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The Honorable Dale Bumpers
Chairman, Committee on Small Business
United States Senate

The Honorable John J. LaFalce
Chairman, Committee on Small Business
House of Representatives

The Honorable Robert A. Roe
Chairman, Committee on Science, Space, and Technology
House of Representatives

The Honorable John D. Dingell
Chairman, Committee on Energy and Commerce
House of Representatives

This report on the effectiveness of Phases I and II of Small Business Innovation Research (SBIR) programs is required by the Small Business Innovation Development Act of 1982, as reauthorized in 1986. In preparing this report, we sent questionnaires to firms carrying out 1,406 SBIR projects begun during fiscal years 1983 to 1985 and to 530 project officers at federal agencies.

Agencies differ in the emphasis they place on the SBIR program goals of meeting federal research and development needs and increasing private sector commercialization of federal research and development. All agencies seek to stimulate technological innovation and to encourage and foster participation by minority and disadvantaged firms. Overall, agency project officers assessed 29 percent of the SBIR projects as being of higher quality than other research under their responsibility and about half as being of the same quality. As required by law, we will provide a report on activities under Phase III of the SBIR programs in 1991.

This work was performed under the direction of Flora H. Milans, Associate Director. Other major contributors are listed in appendix XXVII.

J. Dexter Peach
Assistant Comptroller General

or monitor individual SBIR projects in conjunction with responsibility for other research.

Results in Brief

All agencies seek to stimulate technological innovation and to encourage and foster the participation of minority and disadvantaged firms, but the agencies differ in the emphasis they place on the remaining two SBIR goals. DOD and NASA emphasize meeting federal research and development needs with projects directed toward specific mission requirements. In contrast, programs at NSF and HHS focus on the SBIR goal of private sector commercialization and solicit projects within broader technological areas.

Overall, agency project officers assessed 29 percent of the SBIR projects as being of higher quality than other research under their responsibility and half as being of the same quality. Project officers differed from agency to agency in their overall assessment of research quality and in specific factors, such as the likelihood that projects will lead to new scientific or technical discoveries and the skills and expertise of the project staff. At all agencies, however, project officers rated SBIR projects as more likely than other research to lead to inventing and commercializing new products.

In general, the 11 agency heads that provided judgments concerning the effect of SBIR legislation on their research programs reported favorable impacts. Although they differed on specifics, most agencies reported that SBIR programs had developed new research areas, placed more emphasis on the application of research results, and led to wider use of small businesses as research performers.

Principal Findings

Meeting Program Goals

To stimulate technological innovation, SBIR programs have adopted procedures to identify and select technically superior and innovative proposals. Agency project officers consider many SBIR Phase II projects to be technologically innovative. Furthermore, firms responding to GAO's questionnaire reported that they probably or definitely would not have undertaken 64 percent of their SBIR projects without SBIR funding. According to the questionnaire responses, these projects are about as likely as other projects to result in patents or market testing, indicating

being of higher quality than non-SBIR research and indicated that about half of the SBIR projects were similar in overall quality to other research. Project officers at all agencies rated SBIR projects substantially higher than other research under their responsibility regarding the potential for leading to the invention and commercialization of new products, processes, or services, with NSF having the highest level. Agency project officers differed, however, on other factors, such as the likelihood that the project will lead to new scientific and technical discoveries.

Judgments of Department and Agency Heads

The heads of the 11 departments and agencies with SBIR programs reported generally favorable effects on agency research programs. For example, seven agencies identified ways in which SBIR programs help attain their research goals through filling gaps in other agency research programs, expanding in new research directions, and other means.

Recommendations

GAO is not making recommendations in this report.

Agency Comments

GAO asked the 11 agencies that conduct SBIR programs, as well as the Small Business Administration, to comment on a draft of our report. The agencies either had no comment on the report or expressed agreement with its contents.

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Abbreviations

USDA	Department of Agriculture
DOD	Department of Defense
DOED	Department of Education
DOE	Department of Energy
GAO	General Accounting Office
HHS	Department of Health and Human Services
DOT	Department of Transportation
EPA	Environmental Protection Agency
NASA	National Aeronautics and Space Administration
NSF	National Science Foundation
NRC	Nuclear Regulatory Commission
R&D	research and development
SBA	Small Business Administration
SBIR	Small Business Innovation Research

- the employer of 500 or fewer employees (including employees of subsidiaries and affiliates)
- the primary source of employment for the project's principal investigator at the time of award and during the period when the research is conducted, and
- at least 51 percent owned by U.S. citizens or lawfully admitted permanent resident aliens.

The SBIR legislation requires agencies to evaluate and fund SBIR proposals in a three-phase process. Proposals compete for SBIR funding in two phases. Phase I provides funds to test the proposal's scientific and technical merit and its feasibility. After completion of Phase I, the highest rated proposals are selected for Phase II, which provides funds for further development of the proposed ideas. Phase III consists of either nonfederal funding or federal, non-SBIR, funding for commercial applications of the research conducted under the SBIR programs. According to SBA directives, most Phase I awards should be for $50,000 or less and cover a 6-month work period, while most Phase II awards should be for no more than $500,000 and cover up to 2 years of work.

In addition to the $1 billion provided for fiscal years 1983-87, as shown in table 1.1, SBA has estimated that agencies awarded $350 million for fiscal year 1988 SBIR projects, for a total of about $1.35 billion through fiscal year 1988. Table 1.1 shows the number of SBIR awards that have been made and funding levels through fiscal year 1987, the last year for which detailed data are available.

Table 1.1: Data on SBIR Programs by Fiscal Year, All Agencies

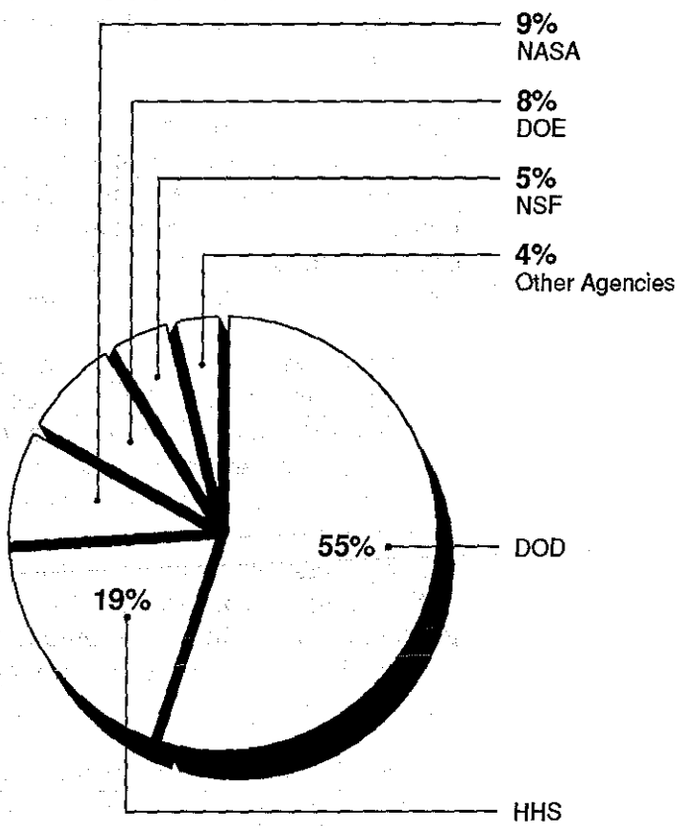
Dollars in thousands

Fiscal year	Proposals received	Phase I awards	Phase II awards	Amount of Phase I and Phase II awards[a]
1983	8,814	686	74	$44,458
1984	7,955	999	338	108,442
1985	9,086	1,397	407	199,129
1986	12,449	1,945	564	297,888
1987	14,712	2,189	768	350,468
Total	**53,027**	**7,216**	**2,151**	**$1,000,385**

Source: SBA, Office of Innovation, Research, and Technology 1983-87 Annual Reports.

[a]SBIR legislation (P.L. 97-219) established a gradual phase-in period, so the percentage of funds set aside for SBIR increased until fiscal year 1987, when all agencies were required to set aside 1.25 percent of their extramural R&D obligations.

Figure 1.1: SBIR Funding by Agency



Source: Small Business Innovation Development Act: Fifth Year Results, SBA (June 1988).

GAO's Prior Reports and Legal Opinion

Between October 1985 and July 1987 we issued four reports on SBIR programs concerning compliance with funding requirements, selection and funding procedures, the characteristics and opinions of participating firms, and other issues. In addition, we issued a legal opinion in 1988 in which we concluded that federal agencies were not precluded from voluntary participation in SBIR.

In an October 25, 1985, report entitled Implementing the Small Business Innovation Development Act—The First 2 years (GAO/RCED-86-13), we assessed the extent to which agencies established, funded and monitored SBIR program activities. We found that in fiscal years 1983 and 1984, 11 out of the 12 federal agencies that met the criteria for creating SBIR programs had established such programs. During fiscal year 1985, all 12 eligible agencies had carried out SBIR activities. We concluded that the agencies, for the most part, were complying with the act's funding

- the quality of the research supported by the SBIR program compared with that traditionally supported by the affected agencies, and
- the judgments of the heads of departments and agencies as to the effect of SBIR legislation on research programs.

Public Law 99-443 requires GAO to report on SBIR Phase III activities by December 31, 1991. Accordingly, this report includes only preliminary information on this aspect of SBIR activities.

To obtain information on the SBIR program goals of stimulating technological innovation and increasing private sector commercialization and to obtain information on current project status, we selected 1,406 SBIR projects that had been conducted in fiscal years 1983 through 1985, according to a stratified sampling plan described in appendix V. We mailed the firms that conducted these projects a questionnaire asking for information about the firms' experiences with the SBIR program and the characteristics of the firm at which the project took place. We adjusted the analysis of responses to reflect the stratification of the project sample, as described in appendix V. The questionnaire, summary of responses, response rate, and selected sampling errors are included in appendix II.

To obtain information on the goals of stimulating technological innovation and meeting federal R&D needs, as well as the quality of SBIR research projects in comparison with other research supported by R&D agencies, we mailed two types of questionnaires to 530 project officers who had administered SBIR projects in DOD, DOE, HHS, NASA, and NSF—agencies that together administer 96 percent of all SBIR funds. All project officers received one questionnaire asking for responses concerning the SBIR program in general, as well as one or more questionnaires concerning individual SBIR projects that they had been responsible for. The questionnaire concerning individual SBIR projects asked the project officers to compare the SBIR project with non-SBIR research for which they were responsible. To measure research quality, we asked project officers to compare specific SBIR projects with other research that they were responsible for according to factors that we identified as potentially relevant to research quality by consulting science policy experts, reviewing published material, and pretesting questionnaires. To obtain information concerning incomplete or unclear responses, we followed up with telephone calls to selected respondents to all three questionnaires. The questionnaire concerning the SBIR program in general, together with a summary of responses and response rate, is included in appendix III. The questionnaire about individual SBIR projects, with responses and

Are SBIR Programs Meeting Their Goals?

Three of the four SBIR program goals—to stimulate technological innovation, use small business to meet federal R&D needs, and increase private sector commercialization of innovations from federal R&D—are complex, interrelated, and hard to measure. For example, the development of new technological innovations may be critical to meeting federal R&D needs. Private sector commercialization, which depends on the development of new technological innovations, may contribute to meeting federal R&D needs in areas such as health or aeronautics. Although all agencies seek to stimulate technological innovation, agencies differ in the emphases they place on meeting federal R&D needs and on increasing private sector commercialization of federal R&D.

SBA and agencies with SBIR programs seek to achieve the fourth SBIR program goal—to foster and encourage participation by minority and disadvantaged persons—through outreach programs to inform them about SBIR activities. According to data compiled by SBA, the percentage of money awarded to minority and disadvantaged firms was lower in fiscal years 1986 and 1987 than in the 2 previous fiscal years, but SBA officials believe that the data may contain some inaccuracies because of inconsistent reporting by participating firms.

DOD and NASA have SBIR programs that strongly emphasize the goal of meeting federal R&D needs by soliciting and funding projects that are closely coordinated with agency applied R&D programs to meet agency mission objectives. In contrast, programs at NSF and HHS emphasize the selection of projects with high potential for private sector commercialization within broad technological categories of interest to these agencies, and SBIR projects are less closely coordinated with other agency programs, which focus mainly on basic research at academic institutions. SBIR programs at other agencies, such as DOE, seek—like DOD and NASA—to meet specific agency R&D objectives with some projects but also try to support private sector commercialization with other projects.

Stimulating Technological Innovation

Technological innovation is a complex, hard to measure process, and federal agencies seek to stimulate technological innovation in many different areas. Although difficult problems in assessing technological innovations exist, and only limited comparisons are possible across the wide range of federal efforts to stimulate innovations, several factors indicate that SBIR programs have been supporting projects that contribute to technological innovation.

Some innovative firms will file many patent applications, while others will prefer to retain trade secrets.

Because of the wide diversity in the R&D responsibilities of federal agencies, the agencies seek to encourage innovation in many different technological areas, making comparisons difficult. NASA, for example, seeks innovation in areas related to aeronautics and astronautics, such as new aircraft designs, power systems for spacecraft, and lightweight construction methods. Similarly, DOD, DOE, HHS, and other agencies try to develop new technologies that can help them meet mission responsibilities in areas such as defense, energy, and health.

In addition to supporting technological innovation to meet a wide range of mission responsibilities, agencies also support research to improve fundamental scientific knowledge that can ultimately lead to technological innovations. NSF funds basic research at universities in a wide range of disciplines, while HHS provides almost all federal support for basic research in biological areas related to health needs, and DOE is responsible for basic research concerning high energy and nuclear physics. Other agencies also fund lesser amounts of basic research.

Selection of SBIR Projects

SBIR programs seek to promote technological innovation primarily through the identification and funding of project proposals with high scientific and technical merit. SBA has established the following criteria, which must be considered in the evaluation of Phase I and Phase II SBIR proposals:

- the technical approach and the anticipated benefits to be derived from the research,
- the adequacy of the proposed effort and its relationship to fulfilling the requirements of the research topic or subtopics,
- the soundness and technical merit of the proposed approach and its incremental progress toward topic and subtopic solution, and
- qualifications of the proposed principal investigators.

When Phase II proposals are of equal technical and scientific merit, special consideration is to be given to proposals that demonstrate commitments from nonfederal sources to support further development after completion of Phase II (Phase III follow-on funding commitments). An SBA official said that a main purpose of these criteria is to identify proposals of high technical merit that are likely to lead to innovations. In addition to directing use of these criteria, SBA encourages SBIR programs

Table 2.1: SBIR Proposal Selection Rate, Fiscal Years 1983-87

Fiscal year	Phase I proposals	Phase I awards	Percentage receiving awards
1983	8,814	686	8
1984	7,955	999	13
1985	9,086	1,397	15
1986	12,449	1,945	16
1987	14,723	2,189	15

Source: SBA.

Only a small fraction of all SBIR proposals obtain substantial SBIR funding. As table 2.1 shows, since 1984, about 15 percent of the proposals have received the relatively small Phase I awards. In fiscal year 1987, only 35 percent of the projects completing Phase I were selected for the larger Phase II awards. Thus, only about 5 percent of all proposals received Phase II funding in 1987.

SBIR Project Officer Responses Concerning Technological Innovation

Our mail questionnaires asked SBIR project officers to assess (1) how well SBIR programs stimulate technological innovation, (2) whether individual SBIR projects were innovative, and (3) whether individual SBIR projects were more likely than other research for which the officer was responsible to lead to innovation and commercialization. As table 2.2 shows, a large majority of project officers responded that the SBIR program definitely or probably supports technological innovation. The percentage of project officers that thought that the SBIR program certainly or probably helped stimulate technological innovation was highest at NASA (89 percent), followed by DOD (88 percent), DOE (78 percent), HHS and NSF (73 percent each).

Table 2.2: Project Officer Responses Concerning SBIR Support of Technological Innovation

Project officer response for all agencies	Percentage
Definitely yes or probably yes	83
Uncertain	12
Definitely no or probably no	5

Source: GAO questionnaire.

When we asked about specific Phase II SBIR projects that the officers had managed, 23 percent of the project officers rated the project as very innovative, while 38 percent believed their project was moderately innovative. Only 5 percent reported that the project that they managed was not innovative at all. Project officers at different agencies again varied in their assessments of individual projects. NASA project officers rated

Table 2.3: Firm Responses Concerning Indicators of Innovation for SBIR Projects That Have Completed Phase II

Percent of Projects

Result	Completed projects that probably or definitely would not have been undertaken without SBIR funding	Other completed SBIR projects
Firm is continuing R&D	46	55
Journal papers and/or conference paper being prepared	43	37
Patent applied for but not received	26	23
Patent received	19	19
Project results being market tested	17	14
Project results being sold commercially	20	34

Source: GAO questionnaire.

As table 2.3 shows, firms reported that projects that probably or definitely would not have been undertaken without SBIR funding were about as likely as other SBIR projects to produce patent applications and lead to market testing. These projects were, however, somewhat less likely to result in continuing R&D or have results that were being sold commercially.

To determine whether SBIR programs encouraged firms to invest additional resources in R&D after completion of SBIR funding, we asked firms about the current status of SBIR projects. Firms responding to our questionnaire indicated that SBIR programs encouraged them to continue R&D using their own funds. Firms reported that they are continuing R&D on 49 percent of all SBIR projects that have completed Phase II. In addition, some firms have decided to continue R&D when projects did not receive a Phase II award. Firms reported continuing R&D on 34 percent of the projects that did not receive Phase II funding.

In comments added to their questionnaire responses, several SBIR awardees told us that especially risky efforts would not have been undertaken by their firms without SBIR support. For example, one firm said that SBIR funding from DOE had helped it develop a new medical device to the stage at which it could be demonstrated to the private sector. A second company with an SBIR project investigating the use of X-rays noted that the program's support had allowed it to develop projects that investors were often unwilling to back.

Agencies Differ in Management of SBIR Programs

The difference in how agencies seek to meet R&D needs is reflected in how they solicit, select, and manage SBIR proposals. For instance, DOD's annual SBIR solicitation identifies specific tasks in hundreds of different technical areas, such as the design of body armor, self-sealing truck radiators, and underground chemical storage technology. In contrast, NSF's annual solicitation simply lists about 20 general scientific areas, such as materials research and advanced scientific computing, with a few examples of potential projects from each, and encourages any proposals that fall under these general headings. The National Institutes of Health, which manage almost all HHS research, have a policy of considering any proposal in the health area, whether or not it is responsive to a research area specified in its solicitation.

In addition to differing in the solicitation of proposals, agencies also differ in how they rank SBIR proposals for funding. DOD and NASA follow a decentralized approach in which research managers throughout the agency rank proposals for funding. NSF and HHS use a more centralized approach that relies upon experts from outside the agency to rank projects. At DOE, SBIR proposal reviews are carried out by experts from both inside and outside the agency.

Agencies also differ in their management of SBIR projects. As table 2.4 shows, project officers at DOD and NASA are much more likely to stay in close touch with SBIR awardees over the course of the research project than those in NSF and HHS. DOD and NASA SBIR program managers told us that their agency project officers normally stay in close contact with SBIR and other research contractors to monitor mission-related applied research. In contrast, NSF and HHS project officers normally have less contact with grant recipients because there is no direct agency oversight of research, according to SBIR managers at these agencies.

Table 2.4: Responses Concerning Frequency of Monitoring SBIR Projects

Percent of Responses

Agency	Four or more times per year	Fewer than four times per year
DOD	93	7
NASA	94	6
DOE	49	51
HHS	23	77
NSF	7	93

Source: GAO questionnaire.

closely related to agency programs to support basic research in universities, fewer project officers believe that SBIR programs are meeting agency R&D needs.

When asked about specific projects, officers responded that 23 percent of the projects had made a great or very great contribution to agency R&D goals, while another 65 percent had made at least some contribution. As table 2.6 shows, project officers at DOD and NASA were more likely than those at other agencies to judge their projects as making a large contribution to agency R&D goals.

Table 2.6: Responses Concerning the Extent That Individual SBIR Projects Have Contributed to the R&D Goals of the Agency

Percent

	Agency					
Contribution	DOD	NASA	DOE	HHS	NSF	All agencies
Very great or great	30	36	12	11	8	23
Moderate	44	42	37	38	31	41
Some	18	15	33	34	37	24
Little or no	8	7	18	17	25	12

Source: GAO questionnaire.

Comments provided by project officers on their questionnaires indicate that DOD and NASA SBIR projects contributed to R&D goals by meeting specific R&D objectives. For example, an Air Force monitor said that one SBIR project had contributed by significantly advancing bearing technology for turbine engines. A NASA project officer said that a project to develop a new cooling procedure had made a moderate contribution by helping develop new ways to shield superconducting magnets. Because NSF does not direct SBIR projects toward specific research objectives, project officer comments identified general, rather than specific, benefits to the agency. One project officer, for example, said that research on a new chemical process made some contribution to meeting agency research goals. He noted that the SBIR mission did not exactly coincide with NSF's basic science orientation but that the SBIR effort to apply science was healthy for the agency.

A larger proportion of project officers at NASA and DOD than at the other three agencies identified the SBIR program as a moderately or very important element of their agency's overall research program—69 percent at NASA and 65 percent at DOD. At DOE, 40 percent believed SBIR was a moderately or very important research program element; at HHS, 32 percent; and at NSF, 28 percent.

risk than comparable non-SBIR projects. For example, a NASA project officer commented that a project to predict rotary wing (helicopter) hover performance had made a very great contribution by providing new technology that would not otherwise have been obtained because it was too risky and too expensive to have been supported without the SBIR program. He reported that the new analysis is being used to support a variety of research efforts in NASA and other agencies as well. In contrast, project officers in HHS, NSF, and DOE regarded their SBIR projects as having about the same level of risk as non-SBIR projects.

In our interviews of SBIR program managers, they identified several ways in which their SBIR programs seek to meet needs that were not being met by other agency R&D programs. SBIR programs can be used to support research in technologies for which few immediate benefits appear likely. For example, between 1983 and 1986, DOD, DOE, and NSF supported some SBIR projects on superconductivity, a research area regarded at the time as having little immediate payoff.

In addition, the NSF program manager stated that the SBIR solicitation process, through simplified proposals and expedited review can allow an agency to respond rapidly to new developments. For example, when the discoveries of high temperature superconductivity were confirmed in December 1986, SBIR solicitations allowed agencies to respond quickly by expanding support in this area. DOE had included superconductivity as a topic in its solicitation for proposals due November 1986 and decided to fund a much larger share of those proposals as a result of the developments.

SBIR funding has also been used to support a wide array of technologies. In particular, DOD has used the SBIR program to examine a wide variety of alternative technological approaches as part of the strategic defense initiative.

Private Sector Commercialization of Innovations From Federal R&D

The 1986 SBIR reauthorization directed GAO to make a comprehensive study of SBIR commercialization by December 31, 1991. Accordingly, we did not at this time seek from firms with SBIR projects the information needed to make a thorough analysis of the extent and nature of commercial products and services that have resulted from the projects. We focused instead on how agencies seek to meet the goal of commercial innovation in their selection of projects for their SBIR programs and have also provided some preliminary information concerning the relatively small number of SBIR projects that have completed Phase II.

As noted earlier, agencies with SBIR programs differ in the emphasis they place on commercial potential in selecting SBIR proposals for funding. For example, in making awards for Phase II, NSF places very heavy emphasis upon a proposal's plan for commercial development. In contrast, when NASA selects projects for Phase II, it emphasizes whether the proposed research will meet the agency's research needs and uses commercial potential as a tie-breaker. Unlike NSF, NASA can and does provide the opportunity for follow-on funding by other agency R&D programs.

SBIR legislation requires that when two Phase II proposals are of approximately equal scientific merit, agencies give special consideration to those proposals that submit a nonfederal follow-on funding commitment with their proposal. In funding Phase II SBIR projects, NSF places heavy emphasis on whether the project has a follow-on funding commitment. NSF considers all proposals rated as "very good," its second highest rating category, to be of equal merit and requires these proposers to submit nonfederal funding commitments. These commitments consist of agreements by industrial corporations or other organizations to provide additional development funds for the project if it successfully completes Phase II. For a group of projects initiated in response to a fiscal year 1984 solicitation, 45 of the 49 proposals that received Phase II awards had follow-on funding commitments that had been reviewed and found acceptable by NSF officials.

At other agencies, follow-on funding commitments are much less important in making Phase II awards. Most SBIR program managers stated that they did not have tie-breaking situations and any commitments that proposers submitted were simply used as additional information in the selection process. At DOE and HHS, for example, follow-on funding commitments and other plans for commercial development are given some consideration in deciding which proposals to fund in Phase II, but many projects are funded without such commitments. At DOD and NASA, SBIR program managers said that funding commitments are rarely considered in making awards. NASA's SBIR program manager told us that Phase II proposals are evaluated by headquarters staff to determine whether the project will meet specific NASA needs for research and technology and only rarely was a follow-on funding commitment used to decide on funding a Phase II project. DOD program managers could not remember ever using follow-on funding agreements in selecting proposals.

We also obtained information on some activities that indicate efforts by firms to commercialize the results of projects that have completed Phase II. For example, firms reported that they were market testing results from 16 percent of the projects and that production rights had been sold or licensed for 11 percent of these projects. Firms had formed strategic partnerships, such as joint ventures, and R&D limited partnerships as a result of 18 percent of the completed projects. (Because the same project may be included in more than one of the above categories, these percentages cannot be added together.)

During fiscal year 1988, SBA began a multiyear study to assess the extent to which SBIR participants have commercialized, or are attempting to commercialize, the results of Phase II SBIR projects. On the basis of a sample of completed projects that were begun in fiscal year 1983, SBA reported preliminary results that indicate that some commercialization has occurred—for about 10 percent of the projects, sales have actually resulted from R&D conducted in the SBIR program. For an additional 10 percent of the projects, SBA reports that commercialization is likely because the company has received capital, or a commitment for capital, or signed an agreement for assistance in commercialization. In another 20 percent of the projects, companies were actively pursuing commercialization possibilities.[3]

In addition, SBA reported that for 45 percent of the projects, companies were interested in commercialization but had taken little or no action toward that goal. Commercialization was not expected in the remaining 15 percent of the projects.

Follow-On Funding Commitments

We asked firms about follow-on commitments from nonfederal sources to provide funds after Phase II. Overall, 34 percent of the projects in our survey selected for Phase II had obtained follow-on commitments. The largest number of these commitments (27 percent) was in the range from $100,000 to $250,000. The most common source of these commitments was the firm's own internal funds, followed by other firms and venture capital institutions. The percentage of Phase II projects with nongovernment follow-on commitments ranged widely by agency, from 68 percent at NSF to 18 percent at DOD.

Of the projects that had completed Phase II, 31 percent had received follow-on funding commitments. Of the completed projects with follow-

[3]Fifth Year Results, SBA (Washington, D.C.: June 1988).

- whose management and daily business operations are controlled by one or more of such individuals.

A minority and disadvantaged individual is defined as a member of any of the following groups: Black Americans, Hispanic Americans, Native Americans, Asian-Pacific Americans, and Subcontinent Asian Americans.

According to SBA data, the percentage of money awarded minority and disadvantaged small businesses was lower in fiscal years 1986 and 1987 than in previous years. However, SBA officials believe that firms have little incentive to report their minority status correctly and that the data on minority firm participation in SBIR may contain some inaccuracies.

The amount of SBIR money awarded to minority and disadvantaged firms increased each year from fiscal years 1984 through 1987. (See table 2.7.) When compared with total money awarded to small business, minority and disadvantaged firms received about 12 percent in 1984 and 1985 and about 8.5 percent in 1986 and 1987. The percentage of Phase I SBIR awards received by minority and disadvantaged firms remained about the same for fiscal years 1985 to 1987, but the percentage of Phase II awards received by these firms was lower in fiscal years 1986 and 1987 than it was in 1985.

Table 2.7: Participation in SBIR by Minority and Disadvantaged Firms

	Phase I awards to minority and disadvantaged firms		Phase II awards to minority and disadvantaged firms		Total awards to minority and disadvantaged firms	
Fiscal year[a]	Awards	Percent of Phase I awards	Awards	Percent of Phase II awards	Awards	Percent of total awards
1984	$4,103,000	8.5	$9,351,000	15.5	$13,454,000	12.4
1985	8,458,800	12.2	14,648,600	11.3	23,107,400	11.6
1986	11,184,300	11.4	14,066,000	7.0	25,250,300	8.4
1987	12,782,000	11.7	17,510,000	7.3	30,292,000	8.6

[a]Comparable data are not available for 1983.
Source: SBA, SBIR Annual Reports, 1984-1988.

SBA officials believe, however, that the minority award amounts reported may not be accurate. Firms report minority and disadvantaged status voluntarily on their proposals, and SBA has identified cases in which individual firms have been inconsistent, identifying themselves as minority and disadvantaged on some proposals but not on others. Because minority and disadvantaged firms do not receive preference in

Chapter 3

Quality of SBIR Research Projects

Overall, 29 percent of the SBIR projects were judged to be of higher quality than other agency research, and 50 percent were judged as of similar quality. However, project officers judged SBIR projects differently on some factors important to research quality, and officers differed among agencies in how SBIR projects were rated. For example, project officers at all agencies rated SBIR projects higher than other agency research concerning the likelihood that the project will lead to inventing and commercializing new products, processes, or services. Agency project officers differed on other factors, however, such as the likelihood that the project will lead to new scientific and technical discoveries. Many of the important differences among agencies paralleled the differing emphasis on SBIR program objectives that was described in chapter 2.

In reauthorizing SBIR programs in 1986, the Congress asked us to report on how the quality of SBIR research projects compares with other research supported by each agency. To measure research quality, we sent questionnaires to project officers responsible for overseeing and monitoring SBIR and other research projects at the five agencies responsible for 96 percent of SBIR funds. We asked them to compare the quality of specific SBIR research projects with other research that they manage.

Measuring Research Quality

We identified techniques that had been developed to assess research quality but determined that they were not appropriate to our needs. According to the Office of Technology Assessment, the only quantitative measure of research quality is by analyzing research publications through techniques such as citation analysis.[1] Because SBIR projects involve applied research and do not usually produce scientific articles, this way of measuring research quality was not appropriate to our needs.

Chapter 2 discussed some ways in which agencies try to ensure the quality of their SBIR research projects. Agency project selection procedures, for example, seek to identify and fund SBIR proposals of high scientific and technical merit. In addition, agencies make some use of follow-on funding agreements as a way to identify proposals of high potential for commercial development.

[1]Citation analysis measures the number of times a scientific article is referred to in subsequent research articles and is intended to show how useful the research has been to other scientists. See Research Funding As an Investment: Can We Measure the Returns? Office of Technology Assessment (Washington, D.C.: April 1986).

the projects were judged to be better than other research, while 27 percent were judged to be worse. Responses concerning the likelihood that the project will lead to inventing and commercializing new products, processes, or services were more positive than for other factors. For this factor, most projects (53 percent) were regarded as better than other research, while 29 percent were judged about the same. About 12 percent were judged worse than other research.

Table 3.1: Questionnaire Responses Concerning SBIR Project Quality in Comparison With Non-SBIR Research

Percent

Factor	Much better	Somewhat better	About the same	Somewhat worse	Much worse	Unable to judge/ not applicable/no response
Overall quality of the project	6.1	22.6	50.4	16.1	2.5	2.5
Likelihood that the project will lead to inventing and commercializing new products, processes, or services	17.5	35.7	28.9	9.3	2.2	6.3
Likelihood that the project will lead to new scientific/technical discoveries	6.2	21.1	47.2	18.1	3.8	3.6
Quality of scientific/technical outputs resulting from the project (patents, licensing agreements, research articles, conference presentations, etc.)	6.4	20.8	44.4	16.4	3.5	8.5
The skills and expertise in the scientific/ technical area addressed by research	8.7	20.7	57.2	11.3	0.7	1.4
Appropriateness of experimental and analytical methods used	4.5	16.4	66.6	9.4	1.0	2.2
Scientific/technical facilities and resources	2.5	11.6	55.3	23.4	3.7	3.7
Effectiveness of the management and organization of the project	4.6	18.5	55.0	14.9	2.9	4.1
Creativity in carrying out the project	10.9	24.0	49.9	9.6	2.2	3.5
Dedication of the research team in conducting the project	13.7	22.9	47.5	9.3	1.9	4.8

Source: GAO questionnaire.

Differences Among Agencies Regarding SBIR Project Quality

Although most SBIR projects were judged to be about the same overall quality as other research, the pattern of responses differed among the agencies covered by our questionnaires. In general, these differences in agency response paralleled the differences in emphasis on SBIR goals that were described in chapter 2. At DOD and NASA, agencies that emphasize the SBIR goal of meeting federal R&D needs, project officers rated SBIR projects high on almost all factors in comparison with other research. In contrast, HHS and NSF project officers rated SBIR projects very high concerning the likelihood of private sector commercialization, a goal that

Table 3.2: Analysis of Project Officer Responses Concerning SBIR Quality

Factor	NASA	DOD	DOE	HHS	NSF	OVERALL
Overall quality of the project	.33	.31	.03	−.15	−.25	.14
Likelihood that the project will lead to inventing and commercializing new products, processes, or services	.65	.52	.59	.65	.96	.61
Likelihood that the project will lead to new scientific/technical discoveries	.28	.23	−.03	−.15	−.34	.08
Quality of scientific/technical outputs resulting from the project (patents, licensing agreements, research articles, conference presentations, etc.)	.19	.22	.03	−.01	−.27	.11
The skills and expertise in the scientific/technical area addressed by research	.44	.42	.13	.01	−.15	.26
Appropriateness of experimental and analytical methods used	.23	.27	.05	−.05	−.09	.14
Scientific/technical facilities and resources	.01	−.16	−.11	−.14	−.42	−.14
Effectiveness of the management and organization of the project	.15	.08	.08	−.03	.09	.07
Creativity in carrying out the project	.53	.54	.19	−.04	−.12	.33
Dedication of the research team in conducting the project	.57	.53	.31	.07	.09	.39

Note: Individual questionnaire responses were assigned numerical values to develop an overall agency evaluation, as follows:

Much better than other agency research	2
Somewhat better than other agency research	1
About the same as other agency research	0
Somewhat worse than other agency research	−1
Much worse than other agency research	−2

Source: GAO questionnaire.

At one extreme, NASA project officers rated SBIR projects higher than other research on all factors. DOD's responses are close to, but not quite as positive as, those from NASA. DOD project officers rated SBIR projects better than other research on all but one factor: scientific/technical facilities and resources.

At the other extreme, NSF project officers rated SBIR projects as lower in research quality than other projects overall and lower on six of the nine specific factors. HHS project officers were negative in their overall comparison of SBIR research quality to other agency research and very close to neutral on six of the remaining nine factors. NSF and HHS project officers were, however, very positive concerning the likelihood that SBIR projects would lead to invention and commercialization.

Table 3.4: Differences in Assessments of Research Quality According to Amount of Non-SBIR R&D Time Spent on Basic Research

Percent

Factor	Percentage of SBIR projects rated somewhat better or much better than other research	
	Project officers spending all, or almost all, non-SBIR research time on basic research	Other project officers
Overall quality of the project	20	35
Likelihood that the project will lead to inventing and commercializing new products, processes, or services	59	57
Likelihood that the project will lead to new scientific/technical discoveries	21	32
Quality of scientific/ technical outputs resulting from the project (patents, licensing agreements, research articles, conference presentations, etc.)	22	34
The skills and expertise in the scientific/ technical area addressed by research	21	34
Appropriateness of experimental and analytical methods used	12	26
Scientific/technical facilities and resources	9	17
Effectiveness of the management and organization of the project	20	26
Creativity in carrying out the project	22	42
Dedication of the research team in conducting the project	28	43

Source: GAO questionnaire.

For all but one of the factors in table 3.4, project officers who spent all, or almost all, of their Non-SBIR R&D time on basic research were less likely than other project officers to regard their SBIR projects as better than other research for which they were responsible. For example, 20 percent of the project officers who spent all, or almost all, of their non-SBIR time on basic research said that the SBIR project was of better overall quality than other research, compared with 35 percent of other project officers. However, the project officers who spent all, or almost all, of their non-SBIR project time on basic research were about as likely as the others to assess their SBIR project as more likely than other research to lead to inventing and commercializing new products, processes, or services.

that SBIR gave research managers the opportunity to explore new and innovative approaches to their problems and to obtain expertise not available in-house, while NSF said that SBIR projects had led to the development of instruments and testing procedures to support basic scientific research.

Emphasis on Using Research Results

SBIR programs have produced greater emphasis on the application of research results, in the opinion of six agencies. According to NSF, the SBIR program has "served an important technology transfer function between university and industry research," with more than half of its SBIR projects involving university faculty. HHS believes that SBIR has been instrumental in linking industry researchers with academic investigators by providing an incentive to collaborate, leading to more rapid technology transfer. USDA and DOED also identified SBIR projects as a mechanism for commercializing the results of basic research. DOD noted that the SBIR program helps transfer technology by creating networks among SBIR contractors, government, and academia. NASA stated that SBIR projects had an excellent record in producing useful results for the agency.

Small Businesses as Research Performers

Six agencies highlighted that SBIR provided opportunities to small businesses that had not been provided by other agency research programs. According to DOE, "in almost all Departmental areas the breadth of participation by small business has significantly increased the pool of scientists and engineers now contributing to DOE research." In addition, USDA said that the small business research community that applies to the SBIR program is completely different from that which applies to the agency's main extramural research program. Of the 1,653 proposals received for USDA's main research program in fiscal year 1987, only 8 were from private, profit-seeking organizations while all SBIR proposals are from this type of organization. Similar observations were made by DOT and HHS. DOD and NASA noted that their SBIR programs had helped small businesses become useful performers of agency research.

Agency Comments on Our Draft Report

We asked the 11 agencies that now operate SBIR programs, as well as SBA, to comment on our draft report. Ten agencies provided written responses, which are included in appendixes XVII through XXVI. Although NASA and NSF did not respond in writing, we discussed the draft report with agency SBIR program managers at these agencies.

Questionnaire to Firms With SBIR Projects

U.S. GENERAL ACCOUNTING OFFICE (1-5)
SURVEY OF SMALL BUSINESSES' INVOLVEMENT IN THE 005738 (6-11)
SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM

INTRODUCTION

The U.S. General Accounting Office, an independent agency of the U.S. Congress, is developing information on the Small Business Innovation Research (SBIR) Program's effect on small, high technology firms. This questionnaire is a follow-up to one distributed in 1986, which you may have received. These questions cover specific information about your SBIR project and general information about your firm.

All questions can be answered by simply checking a box or writing in a small amount of information. The questionnaire is based on our discussions with several small businesses.

Your answers will be combined with those of other firms and reported in summary form only. This information will be included in a report to Congress, which will be mailed to all firms that respond to this questionnaire.

Please complete the questionnaire and return it in the enclosed envelope. Your response within 14 days of receipt will help us avoid costly follow-up mailings. If you have questions about any specific items in the questionnaire, please call Joshua Lerner collect at (202) 634-4707. In the event that the envelope is misplaced, please return your completed questionnaire to:

Mr. Joshua Lerner
U.S. General Accounting Office
441 G Street N.W., Room 4476
Washington, D.C. 20548

Thank you for your cooperation in making our review as complete and accurate as possible.

Please fill in the name, title, and phone number of the person completing all (or most) of this form.

Name: _____

Title: _____

Phone number: _____

NOTE: RECORDS SHOW THAT YOUR FIRM RECEIVED THE FOLLOWING SBIR AWARD. PLEASE BASE YOUR RESPONSES TO QUESTIONS 1-20 ON THIS ONE PROJECT EVEN IF YOU RECEIVED OTHER SBIR AWARDS.

Questionnaire Response Data

Universe = 3,241
Projects Selected = 1,406
Responses Received = 1,113
Response rate = 79.2%

(Percentages are adjusted to reflect stratification of sample--see app. V.)

1. What is the current status of your SBIR project? (Please check all items that apply in the list below.) (12-20)

	%	
1.	10.6 (1.5)[a]	Result is being sold commercially
2.	9.1 (1.5)	The result is being market-tested
3.	20.1	This firm is contacting potential investors
4.	53.8 (2.6)	This firm is conducting research and development
5.	5.2	Another firm is conducting research and development
6.	5.2	Project dropped because it was not technically feasible
7.	10.0	Project dropped because it was not commercially viable
8.	32.7 (2.4)	Journal papers and/or conference presentations being prepared
9.	28.1	Other (PLEASE SPECIFY) (21)

[a]Numbers in parentheses represent sampling errors.

7. About the time you made your Phase II application, did you have a commitment for follow-on funding to commercialize this SBIR project after the research was completed? [Follow-on funding could include equity participation, commitment to purchase product, or a loan commitment.] (CHECK ONE)

Because of questionnaire directions, only 960 answered this question. 2/ (42)

1. 32.9% Yes (CONTINUE WITH QUESTION 8) (2.5)
2. 67.1 No (SKIP TO QUESTION 12)

8. What have been the sources of your follow-on funding commitment? (CHECK ALL THAT APPLY)

Because of questionnaire directions, only 362 answered this question. 2/ (43-51)

1. 13.7% Venture capital institution
2. 5.3 Bank
3. 45.2 Other private firm
4. 6.3 Follow-on contract with federal agency
5. 4.0 State or local government
6. 0.8 College or university
7. 51.3 Company's own internal funds
8. 8.0 Personal funds
9. 8.6 Other investment sources

9. What was the total value of all sources for the follow-on funding commitment for this project? (CHECK ONE)

Because of questionnaire directions, only 346 answered this question. 2/ (52)

1. 8.4% Under $25,000
2. 27.5 $25,000 to $99,999
3. 26.8 $100,000 to $249,999
4. 21.3 $250,000 to $499,999
5. 16.0 $500,000 or more

10. What portion, if any, of all follow-on funding commitments has been fulfilled at the present time? (CHECK ONE)

Because of questionnaire directions, only 353 answered this question. 2/ (53)

1. 16.9% All or almost all
2. 7.3 More than half
3. 7.9 About half
4. 9.7 Less than half
5. 58.2 Little or none

11. Did you include a letter or statement attesting to a follow-on funding commitment with your Phase II application? (CHECK ONE)

Because of questionnaire directions, only 363 answered this question. 2/ (54)

1. 80.9% Yes
2. 11.0 No
3. 8.1 Don't know

12. Did your firm receive a Phase II award for this project? (CHECK ONE)

Because of questionnaire directions, only 959 answered this question. 2/ (55)

1. 63.2% Yes (CONTINUE WITH QUESTION 13) (2.7)
2. 34.4 No (SKIP TO QUESTION 16) (2.6)
3. 2.4 Don't know yet (SKIP TO QUESTION 16) (0.9)

2/ Percentages are adjusted to reflect stratification of sample. See app. V.

17. Please indicate for each of the following whether or not your firm has obtained this benefit as a result of this SBIR project. (CHECK "YES", "NO", OR "TOO EARLY TO TELL" FOR EACH ITEM a. - f.)

(73-78)

	YES (1)	TOO EARLY TO TELL (2)	NO (3)	No response
	%	%	%	%
a. Sold production units or services developed with SBIR funding	(1.8) 14.4	(2.4) 27.1	(2.6) 55.5	3.1
b. Obtained additional government contracts	26.0	22.1	48.0	3.8
c. Obtained additional contracts from non-governmental sources	17.1	24.1	53.8	5.0
d. Hired more personnel	40.1	5.9	42.9	4.0
e. Gained new customers	30.2	23.5	42.9	3.4
f. Other (PLEASE SPECIFY)	9.0	3.3	17.2	70.5

18. Have the results (product, process, or service) of this SBIR project been used directly by any of the following parties up to this point? (CHECK "YES", "NO", or "DON'T KNOW" FOR EACH ITEM a. - c.)

(79-81)

	YES (1)	NO (2)	DON'T KNOW (3)
a. Department of Defense	17.8	54.9	27.4
b. Other federal agency	12.8	53.4	33.7
c. Private firm	20.4	49.4	30.2

19. Which of the following, if any, represent ties that your firm has or has had with an academic institution for the purposes of this SBIR project? (CHECK "YES" OR "NO" FOR EACH ITEM a. - f.)

(82-87)

	YES (1)	NO (2)	No response
	%	%	%
a. Subcontracting with university for project work	21.5	74.5	4.0
b. Principal investigator retains part-time academic appointment	10.8	83.7	5.6
c. Principal investigator held full-time faculty position within past five years	8.5	85.6	5.9
d. Faculty used as consultants to the project	42.4	54.9	2.6
e. Graduate students hired for project	23.3	72.2	4.5
f. University laboratory or other facilities used for project	29.4	67.0	3.6

24. How many Phase I and Phase II SBIR awards has your firm received since the SBIR program started in 1983? (CHECK ONE FOR EACH COLUMN)

(99-100)

	PHASE I (CHECK ONE)	PHASE II (CHECK ONE)
	%	%
1. None	12.5	
2. One	21.0	25.8
3. Two	12.7	13.9
4. 3-5	21.3	20.7
5. 6-10	16.7	7.7
6. 11-25	15.9	9.1
7. 26 or more	10.3	1.0
No response	2.1	9.2

25. Before your first SBIR award, had your firm ever received federal support for R&D in the form of a contract, grant, or cooperative agreement? (CHECK ONE)

(101)

	%	
1.	55.5	Yes
2.	42.7	No
3.	1.9	Uncertain

26. After your first SBIR award, has your firm received federal support for R&D other than SBIR awards (i.e., federal contract, grant, or cooperative agreement)? (CHECK ONE)

(102)

	%	
1.	58.0	Yes
2.	39.8	No
3.	2.2	Uncertain and no response

27. Has your firm undergone any of the following changes in the last five years? (CHECK "YES" OR "NO" FOR EACH ITEM a. - d.)

(103-106)

	YES (1)	NO (2)	NO response
	%	%	%
a. Sale of less than 50% of firm to another company	7.7	88.9	3.4
b. Sale of 50% or more of firm to another company	5.9	91.7	2.4
c. Initial public stock offering	6.7	88.7	4.6
d. Bankruptcy or reorganization	2.4	93.0	4.6

28. Is your firm a minority and disadvantaged small business? [PLEASE NOTE: A minority and disadvantaged small business is defined as one that is at least 51 percent owned by one or more minority and disadvantaged individuals; or in the case of any publicly owned business, at least 51 percent of the voting stock of which is owned by one or more minority and disadvantaged individuals; and whose management and daily business operations are controlled by one or more of such individuals.] (CHECK ONE)

(107)

	%	
1.	11.1	Yes
2.	88.3	No and no response

29. If you have additional comments on any items in the questionnaire or any related topics, please write them below or on the back of this page. Your comments are greatly appreciated.

(108)

28.9 percent provided comments.

THANK YOU FOR YOUR COOPERATION.

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(109-117)

2. Does the SBIR program expedite or slow the research needed for your agency's research goals? (CHECK ONE) (16)

	%	
1.	16.4	Greatly expedites
2.	44.4	Somewhat expedites
3.	30.5	Neither slows nor expedites
4.	2.8	Somewhat slows
5.	0.4	Greatly slows
6.	5.5	Doesn't apply/ No basis to judge and no response

3. Have you ever made any decisions to support an SBIR proposal with regular research funds because there were not enough SBIR funds to support it? (CHECK ONE) (17)

	%	
1.	11.9	Yes --> How many? _____ proposals (18-20)
2.	79.4	No
3.	8.7	Don't know and no response

4. Since you began working with SBIR projects, how has the quality of funded Phase II SBIR projects changed, if at all? (CHECK ONE) (21)

	%	
1.	9.3	Improved a great deal
2.	19.6	Improved somewhat
3.	34.7	Remained about the same
4.	1.4	Declined somewhat
5.	0.2	Declined a great deal
6.	34.7	Have not overseen any other SBIR projects and no response

5. Since you first began working with SBIR projects, how has your attitude toward the SBIR program changed, if at all? (CHECK ONE) (22)

	%	
1.	2.6	Much more negative
2.	9.3	Somewhat more negative
3.	32.1	About the same
4.	26.1	Somewhat more positive
5.	26.5	Much more positive
6.	3.4	No basis to judge (Less than one year on SBIR) and no response

10. Of the time that you spend on non-SBIR R&D, how much of it is spent on basic research? (CHECK ONE)

(39)

%	
1. 29.7	All/Almost all of the time
2. 13.5	More than half of the time
3. 12.9	About half of the time
4. 17.0	Less than half of the time
5. 24.4	Little/none of the time
2.4	No response

PLEASE NOTE: The next two questions concern activities other than SBIR. In these questions, please consider your non-SBIR R&D projects.

11. Please estimate the total dollar amount of all non-SBIR R&D projects you have directly overseen in the past twelve months. (CHECK ONE)

(40)

%	
1. 0.6	$100 million or more
2. 1.6	$50-$99.9 million
3. 19.0	$10-$49.9 million
4. 26.7	$2-$9.9 million
5. 20.4	$500,000-$1.9 million
6. 13.5	$150,000-$499,999
7. 14.1	Less than $150,000
4.0	No response

12. What are the smallest and largest non-SBIR projects that you have directly overseen over the past five years (in terms of funding per year)? (CHECK ONE FOR EACH COLUMN)

(41-42)

	SMALLEST NON-SBIR PROJECT (CHECK ONE) %	LARGEST NON-SBIR PROJECT (CHECK ONE) %
1. $50 million or more	0.2	0.8
2. $10-$49.9 million	0.0	6.9
3. $2-$9.9 million	1.2	18.8
4. $500,000-$1.9 million	3.6	31.1
5. $150,000-$499,999	10.3	27.3
6. Less than $150,000	82.2	12.7
No response	2.4	2.4

13. If you have any additional comments on the effect of the SBIR program on your agency's research program or any other issues, please write them here.

(43)

40.4% provided comments.

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THANK YOU FOR YOUR COOPERATION

2. For each of the following areas, please indicate how this SBIR project (both Phase I and II) compares to non-SBIR projects. Use the basis of comparison that you checked in the previous question--either 1) non-SBIR projects of similar duration and funding that you have overseen (preferred comparison) or 2) all non-SBIR projects you have overseen. (CHECK ONE FOR EACH AREA)

(16-25)

COMPARED TO NON-SBIR RESEARCH, SBIR PROJECT IS...	MUCH BETTER (1)	SOMEWHAT BETTER (2)	ABOUT THE SAME (3)	SOMEWHAT WORSE (4)	MUCH WORSE (5)	UNABLE TO JUDGE/ NOT APPLIC-ABLE/NO RESPONSE (6)
a. Scientific/technical facilities and resources	2.5	11.6	55.3	23.4	3.5	3.7
b. Effectiveness of the management and organization of the project	4.6	18.5	55.0	14.9	2.9	4.1
c. The skills and expertise in the scientific/technical area addressed by the research	8.7	20.7	57.2	11.3	0.7	1.4
d. Appropriateness of experimental and analytical methods used	4.5	16.4	66.6	9.4	1.0	2.2
e. Dedication of the research team in conducting the project	13.7	22.9	47.5	9.3	1.9	4.8
f. Creativity in carrying out the project	10.9	24.0	49.9	9.6	2.2	3.5
g. Likelihood that the project will lead to new scientific/technical discoveries	6.2	21.1	47.2	18.1	3.8	3.6
h. Likelihood that the project will lead to inventing and commercializing new products, processes, or services	17.5	35.7	28.9	9.3	2.2	6.4
i. Quality of scientific/technical outputs resulting from the project (patents, licensing agreements, research articles, conference presentations, etc.)	6.4	20.8	44.4	16.4	3.5	8.5
j. Overall quality of the project	6.1	22.6	50.4	16.1	2.5	2.5

7. To what extent, if at all, do you feel that this SBIR project is technologically innovative? By "innovative," we mean the likelihood that the project will lead to new discoveries, or to inventing and commercializing new products, processes, or services. (CHECK ONE)

(30)

	%	
1.	22.6	Very innovative
2.	37.6	Moderately innovative
3.	33.9	Somewhat innovative
4.	4.6	Not at all innovative
5.	1.3	No basis to judge and no response

8. Overall, how does the quality of this SBIR project compare to <u>other Phase II SBIR</u> projects you have overseen? (CHECK ONE)

(31)

	%	
1.	9.8	This SBIR project much better
2.	19.8	This SBIR project somewhat better
3.	29.1	About the same
4.	8.0	This SBIR project somewhat worse
5.	2.6	This SBIR project much worse
6.	30.7	NO OTHER SBIR PROJECTS OVERSEEN AND NO RESPONSE

9. Has this SBIR project met the expectations that your agency had at the time the Phase II proposal was funded? (CHECK ONE)

(32)

	%	
1.	28.8	Definitely yes
2.	36.0	Probably yes
3.	15.6	Uncertain
4.	9.3	Probably not
5.	6.4	Definitely not
6.	3.9	No basis to judge and no response

10. During the course of this SBIR project, how often, if ever, did you make contact either by phone or in person with the SBIR awardee for the purposes of monitoring the progress of the project? (CHECK ONE)

(33)

	%	
1.	6.8	Not at all
2.	13.5	Once a year
3.	12.4	Twice a year
4.	28.0	Four times a year
5.	22.0	Once a month
6.	16.2	More than once a month
	1.0	No response

11. Has this project completed Phase II (including completion of any extensions)? (CHECK ONE)

(34)

	%	
1.	57.5	Yes
2.	41.8	No
	0.7	No response

12. If no SBIR program existed, would your agency have supported this proposal with non-SBIR funds? (CHECK ONE)

(35)

	%	
1.	2.7	Definitely yes
2.	14.6	Probably yes
3.	30.4	Uncertain
4.	39.2	Probably not
5.	12.4	Definitely not
	0.6	No response

Questionnaire Methodology

In preparing this report, we used three survey instruments, as follows:

- a survey of small businesses that had received SBIR awards,
- a questionnaire to project officers responsible for monitoring SBIR projects at DOD, DOE, HHS, NASA, and NSF containing general questions on their agencies' SBIR program, and
- a questionnaire to the same project officers concerning specific SBIR projects.

Survey of Small Businesses With SBIR Projects

Sampling

For this report, we sent the survey contained in appendix II to small businesses using the same sample of SBIR projects that was used in our previous report, Federal Research: Small Business Innovation Research Participants Give Program High Marks.[1] The sample of projects we used was drawn from lists of projects conducted during fiscal years 1983 through 1985 by the 12 federal agencies that sponsored SBIR projects during this period. Questionnaires were sent to all firms having projects except for projects funded by DOD, DOE, HHS, NASA, and NSF. For those agencies, we selected a representative sample as shown in table V.1. In addition, we sent questionnaires concerning all Phase II projects designated as complete by the responsible agency at the time of our survey for the previous report. We assigned appropriate weights during the data analysis to account for the agency of the project and whether or not Phase II was complete. Table V.1 shows the sample size for each agency and the weighted number of projects for each agency in our analysis. (A copy of the survey is in app. II.)

The sample was designed to have sampling errors of no more than 5 percent at the 95-percent confidence level (sampling errors for subsets of the sample could be higher). (App. II shows sampling errors in parentheses for selected key variables.)

[1](GAO/RCED-87-161BR, July 27, 1987).

General Questions to Project Officers

Working with agency officials at DOD, DOE, HHS, NASA, and NSF, we identified and sent questionnaires to 530 officers who had been responsible for monitoring and/or assessing the 739 SBIR projects started at these agencies during fiscal years 1983 and 1984 that resulted in Phase II awards. These five agencies are responsible for 96 percent of all SBIR funds.

Questionnaire Procedures

We developed questions concerning the SBIR program after discussions with agency officials and consultants. We conducted pretests with SBIR project officers at DOD, DOE, HHS, and NSF. During each session an individual project officer filled out the questionnaire in the presence of two GAO observers. After pretesting, the questionnaire was revised as necessary to increase clarity and ease of response.

We sent follow-up letters to nonrespondents, including a second copy of the questionnaire. Later, we made a final follow-up to the remaining nonrespondents by telephone.

Survey Results

We received 495 completed questionnaires from the 530 project officers that we had identified, yielding a response rate of 93.4 percent. Appendix III shows the questionnaire and the frequency of responses to individual questions.

Questionnaire Concerning Specific SBIR Projects

Each project officer who received a questionnaire with general questions about the SBIR program also received one or more questionnaires about specific SBIR projects that were started during fiscal years 1983 and 1984 that resulted in Phase II awards, a total of 739 projects. We followed up nonresponses to this questionnaire in conjunction with the questionnaire concerning general questions about the SBIR program. We received questionnaires concerning 691 projects, a response rate of 93.5 percent.

The questionnaire concerning specific SBIR projects was developed and pretested in conjunction with the general questions concerning the SBIR program. Appendix IV shows the questionnaire and the frequency of responses to individual questions.

(3) SBIR projects are innovative and represent a mechanism for commercialization of the results of basic research. For example, recent progress in animal biotechnology has been used by grantees to design superior vaccines that are quite specific with fewer undesirable side effects. Basic research in plant biotechnology that has made it possible to introduce new genetics material into certain plants has permitted grantees to create new plant varieties that possess superior yield and quality characteristics or enhanced resistance to specific plant pathogens or insect pests. Basic research that led to the development of fiber optics and laser spectroscopy has been built upon with various applications such as an improved soil moisture probe that uses fiber optic technology or a computer-directed, laser guidance system for edging hardwood boards that results in improved yield. Improved breeding methods have led to the development of one of the first American strains of cashmere goat that will be a domestic source of this valuable fiber. A project in Washington State plans to utilize this new strain in an effort to establish domestic cashmere production as a new enterprise that will enhance economic opportunity in rural areas.

(4) The SBIR program is designed to leverage Federal R&D support in Phase I and II with non-Federal support in Phase III. The USDA supports the concept of Phase III funding by strongly encouraging Phase II applicants to include a follow-on funding commitment for Phase III as part of their Phase II grant applications. Grantees are also encouraged to secure matching funds from State or private sources to assist their Phase II effort or to seek bridge grants from their State government to permit the small business to continue its research activity during the period from the end of Phase I until the start of a Phase II grant.

(5) The SBIR program provides support for certain USDA initiatives. For example, last year the USDA initiated a Rural Revitalization Effort. One of the six topic areas in the USDA SBIR program addresses rural and economic development. In FY 88, the number of Phase I applications in this topic area nearly doubled over the previous year and four proposals have been recommended for funding. These projects are all directed at stimulating economic development in rural areas.

The Joint Council on Food and Agricultural Sciences, a major advisory body for USDA research programs, makes recommendations on research priorities. For FY '89, their two top priorities are: (1) maintaining and preserving water quality, and (2) expanding biotechnology and its applications. In both cases the SBIR program has funded a number of important projects. In the area of water quality, these projects include: (a) development of a laser/bacterial assay system for detection of pesticides and other contaminants in ground water; (b) development of a cost-effective integrated flow control device to permit more efficient use of irrigation water; and (c) development of a new membrane system to permit more effective demineralization of brackish ground water. In the biotechnology area there are more than a dozen projects underway dealing with such subjects as: (a) developing safer and more effective animal vaccines;

Letter From the Department of Commerce Concerning the SBIR Program

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Administration
Washington, D.C. 20230

21 MAR 1988

Mr. John Luke, Associate Director
Resources, Community, and
Economic Development Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Luke:

This is in response to your request for the Department of Commerce's judgement on the effects of the Small Business Act, specifically the Small Business Innovation Research (SBIR) program, on our research programs. I am pleased to report that DOC scientists think the SBIR program can contribute to their research and development needs. The Department's first phase two SBIR contracts will not be completed until May 1988; consequently, I can not make a conclusive judgement on the effects of phase two in terms of the application of research results. My comments, therefore, relate to the presently identifiable effects of our phase one efforts.

The SBIR program has provided DOC research managers an opportunity to broaden the scope of their research, facilitated direct communication between our laboratory scientists and their colleagues in small firms, and is creating a growing appreciation of the capabilities of small, innovative firms. The program has encouraged research managers to pursue projects that otherwise may not have been undertaken. By providing a means for accessing the ideas and expertise of competent scientists and engineers in small, technology oriented businesses, the program gives research managers the opportunity to explore new and innovative approaches to their problems and to obtain expertise not available in-house. Currently, we have 20 SBIR funded projects going on in the Department. If successfully completed, these projects will make significant contributions to our research programs.

The Department views SBIR awardees as partners in cooperative research and development. We assign a Technical Representative (TR) to each phase one awardee at the time a contract is awarded. The TR, a laboratory scientist, not only provides technical assistance to contractors during phase one, but he or she also becomes the contractors advocate in the competition for phase two awards. A close working relationship is established between the Principal Investigator and TR. The effect of this partnership is to facilitate not only the exchange of information but also to ensure that the phase one and phase two work remains focused on the needs of the DOC laboratory sponsoring for the research.

75 Years Stimulating America's Progress ★ 1913-1988

Letter From the Department of Defense Concerning the SBIR Program

THE UNDER SECRETARY OF DEFENSE

WASHINGTON, DC 20301

ACQUISITION

1 AUG 1988

Mr. Frank C. Conahan
Assistant Comptroller General
General Accounting Office
441 G Street, NW
Washington, DC 20548

Dear Mr. Conahan:

This is the Department of Defense (DoD) response to your letter of December 3, 1987, requesting a judgment of the effects of the Small Business Innovation Research (SBIR) Program on DoD Research and Development (R&D), (GAO Code 005738).

The SBIR Program has continued to grow since its beginning in 1983 and has become an integral part of all DoD R&D programs. The effect of SBIR on these programs has been positive and the Congressional goals of the law are being met.

Results of recent assessments of the SBIR Program within each of the six participating DoD components show that the quality and innovative nature of the work performed by SBIR contractors are equal to work performed by contractors outside the SBIR Program. The SBIR Program has provided a pool of small businesses willing to investigate new high risk and innovative ideas needed to expedite the accomplishment of DoD goals and objectives. Summaries of the DoD components assessments are enclosed.

Since the DoD SBIR Program began in 1983, minority firms have competed and received twelve to fourteen percent of the SBIR dollars awarded each year. The DoD minority outreach program has paid off in SBIR participation and the Department will continue to incorporate new ideas to inform more minorities about the SBIR Program.

The DoD wholeheartedly supports the Congressional goals of the SBIR Program and is pleased to report its positive effect on all R&D programs.

Sincerely,

Enclosures

Assessment of the Army Small Business Innovation Research (SBIR) Program

A summary assessment of the Army SBIR Program to date indicates that the percentage of small business participation in Army R&D has increased, resulting in more competition for Army business and more second sources for defense technologies. Small firms are learning how to do business with the Army, while the Army is learning how to use the capabilities of small business. Technology is more effectively transferred, as networking among SBIR contractors, government and academia is catalyzed by the SBIR Program. Small businesses are being given the opportunity to bring the fruits of their entrepreneurship to the Army, and they are finding new and better ways of solving Army needs.

Many new and innovative ideas have resulted from SBIR research which Army Laboratories and Research Centers have integrated into mainline programs. Such mainline programs include the Tank Commander Decision Aid; ATR/Tracker Module Generic Robotic Control Module; Sensor Fusion/Situation Analysis; TACJAM-A; Advanced Fusion Technology Test Bed; Advanced Long Wavelength Infrared/Circuit and Array (ALICAT); Standardized Advanced Infrared System (SAIRS); AN/ALQ-136 and 162 PM-ASE Systems; Pocket Radiac Program; APACHE Escort Jammer 2000 NG/NS; and PM-ASE Integrated ASE; PM-MSE; Soldier-Robot Interface; Track Finder; Track Wolf.

Since the inception of the SBIR Program, the quality of the proposals has increased with each successive solicitation. As a result, the Army has reduced the number of topics evaluated for new work, this year, to ensure that funding is available for worthy Phase Two candidates. From the 4900 proposals received in 1987/1988, about 250 projects will be converted into Phase Two.

(Chicago, IL), for the Naval Sea Systems Command. Physical Dynamics, Inc. (San Diego, CA), has developed a unique EM gradiometer using superconductive materials; Foster-Miller, Inc. of Waltham, MA developed a low flow separator; and Fuzetron (San Diego, CA), is developing radar absorbing materials. X-ray diffraction techniques for automatically assessing the quality of energetic materials developed by the Brimrose Corporation of America (Baltimore, MD) led to commercial utilization by Dupont. GTE is interested in electrodes for sulphur discharge lights developed by SMR, Inc. (Santa Clara, CA). Woven Carbon-Carbon composites from Techniweave may be pursued in the Tri-Service Integrated High Performance Engine Technology (IHPET) Program. A second source of stellar sensor optics was developed for the Trident program; and a fast switch may be valuable for Electronic Countermeasures.

Assessment of the Defense Advanced Research Projects Agency (DARPA) Small Business Innovation Research (SBIR) Program

The number of new and innovative ideas submitted to the Agency has increased considerably due to the SBIR Program.

The percentage of the small business community participation in Agency R&D has increased, with the concomitant results of more competition for Agency business and more second sources for vital defense technologies.

Over 80% of the Agency program managers and administrators believe that their participation in the SBIR Program was worthwhile and that they received tangible benefits from it. Forty percent indicated that they were more aware of efforts in their technology area as a result of the Program.

About twice as many Phase I and Phase II proposals are evaluated very highly and recommended for funding than are actually procured. This is indicative of the very high quality of SBIR work for which the Agency awards contracts.

These results are based on a study of the SBIR Program at the Agency conducted by the SBIR program manager. Further results from this study indicate that the Congressional goals of the implementing legislation--the stimulation of technological innovation, the use of small business to meet federal R&D needs, and an increase in the private sector commercialization innovations--have been achieved.

Letter From the Department of Education Concerning the SBIR Program

UNITED STATES DEPARTMENT OF EDUCATION

OFFICE OF THE ASSISTANT SECRETARY
FOR EDUCATIONAL RESEARCH AND IMPROVEMENT

APR 1 1988

Mr. Richard L. Fogel
Assistant Comptroller General
General Accounting Office
Washington, D.C. 20548

Dear Mr. Fogel:

Secretary Bennett delegated responsibility for management of the Small Business Innovative Research Program to Assistant Secretary Chester E. Finn, Jr. I am responding on behalf of Assistant Secretary Finn to your request of December 9, 1987 for an assessment of the effect of the Small Business Act on the Department's research programs.

The enclosed report contains four sections which (1) spell out the appropriate legislative provisions governing the SBIR program, (2) outline the parameters of the Department's SBIR program, (3) summarize the first five years of the SBIR program within the Department, and (4) provide our judgment on the effect of the SBIR legislation on the Department's research programs.

If I can be of further assistance, please let me know.

Sincerely,

Bruno V. Manno
Chief of Staff

Enclosure

WASHINGTON, D.C. 20208

The Department of Education (ED) is one of the eleven Federal agencies meeting the mandates of the Small Business Innovation Development Act, P. L. 97-219, signed by President Reagan in August, 1982, and further supported by a Presidential memorandum to agency heads in September, 1982. Since that time, the Department has complied with the provisions of the SBIR legislation.

SBIR LEGISLATIVE AUTHORITY

SBIR legislation requires every Federal agency with an extramural research and development budget exceeding $100 million to set aside a minimum graduating percentage of that budget up to 1.25 percent annually for a special competition limited to small, profit-making firms, to work on R and D problems of interest to the particular agency.

The purposes of the Act are to stimulate technological innovation; to use small businesses to meet Federal R and D needs; to foster and encourage participation by minority and disadvantaged persons in technological innovation; and to increase private sector commercialization of innovations derived from Federal R and D. The law defines R and D as "...any activity which is (A) a systematic, intensive study directed toward greater knowledge or understanding of the subject studied; (B) a systematic study directed specifically toward applying new knowledge to meet a recognized need; or (C) a systematic application of knowledge toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements."

The legislation requires "... a uniform process having (A) a first phase for determining, insofar as possible, the scientific and technical merit and feasibility of ideas submitted pursuant to SBIR program solicitations; (B) a second phase to further develop the proposed ideas to meet the particular program needs, the awarding of which shall take into consideration the scientific and technical merit and feasibility evidenced by the first phase ... and (C) where appropriate, a third phase in which non-Federal capital pursues commercial applications of the research or research and development and which may also involve follow-on non-SBIR funded production contracts with a Federal agency for products or processes intended for use by the United States Government..."

MANAGEMENT OF ED'S SBIR PROGRAM

In a memorandum dated May 2, 1983, the Under Secretary of Education delegated responsibility for management of the Department's SBIR program to the Assistant Secretary for Educational Research and Improvement. The Assistant Secretary assigned responsibility for day-to-day management of the program across the Department to a Senior Program Coordinator in the Office of Educational Research and Improvement.

Funding for the SBIR Program is provided by individual principal operating components (POCs) allocating monies to support work on topics they identify in the Department's annual Phase I request for proposal solicitation. Within the Department of Education five principal operating components--each with distinct and separate legislation and R and D foci--have participated in the SBIR program over the last five years. These program units are the Office of Special Education and Rehabilitative Services (OSERS), the Office of Bilingual

decision-making, and award processes by September 30 of each fiscal year.

A review of the SBIR projects supported by the Department revealed that nearly all rely on the use of computers to improve one or more facets of American education. For example:

- A Minnesota firm generated an authentic sounding bilingual speaking Spanish/English tutorial program using computers so that students could more readily acquire basic reading and language skills.
- A California small business firm developed a computer based English grammar and spelling monitor for use in schools. The resulting educational word processing software package is intended to permit elementary and junior high school teachers and students to spend more time developing writing and thinking skills.
- A New Hampshire firm worked with a team of scientists, engineers, computer programmers, and educators to design, develop, and evaluate computer hardware and software for use in science laboratory experiments in secondary school classrooms. As a result, science students could receive an expanded number and variety of opportunities to participate in hands-on experiments.
- Two other small business enterprises--one in New Jersey, the other in Florida--each developed courseware authoring systems; i.e., a set of programs to help teachers organize and implement computer based instructional lessons. One authoring system is for language instruction in Chinese, Japanese, and English. The other authoring system is designed to meet the individual basic skill needs in reading, spelling, and mathematics of elementary students with cognitive or learning disorders.

All five of the above mentioned projects are now in the early stages of SBIR's Phase III, the stage at which non-Federal capital pursues the R and D.

The SBIR program has several built-in characteristics which make it unique when compared to most other Department R and D programs. These include: (1) a "feasibility of idea" study stage (Phase I), before emerging into the R and D stage (Phase II); (2) a reliance on the marketing skills of entrepreneurs to get research findings into practice (Phase III); (3) government-wide simplified and standardized SBIR solicitation processes, regulated by Small Business Administration policy directives; (4) retention of rights in data generated in the performance of the contract by small business concerns; and (5) a minimum of regulatory burden associated with participation in the SBIR program for small business concerns. It should also be noted that the Department's SBIR Phase I solicitations contain a variety of topics from which one set of performers, small business firms, for R and D can apply. On the other hand, most of the Department's non-SBIR solicitations for R and D contain only one topic for which a number of types of performers --non-profit and profit-making organizations and individuals--may submit a proposal.

EFFECT OF SBIR ON DEPARTMENT'S R and D PROGRAM

The Department of Education has relied on three different sources to generate data to determine the effect of SBIR on the agency's R and D programs. These

Most of the 19 respondents believed SBIR and non-SBIR research projects were about the same when comparing the overall quality of projects. Their judgments were based on: (1) skills and expertise in the scientific/technical area addressed by the research, (2) experimental or analytic methods used during the research, and (3) effectiveness of the management and organization of the project. Respondents were also of the opinion that creativity in carrying out the projects and the likelihood that projects would lead to new scientific/technical discoveries or products were somewhat better for SBIR projects than for non-SBIR projects. Although most respondents believed that the potential for private sector commercialization of products was average or better for SBIR funded projects, the quality of scientific/technical outputs from projects, e.g. patents, agreements, and research articles, was thought to be somewhat better for non-SBIR projects.

Project officers answered several questions focusing on SBIR and its relationship to the agency's research agenda and mission. In answer to one such question, 63 percent of the respondents believed SBIR projects could make moderate to some contribution to the research agenda and mission of the agency. The remaining 37 percent addressing the same question responded that SBIR projects will make little or no contribution to the research agenda and agency mission. When asked whether the SBIR program is an element of their overall research programs, over 47 percent of the project officers stated that it was not a very important element. The remaining 53 percent believed it was either a somewhat, moderate, or very important element of their overall research programs. Additionally, one-half of the respondents believed the relevance of the scientific/technical problem to the agency's R and D needs tended to be less direct for SBIR projects when compared to that of their non-SBIR projects. Most project officers also stated that if the SBIR program did not exist within the Department, their SBIR projects would probably not be supported by non-SBIR funds.

Project officers were divided in comparing their current attitude toward the SBIR program to their attitudes when they first began working with SBIR projects. Approximately one third felt somewhat more positive, another third somewhat more negative, and the last third felt that their attitude was about the same or that they had no basis on which to compare. Project officers were also equally divided--between somewhat worse and about the same--when queried about the level of scientific/technical risk; i.e., researching an area where results are less easy to be achieved.

When asked about the likelihood that SBIR projects will lead to new scientific/technical discoveries, or to inventing and commercializing new products, processes, or services, project officers were split between better, worse, and about the same. More than two-thirds of the SBIR project officers believed that SBIR projects are technologically innovative i.e., the likelihood that projects will lead to new scientific/technical discoveries, or to inventing and commercializing new products, processes, or services, while 26 percent did not believe they were innovative at all. One individual stated he had no basis on which to judge technological innovation.

In giving their opinions about whether the four legislated SBIR goals are being met, more than half of the respondents (53 percent) stated that SBIR helps the agency meet its R and D needs, 26 percent thought probably not, and 21 percent were uncertain. Some 58 percent of the respondents thought that SBIR

U.S. DEPARTMENT OF EDUCATION
SMALL BUSINESS INNOVATION RESEARCH
PHASE I TECHNICAL TOPICS
FISCAL YEAR 1983-1987

(1) Simplifying and Improving The Creation of Software

(2) Improving the Usability of Software

(3) Research and Development of Models, Guides, and Plans for Handicapped Populations

(4) Technology for Training and Placement of Handicapped Persons

(5) Overcoming Technical Barriers to Improve Education

(6) Input and Output Mechanisms and Devices

(7) Technology and Vocational Education

(8) Innovative Approaches to Bilingual Education

(9) Systems to Improve Instruction and Educational Administration

(10) Informational Exchange Among Educational Organizations

(11) Innovative Inservice Programs for School Personnel

(12) Storing and Retrieving Educational Research Information

(13) Technology for Immigrant Populations

(14) Application of Technology to the Teaching of Uncommonly Taught Modern Foreign Languages

(15) Innovative Approaches to Learning and Instruction at the Elementary School Level

(16) Innovative Applications of Technology to the Communication of Research Results

(17) Innovative Approaches to the Management of Educational Research Programs at the Federal Level

(18) Innovative Approaches to Instruction of Adult Learners

(19) Innovative Approaches to the Assessment of Educational Outcomes

14. National Technical Institute for the Deaf (NTID)	No*
15. Gallaudet University	No*
Vocational and Adult Education; Vocational Education:	
National Programs	
16. Research	Yes
17. Demonstrations	Yes
Adult Education:	
18. Research, Demonstration and Evaluation	Yes
Higher Education:	
19. Fund for Improvement of Postsecondary Education (FIPSE)	Yes
20. International Education and Foreign Language Studies: Domestic Programs	Yes
21. Academic Facilities: Academic Facilities Construction Grants	No
Howard University:	
22. Research	No*
Education Research and Statistics:	
23. Regional Education Laboratories	No
24. National Research and Development Centers	No
25. Field-Initiated Studies Program	Yes
26. Education Research Grant Programs	Yes
27. National Assessment for Educational Progress	No
28. Other Statistics	Yes
29. Educational Resources Information Center (ERIC) System	Yes
30. Libraries: Training and Demonstrations	Yes

NOTE: *These institutions can contract with profit-making organizations but the funds are not ED funds at that point in the process.

Q2. For each of the following areas, please indicate how this SBIR project team compares to non-SBIR project teams? Use the basis of comparison that you checked in the previous question--either 1) non-SBIR projects of similar scope and size that you have overseen (preferred comparison) or 2) all non-SBIR projects you have overseen. (CHECK ONE FOR EACH AREA)

	COMPARED TO NON-SBIR RESEARCH, SBIR TEAM/PROJECT IS...					
	MUCH BETTER (1)	SOMEWHAT BETTER (2)	ABOUT THE SAME (3)	SOMEWHAT WORSE (4)	MUCH WORSE (5)	NOT APPLICABLE (6)
a. The skills and expertise in the scientific/technical area addressed by the research		(3)	(10)	(6)		
b. Appropriateness of experimental and analytical methods used		(1)	(13)	(3)	(2)	
c. Effectiveness of the management and organization of the project		(2)	(14)	(1)		(2)
d. Adequacy of the scientific/technical facilities and resources		(5)	(9)	(5)		
e. Level of effort devoted by the research team to conducting the project		(3)	(13)	(2)		(1)
f. Relevance of the scientific/technical problem to your agency's R&D needs			(9)	(5)	(5)	
g. Creativity in carrying out the project	(2)	(3)	(10)	(4)		
h. Likelihood that the project will lead to new scientific/technical discoveries, or to inventing and commercializing new products, processes, or services	(1)	(6)	(5)	(5)	(2)	
i. Level of scientific/technical risk (researching an area where results are less easy to come by)		(1)	(9)	(9)		
j. Quality of scientific technical outputs resulting from the project (research articles, patents, licensing agreements, conference presentations, etc.)			(6)	(7)	(4)	(2)
k. Overall quality of the project		(1)	(12)	(4)	(2)	

2

09. During the course of this SBIR project, how often, if ever, did you make contact with the SBIR awardee for the purposes of monitoring the progress of the contract? (CHECK ONE)

(2) 1. [ ] Not at all

(4) 2. [ ] Once a year

(5) 3. [ ] Twice a year

(6) 4. [ ] Four times a year

(2) 5. [ ] Once a month

6. [ ] More than once a month

10. If no SBIR program existed in your agency, would this project have been supported by non-SBIR funds? (CHECK ONE)

1. [ ] Definitely yes

(5) 2. [ ] Probably yes

(3) 3. [ ] Uncertain

(8) 4. [ ] Probably not

(3) 5. [ ] Definitely not

4

16. For each of the following goals originally planned for the SBIR program, please give your personal opinion as to whether or not that goal is presently being met. (CHECK ONE FOR EACH STATEMENT)

	DEFI-NITELY YES (1)	PROB-ABLY YES (2)	UNCER-TAIN (3)	PROB-ABLY NO (4)	DEFI-NITELY NO (5)	TOO EARLY TO TELL (6)	NO BASIS TO JUDGE (7)
a. SBIR helps your agency to meet its R&D needs	(1)	(9)	(4)	(3)	(2)		
b. SBIR stimulates technological innovation	(3)	(8)	(6)	(2)			
c. SBIR encourages the private sector to commercialize the results of federally funded R&D	(3)	(6)	(5)	(2)			(3)
d. SBIR encourages the participation of minority and disadvantaged persons in technological innovation		(2)	(10)	(4)			(3)

BACKGROUND INFORMATION

17. Does your office receive a set percentage of SBIR funds, or does it compete for these funds with other research offices? (CHECK ONE)

1. [ ] Competes

(12) 2. [ ] Set Percentage

3. [ ] Combination of 1 and 2

(7) No Answer

18. In what fiscal year did you begin overseeing SBIR projects? (CHECK ONE)

(3) 1. [ ] FY83

(1) 2. [ ] FY84

(5) 3. [ ] FY85

(4) 4. [ ] FY86

(6) 5. [ ] FY87

19. How many Phase I and Phase II SBIR projects have you overseen since then? (CHECK ONE FOR EACH.)

	PHASE I (CHECK ONE)	PHASE II (CHECK ONE)
1. One (7-7)		
2. Two (6-2)		
3. 3-5 (1-4)		
4. 6-10 (4-0)		
5. 11-25		
6. 26 or more		
	(1-6)	No Answer

DEPARTMENT OF EDUCATION
SBIR PROGRAM DATA
FISCAL YEAR 1983-1987
($ IN THOUSANDS)

Phase I Solicitations

Total number of Phase I solicitations.....5

Total number of separate topics included in Phase I solicitation....19

Total number of eligible proposals received in response to Phase I solicitations.....866

Total number of separate small business firms submitting a Phase I proposal.....623

Total number of states from which Phase I proposals have been received (all except AK,ND,NV,SD).....46 & DC

Phase I Awards

Total number of Phase I awards.....76

Total number of separate small business firms receiving at least one Phase I SBIR award.....65

Total 6 month cost for all Phase I awards.....$2,303

Average Phase I award.....$ 30

Total number of states in which Phase I small business firms reside.....26 & DC

Total number of separate minority and disadvantage owned firms receiving a SBIR Phase I award.....12

Phase II Awards

Total number of Phase II awards.....17

Total 2 year cost for all Phase II awards.....$3,043

Average Phase II award for 2 year period.....$ 179

Total number of states in which Phase II small business firms reside.....10

Total number of minority and disadvantaged owned firms receiving a SBIR Phase II award.....2

Comparative Quality of SBIR Projects

An assessment of the DOE SBIR program was undertaken in the summer of 1987 to evaluate the quality of the research supported by the program compared to that traditionally supported by the Department. The assessment leads to the conclusion that the average qualities of SBIR and non-SBIR projects are similar.

The assessment was based on evaluations provided by 17 independent scientific and technical panels that reviewed samples of SBIR and non-SBIR projects. Each panel had four to eight members and represented a research area of the Department. The panels rated individual projects on seven evaluation factors concerning each project's quality. The panels then assigned an overall rating which became the eighth and summary rating for each project.

The sample of SBIR projects consisted of Phase II projects in the first two award cycles of the program. Ninety of 96 such projects were reviewed, all of which had ended or were near completion. For comparison, a sample of 29 non-SBIR projects was selected using the following guidelines: (1) funding level and duration comparable to SBIR projects and (2) technical area compatible with one of the 17 panels. The number of non-SBIR projects (29) was chosen because it was the minimum number required for a statistically valid representation of such projects.

A report detailing the methodology, analyses, and findings is in preparation.

Third, the results of SBIR projects are being integrated into the Department's research programs.

Examples of significant integration include development of heat pipes that will be used on thermionic reactors, spacecraft, and in paper production processes; a precursor seismic signal detector for nuclear plant safety; and the development of a new method to neutralize beams for magnetic fusion reactors. The latter has been incorporated into the design of the International Thermonuclear Experimental Reactor, a joint effort between the US, the USSR, Japan, and European countries. A special case of program integration occurs where SBIR is used to fund exploratory work which is later supported further by the Department in the main program, such as the development of new ceramic membranes for cleaning flue gases.

Finally, the SBIR program has fostered effective technology transfer to the private sector, helping to fulfill the Department's goals.

An important effect of SBIR on the Department's research programs is to move products and processes more quickly into the commercial marketplace. To cite one of many examples: a very promising new low-cost cyclotron for positron emission tomography is being built by an SBIR awardee in close collaboration with UCLA. In addition, the private sector has expanded its knowledge of the Department's programs and has developed its ability to better serve the Department's needs. The spin-offs into areas beyond the needs of the Department's R&D programs are growing in number including, as an example, a high-efficiency fiber optic connector usable in telecommunications and in the aerospace industry.

A major reason for this effective technology transfer is the fact that many SBIR proposers utilize technology from the national laboratories. National laboratory and university scientists and engineers often assist in proposal preparation and serve as consultants while projects are being conducted. In addition, SBIR contractors frequently utilize facilities at national laboratories and universities to carry out their projects.

The Department of Health and Human Services

Small Business Innovation Research Program

Introduction

This report, on the Department of Health and Human Services', Small Business Innovation Research (SBIR) Program, is in response to the request of the General Accounting Office (GAO) for views on the effect of the SBIR legislation on HHS research programs. It is the intent of this report to address, to the extent possible, the "effect" elements of the questions posed by the GAO without examining the other questions (stated in Public Law 99-443) concerning the effectiveness of Phase I and Phase II and the quality of research supported by the SBIR Program compared to that traditionally supported by the Department.

Any assessment of "effect" or "impact" must take into consideration that SBIR funds constitute only 1.25% of the Department's extramural R&D budget. Thus SBIR projects make up a very small portion of the Department's research portfolio. To anticipate a significant impact from such a circumscribed research program would be neither realistic nor appropriate.

Furthermore, since the SBIR enterprise is intended primarily to increase commercialization of the results of federally funded research, it is important to recognize that the technology transfer process is generally lengthy and time consuming. Therefore, any definitive assessment of the effect of the SBIR Program is somewhat premature at this time. It is our belief that, given sufficient time, the SBIR Program will allow more conclusive findings.

Background

The Department of Health and Human Services includes five Operating Divisions: the Public Health Service, the Social Security Administration, the Office of Human Development Services, the Health Care Financing Administration, and the Family Support Administration. Each of these Divisions, as well as the Office of the Secretary, administers an extramural research program.

In HHS, extramural research spending has grown from approximately $3.3 billion in FY 83 to approximately $5.4 billion in FY 87. Of this amount, approximately 98% are funds of the Public Health Service. Over the same period of time, the SBIR set-aside goal has grown from $6.6 million to $67.1 million.

When the SBIR Program was first implemented in DHHS, a policy decision was made to require all departmental components with extramural research activities to participate in the SBIR Program. Although the objectives of some HHS research programs were not compatible with the goals of the SBIR legislation, the Department attempted initially to insure uniform overall participation by all components. Concern over the incompatibility of these activities was rooted in the fact that there were and still are three types

In the initial conceptualization of the program, it was visualized that both assistance awards (grants) and acquisition awards (contracts) would be used to support SBIR projects. However, to facilitate program implementation and to allow PHS staff sufficient time to familiarize itself with a new set of policies and procedures, only the grant instrument was used in the first two years of the program. In FY 85 contracts were introduced and have since played an important though smaller role in supporting SBIR research. The decision to adopt both funding instruments was based on the recognition that a research agency, especially one such as NIH, needs to support both investigator initiated research as well as research that meets identified agency requirements. While grants have been used very effectively to support a variety of research projects whose ideas came from scientists in small businesses, this funding instrument cannot be used to support research for which the agency has identified a need. The latter type of research constitutes a technical requirement that must be met through a research contract.

In implementing any new program, especially one that cuts across all research programs of the PHS and which involves a new sector of the research community, there is a critical need to invest a significant amount of agency resources, particularly staff, to educate the new constituency. The small businesses that approached the PHS for SBIR support in the first three to four years of the program were, by and large, totally unfamiliar with the agencies within the PHS, their organization, programs, policies and procedures. To counter this problem, PHS staff invested substantial amounts of time not only in familiarizing small research companies with "the way we do business" but also in monitoring and interacting with these firms following the award of SBIR funds. This investment has succeeded in educating our new "clientele" and, in the process, we have gained insights into a research community that heretofore was equally unfamiliar to us.

General Program Information

The SBIR set-aside funds for the PHS have grown from $6,478,998 in FY 83 to $66,267,301 in FY 88. In each of the past fiscal years, the PHS has not only met but also exceeded its set-aside requirements. This points to the fact that a number of funding components within the PHS received proposals of sufficient quality that they contributed more than their allotted share of SBIR funds in order to make additional awards. The annual amounts by which the PHS has exceeded its set-aside requirements has ranged from $163,000 to approximately $740,000.

Since the initiation of the program, over 3000 small businesses have submitted SBIR grant applications and contract proposals to the PHS. Of these over 500 have been successful in competing for SBIR funds. Some companies have produced such high quality proposals that they have received more than 20 SBIR awards each. In fact, as of March 1988 at least 370 firms have received a minimum of two SBIR awards.

Among those companies that have been successful, there is a significant percentage of minority/disadvantaged and women-owned small businesses. This percentage is actually higher than that for PHS' traditional small business

examples of unmet needs that have been addressed by SBIR include the development of simple and reliable screening tests for cystic fibrosis (a lethal, hereditary childhood disease), the development of predictive in vitro drug sensitivity tests for detection of breast cancer, and the application of the concept of "rational drug design" to the development of novel, orally active renin inhibitors (a class of antihypertensive agents.)

(2) SBIR complements and enhances regular research programs.

Since many of the PHS regular research programs are oriented towards basic research, oftentimes there are program needs in applied research that are not addressed. By emphasizing applied research, SBIR provides a needed balance. SBIR represents an additional mechanism for expediting technology transfer and the application of basic research findings to solving clinical problems. SBIR also serves as an alternative vehicle for targeting specific areas of interest. It offers opportunities to exploit basic research findings that have commercial potential but which cannot be pursued through our regular grants program.

(3) SBIR provides additional resources to accomplish program goals.

By attracting small businesses with appropriate expertise to the PHS research community, the SBIR Program has not only identified new resources for achieving program goals but also provided more flexibility to program staff. As a result of the program, private sector researchers with new, exciting and sometimes risky ideas/approaches have been drawn into the federal R&D effort. Consequently, the pool of scientists who can answer some of the critical questions in research and help meet program needs is enhanced. Because of their relative freedom from management and administrative demands, these investigators can frequently devote full time attention to their research and thus achieve their scientific and technical objectives more rapidly.

One of the very important and tangible benefits of SBIR is the coupling of engineering expertise with clinical research to produce an array of products and technology that are highly innovative. When one examines the inventory of products that are being developed with SBIR support, from an electrochemical microsensor that can selectively detect presence of human breath and its alcohol content to the development of infection resistant shunts, it becomes obvious that these articles would not be possible without harnessing the expertise of both engineers and clinicians.

It would be an obvious omission if we did not mention that SBIR has been instrumental in linking industry researchers with academic investigators by providing an incentive to collaborate, leading to more rapid technology transfer. By serving as either

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SBIR has accelerated research in such areas as diagnostic methodology for periodontal diseases and methodology for oral cancer diagnosis. An example is a self-contained, hand-held, periodontal temperature probe that can provide objective and simple assessment of periodontal disease activity. Since there is a correlation between elevated temperatures and disease activity, this probe, which permits a measurement accuracy of better than 0.1°C and a response time of less than 0.2 second, offers a distinct advantage over currently available probes.

Another result of the SBIR activities is that small businesses have developed an extensive array of research resources useful to and required by most individual scientists who lack the time and means to produce these research resources routinely and consistently. These include standardized, high quality assay procedures, reagents, cell lines, etc. needed by basic scientists as well as new instrumentation required by clinical researchers.

One of the areas in which SBIR may play the most significant role is the development of orphan drugs and devices. Larger companies are simply not attracted to this field because they do not perceive the financial returns from development of these drugs/devices to be sufficiently profitable. However, small companies, with lower operating costs, are willing to assume certain risks and proceed with an orphan drug or device because they are not seeking as sizable a return or profit as the larger firms. There is a growing belief among program staff that the SBIR Program may indeed yield some significant impact in the orphan drug and device arena.

A limited but intriguing by-product of the SBIR supported research is that it has created an opportunity for several academic clinical investigators who served as consultants to some of the SBIR awardees to obtain regular research funding for projects using the devices developed by the small businesses.

As the SBIR Program matures, it has become increasingly clear that much of high quality biomedical research relies heavily for success on equally sound research in instrumentation, engineering, physics and mathematics. SBIR has been able to advance R&D more rapidly by marrying together engineering, physics and mathematical concepts that are relevant to biomedical research.

Although a number of the SBIR products described earlier in this report were made possible because SBIR provided the impetus and the opportunity, there are a few research outcomes that probably would not have materialized at all without the presence of the SBIR Program. Although SBIR has accelerated the development of certain devices, instruments, drugs and assays, it is possible that these products would have been developed eventually without stimulation from the SBIR Program. There are other items, however, that would not have been developed at all if SBIR funding had not been made available.

One excellent example is the development of vaccine for parainfluenza viruses, a group of important respiratory pathogens. In a recent Institute of Medicine report that identified the leading diseases that could be

technological breakthrough which provides a significant new treatment modality that can be used safely and efficaciously, even with infants as young as four weeks.

The development of this laser began in 1983 with a Phase I grant from NIH. At that time the company had 17 employees and annual sales of $1 million. Today this firm has 135 employees and sales for this fiscal year are forecasted at more than $15 million. The market for this instrument is not limited to the United States; almost 50% of this year's production is expected to be exported.

Another measure of the success of this SBIR project is the number of articles that have been published in scientific journals. Both investigators on the staff of the company as well as collaborators at various academic institutions have generated almost a dozen articles as a result of the SBIR funded research.

Another example of a product that has been commercialized is the pill electrode and transesophageal stimulator for temporary cardiac pacing. This device consists of two electrodes spaced a few millimeters apart and enclosed in a pill-like capsule that can be swallowed. Two conducting wires attached to the electrodes are free to lead through the mouth for attaching to appropriate electronic equipment. As active electrodes, a current may be injected into the esophageal leads to stimulate heart pacing, either as an emergency procedure or as a temporary procedure until a decision is reached to implant a permanent pacemaker. Since this device has no known risks, the commercial potential appears to be extremely high. Due to its success in this SBIR project, the company that invented this device was acquired by a large corporation in late 1987.

An SBIR product that has received a great deal of media attention over the past year is a device that treats infantile colic. This device has been described in a number of articles in the New York Times, Wall Street Journal, USA Today, Newsweek (International Edition) and featured on the "Good Morning, America" program. Infant colic, a syndrome of unknown etiology, causes sustained, high-pitched, and extremely agitated crying in babies. In addition to the obvious discomfort to the infant, who may cry for hours, it causes considerable stress and anxiety to family members who are generally unsuccessful in calming the infant. The stressful aspects of colic have been associated, in some cases, with child abuse or neglect. SleepTight™ is a noninvasive mechanical device that can be attached to the crib of a colicky infant. It generates vibrations and sounds, stimulating a ride in a closed car, that significantly reduces the crying and agitation of the infant. In studies with 100 colicky infants, 85% ceased crying within an average of four minutes. The company is currently selling the device at the rate of 12,000 units annually and expects to triple its sales volume in the next two years. Since it is estimated that approximately 9% or over 300,000 infants each year become colicky, this projection is not unrealistic.

Prior to the enactment of the Small Business Innovation Research Development Act in 1982, small business participation in the HDS regular research and demonstration (R&D) program was limited. This was due generally to the authorizing legislation under which the HDS programs operate. In most cases, the statutes limited eligibility to local and State governments, and private non-profit institutions. The limited statutory capability to fund "for-profit" organizations as grantees was not used extensively. As a result, awards to small businesses resulted from their participation in other programs within HDS which were not related to research and demonstration. Since the implementation of the SBIR Program in 1983, HDS has awarded 32 grants to small businesses. These awards total over $1.5 million in research and demonstration funds. In the next 5 years, HDS expects to fund an additional $2.5 million in awards under the SBIR Program.

During the initial implementation stage of the SBIR Program in HDS, it was difficult to determine the role small businesses could play in conducting R&D toward the end of commercializing the results of their research. One major concern was that the kind of products that were traditionally derived from HDS' research was informational materials such as "how-to" manuals. For example, one of HDS' regular research priorities in 1983 focused on the development and testing of new service delivery models with a high probability of increasing the efficacy of services at the point of service delivery. HDS questioned whether this kind of research could successfully be conducted and tested within the guidelines of the SBIR Program. Could this research be carried out with the $150,000 combined resources for Phases I and II? And, if so, how would the results be commercialized? What audience would be willing to pay for information previously made available "free" by HDS, or at a nominal cost through an information clearinghouse? Consequently, HDS received only a limited number of proposals under that year's SBIR Solicitation.

Over the next few years, HDS' research and demonstration efforts shifted toward identifying model approaches in human services delivery that have a direct impact on increasing self-sufficiency. With this conversion, a major thrust in HDS' R&D objectives became the dissemination of information about exemplary techniques and approaches that had already proven successful through research and demonstrations. Of equal importance became the need to replicate these models in other geographic locations. It was at this point that HDS realized how potentially valuable small business could be in meeting its R&D needs. Commercialization of the results of HDS' R&D activities has the potential for increasing the practical applications of these techniques and approaches. When a new approach in human services is to be transferred from one location to another, an important step is developing the documentation that captures the "essence" of the innovation. The successful capture--in a report, a videotape, or training materials--provides an ideal opportunity for commercialization which we believe will ultimately lead to increased usage by service practitioners and others in the social field.

With the above concept in mind, in 1988 HDS solicited proposals in areas such as Interactive Learning for Youth. This research topic requested the development of books and/or video materials that utilized "decision theory." In another research topic, HDS sought proposals for the development of simple

Conclusions

- SBIR has enhanced the research portfolio within the Public Health Service. By emphasizing applied research and the application of technology to solving clinical problems, SBIR projects have provided a counterbalance to the PHS basic research programs. In cases where a program's needs in applied research had not previously been met, SBIR has succeeded in filling a variety of scientific gaps in the PHS research programs.

- SBIR has facilitated and expedited technology transfer within the Public Health Service. More than any other single feature, the SBIR Program has clearly accelerated the translation of research findings into useful and marketable products. SBIR awardees have sought innovative means of exploiting fundamental knowledge and technology to develop products that are not only cleverly designed but also meet a market need. Given the SBIR emphasis on commercialization, the overwhelming share of SBIR projects supported by the PHS are intended to develop products, processes or technology with commercial applications.

- SBIR has attracted a new group of scientists to the PHS research community who can contribute toward meeting program goals. Through the SBIR Program, PHS has been able to "tap" a new source of investigators, scientist-entrepreneurs who normally would not be participating in the type of research that is traditionally supported by the PHS. Thus SBIR has drawn "newcomers" with new areas of expertise into the pool of qualified investigators who can assist the PHS in meeting its overall program goals.

- The Office of Human Development Services has identified a significant role that small businesses can play in its R&D programs. HDS feels that small businesses, through the SBIR Program, will provide a vehicle for the transfer, dissemination, and replication of new technology developed by HDS grantees in the areas of human and social services.

- The Department is continuing to find ways in which smaller R&D programs whose missions may seem somewhat incompatible with the SBIR model, can participate in the program in a meaningful manner.

Recommendations

- There is sentiment among staff at the Public Health Service that Phase I is too restricted, in terms of both the period and amount of support. A large number of our SBIR awardees find it difficult to produce meaningful results in six months' time at a funding level of $50,000. Yet these results constitute a critical element in assessing the degree to which the SBIR awardee was successful in meeting Phase I objectives. It has been suggested that a more appropriate timeframe might be 12 months with funding increased to $75,000. This would allow the small business sufficient time and

APPENDIX

Department of Health and Human Services

Small Business Innovative Research Program
SBIR Proposals/Applications Submitted and Funded

GRANTS

	PHS Phase I		PHS Phase II	
	Submitted	Funded	Submitted	Funded
FY 83	707	133	N/A	
FY 84	833	217	91	53
FY 85	881	276	140	104
FY 86	1623	342	240	142
FY 87	1531	317	369	99

CONTRACTS

(Starting in FY 85)

	PHS Phase I		PHS Phase II	
	Submitted	Funded	Submitted	Funded
FY 85	382	156	N/A	
FY 86	385	71	120	23
FY 87	305	34	76	43

	HDS Phase I		HDS Phase II	
	Submitted	Funded	Submitted	Funded
FY 83	50	4	N/A	
FY 84	35	5	2	2
FY 85	40	4	3	3
FY 86	3	3	2	2
FY 87	0	0	9	2

	HCFA Phase I		HCFA Phase II	
	Submitted	Funded	Submitted	Funded
FY 83	35	2	N/A	
FY 84	42	3	2	1
FY 85	39	3	3	2
FY 86	25	5	4	1
FY 87	47	5	3	2

Letter From the Department of Transportation Concerning the SBIR Program

U.S. Department
of Transportation
**Research and
Special Programs
Administration**

The Administrator

400 Seventh Street, S.W.
Washington, D.C. 20590

APR 1 1988

Mr. Neal P. Curtin
Deputy Director
Resources, Community and
Economic Development Division
United States General Accounting Office
Washington, D. C. 20548

Dear Mr. Curtin:

The Secretary of Transportation has asked me to respond to your recent request for judgments of department or agency heads as to the effect of the Small Business Act on their research programs. The Research and Special Programs Administration has been assigned the responsibility for administering the Small Business Innovation Research (SBIR) Program for the Department of Transportation and provides the overall management of the Program. In response to your request, we have obtained information from the various elements of the Department regarding the effectiveness of Phase I and Phase II of the SBIR Program.

The Department has awarded 135 Phase I and Phase II contracts valued at approximately $12 million since the SBIR Program's inception in Fiscal Year 1983. The awards were based on the provisions of Public Law 97-219, as amended, which currently require a minimum of 1.25% of the Department's extramural research budget to be set aside for research or research and development by SBIR awardees.

Our overall assessment of the SBIR Program, based on information provided by our various Operating Administrations, is that the Program has provided an important adjunct to normal contracting mechanisms for meeting the objectives of the Department's research programs. The research objectives of the Department are to provide the information and new technology needed for its operational programs (e.g., air traffic control) and for regulatory programs (e.g., automotive and aircraft safety standards). The SBIR Program has contributed toward meeting these objectives by providing research that has relevance to the improvement of some aspect of the national transportation system or to the enhancement of the ability of the Department to perform its mission. The SBIR Program has also enabled firms that would otherwise not normally be able to compete for federal research funds to provide significant contributions toward a safe, efficient and reliable transportation system.

The SBIR research topic areas are determined annually by each Operating Administration and reflect the Department's priority research needs best met by innovative small business firms. The SBIR Solicitation process has helped the Department meet its current research objectives and provides a timely and cost-effective contracting method with small business firms.

ATTACHMENT

The participating elements of the Department of Transportation's Small Business Innovation Research (SBIR) Program include the Office of the Secretary, United States Coast Guard, Federal Aviation Administration, Federal Highway Administration, Federal Railroad Administration, Maritime Administration, National Highway Traffic Safety Administration, Urban Mass Transportation Administration, and the Research and Special Programs Administration.

Each element has a mission which includes research or research and development opportunities for innovative small business firms as summarized below.

OFFICE OF THE SECRETARY

The Office of the Secretary (OST) supports broad-based policy research on domestic and international transportation issues of importance to the nation.

The SBIR Program in the Office of the Secretary, although small, operates in a cooperative manner with the various Operating Administrations and jointly funds critical projects. This has helped ensure that research priorities in areas such as safety are initiated in selected cases. OST is pleased to continue to contribute and participate with the other modes that support high priority research goals and objectives of the Department.

UNITED STATES COAST GUARD

The U.S. Coast Guard (USCG) supports research to maintain and improve search and rescue systems, environmental protection, marine safety, aids to navigation, the enforcement of laws and treaties and activities which benefit all USCG programs.

The SBIR Program has provided an approach to perform basic research in high priority areas in support of USCG mission requirements. The SBIR Program is an effective method to achieve research objectives that are most appropriate for innovative small business firms. The success of the SBIR Program is demonstrated in projects that have application both to the USCG and to other operating elements both within the DOT and in other federal agencies.

FEDERAL AVIATION ADMINISTRATION

The research program of the Federal Aviation Administration (FAA) is consistent with the needs of the National Airspace System Plan. Current initiatives include enhancing the capability of a wide range of radar systems to meet new operational requirements; continuing the Traffic Alert and Collision Avoidance System Program; increasing system and airport capacity; continuing developmental efforts for Advanced Traffic Management and Automated Enroute Traffic Control; continuing development of radars for detection and tracking of severe weather; and continuing emphasis on initiatives in aviation security through expedited development of devices for detection of weapons, explosives and flammable liquids.

ATTACHMENT (Continued) Page Three

FEDERAL RAILROAD ADMINISTRATION

The Federal Railroad Administration's (FRA) research and development efforts are primarily directed in support of the Administration's rail safety regulation responsibilities.

FRA believes that the SBIR Program should be continued since it provides an efficient means for accomplishing the task it was designed to address. FRA has funded more than the mandatory assessment, when resources have permitted, and views SBIR as a useful way to communicate priority research needs to a broader community of scientists and engineers than might otherwise be reached.

MARITIME ADMINISTRATION

The Maritime Administration's (MARAD) research and development mission has included development of methods, equipment and systems to make the U.S. shipbuilding and ship operating industries more efficient, competitive and productive.

MARAD has supported the objectives of the SBIR Program; however, funds for MARAD's overall research program have been severely reduced eliminating the extramural base on which SBIR funding is assessed. Although the quality of Phase I research supported has been good, none has proceeded far enough along from the initial feasibility effort to enter into a second phase development project.

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

The National Highway Traffic Safety Administration (NHTSA) supports research for motor vehicle and highway safety research and developments including alcohol enforcement and emergency services, crashworthiness and crash avoidance research, the National Occupant Protection Program and the National Driver Register.

NHTSA supports the SBIR Program as a valuable adjunct to the research procurement process to encourage small businesses to develop innovative approaches or concepts. The SBIR Program provides a unique research and development forum in which a desired applied R&D project can be prioritized on the basis of its importance to the highway safety program.

URBAN MASS TRANSPORTATION ADMINISTRATION

The Urban Mass Transportation Administration (UMTA) provides support to research, training and human resources programs in all phases of urban mass transportation services and programs which contribute toward meeting total urban transportation needs at minimum costs. In addition, UMTA supports interdisciplinary research at colleges and universities including training of personnel to conduct further research or to obtain employment in urban mass transportation planning, construction, operation or management.

Letter From the Environmental Protection Agency Concerning the SBIR Program

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MAY 31 1988

THE ADMINISTRATOR

Mr. Neal P. Curtin
Deputy Director
Resources, Community and Economic
Development Division
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Curtin:

In response to your request of December 3, 1987, seeking our views on the effects of the Small Business Innovation Research (SBIR) Program on the U.S. Environmental Protection Agency's research programs, we have enclosed a summary of our findings. Although a determination of the complete impact of our SBIR Program is premature, the enclosed information indicates that such an impact does exist.

If you have further questions please contact Mr. Walter Preston of my staff. His telephone number is (202) 382-7445.

Sincerely,

Lee M. Thomas

Enclosure

Data for our analysis was obtained through a survey letter (Appendix A) which was sent to all of EPA's Phase II awardees, both past and present, totalling twenty-nine.

Interaction directly affecting EPA's research and development and/or any other EPA activity was requested, as was information on the awardees' interactions with other federal agencies relative to their EPA-sponsored SBIR research.

The analysis plan was to provide a synopsis of each response (Appendix B) and to tally the percentage of responses in each category requested.

Results

The following results are based on a brief analysis of the respondents' letters and contain all of the principal characteristics of their responses.

1. All recipients of the survey request responded (29).

2. Sixty-five percent of the respondents indicated that they have had some interaction with EPA or other Federal agencies, State governments, local governments, or private industry.

3. Thirty-one percent of the respondents reported interaction with EPA laboratories or field stations.

4. Fourteen percent of the respondents reported interaction with EPA regional or headquarters program offices.

5. Twenty-eight percent of the respondents reported interaction with State or local governments.

6. Thirty-five percent of the respondents reported having interaction with private industry.

7. Thirty-five percent of the respondents reported that they have not had any interactions with the Agency or other corporations.

8. In addition, the following significant issues and/or items that were not requested in the EPA letter were indicated by the respondents:

    a) There is a potential for useful application of the SBIR work. About 47% of the respondents made this statement.

    b) Twenty-eight percent felt it was too soon to determine success. A number of years would be required to do this.

APPENDIX A

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
RESEARCH AND DEVELOPMENT

Mr. Donald Westermann
Chemical Process Corporation
8701 Watertown Plank Road
Milwaukee, Wisconsin 53226

Dear Mr. Westermann:

The purpose of this letter is to seek information from you on your Small Business Innovation Research (SBIR) projects which are or were supported by the U.S. Environmental Protection Agency (EPA).

The U.S. General Accounting Office (GAO) is required by law to transmit a report to appropriate House and Senate Committees on the effectiveness of the SBIR Program in meeting Federal research and development needs. In accordance with this request, GAO has asked each participating Federal agency to provide them with an assessment of the nature and extent of its SBIR Program's record in supporting such needs.

We are developing EPA's response to the GAO request and would greatly appreciate any information that you, as an EPA-supported SBIR awardee can provide. Specifically we would like any information that you can offer in the following two areas:

(1) Any ways in which your EPA-supported SBIR research affected activities in any of EPA's laboratories, field stations, or other scientific facilities of the Agency, or ways in which EPA's regulatory or other non-scientific activities were supported by such research.

(2) Any ways in which your EPA supported SBIR research affected the activities of Federal agencies other than EPA.

We would appreciate a response even if no interaction with EPA or other Federal agencies occurred.

I thank you in advance for your response, and would like to hear from you by March 14, 1988, at the latest.

If you have any questions, please contact Mr. Walter Preston of my staff. His telephone number is (202) 382-7445.

Sincerely yours,

Roger S. Cortesi, Ph.D.
Director
Office of Exploratory Research (RD-675)

George Alford and Bill Rogers, Consulting Engineers have organized major portions of the First International Symposium on Biofouled Aquifers held by EPA's Robert S. Kerr Environmental Research Laboratory (RSKERL) (Ada, OK) facility, spurred by Alford and Roger's EPA sponsored SBIR project in this area. They have received a contract from the U.S. Army Corp of Engineers for field work on dam and level structures using portions of their technology.

Technology for Energy Corporation has not interacted as yet with EPA laboratories etc.; however, they have been working with DOE's Oak Ridge National Laboratory (ORNL) on a sub-contract following their asbestos analysis techniques developed on their EPA SBIR contracts.

ADA Technologies, Inc. has not interfaced with EPA. However, they have been discussing possible extensions of their EPA SBIR work with DOE project officers at their Pittsburgh Technology Center.

Energy and Environmental Engineering, Inc. has been selected as a final proposer to EPA's Emerging Technologies Program of the Hazardous Waste Environmental Research Laboratory (HWERL) Cincinnati facility using the laser induced hazardous waste destruction process developed under the EPA SBIR Program. The U.S. Army is also interested in possibly testing the process on their pink water problem.

Bio-Recovery Systems, Inc. is similarly engaged in HWERL's Emerging Technologies Program as a final proposer. The U.S. Navy is considering use of their unique heavy metals removal process in treating their electroplating wastewaters.

Aware, Incorporated Although incomplete, laboratory testing techniques and early modelling efforts of their in-situ hazardous waste treatment process funded by EPA's SBIR Program have been used in a larger effort successfully reversing a prior Record of Decision for a Region III Superfund site enabling use of a much more cost-effective remediation process.

Merix Corporation has interacted with the Air and Energy Environmental Research Laboratory Director, et al, in the evaluation of their emulsion Flue Gas Desulfurization scrubbing process. However, a pilot test was not authorized despite indicated technical advantages. The emulsion expertise gained enabled an SBIR award from NASA to produce hollow ceramic spheres. Also, an SBIR award from the National Cancer Institute (NCI) was made possible wherein an emulsion process deheparinizes blood in kidney dialysis and/or open heart surgery. Further, Merix obtained an SBIR Phase I from the Defense Nuclear Agency to make submicron silicon carbide particles with their emulsion technology.

Mr. Donald Westermann
Chemical Process Corporation
8701 Watertown Plank Road
Milwaukee, Wisconsin 53226

Mr. Richard Jahlin
Richard Jahlin and Associates, Inc.
2500 West Club Boulevard
Durham, North Carolina 27705

Mr. Harold K. Lonsdale
Bend Research, Inc.
64550 Research Road
Bend, Oregon 97701-8599

Mr. George A. Jutze
PEI Associates, Inc.
11499 Chester Road
Cincinnati, Ohio 45246

Mr. Thomas W. Mix
Merix Corporation
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Wellesley, Massachusetts 02181

Mr. James E. Porter
Energy and Environmental Engineering, Inc.
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Mr. Jack Ritter
Electrochimica Corporation
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Mr. Dennis W. Darnall
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Mr. Michael P. Manning
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Ms. Liz Potter Neller
Lamar-River Oaks Travel, Inc.
Lamar River Oaks Center
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Houston, Texas 77098

Mr. William C. Pfefferle
William C. Pfefferle Associates
25 Science Park
New Haven, Connecticut

Mr. Ralph D. Wright
Technology for Energy Corporation
One Energy Center, Lexington Drive
Knoxville, Tennessee 37933-0996

Mr. Misha Plam
Sievers Research Inc.
2905 Center Green Court, Suite B
Boulder, Colorado 80301

Mr. James Keane
Kenterprise Research, Inc.
23 South Harlan Street
York, Pennsylvania 17402

Mr. F. Terry Nixon
Incubator Technologies, Inc.
Mead Building
Twitty Drive
Rolla, Missouri 65401

Mr. Albert Zlatkis
Tonics Research, Inc.
22 Sandalwood Drive
Houston, Texas 77024

All our information makes it clear that small businesses are valuable and cost-effective sources of R&D innovations for NASA and that SBIR is an effective way to discover and use them. Without exception, the NASA Center Directors support continuation of the SBIR program and intend to ensure the integration of small business capabilities in their pursuit of NASA's R&D goals.

I was pleased to learn also that significant commercial benefits have already accrued to a number of participating firms. Company officials for 16 of the projects reported commercial sales of products and services to private and public entities and/or receipt of additional R&D funding from private sources and Federal agencies other than NASA. Good prospects for future commercial applications of the results of another 12 projects were also reported. Considering the recent completions of many of the research projects, these findings are impressive.

In summary, I am pleased to report my judgments of the SBIR program: that the quality of most of the research is high, that its effects on NASA's research are positive, and that many small businesses in the SBIR program produce valuable and cost-effective results. We expect continued benefits from SBIR in both its support of the NASA mission and its contributions to the national economy.

Sincerely,

James C. Fletcher
Administrator

eventually became the national SBIR program. Then, as now, it served to stimulate innovation and to couple small high technology firms to the basic research community. In the decade since its inception, SBIR has complemented the Foundation's basic research programs by providing a linking mechanism between these and the marketplace. While many studies may be cited, a Rand Corporation study of 1984 points out that the results of basic research do not readily find their way to the marketplace without the use of intermediate mechanisms. SBIR provides one such mechanism. In addition, the Foundation's experience demonstrates that the program results feed back to the basic research community through the creation of new research instruments, sensors, and materials. Much of this success stems from the program design feature whereby each of the Foundation's research divisions formulates research topics for the SBIR solicitation.

The four purposes stated in the legislation are the basis of NSF's review of the accomplishments of the SBIR program:

* stimulation of technological innovation
* use of small business to meet Federal research and development needs,
* fostering minority and disadvantaged persons to participate in innovation, and
* increasing private sector commercialization of innovations from Federal research and development.

Both the quantity and quality of proposals received from the 1987 solicitation measure the program's success in stimulating innovation. Of the 1250 proposals received, over 300, or one in four, were found by merit review to be scientifically worthy of support. Because of funding limitations only 160 of this group of 300 projects were selected for award.

The SBIR award history shows that the profile of technologies included in the funded projects has tracked the National Academy of Sciences five year outlook of 1981 and the OSTP report to the Congress of 1983 as to projected national technological needs. Another measure of relevance to national needs is the emphasis on increased productivity and competitiveness. Fully 40 percent of the SBIR research projects funded through 1987 related to improved manufacturing processes, productivity, or quality.

The SBIR program fostered the interest and participation of minorities and the disadvantaged in research and innovation. In 1986 the Foundation sponsored a conference for small high technology firms underrepresented in science and technology. A similar session was included in the 1987 "Federal High Tech"

NATIONAL SCIENCE FOUNDATION

SMALL BUSINESS INNOVATION RESEARCH

ONE DECADE LATER

Corporation study of 1984 supported by the Foundation <1> showed clearly that the results of basic research do not readily find their way to the market place without the use of intermediate mechanisms. SBIR provides one such mechanism. In addition the Foundation's experience demonstrates that the program results feed back to the basic research community through the creation of new research instruments, sensors, and materials. Much of this success stems from the design feature whereby each NSF research division formulates research topics for the SBIR solicitation.

MEASURES OF PERFORMANCE

The four purposes of the 1982 legislation are the basis for assessing the accomplishments of the SBIR program at the Foundation, namely:

* stimulation of technological innovation
* use of small business to meet Federal research and development needs,
* foster minority and disadvantaged persons to participate in innovation, and
* increase private sector commercialization of innovations from Federal research and development.

Both the quantity and quality of proposals received from the 1987 solicitation measure the program's success in stimulating innovation. Of the 1250 proposals received, over 300, or one in four, were found by merit review to be scientifically worthy of support. This ratio also generally holds for awards in the basic research directorates of the Foundation. From this group only the best 160 projects were selected for award.

The SBIR award history shows that the profile of technologies included in the funded projects has tracked the National Academy of Sciences five year outlook of 1981 <2> and the OSTP report to the Congress of 1983 <3> as to projected national technological needs. Still another measure of relevance to national needs is

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[1] Tora K. Bikson, Barbara E. Quint, Leland L. Johnson, "Scientific and Technical Information Transfer" Rand Corporation, Report to The National Science Foundation, N-2131-NSF, March, 1984

[2] "Five Year Outlook on Science and Technology-1981", National Research Council, National Academy of Sciences, Washington, D.C., 1981

[3] "Annual Science and Technology Report to the Congress", Office of Science and Technology Policy, Washington, D.C., 1983

SMALL BUSINESS INNOVATION RESEARCH AT NSF
ONE DECADE

1. INTRODUCTION

Required Report. Public Law 99-443 requires that The Comptroller General provide a report to the Congress,

> " evaluating the effectiveness to date of phase one and phase two of the SBIR program as set out in section 9(e)(4) of the Small Business Act. Such report shall examine the quality of the research supported by the SBIR Program compared to that traditionally supported by the affected agencies, and the extent to which the goals of the SBIR Program are being met."

The present study provides data on the accomplishments of the Small Business Innovation Research (SBIR) program at the National Science Foundation for the Comptroller General's report.

Ten Year History. For more than ten years the Foundation has sponsored high quality applied research with small business. Under SBIR more than 1000 competitive research awards have been made to small high technology based firms. Some of these awards have resulted in new commercial products, as private sector investors have committed significant funds to SBIR winners to bring more new products to the market. For example, those firms which received Phase I and Phase II grants from the Foundation between 1977 and 1982 report that, as a result of the SBIR program as a whole, they have experienced in excess of $400 million in commercial activity, one of the original and important objectives of the program. SBIR has also increased technology transfer, another important and historic function of NSF. This further helped to bridge the gap between university and industry research. About 52 percent of the projects reflect some level of collaboration with a university or faculty.

The pioneering NSF program was designed and implemented at the Foundation in 1977, designed to stimulate innovation and structured to follow the technological thrust of the Foundation. The program made its first awards in 1977 and became the model for the 1982 Small Business Innovation Development Act, PL 97-219. From an initial 329 proposals in 1977, some 42 awards were made for Phase I research. By 1987, 1250 proposals were submitted and 160 awards were made for Phase I. This growth in response is indicative of the increased awareness in the small business community of the opportunity which the program presents; details appear in Table 1.

3. ASSESSING THE FOUR MAJOR GOALS

Planning for the original NSF SBIR program began in 1976. It called for the use of a "trial" phase prior to making large grant awards or contracts to a firm, no matter how promising their proposals. This led to a phased program in use today at NSF and at all other agencies with SBIR programs:

Phase I is the initial NSF grant, $50,000 maximum.

Phase II is the major research effort, often a larger NSF grant up to $250,000, usually subject to a commitment of investment by the private sector for the next phase.

Phase III marks the transfer of the completed research project to the private sector for development or commercialization with private sector funding. The level of support for this last phase is one positive indicator of the success of the program. The history of these awards is shown in Table 1.

Goal 1: SBIR PROMOTES INNOVATION

"...to stimulate technological innovation..."

There are several measures of the success of the SBIR program in promoting innovation:

a) the increase in the number of quality proposals received by the program,

b) the increase in the number of quality proposals recommended for awards made each year,

c) the diversity of innovative quality proposals

d) the interest of the private sector as measured by the investment in commercialization, represented by selected examples of resultant innovations.

a) Quality Proposals. One of the main criteria for a Phase I grant is the innovative nature of the proposed research. The ratio of the proposals judged as innovative to the total of those proposals received has grown from about one in seven in 1977 to one in four in 1987, an assessment made possible because the Foundation's SBIR program predates the Act by about five years. This means that there is a longer time line available for the study of the growth of innovation. Typically the Phase I and Phase II research process takes from three to four years to complete, and the private sector Phase III development can take

Table 1: NSF SBIR HISTORY

NUMBERS OF PROPOSALS, AWARDS & NSF FUNDING

SOLICITATION YEAR	FUNDING MILLIONS	PROPOSALS RECEIVED	PHASE I AWARDS	PHASE II AWARDS	PHASE III COMMITMENTS
1977	$1.0	329	42	21	9
1979	3.1	408	54	13	5
1980	2.1	530	62	13	12
1981	5.0	696	86	18	24
1982	5.1	764	108	41	39
1983	5.5	1,186	102	42	37
1984	7.1	976	105	49	47
1985	12.4	937	127	(46)	(45)
1986	15.4	1,199	152	(50)	(45)
1987	16.8	1,248	(160)		

( ) Indicates award action in progress (estimate - not final)

c) Diversity. Another measure of the capacity of the SBIR program to stimulate innovation lies in the diversity of research supported by the program. While the research topics under the Foundation's solicitation follow the major thrusts of the engineering and scientific disciplines, responses are often unique. For example, while the astronomy program sought new sensors or improved instruments, it may in the end support a new materials process which results making a more sensitive light detector or a better mirror. A few examples of some SBIR project titles illustrate the breadth, sophistication, and innovation inherent in the program:

- o Single Sphere, Multiple Detector Neutron Spectrometer
- o Integration of Stochastic Differential Equations on Supercomputers
- o Advanced Dielectric Cap for III-V Ion Implantation
- o Stable Suppression of Gene Activity in Plants
- o High Performance Signal Processing
- o Coherence Holographic Reflector Based Non-Linear Materials
- o Coenzyme Recycling Using a Membrane Reactor
- o High Performance Superconducting Magnetic Bearing

600 to 1200 nm wavelength range. Laser rods were introduced as a product in 1987 and a large company is now developing a tunable solid-state laser system based upon the rods. This should develop into a significant military and commercial market. Customers include Lockheed, Hughes, McDonnell-Douglas, Northrup and Wright-Patterson AFB. University collaboration is with MIT and State University of New York, Stonybrook. Employment has increased from 10 to 24.

- SBIR 82-60166 "Long-Life Catalysts for Immobilized Microorganism Fermentors," 1983-1986, Verax Corporation, Lebanon, NH.

This SBIR funded by NSF and later by NIH resulted in the invention of micro-porous beads to optimally grow mammalian cells before Phase II was completed and what may be the leading continuous process for large scale production of engineered proteins. Investment of $17 million was obtained from Eli Lilly, Combustion Engineering, Genentic and 10 venture capital firms. Cumulative sales now exceed $7 million. University collaboration is with Dartmouth, Rutgers, MIT, Rochester and Virginia. Employment increased from 12 to 80.

- SBIR 81-13807 "Compton Backscatter Computed Tomography," 1982-1985, Advanced Research and Applications Corporation, Sunnyvale, CA.

The NSF research support led to a major Wright-Patterson contract in Phase III for non-destructive evaluation (NDE) equipment totaling $12.5 million, $6.5 million in R&D, and a team venture with Bechtel Corporation for NDE building inspection quality control. University collaboration has been with Stanford and University of California at Berkeley. Employment has increased from 35 to 65.

- SBIR 77-19777 "Coupled Transport Membranes for Metal Recovery," 1977-1980, Bend Research, Bend, OR

This research and other SBIR awards that followed in the membrane area built up a research base that led to $15 million in investment or joint ventures from Bethlehem Steel, W.R. Grace, Pfizer and ENI (Italy). Products resulting from SBIR on the market through joint venture firms include a gas separation element and an insect control formulation. The company believes it is a national leader in membrane technology. University collaboration is with Oregon State, Minnesota and Michigan. Employment has increased from 10 to 105 including the spinoff companies.

Conclusion. Quantitative input and output measures in the form of proposal pressure, proposal quality, and private sector

necessary to compare projected technological trends and requirements with the projects which have been awarded.

2) The National Academy of Sciences in 1981 prepared the **Five Year Outlook on Science and Technology**[6], and

3) the Office of Science and Technology Policy prepared the **Annual Science and Technology Report to the Congress**[7] in 1983.

Research Priorities. Based on review of these major reports, and other data, the perceived research priorities could be summarized under the following general categories:

- o electronic materials and devices
- o lasers and electro-optical devices
- o biological systems, neurobiology
- o robotics and computers
- o fluids, turbulence
- o surface science
- o air and water pollution

Industry Studies. Similar but not identical results emerged from analyses of various industrial indicators such as compound annual growth rates by industry, and the distribution of industrial research expenditures. The resulting industrial R&D priorities are:

- o electronic materials and devices
- o scientific instruments
- o electrical equipment and computers
- o chemicals and chemical processes
- o aerospace systems
- o mechanical systems and machinery

While there is not complete agreement between the governmental forecasters and the distribution of industrial research resources, it became apparent that both perceive electronic materials and computers to be of long term importance.

NSF SBIR Priorities. The foundation made its SBIR awards under a series of research topics representative of the disciplinary research thrusts. These topics have been reviewed and are summarized under the following, more generic categories. These categories make it possible to assess how well SBIR research

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[6] **Five Year Outlook on Science and Technology-1981**, National Research Council, National Academy of Sciences, Washington, D.C. 1981.

[7] **Annual Science and Technology Report to the Congress**, Office of Science and Technology Policy, Washington, D.C., Oct. 1983.

these research activities appear to have tracked both the forecasts and the industrial perceptions of where the action was or would be.

National Needs. About 90 percent of Phase I awards were made in areas relevant to "national needs forecasts," as reported separately by the National Academy of Sciences, and the Office Science and Technology Policy[9]. Moreover, the awards reflected quite accurately the industrial perceptions of areas of technological and economic growth. Proposals received by NSF SBIR in response to the solicitations have provided the Foundation with useful feedback from industry on "hot" technical areas.

Since 1977, the Foundation has made awards in about 30 solicitation or topic areas. One interesting facet of these awards is that a project is often relevant to more than one area of technology or application. For example an award made under radiation physics for research on a pulsed ion or x-ray source has found application as a manufacturing tool for integrated circuits. Thus, the SBIR program has over its ten year life span served as a mechanism for funding industrially relevant research in many disciplines with a broad range of applications.

Conclusions: The analysis of the Foundation's SBIR awards leads to the conclusion that the projects funded by the SBIR program have been relevant to the perceived national technological needs. This is particularly germane to the development of needed new processes in chemistry and manufacturing, new materials in electronics, and new methods in biosciences. The perceptions which the small high tech firms have brought to the Foundation in the form of their proposals has helped in the fight for technological competitiveness.

Goal 3: ENCOURAGE MINORITY PARTICIPATION

"...to foster and encourage participation by minority and other disadvantaged persons in technological innovation...."

The NSF program in small business innovation antedates the Small Business Innovation Development Act of 1982 which specifies this objective. NSF has a long-standing policy of encouraging participation by women, minorities and the disadvantaged. Results from the 1987 solicitation with regard to this objective are given in subsequent paragraphs.

In 1986, the Foundation's Division of Industrial Science and Technological Innovation undertook a concerted effort to present information about the SBIR program to minority and disadvantaged

[9] op. cit.

success in stimulating minority and disadvantaged participation is the increase in the number of awards to these groups.

Goal 4: SBIR INCREASES COMMERCIALIZATION

"...to increase private sector commercialization innovations derived from Federal research and development."

The original 1976 NSF SBIR program emphasized commercialization. Because it was not clear that small high technology firms could perform quality research, the program consisted of three phases. The objective of Phase I was to explore, Phase II to use more NSF support to build on the promise of Phase I, and the real crux of the program was to get to Phase III where the project is handed off to the private sector for funding of development and commercialization. The process is still in use today not only at NSF but at other agencies with SBIR programs. Figures for NSF SBIR activities since 1977 appear in Table 1.

Follow-on Funding. Since 1977 an important factor in achieving results from SBIR, and a basic element of the program design, has been the requirement for follow-on funding commitments. NSF makes few Phase II awards without obtaining, in advance, a signed contingent commitment from a third party for follow-on funding. It states that the third party will fund Phase III with at least $200,000 to enable the small business to pursue commercial product development. (There are two contingencies: Phase II must first achieve the agreed upon technical objectives; and the technology has not been by-passed in the marketplace during Phase II.) In return, following investment, the third party may receive an exclusive or non-exclusive license, shares of stock in the company, prototype instruments, or whatever agreement these parties choose to make. This mechanism has been crucial to take the project from public funding to the private sector.

Phase II research proposals are recommended for award only as a result of their technical merit. If they are accompanied by a satisfactory follow-on funding commitment, they receive preferred consideration in the awards process (as compared to other SBIR proposals.) This is a means of combining SBIR "technology push" with the "market pull" of the follow-on funding commitment from the private sector. In practice, small firms have obtained commitments from major venture capital investors, research and development limited partnerships, and large industrial firms in the United States.

The innovative nature of the research carried out under the SBIR program as well as the commercial potential of some of these

investment from six large industrial firms: Martin-Marietta, McCormick, Sandoz, Elf Aquitaine, Tata and Sumimoto. The firm has also obtained venture capital from Venrock, F.H. Prince, Greylock, Southwest Venture Partners and Newcastle, as well as research and development partnerships from Merrill Lynch, Morgan Stanley, and Paine Webber. Employment in the firm has increased from 40 in 1980 to 450 today. The firm is a world leader in plant genetics.

o Ceramatec, Inc. of Salt lake City, Utah received an SBIR grant in 1983 for the fabrication of a new class of silicon ceramics. This NSF support led to Phase I and Phase II DOE SBIR awards and may result in a Phase III with a major U.S. industrial firm on high wear engine parts. An earlier NSF SBIR award was for "Electrowinning and Refining of Metallic Sodium Using Solid State Rapid Ion Conductors" for use in electrolytic cells for a sodium sulfur battery for the 1990's. This was an SBIR follow-on of NSF research sponsorship by the same principal investigator while a professor at the University of Utah. The Phase III requirement of both projects has resulted in $13 million of venture capital investment by the Koppers Co., ELKEM (Norway), and Whitcom. Ceramic packaging products and contract R&D sales now total $13 million. University collaboration is with Utah, Penn, Northwestern and UC Santa Barbara. Employment has increased from 31 to 130.

o Collaborative Research, Inc. of Bedford, Massachusetts received an SBIR award in 1977 for the enhancement of animal protein production by novel genetic technology. This project was an early applied research effort in genetics in 1977, the same year Genentec was formed. To date the research, which is high risk but high payoff, has not been successful but continues through a Dutch firm. However, Dow Chemical invested an initial $5 million in Collaborative because of its genetics capability and this has increased to $12.5 million. Both the SBIR funded genetics research and the Dow investment led to $30 million in public offerings to provide funding for new facilities, staff growth and major new efforts in DNA diagnostics and enzyme products. The company was the first to identify the cystic fibrosis gene marker. David Baltimore (Nobel Laureate) chairs the company's scientific advisory committee. University collaboration is with Harvard and Massachusetts General Hospital. Employment has increased from 33 to 150.

o Biometric Systems, Inc. of Eden Prairie, Minnesota was awarded an SBIR grant in 1979 for affinity cross-linking for enzyme technology. This research and "Substitute Anatomical Materials with Proclivity for Natural Cell Lining," 1984-1987, has had an important impact on biocompatable coatings and materials. The research led to $2.5 million investment from research and development partnerships and $2 million of private placement investment. Plastic tubing coating for bypass surgery, heart valves, dental and orthopedic devices, contact and interocular lenses, in vitro cell culture systems, diagnostic systems, sensor

provides such a mechanism and further has demonstrated that the program provides feedback to basic research through the creation of new research instruments, sensors, and materials. This may be attributed to NSF procedures which routinely call for the research divisions to formulate research topics for the solicitation.

Judgment. The NSF SBIR program has shown persistent growth and success over the past ten years. It is a worthy peer among the Foundation's activities, useful nationally, validated through additional investments by other agencies and by a variety of private sector capital sources. This, in turn has generated new products, processes, techniques and has provided new jobs. It has attracted proposals from targeted audiences like minorities and the disadvantaged and has rewarded promising applicants with financial support. It has contributed to technology transfer and provided feedback to NSF basic research. The overall data for the program as reviewed and assessed in this report bear this out, and show that the NSF SBIR program has moved strongly in line with Congressional findings and intent, while leaving room for additional efforts and achievements.

$35 million and on our ability to maintain necessary safety research program funding levels. Following this discussion we reevaluated our FY 1988 situation (based upon our mid-fiscal year review) and have concluded that we can participate in the FY 1988 SBIR Program at a level of approximately $500,000. The specific number of Phase I and Phase II awards will depend on the quality and merit of the proposals received. Our level of participation in the FY 1989 program will be based on future budget developments.

I appreciate the opportunity to express our opinions and relate our experience regarding the SBIR program. The primary contact on the program at NRC is Mr. William Forehand, SBIR Program Manager, Office of Nuclear Regulatory Research (301-492-3625).

Sincerely,

Victor Stello, Jr.
Executive Director
for Operations

Enclosures: As stated

U. S. Nuclear Regulatory Commission
SBIR Effectiveness

DEVELOPMENT OF A SIMPLIFIED THERMAL HYDRAULIC MODEL AND COMPUTER PROGRAM FOR USE ON AN IBM PERSONAL COMPUTER

S. Levy, Inc. Campbell, CA
Phase I $ 50,000
Phase II $182,000

The NRC has sponsored complex computer programs to simulate thermal-hydraulic phenomena in power reactor transients. These programs are large, long-running and too costly to be used in simplified studies to get approximate results quickly or for a wide range of input parameters. S. Levy, Inc. proposed a simplified thermal hydraulic model and computer program to be run on an IBM PC.

During Phase I, the program was developed and extensively tested by NRC staff. Feasibility was demonstrated and the need for improvements identified.

During Phase II, the model was extended to allow calculation of two phase (water, steam) conditions. Subsequent testing revealed the need for more model improvements. The results were wholly satisfactory to NRC.

The commercial application of this project has been extensive. During Phase II, Carolina Power & Light provided funds to improve the simulation of plant control systems. Also New York Power Authority and Portland General Electric are using NRC's PWR model, as are 2 customers in Japan. A boiling water reactor (BWR) version was completed in January 1988, and is now being used by IOWA Electric. There are 2 more foreign prospects, 2 additional prospects for the PWR version, and 3 customers are negotiating for the BWR version.

2

U. S. Nuclear Regulatory Commission
SBIR Effectiveness

SYNTHETIC APPERTURE FOCUSING TECHNIQUE
(SAFT) INSPECTION SYSTEM

Sigma Research, Inc. Seattle, WA

PHASE I	$ 50,000
PHASE II	$235,000

At the time that this SBIR proposal was funded the NRC was conducting research on field implementation of the SAFT process for in-service inspection of nuclear reactor components. Previous research had shown the advantages of SAFT processing in obtaining major improvements in flaw detection reliability and sizing accuracy. A disadvantage of SAFT processing is that it requires millions of operations, involving square roots and additions, for the imaging of small volumes. This makes the process very computer intensive and time consuming -- too slow for practical field applications for flaw detection. One of the tasks in the NRC research program was to develop a "real-time" SAFT processor to render the technology useful for field application.

Sigma Research Inc. proposed an innovative idea for accomplishing real-time SAFT-UT (ultrasonic testing) imaging based on a frequency domain correlation process applied to conventional pulse-echo ultrasonic data using residue number system (RNS) computational methods. The frequency domain process has the potential for better discrimination of flaw types. Also SAFT processing in the frequency domain involves multiplications (instead of additions) which can be performed very fast by the RNS computational method.

A Fortran coded software simulation (for frequency domain processing using RNS) was developed by Sigma for extensive analytical studies of the proposed system. Through the use of this code it was determined that real-time SAFT processing in the frequency domain was possible and a system was designed using conventional electronic components. The hardware design concentrated on a custom memory management processor and RNS computational modules. The code was used to quantify the capability of the designed system. The software simulation program has been supplied to an NRC research contractor for its further use in the NRC sponsored program for field validation of a SAFT-UT inservice inspection system. The validity of the Sigma approach has been confirmed.

Because SAFT-UT is a relatively new technology it has not yet seen wide-spread use in the U.S. The Sigma approach represents an alternative method for implementing SAFT and we expect that it will be used extensively by industry.

4

U. S. Nuclear Regulatory Commission
SBIR Effectiveness

DEGRADATION OF NUCLEAR PLANT TEMPERATURE SENSORS

Analysis and Measurement Services Corporation, Knoxville, TN

PHASE I	$ 49,000
PHASE II	$150,000

Resistance Temperature Detectors (RTDs) are used for primary coolant temperature measurement. The RTDs perform an important safety function in monitoring power output and primary coolant safety margins. As a consequence they are required to be accurately calibrated, must maintain their calibration in use, and be both reliable and exhibit fast response with coolant temperature change. An SBIR program was initiated with Analysis and Measurement Services Corp. (AMS) which would provide answers to a number of significant NRC regulatory concerns with RTDs.

a. What qualification test methods are acceptable?
b. What temperature accuracy is achievable in initial calibration?
c. How much does the calibration change with age (time)?
d. How much drift occurs with time?
e. What is a realistic response time achievable with the several installation mounting techniques (thermowells) currently used with RTDs?

Phase II of this program has started in October 1987. It is expected that at the end of the 2 year research effort AMS will have assessed the accuracy of initial RTD calibration and the rate of degradation, as well as established a basis for periodic recalibration requirements.

The RTD calibration and drift measurement capability that AMS will possess as a result of their research is expected to provide a basis for many commercial contracts in the future. Utilities have already contracted with AMS to provide some of these laboratory services. As a result of this research, nuclear power plants are expected to provide more reliable and accurate RTD installations, thus enhancing safe operation.

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U. S. Nuclear Regulatory Commission
SBIR Effectiveness

LIQUID LEVEL DETECTION CONCEPT ASSESSMENT

Mohr and Associates, Richland, WA

PHASE I	$ 49,000
PHASE II	$260,000

The NRC requires nuclear power plant licensees to provide instrumentation in order to detect inadequate core cooling. The licensees, in conformance with this requirement, installed differential pressure cells or heated thermocouple (TC) liquid level probes in their reactor vessels. Both kinds of instruments have some detection limitations. Under Phase I of this contract, Mohr & Associates proposed a liquid level measurement design approach based on time domain reflectometry (TDR) techniques.

Under Phase II Mohr & Associates fabricated a model system and demonstrated its capability in the lab. The concept provides industry with an improved alternative for measuring the liquid level in reactor vessels and monitoring core and primary loop water inventory, both of which are needed for safety in reactor operation.

Mohr & Associates is now marketing their TDR system. Interest in licensing this system has been expressed by Westinghouse, General Electric and Combustion Engineering. Pfizer Chemical has also expressed interest in using this system to measure the true liquid level in chemical process reactors.

8

Comments From the Department of Agriculture

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20250

23 NOV 1988

SUBJECT: GAO Draft Report RCED-89-39, Dated October 31, 1988, Entitled, "FEDERAL RESEARCH: Evaluation of Small Business Innovation Research Programs"

TO: Flora H. Milans
Associate Director
Resources, Community and
Economic Development Division

The Department of Agriculture does not have any comments on the subject draft report. We appreciate the opportunity to review and comment on the report.

ORVILLE G. BENTLEY
Assistant Secretary
Science and Education

Comments From the Department of Defense

THE UNDER SECRETARY OF DEFENSE

WASHINGTON, DC 20301

ACQUISITION

5 DEC 1988

Ms. Flora H. Milans
Associate Director
Resources, Community and
Economic Development Division
U. S. General Accounting Office
Washington, DC 20548

Dear Ms. Milans:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report, "FEDERAL RESEARCH: Evaluation of Small Business Innovation Research Programs," dated October 31, 1988 (GAO Code 005738/OSD Case 7822).

The Department has reviewed the report, concurs with its findings, and has no further comment. The Department appreciates the opportunity to review this draft report.

Sincerely,

Comments From the Department of Energy

Department of Energy
Washington, D.C. 20585

NOV 16 1988

Mr. Keith O. Fultz
Senior Associate Director
Resources, Community, and
Economic Development Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Fultz:

The Department of Energy appreciates the opportunity to review and comment on the General Accounting Office (GAO) draft report entitled "Federal Research: Evaluation of Small Business Innovation Research Programs."

While we have no problem with the overall Report, we would like to request one revision to clarify a reference to an assessment of SBIR projects carried out by the Department's Office of Program Analysis. On page 73, the sentence beginning "An assessment of SBIR projects..." should be replaced with the following:

> "The assessment of SBIR projects performed by DOE's Office of Program Analysis and dated August, 1988 shows a real, although small, difference between the overall average ratings of SBIR and non-SBIR projects, with the non-SBIR projects having a higher rating.[3]"

The Department hopes that this comment will be helpful to GAO in their preparation of the final report.

Sincerely,

Lawrence F. Davenport
Assistant Secretary
Management and Administration

Comments From the Department of Transportation

U.S. Department of Transportation
Research and Special Programs Administration

400 Seventh Street, S.W.
Washington, D.C. 20590

DEC 2 0 1988

Ms. Flora H. Milans
Associate Director
Resources, Community and Economic
Development Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Ms. Milans:

This letter responds to your request for comments on a draft report entitled, "Federal Research: Evaluation of Small Business Innovation Program." We have reviewed the draft report and believe it represents a useful document to the Congress on program operations and results.

We appreciate the opportunity to review and comment on this draft report.

Sincerely,

Charles G. Rogoff
Director, Office of Program
Management and Administration

Comments From the Nuclear Regulatory Commission

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

NOV 15 1988

Ms. Flora H. Milans
Associate Director
Resources, Community, and
Economic Development Division
U.S. General Accounting Office
Washington, DC 20548

Dear Ms. Milans:

We appreciate the opportunity to comment on the draft GAO report, Federal Research: Evaluation of Small Business Innovation Programs (GAO/RCED-89-39). The report provides an excellent overview of the Small Business Innovation Research (SBIR) programs, and we are pleased that the participating agencies reported favorable results.

We agree with the overall findings and have no recommendations for revision to the draft report.

Sincerely,

Victor Stello, Jr.
Executive Director
for Operations

Major Contributors to This Report

Resources, Community, and Economic Development Division, Washington, D.C.

Flora H. Milans, Associate Director (202) 376-9715
Lowell Mininger, Group Director
Dave Balderston, Evaluator-In-Charge
Richard Frankel, Scientist/Evaluator
George Schollenberger, Evaluator
Joshua Lerner, Science Policy Analyst
Fran Featherston, Social Science Analyst
Larry Curtis, Evaluator

Comments From the Small Business Administration

U.S. Small Business Administration
Washington, D.C. 20416

OFFICE OF THE
INSPECTOR GENERAL

NOV 15 1988

Ms. Flora H. Milans
Associate Director
Resources, Community, and Economic
Development Division
General Accounting Office
414 G Street, N. W.
Washington, D. C. 20548

Dear Ms. Milans:

As requested by your letter of October 31, 1988, we have reviewed your draft report entitled "Federal Research: Evaluation of Small business Innovation Programs (GAO/RCED 89-39)" and have no comments.

We appreciate the opportunity to comment on this report.

Sincerely,

for Charles R. Gillum
Inspector General

Comments From the Environmental Protection Agency

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
POLICY, PLANNING AND EVALUATION

NOV 18 1988

Ms. Flora H. Milans
Associate Director
Resources Community, and Economic
Development Division
General Accounting Office
Washington, D.C. 20548

Dear Ms. Milans:

I am in receipt of your letter to the Administrator dated October 31 requesting the Environmental Protection Agency (EPA) review and comment on a General Accounting Office (GAO) report. The report is entitled "Federal Research: Evaluation of Small Business Innovation Programs" (GAO/RCED-89-39). Pursuant to Public Law 96-226, I provide the following response.

Appropriate Agency staff have reviewed the report and the Agency has no comment on the substance of the report. EPA maintains an active innovation research program, and anticipates release of the final report.

I appreciate the opportunity to review and comment on the report.

Sincerely,

Linda J. Fisher

Linda J. Fisher
Assistant Administrator

Comments From the Department of Health and Human Services

DEPARTMENT OF HEALTH & HUMAN SERVICES

Office of Inspector General

Washington, D.C. 20201

NOV 30 1988

Ms. Flora H. Milans
Associate Director
Resources, Community, and
Economic Development Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Ms. Milans:

The Department has no substantive comments on your draft report, "Federal Research: Evaluation of Small Business Innovation Research Programs." Technical comments were provided to a member of your staff on November 28, 1988.

The Department appreciates the opportunity to comment on this draft report before its publication.

Sincerely yours,

Richard P. Kusserow
Inspector General

Comments From the Department of Education

UNITED STATES DEPARTMENT OF EDUCATION
OFFICE OF THE ASSISTANT SECRETARY
FOR EDUCATIONAL RESEARCH AND IMPROVEMENT

NOV 17

Flora H. Milans
Associate Director
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mrs. Milans:

Thank you for the opportunity to review the draft report entitled, Federal Research: Evaluation of Small Business Innovation Research Program (GAO/RCED 89-39).

We have telephoned three editorial comments to Dave Balderston of your staff. We have no other comments.

If you need further assistance, please have your office contact Mr. John Christensen at 357-6065.

Sincerely,

Patricia Hines

Patricia M. Hines
Acting Assistant Secretary

Comments From the Department of Commerce

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Administration
Washington, D.C. 20230

NOV 16 1988

Ms. Flora Milans
Associate Director
General Accounting Office
Washington, D.C. 20548

Dear Ms. Milans:

Thank you for allowing the Department of Commerce to review the draft report, dated October 31, 1988, Federal Research: Evaluation of Small Business Innovation Programs (GAO/RCED-89-39). It is a good report and we're pleased to note the favorable Federal agency response.

Sincerely,

Kay Bulow
Assistant Secretary
for Administration

U. S. Nuclear Regulatory Commission
SBIR Effectiveness

APPLICATION OF METHODOLOGY TO EVALUATE AGING
AND SERVICE WEAR EFFECTS ON NUCLEAR POWER PLANTS

SEA Consultants, Inc. San Jose, CA

PHASE I $ 49,000
PHASE II $264,000

Commercial nuclear power plants are large complexes and are comprised of many different systems, components, and structures which cover a broad spectrum of materials and designs. There are a number of factors that can cause degradation of the functional capability of a component, system, or structure. They include material degradation, operating environment, and improper maintenance. These factors, and others, can act with time to degrade a component, system, or structure. Therefore, technical data and regulatory guidance are needed to account for aging degradation in plant safety systems, support systems, and components. Also, improved regulatory guidance is needed to evaluate the effectiveness of inspection, surveillance, and monitoring methods of aging in nuclear power plants.

In Phase I, SEA investigated and demonstrated the application of modelling systems interactions to identify components with aging significance. The method involves proper characterication of functional and spatial systems interactions.

In Phase II, SEA has applied the systems interaction model procedures, developed in Phase I, to selected safety systems and support systems; identified components and parts which have propensity for aging degradation and generated recommendations for maintenance of the systems to alleviate aging concerns.

This research has provided a method to evaluate age and service wear effects from a spatial and functional system interaction perspective. The methodology provides the capability to model the interactions required to complete a plant function (e.g., core cooling) and assess the effect on plant function due to component aging. The output of the research will be used in performing in-depth engineering studies and in developing guidelines for inspection, surveillance and maintenance to alleviate aging concerns. This research demonstrates an application of a practical method for plant operation and aging management.

SEA has completed a system operability assurance program for a nuclear generating station under construction. The contractor also developed a procedure to systematically investigate system functional interactions that could effect the safety system design basis. In another case, the contractor is involved with a major utility in demonstrating the potential use of the developed methodology for plant maintenance planning and policy.

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U. S. Nuclear Regulatory Commission
SBIR Effectiveness

PROBABILITY OF FLOODS WITH LONG RETURN PERIODS

Linsley, Kraeger Associates Ltd., Los Gatos, CA

PHASE I $ 50,000
PHASE II $240,000

Phase I was completed with publication of an NRC contractor report titled: "A System for Generating Long Steamflow Records for Study of Floods of Long Return Period." Linsley, Kraeger Associates demonstrated the feasibility of coupling a stochastic hourly rainfall generator as input to a deterministic watershed simulation model to develop a synthetic flow record of 1000 years. A stochastic model for the multi-station generation of hourly rainfall was also developed and tested.

The overall Phase II effort provides a practical methodology for including severe external flood events into a probabilistic-risk assessment (PRA) study. It can also assist in the assessment of "Safety Margins" for flood protection at nuclear facilities. This work has received favorable review by the National Research Council's Committee on Techniques for Estimating Probabilities for Extreme Floods.

Consistent with the SBIR Act, the NRC research contract has the potential for making a significant contribution to the commercial application of the model developed by Linsley, Kraeger Associates. Upon the completion of the software enhancements of the stochastic rainfall generator, and successful testing of the model on the two selected watersheds, the contractor will be able to use the developed methodology for various utilities and DOE contractors. The contractor has also begun inquiries with Electric Power Research Institute to formulate a project to initiate the commercialization effort for use by utilities. The work also has potential benefits for the safety assessments of dams whether or not they are associated with NRC-licensed facilities.

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U. S. Nuclear Regulatory Commission
SBIR Effectiveness

PROBABILISTIC RISK ASSESSMENT FOR SEISMICALLY INDUCED EVENTS AT NUCLEAR POWER PLANTS

Future Resources Associates, Berkeley, CA

PHASE I	$ 50,000
PHASE II	$250,000

Probabilistic Risk Assessments (PRAs) performed to date indicate that seismically induced events may be major contributors to the residual risk for some nuclear power plants. One area of this seismic risk analysis that has not been studied well is the effect of relay chatter on plant operation. Experts have felt that during a seismic event, the chattering of relays due to motion may leave the plant in an undesirable and perhaps unknown configuration. This could be a significant factor in our understanding of seismic risks.

The research conducted in this program addressed this specific issue, and developed methods for estimating risk at a plant from seismically initiated relay chatter. The methodology was applied to operating nuclear power plants (Zion 1 and LaSalle 2).

Conclusions from this study will help analysts to quantify risk from seismically initiated relay chatter for plants in the future as part of seismic PRAs. In addition, the study provides insights to the quantification of operator error under high-stress conditions.

The contractor is currently negotiating with a utility to perform the commercialization phase of the research. Preliminary indications are that other utilities are interested in using the tools developed. The report on this research received an award as the best paper presented at American Nuclear Society conferences during 1987.

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U. S. Nuclear Regulatory Commission
SBIR Effectiveness

DEVELOPMENT OF A NUCLEAR POWER PLANT DATA MANAGEMENT SYSTEM

Scientech, Inc. Idaho Falls, Idaho
Phase I $ 49,000
Phase II $451,000

The NRC uses computer simulations to analyze potential power reactor thermal hydraulic transients* during accident scenarios such as breaks in pipes. Preparing for a simulation is an extensive task requiring calculating the geometry of the individual cells of each modelled pipe and other components. To save that labor and to build in an audit trail of the steps in gathering the basic data and creating the model, NRC needed to computerize the process as much as possible.

The work done by Scientech in Phase I met this need by first creating a plant data entry manual, designed for use by a power plant engineer in entering basic plant geometric and operating data. Scientech then created a software package (Plant Data Management System) for data entry, data update, and graphics data retrieval. The package was successfully demonstrated for the primary loop of a reactor. Phase II will incorporate the secondary loop.

Scientech intends to market this software package as a standard tool maintaining a quality assurance database. Users can define a component's data base and its attributes as well as construct a data base for a facility composed of the components. Little customization will be required for a particular plant.

* A transient is an off-normal situation in the functioning of a nuclear power plant system.

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U. S. Nuclear Regulatory Commission
SBIR Effectiveness

DEVELOPMENT OF A ROBOTIC SYSTEM FOR
RADIATION SURVEILLANCE OF NUCLEAR POWER PLANTS

Remote Technology Corporation, Oak Ridge, Tennessee
Phase I $ 50,000
Phase II $250,000

REMOTEC designed and built a tethered survey/inspection robot (SURBOT) utilizing commercially available, low-cost robotic components. The SURBOT is capable of: high resolution TV viewing of components; measurement of radiation levels, temperature, and humidity; two-way sound communication with work crews; air and surface contamination sample collection; and, has a remote controlled arm capable of light maintenance tasks.

In 1986 SURBOT was successfully demonstrated at the Electric Power Research Institute (EPRI) Nondestructive Testing Center. The development and successful demonstration of the robot permits NRC staff to better evaluate licensee proposals to use automated technology. NRC participation in this SBIR project was an opportunity for the agency to further the utilization of what appears to be a cost effective dose reduction technology. The ability to perform more frequent and more sensitive in-service inspection, as demonstrated in this project, will also enhance plant safety.

REMOTEC is marketing four optional concepts featuring SURBOT in wheeled and tracked models with combinations of inspection equipment and operational arms. Considerable interest has been evidenced in the nuclear, defense and security markets. In addition, REMOTEC, partly due to its success on the NRC contract, has been selected to conduct three new SBIR demonstration projects for DOD and DOE.

Letter From the Nuclear Regulatory Commission Concerning the SBIR Program

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

MAY 23 1988

Mr. Neal P. Curtin, Deputy Director
Resources, Community and Economic Development Division
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Curtin:

This responds to your request to Chairman Lando W. Zech, Jr. for an assessment of the Small Business Innovation Research (SBIR) program within the Nuclear Regulatory Commission (NRC).

NRC has participated in the SBIR program since FY 1983 and fully supports the purposes of the Small Business Innovation Development Act. All NRC extramural research is under the direction of our Office of Nuclear Regulatory Research (RES). Accordingly, the requirement for participation in the program is applicable to the extramural research budget of RES. In FY 1987 we provided a high of $1.4M to the program.

NRC believes that the SBIR program offers an opportunity for Federal research program managers to take advantage of new ideas which might not surface through normal contracting avenues. Innovative proposals with commercial applicability can be quickly reviewed because of the simplified SBIR procedures, and the feasibility of ideas can be tested at a relatively low cost. Since the program's inception the NRC has received 548 Phase I proposals and has funded 42 Phase I awards to determine the technical feasibility of promising ideas. From this group, we have funded 15 Phase II awards for only those projects which we considered to have the greatest likelihood of success. The enclosed briefs describe those completed Phase II projects which we believe have a moderate to high potential for commercial success.

Despite the advantages of the program, our current research budget has taken a pecipitious drop in the past year. As a result, NRC's total extramural research budget dropped to $99.8M in FY 1987 and approximately $89.0M for FY 1988. Budget constraints and a legal concern about violating the Competition in Contracting Act of 1984 had caused us to conclude that we could not participate in the SBIR Program in FY 1988. Subsequently, the NRC received a GAO opinion (GAO letter B-230594.2 dated March 15, 1988) which concluded that the NRC is not precluded from voluntary participation in the SBIR Program even though our extramural research budget is less than $100 million.

On April 14, 1988, I met with Representative John J. LaFalce, Chairman of the House Committee on Small Business, to review NRC's concerns. During that meeting, I explained that our level of participation in FY 1988 was directly related to the impact of the NRC's FY 1988 appropriation reduction of

systems, and biomembranes are now being produced and sold. University collaboration is with Minnesota, Wisconsin, Illinois, and North Carolina. Employment has increased from 4 at the time of the first SBIR award to 63.

o Browning Engineering, Inc. of Hanover, New Hampshire received an SBIR award in 1979 for extreme impact velocity metal and ceramic deposition. This research resulted in a process used by G.E. and Rolls Royce to coat turbine compressor blades. The process was also licensed initially to Cabot Corporation which sold the division to a California company. Royalties, R&D and consulting relevant to the project exceed $1 million. A new generation Plaz Jet process has been developed for abrasive coatings. Sales exceed $400,000 but are expected to increase sharply since a major licensing agreement is in process. University collaboration is with Dartmouth and MIT. Direct employment has not grown because the company licenses its products to others.

Summary: Small high technology firms are important to technological innovation and economic growth, including increases in domestic employment. There is evidence that they represent one of the most efficient mechanisms for the conversion of science and technology to commercial products. They increase technological competitiveness and appear to be especially effective when these firms are coupled to universities, large industrial companies and venture capital. The Foundation's SBIR program is designed to take advantage of this route to commercial use of Federal research and development.

4. COMMENTS ON THE EFFECT OF THE PROGRAM

The Small Business Innovation Act of 1982 (amended) requires the judgment of the director of the National Science Foundation "as to the effect of this Act on research programs."[10]

Technology Transfer. While the present report deals with the four explicit mandated objectives, there also should be mention of an important additional objective, technology transfer, merely implied under the first goal, Innovation, and the second goal, Federal R&d Needs. In this case SBIR provided an important linking mechanism between basic research and the market place. While many studies can be cited, the Rand Corporation study of 1984[11] showed clearly that the results of basic research do not readily find their way to the market place without the use of intermediate mechanisms. SBIR

[10] PL 97-219, Sect.6.

[11] Tora K. Bikson, Barbara E. Quint, Leland L. Johnson, "Scientific and Technical Information Transfer" Rand Corporation, Report to the National Science Foundation, N-2131-NSF, March, 1984.

developments has not been lost on private sector investors. A listing of participants in Phase III commercialization includes:

Industrial Firms:

IBM	Westinghouse
General Electric	Du Pont
Ford	Kodak
W.R. Grace	Cabot Corporation
North American Phillips	Eveready Battery
Hercules, Inc.	Coca-Cola
Dow Corning	Borg Warner

Venture Capital and Financial Institutions:
- American Research and Development
- Venrock
- Sutter Hill
- Continental Capital
- Citicorp

Research and Development Limited Partnerships:
- Merrill Lynch
- Morgan Stanley
- Paine Webber

The listing is only a sample of the types of institutions which have made commitments to invest in successful outcomes from the Foundation's SBIR program. Equally impressive is the amount of follow-on funding which NSF awardees from 1977 through 1982 were able to obtain as a result of their participation in the SBIR program as a whole. This group of awardees has obtained combined Phase III commitments, equity investment, and product sales which are estimated to exceed $400 million.

Additional Indicators. In addition to the diversity of the Phase III investors and the estimates of the follow-on commitment, two factors attest to the success of the Foundation's efforts to commercialize SBIR products: The volume of product sales, and the increase in employment for the firms. Here are illustrations:

o Flow Research of Kent, Washington, had 190 employees in 1981 at the time of its first SBIR award. The firm now has 940 employees counting those working for the three spin-off companies, largely as a result of their successful SBIR research. The parent firm and the spin-off companies have received $54 million in venture capital from research and development limited partnerships, with an estimated one-half of this sum attributable to SBIR program participation. Some $50 million in sales to date may be attributed to SBIR.

o Native Plants, Inc. of Salt Lake City has had three major breakthroughs. SBIR has been the principal reason, NPI explains, why the company has been able to obtain $65 million of private

individuals and groups stressing their potential for participation in the program through the submission of high quality research proposals.

The program addressed groups and associations which were science and engineering based, associated with minority institutions of higher learning, minority business associations, and other identifiable sources of minority participation in science and business. One of the most significant steps has been an outreach effort carried out in conjunction with the annual Federal High Tech Conference. The Foundation sponsored a one day meeting just prior to the Conference in Atlanta and to address the particular needs of minority and disadvantaged firms in preparing proposals under the SBIR program. This meeting and workshop addressed not only the Foundation's SBIR activity, but the special needs for responding to the solicitations from all of the participating agencies. While it is too early to tell whether this outreach approach has helped with the minority participation in the SBIR for other agencies, the results of the Foundation's 1987 solicitation and awards are very gratifying toward Goal 3.

Results. In response to the 1987 SBIR solicitation the Foundation received 1250 proposals. Of these, 172 were from minority owned firms and 97 were received from firms owned by women. Thus the combined response from minority and women owned firms was more than 20 percent. In terms of awards, the Foundation has made 160 awards; of the winners, 15 are firms owned by minority and ten are owned by women. The combined share is about 16 percent of Phase I awards. In percentage terms these awards by the SBIR program surpass the record of the Foundation as a whole in fiscal year 1987 for awards to minority or women principal investigators. From 1983 to 1986 the SBIR program received about 820 proposals from minority and women owned firms. For this period the program made 24 awards to women owned firms and 39 to minority owned firms. These figures indicate that the SBIR program has in large measure succeeded in promoting the participation of minorities in the innovation process.

Further Activities. Given the positive response to the recently increased outreach activities, the Foundation is planning to broaden its SBIR program outreach to black and hispanic business and professional organizations and Chambers of Commerce. This effort will stress working with scientific, technical and business groups. It will focus on those geographic areas characterized by high concentrations of these groups as proposers of innovative research under the SBIR program.

Conclusion. The Foundation built on a good record when it took aggressive action and got positive results by organizing workshops and conferences to enhance minority and disadvantaged participation in research and innovation. The outreach program has helped to improve SBIR participation. The output measure of the

matched larger Federally published objectives and priorities:

- o Electro-optic materials
- o Manufacturing Processes
- o Industrial/Chemical Processes
- o Instruments/Sensors
- o Biosciences/Genetics
- o Computers/Robotics
- o Surface Science
- o Communications
- o Other[8]

The Foundation's solicitation topics during the past decade have coincided largely with the larger national scientific and engineering research activities. This approach permits an assessment of these activities over the span of the program with comparisons to the cited forecasts.

Distribution of Awards. Table 2 is a categorization of Phase I awards for the years from 1977 through 1987, in accordance with the preceding listing:

Table 2: **NSF SBIR PHASE I AWARDS BY CATEGORY 1977-1987**

Solicitation Year	-77-	'79-	'80-	'81-	'82-	'83-	'84-	'85-	'86-	'87-	Tot'l
Elect/Optic Mat'l	0	5	1	5	6	3	7	9	13	13	62
Mfg. Processes	5	11	6	11	13	7	6	7	14	15	95
Indust/Chem Proc.	8	10	11	11	20	24	16	15	27	29	171
Instrument/Sensor	5	7	9	12	16	15	25	20	33	43	185
Bioscience/Genetic	12	8	7	14	21	15	13	22	18	18	148
Computer/Robot	3	4	7	20	22	24	22	35	29	22	188
Surface Science	0	1	0	0	2	3	6	5	4	4	25
Communications	1	0	3	3	5	2	0	1	5	5	25
Other	8	8	18	10	3	9	10	10	9	11	96
Total	42	54	62	86	108	102	105	124	152	160	996

This ten-year summary of the Foundation's Phase I SBIR activities indicates that the bulk of the research has been concerned with electronic materials, industrial chemical processes, instrumentation, biosciences, and manufacturing technology. When compared with the 1981 forecasts and the industrial indicators,

[8] "Other" has been used by NSF in many research programs; it leaves open the door for new ideas, especially those not readily classifiable by discipline or topic.

participation have been presented. These support the contention that the SBIR program has been successful in stimulating innovation. Among the small business firms responding to the solicitation innovation has grown in the ten years of the program's existence and the quality of the research proposals has increased markedly. Probably the most persuasive indicator of success is the measurable financial participation from the private sector in the products and processes coming from SBIR research.

Goal 2: SBIR RESPONDS TO NEEDED R&D

"...to use small business to meet Federal research and development needs..."

When it established SBIR, Congress formally stated that technological innovation creates jobs, increases productivity, competition, economic growth, and is valuable in reducing inflation and improving the balance of payments.[4]

Further, while most federally funded R&D is conducted by large business, universities, and Government laboratories, small business is the principal source of innovations.

Finally, Congress determined that small businesses are among the most cost-effective performers of R&D and are particularly capable of transforming R&D into new products.

Three Major Studies. In making these findings, Congress had access to studies and reports which had provided the earlier impetus for the small business set-aside under the NSF SBI program, as well as the NSF's experience with this program. Three of these studies are especially relevant:

1) A Commerce Department report on innovation published in 1967[5] showed that small high technology firms were responsible for a disproportionately large share of new technology when compared with their three percent share of Federal research and development support. The report set the stage for what has become the SBIR program, first at the National Science Foundation, and in 1982 at all of the major research funding agencies in the government. As to how well the SBIR program has succeeded in stimulating this innovation and how well the small high tech firms have succeeded in providing innovation which meets our national needs, it is

[4] PL 97-219, Sec. 2 (a).

[5] Holloman, J.H., **Technological Innovation, Its Environment and Management**, U.S. Department of Commerce, Washington D.C. 1967

o Mixed Vapor Growth of Organic Non-Linear Optical Materials.

d) Private Sector Commercialization. The interest of the private sector is exemplified by investment in development and actual product sales. Following are five examples of SBIR awards which have been completed. "Completion" in this context means that the projects have gone through Phases I, II, and III.

o SBIR 81-14274 "Distributed Data Base Management on Local Networks." 1982-1985, Relational Technology, Alameda, CA

The first known research on DBM on local networks was conducted under this project and resulted in the highly successful INGRES Star software. Sales now exceed $105 million and private investment from Sutter Hill, Berkeley International, Morgan Stanley, T. Rowe Price, Citicorp, Bankers Trust and Bank of New South Wales totals $18 million. The company attributes one-third of the investment and sales to the NSF research. The consultant from the University of California, Berkeley, said that SBIR was the principal reason for the company's success, thanks to the breakthrough made possible by NSF research support. Employment at the time of the proposal in 1981 was 6; today it is 475. University collaboration has been with University of California at Berkeley, Carnegie-Mellon and MIT.

o SBIR 80-096001 "Theoretical Modeling of an Innovative Unidirectional Surface Acoustic Wave (SAW) Transducer." 1981-1984 RF Monolithics, Inc., Dallas, TX.

The research represented a new concept in the design of low-loss frequency filters by four engineers who spun off from Texas Instruments. The project explored four new ideas; all were successful. Twelve product lines of receivers, oscillators (IFF and radar), SAW devices, resonators, transmitters, microtransmitters, filters, notch elements resulted directly and indirectly from the research and are now being sold. Venture capital investment came to $13.1 million in three rounds of financing from 12 firms. Sales have totalled $16.3 million. University collaboration has been with the Universities of Maine and Central Florida. Employment has increased from 5 to 85.

o SBIR 79-17180 "Growth of Ruby Crystals by the Heat Exchanger Method," 1979 - 1982, Crystal Systems, Inc. Salem, MA.

The research formed the base for a new class of laser materials and for another NSF SBIR award for titanium-doped alumina crystals. This significant advance resulted in the first tunable solid-state laser to be commercialized in the

several years. Output from the program takes five to six years. The selected examples given at the end of this section have completed this innovation cycle.

b) Recommended Awards. As shown in Table 1, in 1977 the Foundation received about 330 proposals. After merit review more than 50 proposals were judged worthy of award but available funds resulted in only 42 actual awards. By 1987 response to the Foundation's SBIR solicitation almost quadrupled to 1250 proposals. Merit review of these resulted in recommendations that about 300 qualified for a Phase I award, but available funds limited these to 160 Phase I awards.

There has been a fourfold increase in the number of proposals received in response to the solicitation. Similarly one in four of these proposals was judged innovative and worthy of support. These are input indicators of innovation stimulation because the number and the quality of these proposals has grown. The Foundation has judged the quality by criteria similar to its customary review procedures which apply to all research proposals, including SBIR.

Increased interest by the private sector also points to the value of the research results obtained from the SBIR program. Significant private sector financing has gone into the Phase III portion of the program to convert research results into developed products and services. For those small firms which received awards during the first five years of the Foundation's program the total private sector activity now exceeds $400 million. This is a quantitative output indicator of the financial value of the innovations from these firms to the economy.

The present report is based on several working papers which describe in greater detail some of the topics summarized below. The working papers, in addition to a statistical report, include:

SBIR Promotes Innovation
SBIR and Private Sector Commercialization
Fostering Minority and Disadvantaged Participation
SBIR and Long Term National Technological Objectives
Manufacturing Related Research in SBIR
SBIR and State & Local Activities

The operation of the program follows the original 1977 process: Topics of current interest to the research of the basic science and engineering disciplines are selected for the annual solicitation. These proposals are reviewed and, based on the Foundation's merit review system, are eligible for awards. The solicitation's structure and the evaluation procedures assure integration of the SBIR program with the other activities of the Foundation.

2. THE FOUR MAJOR GOALS OF THE ACT

The Small Business Innovation Development Act of 1982 specified four major goals:

1. to stimulate technological innovation,
2. to use small business to meet Federal research and development needs,
3. to foster minority and disadvantaged persons to participate in technological innovation, and
4. to increase private sector commercialization of innovations from Federal research and development.

Since its inception in 1977 the NSF SBIR program has addressed each of these objectives. For Goal 1, the responses to the 1987 SBIR solicitation are a measure of the Foundation's stimulation of the innovation process. Twenty five specified research topics at the leading edge of applied research resulted in over 300 innovative proposals judged as scientifically meritorious. For Goal 2, a review of SBIR awards indicates that about 90 percent were made in technical areas relevant to "national needs forecasts." Concerning Goal 3, minority and female participation has grown significantly in the past ten years. The 1987 solicitation resulted in 270 submissions from firms owned by women; submissions from minority firms lead to 25 Phase I awards. For Goal 4, success in commercialization is shown by the products already being marketed and by the magnitude of the financial commitments from the private sector to Phase III to Phase II awardees.

the emphasis on increased productivity and competitiveness. Fully 40 percent of the SBIR research projects funded through 1987 related to improved manufacturing processes, productivity, or quality. New products, processes and software have resulted and are already in the marketplace.

The Foundation has sought to foster the interest and participation of minorities and the disadvantaged in research and innovation. In 1986 the Foundation sponsored a conference for small high technology firms underrepresented in science and technology. A similar session was included in the 1987 "Federal High Tech" conference. In response to these NSF outreach activities 270 SBIR proposals were received in 1987 from minority and disadvantaged firms resulting in 25 research awards.

Finally, the program's success in commercialization is best evidenced by the extent of private sector participation. Major industrial firms such as Dow, Eli Lilly, and Martin-Marietta Corporation have supported the development of products or licenses from the small firm to produce or use the product or process. One quantifiable output measure is the program's leverage. While the Foundation awarded $ 20.6 million from 1977 through 1982, the firms participating in these awards have since been able to show $400 million of private sector activity as a result of their SBIR activities as a whole. Two examples of successful commercial SBIR research products on the market are a process for the deposition of silicon carbide used by General Electric for turbine blades and ultra high pressure water jet abrasive machine tools; cumulative sales reached $22 million in 1987.

CONCLUSIONS

SBIR accomplishments show that the program at the Foundation has met the goals of the legislation. The research quality has been high. New products and processes have reached the market and enhance the competitiveness of American industry. Major industrial firms have sponsored commercialization of the research, have licenced the patents, or in a few cases bought the company. The feedback to the conduct of basic research has resulted in improved instruments, sensors, or materials. In addition, the linkage between the SBIR program and the traditional activities of the Foundation is evident in the high degree of university and faculty interaction with the small firms. In summary, the Foundation SBIR program, designed and implemented in 1977, has met the applied research standards of the Foundation and the goals of the legislation. The results obtained to date warrant the continuation of the program as one means of stimulating industrial competitiveness and transferring research output to the private sector.

SMALL BUSINESS INNOVATION RESEARCH AT NSF ONE DECADE

EXECUTIVE SUMMARY

INTRODUCTION

This study indicates that research of high quality has been carried out by small high technology firms during the past ten years under the Foundation's SBIR program. This report furnishes the Comptroller General with details on the success of the Small Business Innovation Research (SBIR) program at the National Science Foundation. The data presented respond to the legislative requirement for "evaluating the effectiveness to date of phase one and phase two of the SBIR program as set out in section 9(e)(4) of the Small Business Act. Such report shall examine the quality of the research supported by the SBIR Program compared to that traditionally supported by the affected agencies and extent to which the goals of the SBIR program are being met."

The high quality of the SBIR funded research stems first from the program's adherence to the Foundation's research objectives. Second, the use of the Foundation's standard merit review procedures assures quality in selection. Finally the requirement for commercialization establishes the need for economic relevance. These factors insure the selection of scientifically meritorious innovative proposals. In addition the process assures comparability with those proposals traditionally supported by the Foundation. Although not required by the Act, the program has also served an important technology transfer function between university and industry research. More than 50 percent of these projects involved collaboration with universities or their faculty.

BACKGROUND

The Small Business Innovation Research program was designed and implemented by the Foundation in 1977. It served as the model for the Small Business Innovation Development Act of 1982 and eventually became the national SBIR program. Then as now it served to stimulate innovation and to couple small high technology firms more closely to the basic research community. In the decade since its inception, SBIR has complemented the NSF basic research programs by providing a linking mechanism with the market place. While many studies may be cited, The Rand

conference. In response to these Foundation outreach activities, 270 SBIR proposals were received in 1987 from minority and disadvantaged firms, resulting in 25 research awards.

Finally, the program's success in commercialization is best evidenced by the extent of private sector participation. Major industrial firms such as Dow, Eli Lilly, and Martin-Marietta Corporation have supported the development of products or licenses from the small firm to produce or use the product or process. One quantifiable output measure is the program's leverage. While the Foundation awarded $20.6 million from 1977 through 1982, the firms participating in these awards have since been able to show $400 million of private sector activity as a result of their SBIR activities as a whole. Two examples of successful commercial SBIR research products on the market are a process for the deposition of silicon carbide used by General Electric for turbine blades and ultra high pressure water jet abrasive machine tools; cumulative sales reached $22 million in 1987.

Accomplishments of the program show that the NSF's SBIR program has met the purposes of the legislation. Research quality has been high. New products and processes have reached the market and enhance the competitiveness of American industry. Major industrial firms have sponsored commercialization of the research, have licensed the patents or, in some cases, have bought the company. The feedback to the conduct of basic research has resulted in improved instruments, sensors, or materials. In addition, the linkage between the SBIR program and the traditional activities of the Foundation is evident in the high degree of university and faculty interaction with the small firms.

In summary, I believe that the Foundation's SBIR program, designed and implemented in 1977, has met both the research standards of the Foundation and the purposes of the legislation. Further, in my view, the Foundation deserves major credit for the development and implementation of this major program of the United States Government. The results obtained to date warrant the continuation of the program as one means of stimulating industrial competitiveness and transferring research output to the private sector.

Sincerely,

Erich Bloch
Director

Enclosure

Letter From the National Science Foundation Concerning the SBIR Program

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

OFFICE OF THE DIRECTOR

April 1, 1988

Mr. Neal P. Curtin
Deputy Director
Resources, Community, and
Economic Development Division
United States General Accounting Office
Washington, D.C. 20548

Dear Mr. Curtin:

This letter responds to your request of December 3, 1987 for NSF's views of the Small Business Innovation Research program (SBIR) as it has been implemented by the National Science Foundation. As you know, the SBIR program was initiated at the Foundation in 1977 and served as a model for the overall legislation.

The NSF review of the program indicates that research of high quality has been carried out by small high technology firms during the past ten years under grants from the Foundation. This letter and the enclosure furnishes you with details on the success of the SBIR program at the National Science Foundation. The data presented respond to the legislative requirement for "evaluating the effectiveness to date of phase one and phase two of the SBIR program as set out in section 9(e)(4) of the Small Business Act."

The high quality of the SBIR-funded research stems first from the program's adherence to the Foundation's research objectives. Second, the use of the Foundation's merit review procedures assures quality in the selection of projects to be supported. Finally, the need to aim for commercialization establishes the capacity to contribute to economic competitiveness. These factors ensure the selection of scientifically meritorious innovative proposals. The program has also served an important technology transfer function between university and industry research. More than 50 percent of these projects involved collaboration with university faculty.

The Small Business Innovation Research program was designed and implemented by the Foundation in 1977. It served as the model for the Small Business Innovation Development Act of 1982 and

Letter From the National Aeronautics and Space Administration Concerning the SBIR Program

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

July 27, 1988

Honorable Charles A. Bowsher
Comptroller General of the United States
General Accounting Office
Washington, DC 20548

Dear Mr. Bowsher:

A letter from the General Accounting Office dated December 3, 1987, requested my judgments of the effects of our Small Business Innovation Research (SBIR) activities on the research programs of the National Aeronautics and Space Administration (NASA), and the basis for those judgments. This letter conveys my judgments on SBIR and outlines the process by which they were developed.

To assess SBIR's effects, we conducted a study of all SBIR Phase II projects which had been completed or which were nearly completed by the end of 1987. This group consisted of 73 projects carried out by 63 small business firms. Most of the projects stemmed from our 1983 and 1984 SBIR Program Solicitations.

Our study concentrated on the effects these projects have had on the performance of the NASA mission in aeronautics and space, and it also addressed the quality of research sponsored by the agency. In addition, we investigated the extent to which the results of the 73 completed projects were being utilized in commercial and/or other Federal agency applications outside the NASA program.

The information for our study was obtained from comprehensive interviews with NASA personnel who had managed the research and with the principal investigators and company officials of the firms performing the research. Finally, we obtained the opinions of each NASA Center Director on the value of the SBIR Program to the Center's activities and to the NASA mission.

Our interviews revealed that the technical staff at each NASA Center highly rated the quality of research in most of the 73 SBIR projects, judging it to be equal to or better than other contract research for which they were responsible. Many reported that some of these SBIR projects (and others not yet completed) have established new insights and directions for NASA's research efforts. They also reported that the results of at least 39 of the 73 projects are either now in use by NASA or will likely be chosen for use within five years, including mission applications in mainline NASA programs. This is an excellent record for research projects of this nature.

Mr. James H. Clark
Aware Incorporated
227 French Landing Drive
Metro Center
Nashville, Tennessee 37228

Mr. Martin H. Wolf
Cambridge Analytical Associates, Inc.
1106 Commonwealth Avenue
Boston, Massachusetts

Mr. Richard L. Angstadt
Chemical and Metal Industries, Inc.
4701 Dahlia Street
Denver, Colorado 80216

Mr. George M. Savage
Cal Recovery Systems, Inc.
106 Broadway, Suite 200
Richmond, California 94804

Mr. George Alford
George Alford and Bill Rogers,
Ground Water Consultants
900 Atlantic Drive, N.W.
Atlanta, Georgia 30318

Mr. G. N. Patel
J. P. Laboratories, Inc.
26 Howard Street
Piscataway, New Jersey 08854

Mr. Harry Pepper, III
Process Dynamics Incorporated
119 West 8th Street
Jacksonville, Florida 32206

Mr. Stephen S. Adams
Engineering Resources, Inc.
1400 Kings Drive
Fayetteville, Arkansas 72701

Mr. L. G. Twidwell
Montana Enviromet, Inc.
54 Apple Orchard Road
Butte, Montana 59701

Mr. Thomas L. Powers
Sun Nuclear Corporation
415-C Pineda Court
Melbourne, Florida 32940

Mr. Thomas H. Rose
Eastern Technical Associates
2412 Atlantic Avenue
Raleigh, North Carolina 27604

Mr. Lee R. Phillips
Lee Scientific, Inc.
4426 South Century Drive
Salt Lake City, Utah 84123

Ms. Judith A. Armstrong
ADA Technologies, Inc.
6973 South Andes Circle
Aurora, Colorado 80016

CAA Bioremediation Systems methanotropic process, based on an original idea of Dr. John Wilson of EPA's Ada, OK laboratory, to destroy chlorinated solvents in-situ in contaminated soils has had significant impact on Ada's research program. Since results were published in a peer reviewed journal, this has influenced much research at universities as well. Indirectly their unsuccessful attempts to obtain clearance to try their process at a Superfund site appears to have influenced EPA to consider using Superfund sites as demonstration sites in the Emerging Technology Program.

APPENDIX B

GAO Response Notes

Kenterprise Research, Inc. has briefed some 10 EPA personnel from Region III's field office introducing their new dioxin removal process developed under EPA's SBIR Program. This work is continuing and, if fully successful, would significantly change EPA's approach to oil soluble toxic wastes clean-up.

Lee Scientific has had perhaps the most interaction with EPA and other Federal agencies enabling analysis of chemicals heretofore impossible or extremely difficult to analyze. Included are laboratories at U.S. Environmental Protection Agency (EPA), U.S. Department of Energy (DOE), U.S. Food and Drug Administration (FDA), U.S. Department of Defense (DOD), U.S. Department of Agriculture (USDA), U.S. Department of Commerce (USDC) who have purchased a total of 16 instruments featuring supercritical chromatographic instrumentation.

Sievers Research, Inc. also produces environmental analytical instrumentation which is in use at EPA's Research Triangle Park's Environmental Monitoring Systems Laboratory (EMSL) and the Motor Vehicle Emissions Laboratory, Ann Arbor, MI. Other Federal agencies using their EPA SBIR products are DOD (Army, Navy, Air Force), with interest shown by DOE, FDA, National Institutes of Health (NIH), and National Aeronautics and Space Administration (NASA), including some 100 inquiries from various Federal agencies on their latest device.

JP Laboratories, Inc. have potential to influence the National Institute of Occupational Safety and Health (NIOSH) regulations on hexavalent chromium in air as plastic platers are likely to adopt their chromium acid-free plastic etchant developed under EPA's SBIR Program. Further, it will enable platers to meet ever stringent chromium discharge regulations thereby making EPA's enforcement task easier in this large area of concern.

Sun Nuclear Corporation has developed the first and only inexpensive continuous radon monitor through EPA's SBIR Program. It is being used in private and governmental (EPA, State and local) agencies in large scale radon screening programs. One model is in use in a joint EPA/University of Florida radon gas research project.

William C. Pfefferle Associates work on internal combustion engine ignition promotion through catalytic implants has resulted in indirectly influencing work on methanol combustion at EPA's Air and Energy Environmental Research Laboratory at RTP and Mobile Sources laboratories, especially the latter. NASA has funded Pfefferle in some work on rotary aircraft engines as an extension of this technology.

c) About 75% of the respondents indicated that the major potential for useful application was not directed toward EPA or other Federal, State or local agencies but rather toward the private sector who could use the results of the EPA SBIR research (instrument, process, etc.) to support pollution control activities which in many cases will be directed toward meeting regulations in a cost-effective manner.

Specific examples of the SBIR program's interactions with EPA, other federal agencies, or the private sector are provided in Appendix B.

Conclusions

General conclusions which we have drawn from the results of our survey are as follows:

1. It is too soon to tell what the real impact of the EPA SBIR program will be on efforts to meet EPA regulations. Many of the projects are still in the development phase.

2. There has been a moderate degree of direct interaction with EPA already.

3. There has been a moderate degree of interaction with other agencies.

4. Most potentially useful applications affect EPA or other agencies indirectly, i.e., development of methods which may change a standard government measurement method, or a device or process that will assist institutions in meeting a pollution standard.

SMALL BUSINESS INNOVATION RESEARCH PROGRAM

REPORT TO

THE U.S. GENERAL ACCOUNTING OFFICE

Introduction

The U.S. General Accounting Office (GAO) has requested the U.S. Environmental Protection Agency (EPA) to assess the effectiveness of its Small Business Innovation Research (SBIR) Program in strengthening the role of small businesses in meeting EPA's research and development needs and the needs of other agencies. EPA's response and those from the other Federal agencies with SBIR programs will enable GAO to transmit a report on this subject to appropriate House and Senate Committees by December 31, 1988, as required by Public Law 99-443. This report represents EPA's response to GAO's request.

Description of EPA's SBIR Program

In an effort to fulfill the mandate of the SBIR Act, EPA's SBIR program seeks basic innovative research projects that are concerned with national pollution control in solid, liquid, and gaseous media. Innovation in emission reduction/control processes are sought which concern, but are not limited to industrial, municipal, drinking water, hazardous material, and energy production sources. Performance and cost effective approaches featuring conservation, reuse, recycle, and increased efficiencies are of special interest. Research in the development of environmental instrumentation and measurement methods is also solicited, where they are directly connected to pollution control processes.

In order to cultivate the widest array of innovation in research and development approaches, EPA has provided wide latitude to the recipients in the conduct of their programs, and has avoided the use of the SBIR program as a procurement tool.

Methods of Analysis

As in other federal SBIR programs, EPA's SBIR program is divided into two phases: a Phase I which consists of a six-month feasibility study and a Phase II, which is a development study of at most 2 years. The purpose of the Phase II research is to produce a commercial product or process in the area of pollution control, instrumentation or measurement methods.

As part of our analysis, we have restricted our response to Phase II SBIR projects, since the six-month Phase I feasibility studies are too short to provide enough significant data to influence EPA's overall research and development program, and is not intended to produce a saleable product or process.

ATTACHMENT (Concluded) Page Four

The SBIR Program provides UMTA with the ability to solicit and obtain innovative approaches to address current initiatives. The Program has resulted in research efforts which address transit efficiency and promote greater competition and involvement of the private sector in the movement of people in urban areas. The Program is an important part of UMTA's research and development efforts because it enables innovative entrepreneurs to propose and test new concepts.

RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION

The Research and Special Programs Administration (RSPA) provides support for research in hazardous materials, pipeline safety, radio-navigation, transportation statistics and emergency transportation.

RSPA's contribution to the SBIR Program is limited due to the small size of the overall RSPA research program.

ATTACHMENT (Continued) Page Two

The SBIR Program plays an important part in FAA's research and development activities. This role is both supplementary and complementary in nature to the overall FAA mission. The SBIR Program supplements near-term, applications-oriented research and development programs with innovative, forward-looking research objectives. This longer term approach (as distinguished from basic research for which the FAA is not chartered) would not ordinarily be performed under existing programs.

The SBIR Program also complements FAA research and development efforts by filling gaps and offering alternative solutions and avenues of investigation in various R&D programs. An example of this complementary function is noted in the area of aviation security. A recent SBIR project has demonstrated the feasibility of using a complementary nonradioactive electrically driven source of neutrons for baggage interrogation at airports. This Phase I effort proved to be successful and will be funded in Phase II with project funds, thereby freeing up allocated SBIR funds for other worthy FAA research tasks.

A noteworthy feature of the SBIR Program is the unique process by which research needs are solicited from the various technical groups who are aware of the most pressing agency needs. SBIR topical areas resulting from this solicitation process currently include aircraft safety, aviation security, avionics, air traffic control/flight services technology, aeromedicine and human factors.

An additional feature of the SBIR Program is its ability to apply either allocated SBIR funds or project funds to accomplish R&D tasks. This flexibility to apply diverse financial resources coupled with the minimal administrative burden of SBIR provides an extra level of speed and responsiveness to FAA needs.

FEDERAL HIGHWAY ADMINISTRATION

The Federal Highway Administration (FHWA) supports research programs in highway planning, design, construction and maintenance to ensure an effective and efficient national highway system. Research is also conducted to identify and correct impediments to highway safety and to improve common carrier safety.

The SBIR Program effort, although small in relation to other FHWA research programs, is carefully selected by the Office of Research, Development and Technology (RD&T) to assure that it complements and supports the other federally funded highway research programs nationwide. The research work which has been performed under the SBIR Program already has had a significant effect on portions of the highway research program. The SBIR work addresses issues in major RD&T categories including safety, traffic operations, structures, hydraulics, materials and pavements.

The SBIR Program is viewed as making a significant contribution to the overall highway research program. SBIR provides an opportunity for small business firms to propose novel research ideas and bring them to fruition. FHWA plans to continue to utilize the SBIR Program to pursue innovative solutions to highway research problems.

The supporting information for the judgment provided above is included in the attachment. I hope this information is useful to your overall assessment of the SBIR Program. Please let me know if there is any additional information needed.

Sincerely,

M. Cynthia Douglass

Attachment

DHHS SUMMARY

	Phase I		Phase II	
	Submitted	Funded	Submitted	Funded
FY 83	792	139	N/A	
FY 84	910	225	95	56
FY 85	1342	439	146	109
FY 86	2036	421	366	168
FY 87	1883	356	457	146

resources to carry out the Phase I effort whose results figure very heavily in the evaluation of the Phase II proposal. If Phase I can be extended to 12 months, it would also make it possible for the PHS to accept a Phase II proposal prior to expiration of the Phase I project and thus minimize the funding hiatus that currently exists between the two phases.

- The Department supports the concept of allowing an agency to accept Phase II proposals from a small business that has already completed its technical feasibility study with non-federal funds. The current program structure will not allow this and thus forces a number of companies to construct a Phase I study which in fact has already advanced beyond the technical feasibility stage. It appears that the interests of both the small business community and the federal agencies would be served by allowing exceptions to the current process in which a small business must receive a Phase I award in order to be eligible for Phase II funding. While such an approach might invite small firms to apply for larger awards in Phase II without carrying out the Phase I effort, this potential problem could be avoided by establishing strict requirements for documentation of the Phase I effort and its results.

low cost products and devices that would enable older persons to perform the tasks of daily living. These and other research areas drew an overwhelming response from small businesses. Approximately one hundred proposals were received for the combined 7 research topics announced in our 1988 SBIR Solicitation. Thus, this was a dramatic turnaround in the number of applicant proposals received. HDS views the SBIR Program as a significant step toward stimulating the small business community in participating in its research program and in helping HDS to achieve dissemination and replication, as well as other aspects of its mission. HDS anticipates that the most highly visible technological innovations conducted by small businesses will be an outgrowth of its 1988 SBIR Program.

The Health Care Financing Administration's (HCFA) Experience

The focus of the Health Care Financing Administration's research and demonstration programs is the study and resolution of major health care financing issues and the development of improved methods of administering the medicare and medicaid programs. HCFA is responsible for studying the programs it manages and the segment of the economy in which these programs operate. There is little likelihood that marketable innovations or products will be produced as a result of this kind of research. The major thrust of HCFA's R&D program is incompatible with the SBIR model. HCFA's relatively small R&D budget further aggravates the situation. HCFA's SBIR set-aside has grown from $60 thousand in FY 83 to $330 thousand in FY 87.

Prior to the enactment of the SBIR Program, HCFA attempted to utilize small business firms to the maximum extent possible in its research and demonstration programs. This approach was emphasized prior to the implementation of the SBIR Program and has continued subsequent to its implementation. Generally, small business firms have been used as subcontractors on large R&D projects or as prime contractors on small, usually short term, analytical projects.

Because of the relatively small size of its SBIR program it has been difficult for HCFA to develop SBIR topics which are totally commensurate with its mission. However, HCFA has developed a number of topics for the SBIR Program which are somewhat compatible with its mission. Few if any of these topics, however, are of sufficient priority to warrant funding were it not for the SBIR set-aside requirement. HCFA has been able to attract an adequate number (30-50 each year) of small businesses interested in its SBIR topics.

The commercial potential of Phase II awards, to date, has been very limited. The type of research HCFA needs is somewhat removed from technological innovation and product commercialization. HCFA's research projects results mostly in research papers and statistical studies, both have very limited commercial application. To date, no marketable technological innovations have resulted from HCFA's SBIR Awards.

SBIR Contributions to Scientific Knowledge

In general, SBIR does not add to scientific knowledge in the rigorous, formalized manner that basic research does. Since most SBIR projects focus on applied research, any new knowledge that is generated is generally related to the application of research findings and it appears that SBIR provides experimental evidence to refute or confirm certain theoretical expectations. Frequently it offers information or data relative to the efficacy of treatment for specific disorders, and in that process it provides insights into the characteristics of the disorders.

The SBIR projects that utilized RNA and DNA hybridization techniques to develop assays to detect cytomegalovirus in blood provided greater insights into the nature of persistent viral infections of blood cells. The companies that developed devices or drugs to treat skin conditions were successful in substantiating some of the theories concerning specific interactions on a cellular level between external energy or drug sources and abnormal skin. This resulted in new insights into the potential pathogenesis and treatment of a number of common skin diseases. The project on production of human renin provided further understanding of the molecular genetics of renin.

On a more applied level, SBIR has brought to the attention of program staff valuable information on methods and processes that make possible the miniaturization of oxygen delivery devices for patients who need oxygen therapy, the fabrication of percutaneous electrodes that can produce higher charge density stimulation of neural tissue in a safe and effective manner, and the isolation and cloning of human surfactant proteins which paves the way for development of a clinically effective preparation (absence of pulmonary surfactant, essential for normal lung function, is largely responsible for Respiratory Distress Syndrome of the newborn, a leading cause of neonatal mortality and morbidity).

Although a number of these SBIR projects have resulted in publications, there is less of an incentive among SBIR awardees to publish research findings because of the proprietary nature of a significant amount of their research. Furthermore, career advances for scientists in industry are generally not tied to their publication records. Nonetheless, articles have been published in a number of well-established refereed journals.

The Office of Human Development Services (HDS) Experience

The Office of Human Development Services' mission is directed at reducing dependency and increasing self-sufficiency among our most vulnerable citizens, including the aged, children, youth, and families, Native Americans, and individuals with developmental disabilities. Emphasis on this mission is focused at helping more Americans live independent and more productive lives, thereby reducing the need for services. HDS' SBIR set-aside has grown from $60 thousand in FY 83 to $593 thousand in FY 87.

prevented by the development of appropriate vaccines, parainfluenza viruses were listed as candidates for vaccine development. Yet no regular grant applications had been submitted, much less funded, in this area. Today there are two small companies that are developing parainfluenza vaccines. These two projects constitute the only research of its kind funded by NIH. One of the vaccines is now being considered for human clinical trials, and some large pharmaceutical companies have already expressed an interest in manufacturing it.

The development of human renin by another SBIR awardee provides a unique source of this material for research. Renin inhibitors constitute a class of potent yet highly specific antihypertensive agents which offer significant improvements over currently available therapies. However, a major impediment to the design of clinically useful renin inhibitors is the lack of human renin which is very difficult to obtain. A small business has succeeded in producing human renin in sufficient quantities that will allow X-ray analysis and subsequent computer aided design of orally active renin inhibitors.

Other examples of research products attributable exclusively to the SBIR Program include the use of DNA and RNA hybridization techniques to develop tests for detecting cytomegalovirus in blood specimens. Cytomegalovirus, a member of the herpes virus group, is present in the blood of a large portion of the human population. However, administration of this blood to high risk patients may result in death. Therefore, assays that are fast, simple, sensitive and specific are extremely valuable tools.

In the area of communicative disorders, a small firm has developed a microcomputer aided therapy program to produce fluent, normal sounding speech in adolescents and adults who stutter. It is the only research project on stuttering funded by NIH. The program, which can be easily used by any qualified speech pathologist, appears to be equally effective in English and other languages.

Potential for Commercialization of SBIR Results

Although one of the primary objectives of the Small Business Innovation Development Act is to increase commercialization of the innovations derived from SBIR research, the relative youth of the program makes it somewhat premature at this time to gauge whether it is has succeeded in meeting this objective. As various studies of technology transfer have affirmed, the process of translating research findings into a definable product that is subsequently marketed successfully takes at least 5-10 years. The GAO report due in 1993, rather than the one to be submitted to Congress this year, will likely provide more definitive data on the commercialization of SBIR results.

There are, however, a small number of examples of SBIR products that have reached the commercial market. The most significant of these is an innovative tuneable dye laser that uses selective photothermolysis to treat port wine stains (PWS) and hemangiomas. This instrument, which is target specific, can erase PWS birthmarks and yet leave the tissue surrounding the target unaffected. It is anticipated that, because of its advantages, this laser may displace existing argon laser techniques. This device represents a

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consultants or subcontractors to small businesses, university-based researchers have helped to enhance the outcome of the research funded under the SBIR Program.

(4) SBIR provides an opportunity to support projects that might not otherwise have come to our attention.

Since regular research programs do not expressly support product development, many of the products, processes and technology supported by SBIR funds might not have been developed if the SBIR Program had not been instituted. Several areas of SBIR research represent serendipitous opportunities that had not previously been considered as potential areas of R&D by PHS research programs. Examples include the development of a more biocompatible intraocular lens for implants after cataract surgery, pediatric catheters that can be monitored without X-ray or other invasive process, and an inexpensive, portable, microcomputer based electroencephalographic system that allows direct input of EEG signals to the computer for instant, on-line graphic presentations. The complete list is, of course, far more extensive and points up that SBIR has created research opportunities in areas that had not previously been considered by our programs.

Impact of the SBIR Program

Despite the relatively small size of the SBIR Program in relation to the larger PHS research portfolio, SBIR has yielded some interesting results for the PHS. It has demonstrated that available scientific knowledge is readily applicable to the development of innovative methodologies. For example, in the area of environmental health sciences, it has stimulated the application of fundamental knowledge to solving a specific problem with an invitor assay that is currently used to identify potential mutagens or carcinogens. The original assay is labor and material intensive. By modifying the protocol, a small business has reduced the costs by approximately 50% and has enhanced the reliability of the assay as well. This assay system is important because chemicals being considered for drugs and those introduced into the environment must be tested for potential carcinogenicity and health hazards to humans prior to industrial deployment.

SBIR projects have also helped NIH respond to the Congressionally mandated initiative to fund research in learning disabilities and enhanced research in high priority areas such as Sudden Infant Death Syndrome (SIDS). A computer system is being developed to teach reading and spelling to dyslexic children. It incorporates animated color graphics, voice response through speech synthesizers and a touch-sensitive display for response by the child. This system will be used to teach sound-symbol correspondence to the point that children can decode words automatically and focus attention on word meaning. The research on SIDS involves the development of a simple, noninvasive instrument capable of accurate and efficient acoustical analysis of infants' cries to identify term infants at risk for SIDS.

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set-aside contracts program. Based on data from FY 83 through FY 87, 94 awards have been made to minority/disadvantaged companies, 115 have been made to women-owned firms and 33 have been made to small businesses whose ownership is in the hands of minority/disadvantaged women.

Although small businesses may submit grant applications for research on any subject matter within the mission of the participating PHS agencies, the SBIR solicitations issued by the PHS offer over 375 major topics as examples of areas of interest. These solicitations cover a very broad range of research topics, ranging from the development of antiviral drugs and biologicals for the treatment of Acquired Immunodeficiency Syndrome (AIDS) infections, to the refinement of technologies for screening of active anticancer agents, to the development of devices and instruments to help the visually impaired maximize the use of their residual vision, to research on the multiple biopsychosocial processes involved in the response to stress and how these responses relate to the onset and maintenance of physical and mental stress. There is hardly any area of biomedical or behavioral research in which small businesses are precluded from submitting proposals. To encourage small research oriented companies to participate in the PHS SBIR Program, a policy decision was made in the early stages of planning that grant applications would be considered in any program area within the mission of the participating PHS agencies. While the Small Business Administration was initially reluctant to accept this approach to proposal submission, eventually the PHS was able to negotiate this flexibility into its SBIR Program. As a result of this approach, the PHS was able to fund 245 meritorious research projects over the last five years that would not otherwise have been eligible for consideration.

The Appendix to this report shows the number of grant applications and contract proposals that have been submitted to the PHS SBIR Program since FY 83 and the number of awards over the same period of time.

Positive Features of the SBIR Program

While the SBIR Program offers a variety of positive features, the specific benefits that the PHS has reaped from supporting SBIR research include the following:

(1) SBIR addresses previously identified gaps in HHS research programs.

A large number of these gaps appear to be in the area of medical instrumentation, for example, the development of devices for the diagnosis, treatment and rehabilitation of patients with communicative and sensory disorders, i.e., patients with impairments of hearing, speech, language, taste, touch or smell. Instruments for the treatment of dermatological and corneal diseases had also been identified as research gaps but had received minimal attention from researchers prior to inception of the SBIR Program. Indeed, SBIR has proved to be a very effective means of encouraging the development of devices, instruments and other hardware that have not otherwise been addressed. Other

of research programs within DHHS that experience significant difficulties in adapting the SBIR Program model. First, there are some very small departmental programs whose 1.25% set-aside is too limited to meaningfully support SBIR activities. Secondly, there are programs that are legislatively prohibited from making awards to for-profit enterprises and lastly there are programs whose missions are removed from either technological innovation or product commercialization.

Consequently, a number of the smaller programs have since been dropped from the SBIR Program because either their extramural research budgets were too small to provide for a viable and cost effective program or their research objectives were not compatible with SBIR goals. Since the SBIR set-aside requirement is applied against the overall departmental extramural budget rather than against individual programs, HHS has been able, through administrative action, to meet the set-aside requirement.

The experiences of each of the Divisions participating in the SBIR Program are described below:

The Public Health Service (PHS)[1] Experience

Program Implementation

Prior to the inception of the SBIR Program, the experience of the PHS agencies--particularly the National Institutes of Health (NIH)--with small businesses had been restricted generally to contracts for technical or logistical support services and for procurement of materials and supplies. While there were some R&D contracts, these were relatively few in number. The SBIR Program became the first, systematic, NIH-wide program to involve small businesses actively in grant supported research. This ushered in a new era for the research oriented PHS agencies which, until then, had interacted almost exclusively with academic institutions and not-for-profit research institutes. The SBIR Program also introduced an entirely new group of organizations and investigators to the PHS--companies and scientists that had never "done business" with the PHS agencies before FY 83.

At the outset of program implementation, the Assistant Secretary for Health designated NIH as the lead agency in the Public Health Service for SBIR related activities. This decision was based largely on two factors: (1) the SBIR set-aside funds at NIH constitute 92% of all PHS SBIR set-aside funding and (2) NIH has had the largest program and the longest tradition in supporting research. As a result, NIH has played the principal role in developing SBIR implementing policies and procedures for the PHS.

[1]The Public Health Service agencies/offices participating in the SBIR Program include the National Institutes of Health, the Alcohol, Drug Abuse and Mental Health Administration, the Centers for Disease Control, the Food and Drug Administration, the National Center for Health Services Research and Health Care Technology Assessment and the Office of Adolescent Pregnancy Programs.

Letter From the Department of Health and Human Services Concerning the SBIR Program

THE SECRETARY OF HEALTH AND HUMAN SERVICES
WASHINGTON, D.C. 20201

JUN 15 1988

Mr. Lawrence Thompson
Assistant Comptroller General
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Thompson:

In response to a December 8 request from Mr. Richard Fogel, I am enclosing a report reflecting this Department's judgment of the effects of the Small Business Innovation Research (SBIR) Program on Health and Human Services programs.

In preparing this report, we have not attempted to address the issue of the quality of research nor the effectiveness of Phase I and Phase II. We understand that these issues will be the focus of the report being developed by the GAO.

In summary, we have generally been pleased with the results of the HHS SBIR Program and look forward to continuing our support for this successful enterprise.

Sincerely,

Otis R. Bowen M.D.

Otis R. Bowen, M.D.
Secretary

Enclosure

SBIR Program Effectiveness

Cognizant staff of the Office of Energy Research met separately with one or more managers of each of the technical areas participating in the Department's SBIR program, including representatives designated by the respective Assistant Secretaries as liaisons with SBIR. The technical areas are Conservation and Renewable Energy, Energy Research, Fossil Energy, and Nuclear Energy. These representatives were able to provide first-hand opinions, supplemented by additional information gathered from within their program areas, on the effect of SBIR on the respective research programs. The significant findings, all coordinated with the Assistant Secretaries' representatives, follow.

First, in almost all Departmental areas the breadth of participation by small business has significantly increased the pool of scientists and engineers now contributing to DOE research.

The qualified bidder's lists have been expanded. Outreach efforts of the SBIR program have identified an increasing number of qualified small business research firms each year. In fact, some areas in the Department previously had virtually no participation by small businesses. The expanded pool includes SBIR awardees and unsuccessful SBIR proposers who eventually are successful with unsolicited proposals.

Second, SBIR has given the Department the opportunity to enrich its research programs.

Research pursuits have expanded in directions not traditionally followed, and advances have been made in many areas that would probably not have occurred without SBIR. (Examples include an industrial expert system incorporating sensor-based process control, and a magnetic-switching controller for a pulsed laser.) This has been brought about, of course, at some expense to the ongoing programs, since the funding for SBIR results in an explicit decrease of the same total amount in funding for other R&D programs. The benefits foregone because of this decrease are difficult to evaluate.

Expansion in directions not traditionally followed has occurred because: (1) technical topics have been included in the SBIR solicitations in areas that had not been emphasized in the traditional programs, and (2) high-risk efforts are frequently easier to fund in the SBIR program than in traditional programs. SBIR has contributed to the expansion of the technology base with such developments as improved performance of new cryogenic hardware for helium refrigerators, solar neutrino detectors, improved drill-bits for geothermal hard-rock drilling, and enhanced performance of conventional superconductors that have potential application in accelerator magnets.

Letter From the Department of Energy Concerning the SBIR Program

THE SECRETARY OF ENERGY
WASHINGTON, D.C.

March 28, 1988

Dear Mr. Fultz:

This is in response to your letter of December 8, 1987, that requested a judgment from the Department of Energy (DOE) on the effect of the Small Business Innovation Development Act on the Department's research programs. We believe that the Small Business Innovation Research (SBIR) program has had a positive impact on DOE's R&D programs, and that the initial uncertainty concerning its value has been replaced by strong support for the program within the Department.

An assessment of the DOE SBIR program was undertaken during 1987 to evaluate the quality of the research supported by the program compared to that traditionally supported by the Department. The assessment leads to the conclusion that SBIR and non-SBIR projects are of similar quality. Enclosure 1 describes the process and findings in more detail.

During February of this year, designated representatives of the technical areas participating in the Department's SBIR program were interviewed on the program's effectiveness. The conclusion of this survey is that the program has effectively broadened the pool of available researchers and enriched the Department's research programs. Also, in many areas, the SBIR efforts have been integrated with the ongoing DOE research and development in a complementary and effective manner, and technology developed under SBIR support has been transferred to the private sector. Enclosure 2 describes these findings in more detail.

The Department regards the goals of the SBIR program as admirable and is pleased to report that the results achieved are worthwhile.

Yours truly,

John S. Herrington

2 Enclosures

Mr. Keith O. Fultz
Associate Director
U.S. General Accounting Office
Washington, DC 20548

20. What percent of your time do you spend on SBIR and non-SBIR projects as compared with other work that you do? (ENTER SBIR AND NON-SBIR TIME TO NEAREST PERCENT IN TWO BOXES BELOW)

(15) 5% or less on SBIR projects
(3) 15 to 30% on SBIR Projects
(1) No Answer

SBIR		NON-SBIR		OTHER		TOTAL
	+		+	???	=	100%

21. Based on the dollars spent on non-SBIR research, what are the smallest and largest non-SBIR projects you have overseen over the past five years? (CHECK ONE FOR EACH COLUMN)

		SMALLEST PROJECT (CHECK ONE)	LARGEST PROJECT (CHECK ONE)
(14-4)	1. $50,000 or less		
(4-1)	2. $51,000-$150,000		
(0-4)	3. $151,000-$500,000		
(0-6)	4. $501,000-$2 million		
(0-3)	5. $2.1-$10 million		
	6. $10.1-$50 million		
	7. Over $50 million		
(1-1)	No Answer		

22. Please estimate the total dollar amount of all non-SBIR research projects you have overseen in the past twelve months. (CHECK ONE)

(5) 1. [ ] $150,000 or less
(1) 2. [ ] $151,000-$500,000
(4) 3. [ ] $501,000-$2 million
(7) 4. [ ] $2.1-$10 million
(1) 5. [ ] $10.1-$50 million
6. [ ] $50.1-$100 million
7. [ ] Over $100 million
(1) No Answer

23. If you have any additional comments on the SBIR program or on its effect on your agency's research program, please write them here.

THANK YOU FOR YOUR COOPERATION

7

GENERAL QUESTIONS ON THE SBIR PROGRAM

11. How important, if at all, is the SBIR program as an element of your overall research program? (CHECK ONE)

(1) 1. [ ] Very important

(2) 2. [ ] Moderately important

(7) 3. [ ] Somewhat important

(9) 4. [ ] Not very important

12. Does the SBIR program expedite or slow the research needed for your agency's research agenda? (CHECK ONE)

1. [ ] Greatly expedites

(1) 2. [ ] Somewhat expedites

(12) 3. [ ] Neither slows nor expedites

(2) 4. [ ] Somewhat slows

(1) 5. [ ] Greatly slows

(3) 6. [ ] No basis to judge

13. Have you made any decisions to support an SBIR proposal with regular research funds because there were not enough SBIR funds to support it? (CHECK ONE)

1. [ ] Yes --> How many?

_____ projects

(12) 2. [ ] No

(7) 3. [ ] Don't know

14. Since you began overseeing SBIR projects, how has the quality of SBIR projects changed. (CHECK ONE)

(1) 1. [ ] Improved a great deal

(5) 2. [ ] Improved somewhat

(7) 3. [ ] Remained about the same

(1) 4. [ ] Declined somewhat

(5) 5. [ ] Declined a great deal

6. [ ] Have not overseen any other SBIR projects

15. Since you first began working with SBIR projects, how has your attitude toward the SBIR program changed, if at all? (CHECK ONE)

1. [ ] Much more negative

(6) 2. [ ] Somewhat more negative

(5) 3. [ ] About the same

(5) 4. [ ] Somewhat more positive

(1) 5. [ ] Much more positive

(2) 6. [ ] No basis to judge (Less than one year on SBIR)

5

Q3. Is the ratio of administrative costs to total costs higher, lower, or about the same for this SBIR project compared to non-SBIR projects? Please consider only those administrative oversight costs incurred after the award was made. (CHECK ONE)

1. [ ] This SBIR project much higher
2. [ ] This SBIR project somewhat higher
(10) 3. [ ] About the same
(6) 4. [ ] This SBIR project somewhat lower
(3) 5. [ ] This SBIR project much lower

OTHER ASPECTS OF THIS SBIR PROJECT

Q4. To what extent do you feel that this SBIR project has contributed to the research agenda and mission of your agency? (CHECK ONE)

1. [ ] Very great contribution
2. [ ] Great contribution
(9) 3. [ ] Moderate contribution
(3) 4. [ ] Some contribution
(7) 5. [ ] Little or no contribution
6. [ ] No basis to judge

Q5. What potential, if any, do you feel this SBIR project has for private sector commercialization? (CHECK ONE)

(1) 1. [ ] Very high
(7) 2. [ ] High
(5) 3. [ ] Average
(3) 4. [ ] Low
(1) 5. [ ] Very low
(2) 6. [ ] No basis to judge/ Not applicable

Q6. To what extent, if at all, do you feel that this SBIR project is technologically innovative? By "innovative," we mean the likelihood that the project will lead to new scientific/technical discoveries, or to inventing and commercializing new products, processes, or services. (CHECK ONE)

(4) 1. [ ] Very innovative
(3) 2. [ ] Moderately innovative
(6) 3. [ ] Somewhat innovative
(5) 4. [ ] Not at all innovative
(1) 5. [ ] No basis to judge

Q7. Overall, how does the quality of this SBIR project compare to other SBIR projects you have overseen? (CHECK ONE)

(2) 1. [ ] This SBIR project much better
(3) 2. [ ] This SBIR project somewhat better
(10) 3. [ ] About the same
(2) 4. [ ] This SBIR project somewhat worse
5. [ ] This SBIR project much worse
(2) No Answer

Q8. Has this SBIR project met the expectations that your agency had at the time the Phase II proposal was funded? (CHECK ONE)

(1) 1. [ ] Definitely yes
(6) 2. [ ] Probably yes
(4) 3. [ ] Uncertain
(3) 4. [ ] Probably not
5. [ ] Definitely not
(5) 6. [ ] No basis to judge

3

U.S. GENERAL ACCOUNTING OFFICE
SURVEY OF PROJECT OFFICERS IN THE
SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
December 28, 1987

INTRODUCTION

The U.S. General Accounting Office is currently studying the quality of the research conducted in projects obtaining funding under the Small Business Innovation Research Program (SBIR). In order to report this information accurately to the U.S. Congress, we are sending questionnaires to the project officers responsible for monitoring these projects. This questionnaire covers one or more specific SBIR projects as well as your opinions about the SBIR program in general. We are particularly interested in your opinions about these projects and the SBIR program. We will be requesting separate judgments from your agency head on the overall effectiveness of the SBIR program.

The questionnaire has been designed to be answered in fifteen or twenty minutes by checking boxes or writing in a short answer. Project officers like yourself have helped us to make sure that questions are easy to understand and answer. If the format does not fit your situation, please give us any additional comments necessary to describe your experience with SBIR projects. There is room at the end of the questionnaire for additional comments or explanations.

Please help us avoid costly followup mailings by returning the questionnaire within 14 days. If you have questions about any specific item, please call Dr. Richard Frankel at FTS 634-4900 or collect at (202) 634-4900. In the event that the envelope is misplaced, questionnaires should be returned to:

Dr. Richard Frankel
U.S. General Accounting Office
441 G Street N.W., Room 4476
Washington, D.C. 20548

Identification Number of Selected Project:

Selected Project Title:

Selected Project Agency:

Project Officer Name:

Project Officer Agency:

COMPARISON OF SBIR AND NON-SBIR RESEARCH PROJECTS

Q1. The first series of questions (numbers 1 through 10) concerns comparisons of the SBIR project listed above with other non-SBIR projects you have overseen. If some non-SBIR research projects that you have overseen are of approximately the same size and scope as the SBIR project, please compare the SBIR project to these. If not, compare this SBIR project to all non-SBIR research you have overseen.

What basis of comparison will you use for comparing this SBIR project with your non-SBIR projects in the questions below? (CHECK ONE)

(10) 1. [ ] Some of my non-SBIR projects are of similar size and scope, so I will use them for comparisons.

(8) 2. [ ] None of my non-SBIR projects are similar in size and scope and so I am using these dissimilar projects for comparisons.

(1) No Answer

U. S. DEPARTMENT OF EDUCATION
RESEARCH AND DEVELOPMENT PROGRAM

The following programs have research and development funding. Those indicated have basic statutes which permit profit-making organizations to receive ED funds.

In summary, out of 30 programs with R&D funding, 19 can award to profit-making organizations.

	Profit-making Authority
1. Chapter 1 of Education Consolidation and Improvement Act (ECIA) Evaluation, Technical Assistance, and Demonstrations.	Yes
2. School Improvement Programs: Secretary's Discretionary Fund: Other Discretionary Programs	No
3. Drug-free Schools and Communities: National Programs	Yes
4. Science and Mathematics Education: Programs of National Significance	No
5. Bilingual Education: Support Services	Yes
Education for the Handicapped: Innovation and Development:	
6. Research and Demonstration Projects in Education of Handicapped Children	No
7. Research and Demonstration Projects in Physical Education and Recreation for Handicapped Children	Yes
8. Special Studies	Yes
Rehabilitation Services and Handicapped Research: National Institute on Disability and Rehabilitation Research (NIDRR)	
9. Research and Training Centers	Yes
10. Rehabilitation Engineering Center	Yes
11. Research and Demonstration Projects	Yes
12. Field-Initiated Research	Yes
Special Institutions for the Handicapped:	
13. American Printing House for the Blind (APHB)	No*

NOTE: *These institutions can contract with profit-making organizations but the funds are not ED funds at that point in the process.

stimulates technological innovation, 32 percent were uncertain, and 10 percent felt it does not. Almost half of the project monitors (47 percent) believe SBIR encourages the private sector to commercialize the results of federally funded R and D, another 26 percent were uncertain, 16 percent had no basis for judgment, and the final 11 percent believed it probably did not encourage private sector commercialization. Sixty-eight percent of respondents were either uncertain or had no basis for judgment when asked about the fourth legislated SBIR goal--to encourage participation of minority and disadvantaged persons in technological innovation. The remaining 32 percent were split between "probably yes" and "probably no" when asked about that fourth legislated SBIR goal.

Just over 50 percent of the respondents indicated they have been monitoring an SBIR project for two years or less. Only three of the nineteen respondents have been monitoring an SBIR program for five years. Nearly all respondents (84 percent) stated they spend 5 percent or less of their work time on SBIR related activities. Nine respondents stated they have overseen two or fewer SBIR projects since the SBIR program began. Three others indicated they have overseen three to five SBIR projects, and another seven respondents indicated experience with six or more SBIR projects. It should be noted that each project officer received and responded to only one questionnaire regardless of the number of SBIR projects he or she has overseen.

A copy of the survey questionnaire that was used with the Department's project officers is provided in Attachment C. The total number of respondent answers is provided in parenthese next to each possible answer.

3. LEVEL OF INTEREST AMONG FIRMS IS HIGH

On the average, each year the Department distributes a copy of its SBIR Phase I request for proposal solicitations to over 1,200 separate small business firms. In response to those solicitations, over the past five years, the Department received a total of 858 eligible proposals from more than 620 small business firms. While firm data are not available, comments from SBIR project officers indicate that for a number of these firms, it is the first time they have responded to a Department of Education request for proposal solicitation. The number of responses to the competition indicates the small business community has a strong interest in the Department's SBIR program.

As already noted, the Department has funded 76 Phase I proposals from fiscal year 1983 through fiscal year 1987. During that same period, each of 154 proposals received an average score of 80 out of a possible 100 from three independent reviewers using the evaluation criteria stated in the request for proposal solicitations and were recommended for funding. Any SBIR proposal receiving an average score of 80 or above is deemed a high quality proposal. Using that standard, the Department funded almost 50% of the proposals deemed to be of high quality during the first five years of the SBIR program.

The 76 Phase I SBIR proposals funded through fiscal year 1987 were awarded to 65 small business firms. Nine of the 65 small business firms received a second Phase I award. One of the 65 small business firms received three Phase I awards during the agencies first five years of the SBIR program. Additionally, analyses of the regional distribution show that the 76 Phase I awards have spanned 26 States and the District of Columbia.

A table summarizing appropriate SBIR data for fiscal years 1983-1987 is provided in Attachment D.

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are (1) an analysis of the appropriate legislation governing the implementation of SBIR within the Department; (2) an analysis of a recent survey conducted by the Department of its SBIR project monitors; and (3) a review and analysis of the historical data, program solicitations, award topics, and completed Phase II awards. The outcomes of these-in house reviews elicited the following comments about the SBIR program within the Department.

1. FUNDS FOR SBIR ARE NOT AVAILABLE FROM ALL ELIGIBLE R&D PROGRAMS

Implementing SBIR in the Department of Education is not without its difficulties. Phased in over a four-year period, the current and continuing SBIR set-aside of 1.25 percent now commands approximately $1.7 million of the Department's R and D budget. Some 30 separate R and D programs whose funding, when aggregated, exceed the $100 million threshold for extramural research and development should technically be available for contribution to the SBIR set-aside. However, each such R and D program has separate authorizing legislation and congressional budget earmarks governing its use and direction, thereby affecting its availability for SBIR purposes. Specifically, only 19 of the 30, or 63 percent, of the R and D accounts used to determine whether ED meets the $100 million threshold have authorizing legislation permitting them to make awards to profit-making firms--the only eligible awardees under the SBIR program. A table identifying the 30 R and D programs is provided in attachment B.

Additionally, statutory minimums and appropriation earmarkings of R and D funds restrict potential SBIR funding sources. For example, 97 percent of the Department's Education Research and Statistics account can only be used to support the Regional Educational Laboratories, National R and D Centers, the Center for Education statistics, the National Assessment of Educational Progress, Field Initiated Research Grants, and the Educational Resources Information Center (ERIC).

The impact of these legislative constraints is evident in the small number of R and D programs in the Department which are required to contribute a disproportionately high share of their appropriated funds to satisfy the SBIR set-aside. Because of this situation, over 64 percent of the SBIR dollars obligated since 1983 have come from programs associated with the physically and emotionally disabled.

2. ED PROGRAM AND PROJECT OFFICIALS HAVE MIXED VIEWS OF THE SBIR PROGRAM

A questionnaire, developed by the General Accounting Office for its use with a random sample of SBIR project officers, was recently used by the Department of Education to survey its project officers who monitor SBIR and non-SBIR projects. The questionnaire sought project officers' opinions about (1) the SBIR projects they monitor, and (2) the overall SBIR program. Background information about each project officer was also solicited in the questionnaire. Of the 24 project officers who have SBIR projects and were sent the questionnaire, 23 responded. Four of the 23 did not complete most of the questions, stating that they had not been SBIR project officers long enough to form opinions. One other project officer left the agency before completing the questionnaire. Data from the 19 project officers responding with completed questionnaires were aggregated, analyzed, and used for this report.

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Education and Minority Language Affairs (OBEMLA), the Office of Educational Research and Improvement (OERI), the Office of Postsecondary Education (OPE), and the Office of Adult and Vocational Education (OVAE).

SBIR is managed through a working group composed of a representative from each of the POCs that make financial contributions. Working group members participate by submitting technical topics for solicitations, providing proposal reviewers, and monitoring projects funded from the units they represent. They also coordinate SBIR activities within their respective organizations. It should be noted that final decisions on projects to be funded under a given topic in the SBIR program are made by a senior program official in the responsible principal operating component.

SUMMARY OF DEPARTMENT'S SBIR PROGRAM--1983-1987

The Department has complied with the provisions of SBIR legislation since its enactment in fiscal year 1983. In fact, it has slightly exceeded the legislated set-asides which were 0.2 percent, 0.6 percent, and 1.0 percent respectively for fiscal years 1983, 1984, and 1985. Additionally, it has exceeded the now continuing set-aside of 1.25 percent for fiscal years 1986 and 1987, and expects to do the same for fiscal year 1988.

During fiscal years 1983 through 1987, the Department had five Phase I and four Phase II requests for proposal competitions, each conducted annually during the winter and early spring. These solicitations included a total of 19 distinct R and D topics (see attachment A) and generated a total of more than 850 Phase I eligible proposals from over 650 separate small business firms. Some 76 Phase I and 17 Phase II awards totalling over $5.3 million were negotiated with 65 separate small business firms in 26 States and the District of Columbia. Currently, the Department has 28 active Phase I awards, 10 active Phase II awards, and 7 awards which are now in Phase III (all of which reached that status within the last two years).

The Department's review procedures for SBIR proposals have remained essentially unchanged during the program's five year history. Each proposal is individually reviewed and rated by a minimum of three qualified individuals. Each reviewer rates a proposal based on published criteria outlined in each SBIR request for proposal solicitation. The reviewers are selected from rosters of qualified individuals maintained by each participating principal operating component. Each reviewer is asked not only to rate an assigned proposal but to identify its strengths and weaknesses.

Subsequently, the senior program official in each POC makes funding decisions. These decisions are then conveyed to the appropriate Grants and Contracts Service unit personnel via procurement action requests. The Grants and Contracts Service unit then negotiates with offerors who have been recommended to receive an SBIR award, and notifies, by letter, those who will not receive an award.

Once all awards have been consummated, requests for debriefing information; i.e., a copy of the ratings with reviewer comments, are made available at the written request of the proposer.

The closing date for each Phase I request for proposal solicitation is mid-March, and the closing date for each Phase II request for proposal solicitation is mid-April. The Department completes its review,

-2-

REPORT ON THE SMALL BUSINESS INNOVATION RESEARCH PROGRAM

IN THE

UNITED STATES DEPARTMENT OF EDUCATION

MARCH, 1988

As required by

P. L. 99-443

Assessment of the Defense Nuclear Agency (DNA) Small Business Innovation Research (SBIR) Program

The Defense Nuclear Agency believes that the SBIR program has had a beneficial effect on the agency's research and development programs.

DNA's technical managers give the SBIR program high grades for both innovativeness and quality of performance. They feel it is a unique source of fresh, innovative ideas and offers an inexpensive opportunity to explore high risk, high payoff ventures. They rate the quality of performance equal to or better than that obtained on non-SBIR contracts. Some of them also feel that SBIR contractors give more value for the dollar than some of the larger contractors.

The SBIR program has been valuable to DNA as a means of broadening its contractor base. It offers small businesses an opportunity to suggest ways they can contribute to DNA's research and development programs and affords DNA an inexpensive vehicle for judging the capabilities of companies new to DNA's areas of interest.

Some of DNA's technical managers have suggested that the SBIR program might be improved by raising the suggested dollar levels for Phase I proposals to $75,000-$100,000.

Assessment of the Air Force Small Business Innovation Research (SBIR) Program

SBIR contractors are offering new technologies and practical solutions to Air Force problems not previously considered. They are also very responsive and perform extremely well. This is noteworthy considering that many are contracting with the Air Force for the first time. The positive results of the program are related to the contractors' personal stake in the outcome of the projects. For example, a project in radiation-hard fiber optics established an SBIR contractor as a key producer of heavy metal fluoride glass. Another SBIR project resulted in giving the Air Force the lead in impulse radar technology, which is now a candidate for a major development program.

New technologies and innovations coming from SBIR are already finding commercial application. Commercialization is occurring in both defense and non-defense industries, and is dependent upon the energy a company applies to searching out commercial opportunities. Many of the SBIR contractors have been successful in subcontracting their technology to a large business, licensing another company to manufacture, or acting as a prime contractor in developing a product for the Air Force or consumer market. We are experiencing a large number of success stories throughout the Air Force with these programs. These include fiber optics, digital optronics, multispectral analysis, material processing, manufacturing technology, synthetic aperture radar, composite materials technology, airborne sensor platforms and computer-aided engineering design tools.

The inexperience of SBIR contractors with Government contracting procedures has increased the administrative burden of the Air Force for the initial contractual actions, i.e., pre-award survey, approval of accounting systems, negotiations and reporting. Once the administrative tasks are completed, the burden of SBIR contracts is less than non-SBIR projects. The Air Force has worked aggressively to reduce any unnecessary administrative burden by simplifying the solicitation, purchasing request preparation and contracting procedures. This effort has been successful in reducing the government and contractor administrative burden. Many of the Air Force project officers responsible for managing SBIR projects believe that the innovation and responsiveness of the SBIR contractors are higher than with routine contracting procedures. The Air Force has used greater contractual flexibility and commercialization as SBIR contractor motivators.

Since SBIR began in 1983, it has become a key part of the Air Force Research and Development program. It has been responsible for key technology breakthroughs and new products, benefiting both the Air Force and the consumer. It has demonstrated that small businesses are capable of performing quality research and development in response to Air Force requirements.

Assessment of the Navy Small Business Innovation Research (SBIR) Program

The subject assessment has been prepared in conjunction with a majority of the Navy SBIR Administrating and Sub-Administrating Offices. The response by small businesses to the Navy's topics published in the annual Department of Defense Solicitation brochure has been excellent. The two thousand proposals received for about 250 topics, during both of the last two fiscal years, indicates that the Navy has made an effective outreach to small businesses, some being minority owned. The cream of the small businesses (approximately 15 percent of those making proposals) are receiving Phase I awards. Experience has shown that about 50 percent of the Navy's Phase I contracts transition to Phase II efforts. These trends have been found by the Navy as prudent practice considering the difference in scope and funding level between Phase I and Phase II awards. The result of this award behavior has been that the SBIR Program has proven highly beneficial as an adjunct to developing new technologies and broadening the Navy's industrial pool of capabilities.

Navy SBIR contracts are developed and implemented by nine (9) Administrating and seventeen (17) Sub-Administrating Offices. Navy SBIR topics are selected by technologists to support anticipated research and development requirements in support of six naval warfare mission areas. As a result, Navy SBIR topics focus on important R&D thrusts including computer software, directed energy, guidance and navigation, sensors, materials, power sources, signal processing, telecommunications/fiber/optics, conventional warheads and, in particular, new fields of advanced composites, ceramics, high temperature superconductors, robotics and artificial intelligence.

The effectiveness of Navy Phase I and II contracts is demonstrated by the number of transitions into Phase III which are beginning to occur, with funding support derived from both government and commercial sources. Three Navy SBIR Phase III successes are particularly worthy of mention. The Office of Naval Technology sponsored development of technology assessment methodology by B-K Dynamics, Inc. (Rockville, MD). A personal computer based management system will be implemented to facilitate tech base program planning. The Navy Explosive Ordnance Disposal Test Center is funding delivery of a prototype three-axis electromagnetic (EM) gradimeter from Dynamics Technology, Inc. (Torrance, CA), which will be used to detect deeply buried ordnance. The ROBOCOM Systems, Inc. (Levitown, NY), contract with the Naval Supply System Command is evolving into a budgeted and approved, one-year $9M Phase III contract to automate currently manual warehouse processes.

In addition to these successful projects, several current Navy SBIR contracts have great potential. A new theory for mine warfare planning is being developed by Horrigan Analytics, Inc.

Assessment of the Strategic Defense Initiative Organization (SDIO) Small Business Innovation Research (SBIR) Program

SDIO has not yet completed any Phase Two contracts and is thus unable to help measure SBIR results. But SDIO has had a rich bounty of proposals to choose from and has started some excellent innovations in Phase Two.

While SBIR has brought in many proposals, it does impose a burden to administer the highly structured program to satisfy the Public Law. It does seem, however, to be the unchanging will of Congress to foster Small Business enterprise and SBIR is at least as useful as any other way to bring in the voice of the small entrepreneur.

It is difficult to compare the results of a small firm with that of a large firm. The internal dynamics of innovation in a large firm tend to force profitability criteria on innovations very early in their evaluation. In the small firm, the innovation itself stimulates hard work despite the little return and a higher risk. The human urge to pursue a brainchild whips the innovator far harder than the cold calculation of profit. And SBIR rewards what SDIO needs - the risk-taker.

SDIO finds SBIR a worthwhile endeavor and anxiously awaits the day when it will have enough data from Phase Two results to evaluate SBIR as a program.

The SBIR program has created a small, but growing number of advocates at the laboratory level. Because our program is comparatively small and relatively new, only a few of our researchers have been exposed to or benefited from opportunities the program offers. However, those that have been are quite enthusiastic about the program. In terms of the SBIR program's future, I believe this enthusiasm has an important effect. The success of the program is quite clearly dependent upon the continuing interest and cooperation of laboratory and program level scientists. They must provide the topics for solicitations, evaluate proposals, and participate in the selection of awardees.

Based upon peer review of completed phase one work and progress thus far in phase two, there is no doubt about the competence of our SBIR awardees. I am convinced there is sufficient evidence to conclude that the SBIR program can make significant contributions to DOC research and development needs. If your staff requires more details on our SBIR program, Mr. Ed Tiernan, the program's technical manager, will be happy to provide them. He can be reached at (301) 763-4240.

Sincerely,

Hugh L. Brennan
Director, Procurement
Administrative Services

(b) using recombinant molecular techniques to produce porcine cytokines, which have the potential for improving the effectiveness of vaccines in pigs; (c) development of new corn varieties with enhanced methionine levels for improved animal feed; and (d) introduction of genes for chitinase (enzyme that digests chitin) into tobacco to produce plants with increased resistance to fungal attack (fungal cell walls contain chitin).

(6) The SBIR program has proven to be an effective vehicle for support of women- and minority-owned small businesses. Proposals are evaluated strictly on merit, but women- and minority-owned small businesses are encouraged to apply. In FY '88, out of 230 Phase I proposals, 20 were from women-owned and 22 from minority-owned small businesses. A total of 26 Phase I awards have been recommended for funding, and of these, four are women-owned and three are minority-owned. The USDA is pleased with these results and hopes women- and minority-owned small businesses will continue to be successful in obtaining SBIR funds in the future.

In conclusion, the USDA views the SBIR program as being an effective way to involve the small business community in Federal R&D funds. The projects being funded are innovative and of high quality and offer good prospects for eventual commercialization. The SBIR program has earned the respect of the Department of Agriculture and of the agricultural scientific community.

Sincerely,

Orville G. Bentley

Orville G. Bentley
Assistant Secretary

Letter From the Department of Agriculture Concerning the SBIR Program

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20250

22 APR

Mr. Neal P. Curtin
Deputy Director
Resources, Community, and Economic
Development Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Curtin:

I am pleased to respond to your request for an evaluation by the U.S. Department of Agriculture (USDA) of the effectiveness of the Small Business Innovation Research (SBIR) program within the USDA. This evaluation is based in part on extensive consultations by the SBIR Office with grantees, scientists who have served on both SBIR and USDA Competitive Research Grants Office (CRGO) panels, and various USDA officials. It is also based upon information documented by the SBIR Coordinator, Dr. Charles F. Cleland, who has made nearly 30 site visits to Phase I and Phase II grantees since he joined USDA's SBIR program in May of 1987.

In our opinion the SBIR program is proving to be a sound investment of Federal R&D funds for the following reasons:

(1) The research community that applies to the SBIR program is completely different from that which applies to the Competitive Research Grants program, which is USDA's primary extramural research grant program. In FY '87, the Competitive Research Grants program received a total of 1653 grant proposals with only eight coming from private profit organizations. A total of 363 grants were awarded with just two going to private profit organizations (both were awarded to Weyerhaeuser Company). The SBIR program in FY '87 received 178 Phase I applications and 24 Phase II applications, and made 23 Phase I awards and 12 Phase II awards. Thus, for science and technology-based small business firms, the SBIR program represents their best opportunity for access to USDA R&D funds.

(2) The quality of successful SBIR proposals compares favorably to the quality of successful proposals submitted to the Competitive Research Grants program. Scientists who have served as panelists in both programs indicate that while the nature of the research is clearly different, the scientific and technical merit is very high in both cases. Competitive Research Grants projects are usually for a two to three year period and are focused on basic research, while SBIR Phase I grants are for only 6 months and have a more applied focus. Consequently, there are limitations on what can realistically be proposed in a Phase I grant, but this does not detract from the scientific merit of the proposals.

Questionnaire Procedures

We developed the questionnaire after discussions with agency officials and consultants. We conducted pretests with eight companies in the Washington, D.C., and Boston areas that participated in SBIR projects. During each session, an individual respondent filled out the questionnaire in the presence of two GAO observers. After the pretests, we revised the questionnaire as necessary to increase clarity and ease of response.

We mailed questionnaires to the principal investigator of each project in the sample. Because we based our sample on projects rather than companies, 212 companies received 2 or more questionnaires. A total of 954 companies received our questionnaire.

We sent follow-up letters to nonrespondents, including a second copy of the questionnaire, and also sent a final reminder to nonrespondents to encourage them to return their questionnaires.

Survey Results

We received 1,113 completed questionnaires out of 1,406 that were mailed, yielding a response rate of 79 percent. These responses were weighted to account for our stratified sampling of agency projects. Appendix II shows the questionnaire and the frequency of responses to individual questions.

Table V.1: Sampling Plan

Department/agency	Universe	Sample	Returned	Estimated number of projects represented by questionnaires returned
NASA	380	189	141	284
Commerce	7	7	6	6
Agriculture	53	53	41	41
Interior	21	21	14	14
Transportation	53	53	38	38
EPA	40	40	34	34
Education	34	34	24	24
NRC	22	22	14	14
Energy	318	177	150	264
HHS	802	263	212	638
NSF	333	244	208	266
DOD	1,178	303	231	869
Total	**3,241**	**1,406**	**1,113**	**2,492**

13. What are the benefits, if any, of this SBIR project to your agency? (CHECK ONE)

(36)

	%	
1.	43.0	Too early to tell
2.	8.2	No benefits
3.	8.0	Don't know/Not applicable
4.	40.8	The benefits are explained below:

14. What actions, if any, did you or your agency take to use the results of this SBIR project? (CHECK ONE)

(37)

	%	
1.	34.9	Too early to tell
2.	25.1	No actions taken
3.	6.7	Don't know/Not applicable
4.	33.3	The actions taken are explained below:

15. Please add any additional comments or note any special circumstances concerning this project.

(38)

38.8% provided comments.

faf: 005738: 3/88

3. Is the level of scientific/technical risk higher, lower, or about the same for this SBIR project compared to the non-SBIR projects you were considering in the previous question? ["Scientific/technical risk" refers to researching an area where results are less easy to come by.] (CHECK ONE)

(26)

	%	
1.	9.3	This SBIR project much higher risk
2.	30.4	This SBIR project somewhat higher risk
3.	37.3	About the same level of risk
4.	15.3	This SBIR project somewhat lower risk
5.	5.6	This SBIR project much lower risk
6.	2.0	UNABLE TO JUDGE, NO RESPONSE

4. Is the ratio of your agency's administrative costs to total costs higher, lower, or about the same for this SBIR project compared to non-SBIR projects? Please consider only those administrative oversight costs (such as monitoring time, site visits, etc.) incurred after the award was made. (CHECK ONE)

(27)

	%	
1.	4.1	This SBIR project much higher
2.	8.7	This SBIR project somewhat higher
3.	51.8	About the same
4.	24.0	This SBIR project somewhat lower
5.	9.3	This SBIR project much lower
	2.2	No response

SECTION II: OTHER ASPECTS OF THIS SBIR PROJECT

5. To what extent do you feel that this SBIR project has contributed to the research goals of your agency? (CHECK ONE)

(28)

	%	
1.	5.5	Very great contribution
2.	17.2	Great contribution
3.	39.4	Moderate contribution
4.	23.4	Some contribution
5.	11.7	Little or no contribution
6.	2.7	No basis to judge

6. If this project were successful, what potential, if any, do you feel it would have for private sector commercialization? (CHECK ONE)

(29)

	%	
1.	15.8	Very high
2.	35.0	High
3.	29.2	Average
4.	11.1	Low
5.	0.0	Very low
6.	8.9	No basis to judge/ No response Not applicable

Questionnaire to SBIR Project Officers Concerning Specific Projects

U.S. GENERAL ACCOUNTING OFFICE
SURVEY OF PROJECT OFFICERS: PROJECT QUESTIONS
SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM

(1-6)
02(7-8)
005738 (9-14)

INTRODUCTION

This questionnaire concerns your opinions in regard to a particular SBIR project that you monitored. Please answer all questions on this questionnaire in regard to this particular SBIR project. The other questionnaire in this packet concerns your general opinions about the SBIR program.

If you are not the person on the label below, please give your name and a phone number where you can be reached.

Name: _____

Phone number: _____

Questionnaire Response Data

questionnaires mailed = 739

responses received = 691

response rate = 93.5

Identification of Selected SBIR Project:

SECTION I: COMPARISON OF SBIR AND NON-SBIR RESEARCH PROJECTS

1. The first series of questions (numbers 1 through 4) concerns comparisons of the SBIR project listed above with non-SBIR projects you have overseen. If some non-SBIR research projects that you have overseen are of approximately the same duration and funding level as the SBIR project, please compare the SBIR project to these. If not, compare this SBIR project to all non-SBIR research you have overseen.

What basis of comparison will you use for comparing this SBIR project with your non-SBIR projects in the questions below? (CHECK ONE)

(15)

%	
1.62.4	Some of my non-SBIR projects are of similar duration and funding, so I will use them for comparisons.
2.36.9	None of my non-SBIR projects are similar in duration and funding and so I am using these dissimilar projects for comparisons.
0.7	No response

6. For each of the following goals originally planned for the SBIR program, please give your personal opinion as to whether or not that goal is presently being met. (CHECK ONE FOR EACH STATEMENT) (23-26)

	DEFI-NITELY YES (1)	PROB-ABLY YES (2)	UNCER-TAIN (3)	PROB-ABLY NO (4)	DEFI-NITELY NO (5)	TOO EARLY TO TELL (6) /NO RESPONSE
	%	%	%	%	%	%
a. SBIR helps your agency to meet its R&D needs	39.8	36.2	12.1	7.3	2.4	2.2
b. SBIR stimulates technological innovation	43.8	39.0	11.5	4.4	0.4	0.8
c. SBIR encourages the private sector to commercialize the results of federally funded R&D	25.7	36.4	22.6	8.1	1.8	5.5
d. SBIR encourages the participation of minority and disadvantaged persons in technological innovation	9.9	27.9	43.2	13.7	3.2	2.0

BACKGROUND INFORMATION

7. In what fiscal year did you begin overseeing SBIR projects? (CHECK ONE) (27)

	%	
1.	4.4	Before FY83 (NSF and DOD only)
2.	24.0	FY83
3.	25.9	FY84
4.	23.4	FY85
5.	13.3	FY86
6.	7.9	FY87
	1.0	No response

8. How many funded Phase I and Phase II SBIR projects have you overseen since then? (CHECK ONE FOR EACH) (28-29)

		PHASE I (CHECK ONE)	PHASE II (CHECK ONE)
		%	%
1.	One	26.1	48.5
2.	Two	15.6	21.8
3.	3-5	23.0	20.6
4.	6-10	13.1	5.9
5.	11-25	8.9	1.8
6.	26 or more	3.8	0.2
7.	(zero)	7.3	
	No response	2.2	1.2

9. What percent of your time do you spend on SBIR and non-SBIR proposals and projects as compared with other work that you do? (ENTER SBIR AND NON-SBIR TIME TO NEAREST PERCENT IN BOXES BELOW) (30-38)

	SBIR R&D PROPOSALS AND PROJECTS		NON-SBIR R&D PROPOSALS AND PROJECTS		OTHER ACTIV-ITIES		TOTAL
(mean value)	10%	+	50%	+	40%	=	100%

Questionnaire to SBIR Project Officers on Experience With SBIR Program in General

U.S. GENERAL ACCOUNTING OFFICE
SURVEY OF PROJECT OFFICERS: GENERAL QUESTIONS
SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM

INTRODUCTION

The U.S. General Accounting Office is currently studying the quality of the research conducted in projects obtaining funding under the Small Business Innovation Research Program (SBIR). In order to report this information accurately to the U.S. Congress, we are sending questionnaires to the project officers responsible for these projects. We are particularly interested in your opinions about these projects and the SBIR program. We will be requesting separate judgments from your agency head on the overall effectiveness of the SBIR program.

Two questionnaires are enclosed. This one covers your general opinions on the SBIR program. The other questionnaire covers a specific SBIR project that you have monitored. Because we are requesting information on all SBIR projects awarded Phase II funding in 1984 through 1986, we may have sent you more than one project-oriented questionnaire. We hope you will be able to fill out each questionnaire that is enclosed. The questionnaires have been designed to be answered in five or ten minutes each by checking boxes or writing in a short answer. Project officers like yourself have helped us to make sure that questions are easy to understand and answer. If the format does not fit your situation, please give us any additional comments necessary to describe your experience with SBIR projects. There is room at the end of this questionnaire for additional comments or explanations.

(1-6)
01(7-8)
005738 (9-14)

Please help us avoid costly followup mailings by returning the questionnaires within 14 days. If you have any questions or feel that you are not the correct person to fill out a questionnaire, please call Dr. Richard Frankel at FTS 634-4900 or collect at (202) 634-4900. In the event that the envelope is misplaced, questionnaires should be returned to:

Dr. Richard Frankel
U.S. General Accounting Office
441 G Street N.W., Room 4476
Washington, D.C. 20548

PROJECT OFFICER AND AGENCY:

Questionnaire Response Data

questionnaires mailed = 530

responses received = 495

response rate = 93.4%

01. How important, if at all, is the SBIR program as an element of your agency's overall research program? (CHECK ONE)

(15)

	%	
1.	22.8	Very important
2.	31.7	Moderately important
3.	29.3	Somewhat important
4.	14.9	Not very important
	1.2	No response

20. Did the idea for this SBIR project arise from work conducted at an academic institution? (CHECK ONE)

(88)

	%	
1.	14.2	Definitely yes
2.	8.8	Probably yes
3.	3.7	Uncertain
4.	10.9	Probably no
5.	62.2	Definitely no
	0.2	No response

GENERAL INFORMATION ON YOUR FIRM

The questions below concern your firm and will help us to determine how SBIR is viewed by different types of firms. This is a very important part of the survey, but we realize some of you might not feel comfortable estimating the answer to a particular question. If so, please help us by contacting someone in your firm who would be able to provide an answer so that our information will be as complete as possible.

21. How many full-time-equivalent employees currently work for your firm? (ENTER NUMBER OF EMPLOYEES)

(89-92)

median = 20 Employees

If your firm exceeds 500 employees, please give approximate date that change in status occurred: (ENTER TWO DIGIT EQUIVALENTS FOR MONTH AND YEAR)

(93-96)

median = 1 / 87 /
Month Year

22. What was the approximate gross revenue for your firm during your firm's 1987 fiscal year? (CHECK ONE)

(97)

	%	
1.	8.9	Less than $100,000
	(1.6)	
2.	17.9	$100,000 to $499,999
	(2.0)	
3.	13.4	$500,000 to $999,999
	(2.0)	
4.	29.0	$1 million to $4,999,999
	(2.7)	
5.	14.8	$5 million to $20 million
	(2.1)	
6.	4.4	Over $20 million
	(1.4)	
	11.6	No response

23. Considering both your firm's 1986 and 1987 fiscal years together, what is the approximate percentage of gross revenue that your firm derived from SBIR awards? (CHECK ONE)

(98)

	%	
1.	49.6	Less than 25%
2.	15.9	25% to 50%
3.	10.1	51% to 75%
4.	10.8	More than 75%
5.	14.6	No basis to judge and no response

13. Have you completed Phase II? (CHECK ONE)

Because of questionnaire directions, only 606 answered this question. 3/ (56)

1. 42.7% (3.5) Yes (CONTINUE WITH QUESTION 14)
2. 57.3% No (SKIP TO QUESTION 16)

14. How much of your firm's expenses for Phase II did the SBIR award cover? (CHECK ONE)

Because of questionnaire directions, only 284 answered this question. 3/ (57)

1. 65.6% All or almost all -- SKIP TO 16
2. 26.2 More than half
3. 5.9 About one half
4. 2.3 Less than half

(2-4: CONTINUE WITH QUESTION 15)

15. What was the source(s) of additional funding used to complete Phase II? (CHECK ALL THAT APPLY)

Because of questionnaire directions, only 104 answered this question. 3/ (58-66)

1. 87.3% Company's own internal funds
2. 6.7 Venture capital institution
3. 6.8 Bank
4. 12.0 Other private firm
5. 10.4 State or local government
6. 3.6 Other federal funding
7. 2.0 College or university
8. 16.3 Personal funds
9. 9.6 Other investment sources

PROJECT RESULTS

16. Which of the following actions, if any, have you already taken as a consequence of this SBIR project? (CHECK "YES" OR "NO" FOR EACH ITEM a. - f.) (67-72)

	YES (1)	NO (2)	No response
	%	%	%
a. Preparing patent application	18.2	67.4	14.4
b. Applied for patent but not yet received	(1.9) 12.0	71.9	16.2
c. Received patent	(1.5) 6.8	75.7	17.5
d. Sold rights or licensed	4.0	77.4	18.5
e. Formed strategic partnership (joint venture, R&D limited partnership, etc.)	8.3	74.4	17.3
f. Anything else? (PLEASE SPECIFY)	27.5	35.5	37.0

3/ Percentages are adjusted to reflect stratification of sample. See app. V.

2. In the absence of the SBIR program, would you have undertaken this research? (CHECK ONE) (22)

%	
1. 4.2 (1.0)	Definitely yes
2. 12.0 (1.7)	Probably yes
3. 20.1 (2.1)	Uncertain
4. 36.1 (2.5)	Probably no
5. 27.6 (2.4)	Definitely no

3. Was any additional funding (including your firm's own funds) used to complete the Phase I portion of the project? (CHECK ONE) (23)

%	
1. 49.8	Yes (CONTINUE WITH QUESTION 4)
2. 49.9	No (SKIP TO QUESTION 5)
0.3	No response

4. From what sources did you obtain additional funding to complete Phase I? (CHECK ALL THAT APPLY) (24-32)

Because of questionnaire directions, only 565 answered this question. 1/

%	
1. 90.2	Company's own internal funds
2. 4.1	Venture capital institution
3. 3.4	Bank
4. 4.6	Other private firm
5. 3.0	State or local government
6. 3.7	Other federal funding
7. 2.0	College/university
8. 13.1	Personal funds
9. 4.4	Other investment sources

5. Did your firm submit a Phase II proposal for this project? (CHECK ONE) (33)

%	
1. 84.6	Yes (SKIP TO QUESTION 7)
2. 15.1	No (CONTINUE WITH QUESTION 6 AND THEN SKIP TO QUESTION 16)

6. Why didn't your firm submit a Phase II proposal? (CHECK ALL THAT APPLY) (34-40)

Because of questionnaire directions only 146 respondents answered this question. 1/

%	
1. 27.1	Firm determined that idea was not technically feasible or results were inconclusive.
2. 22.0	Firm determined that idea was not commercially viable.
3. 3.8	Went immediately into sale of product/process/service.
4. 3.8	Company growth made firm ineligible for SBIR program.
5. 19.8	Company did not submit timely application because of internal problems or personnel changes.
6. 11.0	Agency advised that funds were no longer available.
7. 28.7	Other (PLEASE SPECIFY) (41)

NOTE: SKIP TO QUESTION 16 AFTER ANSWERING QUESTION 6 IF YOU DID NOT SUBMIT A PHASE II PROPOSAL FOR THIS PROJECT.

1/ Percentages are adjusted to reflect stratification of sample. See app. V.

Data on Individual Agency SBIR Programs, Fiscal Year 1987

Dollars in thousands

Agency	Phase I proposals received	Phase I awards	Phase II awards	Amount of Phase I and Phase II awards
USDA	178	23	12	$3,506
COMMERCE	184	14	6	1,503
DOD	7,536	1,270	401	193,732
DOED	204	28	3	1,644
DOE	942	111	43	28,390
HHS	1,883	356	147	66,348
DOT	371	26	10	2,740
EPA	240	24	12	2,981
NASA	1,828	172	81	31,760
NSF	1,248	155	50	16,688
NRC	111	10	3	1,177
Total	**14,725**	**2,189**	**768**	**$350,468**

Source: Small Business Innovation Development Act: Fifth Year Results, SBA (June 1988).

Agencies either had no comment on our draft report or expressed agreement with its contents. Some agencies suggested technical changes in the report, which we incorporated as appropriate.

How Agencies View Their SBIR Programs

We asked the heads of 11 agencies who fund SBIR projects to provide their judgments on the effect of SBIR legislation on their agency's research programs, as required by the reauthorization of the Small Business Innovation Development Act of 1982 (P.L. 99-443). In general, the agencies regarded the overall impact of the SBIR program on their research activities as favorable. The agencies differed in the specific impacts of SBIR legislation that they reported, but some themes were common to most agency responses. Most agencies identified ways in which their SBIR programs had (1) developed new research areas, (2) placed more emphasis on the application of research results, and (3) contributed to wider use of small businesses as research performers. (See apps. VI through XVI.)

We also asked the same agencies, as well as SBA, to comment on our report in draft form. The agencies either had no comment on our report or expressed agreement with its contents.

Common Themes in Agency Judgments of SBIR Programs

New Research Areas

Seven agencies identified ways in which the SBIR program has helped them support new kinds of research. For example, HHS noted that the SBIR projects addressed gaps in its research programs.

> "A large number of these gaps appear to be in the area of medical instrumentation, for example, the development of devices for the diagnosis, treatment and rehabilitation of patients with communicative and sensory disorders.... Indeed, SBIR has proved to be a very effective means of encouraging the development of devices, instruments and other hardware that have not otherwise been addressed."

Similarly, NRC stated that the SBIR program offers an opportunity for federal research program managers to take advantage of new ideas that might not surface through normal contracting avenues. According to DOE, research pursuits have been expanded in directions not traditionally followed, and advances have been made in many areas that would probably not have occurred without SBIR.

USDA, Commerce, DOT, and NSF also reported ways in which SBIR had led to the support of new kinds of research. For example, Commerce said

DOE's responses fell between the extremes established by the other agencies, in the assessment of overall research quality, and in several of the specific factors. The assessment of SBIR projects performed by DOE's Office of Program Analysis and dated August 1988 shows a real, although small, difference between the overall average ratings of SBIR and non-SBIR projects, with the non-SBIR projects having a higher rating.[2]

In comparing responses among agencies, it should be noted that project officers differ among agencies in the amount of non-SBIR basic research that they oversee, as table 3.3 shows. This table indicates that more project officers at NSF and HHS than at other agencies reported devoting all, or almost all, of their time to overseeing basic research when they were not working with SBIR projects.

Table 3.3: Share of Project Officer's Non-SBIR Research Time Devoted to Basic Research

Percent

Time devoted to basic research	NASA	DOD	DOE	HHS	NSF
All/almost all	24	17	34	47	85
Some	58	48	41	37	10
Little/none	18	35	25	16	5

Source: GAO questionnaire.

As table 3.4 shows, project officers who spent all, or almost all, of their non-SBIR R&D time on basic research differed from other project officers in their responses concerning research quality.

[2]The DOE assessment was based on evaluations provided by 17 independent scientific and technical panels that reviewed samples of SBIR and non-SBIR projects.

these agencies emphasize in their SBIR programs, but lower on some other factors—as table 3.2 indicates.

To compare agency responses in table 3.2, we assigned numerical values to the questionnaire responses, as follows:

Much better than other agency research	2
Somewhat better than other agency research	1
About the same as other agency research	0
Somewhat worse than other agency research	−1
Much worse than other agency research	−2

Responses of "unable to judge" or "not applicable" were not included in this analysis. For each factor, we added up the numerical value of the agency responses and divided by the number of responses to obtain an average agency response for each factor. As table 3.2 shows, the average scores in many cases were generally slightly above or very close to 0, indicating that many projects were regarded as of much the same quality as non-SBIR research.

We decided, on the basis of our own experience and the views of science policy experts we consulted, that the most feasible additional approach to measuring research quality was to enlist the judgments of technically knowledgeable persons who were familiar with the SBIR project but were not actually participating in the research. In addition to SBIR projects, agency project officers are normally responsible for other research activities. Therefore, we asked agency project officers to compare SBIR research with other research for which they were also responsible.

SBIR research is a relatively small part of the responsibilities of most project officers. Almost 80 percent of the project officers responding to our questionnaire said that SBIR proposals and projects required no more than 10 percent of their time. Their remaining time was devoted to non-SBIR R&D proposals and projects and to other activities.

To measure research quality, we asked project officers to compare specific SBIR projects with other research projects that they were responsible for, according to nine factors that we had identified as potentially relevant to research quality (by consulting science policy experts, reviewing published material, and pretesting questionnaires), and to assess overall project quality. These factors, which are listed in table 3.1, included, among others, the likelihood that the project would lead to new scientific/technical discoveries or to inventing and commercializing new products, processes, and services. In order to focus on projects that had been going on long enough to produce results, we sent questionnaires to 530 project officers concerning the 739 projects begun during 1983 and 1984 that had been later selected for Phase II awards. Appendixes III, IV, and V contain additional information on our questionnaires and the project officers' responses.

Overall Assessment of Research Quality

Overall, about half of the SBIR projects were judged to be of about the same quality as other research under the project officer's responsibility. As table 3.1 shows, 50 percent of the SBIR projects were rated as having about the same overall quality as other research, while 29 percent were regarded as somewhat or much better and 19 percent were regarded as somewhat or much worse. A similar rating pattern is found for most of the specific factors regarding research quality.

For all but one of the factors, more projects were rated better than were rated worse than other projects. The one exception was the quality of scientific and technical facilities and resources, for which 14 percent of

the SBIR proposal process, SBA officials believe a firm has little incentive to report its status accurately.

SBA and agencies with SBIR programs have undertaken outreach efforts to encourage participation by minority and disadvantaged firms, often as part of general outreach efforts to inform small businesses about SBIR. These efforts have taken several forms: national conferences; regional seminars; and mailings to state agencies, historically minority universities and colleges, and individual firms. For example, in April 1987 DOD, NASA, and DOE held a joint 2-day workshop on the SBIR program that was sponsored by Virginia state government. In addition, a session for minority and disadvantaged firms was held in October 1987, as part of a conference in Atlanta attended by all SBIR agencies.

The SBIR program has attracted some minority and disadvantaged firms that have not previously participated in federal contracting activities. About 26 percent of the projects by minority and disadvantaged firms identified in our questionnaire sample were performed by firms that had not had a contract or grant from the federal government prior to receiving their first SBIR award.

SBA sponsored a study during 1985 to identify minority and disadvantaged firms capable of and interested in participating in the SBIR program. The study was completed in 1986 and the over 300 firms identified were entered in the SBIR mail list system and sent publications on the program. The study found that the number of firms that are primarily R&D-oriented is small compared to the total number of minority and disadvantaged firms. The study also found that many minority and disadvantaged individuals who have the technical training and capability for participation in the program are employed in large corporations or in the government and are not interested in applying for the program.

on agreements, about 39 percent reported that the products or services resulting from the SBIR project were being sold commercially. In comparison, for 18 percent of these Phase II completions that had not received follow-on funding commitments, firms reported that they were selling the results of their SBIR project commercially.

Firms With Multiple SBIR Awards

In its 1987 annual report to the Congress on SBIR programs,[4] SBA provided information on efforts by firms that had received seven or more Phase I SBIR awards to commercialize their SBIR projects. SBA made these observations in response to concerns that firms with large numbers of SBIR awards were not taking adequate steps to ensure the commercialization of the resulting projects. SBA determined that no particular problems existed with the management and commercialization of multiple awards. In SBA's opinion, companies with multiple awards were "just as committed, or more so, to the successful performance and commercialization of SBIR projects...."

Firms that responded to our questionnaire concerning their SBIR projects indicated that the number of SBIR awards received makes little difference in the rate of commercialization. We examined the data reported by firms that had received 11 or more Phase I awards. Of the projects that had completed Phase II, 25 percent had been performed by firms with 11 or more Phase I awards. For both groups of firms, about 25 percent of the completed projects resulted in products or services that were being sold commercially.

Fostering Minority and Disadvantaged Participation

SBA and agencies with SBIR programs seek to accomplish the program goal of fostering and encouraging participation by minority and disadvantaged small businesses through outreach efforts to inform them about SBIR programs.

SBA defines a minority and disadvantaged small business concern as one

- that is at least 51 percent owned by one or more minority and disadvantaged individuals or, in the case of any publicly owned business, at least 51 percent of the voting stock of which is owned by one or more minority and disadvantaged individuals and

[4]Fourth Year Results Under the Small Business Innovation Development Act of 1982, SBA (Washington, D.C.: June 1987), p. 11.

In our June 1987 report,[2] we found that all agencies consider the innovation and commercial potential of their SBIR proposals in their SBIR evaluation and selection processes. However, officials at most agencies said that research needs and priorities are usually given emphasis over these factors.

Preliminary Information on Commercialization

As noted earlier, we did not seek the information needed to make an analysis of the extent and nature of commercial products and services that have resulted from SBIR projects. We will report on Phase III commercialization activities in 1991, when more SBIR projects have entered that phase. However, some preliminary information is available. We asked firms to provide information on commercial products resulting from completed Phase II projects. SBIR firms responding to our questionnaire report that 285 projects have completed Phase II out of 604 that were selected for that phase. The projects selected for our questionnaire were started during fiscal years 1983 through 1985, the first years of the SBIR program. SBA officials told us that very few of the projects begun since fiscal year 1985 have completed Phase II.

Commercialization Activities

For 24 percent of the projects that have completed Phase II, firms report that the resulting products and services are now being sold, but we did not obtain any information on the extent of these sales. Agencies differ concerning the percentage of completed projects resulting in products and services that were being sold commercially. For HHS projects, 48 percent were being sold commercially, while the rate for DOE, NSF, NASA, and DOD ranged from 24 percent to 16 percent.

Questionnaire responses indicate that for most projects that have completed Phase II, the level of commercial activity has remained fairly small. Over half (54 percent) of the projects that had sales were by firms with 25 or fewer employees; and for most projects (78 percent), the firms had 1987 revenues of less than $5 million. For 45 percent of these projects, less than 25 percent of the firms' revenues derived from SBIR awards. These proportions are similar to those for all respondents to our questionnaire: 56 percent of all projects were by firms with 25 or fewer employees; and for 78 percent of the projects, firms had revenues of less than $5 million.

[2](GAO/RCED-87-63, June 2, 1987).

We found that agencies with SBIR programs differ in the emphasis they place on commercial potential in selecting SBIR proposals for funding. However, in response to our questionnaire, SBIR project officers stated that about half of the SBIR projects have high potential for commercial development. Preliminary information on commercialization indicates that some completed projects have resulted in the sale of goods and services and that firms are taking steps to commercialize the results from other projects.

Selection of Projects With High Commercial Potential

According to their responses to our questionnaires, SBIR project officers believe that about half the Phase II projects have high potential for commercialization. Although all agencies have procedures for considering the innovativeness and commercial merit of SBIR proposals, they differ in the emphasis they place on commercialization potential, especially on the existence of commitments for follow-on funding when selecting Phase II projects.

SBIR project officers, according to their responses to our questionnaires, believe that many of the Phase II projects they manage have high potential for commercial development. They rated about half of the SBIR projects as having high or very high potential for commercialization. When the project officers compared individual SBIR projects with other agency research activities, 53 percent of the projects were assessed as having more likelihood of leading to the inventing and commercializing of new products, processes, and services, while 12 percent were judged to have less potential for development. Overall, 62 percent of the project officers said that their agency's SBIR program definitely or probably encouraged the private sector to commercialize the result of federally funded R&D, while only 10 percent thought the SBIR program was unlikely to do so. The remaining 28 percent were uncertain or believed it was too early to tell.

When asked to compare SBIR projects to other research for which they were responsible, project officers identified 53 percent of the SBIR projects as having somewhat better or much better likelihood of leading to inventing and commercializing new products, processes, or services. At NSF and HHS, about two-thirds (67 percent) of SBIR projects were judged more likely than other research to lead to commercialization, while about half (53 percent) of the projects at DOD, NASA, and DOE were rated the same way. (This information is analyzed more extensively in ch. 3.)

In their comments on questionnaire responses, SBIR project officers indicated several ways in which their SBIR programs contributed to research objectives. For example, one NASA project officer noted that the program attracted talent "hidden" in small businesses to R&D areas important to his division, while another said that the SBIR program was an excellent vehicle for starting up projects not in the mainline of agency R&D—which might become part of the mainline R&D if successful. Similarly, a DOD project officer commented that the SBIR program provided an easy method to forge relationships with innovative small businesses and allowed a method of judging the state of the art.

SBIR Programs Fund Projects That Agencies Might Not Support Otherwise

Through SBIR programs, agencies support many projects that they would not otherwise sponsor. SBIR project officers reported that 52 percent of their projects probably or definitely would not have been funded by the agency if the SBIR program did not exist and were uncertain about an additional 30 percent. In their opinion, only about 17 percent of SBIR projects were likely to have been funded without an SBIR program.

There are some differences, however, among agencies over whether projects would have been funded if the SBIR program did not exist. At DOD, project officers thought that the agency would definitely or probably have funded 23 percent of the projects, while at the next highest agencies (NSF and HHS), the percentage was 16 percent. For the five agencies, the percentage of projects that probably or definitely would not have obtained funding without the SBIR program ranged from 47 percent to 62 percent.

At NSF and HHS, SBIR projects have an applied research focus and emphasize private sector commercialization so they are different from most other agency research. Thus, it is reasonable to expect that many SBIR projects would not have obtained non-SBIR funding at these agencies. However, at DOD and NASA where SBIR projects are more similar to other agency research activities, the large percentage of projects (49 percent at DOD and 59 percent at NASA) that would not have received funding outside the SBIR program is more unexpected.

According to questionnaire responses, DOD and NASA are using SBIR projects to undertake high-risk research—research in areas where results are less easy to achieve. In these two agencies, about half of the Phase II SBIR projects were rated by project officers as having higher levels of risk than non-SBIR projects that they managed. Only 13 percent of the projects in these agencies were assessed as having lower levels of

Attitudes of Agency Officials

In their written responses to us concerning SBIR R&D, the heads of 11 agencies and departments provided information on how SBIR programs helped meet their agency R&D needs. Our questionnaire to project officers also asked whether SBIR programs helped meet agency R&D needs and what contribution individual SBIR projects had made in meeting R&D needs.

The 11 agency and department heads generally replied that their SBIR programs were helping to meet R&D needs. (See ch. 4.) Their responses differed, however, in the specific contributions reported for SBIR programs. DOD and NASA, for example, emphasized how SBIR projects helped fulfill R&D mission needs. On the other hand, NSF stated that its SBIR program complemented its basic research programs by providing a linking mechanism to the marketplace. Like NSF, HHS said that the primary purpose of its SBIR program was to increase the commercialization of the results of federally funded R&D.

Many project officers monitoring SBIR projects also believed that SBIR programs helped meet agency R&D needs. Of the respondents to our questionnaire, 41 percent reported that the SBIR program definitely helped meet agency R&D needs, and another 37 percent thought that the program probably did so. Only 10 percent thought that SBIR programs probably or definitely made no contribution to agency research needs. However, as table 2.5 shows, agency project officers differed in their attitudes.

Table 2.5: Responses on Whether the SBIR Programs Help Meet Agency R&D Needs

Percent

	Agency					
Response	**NASA**	**DOD**	**DOE**	**HHS**	**NSF**	**All agencies**
Definitely yes	50	54	22	12	15	41
Probably yes	37	33	49	47	26	37
Uncertain, too early to tell	8	8	11	27	23	12
Probably no	4	5	16	11	15	7
Definitely no	1	0	2	3	21	3

Source: GAO questionnaire.

At NASA and DOD, where SBIR projects are solicited, selected, and managed to meet specific R&D objectives, a high percentage of project officers believe that the SBIR program definitely or probably helps meet agency R&D needs. On the other hand, at NSF and HHS, where SBIR projects are not

Using SBIR Programs to Meet Federal R&D Needs

Agencies with large R&D programs have different needs because of different mission responsibilities and different ways of managing and overseeing research. These differences are reflected in the solicitation of SBIR proposals; the ranking and selecting of such proposals for funding, and the management of the SBIR projects. Despite these differences, agency and department heads generally indicated that their SBIR programs were helping to meet R&D needs. About three quarters of the project officers also responded that SBIR programs probably or definitely helped meet agency R&D needs. In addition, project officers said that through SBIR programs, agencies support many projects that they would not otherwise sponsor. In their opinion, about half of the projects probably or definitely would not have been funded if the agency did not have an SBIR program.

Differences in Agency R&D Needs

DOD and NASA conduct a high proportion of applied research and development to meet specific defense, aeronautic, and space technology needs in addition to some basic research. Much of their applied research and development is performed through contracts with private industry, under the supervision of agency managers. On the other hand, NSF and HHS fund a much higher proportion of basic research through grants to universities than do DOD and NASA. Such basic research is performed with little supervision by NSF or HHS officials. DOE, like DOD and NASA, supports applied research but, like NSF and HHS, also supports basic research, particularly in the field of high energy and nuclear physics.

NASA and DOD conduct their SBIR programs primarily to meet specific objectives as an integral part of agency R&D programs. In contrast, SBIR projects at NSF and HHS differ from other research at these agencies in that they have an applied research focus and emphasize private sector commercialization. NSF and HHS solicit proposals within broad technological areas and emphasize the selection of proposals with high potential for private sector commercialization. As a result, SBIR programs at these agencies are less coordinated with other agency research, which tends to be fundamental in nature and does not emphasize commercialization. At DOE, SBIR projects in some areas, such as magnetic fusion and basic energy research, are geared toward specific agency R&D objectives, while those in other areas, such as energy conservation and fossil fuel, focus on private sector commercialization.

the highest percentage of projects in our survey as moderately or very innovative (73 percent), followed by DOD (64 percent), DOE (63 percent), HHS (48 percent), and NSF (48 percent).

Project officers believed that over half (53 percent) of the SBIR projects were more likely than non-SBIR research under their responsibility to produce inventions or products. Another 29 percent of the SBIR projects were assessed as having the same likelihood of invention or commercialization as non-SBIR projects. (Ch. 3 includes more information on these responses as part of our analysis of research quality.)

SBIR Firm Responses Concerning Technological Innovation

To obtain information on whether SBIR projects were funding research that would not be done otherwise, we asked firms whether they would have undertaken the research without this support and then analyzed the reported results of these projects. We also asked firms whether they were continuing R&D on projects that were no longer receiving SBIR funding.

Firms reported that much of the research would not have been undertaken without SBIR. Only 16 percent said they would have definitely or probably done the research without the SBIR program, 20 percent were uncertain, and 64 percent said they definitely or probably would not have proceeded.

We analyzed the questionnaire responses to see whether completed projects that firms probably or definitely would not have undertaken without SBIR program support had produced results similar to those of other completed SBIR projects, to determine whether SBIR has encouraged firms to undertake worthwhile projects. Table 2.3 shows these responses for six factors we identified as indicative of the project's innovativeness and technical merit, including the willingness of the firm to continue R&D after SBIR funding has been completed, preparation of journal and conference papers, patent applications and awards, market testing, and sales.

to adopt proposal selection procedures used in funding other agency research.

At all agencies, the selection procedure starts with a widely distributed proposal solicitation, usually issued annually. In some agencies, awards decisions are made by the central SBIR office after the awards are reviewed and rated by technical officers, while at others the decisions are made in a decentralized manner.

In a June 1987 report,[1] we reviewed the selection procedures for SBIR awards at 11 agencies. All agencies used four procedures to ensure selection of proposals of high technical quality: (1) evaluations by technical experts, (2) use of SBA's selection criteria, (3) utilization of a system to rate or rank proposals, and (4) selection based on a ranking system. While we found some differences in emphasis among agencies, we concluded that agencies are making a good faith effort to maintain a system that is fair and provides for final selection based on technical merit. Although innovation is not addressed specifically by SBA's selection criteria, all agencies have revised SBA's criterion concerning technical merit to include consideration of a proposal's innovativeness and originality in making Phase I awards.

In addition, the following factors indicated SBIR programs were funding proposals of high technical quality:

- the SBIR proposal selection process was highly competitive, because a large "pool" of proposals was available for agencies to consider in selecting proposals that meet standards of technical quality;
- the high average scores received by successful proposals indicated that quality research was being funded under agencies' SBIR programs; and
- SBIR program managers judged the quality of funded proposals as good to excellent.

[1]Federal Research: Effectiveness of Small Business Innovation Research Program Procedures (GAO/RCED-87-63, June 2, 1987).

- SBIR programs have adopted highly competitive selection procedures to identify those proposals of highest technical quality and innovative potential, and only about 5 percent of the proposals obtain funding through Phase II.
- According to their questionnaire responses, agency project officers rated many Phase II projects as technologically innovative and in general ranked many SBIR projects more likely than other research for which they were responsible to lead to inventing and commercializing new products, processes, and services.
- Responding to our questionnaire, firms reported that a high proportion of projects would not have been undertaken without SBIR funding. In analyzing the questionnaire responses, we found that projects that probably or definitely would not have been undertaken without SBIR funding were about as likely as other projects to produce patent applications, or lead to market testing, and somewhat less likely to result in follow-on R&D or commercial products, indicating that SBIR programs are contributing to technological innovations that might not have occurred otherwise. Firms also indicated that they are continuing R&D on some projects after SBIR funding is completed.

Difficulties in Measuring Technological Innovation

Although definitions vary, there is widespread agreement that technological innovation is a complex process, particularly in the development of sophisticated modern technologies. Technological innovation can involve many steps, including research, engineering, prototype testing, and product development. The steps necessary for technological innovation can differ, depending on the specific situation. Technological innovation is closely related to the process of commercialization, which includes the development and marketing of new goods and services. It is important to recognize that technological innovation is an uncertain process so that, even in an ideal world, the results of the SBIR projects would not be all positive: supporting truly innovative, ground-breaking research implies that failed or unsuccessful projects will be a regular, and even frequent, occurrence.

Measuring technological innovation is difficult, for several reasons. Because technological innovation occurs in many different ways, no one indicator can accurately assess innovativeness. For example, patents may serve as a good indicator of technological innovation in the development of some products but be less useful in measuring other innovations, such as new computer software, where patents are less relevant. In addition, differences among firms can create measurement problems.

response rate, is included in appendix IV. Appendix V contains information on the selection approach and the techniques we used for all questionnaires.

We interviewed SBIR program managers and other officials and reviewed records in DOD, DOE, DOED, HHS, NASA, NSF, EPA, NRC, and SBA to obtain information about efforts to foster and encourage participation by minority and disadvantaged persons in technological innovation and about the extent to which program goals are being met and the quality of SBIR research. We also consulted with experts in research evaluation, technological innovation, and government policies to encourage the commercialization of R&D. These experts were located in government agencies, academic institutions, and private practice. We also solicited, and received, judgments concerning the effect of SBIR legislation on research programs in 11 agencies: USDA, Commerce, DOD, DOED, DOE, HHS, DOT, EPA, NASA, NSF, and NRC. Their responses are included in appendixes VI through XVI.

We performed this review in accordance with generally accepted government auditing standards. This review was conducted from September 1987 to September 1988, primarily at the agencies' headquarters offices in the Washington, D.C., area.

requirements but that most were not fully adhering to the act's reporting requirements concerning the reporting of small business participation goals.

Our March 21, 1986, report entitled Research and Development: A Profile of Selected Firms Awarded Small Business Innovation Research Funds (GAO/RCED-86-113FS) provided information on 19 small firms participating in the SBIR program and discussed the availability of venture capital funds for commercializing results developed with SBIR awards in response to a congressional request for information.

Our report, Federal Research: Effectiveness of Small Business Innovation Research Program Procedures (GAO/RCED-87-63, June 2, 1987), evaluated federal agencies' procedures for making SBIR selections and awards. We found that federal agencies with SBIR activities had established evaluation and selection procedures that reasonably ensured that awards were based on technical merit. However, less than one half of the participating agencies had awarded their SBIR Phase I contracts and grants within 6 months of receiving the proposal, a goal established by SBA guidelines. In addition, we could not determine the length of time needed to make Phase II awards at many agencies because of limitations in agency data.

Federal Research: Small Business Innovation Research Participants Give Program High Marks (GAO/RCED-87-161BR, July 27, 1987) contains information on the characteristics of SBIR recipient firms, the reported effects of the program on firms' operations and products, and the firms' perceptions of the administration of the program.

On March 15, 1988, we issued a legal opinion (B-230594.2), at the request of the Chairman of the House Committee on Small Business, on whether the NRC could maintain an SBIR program if its extramural R&D budget dropped below $100 million. We concluded that federal agencies are not precluded from voluntary participation in SBIR, even when their external R&D budget is below $100 million. NRC subsequently decided to continue its SBIR program on a voluntary basis during fiscal year 1988.

Objectives, Scope, and Methodology

This report was prepared in response to Public Law 99-443, which reauthorized SBIR programs until 1993. The law directs GAO to report on the effectiveness of Phase I and Phase II of the SBIR program, including

- the extent to which the goals of the SBIR program are being met,

Agencies Conducting SBIR Programs

Since 1983, the following 12 agencies have conducted SBIR programs:

Department of Agriculture (USDA)
Department of Commerce (Commerce)[1]
Department of Defense (DOD)
Department of Education (DOED)
Department of Energy (DOE)
Department of Health and Human Services (HHS)
Department of the Interior (Interior)[2]
Department of Transportation (DOT)
Environmental Protection Agency (EPA)
National Aeronautics and Space Administration (NASA)
National Science Foundation (NSF)
Nuclear Regulatory Commission (NRC)

Each agency has a small SBIR administrative unit that is responsible for managing and coordinating the program. The staff of these SBIR units, which we refer to as SBIR program managers, typically devote most or all of their time to SBIR activities. In addition to the SBIR administrative staff, other agency research personnel are also involved in the selection of SBIR proposals and oversight of projects. These research personnel, which we refer to as SBIR project officers, oversee individual SBIR projects in conjunction with other research responsibilities. The formal titles of the SBIR project officers vary from agency to agency.

The SBIR legislation requires that each agency allocate at least 1.25 percent of its external R&D obligations for SBIR projects when its total external obligations exceed $100 million.[3] Because agencies differ widely in the size of their external research budgets, their SBIR obligations differ greatly. DOD has by far the largest SBIR program, with fiscal year 1987 obligations of about $194 million. In contrast, the SBIR programs at USDA, Commerce, DOED, DOT, EPA, and NRC each received less than $4 million in 1987. As figure 1.1 shows, 5 agencies were responsible for 96 percent of all 1987 SBIR awards. Appendix I contains additional information on fiscal year 1987 awards by each agency.

[1]Commerce began SBIR activities in fiscal year 1985.

[2]Interior withdrew from SBIR activities after fiscal year 1985 because of budget reductions.

[3]SBA reports annually on agency SBIR expenditure levels: Small Business Innovation Development Act of 1982: Fifth Year Results, SBA (Washington, D.C.: June 1988), and previous annual reports.

Introduction

Since fiscal year 1983 federal agencies with large research and development (R&D) budgets have operated Small Business Innovation Research (SBIR) programs to strengthen the role of small, innovative firms in federally supported R&D. The Small Business Innovation Development Act of 1982 (P.L. 97-219) requires that all agencies with yearly extramural (external) research obligations of more than $100 million establish SBIR programs to solicit research proposals from small business and provide funds for those proposals that are judged most qualified. In 1986 the Congress reauthorized the Small Business Innovation Development Act until 1993. SBIR awards to small businesses have totaled about $1.35 billion through fiscal year 1988.

SBIR program goals are to

- stimulate technological innovation,
- use small businesses to meet federal R&D needs,
- increase private sector commercialization of innovations derived from federal R&D, and
- foster and encourage participation by minority and disadvantaged persons in technological innovation.

How the SBIR Program Is Administered

Responsibility for SBIR program administration is shared between the Small Business Administration (SBA) and participating R&D agencies. SBIR legislation requires that SBA issue policy directives for the general conduct of the program. However, each participating R&D agency has unilateral responsibility for determining the research areas to be included in its SBIR program, receiving and evaluating research proposals, selecting awardees, and administering payments.

SBA has issued directives that include instructions for preparing agency SBIR program solicitations and for accepting and processing project proposals. It has also provided guidance for agencies in issuing standardized and timely program solicitations and for minimizing the regulatory burden of firms participating in the program.

To be eligible for an SBIR award, SBA's SBIR program policy directive states that small businesses must be

- independently owned and operated,
- other than the dominant firms in the field in which they are proposing to carry out SBIR projects,
- organized and operated for profit,

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that SBIR programs are encouraging technological innovations that might not occur otherwise.

Heads of agencies and project officers responsible for SBIR projects reported that SBIR programs help meet their agency research and development needs. SBIR program managers and project officers identified ways in which SBIR programs helped accomplish this, including support of high-risk research and research on technologies with long-range potential. Agencies differ in their efforts to use small business to meet research and development needs. DOD and NASA solicit and fund SBIR projects that meet specific agency research and development objectives, while NSF and HHS select projects with high potential for private sector commercialization, within broad categories of technological interest to the agency. Other agencies fall between these extremes. These differences in agency emphasis are reflected in proposal solicitation and in research management. In comparison with NSF and HHS, DOD and NASA proposal solicitations are more specific and their projects are more closely monitored.

Because only a small portion of all SBIR projects have completed Phase II, it is too soon to make a thorough analysis of how well SBIR programs are promoting commercial innovation. But, preliminary analysis, based on questionnaire responses by firms, indicates that some projects are moving toward commercialization. Agencies differ in the emphasis they place on commercial potential in evaluating proposals. NSF, for example, places heavy emphasis on plans for commercial development that include follow-on funding commitments by outside parties. Other agencies vary in the emphasis they place on follow-on funding commitments.

The Small Business Administration and agencies with SBIR programs foster and encourage participation by minority and disadvantaged persons through outreach activities to inform them about SBIR activities. According to the Small Business Administration, the percentage of money awarded to minority and disadvantaged firms was lower in fiscal years 1986 and 1987 than in the 2 previous fiscal years; however, agency officials believe some inaccuracies may exist in the data on minority firm participation in SBIR.

Quality of SBIR Projects

To compare the quality of SBIR projects with other agency research, GAO sent questionnaires to 530 project officers who monitor SBIR research as well as other projects at the 5 agencies providing 96 percent of all SBIR funding. Overall, respondents assessed 29 percent of the SBIR projects as

Executive Summary

Purpose

Since 1983, federal agencies with large research and development budgets have operated Small Business Innovation Research (SBIR) programs to strengthen the role of small innovative firms in federally supported research and development. SBIR awards to small business have totaled over $1.35 billion through fiscal year 1988.

In reauthorizing SBIR programs in 1986, the Congress directed GAO to study their effectiveness in meeting SBIR goals, which are to (1) stimulate technological innovation, (2) use small businesses to meet federal research and development needs, (3) increase private sector commercialization of innovations from federal research and development, and (4) encourage participation by minority and disadvantaged firms in technological innovation. The Congress also directed GAO to compare the quality of SBIR research with more traditional agency research and to obtain the views of agency and department heads on how SBIR programs have affected other research activities at their agencies. To obtain information on how well SBIR programs are meeting their goals and on the quality of research, GAO sent questionnaires to firms with SBIR projects and to government project officers responsible for SBIR and other research.

Background

SBIR legislation gives the Small Business Administration responsibility for issuing directives for the general conduct of SBIR programs, but each agency with an SBIR program is unilaterally responsible for targeting research areas, reviewing proposed projects, and making research awards. The legislation requires a three-phase process for SBIR programs: Phase I is a 6-month test of scientific merit and feasibility; Phase II provides funding for 1 to 2 years of further development; and Phase III consists of either nonfederal funding or federal, non-SBIR, funding for developing applications of the SBIR research for either private sector or government use.

When an agency's external research and development obligations exceed $100 million, SBIR legislation requires the agency to spend 1.25 percent of those obligations on SBIR projects. In 1988, 11 agencies conducted SBIR programs. The Department of Defense (DOD) is responsible for about 55 percent of all SBIR funding. Together, DOD, the Departments of Energy (DOE) and Health and Human Services (HHS), the National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF) are responsible for 96 percent of all SBIR funds. At each agency a small staff of SBIR program managers coordinates the management of the program, while project officers throughout the agency normally oversee