Norm Latker

CASE STUDIES EXAMINING THE ROLE OF GOVERNMENT R&D CONTRACT FUNDING IN THE EARLY HISTORY OF HIGH TECHNOLOGY COMPANIES

RESEARCH & PLANNING INSTITUTE, INC.

137 MAIN STREET

CAMBRIDGE, MA 02142

JULY, 1980

FINAL REPORT

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CONTRACT NO. SBA-2633-OA-79

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The research forming the basis for this report was conducted pursuant to Contract No. SBA-2633-OA-79 from the Small Business Administration. The statements and conslusions contained herein are those of the contractor and do not necessarily reflect the views of the U.S. Government in general or the Small Business Administration in particular.

ACKNOWLEDGEMENTS

A great deal of coordination and cooperation were required to bring this research project to a successful conclusion. My appreciation goes to Dr. Richard Block and Lee Buffington from Approtech, Inc., Burlingame, California, who ably provided the San Francisco Bay area fieldwork, and to Dr. John Komives, of Lakeshore Group, Ltd., who conducted the Milwaukee area interviews.

A special word of gratitude to my research assistant, Elizabeth Clark, who did much of the early company background checking, accompanied me on many interviews and did a major portion of the writing and editing of the final case studies. Other members of the Research & Planning Institute staff who were actively involved and extremely helpful in this project were my two Co-Principal Investigators, Dr. William Gruber and Dr. Arthur Obermayer, as well as Bernard Campbell, research assistant and Sheila Murray, secretary.

Judith H. Obermayer, Ph.D.
Project Leader
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TABLE OF CONTENTS

LIST OF TABLES

CASE STUDIES

EXAMINING THE ROLE OF GOVERNMENT R & D CONTRACT FUNDING

IN THE EARLY HISTORY OF HIGH TECHNOLOGY COMPANIES

CONTRACT NO. SBA-2633-OA-79

SUMMARY OF THE RESULTS

This project was to prepare case studies of the early stages of the evolution and growth of thirty-three currently successful, innovative high technology companies. The primary source of information was an interview with a founder of the company. Of particular importance were examinations of the factors integral to their commercial success and the role, if any, played by government research and development contracts in the company histories.

The following seven hypotheses, formulated to help structure the study, were generally supported by the case histories:

Hypothesis 1: A long gestation period is required between the conception of an idea and profitable sales of a high technology invention.

Hypothesis 2: Government R & D contracts provided an important source of cash flow required during the early years of a significant percentage of these high technology companies.

Hypotheses 3: Government R & D contracts provided an important source of funding for the development of technology and expertise used commercially by the company.

Hypothesis 4: Most of the cost of innovation occurs not in the initial research stage, but rather in the later phase of development, manufacturing and marketing.

Hypothesis 5: In those instances where the government was not the ultimate buyer of products developed, government R & D contract money alone was insufficient to accomplish successful commercialization.

Hypothesis 6: Market forces were the critical factor in successful commercialization. Technology push without market forces was insufficient to make a viable business.

Hypothesis 7: The dominance of government R & D contracts in the growth of a high technology company is reduced as a function of increases in firm size during the company life cycle.

The study documents the enormous technological contribution made by these companies toward the solution of our nation's social and economic problems. Their ability to create jobs is significant, even among the older, mature companies that normally produce few new jobs.

The availability of government R & D contracts was frequently an important incentive for companies' formation and a key factor in early survival. But government funding is somewhat erratic and undependable and abrupt changes in government research and procurement policies posed severe problems for many companies in our study. In addition, procurement guidelines and procedures tend to inhibit the kinds of market orientation and business attitudes necessary to commercialize technology.

Some of the other conclusions that seemed significant related to: the importance of funding unsolicited proposals; the prevalence of anti-business attitudes in some government agencies; the strong geographic variations in the use of government R & D contract funds, the use of SBA loans and assistance, the role of universities and the role of venture capital; and the preponderance of companies started by a team of founders rather than an individual entrepreneur.

1. OVERVIEW OF THE PROBLEM AND RESEARCH PLAN

1.1 SIGNIFICANCE OF THE PROBLEM

The lower rate of productivity increase and the serious deficits in international trade experienced by the United States during this last decade are, in part, caused by a decline in industrial innovation. Foreign firms have taken over the technological leadership that previously belonged to U. S. companies in such important industries as auto, steel, pharmaceuticals, consumer electronics, and a number of categories of industrial machinery. These problems affect the value of the dollar relative to other currencies, job creation and the rate of employment, and the standard of living in the United States.

A Domestic Policy Review has been completed in response to President Carter's concern in this area. There is impressive evidence that small firms have made a disproportionately large contribution to U. S. economic growth through technological innovation. An excellent combined source of documentation is the report of the joint Senate/House committees on "Underutilization of Small Business in the Nation's Efforts to Encourage Industrial Innovation", August 9 and 10, 1978.

As an outgrowth of these economic concerns, there has been a great deal of discussion about how to encourage the development and growth of the small high technology company. A number of recommendations have been generated to help improve the current environment for these companies. One such proposal is to set aside a significant portion (for example, 10 percent) of all government R & D funds for small business. Not only might this lead to creative new technologies for direct government use, but it is anticipated that such government funding could lead to technological innovations that would benefit the economy. Other suggested changes deal

GEOGRAPHIC AREA	YEAR OF FOUNDING 1946-1957	1958-1968	1969-1978	
Boston	6	6	3	15
Milwaukee	1	3	2	5
San Francisco	0	8	4	12
	7	17	9	33

TABLE 1

DISTRIBUTION OF COMPANIES

insufficient to make a viable business.

Hypothesis 7: The dominance of government R & D contracts in the growth of a high technology company is reduced as a function of increases in firm size during the company life cycle.

The majority of these companies are working on "state of the art" technology and reinvest significant portions of the capital they generate into additional research and development. A number of the founders seemed to be motivated not only by financial rewards, but also by the desire to contribute to the solution of societal problems. If the accomplishments of these companies are a true indicator, substantial progress can be made by nurturing and encouraging the participation of similar companies in the economic life of our country.

2.2 JOB CREATION

The average annual employment growth rate for 30 of the companies in our study from founding to 1979 was a remarkable 30 percent[1]. In the early years of company growth, when the numbers of employees are small, a fairly high growth rate is to be expected. However, there is generally a tendency for the job creation rate to level off sharply as the company matures. While this trend is certainly evident for these companies, the last five years still shows significant job growth. Table 2 shows the employment growth during the last five years. The younger companies have higher growth rates, but the oldest companies still contributed almost half of the new jobs.

One other element should be factored into the total impact of these companies on job creation. Several new companies were spawned from the firms included in our study (see Case 15). Although it is difficult to provide a quantitative measure, it is clear that these spin-off companies also created additional jobs.

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[1] Clear data was not available for three of the companies.

2.3 GOVERNMENT INVOLVEMENT

The case studies clearly document the richness and diversity of experiences technology based companies have with the Federal government in their early years of development. The availability of government R & D contracts was frequently an important incentive for companies' formation and a key factor in early survival. In some cases, government R & D contracts provided an important source of funding for the development of technology and expertise later used commercially by the company. In other cases, the government R & D contracts provided a stable financial base and contributed to the training and build-up of general staff competence and support staff until a clear commercial thrust could be made.

It is also apparent that the availability of government support played a major role in producing technology related to solving societal problems. Government support can come in various forms. One method is to fund the research and development of desired technology, as it is currently done in areas such as health care and solar energy. The government can create a market by subsidizing the consumers of the product, such as equipment for university research laboratories or kidney dialysis equipment. Finally, the government can create a market by issuing regulations that require certain kinds of equipment for compliance. There is a great deal of power available to the government through these various mechanisms and care should be exercised to insure that it is used fairly and wisely.

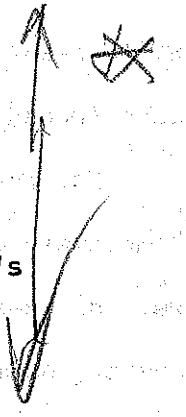
2.3.1 POLICY CHANGES

Government funds frequently proved to be a mixed blessing. Government funding is somewhat erratic and undependable, and the rules

Some of the reasons relate to the difference in behavior modes necessary to succeed in government markets as compared to commercial markets. In looking for R & D, the government is primarily concerned with the technology and whether it is of use in highly specialized, non-cost sensitive areas.

The general procurement guidelines and accounting procedures required for government R & D contract sales tend to inhibit the kinds of market orientation and business attitudes necessary to commercialize technology. A number of companies that eventually became extremely successful commercially did so by acquisition and not by pursuing the technology they had developed under government contract. Some of the problems are the following:

1. Many government agencies will not give a company exclusive rights to patents developed under contract.
2. Market research is not an allowable overhead expense.
3. Limits on allowable bid and proposal expenses and independent R & D expenses are unreasonably low, especially for a new company.
4. Interest paid on money borrowed is not an allowable overhead expense (even when it is due to the government's delay in paying its bills).
5. Cost sharing is often required.



Another problem related to government policies is the insensitivity of many government agencies to technological changes and improvements. Procurement specifications often include the design criteria as well as those for performance. Bureaucrats are frequently intransigent in their

related and the propensity, when in doubt, to give money out in large segments to well known companies, all work against the development of new, exciting technical advances.

2.3.4 DIRECT SUPPORT AND ASSISTANCE

A small number of companies in the study made use of SBA loan guarantees. Most viewed such loans as unable to meet their needs and never considered applying. Several companies provided testament to the positive results obtained in exporting through the aid of the Department of Commerce. Several mentioned the importance of both the encouragement received and the subsidy available for attending international trade shows. One company mentioned the excellent help received through the SBA SCORE and ACE programs.

2.3.5 ANTI-BUSINESS ATTITUDES

One problem that came up several times was the inability of small business to receive basic research support from certain agencies, especially NSF and NIH, which primarily fund research at university and non-profit institutions. In fact, their ideas are not even given a fair hearing. One company, that wished to gain support for basic research to better understand the scientific underpinnings of its technology, created a non-profit laboratory facility. The non-profit institution was able to obtain basic research funds to pursue the originally proposed research. While most people were in favor of government support of basic research, there was resentment that in those cases where a profit making business could do the work better than another institution at no additional cost, it still was denied the opportunity to do so.

into the future."

"In 1972, the company decided to develop a commercial product in the gas analyzer business and introduce it on the market. In 1973, the company made the first sale of the product. The company tried to enter the auto emission market in 1974, but the product didn't gain acceptance until 1979."

"Even though the company was formed in 1965, they didn't make their first major delivery of a product until October, 1967."

Hypothesis 2: Government R & D contracts provided an important source of cash flow required during the early years of a significant percentage of these high technology companies.

15 of the companies relied on government funding in their early years for more than 50 percent of sales, with 14 companies counting on this source of funds for more than 75 percent of their sales. As an average, government funding, both direct and indirect, accounted for 46 percent of sales. These sales figures were derived from first year sales. If first year sales amounted to zero, the first year when the company made a sale was used as a reference point.

Hypothesis 3: Government R & D contracts provided an important source of funding for the development of technology and expertise used commercially by the company.

22 of the 33 companies examined noted that government R & D contracts provided an important source of funding for the development of technology in terms ranging from "crucial" to "indirectly so",

16 of the 33 have gone public, with 8 of these 16 attributing a need for additional capital as the main reason.

Hypothesis 6: Market forces were the critical factor in successful commercialization. Technology push without market forces was insufficient to make a viable business.

Of the 32 companies addressing this question, 28 of these firms pointed out the importance of market forces in the company growth. Four of the companies point to their unique technologies as reason for success, but two of these firms cited a lack of a defined market as being an obstacle that caused severe problems, and a subsequent reappraisal of values. Several companies were formed by founders who identified a market need first, proceeded to put together the technology necessary to provide what was needed and finally go on the market with it. A number of these companies were successful in a relatively short period of time (see Cases 3, 24, 33).

Hypothesis 7: The dominance of government R & D contracts in the growth of a high technology company is reduced as a function of increases in firm size during the company life cycle.

Today only 10 of the 33 firms rely on government business, direct or indirect, for more than 50 percent of their sales. This contrasts with 15 of the companies relying on more than one-half government work in their first year of sales. Only 6 of the 33 companies today rely on government business for more than 75 percent of their revenues, as opposed to 14 companies relying on more than 75 percent government work in their first year of sales.

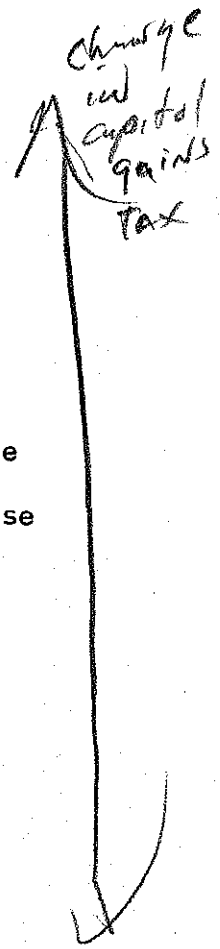
	TOTAL NO. OF COMPANIES	UNIVERSITY RESEARCH NO.	%	GOVERNMENT SPONSORED RESEARCH NO.	%	PREVIOUS INDUSTRIAL EMPLOYER NO.	%	OTHER NO.	%
Boston	15	9	60	12	80	6	40	0	0
Milwaukee	6	1	17	0	0	2	33	3	50
San Francisco	12	2	17	5	42	7	63	3	25
FOUNDED									
1946-1957	7	5	71	5	71	2	29	0	0
1958-1968	17	4	24	9	53	8	47	4	24
1969-1978	9	3	33	3	33	5	55	2	22
TOTAL	33	12	36	17	52	15	45	6	18

TABLE 3

SOURCES OF ORIGINAL TECHNOLOGY

fund research and development or to cover cash flow when sales grew very rapidly. Founders talked repeatedly of the difficulty in raising capital, especially for the very high risk early stages. Table 4 shows a summary of the total amount of capital investment by region and year of founding.

The sharp increase in the Federal capital gains tax during the early 1970's had an indirect but pervasive and deleterious effect on the high technology small business sector of the economy. During the 1960's, considerable high risk financing was available for high technology start ups. This supply was due in part to the existance of a large public market for high technology company stock through which the venture capitalist could easily recover his investment. With the increase in the capital gains tax, the market for new stock issues essentially disappeared, leaving the venture capital community with no means for recovering investments. As a result, venture capital avoided high risk ventures in favor of "sure bets" thereby eliminating supplies of early financing for high technology companies. During the early 1970's high technology company formation activity dropped close to zero nationwide.



In the words of one of the founders of a successful, mature company:

> Most companies that fail do so because they don't have enough money to get off the ground. Venture capital is hardly going to risk its funds when IRS will take away any return it gets on its investment. The recent reduction in the capital gains tax should help, but not enough. So many good ideas are lost because no one is willing to put up the money necessary to develop them.

Founders complain that under the present situation, if they wish to sell the company, they are almost forced to sell to a public company so

they can carry out a tax free exchange of stock.

2.9 INDIVIDUAL FOUNDER OR TEAM

It was observed that many of the most successful companies were started by a team of founders. This seemed to produce more willingness to use the knowledge and experience of various people and to pull in business and management help as needed. This contrasted with the individual founder who sometimes was unwilling to relinquish control of any aspect of the business, even where he had limited experience. In general, the companies that achieved commercial success had someone as part of the management team who was oriented toward management and marketing and not simply a technologist. Table 5 shows the preponderance toward team founders, especially among the larger firms.

2.10 EXPORT SALES

The data we received related to export sales was somewhat incomplete. We do know that seven of the companies do at least 20 percent of their business overseas and a minimum of 13 of the companies have some overseas sales. The companies most active in export activities sell state of the art high technology products in such fields as medical and scientific instrumentation, electronics and telecommunications.

3. POLICY RECOMMENDATIONS

There are a number of changes in Federal procedures, policies, and regulations that could greatly improve the ability of innovative high technology companies to contribute to the technical needs and economic strength of the United States. It is clear from the companies we examined, that the availability of R & D contract funds and other government supported sales opportunities does provide an incentive for the establishment of new firms. In return, the small high technology company frequently does an outstanding job of solving difficult technical problems for the government. If the aim is also to encourage companies to establish a viable commercial business and get their technology into widespread use, then changes, especially in government procurement policy and capital formation areas are critical.

The following recommendations are based on the results of the cases studied:

1. A significant proportion of government research and development contracts in all agencies should be set aside for small business. Provisions should be included for the funding of some unsolicited proposals.

2. Procurement attitudes and regulations should be changed to be more consistent with standard commercial business practices and to remove the problems listed earlier in Section 2.3.2. Whenever possible procurements should be awarded on the basis of total price and a set of performance standards, not on how the company's accounting

4. RESEARCH METHODOLOGY

4.1 SELECTION OF COMPANIES

The proliferation of high technology companies in the Boston and San Francisco areas made them logical areas for inclusion in the study. The Milwaukee area was chosen as a representative region where the number of successful high technology companies is much smaller, although there is a considerable amount of industry. The fact that our company is located in the Boston area and we were able to obtain the services of competent subcontractors to carry out the field work in San Francisco and Milwaukee clearly contributed to our choice of geographic regions.

Using several local resources, as well as a number of companies known to us personally, a list of possible companies was compiled for each region. Information on their year of founding, field of technology, government involvement, current sales, etc., was gathered from many informal sources to form a profile of the company. A number of companies were eliminated when it became clear that a founder would not be available for an interview or the initial information was too limited to be useful. Several companies were selected as first priority because of known government involvement, innovative activities, and close personal contacts with founders. Additions were made to the list based on covering the broadest range of company characteristics possible. The characteristics considered during the selection process included:

field of technology -- included electronics, computers, energy, chemicals, food technology, optics, medical instrumentation, pharmaceuticals, etc.

were able to obtain some historical information about the company before the interview.

4.3 INFORMATION ORGANIZATION AND CASE STUDY PREPARATION

The information obtained from both general sources and the interview was organized in several ways. First, a questionnaire form was filled out which organized the information by specific categories:

Founders

Funding History

Technological History and Investment

Sales and Market History

Employment History

Key Factors and Events

This process was most useful for recording factual and numerical information and formed the basis for the tables in this report.

The information provided about each company was put into a narrative form so that not simply numerical facts, but also the relative significance of various factors and key events could be put in proper perspective. Company identities were protected by generalizing the information, especially the specifics of the technology. The format chosen after consideration of several alternatives, consists of the following sections:

Company Development and Technological History

Financial History

Sales and Employment History[1]

Government Involvement

Significant Events and Key Factors

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[1] In the case studies, Indirect Government Sales are defined as sales to a non-governmental organization where the funds used to purchase the product/service are supplied by the government.

5. THE CASE STUDIES

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1968 to pursue two basic lines of research and development. The first related to basic pumping technology, with particular attention to the medical area. The second research area of interest related to gas spectrometers. The two focuses have remained, and today are reflected in the corporate organization. Of the four founders, however, only two remain with the company; one heading each of the company's two divisions.

Within six months of its founding, the company had its first government sponsored R & D contract. It is apparent the founders of this company had entered preliminary negotiations relating to this contract while with their previous local R & D employers. The nature of the contract, while not directly competitive, was an outgrowth of the research conducted while with these previous employers.

Following the initial R & D contract in 1969, the company continued as a largely government sponsored R & D service operation until the 1971-1972 period. At this point, the company experienced severe financial pressures as a result of one particular contract. This one difficult experience almost put the company out of business and brought about some significant changes in the organization and its business philosophy. In 1972, the company finally decided to develop a commercial product in the gas analyzer business and introduce it in the market. The company also changed its name and experienced its first profitable year of operations.

In 1973, the company made its first sale of their gas analyzer product. This initial sale eventually lead to a licensing/royalty arrangement with a major firm and has provided a positive cash flow that has been highly beneficial to the overall operation.

in equity money. This last investment brought the total equity participation to $800,000. All other financial needs have been met through debt financing. It is anticipated the 1980 sales level should reach $8.0 million, and is largely reflective of the sales growth in the gas analyzer product line. At this time, outside investors hold 80 percent of the company with the remaining 20 percent held by employees (this includes stock options).

The company has a small equity base for a company of this size, and has relied heavily on debt financing for their growth needs. This has not been easy, the banks have often asked for guarantees from the financial backers, which the financial backers have refused to give. The result has been very difficult in terms of shopping around for operating capital, often being in the position of having to take less than favorable conditions. The company did not feel they would be eligible for any government loan guarantee programs.

The company recognizes their success was not, and is not, tied to government sponsored R & D. The obvious difference in success in the two divisions has underscored this point. To a large extent, the difference in the two divisions is one of degree: the one has relied on R & D contracts, and the other has developed products but is still largely selling in a market that is directly government sponsored, or directly created by government action.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1968	$ 23,000	100	4
1979	$2,000,000	65	62

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1970 by three faculty members and a research associate of a major university, who had done extensive research on the application of electronic technology to the communications problems of the deaf, blind and non-oral. During the 1969-70 period, it had become apparent that some of the research at the university was rapidly approaching a product stage. Since production of these devices was deemed inappropriate for the university, the founders set up their own company. They received funding from two private investors and the university.

Operations did not begin until the following year (1971), when the company received a procurement contract from a government agency for fifty of the units developed in the university research labs. The contract included allowances for tooling and start-up costs. At this point, the company hired 10 to 15 employees, using their initial funding to cover cash flow. The company has been profitable since that time.

In the early days, the company relied heavily on the university's continuing research for new products. As time has passed, there have been changes. Since then, the company has established some in-house R & D capabilities as well as research relationships with many other universities. The development of this information stream has been greatly facilitated by the founders credibility in the academic community, and the relatively narrow focus of their attention on communication aids for the handicapped. The management decision to focus on this area has developed a full network of contributors in the academic community who, in turn, fully understand the company's objectives.

have taken place without government support.

On the other hand, the company takes a very strong position with regard to return on equity, and as a result has managed to prosper even with the ups and downs of government funding and a very limited specialized market.

SIGNIFICANT EVENTS AND KEY FACTORS

The company views itself as being better qualified to evaluate the technical issues associated with the introduction of a product than a pure research oriented operation. This would appear to be a very sound decision since they have managed to tie themselves into the research operations of the greater U. S. academic community.

The company would not have been formed nor would it continue to operate without government sponsored research and marketplace financing. The company has been able to maintain a relatively narrow focus. This has been possible due to the early market definition and interest.

The company has patent protection on a number of its products, and feels without that protection, they would not be able to survive in their narrow market area. The company has had little difficulty maintaining its patents, and has greatly benefited by licensing and other arrangements with other firms in related businesses.

The company has had a relatively steady growth rate of 20 percent per year. 1979 sales were at the $8 million level.

In addition to the early financial support, the aerospace firm provided information and licensing agreements plus the use of their science center at a cost plus very nominal fee. While the use of the facilities and the technology exchange were obviously advantageous to the new firm, no commercial products have been developed from this union.

Following the initial round of funding, the company had one additional offering in 1971 during which they sold four million shares at $32 each. In general, the company relies on short-term financing to cover its operating costs. Short term borrowing will run from $0 to $100 million in any given period.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1969	$ 30,000,000	0	100	500
1974	$200,000,000	0	95	3000
1977	$500,000,000	0	90	7000
1979	$800,000,000	0	90	9000

GOVERNMENT INVOLVEMENT

The company views the governmental contract business as an art. Major contractors know how to bid such contracts; i.e., this is their business and they do not make foolish bids. In the waste water business, the municipal governments select the lowest bidder, often ignoring or not making any allowances for the normal safeguards associated with contractor pre-qualifications. As a result, responsible contractors are often put in the position of dealing with other contractors who are literally not qualified to do the work. The result is a project that doesn't perform. The result of this failure is often a law suit against the

three years from the idea stage to the product entering market. In mining products, this cycle is eighteen months.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1965	0	0		4
1975	$1,900,000	0	40	50
1979	$7,000,000	0	20	160

GOVERNMENT INVOLVEMENT

The company has received no direct federal aid. Much of the company's technology, however, was developed under government sponsorship, when the founders were working at the university cyclotron lab. Further, the company's products are sold in markets that, both in the U.S. and abroad, are largely government supported.

SIGNIFICANT EVENTS AND KEY FACTORS

The two key factors in the company's history are its original failure to perform market research, and the development of its overseas market. The company perceived a need for smaller cyclotrons, and began manufacturing before a real market had been identified and developed. Because the company was grounded in an idea, rather than sound business practice, there was a two year lag time before delivery of its first product, and the company spent several years in a severe deficit position.

In the late 1960's, the company began to pursue an overseas market. By 1970, 23 percent of its sales were exports. Since then, exports have accounted for 60 to 94 percent of the company's total sales.

equity interests. In 1978, the company did establish an Employee Stock Ownership Trust. In doing this, the company did benefit in the amount of $320,000 through the repurchase of some of the original shares at less than their 1978 value and through the sale of some treasury shares. The company has relied heavily on bank borrowing to finance its cash flow needs. This debt financing has caused some problems in its relationship with government agencies and will be discussed later.

The company's current business is divided into roughly three parts: 40 percent state and federal government, 40 percent industry and 20 percent international. The international business is largely supported through AID monies.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1968	$ 900,000	60	*	20
1973	$ 4,000,000	53		130
1975	$ 9,000,000	50		210
1979	$20,000,000	42	*	400

*Impossible to estimate indirect government sales, but the amount would be significant.

GOVERNMENT INVOLVEMENT

The company relies heavily on direct and indirect governmental support for its activities. This relationship has not been without its difficulties. This company is in a business that does not have patent protection, and the application of copyright protection is not effective. As a result, they rely largely on trade secrets and licensing agreements.

work the company points out was necessary to successfully complete the assignment. On several occasions, they have found the procurement section of the same agency will not allow reimbursement for this additional work because it was not specified in the initial contract.

The company has also been critical of state and municipal practices of relying heavily on the lowest bid concept in awarding contracts. While the company recognizes the political and other problems associated with other contracting practices, they point out many state and municipal units of government are not qualified to evaluate bidders, or do not pay enough attention to pre-qualifying bidders. The company feels the current practice of this policy will, in many cases, guarantee the state or municipal agency will not receive the best product, and will in the end, cost the taxpayer more money.

SIGNIFICANT EVENTS AND KEY FACTORS

The most important factor in the company's success was the recognition of the initial opportunity. The recognition came about largely because the three founders were working together in an environment that promoted original thinking and, in fact, created the opportunity.

The second key factor was the accounting firm's sponsorship of the company's early operations. While subsequent history indicates the efforts might have been successful without the assistance of the accounting firm, it is not clear that founders would have been willing to take the risk without the security of the accounting firm's support.

Another factor in the company's development was the founders' ability to obtain debt financing to cover their cash flow between the time they sold a contract and the time they received payment for the service. It should be remembered the formative years for this company was not a period

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1967 by an engineer (Founder 1) whose principal interest was in the area of glass to metal seals, and a businessman (Founder 2). They decided to strike out on their own when their previous employer exhibited little interest in the flash lamp business. Shortly after the founding of the company, they were joined by two other men whose primary interests were in ceramic to metal seal technology. These four men had foreseen the need for a company to produce a specialty lamp for a variety of uses. The other firms in the lamp business did not feel this market was a large enough one to justify their interests.

The initial sale of this technology was in OEM sales to the Xerox company for use in their copy machines. After this sale, the company concentrated on sales in the OEM market. This concentration and the prosperity associated with the Xerox contract came to a sudden end in 1970 during the general business downturn. This downturn came at a particularly bad time for this company. When the downturn came with its associated contract cancellations, the company was forced to lay off a large portion of its work force and salaried people were put on half pay. With the business rapidly deteriorating, the company's banker helped them secure an SBA guaranteed loan. During this period, the founders were forced to pledge all of their personal property as security on the existing loans. Fortunately, the business began to pick up shortly after this period, and the SBA financing was replaced with conventional financing. Employees who had been on half pay were offered the opportunity to take their back pay in stock or cash, and the company was back on its feet. It should be noted that this offer of stock in lieu of pay was the last dilution of the company's ownership.

GOVERNMENT INVOLVEMENT

Perhaps the most important point of government involvement came when the company received an SBA guaranteed loan that allowed them to continue operations. With all of the demands placed on the founders for collateral during this period, there is no question the government guarantee had an effect on their ability to obtain additional debt financing.

This company, as were others that were interviewed, has experienced financial problems as a result of the delays in receiving final payment on governmental contracts. The 15 percent set aside provision has been particularly difficult for this company. The company cites numerous contracts that have been completed, but not closed out due to delays in auditing, some for as much as eighteen months. The company feels that allowable margins on government contracts do not provide adequate financial rewards to cover the delays associated with receiving the final 15 percent payment.

SIGNIFICANT EVENTS AND KEY FACTORS

There are three significant factors in this company's history. The first was the decision by the founders that there really was a market for a specialty lamp manufacturer and their ability to attract the necessary venture capital.

The second major factor was the dissolution of their original market. The final and major factor was the ability of the company founders to pick the company up from a disasterous crash and put it back on its feet.

as chairman of the board of directors. After his initial review of the founders activities, the new chairman of the board fired one of the original partners who had been acting as president of the company. This founder left the company and went off to start his own non-competing electronics firm. The remaining partner was made a vice president and placed in charge of the product development. A new president was brought in to take charge of the company.

In early 1971, the company introduced a new product based on their original efforts. This product incorporated other existing technologies to produce a far superior product to anything then on the market. In simple terms, the product measured the light refraction from a particle suspended in liquid. While most competing products could perform this task, they measured the light refraction at right angles to the particle. This company developed a process to measure this light refraction as it was projected in front of the particle. This process allowed measurement of solids suspended in liquids, with obvious implications in waste water treatment. The company's product has met with success in the industrial sector. Following the introduction of this product, the company continued to refine its technology and now has twelve products based on their original concept.

In addition, the company has made a number of acquisitions, both of small companies with useful technologies, and of specific technology from larger companies. These acquisitions should lead to greater product diversity and thus widen markets.

FINANCIAL HISTORY

The company's first round of financing was the $150,000 in venture capital the founders raised from friends and relatives. This financing supported their development of a quality control device for the canning

GOVERNMENT INVOLVEMENT

The most important relationship this company has had with the federal government has been extremely negative. When the company introduced their new product to measure the size of suspended particles, the EPA regulations called for a specific instrument to measure particle size. This specific instrument was even called out by manufacturer and model number. The company attempted to convince the EPA of the merits of their product, to no avail. It was only over the course of time that the company was able to organize enough companies in the particle measurement business to convince the federal agency to change the specifications to the extent that the term "or equivalent" was added. Even this modification did not allow for any measurement other than right angle measurement, even though the forward measurement is recognized to be superior in industry. In order to meet the federal agency specifications, as modified, the company had to go back and develop a right angle measuring device, which the company claims is not as good as their original device.

This experience, as described above, has been a continuing source of irritation to the company and has been going on for over eight years. To further the controversy, the company now feels the manufacturer called out in the specifications is infringing on its patent rights with a new product it is currently introducing.

SIGNIFICANT EVENTS AND KEY FACTORS

Two major factors shaped this company's history, the collapse of its original market and the terms of its second round of financing.

The founders had originally developed a quality control device for the canning industry. Shortly after they brought the device to market, the market collapsed, thereby forcing the founders to apply their technology to the development of another product for another market. Their new product

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

This company was founded in 1972 by an engineer from a large research laboratory who sought to develop the first commercial application of liquid crystal fluorescence, a scientific curiosity that had been discovered nearly eighty years before. Initial sales were exclusively to the consumer products market and were of a fad nature. The product met with a great deal of success in its early years with sales reaching $2.9 million in its second year of existence. However, since barriers to entry into this market were small, and the original patent had not been issued, several small companies entered the field and price cutting began. The impact of this condition can be seen in the following comparison: By the end of 1974, the company had achieved sales of $3 million with a pre-tax profit of $850,000; the following year, sales also reached the $3 million level, but the company lost $850,000. As a result of this situation, the company went into Chapter 11 reorganization in late 1975.

The company made an unusually rapid recovery from its Chapter 11 status as a result of several key moves made before reorganization. Even as prices were falling, and the parent company was losing control of its own manufacturing costs, the company had acquired certain assets and product lines from another company in a similar business. By far the greatest of these assets was the president of the other company, who had been one of the leading scientists in technological innovation in this field. This gentlemen assumed control of product development for the merged companies. Within two years, the company had improved its technology and had introduced products superior to anything then on the market. In addition, it had filed for and been granted fourteen U.S. patents and a number of parellel foreign patents.

Because of this basic technological strength, the company was able

FINANCIAL HISTORY

The company's initial financing was $10,000 the founder raised to set up manufacturing of the company's original commercial product. During the company's period of rapid growth, the founder raised an additional $40,000 from venture capital. In 1976, one of these investors supplied $50,000 to the company during its Chapter 11 reorganization, which both hastened the reorganization process and kept the company afloat.

In 1977, the reorganized company brought in $50,000 of working capital through the sale of preferred stock to an SBIC. These funds enabled the company to make the necessary acquisitions and developments to establish its three major product lines, which between 1977 and 1979 brought in another $320,000 in venture capital.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1972	0	0	0	1
1974	$3,000,000	0	0	75
1979	$3,000,000	0	15	60

GOVERNMENT INVOLVEMENT

The company's involvement with the government has been varied. The government has been an indirect source of technology and financing. It has also been a source of tremendous consternation with regard to new product regulations.

The founder of this company was previously employed in a research capacity in a research organization that does a significant amount of governmental research. There is nothing that would indicate the product manufactured by the company had anything directly to do with the government

in the midwest would have an adverse affect on their manufacturing process. The eventual recognition of this difficulty has resulted in a consolidated, profitable company relocated in California.

The company has been profitable since 1975.

FINANCIAL HISTORY

The company's original financing was $200,000 in private capital raised by the founder. After the company's merger with a telecommunications firm in 1969, it raised working capital through a private stock offering.

In 1971, the company decided to move into the computer field. It financed its initial forays with profits from its telecommunications work. Unfortunately, by 1974, this new venture forced the company into Chapter 11 reorganization. No information is available on company financing since reorganization in 1975.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1967	$ 500,000	100	0	60
1970	$ 700,000	0	10	65
1972	$ 750,000	0	15	95
1973	$ 500,000	0	15	95
1976	$ 800,000	5	10	35
1979	$3,500,000	0	15	55

GOVERNMENT INVOLVEMENT

The company was originally involved in the space program, and like many companies in the electronic business, experienced the boom or bust nature of government sponsored programs. Their experience in the component business has been quite different. The company has had a contract with GSA to supply telecommunications products to government installations. After one year, the company elected not to renew the contract due to the excessive cost of the paper involved in the contract. As an alternative,

CASE #10

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The initial work and concept relating to the primary product of this company was started in 1964 by a doctor at one of the major local hospitals. The intent was to develop a low cost lens to assist in the correction of eye defects in children. By 1969, five years later, the doctor had developed the lenses and formed a company. The formation of the company was financed by a limited stock offering of $1.7 million.

As was indicated earlier, the doctor had developed his product prior to forming the company. The product he developed was intended to replace the wedge shaped prisms being used to correct eye defects (crossed eyes, etc.) with low cost paste-on Fresnel lenses. To accomplish this objective, the doctor took the initial investment and hired fifteen full-time salesmen to cover the eye care market in the U.S. While there was some initial interest exhibited by distributors, the basic response was not positive. Eye care doctors did not want to be in the business of pasting on lenses, and the people in the business of preparing lenses did not want to do the work, because they did not feel it was professional. There was a strong suspicion the profit margins were also too low. In short, after expending approximately $600,000, it became apparent that this was not going to be a successful marketing campaign, regardless of the merits of the product.

The first three years of company operation were at a loss. Then just as things looked darkest, a contact was made with a major manufacturer of instant cameras that resulted in a major contract for the company. The company became the sole source supplier for one of the most popular instant cameras sold in the U.S., and remains in that position today. By 1974, the company had sales of $2 million, of which 65 percent were lenses for the instant camera. At that point, the company producing the instant

CASE #11

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

In 1953, a large U.S. conglomerate bought a majority interest in a small company manufacturing simulation devices for guidance equipment. The small company continued to operate independently for five more years. During this period, a new president was appointed. In 1958, the company was brought into the conglomerate's corporate structure. The former president became the Division Manager. As time passed, several difficulties became evident. First, the division was so small, it was virtually lost in the corporate structure. Second, the division was profitable and could take care of its operating needs but being such a small part of the operation, the division was unable to get funds allocated for new product research and development. This situation continued for three years.

In 1961, the former President and Division Manager raised $300,000 through a public offering to 250 individuals and started a new business. The new business, in effect, introduced the second generation of the product being marketed by the conglomerate; what he had spent three years trying to get the conglomerate to do. The new company received its first order three months after it opened its doors for business. While the company did not make a profit in its first year of operation, by the end of the second year, the company's products had forced the conglomerate's competing products from the marketplace. The new company then purchased, at a very reasonable price, the tooling and drawings for the products the conglomerate was withdrawing from the market. The company viewed this move as a goodwill gesture to the conglomerate's former customers who would need service for their existing equipment. It is to be presumed these same customers would be buying new equipment at some later date.

rather than a catastrophy. They still remember the case with considerable ill feelings toward the government auditors, however.

This is a company that does business with the government, knows their business and understands their customer. They are thoroughly familiar with the process under which they live and prosper under conditions that cause difficulty for others. While they have occassionally been bothered by the 15 percent set aside provisions coupled with slow audits, or a difficult procurement officer, they are not hesitant to call whomever could help, if they feel payment is being unnecessarily delayed. They are also quick to point out properly processed progress payments are paid by the DOD as fast or faster than many of their commercial customers. The company knows and understands the advantages they have as a small business and takes full advantage of their position.

SIGNIFICANT EVENTS AND KEY FACTORS

The impetus for founding this company was clearly the inability of a large firm to recognize and accommodate the needs of a small, innovative division. The parent company was inhibiting the technological investment in R & D necessary to stay competitive and to keep competent technical staff. Another factor was probably the availability of money through the public market in 1961. It is likely that similar start-up financing for a comparable amount of money today would be very difficult to obtain.

The company's ability to purchase the toolings and drawings from the old parent company probably also had a major positive effect. By providing service to previous customers, the new company gained access to some of the major potential users of their newer equipment.

with a minerals exploration company. The objective was to form a jointly owned company that would develop products for the oil well industry, various forms of mineral analysis, and participate in the AEC's Plowshare Program. In 1972, the company acquired all of the rights to the joint venture and the company's stock owned by the former partner was sold on the open market. In 1975, this venture was dissolved.

In 1969, the company acquired a company manufacturing large precision magnets for the high energy particle research. In this case, the company developed the rudementary forms for an ion implantation system. During this period, the company also developed a working relationship with one of the giants in the developing semiconductor field. In the end, the company once again lost interest and the acquisition was sold. In this case, it is interesting to note several of the individuals working on this project left to form their own company when the parent decided to give up the business. These individuals joined others interested in this area of development and are currently doing quite well.

In 1969, the company went public selling 600,000 shares at 8½ per share. The proceeds from this sale were principally used to finance the commercial ventures described above, particularly the desk top calculator. As has been noted previously, the company's sales reached $18 million in 1970, but by 1971, they were down to $14 million, and by 1972, they were down to $9 million. These were difficult times for this company. Its main product, R & D, just was not selling and the company's previous efforts at developing commercial products had not been successful. Nevertheless, the main reason for the big drop in 1972 was the termination of three major research projects, two for the convenience of the government and one due to its completion

The company continued to operate at the $9 million level through 1974

profits increased rapidly. In 1969, the company went public, and raised about $5 million. This money was used primarily to finance the various acquisitions and attempts at commercialization. The details can be found in the history section.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1963	$ 300,000	100	20
1964	$ 1,300,000	100	50
1969	$10,200,000	90	600
1970	$18,000,000	95	700
1972	$ 9,000,000	90	300
1975	$ 9,000,000	90	300
1979	$16,000,000	95	400

GOVERNMENT INVOLVEMENT

This is a company that is almost solely involved in government sponsored research. Similar to other companies interviewed, the company indicated the DOD is the agency it prefers to deal with primarily because it appears to have a better understanding of the industrial research environment. The company also deals with DOE, NASA and HEW and did not have any specific negative comments about their business relations with any of them. In fact, there was an amazing correlation between the responses from this company and the one covered by case #11. In both situations, the companies were oriented toward business with government or other government suppliers with few, if any, commercial products.

One additional item of interest was in relationship to the introduction

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1963 after a patent attorney (Founder 1) suggested to Founder 2 to develop a potentially marketable technology in a patent application he was filing for Founder 2. The applicant (Founder 2), a university professor, had developed a new and promising method (Method A) for separating gases in large diameter columns. Founders 1 and 2 felt that with sufficient investment in research and development, Method A could make a new market then only used for analytical and small scale production. Founder 1 convinced Founder 2 of the advisability of bringing the research out of the university lab and into a private firm.

Founder 1 served as the company's business and legal director on a part-time basis from his law practice. Both founders were responsible for securing the company's initial and subsequent financing rounds. Founder 2 served as technical director, also on a part-time basis from his academic responsibilities.

In 1963, using funds from a private investor, Founder 2 set up a small lab where he and a hand-full of graduate students worked on Method A. The company moved to larger quarters and retained a more permanent staff. In 1967, the company redirected its efforts to a more accessable separation technology (Method B). In that same year, it received a crucial government contract under which the company developed a successful medical device using Method B. The company later licensed this technology into an equally successful industrial device. The company recently divested itself of all government R & D contracts and is pursuing industrial applications of Method B technology.

The company has never gone public. In 1977, it became a wholly owned subsidiary of one of its early investors, but continues to function independently.

FINANCIAL HISTORY

Founders 1 and 2 obtained the company's original financing in 1963 from a private investor industrial firm very much interested in technological innovation and helping small firms get started. The company received $25,000 in materials and services in exchange for 25 percent of its stock. The investor also provided Founder 2 with lab space in the investor's own building. The company used the funds for setting up the lab, product R & D cash flow.

Unfortunately, Founder 2 and the investor did not get along personally and parted company after nine months. In 1964, the company received $108,000 from a very large firm for 25 percent of the company's stock and a member seat on the company's board of directors. The company used $33,000 of these funds to buy back the original investor's stock. The other $75,000 it devoted to setting up a new lab, cash flow and R & D.

In 1967, a second large and different firm paid the company $650,000 for 22 percent of its stock. Later, about 12 percent of the common stock was sold to another and different industrial firm for $400,000. This money was again used for Method B R & D. Also, in 1967, the company received a $220,000 government R & D contract for a specific Method B medical device. After 18 months, when the product seemed viable, the company obtained an additional $900,000 for product development. This financing round had three sources: the federal agency as a government contract; a very large health care products company in exchange for a patent license; and the founders' personal funds as a loan. The outside company became hesitant about the device and its marketability and sold back its interest to the company for less than its investment, since the rest would have been paid in taxes.

With the profits realized from the medical device royalties, as well as its development of industrial applications for Method B technology, the

biomedical divisions.

In 1979, however, the company made a corporate decision to curtail all government work. The company's application of separation technology to the automobile industry had been highly successful. The board of directors, which had never felt comfortable with government work, viewed this as a clear indication that true corporate success lay in further industrial ventures rather than government contracts. They were very anxious not only to increase profits above amounts allowed for government R & D, but also to free the company from bureaucratic paperwork and constant writing of proposals to procurement officers.

SIGNIFICANT EVENTS AND KEY FACTORS

The three important factors in the company's success were its decision to abandon development of Method A in favor of Method B; its 1967 government contract for Method B research, and its relationship to Founder 2's university.

By 1967, the company had spend about $2 million on the development of Method A. Its investors were becoming impatient but no immediate end was in sight. The decision to abandon Method A was a wise one. It took another company 15 additional years and considerable investment to finally bring Method A to market. It seems unlikely that the company would have found the requisite financial backing to complete the project. Method B was far closer to the product stage, and the company's timing in its adoption (unwittingly) coincided with market demands.

The company's 1967 NIH contract catalysed the company's success, both financially and technologically. After the company's essential failure to develop Method A, it could find no private backers for Method B development. The $220,000 NIH contract and its renewal propelled not only the development of a specific product, but also the refinement of Method B for other industrial applications. It helped to finance the technology upon which

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1962 to exploit technology Founder 1 had been developing in his university research. The company's initial goal was to secure research contracts from industry as well as the government. Through these contracts, the founders hoped to put the company on sound financial footing, broaden its technological capabilities, and develop a commercializable product.

In order to retain as much control over its research as possible, and thus its potential products, the company entered into somewhat non-standard research agreements with its industrial sponsors. Rather than enter a contract that granted the sponsor full ownership of the technology in return for payment of research costs, plus a fee, the company sold joint development programs under which the sponsors would cover 60 to 80 percent of the R & D costs in return for a limited royalty-bearing license. In exchange for covering 20 to 40 percent of the R & D costs itself, the company retained ownership of the technology, would receive royalties from the sponsor upon successful commercialization and could commercialize itself applications of the technology not in conflict with the sponsor. The company also negotiated minimum annual royalty payments to help insure a sponsor's diligence in bringing technology to market.

During the course of its research work in the mid 1960's, the company developed unique technology in two different fields. The company established separate divisions to produce and sell each of the two product lines.

The company's first full year's sales of $100,000 were entirely for R & D. Of present sales, which have climed to $20 million, 95 percent represent product sales and only 5 percent R & D. Employment has risen

have recognized the company's need to protect its own technology.

Although the company does minimal direct government R & D, a portion of its product sales, especially for scientific instrumentation, are made to customers who are financed by government grants.

SIGNIFICANT EVENTS AND KEY FACTORS

According to Founder 2, the key factors in his company's success were its joint development programs, the focus of its research on products of commercial significance and its choice of markets.

The company's joint development programs, through which a sponsor covered most, but not all, of a project's R & D costs in exchange for a limited license to the technology, allowed the company to retain control of its technology. The company could then commercialize those aspects of its technology it found most profitable.

The development of the company's technology took many years and a significant investment. The key to success in the field was the company's consistent focus on an ultimate product that was both unique and had well defined markets, and constant reassessment of that product within the constraints of the market.

The company's choice of markets was also important. Instead of approaching a major market that was slow moving and difficult to enter, the company looked for smaller markets that would respond quickly to technological innovations.

to the company's technological development. During the 1950's, four of the staff held full-time or adjunct faculty positions. Even today, when only one of the founders is still teaching, the company maintains close ties with the academic community. This provides the company with new ideas and a source of highly qualified employees.

The technological event that catapulted the company to the forefront of engineering acoustics was the development of the jet engine. The original partnership received a contract from NASA to control the noise created in its Cleveland wind tunnel when jet engines were being tested. The expertise the company gained through this contract had two very important results. The first result was the establishment of the company as experts in the field of jet engine noise. They had an influx of contracts for the reduction of internal and environmental noise from jet engines. The federal government was their primary client, but the company was also hired as a consultant to major airplane manufacturers, airports, and communities affected by jet landing patterns. The company's efforts in quieting jet engine noise also provided technology which could be transferred to its work in other areas of acoustical engineering. The second result was the development of a pre-packaged noise reduction system for jet engine test cells. The demand for this product was so high that its royalties provided the company's early funding required for growth.

In 1957, the company decided to expand into the field of psycho-acoustics. The equipment the company's researchers used to study the human perception of sound included one of the early second generation computers. In designing the software for their experiments, these scientists became excited with the computer technology itself and aware of its tremendous technological and commercial potential. The company established a burgeoning computer division and began applying computer technology to the many other facets of its research.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1961	$ 2 Million	65	111
1979	$ 37 Million	80	1,000

GOVERNMENT INVOLVEMENT

Government R & D contracts have always represented a high percentage of the company's sales. Throughout the 1950's and early 1960's, most of these contracts were in response to unsolicited proposals to various agencies, especially NASA, DOD, and NEL. Later, the contracts more often followed government solicitations, but government R & D contracts have consistently accounted for 65 to 80 percent of the company's sales, with 80 percent being the most recent figure. This very consistency renders the company somewhat of an anomaly among the companies in our study. The Mansfield amendment in 1965, which radically curtailed R & D contracts to many firms, had no effect on the company since all of their research is applied and so was considered mission oriented.

SIGNIFICANT EVENTS AND KEY FACTORS

The four key factors in the company's success were the coincidental development of its acoustical expertise with the development of the jet engine; its decision to explore psycho-acoustics; the availability of unsolicited government contracts in the 1950's and early 1960's; and the company's relationship with the university.

During the 1950's, the company dominated the market in jet engine noise control. A key government contract in 1951 established the company's primacy in the field. This enhanced the company's overall reputation, improved its technology, increased profits, and guaranteed further contracts.

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company is a small, privately held firm doing bio-medical research and manufacturing materials for bio-medical research. It was founded in 1961 by a prominent academic in bio-chemistry. The founder had two major goals. The first was to get his research out of the university with its departmental and political strictures. The second was to move the technology he and his firm developed, out of the lab and into the marketplace, to the benefit of society and his own personal profit. He was confident that much of the contract research he had been performing for the government at the university where he taught would continue to be funded through his company.

The company's very basic technology came from the founder's academic research. The field was, and is, so fast paced, however, that the company's real breakthroughs were developed in its own labs. The availability of government R & D contracts for good, unsolicited proposals in the early 1960's made it possible for the founder to design research projects that would give his company the technical expertise necessary to maintain its vanguard position in bio-medical research. Even after the government curtailed much of its R & D spending and the company began to manufacture research materials, it maintained an extensive R & D program. The founder also works in close cooperation with the top scientists in the field. He is well respected both professionally and personally by his colleagues and they are able to share ideas and specific technological advice.

The company's financial success hinges on its ability to maintain a technological lead among others in the field.

At a low point in contract research, the founder decided to start manufacturing on a larger scale, the high quality materials the company had developed for its own research. Within a few years, the demand for research

GOVERNMENT INVOLVEMENT

The government played and continues to play a significant role in the company's success. In the early years government support was direct. The founder financed all of his early research, and thus his company's acquisition of technical expertise, with government R & D contracts for unsolicited proposals. However, in 1965 the Mansfield amendment required that all federal spending for R & D for the Defense Department be directed toward solving a clear current problem. A number of long-range projects were terminated, leaving the company in a difficult position. The company was forced to re-evaluate its markets and objectives. The result was the gradual buildup of the company's capability to manufacture and sell biomedical research materials.

The company continues to perform contract R & D for the government. In addition, the government is usually the ultimate purchaser of the company's research materials, either directly through sales to national laboratories or indirectly through sales to government supported university labs.

SIGNIFICANT EVENTS AND KEY FACTORS

The critical factors in the company history relate to the availability of government R & D contracts at the time of founding, the abrupt cut back in government funding available in the late 1960's, and the close ties with the national academic community in the company's field of technology.

The company was started with minimal funding, just enough to put together a viable laboratory facility to satisfy government contracting officers. The easy availability of contract funds to a highly qualified researcher made the risk minimal. At that time, the government readily funded good unsolicited proposals, even from private industry. In 1965, when non-mission oriented research was curtailed, the company almost didn't survive. It turned to its ability, largely acquired under government

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company is now a leading R & D firm in the fields of medical technology and electronics. The firm grew out of the part-time consulting work of a university professor of mechanical engineering, and a previous student of his. This consulting continues to comprise approximately 20 percent of the company's work.

Organized in a casual fashion for the first three or four years, the company incorporated in 1957. Growing from its original base in contract research and development, the firm expanded into product manufacturing and marketing in the fields of health and communications. Today, the company engages in three principal lines of business: bio-medical products for the clinical laboratory and for cryosurgery, data communications products for communications and computer network control and testing, and R & D engineering services for industry and government agencies. Through four domestic manufacturing operations, eight foreign marketing subsidiaries, and other distribution outlets, it sells its products worldwide. The 1970's were a time of great prosperity as the firm rode the wave of technological growth to the point where they now have sales of $28 million (1979).

The company's fundamental technology came from its founders' individual academic work and their early collaboration. The firm provided needed research and development engineering services to industrial clients and government agencies. The company began to diversify in the mid 1960's into product manufacturing and sales. Health care became a primary interest and by 1970, the firm had emerged as a world leader in the field of cryosurgical and other medical instrumentation. Further diversification into network control centers in the field of electronic data communication was greatly aided by the acquisition of a southern firm which designed and built various pieces of electronic equipment, as well as providing communications

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1959	$ 150,000	40	5
1974	$ 9 Million	30	?
1979	$ 27.5 Million	30	800

GOVERNMENT INVOLVEMENT

Although, as a general rule, the company tried never to have more than 33 percent government business at any time, there were notable exceptions. The company was involved in the development of a mine sweeping device in the early and mid 1960's, which was a major source of income at the time. However, the general feeling was that dependence on government funding was a dangerous path to follow. Among the criticisms of government funding were a very slow payment process, and the problems resulting from government negotiating away any profits. Even taking these criticisms into account, government funding played a significant role in the growth of the company.

SIGNIFICANT EVENTS AND KEY FACTORS

The three key factors in the company's success were the absence of constricting financial commitments, acquisitions, especially that of the southern engineering firm with the subsequent interdependence between the parent and the acquired, and the company's relationship with the university. Due to the nature of the company's initial organization, a strong financial groundwork was developed very early. This generation of steady cash flow was employed as a means to avoid long-term debt.

The decision to acquire the southern engineering firm was an important factor in the company's take-off in the late 1960's. The idea of acquiring a smaller company to fill in the gaps of one's own organization is based

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company is now a prosperous, technically oriented, international organization, employing over 15,500 people. Initially, the firm's three founders relied on one main product, the design and development of stroboscopes. As time evolved, serious diversification was undertaken, and today the company divides its business activities into five major segments: Instruments, Components, Environmental and Biomedical Services, Custom Services and Systems, and Department of Energy support.

The organization incorporated in 1948. At this time, the majority of their work focused on the stroboscope, whether employing the light techniques in consulting work, or developing the hardware associated with stroboscopes. In this early period, a major university was very supportive of their work, exchanging much needed lab space for some of the technology being developed. In 1949, a unique opportunity presented itself. A member of the Atomic Energy Commission became enamored of their technological expertise and convinced the AEC to finance the firm's research as long as they would give a proper account of where the money was going. The university agreed to handle the paper-work, and the company undertook the contract to develop a component of the atomic bomb. At this time, employment grew from four or five, to eight to ten. This government funding lasted four years and laid a firm financial groundwork for further corporate development.

Soon after this project was completed, a related study pertaining to weapons testing developed, again funded by the government. Up to the late 1950's, no non-governmental work at all was undertaken. Eventually, the firm re-entered the commercial market, again relying on its work with stroboscopes as a base. Now, though the emphasis was much more on hardware and less on R & D, much of their commercial business was developed through acquisition.

with the government allowing them to finance all their work with public funds. It was a very unique and enviable situation. Largely due to these factors, and also because of a strong asset management program, the growth level maintained throughout the 1960's and 1970's was completely financed by internally generated funds -- so much so in fact, that their corporate debt today is nearly zero. For a company of this size, this is a remarkable achievement. In 1978, they bought back most of their shares of stock for approximately $30 million, with short-term loans, and before the year ended the loans were paid back.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1947	$ 500,000	95	5
1974	?	?	10,000
1979	$ 522 Million	45	15,500

GOVERNMENT INVOLVEMENT

As already stated, the firm was virtually "set-up" by the government. A better case for the influence of government funding would be hard to find. The government was willing simply to arrange for a bank account in the firm's name. All the founders had to do was ask, and more money would be deposited. This is an indication both of the relative importance of the project assignments, and the extent to which the government was impressed by the founders' expertise in the field. The assistance offered involved both heavy funding, and a ready supply of quality employees. The current chairman of the board and chief executive officer was originally assigned to the firm by the government. It is impossible to underestimate the role the government played in establishing the firm.

priorities, fostering a very healthy technological atmosphere. The fact that the three original founders remained together through the years is testimony to the healthy attitude the founders took upon entering the business world.

early years it became evident that the company could assume its own marketing activities.

After the long-term agreement expired, the company was able to exert greater control over its activities and is well on its way to commercial products with a variety of corporate and individual partners.

FINANCIAL HISTORY

The company's entire financing to date consists of a $10,000 - $20,000 loan made by one of the founders and repaid within three months. Of that sum, part went to the founders' former employer for licensing of technology, and the rest went to cash flow. This unique financial history was facilitated by the long-term development and licensing agreement the founders struck with a major chemical concern before they had even formed their partnership. The agreement obviated initial expenditures for lab space and equipment. By the time the company moved into expanded facilities in the late 1970's, it had acquired sufficient sales and profits to self-finance the move and expansion.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1970	$ 250,000	0	10
1979	$ 1.2 Million	10	30

GOVERNMENT INVOLVEMENT

The company has done very little contract research for the government. In 1970 it did none; in 1973 government work represented five percent of the company's sales. In 1979, government work represented 10 percent of sales.

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company grew out of a graduate student's thesis work on a technique for detecting trace metals in body fluids and other liquids. His anodic stripping voltammeter was so much more effecient and cost-effective than extant methods for trace metal detection that he and three fellow graduate students decided to form the company to bring this technology to the medical instrumentation market. Between this decision and the company's actual start was a two year hiatus during which the four intended partners scattered to teach at various universities. In 1970, the founder returned with one of his own graduate students to set up shop. With some help from family and from professional management which joined the company within the year, all the start-up capital for the corporation was provided from personal funds. This bootstrap operation was soon producing anodic stripping voltammeters.

The company's original markets were diverse and within a year, the company was delivering anodic stripping voltammeters to medical centers, hospitals, public agencies, and food manufacturers. Within that same year, the company began to show a profit pattern that would support a 50 percent aggregate annual growth rate without additional outside financing.

Although the company produces electroanalytical equipment for general testing purposes, it operates most effectively when addressing a particular problem. The company's first major project came with the advent of public concern over lead paint in older buildings and the consequent high levels of lead in the blood of inner-city children exposed to paint chips. The founder believed that the ASV was particularly well suited to the problem. It also coincided with the founder's desire to investigate the use of technology for the solution of problems that were essentially social in nature. The company began to work closely with various federal and city

the company's initial development.

SIGNIFICANT EVENTS AND KEY FACTORS

The founder was particularly interested not only in starting his own company, but in using his technical knowledge to solve some of society's problems. He looked around for ways to use his technology for the public good and even during graduate school directed his efforts in that direction. It was, and is, his opinion that a small private industry with profit as an absolute yardstick of the utility of a technology and with a minimum of red tape in development and implementation was the best vehicle to implement this goal. The identification of public needs followed by the development of the necessary instrumentation has been the clear impetus for the company's growth.

Another key factor in the company's growth was the recognition of the need to bring professional management, marketing, and financial people into the company immediately.

mind.

The company's first "plant" was in a Cambridge garage. Founder 3, as president, was the first full-time employee. Founder 1 served as chief inventor -- Founder 2 as technical director and chairman. No one drew a salary the first year, but Founders 1 and 2 continued in their university positions. By 1948, however, it became clear that other technology would capture the market for cancer therapy. At this point, the company began developing major equipment for university research labs. The company was reinvesting a record 12 percent of its sales into this research and development. In addition, there was a fairly fluid transfer of useful technology from Founder 2's privately and government supported university research lab.

Besides the transfer of technology from the university, and its own unusually high internal R & D, the company also gained some new technology through the acquisition of a smaller company. This acquired technology combined with extant technology, forms the basis for a product line of plastics and accessory equipment that the company began manufacturing in the mid 1960's. The company is now a leading manufacturer of a variety of electric and electronic equipment. Founder 1 eventually left his university post in 1953 to devote his full energies to the company's research. Founder 2 continued his teaching and research at the university in addition to his role as scientific director of the company.

FINANCIAL HISTORY

The company received its original funding of $250,000 from a private venture capital firm and another investor in return for 60 percent of its outstanding stock (48 percent and 12 percent respectively). The funds were applied to capital equipment purchases, establishment of research facility, product development and the working capital to start the company on its first product.

1964 to 1965, the company's annual sales to U.S. customers dropped precipitously and foreign research institution sales kept the company going.

GOVERNMENT INVOLVEMENT

Throughout most of its 34 years, the company has had no direct government R & D contracts. It has, however, greatly benefited indirectly from government R & D spending and suffered from government R & D spending cuts. The company's great financial success in the 1950's and early 1960's was based on university expenditures for capital equipment. These expenditures were made entirely out of government R & D grants. When the federal government cut awards to university research labs in the early 1960's, the company lost its major market. The company was then forced to find other markets to broaden its product line.

Besides affecting sales, government R & D spending had an impact on the company's technology. Founders 2 and 3 had gained some of thier original expertise in government sponsored labs. To this day, Founder 2 conducts university research under government R & D contracts and concurrently stimulates engineering development at the company. Finally, many of the research scientists who come to work for the company were trained in government sponsored university labs.

SIGNIFICANT EVENTS AND KEY FACTORS

A crucial factor was the nature of the investors in the initial funding round. Both understood the problems of the company's particular field of technology and its long gestation period. Both were willing to wait patiently instead of making unrealistic, early profit demands that could have caused the company to fail. The only contingency of this round of funding was that the company secure exclusive license of the founders' patents held by an independent corporation for the university. The ability

CASE #22

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company grew out of a unique university laboratory that during the 1950's did extensive contract work for the Air Force. The hundred or so engineers, scientists and technicians from diversified fields brought in $1 million worth per year of contracts primarily for optical research and equipment. The lab was also in the forefront of aerial reconnaissance, a field that combined optics and information technology.

In 1957, two former associates of the lab, Founders 1 and 2, conceived of founding a company to exploit a perceived market for graphic information systems in the military's arms control programs and for commercial markets. In September of 1957, they established the company with financial backing from a major private venture capitalist. A few of the lab's scientists joined the venture. On January 1, 1958, the company negotiated a transfer of the lab from the university; with few exceptions, the lab's entire staff also joined the company.

Corporate status made possible the wide expansion of the lab's work both in terms of classified contracts and actual production capacity. It was the general furor created by Sputnik, however, that really catalyzed this expansion into the company's phenomenal early growth. Within a year, sales had reached $3.5 million, employment 100. By 1959, sales reached $25 million, employment 1350.

While the company greatly increased its aerial reconnaissance work for the Air Force, it also initiated an acquisition policy that expanded its capabilities into a variety of related fields, many with commercial applications. Thus, within a few years of founding, the company consolidated its preeminent position as a developer and producer of optics and information systems for the government and established strong positions in business equipment and vision care products.

During the 1960's and 1970's, the company continued to extend its

research groups. While the disbandment is in accord with the company's corporate structure as it has lately evolved, Founder 3 saw it resulting in a sharp decline in the truly creative work made possible by the synergism of the company's original research team.

FINANCIAL HISTORY

The company's original financing was a $180,000 investment, soon raised to $600,000 by a private venture capitalist who enjoyed "way out" projects. He received 15 percent of the company's original stock. The level of sales induced by Sputnik was so large that within three month's of founding, the company was able to go public. The company offered its stock at $21 a share. Eventually the stock was split five to one. In 1966, the company entered the New York Stock Exchange. Aside from the original venture capital funding and public stock offering, the company has been able to maintain its growth on its sales revenues.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1958	$ 3.5 Million	100	500
1959	$ 25 Million	60	1,350
1974	$ 197 Million	50	5,853
1978	$ 265 Million	35	6,282

GOVERNMENT INVOLVEMENT

The company's involvement with government R & D contracts predates even the university lab's aerial reconnaissance work. That lab of 100 engineers and scientists originated from a small optics lab at another

CASE #23

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company is a small physics and engineering firm doing basic and applied research for various agencies of the federal government in the fields of energy technology, environmental sciences, laser devices and applications. The company was founded in 1973, when six scientists at a major research facility became disenchanted with their employer's increasing **emphasis on hardware development and commercialization. They saw the facility's goals as eventually becoming too diffuse to produce either state of the art research or a viable product. The founders left the facility to start their own company focused only on contract research and development.**

The founders spent their first six months writing proposals. By the end of 1974, the company had received research contracts totalling $385,000. By 1979, sales reached $2.4 million and employment had risen from the original 10 to 46.

The founders brought the company's basic technology with them from the previous employment. The company's present technical capabilities, however, are the result of a very careful strategy in their contract research. The company's work with fuel cells is illustrative of this process which extends over all the company's research efforts.

When the Department of Energy initiated its program of fuel cell development, the company wrote a research proposal for an aspect of fuel cells easily within their technological grasp. Through this contract, the company gained access to the other aspects of fuel cell technology. The company used this as a base that has led eventually to its work on **most aspects of second and third generation fuel cells. In addition, the** mathematical modelling the company developed for fuel cells has led to a number of spin-off technologies.

The company's research staff consists almost entirely of Ph.D.'s

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1974	$ 385,000	100		10
1979	$ 2.4 Million	80	20	46

GOVERNMENT INVOLVEMENT

The company was founded to perform contract research and development for the government. With the exception of a few minor industrial contracts, government R & D represents the company's entire sales and is projected to continue to do so well into the future. About half of its work is for the Department of Defense, 40 percent for the Department of Energy, 10 percent for NASA. Within each agency, the company has many individual contract sponsors.

In addition to its present dependence on government contracts, much of its original technology had also been developed under government contract. Like the company, the founders' former employer depended heavily on the government for support of its research.

SIGNIFICANT EVENTS EVENTS AND KEY FACTORS

The company attributes its success to a very clear focus on its corporate goals, a rational strategy for acquiring contracts and technology and the technical competence of its research staff. The company was founded by research scientists who knew that their strength lay in innovative advanced research. They were not interested in commercialization and knew that they did not possess the business acumen and financial wherewithal to translate their research findings into a viable product. They made a conscious decision, therefore, to concentrate the company's efforts on contract research.

The company's strategy in seeking contracts is also important to

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in late 1968 by a recent Ph.D. from a local major university. The initial funding was provided by a large manufacturing firm for whom a relative had worked in return for 60 percent of the equity. **The founder saw a need for better consulting in environmental quality matters and felt from his technological background in nuclear physics, meteorology and geo-physics that with a little time and financial support, he could develop improved consulting methodologies and monitoring systems.**

Within a few months, government contract funds were received and provided the continued financial support necessary to develop this technology. At the same time, the company started to use its technology to assist industry solve problems related to pollution control engineering. The advent of increased concern for environmental quality and the corresponsing tightening of environmental standards and regulations provided a ready market in the private sector for the company's services.

Over the years, the company has had many government contracts with a number of agencies but has always done most of its work for private industry. Initially, it established its technical reputetion by providing air quality **consulting and monitoring services to utilities and highways agencies. Gradually, its related computer capabilities expanded so that it is now involved in the integration of data collection, processing and analysis for complex environmental studies.**

Early in the company's history, the original investing firm was bought out. The company has had steady growth over the years, twice requiring additional capital to keep up with its increasing cash flow requirements. The one difficult period occurred in 1974, when the financing for a large contract requiring expensive new equipment fell through. Attempts at the construction and sale of hardware were unsuccessful and

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1969	$ 119,000	45	34
1975	$ 4 Million	35	200
1979	$ 32 Million	20	700

GOVERNMENT INVOLVEMENT

The founder emphasized the important role the government played in the company's early history. Even though it seldom constituted more than 35 percent of sales, the work came at very opportune times, and led to a number of technological developments instrumental to the firm's growth. The government contracts were self-developed, and were not a result of special "connections". The founder pointed out the healthy technological atmosphere in the late 1960's and early 1970's. Essentially, the firm would appeal to the government with a strong marketing effort behind a unique idea, which at the time was sufficient to achieve much needed funding. The founder felt that today, the more innovative an idea, the less chance it has of being funded. Today's high-technology market is mired in conservatism and afflicted by the preponderance of **earmarked** , government proposals, aiding the large entrenched company, and hurting the small innovator. Government business for the firm still accounts for about 20 percent of sales, but its orientation has changed markedly. Their use of patents has been extensive, with a great deal of success. They have never made money on patents per se, but their existing patents have never been infringed upon, and have been an important tool in protecting technological developments.

SIGNIFICANT EVENTS AND KEY FACTORS

The three key factors in the company's success were the recognition

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company is now a major corporation with somewhat disparate, but highly successful components. Its present work in construction, broadcasting, nuclear and solid state products, however, is completely unrelated to the company's original technology and business plan. When the four founders left their former employer in 1951, they had hoped to perform extensive government R & D contract work for the first few years, thereby gaining the necessary expertise and technology to commercialize a product. Although the company maintained its software division until 1968 and its advanced research group until 1973, neither of these divisions, both of which had been involved in government contract R & D, ever achieved the sales levels the company sought or translated into a commercially viable product. The company's presently successful divisions were all acquisitions, as was all the technology used by those divisions.

FINANCIAL HISTORY

During the company's first few months, while the founders submitted research proposals to government agencies, they supported themselves with per diem consulting work for the Air Force. Once the company began to receive R & D contracts, it needed capital to finance laboratory and office space, laboratory equipment, support staff, cash flow. At the end of its first year, 1951, the company raised $160,000 with a public stock offering. In 1956, the company raised an additional $600,000 by selling to each of two major corporations a 20 percent interest in the company. Since that time, the company has supported all growth through internally generated sales, and a series of mergers and acquisitions.

years it had become more restrictive, and less remunerative. It became clear that the company would never begin to approach the targeted billion dollar sales figures if it remained in that market.

In order to become established on a scale that would lead to major corporation status, the company needed more financing than either the founders, government contracts or small private investors could supply. To go the public market for the requisite capital, however, meant relinquishing most of the founders' personal control over the company. This decision, however, has made it possible for the company to reach some of its corporate goals.

Finally, the company's divisions each represent very different fields of technology and business. Such diversification strengthens the company's overall competitive advantage.

otherwise prefer academic work.

FINANCIAL HISTORY

The company had only one round of financing. When the founders decided to strike out on their own, they personally provided the initial capitalization that was small. The founders put in an all out effort for this first year. They worked seven days and six nights a week. They drew no salary for the first six months. They met with some former contacts in federal agencies, but largely pounded the pavements for new sources of work. After six months, they had their first contract. After a year, the company was profitable, but just barely. During its second year, the company began to exhibit profit levels, which it maintained through the present. These have allowed the company to grow without any additional financing. The company has had a steady growth profile and no cash flow problems. The only bank loans the company has taken were repaid rapidly.

The founder interviewed was aware of the uniqueness of the company's financial history and attributed its above average productivity per research dollar, to hard work, careful planning, and unusual capabilities in technology and personnel.

SALES AND EMPLOYMENT HISTORY

The company has exhibited a steady annual growth in sales and employment of 30 percent. The company's sales are entirely to the government.

GOVERNMENT INVOLVEMENT

It had been the founders' intention from the outset to seek government contract R & D work exclusively. Although the company had a few industrial contracts its first year, it soon established sole source arrangements for certain types of systems work with the Navy and NASA. The founders

CASE #27

COMPANY DEVELOPMENT AND TECHNOLOGICAL DEVELOPMENT

The company is a leading manufacturer of analytical instruments, principally liquid chromatographs. It was the second successful commercial venture of an inventor-entrepreneur who, from 1947 to 1955, ran a firm that produced infrared gas analysers, which he sold in 1955 to his sales outlet. Since 1978, the founder has been running a firm that designs and markets business information systems. The founder built the company around the process control refractometer he had been developing as an out-growth of his earlier work in infrared spectrophotometers. The company began producing laboratory scale refractometers to detect the output from liquid chromatography columns. In 1960, a major chemical firm needed a refractometer detector for the gel permeation chromatograph it had been developing. In 1962, the company received exclusive rights to the gel permeation chromatograph which, with the company's refractometer detector, revolutionized the determination of polymer properties. The company also continued its work with liquid chromatographs.

In 1980, the company was acquired by a larger firm in the instrumentation field with different but complementary technology.

FINANCIAL HISTORY

The founder financed the company in 1958 with his savings. Much of this money came from the sale of his first company. Shortly after founding, a major chemical manufacturer became interested in the company's process control refractometer for use with its gel permeation chromatograph. Sales reached $500,000 by 1962. The company needed additional capital to finance this 40 percent annual growth and cover cash flow. In 1962, a venture capital firm made a common stock investment in the company that provided this much needed capital. In 1964, a venture capital firm and

entrepreneurial skills, and the corporate decision in 1970 to change management and consolidate its development strategy.

The founder was, and is, a very successful entrepreneur. He has tremendous ability, not simply to design instrumentation, but more importantly, to identify key technological problems and develop innovative solutions that will lead to significant markets. His skills led directly and indirectly to the company's success. The gel permeation chromatograph with the company's refractometer detector analyzed polymer characteristics so much faster and more completely than existing methods, that the product had a large market and slaes from its introduction. Further, the founder's previous entrepreneurial success contributed both the company's basic technology and sufficient starting capital that the founder did not have to seek outside financing until 1962.

By 1970, the company had reached a critical growth point which could not be surpassed solely with technological innovations. In order to grow and survive in increasingly competitive markets, the company needed new management, a clear focus on product development, markets and business plan. The founder recognized these needs and was willing to turn over the company's control to more competent managers, while retaining technical directorship. Many other high technology firms have failed at this point in their histories because a founder, who was a technologist but not a manager, was unwilling to relinquish control of his business.

FINANCIAL HISTORY

Information is not available on the original founder's start-up costs. The second owner acquired an almost defunct company and invested about $25,000 during the first year plus an additional $2,000 to buy the patent rights from the estate of the original founder who had died. Soon after he purchased the company, the second owner sold stock to ten outside investors and raised $68,000. Although company sales soon rose, they were rarely sufficient to support rapid company growth or meet cash flow needs.

After his brief stock offering, the new owner financed company growth entirely with loans. In 1973, he secured a $250,000 SBA guaranteed loan from a local bank. Since the SBA prohibited the loan's use for long term capital investment, the owner sought other types of loans, and in 1975, paid off the SBA loan. The owner often meets cash flow problems with short-term borrowing from a bank or with his personal funds.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1968	$ 28,000	15	8
1974	?	?	15
1979	$ 3.5 Million	5	65

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company is the producer of a small computer for use in controlling energy usage. This micro-control energy management system first collects information on energy flow and comsumption, and then prescribes a program for selected equipment to operate. It is intended to control the operation of heating, ventilating and air-conditioning equipment in medium sized operations. The founder worked for several large corporations before deciding to establish his own company. For about nine months, the founder worked out of the basement of his home doing the necessary development. To assist in this initial work, the founder hired two key technicians and paid them from his own savings. At the end of 1977, the founder requested, and received, aid from a large group of businessmen to help in the forming of his new company. In spite of the possibility of providing significant energy savings, the company was unable to secure any help from the federal government in even reviewing the product or trying it out on a federal building to assess its effectiveness. A number of technical improvements have already been accomplished and a domestic unit for households is being developed. The key difficulty seems to be finding more effective ways of penetrating the marketplace. This will require additional financing which is not yet available.

FINANCIAL HISTORY

The initial funding of $18,000 was provided by the founder. Family investors provided $60,000 for 20 percent equity and this permitted the company to obtain a $100,000 bank loan with an SBA guarantee. An additional bank loan of $40,000 was obtained from another bank with a personal guarantee from the founder. When a sales manager was employed during the early stages of the company, an agreement was drawn up to provide 20 percent of equity in lieu of $60,000 of salary. At a later date, five percent

SIGNIFICANT EVENTS AND KEY FACTORS

The most important factor in this company's continued existence seems to be the founder's willingness to risk his own time and resources to keep it going. In addition to money actually invested, one of the bank loans was obtained by using the founder's home for collateral. The major problem currently faced by the company relates to the difficulty of marketing a capital good item. They are now trying to obtain additional capital to be used to improve the marketing effort. Although they have sixty units functioning well, it is too soon to predict long term survival.

GOVERNMENT INVOLVEMENT

The company has generally had little contact with the government. Its one involvement, however, was an SBA loan guarantee which was an important factor in the company's financial history.

SIGNIFICANT EVENTS AND KEY FACTORS

The development of the food storage and cooking technology came from a previous family business. It became clear that these devices went far beyond the limited uses for which they were originally developed. After selling the previous family business, the founders concentrated on the production of more efficient storage and cooking devices for use in many food-related industries.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1959	$ 50,000	5	5
1974	?	?	165
1979	$ 2.7 Million	0	300

GOVERNMENT INVOLVEMENT

The role of the government in the success of this company was very small. However, the help given by the government enabled the company to establish itself in the European market. It was the Department of Commerce that encouraged the company to attend the European trade show. As a direct result of this show, contacts were made in Europe and subsequently sales were made by the company. The only monetary aid given by the government was 80 percent of the trade show booth fee, paid by the Department of Commerce.

SIGNIFICANT EVENTS AND KEY FACTORS

The decision to accept the invitation of the Department of Commerce to attend the European trade show directly resulted in contacts and prospects which led eventually to product sales. The insistence of the company to use traditional electric motor power proved to be fortuitous. The use of this type of motor was accepted over the newer hydraulic power. The founders' strong, realistic company goals established the company as a world leader in the market for their product.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1968	$ 26,000	0	5
1974	?	?	85
1979	$ 3 Million	85	100

GOVERNMENT INVOLVEMENT

The government had no influence in the initial establishment of the company. However, as the private industry funds diminished, the company actively sought, and received, a great deal of government work including money reserved for minority owned firms. The company attributes 85 percent of its annual sales to government contracts. It has also obtained some technical assistance from #406 consultants which was helpful to the company.

SIGNIFICANT EVENTS AND KEY FACTORS

The combined technical backgrounds of the founders led to a successful association with two very large corporations. Several of the founders had experience in performing government contract work before establishing the company. When the commercial business started to decline, the previous knowledge of government contract work of the founders enabled the company to receive large government contracts from several federal agencies. The federal set asides for minority owned businesses clearly made it easier for this firm to obtain government contracts in recent years and government contract work is the majority of the company's current sales. It is not clear why additional commercial work was not obtained. It seems that the company obtained the early commercial work with little effort but failed to keep pace in a rapidly changing market over which it had little control. When sales began to flounder, the first-hand knowledge of government contract

CASE #33

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The founder was on the radiology faculty of a medical college and had been thinking of starting a business for some time. He had been looking for a good product idea, and in 1969, started working on a specific product in his basement to be used as an aid in patient positioning for laser or X-ray treatments. It took over three years, until 1973, to perfect the technology sufficiently to begin real operation of the company. The founder continued to work for the company on the side, with a relative handling the main operations until 1975, when he took over full time management. At that time, he rented space, hired part-time labor and used management assistance help from SCORE, ACE, etc., to get off the ground. Although the company received no contract support from the government to develop the technology, liberal government funding of medical care has made it much easier for hospitals and clinics to purchase this equipment. Sales have grown steadily in recent years, and the company has been profitable since 1975.

The growth of this company is a direct result of a creative technologist's looking at the needs in his own field and developing instrumentation to solve a clearly identified problem. The market need was understood and a commercially viable product to fill that need was always the goal.

FINANCIAL HISTORY

Most of the initial investment was made by the founder using personal time to develop the technology in his basement, plus about $2,000 in out of pocket expenses. The company has never received outside equity financing. The founder loaned $100,000 to the company and recently a $250,000 line of credit has been granted by a local bank.

The U.S. Department of Commerce provided assistance in launching international business which is now the fastest growing segment of their market. DOC provided Trade Center facilities in Mexico City in 1979 that are expected to result in significant sales and other overseas shows are planned.

SIGNIFICANT EVENTS AND KEY FACTORS

The most important factor seems to be the thorough knowledge of the marketplace by the founder, and his unswerving drive to build a piece of equipment to fill a known need. Although the founder had little business experience, he was able to rely on effective help from several different government supported programs: SBA SCORE and ACE programs and the Department of Commerce.

Although the company is doing well at the moment, it has yet to develop a second market area, and it is beginning to face competition in its initial markets. The current product is covered by patent protection both in the U.S. and overseas, but it is not yet clear how well it will stand up if challenged. The next few years, as the company looks for other applications for its technology in markets not as readily understood, will be critical ones in establishing long-term success for the company.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1973	$ 30,000	0	13
1979	$ 1.1 Million	0	30

GOVERNMENT INVOLVEMENT

The government played several different roles in the history of this company, primarily in management assistance and in market support. The current primary user of the company's product is the health care industry in which government funding of both research and services frequently enables institutions to purchase expensive capital equipment that they could not afford otherwise, but which can reduce costs in the long run. Direct sales to the government, e.g., VA hospitals, did not come until after the product was proven in private institutions and had little impact on the company's history.

The founder feels he received key help from SCORE and ACE advisors. Two of the SCORE advisors came with the company in official capacities, one in a managerial role and the other in a financial role. These people were also instrumental in establishing a good relationship with the president of a local bank.

sales by the founders made the change in direction the easiest and most cost effective way to acquire the new technology the company needed to survive.

CASE #32

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company is a leading designer and manufacturer of audio and electro-optical systems. The company was established in 1966, when one of the founders, who had a technical background, was working out of his basement. Of the original seven founders, three were instrumental in the development of a computer memory device for a large corporation. The success of this project led to work with another large corporation. Projects for these two corporations continued for several years. However, the technology began to change and the company which produced a component part lost its two major accounts. The company wanted to utilize proprietary technology and be able to sell a total product of its own. The founders had had previous experience writing proposals and doing government R & D contract work. They now actively sought such contracts to pay for the cost of developing a new product. By 1979, 85 percent of the company's annual business was for federal government agencies such as DOD, the Coast Guard and the FAA.

FINANCIAL HISTORY

The initial investment consisted of $25,000 in personal funds from five founders for the total company equity to be used for cash flow. The contracts with the large corporations provided the working capital for the company. In 1969, the company obtained a loan for $150,000 with the aid of a loan guarantee from the SBA. When the company decided to expand the business in 1975, it obtained a large loan of $350,000 to cover the expansion and partially to replace the 1969 loan.

CASE # 31

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was established in 1959 as an engineering consulting firm. The three founders came from the same corporation in the midwest. During the next several years, the founders were trying to develop a product that would be profitable to manufacture. In 1965, it was decided to try to produce a tracer to allow a machine to make copies of complex tools. The idea came from direct knowledge of customer needs. However, it was several years before this tracer was accepted by industry. The company ran into a number of roadblocks before being able to consider large scale production of the tracer.

The company was persuaded to take the device to Europe to be shown in a Department of Commerce sponsored trade show. The tracer was favorably received at this trade show, unlike a similar show held in Chicago, were the tracer was ridiculed for having electric motor power instead of hydraulic power--the popular, new method--and for having a Japanese motor rather than an American motor. As a result of the European trade show, the company found prospects in several countries.

The company serves their European customers from England, with a manufacturing facility in Ireland. In 1979, company products had an 80 percent share of the world market for tracer equipment.

FINANCIAL HISTORY

An initial family investment of $10,000 for 20 percent equity established the company in 1959. In 1961, the company sold 49 percent of their stock for $50,000 to a large manufacturing concern. All additional equity was generated internally from profits and long-term bank loans. In 1979, the company entered into an agreement with the manufacturing concern to buy back the stock sold in 1961.

CASE #30

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1968 as a family business to manufacture food processing equipment. Both the technology and initial financing came from a previous family business that included five food franchises and a small food processing equipment plant. Although none of the founders had formal technical training, they developed some innovative equipment in response to food transportation problems among their franchises. The company extended its equipment design to address problems of food storage, cooking and reconstitution. The company has enjoyed reasonable success with annual sales stabilized at $4 million since 1976 and a work force of 105.

FINANCIAL HISTORY

The founders financed the company's establishment in 1968 with capital from the sale of another family business. In 1972, the company underwent major financial restructuring. An estimated $100,000 worth of stock was paid to suppliers as payment for outstanding debts. With the aid of a 90 percent SBA loan guarantee, the company was able to obtain a $250,000 loan. The current line of credit for the company is $750,000. There is a program in the company to buy back the stock exchanged to suppliers. The majority of the stock, however, remains in the hands of the founding family.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1968	?	?	?
1975	$ 3 Million	0	95
1979	$ 4 Million	0	105

of the shares of the company were sold to two investors for the sum of $30,000.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1978	$ 8,000	0	6
1979	$ 350,000	2	11

GOVERNMENT INVOLVEMENT

Although the government did provide a loan guarantee which the company is actively using to provide $100,000 of the financing, it was not available until other investors had put in a significant amount of capital. It also was insufficient for covering the company's real needs. Additional financing has been raised by the founder and elsewhere, and more is still needed. It is clear that to establish a viable manufacturing business, even after the development work has produced a product in active use, requires a great deal of working capital which is not easy to obtain.

In this particular instance, it is unfortunate that the federal government was unwilling to try the product in one of its facilities. Although it has now proven itself elsewhere, the testing of this device by the federal government to validate claims made (and possibly, a purchase for use in some public buildings) would have greatly eased its earliest problems.

GOVERNMENT INVOLVEMENT

The 1973 SBA loan guarantee was critical to the company's continued existence at a time when traditional sources of venture capital were essentially unavailable.

The company's only other contacts with the government are through its efforts to meet EPA toxicity standards and its marketing of algicides to state and local governments. The company has embarked on a costly and time consuming testing program to qualify its chemicals for EPA licenses by which they hope to gain some market exclusivity. Its sales to state and local agencies account for less than 15 percent of its total sales.

SIGNIFICANT EVENTS AND KEY FACTORS

The company's success since 1969 is attributable to its innovative products, agressive marketing program and the availability of debt financing at crucial junctures.

The company has consistently developed new copper sulfate derivatives that are effective algicides in many environments. The company has also succeeded in reducing the general toxicity of its chemicals but increasing their specificity, thereby rendering them both more efficient and ecologically desirable.

The owner sought to break the seasonality of his new business by agressively pursuing year-round markets. The company has developed new applications for its products with stable markets. In addition, it has developed extensive markets for its swimming pool products in the south and west where the swimming season is almost year round.

Finally, the availability of debt financing, notably the SBA guaranteed loan, but also short-term bank loans, helped the company through financial difficulties, thereby enabling it to realize the benefits of its marketing and product development programs.

CASE #28

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company produces water treatment chemicals primarily for the swimming pool industry. It was founded in the late 1950's by a biochemist interested in the control of algae growth in freshwater ponds. The founder tinkered with copper sulfate derivatives as a sideline from his work at a large pharmaceutical firm. When he had developed a marketable product, he left his employer to start his own business. The company remained very small but sales to local swimming pool markets were sufficient to support the founder's continued development of new algicides.

In 1969, the founder sold the company to an insurance salesman seeking a career change. The new owner hoped, with better management, marketing and focused product development, to transform the company from a minimally remunerative hobby into a highly profitable business.

The new owner continued to base the company's work on the copper sulfate technology licensed from the founder. He hired additional technical people to broaden the product line. He also instituted an agressive marketing policy to offset the extremely seasonal sales pattern of a company catering primarily to the swimming pool industry in a northern state. The company's technical staff has been developing chemicals that can control algae growth in rice fields without damaging the rice plants, as well as new products for the recreational vehicle industry. The marketing staff has been developing markets for these new products as well as developing new markets for existing swimming pool algicides in the south and west, where the water treatment season is considerably longer than in the north.

In 1979, ten years after the company was purchased by its second owner, sales reached $3.5 million and employment 65. The company has resolved many management and financial problems and looks forward to continued growth and technological development.

a large chemical manufacturer made an additional investment. In 1970, the firm that would buy the company out ten years later made an equity investment. The founder's family retained 45 percent ownership in the company at this time. In 1973, the company went public in response to its investors' demands for liquid stock. The company raised additional capital through two further stock offerings in 1975 and 1977. In 1980, the company became a wholely owned subsidiary of another firm in the bio-medical instrumentation field through a stock transfer.

This firm has far better management resources, so should help alleviate some of the company's management problems associated with growth.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1958	$ 70,000	30	5
1975	$ 17 Million	?	300
1979	$ 70 Million	0	1150

GOVERNMENT INVOLVEMENT

During the company's first three years, 30 percent of its annual sales were government R & D contracts. Afterwards, however, the company suspended all government work. The founder felt that government work entailed far too much paperwork and far too little money to make it worthwhile on a long-term basis. Further, he felt that the staff mindset necessary for success in government work would preclude good commercial development.

SIGNIFICANT EVENTS AND KEY FACTORS

The key factors in the company's success were the founder's

succeeded in diversifying and augmenting their sources of government contracts but have remained almost entirely within the various government agencies.

Because much of the company's work is classified defense contracts, the company has been largely unaffected by cutbacks in government funding.

SIGNIFICANT EVENTS AND KEY FACTORS

According to Founder 1, the key factors in the company's success were its unique technology, high productivity and ability to package and market its services. The computational techniques put the company so far ahead of the rest of the field, that it secured many important sole source contracts with government agencies for this work. The management, personnel make-up, and careful planning of the company render it far more productive per R & D dollar than most other firms, enhancing the company's attractiveness to the agencies spending research dollars. A conscious decision was made to work almost exclusively for the government and always as the prime contractor. This avoids a conflict of interest when evaluating new commercial technology for government agencies. Finally, the company was able to translate its unique technology and high productivity into financial success because it could package and market its varied services.

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company is an R & D firm that develops systems and software primarily for government agencies. It was founded in the mid 1960's when several engineers at a local research facility became dissatisfied with their jobs and wanted to run their own company. This entirely self-funded group received its first contract after six months and showed profit after the first year. The company has both broadened and intensified its markets and extended its technical capabilities. It has exhibited an annual aggregate growth rate in sales and employment of 30 percent but has never had to seek outside capital.

The company designs systems and software for the solution of various problems often associated with defense operations. This work most often involves paper, pencil, laboratory experiments and computer time. The company's original general technology thus consisted not of patented processes or equipment, but rather, the expertise and knowledge of its founders. The company's technological, and thus financial success, however, arose from successful applications of a theoretical breakthrough in computation made in the same time frame as the company's start.

While the company's technological basis was originally focused upon this computational breakthrough, the company has sought very broad applications that draw on employees' expertise in a variety of fields. Among the techniques the company uses are mathematical modeling, systems analysis, economic analysis, engineering optimization, management science, and computer simulation. The company builds on its previous work but constantly expands its capabilities in order to address new problems.

The company exists at the interface between academia and industry. Although all of its research is applied, there is a sufficient underpinning of theory to satisfy top researchers and senior technical staff who might

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1951	$ 250,000	100	8
1979	$136 Million	5	1500

GOVERNMENT INVOLVEMENT

The company depended heavily on government contract R & D in its early years. The founders had developed their original technology under government contract while they worked for their former employer. They did consulting work for the Air Force to support the company during its initial few months. The company's sales during its first few years were almost entirely government R & D contracts. The company's other divisions fairly rapidly surpassed governemnt R & D divisions in sales, and the company was never able to commercialize government sponsored technology. The initial government contract work, however, provided the financial cushion until the company clarified its goals and was able to move into large scale manufacturing of acquired technology as well as into the radio and construction businesses. The situation points up the problems faced by scientists and engineers when they try to bridge the gap between contract research and commercialization.

SIGNIFICANT EVENTS AND KEY FACTORS

The founders attribute the company's present phenomenal success to their decision to abandon contract R & D, their decision to give up control in order to raise capital in the public market, and the company's great diversification.

While contract R & D had gotten the company off the ground, over the

of a market need, the availability of government funding in the development of technology; the emergence of a prosperous market in the company's field of specialization; and the entrepreneurial role model that the founder's father offered.

The founder identified needed but not yet available technology that was within reach, and set out to develop it. The company was able to finance some of the critical technological development through the funding of unsolicited proposals by the government. The founder pointed out that in the company's early years the government would frequently fund an innovative idea with no assurance of success. The founder's family background had a significant influence on his willingness to accept risk and possible failures as a cost of directing an innovative company. The founder's father had been involved in a number of entrepreneurial business ventures and the founder was oriented toward running his own company.

looked unlikely in the future. Recently, the company merged with a much larger, public corporation that can use the technology and has sufficient financial resources and orientation to get hardware to the market.

FINANCIAL HISTORY

The company was founded in late 1968 with the equivalent of $150,000 provided by a large corporation for a 60 percent share of the equity. The funding was not cash; it was budgeted on an "in kind" format. These funds were not sufficient to keep the business operating, and the firm survived on a number of small loans during the first year of operation. Within two years, the firm was able to survive on its own revenues, and it bought back the 60 percent they had originally sold to the investor.

By 1972, the company had developed a solid framework for growth, and any other private financing they have received has been growth oriented. In 1972, the firm received about $300,000 in private funding, and in 1973, an additional $500,000. These influxes of outside capital were compensated with about 30 percent of the company's ownership.

The company experienced a severe financial squeeze in early 1974 when financing for a large contract requiring expensive new equipment fell through. By stretching its payables, the firm was able to weather the crisis, and by early 1975, was again on a firm financial base.

The firm has been expanding rapidly since 1972. In 1977, it merged with a large firm, with the merger presenting some formidable financial resources.

its success. The company secures contracts based on existing technical capabilities that will help extend those capabilities as well as give the company access to new technology. The company also secures contracts from many different sources so that only an across the board cut in federal research allocations would have a severe financial effect on the company.

The third factor in the company's success is the high quality of the company's research staff. Their tremendous expertise and ability to approach complex problems with creativity and insight have strengthened markets for the company's research.

at the forefront of their particular scientific fields. The company is run much more like an academic institution than an industrial research facility. Since the company is not concerned with commercialization, it freely disseminates non-classified findings. The company encourages its staff to participate in scientific conferences. The company runs a regular distinguished speaker series to help its staff keep up with new technological and scientific developments. The company also encourages its researchers with complementary expertise and capabilities to work together on projects, which results in more creative and often more rapid solutions to complex problems.

FINANCIAL HISTORY

The company's only financing was the original $70,000 the six founders put up in 1973 for equity in the company. They used this money to pay their own salaries and that of a secretary while they wrote proposals for research contracts. In the beginning, their research was almost entirely theoretical, so did not require equipment expenditures. As government contracts increased, the company began to acquire experimental equipment through the contracts, which became part of the company's available research facilities. The company also gained access to very advanced equipment and devices at government research laboratories.

The company has never had to seek additional financing. It has been able to support its annual growth of over 30 percent on its own sales revenues. Founder 1 ascribes this success to the company's strong research capabilities and securing contracts from three federal agencies. and enough different departments within those agencies, that the loss of any single contract would have minimal financial repercussions.

university set up by the Air Force during the Second World War. The optics lab moved from the first university which no longer wanted to be involved in classified work for the Defense Department to another in 1947. By 1957, its staff had expanded from 15 to 100 and it had accrued approximately $1 million per year in primarily sole source R & D contracts for the Air Force. Within a year of the company's founding, R & D contracts totaled $3.5 million.

In essence, the company's original technology and basic staff capabilities were developed under government contract. Large government contracts in the early years served the additional function of providing a financial cushion while the company acquired and developed its various subsidiaries. Government sales continue to be important to the company, representing approximately one third of its total sales.

SIGNIFICANT EVENTS AND KEY FACTORS.

The key factors in the company's success were its unique research staff, government R & D contracts, especially in the wake of Sputnik and the company's policy of expansion through acquisition. The first two factors are very closely related. The unique aggregation of scientists and engineers produced phenomenal results for the Air Force which engendered further contracts for aerial reconnaissance and other research work. The government R & D work formed the basis of the company's technology and provided a financial cushion for early expansion into other fields. The general technical expertise of the research staff allowed the company to introduce the technological improvements to transform its acquisitions into financially and technically viable divisions.

The company's acquisition policy was also central to its great corporate success. The company is able to tap vast commercial markets in a variety of fields and to reduce its financial dependence on generally less predictable and remunerative government markets.

capabilities within its various branches as well as to make additional acquisitions. The company consists now of four major divisions: graphic products, vision products (largely commercial), and applied technology optical systems (largely government), which serve both government and public markets. The company's annual sales in 1978 reached a record high of $265 million.

The company's original technology came from the aerial reconnaissance work of the university lab that formed the company's nucleus. A unique aggregation of expertise in a broad range of fields from physics and electronics to optics and chemistry existed in this lab. Its scientists and technologists also exhibited a tremendous ingenuity, motivation and cooperation. The result was an unmatched ability to address very complex problems, and develop the necessary processes and equipment to solve them. In addition, the company had a science advisory board that consisted of some of the nation's top scientists. The company's output on its government R & D contracts during its early years was phenomenal.

The company's acquisitions often had no direct technological connection with the company's original work. The same expertise and motivation that lent brilliance to much of the company's aerial reconnaissance work, however, also led to the technological and fiscal success of the company's acquisitions. For example, in 1958, the company purchased a failing business whose main product, copying equipment, had become obsolete. The central research group was able to apply computer technology and general expertise in a variety of fields to develop the basic equipment that raised the company's graphics division to national importance.

As the years progressed, the company continued to expand through acquisition. Although the company continues to perform considerable contract R & D for federal agencies, primarily the Air Force, by the mid 1970's, it had become too large and diffuse to maintain a central research facility that served all divisions. Individual divisions now maintain their own

of the company to obtain the practical equivalent of patent rights from the university was attributed to the close connections and mutally supportive attitudes among the founders, the university and the major capital source.

The close involvement and interaction with the university has continued to play an important role in the company's development. It has provided an excellent mechanism for technology transfer and has enabled the company to attract some of the best people from the university for its engineering staff.

It is important to note the extremely long gestation period in this field of technology. Despite the company's tremendous R & D expenditures, availability of inventions brought in from the university and technology gained through acquisition, many of the founders' original ideas are just now coming to fruition, while others could remain in the research stage far into the future.

Although the company began showing a profit in the second full year, it continued to have cash flow problems. The company was researching, developing and producing very large expensive pieces of equipment for which it received progress payments that were insufficient for its working capital needs. In 1953, a group of wealthy private investors provided the company with $500,000 new capital. In 1955, this same group invested a further $920,000. In 1961, the company secured a $3 million loan in the form of convertible subordinate notes from a large insurance firm, again for cash flow purposes. The insurance firm saw a great potential in the high technology industry, and in particular in the company. The terms of the loan were very reasonable: 12 years at 4-3/4 percent and a stock option. In 1963, with a fairly secure financial base, the company was listed on the New York Stock Exchange, but without any additional stock offering for the purposes of stock liquidity and acquisitions.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1947	$ 2,165	0	0	3 to 25
1974	$ 41 Million	Small	Small	1,350
1979	$ 65 Million	Small	Small	1,924

The company's original market consisted of hospitals pioneering megavolt cancer therapy. When advances in other modes of cancer therapy forced the company to seek other markets, it found ready customers in university labs doing atomic/electronic research.

1964 witnessed a dramatic cut in university research budgets due to government cuts in university research support, which again forced the company to seek other products and markets. During the transition period,

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1946 because two university professors (Founders 1 and 2) wanted to bring their atomic/electronic technology to the market. They convinced a colleague and former associate (Founder 3) that the venture held great potential benefit for society. They also convinced him that the venture's success would hinge not only on their own inventions, but equally on the effective management of a scientist/president.

All of the company's original technology and many of its later technological developments came from the university research of Founders 1 and 2. The university had transferred management of patents in this field to an independent corporation. At the time of founding, the company entered into a special agreement with this corporation that guaranteed (as closely as was legally advisable for the university as a non-profit institution) exclusive license to the company for those patents of Founders 1 and 2 upon which the company would base its technological development.

Founder 1, a physicist, made his first technological breakthrough in 1931 when he was a graduate student. He continued to pursue the same line of basic research for the rest of his life. Founder 2, an electrical engineer, was an early co-worker of Founder 1, who later became a professor at the same university. In the 1930's, he conceived of applying Founder 1's technology to cancer therapy. He began developing specific equipment for this use. By 1940, he had delivered units to three hospitals.

After a four year interruption caused by WWII, Founder 2 returned to his cancer therapy work. He realized that for the technology to have any impact, he needed to move it out of the university lab and into development and production. The company was founded with this specific application in

public health agencies to develop an effective lead testing program. The founder and his scientists refined the ASV, widened its capabilities, drastically reduced the cost of each test, increased its speed so results could be read immediately, and made units that were light and portable. Public health workers could now bring the ASV to individual field clinics making the lead testing program truly comprehensive.

Its work with the blood lead testing program provided the company with technological and financial impetus. This work also established the company's precedence in the field of trace metal detection. The company now has an uncontested international market for its devices, and it also has a test lab facility to serve those groups that need too few tests to purchase their own equipment.

The company invests at least 25 percent of its sales in R & D. The founder estimates that the company produces a major breakthrough at least every other year. The most recent is a device that tests for iron levels in blood serum at 50 percent of the former cost, and ten times the speed.

EMPLOYMENT HISTORY

YEAR	TOTAL EMPLOYMENT
1970	2
1974	30
1979	100

GOVERNMENT INVOLVEMENT

Although the company's technology is used primarily for diagnostic testing and is particularly applicable to large scale screening, it is infrequently funded directly by public funds. However, the increased awareness of the hazards of lead and the willingness to use public funds to try to deal with the problem, has clearly had a positive effect on

Government contract R & D, however, was the source of the company's original technology. The founders were able to build the company on almost ten years worth of basic and applied research on chemistry and pharamcology of a particular class of drugs, all performed under government contract. Thus, government R & D was integral to the company's development and it could not have been done without the commercial and patent rights from D.O.D.

SIGNIFICANT EVENTS AND KEY FACTORS

The key factors in the company's development were its original government sponsored technology, its initial facilities agreement and the ultimate redefinition and clarification of its goals and business plan.

While the company did not start out with a well defined product, it was not working in the dark. The founders' work for their former employer under government contract had established the feasibility and basic technology for the type of drugs the company sought to develop. This original research would not have been within the financial capabilities of the founders.

The company's initial facilities and marketing agreement provided a financial cushion while the company established its credibility in pharmaceutical research, secured other clients and brought sales and profits to a level that would permit self-financing of later expansion.

Innovative technology and sound financing alone are never sufficient to propel a firm from small scale contract R & D to major corporate success. A firm needs a clearly defined product and market and a clear but flexible business plan. The company's satisfaction of these requirements has already netted positive results and should continue to aid the company's success.

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1970 as a pharmaceutical research and development partnership by four entrepreneurial scientists from industry and academia. For the early years of its existence, it was primarily funded by a large chemical concern. The company subsequently incorporated as it got further into development and marketing. At that time, the company also made a conscious policy decision both to expand its contract research operations and to direct its own R & D towards a commercializable product. The company has since significantly expanded its drug development and testing capabilities. It currently uses a variety of corporate and other capital sources to finance the development and market entry of new drugs without relinquishing any equity.

The company's basic technology came from the founders' work at the R & D firm which they left in 1970. Prior to 1970, the founders and several co-workers who left with them were involved in drug development work for the U. S. government, including the Department of Defense. D.O.D. made an abrupt policy change which had a significant impact. The results of the previous research were declassified and the current contract work was discontinued. As is standard D.O.D. policy, the company was given the commercial patent rights to the technology they had developed under their government contracts. This opened up a whole new body of drugs for further research and commercial development.

The original R & D firm was willing to license the technology to the founders, when they decided to strike out on their own.

The founders planned to continue this line of research then pass drug possibilities on to a major drug company to test, manufacture and market. It was with this goal in mind that the company entered into a long-term R & D licensing agreement with a major chemical concern. Following the

As time progressed, the firm diversified into more commercial fields. Today, government business accounts for less than half of their sales, with about 50 percent of this business in research and development, and about 50 percent in hardware. The work is primarily done in the fields of energy and defense. The firm's founder emphasized the balance that is now kept between commercial and government work. While attempts have been made to use technology developed for the government in commercial applications, they have been largely unsuccessful. The work has just been too specialized, with too many performance requirements.

SIGNIFICANT EVENTS AND KEY FACTORS

The three key factors in the company's success were the role of government funding, the support that the university offered in their early development, and the founders' attitude in setting priorities.

The importance of the firm's government funding should now be obvious. For the first ten years after the company incorporated, government money constituted 95 to 100 percent of their revenue, and laid a firm financial base for further diversification.

Like many other high-technology companies, the role of the university in the company's initial struggle for acceptance is extremely important. By both furnishing lab space and secretarial assistance, it gave the founders a framework around which to organize itself, essentially, free of charge. In addition, the university's policy of encouraging faculty to spend a day a week on outside consulting surely played a role in the company's formation. All three founders are still associated in some capacity with the university.

A less tangible reason for the firm's success relates to attitude. The founders were more interested in solving problems than in making a lot of money, and this kind or orientation was infused into the employees'

The company's fundamental technology stemmed from teaching and research done at the university. All three founders were associated with the university, (and still are) and the role it played in the development of technology cannot be overemphasized. As mentioned, the development and utilization of stroboscopes was the groundwork for much of their early work and led them to work in night-aerial photography, radar, and aircraft gunsights. Projects that the firm explored throughout the 1950's were virtually all government funded. However, in the early 1950's, government funding of atomic weaponry emerged as the company's main revenue source and this technology remained at the top of the firm's priorities right through the 1950's.

Inevitably, this government work had to slow down, and when it did in the late 1950's, stroboscopes again became the main component upon which the business revolved. With successes in both the governmental and commercial fields, sufficient capital had been generated to pursue an active acquisition policy through the 1960's and 1970's, significantly developing their technological breadth. Today, the company's technological developments include manufacturing of nuclear and electronic measuring equipment, the production of geophysical survey instruments, flashtubes, photodiodes, image sensors, and mechanical seals. The firm also provides consulting for national defense, physics research, space exploration, and environmental programs.

FINANCIAL HISTORY

The corporation started with no more than $30,000 in working capital, and until the company went public in 1967, this was an instance in which the founders had chosen to invest their own funds in the organization. In the early years, the overhead was essentially non-existant, with the university supplying them with lab space and secretarial assistance, and

on sound economic planning. In addition, the firm was able to acquire companies and, by using its strong engineering capabilities, improve the existing products and expand into new markets.

A further factor in the company's success was its relationship with the university. The company grew out of a part-time consulting partnership that was stimulated by the university's policy of encouraging faculty to spend one day a week on outside consulting. In addition, one of the founders retained his faculty position, and his students became a source of highly qualified technical employees.

systems.

In the bio-medical area, the firm has developed a system allowing performance of multiple clinical or research laboratory tests on small amounts of blood serum or other body fluids. Designed to increase speed, efficiency, and accuracy, while decreasing costs, this equipment finds wide application in fields of immunology, serology, and microbiology. The firm entered this field by acquiring a company whose products could be greatly improved by the application of sound engineering design. After redesigning the product, the firm was then able to enter the marketplace with a superior product that had far reaching applications. This pattern has been the model for the company's acquisition program and has been particularly successful.

FINANCIAL HISTORY

Because of the part-time nature of its early dealings, the company did not require any initial outside capital. The only form of financing used was through its cash flow. It wasn't until 1962, when business drastically slowed down, that the founders had to inject some capital. At this time, the founders stopped drawing salaries for six to eight months until business improved again. The company did resort to some financing in the mid 1960's in the form of convertible debentures. They were sold only to raise cash flow, and were bought back in the mid 1970's. At this time, they increased their bank loan to about $4 million, but presently that debt has dwindled to $250,000.

The company has generally profited from an extremely favorable cash flow, which allowed it to avoid constricting financial commitments and heavy indebtedness. Even when acquiring the southern firm, it did so with a combination of stocks and cash, avoiding any serious long-term debts. The firm went public in 1968 to make acquisitions easier to accomplish.

contracts, to produce efficiently top quality substances for use in its own research for a viable product. These highly specialized, difficult to produce substances made their way into research facilities all over the world. The close connections maintained with researchers over the years gave them the access and reputation needed to sell their materials.

materials increased, creating a large market especially in university labs. The founder's university connections and the company's reputation for frontier research helped the company dominate that market. The company then went into large scale production, eventually becoming the leading, often sole, supplier of certain laboratory materials with current/annual sales up to around $5 million.

FINANCIAL HISTORY

The company's original financing came from a small group of private investors who gave the founder $50,000 for 20 percent of the company's stock. The founder used this to set up his research facility. The investors were surprised at the small size of the founder's request and expressed willingness to provide additional capital. The founder insisted he didn't need more. He planned to submit unsolicited research proposals and thus have the government fund the company's initial research and solve early cash flow problems.

Within eight months of incorporation, the company received its first government contract. The only additional financing the company ever received was a loan from the founder's personal funds during a particularly bleak period. If the company decides to implement its major expansion plans, it expects to go to the public market for funding.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1961	$ 500,000	100		10-15
1979	$ 5 Million	60	30	85

The 1957 decision to enter the field of psycho-acoustics also induced the company's entry into the computer field. This gave rise to a very profitable computer division. It also markedly augmented the company's capabilities in other fields (e.g., acoustic engineering).

The availability of government funding for unsolicited research proposals during the 1950's and early 1960's contributed substantially to the company's success. The company developed much of its technology and expertise under government contract. It has very effectively transferred key portions of this technology to the marketplace.

The company has a very strong policy of backing promising technologies through spinoffs. This is one of the most successful methods of technology transfer that we have encountered in our study. It is also interesting to note that while the company has provided spinoff technology for other firms to acquire, it has never gained technology through acquisition.

The company's performance in transferring technology gained under government contract provides a strong case for government support for technological development. In a number of cases the company has successfully commercialized a technology to the benefit of national technological development as well as the company's stock holders. Without the initial government R & D support, these technologies would not have been available for commercialization.

A further factor in the company's success was its relationship with the university which encouraged outside consulting. The company grew out of a part-time consulting partnership between two of the founders. In addition, four of the staff retained their faculty positions; their graduate students became a source of highly qualified technical employees.

The company's computer work, both directly and indirectly, gave rise to marketable technologies. When such a technology was identified as with time-sharing in 1963, and packet switching in 1973, the company set up a wholly owned subsidiary to exploit it. A few of the company's researchers moved on to the subsidiary, but for the most part, they provided consulting, advice, and basic technology to the new staff hired for the subsidiary. Eventually, most subsidiaries were sold to individuals or larger firms that would develop the technology further.

FINANCIAL HISTORY

Fortunately for the company, royalties from an early product enabled it to bypass all initial venture capital. Contract work was a constant and growing source of funds. Whenever cash flow became a problem in the 1950's, the company took out commercial bank loans. The only time it received any major outside funding was when it went public in 1961. The $2 million the company made in its first public stock offering, however, was incidental to its primary motive for going public. The company wanted to offer stock options to attract key personnel, but such options are more meaningful with liquid stock on the public market.

While the company never had to seek direct outside funding for itself, it did go to venture capital to finance its subsidiaries. It was very careful to bring outside financers in slowly, however, in order to retain control of the subsidiary. In one case in which the company had invested $250,000 of its own in a subsidiary and raised $25 million for it in outside financing, the company eventually realized a net profit of $14 million from the subsidiary's sale.

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company is now a leading R & D firm in acoustics and computers (information science) with over a thousand employees. It grew out of the part-time consulting work of two university professors who formed a partnership in 1948 when one of them received a major acoustical design contract. Between 1948 and 1953, when the company incorporated, the first two founders received considerably more contracts and brought three former graduate students into the partnership. They also developed a product whose royalties allowed the company to bypass venture capital completely in its early financing needs in the 1950's.

During the 1950's, the company firmly established its reputation in architectural acoustics and noise control doing primarily consulting and contract R & D. In 1957, it made a foray into psycho-acoustics which gave rise in the 1960's not only to an expert department of psycho-acoustics, but also to the company's whole computer operation.

The company went public in 1961. Its employment has grown steadily over the years. The applied nature of its work and its expertise in the field helped the company escape the financial ravages of the Mansfield amendment and Nixon's drastic cuts in research spending. The company has also been a leader in technology transfer and has set up a number of successful subsidiaries to exploit and commercialize spinoff technologies.

The company's fundamental technology came from its initial founders' individual academic work and their early collaboration. The first two founders had worked together during WWII, and afterwards established an acoustical laboratory at the university. In addition to their research, they did regular outside consulting.

Although most actual technology is developed within the company's labs, the university "connection" was, and is, an important contribution

from 8 in 1962 to its present level of 350.

FINANCIAL HISTORY

None of the founders had personal financial resources to contribute to the company's start-up costs. As a result, they gave their initial investors, who included a private venture capitalist and a medium-sized manufacturer, 90 percent interest in the company for the $250,000 they needed for start-up in 1962. Stock options to founders and key employees increased their potential interest from 10 to 35 percent.

From 1964 to 1968, the company raised an additional $800,000 to support general growth. It went public in 1977. Since the purpose in going public was stock liquidity rather than raising capital, the company issued no new stock, but simply registered with the S.E.C.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1962	0	0	0	8
1963	$ 100,000	25	0	8
1974	$ 7 Million	10	15	190
1979	$20 Million	10	15 (approx.)	352

GOVERNMENT INVOLVEMENT

During its early years, up to a quarter of the company's sales represented government R & D work. Because of the difficulties associated with background rights and patents, the company attempted to minimize direct government R & D contracts. The company left the government contract R & D market entirely during the early to mid 1970's. It is presently performing some reeearch for government agencies who

the company is presently based.

The third factor essential to the company's success was its relationship to Founder 2's university. University policy encouraged faculty members to spend one day a week on outside consulting. If Founder 2 had been forced to choose between the company and the university, the company would never have been founded. Instead, he was able to develop commercially a promising technology and fulfill his academic obligations. As noted before, Founder 2's straddling of the university/industry interface also aided in keeping him abreast in the separation field and in providing the company with a renewable source of highly trained technical personnel. At one time, over 10 percent (14) of the university's 10 year output of chemical engineering Ph.D.'s were on the company staff.

company needed no additional outside financing. In 1977, the company was wholly acquired by its second investor, to obtain complete management control.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	TOTAL EMPLOYMENT
1963	0	0	4
1974	$ 3.0 Million (approx.)	70	80
1979	$ 12 Million (approx.)	15	225

GOVERNMENT INVOLVEMENT

The company's direct government involvement did not commence until four years after founding and then under somewhat unusual circumstances. NIH had heard about the company's Method B technology. Another very large chemical firm was developing similar technology and was the only firm in the country applying it to the development of a kidney dialysis device. The federal agency wanted to encourage competition in the field and so asked the company to submit an "unsolicited" proposal to work on this same device.

Although one of the company's board of director members objected to any government involvement, the company had been unable to secure financing for Method B development from any other source. While the company was under contract, the application of Method B (it received a second contract as well) to a particular medical device, it was also able to develop and refine general Method B technology. Thus, government funding was one important factor in the company's later success when it developed more remunerative commercial and industrial applications of Method B.

The company's success under its original government contract facilitated additional awards which for many years supported the work of both its

The company's original technology came from Founder 2's university research. The company hoped to develop and refine Method A of chemical separation into a commercially marketable product, and devoted four years and a lot of effort and money. In addition, two of the later employees became particularly enthusiastic about a second method (Method B) for separation and the company supported their research as well.

By 1967, it had become clear that Method A's development to product stage would require another 10 years research and considerable additional funding. The company made a decision to discontinue Method A research and expand its work on Method B, which was coming close to commercial applicability. Although the company's intent was to improve Method B technology generally, the company's R & D was soon focused on a very specific application.

A federal agency became interested in one aspect of the technology and awarded the company a $220,000 contract to develop it for use in kidney dialysis devices (see Government Involvement section for details). It took another five years and additional financing to develop the technology. The company then licensed the technology to another company for production and marketing. About the same time, an application was developed for the auto industry and now dominates this market worldwide.

In the meanwhile, the company had developed a biomedical division and merged with another company started by Founder 1 and one of the private investors to form an environmental division where they worked on testing devices. However, in 1979, management decided that in view of the problems with government contract work, they would phase out all such work and concentrate on developing industrial applications of its technology (Method B). The biomedical division has been phased out and the environmental division was sold out to an employee.

of new technology. This company cited numerous examples of having a new technology turned down by the U.S. government, and being forced to take that technology overseas and successfully introducing the new technology before the U.S. government would develop an interest. This comment appears in other case studies. It was also noted that they have often encountered situations where the government specifications and the tests don't match, or the specifications and the actual use of the product do not match. One comes away with the impression there may be a serious government procurement problem, i.e., maintaining the procedure while forgetting the purpose.

SIGNIFICANT EVENTS AND KEY FACTORS

There are two fundamental issues and three significant events in the company's history. The first issue is the failure of the company to develop any commercial products. The company struggled with this issue from its very beginning and would appear to have given up on the idea at the present time. The second issue is the company's success in finding a place in the pulsed high power energy field. This was one of the technologies the founders brought to the company, and the company has been a leader in extending the state-of-the-art.

The three significant events include: first, the public offering of their stock, followed by a drop in government sponsored research and their ability to cope with this problem. Finally, the sale of the company and their successful relationship with their new parent.

This company has also, indirectly, been running its own economic development program. There are currently five companies operating in the immediate areas that are technological spin-offs of this company. All five are apparently operating at a profit and producing products for the commercial or governmental markets.

and into early 1975. Once the company went through their initial drop, and took a hard look at their operation, laid off the necessary people and divested themselves of their subsidiaries and wrote down the losses, they found they were in a secure financial position. They were still benefiting from their strong cash position as a result of their stock sale, and in 1973-74, they were able to operate at a profitable level. In fact, once a full evaluation was completed of the 1972 period, they realized the parent R & D company had been profitable, but the subsidiaries had dragged them into the red.

During the period 1973-74-75, the members of the board of directors had been searching for a way to stabilize the company. The board was anxious to find a situation that would give the company a broader based market and strengthen the management. In August, 1975, the company was sold to another research based organization in the Northwest. This merger, which on the surface did not seem to make sense, has been very successful. The company has continued its profitable operations with little interference from the new parent, and both partners appear to be pleased with the resulting organization.

At the present time, the company's sales are divided between direct government (70 percent), indirect government (20 percent), and foreign (10 percent). The company is almost totally in the research and development business with the one proviso that almost half of all of their contracts result in some type of hardware. A major fraction (50-60 percent) of their business involves R & D of pulsed high voltage energy sources.

FINANCIAL HISTORY

The company started in 1962 with a little over $400,000. A small amount came from the technical founders, $150,000 was equity capital, and about $250,000 came from loans. Between 1964 and 1970, sales and

CASE #12

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

This company was formed on July 1, 1962, by three Ph.D. physicists from a major government sponsored research laboratory and venture capitalist. The initial venture capital was composed of small amounts from each of the physicists, $150,000 in equity capital and approximately $250,000 in loans. The company was formed to take advantage of the technical knowledge gained in the founders' work in nuclear research. The founders felt their knowledge had value in and of itself, but they also had over fifty possible products they felt could be developed utilizing the technology developed in their research.

In order to keep the company on a solid footing, however, the founders immediately started looking for R & D contracts. They did not have long to wait, within three months they had their first R & D contract. By 1963, the end of the first year of operation, the company had sales of $300,000 with 20 employees and was operating profitably.

In the time between 1964 and 1970, sales and profits increased rapidly reaching a level of $18 million in 1970 with over 600 employees. This period also saw a number of efforts at diversification.

In 1967, the company acquired the rights to a very small company that produced a line of electro-optical radiometers and was also developing a programmable desk top calculator. The initial acquisition was really a shell; the ideas were there, but little else. The company eventually put over $3 million into this venture. Initially, the operation was allowed to function independently of the company, but in 1969, the acquisition was brought into the corporate structure as a subsidiary. In 1971, this acquisition was sold to a major U.S. supplier of electronic test equipment.

In 1968, the company entered into an agreement to exchange stock

FINANCIAL HISTORY

The initial financing of $300,000 came through a public offering to 250 individuals. Since then, the company's growth has been financed almost totally through retained earnings. There have not been any additional equity offerings, and peak cash flow requirements have been financed through short-term loans.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1961	$ 70,000	85	15	8
1974	$1,500,000	60	5	35
1979	$2,500,000	50	10	50

GOVERNMENT INVOLVEMENT

An important episode in the company's history occurred during the problems associated with the C5A contract. Basically, the prime contractor had seriously underpriced the final product. The effect of this under-pricing had a ripple effect on the sub-contractors. In this case, the company lost $300,000 on their part of the contract. Evenutally, a process was established for the contractors associated with the C5A to recover their losses. This company complied with the requirements, filed the necessary supporting documents, and submitted their claim. Unfortunately, they were the first contractor to file a claim. In the view of the founder, this was the reason the claim was turned down. The people reviewing their claim knew there would be a number of contractors filing claims, including the prime contractor, and they did not want to set any precedents over $300,000. Fortunately for the company, they had other profitable contracts at the time, and this was a major annoyance

the users of the corrective lenses could be clearly identified, the attitudes of people who controlled access to the market were not understood. This is a typical case of believing if the technology works, the product will automatically be successful. This failure must have had a tremendous psychological impact on the company's founder. Especially since he had spent many years perfecting the technology even before the business started.

The other major experience has been associated with the initial contract to produce lenses for the instant camera, and then the discovery that there would be no more orders for an extended period of time, due to an oversupply. Throughout all of these events, the underlying strength of the company and its strong initial financial backing has allowed the company to remain in business. The company is currently financially sound and operating in a profitable and conservative manner.

camera made a discovery. They had made a gross error in their estimation of their need for lenses. As a result, they had an eighteen month supply on hand. 1975 was a year in which the company received no orders for camera lenses, but still managed to make a profit. In 1976, the company hired a new management team and the company began to take on new dimensions.

Under the new management, the company has divided its business along three basic lines. The company and the founder are still in the R & D medical business, attempting to develop ophthalmic instruments. They have developed a strong sub-contractor position in the solar field, and their proprietary lines represent a variety of products from big screen television to a variety of lenses for the auto and direct consumer markets.

FINANCIAL HISTORY

The company raised $1.7 million at the time of its founding through a limited stock offering that was handled by a well known brokerage firm. Almost $600,000 was spent in the unsuccessful attempt to enter the eye lens market and the first years of operation were at a loss. When the camera lens application was discovered, however, the picture improved drastically. In recent years, after a new management team was hired in 1976, the company experienced only one of operation without making a profit. Aside from the initial stock offering, the company has operated almost entirely on retained earnings. The current debt structure of approximately $200,000 is covered by lease arrangements for capital equipment.

they took their mil-spec products and put them in their general product catalog. According to the company, the GSA has continued to buy their product at approximately the same rate, and the company has increased its profit margin per sale by avoiding the paperwork associated with the previous contract.

SIGNIFICANT EVENTS AND KEY FACTORS

This company has been primarily oriented to filling a perceived need in a market rather than developing a market. Their initial product was designed to fit into a need in the space program. The company did not take adequate precautions to protect its assets, or to position itself in another market in case the space program folded. The cycle was repeated in the telecommunications field, and the computer business. The problems with the computer business were compounded by the high risk nature of its entry into a market where they knew they had an inadequate financial base. In the end, the company went back to its basic bread and butter product and have prospered.

CASE #9

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

In 1963, this company was formed by a foreign national to supply products to the space program. After some moderate success, the space program was downgraded in 1967, and the firm was in serious financial difficulty. Unfortunately, there were some other problems relating to the founder and his management of the company. As a result, the founder left the country. In 1968, a new president was appointed and the company began to enter some new fields. In 1969, the company merged with another cash short firm that had a product in the emerging telecommunications field. This proved to be a growing field and the company began to prosper once again. During this period, they were able to attract additional operating capital by privately placing convertible issues of stock.

By late 1971, the company, convinced of the growth potential in the computer industry, made a decision to enter the computer main frame business. The basic decision was to use the profits from their operations in the telecommunications business to finance this new venture. Eventually, the company intended to bring the new computer product to the point that would support a public offering to raise the funds necessary for a long term program.

This program failed for a number of reasons. The 1972-73 recession that hit the electronics business found this company desperately short of cash. The company management had geared up for a crash effort to enter the computer business and when sales dropped in the telecommunications business, there was no way to avoid Chapter 11 proceedings, which they entered in early 1974.

By October of 1975, the company was out of Chapter 11 with a new management. The company dropped all plans for the computer business and has concentrated on the telecommunications business, with one new product line added (also in the telecommunications business) in the last five years.

sponsored research. However, the research environment certainly contributed to the founder's ability to develop the product.

At a critical time in the company's development, it was able to secure additional capital through the sale of stock to an SBIC. Although other sources of capital were abailable to the company, the SBIC offered the best terms.

In the medical area, the company deals with the Food and Drug Administration and has found the FDA regulations for the introduction of products particularly onerous. It feels the FDA unnecessarily restricts the entry of new technology and innovation in the medical field. These restrictions place an additional financial burden on the small manufacturer, and increase the cost of medical products to the consumer once they have been introduced.

SIGNIFICANT EVENTS AND KEY FACTORS

From its inception, this company has been characterized by extremes. The initial commercial application for a relatively well known scientific curiosity was an unqualified success. The company's failure to gain patent protection, failure to control their manufacturing costs, and initial refusal to sell to the OEM market just about finished off the company after two years of operation. On the other hand, in the face of adversity, the company turned back to their basic technology and developed improved products, with protection. This re-orientation attracted the additional capital needed to keep the company in operation. The company also developed a basic marketing strategy that diversified their product line enough to enter three distinct product areas; the original consumer market, the new medical market, and the previously shunned OEM market. In order to put this market strategy into operation, the company merged with two other companies. The initial merger was not totally successful because the merged companies failed to realize the humidity

to come out of Chapter 11 within six months (January, 1976) with new management. During 1976, the company did extensive work to commercialize its many new technological developments, rejuvenate dormant markets, and improve the efficiency of its manufacturing operations. During this period, even though the company was chronically short of cash, it invested heavily in capital equipment. In July of 1976, it also formed a joint venture with its European distributor to market the company's products in Europe, the Middle East and Africa. Many of its products are now manufactured in Europe using OEM components supplied by the parent.

The company had earlier determined to concentrate its efforts into three major areas; OEM supplies, medical products, commercial products for advertising and finished products for mass merchandising. In order to follow this line for their products, the company actively began to seek acquisitions that would help in achieving the desired results. By July of 1977, the company had successfully completed the merger of their company with two other companies. The resulting entity (with a new name) provided the necessary breadth of product line and technology to successfully compete in the desired markets.

Initially, each of the three subsidiaries continued to operate in its field of strength and their combined operations were attractive enough to bring in additional venture capital. However, by 1979 it was clear a consolidation was necessary and a new site in California was chosen for the combined operations.

At the present time, the company's sales in the U.S. amount to $2 million, with an additional non-consolidated $1 million from their European operations. These sales are split roughly in thirds between OEM, medical and consumer sales.

had many more applications than their original product, and thus broader markets. The company now has many different products.

The second factor in the company's development was the restructuring of its management as a condition of its second round of funding. A major problem with many high technology firms is that founders who are good technologists but poor managers often retain control over the company, to the company's financial detriment. Although the restructuring was not pleasant for the founders, it put the company on sure business and management footing.

industry. When the ban on cyclamates decimated this market, the original funding was sufficient to support continued product development. In 1970, however, the founders had to seek additional financing. They secured $500,000 from a midwest venture capital firm. The terms of the agreement included equity in the company, and considerable control over the company's management.

Since the initial venture capital investments, the company has operated on debt financing through the commercial banks, with guarantees by the midwest venture capital company. The company has always been in a cash poor position, and anticipates the new high interest rates will create many new problems for the company. Even with the continuing cash shortage, the company has actively attempted to increase its product line, both internally and through acquisitions. In 1973, the company acquired a small, struggling company that made pH instruments. This acquisition was accomplished with a little cash, some stock, and a performance contract with the owner. In 1977, the company had the opportunity to acquire a product line from a major manufacturer. This acquisition for a product line of self-cleaning instruments was accomplished with cash borrowed from the bank. The company is still paying on this bank loan. In 1978, another company was acquired to obtain rights to their product line of probe-type magnetic flow meters. This last purchase was for some cash, some stock, and a royalty agreement.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1972	$ 0	0	0	2
1980	$5,000,000	5	5	60

CASE #7

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

This company was organized by two individuals doing advanced optical research work for a major U.S. electronics firm.

One of the individuals learned of the need for an optical quality control device in the grading, and quality control of tree fruits in the California canning industry. At the time this grading and quality control function was being done manually and visually by college students employed for the canning season. The manual grading of tree fruits had all of the inconsistencies of any process involving human efforts, but also had a deeper problem in that the farmers were paid for their crops on the basis of this grading. Obviously, if the farmer did not get top dollar then he would complain about the grading.

With this problem in mind, the two founders organized a company in 1967 with $150,000 in venture capital collected from relatives and friends. The purpose of the company was to develop an optical and mechanical grading system for tree fruits. The initial target was to be the cling peach canning process. The partners did develop a product to perform these functions. Unfortunately, the cyclamate ban hit the canning industry about the same time the product was introduced. The cyclamate ban had a devastating financial impact on the canning industry, and the canning industry became much more concerned with financial survival than new technological innovation.

Following the collapse of their original market, the two founders continued R & D on their product. In 1970, it became necessary for the two founders to find additional funding. After a long search, the partners found a midwest venture capital firm willing to invest $500,000. One of the conditions of the agreement was a revision of the company's management. The venture capital firm hired a west coast management consultant to act

The company's current business is approximately 25 percent government contract, 10 percent indirect government contract procurement, and the rest is to the OEM market. The company has, at various times, been the recipient of government R & D contracts, but these contracts have never resulted in a product. In some cases, they have developed an idea to the point of developing detailed manufacturing manuals for the production of a product, but have gone no further.

The company does not consider patents important in this business. They rely on their engineering and marketing ability to remain profitable. Even though the company could be classified as a small business, they have no knowledge of experience with the so-called small business set-asides. They compete directly with major companies in the field.

Technology is generally introduced in this company through their field engineers. The interaction of the company's field engineers and application engineers with their customers is considered to be the prime source of technology.

FINANCIAL HISTORY

The company's original financing was $300,000 of private venture capital. In 1969, they received an additional $200,000 in private venture capital to increase the size of their plant and to buy equipment.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1967				8
1970	$1,000,000	35	10	26
1979	$8,000,000	30	10	190

of prosperity in the engineering business.

A final factor in the company's success is the maintenance of close ties with the academic and industrial communities. In order to keep up with the rapidly changing technology in this field the company relies on its own staff capability, and staying close to the various professional societies and industry publications. When they encounter an area in which they feel the need for assistance, they rely on consultants. As a general rule, the consultants they hire are from a local nationally known university, generally faculty members. By providing these opportunities to the faculty, they have managed to gain considerable insights into the capabilities of the graduating students. This university happens to be the primary source for the company's young employees.

The company also recognizes in their relationship with the government, the sale or licensing of a governmental agency to use their software does not preclude that agency from sharing the technology with other agencies under the inter-governmental services act.

The company will quickly point out the inconsistancies in dealing with the Federal government. As an example, the DOD allows bid preparation costs, the DOE does not. Under most governmental contracts, interest costs on borrowed money are not an allowable expense. The theory being payment is received so promptly, there is no need for borrowing. To this, the company points out numerous delays, specifically one experience in which they waited for payment and when it was finally ready for the government to print the check, the government computer broke down. There was an additional three month delay in printing the check. In the company's opinion, the only segment of government that does pay promptly and has consistantly done so is the DOD. On the other hand, they feel the EPA is so bad, they will no longer do business with them. To further round out and qualify this problem, the company points out that the maximum permissable profit they are able to negotiate on a government contract is 8 percent. If you subtract 2 percent for bid preparation and 2 percent for the cost of money, and if there are no problems and you do receive payment promptly, you might make 4 percent on the contract.

Another problem sighted by the company has to do with internal government communications. This company is in the service business. As a result, their orientation is to help the customer. On several occasions, they have encountered situations where the original contract was not adequate to solve the assigned problem. In working with the governmental customer, it has been decided to do some additional work,

CASE #5

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

This company, a computer based engineering services firm, was formed in 1968. The founders were all employees of a major research organization, and had recognized the need to translate current engineering data into a form consistent with modern computer technology. At this point in time, it had become apparent to the founders that digital technology was, and would continue to be, far superior to the more convenient analog technology then being used by the engineering community. The company as it was originally formed was based on the conversion of engineering problems so as to be soluble on digitally based computers.

The three founders, one an analytical engineer, one a Ph.D. electrical engineer, and the last, a mathematical analyst, convinced a locally based accounting firm to sponsor their initial activities. As a result, an agreement was reached in which their activities would form a new management services division of the accounting firm. From the very beginning, the accounting firm understood that if the venture was successful, the three individuals would eventually leave to form their own company. The concept and the service were immediately successful. As a result, within one year, the three founders had incorporated and established their own business

FINANCIAL HISTORY

In setting up their own business, the partners took the ongoing part of the previous management services operations, and in return gave the accounting firm a note for $240,000. In addition, they sold $50,000 in stock on a private basis and distributed a limited number of shares as founders fees, etc.

Due to the profitable nature of the company's operations, the founders have not been in the position of having to sell additional

CASE #4

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1965 by scientists from a university cyclotron lab, who perceived a need for cyclotron units far smaller than those currently being built. These scientists had identified several medical and industrial uses for smaller cyclotrons, which they felt the country's major nuclear research organizations had completely ignored in their pursuit of ever larger cyclotrons.

Unfortunately for the company, the market they had originally envisioned never materialized. As a result, the company struggled alone, writing off the accumulated deficit in 1972 (reducing the book value of the company). This process was repeated in 1976 with one major difference, the company had made a profit from its operations for the first time in 1975. With the refinement of its technology, enhanced by acquisition of a subsidiary producing neutron tubes, and the broadening of its markets, the company has shown steady growth in sales and employment since 1976.

FINANCIAL HISTORY

The company's original financing was $1 million raised in a public stock offering the founders made through a public brokerage house. During the company's first ten years, the company's additional financing consisted of an issue of subordinated notes which were later converted into stock and a private placement of $200,000 in stock.

The company has also employed some debt financing including a $1 million loan for product development from the Bank of America.

responsible contractors; the others having gone out of business. This situation also exists in the operation of facilities after they are completed. As a result, the firm is withdrawing from this type of business.

The company feels to a large degree the R & D work they have performed for the government has not been effective. The work has advanced the state of knowledge in specific areas, but the impact has been relatively small because the research was not aimed at real world problems. They specifically mentioned the money and time spent on activated carbon as a filtering agent, and yet not one plant operating in the U.S. is using the process.

SIGNIFICANT EVENTS AND KEY FACTORS

The two key factors in the company's success have been its ability to raise significant amounts of venture capital and the initial concept of using existing technology to build a systematic problem-solving approach.

While the company was, and is, oriented to providing a service that is mandated by government policy, the company has also come to recognize the profit potential in governmental business is very small, and has ceased to provide some services in the municipal sector.

The company also recognizes the need for continuing research. Not only do they encourage this type of activity in their divisions, but they actively recruit to improve technology. In specific cases, the company has made acquisitions to achieve a position based on an improved technology, or more complete product line.

The company also recognizes and is apparently willing to fund research and product development even though they admit it takes on average

CASE #3

COMPANY DEVELOPMENT AND TECHNOLOGICAL HISTORY

The company was founded in 1969 by a successful venture capitalist, who saw great commercial potential in a systematic application of existing technologies to the treatment of waste water.

The first action of the new firm was to buy a division of a major U.S. firm. This company made process equipment for the continuous operations of various industries--pulp, paper and mining. The company started in the product business and continues to be in that business today. This business has formed the basis for the company's operations in waste water treatment. Whenever possible, the solution to waste water treatment is incorporated in the use of the firm's process equipment, and in many cases is included in the process itself.

At the present time, it is estimated 75 percent of the company's divisions carry on some form of R & D with less than 10 percent of this effort financed through government grants. The company only has ten or fifteen contracts directly with the federal government, and these have been mostly in the mining field. On the other hand, the majority of the company's business is directly related to federal policy and to a large extent financed by federal grants. The company has also begun to sell their operational experience on a "turn key" basis.

FINANCIAL HISTORY

The founder had three other successful enterprises and therefore did not face the normal financing problems associated with business start-ups. The founder raised $37 million to start the new venture. Of the initial investment, $4 million was contributed by an aerospace firm that had been involved with waste water problems for some time.

FINANCIAL HISTORY

The company's initial funding of $75,000 came equally from two private investors and the university, in exchange for stock.

In 1975, the company sold an additional $150,000 in stock to attain some liquidity for the initial investors. This is the only other equity money in the company. With this small equity base, it is not surprising the company has developed the management posture of requiring outside financing of its R & D efforts, but does consider them a direct reimburseable expense. To some extent, the company has received R & D funds from private foundations but more typically they are government sponsored.

SALES AND EMPLOYMENT HISTORY

YEAR	SALES	% DIRECT GOVERNMENT	% INDIRECT GOVERNMENT	TOTAL EMPLOYMENT
1972	$ 898,000	100	0	32
1973	$1,308,000	100	0	47
1979	$8,324,000	60	5	200

GOVERNMENT INVOLVEMENT

This company would not have been started, nor would it continue to operate without government involvement. The initial research was sponsored to a large degree either directly or indirectly by government grants. Current research is largely government funded; and the products are sold in government supported markets.

The products being developed and sold are targeted at the nation's handicapped citizens. It is difficult to imagine this much research and development taking place without government support. While a number of the developments have some commercial application, this type of an organization, focused on the needs of the handicapped, would not

GOVERNMENT INVOLVEMENT

The company found initial success in gaining government R & D funding in three or four agencies, and has not attempted to gain funds from any other agencies or sources.

The company was founded on the basis of government sponsored R & D, and within three years had found the short comings of this total dependence. The company also provides an opportunity to visualize the advantages of a product oriented company over one relying solely on research.

It is apparent from this case study, the diversification offered by product development has many advantages to a small company, even when the product market is indirectly government supported. One of the more subtle issues in this case related to the company's difficulty in developing a market for its products. This problem may be directly related to the company's very limited experience in marketing its R & D capability; i.e., they have not attempted to develop new sources for R & D contracts after their initial success. The parallel in the product area is the introduction of their initial product in 1974, and the five year lag until 1979, when they began to sell into the automotive OEM market. In short, it is difficult to assign a reason to their business problems (research or commercial) without first looking at their possible difficiencies in marketing their technologies to either the public or private sector.

SIGNIFICANT EVENTS AND KEY FACTORS

The company would not be in business today without the original government sponsored R & D contract. However, the dependence proved to be a double-edged sword, and almost caused the company to go out of business four years after its founding.

Based on their initial success in the gas analyzer product area, the company attempted to enter the auto emission market in 1974. Unfortunately, this product did not gain wide acceptance until the 1979-80 period, when the company began to sell their product to the automotive OEM market for incorporation into larger units.

The two product lines reflect in many ways the character of the founders that run them. The medical pumping technology has remained largely a research type organization, relying on R & D contracts with only minor efforts toward developing a commercial application. This division has relied on in-house technology and its growth has been slow.

The gas spectrometer business has been more aggressive in developing specific products with commercial potential. In this case, the division has relied heavily on specific recruiting efforts to speed up the growth of technology. Growth in this division has been spectacular in the last few years, after a slow start.

FINANCIAL HISTORY

The company's initial financing was $250,000 in private equity funds. In 1972, there was a change in the equity position of the company that reflected a desire on the part of the original investors to achieve some degree of liquidity rather than a significant change of ownership. This transaction, nevertheless, resulted in another $250,000 of new equity monies.

By 1976, the company's combined sales had reached the $1 million level and the original investors were called upon to put in an additional $100,000 in equity money. These funds were used to help cover the cash flow needs of the company.

In 1979, the company's sales had reached the $2 million level and the original investors were once again called on for an additional $200,000

4.4 ANALYSIS OF THE RESULTS

Most of the numerical information which lent itself to tabulation appears in the Tables. A discussion of the major findings including some more subjective and less quantifiable results, as well as conclusions about the original hypotheses of this study appear in Section 2. Discussions were held among the principal interviewers to exchange perceptions about the information obtained and other less tangible factors, and to see whether isolated anecdotal information had more general significance. Although the nature of a set of case studies implies limited, individualized information, the analysis performed was aimed at providing an overview of the company histories. The goal was to identify some of the factors most critical to success, as well as ways in which changes in government policy could encourage the formation and growth of these companies.

year of founding	--	divided into three general eras, post World War II to Sputnik (1957), Sputnik to late 1960's, and from late 1960's to present.
markets currently served	--	included commercial, government both general and military, and foreign.
government R & D funding	--	included both civilian and military agencies.
type of products	--	included service, proprietary product with patent protection, specialty, consumer, industrial.

Very few founders refused to participate in the study, although scheduling difficulties sometimes made it necessary to eliminate a company.

4.2 INTERVIEW WITH FOUNDER

Interviews were generally conducted by teams of two people which provided several useful advantages and safeguards. Most interviews lasted one to two hours. One person directed the discussion to the most salient points, concentrated on follow on questions and made sure that all aspects of concern were covered. The other acted as observer and recorder so that when the interview was concluded, all important information was ready for the next step. In addition, a more accurate interpretation of what was meant is likely when two people can compare impressions and facts gathered earlier. The person to be interviewed was sent a letter explaining the study and its areas of interest. In many instances, we

is done. Contract requirements and auditing procedures should be commensurate with the size of the contract.

3. An effective mechanism needs to be developed to provide accurate assessments of the probable impact of proposed policy and regulatory changes on small business. Such assessments should include possible secondary effects and recommendations to alleviate hardship.

4. Tax incentives for investors to provide high risk, early funding for small high technology companies should be increased. It is necessary to make the rewards sufficient to attract investors away from other lower risk, high reward investments such as real estate.

5. Mechanisms should be established for a founder or early investor to sell out to another individual or small company rather than to a large public company without disasterous tax consequences.

CURRENT SALES	NUMBER OF COMPANIES	TEAM FOUNDERS	INDIVIDUAL FOUNDERS
≤ $ 5 Million	14	7	7
$6 - 20 Million	9	9	0
$21-100 Million	6	4	2
≥ $100 Million	4	3	1
	33	23	10

TABLE 5

INDIVIDUAL OR TEAM FOUNDERS

	UNDER $100,000	$100,000 to $1 Million	$1 Million to $6 Million	OVER $6 Million
Boston	5	5	4	1
Milwaukee	4	2	0	0
San Francisco	0	7	3	1
FOUNDED				
1946-1957	1	2	3	1
1958-1968	4	9	3	0
1969-1978	4	3	1	1
	9	14	7	2

TABLE 4

AMOUNT OF TOTAL INVESTMENT TO DATE

Based on those companies where total was known or could be estimated

2.6 PERIOD OF FOUNDING VARIATIONS

The most obvious difference between the companies founded in various periods was the use of government R & D funds. Most of the companies founded before 1963 had a significant proportion of government sales in their initial period. 62 percent of them had government sales of at least 80 percent for the first year of sales. Of the companies founded in 1963 or later, only 25 percent had government sales of over 50 percent in the first year.

2.7 UNIVERSITY INVOLVEMENT

In an extraordinary number of cases a university played a major role in the history of the company. There were a number of companies started to pursue the results of research done at universities, although generally a significant amount of development work was still required. Often, the original research was performed under government grants. In other cases, especially apparent at MIT, the university encouraged faculty members to do outside consulting work for industry. When the consulting work begins to mushroom, colleagues or students are recruited to help and soon a company is born.

For companies in extremely advanced technologies, a continuing relationship with the academic community not only keeps the senior staff informed of new research developments, but helps the company acquire the most competent technical personnel.

2.8 FINANCIAL RESOURCES

A large number of the cases studied required several infusions of capital as they grew. Most of the capital in the early years was to

2.5 GEOGRAPHIC VARIATIONS

Several characteristic differences emerged between the three regions. The most striking is the role of government R & D contracts. By looking at Table 3 Sources of Technology, it is immediately apparent that the vast majority of the Boston area firms used technology from university laboratories and developed with Federal research and development grants and contracts. The companies in the San Francisco area used some Federal research money, but only one from Wisconsin did, and that was not for its initial product. There was evidence of general reluctance in the Milwaukee area to use government contract funds. On the other hand, it was the Milwaukee area firms that made use of SBA loan guarantees and other kinds of government assistance programs.

In the Boston area, several of the firms received some of their early financing from the same venture capital firm. This firm specialized in providing high risk money to innovative high technology companies that could potentially make a significant contribution to both society and the economy. One founder specifically made reference to the importance of this source of "patient money," an investor who understood how long it takes to get new technology to pay off.

On the other hand, the Milwaukee area companies rarely made use of venture capital sources to finance their business growth. It is not clear whether this source is simply not available generally, not available for innovative companies, not acceptable to the founders or our sample was unrepresentative. Sources of capital generally used were founders and their relatives, bank loans, and, in some cases, the public market.

with a preponderance of replys on the crucial side of the spectrum.

Hypothesis 4: Most of the cost of innovation occurs not in the initial research stage, but rather in the later phase of development, manufacturing and marketing.

Most of these firms have experienced great difficulty going from the research stage into the development, manufacturing and marketing stage. Six of the companies either sub-contract their manufacturing or simply avoid it altogether, choosing to do only R & D. All of these firms cite costs as the reason they chose not to go into production. Of the companies that now do their own production, virtually all cited the crippling transition between R & D and bringing a product to the market. A reading of the individual cases makes the situation clearer, especially when you consider that time means money.

Hypothesis 5: In those instances where the government was not the ultimate buyer of products developed, government R & D contract money alone was insufficient to accomplish successful commercialization.

This was difficult to measure since money earned on one project could be used to fund other activities for the company without a clear identification of what happened. Also, outside capital frequently was used to deal with cash flow problems. Nevertheless, one measure of financial need is how much capital was obtained.

Of the 33 companies examined, 16 of these received capital from the founder(s).

13 of the 33 used some form of venture capital at least once.

2.4 EVALUATION OF WORKING HYPOTHESES

As part of the proposal for this research project, several hypotheses were formulated. This section contains a discussion of the extent to which each was confirmed or rejected by the study.

Hypothesis 1: A long gestation period is required between the conception of an idea and profitable sales of a high technology invention.

For the companies where relevant information is available, the hypothesis is strongly supported. The following are examples taken from the case studies:

"In 1965, it was decided to try to produce a tracer to allow a machine to make copies of complex tools ... However, it was several years before this tracer was accepted by industry."

"The founder ... had been looking for a good product idea, and in 1969, started working on a specific product in his basement... it took over three years to perfect the technology sufficiently to begin real operation of the company."

"While the company began to develop some marketable instrumentation within a year of founding, many aspects of the companies permeation and liquid chromatography took considerably longer to develop."

"Despite the companies tremendous R & D expenditures, many of the founders original ideas (founded in 1946) are just now coming to fruition while others could remain in the research stage far

rejection of the new in favor of safer known products or processes even where the new products promise to be 100 percent better. In several instances, companies have been forced to go abroad to gain acceptance for products that would have been of great benefit to the United States (see Case 7).

2.3.3 UNSOLICITED PROPOSALS

The importance of the government's willingness to fund unsolicited proposals was mentioned repeatedly. When companies come up with creative new solutions to existing problems, it is through the funding of an unsolicited proposal that these new ideas can be explored and tested.

Several of the companies developed significant new areas of technology useful both to the government and to society through government funding of unsolicited proposals, especially in the 1950's and early 1960's. The technical development generally took several years and while results continually flowed out and were evaluated, the projects were funded with long-term results as the goal.

Unfortunately, in recent years this source of funding has almost completely disappeared. If the proposed research does not fit into a well defined segment of the current research strategy of a government agency, no mechanism exists to permit its funding, regardless of its merit. Companies can survive by providing incremental information and developing the appropriate instrumentation to move along an existing, government supported technology. But the radically new ways of solving problems are not given a reasonable chance to prove their validity. The current climate, with its tight R & D budgets that must be defended as mission

for awarding it, as well as the amount available, can change on a moments notice. Abrupt changes in government research, fiscal and procurement policies have posed severe problems for many of the companies in our study. While certain valid justifications existed for these changes, they are usually promulgated without consideration of the probable effects, either primary or secondary, on the small business sector of the economy. In 1965, the Mansfield Amendment required that Department of Defense funded R & D be mission oriented, i.e., focused on the VietNam War effort. D.O.D. suddenly terminated all long-term research projects. Many companies, even those with excellent performance records, faced wrenching readjustments or bankruptcy (see Case 16).

In the late 1960's, Congress reacted to the disturbances on many college campuses by cutting back funding for university research, especially equipment funds. Several companies in the study sold capital equipment primarily to university facilities. Suddenly they had 50 percent or more of their sales vanish overnight. In our cases, the foreign research facilities kept the companies from failing, but there are probably other companies that did not survive (see Cases 4 and 21).

2.3.2 PROCUREMENT REGULATIONS

Providing R & D services to the Federal government requires very different orientation and strategy from developing a standardized commercial product or service. Companies that have tried to do both and succeeded are rare, most have failed. Those that have succeeded tend to have divided the company activities and responsibilities, frequently using separate divisions or even a subsidiary for one or the other of the areas (see Cases 1, 22 and 25).

YEAR FOUNDED	EMPLOYMENT 1974	EMPLOYMENT 1979	NUMBER OF ADDITIONAL JOBS CREATED DURING FIVE YEAR PERIOD	PERCENT OF TOTAL NUMBER OF JOBS CREATED	TOTAL PERCENT INCREASE	AVERAGE ANNUAL GROWTH RATE DURING FIVE YEAR PERIOD
1946-1957 7 companies	18,477	26,497	8,020	47.2	43.4	7.5
1958-1968 17 companies	2,048	4,774	2,726	16.0	133.1	18.4
1969-1978 9 companies	3,275	9,534	6,259	36.8	191.1	23.8
TOTAL	23,800	40,805	17,005	100.00	71.4	11.4

TABLE 2

EMPLOYMENT GROWTH

2. ANALYSIS OF THE RESULTS

2.1 TECHNOLOGICAL CONTRIBUTION

Perhaps the most compelling finding is the enormous technological contribution these companies have made toward the solution of our nation's social and economic problems. The majority of companies have, at some time in their history, produced a useful, technologically advanced product or process that has contributed to our country's technical preeminance and economic strength.

One company developed instrumentation that so reduced the speed and cost of blood tests for lead poisoning that large scale screenings are not only possible but now regularly performed throughout the nation. Another company developed an artificial kidney which represented such an improvement over extant methods of kidney dialysis that it is now the most widely used in the nation. This company has subsequently applied the same basic membrane technology to industrial chemical separation. The increased efficiencies of the new processes have reduced costs for industry and opened a new market for the technology with tremendous potential sales and employment. A third example of technological achievement is that of the company whose acoustical engineering work for NACA led eventually to the acoustical design of most commercial jet airplanes and airports. Other companies have developed communication aids for the handicapped, methods for monitoring pollution in the atmosphere, microprocessors for controlling energy usage and waste water treatment equipment. In short, these companies are essential to our nation's technical and economic strength; the importance of stimulating their growth and formation cannot be over-estimated.

a short time. This project was to try to identify some of the reasons why one group of high technology companies survived, and whether the government played any significant role in their development. The hypotheses include some issues unrelated to government involvement, which we believe are key elements in achieving the successful commercialization of new technological products and processes. The hypotheses chosen were as follows:

Hypothesis 1: A long gestation period is required between the conception of an idea and profitable sales of a high technology invention.

Hypothesis 2: Government R & D contracts provided an important source of cash flow required during the early years of a significant percentage of these high technology companies.

Hypothesis 3: Government R & D contracts provided an important source of funding for the development of technology and expertise used commercially by the company.

Hypothesis 4: Most of the cost of innovation occurs not in the initial research stage, but rather in the later phase of development, manufacturing and marketing.

Hypothesis 5: In those instances where the government was not the ultimate buyer of products developed, government R & D contract money alone was insufficient to accomplish successful commercialization.

Hypothesis 6: Market forces were the critical factor in successful commercialization. Technology push without market forces was

with such areas as patent rights, procurement regulations and tax incentives. However, it is very difficult to predict the probable impact of these changes and whether they will have any of the desired effect. The most useful guide that can be made available is an evaluation of the importance of various relevant factors for company survival and growth in the past.

1.2 OVERALL RESEARCH PLAN

This project was to prepare case studies of the early stages of the evolution and growth of 33 currently successful, innovative high technology companies. The primary source of information was an interview with a founder of the company. Of particular importance were examinations of the factors integral to their commercial success and the role, if any, played by government research and development contracts in the company histories. Other areas that were explored included amounts, sources and timing of financing, source of the technology, and employment history. The companies that participated are located in the Boston, San Francisco Bay and Milwaukee areas. They were chosen to span a large number of technological fields and were founded between 1946 and 1978. Table 1 shows the geographic and year of founding distribution of the 33 companies included in this study. The selection process, as well as other details of procedure and methodology, are discussed in detail in the section entitled Research Methodology.

1.3 WORKING HYPOTHESES

A number of hypotheses were formulated to focus the research on some specific factors whose relative importance could be examined. It is well known and recently verified again[1] that most companies fail within

[1] David L. Birch, The Job Generation Process, Cambridge, 1979.

