legal climate than we have seen over recent years—e.g., price and wage controls, changing energy rules, changing tax laws (usually for the worse), increasing opportunities for time-consuming (and often unfounded) litigation, overlapping and frequently contradictory regulatory rulings by different federal agencies and changing accounting principles. The only exception I can see to this need for certainty is inflation, where the problem is too much certainty—growing feelings that inflation is here to stay. As George Will has said,[45] "It is said business is reluctant to invest because of 'uncertainty'. Actually, business reluctance reflects the virtual certainty that inflation will remain intolerably high and that government will require corporations to devote more resources to environmental and other social purposes."

No democratic government can or should try to iron out all of the bumps in the economic road. There will be periods that are better than others and that's a risk that has to be taken. But a free-enterprise democratic government does have the responsibility of not moving in fits and starts, by applying short-term fixes to long-term problems, changing direction like a broken field runner. The proposed Congressional solution to the saccharin problem mentioned above seems to be an 18-month postponement in lieu of tackling head-on the totally unscientific Delaney Amendment. The government should confine itself primarily to the macroeconomic sector and the correct policies to aid the supply side of the economy, and leave the detailed decisions—the fine tuning—ranging from such minutiae as OSHA's design for safe lavatories (now mostly rescinded) to wage and price controls for thousands of firms (abandoned not long ago) to the pluralistic wisdom of the market and the individual enterprises. As Tom Wicker describes it so well in *The New York Times* of November 13, 1977,

> . . . a businessman trying to make his investment and spending plans at this point does not know whether to expect tax reduction or tax reform—with all its uncertainties—or how much of either. He does know he faces a big Social Security payroll tax increase, higher minimum wages and probably some form of new energy tax. All three will have inflationary effect, and the prospect also is for somewhat higher interest rates. . . No wonder business is looking for a Carter economic policy that it can count on.

An insightful analysis of the secular and cyclical changes which have taken place in the investment climate is given in a recent study by a prominent Wall Street firm.[46] They point out that in recent years investors in stocks have come to demand a higher risk premium over bond yields, citing such factors as inflation, the strains on the international lending institutions and on trade, the rising tax burden on the productive sector of the economy, the decline in the quality of earnings and assets brought about by the rapid buildup in un-

Organization for Innovation

I am convinced organization has a great deal to do with the way any company can succeed in innovation. The top management should be actively and personally involved in the business, *and* the technological leadership and planning. Professor Bradbury put it very well in his paper, *Constraints to Innovation:*[49] "Effective leadership today demands not the good practical man, but the well-trained and broadly trained professional."

From the very beginning, Halcon was managed primarily by technically trained people, chemists and chemical engineers. Our CEO is the man in charge of strategic planning, but we have chemical engineers right in the laboratory, working with our chemists at every stage of process development. Again, to cite Bradbury, "Without an explicit strategy, well understood at the laboratory bench as well as in the board room, the failure rate in innovation may be unacceptably high and ruinously expensive." We have followed this concept from our inception. When you are under-financed, as we were for so many years, you really have no choice. But even now it is part of our fundamental thinking, and we are organized so that our entire top management constitutes our entrepreneurial core, mostly freed from daily operating responsibilities. Where this structure differs from many larger companies is that we control the R&D directly, for the company as a whole, together with the more conventional control over our cash flow. This permits us to deploy all our strengths rapidly, in accordance with the market, existing and potential, with the most effective feedback possible. The Oxirane group is similarly organized, and as mentioned, Halcon Chemical is still another entrepreneurial center. All this is based on our experience that even the larger companies, if they are to be successful in new venture strategy, must imitate the strengths of small company technical entrepreneurship, as Professor Roberts also points out.[50]

The link between size of enterprise and entrepreneurial innovation has been cited frequently in the literature. All the more reason, therefore, to change our tax laws, especially the capital gains section, as mentioned above, so that young companies need not be so frequently gobbled up by larger companies (using the tax-free reorganization devices, for example)[51] but rather have a market for their securities as independent companies.[52]

I feel that we have achieved a very successful mode of continuing innovation, despite the fact that we are much larger than we had originally expected. In this context we have paid close attention to management development. For many years we have had a flow of the brightest young people into all aspects of our work, and we are very strong in the younger generation of management. As mentioned above, many young people prefer an entrepreneurial organization in a way which is most heart-warming to us.

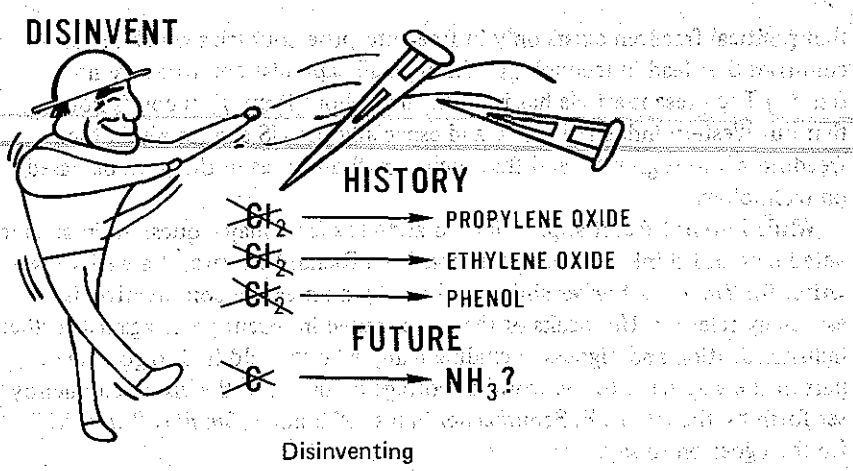


FIGURE 2 Ethylene oxide, propylene oxide and phenol processes all progressed through discarding the use of chlorine. Chlorine is an excellent chemical but it does not appear in the final molecule of the products and hence is a chemical "crutch". Dr. Duncan Davies called it "The Need to Disinvent" at the Brussels Sci in 1974. Throw away the crutches.

stimulating paper, and I will once again use his words, which say what I would have wished, but better:

> . . . the chemical industry has a technological challenge over the next decade of major proportion. Slow growth, expensive resources, high entry fees, must not weaken the resolve to scale even greater technological heights in the next decade. It needs to do so to avoid the failures that have befallen other industries such as the railways since 1860, and cotton since 1900. Technological change in a slow-growth era needs to be selective and sophisticated, and is the only way to ensure a profitable future. From the industry's position of health and strength it can, and I believe will, be done.

I believe in the vital necessity for growth, since without it our free society and solutions to our economic and social problems are doomed. No one can hope to freeze the status quo without dictatorship. A declining economy, needless to say, is unthinkable in a democracy. I have previously written about the debate in this country over the desirability or lack of it for growth,[54] with a concomitant discussion of egalitarianism, which is fundamentally inimical to technology, freedom and morality. (It has been aptly noted in this context

nificant part, the politics of capital formation and allocation of capital investment. Even more, we need more innovations.

But if I believe growth and increased productivity are essential, I also have tried to underline in this article that encouraging entrepreneurship and entrepreneurs is the best way to retain something of the small-is-beautiful concept, rather than force the burden of all economic activity into increasingly larger existing corporations, or what would be even more counter-productive, into the hands of government.

We must put our American ingenuity, technology and market system to better use to permit growth while solving the historical negatives of growth, such as pollution, unsafe conditions, and the like.[58] In short, I know would-be entrepreneurs are still all around us, but will we permit entrepreneurship, risk-taking and innovation to flourish, for the sake of our economy, for the sake of *all* our people, even though some will end up with more than others?

References

1. N. Macrae, *The Economist,* March 12, 1977, p. 38.
2. R. B. Stobaugh, V. A. Calarco, R. A. Morris and Louis W. Stroud, "Propylene oxide: how, where, who - future", *Hydrocarbon Processing,* Jan. 1973, pp. 99-108.
3. *Business Week,* April 4, 1977, pp. 42-95 (an excellent if horrifying treatise on the current state of affairs); "About Regulation", *The Public Interest,* No. 49, Fall 1977, pp. 3-69.
4. R. Landau, Speech at AIChE meeting, New York, Nov. 15, 1977; published in *Chemical Engineering Progress,* Feb. 1978, pp. 21-26.
5. *Science,* May 6, 1977, p. 636.
6. G. Bylinsky, *Fortune,* Dec. 1977, p. 76.
7. US Congress, Hearings of the Joint Economic Committee, Oct. 1, 2, 3, 10, 1974, p. 112, Testimony by R. Landau; R. Landau, "Industrial Innovation: Yesterday and Today", *Chemistry and Industry,* Feb. 2, 1974.
8. *National Review,* April 1, 1977, p. 366.
9. *Chemical Engineering News,* Oct. 17, 1977, p. 4.
10. A. L. Morner, "Junk Aid for Small Business", *Fortune,* Nov. 1977, pp. 204-213.
11. *The Business Roundtable,* 1977.
12. C. L. Schultze, "Regulation", *AEI Journal on Government and Society,* Sept./Oct. 1977, pp. 10-14.
13. R. Salomon, "Second Thoughts on Going Public", *Harvard Business Review,* Sept./Oct. 1977, p. 126.
14. *Wall Street Journal,* Oct. 27, 1977, p. 4, "Burns Asks 'Bold' Tax Policy, Other Steps. . ."
15. *The Business Roundtable, op. cit.*
16. *Wall Street Journal, op. cit.*
17. *Economic Report of the President,* Jan. 1977, pp. 68-69.

52. ————, "The Secret of Getting Out", *Forbes,* Aug. 15, 1977, p. 114.
53. R. Malpas, *Chemistry and Industry,* Feb. 5, 1977, p. 111.
54. R. Landau, "From Chemical Engineering to Moral Philosophy", Speech at the Massachusetts Institute of Technology, March 5, 1976.
55. M. Freidman, "Capitalism and Freedom", University of Chicago Press, 1962.
56. R. Rovere, *The New Yorker,* Jan. 2, 1978, pp. 54-58.
57. K. Deutsch, "Ideas", *Newsday,* Jan. 8, 1978, p. 5.
58. Schultze, *op. cit.*

lation, to insure our ability to compete in the world markets against other rapidly developing industrial nations.

The role of innovation and the factors that influence its environment are not always understood. In 1976, the Office of Federal Procurement Policy, Office of Management and Budget, of the Executive Office of the President, sent a draft memo for comment to all heads of executive departments and agencies which stated the need for recognizing the importance of "innovation". In part this stated:

> The government directly sponsors research and development through the government in-house technical and laboratory activities and through procurement actions with non-government organizations. Additionally, it is the government's responsibility to ensure that its policies and programs stimulate private investments in research and development and to encourage innovation in all sectors of the economy. Acquisition policies for research and development are intended to support these objectives.
>
> In the United States' competitive economic system, the role of industry in research and development is particularly important. Industry transforms new ideas from laboratories into new and improved products and services and brings them to the marketplace for the nation's consumers, including the federal government. Industry has built successfully on advanced developments of the past and provided new products and services of great economic and social value to the nation. This has been demonstrated in many areas, including electronics, computers, aircraft, communications and medical services.

This initial attempt to stimulate interest and action at the highest levels of government was never concluded, but hopefully the current administration will move forward in such a direction.

Government R&D

Government R&D funding has in the past served as a very useful mechanism for the support of high risk research programs and advanced technology. The so called "unsolicited proposal" concept for R&D funding is no longer generally available, and the cost and time required for obtaining R&D support has increased substantially. It is not unusual for the government decision process now to take nine months or a year to fund a research proposal and initiate work even after responsible people agree it should be done. One recently reorganized government agency has been structured to require 17

served. However, the current trend towards the involvement of such institutions in the commercialization of science and technology is not in the best interests of the country.

New Enterprise Generation

New technical enterprises have been a unique source of technological innovation, and of a large number of this country's array of new technically based products. The environment for new enterprise generation has deteriorated substantially in recent years, and neither the role of the small company nor the problems associated with new company generation has ever really been understood by the executive or legislative branches of government. Neither has this country ever had a spokesman on the Washington scene for this important sector of the economy.

In recent years, incentives for both the investor and the entrepreneur have been reduced as a result of Congressional action. Qualified stock options for example, are now no longer available for key management personnel—an important incentive for the small, high risk company which normally has no pension fund or real employment security. Government over-regulation has made the life of the small company manager—and of the entrepreneur—extremely difficult, and the relative costs and executive time associated with such regulatory activities are tremendous. Changes in the personal income tax structure have now reduced the potential advantages of capital gains to the investor and entrepreneur, and the 1976 Tax Reform Act now has a significant impact on the potential long-term benefits to both investors and entrepreneurs involved with successful business ventures in terms of their estate. The cost of financing start-up companies has substantially increased and the prospect of early financial rewards for the investor are greatly tempered by the decreased liquidity of investment.

In spite of these adverse changes in the business environment for new enterprise generation, venture capital is still available even for start-up situations, but the requirements established by the capital sources, which have now become "professionalized", are very exacting. New technical ventures, however, *are* being funded by a variety of venture capital sources—corporate, private, financial institutions and even some universities.

The Industrial Environment

There is reason to believe that the current industrial environment, under which most large corporations now operate, tends to restrict "risk taking"

FIGURE 1 Ability to commercialize innovative technology *today* vs *10 years* ago (132 corporations).

	Much Less	Equal	Much Greater
R&D Directors	15.2%	68.9%	15.9%
CEO	18.1%	52.4%	29.5%

capital organizations. The relatively high response level to this survey suggests a growing natural interest and concern with the subject of technological innovation. While a wide range of opinions was observed, it is clear that the climate for innovation is changing. Most corporations, however, believe they are still innovative and that venture capital is still available for new technical enterprises. Figures 1-9 summarize some of the attitudes of major corporations on these and other pertinent questions, based on the responses to the survey.

Attitudes: Major Corporations. R&D directors of the large corporations surveyed believed that their ability to commercialize innovative technology is about the same today as it was 10 years ago. Nearly twice as many of the chief executives, however, thought their companies are much better in this regard (Figure 1).

When asked to list the relative importance of factors influencing the funding of technical programs, executives and research directors of major corporations agreed that government regulation is the number one problem and that Return on Investment is now the second consideration as compared with the situation 10 years ago (Figure 2). These appear to be new factors that may well have a substantial impact on future innovative programs. The executives and directors also agreed that the following factors influence their reluctance to perform government R&D: opportunity cost; government bureaucracy; know-how disclosure; government patent policy (Figure 3).

FIGURE 2 R&D Directors and CEOs: Significant factors influencing funding of technical programs *today* vs *10 years* ago.

1	Government Regulations	Much More Important
2	ROI	More Important
	Anti-Trust	No Change
	Personnel	No Change
	Management	No Change
	NIH, etc.	No Change

FIGURE 5 Corporate environment.

	10 Years	Today	Change	Companies
Exec. Time Gov. Regs.	8.2%	25.8%	+ 17.8%	32
Innovative Programs	41.4%	58.6%	+ 17.2%	58
Legal, Acct. Expenses			+260 %	41

New ventures are usually successful because of the one entrepreneur who dominates the business activities. There is no more difficult or demanding job than running a new technical enterprise. The added load of government regulations and associated costs can be fatal to a new venture that does not have the management staff or resources of a major corporation.

The Product Development Cycle. The directors of research of 125 major corporations agreed (Figure 6) that the product development cycle for technical products has increased 25% in the last 10 years, although 50 chief executives seem to think the time increase is only 10%. As noted in Figure 1 the directors of research appear to have a different viewpoint than their chief executives—or perhaps they are a little more realistic.

Venture Capital Environment and Attitudes. The venture capital community was asked to rate the factors that influence the financing of new venture (Figure 7). The two considered most important were investment liquidity and increased capital gains tax. Lack of entrepreneurs and the impact of government R&D procedures were not important considerations.

The relative importance of reasons for the failure of small technical companies were submitted by 50 professional venture capital organizations (Figure 8). Management ability was listed the number one factor contributing to the success or failure of a new business, with such items as

FIGURE 6 The product development cycle.

	10 Years Ago	Today	Change
125 R&D Directors	4 Years	5 Years	+1 Year +25%
50 CEOs	3 Years	3.3 Years	+3 Years +10%

FIGURE 9 Financing new enterprises by venture capital sources: average data for venture capital organizations reporting.

	10 Years Ago	Today	Companies Reporting
Start-Up Capital Requests	232/Year	114/Year	29
Average Capital Requested—Dollars	420,000	500,000	27
Capital Devoted to Start-Ups	32%	25%	14

commercially successful. The initial entrepreneur in a new technical enterprise seldom has the management ability—or often the interest—to run a large business.

In the areas of capital availability it appears that the number of requests for the financing of "start-up" companies is half what it was 10 years ago (see Figure 9). Some 14 venture capital organizations say they now invest 25% less of their available funds in "start-up" ventures.

In recent months we have seen evidence of renewed activity in the venture capital business, including some newly formed organizations with substantial financing. Some universities are even getting involved with the venture capital business, from an investment viewpoint. The corporate policy of our larger companies regarding venture capital, dealing with outside entrepreneurs and creating new enterprises appears to be subject to a variety of changes. Some major corporations have activated venture capital programs as a means of seeking new opportunities outside the firms; others are now either less active than five years ago, or have changed their investment policy with respect to the types of mechanisms employed in dealing with new enterprise situations.

References

1. US Department of Commerce, *Technological Innovations: Its Environment and Management*, 1967.
2. ————, *The Role of New Technical Enterprises in the US Economy*. A Report of the Commerce Technical Advisory Board, (1976).
3. US Congress, Subcommittee on Domestic and International Scientific Planning and Analysis, Committee on Science and Technology, April 29, 1976, Testimony by Richard S. Morse; Richard S. Morse, "Socialized R&D", *Sloan Management Review*, Vol. 18, No. 1, Fall, 1976.

us, "don't use the word 'computer'. *Fortune* magazine says no one has yet made any money with computers and they aren't about to make any money", so we took that word out of our proposal. They also said, "5% profit isn't enough to promise if you're asking someone to risk money on you". So we promised 10%. And finally they said, "most of the Board is over 80, so promise fast results". So we promised to make a profit in one year. They bought our proposal but gave us only $70,000 in capital, which we used very frugally.

We did everything ourselves: we cleaned the johns and swept the floors. We did the photography in my basement; made our printed circuit boards with real silk on wooden frames; we etched them in aquarium tanks. Since I was the closest thing we had to a tool maker, I made the tools. Every now and then, while hardening some tools, I'd leave them to answer the 'phone, only to come back and find the tools burned. We learned a lot about all aspects of business.

Now, to the question of what happened to entrepreneurship. As I said earlier, I think we should skip the period of time in the '60s. It was a short interval in the history of business. Things were very unusual. Everybody wanted to invest. There was competition to invest. I was on the board of a risk capital company at that time and there were very few investments we could make. Others were pouring money into new businesses with reckless abandon and there were few opportunities for a careful investor.

What it did to engineers, I think, was not very healthy. Everybody wanted to start a business. Wives were embarrassed to tell other wives that their husband was already 32 and wasn't starting a business. One bank counted *64* firms in the minicomputer business! I think it was closer to 264.

This period of irresponsible investing came to an end in the early 1970s, and the stock market hasn't recovered from it yet. However, the entrepreneurial spirit continued, and there probably have been more new entrepreneurial and technical organizations started in the last few years than during any other period of our history—except for that period in the 1960s.

Sometimes we do not notice today's entrepreneurs because when we look at new companies we often don't see products that will be significant in the future. We forget that those products which are obviously going to be significant in the future will be started by the established companies, whereas those that need entrepreneurs to start are ones that are not immediately obvious to the rest of us.

Sometimes, also, we despair because the entrepreneur cannot start readily in the same fields that people started in 10, 20 and 30 years ago. This should be obvious too. The industries that started at that time are now mature and it takes vast amounts of capital and research to compete. It is hard to get into the business of building jet airplanes or automobiles or even semiconductors.

APPENDIX XI

"INNOVATION AND JOBS," BY WINGATE A. LAMBERTSON, INVENTIVE IDEAS, INC., LEXINGTON, KY., JUNE 1978

INNOVATION AND JOBS

by

Wingate A. Lambertson

Inventive Ideas Inc.
420 Chinoe Road
Lexington, Kentucky
40502

Summary

Small business and industry are an important source of jobs in the U.S.A.. There are many creative people within both big and small business and industry, and the independent inventor/innovators have made many important contributions to this country's growth and vitality. In spite of this recognized importance, federal funding of research and development is directed at the 95 percent level in favor of big business and industry. Changes in federal tax laws have made it all but impossible for innovative small businesses to obtain start-up capital. It is recommended that the first step to turn the decreasing rate of innovation growth trend around is to initiate a substantial and new program for providing start-up venture capital to innovative new small industries.

I. Objectives

The objectives for this proposed new program should be:

A. To devise an improved Federal approach to the creation of jobs through innovation.

B. To focus this effort on the facilitation of creating new innovative small industries.

C. To provide a reasonable and fair means for independent inventors and innovators to obtain start-up venture capital.

II. Introduction

I was first exposed to the vicariousness of Federal programs in 1962 when I learned about the post war efforts to help Japan. The State Department had decided to give the dinnerware industry to Japan. This action--by one of our Federal agencies--to actively work for a foreign government to the detriment of an American industry resulted in the loss of 5,000 jobs along the Ohio River Valley. I was involved with the American Restaurant Chinaware Association, which successfully fought this action and managed to survive.

In 1969 I joined a small business had been created through invention and innovation. While with them I was successful in developing several new products. This company was the beneficiary of the first Small Business Investment Company set up in Kentucky and it received the only loan made by the S.B.I.C..

Use of this reference in this paper is like mixing apples and oranges. What interests us in this paper is the facilitation of innovation in the small industrial sector. Numerous studies since the famous Charpey report in 1967 have been made on the importance of the independent inventor/innovator.(3) This report was by a Department of Commerce Panel on Invention and Innovation, and to my knowledge has led to no substantial help to the independent inventor/innovator. A recent paper by Obermayer brings this story up to the present.(4) In brief, the story is that over half of the important inventions and innovations of the 20th century come from independent inventors or small firms. This was done despite the other statistic that only 5 percent of this nation's research and development funds are spent by small industry.

One may conclude from these statistics that if the independent inventors and small industries are doing so well that the best thing to do is to leave them alone. One seldom reads that 2 important changes have occured since these statistics were gathered. These are:

- The Tax Reform Acts of 1969 and 1976 increased the capital gains tax which in turn discouraged people in the high tax bracket from investing in high risk ventures.

- The 1977 Tax Reform Act reduced the possible number of investors in a new business from 30 to 7.

Thus we now have 2 federally imposed barriers which make it almost impossible for the inventor/innovator team to obtain start-up venture capital. Even before the capital gains tax increases the venture capitalist seldom entered the picture at start-up. This reduction probably had a greater impact on the traditional "family and friends" source of funds. These effects show up later in the statistics as a reduction in the new issues. They could be the 2 most probable reasons for the tremendous decline in the venture capital industry and in the new industrial issues.

In judging from my own experience in both large and small industry, I think that for many innovations the independent inventor and small industrialist can develop new products far more efficiently than can large industries. Certainly there is ample evidence that a large number of ideas are "out there". The primary problem is to find the practical and reasonable way to bring those ideas into fruition. The reason for government to do this is that under the present conditions it is clear that no one else will provide the required large sums of start-up capital. The generation of new jobs and taxes is the dominant justification for a Federal initiative.

to have an assured source of gas to keep warm during the winter. The cost of the new gas will be $6 a thousand cubic feet at the wellhead plus the cost of moving it to the customer, about 4 times the present price of natural gas. My cost of heating could go from $500 a year to $2000. At that level I could elect to oil, electricity or install a solar unit. I have not been asked if I will undertake the obligation. If the customers pull out will I, as a taxpayer, have to take it over? As an insurance policy, I probably will.

In my spare time, I have been working on a novel energy conversion methodwhich will make plants of this type obsolete when perfected. I submitted my idea to 50 different organizations for research funds without success. It is the sort of idea that either works and proves itself, or it doesn't work at all. When it works, I will have to have high risk start-up operating capital to build prototypes, field test, pay attorney's fees, set up a marketing and service organization and go through the usual steps. I will not need to buy a building and expensive equipment. At this time I do not know of anywhere I can go to obtain these funds. This is not the type of activity Small Business Investment Companies or the Small Business Administration would back. I would not have any trouble giving the invention away, but that is not what it is all about. I do not have resources to cover the loans and I would not be able pass the coverage along to existing stockholders or customers. We do have a dual set of standards.

V. State and Federal Activities in R&D Support of Large Industry

The Commonwealth of Kentucky, which ranks 44th in state aid to secondary education, has spent of committed $70 million over the past 4 years for coal conversion research.(7) While a substantial portion has been expended by the University of Kentucky, we have not read of any private small business contracts. This, despite the fact that I was told when I came to Kentucky in 1963 that the greatest need of the state was for:

> "the development of a smokeless still for the small entreprenuers throughout the state."

The bulk of the coal conversion funds have been committed as matching funds with the Federal government to large industrial concerns. I am in agreement with this approach as it was first requested in the budget by the Kentucky Science and Technology Commission when I was the Executive Director.

Kentucky has also committed $38.6 million this year for tourism facilities.(8) These facilities are a source of personal enjoyment but their primary purpose is to attract

At one time I was employed by a large industrial concern to develop government sponsored R&D contracts. This effor was successful and very helpful to some of the corporate long range programs. Last year in a survey of 1,600 industrial organizations on the appropriate role for the federal government in increasing productivity, the General Accounting Office found that the vast majority did not want federal assistance.(13)

We have a situation in which government is placing millions at the state level and billions at the federal level into the support of large industry and the group would prefer to be left alone. Transfer of much of this activity from the large to the small sector over a 10 year period should be a relatively painless operation.

VI. Federal Activities for Innovation in Small Industry

The great white hope for the independent innovator, as presented by Obermayer (4) is the Small Business Innovation Program of the National Science Foundation. NSF was directed by Congress to spend 12½ percent of its Applied Science and Research Applications budget in rewards to small business. Obermayer pointed out that the normal client of NSF is the university and that there was concern about the subtle ways to keep small businesses away from the funds.

My information on the program is secondary as I was not aware of it until recently. As an inventor from Kentucky I would expect to be at a disadvantage in the requirement that to obtain Phase II funds it is necessary to have a commitment from a venture capital source. While this may sound like a good idea on the surface, it does take control away from the innovator and place it with the venture capitalist. It turns into a service program for the venture capital industry. Hopefully this will not be the case.

While this is encouraging we must look at it in terms of the total picture as we are discussing a major undertaking. In the 1978 budget authorization bill, NSF received $855 million.(14) The 1978 RANN budget was $63 million so this works out to be $7.9 million, about 1 percent of the total to efforts made by small R&D organizations. In terms of the relative contribution of small business to our technology this can at best be expected to show the way.

The second arm of the NSF small business program is the "Innovation Centers Experiment" located at MIT, Carnegie-Mellon, and Oregon Universities. According to the Burger report on "An Analysis of the National Science Foundation's Innovations Centers Experiment"(15) they have been quite successful. My one experience was ~~that when~~ I submitted an idea to the University of Oregon I never heard from it.

regional capital development banks to provide venture and expansion capital for private enterprises.(19)

W.F. Ballhaus of Beckman Instruments in his article on "Personal Investment is Necessary for R&D Growth"(20) gives as the solution of our problem 4 changes in our tax laws as follows:

- Permit "rollover" of capital investments.
- Allow 100% writeoff of capital losses.
- Allow 100% writeoff of interest on funds borrowed for investment.
- Abolish tax preferences and minimum taxes accociated with capital gains.

Newsweek reports that Congress is likely to change the capital gains tax back to 25 percent -- where it was in 1969 (21).

We have a clear recognition that independent inventors and innovators have the capabilities of turning our declining innovation trend around and a trend by big business and industry to decrease their long range innovative efforts. We have attempts by Congress to do something with universities and banks, and we have an administration formed committee to do yet another study. We have the drive by large industry to increase the value of their stocks through special legislation.

What I cannot understand is why there are no substantial attempts to make the independent inventor/innovator a part of the process. Why do people seem afraid to discuss the need for start-up venture capital?

VIII. Preferred Approach to Innovation

My third and final premise is that we have a tremendous reservoir for innovation in the independent inventors and innovators and that once we make it financially attractive for them to go into business we will see the highest innovative growth rate in the world. The next step is to develop the legislation which will make this possible.

We need to be clear on the difference between entreprenuership and innovation. When Amy Carter sets up her lemonade stand and goes into business she becomes an entreprenuer. This is not the problem area and our system seems to be generating an abundance of these. Innovation is the act of introducing something new or novel and it seems quite proper to restrict this to some product, device or process that

One is led to believe that all Congress has to do is to change the capital gains laws and that people will be searching for inventors and innovators to take their money. This I do not believe. It will help but the primary benefits will be to wealthy individuals rather than to inventors and innovators. People will have new ideas and inventions regardless of the tax laws. They will not innovate unless they perceive that the gain will be worth the effort. Thus a prudent wealthy investor will see the large corporations such as Exxon and General Motors as the wisest place for their investment dollars.

I recommend that they new legislation set up a substantial allocation for small business start-up venture capital. I think that this should grow over a period of perhaps 10 years to equal the amount currently being funded to large industry. Industrial R&D in 1976 was $26.6 billion of which $9.2 billion came from the federal government. We recommend that our goal be to provide an equal amount to small industry for starting new ventures and that we should reach this equalization in 10 years. In this process we would seek to bring our percent of gross national product devoted to research and development to a level competitive with Russia.

Once the decision is made to increase the rate of innovation growth in this country and to provide the funds to make it possible the next question is ---

> "how should this be done to create the greatest number of jobs and yield the greatest return to the tax payer?"

Naturally I have ideas as to how I think this should be done and I am anxious to share these with the proper decision makers. I shall be grateful to be the project consultant in the development of the procedures.

Wingate A. Lambertson, Ph.D.

Thirty years experience in university, governmental, and industrial, basic and applied research and development. Has actively participated in research and product development at the bench and management levels.

Experience:

INVENTIVE IDEAS INC.	President (1976 -)
WATERSOL YARNS INC.	President (1974 - 1976) Formed company to develop and manufacture a water-soluble thread
SOLVEX CORPORATION	President (1969 - 1974) Developed a solvent fracturing knit-separating thread

Developed the first fusible adhesive monofilament thread in the United States
Initiated the work leading to the use of trichloroethylene in the Solvex process
Invented and developed a thread soluble in trichloroethylene
Invented and developed an adhesive cord and KWIK STIK
Invented and developed a knitting heat-separating thread

KENTUCKY SCIENCE AND TECHNOLOGY COMMISSION	Executive Director (1966 - 1969)
SPINDLETOP RESEARCH	Manager of Physical Sciences and Materials Departments (1963 - 1966)
CARBORUNDUM COMPANY	Manager and Assistant Manager of Applied Research Branch and Research Development Division (1955 - 1963)
UNIVERSITY OF TOLEDO	Full Professor of Silicate Chemistry - Institute of Silicate Research (1953 - 1955)
ARGONNE NATIONAL LABORATORY	Research Associate (1949 - 1953)
RUTGERS UNIVERSITY	Research Fellowship (1947 - 1949)

Education:

Ph.D. Ceramics, Engineering Minor, Rutgers University - 1949
M.S. Ceramics, Physical Chemistry Minor, Rutgers U. - 1948
B.S. Ceramic Engineering, North Carolina State U. - 1941
Special-Industrial Management Course - Harvard University Business School

Professional Activities:

American Ceramic Society (Fellow)
American Chemical Society
American Society for Metals
National Institute of Ceramic Engineers
R.E.S.A.
Kentucky Academy of Science
Keramos
Phi Kappa Phi

Publications and Patents:

Author and Co-Author of 18 Publications and 3 Patents (Details upon request)

Abstract

The report is in two major parts:

Part 1 - First Money and Venture Capital, and
Part 2 - A Procurement Policy Idea.

The objective of Part 1 is to assemble available venture capital and R&D data into a form which is meaningful to the private entrepreneur and analyze the findings.

The entrepreneuring firm or individual is interested in risk capital, not solely venture capital or R&D. In particular, such individuals and firms are interested in two main parts of risk capital, the part they must supply by the use of internal resources, and the part which must be sought from and supplied by outside non-associated sources. The former is labeled First Money, the latter, Venture Capital.

The small technical firm has a difficult problem (as compared to larger established firms) in start-up of a new technical product venture. Private venture capitalists are more likely to provide outside support during a small firm's second or third stage growth than for initial start-up. This means that the unaffiliated individual or newly formed firm is faced with net-worth reduction before sales provide operating revenue and outside sponsors show interest and, perhaps, finance further growth.

Large technical firms may, within limits, mark-up product prices with first money expenses, but price-competitive suppliers of any size are less inclined to venture new products through the use of first money.

Established federal contractors may mark-up the prices of current contracts for federal goods and services by about 4% of federal sales and thus prepare for future federal needs and propose venture capital sponsorship through the use of the federal R&D contract instrument. Nonfederal suppliers of any size, unaffiliated individuals and small technology firms must use equivalent commercial first money instruments for the same purpose.

About 90% of all industrial first money is incurred by the largest 624 firms and the amounts are recovered in both commercial and federal sales. For these firms, an estimated $1.4 billion of a total $18 billion first money (1977) was recovered in federal sales, the rest through commercial sales.

to remove implicit or explicit considerations of an innovating unit's "wealth" (or net-worth) as a criteria for qualification to participate in federal innovation markets. The conceptualization suggests that pre-qualification be based on industrial standards for the hiring of creative scientific and technical personnel. A pre-qualified individual or entrepreneuring unit would receive direct payments for proposal submittals, solicited or unsolicited, to provide nonfederal suppliers of any size with equal entitlements to those found in IR&D/B&P accounts of established federal suppliers. Other aspects of the conceptualization are directed towards equally distributing federal innovation entitlements among pre-qualified unaffiliated individuals, small firms, nonfederal suppliers of any size, and established federal contractors.

In essence, the conceptualization advocates pre-qualifying and providing equal entitlements to those who may successfully innovate in the future and eliminating current criteria and benefits which give unbalanced advantage to those who have successfully innovated in the past.

TABLES

FIGURES

PART 1

FIRST MONEY AND VENTURE CAPITAL

DEFINITIONS

A "catalyst" which motivates effective and efficient communications between participants is risk-capital; the sponsor, to protect his investment; the innovator, to gain rewards for success; the consumer, to arrive at an introduction which meets his needs, goals, and constraints.

Risk capital is a financial resource which pays both operating and facility capital costs as a new innovation proceeds to market introduction.

It is a "risk" capital because at the beginning of innovation, at the idea or concept stage, certainty of meeting the diverse goals of all participants is at its lowest. Unpredictable technical and market events will most always be encountered which may cause a major revision in the direction and goals of an innovation program, or even its termination.

All participants must "adaptively-learn" as uncertainties are encountered and resolved so that all may be benefited by new knowledge as it is gained, and risk capital becomes less financially "risky" as a new innovation nears consumer market introduction.

Risk Capital

Risk capital is defined as a financial resource employed for two purposes: to pay operating and facility costs of new product innovations.

Operating capital pays salaries and benefits of creative scientific, technical, and production people; venture planners and managers; marketing and market research personnel and costs; and other labor-intensive supporting activities. It also pays for purchased services and supplies such as computer services and special materials. Operating capital is expensed as a cost of current product sales and therefore is not taxable.

Some Data Difficulties

Government mission agencies, large technical firms, the Financial Accounting Standards Board (FASB), the U.S. Cost Accounting Standards Board, the Census Bureau of the Department of Commerce, the Securities Exchange Commission, and the Internal Revenue Service use the term "research and development" (R&D) to identify direct and indirect scientific and technical labor costs, a major portion of risk capital.

However, the definitional context of R&D does not include all the financial elements needed to introduce a new innovation into its target market. The FASB R&D accounting procedures are followed in SEC 10-k industrial R&D reporting.[1] But the costs of several activities required to innovate a new product are not included in FASB ground rules, but are included in the definitional context of risk capital. These FASB omissions are market research, capitalized R&D plant and equipment, product testing, and computer programming.

The SEC's 10-k report, is, as a consequence, silent on industrial R&D plant and equipment investments, venture planning, and some support activities--amounts which are included in the concept of risk capital.

But private entrepreneurs require risk capital, not solely expensed R&D, to perform the total innovative process. Official government reports do not report risk capital, but variously and partially report the costs of labor-intensive R&D activities (direct and overhead costs, excluding General and Administrative mark-ups).

The definitional context of R&D apparently varies within government. For example, Securities Exchange Commission 10-k reports of industrial R&D expenditures includes R&D spending by foreign subsidiaries, but the Census Bureau survey covers only domestic expenditures. This difference alone can account for as much as a 25% difference in reporting for a third of the companies covered.

---

[1] R&D Spending Patterns for 600 Companies, Business Week, July 3, 1978, pgs. 58-59.

FIRST MONEY

Some firms may afford the total cost of an innovation by obligation of first money internal resources and not require outside venture capital to complete the innovative process. Whether or not the total cost of an innovation may be internally-afforded depends on scale of resources required and the assessed risk of their recovery through current and expected product sales. For example, the first money scale and risk to fully innovate a supersonic transport was considered beyond the means of any one company. For this reason, in addition to national security reasons, the commercialization of nuclear technologies was also judged unaffordable by any one company. Outside financial support was required in both cases.

Small firms or entrepreneuring individuals may often afford little more than the costs to conceive an idea and communicate it to outside venture capitalists. Their problem may have more to do with decisions about acceptable net-worth reduction to pay first money costs than the risk of cost-recovery through current product sales.

Large Companies

Large companies with established product lines may sometimes mark-up their product prices by a first money expense. The common term for such an expense is "research and development." As pointed out in Definitions, the concept of R&D is not the same as first money even though R&D is a major part of first money. For this reason the data which follows is generally understated as to an accurate representation of large company first money expenses.

Business Week reports that 624 companies (of over $25 million annual sales) spent $18 billion for privately-sponsored R&D activities in 1977. These expenses were recovered on commercial and government sales of $971 billion. What Business Week does not report is that of the $18 billion reported as privately-sponsored, an estimated $1.4 billion was recovered on sales to government (IR&D/B&P cost-recovery of about 2% on industry sales to government of $70 billion). Thus, an estimated $16.6 billion was more likely recovered on commercial sales than the $18 billion reported, and about $1.4 billion independent R&D expense was taxpayer-supplied and not supplied by private consumers of the companies commercial products or services.

34-270 O - 78 - 46

offer consumers unique technical and management capability, or they may be a member of an economic oligopoly wherein a small number of suppliers control the sellers market.

No standard definition of price inelastic suppliers can be found in the literature. Industry concentration data, however, is accumulated by the Bureau of the Census.[2] Arbitrarily defining price inelasticity to be present when over 50% of total industry sales are supplied by four (or less) suppliers, we find the following industries characterized as concentrated and price inelastic. Because these industries are also R&D intensive, firms not in the controlling oligopoly may also supply price inelastic products and services by marketing unique technical capability and management. We would expect to find most privately-sponsored R&D expense incurred by these industries, and, in fact, this is confirmed by Business Week data.

TABLE 2

R&D-Intensive Industries Dominated by Four (or less) Suppliers of Relatively High Sales Volume
(Over $1.5 billion total industrial shipments)

(in billions)

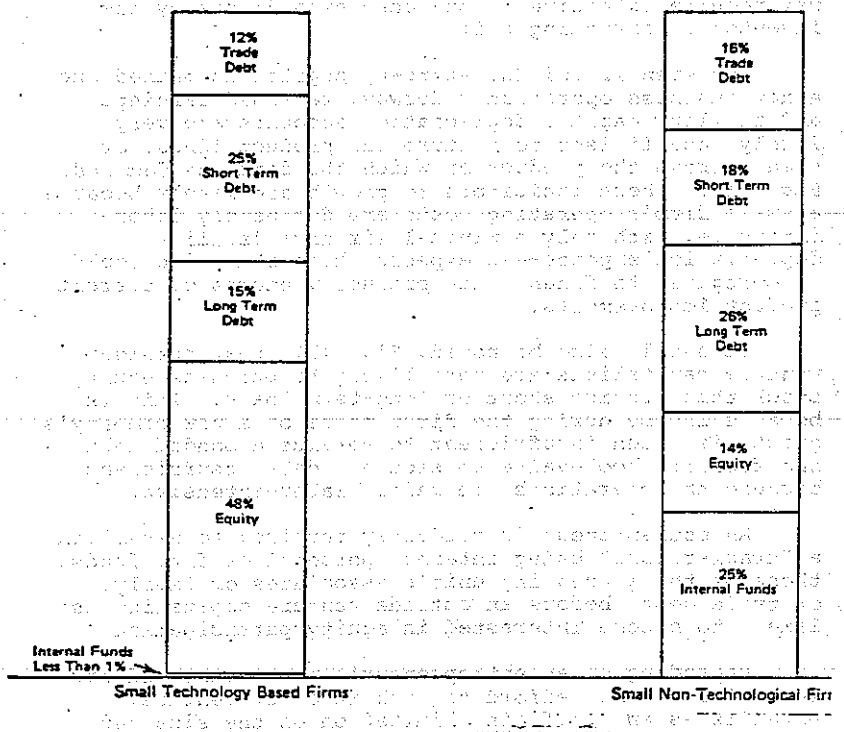
Industry	Sales (1972)
Organic Fibers, Noncelluose	3.6
Soap and Detergents	3.4
Turbines and Turbine Generator Sets	2.2
Internal Combustion Engines	3.3
Ball and Roller Bearings	1.5
Electronic Computing Eqmt.	6.4
Transformers	1.5
Household Refrig. and Freezers	1.7
Telephone and Telegraph Apparatus	4.5
Semiconductors and Related Devices	2.7
Engine Electrical Eqmt.	2.0
Motor Vehicles and Car Bodies	42.9
Motor Vehicle Parts and Accessories	18.3
Aircraft	8.8
Aircraft Engines and Parts	3.6
Railroad Eqmt.	2.5
Guided Missiles and Space Vehicles	4.1
SIC 48, Communication	—

Source: Formulation of an STS (Space Shuttle) Market Development Plan and Sales, (NASA), DGS Associates, Sept. 1977, pg. 21.

[2] Concentration Ratios in Manufacturing, 1972 Census of Manufacturing, U.S. Department of Commerce, Bureau of the Census, MC72(SR)-2.

Fig. (1)

COMPOSITION OF SOURCES OF *ALL* FINANCING OF A SAMPLE OF SMALL FIRMS MAKING INITIAL PUBLIC OFFERINGS 1970-1974



Source: An Analysis of Venture Capital Market Imperfections, NBS-GCR-ETIP 76-12 Charles Rivers Associates Cambridge, Mass., February, 1976.

growth is beyond the inventor's means, the idea has a low chance of surviving into a second or third stage growth pattern.

A Federal First Money Instrument

New product first money is made available to established federal contractors through a taxpayer instrument. First money expenses may be recovered by established federal contractors as a "cost-of-doing-business." Such costs are recovered on current federal sales. This financial first money instrument is known as Independent R&D, Bid and Proposal (IR&D/B&P). IR&D/B&P is an allowable federal contract expense according to the Armed Services Procurement Regulations.

The amount of industrial first money recovered on federal contracts was $887 million for the Defense Department's 91 largest contractors. This amounted to about a 4% price mark-up on their DoD sales of 26.5 billion.[7]

These recoverable independent technical costs must demonstrate relevance to DoD's interests. They also include the contractor's cost to make venture capital propositions to DoD venture capitalists which, if supplied, would be supplied through an R&D contract instrument.

Total first money recovered on federal contracts for all government procurement is not known, but an estimate of 2% on $70 billion industrial sales to government (1975), or $1.4 billion, appears to be reasonable.*

Thus, established federal contractors are indirectly provided taxpayer-supplied first money to independently create and explore new product ideas, assess the agency consumer marketplace, submit solicited or unsolicited venture capital propositions to federal R&D sponsors. First money may be recovered whether a venture capital proposition is successful or not, although federal contractors may sometimes only partially recover the total amount expended. Unaffiliated individuals, small firms

---

[7] Congressional Record, S9250, June 5, 1978.

* IR&D/B&P costs are reported as the sum of direct and indirect costs, excluding General and Administrative cost allocation.

VENTURE CAPITAL

Outside venture capital in support of new product innovation comes by means of several financial instruments:

-- equity stock (common and preferred),

-- bonded debt (convertible or non-convertible debentures),

-- trade debt (outside financial assistance by the supply of services or materials at "no cost" with deferred payment obligation),

-- short or long-term loans (if unsecured, in the bond category; if secured, in the commercial loan category),

-- direct venture capital contracting (commercial or public R&D contracts),

-- grants (reduced sponsor financial and technical engagement and direction as compared to R&D contracts),

-- no-cost use of sponsor owned plant and equipment, i.e. facility capital.

Some of these financial instruments may be employed in different combinations to continue an innovation beyond an affordable first money cost, with, as mentioned, a portion of total first money allocated to meet the informational needs of outside venture capitalists.

Private Venture Capital, Small Technical Firms

Small firms receive outside venture capital from several types of private venture capitalists (see Fig. (2)). Outside support is usually publicly offered at the second or third stages of a small firms growth with previous growth financed as shown.

Figure (2), however, does not specifically reference federal government as an early supplier of venture capital through the instrument of federal R&D contracts, although the category "Unknown" may mainly consist of federally-supplied R&D contracts or grants, rather than equity and loans as shown.

The study also included an analysis of equity funds to all industry and particularly the flow of

equity funds to small technical firms, Figure (3). The study concluded that equity support to small technical firms paralleled general economic activity, with 0.0-0.5 percent to 2 percent of the total equity flowing to such firms.[8] In absolute terms, equity stock, as a venture capital resource for small technical firms, was estimated at $700 million for 1971.

Another independent study found that equity venture capital for the small technical firm declined from $1.1 billion in 1969 to less than $16 million by 1974.[9]

Venture capital data, through the instrument of commercial R&D contracts, is not available but is believed to be almost nonexistent.

Public Venture Capital

In fiscal 1975, federal R&D of $19 billion was distributed mainly to non-market performers;* $10.4 billion vs. $8.4 billion to industry.[10] These distributions were directly made to support agency in-house scientific and technical activities and to industry and private non-market operations by the instrument of R&D contracts.

Also during fiscal 1975, non-market performers received more than 100% more "seed" or start-up

---

[8] Op Cit (1), pg. 8.

[9] Op Cit (4), pg. 8.

*Non-market performers, in the context used, are innovation performers. Such performers are not judged in their cost/performance by economic standards; profit, return on investment, stock or bond market prices. They are non-competitive performers that supply an essential public service which is not otherwise available from competitive private enterprise. We are not referring to a privately-owned monopoly, such as regulated power utility, but to a publicly owned monopoly which supplies a public service. An example would be the Sandia Corp. where "the means of production" of its services are owned by the State and not by private capitalists.

[10] Federal Funds for R&D and Other Scientific Activities, Fiscal Years 1975, 1976, and 1977, Vol. XXXV, NSF 76-315, pg. 1.

capital* than industry; $3.5 billion vs. $1.5 billion.[11]

Small Technical Firms

A survey has been made of federal R&D awarded to small technical firms during fiscal 1975.[12] The study found that of $19 billion total R&D expenditure, about $700 million, or 3.7%, was awarded through the R&D contract instrument.

Large Technical Firms

Large technical firms were awarded about $7.7 billion venture capital in fiscal 1975 through the R&D contract instrument.

However, an observer claims that many of the largest defense companies are more likely non-market operations than profit-motivated companies, and therefore not measured in their performance by economic standards. The Scientific American article[13] claims, for example, that Lockheed's sole source position for follow-on sea based ballistic missiles, starting from the Polaris and continuing through the Trident, removes profit and cost-reduction motivations which are characteristic of the usual understanding of private competitive industry. Several other examples are cited of government's direct and indirect control over the U.S. economy through the employment of non-market mechanisms and operations.

In presenting federal R&D allocations we have used official R&D data which does not distinguish between corporate behavior and motivational patterns of various federally-financed R&D performers, except as such data distinguishes between stockholder owned private firms and chartered not-for-profit operations, such as in-house agency laboratories, technical centers and

*"Applied research" in government terminology. All terms mean the earliest, most risky application of risk capital (subject to previous caveats about R&D definitions). Also, reports of in-house R&D costs are under-reported by about 16%, OMB Press Release, #15, Nov. 21, 1977.

[11]Ibid, pg. 1.

[12]Internal Memorandum, Office of Federal Procurement Policy (draft), May 13, 1976.

[13]The Pluralistic Economy of the U.S. by Eli Ginzberg, Scientific American, Dec. 1976.

FEDERAL INNOVATION MARKETS

Government has supplied venture capital to private sector contractors to meet national security goals since World War II, and, since the late 1950's, to meet the nation's space science goals. Since the early 1950's, the exploration of commercial nuclear power, however, has been mainly a nationalized scientific and technical effort performed by "captured" national laboratories. Industry has only lately taken an active role in its commercial supply.

Starting in the early 1970's, an increasing share of federal R&D has been applied to the innovation of new civilian products, processes, and services to meet housing, energy, transportation, health, environment, and safety national goals. Approximately one-half of total federal R&D ($28 billion, FY 1979) is now targeted towards achievement of such goals.

Broadly, two innovation markets are created by national needs, goals, and priorities.

-- innovations consumed by federal agencies for their own and unique use

-- innovations consumed by nonfederal purchasers responsive to national civil needs, goals, and priorities.

Federal statutes, policies, procedures for the first marketplace cannot be the same for the second. This is because innovation participants for the former are different than those for the latter. That is, innovation creative technical personnel, venture capital sponsors, and ultimate innovation consumers presents an array of combinations for the latter innovation marketplace that bears little correlation to effective and efficient combinations for the former.

Government, as an experienced consumer of innovations for its own and unique use, must separately construct policy for the nonfederal consumer innovation marketplace. This is the challenge facing civil agencies, a difficult challenge because many key personnel are experienced in AEC, DoD, NASA innovation markets where their knowledge is no longer relevant.

About the most that can be said is that DoD, NASA, and AEC (now part of DoE) innovative experience is important generally, but such experience cannot be institutionally applied to civil innovation participants

BRIEF DISCUSSION: Evolution of DoD First Money and Venture Capital Policy

First money to prepare for and propose R&D contracts can be significant depending on the design phase at which competition is invited. This section briefly reviews changes to DoD policy which has governed first money since the early 1960's.

The start of a new weapon's design, like all innovations, begins with an idea or design concept about what the new introduction may be in the future. The idea may be accepted by a company's management for first money expenditure to further explore the idea. But because the introduction of a major weapon into DoD inventory most always incurs a long-term financial burden which even the largest suppliers cannot afford, there is a judgmental limit on how far into the innovative process the company may proceed on its own first money internal resources.

Policies of the 1960's

During the 1960's defense suppliers were asked to principally use internal resources* to move Conceptual weapon's design into Engineering Design before direct R&D contract support would be DoD supplied, and then only supplied to the competitive winner.

A July-August 1967 Harvard Business Review article by Martin Meyerson, Martin Corporation, "Price of Adminission into the Defense Business" describes accumulative first money to remain qualified and prepare for competition. The article describes in some detail the DoD 1960 time-period policy for acquiring new weapons and, in particular, describes the financial burden placed on contractors to qualify and compete for engineering design and production contracts.

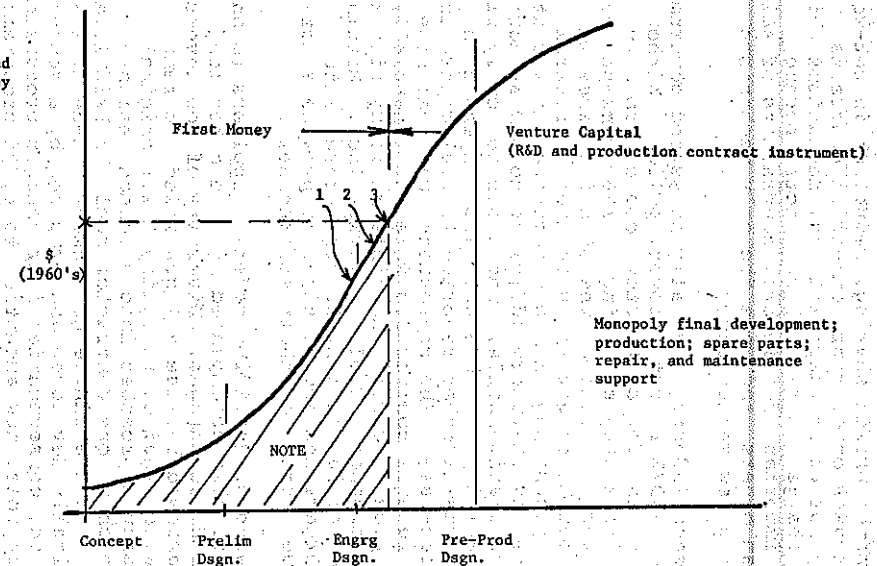
Mr. Meyerson noted that competition would occur in the early phases of a weapon's innovation by periodic sponsorship of R&D "seed" contracts to support DoD's

*Adding to internal first money resources were R&D "seed" contracts. They were periodically and competitively awarded to assist government sponsors refine a procurement specification for a later full-scale engineering competition. Such weapons as the C5A, F-111, F-15, F-14 and several combat ships were introduced using this approach.

34-270 O - 78 - 47

Fig. (4)

THE RELATIONSHIP BETWEEN FIRST MONEY AND ENGINEERING DESIGN COMPETITIONS; 1960 TIME-PERIOD POLICY



1. Request for proposal
2. Submittal
3. Award Announcement

NOTE: Accumulative first money was made-up of:
-- R&D "seed" contracts
-- IR&D/B&P
-- Cost-sharing
-- Prorata share of price-mark-ups on commercial products and services in various combinations.

Source: DGS Associates

The Start of the 70's

In 1971 Deputy Secretary of Defense, David Packard, revised 1960 policy. He reinstated competitive prototype competition, an informal effective and efficient policy of the 1950's, by introducing competition at an earlier design phase than the 1960's mandated Engineering Design phase.

Figure (5) illustrates the reduction in first money to qualify and participate in a competitive prototype competition. These competitions were entered at the Preliminary Design phase of innovation.

Again, the cumulative amount is principally made-up of two parts; first money charges to current federal contracts (IR&D/B&P), and direct R&D "seed" contracts. Some profit-sharing, particularly in company support of R&D "seed" contracts, could be chosen by company managements if it was in the company's interests and was affordable.

But even though first money was reduced by the 1971 revision, the IR&D/B&P policy of the 1960's was not changed and, in fact, remains the same today. As with 1960 policy, a relatively large federal contract sales-base still means relatively less demand on commercial mechanisms to pay first money expenses.

The 1971 policy revision also retained some other features of 1960 policy. After a short prototype competition, a monopoly supplier would be selected for final development of its winning prototype design even though production would not be a contractual item, or, in other ways, guaranteed. There was, as a consequence, little impact on the procurement statutory framework (and procedural regulations), and excessive non-productive monopoly regulatory costs still remained in mark-ups on the prices of federal products and services. Also, the innovative time-period between Conceptual and Preliminary Designs still tended to converge originally separated Conceptual Designs into a common Preliminary Design--although, on balance, the appearance of important and competitive design differences was enhanced by the 1971 policy revision.

The Mid-70's

The U.S. Commission on Government Procurement delivered its report in 1972 to Congress and the President. All federal procurement (about $50 billion, 1971) was examined and 149 recommendations were made

for improvements to the efficiency and effectiveness of federal contract expenditures. One section of its four-volume report treated with "Major System Acquisition," (Volume 2, Part C).

Much has been written and said about the Commission's "system" report which will not be repeated in detail here. The important change recommended by the Commission was that competitive entry into system's competition be moved still further ahead in the design process, to the Conceptual Design phase. This change and relative impact on first money, is shown on Figure (6).

The intent of the Commission's recommendation was to widen the competitive base by permitting contractors less "wealthy" than others, but otherwise pre-qualified, to equally compete by reduction in required first money expenses and ownership of expensive R&D and production plant and equipment. The work to be performed subsequent to conceptual design is mainly labor, not facility capital intensive, so facility capital "wealth" was to be minimized in pre-qualification criteria.

The Commission's recommendations could be characterized in the following way, "...all pre-qualified private suppliers, regardless of corporate net-worth, federal contract sales-base, or principal business should be permitted to respond to federal mission needs at the idea or concept phase of innovation, enter federal innovation markets based on the federal sponsor's judgmental evaluation of their competitive ideas, and achieve corporate growth during later innovative phases by exhibiting tangible competitive results."

By full federal agency policy implementation, the Commissioners believed that diversity of future investment choice would be enhanced and maintained as a hedge against uncertain mission needs, and visible and open competition between alternate designs would achieve economies not otherwise achievable (competitive supply).

In effect, a firm that submitted an acceptable idea or design concept would be clearly responsible, in competition, to develop its own specification for later investment choice by the sponsoring federal agency. Ambiguities about full-weapon's design responsibility would be minimized, if not eliminated. It was believed this feature of new policy would have a significant bearing on enhancing contractual integrity which had reached a nadir during the 1960's.*

*Shipbuilders build what Navy has designed. This is an extreme case of contractual ambiguity, and makes contractual enforcement difficult for Navy, and motivates shipbuilder's claims against Navy. (Is Navy's design faulty, or did the shipbuilder nonresponsively perform what it had contractually committed?)

The Commission's intent was for agencies to directly supply venture capital at the idea or design concept phase of innovation as the preferred financial instrument for commencing and continuing alternate and competitive innovative designs, as long as competitive test results and an updated federal need for the innovation program justified continuance. The requirement to employ commercial first money instruments to keep a competitive pace over long time periods would be markedly reduced. Hence, an effective challenge to defense industry oligopolies, which were created by 1960's policy, could become a feature of U.S. policy.

Clearly, previous innovation policies had fostered financial and new business inequities according to a firm's net-worth, federal contract sales-base, and principle business. While not eliminating inequities, the Commission's main thrust was to minimize them.

The Commission's recommendations were conceived within the rule of law to foster the distribution of equitable financial and new business entitlements; regardless of relative net-worth, federal contract sales-base, or the principle business of a pre-qualified inventive/innovative unaffiliated individual or firm.

Within the rule of law, the Commission's recommendations were also referenced to innovation's primary attributes; that is, to attributes which are independent of technologies, scale of resources, time spans from idea to introduction, and the particular constraints, goals, capabilities, and other characteristics of innovation's performers, sponsors, and ultimate consumers. In this sense, the recommendations were not to govern only a particular major innovation, but to govern all major innovations.* The need to "tailor" a particular innovation program to fit within the particular characteristics of a particular innovation's technologies, resource scale, time spans, and participants was recognized.**

The Commission recommendations were adopted by the Executive Branch in April, 1976 (OMB Circular A-109,

---

*Including Navy's ship acquisition programs.

**A "tailored" innovation program is described by innovation's secondary attributes; sales price, operating cost, performance, and introductory schedules. Each innovation is uniquely separated from others by secondary attributes, but all are the same when referenced to primary attribute.

FEDERAL POLICIES WHICH GENERALLY INHIBIT PRIVATE VENTURING

Both DoD and NASA depend on the creation of unique and innovative ideas in achievement of national security and space science goals, and both are taking policy and procedural steps to reduce first money requirements for entry into their innovation markets.

But some overall federal policies still tend to inhibit private venturing generally, and are policies over which these agencies have little control. The emergence of newer and smaller businesses through reformation of past DoD/NASA innovation policies will decidely improve chances for broadening the private innovative supply of ideas for future needs by extending opportunities to smaller businesses and allow such firms to achieve corporate growth based on a continuing competitive merit. These reformations strengthen private enterprise specifically, and capitalism generally.

However, the emergence of new innovative small firms as idea resources for these agencies is generally inhibited by provisions found in the U.S. tax code.

Friedrich Hayek noted:

> "The most serious consequence (of the system of taxation)...is the restriction of competition. The system tends generally to favor corporate as against individual savings and particularly to strengthen the position of the established corporations against newcomers. It thus tends to create quasi-monopolistic situations."[15]

The tax code drives private venture capital out of the private marketplace into the treasuries of large firms where it is unreachable by unincorporated firms and individuals. The wealthy private capitalist, on whom most private inventors in the past have depended, is fast disappearing.[16]

Another major reservoir of venture capital is the U.S. Treasury, as has been pointed out. But individual

---

[15] The Constitution of Liberty, Friedrich A. Hayek, 1960, Henry Regnery and Co., pg. 320.

[16] The Role of New Technical Enterprises in the U.S. Economy, Commerce Technical Advisory Board, U.S. Dept. of Commerce, January 1976, pg. 8., see also, Op Cit (5), pg. 227.

But the U.S. tax code equally treats tax deductibility of all innovation expenditures regardless of relative risk of expenditure. This clearly motivates private venture capitalists to delay financial participation to later innovative design phases. It is in later innovative phases where most technical uncertainties will have been encountered and resolved, market data made more precise, and expectation of financial return made more realistic and convincing.[18]

The U.S. tax code burdens the private inventor who must pay "seed" money out of his own pocket as outside capital decisions are delayed to relatively expensive late design phases. This artificially limits innovation to only those who may be sufficiently "wealthy" to afford the costs of delay, but individual or corporate wealth of the moment has little to do with the ability to create and explore new product ideas for the future.[19]

What is needed is higher tax deductibility of the costs for new product feasibility demonstrations rather than the same deductibility for expenses incurred during later innovative phases. These later phases would include fully engineered prototype demonstrations and pre-production pilot runs. Such changes would motivate corporate and private venture capitalists to put money "up-front" in the innovative process, a motivation which is clearly absent from current tax policy and stops a new product innovation before it even begins.

---

[18] Op Cit (5), pg. 164, "Most investments made (by private venture capitalists) are not made in start-up but in the second or third stage of development of portfolio companies...later stage investments are thought to be less risky than start-ups."

[19] Science Indicators, 1976, National Science Board, pg. 11. The 1953-1973 innovation rate measured by major innovations per R&D dollar, strongly favored small firms (of less than 1,000 employment) by 4 times the innovation rate produced by medium-sized firms (1,000 to 10,000), and 24 times the innovation rate produced by large firms (10,000 +). The Board suggested that "larger firms tend to produce minor rather than major innovations, e.g. small improvements that reduce the cost of high throughput manufacturing processes rather than completely novel products."

Such an innovation policy would equally apply to all innovations and all innovation performers regardless of their relative net-worth, federal contract sales-base, or principle business. It would apply equally to any innovator that is pre-qualified on the basis of past innovative experience, recognition among peers as an expert in prescribed areas, public presentations or papers which demonstrate new approaches to national needs. In short, such a policy would remove relative "wealth" as a factor in the distribution of federal financial and new business entitlements. It would apply equally to large firms and small ones.

But the U.S. does not have such a national innovation policy. Because it does not, unaffiliated individuals and small firms do not receive equal financial and new business entitlements as compared to federal contractors, their start-up capital is absorbed mainly by non-market operations, and private capitalists are not motivated by the tax system to provide start-up capital for ideas which may have only a single and uncertain consumer market. Thus, newer and smaller businesses are not encouraged to prepare for and enter federal innovation markets by an unwritten and unofficial net public policy.

Large established federal contractors have significantly contributed to national purpose in the past and will continue to do so in the future. Regardless of how a new innovation program begins, large-scale organizations and resources are very often needed at a later time. Providing equalities will not necessarily reduce this need, but may likely reduce the economic concentrations of current supply, and pave the way for the emergence of large companies which are not known today.

the approach for design of an advanced ship's defensive system (SIRCS). Seven qualification proposals were received, and of the seven, three were selected for direct payment of initial and competitive design activities. First money incurred by the firms in proposing qualification information was a small fraction of first money which would have been incurred if the initial proposals had required a conceptual design as a basis for award. The relatively expensive conceptual design activity was, in this instance, directly paid by Navy contracts, and not indirectly incurred by first money charges to current contracts.

Government financial and new business entitlements are limited roughly in proportion to a contractor's federal sales. Those contractors of lesser federal sales may recover proportionately less first money.

This rough proportionality limits smaller contractors to technical and new business activities associated with a proportionately smaller future sales possibility; that is, the limitation preclude smaller firms from directly competing with larger firms for major procurements in the future. The smaller firm is not able to grow to a competitive equivalence.

The A-109 procedure attempts to remedy this "built-in" future business limitation by making first money requirements relatively insensitive to the expected scale of future new business. The intent is that small federal contractors may equally compete with larger ones at the beginnings of innovation, at the idea or concept phase where the contracted work is mainly labor-intensive, and, by continuing competitive merit, permit smaller firms to acquire the R&D and productive plant and equipment needed to qualify for future major procurements. The rough proportionality of first money and current federal sales becomes less of a limitation on future business possibilities, and future competition for procurements of any size becomes more evenly spread among innovative firms, regardless of their comparative net-worths and federal sales at the beginning of innovative activity.

The direct proposal payment idea further extends the A-109 concept by spreading competition over a still wider innovative base. It adds the additional feature of insensitivity to current federal sales of any amount. In short, it is an idea for encouraging and attracting new entries into federal innovation markets by providing equality in federal financial and new business entitlements.

Background 36

This partial list of IR&D/B&P and other general overhead entitlements is a minimum list that the substance of the idea should address.

These entitlements may be generally associated with three areas:

-- pre-qualification, i.e. who should be permitted a direct proposal payment privilege?

-- communications, i.e. how should agency needs, goals, and constraints and private responses be communicated?

-- procedural matters, methods of billing and payment, the agency handling of "demand-pull" ideas vs. "technology-push" ideas, extension or termination of the direct proposal payment privilege.

The alternative to this pre-qualification procedure is well known. Creative and innovative people must be employed by large firms or federal agencies to improve their chances of gaining start-up financing for the ideas which they create. It is within the treasuries of large firms and government where start-up capital is mainly located and private start-up capital for the ideas of individuals or small firms is almost nonexistent.

Constant and Random Needs

Not all mission needs emanate from one level of hierarchical organization such as DoD; they may issue from many levels. Whether one level issues a need for innovative introductions depends on demands for new needs from the next higher level in all hierarchically-connected organizations. If no additional capability demands are placed, no demands for innovative ideas are rational at any level. In other words, if status quo were acceptable for the future, why should a price be paid for new introductions?

But there is one exception to this general rule. There is a particular category of constant demands for ideas at all mission levels. These demands converge to a generality. There is always a need for current capabilities to be delivered at less cost. This is a constant and continuing mission need at any level.

The need for additional capabilities over and above those currently delivered comes only when perceptions of the future require new capability introductions --that if new capability is not introduced, it is perceived that there will be unacceptable national consequences. Such predictions may be made within national security or civilian mission areas by analysis of future political, economic, social, and national security environments. Ideas about new and additional capability may then be rationally sought.

Thus, there is always a standing and constant mission need for cost improvements to the delivery of standard capabilities at any mission level, but only random needs for new and additional capability. The latter can only be based on perceptions of the future environment and the perceived inability of current capability to deliver what is needed in the future. When that perception is made on one mission level, demands for innovative introductions are placed on all subsidiary levels.

Thus, two classes of mission needs are inherent in any mission agency at any mission level:

-- the constant and continuing need to deliver current mission capability at less cost

-- the random need to improve or add capability to a particular mission level based on perceptions of unacceptable national consequences if not delivered.

exploration, and thus avoid monopoly development of the initial technology-push idea. The innovation program, after completing those actions, would proceed under normal demand-pull procedures which are specified in A-109. These procedures are generally applicable to the orderly and rational progress of any innovation program of any "scale."

Methods

The MENS-type document must be distributed equitably to the nation's innovative resource and some significant changes must be made in current communication methods.

Federal contractors indirectly charge contracts with the costs of field marketing operations, technical and new business planning operations and customer visits, brochures, models, mock-ups, displays, a "home-base" planning operation, and other new business planning and marketing operations. The amounts recovered as a cost of federal sales again will be roughly proportional to the company's total federal sales.

Federal contractor communication costs are, therefore, generally paid by taxpayers. But taxpayers do not directly or indirectly pay equitable communication costs which are incurred by small technical firms, unaffiliated individuals, and other nonfederal suppliers. Thus, federal communication entitlements are also inequitably distributed throughout the nation's innovative resource.

What is lacking is a federal policy which requires mission agencies to take communications initiative. Instead, the agencies philosophically adopt the posture that it is up to the contractor to take such initiative and that their role is principally to respond with new business opportunity and planning information when asked.

Government's new business communication document, the Commerce Business Daily, is used by mission agencies to announce new business opportunities. But the method has several serious disadvantages which preclude its remedying communication inequities.

-- it is doubtful that nonfederal suppliers are even aware of its existence

-- it costs too much in terms of value received for the individual or small firm

emergence of newer and smaller businesses, and provide their membership with services of general economic information and analysis; local, state, and federal government rules and regulations, and projections of the future business environment.

All represent an important national resource for the equitable communication of national needs.

Two categories of mission needs have been previously discussed; a constant need for cost improvements to current agency capabilities, and a random need for improvements to current capabilities.

The latter need may come from either internal agency planning, or be the consequence of a technological opportunity.

Federal agencies could annually communicate their constant cost-savings needs to Chambers throughout the U.S. They could communicate capability needs as they are determined and documented in a MENS-type document.

Not all mission needs are of the same priority; some will be more urgent than others, regardless of expected scale of their solution. These could be directly transmitted to local Chambers and a general briefing given by agency planning personnel at several localities. The intent of such briefings would be to convey the agency's mission need to local innovative firms and individuals that are invited by the local Chamber. It would not be a meeting set-up to draw proposed solutions from those who attend, but a meeting designed solely to present and clarify the agency's mission need.

Because national security mission needs can only be constructed by the use of current knowledge, projections of current inventory costs and expected costs of R&D initiatives should not unduly constrain attendance by security classification procedures--most of the mission need information to be conveyed is publicly available in commercial publications and congressional testimony.

A detailed presentation of the rationale which supports goals for defense weapon capability improvement need not be given, but the rationale which supports the mission need's cost goal, could be described as well as unclassified and publicly available characteristics of current weapons. By this procedure defense needs would unquestionably be conveyed to a broader base of innovative talent throughout the U.S. than current practice provides.

PROCEDURAL MATTERS

This brief concluding section conceptualizes some procedural approaches to implement previously explained policy concepts. It will have little interest to those who may believe that inequalities are not fostered by unwritten and net public policy. It may interest those who have been convinced by previous sections that large-scale economic distortions do, in fact, exist. They may ask, what should be done at procedural levels to implement the policy conceptions which have been described? It should be emphasized that much more would need to be done about implementation matters than will be described in this section. The expertise of agency personnel should be brought to bear on the issues and problems which are bound to arise if the paid proposal approach is accepted in principle for further exploration.

Private Enterprise Response to National Needs

MENS-type statements and communication through local Chambers will motivate some private innovating individuals or groups to participate. The MENS-type statement should contain several agency information items which are of concern to private entrepreneurs:

-- a set of pre-qualification technical standards

-- a request for monthly rate cost information

-- a limitation on the amounts to be directly paid by government.

These information items should be standard additions to any MENS-type statement.

Agency Actions

The soliciting agency would be required to set-aside sufficient funds for direct proposal payments in its annual budget request. How much to "set-aside" should be studied in detail. The following are only suggestions for the amounts which may be involved.

-- the initial exploration of ideas which totally replace current inventory; $100,000 maximum payment per action

-- the initial exploration of ideas which retain current products, but are proposed to improve their performance or cost by major part improvements; $50,000 maximum payment per action

expectations. The nonfederal supplier particularly must learn about agency procedures, intraagency relations, and other more subtle workings of a bureaucracy. When first entering the federal innovation market by the instrument of direct proposal payment, it stands to reason that nonsubstantive success factors will be largely unknown, certainly relatively unknown as compared to the acquired knowledge of established federal contractors. Several errors in procedure, form, and style should be expected.

The judgment as to when to terminate pre-qualification would be based on the agency sponsor's assessment of the sources unacceptable progress towards achieving public goals, much in the way judgments about retention of employment within private companies is arrived at.

But, again as within private companies, several chances to succeed should be granted. The newly-installed pre-qualified innovation supplier, indeed, has much to learn about matters of procedure, form, and style that had not been previously experienced within private innovation markets. Disqualification for nonsubstantive reasons such as these would not be fair, and only substantive progress towards goals should be measured and used as a basis for either pre-qualification continuation or termination.

Demand-Pull, Technology-Push

The instrument for initial pre-qualification will have been either a standing or capability mission need which had been transmitted by a local Chamber. Pre-qualification decisions will have been based on agency expectations that the accepted individual, small firm, or large contractor is likely to have creative talent which is appropriate to the achievement of agency mission goals.

This should not by itself mean that pre-qualification selections be limited to only demand-pull responses, but that those selected also should be free to propose technology-push ideas.

The proposal of a technology-push idea is more risky and expensive than responding to demand-pull needs, for demand must be created based on perceptions of a need which has not been formally issued.

The cost to propose a technology-push idea should also be directly paid when proposed by a pre-qualified

APPENDIX XIII

"SMALL BUSINESS INNOVATION APPLIED TO NATIONAL NEEDS," BY ROLAND TIBBETTS, PROGRAM MANAGER FOR SMALL BUSINESS, APPLIED SCIENCE AND RESEARCH APPLICATIONS DIRECTORATE, NATIONAL SCIENCE FOUNDATION

Small Business Innovation Applied to National Needs

Sub-Title: New Program at the National Science Foundation Couples Federal Research to Technological Innovation

The National Science Foundation has introduced a new program, in part as a result of Congressional interest, to increase the opportunities for small science and technology firms in NSF. More important, however, the program represents a new approach to Federal research and its possible role in the economy. Objectives include utilizing small business science and technology firms to a greater degree in Federal R&D and converting Federal research to technological innovation in the private sector. Research proposals on Federal objectives are coupled to potential market applications through venture capital for high-technology areas to increase the return on investment and socio/economic benefits from government research.

"Small Business Innovation Applied to National Needs" is a program which solicits high risk, potentially high payoff, research proposals from small business on the research objectives of the Applied Science and Research Applications (ASRA) Directorate. ASRA is headed by Dr. Jack T. Sanderson, an Assistant Director of NSF. The new program is a three phase approach with the first two phases funded by NSF and the third targeted for private industry.

appear to have commercial potential in addition to meeting Federal objectives receive extra consideration. The importance of the additional point of merit is dependent on the degree of commitment made by venture capital investors with the maximum value resulting from a signed formal agreement with reasonable terms for an amount at least equal to the Federal investment in phase II.

The proposing firm can seek out any firm or institution of its choice to provide venture capital, such as a venture capital firm or a manufacturer. The venture capital firm or manufacturer also may initiate the contact as it seeks potential investment opportunities or sources of new technology. If the small firm wishes to continue on into production and marketing itself if the R&D is successful, it may want to work with venture capital firms. On the other hand, if the potential innovation has a potentially larger market where production and marketing capabilities are important, it might increase its chances of success by working with a major manufacturer already in the field. Both venture capital firms and manufacturers have provided follow-on commitments.

The use of the small firm for its innovation capability and the large firm for production, marketing and financial support has a number of advantages. Small science and technology firms, particularly those competent enough to win in the strong technical competition, may be an excellent "farm system" for technological innovation for large business, as well as the base for a growing independent company. Both large and

The approach also may be one of the fastest and most capital efficient ways to bring new technological ideas to commercial attention and to the market. Highly competent small firms are often highly innovative. But they lack the resources and time to pursue both ideas and capital. They need the assistance of others, but the system has to be efficient not only for them, but for those seeking out potential new technology and investments. The program provides an identification mechanism for both firms and ideas.

If planned government research can serve as a technical and pre-venture capital base to lower the risk and small firms can couple themselves to additional existing resources, both financial and other forms of assistance, much more progress in technological innovation may be possible. For example, the small firm can find not only development funding in a large manfacturer, but the means of obtaining in-place production and marketing facilities and capabilities, and financial and other assistance to help him bring his ideas to commercialization more surely, faster, and with possible greater pay-off. It may also be a major source of new technology for large manufacturers or other firms. Small science and technology firms can be utilized for what they do best and larger firms for their strengths.

An equal opportunity exists for the small firm that wants to go it alone and take its own ideas on into production and the marketplace. Here the coupling is to the venture capital firm or small business investment

Four recent studies point up what the Charpie Report of 1967, a major study by the Department of Commerce, and most economists have known for years. A 1977 study by Data Resources, Inc. for General Electric found that in a comparison of high technology with low technology firms over the 25 year period 1950-1974:

- Employment in high technology firms grew nine times as fast.
- Productivity grew at three times the rate.
- Output expanded twice as fast.
- Prices went up only one-sixth as rapidly.
- And our trade balance increased to a $25 billion surplus in 1974 while the balance for low technology products declined from break-even to a $16 billion deficit.

When we compare job creation differences between older and younger firms, The American Electronics Association Survey in 1977 for the 1969-1974 period showed:

- Firms 10 to 20 years old had an employment growth rate 20 to 40 times the rate of firms more than 20 years old.
- Firms between 5 and 10 years old had a rate 55 times of the mature firms.
- Firms less than 5 years old average 115 times the employment growth rate of the mature firms.
- And, although the mature firms had 27 times the total employment of the firms less than 20 years old as a group, the younger smaller firms created an average of 89 new jobs per company in 1976 versus an average of only 69 new jobs per mature company.

If we look at a similar cross industry study of leading firms in each of three classifications: young technology companies (Data General, National Semi conductor, Compugraphic, Digital Equipment and

indicates that six industries account for 85 percent of total industrial R&D and a paper by Howard Nason states that 31 companies do 60 percent of total U.S. industrial R&D. Zerbe in another study concludes that small business does only three percent of U.S. R&D.

Many economists and others have studied the problem both in the U.S. and elsewhere. A number of programs and experiments have taken place. Key concerns have been the need for coupling government research to market needs; government interfacing with the private market process; the inherent risk capital problems of high technology and small business; avoiding government funding simply displacing private capital; and the barriers which inhibit greater small business participation in Federal R&D. Overriding all is the concern for U. S. technological innovation.

The First Solicitation

Much of this was taken into consideration by NSF in its design of "Small Business Innovation Applied to National Needs." The first solicitation was also stimulated by a Congressional requirement in NSF legislation in 1976 that 7 1/2 percent of the then RANN program (which has been succeeded by ASRA) must go to small business firms. This amount was increased in 1977 to 10 percent and in 1978 to 12 1/2 percent.

The first solicitation resulted in 329 phase I proposals and 42 phase I awards to 39 small firms totaling $1,028,000. Three firms were successful with two proposals. Proposals were received from firms in 34

October. About half also had venture capital commitments or third party letters of conditional intent from venture capital firms or large business with the degree of commitment from firm to weak. Some indicated more than one offer. One found a Japanese firm more willing to commit support than American firms which showed great interest, but could not make a commitment.

Examples of Commitments

One project involved a one-man firm in phase I which would not have been funded without the added benefit of the venture capital intent. The research conducted was of high quality. The firm, however, found it had considerable difficulty in obtaining a venture capital commitment. NSF indicated, however, that the commitment could be particularly important as the project was assigned to NSF's Industry Program of the Intergovernmental Science and Public Technology Division which was specifically interested in incentives to increase technological innovation and R & D investment. The question was asked as to whether the research might have other potential applications than the one proposed which might involve a large market and therefore a better chance of attracting venture capital.

The firm contacted a department at MIT to discuss whether other applications came to mind. The discussion led to a possible application in an entirely different industry. The small firm contacted a

contact prior to the NSF solicitation. An expected impact of a successful phase II is large growth for our firm due to a much greater demand for its technology."

Another firm obtained "three separate commitments from venture capital firms. In addition, a manufacturer wanted to provide a $200,000 commitment, but the agreement could not be worked out in time. Two other SBIC's and one private group also expressed serious interest, but no firm offers were made by the date required."

Other Considerations

The program provides open and equal opportunity for any small business to compete for awards on a merit basis. It is not an assistance program. Evaluation is principally based upon the quality of the research proposed, the feasibility of the idea, and the qualifications of the principal investigators. NSF does not attempt to judge the qualifications of the firm. Our concern is for the quality of idea, the research proposed and the key technical people. To this is added an evaluation of performance and the evaluations implied by the venture capital commitment.

The solicitation seeks innovative approaches to research topics that will have significant public benefit if the research is successful. Proposals may be directed at "proposer initiated ideas" relevant to an agencies mission or "specific topics" designated by the agency where it seeks specific answers to its research program objectives.

The opportunity to submit innovative approaches on Federal research objectives is more appealing to the more competent firms. The phase I proposal is restricted to 20 pages to reduce the time and investment in the initial phase and allows for less effort in the review process in view of the large response. Phase I proposals receive a three person internal review while phase II standard-size NSF proposals go through the normal ASRA outside review process. And the solicited approach allows for payment of full costs and a fee.

Technological innovation is like wild-catting for oil in some ways; the 1,000 wells to get 100 producers, 10 highly profitable wells and one gusher. The solicitation seeks a large number of quality proposals, funds possibly one of ten and possibly one in five in phase II. Fewer still will obtain venture capital and achieve commercial success. Nevertheless, the potential value of a technology based successful new product is well known to small technical firms, to investors and economists. And major innovations have real socio/economic impact as has been described earlier.

Previous Concerns of Government Involvement in the Private Sector

Major concerns of Federal involvement in the private sector include the need for equity to all firms, Government competition in the private sector, the lack of government knowledge of markets, a larger Federal deficit, and the possibility that public funding is replacing private funding.

Federal investment is for research awards under its regular R&D program. It is also felt that the maximum incentive for investment and growth is needed. Government benefits come through the jobs created, economic competitiveness, innovation and income taxes paid. Countries which have required royalties and payback have tended to move away from it. Many of these involved government loans and equity investments which have many problems and are not contemplated here. The program does not result in government investment in the private sector or the need to possibly protect that investment. The exit plan for government is built-in.

Technology transfer from Federal research to the private sector is initiated on day-one of the research planning process, not after the product or research has been completed. It forces small firms to consider from the very beginning whether the Federal research also has commercial potential. Some awardees have indicated how refreshing this was and that it did change their proposal thinking.

Finally, the program is an experiment to see if it can strengthen the small science and technology firms, increase technological innovation in the private sector and investment of venture capital in small firms. On a larger scale, such a program could contribute to improving the return on investment and socio/economic benefits to the public from Federal R&D. Mansfield indicates, for example, that the social return to the public from R&D in the private sector is probably twice the private return.

34-270 O - 78 - 50

References

1. U.S. Department of Commerce, Technological Innovation: Its Environment and Management (Charpie Report), 1967.

2. Vanderslice, T.A., Vice President of General Electric Company speech The Economic Leverage of Technology, based upon study by Data Resources, Inc. for G.E., The Role of High-Technology Industries in Economic Growth, 1977.

3. Zachau, E., American Electronics Association, Hearings before Senate Select Committee on Small Business, 1978.

4. Flender, J. and Morse, R., The Role of New Technology Enterprises in the U.S. Economy, MIT Development Foundation, Inc., 1975.

5. National Science Foundation, Science Indicators, 1976, Washington, 1977.

6. Office of Federal Procurement Policy/Office of Management and Budget, Small Firms and Federal Research and Development, Report by Interagency Panel, 1977.

7. Nason, H., Perceptions of Barriers to Innovation, Research Management, January 1977.

8. Zarbe, R., Research and Development by Smaller Firms, Journal of Contemporary Business, Spring 1976.

9. National Science Foundation Budget Hearings, 1976, 1977, 1978.

10. National Science Foundation, proposal solicitation, Small Business Innovation Applied to National Needs, 1977.

11. U.S. Government, Small Business Act, P.L. 85-536 as amended.

12. Mansfield, E., Federal Support of R&D Activities in the Private Sector, Hearings before the Sub-committee on Priorities and Economy in Government of the Joint Economic Committee, 1976.

Topic 4 - Societal Demand Technology

Block Engineering, Inc. Cambridge, Mass.	Single Ended Photoelectric Hazard Warning	$24,495
Scientific Process & Research, Inc. Highland Park, N.J.	Lowering of Energy Consumption in Plastics Processing	$25,000
Precision Instrument Company Santa Clara, Cal.	SlideStore: (TM) Large Capacity Information Storage	$24,995
Terraspace, Inc. Rockville, Md.	Hydraulic Bursting of Concrete and Rock	$22,012
Ceramic Finishing Company State College, Pa.	Control of Fragment Size Distribution and Damage Penetration During Machining of Ceramics	$24,942

Topic 5 - Improving the Productivity of the Physically Handicapped

Multisystems, Inc. Cambridge, Mass.	Remote Employment of the Physically Handicapped	$24,948
Scientific Systems, Inc. Cambridge, Mass.	Microprocessor - Based Prosthetic Control	$23,670
Integrated Sciences Corporation Santa Monica, Calif.	Visual Feedback Speech Training System for the Deaf	$24,474

Topic 6 - Food Substitutes and Composite Materials (Technology Assessments)

Argos Associates, Inc. Winchester, Mass.	Technology Assessment of Advanced Composite Materials	$24,923
The Futures Group Glastonbury, Ct.	A Technology Assessment of Vegetable Substitutes for Animal Protein as Human Food	$24,992
Applied Engineering Resources, Inc. Santa Barbara, Cal.	Technology Assessment of Advanced Composite Materials	$24,969

Topic 7 - Resources, Environmental, and Productivity

Resources

Collaborative Research Inc. Waltham, Mass.	Enhancement of Animal Protein Production by Novel Genetic Technology	$24,997

Topic 7 - (Cont.)

International Diagnostic Technology Santa Clara, Cal.	Improved Methods for the Rapid Detection of Microbial Contaminants	$25,000
IRT Corporation San Diego, Cal.	In-Vitro Detection of Allergy Using Human Head Hair	$24,646
Kellogg Corporation Littleton, Colo.	Resource Allocation System for Construction Industry Managers	$24,953

Exploratory Research (Appropriate Technology)

Oriental Engineering and Supply Company Palo Alto, Cal.	Commercial Waste Food Recycling for Swine Production	$25,000

Research and Development Incentives

Sea Otter Trawl Gear Arlington, Mass.	Research on a Low Drag Traw Board	$17,494
Plastics Technology Associates, Inc. Breton Woods, N.J.	Composite Materials Comprising Reaction-Injection-Molded Combinations of Carbon Fibers and Thermosetting Resins	$24,725
Ionomet Company Waban, Mass.	Mass Spectrometry Photoplate for Environmental Trace Element Research	$25,000

TABLE OF CONTENTS

INTRODUCTION AND BACKGROUND

The Conference Report of the Congress accompanying the National Science Foundation Authorization for fiscal year 1978 stated:

> "The conferees further believe that more information than has been compiled by the Foundation in the past should be acquired to help determine the degree of interest and technical expertise of the industrial community in basic research. Such data should make possible a more accurate assessment of the extent of the desire of industrial researchers to have their proposals considered on the same basis as those submitted by the university-based researchers.
>
> "The conferees therefore request the Foundation to compile appropriate information, with particular emphasis on the size of profit-seeking firms whose researchers might be expected to become eligible for support and, insofar as feasible, the contribution to the body of scientific knowledge which might result. The Foundation is requested to report its findings to the House Committee on Science and Technology and the Senate Committee on Human Resources..."

Further, the Conference Report of the Congress accompanying the National Science Foundation Authorization for fiscal year 1977 urged preparation of:

> "...a comprehensive report on the scientific and technical capability which exists in the small business community.
>
> "The conferees expect that this report will be carried out in collaboration with private sector organizations representing small business and that it will address the serious gaps which exist in the data concerning the capabilities, utilization and growth potential of the small business sector in science and technology."

This initial report is in partial fulfillment of the request in the FY 1978 conference report. It is related also to the matter of scientific and technical capabilities mentioned in the FY 1977 request though data being prepared as an initial response to that request deal more with small business and less with basic research than is done here. This report is not presented by the Foundation as a completed response to the request of either year.

The report seeks to focus specifically on basic research in response to the FY 1978 Congressional request.

In the NSF section a summary review is provided of NSF research support to industry in FY 1977, showing proposals received and awards made by NSF directorates and by field of science or program area. The NSF section provides considerable information on experience in the Research Applications area, primarily for some possible insights on factors that affect proposal pressure; this relates to interest in the FY 1978 request and also to capabilities and utilization in the FY 1977 request.

A brief account is given of experience of five other Federal agencies that support research in industry. Factors affecting industry interest and likely subject areas of research contributions are discussed.

A summary and conclusions follow this section.

Funding patterns show that company funded basic research though increasing in dollar amounts, is a diminishing portion of company funded r and d. The data indicate that funds for industry basic research have increased more rapidly in firms employing fewer than 1000 employees. The data also suggest--but currently lack sufficient detail to document--that smaller size firms engaged only in research and development may be the most active sector in basic research for companies with fewer than 1000 employees.

Proposal pressure on the National Science Foundation has been substantial from the industrial sector in the research applications area (431 in FY 77) and slight in basic research areas (62 in FY 77). The Foundation's policies toward the support of basic and applied research in industry have been of major consequence in this pattern. Those policies have limited to special circumstances NSF support of unsolicited basic research proposals from for-profit firms. In the applied research area, proposals from all proposers have been considered under the same criteria with special emphasis on awards to small business having been mandated by the Congress since FY 1976.

All National Science Foundation directorates and offices (excluding Research Applications) in fiscal year 1977 received from industry a total of 137 proposals for grant and contract support. Seventy-nine awards to industry were made, 35 of them to small businesses.

Addressing only the major basic research supporting directorates of NSF (Mathematical and Physical Sciences and Engineering; Astronomical, Atmospheric, Earth and Ocean Sciences; and Biological, Behavioral and Social Sciences) in fiscal year 1977 the most proposals from industry were received in the materials research area, with atmospheric sciences, biological sciences, engineering, astronomy and chemistry all receiving four or more. There were 37 basic research awards to industry, mainly in materials research, atmospheric sciences, engineering and biological sciences, with most but not all of the awards to small business supporting analysis or evaluation of data on research materials.

In the Research Applications area, 431 proposals were received from private firms, 329 in response to a solicitation; 110 awards were made to private firms, 95 to small businesses. Experience in the Research Applications area suggests that a known policy of receptivity with some assurance of availability of funds makes a major difference in proposal flow and that a proposal solicitation is a powerful stimulant to proposal flow.

In addition to general data, a listing is provided showing individual NSF grant and contract awards to small business firms.

The experience of five other basic research supporting Federal agencies is discussed briefly. That experience indicates a considerable range of practices among the mission agencies. Industry involvement in basic research ranged from relatively low in NIH and DoE programs (especially

development of scientific R&D in small firms because of their generally good performance in producing technological innovation and generating employment, there should be recognition that such support cannot be turned on and off like a spigot if such a capability is to be developed as a national resource and kept healthy.

Yet in the nature of constantly changing requirements there is need for continuing flexibility in program priorities and use of resources. It is likely that the most acute problems that sometimes arise in these processes of change and adjustment could be made less severe by effective communication and cooperation among the three major sectors involved--industry, government, and academic researchers.

It is possible that the proposed new NSF program for industry-university cooperative research may be one among several steps needed that would foster such cooperation and communication. If the communities of specialists know each other and work together, such communication should be enhanced. But quite beyond such improved understanding as the proposed new program may produce, some structured and specific and recognizable devices for exchanging views and sharing policy advice would need to be developed and pursued.

Population: Scientists and Engineers Conducting Basic Research in Industry: Some Selected Characteristics

The basic resource for capability in science and technology is the supply of trained people. This part of the report begins with a brief section on the total population of scientists and engineers in the United States and then narrows this discussion to focus on researchers at the doctoral level in basic research in industry. The tables and the discussion are based on data not previously published and subject to some later revisions.

TOTAL SCIENTISTS & ENGINEERS IN ALL SECTORS, 1976

Preliminary data indicate that in 1976 there was a total population of 2,705,800 persons identifying themselves or employed as scientists and engineers in the United States. Of these, 286,400 or 10.6% held doctoral degrees; 652,900 or 24.1% held master's degrees; 1,688,800 or 62.4% held bachelor's degrees; and 77,700 or 2.9% "other" that includes those with associate degrees or medical degrees not listed in the degree columns.

Examined by fields, approximately 30% or more held doctorates among physicists/ astronomers, oceanographers, atmospheric scientists, biological scientists, medical scientists and psychologists. Among these, oceanographers were atypically high in doctorates--over 82% of those listed for the field. Doctorates were least frequent among computer specialists (2.6%), and engineers (3.3%); fewer engineers traditionally have sought doctorates than have scientists. Among the psychologists, social scientists, and mathematical scientists and statisticians the master's is the most frequent degree level, and the proportions of master's degree holders are higher in these than other fields.

The data for engineers play an important statistical role in some of the figures. Engineers constitute 50.8% of the total scientists and engineers. As noted, 3.3% of the engineers hold doctorates; 17.6% hold master's degrees and 74.8% hold baccalaureates. Engineers hold 15.9% of scientist and engineer doctorates, 37% of scientist and engineer master's degrees, and 60.9% of scientist and engineer baccalaureates.

Additional background tabulations using 1975 data are in Science Indicators, 1976 (NSB 77-1). Selected tables are provided in Appendix D.

Although most of this part of the report deals with 1976 data just becoming available, an observation based on 1975 data is appropriate. The 1975 data in table 5-10 from Science Indicators, 1976, (see Appendix D) summarized the distribution of employed scientists and engineers by employment sector. It is expected that the 1976 data will show a similar distribution pattern. When the 1975 data for doctoral scientists and doctoral engineers are considered separately, their employment by sector is significantly different.

30-34 cohort is life scientists (359 in the category), and this is the second largest field in each cohort from 35 to 64, except for the 45-49 group.

In summary, the data show that of the ten age cohorts used, 57.8% of the total scientists and engineers in basic research in industry are 39 or younger in 1977 with the largest proportion in the 30-34 range. The dominant fields of work are physical sciences, life sciences and engineering in all cohorts through age 64.

Comparing the distribution of science and engineering doctorates by field with those doctoral scientists and engineers employed in business and industry and working in basic research, the data indicate that:

Physical scientists, mathematicians and statisticians are in basic research in industry in proportions substantially higher than their ratios among the total of doctoral scientists and engineers.

Computer scientists, engineers, environmental scientists, and medical scientists as a subset of life scientists, are in basic research in industry in about the same proportions as their distribution among the total population of doctoral scientists and engineers.

Life scientists as a group, psychologists, and social scientists are in basic research in industry in proportions substantially lower than their distribution in the general population of scientists and engineers.

These observations should be viewed along with funding patterns to assess current emphases in industry (see page 31).

Table I-2

13.

Number of Scientists and Engineers By Field and Highest Degree, 1976

BY FIELD DISTRIBUTION AT EACH DEGREE LEVEL

Preliminary Data, Subject to Revision

Field	Field Total	Doctorates % by Field	Master's % by Field	Bachelor's % by Field	Others 1/ % by Field
TOTAL:	2,705,800	286,400 100%	652,900 100%	1,688,800 100%	77,700 100%
Physical Scientists	280,600	22.69%	9.25%	9.07%	2.57%
Chemists	186,100	15.39%	4.74%	6.45%	2.57
Physicists/astronomers	69,500	7.29%	3.89%	1.37%	2/
Other physical scientists	25,000	2/	.61%	1.24%	2/
Mathematical scientists & statisticians	110,200	5.79%	7.56%	2.45%	3.60%
Computer specialists	179,900	1.64%	5.69%	8.16%	.25%
Environmental scientists	85,700	4.50%	2.84%	3.20%	2/
Earth scientists	80,300	3.52%	2.68%	3.11%	2/
Oceanographers	1,700	.48%	.03%	.005%	2/
Atmospheric scientists	3,800	.48%	.15%	.08%	2/
Engineers	1,375,200	15.85%	36.98%	60.90%	72.97%
Life scientists	314,100	25.90%	10.03%	9.58%	16.21%
Biological scientists	139,800	15.74%	6.08%	3.25%	.12%
Agricultural scientists	128,700	5.06%	2.51%	5.77%	.38%
Medical scientists	45,600	5.09%	1.43%	.56%	15.70%
Psychologists	122,900	12.77%	5.68%	1.75%	.12%
Social scientists	237,200	10.82%	1.97%	4.85%	.38%
Economists	60,000	3.98%	3.84%	1.37%	.25%
Sociologists/ anthropologists	50,500	3.38%	3.17%	1.49%	2/
Other social scientists	126,700	3.45%	11.96%	2.27%	.12%

1/Other includes professional medical, associate and other degrees.
2/Too few cases to estimate.
NOTE: Detail may not add to total because of rounding.

SOURCE: National Science Foundation
Division of Science Resources Studies

Table I-4

Doctoral Scientists & Engineers Employed in Business & Industry and Working in Basic Research as Primary or Secondary Work Activity, by Field & Age, 1977[1]
Showing within each age cohort the distribution by field
(%'s by field add to 100 reading vertically)

Field	No.	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70+	No Report
Cohort Total No.	9014	428	2418	2370	1392	922	714	466	251	40	2	11
%		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Physical scientists	5264	59.8%	55.4%	60.7%	61.4%	66.9%	52.2%	47.9%	60.6%	30.0%		
Life scientists	1393	5.8%	14.8%	17.2%	14.9%	9.5%	21.6%	19.7%	19.1%	30.0%		
Engineers	1294	11.2%	17.8%	11.7%	12.4%	12.1%	19.2%	12.9%	17.9%			100
Environmental scientists	399	4.4%	4.4%	4.3%	3.2%	5.7%	2.4%	11.2%	1.2%			
Psychologists	197	5.1%	1.3%	1.7%	1.9%	2.4%	1.5%	5.6%		40.0%	100	
Mathematical scientists	184	2.1%	1.7%	2.1%	3.5%	2.2%	2.2%					
Computer scientists	153	4.2%	3.6%	.8%	.8%	1.1%	.4%		1.2%			
Social scientists	130	7.2%	.9%	1.4%	2.0%		.4%	2.8%				

1/NSF Division of Science Resources Studies, Survey of Doctoral Scientists and Engineers, 1977 (Data not previously published).

17.

PART II

Funds for Basic Research in Industry, 1976

Scientists and Engineers Population and Funding

in 1971 to $14 million in 1976. The numbers are small, and specific industries are not identified. More information is needed on specific details of the work covered in this broad category as well as grouping of the data so as to tell more of the characteristics of firms of various sizes.

Table II-11 also by industry sector, shows data for firms with under 1000 employees. The sectors or industry groups with outlays amounting to 10% or more of the total are:

Chemicals and allied products ("other chemicals" than industrial chemicals or medicines amounts to 14.7%)	26.5%
Electrical equipment and communication ("other electrical equipment" than communication-related is 14.7%)	20.6%
Nonmanufacturing industries This category includes commercial r & d firms that generally do not manufacture; their share of this data group is not now identifiable.	30.9%

In contrast to the Table II-9 data on all industry, the category "aircraft and missiles" is absent for firms employing fewer than 1000 employees. Tabulations available at a later date are expected to show these data.

In further sharp contrast to the all industry data, the nonmanufacturing industry group is nearly 31% of the smaller industry basic research funds total; it is 4% of the all industry total. Commercial research and development firms are thought to be a significant element of this category. The available data lead us to want more data as well as further analysis of the existing base.

Table II-1

Share of Total Federal Basic Research Performed by Industry[1/],

Fiscal Years 1970 - 78

Fiscal Year	Percent of Total
1970	12%
1971	10%
1972	8%
1973	11%
1974	6%
1975	6%
1976	6%
1977(est)	7%
1978(est)	8%

1/ Includes federally funded research & development centers (FFRDC's) administered by this sector.

Source: Federal Funds surveys. NSF
1/25/78

Funds for Basic Research in Industry

Tables II-1 through II-11 show the latest available data on funding of basic research in industry. Some breakouts of data distinguish between funding from company sources and federal agency sources. Some of the data identify funding in smaller size firms, though the category of smallest size is for firms of less than 1000 total employees. Categories of smaller size are needed and, within the smaller size groups, more detail.

The shifting proportions among Federal agencies of support for basic research in industry shown in Table II-3 is due in the main to a shift in emphasis in basic research areas from space to other budget emphases, particularly energy. Table II-4 indicates that company outlays for basic research in industry have been at or near 78% of the combined federal/company outlays as a source of funds since 1971. The estimated $700 million for 1978 of company funds supporting basic research indicates a significant capability in industry to perform basic research, particularly since the $205 million in Government support for industry basic research estimated for 1978 brings the estimated total to over $900 million. But Table II-5 tends to reinforce the concern expressed elsewhere (e.g., in Science Indicators, 1976) that company-funded basic research is losing ground as a proportion of company funded research and development.

Industry is the second largest performer of basic research whether measured by overall expenditures (company and Federal funds) or by source of funds. Measured by overall expenditures, the rank ordering is universities highest ($1.9 billion), followed by industry ($.58 billion), Federal government laboratories ($.56 billion), federally funded research and development centers administered by universities ($.25 billion), and other nonprofit institutions ($.22 billion). (Data in Science Indicators, 1976, tables 3-2 and 3-3).

Table II-7 data indicate that funds for industry basic research have grown more rapidly in firms of less than 1000 employees than in other size ranges. The data do not show fields of science by industry size, but Table II-8 showing fields of science for basic research in all industry indicates growth rates substantially faster than inflation rates in environmental sciences (where dollar outlays have been and continue to be proportionately small), and in biological sciences. The largest outlays by field are in the physical sciences (particularly chemistry) and engineering.

When funds for basic research in industry are sorted by the standard industrial code (SIC), the largest increases are in petroleum extraction and refining, machinery, drugs and in other industries not differentiated. Perhaps of greatest interest in the context of this report is the nonmanufacturing category in Tables 9, 10, and 11. It is this category that includes commercial firms specializing in research and development. The funds for basic research for the nonmanufacturing category of industries dropped slightly from 1971 to 1976 primarily because federal funds decreased from $24 million in 1971 to $15 million in 1976. But company funds increased from $7 million

Table I-5

Doctoral Scientists & Engineers Employed in Business & Industry and Working in Basic Research as Primary or Secondary Work Activity, by Field & Age, 1977[1/]
Rank Ordered by Numbers Employed in Field
Showing by field the age cohort percent distribution
(%'s add to 100 reading across)

Field	No.	%	25-29*	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70+	No Report
Total	9014	100	4.7%	26.8%	26.3%	15.4%	10.2%	7.9%	5.2%	2.8%	.4%	.002%	.1%
Physical scientists	5264	100	4.9%	25.4%	27.3%	16.2%	11.7%	7.1%	4.2%	2.9%	.2%		
Life scientists	1393	100	1.8%	25.8%	29.3%	14.9%	6.3%	11.1%	6.6%	3.4%	.9%		
Engineers	1294	100	3.7%	33.3%	21.5%	13.3%	8.7%	10.6%	4.6%	3.5%			.9%
Environmental scientists	399	100	4.8%	26.8%	25.8%	11.3%	13.3%	4.3%	13.0%	.8%			
Psychologists	197	100	11.2%	15.7%	20.8%	13.2%	11.2%	5.6%	13.2%		8.1	1.0	
Mathematical scientists	184	100	4.9%	22.3%	26.6%	26.6%	10.9%	8.7%					
Computer scientists	153	100	11.8%	57.5%	13.1%	7.2%	6.5%	2.0%		2.0%			
Social scientists	130	100	23.8%	16.9%	25.4%	21.5%		2.3%	10.0%				
TOTALS	9014		428	2418	2370	1392	922	714	466	251	40	2	11

*None in sample reported under 25 years of age.

1/NSF Division of Science Resources Studies, Survey of Doctoral Scientists and Engineers, 1977 (Data not previously published).

Table I-3

DOCTORAL SCIENTISTS & ENGINEERS EMPLOYED IN BUSINESS & INDUSTRY & WORKING IN BASIC RESEARCH AS PRIMARY OR SECONDARY WORK ACTIVITY, BY FIELD, 1977[1/]

Rank Ordered by Field and by Subject Area within Field, According to Numbers Employed (1977 Data)

Field/Subject Area	Field Total	% of Total by Subject Area	Total Field Percentage
TOTAL	9,014[2/]		
Physical Scientists	5,264		58.4%
Chemists		43.2%	
Physicists/Astronomers		15.2%	
Life Scientists	1,393		15.5%
Biologists		9.6%	
Medical scientists		4.5%	
Agricultural scientists		1.4%	
Engineers	1,294	14.4%	14.4%
Environmental Scientists	399		4.4%
Earth scientists		3.9%	
Atmospheric scientists		.5%	
Oceanographers		.02%	
Psychologists	197	2.2%	2.2%
Mathematical Scientists	184		2.0%
Mathematicians		1.6%	
Statisticians		.4%	
Computer Scientists	153	1.7%	1.7%
Social Scientists	130		1.4%
Economists		.7%	
Other social scientists		.7%	
Sociologists/Anthropologists		.02%	

1/NSF Division of Science Resources Studies, Survey of Doctoral Scientists & Engineers, 1977 (Data not previously published).

2/All percents shown above are of the total 9,014.

Table I-1

Number of Scientists and Engineers by Field and Highest Degree, 1976

BY DEGREE DISTRIBUTION WITHIN FIELD

Preliminary Data, Subject to Revision

Field	Field Total		Doctorates % of Field	Master's % of Field	Bachelor's % of Field	Others[1] % of Field
TOTAL:	2,705,800	100%	286,400	652,900	1,688,800	77,700
Physical scientists	280,600	100%	23.16	21.52	54.63	.71
Chemists	186,100	100%	23.69	16.65	58.57	1.07
Physicists/ astronomers	69,500	100%	30.07	36.54	33.52	[2]
Other physical scientists	25,000	100%	[2]	16.0	8.4	[2]
Mathematical scientists & statisticians	110,200	100%	15.06	44.82	37.56	2.54
Computer specialists	179,900	100%	2.61	20.67	76.65	.11
Environmental scientists	85,700	100%	15.05	21.70	63.24	[2]
Earth scientists	80,300	100%	12.57	21.79	65.50	[2]
Oceanographers	1,700	100%	82.35	11.76	5.88	[2]
Atmospheric scientists	3,800	100%	36.84	26.31	36.84	[2]
Engineers	1,375,200	100%	3.30	17.56	74.78	4.12
Life scientists	314,100	100%	23.62	20.85	51.54	4.01
Biological scientists	139,800	100%	32.26	28.39	39.27	.07
Agricultural scientists	128,700	100%	11.26	12.74	75.75	.23
Medical scientists	45,600	100%	32.01	20.61	20.83	26.75
Psychologists	122,900	100%	29.78	46.13	24.08	.08
Social scientists	237,200	100%	13.06	52.23	34.56	.12
Economists	60,000	100%	19	41.83	38.83	.33
Sociologists/ Anthropologists	50,500	100%	19.20	40.99	40	[2]
Other social scientists	126,700	100%	7.81	61.64	30.38	.07

[1] Other includes professional medical, associate and other degrees.
[2] Too few cases to estimate.
NOTE: Detail may not add to total because of rounding.

SOURCE: National Science Foundation
Division of Science Resources Studies

Among doctoral scientists, 20% are employed by business and industry, 63% by educational institutions (61% by four-year colleges and universities) and 10% by government (8% by the Federal government). Among doctoral engineers, 52% are employed by business and industry, 35% by educational institutions (virtually all by four-year colleges and universities), and 10% by government (9% by the Federal government).

DOCTORAL SCIENTISTS & ENGINEERS IN BASIC RESEARCH IN BUSINESS & INDUSTRY

For this report, a special subset of the new data was extracted. Tables I-3, 4, and 5, show the field of science and age distribution of doctoral scientists and engineers in business and industry, who have basic research as a primary or secondary work activity. This data base does not enable analysis by size of firm.

It is essential to note that these new 1976 data on basic research work activity in industry are based on primary and secondary work activity. It is thought that this provides a more realistic assessment of actual activity and potential capabilities than earlier data based on primary work activity alone. For this reason, comparisons with 1975 and earlier data on basic research work activity in industry are not valid. The 1976 data show more physical scientists than other scientists or engineers in each age cohort, except for the small sized (40 person) cohort age 65-69; there, psychologists are the largest group, but the small number entails a higher probability of statistical error. Other sizable groups are life scientists and engineers.

In most of the fields, the largest proportions are in the age groups spanning 30-44, these accounting for 68.5% of the total. The largest numbers of these are physical scientists, life scientists, and engineers, accounting for 60.9% of the total.

Of the 10 age cohorts used, the youngest group--those of age 25-29--rank seventh in size, constituting 4.7% of the total; it has been suggested that one factor operating here is that industries often do not move new graduates immediately into basic research. The 30-34 age group is largest, and includes 26.8% of the total and the cohorts gradually decrease by age group from the high-point. The three youngest cohorts combined, from 25 through 39, include 57.8% of the total. In each of the two youngest cohorts, physical scientists are by far the most numerous (58.4% of total) with engineers next (15.5%). In the 25-29 cohort, social scientists are third most numerous, but since the number in the expanded sample is only 31, possibility of statistical error is higher. The third largest field in the

8.

PART I

The Population

Scientists and Engineers in All Sectors, 1976

Doctoral Scientists and Engineers Conducting Basic Research in Industry, 1976

the use of unsolicited proposals from industry) to substantial in the high technology part of NASA bioengineering research. The use of solicitations appears to be a major stimulant. It appears likely also that the mission specificity of agencies other than NSF structures the context of research proposals more clearly. This may facilitate proposals from industry by making it easier to link industry skills and interest to the research areas of those agencies.

The Foundation has not issued solicitations for specific basic research proposals; program announcements or program solicitations are issued on occasion, but these are relatively general in scope, leaving substantial latitude to the proposers. The NSF has relied very largely on generation of the most significant questions, as well as the development of individual projects, from the scientific community and its proposal flow. This has been particularly true in the basic research areas, where broad program areas have been established but great latitude has prevailed within them. It is the single science agency of government that has been so structured; its title does not say "...for..." or "...of..." Even its directorate and division titles have been kept very general in the basic research areas and have usually retained a broad focus in research applications areas also. This fact, added to the long-term effect of NSF basic research support policies probably has kept basic research proposal flows from industry at a low level. It is suggested that in reviewing and assessing these practices and patterns the unique role of the National Science Foundation within the entire spectrum of science-supporting Federal agencies be borne in mind.

Among factors that bear on the interest and expertise of researchers in industry, the experiences of the five agencies, NSF's experience with industry in research applications and with universities in basic research and research applications, and experience with earlier DOD and NASA research programs, all indicate that capability and interest are nurtured by known availability of funds and by identifiable and addressable agency program interests. If funds and program needs are known and accessible over any extended period, capacity seems to develop to meet the resources. This occurred in the universities as NSF programs for the support of research and education in the sciences made new resources available in the 1950's and 1960's, and it happened in the universities and particularly in industry as defense and space programs grew. Equally important is the recognition, based also on experience, that marked drops in support or major shifts in program emphases can leave stranded the organizations and capabilities that have been created. Institutions or organizations with specialized and sometimes unique capabilities have been brought into being to produce certain outputs, and they develop accompanying needs for resources.

Decisions to encourage or stimulate capacities carry important implications. If as a matter of agency or national policy new institutional capabilities are developed, long-term considerations are involved. For example, if a coherent national policy were defined and implemented to foster growth and

SUMMARY AND CONCLUSIONS

This is an initial report addressed mainly to the request for more information about the industrial community's capabilities and interest in basic research. It is a first step that will be followed by other information to respond to the request in NSF's Fiscal Year 1978 Authorization Conference Report. The report contains information that bears also on some aspects of the requests for information in NSF's Fiscal Year 1977 Authorization Conference Report; additional information is expected soon from two surveys that were designed in part to aid in meeting the FY 1977 request.

In this section main points of the report are summarized, some conclusions are drawn from these points, and other observations are offered.

Capabilities in science and technology are founded on trained people. In 1976 there were 2.7 million individuals in the United States identified as scientists and engineers. Of these, 10.6% held doctorates, 24% held master's degrees and 62.4% held baccalaureates. Among doctorates, 22.7% were physical scientists, 25.9% were life scientists, and 15.9% were engineers--the three largest broad occupational fields.

The principal focus of this report is on basic research in industry. There were 9000 doctoral scientists and engineers in basic research in industry in 1976. Of these, 58.4% were physical scientists, 15.5% were life scientists, and 14.4% were engineers. The largest single age group is in the 30-34 range, with 26.8% of the total. Nearly 58% of the doctoral basic researchers in industry are 39 or younger.

Physical scientists (chemists in particular), mathematicians and statisticians are employed in basic research in industry in proportions substantially higher than their ratios among the total of doctoral scientists and engineers. The physical sciences (especially chemistry) and engineering lead other fields significantly in their proportions of funding for industrial basic research. Life sciences are third in levels of funding and proportions of doctorates in basic research in industry. These patterns suggest that currently industrial basic research strength and interest probably are highest in the physical and life sciences and engineering.

Basic research activity by industry sector is funded most heavily in the areas of chemicals and allied products and electrical and communications equipment; these areas were high also for those industries employing fewer than 1000 people.

The fiscal year 1977 request of the Congress led NSF to modify and change the timing of two surveys for more data on scientific research and development activities in the small business community. The first data from one of these surveys is used in this report. More data and analysis will be available in approximately 90 days. These are part of efforts in progress that began some months ago in NSF's Division of Science Resources Studies (SRS) to improve NSF's data base on research in industry. Additional improvements will be made when final results of these two most recent small business surveys are in hand. The NSF Office of Small Business Research and Development also obtained a literature search and guidelines study, "A Preliminary Study of Indicators for Small Business R & D Capabilities," preparatory to the complex task of trying to assess capabilities, utilization and growth potential; that study addresses some of the current inadequacies in the data base. These are intricate problem areas about which the small business community itself has little information, and finding means to measure and assess them is proving difficult.

In this report, prompted by the FY 1978 request from the Authorization Conference, the first of the new data from the studies noted above is used. This initial report compiles more information than the Foundation has done in the recent past, and it seeks by examination of general information, of NSF proposal and awards data, and through a very brief review of experience of five other Federal agencies, to shed some light on the degree of interest in basic research performance by industry.

The Foundation expects to forward to the Congress additional reports as more data are available and analyzed. We plan in the immediate future to assess further the range of data available from a variety of sources and from the two most recent SRS small business surveys. In this assessment we will invite participation of several interest groups, including Congressional staff, that are users of the data. The unfinished tasks in the congressional requests of the two fiscal years will be reviewed and advice will be sought in plans for next steps. Several concerns are immediately apparent: how to assess capabilities, get useful data and have such an assessment acceptable to the community; how to assess desire or interest without merely compiling a shopping list; how to obtain the information without overburdening an already survey-weary community; how to obtain the information on a reasonable time-cost basis; how to accomplish long-term improvements in the continuing data base on research in industry and on small business; and how to deal with the important variable that actual experience seems to demonstrate that both interests and performance capability rise and fall with available funds and the market created by program needs.

This report provides selected data on the population of basic researchers in industry and on funding patterns for basic research in industry. Latest data available, some of it preliminary, is used. The population base of scientists and engineers, its distribution and support among the various disciplines and industry, are basic to the questions of expertise, capabilities and potential interest.

APPENDIX XIV

"INITIAL REPORT—SELECTED DATA ON RESOURCES FOR BASIC RESEARCH IN INDUSTRY AND NATIONAL SCIENCE FOUNDATION AWARDS," OFFICE OF SMALL BUSINESS RESEARCH & DEVELOPMENT, NATIONAL SCIENCE FOUNDATION, FEBRUARY 1978

INITIAL REPORT

SELECTED DATA ON

RESOURCES FOR BASIC RESEARCH IN INDUSTRY

AND NATIONAL SCIENCE FOUNDATION AWARDS

National Science Foundation
Office of Small Business
Research & Development
February, 1978

Topic 7 - (Cont.)

Biospherics, Inc. Rockville, Md.	Bioconversion of Saline Water	$25,000
Environment		
Earthquake Engineering Systems, Inc. San Francisco, Cal.	A Rational Approach to Damage Mitigation in Existing Structures Exposed to Earthquakes	$20,095
IRT Corp. San Diego, Cal.	Immunochemical Assay for Abestos in the Environment	$24,854
S.B. Barnes & Associates Los Angeles, Cal.	Methodology for Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings	$25,000
Kariotis, Kesler & Allys South Pasadena, Calif.	Mitigation of Seismic Hazards in Existing Unreinforced Masonry Wall Buildings: Performance of Undesigned & Modified Elements: Evaluation of Modification Methods	$24,391
Applied Nucleonics Company, Inc. Los Angeles, Cal.	A Portable Vibrating Structure for Soils Investigations	$24,282
Agbabian Associates El Segundo, Cal.	Research on the Response of Existing (Masonry Building) Systems to Earthquake Motion	$25,000
George D. Ward & Associates Portland, Oregon	Controlled Soil Microbial Detoxification of Herbicide Residues	$25,000
Martin & Cagley Rockville, Md.	Seismic Hardening of Unreinforced Masonry Walls Through A Surface Treatment	$25,000
Scientific Service, Inc. Redwood City, Cal.	The Use of Structural Foams to Improve Earthquake Resistance in Buildings	$24,517
Productivity		
Terra Tek, Inc. Salt Lake city, Utah	Research on the Simplification of Methods for Measuring Fracture Toughness	$24,993
Amtech Incorporated Newton, Mass.	Micro-Isotope Tool Wear Detection	$25,000
Terra Tek, Inc. Salt Lake City, Utah	Hydromechanical Sensing of Deep Hole Drilling Deviations	$24,970

SMALL BUSINESS INNOVATION APPLIED TO NATIONAL NEEDS

Phase I Awards

Companies receiving awards in seven topic areas

Topic 1 - Hydrometallurgical and Solvent Extraction of Minerals

Company	Project Title	Phase I Award
EIC Corporation Newton, Mass.	Recovery of Chromium from Nickeliferous Laterites	$24,740
Garrett Energy Research & Engineering Co., Inc. Claremont, Cal.	Solution Mining Process Using Ion Exchange	$25,000
Bend Research, Inc. Bend, Oregon	Coupled Transport Membranes for Metal Recovery	$24,988
Giner, Inc. Waltham, Mass.	The Development of Electrochemical Methods for the Enhancement of Flotation Extraction with Specific Reference to Chromium Ores	$24,960
Moleculon Research Corporation Cambridge, Mass.	Bound Liquid Membranes for Hydrometallurgical Processing	$24,938

Topic 2 - Feasibility of Introducing Food Crops Better Adapted to Environmental Stress

Soil and Land Use Technology, Inc. Columbia, Md.	Feasibility of Introducing Food Crops Better Adapted to Environmental Stress	$24,919

Topic 3 - Chemical Threats to Man and the Environment

SISA Inc. Cambridge, Mass.	Mycotoxins as a Potential Human Health Hazard	$25,000
Fein-Marquart Associates, Inc. Baltimore, Md.	Approaches for the Acquisition of Mass Spectral Data for Inclusion in the NIH/EPA Mass Spectral Data Base	$24,874
Western Chemical Research Corporation Fort Collins, Colo.	Development of Antisera to Benzo(a) pyrene and Its Metabolites	$25,000
Moleculon Research Corporation Cambridge, Mass.	Reactive Tapes for Automatic Environmental Analyses	$24,805

The program has received the strong support of the small business and venture capital community. NSF received the first annual Award for Federal Program Excellence from the Council of Small and Independent Business Associations (COSIBA) in late 1977 for the program's creativity and potential importance to the small business and venture capital communities.

Roland Tibbetts
Program Manager for Small Business
Applied Science and Research
Applications Directorate
National Science Foundation

The program is designed to meet each of these. The opportunity to submit proposals is open to all small business. The Small Business Act and Federal Procurement Regulations support such set-asides as does ASPR. Proposals are on existing Federal research objectives and directed at existing Federal R&D budgets, programs and organizations. Private sector decision making as to market potential, the small firms management and other capabilities, the investment risk and negotiations are all left to the private sector. They are forced to take place, however, by government through the third party venture capital agreement.

Another reason why Federal funding will not be replacing private funding is the lengthy Federal process. Phase I requires a year from submitting the proposal to completion. There is then a delay of about five months which is necessary for phase II proposal preparation, evaluation and award. Phase II then runs for 1-2 years before the phase III development effort starts. Venture capital firms and larger manufacturers like the idea but have told NSF that the minute the outlook is sufficiently promising and the risk low enough they would step in to supplement existing government support or take it over themselves to move the idea to the market as rapidly as possible for competitive reasons.

Recoupment of any Federal investment through royalties or repayment has been considered and rejected. The principal reason is that the

NSF uses the Small Business Administration definition of a small firm for R & D purposes which is essentially a profit seeking firm, with 500 or less employees in all affiliated firms, and independently owned and operated. Research proposals are submitted to NSF on NSF program objectives. The proposals are reviewed both internally and by outside reviewers on a confidential basis for technical quality. NSF makes all award decisions.

The solicitation also offers the small firms rights to any patentable invention as a result of the research in advance. Venture capital commitments would be impossible otherwise to obtain. Such rights are contingent upon the actual investment of the follow-on venture capital to pursue commercialization and in an amount equal to or greater than the government investment. To obtain rights the small firm must also provide NSF with a business plan to pursue commercialization. Government retains rights for government use of the invention and march-in rights, including rights to any related background patents, if the firm does not pursue commercialization.

Other incentives have been built into the design to attract the best of small business. These include multiple research topics to broaden the opportunity for narrowly based small firms. The 40 awards planned in phase I and potential for a larger phase II follow-on projects. The venture capital phase provides them with a reason to approach other firms and easier access to them because they have a specific idea, front-end support and some proof of technical competence to offer.

company in that industry which indicated the idea appeared to have great merit and that it would be glad to enter into such a commitment for $250,000. Further discussions with MIT, a major U.S. laboratory, and a leading firm in the new field resulted in an offer from the latter and a firm commitment for $250,000 follow-on venture capital. This is contingent, however,(as was intended) that the research in phase II achieve certain agreed upon technical objectives. The importance of the venture capital incentive which forced the firm to seek other applications of the same research is shown by the manufacturer in the commitment cover letter. It states, "We wish to acknowledge the existence of a potential breakthrough of national importance." The proprietary letter went on to describe in detail why this was so potentially important. The proposed research, however, was of such high risk that the manufacturer would not make the investment at this stage, but was anxious to do so if certain research objectives in phase II could be met.

The proposal included a paragraph which stated "The high incentive NSF program to which this proposal responds is a dramatic example of how a one-man high-technology organization with the help of government support may be given the opportunity to tie its expertise to the needs of a giant industry. Without the format of this three phase NSF offering, it is not apparent that industry recognition of the type indicated by the venture capital contract could have come about. Certainly the two parties, (we) and our venture capital source had no

States and the District of Columbia. Awards went to companies ranging from a one-person firm to 195 employees with the average firm having 33 people. Awards were in seven topic areas and a listing of these areas, the winners of phase I awards and their research topics is shown at the end of this article.

About seventy percent of the proposing firms and of the awardees in phase I stated that they felt their research also had commercial potential and that they would seek venture capital commitments. The phase I effort was completed last March 31. Phase II proposals were due by May 30. Some of the research objectives in the first solicitation were not conducive to potential commercialization, such as technological assessments, the social science and earthquake research. This is being improved in the second solicitation now being planned.

Overall the research conducted in phase I was of high quality and ranged from poor to excellent. Two of the phase I winners, Block Engineering and International Diagnostic Laboratories were acquired prior to phase II by larger firms, the latter by a German firm. Only five did not submit phase II proposals based on phase I results. Three small firms found that they were in the same geographical location and in the same field and decided to set up a joint venture to bid for a phase II proposal combining their capabilities in a complementary and larger scale effort. Thirty-three proposals are under review and it is estimated that about one-half will be funded in September or

Marion Laboratories); larger innovative companies (Polaroid, 3M, IBM, Texas Instruments and Xerox); and the mature industry leaders (Bethlehem Steel, Dupont, GE, Proctor and Gamble, General Foods and International Paper), a 1975 MIT Development Foundation Study found:

- The five young technology companies with ending sales only 2 percent of the sales of the six mature firms actually hired 34 percent more people during the 1969-1974 five year period.
- The larger innovative companies with ending sales only 58 percent of the mature leaders created four times as many new jobs during the same period.
- In addition, these same larger innovative companies provided 52 percent more income tax revenue or a ratio of nearly 3 to 1 in tax revenue to sales compared to the mature companies during the period.

A final important reference is from NSF's Science Indicators 1976 which stated that in a large study of major innovations between 1953-1973:

- Small firms produced about 24 times as many major innovations as large firms and nearly four times as many as medium-sized firms per R&D dollar expended.
- Small firms also had a ratio of innovations to R&D employment four times greater than large firms.
- The total number of major innovations by small firms was greater than by large or medium-sized firms.
- The total cost per scientist and engineer was almost twice greater in firms of over 1000 employees as it is in firms of less than 1000 employees.

In spite of these results, small firms receive only 3 1/2 percent of total Federal R&D obligations and 8 percent of total R&D awards to industry. This contrasts with small business obtaining more than 23 percent of total Federal procurement and its providing nearly 75 percent of all jobs in the private sector. R&D in the U.S., if not technological innovation, is dominated by large firms. Science Indicators

company. They, too, can provide the path, future support and assistance in some areas which can improve the chances for high technology ideas and competent small firms to survive and grow.

A third option also exists for those ideas which are not far enough along in the research stage to attract venture capital commitments, but still have promise. The Connecticut Product Development Corporation and the proposed Massachusetts Technology Development Corporation both have indicated an interest in the program. They would contact award winners in their State which were unable to obtain private commitments to determine if State funds should provide support for further development. They might also assist in their obtaining private capital after some development effort had taken place. The Swedish Industrial Corporation and the Israel - U.S. Binational Industrial Research and Development Foundation (BIRDF) also have discussed possible funding support or joint R&D efforts in return for licenses to utilize the technology in their own or other selected countries.

The Real Leverage of High Technology and Small Firms

The leverage of high technology and small innovative firms in creating jobs, improved productivity, business expansion, and in meeting inflation and trade deficits can be enormous. Research is critical to high technology and to most technological innovation.

small firms are important to innovation and the incentives for all parties can be high. Small firms must not only meet Federal program objectives to obtain a research award, but phase I performance must be excellent to justify phase II support. It also must be of sufficient potential market importance and quality to attract venture capital. The phase II proposal must be of high quality and the research objectives agreed upon with private investors met if the venture capital commitment is to be exercized. The performance incentives for the small firm are substantial.

The financial opportunity incentives to the small firm are also considerable. Not only does the program offer opportunity to participate in Federal research but it opens a door to front-end high risk capital and a path to continued support all the way to commercialization if the performance is there and the idea has market potential. Government research in both phase I and II can be substantial if the research supports it and can serve as pre-venture capital. This research can lower the risk for private capital which in turn can provide an avenue of continuing future financing to the small firm. Most of all, the whole approach could stimulate more scientists and engineers to think about and pursue high technology ideas which, while high risk, can also result in major benefits to themselves, their firm and society. Moving science on into technological innovation may be one of the ways to respond to the innovation, job creation and productivity needs of the nation and their contributions to the economy, international competitiveness, meeting inflation and trade deficits.

Phase I solicits small feasibility research proposals from small business to determine as much as possible the feasibility of the idea and the capabilities of the firm within the limits of $25,000 six month awards. This provides a screen for the large number of proposals received from small business and limits initial risk to small amounts before taking a greater risk with larger awards. Phase II is for the principal research effort at levels of 2-3 professional person years for 1-2 years. Phase II also requests, in addition to the research proposal, a commitment for follow-on venture capital from a third party, at least equivalent to the amount of research funds requested from NSF, and represents an important coupling to the market.

The venture capital is for a follow-on development effort (phase III) to pursue commercial objectives if the research meets certain agreed upon objectives sufficient to justify continuing investment. Federal funds are for research on Federal objectives. Private venture capital is used to fund further development directed toward commercial objectives. Obtaining the venture capital commitment from a third party is a key to the approach and is discussed later.

Proposals are judged in phase I and II principally on a scientific merit basis. Then a critical additional consideration is applied. If proposals are found to be of approximately equal technical merit, the venture capital commitment provides an extra point-of-merit in the evaluation and award process. In other words, proposals which also

source. This privilege is currently granted federal contractors through the IR&D/B&P instrument, and should be equivocated in the procurement policy idea which has been discussed.

-- the initial exploration of ideas which retain the product, major parts, but are proposed to improve the performance or cost by componentry improvements; $25,000 maximum payment per action

-- the initial exploration of ideas which retain the product, major parts, and components, but are proposed to improve the performance or cost of component materials and production methods; $10,000 maximum payment per action.

Presuming that at least four ideas are to be competitively explored at each innovation mission level, $750,000 per MENS-type solicitation would be set-aside. The number of MENS-type solicitations, per year, cannot be precisely specified at this time, but presuming that for each mission area one constant and nine capability MENS-type statements were annually released, approximately $7,500,000 total annual set-aside would be programmed per agency mission area.

It is to be noted that capability or cost improvements may come from innovative introductions at any product level. The product may be proposed to be entirely replaced; retained, but with new major part introductions; components; materials or methods. The freedom to choose any product level as a basis for response to common mission goals would be granted pre-qualified proposers. Common mission goals would apply to judge follow-on funding by the direct R&D contract instrument.

The MENS-type statement should also pre-announce the number of pre-qualified proposers which will be accepted at each product level. Thus (in our example), the MENS-type statement would pre-announce that proposal payment for only four conceptual design proposals at each product level would be financed.

To preclude relative corporate "wealth" from biasing the evaluation of responses, the pre-qualification standards should be strictly adhered to and any additional "brochure type" information graded of zero value.

Retention of Pre-Qualification or Termination

It may be recalled that pre-qualification will have been based on expectations of public goal achievement, and only actual performance may be measured against expectations. To be fair, and to simulate industrial personnel policy, the pre-qualified innovative unit or individual should be given several chances to prove

Costs to enlist the administrative support of local Chambers should be borne directly by government and not burden any firm, large or small, that is invited to attend.

The suggested method directly links agency needs to local innovative talent, a linkage which is absent from current practice and results in the inequitable distribution of federal communication entitlements. It is recommended that the suggested method be further explored to discover issues and problems inherent in its conceptualization which need to be resolved and solved. The conceivable benefits towards achieving equalities appear to justify a closer examination.

-- it is generally felt even by planners within large federal contractors that a new business announcement is already "locked-in" to some other company that had assisted the agency in the need and approach for the pre-announced procurement.

With regard to the last, large contractors depend almost wholly on their in-company new business operations to detect the emergence of new opportunities and will very often assist agencies in developing the procurement. This work can precede a formal procurement announcement by many months and thus provide "inside" information about emerging new business opportunities which is not generally available to others.

A new and more equitable communication method for agency mission needs is not just required, it is mandatory to reduce or eliminate inequitable communication entitlements which are fostered by current practice.

The suggested communications method is based on the following principles and considerations:

-- it is government's responsibility to communicate its needs

-- local organizations are decidedly better informed about emerging new businesses within their communities than federal agency technical and procurement personnel

-- the cost of communications must be directly borne by government with objective to foster equity in the distribution of federal communications entitlements.

There are over 5,000 local Chambers of Commerce throughout the United States, of which 2,500 are members of the U.S. Chamber in Washington. Forty overseas Chambers of Commerce are members of the U.S. Chamber,* and most developed countries have also established national Chamber and local Chamber organizations.

These organizations are professionally knowledgeable about business operations within their communities, the

---

*The World Wide Chamber of Commerce Directory, The Johnson Publishing Company, Box 455, Loveland, Colo. 80537.

The first mission need is constant and issued at all hierarchical mission levels. The second may be issued from a particular mission level in response to the next higher level's demand and will appear randomly.

Technology-Push as a Source for Mission Needs

The need for additional capability at any mission level may come from a "technology-push" idea. This is an idea which is independently offered at a particular mission level based on the inventor's perception of need at that level. The idea will not be "demand-pulled" by a formal MENS-type solicitation.

Should the promised additional capability be acquired if the next higher mission level has not demanded it? Why should a price be paid for its introduction if higher levels are apparently satisfied with status quo?

These are the key questions. The answers may take one of two forms:

-- additional capability is promised at a cost no greater than the cost for future delivery of current capability

-- additional capability is promised as a "hedge" against an unforeseen future. The idea may not have to be produced, but it should be developed.

If either answer is acceptable to higher mission levels a demand will be placed on the idea's exploration and development.

Technology-Push and Monopoly

Such a decision has significant economic overtones depending on subsequent actions. If the development of the technology-push idea is performed under monopoly conditions no effective check-and-balance on the program's cost is possible.

The decision, instead, should set in motion two sequential actions; the first, to construct a MENS-type document for communication to other innovative sources; and the second, to negotiate a sole-source exploratory contract as a reward for the inventor's initiative. Other ideas and concepts in response to the MENS-type communication may then also be selected for competitive

COMMUNICATIONS

The agency should convey its needs, goals, and constraints to the national innovative resource to motivate the submittal of pre-qualification information. The agency should adopt equitable communication methods and not "favor" known sources in communications of needs.

The Communication Document

The concept of MENS, Mission Element Need Statement, is embodied in A-109 and is under detailed study by various offices within DoD and other agencies. It is to be the basic document for communicating an agency's innovative needs to private innovative suppliers. It is not to contain pre-determinations of technical approaches or any other internal constraints on the creation of ideas. But it is to contain an interface specification which externally constrains ideas to match the idea to an external and agency-prescribed operating environment.

It is also to contain a "cost goal" based on extrapolation of costs of current products and known R&D initiatives, both having been judged as nonresponsive to future mission capability needs, and, hence, new initiatives are sought. New initiatives are to "cost less" than projected costs for procurement and operations of known products and expected costs of R&D initiatives which have been judged inadequate. Thus, the "cost goal" is based on current knowledge, but is not based on someones perception of what a solution may be "worth" in the future, an approach which implicitly pre-determines the solution.

Major and Minor Communications

The procurement policy idea requires a communication document similar to MENS, but the MENS concept should be extended to all innovative needs of an agency regardless of agency perceptions of the "scale" of responses. For, indeed, with full freedom in response to a MENS-type solicitation, some acceptable ideas may not fit "major" standards even though they have been solicited under "major system" procedures.

This comment is simply a recognition that, in searching for equalities, it is irrational to foster communications where one procedure applies when responses are expected to be "major," but another applies when the responses are expected to be "minor." The identical communication procedure should apply.

PRE-QUALIFICATION

Industry employs scientific and technical personnel based on expectations of their contributions to company commercial goals. An applicant's hiring chances are improved if background and experience is relevant to the technologies embodied in the company's product lines and marketplace; if the applicant has demonstrated acceptable innovation management capability in the past; has general peer recognition for creative approaches to problems; has published papers which demonstrate scientific, technical or management capabilities and insights.

In short, some applicants are judged more likely than others to contribute to the company's commercial goals. These are the ones that will most likely be hired, and they will be hired based on expectations.

Agency pre-qualification for the privilege of direct proposal payments should be based on identical standards. That is, it should be based on an applicant's background and experience and agency expectations of the applicant's contribution to public goals.

As in the case of industrial employment, some that are selected will not achieve expectations, others will, and a still smaller number may exceed expectations.

In effect, the agency would temporarily "employ" unaffiliated individuals, small firms, and other non-federal suppliers. The agency would provide the start-up financing so that those selected may attempt to enter and be successful in federal innovation markets, and, if they become commercially successful, they would also fulfill the needs of the agency by the introduction of ideas which would otherwise not have been available.

The essence of the pre-qualification procedure is that the agency take the financial risk that its selections will contribute to agency goals, and that the cost for the early exploration of ideas which are proposed and directly paid is well worth the benefits received. The benefits will be mainly centered on the broader base of idea sources which the procedure provides as compared to current practice, and the competitive challenge which is introduced by the procedure to larger established firms, particularly at the earliest, least expensive, and most creative phase of innovation.

ENTITLEMENTS

To be equal, the procurement policy idea should provide financial and new business entitlements equal to those granted by the IR&D/B&P procurement instrument and other general overhead accounts found in federal contracts. Some federal contractor entitlements which should be embodied in the procurement policy idea are the following:

Federal contractors:

-- recover all or some first money to propose new business to federal agencies; thus they are not generally required to employ commercial first money instruments

-- have technical independence in their approaches to agency problems

-- internally have flexible and "quick reaction" procedures to respond to new business opportunities; thus they are not impeded in organizing a new business technical and proposal activity and may do so rapidly

-- are able to recover the cost of "waiting" for R&D contract award decisions and may extend internal work to the point of award decision

-- are able to assign scientific and technical people to new business technical and planning activities without prior agency approval

-- may use indirect contract charges as a scientific and technical employment leveling mechanism to fill-in the ups and downs of direct R&D contracting

-- may permit a new employee to "learn" the business, become familiar with customer needs, participate in several new business proposals

-- are provided communication and new business marketing costs in general overhead accounts; some may recover the costs of field marketing operations, technical and venture planning, and market research (the extent of recovery depending on federal sales level).

PART 2

A PROCUREMENT POLICY IDEA

BACKGROUND

Tax reforms to equally tax the savings of individuals, nonincorporated firms, and corporations, and provide venture capitalists with a "front-end" financial incentive will generally encourage new product innovation. The dominance of non-market performance of new product start-up activities is a matter of applying a 20-year federal "make-or-buy" policy to new product innovative activities. Reforms in these two areas will greatly invigorate new product innovation generally.

The procurement policy idea discussed in this section is conceived to provide equal financial and new business entitlements to all pre-qualified innovators.

The idea is to directly pay the costs of new business proposals when they are submitted by pre-qualified innovative units.

The idea is neither new or involves complex principles or procedures. And yet direct first money payments may be equated to indirectly recovered first money for the same purposes. The latter instrument is provided current federal contractors, the former is the substance of the idea.

The idea has been explored by at least two agencies. The General Services Administration is statutorily authorized (PL 92-582) to assess the competitive design capabilities of Architectural and Engineering (A&E) firms and select those that are judged capable. A fixed and equal amount of money is directly awarded to those selected for the purpose of preparing an initial design proposal based on GSA functional specifications. Thus the costs of the initial proposal are directly paid. One or more of the submitted designs may then be additionally financed for further competitive engineering studies before a single design is selected for construction.

The Navy also has experience in pre-qualifying firms as capable of system design activities and has directly paid proposal activities. All firms that were interested in solving a common Navy problem, and believed they had a competitive design capability, were invited to submit their qualifications and

NET POLICY OUTCOME

Taxation on savings and venture capital, the IR&D/B&P procurement instrument, and lack of application of government's 20-year "make-or-buy" policy to innovative activities combine to foster a net unwritten public policy. This net unwritten public policy fosters inequitable distributions of financial and new business entitlements by favoring large federal contractors and inhibiting new business start-ups and small firm growth. Thus the net public policy fosters the appearance of economic oligopolies within the U.S. economy.

Each policy standing alone produces the public benefits for which the policy was instituted. The IR&D/B&P procurement instrument, for example, has permitted technical and new business independence and has maintained competition for future procurements, as claimed by IR&D/B&P advocates. The system of taxation has redistributed wealth as intended, and by not taxing new product developments, encourages them. Government's dominant allocations of new product start-up capital to non-market operations has provided the agencies with in-depth scientific and technical knowledge so that contractor representations may be professionally assessed and major agency programs professionally managed.

But it is the net public policy caused by their interactions which distributes inequities, according to relative net-worth, federal contract sales base, and principle business. Hence the net policy fosters economic concentrations and oligopoly.

The A-109 "major systems" policy will tend to redress financial and new business inequities in the future by reducing competition pre-qualification requirements to a low-scale and labor-intensive phase of design, thereby reversing the previous need for high first money expenses and down-stream R&D plant and equipment (or financial resources to acquire them) as a competition pre-qualification requirement. This feature of A-109 policy should permit smaller technical firms to equally compete with larger ones at the outset of new product innovation. But A-109 does not apply to "minor" systems or general innovative activities which are usually aggregated under the label of "technology base" activities.

What is needed is a national innovation policy, constrained by the rule of law, and referenced to a framework of innovation's primary attributes.

and small firm access to this centralization is blocked by 4,000 procurement-related statutes and 3,000 pages of regulatory instructions.*

The net outcome is that unaffiliated individuals and creative and innovative people employed by small firms and nonfederal suppliers are motivated to leave private entrepreneurship and joint large firm and government employment.[17] In the long-term this will tend to defeat DoD's and NASA's new policy objectives by fostering economic concentration within high-capital wealth companies.

Another tax-inhibitor to private entrepreneurship is found in unrealistic treatment of venture capital in the U.S. tax code.

The cost of venturing new products is properly considered a "cost-of-doing-business" and therefore not taxable, but tax-deductibility is arrived at in an unrealistic way. Those who have directly participated in new product innovation fully understand that if "seed capital," "start-up money," or "applied research" (in government terminology) cannot be gained very little else will happen. Thus, a new product innovation is stopped before it begins.

"Seed" capital is needed to start new product innovation and is the lowest of all innovation expenditures, but it is also the most financially risky. Market uncertainties combine with new product technical uncertainties at the beginning of innovation to put the highest financial risk on innovation's lowest expenditures.

---

*It should be noted that established federal contractors are indirectly paid by taxpayers to comply with these administrative complexities and prepare for and propose new agency business.

[17] Characteristics of the National Sample of Scientists and Engineers, 1974 (updated to 1976), Part 2 Employment, NSF 76-323, pg. 149. The two concentrated risk capital sources, government and large corporations, motivates creative entrepreneurs to seek employment with them and, in so doing, further concentrates economic power. But when such people leave private entrepreneuring they are more motivated to join federal than private employment: median salary $24,900 federal vs. $23,100 private, without correction for recent top federal salary increase from $36,000 to $47,500, plus better benefits, including job security.

"Major Systems Acquisition"). All R&D agencies are subject to its provisions.

As a final comment, 1960 policies, and their revision in 1971, required a competitive proposer to evidence full capability to complete the totality of the innovative process by completing development, introducing production items into DoD inventory, and providing appropriate spare parts, repair, and maintenance support as required. Contractors either had to have the required full-run facilities; plant, equipment, and personnel, in place, or demonstrate an acceptable financial and personnel plan to acquire them.

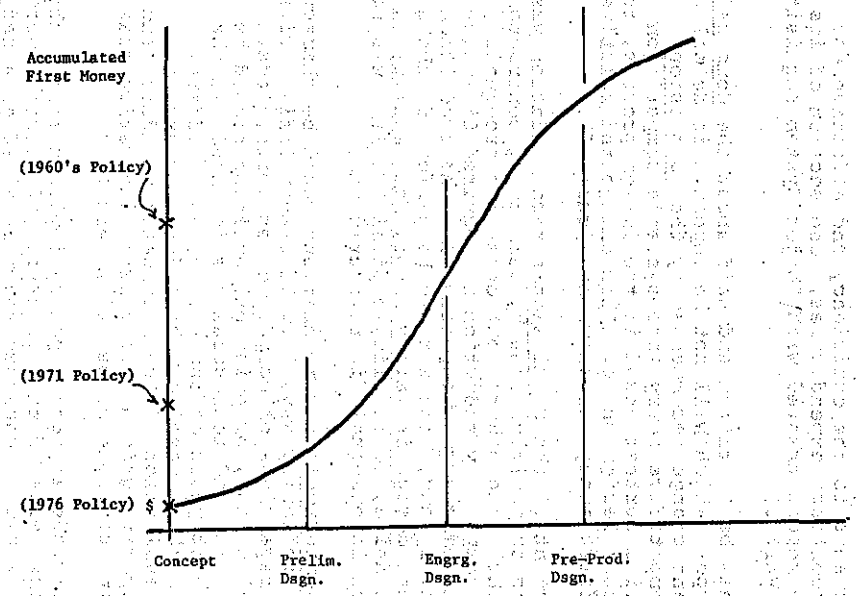
It is generally understood that entry into a prototype competition (Prelim. Dsgn.), or an engineering competition (Engrg. Dsgn.), are at phases of innovation which exhibit an increasing rate of resource expenditure--relatively large expenditures are still to come.

While venture capital and some special facility capital may be government-supplied, several "large-ticket" items usually remained for the company to supply out of its own resources. Pre-qualification at these late innovative phases emphasized capital "wealth" rather than ideas which create capital wealth through successful introduction. It was based more on pre-qualifying those who had successfully innovated in the past, rather than on pre-qualifying those who may successfully innovate in the future.

The new policy opens the possibility of a consortium of small firms to directly challenge larger established firms. The small firm consortium's total internal resources (mainly people) should suffice to demonstrate pre-qualification capability without unaffordable demands on future resource expenditure as a pre-condition for qualification. This is the essence of a policy which fosters ..."corporate growth based on competitive merit," a policy which is supportive to private enterprise, capitalism and a free and democratic society.

Fig. (6)

THE RELATIONSHIP BETWEEN FIRST MONEY AND CONCEPTUAL DESIGN COMPETITIONS; 1976 POLICY

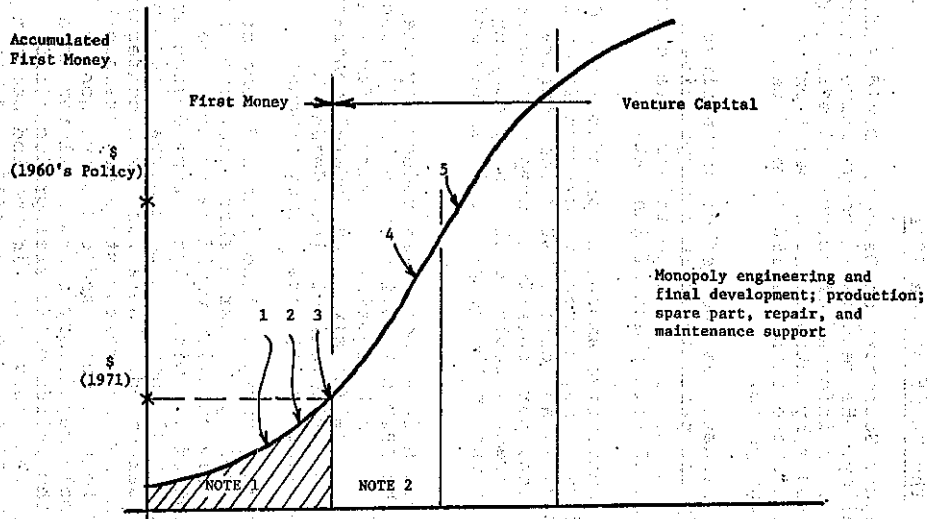


Transitions through design phases are to be sequentially funded by fixed level commitments, venture capital directly supplied by R&D contracts, and agency investment choice delayed as far through an innovation program as affordable and appropriate to meet operating time-period goals.

Source: DGS Associates

Fig. (5)

THE RELATIONSHIP BETWEEN FIRST MONEY COST AND PROTOTYPE COMPETITIONS: 1971 POLICY



1. Prototype Proposal Request
2. Submittal
3. Award
4. Competitive "fly-off"
5. Engineering Award

NOTE 1: -- R&D "seed contracts
-- IR&D/B&P
-- Cost sharing
-- Prorata share of price mark-ups on commercial products and services

NOTE 2: Direct contrac possibl cost-sharing

Brief Discussion:

competitive pace; profit-sharing, reduction in net-worth, or price increases on current commercial contracts. The necessity for using these internal mechanisms which could not be charged to federal contracts, became increasingly important for federal contractors of sales-base less than others, and were the only mechanisms available for a new market entry.

The defense industry logically pressured government to liberalize IR&D/B&P cost-recovery policy. Without liberalization very few contractors could afford to keep a competitive pace according to 1960 time-period policy. Towards the close of the 60's increases in recoverable amounts caught the attention of several congressional groups and rigorous accountability controls were instituted by statutory additions to DoD authorization and appropriation bills. The costs to comply with these accountability controls were also expensed in federal contracts, further favoring federal contractors of larger sales-base. The consequence was that some medium-sized federal contractors were not financially able to keep pace (including Martin's military aircraft business) and dropped out of the marketplace. Martin and several other larger contractors entered into industrial mergers and acquisitions to provide a more stable revenue source for their stockholders.

A narrowing of qualified defense suppliers to only larger ones was also accompanied by some other long-term economic disadvantages. Diversity of DoD investment choice was narrowed because all qualified and remaining competitors were required to modify their originally separated design approaches into a common design--a design for which no one contractor could be held legally accountable. And the single government pre-determined design was finally developed and produced by a monopoly supplier; hence, consequential increases in procurement regulatory controls, now amounting to 4,000 procurement-related statutes and 3,000 pages of implementing instructions.

It takes little insight to realize that 1960 policies fostered oligopoly by making entry-cost unaffordable for new companies and companies of less federal sales than others, large increases in non-productive costs through the proliferation of monopoly regulatory controls, a narrowing of investment choice by a "wash-out" of competitive technical design features, an inappropriate emphasis on quoted sales price which motivated "price buy ins," and a weakening of contractual integrity by ambiguous assignments for overall weapon's design responsibility.

development of a full-scale weapons procurement specification. This engineering specification, developed over several years, would be sent to those companies which had kept pace and remained competitive.* DoD would ask companies to propose final engineering, development, test, and production of the weapon described in its solicitation. A company's accumulated first money to keep pace and responsively compete would continue to increase from the conceptual phase of a new weapon and terminate only when a single award winner had been announced. Figure (4) illustrates the accumulative first money to remain competitive until the final competition was held and the winner announced.

The delay of competition until innovation's Engineering phase placed a high financial burden on qualified defense suppliers. Mr. Meyerson concluded, "that it is (was) possible to spend about five years or more and upwards of $25 million on one or several aircraft programs and still not meet the threshold of minimum success in the military aircraft business." (pg. 4-6), that it took "a company 4.5 years, with 96 senior men employed every month during that period (prior to engineering competition)" (p. 4-12).

First money was spent to be responsive to government's "demand-pull" designs which were represented by highly detailed engineering-type specifications. However, Mr. Meyerson added an interesting comment about the evolution of "technology-push" ideas; "...systems which are 'invented' by the company take about 7 years and require a company to invest up to 90% for their evolution." (pg. 4-13).

But the "crunch" came when a contractor's federal sales-base was not sufficient to write-off first money expenses on federal contracts. A contractor without a sufficient federal sales-base against which to write-off these charges had to consider the employment of three other internal first money mechanisms to keep a

*It is very important to point out that losers of competitive R&D "seed" contracts had to use internal first money resources, mainly IR&D, to perform the technical activity they had proposed and lost. In effect, they would not "lose," but continue what had been lost on indirect charges to government contracts rather than direct R&D contract charges. This they had to do to remain competitive.

because they exhibit a wide diversity in goals and priorities, even though achievement of common national civilian goals is a common objective. What is satisfactory for one nonfederal purchaser is likely not satisfactory for another, even though both choices may be responsive to national civil capability goals which are commonly constrained by national social regulations, such as those for health, safety, and environment.

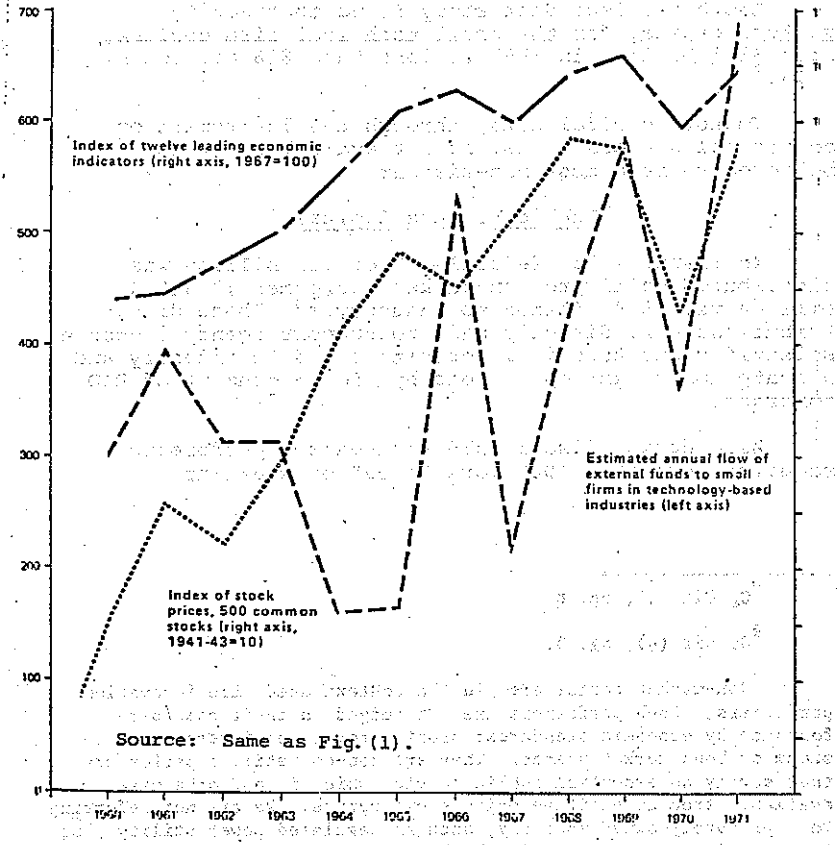
As an example of the necessity for diversity of nonfederal choice, a personal transportation system appropriate for one locality may be entirely unacceptable for another--a single personal transportation choice created by the federal level of government may have little marketability nationally. Commercial and profit-motivated suppliers would rationally be uninterested in participating in such non-market technical activities, because the particular and unique needs of multiple and diverse consumers stands a low chance of being met.[14]

[14] Federal Funding of Civilian R&D Volume 1; Summary, A.D. Little, Inc., Wash., D.C., Feb. 1976, pg. 1. and Analysis of Federally-Funded Demonstration Projects Volume 1: Executive Summary, Rand, Santa Monica, CA, April 1976, pages IV, V.

nationalized laboratories; and noncompetitive private administration and operations of government-owned R&D plant and equipment. The Sandia Corp., Livermore Laboratories and thirty others fit into the latter category. Some not-for-profit operations are also privately owned and operated and do, from time to time, compete for federal sponsorship, but usually not on a price-competitive basis. Other government levels, state and local, also perform or contract R&D activity through a partial use of federal block grants. Such amounts, however, are not reported.

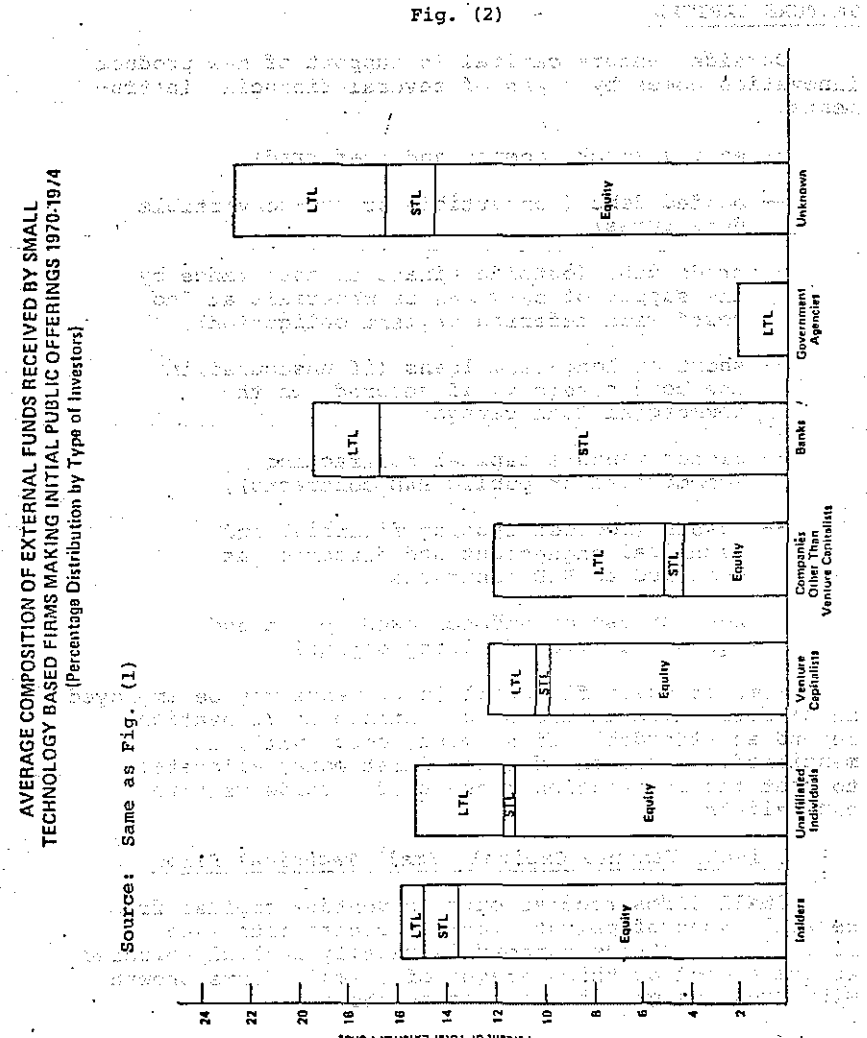
Fig. (3)

ESTIMATED EXTERNAL FLOW OF FUNDS,
INDEX OF TWELVE LEADING ECONOMIC INDICATORS,
AND INDEX OF 500 COMMON STOCK PRICES
1960-1971
Annual



Source: Same as Fig. (1).

Fig. (2)


AVERAGE COMPOSITION OF EXTERNAL FUNDS RECEIVED BY SMALL TECHNOLOGY BASED FIRMS MAKING INITIAL PUBLIC OFFERINGS 1970-19/4
(Percentage Distribution by Type of Investors)
Source: Same as Fig. (1)
Percent of Total External Funds
24
22
20
18
16
14
12
10
8
6
4
2
LTL
STL
Equity
Insiders
Unaffiliated Individuals
Venture Capitalists
Companies Other Than Venture Capitalists
Banks
Government Agencies
Unknown

and nonfederal suppliers of any size must employ commercial first money instruments for the same purposes.

The IR&D/B&P procurement instrument, therefore, provides a cost reimburseable mechanism and a continuum of independent technical and marketing activities in transitioning the exploration of an idea from internally-supplied first money to externally-supplied venture capital. It is a government-paid instrument which is available only to established contractors, but unavailable to those that may wish to enter federal markets by challenging those already there.

Entrepreneur first-money costs to gain start-up equity capital may be significant in relation to the entrepreneuring firm's or individual's net-worth. The report noted, "Most investments made (by private venture capitalists) are not made in start-up, but in the second or third stages of development of portfolio companies...later stage investments are thought to be less risky than start-ups."[6] This suggests that initial start-up equity capital, where financial risk is the greatest, is relatively more difficult to come by, and may require extensive first-money expenditure by the inventor or inventing unit.

But even if initial start-up capital is gained and a new business operation underway, retained earnings and facility capital depreciation accounts are very likely insufficient to venture new product lines, or even improve the product on which the firm was founded, Fig. (1). These inhibitors to growth are likely because a small firm's operating costs are dominantly labor-intensive, with only a minimal (if any) facility depreciation expense--an expense which otherwise could be mortgaged to finance new product ventures or current product improvements.

It should also be noted, Fig. (1), that outside venture capitalists are more likely to purchase equity stock than provide short or long-term loans. This is because income during the first phase of a new company's growth is often insufficient to service a bonded debt, and facility book-value to secure a debt insufficient because the operations are mainly labor-intensive.

An entrepreneur is evidently required to establish a "track-record" using internal personal or firm funds, those of the innovating unit's associates or family, or trade debt* before an outside venture capitalist is likely to become interested in equity participation.

Depending on an entrepreneur's net-worth, and how much of it he may afford to risk in a new venture, establishes an artificial limitation on the size and scope of any new product venture the entrepreneur may conceive. That is, an entrepreneur may invent a particularly attractive idea, but if start-up and expansion to the second or third stages of the firm's

---

[6] Ibid, page 164.

* Suppliers deliver at no cost, but with future obligation for payment.

Non-concentrated industries (industry sales not dominated by 4 (or less) firms) where price-competition is evident and R&D intensity is low demonstrate relatively low R&D expenses as a percent of sales: Metal and Mining 1.0%, Fuels 0.4%, Containers 1.1%, Building Materials 1.0%.[3]

Thus, R&D-intensive oligopolies generally characterize industries within which firms are most likely to demonstrate relatively high new product first money expenses for the venturing of new products. These expenses will likely be recovered in current product sales to both private and public consumers.

Small Technical Firms

Information about first money for small technical firms of less than $25 million annual sales is very difficult to find. One study noted, "data regarding the financing of technical 'start-up' situations and very new companies are almost nonexistent."[4]

Another research study[5] examined the public prospectuses which were offered during the period 1970-1974 by 31 small technology firms.

The Securities Exchange Commission requires that three prior-year financial data be included in statements of public offerings and, by analysis of the admittedly small sample, the study demonstrated that small technology firms (under $5 million capitalization) depend almost totally on outside venture capital for their start-up, Fig. (1). This finding can be interpreted to imply that the individual entrepreneur most likely employed personal first money resources in attempts to gain outside equity capital. There literally are no research data of entrepreneur-incurred personal or firm costs to gain start-up equity capital.

---

[3] Op Cit (1).

[4] The Role of New Technical Enterprises in the U.S. Economy, Commerce Technical Advisory Board, Department of Commerce, January 1976, pg. 7.

[5] An Analysis of Venture Capital Market Imperfections, NBS-GCR-CTIP 76-12, Charles Rivers Associates, Cambridge, Mass., Feb. 1976.

TABLE 1

All-Industry Composite Data

Sales	Profit	R&D Expense			
$(M)	$(M)	$(M)	% of Sales	% of Profit	$ per Employee
971,562	52,132	18,048	1.9	34.6	1,240

Source: Business Week, July 3, 1978, pg. 77.

Amdahl, a computer company of $189 million 1977 sales, expensed the most R&D dollars per employee, $8,679; and Systems Engineering Laboratories, another computer company of $31 million 1977 sales, expensed the highest R&D dollars as a percent of sales, 12.1%.

General Motors expensed the most R&D dollars, $1,451 million, but some other large companies, such as Mobil Corp. and Tenneco, did not report R&D expenses, presumably because their expenses were less than 1% of sales, a cut-off in SEC 10-k reporting.

Large Companies and Price Inelasticity

Companies which dominantly supply price elastic markets are less motivated to perform new product innovation on first money resources than companies which dominantly supply price inelastic markets. Thus, one would expect to find first money expenses mainly within the cost-of-sales of price inelastic suppliers.

This relative lack of new product motivation is a consequence of price competition within the firm's price elastic marketplace. That is, when a product's price is reduced, the firm's sales volume will likely increase, or the converse will likely happen. The addition of nonproductive R&D expense to a product's price, holding profit constant, will likely result in a sales volume reduction and overall profitability objectives not likely achieved. Thus, with profit-related objectives in command of corporate strategy, less motivation exists to venture new products for the future.

A price inelastic supplier, on the other hand, may increase product prices by addition of an R&D expense, holding profit constant, with only a marginal (or no) decrease in sales volume. Such firms may mark-up their product prices by an R&D expense because their sales are not generally price-competitive. They may

Also, an entrepreneur is more interested in risk capital to carry his innovation to a critical design review point than in the "kind" of technical work which is to be performed; applied research, exploratory development, advanced development, and final development. He will organize his program according to preliminary, engineering, pre-production, and production design review points and be less concerned about the "kind" of technical work needed within each transition phase. Indeed, applied research "kinds" of activities may be found in late design phases.

Publicly reported data, however, is organized according to "kind" rather than according to "design."

Analysis of official government R&D data, therefore, will contain source data errors when used in the context of risk capital analyses. When used in analysis, such data will be generally understated as to true risk capital costs.

With these caveats in mind, the following First Money data is from the latest industrial R&D survey reported by Business Week. Security Exchange Commission 10-k reports were used by Business Week in compiling industrial R&D on a company-by-company basis. The survey was limited to companies of over $25 million annual sales and of those companies, R&D expenses which amounted to more than 1% of sales.

The section which follows First Money describes current knowledge about Venture Capital, externally supplied risk capital.

Facility capital pays acquisition costs of R&D and productive plant and equipment. Such costs are not "written-off" in the tax year such costs are incurred,* but depreciated over their useful life. Facility capital depreciation accounts are cash reserves which are set-aside to purchase new plant equipment in the future.** The amount depreciated in one year according to Internal Revenue Service rules will be expensed in the cost of current product sales of that year, and therefore not taxable.

First Money and Venture Capital

The private entrepreneur must pragmatically treat with operating and facility capital. Equipments and facilities may require an initial cash-outlay, or assumption of debt. Personnel wage and salary and other operating expenses must be competitive and offered over a reasonable time-period to attract and retain creative talent.

The practical question the entrepreneur must answer is how much risk capital can he personally afford and to what extent must that be supplemented by borrowing from friends, family, associates, or by mortgage of current assets?

The private entrepreneur explicitly separates risk capital into two parts:

First Money:	the risk capital personally (or internally) supplied by the entrepreneur
Venture Capital:	the risk capital externally supplied by outside non-associated sources.

First money may supply the total risk capital needed to introduce a new product, or a combination of first money and venture capital may be required. First money and venture capital may be spent for both operating and facility capital purposes.

*Government, however, does expense its own facility capital expenditures in the year incurred in conformance with the federal budgeting process.

**Inflation has caused such cash set-asides to be inadequate for future purchases of new facilities.

INTRODUCTION

This report is a first attempt to combine publicly available venture capital and R&D data. Unfortunately, venture capital reports include some costs of new product development which are not included in R&D reports. Thus such costs cannot be directly compared even though they are both applied to a common purpose, to explore and develop new products, services, and processes. More meaningful data and analysis would be a consequence if all new product capital were to be reported using common ground rules.

The thesis advanced in this report is that private entrepreneuring firms and individuals are more interested in risk capital than they are in either venture capital or R&D. Further, they explicitly separate risk capital into two component parts; the part which must be internally-supplied, First Money, and the part which must be externally-supplied by non-associated outside sources, Venture Capital.

Because of data incomparabilities and difficulties, no in-depth analysis was possible of federal policies which have a net effect of distributing risk capital entitlements throughout the nation's innovative resource. Only some broad implications could be drawn.

While reported absolute amounts may be questioned as to accuracy when placed in the context of risk capital, we believe the data have sufficient substance on which to draw preliminary policy conclusions. The second part conceptualizes a policy remedy to what was found and concluded.

TABLE OF CONTENTS

Venture capital is supplied by several financial instruments; stocks, bonds, trade debt, commercial loans, and federal R&D contracts. Private venture capital available to the small technical firms has been in serious decline since the start of the 1970's. Public venture capital is distributed by the instruments of federal R&D contracts and in-house budgets ($19 billion, fiscal 1975).

Most public venture capital was distributed to non-market performers that are not measured in their performance by economic standards; stock and bond market prices, profits, ROI, and other measures of economic performance. This is particularly the case for the earliest and most creative phase of innovation where a ratio of over 2:1 favors non-market vs. market performers in government venture capital distributions. Small technical firms were awarded about 4% of the $19 billion total in 1975.

Two innovation markets are created by national needs, goals, and priorities; innovations consumed by a sponsoring agency, and innovations consumed by nonfederal purchasers. Because the consumer is a monopsonist for the former and multiple and diverse for the latter, federal administrative law and procedure which governs private and public relationships for one innovation market cannot be the same as for the other. However, recognition of innovation marketplace differences is not evident in federal policy.

A brief review of DoD's evolution of first money and venture capital policy is presented, from the early 1960's to the present (OMB Circular A-109). The key finding is that policy evolution has consistently reduced first money requirements to qualify for participation in DoD innovation markets.

Certain features of the U.S. tax code are identified as inhibiting private entrepreneurship generally, and are features which will tend to defeat the objectives of federal mission agency first money cost reductions.

The conclusion of Part 1 is that several U.S. policies uniquely combine to result in an unwritten and unofficial U.S. policy. It is this net policy which fosters inequitable distributions of federal innovation entitlements throughout the nation's innovative resource, and, as a consequence, fosters the formation of economic supply concentrations in the private sector.

Part 2 conceptualizes a procurement policy idea to partially remedy the problem. Its main thrust is

Appendix XII

"First Money, Venture Capital, and a Procurement Policy Idea," Prepared for the Office of Naval Research Under Contract No. 00014-78-C-0193, DGS Associates, Washington, D.C., August 1978

FIRST MONEY, VENTURE CAPITAL

AND

A PROCUREMENT POLICY IDEA

DGS ASSOCIATES
Washington, D.C.
August, 1978

Prepared for the Office
of Naval Research under
Contract #N00014-78-C-0193
Project Number 434

References

1. "Government to Review Industrial Innovation," C&EN May 22, 1978, p. 8.
2. "Small Business to Remain Strong," Mitchell P. Kobelinski, The Lexington Leader, November 3, 1976, p. B-8.
3. "Technological Innovation: Irs Environment and Management," Department of Commerce, 1967, Report of the Panel on Invention and Innovation (The Charpie Report.)
4. Arthur S. Obermayer, "Innovation Under Government Guidance," Chemtech, May, 1978, p. 261.
5. Howard K. Nason, "R&D Seen Declining: Government Blamed," ASM News, October 1977, p. 4.
6. "Companies Want Consumers to Underwrite G sification Risk," ASM News, October 1977, p. 4.
7. "Coal Conversion Research Includes Reducing Hazards from Waste," Lexington Herald-Leader, May 14, 1978, Section C.
8. "Kentucky to Spend $38.6 million on Tourism," Lexington Herald Leader, May 28, 1978, Section C-15.
9. "Development Prospects for Guayule Improve," C&EN, May 8, 1978m p. 5.
10. "Coal Liquefaction Project Under Way," C&EN, May 22, 1978, p. 27.
11. "Gas Turbine Engine Development," Industrial Research/ Development, May 11, 1978, p. C-2.
12. "There's No Shortage of Suggestions," Lexington Leader, May 11, 1978, p. C-2.
13. Elmer B. Staats, "Productivity Loss Challenges Government, Private Sector," ASM News, May, 1978, p. 4.
14. "Research Does Okay in 1978 Federal Budget," C&EN, Jan. 24, 1977, p. 6.
15. "An Analysis of the National Science Foundations Innovation Centers Experiment, R.M. Burger, Research Triangle Institute, NTIS, Department of Commerce.
16. H. Paris Burstyn, "Education for Invention," Industrial Research/Development, April, 1978, p. 121.
17. "Big Science --from Whence and Whither," Chemtech, September, 1977, p. 541.
18. 95th Congress, 1st Session, S.972, in the House.
19. 94th Congress, 2nd Session, HR.14943, in the House.
20. W.F. Ballhaus, "Personal Investment is necessary for R&D Growth," Industrial Research Development, April 1978, p. 84
21. "Deforming Reform," Newsweek, June 5, 1978, p. 74.
22. "Uncertain Future for Academic Research," C&EN, Nov. 29, 1976, p. 25.

can be manufactured or used in an industrial environment. Thus we would eliminate new clothing stores, restaurants and retail establishments which constitute the bulk of S.B.A. activities, from the suggested new program.

We know that there are many good ideas seeking an opportunity as evidenced by the General Motors case and the Innovation Centers experience cited earlier. Our own experience is that there are alread a number of good sources of business advice, many of which are free. I was favorably impressed with the help of the SCORE office of the SBA. A young friend of mine was more favorably impressed with the help of the University of Kentucky's Center for Business Development.

In addition to the idea and the professional advice, the inventor needs an innovator. This is a person who can take a half-way developed idea and forge it into a practical and full fledged business. The innovator is the individual who knows how to put it together and make it work. The inventor and innovator may be one and the same or two different persons.

My experience has been that innovators are rare in number but that there is a tremendous reservoir in the senior scientist and senior engineer pool. This group is being displaced, usually involuntarily, and find it extremely difficult to find employment. There have been suggestions that this group retire early from industry and universities and enter new careers.(22) It seems that here we have an unusual opportunity to take advantage of both years of outstanding experience and a serious unemployment problem at the same time. New engineering graduates have no trouble finding jobs. I wonder why we set up a new program to change the careers of a group that is already in great demand? I am saying that we should draw our innovators from the mid-career scientist and engineer unemployment pool.

As we have a large source of ideas and a source of innovators which can be developed the key step is to provide the start-up venture capital. As far as I have been able to determine, there is no organized source of start-up venture capital in this country. I am turned off by promoters that charge $100 an hour, require a follow-on consulting contract and sometimes a part of the business to act as a finder. I have been advised to go to New England in Kentucky and in New England to go to Kentucky. One wealthy individual here suggested that I work out all the problems and prove the idea 100 percent and that he would then be willing to take over the invention for me.

It is not clear whether the primary goal of the experiment is education, research, or the creation of jobs through innovation. The program allocation was $200,000 per school per year, which seems miniscule. In spite of the small amount the universities participated in the creation of over 30 new ventures with about 1,000 new jobs and $6 million in tax revenues--clearly a good investment for the tax payer.

A separate report on this experiment indicates that the primary emphasis in on education.(16) It tells that some of the innovators obtained substantial amounts of start-up capital from Center funds. Quite possibly this is the unmentioned key to the whole process. When I went to the University of Kentucky Center for Business Development fpr help I was told that if I could come up with $5,000 for a market study, that they would be glad to help me.

We can see that it is natural for the National Science Foundation to be actively pursuing all phases of research including innovation. If they can generate the jobs and return reported this is tremendous and their program should be accelerated by a factor of 1000. Then we will be getting into the order of magnitude that the situation warrents.

VII. Present Trend in Innovation

We have gone through a period of essentially level rate of national research and development effort for the past 10 years with a decline of federal activity offset by an increase in industrial spending.(17) We have seen a trend away from innovation by industry towards short range development and defensive research. We have seen tremendous obstacles placed in the path of innovative small business start-ups and we have seen an increasing national concern about our decreasing competitiveness in industrial innovation. If the concern is widespread, and I believe it is, we can also read the signs as to the probable direction of the action.

I was once told in Washington that one sure way to avoid action without repercussions was to form a committee to study the problem and write a report. The problem was studied by an outstanding panel in 1967 by the Department of Commerce. Now the players have changed and the problem has only become worse.

Congress has made some attempts at the problem but no one person seems willing to describe it nor a way to solve it. Legislation was enacted that NSF spend a fixed percentage of one program with small business. The Small Business Development Center Act of 1978, S.972 was drawn up for the Small Business Administration to give universities throughout the country $400,000 each to provide advice for small business.(18) The Harrington bill of 1976, H.R. 14943, was designed to establish a national system of

income from outside the state and to provide jobs for service personnel. The principal beneficiary in Lexington would be the Hyatt Regency chain which leases the hotel built with the bond issue which is in turn guaranteed by the local government. We need to be thinking of similar ways in which local born industries can get started.

There is not one local or state source of start-up venture capital which I have been able to identify. Yet large sums are allocated in promoting our area to big industry and big business. There are about 1000 new plants built in this country a year. To solicit those plants about 4,000 people are employed full time. This waste of our resources is now being extended to Japan and Europe.

At the Federal level the Senate Committee on Environment & Public Works recently completed a bill that would provide $30 million over the next 4 years for development work on guayule.(9) This resulted from a National Academy of Sciences report recommending that the U.S. initiate such a program. As this does not lend itself to a small business operation a large rubber company would normally be expected to become the prime contractor. I am not aware of the National Academy recommending that anything be done to help the independent inventor and innovator. The reason is obvious.

The tremendous job ahead of us in energy conversion has attracted the resources of our largest industries, and I would imagine at the request of our government. It was recently announced that Exxon's donor-solvent coal-liquefaction process was being taken to the pilot plant stage at a cost of $110 million.(10) "The project is funded half by the Department of Energy and half by a group of U.S. and Japanese companies and the Electric Power Institute.(in other words our utilities and their customers." (11)

The Detroit Diesel Allison Division of General Motors was just awarded a $43 million contract to develop ceramics for gas turbine engine development for automobiles and trucks.(12) General Motors is unusual in that it maintains a 10 man section to analyze the 5,000 calls and letters a year on new ideas. This leads to the acceptance of 2 inventions a year.(12) Coincidentally I had submitted a preliminary description of an idea in the same area about 2 years earlier both to the sponsor, NASA, and to General Motors. I was told that there was no interest in my process.

What I wish to point out here is that even though an independent inventor may have an idea 2 years before a large organization perceives the need, there is no practical mechanism for him to become a useful part of the process.

IV. Large Industry and Mass Production

My second premise is that the multi-national corporation of today is the most efficient vehicle for the reduction of manufacturing and distribution costs and of the rapid transfer of technology to the greatest benefit of the most people that the world has ever known.

Certain tasks can only be undertaken by very large industrial concerns just as certain others can only be accomplished by large government. But this does not mean that they do all tasks in the best manner for all people. The preponderance of evidence is that the tilt of our current system is towards big industry and big government and that the combination of the two, probably without intention, is towards the elimination of innovative new industries. I find, for example, that the development of an idea to manufacture a product here and brind jobs back from overseas has a negative sales appeal. I think that innovations of this nature warrent extra consideration.

During one discussion of an innovative new idea with a large energy conservation potential the large industry representative put it this way - "We are going to get ¼ of the market if we do nothing and we will only get ¼ if we develop your idea, so why spend the money?"

While we are going through a period of increased concentration of large industry, funding of R&D is said to be barely keeping up with inflation with a trend in expenditures away from innovation towards defensive short range product and process improvement. (5)

An excellent example of our current duel system of innovation is given in the current plans to build the nation's first commercial plant to make pipeline gas from low-grade coal. (6) A consortium of American Natural Resources of Detroit, Peoples Gas Co. of Chicago, Columbia Gas System Inc. of Wilmington, Del., Tenneco Inc. of Houston, and Transco Companies Inc. was formed to produce 125 million cubic feet of synthetic natural gas from lignite each day. The project will cost $900 million of which the partnership will put up $225 million and borrow the remaining $675 million. I assume that the $225 million will come from earnings which in turn come from customers and from rates approved by the public Service Commission . In one way it is a stockholder's risk in the form of reduced dividends and in another it is an added charge to the customer. The borrowed $675 million would normally be a risk of the lending institutions such as banks and insurance companies.

The "kicker" in the plan is that they want the Federal Energy Regulatory Commission to approve a plan to permit them to recover the $675 million from their customers if the plant should fail. As a Columbia Gas customer I am very interested

In 1974 I set up my first small business which was formed to develop a product for an industry which was totally dependent upon 2 Japanese manufacturers. With the advent of the oil crisis there was a question as to whether or not they would continue to supply the U.S. market. Fortunately or unfortunately the crisis went away and with it, my support.

At the time I formed my first company I visited the Kentucky office of the Small Business Administration to develop part of my start-up capitalization. It was at that time that I first learned that the SBA is really not set up to financially help the start-up of small businesses. In 1975 I first discussed the need for a source of start-up venture capital with my Congressman. At that time he expressed a concern to me about the increasing frequency of reports on the declining rate of innovation in the U.S.A. relative to the rest of the free world. He helpfully put me in touch with people in the National Science Foundation, the Departments of Commerce and Agriculture.

In my initial contacts with the National Science Foundation I was told that the official position was that there was no shortage of start-up venture capital although unofficially, this was known not to be true. I received a report funded by NSF with a venture capital organization which used obsolete data and rather different reasoning to prove that there was an adequate supply of start-up capital.

Now, when I read that the White House has established an inter-agency committee to conduct a comprehensive review of issues and problems related to industrial innovation, I react with mixed emotion.(1) First, I am grateful that this problem is finally going to be tackled at a high level, and encouraged that a proper solution initiated. Second, I am concerned that this may be just another delaying tactic to put off doing the obvious. Some of my thoughts are given in the following.

III. Small Business and Jobs Creation

My first premise is that small businesses are important to this country and that most people are in favor of encouraging the formation of--and continuation of--small businesses.

"Small business activity makes up about 48 percent of our (private) business gross national product... It employes 58 percent of those employed in the business sector and something in the vicinity of 100 million persons rely directly or indirectly on small businesses. We also estimate that somewhere over 95 percent of all businesses in America are small businesses.(2)"

June, 1978

OUTLINE

The place for the entrepreneur is not in the industries that have been established, but rather those that still have to be proven.

The role of the entrepreneur in our society is to do those things which the larger, established company cannot or will not do. The entrepreneur has the drive and the spirit the established company cannot buy with just salary. The entrepreneur can and will take risks that the larger company cannot. When the entrepreneur fails he just disappears. When the large company fails on a project, it has to pay dearly to recover and take care of its customers. The large number of entrepreneurs can try an infinite number of ideas. I propose that we need entrepreneurs and I propose that society and government should encourage and promote the entrepreneurial spirit.

In our society we discourage entrepreneurship by giving more value to the individual who criticizes than on the organization that does things. Most people want to be on the side of the "hassl*ers*" and not the "hassl*ees*". Not long ago, it was very hard to find a president or a dean for a college. If you were a college professor, you made points with your social group by hassling the dean and the president. No one wanted to be the hasslee.

For example, we as a society are very interested in protecting the privacy of the individual, particularly if he or she has some criminal history. There is no privacy at all for someone in business. The government can ask for your personal check stubs for the last 10 years or all your files, your correspondence. Then, once the government has your material, it's open to everybody.

Our society holds business responsible for safety, pollution, integration, it seems; but individuals are protected from any responsibility.

What can our government do to help? I would like to propose that most important is to stop the constant changing of rules. People need a feeling of stability if they are going to invest their efforts as entrepreneurs or their money as investors. I would even suggest that they don't change the tax laws to encourage entrepreneurship. The feeling that the rules are unstable is probably the biggest discouragement to investment.

The computer industry in this country is one of the most fascinating stories in modern industry. It moved so fast in this country that the government could not catch up with it to "help" it or control it, much to the frustration of many of the bureaucrats. Many other governments worked hard to encourage and help their computer industries, yet the Americans have dominated from the start. And we'll probably continue to dominate, if the government doesn't step in to "help".

The Entrepreneur: An Endangered Species

KENNETH H. OLSEN

I will not continue the lambasting of the government, at least not very much. Many people lament the passing of the entrepreneurs and blame the government for their extinction. Instead, I'm going to attempt to put the current condition of the entrepreneurial spirit into some perspective for you. To do that, I would like to start with three basic points:

First, "the good old days" of twenty or thirty years ago were not times when it was easy to start a company.

Second, the period of the late '60s and early '70s, which saw a flurry of new business start-ups, was not a norm but a spurt, and should not be considered the point of reference. At that time many private investors, including some very conservative endowment funds, decided to invest recklessly; at the same time the government joined the act and decided to encourage aggressively new businesses with the formation of Small Business Investment Corporations.

Third, we probably have more entrepreneurial spirit and activity today than at any other time in our history, except for that time in the late '60s, but we must be careful that we don't stifle that spirit and lose the advantages that come with it.

I can tell you a little bit more about what it was like to start a technical company in "the good old days" of just 20 years ago. Several of us were making transistor computers at MIT. The world laughed at us and said that what we were doing wasn't useful because we were academics. We felt we had to show them that high-speed transistor computers were simple, inexpensive and reliable, so we started a company.

We had no money, so we went to American Research and Development (AR&D) Corporation, a risk capital company, and proposed our idea to make computers. The Korean War was over and a recession had started and the people at AR&D were a little nervous. But they were fascinated enough to send us to their Board of Directors armed with three bits of advice. They told

FIGURE 7 Factors which influence financing new enterprises.

	Relative* Importance
1 Investment Liquidity	9.2
2 Increased Capital Gains Tax	7.6
3 Reduced Management Incentives	7.2
4 Increase in Business Risk	7.2
5 Larger Capital Requirement	6.4
6 Fewer Entrepreneurs	5.6
7 Government R&D Procedures	3.4

*10—Very Important

patentability and the difficulties of government R&D considered of minor interest.

These results are consistent with the views of almost all of the venture capital community. A recent review of early records of two of the country's largest venture capital organizations showed that not one single company founder had survived in the chief executive position after his company was

FIGURE 8 Relative importance of factors relating to failure of small technical companies (50).

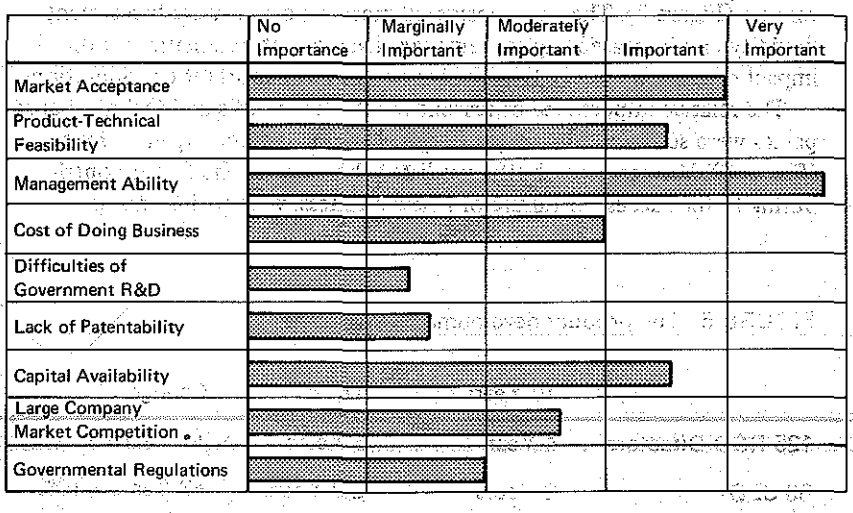


FIGURE 3 R&D Directors and Executives: Relative factors influencing reluctance to perform government R&D.

1. Opportunity Cost
2. Government Bureaucracy
3. Know-how Disclosure
4. Government Patent Policy

One hundred twenty-five directors of research rated their corporations relative to other industrial organizations in terms of their relative ability to commercialize innovative technology (Figure 4). Less than 5% of the research directors believed that their companies were better than Xerox, IBM, Sony and Hitachi; and 55-66% felt they were much less innovative than these groups. Nearly 48% of these directors said they were much *more* innovative than US or Bethlehem Steel.

These answers are in general agreement with early studies at the Sloan School at MIT which indicate that our more mature industries such as steel and automobile are *considered* to be far less innovative than our newer industry groups which have been developed on the basis of recent advanced technology, and maybe are not so dependent on large capital expenditures and labor costs.

Corporate Environment. Thirty-two corporate executives reported that their time spent on government regulation had increased 17.8% in the past 10 years. The average cost of legal-accounting expenses of 41 companies is up 260% (Figure 5).

This information is not entirely unexpected in view of the current trend of affairs in this country. While the impact of the executive time devoted to government regulations and the corporate expense are important, such factors are having a tremendous influence on the small company community.

FIGURE 4 Ability to commercialize innovative technology (125 R&D Directors).

Relative to	Much Less	Equal	Much Greater
Xerox, IBM	66.4%	31.3%	2.3%
Sony, Hitachi	54.5%	40.6%	4.9%
GE, West., RCA	32.6%	58.1%	9.3%
US, Beth. Steel	9.4%	42.9%	47.7%

and the commercialization of innovative new technology. The very size alone of our major corporations, with the attendent rigid structure and necessity for long range planning and financial control, creates an atmosphere that is not attractive to the entrepreneur or innovator. Our national preoccupation with large "systems" and the never ending repetitive systems analyses, economic and engineering studies and computer modeling leave no room for an innovative scientist or engineer to develop something new to meet an unknown market.

Most large industrial companies now operate on the principle of "Management by Objectives", are organized on a group or division basis by market area and have well conceived executive incentive plans based on performance. Unless appropriate mechanisms are provided, some management incentive plans may overemphasize short-term financial results at the expense of taking technological risks and long-term research programs that may be essential for *future* corporate growth and even greater ultimate profitability. The increased cost of capital and executive empahsis on "Return on Investment" (ROI) now tends to place greater emphasis on cash management and the financing of programs associated with cost reduction and the purchase of fixed assets that can demonstrate a known ROI.

The very magnitude and length of the R&D cycle of most government, and many industrial development programs, leaves little room for the entrepreneur or really innovative individual. It's hard to visualize just how an Edison or Land could contribute effectively to multi-billion dollar, 20-year programs such as the B-1 bomber or the breeder reactor program of the Department of Energy. Inventors and entrepreneurs are unique individuals. They do not usually "fit" into structured organizations. They are impatient and want to see early *results* of their endeavors. Few real innovators would put up with the ever increasing analytical studies, economic analyses and now so-called "risk analysis" programs associated with highly structured R&D. Very few of our truly innovative ideas would ever pass through the types of analytical filters being imposed by the decision makers—who usually never have been involved in real hardware research, and falsely assume you can schedule creativity.

There is a great difference between conducting large development programs associated with known technical objectives and the environment in which a real entrepreneur or innovator will operate. The incentives for "high risk" ventures in areas of uncertain markets and unproven technology are hard to sell to management in many industries in the current business environment, particularly those which require heavy capital investment.

In an effort to obtain some current thinking on these subjects, an opinion survey was mailed to the principal executives of our major corporations, their directors of research, selected small high technology companies and venture

different approvals prior to the start of a research contract. Government regulations and the program, technical and management control systems introduced by the government bureaucracy have now reached the point where many small companies as well as larger ones have elected to go out of the government R&D business—some of our more innovative and better managed organizations are no longer available as support for important government programs.

This country has now developed a very large "in-house" component of our national R&D effort which consists of the defense/aerospace industry, government laboratories and a variety of profit and nonprofit institutions, whose "business" depends exclusively on funding by the federal government.[3] In general, these organizations do not have the ability or experience to commercialize the results of their research, and the all important "coupling to the marketplace" factor found in a well run R&D program, is missing.

Because of their size and experience in dealing with the government, larger companies have a substantial advantage over any small technical company. In fact there is reason to believe that there is a critical corporate size below which it is rather impractical for a technical company to seek effectively government contracts for support of new technology.

With creation of the Energy Research and Development Administration, and now the Department of Energy, we have an urgent need to develop a better working relationship with our more innovative large and small technically based industrial companies. Now for the first time we have a tremendous new department with the sole objective of commercializing its R&D programs. This objective is quite different from that of the National Aeronautics and Space Administration or the Department of Defense. No national R&D effort has been launched on such a scale whose success is solely dependent upon public acceptance of new products and processes and ultimate industrial participation in the market place with private capital.

The responsibility for technical and program management, and financial control of contracts in the energy field are now delegated to in-house laboratories and/or non-profit institutions. These same laboratories and non-profit institutions are also often in direct competition with industry for funds to maintain or expand in-house staff and programs. Current government policy permits R&D funds to be transferred to government laboratories, or contracts made with non-profit institutions, much easier and faster than a contract can be given to industry. This factor is often responsible for the support of government labs and non-profit institutions even when such work might be more effectively performed by large or small industrial organizations.

Government employee salaries are now often higher than industry, and the industrial experience, knowledge and ability to commercialize R&D results is not available in this government lab/non-profit sector. These institutions are a great national asset and their unique expertise and resources should be per-

The Changing National Environment for Innovation

RICHARD S. MORSE

The process of technological innovation and the ability of industry to commercialize the results of research and development activities are fundamental aspects of the American economy. Our past position as a leading industrialized nation and exporter of high technology products has been directly dependent upon the concept of rapid exploitation of innovative technology. The creation of new employment opportunities and the generation of *new* technical enterprises depend upon our continued ability to commercialize the results of R&D activities, and the availability of management talent, entrepreneurs and risk capital.

There is also ample evidence that a disproportionate number of innovative ideas emanate from our smaller technically based corporations.[1] It is the growth of these smaller companies which is so essential to counteract the relative loss of employment in many of our older and more mature industries. A recent study[2] by the Commerce Technical Advisory Board, for example, showed that over a five year period, five high technology companies—only six to 14 years old—created 35,000 new jobs. These 35,000 jobs were direct employment with the companies and did not include the additional jobs associated with such corporate activities.

For a similar period six mature companies such as du Pont, Bethlehem Steel and General Electric, with combined sales of $36 billion, had a gain of only 25,000 jobs. If this country wants to *create* jobs, lets *create* a national environment in which our great human, technological and financial resources can be more effectively employed.

Many factors in our national environment—within the government and industrial sectors, and probably the academic community—have now changed. These changes appear to militate against the continuing role of technological innovation and the generation of new technically-based enterprise. The United States has a unique position of technological superiority in an ever decreasing number of commercial areas. American industry also does not enjoy the effective cooperation of government, particularly in the areas of finance and regu-

18. *Economic Report of the President,* Jan. 1976, pp. 39-47.
19. *Technology, Trade and the US Economy,* Report of a Workshop held at Woods Hole, Mass., Aug. 22-31, 1976, conducted by the Office of the Foreign Secretary, National Academy of Engineering and the Assembly of Engineering, National Research Council. (In press.)
20. *The Business Roundtable, op. cit.*
21. *Fortune,* Nov. 1977, p. 103.
22. J. Anthony Boeckh, "Investing in an Unstable World", an address to the Financial Analysts Federation Annual Conference, Montreal, May 1-4, 1977.
23. Remarks in the Symposium, "Innovators and Entrepreneurs—An Endangered Species?" National Academy of Engineering, Nov. 10, 1977, Wash., D.C.
24. Schultze, *op. cit.*
25. J. Moore, "The Cost of Carrying the State Workers", *The Daily Telegraph,* Nov. 1, 1977.
26. C. Harlow, *Innovation and Productivity Under Nationalization: The First Thirty Years,* Allen and Unwin, London, 1977.
27. *The Economist,* July 2, 1977, p. 115.
28. National Science Foundation, *Relationships Between R&D and Economic Growth/Productivity,* Nov. 9, 1977, pp. C-8.
29. *Economic Report of the President,* Jan. 1977, pp. 45-48.
30. Chemical Bank of New York, *Report from Europe,* Vol. 4, No. 10, 1977, p. 1.
31. National Science Foundation, *op. cit.*
32. R. Atkinson, "Basic Research", *The MacNeil/Lehrer Report,* televised N.Y., Nov. 30, 1977.
33. C. E. McClure, Jr. and S. S. Surrey, *Harvard Business Review,* Sept./Oct. 1977, pp. 169 et seq.
34. *Barrons,* July 4, 1977.
35. R. Carswell (Deputy Secretary of the Treasury), Remarks before the Securities Industry Association, Nov. 30, 1977.
36. *The New York Times,* June 26, 1977, p. F-14.
37. M. G. Zahorchak, *The Art of Low Risk Investment;* Second Edition, Van Nostrand Reinhold, N.Y., 1977.
38. *Barron's,* Editorial, March 28, 1977.
39. J. Carson-Parker, *Business Week,* March 14, 1977, p. 82.
40. J. W. Davant, *The New York Times,* Nov. 30, 1977, p. A-25.
41. *Ibid.*
42. A. F. Ehrbar, "Those Pension Plans Are Even Weaker Than You Think", *Fortune,* Nov. 1977, p. 104.
43. Quoted by Dr. Gabriel Hauge, Chairman of the Board, Manufacturers Hanover Corp., in a speech before the Economic Club of Detroit, Oct. 31, 1977.
44. *Science,* May 6, 1977, p. 636.
45. G. F. Will, *Washington Post,* Dec. 11, 1977.
46. "Investment Strategy Highlights; Overview: Are Stocks a Bargain?" A discussion of the Equity Risk Premium, Nov. 1977, Goldman, Sachs & Co.
47. Alan Greenspan, *The Economist,* Aug. 6, 1977.
48. R. Landau and A. I. Mendolia, "International Chemical Investment Patterns - Reviewed", *Chemistry & Industry,* Nov. 19, 1977, pp. 902-910.
49. F. R. Bradbury, *Chemtech,* Jan. 1977, p. 23.
50. E. B. Roberts, *Technology Review,* Oct./Nov. 1977, pp. 27 et seq.
51. T. P. Murphy, *Forbes,* Oct. 14, 1977, p. 174.

that political freedom exists only in free-enterprise countries which are also countries that lead in technology, although all capitalist countries are not free.[55]) The present article has implicit throughout it my firm conviction that our Western industrial world and especially the US cannot retain their freedom without growth, and that such growth must, as in the past, be based on technology.

While I do not feel it appropriate to address such a major question in greater detail herein, I think a recent quotation from Richard Rovere,[56] a well known writer for *The New Yorker* and one who is by no means a conservative, is especially relevant. He speaks of the voices raised in recent years against further industrialization and bigness, including many who "would like to go at least part of the way back to the world of cottage industry, to the vision eloquently set forth by the late E. F. Schumacher in his 1973 book, *Small is Beautiful.*" He then goes on to say,

> Advocates of the small-is-beautiful view make many telling points . . . But for most people in most societies, growth is the way out of such miseries as hunger, severe heat and cold, disease, illiteracy and wars undertaken for plunder. Mere growth cannot alleviate suffering, but it can provide the necessary condition—capital, infrastructure, employment—for a social approach to alleviation. Growth in itself cannot bring abundance, leisure and convenience, but they are seldom to be had without it, and to oppose growth on the ground that it is aesthetically offensive or that we would all be better off leading simpler lives is to take a rather callous view of the human condition in those parts of the world—including sections of this country—where life tends to be simple indeed . . . To ask the poorer countries to conserve oil and to eschew nuclear energy is to ask them to accept continued poverty as a condition of their existence. To ask Americans to mark time until solar energy comes into our homes and factories is to resign ourselves to a rate of unemployment higher than the seven percent—far higher in some places and categories—that most find intolerable. (The prospect that such a proposal offers is of a society in which by the end of the century almost the entire industrial labor force is idle and the engines of agriculture are men and horses.)

Karl Deutsch, Professor of Peace at Harvard, puts the same thought this way:[57]

> . . . in order to keep life tolerable, we must continue to grow economically in the highly developed countries . . . The doctrine of ending growth here and now is a doctrine of civil war within most countries, and a doctrine of international war . . . The politics of the next 35 years will be, in sig-

The Need for Innovation

There is still a continuing great need for innovation in chemical technology. My friend, Robert Malpas, an executive director of ICI and former Chairman of ICI Europa, has written a paper recently on this topic, which he called *Chemical Technology–Scaling Greater Heights in the Next Ten Years?*[53] It is a very thought-provoking account of both the difficulties and the needs for chemical innovation. There are two charts he shows to illustrate some of his points, and I take the liberty of reproducing them (with permission). It is no coincidence, I feel, that Halcon is not only mentioned therein, but the second chart on "disinventing" seems to have been drawn with us in mind! He, too, addresses the organizational question, saying,

> . . . organizations must cater both for the optimization of existing assets and fundamental change. They probably need two different cultures existing within the same organization, staffed by different types of people. There must not be a conflict between the full utilization and improvement of existing technology and the creation of new. The first must finance the second, and the second is needed to remain profitable in the long run.

I agree with the conclusion contained in the final paragraphs of Mr. Malpas's

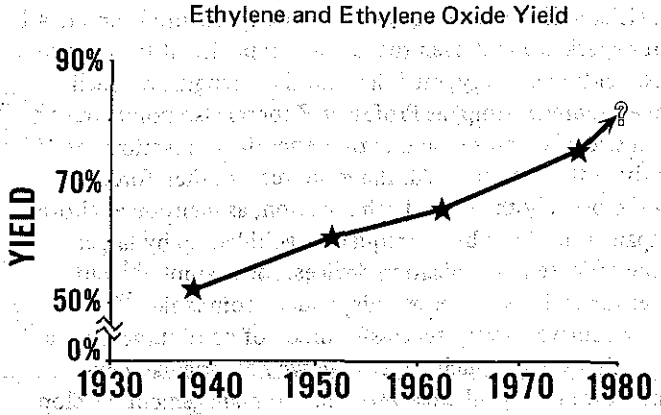


FIGURE 1 Ethylene oxide yields have improved greatly over the years, and they are still improving through better catalysts. Now Halcon International have proposed an alternative route through to ethylene glycol with even higher yields.

funded corporate pension fund liabilities, the problems of the Wall Street firms themselves, etc. Thus, investors today are emphasizing risk and return, rather than return exclusively. And if the risk premium is unusually great for investment in large companies, then it must become astronomically high for new risky enterprises, and this is why so few can "make it" or even get started today.

The former Chairman of the Council of Economic Advisers, Alan Greenspan, has also written about investment risk assessment by business today.[47] He says, "Thus, the critical focus of economic policy in the western world has got to be to reduce these abnormally high risk premiums. They have created a private decision-making atmosphere which gives short shrift to long-term benefits and costs and undue emphasis to the short run." He stresses that because most Western governments have been activist in policy and will not reduce such intervention overnight, it is all the more important to lower taxes on business and capital. These cuts, he says, are not a "permanent substitute for lowering risk, but to the extent that after-tax returns to capital are increased, they will offset some of the high-risk (discount) in the investment process . . .There is no substitute for a non-inflationary environment if prosperity is our goal." Another expression of this viewpoint was also contained in the *1977 Economic Report of the President* (p. 28).

I have been and am involved with many such investment decisions both as a shareholder and as a chief executive officer, and I can only confirm the truth spoken by these authorities on the subject. Entrepreneurial risks require a longer time horizon than is currently demanded by investment and uncertainty conditions today—about a four-year span, which accounts for the currently low price/earnings multiples. In a recent speech in Vienna[48] I amplified some of these subjects as they affect the international chemical industry investment patterns. Another example from current industrial real-life situations may be found in the aluminum industry. It is no secret that new technology is within reach to permit utilization of the abundant domestic clay resources instead of imported bauxite, which therefore would contribute greatly both to national security and the balance of payments. But the inflationary bias of our economy is reflected most acutely in the rapidly escalating costs of building new and risky capital projects of this kind. In addition, the long range policy of the US with regard to the structure of power costs and pricing, choice of fuels, environmental restrictions, forced recycling, etc., is undecided if not contradictory. Any such conversion of the aluminum industry to domestic raw materials requires not only adequate profitability expectations such as a closer approach to replacement pricing (taking the competition from other materials into account) but a reduction in the uncertainty levels so that longer range earnings need not be so heavily discounted as at present. There are examples like this throughout the US, in old as well as new enterprises.