on the arrows depicting the flow of students in Figure III-1. As will be noted, these fractions account for the entire flow from the crigin state to all possible terminal states between the two points in time. As a consequence, the summation of the rates from any one origin state must be equal to 1.0.

FIGURE III-1

ILLUSTRATIVE EXAMPLE OF THE FLOW OF STUDENTS FROM ONE ORIGIN STATE TO ALL POSSIBLE TERMINAL STATES



In a similar manner, the various flows of students in the hypothetical institution between each of the origin states and each of the possible terminal states at their respective sequential points in time may be depicted as shown in Figure III-2. The distribution of the enrollment in each origin state among all possible terminal states for the illustrative example is shown in Table III-1 and the appropriately calculated transition rates are listed in Table III-2.

FIGURE III-2

ILLUSTRATIVE EXAMPLE OF THE FLOW OF STUDENTS FROM ALL ORIGIN STATES TO ALL POSSIBLE TERMINAL STATES

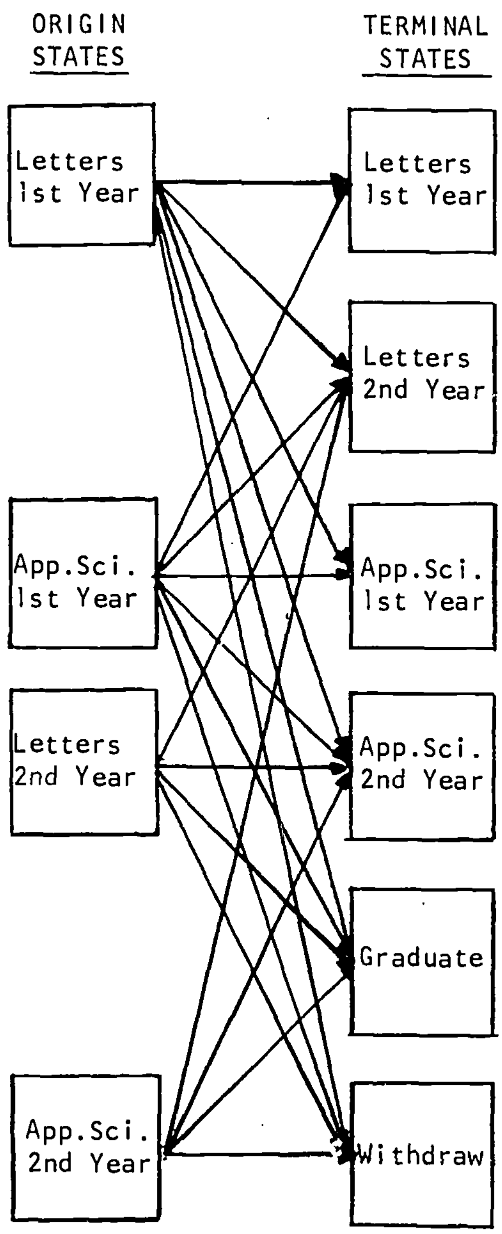


TABLE III-1

ILLUSTRATIVE EXAMPLE OF DISTRIBUTION OF ENROLLMENT IN ORIGIN STATE AMONG TERMINAL STATES

Origin		Enrollment At Terminal State					
State	Enrollment	Letters-1	Letters-2	App. Sci.-1	App. Sci.-1	Grad.	Withdraw
Letters-1	100	10	60	10	5		15
Letters-2	55		3			47	5
App. Sci.-1	50	1	4	5	25		15
App. Sci.-2	35				5	25	5

TABLE III-2

ILLUSTRATIVE EXAMPLE OF TRANSITION RATES BETWEEN ORIGIN AND TERMINAL STATES

Origin State	Transition Rates To					
	Letters-1	Letters-2	App. Sci.-1	App. Sci.-2	Grad.	Withdraw
Letters-1	.100	.600	.100	.050		.150
Letters-2		.055			.855	.090
App. Sci.-1	.020	.080	.100	.500		.300
App. Sci.-2				.143	.714	.143

Projection Model

Provided that the rates comprising the transition matrix are stable over time, it may be employed together with the enrollment of returning students and a given forecast of new admissions at one point in time to generate projections of the enrollment of returning students at the next point in time. This is done by multiplying the sum of enrollment of returning students and of new admissions for each year by the appropriate rates in the transition matrix and then aggregating the products over common states to derive the enrollment of returning students for the following period of time. The process is then repeated in an iterative mode until projections are developed for the entire projected time-frame.

To illustrate in tabular form how the process proceeds in an iterative fashion, assume for the hypothetical institution an input of returning students for time-period 1 and forecasts of new admissions for time-periods 1, 2, and 3 and the applicability of the transition matrix shown in Table III-2. The steps involved in developing enrollment projections for three time-periods are depicted in Table III-3.

The number of possible student-flows has been limited in this example in order to illustrate diagramatically as well as computationally the steps involved in the projection process. However, conceptually the steps described in the example are equally applicable to any student-flow problem regardless of the number of dimensions - academic levels, fields of specialization, and locations - used to describe origin and terminal states.

TABLE III-3

ILLUSTRATIVE EXAMPLE OF PROJECTION MODEL

(INPUT) (OUTPUT) (TRANSITION MATRIX)

	Enrollment at Time=1					Transition Rates							Returning Enrollment for Time=2					
	New	Return		Total		Letters-1	Letters-2	Ap.Sci.-1	Ap.Sci.-2	Grad.	Withdraw		Letters-1	Letters-2	Ap.Sci.-1	Ap.Sci.-1	Grad.	Withdraw
Letters-1	110 +	10	=	120	x	.100	.600	.100	.050		.150	=	12	72	12	6		18
Letters-2	5 +	75	=	80	x			.055		.855	.090	=			5		68	7
Ap.Sci.-1	60 +	20	=	80	x	.020	.080	.100	.500		.300	=	2	6	8	40		24
Ap.Sci.-2	2 +	58	=	60	x				.143	.714	.143	=				9	43	8
													14	78	25	54	111	57

	Enrollment at Time=2					Transition Rates							Returning Enrollment for Time=3					
	New	Return		Total		Letters-1	Letters-2	Ap.Sci.-1	Ap.Sci.-2	Grad.	Withdraw		Letters-1	Letters-2	Ap.Sci.-1	Ap.Sci.-1	Grad.	Withdraw
Letters-1	120 +	14	=	134	x	.100	.600	.100	.050		.150	=	13	81	13	7		20
Letters-2	10 +	78	=	88	x			.055		.855	.090	=			5		75	8
Ap.Sci.-1	80 +	25	=	105	x	.020	.080	.100	.500		.300	=	2	8	11	52		32
Ap.Sci.-2	10 +	54	=	64	x				.143	.714	.143	=				9	46	9
													15	89	29	68	121	69

	Enrollment at Time=3			
	New	Return		Total
Letters-1	125 +	15	=	130
Letters-2	5 +	89	=	94
Ap.Sci.-1	100 +	29	=	129
Ap.Sci.-2	10 +	68	=	78

MATHEMATICAL RELATIONSHIP

Mathematically the enrollment at some point in time may be projected from a prior point in time by means of the following relationship:

$$E_{j,t+1} = \sum_{i=1}^{m} E_{j(i),t} + N_{j,t+1} \text{ for } j = 1, 2 \ldots m \qquad (1)$$

where: $E_{j,t+1}$ = student enrollment in year t+1 in terminal state j, where j defines a unique set of characteristics common to all students in that terminal state.

$E_{j(i),t}$ = student enrollment in year t in origin state i who move to terminal state j in year t+1, where i and j define sets of characteristics common to all students in each of the respective states.

$N_{j,t+1}$ = new students entering the system in year t+1 in state j.

Since $E_{j(i)}$ represents measures of the flows between origin state i and terminal state j of students already in attendance, transition rates expressing the distribution of students in state i among state j may be computed from historical data as follows:

$$f_{ij} = \frac{E_{j(i),t}}{E_{i,t-1}} \text{ for } j = 1, 2 \ldots m \qquad (2)$$

where: f_{ij} = transition rate of students between origin state i and terminal state j.

Therefore, Equation 1 may be expressed as follows:

$$E_{j,t+1} = \sum_{i=1}^{m} f_{ij} E_{i,t} + N_{j,t+1} \text{ for } j = 1, 2 \ldots m \qquad (3)$$

IV: DEVELOPMENT

In the previous chapters, it was shown

1: *that in a multi-campus institution of higher education, the patterns of student movement among academic levels, fields of specialization, and campuses have a significant impact upon the magnitude and major-program composition of enrollment at any one location, and*

2: *that these patterns of movement may be described by sets of transition rates expressing the probabilities of students following various paths between successive points in time.*

This chapter is concerned with establishment of a suitable base of historical data from which the transition matrices as well as ancillary relationships may be developed for incorporation with a model for projecting student-flow for a large multi-campus institution, namely The Pennsylvania State University.

CRITERIA FOR STRUCTURE

Inasmuch as the composition of the output from a model is dependent upon both the structure of the model and the data used to develop it, a delineation of required output constitutes the initial step in design. This is necessary to assure the utility of a model as a vehicle for supplying both explicit and perceived informational needs.

At The Pennsylvania State University, admissions are planned by means of an iterative process, involving the generation of enrollment projections for a series of options concerning the magnitude and composition of admissions with subsequent selection for implementation of the one option which produces an enrollment projection reflecting the greatest consistency with that representing both policy and resource constraints. This projection of enrollment is then employed as the basic input to the procedures employed for developing the University's internal budget and for preparation of documents in support of the appropriation request to the Commonwealth. Although the contents of the projection output required for these three interrelated processes differ from one another, any model from which they are derived must possess a commonality of base to provide assurance of consistency.

For the iterative process involved in planning admissions and enrollments, the enrollment projections must be displayed in a disaggregated form by campus and by degree-level in the initial phase of testing various optional levels of admission. Once the resulting enrollments are in general alignment with policy and resource constraints, further disaggregation by degree-level and in the case of the University Park Campus by college or category of enrollment is usually required.

For application to the internal budgetary process, projections of enrollment are used both as a direct - as well as an indirect - input with the latter involving subsequent use in deriving instructional activity consumption and production from the Instructional Activity Model. As a direct input, the levels of disaggregation required of enrollment projections in the final stage of the admission and enrollment planning process satisfy the requirements of budgetary responsibility, which currently rests at the so-called administrative-division level. However, for analytical purposes, the enrollments are further subdivided by department for the University Park and Capitol Campuses as well as the Hershey Medical Center and by college for the balance of the campuses in the system.

At the present time, in support of the University's appropriation request to the Commonwealth both PPBS and formula submissions are required. Currently enrollment projections on a head-count basis are not required for these submissions. They do, however, represent an indirect input since they are employed in the Instructional Activity Model to derive instructional activity consumption and production values, which are inherent parts of both sets of documents, and to derive projections of degrees-awarded by HEGIS discipline-division in the case of the PPBS process.

For the three interrelated processes, there is consistency in the content required of enrollment projections with respect to campus, degree-level, and student-level. Although somewhat of a dichotomy does exist concerning the level of aggregation required for specifying fields of specialization, the need to delineate these fields at the departmental level for certain campuses of the University and at the HEGIS discipline-division level for the PPBS submission makes it necessary to produce enrollment projections for all campuses at the departmental level of specialization.

CATEGORIZATION OF STUDENTS

In accord with the broad criteria adopted for assessing the utility of enrollment projections in relation to both internal and external needs, students are categorized in accord with attributes identifying physical location, academic level, and field of specialization. Physical location is denoted by campus, academic level by degree-level and within same where appropriate, by student-level, and field of specialization by college or category of enrollment and, within same where appropriate, by departmental responsibility for major programs of study. All measurements of the number of students within each category are in terms of head-count enrollments applicable to the Fall term of each academic year.

Location

Twenty-five geographical identities are currently employed to classify the locations of attendance for the resident education function of the University. These encompass the twenty-two campuses and centers of the University as well as three other geographical identities which are essentially extensions of programs administered by organizational units at the University Park Campus. For this reason the latter three - involving the nursing program conducted at selected hospitals, graduate students registered for off-campus research, and students enrolled in the study-abroad program - are included for purposes of classifying enrollments as part of University Park Campus. Shown below are the twenty-two locations adopted for use in categorizing students.

TABLE IV-1

CAMPUSES

Allentown Center
Altoona Campus
Beaver Campus
Behrend Campus
Berks Campus
Capitol Campus
Delaware County Campus
DuBois Campus
Fayette Campus
Hazleton Campus
Hershey Medical Center
King of Prussia Graduate Center
McKeesport Campus
Mont Alto Campus
New Kensington Campus
Ogontz Campus
Schuylkill Campus
Shenango Valley Campus
University Park Campus
Wilkes-Barre Campus
Worthington-Scranton Campus
York Campus

Academic Level

Within the hierarchy conceived and used to describe the academic levels of students, students may be categorized from the standpoint of degree-level - associate, baccalaureate, etc. - and within certain of these by student-level - first year, second year, etc. The relationships between these measures of academic level are shown in Table IV-2.

TABLE IV-2
HIERARCHY OF ACADEMIC LEVELS

DEGREE-LEVEL	STUDENT-LEVEL
Associate	1 2
Baccalaureate	1 2 3 4 & 5
Graduate	1 2 or more
Adjunct	Not Applicable

For the application under review, students are classified by degree-level and within same by student-level with one exception. The specific exception concerns suppression of student-level within the graduate degree-level, an expedient necessitated by current data limitations.

Fields of Specialization

Within the hierarchy used to describe fields of specialization, most students may be categorized in accord with the specific major program of study in which they are enrolled, the department having responsibility for the curriculum content of the program, or the college in which the department is situated for organizational and fiscal purposes. For application to the Student Flow Model, student categorization by field of specialization is limited to the aggregations of majors at the college and departmental organization levels. Although subdivision by major program was conceived as a desirable goal, it was considered to be infeasible to derive reliable projections of enrollment by major at each student-level. It was necessary to impose this limitation because of the very small numbers of students enrolled in most majors - and frequently exhibiting random patterns over time - at many of the campuses of which the University system is composed.

In addition to the eleven colleges offering degree programs at one or more degree-levels, there are four administrative categories in which a student may be classified for purposes of enrollment. These categories of enrollment are Division of Counseling, Capitol Campus, Inter-College, and Non-Degree. For undergraduate study, a student's program is administered by the Division of Counseling if he has not selected a major for study. At the Capitol Campus, the responsibility for undergraduate majors rests with the faculty at that location and the same is true for the preponderance of graduate programs. Students in interdisciplinary programs are classified within the Inter-College category for purposes of enrollment. A student will be assigned non-degree status for purposes of enrollment categorization if he has been admitted to the Graduate School but has not selected a field of study or if he has simply adjunct status. Within each of the eleven colleges as well as the Capitol Campus and Inter-College categories, a further subdivision of major program assignment may be made to departmental units.

Shown in Table IV-3 are the colleges or categories of enrollment and, where applicable within same, the departments adopted for classifying students in accord with their fields of specialization, together with the appropriate five-digit budget code used internally by the University for resource assignment. In addition is shown for each department the HEGIS discipline-division code applicable to the preponderance of major programs within its area of responsibility.

TABLE IV-3

HIERARCHY OF FIELDS OF SPECIALIZATION*

College of Category of Enrollment	Department of Enrollment: Name	Department of Enrollment: Budget	HEGIS Code: Bacc.	HEGIS Code: Assoc.
College of Agriculture	Agricultural Economics	204-08	01	54
	Agricultural Education	204-10	08	55
	Agricultural Engineering	204-12	09	53
	Entomology	204-13	04	54
	Agronomy	204-15	01	54
	Plant Pathology	204-16	04	54
	Animal Science	204-17	01	54
	Dairy Science	204-37	01	54
	Forestry	204-53	01	54
	Horticulture	204-66	01	54
	Poultry Science	204-77	01	54
	Veterinary Science	204-88	04	54
	Inter-Department	204-00	01	54
College of Arts and Architecture	General Education	205-07	10	50
	Architecture	205-11	02	53
	Art History	205-14	10	50
	Landscape Architecture	205-33	02	53
	Music	205-38	10	50
	Art	205-44	10	50
	Theatre	205-48	10	50
	Inter-Department	205-00	10	50
College of Business Administration	Accounting	206-11	05	50
	Business Logistics	206-15	05	50
	Finance	206-19	05	50
	Insurance and Real Estate	206-24	05	50
	Management Science	206-35	05	50
	Marketing	206-36	05	50
	Inter-Department	206-00	05	50

*Status at end of 1971-72 Academic Year.

TABLE IV-3 (continued)

HIERARCHY OF FIELDS OF SPECIALIZATION

College or Category of Enrollment	Department of Enrollment: Name	Department of Enrollment: Budget	HEGIS Code: Bacc.	HEGIS Code: Assoc.
College of Earth and Min. Sciences	Geography	224-12	22	55
	Meteorology	224-18	19	53
	Geosciences	224-19	19	53
	Mineral Economics	224-24	19	53
	Mineral Engineering	224-25	09	53
	Materials Science and Constitution	224-36&20	09	53
	Inter-Department	224-00	19	53
College of Education	Academic Curriculum and Field Exp.	212-06&32	08	55
	Art Education	212-08	08	55
	Counselor Education	212-09	08	55
	Educational Psychology	212-10	08	55
	Educational Policy	212-12	08	55
	Vocational Education	212-14	08	55
	Home Economics Education	212-21	08	55
	Music Education	212-24	08	55
	Special Education	212-31	08	55
	Inter-Department	212-00	08	55
College of Engineering	Aerospace Engineering	205-14	09	53
	Architectural Engineering	205-17	09	53
	Chemical Engineering	215-19	09	53
	Civil Engineering	215-21	09	53
	Electrical Engineering	215-31	09	53
	Acoustics	215-33	09	53
	Engineering Mechanics	215-37	09	53
	Engineering Science	215-38	09	53
	Industrial Engineering	215-44	09	53
	Mechanical Engineering	215-51	09	53
	General Engineering	215-55	09	53
	Nuclear Engineering	215-56	09	53
	Inter-Department	215-00	09	53

TABLE IV-3 *(continued)*

HIERARCHY OF FIELDS OF SPECIALIZATION

College or Category of Enrollment	DEPARTMENT OF ENROLLMENT		HEGIS CODE	
	Name	Budget	Bacc.	Assoc.
College of Health, Physical Education and Recreation	Instruction	227-11	08	55
College of Human Development	Individual and Family Studies	218-11	13	50
	Biological Health	218-12	12	52
	Biological Health, Nursing	218-13	12	52
	Community Development	218-14	21	55
	Man-Environment Relations	218-15	13	50
	Inter-Department	218-00	21	55
College of Liberal Arts	General Education	221-07	15	50
	Anthropology	221-12	22	55
	Classics	221-15	11	50
	Economics	221-18	22	55
	English	221-20	15	50
	French	221-28	11	50
	German	221-31	11	50
	History	221-34	22	55
	Journalism	221-41	06	50
	Labor Studies	221-43	05	50
	Linguistics	221-46	15	50
	Philosophy	221-51	15	50
	Political Science and Public Administration	221-54&37	22	55
	Psychology	221-55	20	55
	Religious Studies	221-56	15	50
	Slavic	221-59	11	50
	Sociology	221-64	22	55
	Spanish, Italian, Portugese	221-65	11	50
	Speech	221-67	15	50
	Inter-Department	221-05	49	50

TABLE IV-3 (continued)

HIERARCHY OF FIELDS OF SPECIALIZATION

	DEPARTMENT OF ENROLLMENT		HEGIS CODE	
College or Category of Enrollment	Name	Budget	Bacc.	Assoc.
College of Medicine	Anatomy	217-12	04	54
	Anesthesiology	217-14	12	52
	Comprehensive Medicine	217-15	12	52
	Behavioral Science	217-18	12	52
	Biological Chemistry	217-22	12	52
	Family Medicine	217-25	12	52
	Medicine	217-41	12	52
	Obstetrics	217-47	12	52
	Pathology	217-49	04	54
	Pediatrics	217-51	12	52
	Pharmacology	217-52	12	52
	Psychiatry	217-59	12	52
	Radiology	217-62	12	52
	Surgery	217-67	12	52
College of Science	General Education	228-07	04	54
	Astronomy	228-09	19	53
	Biochemistry	228-12	04	54
	Biology	228-15	04	54
	Chemistry	228-21	19	53
	Computer Science	228-28	07	51
	Mathematics	228-44	07	51
	Microbiology	228-46	04	54
	Physics	228-54	19	53
	Statistics	228-74	17	53
Division of Counseling	—			
Capitol Campus	Humanities, Social Sciences, and Education	260-10	22	55
	Engineering Technology	260-20	09	53
	Business Administration	260-30	05	50
	Mathematics	260-90	07	51

TABLE IV-3 (continued)

HIERARCHY OF FIELDS OF SPECIALIZATION

	DEPARTMENT OF ENROLLMENT		HEGIS CODE	
College or Category of Enrollment	Name	Budget	Bacc.	Assoc.
Inter-College	Environmental Pollution Control	231-20	49	50
	Regional Planning and Admin.	231-22	49	50
	Other Graduate Inter-College	232-01	49	50
	Undergraduate Inter-College	231-09	49	50
Non-Degree	—			

DATA REQUIREMENTS

In Chapter II, it was stated, that although the Student Flow Model described in this report was Markovian in concept, it was necessary to rely on other methodology to circumvent current data limitations.

For projecting both associate and baccalaureate degree-level enrollments, which collectively comprise over 80% of the University's resident education enrollment, the flows of students are developed in accord with a Markov-type process, as described conceptually in Chapter III. In this step students were categorized in origin and terminal states in accord with their campus, degree-level, student-level, and college or category of enrollment. Although the basic record, from which the data on student flow were extracted, would have permitted identification of major programs of study, which in turn could have been aggregated to the departmental level, this option was not exercised because of the very small enrollments observed in many of the major programs of study in the various campuses of the University.

In the current absence of machine-addressable longitudinal records on both adjunct and graduate degree-level students, it is not possible to utilize a Markov process as a basis for projecting enrollments of these two classes of students. For adjunct enrollments it is necessary to employ an empirical relationship between the number of adjunct students at a campus and the enrollment of baccalaureate and associate degree-level students. Graduate enrollment projections are developed from linear regression equations by college or category of enrollment at each campus.

Further disaggregation of the enrollment projections for all degree-levels of students by field of specialization from the college to the departmental level is achieved by use of a so-called Organization Matrix, which subdivides the college enrollments on the basis of prior history.

In summation the data requirements may be classified in accord with their application in development of the components of the model as follows:

1: Transition matrices for use in the Markov process describing the flow of associate and baccalaureate students.

2: An empirically observed relationship between adjunct students and undergraduate enrollments.

3: Sets of linear regression equations applicable to graduate enrollments.

4: An Organization Matrix for disaggregation of enrollments to the departmental level.

Associate and Baccalaureate Transition Matrices

For projecting both associate and baccalaureate degree-level enrollments, four types of transition matrices are developed for use in "moving" students from each origin state in a Fall term to all possible terminal states in the next Fall term. These are as follows: Campus, Progression, Inter-Campus, and Switch Degree.

The Campus Matrix is the basic vehicle by which students are "moved" from one year to the next within a campus. For each campus at which associate degree-level programs are offered, there are two such matrices,. one for each student-level; for campuses offering baccalaureate study there are four, one for each student-level. Each matrix consists of a series of vectors - one for each college of enrollment in an origin state - each of which in turn is comprised of a set of fractions representing the distribution to all terminal states. Within each of these college vectors, the terminal states consist of the colleges of enrollment and additionally the proportions graduating, withdrawing, switching to the other undergraduate degree-level, and transferring to another campus.

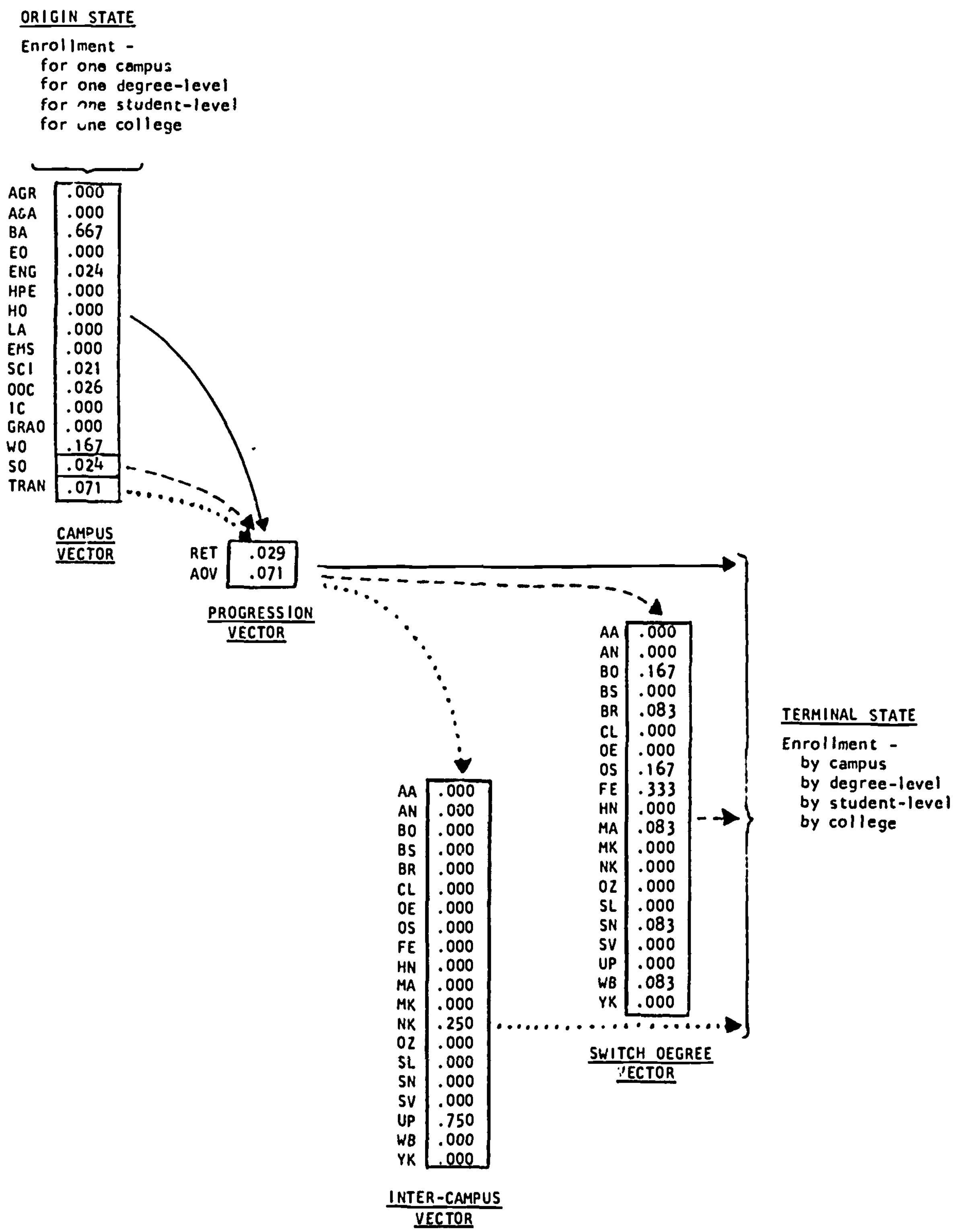
In series with each Campus Matrix is a Progression Matrix, by which students are retained at the same student-level or advanced to the next student-level. Each of the vectors, of which the matrix is composed, consists of the two fractions representing the shares advancing and being retained.

Two other types of matrices are used to "move" students among campuses. The first is an Inter-Campus Matrix which, when used in conjunction with the flow of students through the so-called "transfer-cell" in a vector of a Campus Matrix, distributes students of the same degree-level among the campuses. The second is a Switch Degree Matrix which, when used in conjunction with the flow of students through the so-called "switch-degree" cell in a vector of a Campus Matrix, not only distributes students among the campuses but also changes the degree-level of their program of study.

Shown in Figure IV-1 are examples of vectors drawn from the four types of transition matrices and their relationship to one another in the student flow process from an origin to a terminal state.

FIGURE IV-1

INTERRELATIONSHIPS AMONG TRANSITION MATRIX VECTORS



These matrices are developed from what is referred to as the Student Master Research Tape - or SMART - which is a series of longitudinal records over time of each undergraduate student indicating his term by term status with respect to degree-level, student-level, major program of study, campus, and attendance status from the time of admission to graduation or alternatively a maximum of twenty elapsed terms. (6) For the purpose of this application, only certain of the fields of each term-record on each student are employed. In Table IV-4 are the appropriate fields within each record on SMART utilized for developing the transition matrices.

For use with the Student Flow Model, the transition matrices are developed annually from data applicable to the changes occurring between the most recent sequential pair of Fall-terms. These values are assumed to be applicable over the entire projected time-frame. The validity of this assumption, however, was subject to evaluation prior to its adoption by generating the matrices for each sequential pair of Fall-terms over the past seven years and examining the patterns of behavior of corresponding values over time. The analysis revealed that the transition probabilities for corresponding categories remained relatively stable when the values were either relatively large in magnitude (i.e. between 0.5 and 1.0 as contrasted to less than 0.1) or were computed from relatively large populations of students. Since both of these conditions contribute to the ability of the model to generate reasonably accurate projections of enrollment, it was concluded that the transition rates were sufficiently stable over time to assume their applicability in the future for purposes of enrollment projection.

<u>Empirical Relationship for Adjunct Enrollment</u>

The projected enrollment of adjunct students is computed by means of an empirical relationship, which on the basis of historical data was found to be applicable at all but four campuses. Basically, the relationship is

TABLE IV-4

FIELDS IN SMART RECORD USED TO CATEGORIZE STUDENTS AT EACH FALL TERM

STUDENT CATEGORY	NAME OF FIELD	CODE IN FIELD
Campus	Campus	2 character Campus Code
Degree-Level	Degree	2 for associate 2 for baccalaureate
Student-Level	Term Standing	1-3 for first year 4-6 for second year 7-9 for third year 10 and over for fourth and fifth year
College or Category of Enrollment	College/Major	3 character Major Code
Switch Degree	Legend	8 for associate to baccalaureate 9 for baccalaureate to associate
Withdrawn	Legend	4, 5, or 6

based on the observation that, as the enrollment of students at the associate and baccalaureate degree-levels at a campus increases, the expression of adjunct enrollment as an equivalent fraction of the associate and baccalaureate enrollment decreases. Utilizing the fractions calculated from historical data and the projected enrollments of associate and baccalaureate degree-level students, adjunct enrollment at a campus is computed using the following relationship:

$$E_{D,ct} = (E_{A,ct} + E_{B,ct})\ (f_a)$$

where: $E_{D,ct}$ = adjunct enrollment at campus c in year t

$E_{A,ct}$ = associate enrollment at campus c in year t

$E_{B,ct}$ = baccalaureate enrollment at campus c in year t

f_a = adjunct enrollment as a fraction of associate and baccalaureate enrollment.

The values of f_a for the Altoona and Ogontz Campuses is 0.15 and for the Fayette and New Kensington Campuses is 0.40. For the balance of the campuses in the system, the value of f_a is related to the combined associate and baccalaureate degree-level enrollment at the campus as follows:

Associate and Baccalaureate Enrollment	f_a
< 100	.40
101- 300	.20
301- 500	.10
501- 700	.06
701-1000	.04
1001-2000	.03
>2001	.01

Although the relationship is incorporated within the program logic, it must be reviewed periodically for applicability.

Regression Equations for Graduate Enrollment

Graduate degree-level enrollments are developed from linear regression equations, which are incorporated within the model and are updated annually to reflect new data. The equations represent the graduate degree-level enrollments by college or category of enrollment for each campus of the University over time. The summation of the extrapolated values for any one campus at any point in time is subject to normalization relative to maximum and/or minimum levels of graduate degree-level enrollments permitted at the particular campus. These maximums and minimums are supplied as input to the model.

Organization Matrix

The Organization Matrices are employed to disaggregate enrollments in various fields of specialization from the college to the departmental level. Each matrix consists of a series of vectors - one for each college or category of enrollment at each student-level within degree-level for each campus - each of which in turn is comprised of a set of fractions representing the distribution of a given college's enrollment among the departments of which it is composed. The Organizational Matrices are updated annually from the data issued in the Final Distribution of Enrollment Report for the Fall term.

V: PROJECTION MODEL

In the previous chapters, it was shown

1: *that in a multi-campus institution of higher education, the patterns of student movement among academic levels, fields of specialization, and campuses have a significant impact upon the magnitude and major-program composition of the enrollment at any one location,*

2: *that these patterns of movement may be described by sets of transition rates expressing the probabilities of students following various paths between successive points in time, and*

3: *how a suitable base of historical data may be compiled and used for development of these matrices.*

This chapter is concerned with the use of the components described in the previous chapter as an integrated model, which, given the current enrollment and a forecast of new admissions, may be employed to generate projections of enrollment.

COMPONENTS

The projection model consists of the following major components:

1: A series of transition matrices - Campus, Progression, Inter-Campus, and Switch-Degree - consisting of vectors of the fractional distribution of undergraduate enrollment at one origin state - campus, degree-level, student-level, and college or category of enrollment - in the Fall term of one year among all possible terminal states in the subsequent Fall term.

2: A curvilinear relationship between the number of associate and baccalaureate degree-level students at a campus and the equivalent fraction of these students representing adjunct enrollment.

3: A series of regression equations representing the enrollment of graduate students over time in each college or category of enrollment at each campus.

4: A series of Organizational Matrices - one for each student-level within each degree-level at each campus - consisting of vectors of the fractional distribution of the enrollment in each college or category of enrollment among the departments responsible for the major programs of study.

INPUT

The inputs to the projection model are as follows:

1: Actual Fall term enrollment for the most recent historical year subdivided by campus, degree-level, student-level where appropriate, and college or category of enrollment, as developed from the Final Distribution of Enrollment Report issued by the Records Office of the Division of Admissions, Records, and Scheduling

2: Projections of freshmen admissions for each calendar year, but expressed in terms of those registered in the Fall term of the particular year, for as many years as desired by campus, degree-level, and college or category of enrollment, as generated by the Admissions Model (14).

3: Projections of both advanced-standing and adjunct-to-degree undergraduate admissions as well as undergraduate readmissions for each calendar year for as many years as desired by campus, degree-level, student-level, and college or category of enrollment, as generated by the Admissions Model (14).

4: Parameters establishing the maximum and minimum levels of graduate enrollment by campus for each year in the projected time-frame.

OPERATION

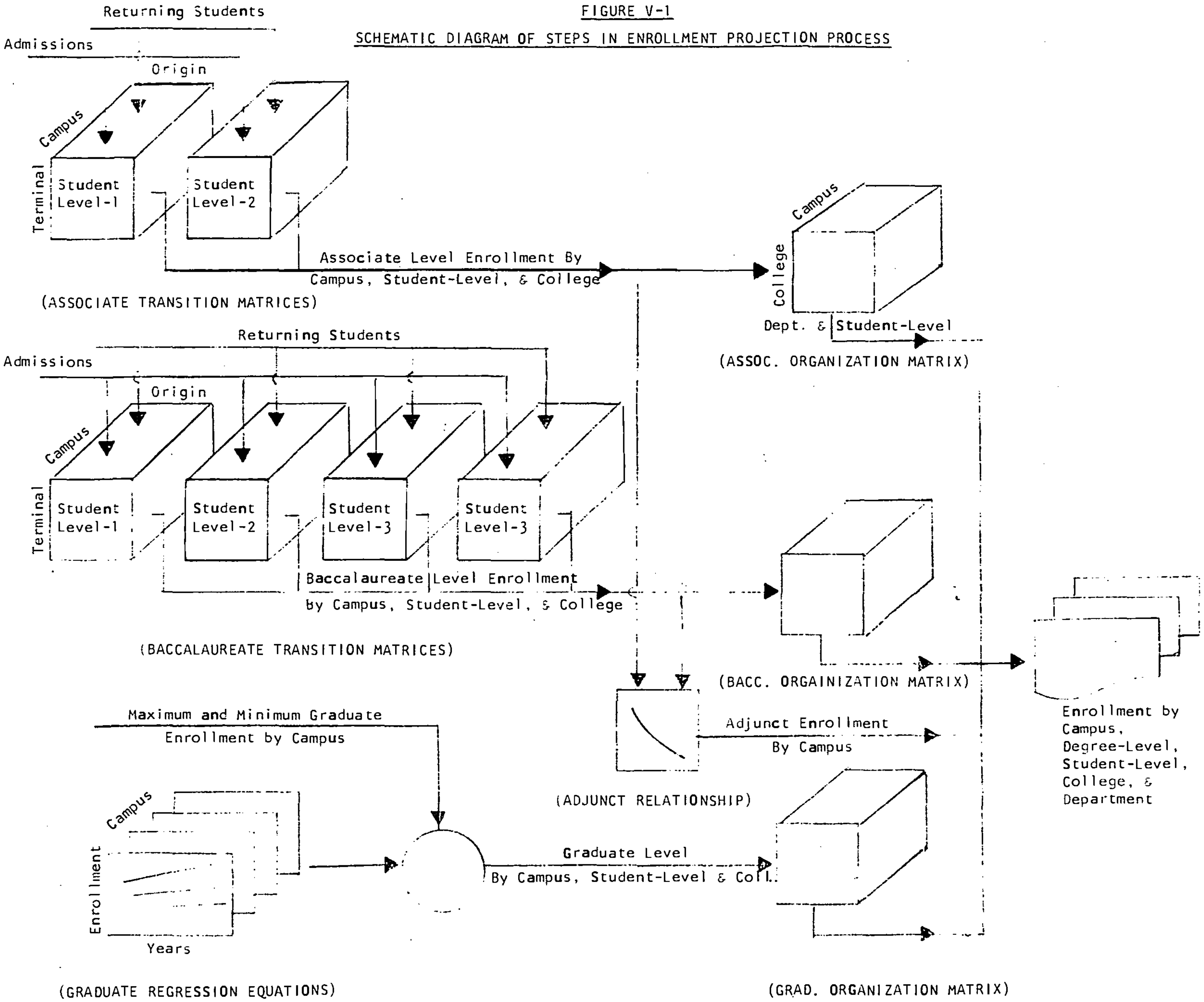
Procedurally the following steps, as schematically depicted in Figure V-1, are involved in the projection process of the model:

1: The actual associate and baccalaureate degree-level enrollment by campus, student-level, and college of enrollment for the most recent Fall term is iterated through the Campus, Progression, Inter-Campus, and Switch-Degree Matrices to derive the enrollment of returning students in the Fall term of the first year in the projected time-frame. To these values are added the forecast of new admissions and of re-admissions to generate the projected undergraduate degree-level enrollments for the first year.

2: The projected enrollments for the first year in the time-frame are then iterated through the matrices to derive returning students for the second year. To these are added the forecasts of new admissions and readmissions to generate projected undergraduate degree-level enrollments for the second year.

FIGURE V-1

SCHEMATIC DIAGRAM OF STEPS IN ENROLLMENT PROJECTION PROCESS



3: The process is then repeated until undergraduate degree-level enrollment projections have been developed for each year in the projected time-frame.

4: For each year in the projected time-frame, adjunct enrollments are computed for each campus using the empirical relationship provided within the model.

5: For each year in the projected time-frame, graduate enrollments by campus and college or category of enrollment are projected using the regression equations provided within the model and the input parameters relating to the minimum and maximum enrollments by campus.

6: The projections of enrollment by college or category of enrollment for each year in the projected time-frame are then disaggregated to the departmental level.

OUTPUT

Output from the projection model is of two types. Common to both is a subdivision of Fall term enrollment for each year in the projected time-frame by degree-level and within same by student-level wherever appropriate.

Detailed Output

The first of the two types is characterized as detailed output of Fall term enrollment and contains for each campus an analysis by college or category of enrollment as well as department wherever appropriate. In order to provide further identification of each departmental entity, the internal five-digit budget and two-digit HEGIS discipline-division codes are also shown. A sample of this output for one campus and one year is shown in Table V-1.

Summary Output

The second type is characterized as summary output. Here the detail by college and department is suppressed to provide on a single page the Fall term enrollment by campus for the entire University system. A sample of this output for one year is shown in Table V-2.

TABLE V-1: DETAIL OF PROJECTED FALL TERM 1975 RESIDENT EDUCATION ENROLLMENT - UNIVERSITY PARK CAMPUS

			ASSC 1	ASSC 2	BACC 1	BACC 2	BACC 3	BACC 4	GRAD	ADJ	TOTAL
AGRICULTURE		TOTAL:	0	17	302	336	457	403	346		1861
AGRIC ECO	204-08	01*	0	17	0	13	23	32	62		147
AGRIC EDUC	204-10	0E	0	C	0	37	55	52	24		168
AGRIC ENG	204-12	05	0	C	0	7	14	12	0		33
ENTOMOLOGY	204-13	04	0	0	0	0	0	0	24		24
AGRONOMY	204-15	01	C	0	0	24	23	20	38		105
PLANT PATH	204-16	C4	C	0	0	0	0	0	31		31
ANIMAL SCI	204-17	01	C	0	0	84	105	64	38		291
DAIRY SCI	204-37	01	0	0	0	0	0	0	10		10
FORESTRY	204-53	C1*	0	0	0	60	114	117	59		350
HORTIC	204-66	01	0	0	0	24	32	28	17		101
PLTRY SCI	204-77	C1	0	0	0	0	0	0	3		3
VET SCI	204-88	C4	0	0	0	0	0	0	10		10
INTER DEPT	204-00	01*	C	0	302	87	91	77	28		585

			ASSC 1	ASSC 2	BACC 1	BACC 2	BACC 3	BACC 4	GRAD	ADJ	TOTAL
ARTS & ARCH		TOTAL:	0	0	229	267	272	363	249		1387
ARCH	205-11	02	0	0	0	53	50	178	17		298
ART HIST	205-14	1C	0	C	0	8	20	7	82		117
LAND ARCH	205-33	02	0	0	0	27	47	36	0		110
MUSIC	205-38	1C	0	0	0	24	22	11	C		57
ART	205-44	1C	0	0	0	67	73	80	40		260
THEATRE	205-48	1C	0	0	0	64	67	47	27		205
INTER DEPT	205-00	10	0	0	229	24	0	4	82		339

			ASSC 1	ASSC 2	BACC 1	BACC 2	BACC 3	BACC 4	GRAD	ADJ	TOTAL
BUSINESS ADM		TOTAL:	0	0	268	443	991	921	377		3005
ACCOUNTING	206-11	05	0	0	0	4	297	378	0		679
BUS LOG	206-15	C5	0	0	0	0	30	74	0		104
FINANCE	206-19	05	0	0	0	0	40	83	0		123
INS & R E	206-24	05	0	0	0	0	30	64	0		94
MGT SCI	206-35	05	0	0	0	4	89	129	0		222
MARKETING	206-36	C5	0	C	0	4	69	138	0		211
INTER-DEPT	206-00	05	0	0	268	435	436	55	377		1571

TABLE V-1 (continued)

			ASSC 1	ASSC 2	BACC 1	BACC 2	BACC 3	BACC 4	GRAD	ADJ	TOTAL
EDUCATION		TOTAL:	0	0	296	497	1059	922	1020		3794
AC CURR & E EXP	212-0632	08	0	0	0	204	688	645	224		1761
ART ED	212-08	08	0	0	0	40	74	65	61		240
ED PSYC	212-10	08	0	0	0	0	0	0	41		41
ED POLICY	212-12	08	0	0	0	65	138	101	194		498
VOC ED	212-14	08	0	0	0	25	42	28	61		156
HOME ECO ED	212-21	08	0	0	0	0	0	0	41		41
MUSIC ED	212-24	08	0	0	0	25	32	37	31		125
SPEC ED	212-36	08	0	0	0	99	74	46	173		392
INTER-DEPT	212-00	08	0	0	296	40	11	0	0		347
COUN ED	212-09	08	0	0	0	0	0	0	194		194

			ASSC 1	ASSC 2	BACC 1	BACC 2	BACC 3	BACC 4	GRAD	ADJ	TOTAL
ENGINEERING		TOTAL:	0	0	550	464	697	665	415		2791
AERO ENG	215-14	09	0	0	0	14	21	20	37		92
ARCH ENG	215-17	09	0	0	0	79	42	53	12		186
AGRIC ENG		09	0	0	0	14	14	20	12		60
CHEM ENG	215-19	09	0	0	0	37	77	47	46		207
CIVIL ENG	215-21	09	0	0	0	74	139	133	83		429
ELECT ENG	215-31	09	0	0	0	93	181	140	58		472
ENG MECH	215-37	09	0	0	0	19	28	33	33		113
ENG SCI	215-38	09	0	0	0	5	21	20	0		46
IND ENG	215-44	09	0	0	0	14	42	66	41		163
MECH ENG	215-51	09	0	0	0	56	105	113	46		320
GEN ENG	215-55	09	0	0	0	0	0	0	8		8
NUCL ENG	215-56	09	0	0	0	19	21	20	37		97
INTER-DEPT	215-00	09	0	0	550	42	7	0	0		599

			ASSC 1	ASSC 2	BACC 1	BACC 2	BACC 3	BACC 4	GRAD	ADJ	TOTAL
HEALTH & PE		TOTAL:	0	0	100	206	275	297	155		1033
HPE INSTRN	227-11	08*	0	0	100	206	275	297	155		1033

TABLE V-1 (continued)

			ASSC 1	ASSC 2	BACC 1	BACC 2	BACC 3	BACC 4	GRAD	ACJ	TOTAL
HUMAN DEV		TOTAL:	0	0	310	707	1065	940	170		3192
INF & FAM STUD	218-11	13	0	0	0	148	319	244	95		806
PICL HLTH	218-12	12*	0	0	0	49	75	38	27		189
PICL NURS	218-13	12	0	0	0	141	117	85	0		343
COMM DEV	218-14	21	0	0	0	199	351	376	0		925
MAN-ENVIR	218-15	13*	0	0	0	85	202	197	48		532
INTER-DEPT	218-00	21	0	0	310	85	0	0	0		395

			ASSC 1	ASSC 2	BACC 1	BACC 2	BACC 3	BACC 4	GRAD	ACJ	TOTAL
LIBERAL ARTS		TOTAL:	0	0	1014	999	1706	1400	1056		6175
ANTHRO	221-12	22	0	0	0	11	44	34	53		142
CLASSICS	221-15	11	0	0	0	0	3	1	11		15
ECONOMICS	221-18	22	0	0	0	2	26	34	74		136
ENGLISH	221-24	15	0	0	0	23	133	146	127		429
FRENCH	221-28	11	0	0	0	9	43	36	53		141
GERMAN	221-31	11	0	0	0	2	17	15	32		66
HISTORY	221-34	22	0	0	0	8	84	91	74		257
JOURNALISM	221-41	06	0	0	0	25	171	116	53		365
LABOR STUD	221-43	05	0	0	0	2	26	25	0		53
LINGUISTICS	221-46	15	0	0	0	0	10	10	21		41
PHILOSOPHY	221-51	15	0	0	0	6	32	27	53		118
POL SC & PUB AD	221-543722		0	0	0	27	288	217	148		680
PSYCHOLOGY	221-55	20	0	0	0	42	210	185	116		553
RELIG STUD	221-56	15	0	0	0	2	15	11	21		49
SLAVIC	221-59	11	0	0	0	4	5	3	11		23
SOCIOLOGY	221-64	22	0	0	0	25	172	144	53		394
SP IT & POR	221-66	11	0	0	0	22	29	17	42		110
SPEECH	221-67	15	0	0	0	5	60	74	95		234
INTER-DEPT	221-05	49	0	0	1014	784	338	214	21		2371

			ASSC 1	ASSC 2	BACC 1	BACC 2	BACC 3	BACC 4	GRAD	ACJ	TOTAL
EARTH & M S		TOTAL:	0	0	138	141	196	160	448		1083
GEOGRAPHY	224-12	22	0	0	0	3	4	6	54		67
METEOROLOGY	224-18	15	0	0	0	28	41	30	58		157
GEOSCIENCES	224-19	19	0	0	0	30	49	37	148		264
MIN ECO	224-24	19	0	0	0	6	22	18	36		82
MIN ENG	224-25	09	0	0	0	47	37	40	58		182
MAT SCI & CONST	224-342009*		0	0	0	18	43	29	94		184
INTER-DEPT	224-00	19	0	0	138	10	0	0	0		148

TABLE V-1 (continued)

				ASSC 1	ASSC 2	BACC 1	BACC 2	BACC 3	BACC 4	GRAD	ADJ	TOTAL
SCIENCE			TOTAL:	0	0	865	751	1188	917	683		4404
GEN EDUC	228-07	04*		0	0	865	263	273	220	27		1648
ASTRONOMY	228-09	19		0	0	0	15	12	9	20		56
BIOCHEM	228-12	04		0	0	0	45	48	46	68		207
BIOLOGY	228-15	04		0	0	0	210	309	266	41		826
CHEMISTRY	228-21	19		0	0	0	30	71	46	143		290
COMP SCI	228-28	07		0	0	0	90	166	128	123		507
MATH	228-44	07		0	0	0	23	131	64	102		320
MICRO	228-46	04*		0	0	0	53	154	110	27		344
PHYSICS	228-54	19		0	0	0	23	24	28	102		177
STATISTICS	228-74	17		0	0	0	0	0	0	27		27

				ASSC 1	ASSC 2	BACC 1	BACC 2	BACC 3	BACC 4	GRAD	ADJ	TOTAL
D.O.C.			TOTAL:	0	0	155	267	213	15	0		650

				ASSC 1	ASSC 2	BACC 1	BACC 2	BACC 3	BACC 4	GRAD	ADJ	TOTAL
INTER-COLLEGE			TOTAL:	0	0	0	0	0	0	152		152
ENV POL CONT	231-20	49		0	0	0	0	0	0	12		12
REG PL & ADM	231-22	49*		0	0	0	0	0	0	32		32
PHY GEN SP EF	232-01	04*		0	0	0	0	0	0	88		88
ACOUSTICS	231-XX	09		0	0	0	0	0	0	20		20

				ASSC 1	ASSC 2	BACC 1	BACC 2	BACC 3	BACC 4	GRAD	ADJ	TOTAL
NON-DEGREE			TOTAL:	0	0	0	0	0	0	479		479

				ASSC 1	ASSC 2	BACC 1	BACC 2	BACC 3	BACC 4	GRAD	ADJ	TOTAL
UNIV. PARK	CAMPUS TOTALS:			0	17	4227	5083	8126	7023	5544	366	30366

TABLE V-2: SUMMARY OF PROJECTED FALL TERM 1975 RESIDENT EDUCATION ENROLLMENT - THE PENNSYLVANIA STATE UNIVERSITY

		ASSO 1	ASSO 2	BACC 1	BACC 2	BACC 3	BACC 4	GRAD	ADJ	TOTAL
ALTOONA	CAMPUS TOTALS:	263	145	638	429	7	0	0	222	1704
ALLENTOWN	CAMPUS TOTALS:	0	0	67	17	12	0	0	38	134
BEHREND	CAMPUS TOTALS:	120	65	834	500	52	37	90	48	1746
BERKS	CAMPUS TOTALS:	188	84	348	147	1	0	0	30	798
BEAVER	CAMPUS TOTALS:	99	50	529	311	6	3	0	39	1037
CAPITOL	CAMPUS TOTALS:	0	0	0	1	1175	908	667	31	2782
DELAWARE	CAMPUS TOTALS:	115	49	582	362	10	2	0	33	1153
DUBOIS	CAMPUS TOTALS:	124	68	193	86	0	0	0	47	518
FAYETTE	CAMPUS TOTALS:	137	148	326	179	4	3	0	318	1115
HAZLETON	CAMPUS TOTALS:	55	35	449	197	3	2	0	29	770
MONT ALTO	CAMPUS TOTALS:	180	84	303	142	1	0	0	28	738
MCKEESPORT	CAMPUS TOTALS:	77	51	667	378	10	4	0	35	1222
NEW KENSINGTON	CAMPUS TOTALS:	165	88	353	208	7	1	0	328	1150
OGONTZ	CAMPUS TOTALS:	110	61	680	561	8	1	0	213	1634
SCHUYLKILL	CAMPUS TOTALS:	63	36	302	198	1	2	0	36	638
SCRANTON	CAMPUS TOTALS:	128	67	313	203	6	0	0	28	745
SHENANGO	CAMPUS TOTALS:	78	35	245	116	1	0	0	47	522
UNIV. PARK	CAMPUS TOTALS:	0	17	4227	5083	8126	7003	5544	366	30366
WILKES BARRE	CAMPUS TOTALS:	89	55	67	20	0	0	0	46	277
YORK	CAMPUS TOTALS:	91	43	312	144	4	1	0	35	630
HERSHEY	CAMPUS TOTALS:	0	0	0	0	0	0	434	0	434
KING OF PRUSSIA	CAMPUS TOTALS:	0	0	0	0	0	0	255	0	255
PENN STATE UNIVERSITY	GRAND TOTALS:	2082	1181	11435	9282	9434	7967	6990	1997	50368

EVALUATION

Evaluation of the performance of a predictive model usually involves providing actual historical data as input and n comparing the output with the appropriate historical records. By utilizing such an approach any variations between the output from the model and historical data may be attributed to the characteristics of the model itself. However, for evaluation of the model described in this report, a departure from this type of procedure has been adopted which actually provides a somewhat more stringent basis for measurement of validity. Rather than using actual admissions data as input, the output from the Admissions Model (14) was employed. Thus the evaluation is in reality an evaluation of both the Admissions and Student Flow Models on a combined basis. In brief this approach was adopted because of the existence of certain empirical relationships, interfacing between the two models, which essentially translate student admissions throughout a given calendar year into student registrations in the Fall term of the same year with an ensuing question arising as to the proper assignment of these relationships to one of the two models for purposes of evaluation. Adoption of the combined approach eliminates the need for what would otherwise be an arbitrary assignment.

For this reason the evaluation was conducted by comparing the actual 1972 enrollments with those projected by the Student Flow Model, which in turn was provided with input from the Admissions Model containing the targets and parameters which had been established in January 1972 for guidance of the admissions process for that calendar year. From a system-wide standpoint, the total projection of enrollment differed only by 0.5% from the actual.

However, this value is of limited significance for internal management application, since it is achieved in part as a result of compensating errors in over- and under-projecting the individual sectors of which the University's total enrollment in resident education is composed. Furthermore, since enrollments are ultimately determinants of the demand for instructional services and it is usually infeasible from an operational view to consider the interchange among campuses of resources for the instructional function, the forecast errors of the campus enrollments are of importance. The differences between the projected and actual enrollments for each campus are shown in Table V-3. The summation of these differences, without regard for sign, expressed as a percentage of the actual enrollment for the total system amounts to 4.0%. This means that this fraction of the projected enrollment was distributed among campuses in a manner differing from that which actually occurred.

For evaluation purposes, two other bases may also be of possible interest. In the report on the Instructional Activity Model (13), it was stated that the interchange of resources for providing instructional activity was operationally infeasible not only among the campuses but also, in the case of the University's largest campus at University Park, among colleges. However, errors in the composition of the enrollment at any one location are somewhat mitigated in their impact upon the composition of demand for instructional activity because students register for courses not only within their own college but in others as well. Nevertheless, for evaluation purposes there is interest in the forecast errors among the individual colleges at the University Park Campus and the balance of the campuses as unitary organizations since collectively these units, which internally are categorized as administrative divisions, constitute the level of budgetary responsibility in the University. As shown in Table V-4, the summation of the differences, without regard for sign, between the actual and projected enrollments for these units amounts to 7.9% of the actual enrollment for the total system, which implies that this fraction of the enrollment was distributed by the model among administrative divisions in a manner differing from that which actually transpired.

TABLE V-3

COMPARISON OF ACTUAL AND PROJECTED FALL-TERM 1972 ENROLLMENT BY CAMPUS

	ENROLLMENT		
	ACTUAL	PROJECTED	DIFFERENCE
	1,700	1,581	-119
	212	145	- 67
	1,573	1,626	+ 53
	714	685	- 29
	936	1,023	+ 87
	2,190	2,495	+305
	1,021	871	-150
	497	471	- 26
	1,062	960	-102
	773	849	+ 76
	749	703	- 46
	1,053	1,041	- 12
	1,026	1,020	- 6
	1,757	1,642	-115
	660	727	+ 67
	649	722	+ 73
	550	499	- 51
	396	293	-103
	564	534	- 30
	301	353	+ 52
	245	341	+ 96
	28,635	28,921	+266
TOTAL	47,263	47,502	+239 (0.5%)
ABSOLUTE SUM	47,263		1,931 (4.0%)

TABLE V-4

COMPARISON OF ACTUAL AND PROJECTED FALL-TERM 1972 ENROLLMENT BY ADMINISTRATIVE DIVISION

	ENROLLMENT		
	ACTUAL	PROJECTED	DIFFERENCE
	1,700	1,581	-119
	212	145	- 67
	1,573	1,626	+ 53
	714	685	- 29
	936	1,023	+ 87
	2,190	2,495	+305
	1,021	871	-150
	497	471	- 26
	1,062	960	-102
	773	849	+ 76
	749	703	- 46
	1,053	1,041	- 21
	1,026	1,020	- 6
	1,757	1,642	-115
	660	727	+ 67
	649	722	+ 73
	550	499	- 51
	396	293	-103
	564	534	- 30
	301	353	+ 52
	245	341	+ 96
	1,617	1,395	-222
	1,311	1,260	- 51
	2,737	2,710	- 27
	4,255	4,576	+321
	2,781	2,730	- 51
	992	841	-151
	3,045	2,808	-237
	5,698	6,218	+520
	1,013	1,001	- 12
	3,693	3,779	+ 86
	573	672	+ 99
	212	56	-156
	708	875	+167
TOTAL	47,263	47,502	+239 (0.5%)
ABSOLUTE SUM	47,263		3,765 (7.9%)

The last basis for evaluation purposes concerns the convention which seems to prevail for displaying the enrollment projections resulting from the admissions and enrollment planning process, described briefly in Chapter IV. For this purpose, the projections are subdivided not only by administrative division but also by degree-level. In this case, as shown in Table V-5, the summation of the differences, without regard for sign, between actual and projected enrollments by degree-level for each administrative division amounts to 10.0% of the actual enrollment for the total system, which implies that this fraction of the enrollment was distributed among degree-levels and administrative divisions in a manner differing from that actually occurring.

In closing, it should be noted that the forecast errors, described above, are limited to a one-year projection into the future. At the present time it is obviously not possible to provide an evaluation beyond this time-frame.

TABLE V-5

COMPARISON OF ACTUAL AND PROJECTED FALL-TERM 1972 ENROLLMENT

BY DEGREE-LEVEL WITHIN ADMINISTRATIVE DIVISION

ENROLLMENT			ENROLLMENT				ENROLLMENT			
ACTUAL	PROJECTED	DIFFERENCE	ACTUAL	PROJECTED	DIFFERENCE		ACTUAL	PROJECTED	DIFFERENCE	
443	356	- 87	823	704	-119		299	355	+ 56	
56	70	+ 14	266	241	- 25		893	937	+ 44	
184	203	+ 19	474	469	- 5		448	431	- 17	
281	229	- 52	604	669	+ 65		126	139	+ 13	
170	210	+ 40	436	413	- 23		169	160	- 9	
131	134	+ 3	870	857	- 13		938	1,027	+ 89	
195	188	- 7	539	493	- 46		408	459	+ 51	
262	217	- 45	1,390	1,261	-129		717	739	+ 22	
142	148	+ 6	505	548	+ 43		209	56	-153	
285	251	- 34	406	452	+ 46		449	412	- 37	
153	154	+ 1	318	322	+ 4		198	206	+ 8	
240	236	- 4	96	30	- 66		60	24	- 36	
159	167	+ 8	369	343	- 26		121	44	- 77	
108	138	+ 30	1,226	1,047	-179		48	38	- 10	
179	230	+ 51	1,120	1,031	- 89		53	39	- 14	
113	132	+ 19	2,437	2,355	- 82		39	55	+ 16	
226	215	- 11	3,362	3,639	+277		67	33	- 34	
146	143	- 3	2,330	2,299	- 31		35	42	+ 7	
36	26	- 10	864	702	-162		326	274	- 52	
1	0	- 1	2,875	2,643	-232		27	32	+ 5	
3	0	- 3	4,760	5,191	+431		28	39	+ 11	
2	0	- 2	605	542	- 63		30	30	0	
1	5	+ 4	2,975	3,040	+ 65		247	291	+ 44	
1	0	- 1	573	672	+ 99		208	214	+ 6	
3	0	- 3	61	106	+ 45		47	41	- 6	
1,059	1,019	- 40	502	603	+101		64	40	- 24	
96	51	- 45	1	0	- 1		119	45	- 74	
1,027	1,273	+ 66	301	353	+ 52		74	48	- 26	
385	418	+ 33	244	341	+ 97		49	48	- 1	
713	774	+ 61	355	322	- 33		1	0	- 1	
1,649	1,837	+188	191	229	+ 38		259	463	+204	
						TOTAL	47,263	47,502	+239	(0.5%)
						ABSOLUTE SUM	47,263		4,728	(10.0%)

VI: SYSTEM APPLICATION

In the previous chapters, it was shown

1: *that in a multi-campus institution of higher education, the patterns of student movement among academic levels, fields of specialization, and campuses have a significant impact upon the magnitude and major-program composition of the enrollment at any one location,*

2: *that these patterns of movement may be described by sets of transition rates expressing the probabilities of students following various paths between successive points in time,*

3: *how a suitable base of historical data may be compiled and used for development of these transition matrices, and*

4: *how these matrices together with ancillary relationships may be used as a projection model, which, given the current enrollment and a forecast of new admissions, may be employed to generate projections of enrollment.*

This chapter is concerned with a description of the system developed to carry out the steps outlined in Chapters IV and V for routine application within The Pennsylvania State University for generation of projections of enrollment for the Fall term. The interrelationships among the components are delineated and the function, procedural steps, and operational cost of each programmed module are outlined in brief. Details concerning the program logic and application are shown in the Appendices.

COMPONENTS

The system comprising the Student Flow Model consists of three modules. These are programmed in Fortran IV for operation on the IBM System 370/165 in the Computation Center. The first of the modules, COEF-1, is concerned with generation of the various matrices from the Student Master Research Tape. The second, ITER-1, utilizes these matrices as a mechanism for iterating undergraduate students through the system. The third, DISAG-1, generates projections of both graduate and adjunct students and disaggregates both these and undergraduate projections to the departmental level.

The relationship of these modules to one another is shown in Figure VI-1 and a brief description of each is provided below.

COEF-1 Module

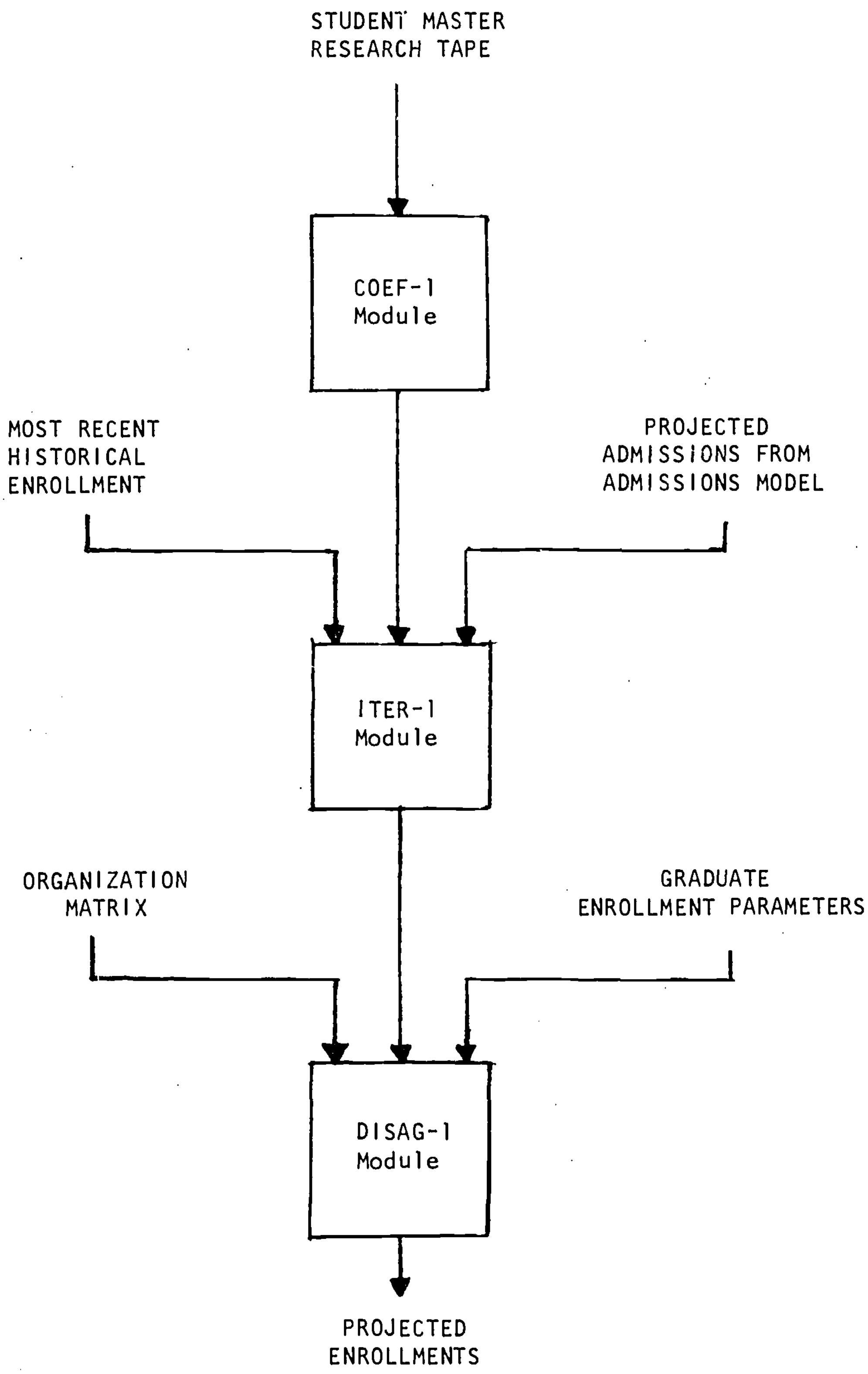
The COEF-1 program generates the Campus, Progression, Inter-Campus, and Switch-Degree Matrices from the Student Master Research Tape. Each record on SMART is read and aggregations of enrollment are prepared for the Fall term of each calendar year on the basis of commonality of campus, degree-level, student-level, and college or category of enrollment as well as distributions of the enrollment for each common group among the campus, degree-level, student-level, and college of enrollment for the subsequent Fall term. The distributions to terminal states are then computed as fractions of the total for the corresponding origin states and produced in punched-card form.

ITER-1 Module

The ITER-1 program generates projections of Fall term undergraduate enrollments from the most recent historical enrollment and the projections of admissions for as many years into the future as desired by means of the transitions matrices

FIGURE VI-1

FLOW DIAGRAM OF MODULE INTERRELATIONSHIPS



generated by the COEF-1 module as applicable to the most recent year. The summation of the enrollments of returning students and new admissions is computed for each common group for a Fall term and then multiplied by the appropriate coefficients in the matrices to derive enrollments for the following Fall term. The process is then repeated for as many years into the future as admission projections are provided. The resulting enrollments for associate and baccalaureate students are written for output onto tape.

DISAG-1 Module

The DISAG-1 program reads the undergraduate enrollments from the output of ITER-1, computes the adjunct student enrollment for each campus from the empirical relationship, and by means of regression equations generates enrollment of graduate students. These enrollments, which are produced for each campus, degree-level, student-level, and college or category of enrollment for each Fall term in the projected time-frame, are then disaggregated to the departmental level by means of the Organization Matrix and produced in hard-copy form, as described in the previous chapter.

COST OF OPERATION

The system as described serves two major purposes. The first is concerned with generation of the various transition matrices employed to simulate student movement and the second with the use of these matrices plus additional input for projection application.

Generation of the transition matrices involves the use of the COEF-1 program. This procedure must be carried out only once a year and is characterized as part of the updating process. The overall cost of operation involves an expenditure of $110 per year.

The projection process involves the input of the matrices from the COEF-1 program, the Organization Matrix computed from the Final Distribution of Enrollment Report, and a forecast of admissions for as many years into the future as desired as supplied from the Admissions Model. Once the updating for a year has been completed, the projection procedure may be conducted any number of times without the necessity of repeating the steps involved in updating. The cost of each projection run of ten-years duration using ITER-1 and DISAG-1 is $35.

Shown in Table VI-1 are the operating characteristics involved in application of the three modules as described. It is of note that the data in this table were compiled on the basis of operation on an IBM 360/67. With the installation of a 370/165, CPU time and cost for each module are expected to be lower.

TABLE VI-1

OPERATING CHARACTERISTICS

	CPU Time-Seconds	Records	Cost
COEF-1 (Baccalaureate)	350	22,000	$65
COEF-1 (Associate)	130	7,000	45
ITER-1*	100	7,000	14
DISAG-1*	100	21,000	21

*For a run with a projected time-frame of 10 years.

VII: FUTURE EFFORTS

An appraisal of the results of this project and the perceived use of the model have made it desirable that consideration be given to incorporation of certain innovations within the model. Most of these, as will be noted below, are concerned with improvement in predictability.

Projection of Transition Rates

Explicit in the application of the basic Markov process is the assumption that the transition probabilities are stable over time. An analysis of historical data during the development process confirmed the general validity of this assumption for the model in question. However, some exceptions were noted. As an entirely separate project, a multi-method general-forecasting procedure for time-series projection has now been developed. The procedure will be applied on a test basis to historical time-series of transition rates. If significant improvement in predictability is achieved, consideration will be given to incorporation of the procedure within the model.

Inter-Campus Flow

Of major significance in the projection of enrollments of the campuses of The Pennsylvania State University is the impact of student movement among different locations. Currently, inter-campus movement is handled within the model by a two-step process. A single-step process has now been conceived and deemed feasible for implementation. Since application may improve the accuracy of the projections and will permit identification of the flows between campuses, an aspect which is not possible through the existing procedure, early consideration will be given to implementation.

Graduate and Adjunct Enrollment Methodology

As indicated previously, current record limitations preclude the application of the Markov process for determination of both graduate and adjunct enrollments. If and when suitable records become available, the techniques currently used within the model should be replaced by ones conceptually based upon the Markov process. It is of note that the forecast error by degree-level within administrative division of associate and baccalaureate enrollments, which were projected by application of the Markov concept, is only 8% as contrasted to 18% for graduate and adjunct enrollments, which do not use this methodology.

Organization Matrix

The Organization Matrices, which are used for disaggregation of enrollments to the departmental level in regard to field of specialization, must be updated annually. Currently this is done by a manual procedure from hard-copy records, a process which is not only extremely time-consuming but also is inherently prone to inclusion of human error. An alternative source of data must be developed and the procedure programmed for computer operation. To improve the efficiency of the annual updating process, an investigation must be conducted concerning other sources of data for this purpose and the procedure programmed for computer application.

REFERENCES

1. Baisuck, A. and Wallace, W. A., "A Computer Simulation Approach to Enrollment Projection in Higher Education", Rensselaer Research Corporation, Rensselaer Polytechnic Institute, 1970.

2. Firmin, P. A. et al., "University Cost Structure and Behavior", Tulane University, 1967.

3. Gani, J., "Formulae for Projecting Enrollments and Degrees Awarded in Universities", Journal of Royal Statistical Society, Series A, 1963.

4. "Higher Education Enrollment Projections", Office of Program Planning and Fiscal Management, State of Washington, 1970.

5. Koenig, H. E. et al., "A Systems Model for Management, Planning, and Resource Allocation in Institutions of Higher Education, Division of Engineering Research, Michigan State University, 1968.

6. Lindsay, C. A. et al., "Development and Utilization of a Student Master Research Tape", Office of Student Affairs, The Pennsylvania State University, 1969.

7. Lovell, C. G. "Student Flow Models: A Review and Conceptualization", N.C.H.E.M.S. at W.I.C.H.E., 1971.

8. Marshall, K. T. et al., "Undergraduate Enrollments and Attendance Patterns", Administrative Studies Project, University of California 1970.

9. Newton, R. D., "Projections of Enrollments and Degrees Awarded", Office of Vice President for Planning, The Pennsylvania State University, 1968.

10. Oliver, R. M., "Models for Predicting Gross Enrollments at The University of California, Ford Foundation Research Program, University of California, 1968.

11. Richard, H. G. "Complex Linear Flow Model of Student Flow", Graduate School and Department of Industrial Engineering, The Pennsylvania State University, 1969.

12. Smith, W. R., "Review of Student Flow Model", University of California at Los Angeles, 1970.

13. Tallman, B. M. and Newton, R. D., "A Model for Projection of Instructional Activity in A Multi-Campus University", Office of Budget and Planning, The Pennsylvania State University, 1973.

14. Tallman, B. M. and Newton, R. D., "A Model for Projection of Undergraduate Admissions in A Multi-Campus University", Office of Budget and Planning, The Pennsylvania State University, 1973.

15. Thonstad, T., "A Mathematical Model of the Norwegian Education System", O.E.C.D., 1967.

16. Zabrowski, E. K., et al., "Student-Teacher Population Growth Model", U. S. Office of Education, 1968.

A: COEF-1 MODULE

The user must supply in addition to the SMART tape the following card input:

1: Parameter Card: The following information must be provided in a right justified form in the Column positions noted.

Columns 1- 2: Number of campuses.

Columns 3- 4: Number of years of data to be extracted.

Columns 5- 6: Number of student-levels.

Columns 7- 8: Number of terminal states in campus matrix.

Columns 9-10: Number of colleges or categories of enrollment.

Columns 11-12: Last two digits of last year on SMART.

Columns 13-14: Last two digits of first year of data to be extracted.

Columns 15-16: Degree-level (2 for associate and 4 for baccalaureate).

2: Campus Name Cards: One card per campus with abbreviation and name of campus.

Columns 1- 2: Campus abbreviation.

Columns 3-18: Campus name.

3: Terminal State Name Cards: One card per terminal state with college code in Column 1 and abbreviation in Columns 2-4 for colleges and with abbreviation only in Columns 2-4 for other states.

Column 1	Columns 2-4
A	AGR
B	AA
E	BA
F	ED
G	ENG
H	HPE
J	HD
L	LA
N	EMS
S	SCI
T	DOC
V	IC
	GRADUATE
	WITHDRAW
	SWITCH-DEGREE
	TRANSFER
	RETAIN
	ADVANCE

The COEF-1 program produces as printed output the Campus, Progression, Inter-Campus, and Switch-Degree Matrices for all years. In addition, punched cards for each Matrix for the most recent year are produced.

FIGURE A-1: MACRO FLOW CHART OF THE COEF-1 MODULE

(001)

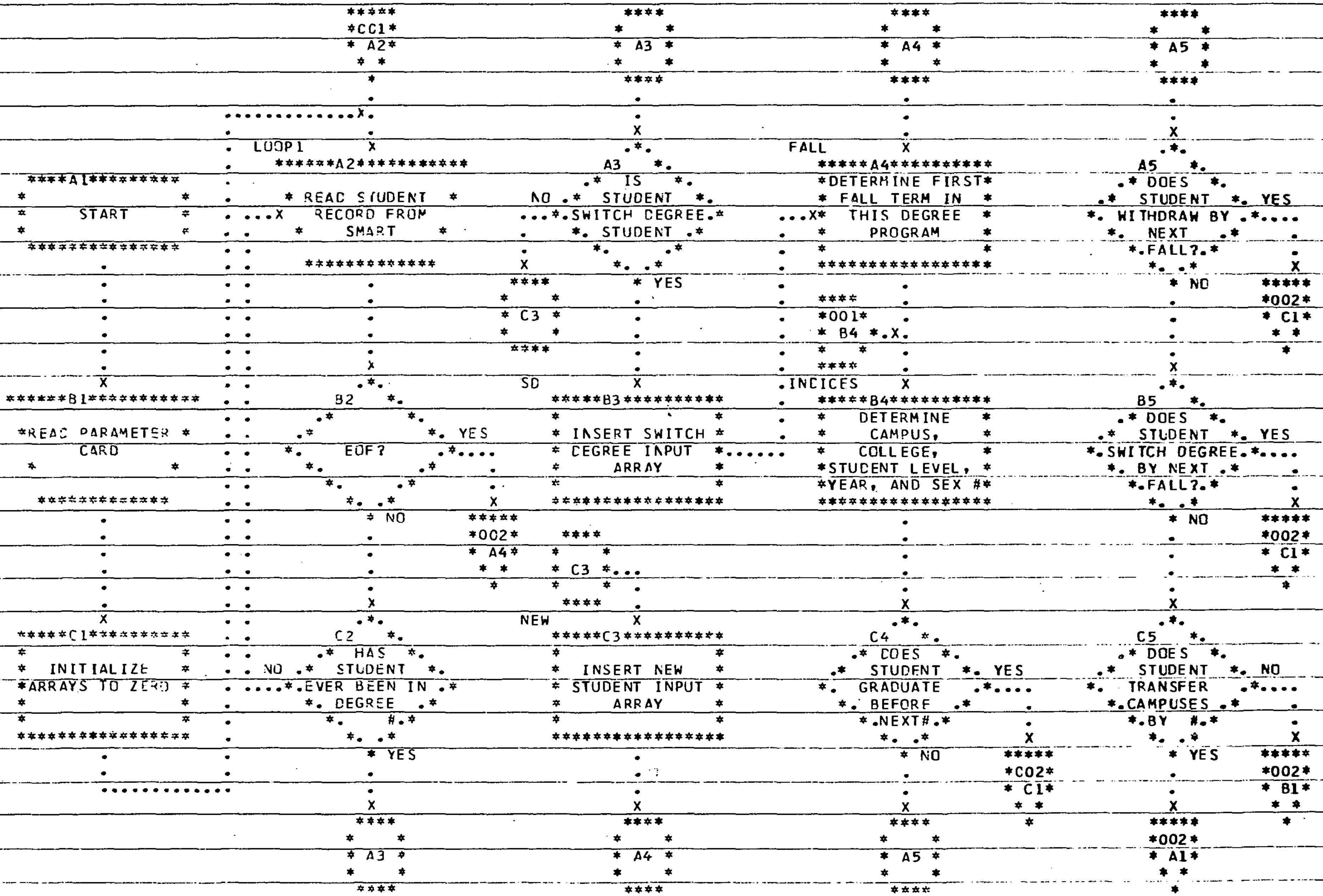
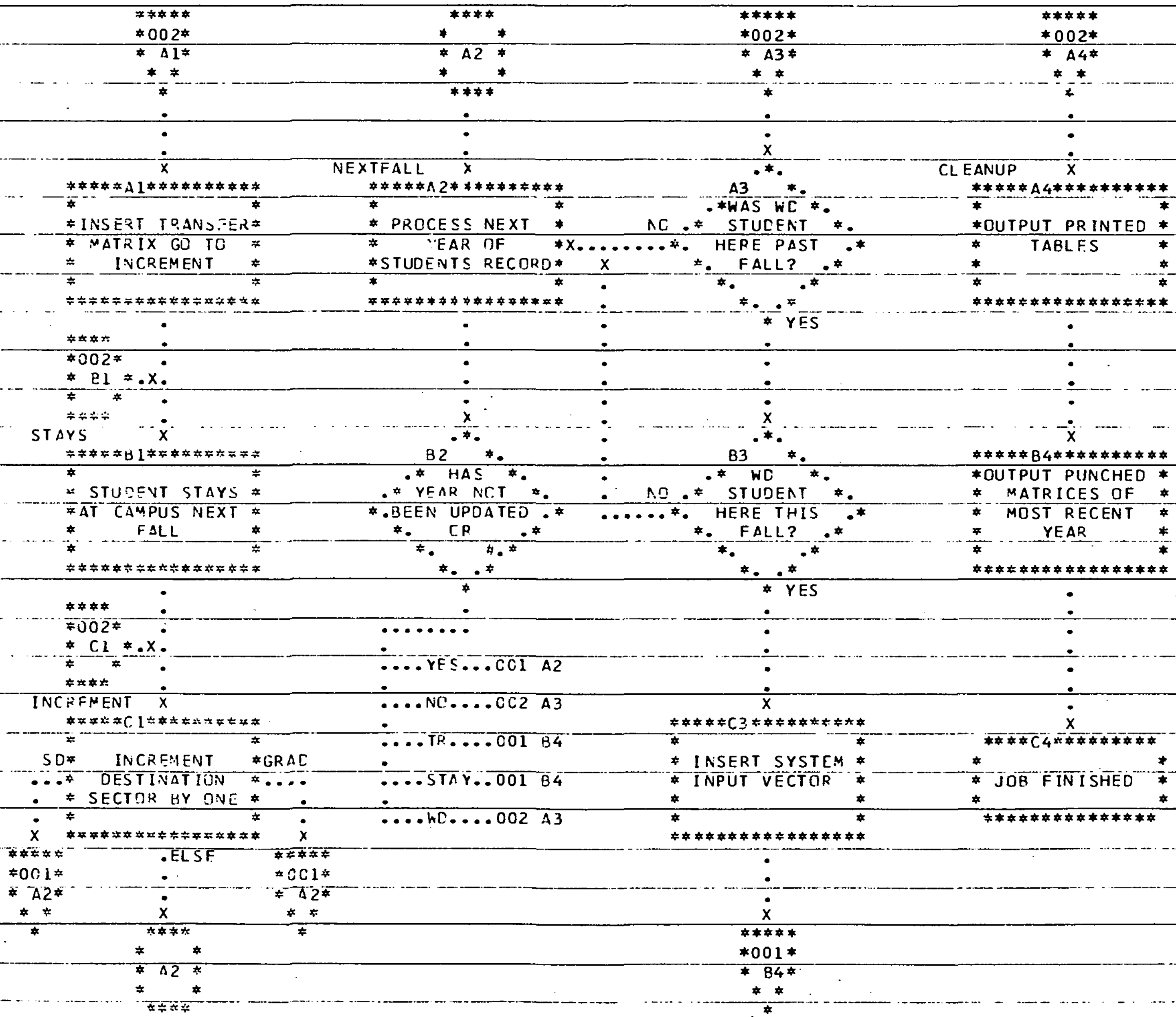


FIGURE A-1: MACRO FLOW CHART OF THE COEF-1 MODULE (continued)

(002)



001:

C2. PROGRAM BEING PROCESSED?

B4. INDICES.

C4. FALL

C5. NEXT FALL?

002:

B2. DOES NEXT FALL TERM EXCEED 20 TERM LIMIT?

```
//    EXEC FGCLG,PARM.OBJECT='MAP'
//SOURCE.INPUT DD *
      FIFTED 11/21/72 -- FIFT * VERSION 2.12 *
      IMPLICIT INTEGER (A-Z)
      LOGICAL P,Q,R,SWITCH
      REAL INPUTS
      REAL COEF(7,17)
      INTEGER*2 SUB(20,7,2,12)
      INTEGER*2 INPUT(20,7,2,11)
      INTEGER*2 FILE(20,7,2,17,11),MS(20,7,2,11),TRANS(20,7,2,11),SYS(20
     1,7,2,11),SD(20,7,2,11),T(20,20)
      INTEGER*2 DEGREE(20),LEGEND(20),TERM(20),TYPE,YEAR,STERM,BUFF2(125
     1),DEG
      INTEGER*2 TAB(20,5,11)
      LOGICAL*1 SSN(9),RC,SEX,PLACE(2),COLLEG(3),COLMAJ(3,20),CAMPUS(2,2
     10),CC(2),COLNAM(4,17),CAMNAM(20,20)
      LOGICAL*1 BUFF1(250)
      COMMON /L5/P,Q,R,SWITCH
      COMMON /L1/FILE,MS,TRANS,SYS,SD,T,L,Y,SLO,MFR,FROM,TO,COLNAM,CAMNA
     1M
      COMMON /L2/BUFF1
      EQUIVALENCE (BUFF2(1),BUFF1(1))
      EQUIVALENCE (BUFF2(1),TYPE),(BUFF2(2),YEAR),(BUFF2(3),STERM),(BUFF
     12(4),DEG),(BUFF2(5),TERM(1)),(BUFF2(25),DEGREE(1)),(BUFF2(45),LEGE
     2ND(1))
      EQUIVALENCE (BUFF1(130),SSN(1)),(BUFF1(140),RC),(BUFF1(141),SEX),(
     1BUFF1(142),CC(1)),(BUFF1(144),PLACE(1)),(BUFF1(146),COLLEG(1)),(BU
     2FF1(149),COLMAJ(1,1)),(BUFF1(209),CAMPUS(1,1))
C
C
C****************************SET-UP SECTION****************************
C          INITIALIZE FILES TO ZERO
      READ (5,100) CN,YN,LN,DN,SN,XYEAR,FYEAR,SD
  100 FORMAT (8I2)
      WRITE (6,102) CN,YN,LN,DN,SN,XYEAR,SD
  102 FORMAT (1'ICN= ',I2,5X,'YN= ',I2,5X,'LN= ',I2,5X,'DN= ',I2,5X,'SN=
     1',I2,5X,'XYEAR= ',I2,5X,'SD= ',I2)
      DO 108 C=1,CN
      T(C,C)=0
      DO 108 Y=1,YN
      DO 108 L=1,LN
      DO 104 D=1,DN
      DO 104 S=1,SN
  104 FILE(C,Y,L,D,S)=0
      DO 106 S=1,SN
      TAB(C,L,S)=0
      SUB(C,Y,L,S)=0
      MS(C,Y,L,S)=0
      SYS(C,Y,L,S)=0
      SD(C,Y,L,S)=0
      TRANS(C,Y,L,S)=0
  106 CONTINUE
  108 CONTINUE
C          INITIALIZE VARIABLES
      ICCOM1=0
      JCCOM1=0
      MCCOM1=0
      SCCOM1=0
      P=.TRUE.
      R=.TRUE.
```

```
      P=.FALSE.
      R=.FALSE.
      Q=.TRUE.
      U=.FALSE.
      Y2=XYEAR*10+2
C
C        READ CAMPUS NAMES AND ABBREVIATIONS
      DO 112 I=1,20
      READ (5,110) (CAMNAM(J,I),J=1,20)
  110 FORMAT (20A1)
  112 WRITE (6,114) I,(CAMNAM(J,I),J=1,2),(CAMNAM(J,I),J=3,20)
  114 FORMAT (' FILE=',I2,5X,'CAMPUS ABBREVIATION=',2A1,5X,'CAMPUS=',18A
     11)
C
C        READ COLLEGE SECTOR NAMES
      DO 118 I=1,40
      READ (5,116) (COLNAM(J,I),J=1,4)
  116 FORMAT (4A1)
  118 WRITE (6,120) COLNAM (1,I),(COLNAM(J,I),J=2,4)
  120 FORMAT (' CODE= ',A1,5X,'DESI= ',3A1)
C
C ****************************** INPUT SECTION ******************************
C
  122 ICOUNT=ICOUNT+1
      CALL GET (9,MEMF1,250,KEY)
      IF (KEY) 166,124,166
  124 CONTINUE
C
C************************************* MELDING SECTION ******************************
C
      Y1=YEAR*10+STERM
      IF (Y1.GT.Y2.OR.YEAR.LT.FYEAR) GO TO 122
      START=1
  126 DO 128 I=START,20
      MARK=I
      IF (DEGREE(I).EQ.XD) GO TO 130
  128 CONTINUE
      GO TO 122
  130 JCOUNT=JCOUNT+1
C******** DECISION RULE FOR PRINTING STUDENT INPUT RECORDS ***************
      IF (P) WRITE (6,132) ICOUNT,JCOUNT,MCOUNT,SCOUNT
  132 FORMAT ('0# STUDENTS READ= ',I5,3X,'# DESIRED STUDENTS= ',I5,3X,'#
     1 MEM STUDENTS= ',I5,3X,'# SO STUDENTS= ',I5)
      IF (P) CALL PIPUT
C        DETERMINING WHICH TERM IS THE FIRST FALL TERM DESIRED
      I=MARK
  134 IF (LEGEND(I).EQ.0.OR.I.GT.20) GO TO 122
      SI=STERM+I-1
      J=MOD(SI,4)
      IF (J.EQ.2.AND.(LEGEND(I).EQ.2.OR.LEGEND(I).EQ.3.OR.LEGEND(I).EQ.7
     1)) GO TO 136
      I=I+1
      GO TO 134
C******************************** DATA PROCESSING SECTION ******************
C
C        INITIALIZATION FOR THE FIRST FALL TERM
C
  136 CONTINUE
      CALL SEARCH (CAMPUS(I,1),2,CAMNAM,K122)
      CALL SEARCH (COLMAJ(I,1),1,SM,FROM,&122)
```

```
      OLD=NEW
      YEAR=YEAR-FYEAR+1
      L=TERM(I)/4+1
      IF (L.GT.LN) L=LN
      Y=YEAR+1/4
      IF (MARK.NE.1) GO TO 140
      NS(NEW,Y,L,FROM)=NS(NEW,Y,L,FROM)+1
      SCNEW)=SC(NEW)+1
      TAB(NEW,L,FROM)=1
      IF (W) WRITE (6,138) NEW,Y,L,FROM
  138 FORMAT (' NEW STUDENT VECTOR:',3X,'NEW= ',I2,3X,'Y= ',I2,3X,'LEVEL
     1= ',I2,3X,'SOURCE= ',I2)
      IF (Y.EQ.6) GO TO 122
      GO TO 142
  140 SD(NEW,Y,L,FROM)=SD(NEW,Y,L,FROM)+1
      SC(NEW)=SC(NEW)+1
      TAB(NEW,L,FROM)=1
C        CHECK FOR GRADUATION OR SWITCH DEGREE DURING THE YEAR
      IF (Y.EQ.6) GO TO 122
  142 CONTINUE
      SWITCH=.FALSE.
      I3=I+3
      DO 148 M=I,I3
      IF (M.GT.20.OR.LEGEND(M).EQ.0) GO TO 122
C        GRADUATE ?
      IF (LEGEND(M).NE.7.OR.SWITCH) GO TO 144
      SWITCH=.TRUE.
      CALL WRITE (12)
      GO TO 148
C        SWITCH DEGREE ?
  144 IF (DEGREE(M).EQ.XD.OR.DEGREE(M).EQ.0) GO TO 148
      CONTINUE
      CALL WRITE (14)
      CALL SEARCH (CAMPUS(I,M),2,CM,OLD,&122)
      CALL SEARCH (COLMAJ(I,M),1,SM,TO,&122)
      SDB(OLD,Y,L,TO)=SDB(OLD,Y,L,TO)+1
      IF (W) WRITE (6,146) OLD,Y,L,TO
  146 FORMAT (' OSUDB MAJ[illegible]',3X,'M= ',I2,3X,'CAMPUS= ',I2,3X,'Y= ',I2,3X
     1'L= ',I2,3X,'TO= ',I2)
      START=
      GO TO 126
  148 CONTINUE
      IF (SWITCH) GO TO 122
C        PROCESS NEXT YEAR
  150 I=I+4
      IF (I.GT.20.OR.LEGEND(I).EQ.0) GO TO 122
      IF (LEGEND(I-4).GE.4.AND.LEGEND(I-4).LE.6) GO TO 154
      K=LEGEND(I)
      GO TO (150,154,154,152,152,152,150,154,154), K
C        IF LEGEND EQUALS 4,5, OR 6 IN THIS FALL TERM AND THE STUDENT
C              HAS ENROLLED THE PREVIOUS FALL , THE STUDENT HAS WITHDRAWN
  152 CALL WRITE (13)
      GO TO 150
  154 CONTINUE
C        IF NOT ENROLLED LAST FALL , SEE IF ENROLLED THIS FALL
      IF (LEGEND(I).GE.4.AND.LEGEND(I).LE.6) GO TO 150
C
C        SEE IF STUDENT HAS SWITCHED DEGREE IN THE FALL TERM
C
      IF (DEGREE(I).EQ.XD) GO TO 156
```

```
      CALL PFILE (14)
      CALL SEARCH (CAMPUS(1,1),2,CM,OLD,&122)
      CALL SEARCH (COLMAJ(1,1),1,SM,TO,&122)
      SOB(OLD,Y,L,TO)=SOB(OLD,Y,L,TO)+1
      IF (P) WRITE (6,146) I,OLD,Y,L,TO
      START=1
      GO TO 126
C
C
  156 CONTINUE
      CALL SEARCH (COLMAJ(1,1),1,SM,TO,&122)
      LNEW=TERM(I)/4+1
      IF (LNEW.GT.LM) LNEW=LM
      OLD=NEW
      CALL SEARCH (CAMPUS(1,1),2,CM,NEW,&122)
      IF (NEW.NE.OLD) GO TO 162
C        IF NOT ENROLLED PREVIOUS FALL AND ARE ENROLLED THIS FALL.
C        INSERT INPUT VECTOR
      IF (LEGEND(I-4).GE.4.AND.LEGEND(I-4).LE.6) GO TO 158
      CALL PFILE (10)
      IF (LNEW.EQ.L) CALL PFILE (16)
      IF (LNEW.NE.L) CALL PFILE (17)
  158 CONTINUE
      Y=YEAR+I/4
      IF (Y.GE.7) GO TO 122
      L=LNEW
      SYS(NEW,Y,L,TO)=SYS(NEW,Y,L,TO)+1
      IF (P) WRITE (6,160) NEW,Y,L,TO
  160 FORMAT (' SYS INPUT VECTOR: ',3X,'CAMPUS= ',I2,3X,'Y= ',I2,3X,'
     1 LEVEL= ',I2,3X,'SOURCE= ',I2)
      TAB(NEW,L,TO)=1
      GO TO 142
  162 CONTINUE
      IF (LEGEND(I-4).GE.4.AND.LEGEND(I-4).LE.6) GO TO 164
      CALL PFILE (15)
  164 CONTINUE
      L=LNEW
      IF (LNEW.NE.L) CALL PFILE (17)
      IF (LNEW.EQ.L) CALL PFILE (16)
      Y=YEAR+I/4
      IF (Y.GE.7) GO TO 122
      TRANS(NEW,Y,L,TO)=TRANS(NEW,Y,L,TO)+1
      IF (P) WRITE (6,166) NEW,Y,L,TO
  166 FORMAT (' TRAN INPUT VECTOR:',3X,'NEW= ',I2,3X,'Y= ',I2,3X,'LEVEL=
     1',I2,3X,'TO= ',I2)
      TAB(NEW,L,TO)=1
      GO TO 142
C
C
  168 CONTINUE
      YN=5
      WRITE (6,132) ICOUNT,JCOUNT,NCOUNT,SCOUNT
      DO 204  C=1,CM
      DO 202  L=1,LM
      DO 200  S=1,SM
      DO 178  Y=1,5
      IF (TAB(C,L,S).EQ.0) GO TO 200
      INPUT(C,Y,L,S)=NS(C,Y,L,S)+TRANS(C,Y,L,S)+SOB(C,Y,L,S)+SYS(C,Y,L,S)
      INPUTS=0.0
      DO 170  D=1,15
```

```
170 INPUTS=INPUTS+FILE(C,Y,L,D,S)
    DO 172  D=1,15
    COEF(Y,D)=0.0
    IF (INPUTS.NE.0.0) COEF(Y,D)=FILE(C,Y,L,D,S)/INPUTS
172 CONTINUE
    INPUTS=FILE(C,Y,L,16,S)+FILE(C,Y,L,17,S)
    DO 174  D=16,17
    COEF(Y,D)=0.0
    IF (INPUTS.NE.0.0) COEF(Y,D)=FILE(C,Y,L,D,S)/INPUTS
174 CONTINUE
    IF (Y.EQ.5) WRITE (7,176) Y,C,L,S,(COEF(Y,D),D=1,DM)
176 FORMAT ('ACOEF',1X,4I2,1X,10F5.3,/,10F5.3)
178 CONTINUE
    WRITE (6,180) (CAMNAM(I,C),I=3,20)
180 FORMAT ('1THE PENNSYLVANIA STATE UNIVERSITY',25X,'ENROLLMENT MODEL
   1',25X,18A1)
    IF (XO.EQ.2) WRITE (6,182) (COLNAM(I,S),I=2,4),L
    IF (XO.EQ.4) WRITE (6,184) (COLNAM(I,S),I=2,4),L
182 FORMAT ('0ASSOCIATE DEGREE STUDENTS',33X,'COLLEGE= ',3A1,30X,'LEVE
   1L= ',I1)
184 FORMAT ('0BACCULARATE DEGREE STUDENTS',31X,'COLLEGE= ',3A1,30X,'LE
   1VEL= ',I1)
    WRITE (6,186)
186 FORMAT (/,'0DESTINATION',3X,'1966',5X,'1967',5X,'1968',5X,'1969',5
   1X,'1970')
    DO 188  D=1,SM
188 WRITE (6,190) (COLNAM(I,D),I=2,4),(COEF(Y,D),Y=1,YM)
190 FORMAT (' ',5X,3A1,6X,7(F5.3,4X))
    DO 192  D=12,DM
192 WRITE (6,190) (COLNAM(I,D),I=2,4),(COEF(Y,D),Y=1,YM)
    WRITE (6,194)
194 FORMAT ('5YEAR',6X,'TOTAL',5X,'NEW',4X,'SYS',4X,'TRANS',3X,'SO')
    DO 198  Y=1,6
    YY=FYEAR+Y+1965
    INPUT(C,Y,L,S)=NS(C,Y,L,S)+TRANS(C,Y,L,S)+SO(C,Y,L,S)+SYS(C,Y,L,S)
    WRITE (6,196) YY,INPUT(C,Y,L,S),NS(C,Y,L,S),SYS(C,Y,L,S),TRANS(C,Y
   1,L,S),SO(C,Y,L,S)
196 FORMAT ('0',I4,6X,I5,' = ',3(I5,' + '),I5)
198 CONTINUE
200 CONTINUE
202 CONTINUE
204 CONTINUE
    DO 214  Y=1,YM
    DO 214  L=1,LM
    WRITE (6,206)
206 FORMAT ('1THE PENNSYLVANIA STATE UNIVERSITY',25X,'ENROLLMENT MODEL
   1',25X,'TRANSFER MATRIX')
    WRITE (6,208) Y,L
208 FORMAT ('0ASSOCIATE DEGREE STUDENTS',31X,'YEAR= ',I4,30X,'LEVEL= '
   1,I1)
    WRITE (6,218) ((COLNAM(J,S),J=2,4),S=1,SM)
    DO 212  C=1,CM
    WRITE (6,210) (CAMNAM(J,C),J=3,20),(TRANS(C,Y,L,S),S=1,SM)
210 FORMAT (' SECTOR= ',18A1,3X,11(I5,3X))
212 CONTINUE
214 CONTINUE
    DO 222  Y=1,YM
    DO 222  L=1,LM
    WRITE (6,216)
216 FORMAT ('1THE PENNSYLVANIA STATE UNIVERSITY',25X,'ENROLLMENT MODEL
```

```
     1',25X,'SD MATRIX')
      WRITE (6,208) Y,L
      WRITE (6,218) ((COLNAM(J,S),J=2,4),S=1,SN)
  218 FORMAT ('0CAMPUS',25X,11(3A1,5X))
      DO 220  C=1,CN
      WRITE (6,210) (CAMNAM(J,C),J=3,20),(SUB(C,Y,L,S),
  220 CONTINUE
  222 CONTINUE
      Y=5
C
C
C         PUNCH SWITCH DEGREE COEFFICIENTS.
C
      DO 230  L=1,LN
      DO 230  S=1,SN
      INPUTS=0.0
      DO 224  C=1,CN
  224 INPUTS=INPUTS+SUB(C,Y,L,S)
      DO 226  C=1,CN
      COEF(1,C)=0.0
      IF (INPUTS.NE.0.0) COEF(1,C)=SUB(C,Y,L,S)/INPUTS
  226 CONTINUE
      WRITE (7,228) Y,L,S,(COEF(1,C),C=1,20)
  228 FORMAT ('SICOEF',4X,3I2,4X,10F5.3,/,10X,12F5.3)
  230 CONTINUE
C
C
C         PUNCH TRANSFER COEFFICIENTS.
C
      DO 238  Y=5,6
      DO 238  L=1,LN
      DO 238  S=1,SN
      INPUTS=0.0
      DO 232  C=1,CN
  232 INPUTS=INPUTS+TRANS(C,Y,L,S)
      DO 234  L=1,CN
      COEF(1,C)=0.0
      IF (INPUTS.NE.0.0) COEF(1,C)=TRANS(C,Y,L,S)/INPUTS
  234 CONTINUE
      WRITE (7,236) Y,L,S,(COEF(1,C),C=1,20)
  236 FORMAT ('TICOEF',4X,3I2,4X,10F5.3,/,10X,12F5.3)
  238 CONTINUE
C
      STOP
      END
      SUBROUTINE SEARCH (KEY,NUMBER,N,INDEX,*)
      IMPLICIT INTEGER (A-Z)
      LOGICAL R,JR,SWITCH
      INTEGER*2 FILE(20,7,2,17,11),NS(20,7,2,11),TRANS(20,7,2,11),SYS(20
     1,7,2,11),SO(20,7,2,11),T(20,20)
      INTEGER*2 DEGREE(20),LEGEND(20),TERM(20),TYPE,YEAR,STERM,BUFF2(125
     1),DEG
      LOGICAL*1 SSN(9),RC,SEX,PLACE(2),COLLEG(3),COLMAJ(3,20),CAMPUS(2,2
     10),CC(2),COLNAM(4,17),CAMNAM(20,20)
      LOGICAL*1 BUFF1(250)
      LOGICAL*1 KEY(NUMBER)
      COMMON /L5/R,JR,SWITCH
      COMMON /L1/FILE,NS,TRANS,SYS,SO,T,L,Y,OLD,NEW,FROM,TO,COLNAM,CAMNA
     1M
      COMMON /L2/BUFF1
```

```
      EQUIVALENCE (BUFF2(1),BUFF1(1))
      EQUIVALENCE (BUFF2(1),TYPE),(BUFF2(2),YEAR),(BUFF2(3),STERM),(BUFF
     12(4),DEG),(BUFF2(5),TERM(1)),(BUFF2(25),DEGREE(1)),(BUFF2(45),LEGE
     2ND(1))
      EQUIVALENCE (BUFF1(130),SSN(1)),(BUFF1(140),RC),(BUFF1(141),SEX),(
     1BUFF1(142),CC(1)),(BUFF1(144),PLACE(1)),(BUFF1(146),COLLEG(1)),(BU
     2FF1(149),COLMAJ(1,1)),(BUFF1(209),CAMPUS(1,1))
C
C
C       THIS SUBROUTINE DOES A BINARY SEARCH.
C        M IS THE LARGEST INDEX IN THE DESIRED ARRAY
C
C
      IF (W) WRITE (6,100)
  100 FORMAT ('0***** SUBROUTINE SEARCH ENTERED *****')
      I=1
      J=2
  102 K=((I*N)/J)+1
      I=I*2
      IF (NUMBER.EQ.1) CALL CHCOMP (KEY(1),COLNAM(1,K),1,&104,&124,&106)
      IF (NUMBER.EQ.2) CALL CHCOMP (KEY(1),CAMNAM(1,K),2,&104,&128,&106)
  104 I=I-1
      GO TO 108
  106 I=I+1
  108 IF (J.GT.M) GO TO 110
      J=J*2
      GO TO 102
  110 IF (NUMBER.EQ.2) CALL CHCOMP (KEY(1),'C',1,&114,&112,&114)
      GO TO 118
  112 INDEX=1
      RETURN
  114 CALL CHCOMP (KEY(1),'SA',2,&118,&116,&118)
  116 INDEX=OLD
      RETURN
  118 WRITE (6,120) KEY
  120 FORMAT ('0THIS KEY= ',2A1,' IS NOT FOUND')
      CALL PINPUT
      IF (W) WRITE (6,122)
  122 FORMAT ('0***** SUBROUTINE EXITED *****')
      RETURN
  124 INDEX=K
      IF (W) WRITE (6,126) INDEX,NUMBER,KEY
  126 FORMAT (' INDEX=',I2,5X,'NUMBER=',I2,5X,'KEY=',2A1)
      IF (W) WRITE (6,122)
      RETURN
  128 INDEX=K
      IF (W) WRITE (6,126) INDEX,NUMBER,KEY
      IF (W) WRITE (6,122)
      RETURN
      END
C     FIFIED 11/21/72 -- FIFL * VERSION 2.12 *
C     FIFIED 11/21/72 -- FIFL * VERSION 2.12 *
      SUBROUTINE PFILE (DEST)
      IMPLICIT INTEGER (A-Z)
      LOGICAL P,Q,R,SWITCH
      INTEGER*2 FILE(20,7,2,11),MS(20,7,2,11),TRANS(20,7,2,11),SYS(20
     1,7,2,11),SO(20,7,2,11),T(20,20)
      INTEGER*2 DEGREE(20),LEGEND(20),TERM(20),TYPE,YEAR,STERM,BUFF2(125
     1),DEG
      LOGICAL*1 SSN(9),RC,SEX,PLACE(2),COLLEG(3),COLMAJ(3,20),CAMPUS(2,2
```

```
10),CC(2),COLNAM(4,17),CAMNAM(20,20)
 LOGICAL*1 BUFF1(250)
 COMMON /L5/P,Q,R,SWITCH
 COMMON /L1/FILE,NS,TRANS,SYS,SD,T,L,Y,OLD,NEW,FROM,TO,COLNAM,CAMNA
1M
 COMMON /L2/BUFF1
 EQUIVALENCE (BUFF2(1),BUFF1(1))
 EQUIVALENCE (BUFF2(1),TYPE),(BUFF2(2),YEAR),(BUFF2(3),STERM),(BUFF
12(4),DEG),(BUFF2(5),TERM(1)),(BUFF2(25),DEGREE(1)),(BUFF2(45),LEGE
2ND(1))
 EQUIVALENCE (BUFF1(130),SSN(1)),(BUFF1(140),RC),(BUFF1(141),SEX),(
1BUFF1(142),CC(1)),(BUFF1(144),PLACE(1)),(BUFF1(146),COLLEG(1)),(BU
2FF1(149),COLMAJ(1,1)),(BUFF1(209),CAMPUS(1,1))
C
C
C
 IF (Q) WRITE (6,100)
100 FORMAT ('0***** SUBROUTINE PFILE ENTERED *****')
 FILE(OLD,Y,L,DEST,FROM)=FILE(OLD,Y,L,DEST,FROM)+1
 IF (P) WRITE (6,102) (CAMNAM(J,OLD),J=1,2),Y,L,DEST,FROM
102 FORMAT (' END OF YEAR SECTOR: ',3X,'CAMPUS= ',2A1,3X,'Y= ',I1,3X,'
1LEVEL= ',I1,3X,'DEST= ',I2,3X,'SOURCE= ',I2)
 IF (Q) WRITE (6,104)
104 FORMAT ('0***** SUBROUTINE EXITED *****')
 RETURN
 END
C FIFTED 11/21/72 -- FIFT * VERSION 2.12 *
 SUBROUTINE RINPUT
 IMPLICIT INTEGER (A-Z)
 LOGICAL P,Q,R,SWITCH
 INTEGER*2 FILE(20,7,2,17,11),NS(20,7,2,11),TRANS(20,7,2,11),SYS(20
1,7,2,11),SD(20,7,2,11),T(20,20)
 INTEGER*2 DEGREE(20),LEGEND(20),TERM(20),TYPE,YEAR,STERM,BUFF2(125
1),DEG
 LOGICAL*1 SSN(9),RC,SEX,PLACE(2),COLLEG(3),COLMAJ(3,20),CAMPUS(2,2
10),CC(2),COLNAM(4,17),CAMNAM(20,20)
 LOGICAL*1 BUFF1(250)
 COMMON /L5/P,Q,R,SWITCH
 COMMON /L1/FILE,NS,TRANS,SYS,SD,T,L,Y,OLD,NEW,FROM,TO,COLNAM,CAMNA
1M
 COMMON /L2/BUFF1
 EQUIVALENCE (BUFF2(1),BUFF1(1))
 EQUIVALENCE (BUFF2(1),TYPE),(BUFF2(2),YEAR),(BUFF2(3),STERM),(BUFF
12(4),DEG),(BUFF2(5),TERM(1)),(BUFF2(25),DEGREE(1)),(BUFF2(45),LEGE
2ND(1))
 EQUIVALENCE (BUFF1(130),SSN(1)),(BUFF1(140),RC),(BUFF1(141),SEX),(
1BUFF1(142),CC(1)),(BUFF1(144),PLACE(1)),(BUFF1(146),COLLEG(1)),(BU
2FF1(149),COLMAJ(1,1)),(BUFF1(209),CAMPUS(1,1))
C
C     THIS SUBROUTINE PRINTS THE INPUT RECORDS FROM UNIT 4
C
 WRITE (6,100)
100 FORMAT ('0***** SUBROUTINE RINPUT ENTERED *****')
 WRITE (6,102)
102 FORMAT ('0',40X,'ADMISSIONS RECORD')
 WRITE (6,104) SSN,YEAR,STERM,DEG
104 FORMAT (' SOC SEC NUMBER= ',9A1,15X,'YEAR&TERM= ',I2,',',I1,25X,'D
1EGREE= ',I1)
 WRITE (6,106) (PLACE(I),I=1,2),TYPE,SEX
106 FORMAT (' CAMPUS ADMITTED= ',2A1,21X,'TYPE= ',I1,33X,'SEX=',A1)
```

```
      WRITE (6,108) (COLLEG(I),I=1,3),RC,(CC(I),I=1,2)
  108 FORMAT ('  COLLEGE&MAJOR= ',3A1,22X,'RESIDENCE CLASS = ',A1,21X,'CO
     1UNTY CODE= ',2A1)
      WRITE (6,110)
  110 FORMAT ('0',40X,'ACHIEVEMENT RECORD')
      WRITE (6,112) (TERM(I),I=1,20)
  112 FORMAT (' TERM=',2X,20(1X,I2,2X))
      WRITE (6,114) (COLMAJ(1,I),COLMAJ(2,I),COLMAJ(3,I),I=1,20)
  114 FORMAT (' COLLEGE=',20(1X,3A1,1X))
      WRITE (6,116) (CAMPUS(1,I),CAMPUS(2,I),I=1,20)
  116 FORMAT (' CAMPUS=',1X,20(2X,2A1,1X))
      WRITE (6,118) (DEGREE(I),I=1,20)
  118 FORMAT (' DEGREE=',1X,20(2X,I1,2X))
      WRITE (6,120) (LEGEND(I),I=1,20)
  120 FORMAT (' LEGEND=',1X,20(2X,I1,2X))
      WRITE (6,122)
  122 FORMAT ('0***** SUBROUTINE EXITED *****')
      RETURN
      END
//DATA.FT09F001 DD UNIT=2400,DCB=(RECFM=FB,LRECL=330,BLKSIZE=3300),
//     VOL=SER=M411,DSN=ENROLL,LABEL=(,,,IN)
//               DD UNIT=2400,DCB=(RECFM=FB,LRECL=330,BLKSIZE=3300),
//     VOL=SER=MST2,DSN=ENROLL,LABEL=(,,,IN)
//DATA.INPUT DD *
2007021711726602
AAALTOONA
ANALLENTOWN
BOBEHREND
BKBERKS
BRBEAVER
CLCAPITOL
DEDELAWARE
DSDUBOIS
FEFAYETTE
HNHAZLETON
MAMONT ALTO
MKMCKEESPORT
NKNEW KENSINGTON
07OGONTZ
SLSCHUYLKILL
SNSCRANTON
SOSCHENANGO
UPUNIV. PARK
WBWILKES BARRE
YKYORK
AAG 01
EBA 03
EEO 05
GEN
HHPE07
JHU 08
LLA 09
MEMS
SSC11
100C11
G
MD
SD
TR
RE
```

D
/* THIS IS A SLASH ASTERISK CARD

B: ITER-1 MODULE

The user must supply the following card input for use of the INDEX-1 module:

1: Parameter Card:

Columns 1- 2:	Number of years to be projected.
Columns 3- 4:	Maximum number of student-levels for any one degree-lev.
Columns 5- 6:	Maximum number of origin colleges for any one degree-level.
Columns 7- 8:	Maximum number of terminal states in Campus and Progression Matrices for any one degree-level.
Columns 9-10:	Number of campuses.
Columns 11-12:	Row number of "transfer" in Campus and Progression Matrices.
Columns 13-14:	Row number of "switch degree" in Campus and Progression Matrices.
Columns 15-16:	Row number of "retained" in Campus and Progression Matrices.
Columns 17-18:	Row number of "advanced" in Campus and Progression Matrices.
Columns 19-20:	Last two digits of base year.

2: Campus Cards: One card per campus with the campus abbreviation in Columns 1-2 and name in Columns 3-20.

3: Terminal State Names: One card for each row in the Campus Progression Matrices.

4: Coefficient Cards: The Matrices produced as punched output from COEF-1 in the following order.

Campus and Progression: Baccalaureate

Inter-Campus: Baccalaureate
Switch-Degree: Baccalaureate
Inter-Campus: Associate
Switch-Degree: Associate
Campus and Progression: Associate

The last card in the two sets of Campus and Progression Matrices must have a 9 punched in Column 8.

5: Enrollment Cards: Enrollments for the base year must be read in on cards with the following format:

Columns 3-4: Campus number equal to the order in which the campus is processed, which is in alphabetic order of the campus codes.

1: Altoona
2: Allentown
3: Behrend
4: Berks
5: Beaver
6: Capitol
7: Delaware
8: DuBois
9: Fayette
10: Hazleton
11: Mont Alto
12: McKeesport
13: New Kensington
14: Ogontz
15: Schuylkill
16: Scranton
17: Shenango
18: University Park
19: Wilkes Barre
20: York

Columns 5-6: Student-level of enrollment 1, 2, 3, or 4.

Columns 7-8: College of enrollment number equal to order in which colleges are processed.

1: Agriculture
2: Arts and Architecture
3: Business Administration
4: Education
5: Engineering
6: Health and Physical Education
7: Human Development
8: Liberal Arts

9: Earth and Mineral Sciences
10: Science
11: Division of Counseling
12: Inter-College

Columns 11-15: Baccalaureate enrollment.

Columns 16-17: Associate enrollment.

The last card must have a 9 punched in Colunm 2. All fields must be right justified.

Example:

Altoona, Freshmen, Agriculture, 41 Baccalaureate, 14 Associate.

ƀƀØ1Ø1Ø1ƀƀƀ41ƀƀƀ14

Example:

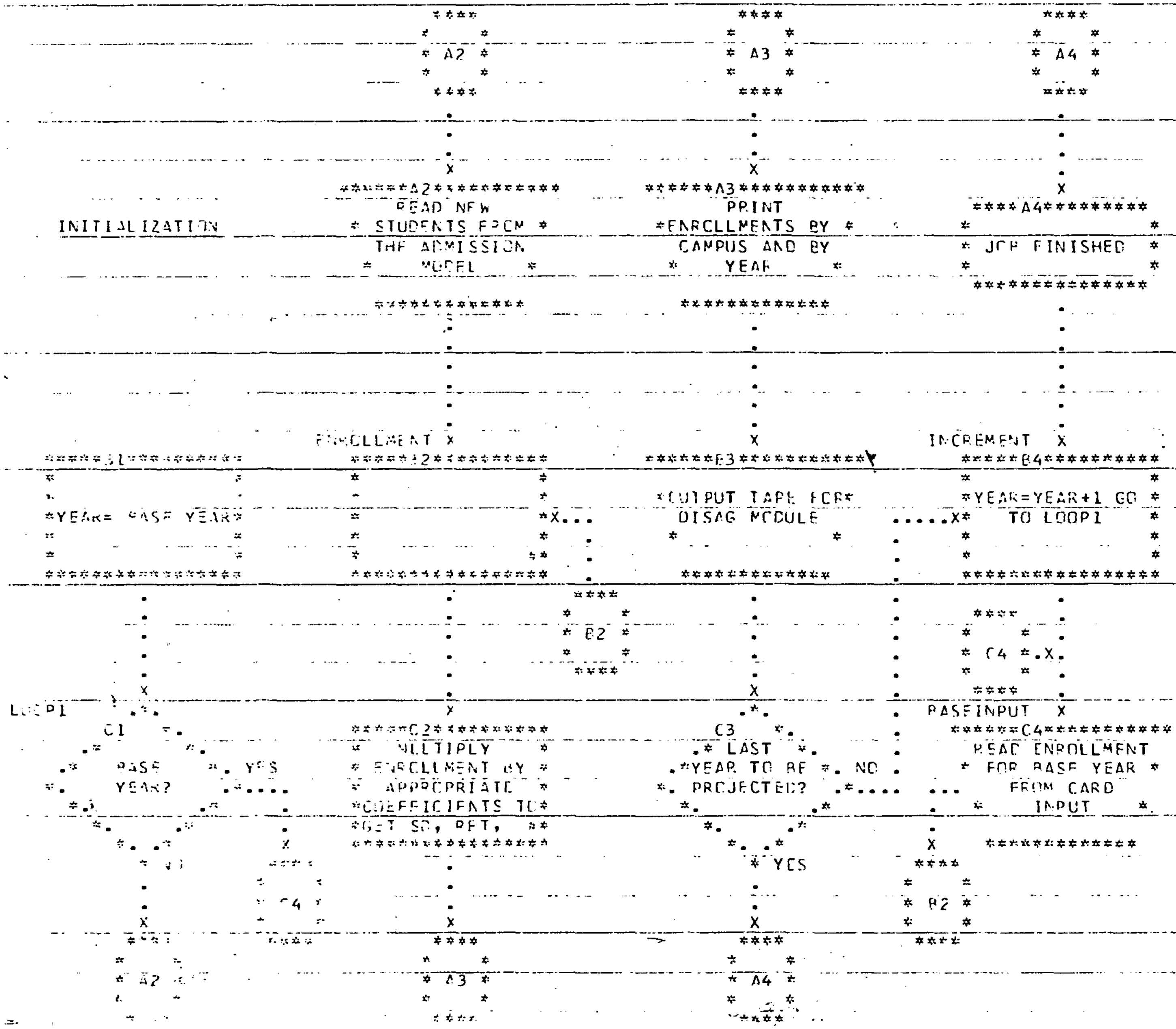
Berks, Freshmen, Engineering, 34 Baccalaureate, 63 Associate.

ƀƀØ4Ø1Ø5ƀƀƀ34ƀƀƀ63

The ITER-1 program produces printed output of enrollment by campus, degree-level, student-level, and college of enrollment at the undergraduate level. In addition, a tape output is produced.

FIGURE B-1: MACRO FLOW CHART OF THE ITER-1 MODULE

(001)



B2. ENROLLMENT = NEW + SWITCH DEGREE + RETAINED + ADVANCING + TRANSFER STUDENTS.

C2. ADVANCING AND TRANSFER STUDENTS FOR THE FOLLOWING YEAR.

```
// EXEC FGG
//SOURCE.INPUT DD *
      IMPLICIT INTEGER (A-Z)
      REAL*8 COLNAM(10,2)
      INTEGER*4 JSUM(6)
      INTEGER*4 INPUT(20,4,12,2),MS(20,4,12,2),MS1(1920)
      INTEGER C,CN,S,SM,D,DM,Y,YM,I,A,K,SD,FYEAR
      INTEGER*2 TAB(20,4,12),TAB1(20,2,12)
      REAL*4 TEMP(20),ADV(20,4,12,2),RET(20,4,12,2),TRAN(20,4,12,2),
     *ENDL(4,12),COEF(20,4,4,12),IN(4,12),SUM(4,12),ADV1(20,2,12,2),
     *RET1(20,2,12,2),TRAN1(20,2,12,2),SWDA(20,2,12,2),ACOEF(20,2,16,12)
     *,TRI(2,12),SUB(2,12),ICOEF(20,4,12),TICOEF(20,2,12),
     *SWD(20,4,12,2)
      REAL*4 SBCOEF(20,4,12),SACOEF(20,2,12)
      LOGICAL*4 SWITCH
      LOGICAL*1 CAMNAM(20,20)
      EQUIVALENCE (MS(1,1,1,1),MS1(1))
C
C
C
C     THIS PROGRAM READS IN A SET OF TECHNICAL COEFFICIENTS AND THEN
C         PROJECTS ENROLLMENT FOR ANY DESIRED NUMBER OF YEARS, WHO
C         STUDENTS BY CAMPUS,LEVEL, AND COLLEGE IS THE INPUT DESIRED
C         FOR EACH YEAR DESIRED. THIS INPUT IS READ BY THE CARD
C         READER FOR THE BASE YEAR. FOR ALL OTHER YEARS THE INPUT IS
C         ON THE TAPE 'RATIO' WHICH IS GENERATED BY THE
C         "ADMISSIONS MODEL".
C
C
C
C     VARIABLE 'YM' IS THE DESIRED NUMBER OF YEARS TO BE PROJECTED.
C     VARIABLE 'CN' IS THE NUMBER OF CAMPUSES.
C     VARIABLE 'LM' IS THE NUMBER OF STUDENT LEVELS FOR EAC. STUDENTS
C     VARIABLE 'SM' IS THE NUMBER OF COLLEGES.
C     VARIABLE 'FYEAR' STANDS FOR BASE OR INITIAL YEAR. IN THIS
C     YEAR THE COMPLETE ENROLLMENT IS READ FROM CARDS. HOWEVER
C     ADVANCING, RETURNING, TRANSFER, AND SWITCH-DEGREE STUDENTS
C     FOR THE NEXT YEAR ARE CALCULATED.
C
C
COMMENT:        GENERAL DESCRIPTION OF ARRAYS.
C
C               1. 'C' IS A CAMPUS INDEX.
C               2. 'L' IS A STUDENT LEVEL INDEX.
C               3. 'S' IS A SOURCE COLLEGE OF ENROLLMENT INDEX.
C               4. 'D' IS A DESTINATION COLLEGE OF ENROLLMENT INDEX.
C
COMMENT:        DEFINITION OF ENROLLMENT VARIABLES AND ARRAYS.
C               1. ARRAY 'INPUT' CONTAINS THE TOTAL ENROLLMENT EQUAL TO
C               THE SUM OF NEW, RETURNING, ADVANCING, TRANSFERRING, AND
C               SWITCH DEGREE STUDENTS.
C               2. ARRAY 'RET' CONTAINS THE NUMBER OF STUDENTS WHO WILL
C               RETURN TO THE SAME LEVEL IN THE NEXT YEAR. SECTION 'R' IN
C               THE COEFFICIENT MATRIX IS THE RETURNING COEFFICIENT FOR
C               THAT SECTION.
C               3. ARRAY 'ADV' CONTAINS THE NUMBER OF STUDENTS WHO WILL
C               ADVANCE TO THE NEXT LEVEL NEXT YEAR. SECTION 'A' IN THE
C               COEFFICIENT MATRIX IS THE ADVANCING COEFFICIENT FOR THAT
C               SECTION.
COMMENT:        DEFINITION OF WORKING VARIABLES AND ARRAYS.
```

```
C
C     ARRAY 'END(D,S)' IS USED TO CONTAIN THE TRANSITION MATRIX
C     CALCULATED FROM MULTIPLYING A TECHNICAL COEFFICIENT MATRIX BY
C     AN ENROLLMENT VECTOR.
C     ARRAY 'TR' CONTAINS THE NUMBER OF BAC. STUDENTS TRANSFERING
C     INTO LEVEL 'L' AND COLLEGE 'S'.
C     ARRAY 'TR1' CONTAINS THE NUMBER OF ASS. STUDENTS TRANSFERING
C     INTO LEVEL 'L' AND COLLEGE 'S'.
C     ARRAY 'SDA' CONTAINS THE NUMBER OF BAC. STUDENTS SWITCHING
C     DEGREES INTO LEVEL 'L' AND 'COLLEGE 'S'.
C     ARRAY 'SDB' CONTAINS THE NUMBER OF ASS. STUDENTS SWITCHING
C     DEGREES INTO LEVEL 'L' AND COLLEGE 'S'.
C
      M2=5
      M1=5
      SWITCH=.FALSE.
      SWITCH=.TRUE.
      M3=5
C
C     READ PARAMETERS
C
      READ(5,5)YM,LM,SM,DM,CM,I,SD,K,A,BYEAR
5     FORMAT(40I2)
      BYEAR=BYEAR+1900
      WRITE(6,6)YM,LM,SM,DM,CM,I,SD,K,A,BYEAR
6     FORMAT(' YM=',I2,3X,'LM=',I2,3X,'SM=',I2,3X,'DM=',I2,3X,'CM=',I2,
     *3X,'I=',I2,3X,'SD=',I2,3X,'K=',I2,3X,'A=',I2,3X,'BYEAR=',I2)
C
C
C     READ CAMPUS NAMES AND ABBREVIATIONS
      DO 10 C=1,CM
      READ(5,11)(CAMNAM(J,C),J=1,20)
11    FORMAT(20A1)
      WRITE(6,12)C,(CAMNAM(J,C),J=1,2),(CAMNAM(J,C),J=3,20)
12    FORMAT(' FILE=',I2,5X,'CAMPUS ABBREVIATION=',2A1,5X,'CAMPUS=',18A1
     A)
10    CONTINUE
C
COMMENT: READ AND PRINT THE DEFINITIONS OF THE COLLEGE SECTORS.
C
      DO 20 S=1,SM
      READ(5,21)(COLNAM(S,J),J=1,2)
21    FORMAT(2A8)
      WRITE(6,22)S,(COLNAM(S,J),J=1,2)
22    FORMAT(' ',I2,5X,'COLLEGE= ',2A8)
20    CONTINUE
C
C
C
C     INITIALIZE VARIABLES TO ZERO
C
      DO 30 S=1,SM
      DO 30 D=1,DM
      END(D,S)=0.
      DO 30 C=1,CM
      DO 35 L=1,LM
      IMPUT(C,L,S,1)=0
      IMPUT(C,L,S,2)=0
      RET(C,L,S,1)=0.
      RET(C,L,S,2)=0.
```

```
      ADV(C,L,S,1)=0.
      ADV(C,L,S,2)=0.
      TRAN(C,L,S,1)=0.
      TRAN(C,L,S,2)=0.
      SWDB(C,L,S,1)=0.
      SWDB(C,L,S,2)=0.
      TAB(C,L,S)=0
      SBCOEF(C,L,S)=0.
      TCOEF(C,L,S)=0.
   35 COEF(C,L,D,S)=0.
      DO 36 L=1,2
      TAB1(C,L,S)=0
      TICOEF(C,L,S)=0.
      SACOEF(C,L,S)=0.
      ADV1(C,L,S,1)=0.
      ADV1(C,L,S,2)=0.
      RET1(C,L,S,1)=0.
      RET1(C,L,S,2)=0.
      TRAN1(C,L,S,1)=0.
      TRAN1(C,L,S,2)=0.
      SWDA(C,L,S,1)=0.
      SWDA(C,L,S,2)=0.
   36 ACOEF(C,L,D,S)=0.
   30 CONTINUE
C*********************************************************************
C
C     READ TECHNICAL COEFFICIENTS FOR BAC.STUDENTS.
C
   50 READ(N1,55)I,C,L,S,(TEMP(J),J=1,DN)
   55 FORMAT(6X,4I2,1X,10F5.0,/,10F5.0)
      IF(I.EQ.9)GO TO 60
      TAB(C,L,S)=1
      D1=DN-1
      DO 58 D=1,D1
      IF(D-12)56,57,59
   56 COEF(C,L,D,S)=TEMP(D)
      GO TO 58
   57 COEF(C,L,D,S)=0.
   59 COEF(C,L,D+1,S)=TEMP(D)
   58 CONTINUE
      GO TO 50
   60 IF(SWITCH)GO TO 70
      DO 65 C=1,CN
      DO 65 L=1,LN
      WRITE(6,61)(CAMNAM(J,C),J=3,20),L
   61 FORMAT('1CAMPUS=',18A1,20X,'BAC. COEFFICIENTS',10X,'LEVEL=',I2)
      DO 65 D=1,DN
   65 WRITE(6,66)(COLNAM(D,J),J=1,2),(COEF(C,L,D,S),S=1,SN)
   66 FORMAT(' ',2A8,3X,12(F5.3,3X))
C
C
C
C
C     READ TRANSFER COEFFICIENTS FOR BAC.STUDENTS.
C
   70 CONTINUE
      S1=SN-1
      DO 80 L=1,LN
      DO 80 S=1,S1
      READ(N2,85)(ICOEF(I,L,S),I=1,CN)
```

```
   85 FORMAT(19X,10F5.3,/,10X,12F5.3)
   80 CONTINUE
C
C        READ SWITCH DEGREE COEFFICIENTS FOR BAC.STUDENTS.
C
      DO 95 L=1,LN
      DO 95 S=1,S1
      READ(N2,85)(SHCOEF(I,L,S),I=1,CN)
   95 CONTINUE
      IF(SW.I(CH)GO TO 90
      DO 86 L=1,LN
      WRITE(6,87)BYEAR,L
   87 FORMAT('1TRANSFER MATRIX BAC. STUDENTS',10X,'YEAR=',I4,10X,
     *'LEVEL=',I2)
      WRITE(6,88)(COLNAM(S,1),S=1,SN)
   88 FORMAT('0',23X,12A8)
      DO 86 C=1,CN
      WRITE(6,89)(CAMNAM(J,C),J=3,20),(TCOEF(C,L,S),S=1,SN)
   89 FORMAT(' ',18A1,5X,12(F5.3,3X))
   86 CONTINUE
      DO 96 L=1,LN
      WRITE(6,97)BYEAR,L
   97 FORMAT('1SWITCH DEGREE MATRIX BAC. TO ASS.',5X,'YEAR=',I4,5X,
     *'LEVEL=',I2)
      WRITE(6,88)(COLNAM(S,1),S=1,SN)
      DO 96 C=1,CN
      WRITE(6,89)(CAMNAM(J,C),J=3,20),(SHCOEF(C,L,S),S=1,SN)
   96 CONTINUE
   90 CONTINUE
C
C        READ ASS. TRANSFER MATRICIES
C
      DO 101 L=1,2
      DO 101 S=1,S1
      IF(S.EQ.1)READ(N2,111)(TCOEF(C,L,S),C=1,CN)
      IF(S.NE.1)READ(N2,111)(TCOEF(C,L,S+1),C=1,CN)
  101 CONTINUE
C
C        READ ASS. SWITCH DEGREE TO BAC.
C
  109 DO 110 L=1,2
      DO 110 S=1,S1
      IF(S.EQ.1)READ(N2,111)(SACOEF(C,L,S),C=1,CN)
      IF(S.NE.1)READ(N2,111)(SACOEF(C,L,S+1),C=1,CN)
  111 FORMAT(20X,10F5.3,/,10X,12F5.3)
  110 CONTINUE
C
C        READ TECHNICAL COEFFICIENTS FOR ASS.STUDENTS.
C
  120 READ(N1,55)I,C,L,S,(TEMP(J),J=1,D)
      IF(I.EQ.9)GO TO 130
      IF(S.GE.2)S=S+1
      TAB1(C,L,S)=1
      DO 125 D=1,D1
      IF(D-2)126,127,128
  126 ACOEF(C,L,D,S)=TEMP(D)
      GO TO 125
  127 ACOEF(C,L,D,S)=0.
  128 ACOEF(C,L,D+1,S)=TEMP(D)
  125 CONTINUE
```

```
      GO TO 120
130   IF(SWITCHIGU TO 190
      DO 140 C=1,CN
      DO 140 L=1,2
      WRITE(6,141)(CAMNAM(J,C),J=3,20),L
141   FORMAT('1CAMPUS=',18A1,20X,'ASS. DEGREE COEFFICIENTS',10X,'LEVEL='
     *,I2)
      WRITE(6,88)(COLNAM(S,1),S=1,SN)
      DO 145 D=1,DN
145   WRITE(6,66)(COLNAM(D,J),J=1,2),(ACOEF(C,L,D,S),S=1,S
140   CONTINUE
      DO 150 L=1,2
      WRITE(6,155)BYEAR,L
155   FORMAT('1SWITCH DEGREE MATRIX ASS. TO BAC.',5X,'YEAR=',I4,5X,
     *'LEVEL=',I2)
      WRITE(6,88)(COLNAM(S,1),S=1,SN)
      DO 160 C=1,CN
160   WRITE(6,89)(CAMNAM(J,C),J=3,20),(SACOEF(C,L,S),S=1,SN)
150   CONTINUE
      DO 170 L=1,2
      WRITE(6,175)BYEAR,L
175   FORMAT('1TRANSFER MATRIX ASS. STUDENTS',10X,'YEAR=',I4,10X,
     *'LEVEL=',I2)
      WRITE(6,88)(COLNAM(S,1),S=1,SN)
      DO 180 C=1,CN
180   WRITE(6,89)(CAMNAM(J,C),J=3,20),(TTCOEF(C,L,S),S=1,SN)
170   CONTINUE
190   CONTINUE
C
C****************************************************************************
C                                START ITERATION PROCESS
C
COMMENT: VARIABLE YN IS THE BASE YEAR PLUS THE NUMBER OF YEARS
C               TO BE PREDICTED.
C
      YN=YN+1
      DO 1000 Y=1,YN
      KK=MOD(Y,2)+1
      NN=1
      IF(KK.EQ.1)NN=2
      IF(Y.EQ.2)N3=10
C       REINITIALIZE VARIABLES
      DO 810 I=1,1920
810   NS1(I)=0
      DO 850 S=1,SN
      DO 850 L=1,4
      TR(L,S)=0.
      SDA(L,S)=0.
      IF(L.GT.2)GO TO 850
      TRI(L,S)=0.
      TRI(2,S)=0.
      SDB(L,S)=0.
850   CONTINUE
C
COMMENT: READ NEW STUDENTS FROM THE ADMISSIONS MODEL.
C
851   READ(N3,860)I,C,L,S,II,JJ
860   FORMAT(4I2,2X,2I5)
      IF(I.EQ.9)GO TO 999
      NS(C,L,S,1)=II
```

```
      NS(C,L,S,2)=JJ
      GO TO 851
999   CONTINUE
      IF(Y.NE.2.OR.N3.NE.10)GO TO 4000
      N3=5
      GO TO 851
4000  N3=10
C**************************************************************************
C
C                      BACCULARATE SECTION
C
C**************************************************************************
      DO 300 L=1,LN
      DO 400 C=1,CN
      DO 200 S=1,SN
C     ENROLLMENT IS EQUAL TO NEW STUDENTS,PLUS ADVANCING STUDENTS,
C             PLUS RETURNING STUDENTS. PLUS TRANSFER STUDENTS.PLUS SWITC
C             STUDENTS
      IF(Y.NE.1)INPUT(C,L,S,1)=NS(C,L,S,1)+ADV(C,L,S,KK)+RET(C,L,S,KK)+
     *TRAN(C,L,S,KK)+SWDB(C,L,S,KK)+.5
      IF(Y.LE.2.OR.L.EQ.1)INPUT(C,L,S,1)=NS(C,L,S,1)
      IF(TAB(C,L,S).EQ.0.AND.INPUT(C,L,S,1).NE.0)WRITE(5,198)C,L,S
     *,NS(C,L,S,1),ADV(C,L,S,KK),RET(C,L,S,KK),TRAN(C,L,S,KK),
     *SWDB(C,L,S,KK)
198   FORMAT('0MISSING BAC. COEFFICIENT MATRIX:',5X,'C=',I2,3X,'L=',
     *I2,3X,'S=',I2,/,I15,' NS=',I5,3X,'ADV=',F6.2,3X,'RET=',F6.2,
     *3X,'TR=',F6.2,3X,'SWDB=',F6.2)
      IF(C.EQ.18)WRITE(6,853)(COLNAM(S,J),J=1,2),L,NS(C,L,S,1),ADV(C,L,
     *S,KK),RET(C,L,S,KK),TRAN(C,L,S,KK),SWDB(C,L,S,KK)
853   FORMAT(' 0B',3X,2A8,'LEVEL=',I2,3X,'NS=',I5,3X,'ADV=',F6.2,3X,
     *'RET=',F6.2,3X,'TRAN=',F6.2,3X,'SD=',F6.2)
C
C        COMPUTE ADVANCING STUDENTS, RETURNING STUDENTS, TRANSFER STUDEN
C             AND SWITCH DEGREE STUDENTS FOR THE FOLLOWING YEAR.
C
      DO 100 D=1,DN
100   END(D,S)=COFF(C,L,D,S)*INPUT(C,L,S,1)
C
C        CALCULATE INPUT FOR TRANSFER & SWITCH DEGREE COEFFICIENTS.
C
      LL=L+1
      IF(LL.LE.LN)TR(LL,S)=TR(LL,S)+END(T,S)*COFF(C,L,A,S)
      TR(L,S)=TR(L,S)+END(T,S)*COFF(C,L,R,S)
      SDA(L,S)=SDA(L,S)+END(SD,S)
200   CONTINUE
C
C        VARIABLE 'SUM' IS THE NUMBER OF STUDENTS WHO WILL BE IN
C             COLLEGE "S" NEXT YEAR.
C
      DO 300 D=1,SN
      SUM=0.
      DO 350 S=1,SN
350   SUM=SUM+END(D,S)
      IF(LL.LE.LN)ADV(C,LL,D,NN)=SUM*COFF(C,L,A,D)
      RET(C,L,D,NN)=SUM*COFF(C,L,R,D)
300   CONTINUE
400   CONTINUE
      IF(L.NE.3)GO TO 825
C
C**************************************************************************
```

```
C
C
C                         ASSOCIATE DEGREE SECTION
C
      DO 800 C=1,CN
      DO 650 S=1,SN
      IF(Y.NE.1)INPUT(C,L,S,2)=NS(C,L,S,2)+ADVI(C,L,S,KK)+RETI(C,L,S,KK)
     *+TRANI(C,L,S,KK)+SWDA(C,L,S,KK)+.5
      IF(Y.LE.2.OR.L.EQ.1)INPUT(C,L,S,2)=NS(C,L,S,2)
      IF(TABI(C,L,S).EQ.0.AND.INPUT(C,L,S,2).NE.0)WRITE(6,199)C,L,S,
     *NS(C,L,S,2),ADVI(C,L,S,KK),RETI(C,L,S,KK),TRANI(C,L,S,KK),
     *SWDA(C,L,S,KK)
  199 FORMAT('0MISSING ASS. COEFFICIENT MATRIX:',5X,'C=',I2,3X,'L=',
     *I2,3X,'S=',I2,/,T15,' NS=',I5,3X,'ADV=',F6.2,3X,'RET=',F6.2,
     *3X,'TR=',F6.2,3X,'SWDA=',F6.2)
C*******************************************************************
C
C        COMPUTE ADVANCING STUDENTS, RETURNING STUDENTS, TRANSFER STUDEN
C              AND SWITCH DEGREE STUDENTS FOR THE FOLLOWING YEAR.
C
      DO 600 D=1,DN
  600 END(D,S)=ACOEF(C,L,D,S)*INPUT(C,L,S,2)
      TRI(2,S)=TRI(2,S)+END(T,S)*ACOEF(C,L,A,S)
      TRI(L,S)=TRI(L,S)+END(T,S)*ACOEF(C,L,R,S)
      SOB(L,S)=SOB(L,S)+END(SO,S)
  650 CONTINUE
C
C        VARIABLE 'SUM' IS THE NUMBER OF STUDENTS WHO WILL BE IN
C              COLLEGE "S" NEXT YEAR.
C
      DO 700 D=1,SN
      SUM=0.
      DO 750 S=1,SN
  750 SUM=SUM+END(D,S)
      IF(L.NE.2)ADVI(C,2,D,NN)=SUM*ACOEF(C,L,A,D)
      RETI(C,L,D,NN)=SUM*ACOEF(C,L,R,D)
  700 CONTINUE
  800 CONTINUE
  825 CONTINUE
C*******************************************************************
C
  500 CONTINUE
C
COMMENT: CALCULATE AND DISTRIBUTE TRANSFER AND SWITCH DEGREE STUDENTS
C              FOR THE NEXT YEAR.
C
      DO 830 L=1,4
      DO 830 S=1,SN
      DO 830 C=1,CN
      TRANI(L,L,S,NN)=TR(L,S)*TCOEF(L,L,S)
      SWDB(C,L,S,NN)=0.
      IF(L.GT.2)GO TO 830
      SWDB(C,L,S,NN)=SOB(L,S)*SACOEF(C,L,S)
      IF(L.EQ.1)SWDA(C,L,S,NN)=SDA(1,S)*SBCOEF(C,1,S)
      IF(L.EQ.2)SWDA(C,L,S,NN)=SDA(2,S)*SBCOEF(C,2,S)+SDA(3,S)*SBCOEF(C,
     *3,S)
      TRANI(C,L,S,NN)=TRI(L,S)*TICOEF(C,L,S)
  830 CONTINUE
C
      DO 6000 S=1,12
```

```
      WRITE(6,6500)(COLNAM(S,J),J=1,2),(TR(L,S),L=1,4)
6500  FORMAT(' ',2A8,4X,4(F10.2,3X))
6000  CONTINUE
C        CAMPUS OUTPUT SECTION.
      IY=Y+BYEAR-1
      DO 915 C=1,CN
      WRITE(6,900)(CAMNAM(J,C),J=3,20),IY
900   FORMAT('1THE PENNSYLVANIA STATE UNIVERSITY',T55,'ENROLLMENT MODEL'
     *,T90,'CAMPUS:',3X,18A1,T120,'YEAR:',3X,I4)
      DO 915 L=1,3,2
      L1=L+1
      WRITE(6,930)L,L1
930   FORMAT(/,'0',8X,'LEVEL=',I2,T25,'BACCALAUREATE',5X,'ASSOCIATE',
     *23X,'LEVEL=',I2,7X,'BACCALAUREATE',5X,'ASSOCIATE')
      B1SUM=0
      A1SUM=0
      B2SUM=0
      A2SUM=0
      DO 920 S=1,SN
      B1SUM=B1SUM+INPUT(C,L,S,1)
      A1SUM=A1SUM+INPUT(C,L,S,2)
      B2SUM=B2SUM+INPUT(C,L1,S,1)
      A2SUM=A2SUM+INPUT(C,L1,S,2)
      WRITE(6,925)(COLNAM(S,J),J=1,2),(INPUT(C,L,S,D),D=1,2),
     *(COLNAM(S,J),J=1,2),(INPUT(C,L1,S,D),D=1,2)
925   FORMAT(' ',2A8,10X,I5,10X,I5,20X,2A8,10X,I5,10X,I5)
920   CONTINUE
      WRITE(6,923)B1SUM,A1SUM,B2SUM,A2SUM
923   FORMAT('0CAMPUS TOTAL',T27,I5,10X,I5,20X,'CAMPUS TOTAL',14X,I5,
     *10X,I5)
915   CONTINUE
      DO 950 C=1,CN
      DO 949 S=1,SN
      WRITE(15,889)C,S,Y,(INPUT(C,L,S,2),L=1,2),(INPUT(C,L,S,1),L=1,4)
889   FORMAT('00',3I2,2X,6I10,10('0'))
949   CONTINUE
      DO 955 S=13,15
955   WRITE(15,965)
      DO 945 K=1,6
945   JSUM(K)=0
      DO 940 S=1,SN
      JSUM(1)=JSUM(1)+INPUT(C,1,S,2)
      JSUM(2)=JSUM(2)+INPUT(C,2,S,2)
      JSUM(3)=JSUM(3)+INPUT(C,1,S,1)
      JSUM(4)=JSUM(4)+INPUT(C,2,S,1)
      JSUM(5)=JSUM(5)+INPUT(C,3,S,1)
      JSUM(6)=JSUM(6)+INPUT(C,4,S,1)
940   CONTINUE
      ISUM=JSUM(1)+JSUM(2)+JSUM(3)+JSUM(4)+JSUM(5)+JSUM(6)
      WRITE(15,891)JSUM,ISUM
891   FORMAT('0100000000',7I10)
950   CONTINUE
      DO 970 C=21,22
      DO 970 S=1,16
      WRITE(15,965)
965   FORMAT(80('0'))
970   CONTINUE
1000  CONTINUE
      STOP
      END
```

```
/*      THIS IS A SLASH ASTERISK CARD                                    4800                           PAGE    9
//DATA.FT15F001 DD UNIT=(2400,,DEFER),VOL=SER=BMI15,DSN=BMI15,                                           UT3H=42
//    DISP=(NEW,KEEP),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200)
//DATA.FT10F001 DD UNIT=(2400,,DEFER),VOL=SER=BMI19,DSN=BMI19,
//        DISP=(OLD,KEEP),DCB=(RECFM=FB,LRECL=20,BLKSIZE=3200)
//DATA.INPUT DD *                                                        4850
```

C: DISAG-1 MODULE

In addition to the tape output from ITER-1, the user must provide the following card input:

1: Campus Cards: One card per campus. The first twenty campuses are in campus abbreviation order as specified for ITER-1. King of Prussia and Hershey are 21 and 22 respectively.

Columns 1- 2: Campus code.

Columns 3-18: Campus name.

2: College Cards: One card per college or category of enrollment. The number of departments within each college is right justified in Columns 1-2. The college name follows beginning in Column 3 with the order of colleges as shown below.

Agriculture
Arts and Architecture
Business Administration
Education
Engineering
Health and Physical Education
Human Development
Liberal Arts
Earth and Mineral Sciences
Science
Inter-College
Capitol
Medicine
Non-Degree

3: Department Cards: The department names and associated budget and HEGIS discipline-division code of the first college, followed by the names of the second etc. One card per department is left justified.

Columns 3-18: Department name.

Columns 19-26: Budget-code.

Columns 27-34: HEGIS code.

4: Organization Matrix Cards: One card per department showing the fraction of each college's enrollment, degree-level, and student-level at a campus represented by the department.

Columns 1- 2: Campus number, right justified.

Columns 11-12: College code.

Columns 14-15: Department number, right justified.

Columns 21-25: Fraction of first year associate with decimal point at 22.

Columns 26-30: Fraction of second year associate with decimal point at 27.

Columns 31-35: Fraction of first year baccalaureate with decimal point of 32.

Columns 36-40: Fraction of second year baccalaureate with decimal point at 37.

Columns 41-45: Fraction of third year baccalaureate with decimal point at 42.

Columns 46-50: Fraction of fourth year baccalaureate with decimal point at 47.

Columns 51-55: Graduate with decimal point at 52.

20X,7F5.0

5: Campus Graduate Regression Equations: These project the number of graduate students at each campus and are prepared using library program POLY-2. One card per campus.

6: College Graduate Regression Equations: One card per college at each campus having graduate enrollment with the campus number in Columns 1-2 and the college number in Columns 3-4, where the number represents the order in which the campus and college cards are entered.

7: Year Card: One card for each year of enrollment.

Columns 1- 5: Planned level of graduate enrollment right justified.

Columns 6-10: Number of campuses with graduate enrollment constraints right justified.

Column 15: Index for type of output desired.

1 = output by campus
2 = output by campus and college
3 = output by campus, college, and department

8: Graduate Constraint Cards: The number of cards will be the number specified in Columns 6-10 of the Year Card.

Columns 1- 5: Campus number right justified.

Columns 6-10: Minimun constraint.

Columns 11-15: Maximum constraint. (Note maximun constraint must be denoted as 99999).

In addition to the printed output of enrollment by year, campus, degree-level, student-level, college, and department, a tape output is generated for use into CONSUM-1 of the IA-1 model.

FIGURE C-1: MACRO FLOW CHART OF THE DISAG-1 MODULE

(001)

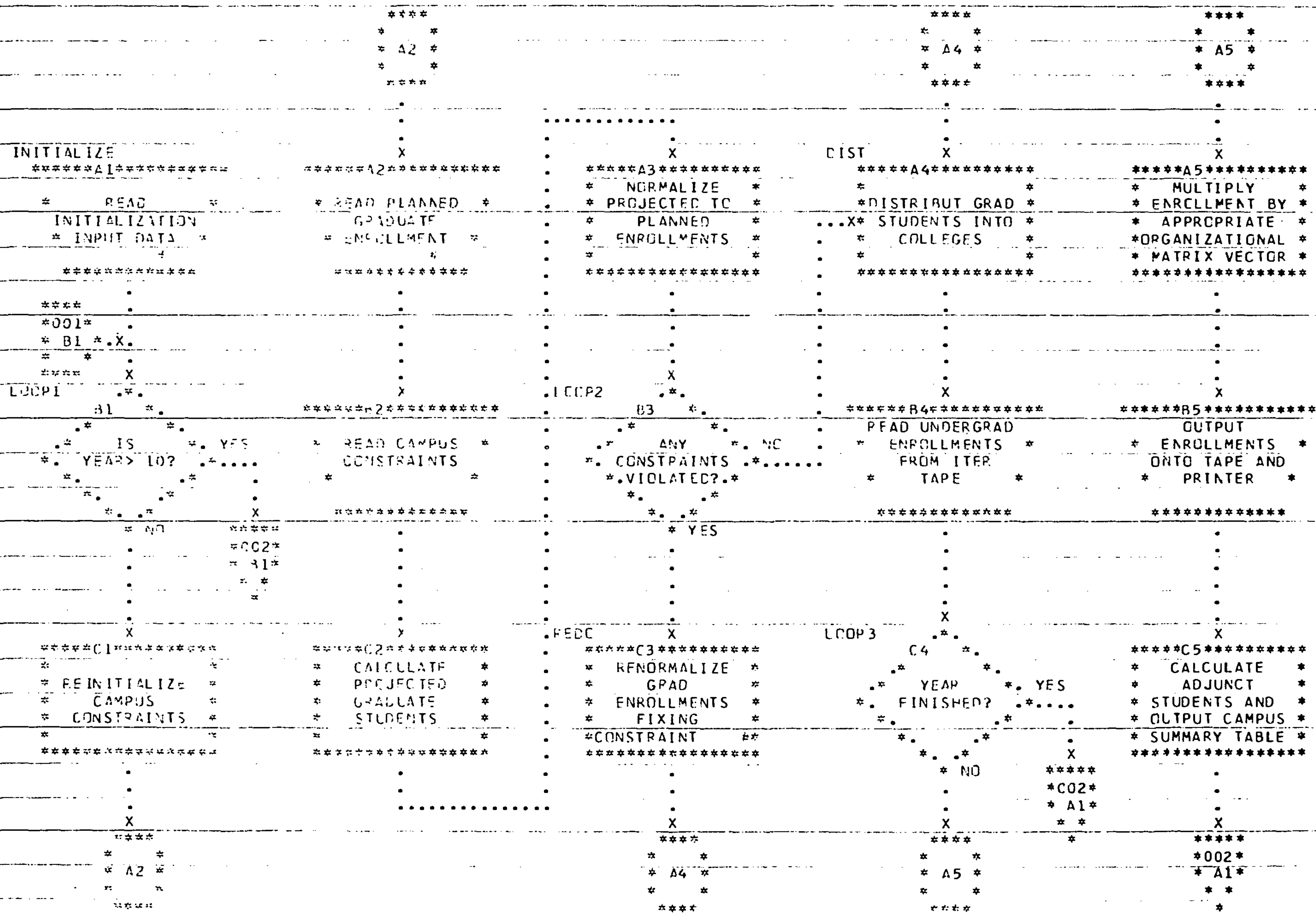


FIGURE C-1: MACRO FLOW CHART OF THE DISAG-1 MODULE (continued)

(002)

```
           *****
           *002*
          * A1*
            * *
             *
             .
             .
             .
 INCREMENT   X
     *****A1**********
     *               *
     *INCREMENT YEAR *
     *     BY ONE    *
     *               *
     *               *
     *****************
             .
             .  ****
             .  *001*
             ..X* B1 *
                *   *
                ****
 STOP

      ****B1*********
     *              *
     * JOB FINISHED *
     *              *
      ***************
```

A1. INCLUDING CAMPUS NAMES, NUMBER, DEPARTMENTS AND COLLEGE NAMES, DEPARTMENT NAMES, THE ORGANIZATION MATRIX, CAMPUS GRADUATE REGRESSION EQUATIONS, AND COLLEGE GRADUATE REGRESSION EQUATIONS. ALSO SET YEAR=1.

A2. AND NUMBER OF CAMPUSES WITH ENROLLMENT CONSTRAINTS AND TYPE OF OUTPUT DESIRED FOR THIS YEAR.

C3. VIOLATIONS.

```
// EXEC FHCG
//SOURCE.INPUT DD *
C     FIFTH 11/20/72 -- FIFT * VERSION 2.12 *
      REAL*8 DEP1(15,21,4),COLL(15,2),CAMNAM(22,2)
      LOGICAL*4 SWITCH,ON,TAPE,PRINT
      REAL*4 DIST(15),ADJ(22),COEF(22,7,15,21),GE(22),A(22),B(22),BC(22,
     115),NC(22,15),SUM1(7)
      INTEGER*4 MINIAL(9)
      INTEGER*4 OUTPUT,YEAR,INPUT(7),KOW(7),KSUM(7),MAX(22),MIN(22),C,S,
     1Y,Y2,CN,ADJNUM,NDEP1(15)
C
C*****************************************************************
C
COMMENT:          INSTRUCTIONS FOR THE YEAR CARD.
C
C
C              1. PUT PLANNED LEVEL GRADUATE ENROLLMENT RIGHT JUSTIFIED
C                 IN COL. (1-5).
C              2. PUT NUMBER OF CAMPUSES WITH GRADUATE ENROLLMENT
C                 CONSTRAINTS RIGHT JUSTIFIED IN COL. (6-10).
C              3. PUT IN COL. 15 THE INDEX FOR TYPE OUTPUT DESIRED.
C                 A. INDEX=1 FOR OUTPUT BY CAMPUS.
C                 B. INDEX=2 FOR OUTPUT BY CAMPUS AND COLLEGE.
C                 C. INDEX=3 FOR OUTPUT BY CAMPUS, COLLEGE, AND DEPARTMENT
C
C
C*****************************************************************
      OUTPUT=3
      SWITCH=.TRUE.
      ON=.TRUE.
      ON=.FALSE.
      TAPE=.FALSE.
      TAPE=.TRUE.
      PRINT=.FALSE.
      PRINT=.TRUE.
      ADJ(13)=0.40
      ADJ(1)=0.15
      ADJ(14)=0.15
      ADJ(9)=0.40
      Y=10
      CN=22
      IC=0
C
COMMENT: READ IN THE CAMPUS NAMES.
C
      READ (5,100) ((CAMNAM(I,J),J=1,2),I=1,CN)
  100 FORMAT (2X,2A8)
      IF (ON) WRITE (6,102)
  102 FORMAT ('1')
C
COMMENT: READ IN THE NUMBER OF DEPARTMENTS FOR EACH COLLEGE.
C
      DO 106  I=1,15
      READ (5,104) NDEP1(I),(COLL(I,J),J=1,2)
  104 FORMAT (I2,2A8)
  106 CONTINUE
C
COMMENT: READ IN THE NAMES OF THE DEPARTMENTS FOR EACH COLLEGE.
C
      DO 112  I=1,15
```

```
      M1=NDEPT(I)
      IF (DM) WRITE (6,108) (COLL(I,J),J=1,2),NDEPT(I)
  108 FORMAT ('0COLLEGE=',2A4,5X,'NUMBER OF DEPARTMENTS=',I2)
      IF (M1.EQ.0) GO TO 112
      DO 110  K=1,M1
      READ (5,136) (DEPT(I,K,J),J=1,4)
      IF (DM) WRITE (6,138) K,(DEPT(I,K,J),J=1,4)
  110 CONTINUE
  112 CONTINUE
C
COMMENT: READ IN THE DISTRIBUTION VECTOR FOR EACH COLLEGE.
C
      DO 134  C=1,6
      DO 134  S=1,15
      IF (DM) WRITE (6,114) (CAMNAM(C,J),J=1,2),(COLL(S,J),J=1,2),NDEPT(
     1S)
  114 FORMAT ('1','CAMPUS=',2A4,15X,'COLLEGE=',2A4,15X,'NUMBER OF DEPART
     1MENTS=',I5)
      IF (DM) WRITE (6,212)
      JN=NDEPT(S)
      DO 116  L=1,7
  116 SUM1(L)=0.0
      DO 124  J=1,JN
      READ (5,118) (COEF(C,L,S,J),L=1,7)
  118 FORMAT (25X,7F5.0)
      IF (DM) WRITE (6,120) (DEPT(S,J,K),K=1,4),(COEF(C,L,S,J),L=1,7)
  120 FORMAT (' ',5X,4A4,15X,7F10.3)
      DO 122  L=1,7
  122 SUM1(L)=SUM1(L)+COEF(C,L,S,J)
  124 CONTINUE
      DO 132  L=1,7
      IF (SUM1(L)-1.0) 126,132,126
  126 IF (SUM1(L)-0.0) 128,132,128
  128 CONTINUE
      IF (DM) WRITE (6,130) L,SUM1(L)
  130 FORMAT ('0ERROR: ',5X,'L=',I2,5X,'SUM=',F8.4)
  132 CONTINUE
  134 CONTINUE
  136 FORMAT (2X,4A4)
  138 FORMAT (' ',I2,5X,4A4)
      IF (SWITCH) WRITE (6,102)
C
COMMENT: READ AND PRINT GRADUATE CAMPUS REGRESSION LINES.
C
      DO 144  C=1,6
      READ (5,140) M(C),B(C)
  140 FORMAT (10X,2F10.0)
      IF (SWITCH) WRITE (6,142) C,(CAMNAM(C,J),J=1,2),M(C),B(C)
  142 FORMAT (' ',I2,5X,'CAMPUS REGRESSION EQUATION:',5X,2A4,5X,'Y=',F1
     14.4,' * X',' + ',F10.4)
  144 CONTINUE
C
COMMENT: READ COLLEGE REGRESSION LINES FOR EACH CAMPUS.
C
      DO 146  C=1,6
      DO 146  S=1,15
      MC(C,S)=0.0
      BC(C,S)=0.0
  146 CONTINUE
  148 READ (5,150) C,S,XX,YY
```

```
  150 FORMAT (2I2,6X,2F10.0)
      IF (C.EQ.0) GO TO 152
      BC(C,S)=XX
      MC(C,S)=YY
      GO TO 148
  152 CONTINUE
C*************************************************************************
C
C
C
COMMENT: START OF ITERATION PHASE.
C
C
C
C*************************************************************************
      DO 233  Y=1,YN
      DO 154  M=1,9
  154 QTOTAL(M)=0
      DIFF=0.0
      ITER=1
      IY=1970+Y
      YEAR=Y+6
      WRITE (9,155) IY
  155 FORMAT (1H1,'PENNSYLVANIA STATE UNIVERSITY',I55,'STUDENT FLOW MOD
     1EL ',I90,'CAMPUS TOTALS',I6X,I4,//,'0')
      WRITE (9,212)
      IF (Y.LE.2) GO TO 192
C*************************************************************************
C
COMMENT: GRADUATE ENROLLMENT PHASE.
C
C*************************************************************************
      IF (SW(IC-)) WRITE (6,155) IY
  155 FORMAT ('1',T30,'PENNSYLVANIA STATE UNIVERSITY ENROLLMENT PROJECTIO
     1NS FOR ',I4)
C
COMMENT: RE-INITIALIZE CAMPUS CONSTRAINTS EVERY YEAR.
C
      DO 160  C=1,CN
      MIN(C)=0
  160 MAX(C)=0
C
COMMENT: READ PLANNED LEVEL GRADUATE ENROLLMENT AND NUMBER CAMPUSES
C             WITH ENROLLMENT CONSTRAINTS AND TYPE OUTPUT DESIRED FOR
C
COMMENT: READ "YEAR" CARD.
C
      READ (5,162) IPGE,ICOM,OUTPUT
  162 FORMAT (10I5)
      IF (ICOM.EQ.0) GO TO 155
C
COMMENT: READ CAMPUS CONSTRAINTS FOR YEAR "Y".
C
      DO 166  I=1,ICOM
      READ (5,164) C,J,K
  164 FORMAT (3I5)
      MIN(C)=J
  166 MAX(C)=K
  168 CONTINUE
C
```

```
COMMENT: CALCULATE PROJECTED ENROLLMENT FROM REGRESSION EQUATIONS.
C
      SUM=0.0
      IF (SWITCH) WRITE (6,170)
  170 FORMAT ('0',T30,'UNNORMALIZED PROJECTED GRADUATE VALUES')
      DO 172  C=1,CN
      GE(C)=M(C)*YEAR+B(C)
      IF (SWITCH) WRITE (6,180) C,(CANNAM(C,J),J=1,2),MIN(C),MAX(C),GE(C)
     1)
  172 SUM=SUM+GE(C)
C
COMMENT: NORMALIZE PROJECTED ADMISSIONS TO PLANNED LEVEL OF ADMISSIONS.
C
      DO 174  C=1,CN
      GE(C)=GE(C)*(IPGE/SUM)
  174 CONTINUE
C
COMMENT: RENORMALIZE IF ANY ENROLLMENT CONSTRAINTS ARE VIOLATED.
C
      SUM=IPGE
  176 CONTINUE
      DIFF=0.0
      IF (SWITCH) WRITE (6,178) ITER,DIFF,IPGE
  178 FORMAT ('1ITERATION=',I3,T40,'DIFF=',F10.0,T75,'PLANNED GRADUATE ENR
     1ROLLMENT=',I5)
      DO 188  C=1,CN
      IF (SWITCH) WRITE (6,180) C,(CANNAM(C,J),J=1,2),MIN(C),MAX(C),GE(C
     1)
  180 FORMAT (' ',I2,5X,2A8,5X,'MIN GRADE=',I10,5X,'MAX GRADE=',I10,5X,'
     1 PROJECTED ENROLLMENT=',F10.0)
      IF (GE(C).LE.MAX(C)) GO TO 184
      DIFF=DIFF+GE(C)-MAX(C)
      IF (SWITCH) WRITE (6,182) (CANNAM(C,J),J=1,2),MAX(C),GE(C)
  182 FORMAT ('0',2A8,3X,'MAXIMUM CONSTRAINT VIOLATED=',I10,5X,'PROJECTE
     1D ENROLLMENT=',F10.0)
      SUM=SUM-GE(C)
      GE(C)=MAX(C)
      GO TO 188
  184 IF (GE(C).GE.MIN(C)) GO TO 188
      DIFF=DIFF+GE(C)-MIN(C)
      IF (SWITCH) WRITE (6,186) (CANNAM(C,J),J=1,2),MIN(C),GE(C)
  186 FORMAT ('0',2A8,3X,'MINIMUM CONSTRAINT VIOLATED=',I10,5X,'PROJECTE
     1D ENROLLMENT=',F10.0)
      SUM=SUM-GE(C)
      GE(C)=MIN(C)
  188 CONTINUE
      DO 190  C=1,CN
      IF (DIFF.GT.0. .AND.GE(C).NE.MAX(C)) GE(C)=GE(C)+DIFF*(GE(C)/SUM)
      IF (DIFF.LT.0. .AND.GE(C).NE.MIN(C)) GE(C)=GE(C)+DIFF*(GE(C)/SUM)
  190 CONTINUE
      ITER=ITER+1
      IF (DIFF.NE.0) GO TO 176
C*********************************************************************
C
COMMENT: OUTPUT PHASE REQUIREMENTS.
C
C*********************************************************************
  192 CONTINUE
      DO 234  C=1,CN
C
```

```
COMMENT: DISTRIBUTE GRADUATE STUDENTS INTO THE COLLEGES AT CAMPUS NCR.
C
      DO 194  I=1,15
  194 DIST(I)=0.0
      IF (Y.GT.2) GO TO 198
      READ (5,196) GF(C),ADJUNI,DIST
  196 FORMAT (10X,F10.0,I10,10F5.0/,10F5.0)
      GO TO 204
  198 CONTINUE
      ISUM=0
      DO 200  I=1,15
      DIST(I)=AL(C,I)*YEAR+BC(C,I)
  200 ISUM=ISUM+DIST(I)
      DO 202  I=1,15
      IF (ISUM. [illegible]) DIST(I)=(DIST(I)/ISUM)*GF(C)
  202 CONTINUE
  204 CONTINUE
C
COMMENT: PRINT PAGE HEADINGS.
C
      IF (PRINT) WRITE (6,206) (CAMPUS(C,J),J=1,2),IY
  206 FORMAT ('1THE PENNSYLVANIA STATE UNIVERSITY',14X,'STUDENT FLOW
     1FC',T40,2A8,10X,I4)
      LINE=1
C
      DO 224  K=1,15
      S=K
      READ (15,208,END=240) INPUT
  208 FORMAT (10X,7I10)
      IF (C.EQ.6.AND.S.EQ.13) GO TO 224
      IF (C.EQ.8.AND.S.EQ.11) S=15
      UI=UEPT(S)
      IF ((LINE+[illegible](172)).LT.55) GO TO 210
C
COMMENT: PRINT PAGE HEADINGS.
C
      IF (PRINT) WRITE (6,206) (CAMPUS(C,J),J=1,2),IY
      LINE=1
C
  210 CONTINUE
      INPUT(7)=DIST(S)+0.5
      JSUM=INPUT(1)+INPUT(2)+INPUT(3)+INPUT(4)+INPUT(5)+INPUT(6)+INPUT(7
     1)
      IF (JSUM.EQ.0) GO TO 224
      IF (PRINT) WRITE (6,212)
  212 FORMAT (///,T9,'147,'ASSOC 1',T5,'ASSOC 2',T45,'BACC 1',T77,'BACC 2
     1',T87,'BACC 3',T97,'BACC 4',T107,'GRAD ',T117,'ADJ',T126,'TOTAL')
      IF (PRINT) WRITE (6,214) (CELL(S,J),J=1,2),(INPUT(I),I=1,7),JSUM
  214 FORMAT ('0',2A8,15X,'TOTAL ',7I10,10X,I10/,'+',130('_'))
      J7FRQ=0
      IF (TAPE) WRITE (14,216) Y,C,S,INPUT,J7FRQ
  216 FORMAT (3I2,4X,8I5)
      LINE=LINE+6
      IF (OUTPUT.LT.4.OR.C.EQ.1) GO TO 224
      DO 222  II=1,4
      DO 218  I=1,7
      ROW(I)=0
      IF (COEF(C,I,S,II).NE.0.0) ROW(I)=INPUT(I)*COEF(C,I,S,II)+0.5
  218 CONTINUE
      IF (ROW(1).EQ.0.AND.ROW(2).EQ.0.AND.ROW(3).EQ.0.AND.ROW(4).EQ.0.A
```

```
      1O.ROW(5).EQ.0.AND.ROW(6).EQ.0.AND.ROW(7).EQ.0) GO TO 222
      JSUM=ROW(1)+ROW(2)+ROW(3)+ROW(4)+ROW(5)+ROW(6)+ROW(7)
      IF (PRINT) WRITE (6,220) (DEPT(S,I,KK),KK=1,4),(ROW(I),I=1,7),JSUM
  220 FORMAT ('0',5X,4A8,/I10,10X,I10)
      LINE=LINE+1
  222 CONTINUE
  224 CONTINUE
      READ (15,208,END=240) INPUT
      ENROLL=INPUT(7)
      INPUT(7)=GE(C)
      IF (C.EQ.1.OR.C.EQ.5.OR.C.EQ.13.OR.C.EQ.14) GO TO 226
COMMENT: DETERMINE PERCENTAGE VALUE TO CALCULATE ADJUNCT ENROLLMENT.
      IF (ENROLL.LE.100) ADJ(C)=0.40
      IF (ENROLL.GT.100.AND.ENROLL.LE.300) ADJ(C)=0.20
      IF (ENROLL.GT.300.AND.ENROLL.LE.500) ADJ(C)=0.10
      IF (ENROLL.GT.500.AND.ENROLL.LE.700) ADJ(C)=0.05
      IF (ENROLL.GT.700.AND.ENROLL.LE.1000) ADJ(C)=0.04
      IF (ENROLL.GT.1000.AND.ENROLL.LE.2000) ADJ(C)=0.03
      IF (ENROLL.GT.2000) ADJ(C)=0.02
  226 CONTINUE
COMMENT: CALCULATE ADJUNCT ENROLLMENT.
      IF (Y.GT.2) ADJUNT=ENROLL*ADJ(C)
      IF (TAPE) WRITE (14,228) Y,C,ADJUNT
  228 FORMAT (2I2,'15',4X,35('0'),I7)
      JSUM=ENROLL+INPUT(4)+ADJUNT
      IF (PRINT) WRITE (6,212)
      IF (PRINT) WRITE (6,230) (CAMPAS(C,J),J=1,2),INPUT,ADJUNT,JSUM
      WRITE (9,230) (CAMPAS(C,J),J=1,2),INPUT,ADJUNT,JSUM
  230 FORMAT ('0',2A8,'CAMPUS TOTALS:',2X,9I10,/,'+',130('_'))
      DO 232 I=1,7
      WTOTAL(9)=WTOTAL(9)+INPUT(9)
  232 WTOTAL(8)=WTOTAL(8)+INPUT(8)
      WTOTAL(8)=WTOTAL(8)+ADJUNT
      WTOTAL(9)=WTOTAL(9)+ADJUNT
  234 CONTINUE
      WRITE (9,236) WTOTAL
  236 FORMAT (//,' 'PENNSTATE UNIVERSITY GRAND TOTALS:',18X,9I10,/,'+',
     1',130('_'))
  238 CONTINUE
C
C
  240 CONTINUE
      STOP
      END
//DATA.FT15F001 DD DCB=2400,VOL=SER=...,DSN=...,DISP=(OLD,KEEP),
//  DCB=(RECFM=FB,LRECL=80,BLKSIZE=...)
//DATA.FT09F001 DD SYSOUT=A,DCB=(RECFM=FA,LRECL=133,BLKSIZE=3325)
//DATA.FT14F001 DD UNIT=(2400,,DEFER),VOL=SER=...,DSN=...,
//  DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200)
//DATA.INPUT DD *
```