DOCUMENT RESUME

ED 472 658	HE 035 636
AUTHOR	Kutina, Kenneth L.; Zullig, Craig M.; Starkman, Glenn D.; Tanski, Laura E.
TITLE	MUSE--Model for University Strategic Evaluation. AIR 2002 Forum Paper.
PUB DATE	2002-09-00
NOTE	17p.; Paper presented at the Annual Forum for the Association for Institutional Research (42nd, Toronto, Ontario, Canada, June 2-5, 2002).
PUB TYPE	Reports - Descriptive (141) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01/PC01 Plus Postage.
DESCRIPTORS	*Colleges; Evaluation Methods; Higher Education; *Institutional Evaluation; Models; Simulated Environment; *Simulation
IDENTIFIERS	*System Dynamics

ABSTRACT

A model for simulating college and university operations, finances, program investments, and market response in terms of applicants, acceptances, and retention has been developed and implemented using the system dynamics approach. The Model for University Strategic Evaluation (MUSE) is a simulation of the total operations of the university, although its current formulation is oriented to investigating policy and planning questions around the undergraduate educational program. System dynamics is a simulation modeling methodology designed for representing complex, dynamic structures that involve interconnected sequences of causes and effects. The university simulator discussed in this paper is relevant to any higher educational institution. The paper explains the model's structure, mechanics, and data requirements, and demonstrates its application. (Author/SLD)

MUSE – Model for University Strategic Evaluation

Association for Institutional Research
42nd Annual Forum
June 2-5, 2002
Toronto, Canada

By

Kenneth L. Kutina, Ph.D.
Vice President for Institutional Planning
klk2@po.cwru.edu
(216) 368-6908

Craig M. Zullig
Associate, Institutional Planning
cmz@po.cwru.edu
(216) 368-6908

Glenn D. Starkman, Ph.D.
Associate Provost for the Undergraduate Initiative
gds6@po.cwru.edu
(216) 368-4388

Laura E. Tanski
University Director for Budget & Financial Planning
let3@po.cwru.edu
(216) 368-4350

Case Western Reserve University
10900 Euclid Avenue
Cleveland, Ohio 44106

MUSE – Model for University Strategic Evaluation

Abstract

A model for simulating college and university operations, finances, program investments, and market response in terms of applicants, acceptances, and retention has been developed and implemented using the system dynamics approach. System dynamics is a simulation modeling methodology designed for representing complex, dynamic structures that involve interconnected sequences of causes and effects. The university simulator discussed in this paper is relevant to any higher educational institution. The authors explain the model's structure, mechanics, and data requirements, and demonstrate its application.

MUSE – Model for University Strategic Evaluation

Overview

MUSE is a simulation model that incorporates college and university operations, finances, program investments, and market responses in terms of applicants, acceptances, and retention. It is a simulation of the total operations of a university, but its current formulation is oriented to investigating policy and planning questions around the undergraduate educational program, including the marketing impact of program enhancements and changes in tuition, student aid, student-faculty ratio, etc. It has been developed and implemented using the system dynamics methodology. The structure of the simulator is relevant to any higher educational institution.

As the name indicates, ***MUSE*** was created for strategic analyses. In this regard, it is important to emphasize that strategic planning is not forecasting or predicting. Rather, its purpose is to provide the bases for decisions that must be made today to achieve the long-term goals and objectives of the institution. To have optimal impact, the model must simulate as far into the future as today's decisions will have influence ("planning horizon"). Strategic analysis is difficult because many factors must be considered simultaneously. These factors are often interrelated. They frequently form feedback loops that amplify or resist change, while their values change over time. ***MUSE*** is designed to take into account these complex factors and to provide a "non-invasive" means of evaluating the potential impact on the institution as a result of implementing a variety of policy and strategic changes and interventions.

Methodology

The ***MUSE*** simulation utilizes the systems dynamics approach. System Dynamics (Goodman, 1989; Morecroft and Sterman, 1994; Randers, 1980; Wolstenholme, 1990) is a simulation methodology that is based on systems analysis and utilizes fluid dynamics concepts to represent real-world structures. It has been used successfully to simulate entities ranging from biologic organisms, to large industrial complexes, to epidemiological phenomena, as well as a broad range of socio-economic enterprises. It is capable of readily incorporating feedback control loops, time-dependent variables, and parameters for which only intuitive representations are available.

For institutional simulations, a special-purpose software package known as ***ithink*** is available. ***ithink*** was developed by the firm of High Performance Systems for the express purpose of writing and implementing system dynamics simulation models of socio-economic systems (***ithink*** Technical Documentation, 1997). It can be purchased for various platforms from High Performance Systems. The approach uses a standard series of functional elements as the basic building blocks of the simulator.

Exhibit 1 shows a very basic model structure incorporating the fundamental components with which a simulation model is constructed. It is a very simple college enrollment model. Referring to Exhibit 1, a stock is an accumulator in which tangible items with physical meaning such as the number of students, or dollars are collected, or more conceptual measures such as perceived attractiveness of the institution to potential applicants are accumulated. In this simple example, the stock represents number of students. A flow is the pipeline that feeds material into or out of a stock, such as "adding endowment principle," or "consuming endowment principle." In Exhibit 1, the inflow is "enrollees" and the outflow is "graduates." Converters, represented by circles in the diagram, perform mathematical manipulations or serve as data entry portals to change key parameters when investigating various policy or strategic alternates.

The model in Exhibit 1 shows three converters: "desired enrollment," "response rate," and "graduation rate." The "response rate" refers to the number of students admitted each year. It is a graphical relationship in this model (note the small graphical indicator within the circular converter icon). It is controlled by comparing the desired enrollment to the actual enrollment. The wires that connect converters, flows, or stocks represent transfers of signals or information. For example, in Exhibit 1 the wires from the student stock transmit the level of current enrollment information to the flow of graduates and to the response rate which controls the rate at which new students enroll.

To run the model shown in Exhibit 1, the following must be specified: time period (years were selected for this model), the simulation run length (20 years was chosen) and the "DT," which is the frequency at which the model recalculates all variable positions (0.25 year was chosen). The frequency at which the model recalculates affects the "smoothing" that occurs within the output of curvilinear relationships. Exhibit 2 is a graphical display from a simulation run showing the number of students over the twenty-year time frame. For this simulation the stock of students was started at 500, and the desired enrollment was set at 1,000. As can be seen in the graphical output, it took the simulated system about 16 years to reach a final steady state enrollment level of 1,000 students.

ithink is a graphically oriented language. The model is created by literally drawing its structure on a computer screen using the functional elements provided by the language and the structural rules inherent to the software. The software then creates, behind the scenes, the time dependent difference equations necessary to execute the simulations. The system dynamics approach and ***ithink*** software utilize techniques which are particularly useful for incorporating functional relationships, where experts in the field know the general nature of the response curve, but for which precise mathematical representations are not available.

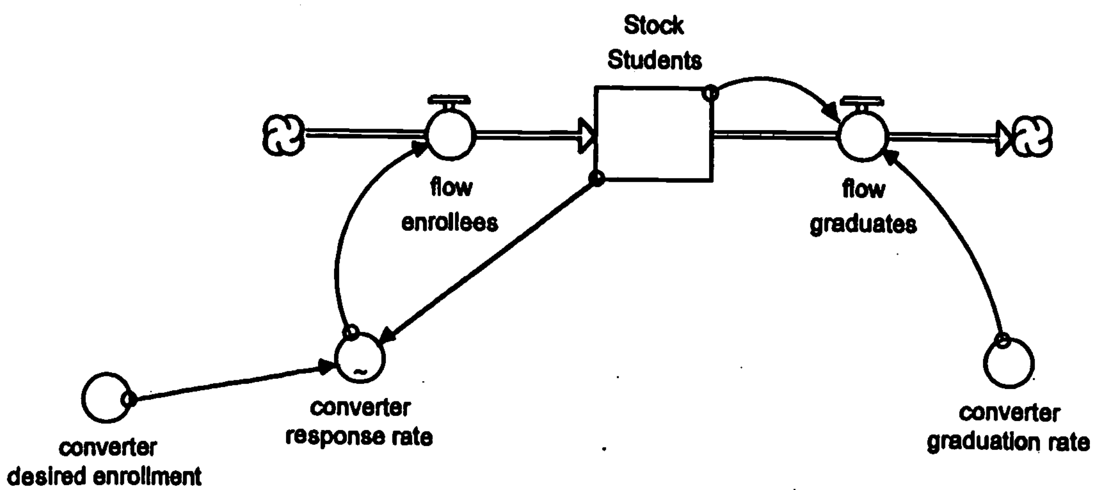


EXHIBIT 1

Simple Enrollment Model Showing
Basic Modeling Components

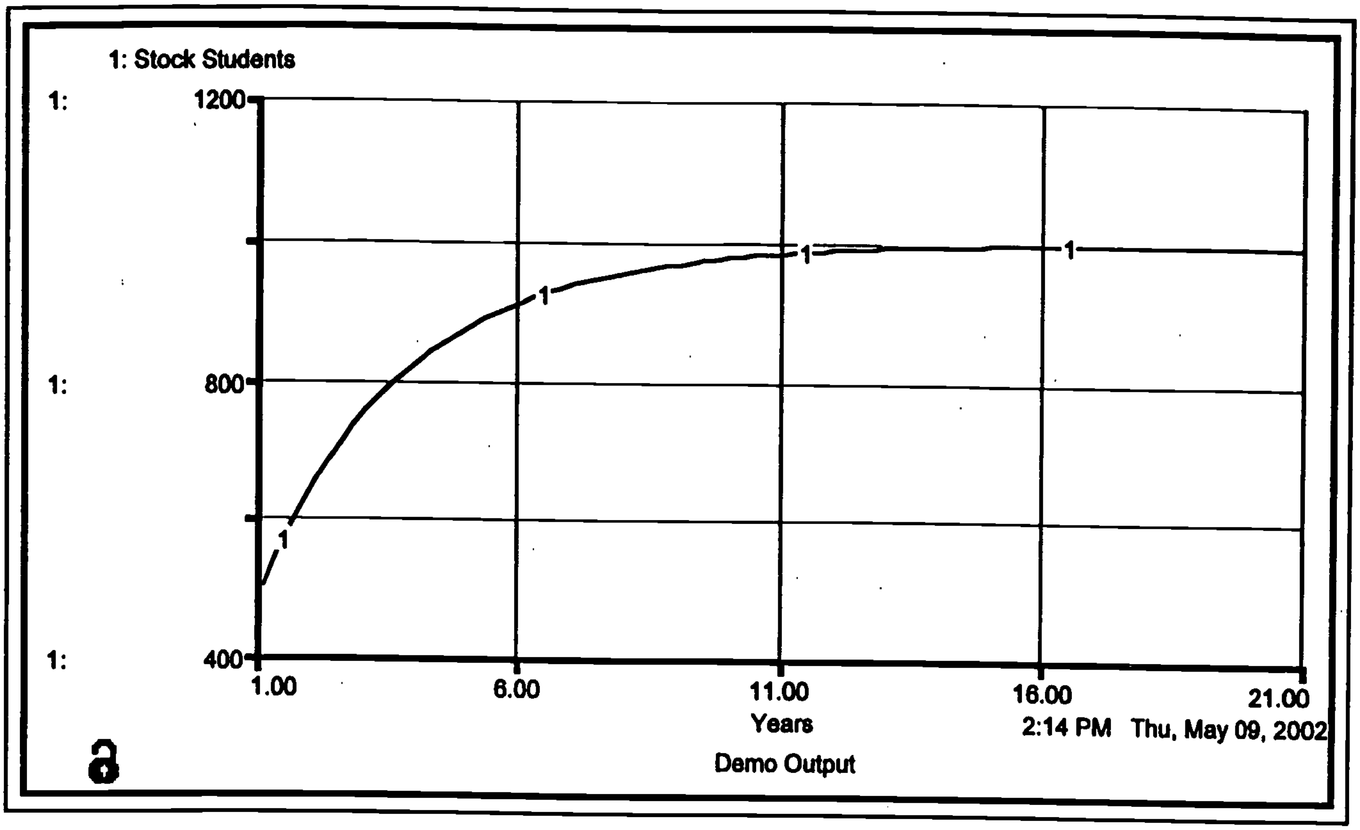


EXHIBIT 2
Output of Simple Enrollment Model

BEST COPY AVAILABLE

Description of MUSE

A causal loop diagram of ***MUSE*** is shown in Exhibit 3. For simplicity, this diagram shows only the major variables and relationships in the model. For example, in the full model there are stocks for freshman, sophomores, juniors, seniors, and fifth year undergraduates. To make it easier to depict in the causal loop diagram, undergraduate enrollment is shown aggregated into a single variable. The arrows in Exhibit 3 show the major ways each variable is impacted by other variables. There are a number of feedback loops in the model which amplify change (positive feedback loop) or resist change (negative feedback loop).

For example, the variable "Reserves," the variable "Interest Earnings," and the variable "Net Income" form a positive feedback loop. As reserves increase, more interest earnings are generated and therefore more net income is created. The reverse is true if reserves are negative. In this case, the model assumes borrowing is necessary and the interest expense reduces net income, thereby further reducing reserves. Positive feedback loops such as this represent a "spiraling" or continuously compounding phenomenon which would simply compound itself indefinitely in a single direction unless controlled by goal-seeking negative feedback loops elsewhere in the simulator, such as is the case in ***MUSE***. A negative feedback loop is formed by the variables "Number of Applicants," "Number of Students," "Class Size" and "Perceived Attractiveness." As applicants increase, enrollment increases. As enrollment increases, class size increases. As class size increases, attractiveness decreases and subsequently the number of applicants declines. This loop seeks a steady state level instead of increasing without bounds. ***MUSE*** contains a number of both negative and positive feedback loops and as such is a stable, goal seeking entity in aggregate.

The full diagrammatic representation of the ***MUSE*** simulator is shown in Exhibit 4. It has 20 variables that are represented as stocks. A linked chain of stocks (an outflow from one is the inflow to the next) is the number of applicants, the number admitted, and the numbers of first, second, third, fourth, and fifth year students, and graduates. Other important stocks are the number of faculty who teach undergraduates, the square feet of space required for classrooms, the space required for faculty offices and laboratories, the endowment principal, and the perceived level of attractiveness of the institution to potential applicants. Every stock has at least one inflow and outflow. For example, in the case of the stock representing space required for classrooms, the inflow is "building facilities" and the outflow is "demolishing facilities." In ***MUSE***, "hiring faculty" is a flow into the stock of existing faculty. "Faculty leaving" is a flow that reduces the current stock of faculty. The student stocks generally have two outflows. For example, at the end of the freshman year, students can either move on to the sophomore year or leave the institution. The "perceived level of attractiveness" stock is an arbitrarily scaled stock (relative to current conditions) that changes depending on a series of factors such as student-faculty ratio, tuition level, student aid level, and quality of undergraduate programs.

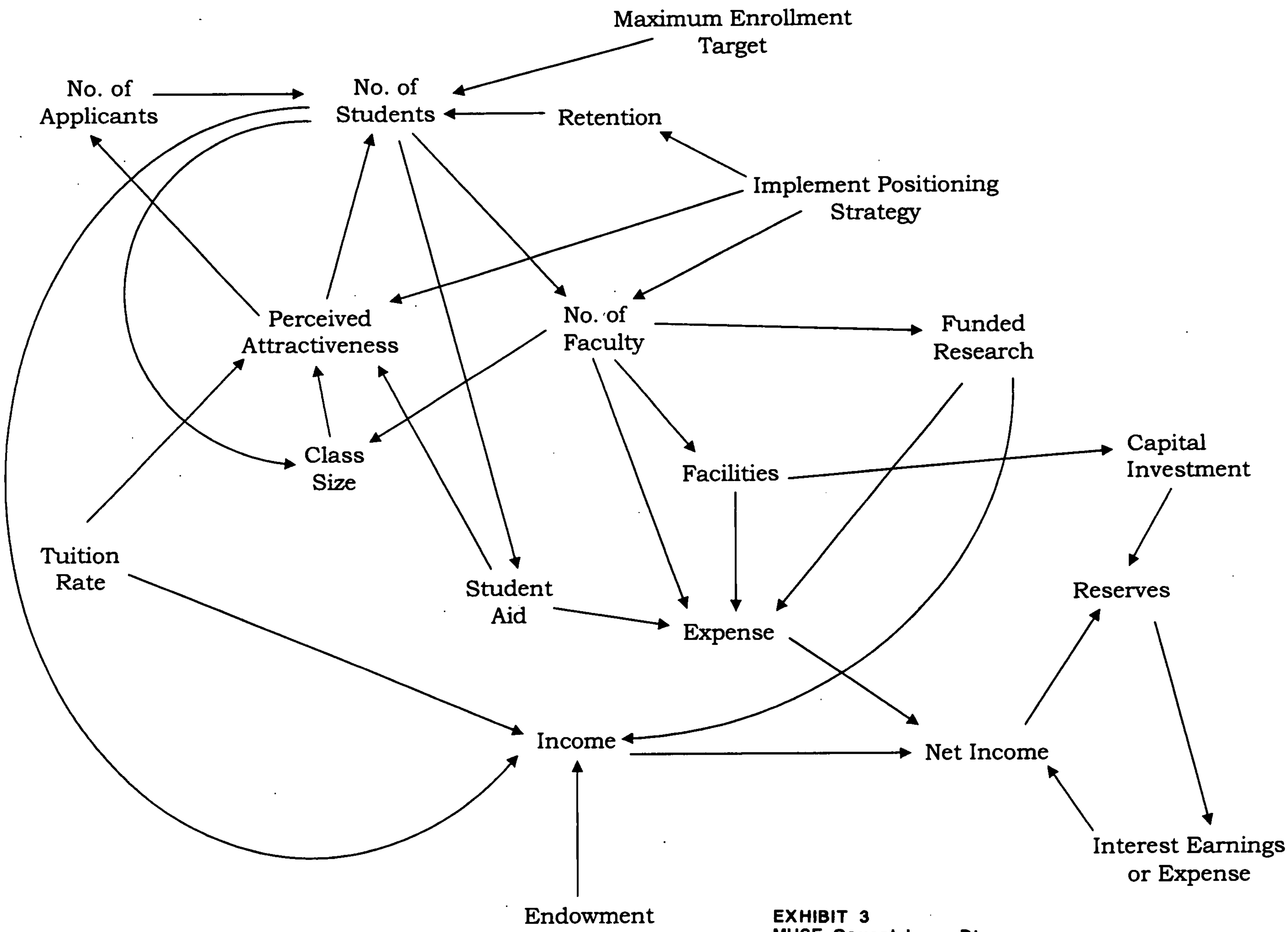


EXHIBIT 3
MUSE Causal Loop Diagram

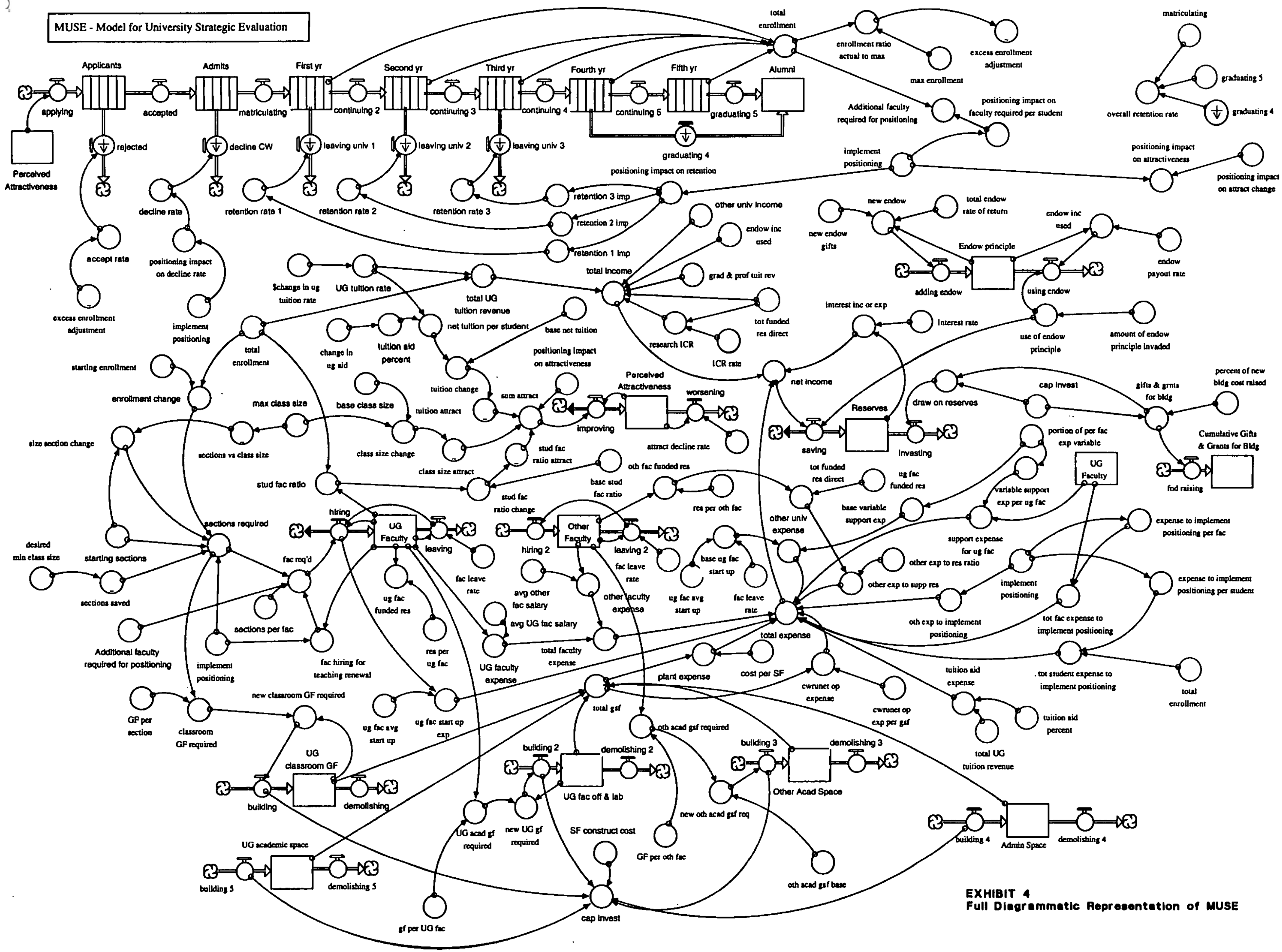


EXHIBIT 4
Full Diagrammatic Representation of MUSE

9A

MUSE incorporates about 130 converters. These range from a simple converter to input the current tuition rate, or average research revenue generated per faculty member, to graphical relationships which serve to relate two or more other converters. For example, the number of undergraduate class sections is related to the desired maximum class size using a graphical relationship in a converter. Another graphical function in a converter relates the expected change in institutional attractiveness to tuition level. A similar graph relates average level of student aid to institutional attractiveness.

Data Sources

The University employed an external consulting firm to develop estimates of the expected impact of possible innovative improvements in the undergraduate academic programs, as well as changes in student-faculty ratio, tuition level and average levels of student aid. The consultants estimated the changes that the University could expect in terms of number of applicants and percentages of applicants converted to enrollees. They based their estimates on statistical studies of data gathered through interviews of potential applicants and actual applicants as well as comparison studies of similar institutions. An internal task force appointed by the President of the University to study undergraduate education and life estimated potential changes in student retention rates. The deans' offices provided data on faculty teaching loads. Data on course section sizes were provided by the Registrar's office. Financial data were provided by the University's office of Budget and Financial Planning. Space for classrooms and teaching laboratories, faculty offices, and research laboratories was provided by the Institutional Planning office, as was the cost of creating additional facilities.

Application

The value of the ***MUSE*** simulation model is that it provides the capability of rapidly assessing the likely impact of simultaneously implementing a series of possible policy or strategic changes that would be too complex to effectively assess mentally or analytically and too slow, risky and expensive to assess by real-world implementation. Scenarios involving a wide variety of combinations and levels of changes in tuition rate, student aid, student-faculty ratio, enhancements in undergraduate programs, maximum/minimum class size, and endowment returns and utilization policies have been evaluated. The output variables are number of applicants, enrollment, number of faculty, space requirements, income, expense, and level of financial reserves. Analyses with ***MUSE*** have indicated that viable scenarios exist that yield a 62% increase in the number of applicants, raise enrollment to a predetermined target level, and achieve financial equilibrium. An example of such a series of analyses is presented in the following paragraphs.

To analyze the likely impact on the institution of a series of proposed strategic changes targeted toward dramatically increasing the number of applicants to the university's undergraduate programs and increasing the undergraduate enrollment to a prescribed target level, a series of three case studies were analyzed:

1) Case 1 is the base scenario. It assumes no major changes are implemented and that the university continues to operate under the existing conditions.
2) Case 2 assumes that major programmatic changes that were recommended by a special Presidential Commission on Undergraduate Education and Life are put in place and broadly marketed. Primarily, these changes involve modifying the curriculum to incorporate a strong focus on experiential learning, special undergraduate introductory seminars, and a substantial reduction in the maximum class size.
3) Case 3 incorporates the Case 2 changes and, to pay for these changes, increases undergraduate tuition and reduces financial aid to the maximum extent the President's Commission felt is advisable and within the range analyzed by the external consultants. Tuition was increased by approximately 20 percent, and student aid was decreased by about 14 percent. Also, minimum class size is increased from one to eight.

Results

The impact of the above changes on applicants, enrollment, number of faculty required, square feet of facilities required, and financial reserves are shown in Exhibits 5 through 9 respectively. The cases were analyzed by running the ***MUSE*** simulator for 20-year periods.

As can be seen in the graphs, Case 1 shows the steady state conditions are maintained when no changes are implemented. Case 2 shows substantial growth in number of applicants (65 percent) and achieves the targeted growth in enrollment of about 25 percent. However, undergraduate faculty grows by 70 percent, required square feet of facilities increases by about 60 percent, and reserves nosedive to a deficit of $670 million. The additional changes implemented in Case 3 are aimed at stabilizing the finances of the institution at a neutral level. As shown in the graphs, the latter objectives of financial neutrality and stability are achieved in Case 3. An initial investment which reaches a maximum level of about $22 million is required, but the return on this investment is such that it is fully paid off, including interest, in fifteen years. A small drop in the increase in number of applicants, from 65 percent to 60 percent is experienced, but still a substantial increase in the ratio of applicants to first year enrollees (selectivity) from 5.5:1 in the base case to 8:1 in Case 3, an almost 50 percent improvement.

Conclusions

The ***MUSE*** simulator described and illustrated in this paper is shown to be a very powerful tool to analyze and assess the impact of a broad range of strategic initiatives on the performance, operations, and finances of an institution of higher education. The structure and uses of the model are applicable to a broad range of institutions by customizing the parameter values to any college or university.

EXHIBIT 5

Total Applicants to Undergraduate Program

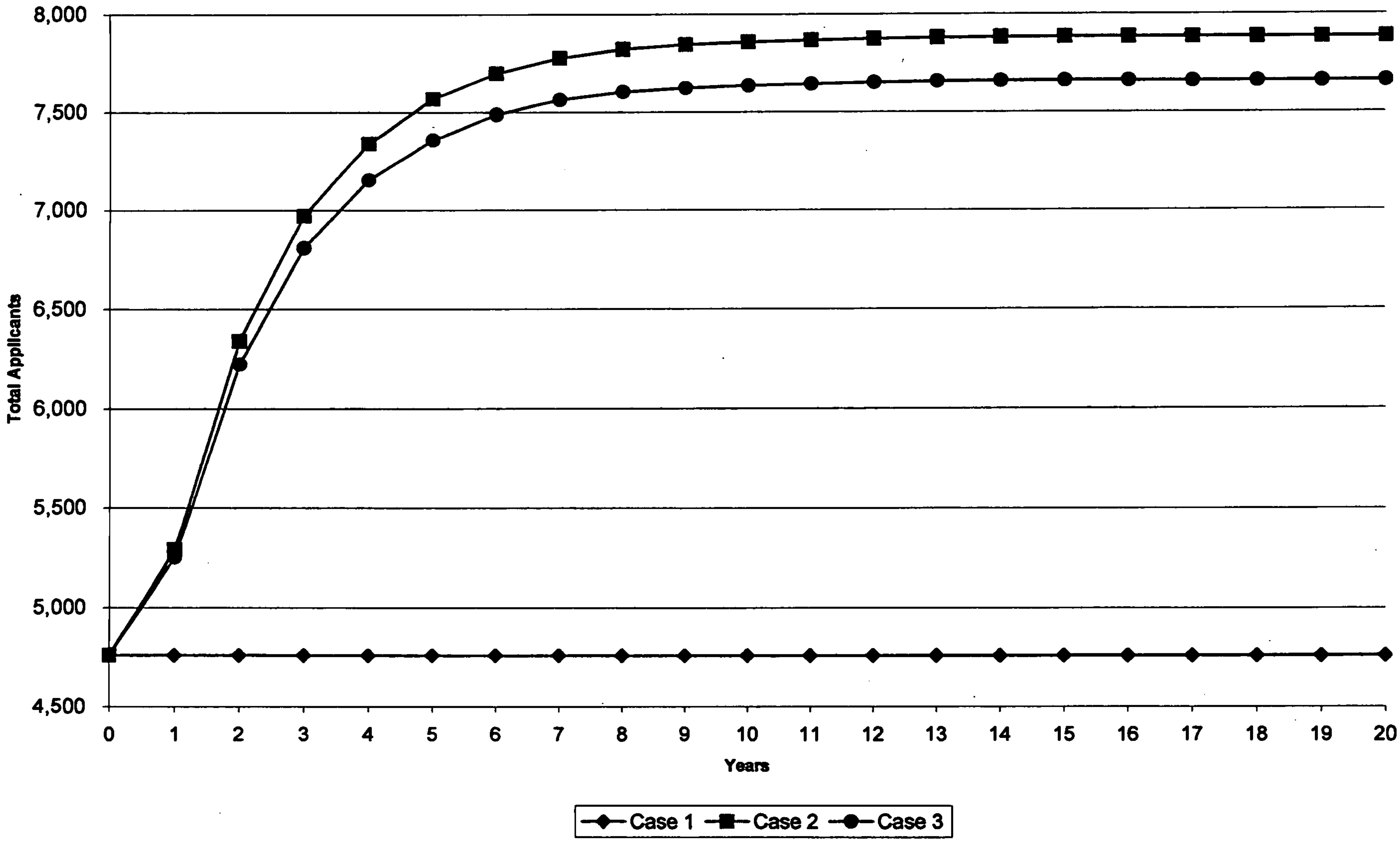


EXHIBIT 6

Total Undergraduate Enrollment

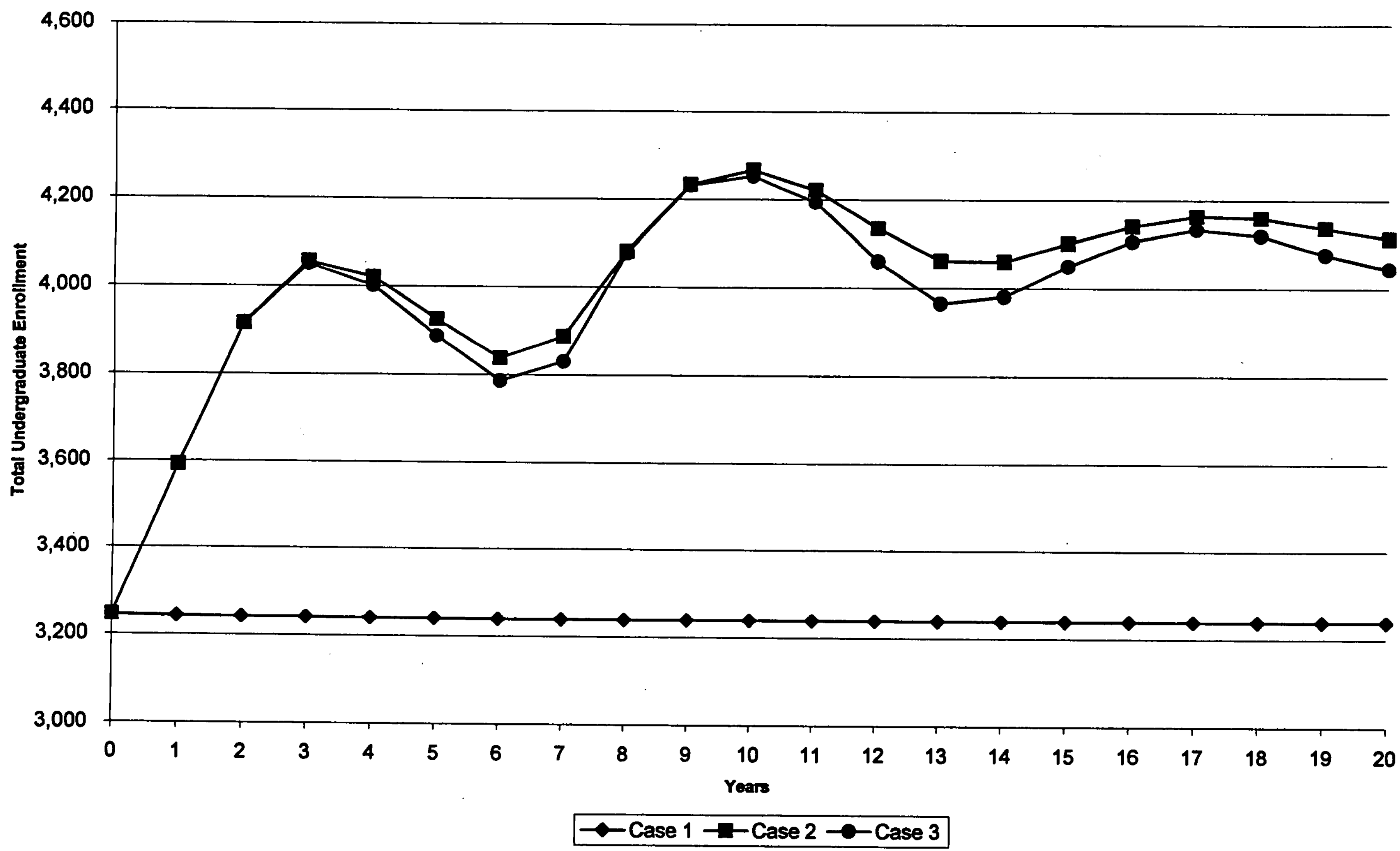


EXHIBIT 7

Undergraduate Faculty Required

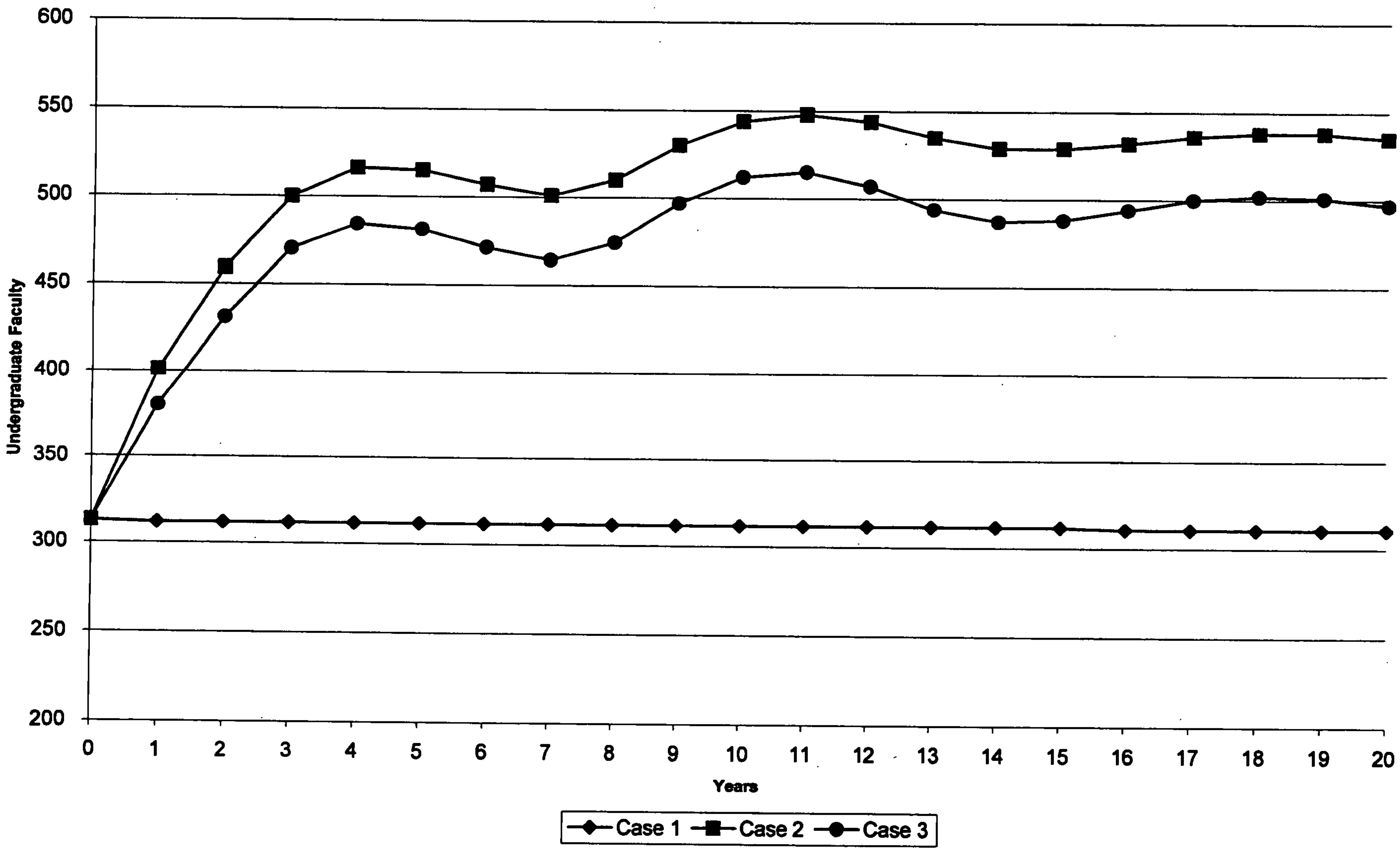
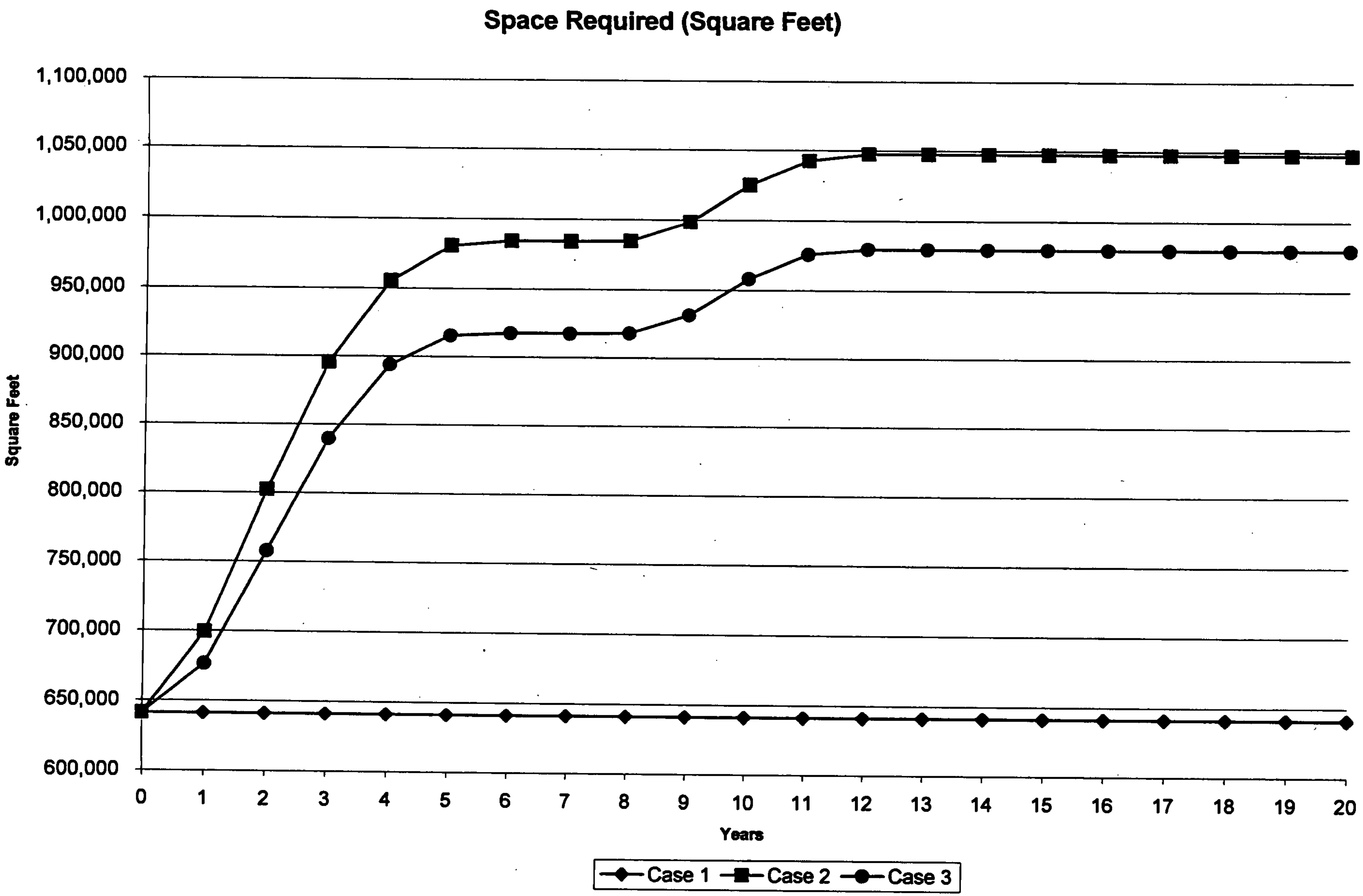


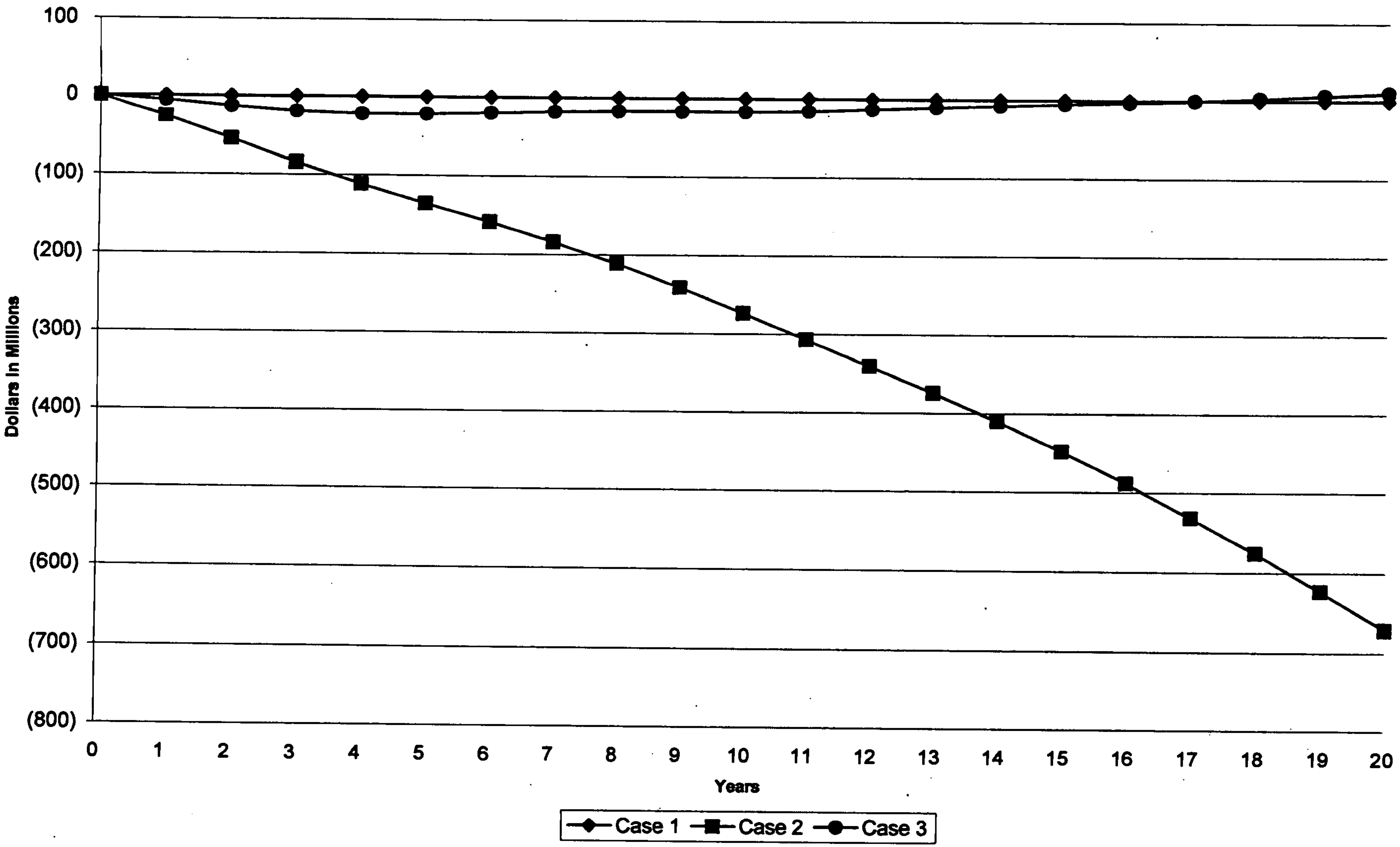
EXHIBIT 8



Space Required (Square Feet)
1,100,000
1,050,000
1,000,000
950,000
900,000
850,000
800,000
750,000
700,000
650,000
600,000
Square Feet
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Years
Case 1
Case 2
Case 3

EXHIBIT 9

Financial Reserves



Bibliography

Goodman, Michael R. (1989). *Study Notes in System Dynamics*. Cambridge, Mass.: MIT Press.

Morecroft, John D.W. and Sterman, John D. (eds.) (1994). *Modeling for Learning Organizations*. Portland, Oregon: Productivity Press.

Randers, Jorgen (ed.) (1980). *Elements of the System Dynamics Method*. Cambridge, Mass. and Norwalk, Conn.: Productivity Press.

Wolstenholme, Eric F. (1990). *System Enquiry: A System Dynamics Approach*. Chichester: John Wiley & Sons Ltd.

ithink *Technical Documentation* (1997). Hanover, New Hampshire: High Performance Systems, Inc.

NOTICE

Reproduction Basis

X	This document is covered by a signed "Reproduction Release (Blanket)" form (on file within the ERIC system), encompassing all or classes of documents from its source organization and, therefore, does not require a "Specific Document" Release form.
	This document is Federally-funded, or carries its own permission to reproduce, or is otherwise in the public domain and, therefore, may be reproduced by ERIC without a signed Reproduction Release form (either "Specific Document" or "Blanket").