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ABSTRACT

This report discusses the development of a rational process for making decisions about current operations and managing change to secure future goals. The first section describes the seven basic approaches to budgeting, distinguishes between them, and identifies the principal advantages and disadvantages. The section closes with an overview of a proposal for a comprehensive system of university budgeting that uses all seven of these approaches, but which is critically dependent upon Zero-base Budgeting and the techniques of objectives, strategies, and tactics. Section II presents a statistical report and evaluation of trends at Southern Methodist University. Emphasis is placed on enrollment figures and trends, a brief description of a co-operative program and the TAGER television system, and future prospects in graduate engineering. (MJM)

MU Institute of Technology **1973 Annual Report**

Contents

In the most general case, a budget is merely a spending plan constrained to fall within the bounds of estimated revenues over some specified interval of time. But because budgets are so intimately involved with the attitudes of the people who must manage them, not everyone views budgets with quite this degree of academic detachment. Some people regard a budget as an open-ended license to spend, assuming the details of the budget to merely represent general expenditure guidelines; others see it as a precisely defined spending plan to be followed without exception. Still others view a budget as a carefully defined strategic plan aimed at achieving specific organizational objectives, a one-year snapshot of a long-range plan that spans several years. There are some who simply view a budget as the end result of a series of politically expedient decisions and negotiated agreements reflecting "business as usual." It is clear that budgets have many different interpretations. But, in any case, the process by which budgets are constructed reveals much about the decision-making apparatus of the organization.

Moreover, the techniques used in budget construction are many and differ significantly in their approaches. It is possible to identify seven such approaches which are distinctly different from one another and which have been used, or could be used, in university budgeting. These include the following:

(1) Every Tub On Its Own Bottom (ETOB)
(2) The King's Decree (KING)
(3) The Squeaky Wheel Gets the Grease (SWGG)
(4) Formula (FMLA)
(5) Planning, Programming and Budgeting Systems (PPBS)
(6) Zero-Base Budgeting (ZBB)
(7) Objectives, Strategies and Tactics (OST)

Each of these approaches to budgeting tries to overcome certain budgeting problems. Thus, the focus of each is quite different and each has certain advantages and disadvantages. Proponents of each plan tend to promote the use of one plan exclusively. However, it will appear here that *all seven* systems need to be used to some degree. The key management problem is finding the appropriate mix.

The first five approaches are relatively well known in higher education and receive only cursory attention here. However, Zero-base Budgeting and the techniques of Objectives, Strategies and Tactics are not generally known and understood in the academic community. Accordingly, they are covered in considerable detail.

It is the purpose of this year's Annual Report to show that Zero-base Budgeting *and* the use of Objectives, Strategies and Tactics are unusually powerful tools in university budgeting and decision making. It is further shown that *all seven* budgeting systems listed are involved in the proper construction of a university budget. The overall result is a systematic and rational process for university decision making and long-range planning.

It will be shown that all budgets should include two components — an operating budget covering near-term activities and a strategic budget which aims at long-term objectives. Many university administrators profess to have a strong orientation toward the future, and many do. Yet the typical university budget-making process and apparatus for decision making generally give little attention to the future.

The concern in this Report is the development of a rational process for making decisions about current operations and managing change to secure future goals. It is within the framework of the much longer picture that the budgeting techniques become important. It is essential to remember that it is the decision-making process that is essential — the budget is a result.

The emphasis placed here on "decision making" could mislead the reader into believing that university administrators are like industrial managers, that they have full freedom to choose and control the directions and goals of the institution. But this is not true and can never be true because of the uniqueness of universities as social instruments and the oddities of their finances. Universities are strongly influenced by gifts, grants, contracts, public and governmental moods and fads. Their directions are correspondingly swayed. While managers in industry are similarly influenced by similar factors, they have a degree of authority to make decisions that has no parallel in education. Consequently, the discussion here recognizes these limitations on academic administrators even though the converse may seem to be implied at times.

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SYNOPSIS OF BUDGETING SYSTEMS

This first section describes the seven basic approaches to budgeting, distinguishes between them and identifies the principal advantages and disadvantages of each. The section closes with an overview of a proposal for a comprehensive system of university budgeting which uses all seven of these approaches, but which is critically dependent upon Zero-base Budgeting and the techniques of Objectives, Strategies and Tactics. Because the proposed system is so critically dependent upon these two approaches, and because they are not generally well understood in academe, they are covered in detail in later sections.

The proposal actually describes a process for systematic decision making regarding the allocation of institutional resources for current operations and for the future.

Every Tub On Its Own Bottom (ETOB)

The ETOB approach to budgeting is more or less self-explanatory. The ETOB system recognizes various clearly defined expenditure and revenue centers and then requires that each such budgeted center generate enough revenue to offset its expenditures, both direct and indirect. In theory, this is the way that SMU has operated for many years, but the appearance and the reality diverge somewhat. The most famous example generally cited is Harvard University.[7]

At first glance this is a very attractive concept to the central administration because responsibility for the very difficult and delicate problem of prudent, yet innovative, operation within revenue expectations is delegated downward to deans and other administrators. This saves many headaches for the president and his staff, but it begets others.

For example, one very important problem arises largely as a result of Parkinson's Second Law:

Expenditure rises to meet income.

That is, those budgetary units having increasing revenues always expand their activities so that the increased costs equal the increased revenues. Unfortunately, the converse almost never occurs; that is, those units whose revenues fall below expenditures do not correspondingly *reduce* their expenditures. With the faculty tenure situation being what it is, universities seldom possess the ability to incrementally reduce expenditures in the most effective way. Thus, the particular tub is not supported fully by its own bottom and is in a deficit position through inability, or unwillingness, to respond to changed circumstances. The overall university thereby ends up in a deficit position whenever any one of its tubs fails to be supported on its own bottom. In the absence of large, uncommitted endowment funds, the university does not have the ability to adjust to the problem.

The Harvard University Committee on Governance[7] examined the advantages and disadvantages of ETOB in considerable detail. They noted that:

"ETOB, in combination with a host of specific restrictions on specific gifts agreed between the donor and the member of the university pursuing him, has two related, specific consequences worth noting.

- *Only a small fraction of the total resources on Harvard's books are freely available for allocation by the President and Fellows.*
- *The fortunes of each school and 'tub' have been exceedingly sensitive to the pocketbooks of its own alumni; the popularity of its subject matter among rich patrons, foundations, and the government; the income status and expectations of its students; and in some cases, to the general state of the federal budget."*

Moreover, there are some additional problems that arise because of the ambiguous character of those central university functions such as the library, computing laboratory, admissions office and the like, which are exposed to "the hazards of all things that are both everybody's business and nobody's."[7]

The most telling criticism of budgeting by ETOB is contained in the Report of the Harvard Governance Committee[7] in the following statement:

"On its face, there is something peculiar about the notion that it is somehow right for a great university to be shaped more or less by happenstance, by the largely uncoordinated entrepreneurial activities of deans, professors, and administrators, and the proclivities of donors. No doubt, 'Every Tub On Its Own Bottom' has much to commend it. It sidesteps a good many unresolvable arguments about purposes; decisions about the shape of the university are ad hoc, sequential, and by and large implicit. But so are the results. (The proposition that such a regime is 'right' because *every activity which survives is 'self-supporting', is indefensible. This is not a domain where one can count on Adam Smith's invisible hand to make 'competition' efficient in serving any reasonable set of values.)"*

This criticism is most appropriate when there are many small tubs which differ widely in their income and cost potentials.

Moreover, it must be said that in certain instances the ETOB method of budgeting and operational control has worked. It has certainly served Harvard well in the past because it stimulated many different people in the administration, in the office of the President, and even individual professors, to participate in the fund-raising enterprise. This occurs with ETOB because it is necessary for those who care about an activity to find some way of financing it. It provides great incentives at the grassroots to raise money and to increase the return from money that is spent. If the extra income brought in by a unit is siphoned off to another unit there is little incentive to raise the extra money. Similarly, if a tub is efficient and saves money that is then taken away, the desire to be efficient is cancelled. ETOB thus tends to make the university quite "sensitive to changing social needs as perceived by different parts of the community."[7]

The Harvard Governance Committee squarely faced the issue of whether ETOB should continue as the basic budgeting mode at Harvard or whether it should be replaced with some more centralized decision-making and control apparatus. In substance, the Committee concluded that total withdrawal from ETOB is probably not possible for Harvard. But even if it were possible it would not be desirable. They concluded that ETOB should be retained in part and mixed with other budgeting and decision-making apparatus, the mix being more important than exclusive use of any one method.

There is a fairly obvious industrial counterpart to academic ETOB. This is a case of decentralization in which every profit, or cost, center is constrained to operate like a small, complete business with its own responsibilities in marketing, personnel, finance and so on. This approach is widely used in business and industry with considerable success and has its advocates on the campus. It is not without its faults, however, as noted by Grant Dove:[12]

> *"The difficulty with this approach* by itself *(my emphasis) is that the innovative efforts, even when they exist, tend to come out fitting the size and resources of the decentralized units. In other words, if left alone, there is likely to be little or no real break-through strategic efforts, that is: action which, if successful, could impact the whole corporation in a major way and exploit the whole corporation's total variety of resources, far exceeding the vision of any single manager of a decentralized unit."*

Dove then concludes his statement by saying:

> *"A major role of management is to shape the goal structure toward opportunities and problems which are the right scale for the total corporation."*

This is generally impossible in a wholly decentralized ETOB budgeting plan because resources and options are not left to the discretion of the administration at the center.

The King's Decree (KING)

In this mode of budgeting the total revenue pool is estimated by the central administration. The central administration, with or without consulting various advisors, then determines the amount of money to be allocated to each of the operating and service divisions of the university. This is a completely authoritarian system whose effectiveness depends in large measure upon the accuracy of the information presented to the decision maker by the supporting staff and organizational heads prior to the time the allocations are made. It is the exact converse of ETOB.

The advantages of the King's Decree over ETOB are obvious in certain respects. It makes it possible for resources to be allocated to carefully defined and internally consistent objectives sought by the entire organization, at least as the King perceives them. In contrast, ETOB tends to be a haphazard development, depending upon the fund-raising abilities of individual members of the faculty and the intentions of donors as outlined earlier.

While there can be many objections to an authoritarian system of management, the unusual combination of factors influencing the future of higher education in the United States suggests that the time has come for strong and decisive action which is not possible in the internally competitive entrepreneurial atmosphere created by the ETOB system. There is no question but that the costs of higher education are going to rise, and it is not at all clear that the availability of supporting funds will increase proportionately. Consequently, it is occasionally argued that the ability of the strong executive at the center to carefully allocate resources in an authoritarian way may be crucial to the survival of many educational institutions.

Given the foregoing advantage, it is also fair to say that it is unlikely that any individual, no matter how talented nor how well he surrounds himself with talented advisors, is in a position to accurately assess the needs for resources and to allocate them in such a way as to achieve the most broadly sought objectives of an institution as complex as a university.

For all practical matters the opportunity to operate entirely on the basis of the King's Decree has long since vanished. The complex governance systems in vogue at many universities couple with the tenure system and federal laws governing employment to such a degree that university administrations retain very few discretionary options. While the King's Decree is not a realizable mode of operation, even if it were desirable, the essential quality of decisive leadership can be achieved and mixed with other systems.

Most importantly, the King's Decree suffers from a basic limitation singularly appropriate to higher education — it ignores the intrinsic faculty hostility to arbitrary authority at the center.

F. E. Terman put it this way:

> *"In practice, the King cannot be completely authoritarian in dividing the pie without generating rebellious subjects, who when once antagonized, forget very slowly. This is true irrespective of how fair or right the King's decision may be, because each dean, department head and faculty member is biased toward his special interest and feels he is short-changed when he is actually being treated equitably. As a result, the King's Decree approach generates intense internal competitive entrepreneurship with the King at the center of the pressure.*
>
> *In contrast, ETOB avoids internal competition because each tub has available the entire world as its source of funds, and any successes that one tub may have in obtaining extra money clearly and obviously does not take money away from the other tubs. However, with the King's Decree, everyone is fighting for the same money and what the King gives to one tub is considered by the other tubs to have been taken away from them."*

The Squeaky Wheel Gets the Grease (SWGG)

The Squeaky Wheel Gets the Grease (SWGG) method is fairly obvious and quite common in practice. This is usually found in universities which do not have systematic budgeting and goal-setting procedures. The administration at the center may be weak and indecisive, or it may be strong and capricious. In either case, because of the lack of commonly understood goals, the annual revenue pool is attacked by the head of each budgetary unit with the aim of securing the maximum portion for his unit independent of its true need. This causes budgetary allocation to be determined largely by bureaucratic infighting, politicking, extravagant claims, misleading statistics, and all the other tools of the squeaky wheel. The resulting budget is a political document instead of a goal-oriented financial plan.

In common with ETOB, The Squeaky Wheel Gets the Grease fails to provide a budgeting system which focuses upon accepted institutional objectives. Instead, progress tends to be erratic and dependent upon the relative success of different academic bureaucrats in their ability to persuade or coerce the administration at the center to allocate a disproportionate share of the available revenue to their operating divisions. Such operating conditions breed a situation in which the university is not controlled by intelligently set objectives, but by the arbitrary resolution of antagonistic efforts by different members of the administration. This is scarcely a rational process, and one which cannot produce long-term organizational success. Nevertheless, in far too many cases, administrators feel that it is their responsibility to function in this mode.

The revenue pool for universities has four components: tuition income (or the state appropriated equivalent), contracts and grants, gifts and endowment income. In most schools the tuition component (or state equivalent) of the pool is predominant. Given contemporary college population statistics then, the revenue pool for a university is, to a large degree, essentially fixed during any reasonable budgetary period. Consequently, what is known in mathematics as a "zero-sum game" is being played. That is, as the head of one budgetary unit takes more of the revenue pool for his uses, there is usually less available for the use of other operating divisions. This is recognized by all on the campus and breeds suspicions about everyone's motives. Interdepartmental cooperation is correspondingly difficult, if not impossible.

It would be unfair to drop the Squeaky Wheel at this point. In most cases, the Squeaky Wheel is not simply an aggressive, threatening desk pounder. Instead, he very often succeeds because he is more articulate, more persuasive and more imaginative than his competitors. It is not a uniformly bad thing to give such people greater access to resources because they are likely to accomplish more with it. Indeed, the SWGG system tends to put a premium on this type of individual and he tends to surface into leadership positions in such organizations.

Thus, as with all systems, SWGG has its advantages and disadvantages. While it would be a mistake to use it as a system to the exclusion of all others, it does have the feature of drawing out persuasive people with attractive ideas.

The Formula (FMLA)

To overcome the obvious problems of SWGG, and to achieve greater equity in the allocation of resources to the various operating divisions, more and more groups, particularly in state-supported institutions, are going to the use of formula-based budgetary plans. In these schemes available funds are allocated to the various operating divisions in accordance with some unit of production — generally the Student Credit Hour (SCH). The SCH are often weighted according to level — lower division, upper division, graduate, doctoral, etc. Other quantitative factors such as full-time equivalent students, or "head count," or other easily obtainable factors may be used.

Formulas are one form of a more general technique known as *resource allocation models*.[14] These attempt to translate the inputs to the resources required — for example, translating enrollment changes into changes in demand for courses, faculty, facilities, support functions, and so on. The advantage of formulas and resource allocation models is that they allow the budgeter to systematically play the game of "What if?" That is, what if enrollment goes down (up) in engineering (business), arts (science), etc.? As such, this approach is more commonly used as a decision-making tool rather than as a specific technique for budgeting.

An extensive study was made of funding formulas for education, particularly in engineering education, and reported in 1971.[13] As a result of this survey, the following general observations were made:

"(1) Of those using or anticipating a formula, an asking figure is calculated and, in general, a percent (of the asking figure) is funded.

(2) In general, complex state-supported systems view a formula as necessary or desirable.

(3) Less than one-half of the formulae in use or being considered differentiate between level and discipline.

(4) If a differentiation is made as to discipline, engineering is lumped with other sciences and not with professional colleges.

(5) Less than half of the formulae used or being considered, consider research needs separately.

(6) Slightly over one-half of the formulae in use or being considered, consider administration, maintenance and services as separate items instead of as percent allowances as determined by instruction.

(7) The most prevalent fundamental basis of formula allocation seems to be based on SCH (Student Credit Hour) and FTES/FTEF (full-time equivalent student/full-time equivalent faculty) ratio or combinations of these.

(8) Generally, funds are *not* allocated on a formula within institutions."

These are significant results. For example, the first observation shows that schools receive only a percentage (less than 100 percent) of the funds requested according to the formula. They survive and apparently perform creditably at this reduced expenditure level. Thus, it must be concluded that formulas are generally not accurate predictors of actual, justifiable educational expense. Instead, they seemingly establish the point at which budgetary negotiations begin.

The second point that state-supported systems view a formula as necessary is hardly surprising. In the highly charged atmosphere of state-level budget making and in the allocation of funds to competing schools, formula systems may be the only recourse to pork-barrel politics.

There is a strong tendency for formula systems to reflect certain intuitive preconceptions about *who* should receive the most for *what*, despite the claim of attempts to achieve equity. For example, in the Texas formula system there is an allocation of funds for research, an allocation that can be substantial. The funding level is calculated through the use of an *institutional complexity factor*, or IC, which is defined as follows:

$$IC = \frac{.015U + (.50M_1 + .10M_2 + .25M_3) + (6D_1 + 1D_2 + 3D_3)}{U + M + D}$$

where:

U — Undergraduate FTSE
M — Masters FTSE
- M_1 — Masters FTSE in Science and Engineering
- M_2 — Masters FTSE in Teacher Education
- M_3 — Masters FTSE in all other programs

D — Doctoral FTSE
- D_1 — Doctoral FTSE in Science and Engineering
- D_2 — Doctoral FTSE in Teacher Education
- D_3 — Doctoral FTSE in all other programs

The amount of money requested for research is computed by multiplying the IC by the faculty salary total and then adding 5 percent of the sponsored research funds expended in the previous biennium.

It is clear that the formula strongly supports
(1) existing, well-established graduate schools of large enrollment
(2) doctoral programs
(3) science and engineering more strongly than teacher education

Thus, it is not equitable in the truest sense — it is only a base for calculations of the approximate effects of enrollment changes on resource requirements.

This conclusion is reinforced by the eighth and last conclusion drawn from the aforementioned survey. It indicates that universities use formulas to request funds, and they are often allocated within large state systems in accordance with these formulas. However despite careful formula distinctions between costs in different academic fields, once the money is appropriated to the university, these alleged cost differentials are largely ignored and funds are disbursed either by Kingly Decree or by SWGG. It has been noted recently, however, that as financial resources available to educational institutions have dwindled, there has been an increasing tendency for the central administrations of large state universities to try to compel the subdivisions within the university to comply more nearly with formula allocations.

Formulas are one type of resource allocation model as noted earlier. Allocation parameters are any conveniently available data base, most commonly one or more of the following:
(1) student credit hours
(2) student contact hours
(3) full-time equivalent faculty
(4) full-time equivalent employees
(5) student head count
(6) total salary expenses
(7) assignable square feet

Other parameters, usually less easily obtained or applied, include:
(1) number of sections
(2) percent of usage

The National Center for Higher Education Management Systems[18, 19] (NCHEMS) is developing a Resource Requirement Prediction Model (RRPM), using such allocation parameters. In addition to direct estimates of faculty costs, it allocates the expenses of all supporting functions (registrar, health center, computing laboratory, library, etc.) to any one of seven program classifications. The model has been tested successfully and is under constant refinement.

A somewhat more complex system was developed and used at the University of Toronto. It is known as Computerized Analytical Methods in Planning University Systems, or CAMPUS. There are a number of other systems.[34]

In any event, these systems are basically not tools for budget construction. Instead, they are intended as tools to play the game "What if," to supply a systematic basis for decision making, for choosing between various possible alternatives.

Planning, Programming and Budgeting Systems (PPBS)

It is clear from the name of the system — Planning, Programming and Budgeting Systems — that there are three major steps in the process. The first step, *planning*, sets goals, objectives and makes policy. It requires a selection of specific *objectives* which are analyzed systematically in terms of cost and benefits, presumably using formulas and resource allocation models. Each potential course of action to attain these objectives is analyzed on this cost/benefit basis. This is intended to be long-range planning within a time frame of 5-15 years. *Programming* is a selection process in which specific courses of action, which are known as programs, are chosen and mechanisms for review and control are enunciated. These are usually defined within a shorter time frame of 1-5 years. The final step is *budgeting*, the translation of planning and programming decisions into specific financial plans in time frames of about one year. Budgets are specific financial, manpower and policy plans to be implemented during the budget period.[6] The budgeting process analyzes organizational functions and activities necessary to achieve the goals and objectives by many and various alternatives that have been identified.

The objective of PPBS is to improve the basis upon which major program decisions are made. It forces the identification of program objectives and the consideration of alternate methods of achieving these objectives. These are subjected to systematic comparison to determine the "best" way. Additionally, PPBS reflects future, as well as current, implications of decisions which might be made and allows for the appropriate planning of contingencies. Somewhat more implicitly, the principal purpose of PPBS has been defined as follows:[6]

"To compare alternative methods of pursuing an imperfectly determined policy objective; analyzing alternative ways to accomplish objectives; seeing the complementary relationships among programs or subprograms; allowing for overlapping structures where objectives call for them; and planning total costs."

It is obvious that PPBS depends upon multi-year planning. Moreover, it attempts to relate in direct ways outputs and inputs, consequences with decisions, and effects with causes. Simultaneously, it aims to quantify and evaluate both direct and indirect costs in systematic ways.

PPBS has seven identifiable characteristics.[29] These can be identified very briefly as follows:

(1) Identification of goals
(2) Definition of objectives
(3) Program description to accomplish objectives
(4) An extended time frame
(5) Explicit consideration of alternative approaches
(6) Evaluation of all approaches and selection of the "best" route
(7) Replanning

This makes it clear that the effective implementation of Planning, Programming and Budgeting Systems depends in a critical way upon the existence of effective, quantitative Management Information Systems (MIS). It is the combination of MIS and PPB systems which combine to produce the effect finally desired.

"MIS and PPB systems act as powerful, heuristic and recollective devices in their impact upon administrators. The program planning discipline requires that the university leadership confront with great concreteness questions of objectives, evaluation criteria, and priorities which are otherwise easily let slide in the press of daily affairs."[29]

Unfortunately, there are very few schools which currently have adequate management information systems and appropriate, well-defined data bases. The most outstanding examples of partial success have occurred at Ohio State University, Stanford University, University of Pittsburgh, University of Toronto, University of California, and a few other institutions. In an effort to overcome this problem, the National Center for Higher Education Management Systems (NCHEMS) has been established at the Headquarters of the Western Interstate Commission on Higher Education, in Boulder, Colorado. It is hoped that there will be forthcoming from this enterprise management information systems appropriate to university operations which would enhance the implementation of PPBS.

Unfortunately, PPBS has not succeeded very well, neither in universities nor in government. The tendency has been for the proponents of PPBS to focus more upon activities rather than objectives, more upon the mathematical models than upon the results they were hopefully to achieve, more upon the mechanics and formalism rather than upon the concept and spirit. It is clear that if PPBS is to succeed in higher education, some way must be found to change this, to place the emphasis upon the concept and spirit of the idea rather than upon the mechanics and formalism of the process. However, there are those who believe that the formalism of PPBS is so organic to the process itself that it will never be worth the costs which are introduced by the enormous machinery necessary to respond to the formalistic requirements of the system.

It should not be surprising that PPBS has not generally been successful because it is extremely difficult to identify systematically the benefits produced by the activities of educational institutions. Costs can be determined, but benefits are very elusive and depend upon a degree of consideration of the aims and objectives of higher education which has not yet been approached systematically.

In spite of the criticism of the detailed mechanics of PPBS, the concept and the spirit are certainly valid, particularly in the realm of higher education. Traditionally, universities develop their programs and activities simply in accordance with what they estimate the available funds to be. This is certainly not a rational process and will not be acceptable in the future. Such an approach fails to consider the overall goals of the university. Until resources are allocated in accordance with clearly defined goals and objectives it is unlikely that resource utilization in higher education will approach the efficiency of business and industry.

A method for accomplishing PPBS in universities is described in this presentation. The method overcomes most of the criticism of excessive formalism while maintaining compliance with the spirit of the system.

Zero-Base Budgeting (ZBB)

It is quite common to speak of *the* budget and to refer to *the* budget-making process. But, in reality, there either are, or should be, two distinctly different budgets serving two distinctly different purposes. There is the *operating budget* which is concerned with near-term objectives, and there is the *strategic budget* which is concerned with long-term objectives. This section is concerned only with the operating budget.

The operating budget is the one that concerns most people and which involves most of the available funds. It deals with those cost elements necessary to maintain *current* operating levels, those items necessary to meet existing commitments, those activities necessary to near-term objectives. Accordingly, the operating budget is concerned primarily with non-discretionary funds. It provides for the planning and control of month-to-month operations, usually seeking to optimize year-end results.

Generally speaking, most operating budgets are made by taking the current year's operating level and then increasing it to take care of inflation, salary raises, and certain additional actitvities. Budget defense is then largely a matter of justifying the *increase;* the current year base is accepted on the premise that it was justified previously.

But times change, often with startling rapidity, and what was justified one year may not be justifiable this year. This is the origin of the concept of Zero-base Budgeting, a process that requires each manager to justify his *entire* budget in detail, just as though it was being started for the first time.

The originator of practical Zero-base Budgeting (ZBB) is Texas Instruments Incorporated, a high-technology, large corporation home-based in Dallas. The individual originator was Peter A. Pyhrr.

The first step in the use of ZBB requires that each discrete organizational activity be described in terms of a "decision package." Secondly, each of these decision packages is carefully evaluated and ranked in sequential order by the methods of cost/benefit analysis and according to some system of priorities. Finally, the available resources are allocated by establishing an expenditure cutoff level in the rank-ordered list of decision packages; all packages above this cutoff line are funded. The mechanics of this process are described in detail later in this Report.

A decision package identifies and describes a specific activity in such a manner that the administration can evaluate and rank it against other activities, also described in terms of a decision package, competing for the same or similar limited resources of money, manpower or facility. In addition, decision packages must include enough detail so that the administration can decide whether to approve or disapprove the request for action on that decision package.

There are fundamentally three types of decision packages. The first of these, the *base package,* satisfies requirements for the minimum operating level of that particular activity. The second type of package is mutually exclusive; these identify alternative methods for performing the same function. Of course, the best alternative is chosen and the others are then discarded. Finally, there are *incremental* packages which reflect different levels of effort that may be expended on a specific function. The "base package" establishes the minimum level. The other decision packages identify higher levels of activity or higher levels of cost.

In industry, Pyhrr found that Zero-base Budgeting is most appropriate when applied to service and support functions. In contrast, manufacturing activity tends to be determined by its sales volume, and the resulting production level then determines how much the company shall spend on labor, materials, and overhead. In other words, it would be possible to increase expenditures for manufacturing and thereby increase production, but there is no assurance that this would increase sales. Consequently, there is no simple relationship between the cost and the benefit of the activity under discussion. Hence, Zero-base Budgeting cannot be applied directly to manufacturing operations as easily as it can to service and support functions. Put somewhat differently, Zero-base Budgeting finds its principal use in areas where expenditures are not determined directly by the operations themselves. It is most helpful in areas where it is necessary to choose between different activities, or levels of activity, having different direct cost and benefits. This would be in such areas as marketing, finance, quality control, engineering, research, personnel, data processing, and so on.

It is shown later that ZBB can be applied to *all* phases of the university operation, including academic activities. Despite the superficial similarity to manufacturing because of academic "production," academic activities will be shown to have the same fundamental characteristics as service and support activities.

The entire process of Zero-base Budgeting is covered in extended detail later in this Report. It should be noted at this point, however, that ZBB is closely related to PPBS — PPBS tends to look at problems from the top down while ZBB tends to look at problems from the bottom up. Both depend upon clear statements of organizational objectives.

Objectives, Strategies and Tactics (OST)

This section deals with one method for handling the second part of the total budget, the *strategic budget.* This is composed of items that are discretionary to current operations and which seek to optimize long-term results. These are activities that are related to growth, expansion, new programs and new activities. Such expenses are always avoidable or postponable, in contrast to current operating expenses which are not. Not surprisingly, there is always a tendency on the part of administrators to delay and cut back on strategic efforts every time an operating crisis occurs or appears imminent. This is a hard administrative decision. Indeed, one of the most basic questions confronting the administration is how to decide how much of the total revenue pool should go into current operations and how much into investments in the future in the strategic budget. Some assistance in making this decision is given later in this Report. Unfortunately, very few universities have a strategic budget so that the decision seldom even comes up.

In business and industry, strategic budgeting is crucial to long-term corporate success. Company assets are deployed into activities which are expected to provide significant returns from the investments in the future. Universities have a semantic problem in this connection because few administrators consider the possibility of a return on investment. Budgeting is constrained primarily by the desire to retain what currently exists.

The most effective system of strategic budgeting is known as OST — where the letters stand for Objectives, Strategies and Tactics. OST was the brainchild of Patrick Haggerty and evolved during the time he was President of Texas Instruments Incorporated. Haggerty's aim was to systematize innovation because he clearly perceived that innovation is the essential ingredient of the strategic budget. He had noted that there were important similarities in the thought processes and procedures that had been followed in the achievement of each major breakthrough at T.I., whether in products or in processes. In each case, he found that major innovations had occurred when company leadership was able to focus on objectives and goals without worrying too much about the method and techniques, the strategies and tactics involved in the achievement of these objectives.

In his plan, the word *objective* denotes broadly-defined, *quantitative* statements of intentions and purposes. *Strategies* are then resource allocations in selected plans designed to achieve an objective; they are long-term, general courses of action. Finally, *tactics* are short-term courses of action in support of a strategy. These ideas, and their implementation, are covered later in much greater detail.

It should be clear from the hierarchical nature of OST that a single objective could eventuate in a large number of tactical actions. These tactical actions are then grouped together into logical, stand-alone *decision packages* of the same type as were used and described in the discussion of Zero-base Budgeting. A decision package is ordinarily a simply stated proposal on a page or two outlining one or more Tactical Action Programs (or TAP's) for the use of funds in a short-term activity supporting a strategy. During the long-range planning of the strategic budget, these decision packages are rank ordered by management according to priority. It is then possible to decide which of these packages is to be funded into the strategic budget. After funding, each package is reduced into one or more tactical action programs.

OST is a system for management planning, review and control which cuts across organizational lines. And, it provides a mechanism for coupling long-range strategic planning to near-term budgetary operations. The details of OST are presented later.

Proposed Budgeting System

Seven different methods for budgeting have been described very briefly in the preceding discussion. While each of these appears to be a separate system and while there are probably examples that can be cited of some organization that uses one scheme exclusively, in the most practical sense all systems and approaches should be used simultaneously. At least, that is the position taken here.

The complete budget for a university, or any of its subordinate units, should consist of two distinct parts:

(1) The operating budget — which should be constructed in accordance with the principles of Zero-base Budgeting.
(2) The strategic budget — which should be constructed in accordance with the principles of OST.

Both of these techniques are discussed in much greater detail in the sections that follow.

Zero-base Budgeting techniques produce an operating budget in the form of a series of rank-ordered decision packages in association with a projected cutoff level for operating expenses. Similarly, the techniques of OST produce a strategic budget in the form of a series of rank-ordered decision packages in association with a proposed expenditure cutoff level. The two budgets together represent the total overall institutional expense budget, which is the sum of all the expenses of *both* types of decision packages appearing above their respective cutoff levels. When the complete budget is presented in this form it is comparatively easy to assess the impact of changes in cutoff levels. Obviously, increasing the investment in the future by increasing the number of strategic decision packages will cause a corresponding decrease in funding of operating decision packages. The effects of such variations can therefore be assessed with some precision and this is a considerable aid to budgetary decision making.

The most difficult decision in academic budgeting, in all budgeting for that matter, arises at precisely this point — how to proportion expenditures, where exactly to set the two cutoff levels. While there is no final easy solution, the techniques of ZBB and OST bring the problem down to manageable proportions where understandable trade-offs can be made.

The merging of the two lists of rank-ordered decision packages achieves a number of desirable results.

(1) It assures that the desired balance is achieved between near-term and long-term objectives.
(2) Duplication of effort is minimized.
(3) Fast growing aspects of the university do not suffer because of lagging programs or activities.
(4) It is useful in securing the best mix between low risk, low payoff programs and those with high risks and high payoffs.

While these advantages are secured, it is still possible to keep the investment in the future separate from the day-to-day pressures of the surplus and deficit considerations of the operating budget.

It should be clear that the combined approaches of ZBB and OST, with the decision package technique, provide rational and practical mechanisms to carry out the intentions of Planning, Programming and Budgeting Systems. Thus, ZBB and OST add up to intelligent PPBS.

Each of the other four budgeting systems described also plays a role in this overall process. Consider the decision packages and their rank ordering. It is clear that the extent to which a decision package truly stands on its own revenues is unquestionably a very important factor in establishing its priority at a high level compared to other decision packages which do not reflect ETOB. Thus, the attitudes associated with the ETOB process manifest themselves in significant ways.

The Squeaky Wheel Gets the Grease appears to some degree in this plan also. The entrepreneurial ability of department heads and deans to present their decision packages attractively and persuasively will undoubtedly affect the rank-ordering process. Aggressive and somewhat abrasive administrators may also affect the final decision regarding the locations of the two cutoff levels

The development of decision packages always involves the consideration of alternatives. It also requires that estimates be made of the costs of both the recommended solution and all of its alternatives. It is in this process that the formula system and resource allocation models find their proper uses because they provide systematic and consistent standards for cost estimating. Even though the formulas or models may be somewhat imprecise, the results are more amenable to rational consideration than those obtainable by any other method.

Finally, of course, the eventual decision on the actual expenditure cutoff levels, and the proportion between the two, can only be made by the King's Decree.

To recapitulate, the proposed budgeting plan presented here involves a mixture of all seven budgeting systems described briefly thus far:

(1) SWGG yields imaginative decision packages and affects the ranking.
(2) ETOB is a major consideration in ranking decision packages.
(3) FMLA is used to provide a basis for cost comparisons between alternative decision packages.
(4) The King decrees the expenditure cutoff levels.
(5) ZBB develops the operating budget decision packages.
(6) OST develops the strategic decision packages.
(7) PPBS results from the foregoing.

Detailed procedures for the use of ZBB and OST are covered in the two major sections that follow.

ZERO-BASE BUDGETING

The general concepts underlying Zero-base Budgeting were presented earlier. It is the purpose here to expand on those ideas in greater detail and to outline the general methodology developed by the originator, Peter A. Pyhrr.[1, 33] Bear in mind that ZBB is applied to the development of the current operating budget, not to the strategic budget. Thus, it deals with those funds necessary to maintain current operations. ZBB is primarily a decision-making technique rather than a procedure for budget management or control.

In its most general form, Zero-base Budgeting involves only three steps:

(1) *Identify* and *specify* all organizational activities or functions in terms of *decision packages*.
(2) *Rank* the decision packages in order of importance according to some system of priorities.
(3) Decide where to *cut off* the funding of decision packages so that all packages above the cutoff line are funded.

While it is easy to make these three statements, their execution is considerably more difficult.

The process is spelled out in great detail here, at least from the university perspective. Full implementation would probably be resisted by the faculty because most would feel that the process is too regimented and complex with too much paperwork and emphasis on detail. Such criticism may well be valid in some cases. The obvious answer is simply to streamline the process into a less formal procedure which still elicits the data necessary to rational decision making, thereby retaining the essential concept while removing some of the apparent operational complexity.

Identification of Decision Packages

A decision package describes a discrete activity in enough detail so that decisions about its relative importance can be made. Pyhrr[33, p. 51] identifies six general subject areas in which one might likely define decision packages:

(1) People
(2) Projects or programs
(3) Service received or provided
(4) Line item of expenditure
(5) Cost reduction
(6) Capital expenditures

The last five of these are fairly obvious. But that first one — people — creates mental stumbling blocks right away. Pyhrr further observes that the problem is doubly severe because, "People are the most common subjects for decision packages because they both spend money and create expenses through their wages and salaries." Because the aim of Zero-base Budgeting is to improve effectiveness primarily by reducing costs, and because costs can be reduced by eliminating decision packages, and because "people" comprise a large number of decision packages, it is not surprising that many people feel threatened by ZBB.

Pyhrr addressed this difficulty directly when he installed ZBB in the Georgia state system. He observed:[33, pp. 128-129]

> *"Some agency managers in Georgia challenged the effectiveness of Zero-base Budgeting in state government because of the potential impossibility of firing state employees and commented that 'good employees terminate or qualify for transfers while poor employees hang on forever'. However, with a 20 percent turnover rate experienced in many government agencies, significant reductions can take place as long as specific operations and jobs are designated to be reduced or phased out. This will accomplish the major cost savings desired even if there are a few 'hangers-on'."*

Much the same objection to Zero-base Budgeting can, and will, be made by the academic community where the turnover of personnel is nowhere near 20 percent per year. Granted that the application of ZBB will be more difficult in academe than in business, it is not impossible because there is *some* turnover and it still offers many advantages not otherwise available to the administrator.

The basic educational and general budget* of the

**The E and G budget does not ordinarily include student housing, food service, health services, student center, book store, intercollegiate athletics, and all other expenses associated with auxiliary enterprises.*

typical university rather closely resembles the operating budget of an industrial company. Both include two major components to cover (1) the producing operations and (2) the service and support operations. The university's *academic* budget includes the costs of all academic departments of instruction, the library and computing laboratory, principal academic officers, and so on. Though it will probably make the professors wince, this is closely analogous to the *manufacturing* part, the producing operation, of an industrial budget. Similarly, the expenses associated with *services and support* in the university — for all nonacademic functions which support the academic enterprise — have their exact service and support analogs in industry and which support the manufacturing activity. In the university these supporting functions include such things as the registrar, admissions office, personnel deans and student services, physical plant operation and maintenance, and so on.

The reason for making these distinctions derives from the fact noted earlier that the "services and support" function in industry has been found to be the one most susceptible to Zero-base Budgeting. Correspondingly, it is reasonable to expect a similar susceptibility for such functions in the university.

Pyhrr asserts that Zero-base Budgeting is more difficult to apply to the manufacturing budget because manufacturing activity tends to be determined by sales. Moreover, at any given moment, unit manufacturing costs are essentially fixed because wage scales are set, material costs and operating expenses are known. They may change, or new techniques may be introduced, but these are essentially perturbations in the system and can, in many cases, be handled as decision packages. The essential point is that the expenditures are determined primarily by the activity itself. As a result, this is *not* a place where Zero-base Budgeting is particularly appropriate.

It would appear that similar considerations should apply to a university *academic* budget. In addition to the "people" and tenure problems alluded to in the Georgia effort, there is the added fact that student enrollment (sales) largely determines the academic budget. This is the basis for virtually all appropriation formulas and resource allocation schemes as noted earlier. Thus, the analogy to manufacturing operations seems appropriate. But the situation differs from that in industry because there is nothing immutable about many of the components of the academic costs, not even at a given instant. While faculty salaries may be fixed, such factors as average class size, average teaching load, and student-faculty ratio can be varied at will, producing wide variations in potential academic costs. Thus, it would appear that *academic* matters do lend themselves to Zero-base Budgeting equally as well as budgeting for services and support. Of course, the tenure problem is a serious constraint, but one that can be accommodated if sufficiently long-time spans are used in setting objectives.

In the academic budget, decision packages should be developed at the departmental level. This is usually the lowest budgeted cost center and the department chairman and his faculty colleagues are more knowledgable about departmental activities and correspondingly best able to identify decision packages. This identification process is a much more difficult problem in the purely academic departments of the university than in the service and support areas or in industry.

However, there are certain activities in academic departments which readily lend themselves to the decision package approach. Not surprisingly, these are primarily in the service and support functions which the department provides for itself, for others, or purchases from someone else. These include such things as secretarial and technician services, travel requirements, duplicating and copy services, and so on. Another type of fairly obvious decision packages are those proposing to add something or to change something already present. Examples include a proposal to add a new faculty position, or to build, expand or change a laboratory facility.

The almost invariable first tendency among academic administrators is to conclude that each faculty member must be treated as a separate decision package. This is a fairly natural inclination because it is an article of faith in universities that individual faculty members are central to all university accomplishments. But this generally proves unworkable. For example, decisions on tenure, promotion and, in some cases, in decisions involving continuance of a nontenured faculty member are major strategic decisions. But there are usually well-established university criteria and procedures dealing with these matters that, quite bluntly, resist conformance to the decision package format. And, of course, if a faculty member already has tenure no "decision" is involved given present circumstances.

Moreover, one aim of Zero-base Budgeting and the decision package approach is to allow consideration of varying levels of support for each activity, increasing incrementally above some minimum level. It is difficult to apply this concept to the case of a single faculty member. Thus, although faculty can be involved in decision packages, either singly or in groups, the decision package should *not* be defined *in terms of* a single faculty member.

There is a way out of this apparent dilemma. Every academic department tends to be a collection of subdisciplines. These may arise simply from administrative convenience, or they may represent traditional subdivisions of a classical discipline with a long history of acceptance. Each of these subdisciplines is defined by a grouping of several courses associated with at least one faculty member, but with as many as two, three, or four, or more in other cases. Decision packages should be developed for each of these activities within the department although cases do arise in which entire departments or even schools may be treated as decision packages.

But consider the definition of subdisciplines as decision packages. For example, an electrical engineering department might be defined in terms of the following main subject areas:*

(1) Electronic/Electrical Materials
(2) Electronic/Electrical Devices
(3) Quantum Electronics and Electromagnetics
(4) Networks and Circuits
(5) Information and Communication
(6) Computers
(7) Large-Scale Electronic/Electrical Systems
(8) Societal Systems
(9) Biomedical Technology

Each of these areas typically involves the attention of one or more faculty members. Depending upon institutional objectives and environmental constraints, an acceptable Electrical Engineering Department could be defined which did not include *all* of these areas. For example, many departments currently exist which do not include items (1), (7), (8) and (9). These are appropriate activities for description in decision packages.

Other departments can be partitioned in similar ways from convenient decision packages for activities. For example, the activities of a Mechanical Engineering Department might be specified in terms of the following areas:

(1) Mechanical Design
(2) Thermodynamics and Statistical Mechanics
(3) Heat Transfer and Transport Phenomena
(4) Fluid Dynamics
(5) Lubrication Theory
(6) Thermal System Design
(7) Materials Engineering and Metallurgy
(8) Control Systems
(9) Solid Mechanics
(10) Gas Dynamics

Similarly, a Department of Computer Science and Operations Research could be defined in terms of the following:

(1) Computer Systems Software
(2) Digital Hardware
(3) Deterministic Models and Techniques
(4) Stochastic Models and Techniques
(5) Information Systems
(6) Mathematics of Computation

Specification of Decision Packages

As noted before, decision packages are developed around discrete functions or activities or, in special cases, around people. Once these are identified it is necessary to clearly delineate their purposes or objectives. The specification of the decision package then begins with an exploratory phase. First, an analysis is made of all of the possible ways that the objectives might be achieved. The "best" one, however defined, is chosen and recommended. Second, with the recommended method established, the effects of different levels of effort must be analyzed and understood. Finally, a minimum level of effort must be identified which will attack the most important elements of the function or activity, even though the purpose of the function may *not be fully* achieved at this minimum level. This defines the decision package for the minimum level of effort. Except in rare cases, the minimum level of support so identified should always be less than the current year's level of support. Additional levels of support are identified as separate decision packages.

The complete written specification of a decision package should be reduced to a single page, or two pages at most, and must include the following components:

(1) A statement of goals, purposes, objectives or intentions of the function or activity or people associated with the decision package.
(2) The program, or course of planned actions, by which the objectives are currently or will be achieved.
(3) The benefits and achievements to be expected from the planned actions.
(4) Consequences of not approving the package.
(5) Quantitative measures of performance appropriate to the actions of the package.
(6) The expenditure of funds, personnel and other resources needed to implement the activity. Also necessary to show the sources of the funds required.
(7) The alternatives to the recommended decision package:
    (a) Different levels of effort, but following the same action plan.
    (b) Different ways of performing the same function.

The key point in formulating a decision package is the maintenance of a clear focus on the benefits derived for a given cost — what is accomplished at *what* cost. A sample form for use in defining academic decision packages is shown in Figure (1).

The formulation and specification of decision packages is a very difficult process, especially the first time. Pyhrr[33] identifies six difficulties that commonly arise in the process.

(1) It is difficult to decide which activities, functions, or people should be described in terms of a decision package.
(2) It is difficult to define the minimum level of effort as being *below* the current level. The difficulty is that people then naturally assume that this minimum level will become the actual level of support. This will occur in some cases, but not all. It is not a precise level. For an academic department it could be defined as that level necessary to support the minimum acceptable and survivable program in its particular environment. What is minimally acceptable and survivable are tough questions to face squarely, but they can be answered approximately even if the answers are unpleasant. For example, in engineering, a minimally acceptable and survivable program must include

These are nonunique, but consistent. Energy and power technology are not included as separate areas because they are assumed to be included in various other areas such as electromagnetics, systems and societal technology.

the B.S. and M.S. levels — but not necessarily the Ph.D.

(3) It is difficult to avoid the tendency to try to keep personnel requirements at current levels, even when overall costs are being reduced. The reduction of needed incidental expenditures while keeping unnecessary people is a common problem which can effectively cripple organizational effectiveness.

(4) It is difficult to identify meaningful quantitative measures of performance. Even when they are defined, it is often difficult to find adequate historical data. This is a particular problem in most universities which have inadequate management information systems.

(5) It is difficult to estimate costs associated with decision packages. Formulas can be used here, though they are often of dubious validity.

(6) It is difficult to identify cost reduction potentialities *within* the action plan described for each decision package.

The general procedure for the specification of decision packages is basically a three-step process accomplished within initial constraints specified by the top administration. Thus, in consultation with deans and other advisors, the president of the university is expected to issue a formal set of assumptions regarding enrollment levels in various schools and at various levels, estimated revenues from tuition and fees, gifts and endowment, state and federal or other governmental funding, projected wage and salary increases, and so on. With these established, decision package formulation proceeds in three steps:

Step 1 — As described earlier, current operations are analyzed and separated into discrete decision packages.

Step 2 — These packages are identified basically as "business as usual" packages, because they merely cast this year's operations in terms of next year's costs, using the assumptions issued by the president.

Step 3 — These "business as usual" packages are separated into two categories:

(1) True "business as usual" packages in which no variations are possible or justifiable as far as the department head or dean can see. This would include all those people on tenure, for example.

(2) Alternatives to "business as usual" packages. These decision packages

FIGURE 1

Sample Form Used for Defining Decision Package

PACKAGE NAME	SCHOOL	DEPARTMENT	ACTIVITY	RANK

STATEMENT OF PURPOSES OR OBJECTIVES OF DECISION PACKAGE

PROGRAM, OR COURSE OF ACTIONS, TO ACHIEVE OBJECTIVES

BENEFITS AND ACHIEVEMENTS EXPECTED FROM THE PLANNED ACTIONS

CONSEQUENCES OF NOT APPROVING THE DECISION PACKAGE

QUANTITATIVE PACKAGE MEASURES (PROGRAM)	FY	FY	FY	RESOURCES REQUIRED $ IN THOUSANDS	FY	FY	FY
				SALARIES, WAGES			
				CAPITAL OUTLAY			
				EXPENSE/SUPPLY			
				TOTAL			
				PEOPLE (NUMBER)			

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PACKAGE NAME	SCHOOL	DEPARTMENT	ACTIVITY	RANK

ALTERNATIVES (DIFFERENT LEVELS OF EFFORT AND COST)

ALTERNATIVES (DIFFERENT WAYS OF PERFORMING THE SAME FUNCTION)

SOURCE OF FUNDS $ IN THOUSANDS		FY	FY	FY	FUTURE RESOURCE NEEDS
Salaries, and Wages	Federal				
	Private				
	S.M.U.				
Capital Outlay	Federal				
	Private				
	S.M.U.				
Expenses, Supplies	Federal				
	Private				
	S.M.U.				

Back

would consist first of a base package representing the minimum level of effort. and incremental packages which describe different levels of effort or different ways of securing the objective. Remember that, in almost every case, the "minimum level" of effort should be less than the level for the current year.

The next step requires that all of the decision packages so developed be ranked in order of priority. This process is described in the next section.

The Ranking Process

The various decision packages are developed initially at the cost center level — at the departmental level and their nonacademic counterparts in a university. It is then necessary to rank all of these decision packages to be able to answer two questions.

(1) How much money should the university spend on its operations?
(2) Where should the money be spent?

It is obvious that the ranking could be done at the presidential level where overall university goals are presumably known and appreciated, or at the departmental level where the greatest degree of informed judgment can be brought to bear. Each of these possibilities is beset by its own unique and fairly obvious problems, including the lack of detailed expert knowledge in the president's office and the tendency toward the parochial view in the department.

Consequently, ranking is best accomplished through *consolidation* as the decision packages move upward through the administrative hierarchy of the university. That is, the department heads submit their rank-ordered decision packages to the dean. The dean consolidates all of his departmental decision packages into *one* consolidated, overall rank-ordered list. This consolidation in ranking is probably best made by a committee of the department heads with the dean serving as chairman. The final rank-ordered list is then transmitted to the president. The president consolidates the deans' lists similarly in a committee composed of the deans, with the president serving as chairman. The final rank-ordered list is then transmitted to the governing board.

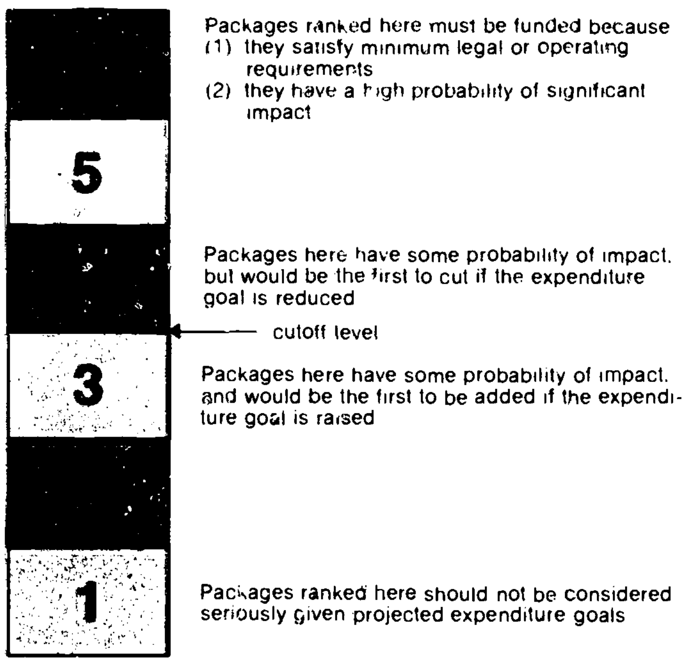
It is obvious that this process leads to an excessive number of packages to be considered and ranked at the presidential level. Moreover, many packages are required, either legally or operationally; no decision is really involved in such cases and there is no reason for administrators to waste their time worrying about these types of decision packages. Consequently, some cutoff method must be introduced to limit the number of decision packages requiring detailed consideration at any level. This cutoff procedure is described in the next section.

The rank-ordering process is extremely difficult in any case, but the use of committees, as described earlier, would render it impossible if unanimous agreement or ranking was required. Obviously, some sort of voting mechanism must be used. The simplest plan is to give each committee member one vote on some numerical scale of points. Then ranking is made in accordance with the number of points the committee votes for that decision package. A sample ballot is shown in Figure (2). Phyrr states that ballots with an even number of points — say 6, 8, or 10 — are best because they force a decision. It is not possible to be totally neutral by voting directly at the mid-point as would be possible on a scale of 5. Of course, much more complex voting schemes could be used, with voting on several criteria. But the problem is difficult enough, particularly at the outset, and further complications should be avoided where possible. It is probable that the committee chairman, in each case, should have two or three votes, depending upon the committee size.

The ranking and voting process is also made difficult because everyone involved knows that the funding requests are virtually certain to exceed available revenues. Moreover, almost all requests have some degree of legitimacy given the usually cloudy and imperfectly stated goals of a university. Additionally, there tend to be a great many moral or implied demands on the available revenues, further limiting the range of choice. Finally, universities seldom have any well-defined methods of program evaluation and generally resist all attempts to introduce them. Yet, evaluation is the crux of the budgeting process. The difficulties must be accepted, but they cannot be used as an excuse not to evaluate. Rational budgeting by *any* process requires systematic evaluation — this is obvious in ZBB. Unfortunately, most present budgeting is *not* rational and evaluation is not systematic.

FIGURE 2

Sample Voting Ballot*



*Adapted from p. 118 of Ref. 33.

Interaction analysis may be a useful aid in the ranking process. The process involves two types of matrices as shown in Figure (3), a *self-interaction* matrix and a *cross-interaction* matrix. For example, the interaction among the faculty members (indicated by A, B, . . . P) in a given department could be displayed with a self-interaction matrix. If Professors A and B interact strongly, an X would be appropriately placed in the matrix. On the other hand, a cross-interaction matrix could be used to analyze the degree of interaction between faculty members (A, B, C, etc.) in one department and those (1, 2, 3, etc.) in other departments. The self-interaction matrix is appropriate in analyzing the major subject area divisions within a department which provide the basis for many decision packages. The cross-interaction matrix is useful in assessing interactions such as:

(1) between subject areas (decision packages) in different departments
(2) between subject areas and degree programs
(3) between subject areas and faculty members

While this process reveals nothing new, it does systematically display what is known and assists in the assessment of the comparative importance of various factors. This assists in the ranking process. Obviously, for example, a subject area which interacts slightly with only a few degree programs would receive a low rank among decision packages.

The Cutoff Process

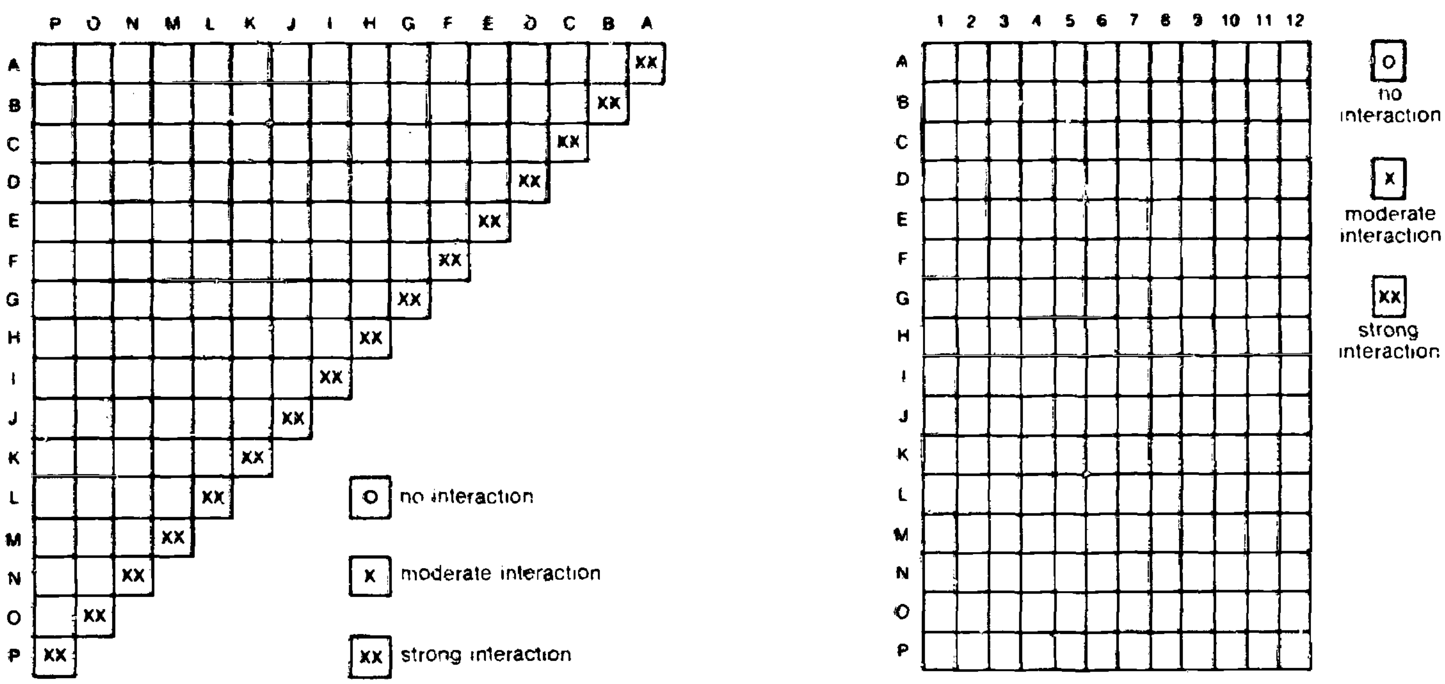
The chief executive officer of the university, president or chancellor as appropriate, must estimate the expense that might be *approved* by the governing board. This estimate is derived in part from his estimates of revenues. He must then make a tentative first decision regarding how much of this total revenue can be applied to the operating budget and how much, as a result, is available for investment in the future in the strategic budget. It is precisely here that rational university budgeting usually breaks down because very, very few (if any) universities have any funds generally available for a strategic budget. Revenues from tuition, research, gifts and endowment are nearly always virtually committed in total to sustaining current operations. Investments in the future, if any, depend upon the relative success of the entrepreneurial activities of faculty and deans with private foundations.

As a result, it is obvious that the budgeting plan proposed here can only be implemented gradually over a period of 10 years or so. For example, in the first year, perhaps only half to one percent of the total revenue might be assigned to the strategic budget. But it would be a start, and it could be increased possibly half to one percent per year until it reached ten percent or more.

With the operating budget revenue thus estimated, the president then defines an *expense cutoff* point to apply to the administrative level below him, at the deans' level or other equivalent operating division involving several cost centers. This cutoff level is less than what he expects to be approved, say X percent of what the governing board might reasonably be expected to approve for the operating budget. X might be about 80 percent, for example. This allows some freedom later in making trade-offs between divisions whose packages are being ranked relative to one another. It permits similar trade-offs to be made between the operating budget and the strategic budget.

FIGURE 3

Interaction Matrices



Each dean or operating division head is then given a preliminary total expense allowance for the year to use as a target in his budget planning. This could be determined in several ways. It might simply be last year's expense budget for operations. Better, it could be his share of the projected revenue pool based upon forecasts of enrollment, research, and gifts. Additionally, the X percent cutoff level is specified.

At the dean's level, or the level of other major administrative units, a cutoff point of Y percent is set. Y is always less than X. In fact, Y should be significantly less than X, as for example, X might range from between 80-85 percent while Y might range between 60-65 percent. This process allows the exercise of discretion and trade-offs at each level above the original cost centers. The amount of flexibility depends upon the values selected for X and Y. In universities, these should probably be larger than industry because there is less flexibility in universities through the effects of tenure and other specialized constraints which greatly limit the range of administrative discretion.

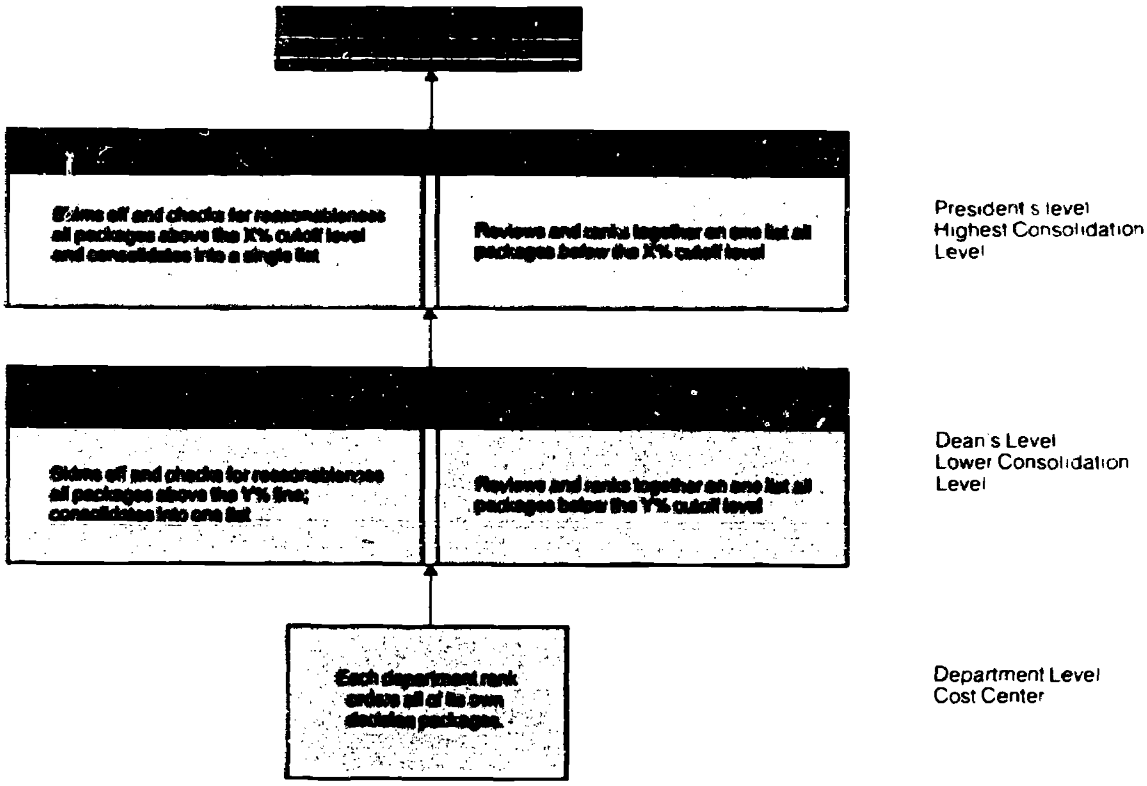
In the consolidation process the packages move upwards through the hierarchy. The packages submitted from the departments to the deans, or other administrative officials, are reviewed and the top ones, totaling Y percent of last year's budget, are skimmed off and checked for reasonableness. The *remainder* are then consolidated, evaluated, and ranked and handed up to the president. Obviously, *all* packages ranked above the Y level will be funded. In addition, many of those falling between the X and Y levels will be funded depending upon how they fare in competition with those from other units.

With the cutoff level set at X percent, the president looks over the package rankings handed up to him from the deans and his other administrative heads. First, he skims off the highest-ranked ones until their expenditures total X percent of last year's budget for the area in question. These packages are then quickly reviewing for general reasonableness. The *remaining* packages are then examined carefully, ranked, and passed up to the governing board along with the others. These are the more discretionary packages and the final budget is determined by Board action in deciding where *it* will draw the actual cutoff level and which of these decision packages it will fund. The overall process is shown schematically in Figure (4). The final level set will depend upon the relationship between the operating budget and the strategic budget. It is obvious that approval of more operating decision packages will reduce the number of strategic packages that can be funded.

It is clear that this process allows attention to be concentrated on those packages at the cutoff levels and keeps the total number of packages that need to be ranked within manageable proportions at each administrative level. Simultaneously, it allows each administrative level some flexibility so that trade-offs are possible and administrative discretion can be exercised. This is possible with competing operating decision packages and with strategic decision packages.

FIGURE 4

The Cutoff and Consolidation Process*



*From Ref 33, p 118

PACKAGE NAME	SCHOOL	DEPARTMENT	ACTIVITY	RANK
Computer Software Faculty	*IOT*	*CS & OR*	*Computer Science*	

STATEMENT OF PURPOSES OR OBJECTIVES OF DECISION PACKAGE

Strengthen and provide leadership in the area of computer systems software in research activities and educational programs (B.S., M.S., and Ph.D.) of the Department of Computer Science and Operations Research.

PROGRAM, OR COURSE OF ACTIONS, TO ACHIEVE OBJECTIVES

Recruitment of a faculty member in the Computer Systems Software area with the rank of a Professor with Tenure.

BENEFITS AND ACHIEVEMENTS EXPECTED FROM THE PLANNED ACTIONS

(1) Increased teaching capability in the computer software area.
(2) Younger faculty will get relief from advising a large number of graduate students.
(3) Provide research leadership for younger faculty.
(4) Increased prospects of obtaining research funds.

CONSEQUENCES OF NOT APPROVING THE DECISION PACKAGE

(1) Lack of leadership in computer software area.
(2) Deterioration of standards, through lack of experience.
(3) Deterioration of standards, through overburden to younger faculty.
(4) Dim prospects of obtaining research funds.

QUANTITATIVE PACKAGE MEASURES	FY 74/75	FY 75/76	FY 76/77	RESOURCES REQUIRED $ IN THOUSANDS	FY 74/75	FY 75/76	FY 76/77
NO. OF PH.D.'S PRODUCED	2	4	4	SALARIES, WAGES	27.5	28.9	30.3
NO. OF M.S. STUDENTS ADVISED	10	12	12	CAPITAL OUTLAY	3	-	-
NO. OF SCH'S PRODUCED	210	240	270	EXPENSE/SUPPLY	6	6.5	7
EXPECTED RESEARCH FUNDING IN $	13.5	32.1	41.2	TOTAL	36.5	35.4	37.3
IN THOUSANDS	-	-	-	PEOPLE (NUMBER)	1	1	1

PACKAGE NAME	SCHOOL	DEPARTMENT	ACTIVITY	RANK
Computer Software Faculty	*IOT*	*CS & OR*	*Computer Science*	

ALTERNATIVES (DIFFERENT LEVELS OF EFFORT AND COST)

(1) Recruitment of a faculty member in the computer software area at the Associate Professor level. Cost: $24,500 (73-74). Because of the aspects of leadership and experience, benefit ratio between this alternative and the course of action will be much smaller than the cost ratio = 2/3 approximately.

(2) Recruitment of a faculty member at the Assistant Professor level - unacceptable because of reasons stronger than in (1).

ALTERNATIVES (DIFFERENT WAYS OF PERFORMING THE SAME FUNCTION)

(3) Use of Visiting Professors as Instructors in courses. Does not solve the problem of the lack of leadership.

(4) Encourage students to work in other areas. This may result in turning many students away from our Department.

(5) Appoint a Visiting Professor on a short-term basis. This will not give continued strength to the area.

SOURCE OF FUNDS $ IN THOUSANDS		FY 74/75	FY 75/76	FY 76/77
Salaries, and Wages	Federal	10.5	28.6	37.2
	Private	7	-	-
	S.M.U.	10	0.3	-
Capital Outlay	Federal	-	-	-
	Private	-	-	-
	S.M.U.	3	-	-
Expenses, Supplies	Federal	3	3.5	4
	Private	-	-	-
	S.M.U.	3	3	3

FUTURE RESOURCE NEEDS

Continued salary support increasing annually at about 5%.

PACKAGE NAME	SCHOOL	DEPARTMENT	ACTIVITY	RANK
Duplicating Lab	*IOT*			

STATEMENT OF PURPOSES OR OBJECTIVES OF DECISION PACKAGE

To provide duplicating and copy service at one central location for the departments of the IOT at a minimum cost and best acceptable quality.

PROGRAM, OR COURSE OF ACTIONS, TO ACHIEVE OBJECTIVES

(1) *Install a XEROX 7000 with metered usage and reduction capabilities to provide copy service for departments. Also, provide 50 bin sorter for collating letters, reports, etc., which will reduce labor-time spent with present equipment without any sorting attachments.*

(2) *Install an inexpensive ($175 to $250) Ditto machine in each of the departments to provide class notes, test papers and other duplicating items not requiring better quality copy.*

BENEFITS AND ACHIEVEMENTS EXPECTED FROM THE PLANNED ACTIONS

(1) *The features of the XEROX 7000 allow greater versatility; can reproduce all the work presently being done on seven (7) machines.*

(2) *It permits two-sided copying, colored stock and copies onto letterhead stock.*

(3) *Additional benefits are no master preparation, no skilled operator, no capital investment, reduction of oversized originals, no obsolescence and fewer service and supply problems.*

(4) *Service will be available on a 24-hour-a-day basis, rather than 40 hours per week.*

CONSEQUENCES OF NOT APPROVING THE DECISION PACKAGE

The present standard of service and quality is not acceptable but would be continued if this package is disapproved. We are dependent upon commercial repair and service for the off-set printer, master-maker, mechanical collator, ditto duplicator, and the thermo-fax machine. The XEROX 720 and IBM copier are rented and serviced by those companies. There are no back-up machines nor operator. The "turn-around" time for service is from one to eight working hours. There are periods of delays from one to three days, when the operator is absent.

QUANTITATIVE PACKAGE MEASURES	FY 70/71	FY 71/72	FY 72/73	RESOURCES REQD. $ IN THOUSANDS	FY 70/71	FY 71/72	FY 72/73
TOTAL COPIES	277,000	283,330	280,000	SALARIES, WAGES	8	6	-
				CAPITAL OUTLAY	1	3	1
COST PER COPY	.065	.06	.05	EXPENSE/SUPPLY	9	8	13
				TOTAL	18	17	14
				PEOPLE (NUMBER)	1.5	1.5	-

PACKAGE NAME	SCHOOL	DEPARTMENT	ACTIVITY	RANK
Duplicating Lab	*IOT*			

ALTERNATIVES (DIFFERENT LEVELS OF EFFORT AND COST)

(1) Discontinue the ditto duplicating and replace with one (1) IBM Copier near the high-volume user. Additional expense estimated to be $200 per month. Discontinue both offset and ditto processing, expense estimated to be $350 per month for two (2) IBM copiers.

ALTERNATIVES (DIFFERENT WAYS OF PERFORMING THE SAME FUNCTION)

(2) Discontinue the offset operation and route all orders to the printshop. Cost per copy will increase due to minimum copies of 100 per run.

(3) Discontinue the ditto operation, and allow the departments to procure their own Ditto machine, supplies, etc., and arrange for the work to be done by the secretaries and/or students. It is doubtful if any savings would be realized, because maintenance would increase and higher-paid personnel would be spending their time on duplicating.

(4) Persuade the University to set up a central copy center in our area to service engineering and other colleges surrounding. Doubtful at this time that resources would be available to the University for such an installation.

SOURCE OF FUNDS $ IN THOUSANDS		FY 70/71	FY 71/72	FY 72/73
Salaries, and Wages	(*) Federal	2	2	-
	Private	-	-	-
	S.M.U.	6	4	-
Capital Outlay	(*) Federal	-	-	-
	Private	-	-	-
	S.M.U.	1	3	1
Expenses, Supplies	(*) Federal	2	2	3
	Private	-	-	-
	S.M.U.	7	6	10

FUTURE RESOURCE NEEDS

(*) *Estimated Cross-Charged to Grants/Contracts.*

PACKAGE NAME	SCHOOL	DEPARTMENT	ACTIVITY	RANK
Industrial Engineering	*IOT*	*CS & OR*	*B.S. and M.S. programs in I.E.*	

STATEMENT OF PURPOSES OR OBJECTIVES OF DECISION PACKAGE

Maintaining an Industrial Engineering Program that will satisfy the needs of the North Texas region (oriented towards computer systems, operations research and manufacturing engineering).

PROGRAM, OR COURSE OF ACTIONS, TO ACHIEVE OBJECTIVES

To offer a program accredited by the Engineering Council for Professional Development (ECPD).

BENEFITS AND ACHIEVEMENTS EXPECTED FROM THE PLANNED ACTIONS

(1) Satisfy the needs of the region by training graduates in I.E. oriented towards computer systems, operations research and manufacturing engineering.
(2) An ECPD accredited program is valuable to students for future employment.
(3) Chances of attracting a larger number of students are better.

CONSEQUENCES OF NOT APPROVING THE DECISION PACKAGE

(1) Lack of ECPD accreditation may handicap students in future employment.
(2) Lack of ECPD accreditation may result in decreased number of students.
(3) If offered under Systems Engineering Program, problem of identification may arise.

QUANTITATIVE PACKAGE MEASURES (PROGRAM)	FY 73/74	FY 74/75	FY 75/76	RESOURCES REQUIRED $ IN THOUSANDS	FY 73-74	FY 74-75	FY 75-76
NUMBER GRADUATING (B.S.)	3	5	16	SALARIES, WAGES	17.5	23	24.2
NUMBER GRADUATING (M.S.)	2	5	5	CAPITAL OUTLAY	2.5	-	-
NUMBER OF STUDENTS IN U.G. PROGRAM	25	40	65	EXPENSE/SUPPLY	6	6.5	7
NUMBER OF STUDENTS IN M.S. PROGRAM	2	5	5	TOTAL	26.0	29.5	31.2
				PEOPLE (NUMBER)	1	1	1

PACKAGE NAME	SCHOOL	DEPARTMENT	ACTIVITY	RANK
Industrial Engineering	*IOT*	*CS & OR*	*B.S. & M.S. Program in I.E.*	

ALTERNATIVES (DIFFERENT LEVELS OF EFFORT AND COST)

(1) Add two more Industrial Engineering faculty. It would strengthen the program considerably. Additional cost will be about $25,000 per year. Return is unlikely to be anywhere near this range. This alternative is unacceptable.

ALTERNATIVES (DIFFERENT WAYS OF PERFORMING THE SAME FUNCTION)

(2) Offer the same programs (I.E.) without concern for ECPD accreditation. But it will affect student enrollment. Accreditation is crucial in many employment categories.

(3) Offer the same programs under the accredited program of System Engineering. There may be some dissatisfaction among students who would prefer to be called Industrial Engineers.

SOURCE OF FUNDS $ IN THOUSANDS		FY 73/74	FY 74/75	FY 75/76
Salaries, and Wages	Federal	-	9	10
	Private	12	8.5	8.7
	S.M.U.	1.5	5.5	5.5
Capital Outlay	Federal	-	-	-
	Private	-	-	-
	S.M.U.	2.5	-	-
Expenses, Supplies	Federal	-	2	2.5
	Private	-	-	-
	S.M.U.	6	4.5	4.5

FUTURE RESOURCE NEEDS

Clearly, continued funding from private sources (foundation) would be needed.

OBJECTIVES, STRATEGIES AND TACTICS

Zero-base Budgeting, as described, is a decision-making technique for dealing with the operating budget. But a different approach is required for the *Strategic Budget* which attempts to manage change. Changing the level, scope or character of activity within an organization is the purpose of the strategic budget. Accomplishment of these changes requires systematic attention to the following:

Objectives — Broadly defined quantitative statements of intentions and purposes.
Strategies — Long-term general plans of actions aimed at the achievement of an objective; resource allocations in selected plans.
Tactics — Short-term action programs in support of a strategy.

The purpose of the OST technique developed by Haggerty* is to make organizational objectives clear through documented quantitative statements — statements that ideally are a[17] "shocking challenge to jolt managers away from traditional, in-a-rut thinking." The chance for innovation is enhanced by separating the setting of Objectives from the methods for achieving them, through separation of Objectives from the Strategies and Tactics.

Before moving into a simplified explanation of OST, a short digression is in order to clarify the distinctions between the words "goals" and "objectives." Thus, about the first third of the discussion that follows is devoted to goals, objectives and intent structures. The remaining two-thirds present a simplified summary of the techniques of OST.

Goals and Objectives

The budgeting process is fundamentally a formal system for the allocation of institutional resources. These commitments of resources obviously have important effects upon the subordinate units in the organization, effects that are complex and which often propagate in many directions through the organization. It is obvious that decisions allocating resources will be most beneficial when made to conform to well-defined organizational goals. Moreover, the existence of well-understood goals at the top permits every level within the organization to formulate its goals so that all components are working together toward common institutional goals.

There is generally a great deal of confusion regarding the usage of the words "goals" and "objectives" because they tend to be used interchangeably. However, for the purposes of this presentation it is necessary to make a rather precise differentiation between the meanings of the two words. This will be done shortly. In the meantime, it is assumed that objectives and goals are two different types of *intentions*.

Various management methodologies attach different meanings to these words. For example, the technique of Objectives, Strategies and Tactics, as used by Texas Instruments, depends upon intentions stated in *quantitative* terms within specified time frames. In contrast, in the theory of intent structures as developed by Warfield[1] it is necessary to state organizational intentions in both quantitative and nonquantitative terms which ignore time frames. Yet, both techniques use the words "goals" and "objectives" essentially interchangeably. It seems necessary to remove such ambiguities.

Patrick E. Haggerty, Chairman of the Board, Texas Instruments Incorporated.

It is essential to note that the plural has been used in all three words — intentions, goals, and objectives. Complex organizations, such as universities, are characterized by a complex multiplicity of interrelated intentions. Not surprisingly, the formal expression of institutional intentions and the description of their interrelationships is an extremely difficult process. It is so difficult, and people generally object to the process so vehemently, that many institutions simply do not have clearly defined intentions against which daily actions, or even long-range decisions, can be evaluated.

The process is made very difficult by a series of attitudes and factors summarized by Warfield.[1] For example, he notes that there is nearly always confusion between "goals" and "objectives," over whether one is long range and the other short, or whether one is measurable and the other is not. Consequently, all too often, attempts to define intentions bog down into arguments over these matters and, as Warfield says, "Nothing gets done."

To avoid that difficulty in this exposition, the meanings attached to these two concepts are differentiated as follows:

(1) A *goal* is a statement in the following form:
To (action word) (object) (qualitative modifying phrase)

For example, the following statements are examples of goals.

To prepare students for professional careers.
To pursue research fundamental to national needs.
To provide students a basic liberal education.

Goals are axiological intentions because their attainment is a matter of subjective judgment.

(2) In contrast, an *objective*, as used here, denotes an intention whose degree of achievement can be determined by comparison with specific objective measures, very often within specific time frames. Thus, objectives are statements in the following form:
To (action word) (object) (quantitative modifying phrase).

For example, the following statements of intentions are objectives.

To increase freshman enrollment by 10 percent in two years.
To reduce utility costs by $10,000 in six months.

It is not always necessary to include a time frame. For example:

To reduce vandalism in the dormitories.

This is a measurable intention and is an *objective* as defined here; the objective measure is not specifically identified, however.

Thus, in this presentation, *objectives* denote *measurable* intentions.

The foregoing distinction between goals and objectives is reasonably consistent with the fine difference found in the dictionary. There we find that a *goal* is an end, or a final purpose; the line or place at which a race is ended; an end to be achieved. In this sense, goals represent ideals, or pinnacles of aspiration for the organization. In contrast, objectives are not ends. Instead, their achievement marks progress toward idealized intentions.

Intent Structures

Warfield[1] notes that many people are reluctant to discuss institutional intentions because of the semantic difficulties just noted. In addition, they often feel that organizations and people have intentions and value structures they do not wish to discuss. This may be because the statement of these intentions or values could lead to discord, conflict and divisiveness. Thus, these people feel that there is an "invisible intent" structure that can never be formally and publicly identified. Other difficulties originate because people quite generally find it difficult to state their goals; others prefer to concentrate on actions; still others worry over who "owns" what goal and how these different owners may be brought into conflict. Despite these objections, large, modern organizations must have formally stated goals. Organizations without clearly defined goals flounder. As Grant Dove[32] put it:

"We believe that few things can paralyze an organization more than uncertainty about the strategies and value systems of the chief executive. It is also true that uncertainty about goals at any level of organization has a paralyzing effect, not only on that particular unit, but also on its role with other units.

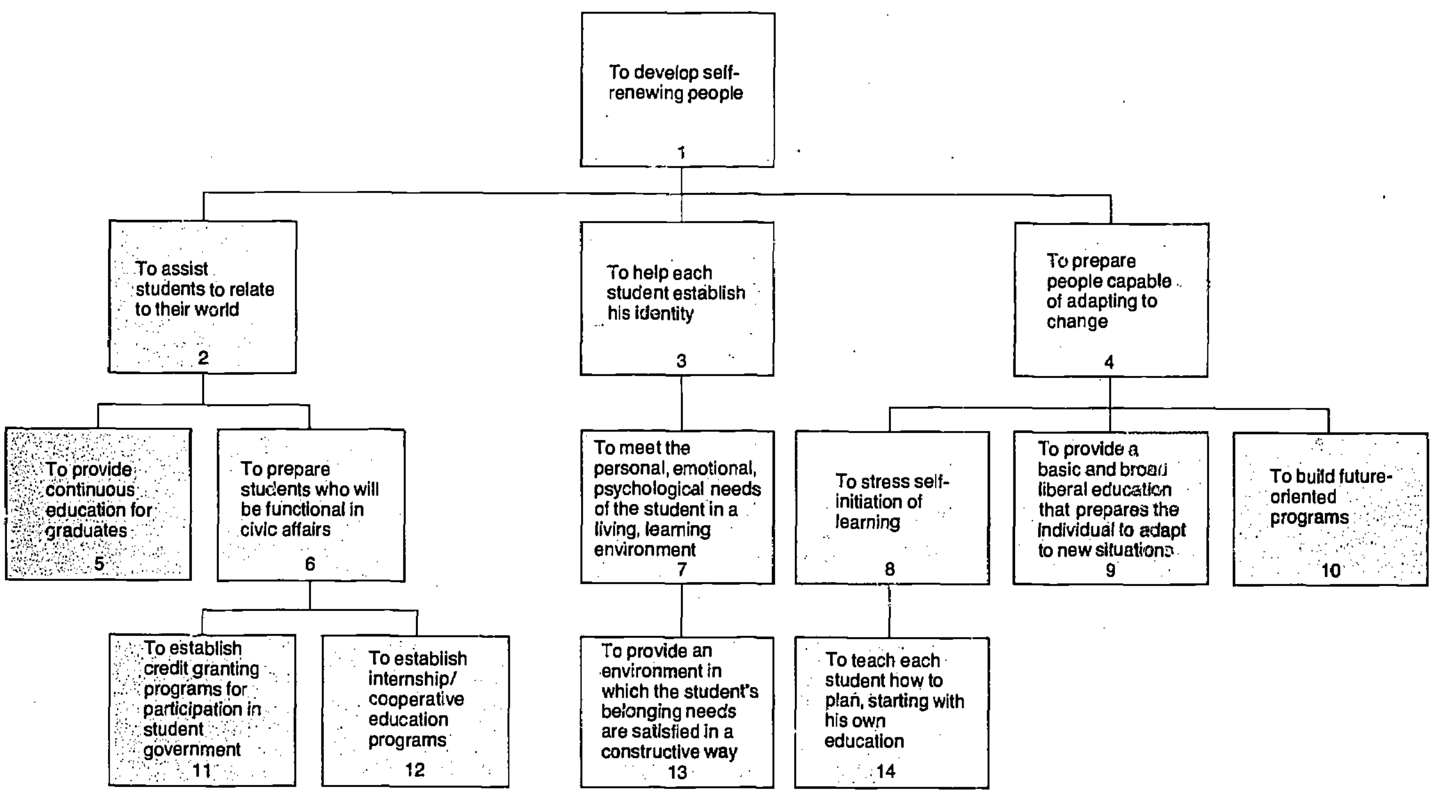
"When goals are lacking, or not clearly expressed, conflicts may occur at middle management levels and lead to compromise solutions which are invisible to top management and not in the best interests of the corporation."

Warfield[1] explains that most of these problems can be overcome, or at least minimized, through the methodology of *intent structures*. An intent structure is a multilevel, hierarchical array of goals. Objectives may also be included in the overall intent structure. However, it is generally best, particularly in the early stages of goal definition, to omit any consideration of time, or comparative time phasing. Thus, time constraints appearing in objectives should be neglected at this stage. Accordingly, the general term *intentions* is used in this discussion to denote *both* goals and objectives specified without constraints of time.

A modern university is characterized by a multiplicity of intentions. These are interconnected so that some reinforce others; others are independent of one another. Thus, a hierarchy of intentions can be discerned and shown as a *graph*. An example of part of such a graph for a university was given by Warfield[3] and is reproduced in Figure (5). This is a special type of graph known to mathematicians as a *tree* for reasons obvious from an inspection of Figure (5). Although the tree form is fairly common, it is probable that most graphs

FIGURE 5

Part of a University's Objectives Tree



of organizational intentions are not simple trees.

The relationships between the various intentions may be any one of three types:

(1) To attain intention A it is first necessary to attain intentions B, C, D, etc. Thus, B, C, D, etc., are *necessities for* the achievement of intention A. In the hierarchy of intentions it is clearly necessary that B, C, D, etc., fall below A as shown in Figure (6 a). In logic theory this is known as an AND logic element.

(2) Intention A can be attained if *any* one or combination of intentions B, C, D, etc., and their various combinations, are achieved. Thus, there are many *alternatives*, or different ways, to achieve intention A. Consequently, in the hierarchy of intentions, the alternatives B, C, D, etc., always falls below intention A as shown in Figure (6 b). In logic theory this is known as an *inclusive* OR element.

(3) Intention A can be attained by achieving the subordinate intentions B, or C, or D, but *not* by attaining them collectively. In this case the alternatives are mutually *exclusive*, rather than inclusive. Not surprisingly, this is known as an *exclusive* OR element. As shown in Figure (6 c), the exclusive alternatives B, C, D, etc., fall below A in the hierarchy of intentions.

The addition of these logic elements to the graph of intentions produces the characteristic *intent structure* of the organization.

The use of these graphs and logic functions can be very helpful in the identification of the interrelationship between organizational intentions. It is a systematic approach to dealing with complexity that does not bog down into excessive formalism. Moreover, as Warfield[1] notes, the elimination of time sequencing at this stage in the planning process permits concentration upon the important initial issues:

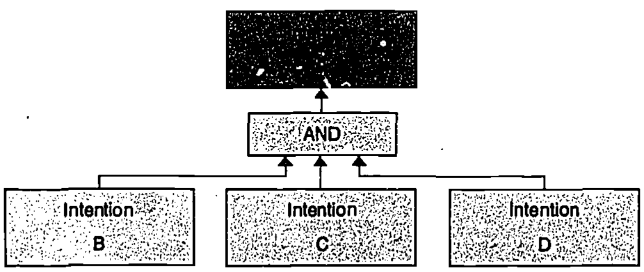
(1) What is it that the organization is to accomplish?

(2) What are the alternative ways to accomplish these intentions?

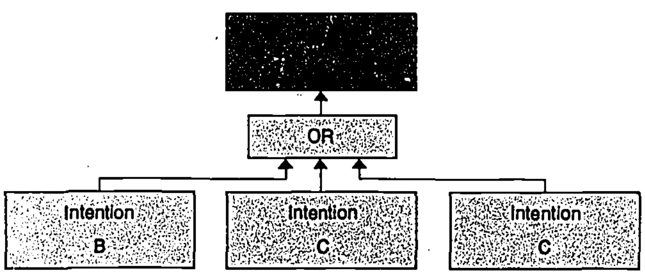
It is generally not possible to construct an organizational intent structure systematically. Rather, an intensive effort is mounted initially to identify as many intentions as possible without regard to their interconnection or position in the hierarchy. Once these have been assembled, trial and error plus revision of intentions are used to develop the hierarchy and logic elements in accordance with some organizational value structure.

FIGURE 6

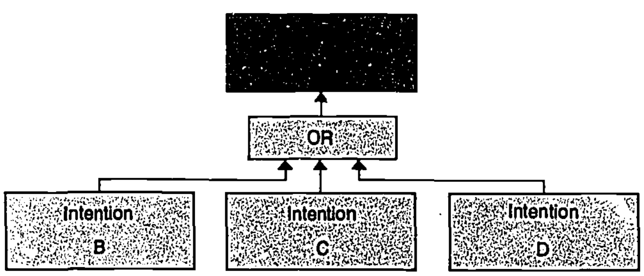
Logic Elements Found in Intent Structures



(*a*) The AND function: attainment of intentions B, C, D, is necessary to achieve intention A.



(b) The inclusive OR element: intention A is achieved if any one or combination of intentions B, C, D are attained.



(c) The exclusive OR element: intention A is achieved only by attaining intention B, or C, or D, but not by attaining them collectively.

A *self-interaction* matrix (2) is a useful tool to aid in developing the graph of intentions. Such a matrix is shown in Figure (7) for a case of 15 intentions. Thus, for example, if intention 1 depends upon intention 3, this interaction is indicated by blackening the square corresponding to the intersection of intentions 1 and 3. Figure (8) shows the interaction matrix for the graph of university intentions of Figure (5). While this matrix contains exactly the same information as the graph:

(1) The matrix is most useful in the early stages when intentions are being ranked relative to one another.

(2) The graph is most useful in visualizing and understanding the complex structure of organizational intentions.

Educational Objectives

At this point we return to the specifics of the technique of strategic budgeting through OST. As has been shown, Objectives are specific quantitative statements of purpose clearly enunciating university intentions. They permit the measurement of progress and show that organizations are always characterized by a multiplicity of interrelated objectives.

Educational objectives may be specified in terms of the following quantitative objective measures, but are not limited to these:

(1) enrollment; also distribution of commuting and residential students
(2) faculty size
(3) faculty qualifications
(4) annual degree production; by level, by field; new fields
(5) cost of producing each degree
(6) enrollment per course; per curriculum; per professor
(7) number and dollar value of research contracts; degree of agency penetration
(8) expenditure rates on contracts; invoicing time
(9) research dollars per graduate student
(10) faculty teaching and/or research productivity
(11) faculty Ph.D. productivity
(12) space utilization
(13) enrollment per degree program
(14) distribution of students by geogrophy, sex, ethnic group, or area of study

These are only suggestive areas for objectives. Others in student health care, building maintenance, public service and the like can also be identified. The key point, to once again quote Dove,[32] is that the Objectives should be set as a "shocking challenge to jolt (department heads) away from traditional, in-a-rut thinking." An objective such as — To reduce tuition by 20 percent in three years — is indicative of the sort of shock that is desired.

In the general sense, it is the responsibility of the president to set the objectives for the university in consultation with appropriate advisors and with the approval of his governing board. Deans and other administrative heads are responsible for setting the objectives of their respective units, and in such ways as to contribute to and support the university goals and objectives

FIGURE 7

Self-interaction Matrix Useful in Developing Graphs of Intentions

Intentions	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															

FIGURE 8

Self-interaction Matrix for The Tree of Intentions Shown in Figure (5)

Intentions	14	13	12	11	10	9	8	7	6	5	4	3	2	1
1											X	X	X	
2									X	X				
3								X						
4					X	X	X							
5														
6			X	X										
7		X												
8	X													
9														
10														
11														
12														
13														
14														

within the specified time period of each.

The foregoing statement regarding the matter for setting objectives suggests that they originate at the top. This could well be the case; but it is more likely that the original impetus came from elsewhere. For example, a professor in the Civil Engineering Department might observe that the ability of his department to attract students would be greatly enhanced by the acquisition of a faculty member with a background in Operations Research. As the suggestion moves upward through the department head, to the dean, to the office of the president, similar needs are perceived in Electrical, Industrial and Mechanical Engineering, in the Business School and in Computer Science. Out of this might come the eventual objective to establish a capability in the field of Operations Research to serve the needs of the entire university — to acquire this capability and to enroll 100 full-time undergraduate students majoring in Operations Research within ten years. It is important to note that the objective does not tell *how* it is to be accomplished; for example, a department of Operations Research could be set up; or capabilities could be introduced into the various interested departments and an interdepartmental program established, and so on. These are *strategies* which aim to achieve the objective. The strength of OST is that it separates the Objective from the means of its accomplishment — thereby encouraging courage in setting objectives and innovativeness in devising strategies.

Objectives must be set to produce a maximum contribution toward the achievement of university goals; but they must also be realistically achievable rather than mere wishful thinking. Therefore, each objective must be supported by a written statement which provides specific answers to the following questions:

Concerning the Objective

(1) What is the specific quantitative Objective and the date for its accomplishment?

(2) Is the Objective associated with the entire university? If it is owned by subordinate units — schools, institutes, departments — who are they?

(3) What is the present performance of the affected units relative to this Objective?

Concerning the Characteristics and Capabilities

(4) In the abstract and general sense, what fundamental characteristics and capabilities define the unit, or units, involved with the Objective?
   (a) Which of these are essential, or fundamental to the success of the unit?
   (b) Which of these will determine if the objective can be achieved?

(5) Which of the characteristics and capabilities described in (4) are
   (a) existing strengths in the affected units?
   (b) Which are existing weaknesses?

(6) To achieve the Objective
   (a) what capabilities need strengthening and at what estimated cost?
   (b) What new capabilities need to be developed, and at what cost?
   (c) To what extent, if any, do the new or strengthened capabilities conflict, overlap, or augment the activities of other administrative units?

Concerning the Unexpected

(7) What external influences and limitations may interfere with the achievement of the Objective?

(8) What contingencies and/or uncertainties in the achievement of the Objective are introduced by the negative factors listed in (7)?

With the Objectives fully documented by the responses to these questions, the next and most important step is to devise the Strategies, the long-range plans, by which these Objectives will be achieved.

Strategies

Strategies are selected plans by which resources are deliberately aligned to capitalize an opportunity despite potential limiting factors. They outline the broad actions and innovations required over the planned period to reach the Objective, designate critical check points, and assign responsibility for accomplishment. At least one Strategy must be developed for each Objective, although one Strategy may often contribute to more than one Objective. Moreover, more than one Strategy may support a given Objective.

Although all strategies possess the same general characteristics, it is helpful to distinguish three different types:

(1) Educational or research strategies
(2) Financial enhancement strategies
(3) Organizational support strategies

Each of these is described briefly in the paragraphs that follow.

Educational or *Research Strategies* are those which are basically academically oriented. Their purpose is to assure a position of creative leadership rather than a responding acceptance-type posture which provides for mere participation rather than aggressive innovation. Such strategies are associated with such objective measures as enrollment, degrees produced, research volume, and so on. Earlier an example of an Objective was given as follows:

To establish a capability in Operations Research to serve the needs of the entire university and to enroll 100 undergraduate majors, all within ten years.

The creation of a new department to achieve this would be one example of an educational strategy. An alternative strategy might be to expand the charter of another department, Computer Science or Statistics or applied Mathematics, to encompass Operations Research.

Financial Enhancement Strategies are internally oriented to control costs and/or expenses. These are long term and may be university wide, or could relate to a single school or department. Their progress is related to such objective measures as faculty productivity, cost per FTE student, graduate students per dollar of research support, and so on. For example, an objective could be to increase faculty productivity from 270 student credit hours per year to 350 over a seven-year period. One way to accomplish this, one strategy, would be to keep faculty acquisitions below losses on a schedule to achieve the Objective.

Another strategy concerned with student recruiting could also be involved. Both are financial enhancement strategies.

Organizational Support Strategies refer to strategies associated with necessary staff and support functions such as the central shops, libraries, the computing center, admissions office, registrar, and other administrative activities. For example, an Objective in this area might be to increase undergraduate student use of the library resources by 25 percent in five years. Possible strategies could then involve the opening of branch libraries, one possibly in the Student Center.

The Strategy Manager is the key figure in this entire system of operation. Ordinarily, he will be a dean, vice president, department head, or head of some administrative unit, but professors and staff members may also serve. Once appointed by the president (or dean as appropriate), the Strategy Manager must:

(1) Think through and develop a long-range course of action for the effective use of resources to achieve the Objective.
(2) Formalize the Strategy in the prescribed format
(3) Insure the successful pursuit and accomplishment of the Strategy.
(4) Hold periodic reviews to evaluate performance on specific tactical action programs.

The formalization of a Strategy involves four basic steps: (1) the Strategy Statement, (2) identification of major long-range checkpoints, (3) evaluation of contribution and impact, and (4) an estimate of success probability. Each of these is discussed briefly in the section that follows.

Strategy Statements

As noted earlier, each Objective must be supported by at least one strategy. However, there can be several strategies for each Objective and each Strategy can support several Objectives. A *Strategy Statement* is a written scenario of the Strategy detailing the principal opportunity to which the Strategy is oriented, the innovations necessary, the obstacles to be encountered and the commitments required for achievement. A strategy ordinarily encompasses a long-time span of five to 15 years. Thus, the Strategy Statement must be comprehensive and complete.

These considerations are represented in the following five Strategy Statements which *must* be made:

(1) Opportunity: This statement examines the needs to be satisfied and the problems to be solved. The solutions to these needs and problems represent *opportunities* to reach the Objective which this strategy supports. The purpose of this statement is to *create opportunities*, thereby avoiding mere response or reaction to opportunities. Thus, the problem or need must be understood well enough so that a solution can be identified before it becomes critical. This creates opportunities.
(2) Innovations required: Identification of the innovations needed for the success of the Strategy is the single most important matter. The critical innovation, regardless of character, can provide the step function for growth opportunity. The support necessary for achieving the innovation, the resulting impact of the innovation, and possible alternative innovation considerations must be described. The required innovation may consist of a group or sequence of innovations over a period of time. If so, their interdependence and optional approaches should be explained, particularly when several different administrative units are involved.
(3) Competitive action: Competitive action may appear in a variety of ways — by directly competing programs or services, faculty or student recruitment programs of other institutions, or a new program or institution that eliminates the need for a current program. An analysis of current and potential competition Strategies must be developed. The impact of the proposed Strategy on competition must be developed together with a description of how this impact may be exploited.
(4) Contingencies: In any long-term program there are contingencies that can alter significantly any planned course of action. Such contingencies can arise from many sources — government action (wars, laws, regulations, new state schools, and so on), industry associations, high school programs, economic expansion or deflation, and so on. The most significant contingencies must be identified and their impacts analyzed.
(5) Major Commitments: Once a strategic program is developed, its implementation requires commitments of people, facilities, organizations, finances, and so on. Both the near and long-term commitments of these items must be delineated specifically. Those commitments which will be required and which are significant departures from current operations should be presented and explained clearly: those implemented are the initial manifestation of the establishment of the Strategy.

This completes the Scenario for the Strategy.

An essential ingredient in the formalization of a strategy is the identification of *checkpoints,* or milestones. The major long-range checkpoints represent a sequence of key accomplishments considered necessary for the success of the Strategy. Although near-term checkpoints are more readily identified, even tentative long-range checkpoints and actions should be described: otherwise there is no basis for evaluating the direction of the needed near-term effort. A flow chart or diagram is usually helpful in developing these checkpoints. Tactical Action Programs (TAP's) are actions aimed at achieving each of these checkpoints within the Strategy.

The Strategy is completed by a statement designed to indicate its probable results. Because the success probability will vary with time, it should be expressed for each year.

Capital requirements, personnel, and financial commitments must be evaluated relative to the impact on current operations, compared to the gains to be secured, and their estimated payoff probabilities.

Tactical Action Programs "TAP's" And Decision Packages

Tactical Action Programs (TAP's) are discrete action programs aimed to achieve each major checkpoint or milestone in a given strategy. There may be more than one TAP per milestone. Or, one TAP may contribute to the achievement of more than one checkpoint. In any case, the TAP required for each strategic milestone must specify explicitly:

(1) The title of the program (TAP Title)
  (a) The Strategy which it supports.
  (b) and the Objective the Strategy supports.
  (c) The strategic checkpoint it aims to achieve.
(2) The name of the person responsible for the TAP.
(3) The start and completion dates of the activity. These should range from six to 18 months.
(4) A quantitative statement explaining how the program will contribute to reaching the strategic checkpoint.
(5) An accurate, nonambiguous statement of support requirements of personnel, facilities, finance, and so on.
(6) A step-by-step statement of measurable tactical activities, using a schedule bar graph or PERT Network, to show each start and stop date, the person responsible and the commitments of resources.

This information can generally be confined to a page or two by devising appropriate forms.

The eventual output desired from this process is a set of rank-ordered strategic decision packages which can then be considered in parallel with the decision packages produced for the operating budget by Zero-base Budgeting procedures. It sometimes happens that certain TAP's can be treated as decision packages. However, in other cases, the TAP's may fall rather logically into groupings which form stand-alone decision packages. In any event, all of the TAP's, either singly or in groups, must be organized into Strategy decision packages using the format for presentation described in Zero-base Budgeting.

Once the strategic decision packages are identified, they must be ranked and a cutoff process applied similar to that used in ZBB. The rank-ordered list of decision packages then moves up through the OST hierarchy in the consolidation and cutoff process. The process was then explained by Dove[17] as follows:

"The tactics are then grouped into logical, stand-alone decision packages which are rank ordered by the Strategy Managers. Based upon the guidelines for strategic funding, a cutoff line is drawn, and packages above the line are given a tentative approval. Those falling below the line . . . remain in . . . (the) 'creative backlog' and have an opportunity to move up for approval at a later time when resources become available. This process is repeated at the Objective level, where adjustments in the allocation between strategies may be made and decision packages falling below the cutoff line at the Strategy level have another opportunity for approval . . . Finally, a segment of the strategic funding is allocated directly at the corporate level to certain decision packages. This is primarily a method for starting new ventures which for many reasons, might not be started by one of the divisions."

It is clear that this process is exactly equivalent to that followed in Zero-base Budgeting.

It is clear that the OST process yields a hierarchical set of objectives that usually, but not always, follows the hierarchy of the organization. This is so because Tactics are usually carried out by department heads, Strategies by deans, and Objectives commonly are enunciated at the presidential level. There are some exceptions, however. But, mainly, the administrative hierarchy coincides with the OST hierarchy of goals. Correspondingly, in most cases, decision packages will be consolidated first at the deans' level (Strategy Managers) and then passed on to the presidential Objectives) level. But, despite this, the Strategy Manager can reach across school and departmental boundaries to implement his TAP's so the system does get around the usual organizational rigidities. This can be understood from the sketch shown in Figure (9). The basic university organization is shown at the top and the OST structure at the left. Each X denotes responsibility for a TAP.

After approval, decision packages are disaggregated into TAP's, individual assignments are made for each tactic,and a system of periodic TAP review is instituted.

FIGURE 9

The OST and Operating Matrix

			THE UNIVERSITY									
			Institute of Technology			School of Humanities and Sciences						
			CE/ME Dept	EE Dept	CS/OR Dept	Phys Dept	Math Dept	Chem Dept	Biol Dept	Econ Dept	Soc Dept	Geol Dept
1	A	1	X									
		2							X			
	B	1		X								
		2			X							
		3				X						
	C	1						X				
2	A	1		X								
		2	X									
		3										X
		4			X							
	B	1	X									
		2		X								
		etc.										

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Freshman Engineering Enrollment

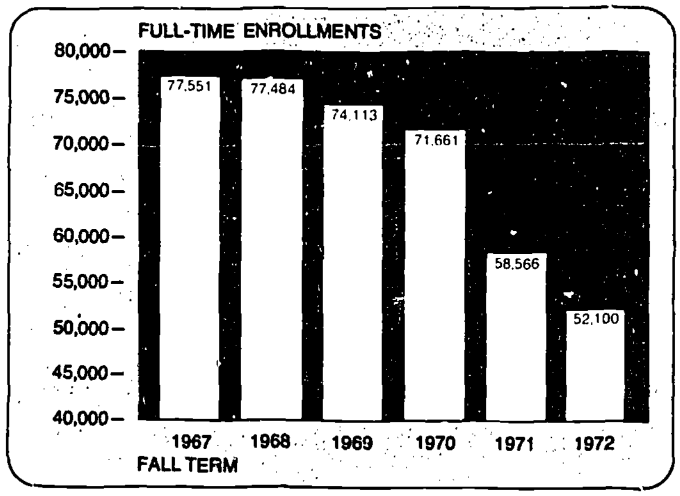
From the mid 1960's through 1970, the number of freshmen enrolled at Southern Methodist University increased from 96 in 1965 to 192 in 1970. This steady rise in admissions was the direct result of a reorganization of the Engineering School at SMU. The reorganizing of the Institute of Technology brought new programs of study, and a strong recruiting program was launched. As shown in Figure (10), the rise in freshman enrollment through 1970 actually ran counter to the national trend for freshman engineering enrollment.[1] In the late 1960's, the competition among engineering schools for top high-school graduates sharpened as the pool of potential freshman engineering students began to decline across the country. The drop in freshman enrollments at SMU in 1969 was the direct result of intense competition in the Southwest region. The sharp falloff in freshman registrations since 1970, which followed the national trend, can be attributed to two important factors: the "bad press" given the engineering profession and the changing pattern of educational options for high-school graduates. Another significant deterrent to freshman enrollment at the SMU Institute of Technology has been the sharp rise in tuition and fees since 1970.

The quality of the students attracted to engineering at SMU has remained high as measured by college entrance test scores shown in Figure (11). Fortunately, the trends in freshman enrollment appear to be turning up again, and engineering educators are more optimistic as they view freshman enrollment predictions for the fall of 1973. This is definitely the case at the SMU Institute of Technology where there has been a more favorable response to recruiting efforts and a marked rise in admissions activity.

[1] *Engineering Manpower Commission of Engineers Joint Council, "Engineering and Technology Enrollments," Fall, 1972, p. 11.*

FIGURE 10

Freshman Engineering Enrollment
All Schools Offering Engineering Programs



SMU Institute of Technology

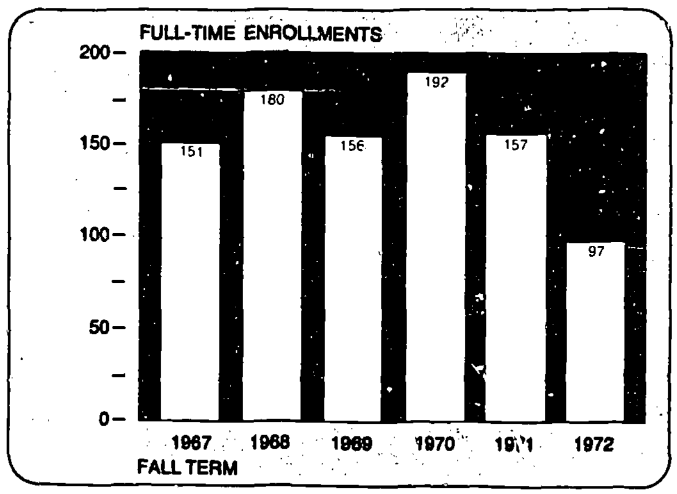


FIGURE 11

Freshman Engineering Student Characteristics

1966	62	22	15	1	532	612	1144
1967	79	21	0	0	551	642	1193
1968	81	19	0	0	561	654	1215
1969	82	18	0	0	556	652	1208
1970	85	15	0	0	568	647	1215
1971	89	11	0	0	565	667	1232
1972	87	13	0	0	568	660	1228

FALL TERM

Total Undergraduate Engineering Enrollment

The rise in freshman enrollment along with an increase in sophomore transfers, in the period from 1966 through 1970, caused the total undergraduate engineering population at SMU to rise steadily even though the number of students registered in engineering schools across the nation began to decline in the late 1960's.[1] See Figure (12). The drop in undergraduate engineering registrations at SMU since 1970 to some extent reflects the results of the falloff in freshman enrollment, but more than that, it points up an attrition problem occurring at the sophomore and junior level. The reports of mass layoffs of practicing engineers and the invisioned slim prospects for employment upon graduation caused a significant number of upper-division students to reconsider their career goals and transfer to other preprofessional programs such as prelaw and premedicine. The impact of the freshman enrollment problem and the attrition of upper-division students will be felt for some time. On the plus side, however, the word is getting out to students that employment prospects for engineering graduates are very good, and it is expected that the strong employment situation for graduates and practicing engineers will alleviate this temporary attrition problem.

The prospects for increasing the number of undergraduate engineers at SMU are actually very bright at present because of a new program aimed at enrolling persons employed as technicians in professional engineering degree programs.

The plan, developed in conjunction with Texas Instruments Incorporated of Dallas, is in a sense a reverse of the traditional co-operative education plan. Instead of students leaving the campus for an employment experience, employees are coming to the campus for regularly scheduled undergraduate course offerings on a half-time basis and are continuing in their jobs half-time while receiving full pay. More than 40 Texas Instruments employees with some engineering education background have registered for summer refresher courses, and the number of students in the program is expected to reach as many as 75 for the 1973 fall term. In addition to providing the needed engineering talent for their employer, this arrangement will more than offset the declining freshman enrollment and attrition problems of the past two years. As the students currently registered for the program progress toward their degree goal, it is anticipated that other employers in the North Texas area will consider similar arrangements for their employees.

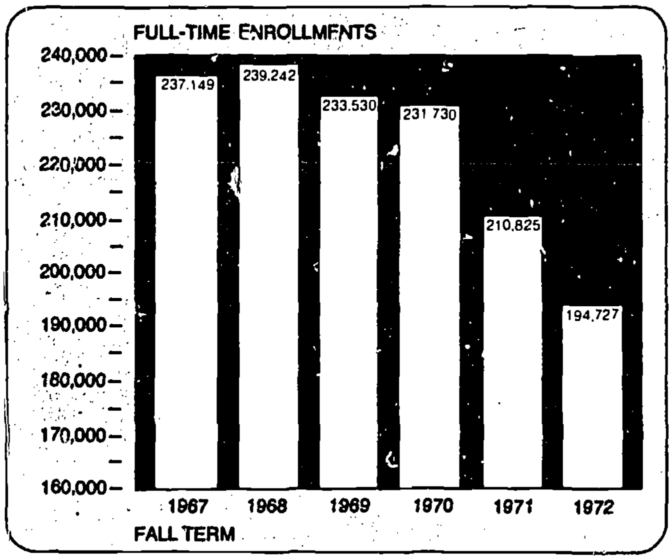
The Undergraduate Engineering Co-operative Program

Co-operative education has been an important program since the inception of the Engineering School at SMU in 1925. Originally, the Co-op Plan, combining alternating periods of study and engineering work in

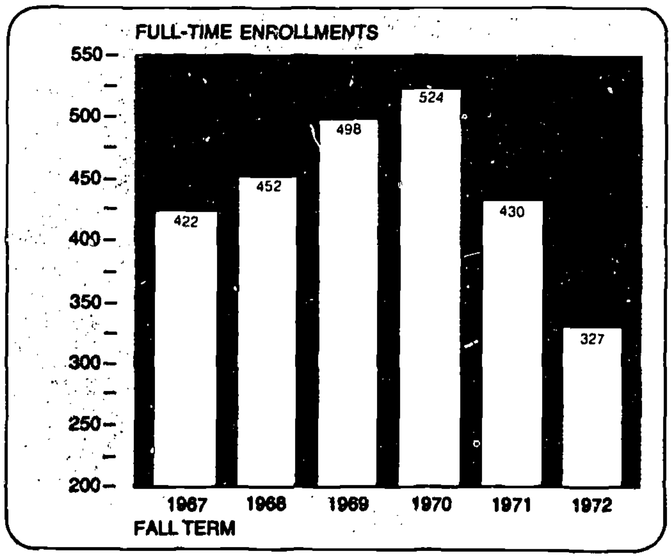
[1] ibid p 11

FIGURE 12

Undergraduate Engineering Enrollments
All Schools Offering Engineering Programs



SMU Institute of Technology



industry, was a requirement for all students. The plan was made voluntary in 1965. Figure (13) shows the trends of student participation in the plan. It appears that a relatively stable situation has been achieved with the total number of students enrolled in the plan remaining constant. During the past year, industrial demand for co-op students has been strengthening and far exceeds the number of students available.

The companies participating in the Co-op Program in 1972-73 are:

Baylor University Medical Center
Blue Cross-Blue Shield of Texas
Herman Blum Associates
Bell Helicopter Company
City of Dallas
Core Laboratories, Inc.
Dallas Power and Light Company
E-Systems, Incorporated
General Electric Corporation (Tyler, Texas)
Haggar Company
Albert H. Halff and Associates, Inc.
LTV Corporation
Mobil Oil Group
Raymond D. Nasher Company
NASA
Otis Engineering Corporation
Southwestern Bell Telephone Company
(Dallas and Houston)
Teleswitcher Corporation
Texas Highway Department
U. S. Air Force (Security Service, San Antonio)
Weben Industries
Western Union

Graduate Engineering Enrollment

Figure (14) compares the changes in full-time student enrollment levels for all U. S. schools offering graduate engineering programs with the enrollment in graduate engineering at SMU.[1] It should be noted that SMU enrollments are shown using the full-time equivalent measure rather than the head-count statistic. The full-time equivalent more accurately reflects the graduate programs at SMU because all of the industrial students are enrolled in regularly scheduled graduate course sections with on-campus students. The only difference is that the students from industry participate in the courses via the TAGER Television System, the closed circuit "talk-back" TV network which interconnects North Texas industry and North Texas higher education.

[1]ibid: p. 11.

FIGURE 13

Engineering Cooperative Program

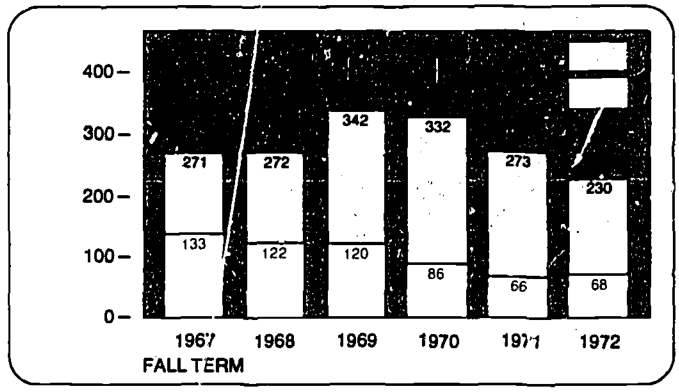
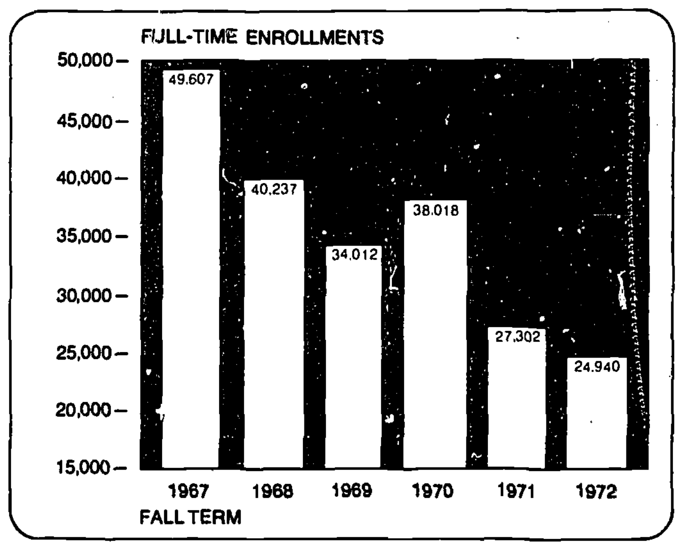
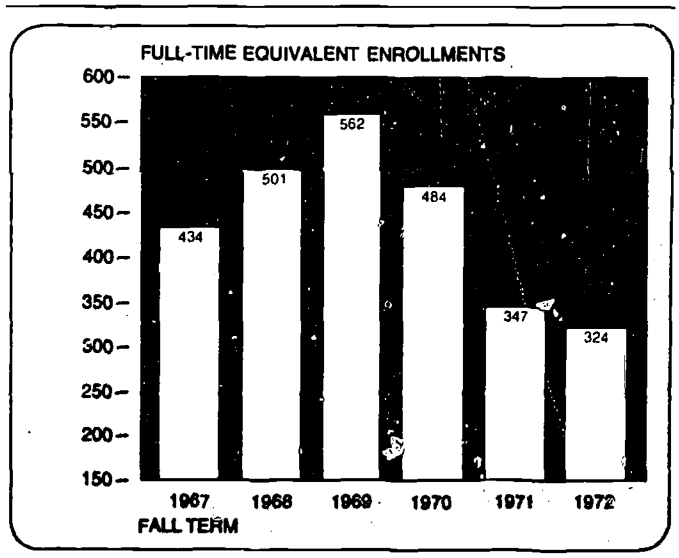


FIGURE 14

Graduate Engineering Enrollment
All Schools Offering Engineering Programs



SMU Institute of Technology



The sharp rise in graduate enrollments in 1968 and 1969 reflects the growth of the North Texas science-based industries and the overall strengthening of the quality of the Institute's graduate programs. This is apparent in Figure (15) which shows the graduate enrollment head count. Again, prior to 1970, as was the case with the undergraduate population, the enrollment increases recorded at the graduate level countered the decline which appeared on the national scene in 1968. The dramatic cutbacks in federal spending, coupled with the industrial recession, caused enrollments to fall off rapidly from 1970 through 1972. This downturn resulted in the loss of large numbers of industrial students enrolled via the TAGER TV Network.

The TAGER Television System

Since the inception of the TAGER television network in 1967, almost all of the graduate courses offered by the Institute have been presented on the network to the various industrial affiliates. The enrollment pattern on the network is shown in Figure (16). The effect of the declining economic situation in the science-based industries is apparent from this distribution and Figure (17).

The number of industrial students enrolled in graduate courses offered by the Institute is a function of the number of "new hires" of engineers by the TAGER industrial affiliates. Since 1969, the number of "new hires" by industrial affiliates has been greatly reduced while in the same period the unusually large number of graduate degrees awarded has had the effect of pumping out the pool of available graduate engineering students. Figure (18), which shows a comparison of on-campus and off-campus enrollments on the network by academic centers, indicates a slight rise in off-campus enrollments for 1973 and suggests that the increase in "new hires" by industrial affiliates, which occurred in early 1972, is beginning to show a positive impact on the off-campus enrollment category. The decline in on-campus graduate enrollments shown in this figure can be attributed to the shifting patterns in federally sponsored research which resulted in a reduction of the amount of support available for full-time graduate students.

Graduate Degree Production

Master's Degree

The number of Master's degrees conferred in 1972 held up well and is still above the 1968 and 1969 levels, as shown in Figure (19). For the past several years, including 1972, the Institute of Technology has been the leading producer of Master's degrees in Texas and, in this category, ranks above all engineering schools in the South and Southeast with the exception of Georgia Institute of Technology. The sharp increase in Master's degrees conferred in 1970 and 1971 served to reduce the pool of Master's degree candidates, but it is likely that the number of degrees to be awarded in the next two years will hold constant with the possibility of a slight decline.

FIGURE 15

Graduate Engineering Enrollment

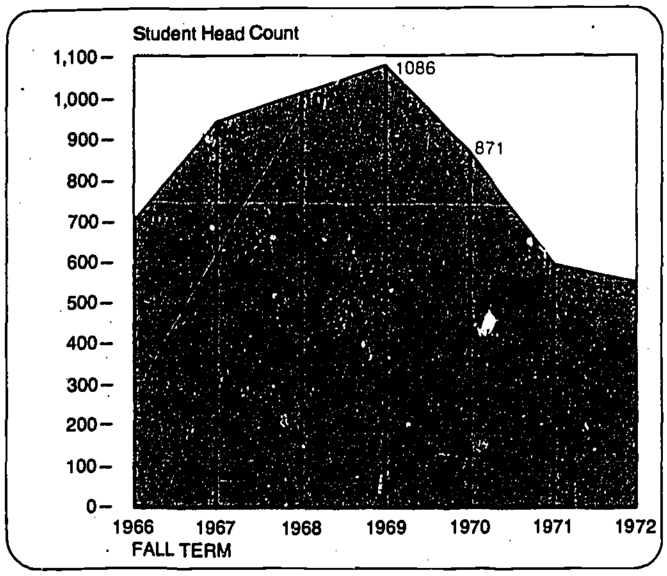


FIGURE 16

Geographical Distribution of TV Enrollments

Atlantic Richfield		7			3	1
Collins Radio	8					
E-Systems—Garland	3				12	11
General Dynamics	23	50	35	10	28	19
LTV—Grand Prairie	3	21	19	8	19	11
Mobil	3	12	11	1	4	4
Texas Instruments Dallas	38	169	163	53	210	174
Texas Instruments Sherman			2		1	3
SMU-On-Campus	122	406	378	65	367	331
Southwestern Medical School		2	2		1	2
Texas Christian University		1			5	1
Univ. of Dallas		1	3		3	2
Univ. of Texas at Dallas		5			4	5
Total	200	674	813	137	657	564

FIGURE 17

TV Enrollment

	1971-72 Year		Difference
	200		−63
	674		−13
	577		−13
	1451		−89

FIGURE 18

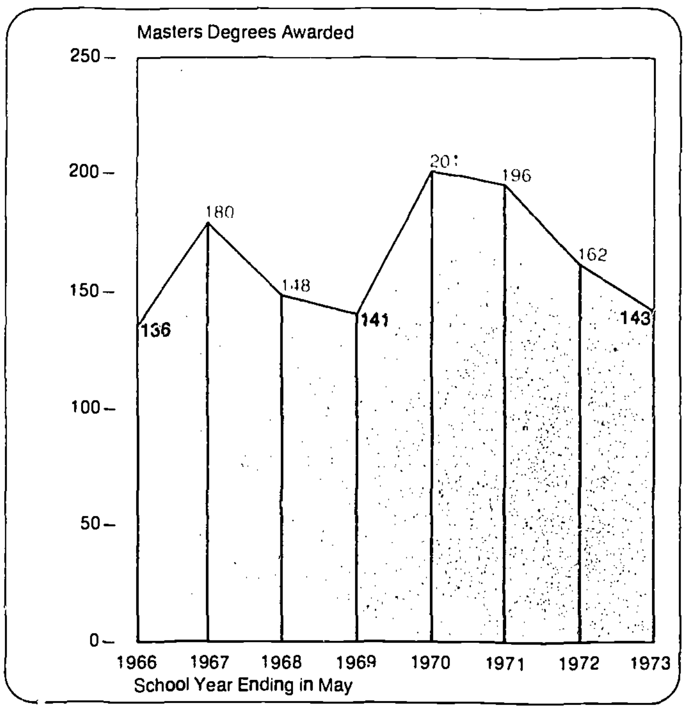
Graduate TV Enrollments by Centers (1971-1972 & 1972-1973)

Center	Summer 1971 off campus	Summer 1971 on campus	Summer 1971 total	Fall 1971 off campus	Fall 1971 on campus	Fall 1971 total	Spring 1972 off campus	Spring 1972 on campus	Spring 1972 total
Computer Science/ Operations Research	12	70	82	98	208	306	52	207	259
Electronic Sciences	0	0	0	35	39	74	31	32	63
Information/Control	49	39	88	99	121	220	94	88	182
Solid Mechanics	15	7	22	20	24	44	14	33	47
Thermal/ Fluid Sciences	2	6	8	16	14	30	10	16	26
	78	122	200	268	406	674	201	376	577
	11 Courses			35 Courses			33 Courses		

Center	Summer 1972 off campus	Summer 1972 on campus	Summer 1972 total	Fall 1972 off campus	Fall 1972 on campus	Fall 1972 total	Spring 1973 off campus	Spring 1973 on campus	Spring 1973 total
Computer Science/ Operations Research	22	46	68	85	196	281	81	172	253
Electronic Sciences	0	0	0	61	43	104	37	24	61
Information/Control	40	11	51	97	91	188	77	78	155
Solid Mechanics	6	4	10	17	18	35	27	25	52
Thermal/ Fluid Sciences	4	4	8	19	20	39	11	32	43
	72	65	137	279	368	647	233	331	564
	8 Courses			34 Courses			38 Courses		

FIGURE 19

Master's Degrees in Engineering



Doctoral Degrees

When the Doctoral program was launched in 1966, a goal of 25 Ph.D.'s per year was set for 1972. This goal was actually achieved in 1971, and 1972 turned out to be a banner year with the awarding of 42 Ph.D.'s. See Figure (20). The goal of a stable output of 25 to 30 Ph.D.'s a year is a reasonable expectation in light of the stable enrollments in the Doctoral program. Even though the large number of Ph.D.'s conferred in the past three years has reduced the number of Doctoral students in the pipeline, current enrollment still stands at 120. In addition to the Ph.D. candidates, 11 students are enrolled in the Doctor of Engineering degree program.

The Engineer's degree, which falls midway between the M.S. and the Doctorate, continues to meet a definite need. In 1971, 12 students received this degree, 13 were conferred in 1972, and 7 in 1973. There are presently 17 students enrolled in this degree program.

Graduate Engineering Prospects for the Future

Historically, graduate enrollments in engineering have responded to two outside forces: the employment situation for practicing engineers and the availability of sponsored research funds for graduate student support. These factors have been dominant during the past decade when the number of B.S. degrees being produced was essentially constant. Now, the marked decline in B.S. degree production will make itself felt, tending to offset increases that would otherwise occur because of improvements in the economy and federal support for university research. The challenge for the Institute of Technology and for all of engineering education is to find ways to recoup the losses in undergraduate students in recent years. The answer to this challenge may be in further developing new programs such as the forward-looking employee development plan instituted by Texas Instruments Incorporated, which was described earlier in this Report

A preoccupation with all of the factors causing the downward trend in graduate engineering education could well leave the interested observer in a permanent state of depression. Fortunately, there are signs which indicate the trend lines have bottomed out. Although no sharp upturns are predicted for graduate enrollments in the fall of 1973, there is plenty of reason to forecast some increase in enrollments in both fall and spring terms. There has been a definite increase in graduate level admissions activity from the "new hires," and former students who suspended their work on degree programs are again making enrollment inquiries. These prospects for a rise in graduate enrollments stem directly from the positive economic climate experienced by the science-based industries in the past 18 months.

FIGURE 20

Ph.D. Degrees in Engineering

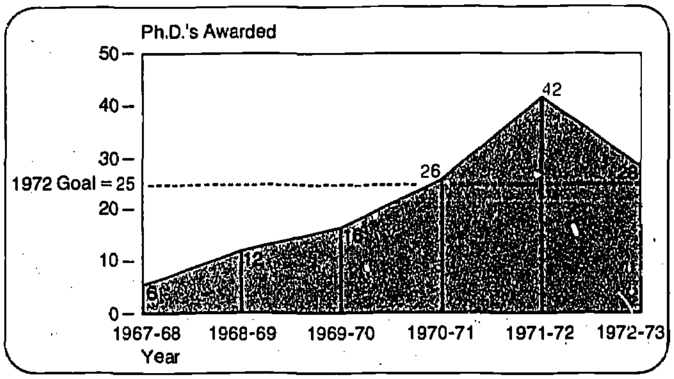


FIGURE 21

Expense Budget*

Item	1971-72	1972-73	Projected 1973-74
OFFICE OF THE DEAN			
Gen. Admin.	$ 254,295	[illegible]	$ 273,133
Contr. Media	49,762	[illegible]	50,800
Prof. Devl.	19,960	[illegible]	0
Foundation	130,850	[illegible]	41,780
Machine Shop	9,400	[illegible]	11,665
Computer Sci/Opr Res	245,357	[illegible]	316,264
Electronic Sciences (1)	185,087	[illegible]	0
Info & Control Sciences (1)	278,713	[illegible]	0
Electrical Eng Dept (1)	0	[illegible]	476,284
Solid Mechanics (2)	167,353	[illegible]	0
Thermal & Fluid Sciences (3)	175,515	[illegible]	0
Civil & Mech Eng Dept (2) (3)	0	[illegible]	295,107
Academic Computing Lab	0	[illegible]	279,155
TOTAL	$1,516,292	[illegible]	$1,744,188

(1) & (2) Formed ... Departments [illegible]

* Non-Federal Funds

Revenue/Expense Summary*

Item	1971-72	1972-73	1973-74
REVENUE			
Tuition [illegible]	$ 706,058	[illegible]	$ 680,000
[illegible]	36,900	[illegible]	30,000
[illegible]	11,000	[illegible]	—
[illegible]	69,224	[illegible]	70,033
[illegible]	35,000	[illegible]	35,000
SMU [illegible]	658,110	[illegible]	650,000
SMU [illegible]	0	[illegible]	279,155
TOTAL REVENUE	$1,516,292	[illegible]	$1,744,188
EXPENSES	$1,516,292	[illegible]	$1,744,188

* [illegible]

Semester Credit Hour Production

The basic unit of academic production is the student semester credit hour. Known as SCH, it is defined as the product of the enrollment in each class multiplied by the semester credit hours assigned to that course. The SCH production for the three terms of 1971-72, and 1972-73 is shown in Figure (22).

Reorganization of the Institute of Technology

A number of events intersected during the past year which suggested that the time had arrived to consider a rather simple but constructive reorganization of the Institute of Technology. This decision was strongly influenced by the reports of the visiting committees of the SMU Technical Advisory Council which were completed in the spring of 1972. All of the members of the Council hold positions of primary responsibility for research and development in science-based industrial firms in the North Texas Metroplex, and most of the members hold an earned doctorate in engineering. The Council provides an important link with the local technical community and serves in an advisory capacity to the Institute of Technology. The conclusions of the Council's visiting committees were confirmed by the ECPD (Engineering Council on Professional Development) inspection which was conducted in January of 1973. Also, it had been apparent to the faculty and the administration of the Institute, that there was a definite need for improvement in achieving coordination of the undergraduate programs and laboratory activities that should be characteristic with a school of a general quality corresponding to the Institute's goals.

The grid form of organization structure, which has been in operation at the Institute of Technology since 1967, was introduced as an administrative device to bring about a major change in the fundamental character of what was then known as the School of Engineering at SMU. The School of Engineering had on-going accredited programs in several fields of undergraduate engineering including Civil Engineering, Electrical Engineering, Industrial Engineering, and Mechanical Engineering.

The School's graduate programs were limited to the Master's degree and the Ph.D. in ME and EE; they were not as extensive or as comprehensive as local industry required. The grid structure was created with the formation of the five principal Engineering Science Centers.

(1) Computer Science Operations Research
(2) Electronic Sciences
(3) Information and Control Sciences
(4) Solid Mechanics
(5) Thermal Fluid Sciences

This organization permitted a major upgrading in the graduate programs and research activities of the Institute to the point where these operations at the Doctorate and Master's level are now comparable to those offered by the best schools in the United States. This conclusion agrees with observations by both the Technical Advisory Council and the recent ECPD inspectors. Thus, in viewing the possibility of change, it was considered to be essential that any plan for reorganization of the Institute preserve the strengths which have been developed while acting to correct weaknesses that had been observed.

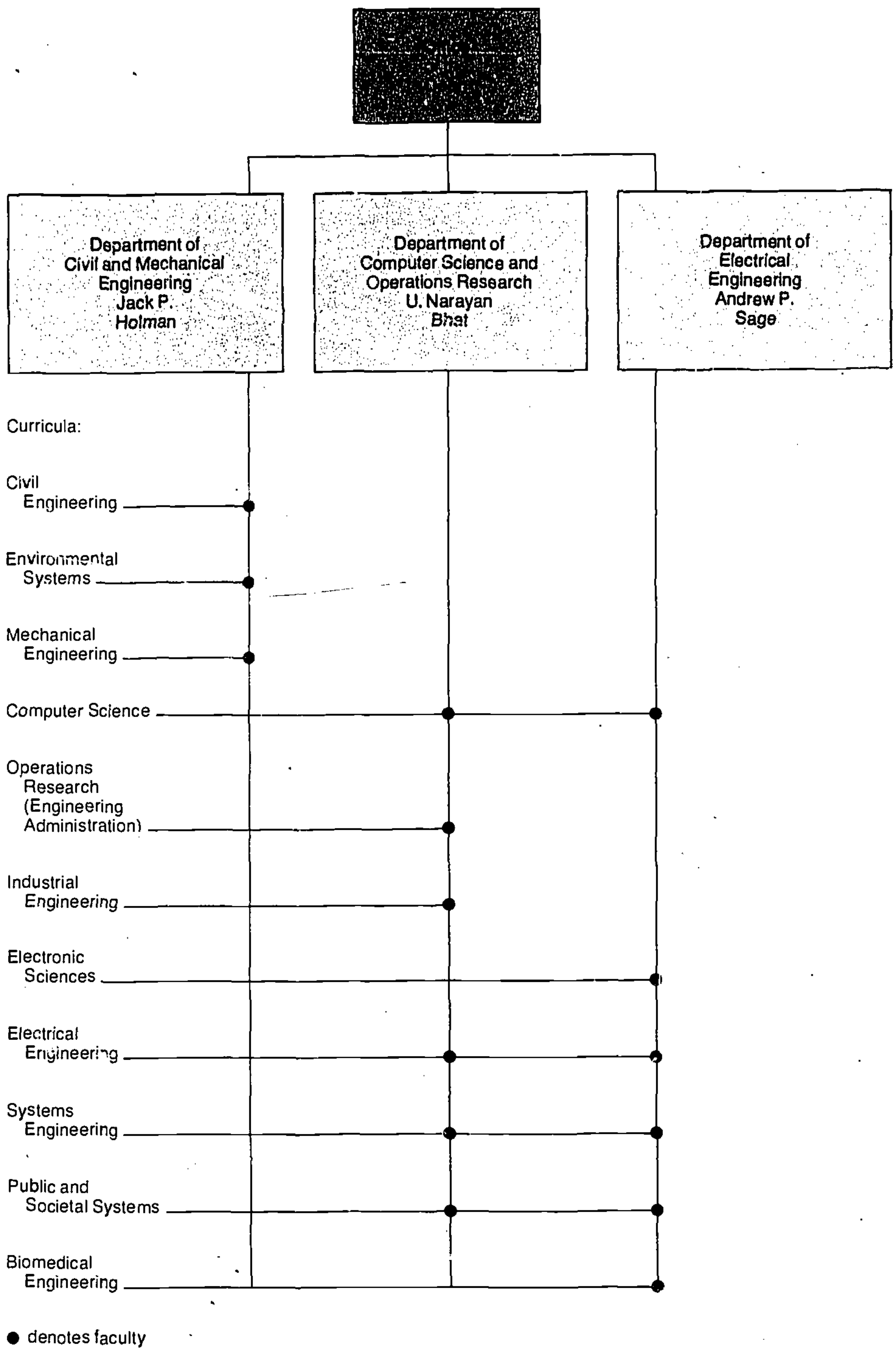
FIGURE 22

Semester Credit Hours Production

Term	Total SCHs	Undergrad SCHs	Graduate On Campus	SCHs Off Campus	Product Grad Total
Summer 1971	1,257	345	675	237	912
Fall 1971	5,356	2,383	2,169	804	2,973
Spring 1972	4,914	2,046	2,163	705	2,868
Total	11,527	4,774	5,007	1,746	6,753
Summer 1972	1,160	302	450	408	858
Fall 1972	5,121	2,192	2,155	774	2,929
Interterm 1973	6	0	6	0	6
Spring 1973	4,495	1,793	2,003	699	2,702
Total	10,782	4,287	4,614	1,881	6,495

The results of the reorganization effort are shown in Figure (23). The administrative responsibilities assigned in the revised structure provide a stronger focus on the responsibility for coordinating the undergraduate curriculum and enhancing the undergraduate student's professional identification.

FIGURE 23



FACULTY — As of May 31, 1973

Computer Science/Operations Research Center

Resident Faculty

U. Narayan Bhat
Professor and Director
Ph.D. (Stat) University of Western Australia
Leon Cooper
Associate Dean and Professor
Ph.D. (Ch.E.) Washington University
Dennis J. Frailey
Assistant Professor
Ph.D. (CS) Purdue University
Myron Ginsberg
Assistant Professor
Ph.D. (CS) University of Iowa
Harvey J. Greenberg
Associate Professor
Ph.D. (OR) Johns Hopkins University
Robert R. Korfhage
Professor
Ph.D. (Math) University of Michigan
Richard E. Nance
Associate Professor
Ph.D. (IE) Purdue University
William C. Nylin
Assistant Professor
Ph.D. (CS) Purdue University
Robert J. Smith, II
Assisant Professor
Ph.D. (CS) University of Missouri
Stephen A. Szygenda
Professor
Ph.D. (CS) Northwestern University
Alan C. Wheeler
Associate Professor
Ph.D. (Stat) Stanford University

Visiting Industrial Professors

Charles R. Blackburn, II
Assistant Professor
MBA (OR) Tulane University
Howell N. Forman, Jr.
Associate Professor
M.S. (IE) Southern Methodist University
Raj K. Minocha
Assistant Professor
M.S. (IE) University of Pittsburgh

Electronic Sciences Center

Resident Faculty

Kenneth L. Ashley
Professor
Ph.D. (EE) Carnegie-Mellon University
Jerome K. Butler
Associate Professor
Ph.D. (EE) University of Kansas
William N. Carr
Professor
Ph.D. (EE) Carnegie-Mellon University
Shirley S. C. Chu
Assistant Professor
Ph.D. (Chem.) University of Pittsburgh
Ting L. Chu
Professor
Ph.D. (Chem.) Washington University
Jon W. Eberle
Associate Professor
Ph.D. (EE) Ohio State University
Kenneth W. Heizer
Professor
Ph.D. (EE) University of Illinois
Lorn L. Howard
Professor
Ph.D. (EE) Michigan State University
William F. Leonard
Associate Professor
Ph.D. (EE) University of Virginia
Thomas L. Martin, Jr.
Professor
Ph.D. (EE) Stanford University
Charles R. Vail
Professor
Ph.D. (EE) University of Michigan

Visiting Industrial Professors

Gordon Cumming
Assistant Professor
Ph.D. (EE) University of Southern California
Jack S. Kilby
Professor
M.S. (EE) University of Illinois
Jack P. Mize
Associate Professor
Ph.D. (Phys.) Iowa State University
Jack Reynolds
Assistant Professor
Ph.D. (Phys.) University of Lund

Information and Control Sciences Center

Resident Faculty

David L. Cohn
Assistant Professor
Ph.D. (EE) MIT
Yumin Fu
Associate Professor
Ph.D. (EE) University of Illinois
Someshwar C. Gupta
Professor
Ph.D. (EE) University of California at Berkeley
James L. Melsa
Professor
Ph.D. (EE) University of Arizona
Louis R. Nardizzi
Associate Professor
Ph.D. (EE) University of Southern California
Behrouz Peikari
Associate Professor
Ph.D. (EE) University of California at Berkeley
Andrew P. Sage
Professor
Ph.D. (EE) Purdue University

John A. Savage
Professor
M.S. (EE) University of Texas
Edmund W. Schedler
Associate Professor
M.S. (EE) Oklahoma State University
Mandyam D. Srinath
Professor
Ph.D. (EE) University of Illinois
Finley W. Tatum
Professor
Ph.D. (EE) Texas A&M University

Visiting Industrial Professors

James M. Davis
Assistant Professor
Ph.D. (EE) University of Illinois
William S. Ewing
Assistant Professor
Ph.D. (EE) Southern Methodist University
Manus R. Foster
Professor
Ph.D. (Math-Physics) University of Kansas
Robert E. Griffin
Assistant Professor
Ph.D. (EE) Southern Methodist University
Gustave Hoehn
Associate Professor
Ph.D. (EE) Stanford University
Stephen K. Jones
Assistant Professor
Ph.D. (EE) Southern Methodist University
Lucien Masse
Professor
Ph.D. (Geophysics) Colorado School of Mines
J. Robert McLendon
Assistant Professor
Ph.D. (EE) Southern Methodist University
Theo J. Powell
Assistant Professor
Ph.D. (EE) University of Illinois

Solid Mechanics Center

Resident Faculty

Charles E. Balleisen
Professor
M.S. (ME) MIT
Jan Cernosek
Associate Professor
Ph. D. (Exper.Mech.) Technical University of Prague
LeVan Griffis
Professor
Ph.D. (CE) California Institute of Technology
David B. Johnson
Associate Professor
Ph.D. (EM) Stanford University
Robert M. Jones
Associate Professor
Ph.D. (Appl.Mech.) University of Illinois

W. Scott McDonald, Jr.
Associate Professor and Director
Ph.D. (EM) University of Kansas
Hal Watson, Jr.
Associate Professor
Ph.D. (EM) University of Texas
Marion W. Wilcox
Professor
Sc.D. (Engr.Sci.) University of Notre Dame

Visiting Industrial Professors

Bill L. Gunnin
Assistant Professor
Ph.D. (CE) University of Texas
Vernon A. Lee
Associate Professor
Ph.D. (AE) University of Texas
Robert C. McWherter
Assistant Professor
M.S. (AE) University of Texas
Raymond P. Peloubet
Associate Professor
M.A. (SE) Ohio State University
Kondhamur S. Rajagopalan
Assistant Professor
Ph.D. (CE) University of Texas
Edward M. Schall
Assistant Professor
Ph.D. (Appl.Mech.) Michigan State University
Wilbur C. Schoeller
Professor
Ph.D. (CE) University of Texas

Thermal and Fluid Sciences Center

Resident Faculty

Harold A. Blum
Professor
Ph.D. (Ch.E.) Northwestern University
Michael A. Collins
Assistant Professor
Ph.D. (CE) MIT
Carlos W. Coon
Associate Professor
Ph.D. (ME) University of Arizona
Jack P. Holman
Professor and Director
Ph.D. (ME) Oklahoma State University
Roger L. Simpson
Associate Professor
Ph.D. (ME) Stanford University
Cecil H. Smith
Associate Professor
Ph.D. (CE) University of Texas
Edmund E. Weynand
Professor
Sc.D. (ME) MIT
W. Gerald Wyatt
Associate Professor
Ph.D. (ME) University of Minnesota

Special Studies Center

Thomas P. Hughes
Professor
Ph.D. (History) University of Virginia

Adjunct Faculty from The University of Texas Health Science Center Southwestern Medical School at Dallas — Biomedical Engineering Program

Gunnar C. Blomqvist
Assistant Professor of Internal Medicine
M.D. University of Lund

Ivan E. Danhof
Associate Professor of Physiology
M.D. University of Texas Southwestern Medical School

Javad Fiuzat
Assistant Professor of Thoracic and Cardiovascular Surgery
M.D. University of Tehran

Charles F. Gregory
Professor of Orthopedic Surgery
M.D. Indiana University School of Medicine

Robert L. Johnson, Jr.
Assistant Professor of Internal Medicine
M.D. Northwestern Medical School

Robert M. Lebovitz
Assistant Professor of Physiology
Ph.D. (Neurophysics) University of California

Jere H. Mitchell
Professor of Internal Medicine and Physiology
M.D. University of Texas Southwestern Medical School

Steven P. Pakes
Associate Professor of Veterinary Medicine
DVM Ohio State University

Louis H. Paradies
Associate Professor of Orthopedic Surgery
M.D. Northwestern Medical School

John C. Porter
Professor of Physiology
Ph.D. (Phys.) Iowa State University

William J. Rea
Assistant Professor of Thoracic and Cardiovascular Surgery
M.D. Ohio State University College of Medicine

Floyd C. Rector, Jr.
Professor of Internal Medicine
M.D. University of Texas Southwestern Medical School

William E. Romans
Assistant Professor of Biophysics
M.S. (EE) Southern Methodist University

Winfred L. Sugg
Associate Professor of Thoracic and Cardiovascular Surgery
M.D. University of North Carolina School of Medicine

George H. Templeton
Assistant Professor of Physiology
Ph.D. (Biophys.) University of Texas Southwestern Medical School

John C. Vanatta
Professor of Physiology
M.D. Indiana University School of Medicine

Hal T. Weathersby
Professor of Anatomy
Ph.D. (Anatomy) Tulane University

Faculty Awards

Dr. James L. Melsa, Professor of Information and Control Sciences, received the 1972/73 Western Electric Fund Award of the American Society for Engineering Education, Gulf Southwest Section. This award was in recognition of his extensive and outstanding contributions to the engineering profession.

Also in 1972, Dr. Thomas P. Hughes, Professor of History of Technology, was awarded the Dexter Prize for his book, *Elmer Ambrose Sperry: Inventor and Engineer*. Dr. Hughes was singled out for this international honor by the Society for the History of Technology.

New Appointments

Dr. Jan Cernosek, Associate Professor of Solid Mechanics, joined the faculty of the Civil/Mechanical Engineering Department on April 1, 1973. Dr. Cernosek came to SMU from Brazil.

Dr. Jeff L. Kennington received his Ph.D. from Georgia Institute of Technology. He joins the faculty of the Department of Computer Science and Operations Research as Assistant Professor on June 1, 1973. His area of specialization is Mathematical Programming and Production Control of Operations Research.

Dr. Larry J. LeBlanc received his Ph.D. from Northwestern University. He specializes in Mathematical Programming and Network Theory of Operations Research and joins the faculty of the Department of Computer Science and Operations Research as Assistant Professor on September 1, 1973.

Dr. John L. Fike received his Ph.D. from Southern Methodist University. He specializes in Digital Systems Design and Fault-Tolerant Computing in Computer Science and joins the faculty of the Department of Computer Science and Operations Research as Assistant Professor on June 1, 1973. He has also spent a year as a postdoctoral fellow in the Department prior to joining the faculty.

Promotions

Effective Fall Semester 1973

- Shirley S. C. Chu, to Associate Professor
- Michael A. Collins, to Associate Professor
- Roger L. Simpson, Associate Professor, given tenure
- Hal Watson, Jr., Associate Professor, given tenure

Changes and Leaves

In October 1972, Dr. Robert R. Korfhage resigned as the Director of the Computer Science/Operations Research Center, and Dr. U. Narayan Bhat, Associate Professor in the Center from 1969-1971 and a Professor since 1971, took over the responsibilities as Director soon thereafter.

Dr. Hal Watson, Jr. returned from a six month leave of absence in Brazil where he served on the faculty of the Federal University of Rio Grande do Sul from May, 1972 to January, 1973.

Resignations

Dr. David L. Cohn, Assistant Professor of Information and Control Sciences for the three-year period from September, 1970 to May, 1973, resigned effective May 31, 1973, to accept a position as Assistant Professor of Electrical Engineering at the University of Notre Dame.

Dr. Carlos W. Coon, Associate Professor of Thermal and Fluid Sciences, resigned effective May 31, 1973, to go into private business.

Dr. Harvey J. Greenberg, Associate Professor of Computer Science/Operations Research, resigned effective May 31, 1973, to accept a position at Management Science Systems, Rockville, Maryland.

Dr. David B. Johnson, Associate Professor of Solid Mechanics, resigned effective May 31, 1973, to go into private business.

Dr. James L. Melsa, Professor of Information and Control Sciences for the six-year period from June, 1967 to August, 1973, resigned effective August 31, 1973, to accept a position as Professor and Chairman of the Electrical Engineering Department at the University of Notre Dame.

Dr. Richard E. Nance, Associate Professor of Computer Science/Operations Research, resigned effective July 31, 1973, to accept the position of Department Head, Computer Science Department, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Dr. Stephen A. Szygenda, Professor of Computer Science/Operations Research and Electrical Engineering, resigned effective May 31, 1973, to accept a position as Professor in Electrical Engineering at the University of Texas at Austin.

Textbook Publications

U. NARAYAN BHAT, Ph.D., (University of Western Australia) Professor and Department Head

A Study of Queueing Systems M/G/1 and GI/M/1, Springer Verlag, 1968.

Elements of Applied Stochastic Processes, John Wiley & Sons, 1972.

HAROLD A. BLUM, Ph.D., (Northwestern University) Professor

A Compact Course in Fortran Programming, Audio Tutorial Associates, Inc., Dallas, 1970.

LEON COOPER, Ph.D., (Washington University) Professor and Associate Dean of the Institute of Technology

An Introduction to Methods of Optimization, with D. I. Steinberg, W. B. Saunders and Co., Philadelphia, 1970.

SOMESHWAR C. GUPTA, Ph.D., (University of California at Berkeley) Professor

Transform and State Variable Methods in Linear Systems, John Wiley and Sons, 1966.

Fundamentals of Automatic Control, with L. Hasdorff, John Wiley and Sons, 1970.

Circuit Analysis: With Computer Applications to Problem Solving, with J. W. Bayless and B. Peikari, Intext Educational Publishers, 1972.

JACK P. HOLMAN, Ph.D., (Oklahoma State University) Professor and Department Head

Heat Transfer, McGraw-Hill Book Co.: first edition, May, 1963; second edition, February, 1968; third edition, January, 1972.

Experimental Methods for Engineers, McGraw-Hill Book Co.: first edition, February, 1966; second edition, May, 1971.
Thermodynamics, McGraw-Hill Book Co., June, 1969.
Review of Heat Transfer, Audio Tutorial Associates, Inc., Dallas, 1969.
Experiment Planning and Data Analysis, Audio Tutorial Associates, Inc., Dallas, 1970.
Review and Problem Sessions in Heat Transfer, McGraw-Hill Book Co., January, 1972.

THOMAS P. HUGHES, Ph.D. (University of Virginia) Professor
The Development of Western Technology Since 1500, Macmillan, 1964.
Elmer Sperry: Inventor and Engineer, The Johns Hopkins Press, 1971.

STEPHEN K. JONES, Ph.D., (Southern Methodist University) Assistant Professor
Computer Programs for Computational Assistance in the Study of Linear Control Theory, with J. L. Melsa, McGraw-Hill Book Co., second edition, 1973.

ROBERT R. KORFHAGE, Ph.D., (University of Michigan) Professor
Logic and Algorithms, John Wiley & Sons, 1966; Spanish edition, 1970; Japanese edition, 1971.
Calculus, with H. Flanders and J. J. Price, Academic Press, 1970.
A First Course in Calculus with Analytic Geometry, with H. Flanders and J. J. Price, Academic Press, 1973.

WILLIAM F. LEONARD, Ph.D., (University of Virginia) Associate Professor
Electrons and Crystals, with Thomas L. Martin, Jr., Brooks/Cole Publishing Co., 1970.

THOMAS L. MARTIN, JR., Ph.D., (Stanford University) Professor and Dean of the Institute of Technology
Ultrahigh Frequency Engineering, Prentice-Hall, Inc., 1950.
Electronic Circuits, Prentice-Hall, Inc., 1955; Japanese edition, 1956; Russian edition, 1957.
Physical Basis for Electrical Engineering, Prentice-Hall, Inc., 1957; British edition (MacMillan), 1958; Japanese edition, 1963.
Strategy for Survival, with D. C. Latham, University of Arizona Press, 1963.
Electrons and Crystals, with W. F. Leonard, Brooks/Cole Publishing Co., 1970.
The Britannica Review of Developments in Engineering Education, Chapter 1, "Administrative Organization," Vol. 1, 1970, *Encyclopedia Britannica*; ed. Newman Hall, sponsored by A.S.E.E.

JAMES L. MELSA, Ph.D., (University of Arizona) Professor
Linear Control Systems, with D. G. Schultz, McGraw-Hill Book Co., 1969.
Computer Programs for Computational Assistance in the Study of Linear Control Theory, with S. K. Jones, McGraw-Hill Book Co., second edition, 1973.
Introduction to Probability and Stochastic Processes, with A. P. Sage, Prentice-Hall, Inc., 1972.
...ate Functions and Linear Control Systems, ...cGraw-Hill Book Co., 1967.
Estimation Theory with Applications to Communication and Control, McGraw-Hill Book Co., 1971.
System Identification, with A. P. Sage. Academic Press, 1971.

LOUIS R. NARDIZZI, Ph.D., (University of Southern California) Associate Professor
Basic Circuits and Electronic Experiments: a unified laboratory manual and text. Van Vostrand. 1973

BEHROUZ PEIKARI, Ph.D., (University of California at Berkeley) Associate Professor
Circuit Analysis: With Computer Applications to Problem Solving, with S. C. Gupta and J. W. Bayless, Intext Educational Publishers, 1972.

ANDREW P. SAGE, Ph.D., (Purdue University) Professor
Optimum Systems Control, Prentice-Hall, Inc., 1968.
Estimation Theory with Applications to Communication and Control, with J. L. Melsa, McGraw-Hill Book Co., 1971.
System Identification, with J. L. Melsa, Academic Press, 1971.
Introduction to Probability and Stochastic Processes, with J. L. Melsa, Prentice-Hall, Inc., 1972.

CHARLES R. VAIL, Ph.D., (University of Michigan)
Circuits in Electrical Engineering. Prentice-Hall, 1950.

80-60 K. L. Ashley $15.000
Title: "Amphoteric Dopants in the Active Region of GaAs Lasers"
Sponsor: Department of the Army, DAAK02-73-C-0226
Duration: April 1, 1973 to December 31, 1973
85-04 K. L. Ashley $54.648
Title: "Recombination in Semiconductors Through Negatively-Charged Recombination Chambers"
Sponsor: N.S.F. GK-24145
Duration: June 1, 1970 to May 31, 1973
85-05 U. N. Bhat $90.396
Title: "Analysis of Some Queueing Systems"
Sponsor: N.S.F. GK-19537
Duration: September 1, 1970 to October 31, 1973
87-92 H. A. Blum $10.000
Title: "Solar Energy Applications Research"
Sponsor: Alcoa Foundation
Duration: November 13, 1972 to December 31, 1973
88-68 H. A. Blum $2,650
Title: "Massive Solar Energy Applications"
Sponsor: N.S.F. Institutional Grant (84-92)
Duration: August 1, 1972 to July 3, 1973
80-43 J. K. Butler $30,658
Title: "Study of Semiconductor Laser Modal Fields and Their Radiation Patterns"
Sponsor: USAMERDC-DAAK02-71-C-0263, POOOO1
Duration: May 4, 1971 to July 3, 1973
80-59 J. K. Butler $16,216
Title: "Electromagnetic Field Studies in Solid State Injection Lasers"
Sponsor: Department of the Army, DAAK02-73-C-0154
Duration: January 19, 1973 to December 31, 1973
83-44 J. K. Butler $19.151
Title: "Optical Field Distributions and Model Selection Properties of GaAs (ALGA) as Lasers"
Sponsor: N.A.S.A. (Multidisciplinary Grant)
Duration: June 1, 1971 to December 31, 1973
86-78 J. Cernosek $15,000
Title: "Photoelastic Analysis of Helicopter Structures"
Sponsor: Bell Helicopter Company
Duration: April 1, 1973 to December 31, 1973
83-32 T. L. Chu $127,292
Title: "Boron Arsenide Luminescent Devices"
Sponsor: N.A.S.-NGR-44-007-042
Duration: July 1, 1970 to June 30, 1974
83-47 T. L. and S. S. Chu $15,790
Title: "Gallium Nitride Opteolectronic Devices"
Sponsor: N.A.S.A.-Langley-NGR 44-007-052
Duration: September 1, 1972 to August 31, 1972
83-48 T. L. Chu $7,400
Title: "Study of Physical Phenomena Related to Crystal Growth in the Space Environment"
Sponsor: N.A.S.A., NAS1-118699
Duration: July 21, 1972 to January 23, 1973
87-84 S. Chu $24,443
Title: "Crystal Structure Studies of Heterocyclic Sulfur Compounds"
Sponsor: Welch Foundation N-495
Duration: May 1, 1972 to April 30, 1974
88-66 D. Cohn $6,585
Title: "Modeling Social Epidemics"
Sponsor: SMU "Seed Grant"
Duration: February 1, 1972 to May 31, 1973

86-07 M. Collins $113,507
Title: "Optimal Operating Policy for Metropolitan Multiple Water Supply Reservoir System"
Sponsor: OWRR 14-31-0001-3739
Duration: June 1, 1972 to July 31, 1974
88-61 M. Collins $5,118
Title: "Transient Dynamics of Two-Liquid Porous Media Flows"
Sponsor: SMU "Seed Grant"
Duration: January 1, 1972 to December 31, 1972
82-88 J. W. Eberle $1.000
Title: "Supply Allowance for Douglas E. Whitley"
Sponsor: HEW PHS 1F03 GM55506-01
Duration: November 1, 1972 to October 31, 1973
82-90 J. W. Eberle $1,000
Title: "Supply Allowance for Herbert K. Hagler"
Sponsor: HEW PHS 1F03 GM55621-01
Duration: November 1, 1972 to October 31, 1973
84-94 D. J. Frailey $22,150
Title: "Undergraduate Research Participation"
Sponsor: N.S.F. GY-7383
Duration: January 1, 1970 to July 31, 1973
88-57 D. J. Frailey $5,925
Title: "A Study of Storage Allocation Methods for Simple Data Structures"
Sponsor: SMU "Seed Grant"
Duration: June 1, 1971 to June 30, 1973
80-51 S. C. Gupta $50.527
Title: "Minimum Rate Digital Voice Transmission"
Sponsor: Defense Communication Agency #100-72-C-0023
Duration: May 1, 1972 to June 30, 1973
83-30 S. C. Gupta $43,271
Title: "Digital Phase Locked Techniques for Aerospace Communications"
Sponsor: N.A.S.A. NGR 44-007-037
Duration: September 1, 1969 to August 30, 1972
83-39 S. C. Gupta $62,432
Title: "Digital Communications for Aircraft"
Sponsor: N.A.S.A. NGR 44-007-049
Duration: January 1, 1971 to August 31, 1973
82-84 J. P. Holman $33,041
Title: "Air Pollution Control Fluidized Vortex Incineration"
Sponsor: Environmental Protection Agency R-801078
Duration: May 1, 1972 to October 30, 1973
85-20 J. P. Holman $35,568
Title: "Experimental and Analytical Studies of Jet Boiling Cooling Techniques"
Sponsor: N.S.F. GK-24637
Duration: September 1, 1971 to February 28, 1974
82-79 L. L. Howard $1,000
Title: "Fellowship Supply Allowance for Charles L. Meyers, Jr."
Sponsor: HEW-1-F03-GM52121-01-BEN
Duration: August 1, 1971 to July 31, 1973
83-45 D. B. Johnson $22,573
Title: "Dynamics of Flexible Spacecraft"
Sponsor: N.A.S.A. (Multidisciplinary Grant)
Duration: January 1, 1971 to February 28, 1973
80-61 R. M. Jones $17,296
Title: "Plastic Volume Change Effects in Deformation of Graphitic Materials"

Sponsor: Wright-Patterson AFB, F33615-73-C-5124
Duration: March 1, 1973 to November 30, 1973
80-63 R. M. Jones $10,555
Title: "Mechanics of Composite Materials with Different Moduli in Tension and Compression"
Sponsor: ONR No. N00014-72-A-0296
Duration: April 1, 1973 to March 31, 1974
87-88 R. R. Korfhage $11,000
Title: "Statistical Survey of Health Sciences Library"
Sponsor: American Medical Assn., 5R01-LM-0064-1
Duration: June 1, 1972 to February 23, 1973
80-52 W. F. Leonard $70,977
Title: "Characterization and Optimization of Infrared Detector"
Sponsor: WPAFB (4950 Test Wing) F33615-72-C-1818
Duration: June 1, 1972 to December 31, 1974
83-46 W. F. Leonard $14,288
Title: "Vacuum Deposition and Characterization of III-V Antimonide Alloys"
Sponsor: N.A.S.A. (Multidisciplinary Grant)
Duration: June 1, 1971 to December 31, 1973
85-29 W. F. Leonard $68,475
Title: "Thermoelectric Power of Noble Metals"
Sponsor: N.S.F. GH-33178
Duration: March 15, 1972 to February 28, 1974
83-29 W. S. McDonald $18,170
Title: "Photoelastic Model for the Evaluation of Axisymmetric Composite Structures"
Sponsor: N.A.S.A. (Multidisciplinary Grant)
Duration: September 1, 1968 to December 31, 1973
87-78 J. L. Melsa $9,800
Title: "Development of a Remote Time-Sharing Hybrid Computer Terminal System for Off-Campus Students Via TAGER TV"
Sponsor: Alfred P. Sloan Foundation
Duration: August 1, 1971 to August 31, 1972
82-55 L. Nardizzi $2,536
Title: "Fellowship Support — Stokely"
Sponsor: HEW-4F03-GM42941-04
Duration: June 2, 1969 to December 1, 1972
85-02 L. Nardizzi $25,000
Title: "Instructional Scientific Equipment"
Sponsor: N.S.F. GY-8251
Duration: July 1, 1970 to July 31, 1972
85-10 L. Nardizzi $27,030
Title: "Cooperative College-School Science Program"
Sponsor: N.S.F. GW6557
Duration: January 1, 1971 to September 30, 1972
85-25 L. Nardizzi $32,664
Title: "Cooperative College-School Science Programs"
Sponsor: N.S.F. GW-7078
Duration: January 4, 1972 to June 30, 1973
85-32 L. Nardizzi $17,600
Title: "Instructional Scientific Equipment Program"
Sponsor: N.S.F. GY-10155
Duration: July 1, 1972 to June 30, 1974
88-74 W. C. Nylin, Jr. $5,964
Title: "Study of an Automatic Reorganization System for Modular Programs"
Sponsor: SMU "Seed Grant"
Duration: April 1, 1973 to August 31, 1973
83-41 B. Peikari $17,297
Title: "Design of Linear Time-Varying Networks"
Sponsor: N.A.S.A. (Multidisciplinary Grant)
Duration: January 1, 1971 to July 31, 1972
80-35 A. P. Sage $72,309
Title: "Automatic Navigation"
Sponsor: A.F.O.S.R.
Duration: September 1, 1967 to August 31, 1972
(5 year total $800K)
80-54 A. P. Sage $131,034
Title: "Development of a Configuration Concept of a Speech Digitizer Based on Adaptive Estimation Techniques"
Sponsor: Defense Communications Agency 100-72-C-0036
Duration: June 1, 1972 to July 31, 1973
85-31 A. P. Sage $37,994
Title: "System Identification in Large-Scale Systems"
Sponsor: N.S.F. GK-33348
Duration: September 1, 1972 to August 31, 1973
80-48 R. L. Simpson $28,651
Title: "Making Laser Anemometer Measurements in a Separating Boundary Laser Produced by an Adverse Pressure Gradient"
Sponsor: AROD-DA-ARO-D-31-124-72-G31
Duration: October 1, 1971 to September 30, 1973
83-43 R. L. Simpson $22,261
Title: "Development of a New Airfield Anemometer to Improve Operations Efficiency"
Sponsor: N.A.S.A. (Multidisciplinary Grant)
Duration: January 1, 1971 to September 30, 1972
85-07 R. L. Simpson and W. G. Wyatt $21,730
Title: "Hot-Film Anemometer Measurements of Concentration in Turbulent Flow"
Sponsor: N.S.F. GK-20016
Duration: November 15, 1970 to April 30, 1973
80-42 S. A. Szygenda $211,174
Title: "Analysis and Synthesis of Diagnosis and Design Techniques for Digital Systems Requiring High Maintainability/Reliability"
Sponsor: DNR-N00178-71-C-0148
Duration: January 1, 1971 to August 31, 1973
85-16 F. W. Tatum (J. E. Brooks) $6,100
Title: "Fellowship for S. K. Jones"
Sponsor: N.S.F.-7131-12
Duration: June 1, 1971 to August 31, 1973
83-34 W. G. Wyatt $21,344
Title: "Film Conductance Coefficients"
Sponsor: N.A.S.A. (Multidisciplinary Grant)
Duration: June 1, 1969 to November 30, 1972

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The School of Engineering at Southern Methodist University was organized in 1925. Over the years it provided traditional undergraduate education in engineering within the framework of a compulsory cooperative work-study program. The programs, while competent, were not completely responsive to the needs and requirements of the burgeoning Dallas/Fort Worth scientifically based industry which developed in the 1960's. These companies experienced an intense need for graduate programs at the Master's level and at the Ph.D. level, programs which would be at the cutting edge of modern technology. This was recognized in 1965 with the organization of the SMU Foundation for Science and Engineering. A new Dean was hired in 1966, and plans were drawn up to make a major change in the character of the engineering program at SMU.

In 1967, the old School of Engineering was transformed into the Institute of Technology, an organization to be devoted to the development of superior programs of education and research and to superior students at all academic levels. Additionally, it was specified that the new Institute should set its objectives to stand among the very top engineering schools of the United States, using whatever standards of performance defined such ranking.

Many schools set such lofty goals for themselves but all too often fail to specify how they will know whether they are making progress toward those goals. Thus, at a very early stage, it was determined that the *quantitative* evaluation of all elements of the educational process would be necessary for the Institute of Technology to determine whether it was making progress toward its goals and at what speeds. As a result, each year special attention is directed to some fundamental aspect of Institute operations and attempts are made to quantify them. In every case these matters have been written up and presented in the first part of the Annual Report for that year. The second part of each Annual Report then presents a systematic, quantitative review of significant factors which reflect the progress, or lack, of the Institute toward its goals.

A review of the subject matter of past Annual Reports indicates the extent of this effort toward quantitative evaluation.

1969 Annual Report
: Identification of the 11 factors which are common to the very top engineering schools.

1970 Annual Report
: The measurement of quality in schools of engineering and science—can it be done and what are the critical factors?

1971 Annual Report
: The quantitative evaluation of faculty performance and the identification of standards of performance necessary to secure quality and excellence in engineering education.

1972 Annual Report
: Quantitative evaluation of the American economy and college-age population to determine the impact of these factors on the future directions of engineering education.

1973 Annual Report
: New concepts in educational decision making and budgeting which are drawn from industrial methods of Zero-base Budgeting and the techniques of Objectives, Strategies and Tactics.

The 1973 Report, in common with all the others, closes with a quantitative summary of significant factors during the year which reflect on the performance of the Institute.