Innovation at Texas Instruments

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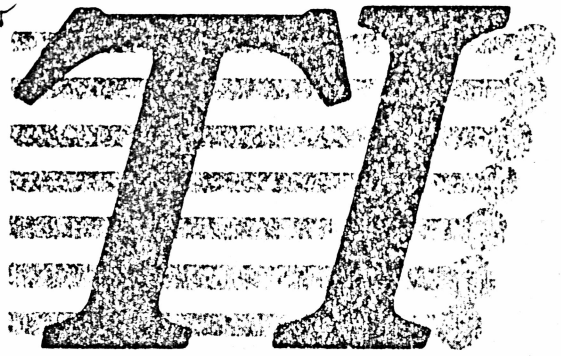
Texas Instruments



Technical Editor's Note:

Perhaps the computer industry's most valuable resource is the creativity of its people. Yet what happens to most innovative ideas? How is creativity managed? How is innovation encouraged?

Texas Instruments has a strong history of innovation. This article describes how TI manages and encourages innovation. The authors are justifiably proud of the result in their company. We will welcome articles from other companies with unique perspectives on the management of creativity.

Portia Isaacson

Innovation at Texas Instruments must be considered in the context of the philosophies that guide the management of the company, and of the way in which it is organized. To quote early leaders and former chairmen of TI,

> "In 1946, together we determined we wanted to accomplish two things. One, to be on the leading edge of technology, and second, to build not only a big company, but the best company in our field."
>
> J. Erik Jonsson

> "By late 1951, it was clear that, in spite of excellent performance, there were even larger opportunities for growth. It was during these years that we decided not to be satisfied with being a good small- to medium-sized company, but to become a good big company. To meet that goal and present a challenge to our many illustrious competitors, it became important that we improve our research and development efforts and enter into broader and even more challenging product lines."
>
> Patrick E. Haggerty

Fundamental to these philosophies is motivation of individuals to become involved in the successful and profitable growth of the corporation. One of the most basic factors is the achievement of a clear understanding, at every level of the organization, of our reason for existence. TI's statement of that reason, which stresses innovation as the means by which we will achieve full effectiveness, is set down in the Preamble to our Corporate Objective:

> "Texas Instruments exists to create, make, and market useful products and services to satisfy the needs of our customers throughout the world. Because economic wealth is essential to the development of our society, we measure ourselves by the extent to which we contribute to that economic wealth—as expressed by sales growth and asset return. We believe our effectiveness in serving our customers and contributing to the economic wealth of society will be determined by our innovative skills."

Also, a vital principle and understanding is that the opportunity to earn a profit is our *incentive*—as well as our *reward*—for doing our job well. TI's responsibility as a business institution is to meet genuine needs and solve vital problems. But Texas Instruments pursues needs and problems only by permission of the societies it serves, and that privilege does *not* include the inherent right to make a profit. On the other hand, without profit TI cannot achieve its objective—indeed it cannot survive as a business.

To achieve our basic goals, many of our strategies center on continually improving our productivity, and the things we do to stimulate productivity may in turn serve to stimulate innovation. But fine-tuning existing technologies and the way we do business yields only grudging gains. The major gains that we strive to achieve in productivity, as well as in new products and services, result only from innovation. Since absolute productivity depends upon the performance of TI as a whole, we stress innovation not only in scientific and technical areas, but also in marketing,

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in personnel relations, and all other areas of the corporation.

To achieve the performance and productivity gains needed, concise goals so challenging as to virtually "shock" the organization must be developed and communicated to everyone. And all TIers must consider themselves members of the team—personally committed to achieving these formidable goals.

The Corporate Objective summarizes the company's philosophy toward the people of TI:

> "We seek to create a working environment where all individuals are motivated to participate in the achievement of TI goals through the pursuit of their personal goals to the maximum possible extent."

Our approach to meeting this portion of the Corporate Objective is based on the interlocking strategies illustrated in Figure 1.

TI's interlocking programs

Productivity is the cornerstone for these three TI programs. Growth, people involvement, and success sharing interlock to create a system in which the positive feedback of one program increases the positive feedback of others.

Starting at the cornerstone, people and asset effectiveness generates increased productivity, which supports cost reduction, which in turn supports market share growth. Cost reduction and market share growth increase earnings per share, permitting increased investment in assets to generate further productivity improvement, cost reduction, and market share growth.

As people perceive that their personal goals are being met, and as they get involved in bringing about change and increase their job satisfaction, they grow as TI grows, producing another gain in productivity.

Similarly, as the rewards generated by growth and people involvement are shared, and as TIers' needs for financial security are met, yet another gain in people involvement is created.

Growth. TI's growth is based in large part on productivity increases, generated by moving from point A to point B in Figure 1, providing a favorable impact on the slope of the experience curve—unit cost versus accumulated volume. As cost reductions make this slope steeper, TI can estaolish more aggressive pricing policies and thereby increase market share and market growth. This market growth is created by making the greatest number of products available to the greatest number of people at the lowest prices possible.

One of the keys to the success of TI's growth strategy is our Design-to-Cost Program. This requires that we use price elasticity in the product planning phase to determine what the selling price (and, therefore, cost) and performance of a new product must be at the time of introduction and *during the life cycle of the product.* Designing to cost makes unit

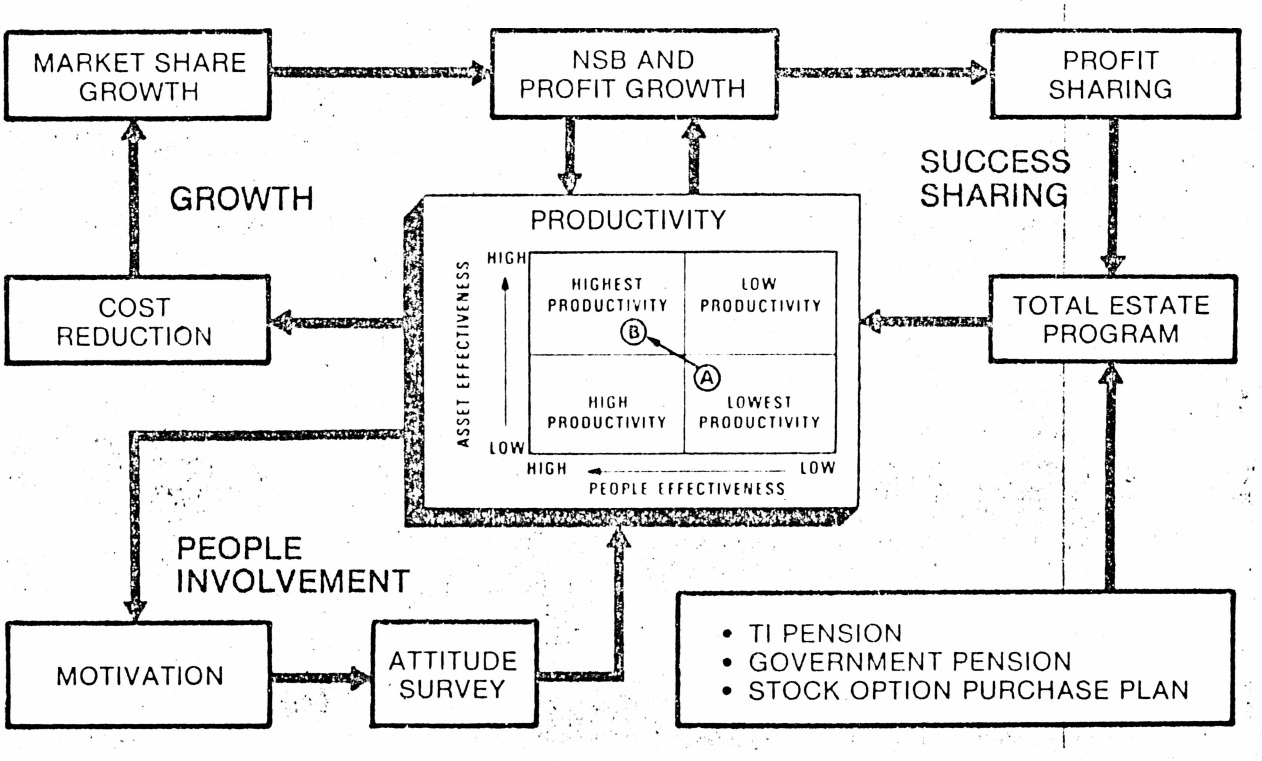

Figure 1. TI's interlocking strategies.

manufacturing cost a primary design specification that must not be exceeded. This technique demands cost-reducing innovations in the product and the manufacturing process over the lifetime of the product.

Also, since manufacturing cost is a function of the number of units produced, the cost (and, therefore, price) of a product can be made to decrease over time until the market for the product matures and begins its decline. Often, evolutionary innovations are made to the product, restoring its growth and extending its life.

People involvement. The second of the interlocking programs is People Involvement. At TI, this means much more than just the job environment. Job environment is important, but the design of the job should not be so centered on optimizing the environment that productivity suffers. TI seeks *maximum* job involvement coupled with *reasonable* job environment.

TI's company-wide People Effectiveness Program is based on involving TIers to the greatest practical extent in the planning and controlling, and not just the doing, of their own work. Each employee must be seen as a source of ideas, not just a pair of hands.

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Motivation is a vital element, but it must be achieved in a way that is compatible with the required distribution of planning and control. It is important to distinguish for an employee between the parts of the job the employee may plan and control and the parts that must be planned and controlled by others. A lathe operator, for example, should have maximum control over how to do the assigned work but should not decide what part to make. A corollary is that every employee is responsible for making managers aware of inefficiencies caused by factors *external* to the employee's area of responsibility. Conversely, managers are responsible for correcting these external factors, or at least explaining to the employee the extent to which the problems they generate are unavoidable.

An important part of the People Involvement Program is the team concept. At this time, more than two-thirds of all TIers worldwide are participating in some type of team program. In this program, teams made up from natural work groups set their own improvement goals and measure their own progress toward these goals. Time after time, team members set what they feel are challenging but realistic goals for themselves, and once the program gets rolling, they find they are not only meeting but exceeding their goals. This is something that rarely happens if goals are set *for* the team, rather than *by* the team. When we talk about "improving people effectiveness," we mean giving people these kinds of opportunities to tap their own creative resources.

A good example of the results achievable with team participation occurred recently when it was determined that a newly installed mechanized line for assembling calculator keyboards was producing only 30 percent of the forecasted benefit. A team was established in the keyboard assembly area involving operators, setup personnel, repair and maintenance, and equipment design. The team established goals for all operations, reviewed daily performance charts, and step-by-step corrective actions were taken as the team directed. Within six months the assembly area had reached the total forecasted performance improvement. Also, the sustaining characteristic of the team solution has been established and the assembly operation is currently performing at 112 percent of the original goal.

Recognition is essential to the motivation process, and at TI it is supplied by immediate supervisors, by managers at all levels, and by various publications, including site newspapers. In addition, people involvement teams regularly make personal presentations on the results of their programs during reviews with TI's management groups at all levels, as well as to the company's board of directors. This environment encourages leadership and innovation much more strongly than the "superior-subordinate" approach. Managers must be leaders, not bosses.

Other important people involvement programs include Work Simplification Training, regular department meetings to inform TIers of the relationship between their personal goals and TI goals, and an "open door" policy dedicated to hearing employee complaints at any time and at any management level.

A more structured method for learning about employees' problems is provided by TI's attitude surveys. During 1977, 41,000 TIers in 36 locations participated in these ongoing surveys. They are important in helping to identify potential trouble spots and in triggering preventive action. Their role is that of sensors to measure such factors as

- employee morale,
- pride in working for TI,
- how TIers perceive the company and management,
- job security,
- career opportunities,
- and many other critical elements.

The action plans that result from these surveys are vital to continuing improvement in attitudes. Results are reviewed with all TIers at scheduled meetings. Corrective action plans are required and follow-up reviews are conducted. Here again, the most successful improvement plans are those that teams of employees, working together, both develop and implement.

People involvement programs are much easier to start than to keep alive. It is necessary to institutionalize them so that they don't die when a new team of managers comes along. Therefore, for continuity, today's managers must explain the culture and experience of the organization to the new generation. At

the same time, all must recognize the importance of being receptive to change.

Success sharing. To create real ongoing involvement, employees must be given a "piece of the action"—which means ownership in the company. "Success Sharing" seeks to fulfill this requirement.

TI's Success Sharing Program ties productivity improvements, plus growth in net sales billed and profit, to the Profit Sharing and the Total Estate Programs for individual TIers. This provides TIers the opportunity for personal financial rewards as the company meets its goals. It also makes possible open discussion of productivity increases.

In TI's plan, the profit sharing percentage is directly related to what we call "PAT/ROA" (profit after tax return on assets) and the "People Effectiveness Index" (defined as net sales billed divided by the sum of payroll plus payroll-related benefits). The percentage of eligible wages is the same for all plan participants worldwide. The relationships are not linear. Profit sharing percentage decreases rapidly as performance drops below goal levels, and rises rapidly as performance exceeds the goals.

Profit sharing payment is made in equivalent shares of TI stock, and approximately half of TI employees now own TI stock through their profit sharing stock accounts. This ownership amounts to over 1,500,000 shares of the approximate 22,800,000 outstanding.

These three fundamental programs—Growth, People Involvement, and Success Sharing—are aimed at increased productivity. As productivity gains are realized, our goals for profitable growth can be met with the addition of fewer people. As TI's success is shared with TIers, they become more involved and more committed and people effectiveness is achieved, producing benefits for TI, TI employees, our other stockholders, and the societies we serve.

Fundamentals of productivity improvement

Our goal at TI is to create an organization and an institutional culture in which continuing productivity increases are viewed as moral obligations to society.

In many organizations, during these years of inflation, raising prices is considered essential—even a right—when costs rise. But we think it is wrong for institutions to believe that just because their costs have risen, they are entitled to raise their prices commensurately. These actions, coupled with wage increases which exceed productivity improvements, exacerbate the pressures of inflation.

At times, there is no other choice; but raising prices must always be the choice of last resort. It will often be the first choice, unless productivity improvement is implicit in the culture of the corporate institution. This must be so thoroughly built into the behavior pattern of a company that it actively, automatically, and continuously seeks to improve its mode of operation to give its customers more for less.

TI: the company

In its early years, the company was known as Geophysical Service Inc. GSI was founded in 1930 to provide reflection seismograph services for use in oil and gas exploration. Since this was new technology, GSI had to manufacture its own electronic instruments. This early manufacturing experience was important in later decisions to begin making equipment for sale to other companies.

During World War II GSI sold electronic equipment to aid in locating submarines, and afterwards established a laboratory and manufacturing division. The name Texas Instruments Incorporated was adopted in 1951. A major government electronics business consisting of airborne radar, air traffic control systems, missile guidance systems, and night vision equipments has been established based on the early wartime sales.

In 1952, TI entered the semiconductor business. This produced a series of technological breakthroughs: mass production of high-frequency germanium transistors, commercial production of silicon transistors, and the invention of the integrated circuit. These developments made possible the transistor radio and many other products using more advanced electronics, such as electronic calculators and digital watches.

TI merged with Metals & Controls Corporation of Attleboro, Massachusetts, in 1959. This added metallurgical knowhow to TI's existing skills in the semiconductor and geophysical areas. In 1960, TI met and exceeded its goal of becoming a "good big company" with more than $200 million in sales billed.

In the early 1960's, TI began to apply digital processing techniques to seismic exploration and expanded its entry into the data processing market in 1971 with minicomputers and terminals. Since that time the company has continued to improve and expand its digital systems products, and distributed computing has become a major growth thrust.

Also in 1971, the "calculator-on-a-chip" was introduced. This was followed in 1972 by TI's entry into the consumer electronics business with a four-function calculator. A major announcement in that field was the programmable TI-59 featuring Solid-State Software™ in exchangeable memory modules. TI is generally recognized as the industry leader in handheld calculators.[1,2] Digital watches were introduced in 1975. Consumer electronics has been established as a major growth thrust for TI.

In 1973, TI met and passed its goal of reaching $1 billion in sales by the early 1970s. Dallas is headquarters for multinational operations including 48 plants in 18 countries serving consumer, industrial, and government markets. TI has established goals to be a $3 billion company in the late 1970s and a $10 billion company in the 1980s. ■

1. "Texas Instruments shows US Business How to Survive in the 1980s," *Business Week*, September 18, 1978, pp. 66-92.
2. *Electronic Calculators*, Creative Strategies, Inc., San Jose, CA, January 1978.

Productivity improvement is a function of investment coupled with research and development. Capital investment usually produces incremental improvements in productivity. But in order to obtain step-function increases in productivity, capital investment must be accompanied by a high level of research and development to increase the *effectiveness of investment.*

Professor Solow at MIT has reached the conclusion that "More than half of the increase in productivity . . . seems to be attributable to technical change—to scientific and engineering advance, to industrial improvement and to know-how of management methods . . . ."[1]

Edward Denison at Brookings has reached a similar conclusion.[2] According to his findings, almost one-half of the US increases in productivity can be attributed to technological innovation. By contrast, only 16 percent is attributable to capital usage.

A great deal of debate and analysis has focused on a potential "capital shortage," yet little if anything has been mentioned about a potential R&D expense shortage.

This does not diminish the importance of capital outlays. They create the new capacity essential to a growing economy, and it is through new equipment and facilities that more advanced technology is injected into the production and distribution streams of the economy. Denison's studies do imply, however, that the impact on productivity of a dollar spent for R&D is several times greater than that of a dollar invested in fixed capital. Somehow this point has been neglected. A great deal of debate and analysis has focused on a potential "capital shortage," yet little if anything has been mentioned about a potential R&D expense shortage.

For the United States, R&D expenditures were equivalent to about 28 percent of business fixed capital investment in 1960. By 1977, this ratio had declined to 21.4 percent, while the investment base had remained near 10 percent of GNP. If these trends continue, the US could lose its standing as one of the world's most innovative countries and one of the largest exporters of high-technology goods. Signs of this deterioration already exist in the increasing failure of US products and services to compete effectively with those coming from Japan and Europe.

The four-loop planning cycle

R&D and capital investment are as vital to the continued health of a corporation as to a nation's economy. At TI we use a four-loop system (Figure 2) for planning our investments in R&D and capital as well as other corporate activities. It also serves as the basis for measurement, feedback, and correction at appropriate intervals.

The first loop is long-range planning. Its focal point is our annual Strategic Planning Conference. Here we focus on where we are going over the next 10 years. In addition to setting measurable quantitative goals, this planning concentrates on projections of markets and products and on the technology advances required to impact those areas.

The second loop is intermediate-range planning. In planning facilities, manufacturing equipment, products, and cost reduction, one year is too short and 10 years is too long. The intermediate loop fills the gap by concentrating on the three years ahead. Authorizations for new products, personnel additions, and capital expenditures are based on the intermediate-loop plan. In this second loop, the current year-plus-one is critical because it ties strategic, intermediate, and rolling planning together.

The third loop is the "rolling plan," a quarterly update of the current year and the following year. Rolling plans are our prime mechanism for operating in near real time, with quick response to changing business conditions.

The fourth loop is the four-month forecasting cycle. This is a monthly operational planning effort that originates at the profit center level and consolidates to the corporate level. It constitutes TI's real-time error detection and control mechanism for near-term profitability.

For each of these loops, financial models and plans are used to forecast and measure performance. The models and plans are supported by computerized management systems to handle the masses of data in as close to real time as possible. With these computerized systems, both the immediate and long-term impact of changes may be quickly evaluated and reacted to, if necessary.

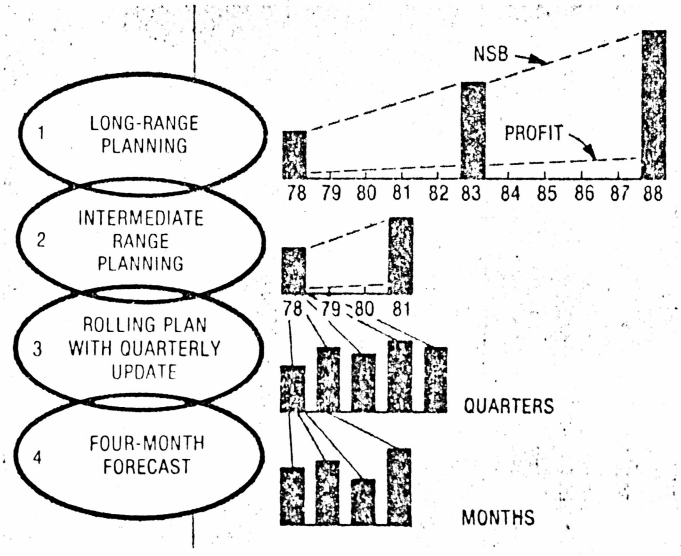

Figure 2. Four-loop planning system.

TI's Board of Directors

Members of TI's Board of Directors as well as managers at all levels in the corporation participate in the major progress reviews tied to the four-loop planning system.

TI's directors attend the annual Strategic Planning Conference, a several-day meeting in which managers worldwide review their businesses and outline their long-range plans. Board members participate in visits to TI facilities in the US and other countries. And one or two directors usually attend each Quarterly Operating Review, in which individual organizations review their performance against the rolling plan.

The Corporate Objectives Committee is the key strategic committee of the board and is chaired by the chairman of the board. Its responsibilities are related to the establishment and achievement of long-range goals for TI, assessment of the company's plans for meeting the goals, and evaluation of the impact of external technological and economic factors on the company's future.

Corporate Operations Committee structure. At the management level four committees are responsible for guiding the operations of the corporation. Singularly and collectively, they are involved in carrying out the programs designed to reach the Corporate Objective. And they provide the link for keeping the Board of Directors informed.

The Operating Committee determines how much money is available to spend on strategic projects and how much should be allocated to new products and services versus productivity improvement programs.

The Capital and Asset Effectiveness Committee reviews *all* capital investments and makes those decisions on investments that fall within its scope as defined by the board.

The Corporate Management Committee is composed of the senior managers of the corporation. Through its meetings, the strategic and operating progress of all entities is communicated.

The Corporate Development Committee allocates strategic funds between the various business objectives and determines what portion of the money should be managed at the corporate level. Its membership consists of appropriate staff and operating managers and it meets at least once a month to review progress towards strategic goals. In carrying out its responsibility of coordinating and aligning the strategic goals of the operating entities with the objectives of the corporation, the CDC must focus on establishing and reviewing strategic goals, prioritizing and allocating strategic resources, initiating new ventures and products, cross-communicating strategic information, and managing the Strategic Planning Conference. In short, it must see that the Objectives, Strategies and Tactics System is implemented by the line organization.

The Objectives, Strategies, and Tactics System

The OST System is TI's way of managing innovation:

- by focusing the attention of management on the future as far as ten years out, it clearly portrays demands for innovation in all phases of the business;
- by reserving major resources for strategic programs that can change the corporation;
- by providing continuity of funding on these long-range programs;
- by providing a system that taps all the resources of the company;
- by ensuring visibility and recognition of innovators at upper management levels;
- by requiring periodic follow-up measurements of progress toward goals so that resources can be added when programs bog down and so that programs can be stopped when the technology required cannot be developed in time.

Not just near-term !

Since OST is a system for institutional self-renewal, it is appropriate that the system itself is the continual subject of innovation and evolution. Just as important as the institutionalization of such a system is the necessity that it be "living" and readily adaptable to change.

The system permeates the entire organization, and it helps manage not only technical programs and growth, but changes in *all* areas of the corporation—whether the charge involves an improved financial control system, a new employee benefit package, or a new plant location. All activities, line and staff, at all levels, use the system to help manage the development and application of innovation.

The OST System may be visualized as a pyramid. The capstone is the Corporate Objective. Supporting it are presently 11 business objectives, which establish the long-range scope and strategic goals for each major business of the company (electronic functions, government electronics, consumer electronics, etc.). Each objective includes a business charter, appraisal of the market potential, projections of technical and market trends, and potential barriers to success. Also, the objective attempts to anticipate change, so it covers evaluations of competition, threats and contingency plans, and possibilities of market shifts. Most important, the heart of the objective is its performance measures. These quantitative growth and profit goals become forcing functions for development of strategic and tactical programs. Objectives change the businesses in which we participate, and strategies change the way we operate a specific business.

Since an objective analyzes the kinds of innovations required for its achievement, it frequently suggests the nature of strategies required for its support. Strategies define the innovations in design, manufacturing, or marketing that are necessary, in concert with other strategies, to support the objective.

Strategies tend to be intermediate-range, with lifetimes of several years. They explore the opportunity environment in terms of projected market growth, identify the innovations necessary to take advantage of the projected environment, and determine whether major new commitments must be made to ensure success. A strategy also includes major long-range checkpoints and its expected financial contribution to the business objective it supports. The analysis required to prepare a strategy suggests the tactics necessary to support it.

Tactical action programs establish the action programs necessary to the success of strategies. These programs cover the full spectrum of business activities, from design and development, through cost reduction, to marketing and merchandising. They set forth the quantitative goals for the program in detail. Resource allocation is based on these tactical action programs, which also pinpoint personal responsibilities, setting forth the "who does what by when" commitments. Tactical action programs have relatively short lifetimes, typically from one to two years.

At TI we have learned that responsibility always exceeds authority.

Much of the power of the OST System results from the way it clearly segregates "strategic" expense from "operating" expense.

"Operating" expense is that necessary to continue current operations at the level required to meet operational goals. It is set at a level that will maintain a strong and healthy existing business.

In contrast, "strategic" expense is discretionary to current operations. It is postponable without hurting *today's* business. It is project-oriented, and focuses on optimizing long-term results. It is dedicated to *changing* the course of the business.

This clear-cut identification of strategic funds, separate from operating funds, is important to OST thinking because it highlights conflict between today's profitability and tomorrow's growth. It also helps us to keep intact the strategic investments that will shape future growth, even during severe business downturns.

Motivational factors under OST. The OST System permits the program manager to cut across group and division lines, and tap the total resources of the corporation. For example, a division manager within TI's Government Electronics Group may, at the same time, be a strategy manager for a project that requires the active involvement of people and other resources in two or three other divisions of the company. In this way, the OST manager wears two hats—one as the head of a strategic organization, the other as the head of a permanent organizational entity. This clear-cut division motivates the manager to concentrate adequate time and attention on implementing plans for future growth, despite day-to-day operating pressures.

The OST System also has helped create a culture that encourages managers to seek enlarged responsibilities. Many still insist that a manager must be given authority that is equal to his responsibility. But at TI we have learned that responsibility always exceeds authority. TI's culture not only encourages, but insists, that a manager generate the respect that gives him authority, and then use that authority to get the job done.

As a result of the OST System, two quite different organizational structures coexist at TI. The operating organization, which deals with day-to-day business activities, is a relatively permanent and conventional form of decentralized organization. But the structure is overlaid by the OST organization, which is fluid, project-oriented, and unbounded except by funding limitations. The OST System gives TI the capability to create strategic programs that attack new opportunities without creating new permanent organizational structures; instead, resources are mobilized to achieve objectives, and then when the job is done, are remobilized in a different matrix for the next problem.

Feeding OST: the IDEA System. The OST System is strengthened further by the IDEA System. The thrust of IDEA is to provide immediate response, visibility, and initial funding for good new ideas.

The name "IDEA" is an acronym for the four steps necessary to convert an idea into an innovation:

Identify the idea as having potential commercial value.
Develop the idea far enough to provide sufficient information on which a management commitment can be based.
Expose the developed idea directly to someone who has the authority to commit necessary resources.
Act upon the idea, by feeding it into the OST System for development and implementation.

A TIer with a new concept can present it to any of the IDEA representatives situated at plant sites throughout TI. Any one of these representatives can give immediate approval of funding up to $25,000. No other approval is required. The originator is free to contact any number of representatives, until one decides to fund the project.

The IDEA representative is limited by only two criteria: the result must fall within the broad business interests of TI, and the project must not already be funded somewhere else in TI.

The IDEA System at work. The story of a TI product called "Speak and Spell,"™ introduced in 1978, illustrates the workings of the IDEA System. Speak & Spell is a talking learning aid that helps children learn to spell and pronounce more than 200 words selected by educators as most troublesome for the elementary school child. In its main mode of operation, it selects a word at random and pronounces it through a loudspeaker using electronic synthesis of speech.

The student responds by keying in a spelling of the word, which is shown on the unit's display. Right answers earn both oral and visual praise; wrong answers elicit encouragement to try again. The Solid State Speech™ integrated circuit used in this product is the result of an IDEA program initially funded in 1976, and patent applications are currently pending. Feasibility was demonstrated in the IDEA phase, and the first units were produced in March of 1978. In this example, an engineer's innovative high-risk concept, which will undoubtedly have many varied applications in the future, was developed into a base product and a new market for electronics.

A culture for innovation

The OST and IDEA Systems are vital to TI's success, but they would be sterile were it not for the culture for innovation that permeates the company.

TI is engaged with industries in which a continuing stream of innovations is not merely essential to success but essential to survival.

A continuing stream of innovations is not merely essential to success but essential to survival.

Throughout TI's history, innovators in all fields, in staff as well as line organizations, have been highly valued. Through our formal Key Personnel Assessment Program, the managers of TI continually strive to identify the top "comers and innovators," to ensure that they are recognized, encouraged, promoted, and otherwise rewarded. For example, technologists who prefer to remain in science and engineering rather than enter the ranks of management are offered a parallel ladder of advancement. Presently, at the top of this ladder are one TI Principal Fellow, two TI Senior Fellows, 12 TI Fellows, and 123 Senior Members of the Technical Staff. This technical ladder is a means, not an end. It is a means of encouraging highly qualified people to continue their unique contributions to the development of the corporation. Often specialists such as these technologists, as well as others from disciplines such as finance, personnel, marketing, law, etc., will become strategy managers.

For success of any tactical program or strategy, a champion is needed. The organizational culture must recognize that this individual, who is dedicated to the success of the effort, may not only come from the ranks of management, but possibly be a strong individual contributor as well. We try to create an environment which stimulates innovation not only at managerial and professional levels, but at all levels. Innovators come from everywhere.

The basic elements in managing the corporation are to define its goals, to make certain they are measurable, and to establish a system for tracking the progress achieved and assuring necessary feedback. Unless the goals can be convincingly com-

municated, and unless the necessary corporate culture can be created to meet them, they will never be achieved.

The key ingredient necessary for the development and success of such a culture is good leadership. People are motivated best by those leaders who are willing to give as well as take, to listen as well as talk (to any member of the organization), to learn as well as teach, to be firm in their convictions and yet able to acknowledge error, and to tolerate failure which sometimes results from pursuing high-risk opportunities. In addition, good leaders must be willing to dream the big dream and be sensitive to maintaining the proper environment for creative thinking. It is these qualities that we seek in TI's leaders.

Good leaders must be willing to dream the big dream.

TI is proud of the culture and systems it has developed to stimulate and support innovation. But other companies with different cultures and systems have also achieved success in innovating. Observation and analysis of many such cases in the history of high-technology industries have proved time and time again that the innovation equation has only one indispensable factor: it all begins—it *only* begins—with creative people. At TI, we are blessed with an abundance. ■

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Mark Shepherd, Jr. is chairman and chief executive officer of Texas Instruments. After service in the US Navy and receiving his master's degree, he joined TI (then Geophysical Service Inc.) in 1948. In 1954, he was promoted to vice-president, with responsibility for semiconductor components. In 1961, he was made executive vice-president, and was elected president and chief operating officer in 1967. He became chief executive officer in 1969 and chairman in 1976.

Shepherd received his BSEE from Southern Methodist University in 1942, and his MSEE from the University of Illinois in 1947.

J. Fred Bucy is president and chief operating officer of Texas Instruments. He joined TI in 1953 and was promoted to vice-president in 1963, with responsibility for TI's government products. In 1967 he was given responsibility for semiconductor components, and in 1972 was elected executive vice-president. He became chief operating officer in 1975 and president in 1976.

Bucy received his BS in physics from Texas Tech University in 1951, and his MS in physics from the University of Texas in 1953.