National Aeronautics and
Space Administration

Commercial Metrics

NASA SBIR Program

October 2002
Commercial Technology Division
Office of Aerospace Technology

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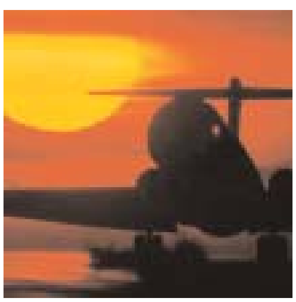
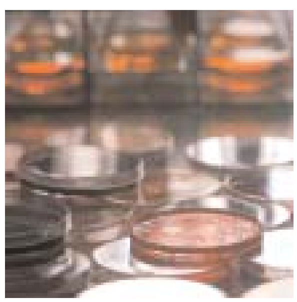

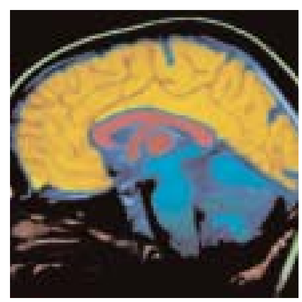

Preface

The Small Business Innovation Research program was created by legislation in 1983 for the purpose of involving the vibrant and capable U.S. small high-tech business sector in Federal agency R&D activities. The purpose was to provide an additional source for innovative research and technology to meet Federal agency mission needs. Over the years, the NASA SBIR program has grown, along with other agencies' SBIR programs, to more than $100M per year. Following the inception of the SBIR program, Congress and others have placed increasing emphasis on the commercial application of national SBIR technology with respect to contributing to U.S. economic growth. Therefore, NASA's SBIR program has elevated the objective of commercial performance to near-equal status with that of technical relevance to NASA missions, the primary goal.

In 1995, NASA instituted strategic changes in SBIR program management and proposal review, both to encourage commercial performance and to increase the rate of utilization of small businesses in NASA mission programs. Consequently, to assess the effectiveness of these strategy changes, we desired to measure changes in commercial and NASA utilization performance both before and after 1995. Moreover, the Government Performance and Results Act of 1993 (GPRA) requires us to assess major NASA programs, and, given the "business" focus of the Commercial Technology program, we are obliged to make assessments analogous to estimating return on investment (ROI) in the business world. It is generally accepted that a traditional ROI computation is very difficult or impossible to do for a Government program. Nonetheless, we still can measure some commercial outcomes that relate to returns to our "stockholders," the taxpayers. Given the dearth of reliable and comprehensive data on NASA SBIR program results from sources outside NASA, we took action to design and implement a systematic effort to determine commercial and other outcomes. Our approach utilizes common business data and is not intended to be a one-time snapshot; rather, it is a continuing assessment that can be used as a management tool to guide future program improvements.

Our corresponding survey collects data on a NASA-wide basis and attempts to inquire about every Phase II project awarded by NASA since the beginning of the NASA SBIR program in 1983. The data yield statistics which enable a comprehensive assessment of and targeted insight into the NASA SBIR program. No attempt was made to make statistical inferences on the basis of sample data because a) the likelihood of missing significant outcomes, as well as firms having large numbers of Phase II awards, was unacceptable; b) successful subsampling of initial non-respondents was considered too uncertain; and c) surveying the universe of NASA Phase II companies (i.e., a census) was considered achievable. In each of the first five years of the survey, we have realized a response rate of over 90 percent of the firms still in existence. The sixth-year survey (FY 2002) thus far has achieved an 85-percent response rate. As a result, we can account for about 84 percent of all Phase II awards made by NASA. To the extent that firms do not respond or cannot be located, we assign values of zero commercial activity (e.g., revenues, resulting products, private capital investment). The effect is that the resulting assessments are most conservative since missing data is assigned a value of zero results. Therefore, the aggregated results and all corresponding derived metrics represent lower bounds or "minimums" for commercial and other NASA SBIR program outcomes. Even with this assignment, we believe that the large, comprehensive body of data we have compiled strongly suggests that the U.S. "stockholders" have, and continue to receive, good value for their dollars invested in the NASA SBIR program.

Robert L. Norwood, Ph.D.
Director, Commercial Technology Division

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Executive Summary

In accordance with the Government Performance and Results Act (GPRA) of 1993, NASA is required to demonstrate the contribution of its programs to the Nation's economic well-being. NASA's Strategic Plan requires commercial relevance of NASA-funded technology as a primary mission goal. Under its Strategic Plan, NASA is also obliged to measure the commercial relevancy of its programs. Therefore, NASA has implemented a technology tracking system (NASA TechTracS) for the purpose of compiling information regarding the commercial relevance of all technologies funded and otherwise sponsored by NASA. As an extension and special-purpose refinement of that effort, NASA has also designed and implemented a metrics system for quantifying commercial activity associated with its Small Business Innovative Research (SBIR) program. Data produced by the special-purpose SBIR metrics system is the basis for this October 2002 report which updates and expands the analysis presented in NASA's SBIR Commercial Metrics Report, dated October 2001.

The primary purpose of NASA's SBIR program is to meet NASA mission-related technology needs by tapping the capabilities of small, high-technology firms, thus also contributing to continued viability of the Nation's small business sector. Although commercial application of NASA-funded SBIR technology is a therefore a secondary objective and an added benefit, it is nonetheless important and necessary. In recent years, the Congress, the General Accounting Office (GAO), and others have been querying NASA with increasing frequency regarding the commercial relevance of NASA's SBIR program.

There are two primary purposes for undertaking this study. One purpose is to measure the impact of strategic changes made by NASA, beginning with its 1995 SBIR Solicitation to align the definition of SBIR technology subtopics more closely with the strategic direction of NASA's business unit Enterprises. The other purpose is to measure the overall impact of NASA's emphasis on commercial relevance in its proposal review and selection process, beginning with the 1995 Solicitation. Therefore, NASA has designed and implemented a commercial metrics survey of its SBIR companies. In accordance with the Paperwork Reduction Act of 1995, NASA obtained Office of Management and Budget (OMB) approval of its survey instrument and methodology in February 1997. In March 2000, NASA obtained OMB reauthorization of the survey instrument and methodology for an additional three years. The survey instrument is designed to identify applications of NASA SBIR technology in non-U.S. Government, NASA, and other U.S. Government markets, as well as associated commercial activity. The survey instrument is also designed to reveal commercial intent in those cases where the firm has taken significant steps toward a commercial venture at least partially based on NASA SBIR technology, but a resulting product or service has not yet been sold.

In each of fiscal years 1997 through 2002, NASA surveyed approximately 200 different firms that had received NASA SBIR Phase II awards at any time from the inception of the SBIR program in 1983 through SBIR award year 1997 and that NASA was able to locate. Given the time required for technologies and associated business ventures to mature, this report is primarily focused on cumulative results compiled to date with respect to NASA SBIR awards made through only the 1996 award year. Accordingly, NASA has completed surveying the universe of 813 firms receiving NASA Phase II awards over the 1983–96 award year period. About 78 percent of the firms have responded; 8 percent have not responded; and NASA has been unable to locate the 14-percent balance of the 1983–96 universe of Phase II firms. Thus, over 91 percent of the firms in the 1983–96 universe of firms that NASA was able to locate have responded to the survey. The responding firms account for about 84 percent of the 1,739 Phase II awards given by NASA over the 1983–96 period. Non-responding firms account for about 8 percent of the Phase II awards, and the firms that NASA has been unable to locate account for approximately 9 percent of all Phase II awards granted by NASA over that period. In some cases, firms having received a significant number of NASA Phase II awards have elected not to respond, notwithstanding significant telephone follow-up by NASA. Some of these firms continue to apply for and receive NASA SBIR awards.

Given the imperative of credibility and recognition of what may be achievable versus what is ideal, NASA identified and applied several principles in its survey methodology. NASA received unanimous support for these principles from expert, outside counsel representing various organizations. Notwithstanding limitations inherent in applying these principles, NASA believes that the commercial metrics obtained are insightful and useful for program reporting and planning purposes. In addition, NASA believes the currently compiled data establish a useful baseline against which future measurements can be made.

The survey data support the following observations:

- Commercial activity associated with NASA SBIR technology is significant. A minimum of 612 products and services at least partially based on NASA SBIR technology have generated at least $2.28 billion of cumulative revenues in non-U.S. Government markets. By comparison, NASA's total investment in the SBIR program over the 1983–96 period is $1.11 billion. The broad spectrum of types of products and services, as well as the corresponding industrial sectors in which NASA SBIR technology is commercially applied, suggest that commercial activity associated with NASA's SBIR Program is pervasive in the economy. A significant amount of strategic alliance partnering by SBIR firms with other private entities regarding these ventures underscores the pervasiveness of commercial activity associated with application of NASA SBIR technology.

- The incidence of commercial application of NASA SBIR technology in non-U.S. Government markets is significant. Specifically, at least 31 percent of all NASA Phase II awards have produced technology upon which ventures generating revenues in non-U.S. Government markets have been at least partially based.

- The likelihood of commercial application of NASA SBIR technology is not independent of technology area. Based on the Small Business Administration's definition of various technology areas, the "Electronics" and "Materials" technology areas are the most productive. Likewise, the "Mechanical Performance of Vehicles, Weapons, Facilities" technology area is the least productive.

- NASA's SBIR firms demonstrate significant commercial intent regarding application of NASA SBIR technology. For at least 38 percent of the Phase II awards made by NASA over the 1983–96 period, either the technology was incorporated in products and services generating revenues in non-U.S. Government markets, or the firm took significant action to develop a commercial venture at least partially based on the technology.

- Growth over time in commercial and other Phase III activity associated with a given set of Phase II technologies appears to be significant. Specifically, a comparison of initial survey results with re-survey results for the 1983–94 Phase II universe of firms reveals a significant increase in commercial activity associated with ventures at least partially based on NASA SBIR technology. For example, cumulative revenues generated in non-U.S. Government markets by ventures incorporating NASA SBIR technology increased more than 100 percent over the approximately four-year span between initial survey and re-survey of largely the same firms, from $1.13 to $2.43 per NASA dollar investment in the corresponding Phase II and Phase I awards. This increase is likely associated with the natural life cycles of the ventures as well as the creation of new ventures subsequent to the initial survey.

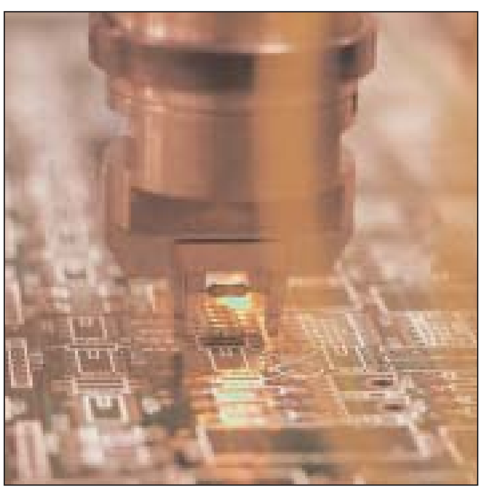
- The effects of NASA's SBIR programmatic changes that were implemented beginning with the 1995 SBIR award year are not yet apparent and would not necessarily be expected to be so, given inherent time lags in the process of commercial application. Survey results reveal that technologies developed under 1995, 1996, and 1997 Phase II awards thus far have resulted in less commercial and other Phase III activity on a per-

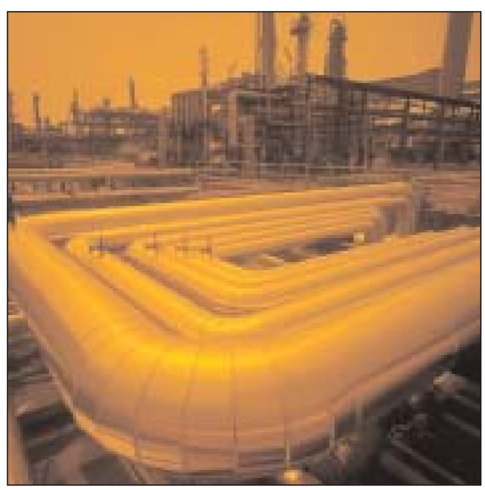
NASA-dollar investment basis when compared to results for the 1983–94 universe of NASA Phase II awards. The difference in results is likely explained by the maturation time required to engineer a technology for commercial application, as well as finance and otherwise develop the corresponding business venture. However, an accelerating trend suggested by the more than tripling of commercial and other Phase III results for 1995 versus 1997 Phase II awards may indicate the beginning effects of NASA's programmatic changes.

- The "mills" presumption does not reasonably apply to the NASA SBIR program. Critics sometimes refer to firms that have won several SBIR awards as SBIR "mills," particularly in those cases where the firm has not demonstrated a significant history of applying the SBIR technology in non-U.S. Government or U.S. Government markets. In the case of NASA's SBIR program, however, about 86 percent of all firms winning NASA Phase II awards for award years 1983–01 have received a total of three or fewer NASA Phase II awards. These firms received about 52 percent of all Phase II awards made by NASA over that period. Only 3.2 percent of NASA's Phase II firms have won ten or more NASA Phase II awards, accounting for about 21.6 percent of all Phase II awards made by NASA through SBIR award year 2001. Over the past seven SBIR award years (1995–01), new entrant firms into the universe of NASA Phase II firms represent about 40 percent of all firms receiving NASA Phase II awards over that period. Also, the firms that have received a greater number of NASA Phase II awards appear to demonstrate greater commercial results associated with NASA's SBIR program.

- The quantitative survey data suggest that NASA has had limited use for the technology it has funded under the SBIR program for SBIR award years 1983–96. Specifically, at a minimum, only about 10 percent of NASA Phase II awards have attracted NASA Phase III funding for either further development or purchase of product or service. Accordingly, only about 20 cents in NASA Phase III funding has resulted per dollar of NASA's total SBIR program investment. However, given other benefits of the SBIR program, such as knowledge spillovers to private sector and Government technical personnel, NASA Phase III funding may be too narrow a proxy measure for NASA's utility of SBIR technology.

- In addition to the significant commercial activity associated with NASA's SBIR program, the program has contributed to the quality of life of individuals in ways that cannot be valued meaningfully by dollars or other commercial measures.

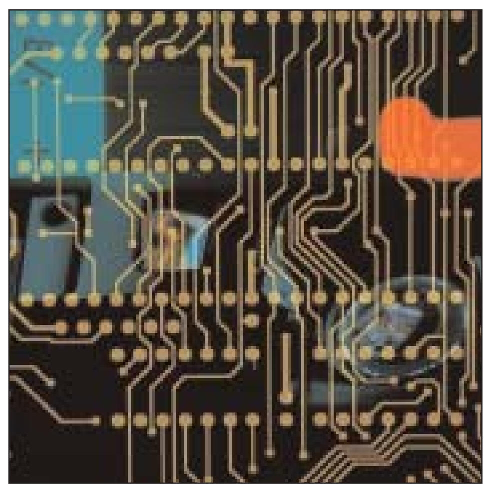




Background

The Government Performance and Results Act (GPRA) of 1993 obliges all Federal agencies to measure the results and contributions of their programs to the Nation. Therefore, NASA must account for its investment in science and technology programs. Accordingly, NASA's Strategic Plan states that NASA "will measure (its) performance . . . demonstrating NASA's relevance and contributions to national needs." Thus, in addition to measuring the extent to which NASA contributes to peaceful exploration of space, increased understanding of science and technology, improved understanding of the environment, and educational excellence, NASA must also measure the contribution of its programs to the Nation's economic well-being. Commercial relevance of NASA-funded technology is a primary NASA mission goal, and NASA's measurement of that contribution is imperative. NASA's obligation to measure and enhance the commercial relevance of its SBIR Program is therefore implicit. Accordingly, NASA has implemented a technology tracking system (NASA TechTracS) for the purpose of compiling information regarding the commercial relevance of all technologies funded and otherwise sponsored by NASA. As an extension and special-purpose refinement of that effort, NASA has designed and implemented a metrics system for quantifying commercial activity associated with its Small Business Innovative Research (SBIR) program. Data produced by the special-purpose SBIR metrics system is the basis for this report.

The primary purpose of NASA's SBIR program is to meet NASA's mission-related technology needs by tapping the capabilities of small, high-technology firms, thus also contributing to continued viability of the Nation's small business sector. Commercial application of SBIR technology is an added, but necessary, benefit of the program. In accordance with GPRA, NASA has strengthened its requirements regarding commercial potential of proposed SBIR technology and the need for proposing firms to demonstrate the intent and capability to commercially apply NASA-funded SBIR technology. NASA incorporated these strengthened requirements as part of its SBIR proposal evaluation criteria beginning with its 1995 SBIR Solicitation. Also, in mid-1996, NASA initiated the design and implementation of a metrics system to enable an objective, quantitative assessment of the NASA SBIR program's contribution to U.S. commercial activity. In addition to meeting NASA's obligations under GPRA, the goals of that effort include providing credible, insightful data to answer increasingly frequent questions by the Congress, the General Accounting Office (GAO), and others concerning commercial relevance of the NASA SBIR program.



Commercial Metrics Survey Design and Methodology

Survey Instrument

For the purposes of defining and collecting data vital to assessing the contribution of NASA's SBIR program to U.S. commercial activity, NASA designed a two-page survey instrument (Appendix A) for which it obtained Office of Management and Budget approval in accordance with the Paperwork Reduction Act of 1995. The survey instrument is designed to identify current and previously existing applications of NASA SBIR-funded technology in non-U.S. Government markets. The survey instrument is also designed to reveal commercial intent in those cases where the firm has taken significant steps toward a commercial venture incorporating NASA SBIR technology, but the venture has not yet sufficiently matured to generate revenues or was terminated prior to generating revenues. Accordingly, the survey instrument includes indicators of commercial intent such as private capital investment placed at risk, spinoff firms created, various types of strategic alliances entered, patents awarded or applied for, and other significant steps taken to develop a business venture. The survey instrument also includes data fields intended to provide some measure of the utility of SBIR technology for NASA and other U.S. Government mission purposes.

Scope

The survey methodology contemplates completion of the survey form by top management of the universe of the 813 firms having received NASA SBIR Phase II awards from the SBIR program's inception in 1983 through the 1996 SBIR award year. The survey form queries the cumulative commercial results of all NASA Phase II contracts received by each company through the date of completion of the form. For the purposes of this report, the commercial results compiled are primarily related to NASA SBIR awards made over the 1983–96 award year period. NASA has been collecting and compiling commercial results regarding later Phase II award years as well. This report focuses primarily on SBIR awards made through only the 1996 award year because commercial application of SBIR technologies and business development of corresponding ventures require sufficient time to mature. Some results associated with the 1983–94 Phase II universe are also presented, given a) NASA's relatively recent strengthened emphasis, beginning with its 1995 SBIR Solicitation, regarding commercial applicability of NASA SBIR technology; and b) the need to establish a baseline by which to measure the effects of recently instituted SBIR program changes by NASA, such as the alignment of SBIR topics with specific mission needs of NASA's business units, called "Enterprises." The report also includes some results for 1997 SBIR award year Phase II awards to the extent that FY 2002 survey responses have been received to date and incorporated in the results. (Although a 90-percent response rate has already been achieved for the FY 2002 survey, the report results reflect only an 85-percent response rate since some delinquent responses were received too late for publication.) The lag between the Government fiscal year and the SBIR award year is also a factor in primarily limiting this report to awards made only through award year 1996. For example, NASA announced its 1997 Program Phase II selections on January 9, 1999. NASA's negotiation of the corresponding SBIR contracts could not be initiated before that date with work under the contracts not beginning until completion of negotiations.

NASA was granted OMB approval of its survey instrument and methodology in February 1997. In March 2001, OMB re-authorized the survey instrument and methodology for an additional three years. NASA located and surveyed approximately 200 firms each year with corresponding mail-outs to SBIR Phase II company top management in June 1997, February 1998, October 1998, January 2000, January 2001, and January 2002, respectively. Thus, NASA surveyed approximately 200 located firms in each of fiscal years 1997 through 2002, inclusive. All companies that received NASA SBIR awards for award years 1983 through 1997 and that NASA has been able to locate have been surveyed. NASA made a significant effort to locate and contact each of its Phase II firms for the purposes of ascertaining the firm's continued existence, current name and address, and current chief executive prior to mailing a cover letter and survey form to the chief executive of each firm. NASA has been unable to locate approximately 14 percent of its Phase II firms for the 1983–96 award year period. For approximately 35 percent of the firms that were located, NASA found that the company name, address, or chief executive of the firm was other than that indicated in NASA's records. Accordingly, the investment of time required to validate company information prior to survey mail-out prevented an even greater expenditure of time that would inevitably have been required to process and follow up on postal returns of survey mailings. Even given the validated address list prior to survey mail-out, generally only about 13 percent of the firms returned completed survey forms without being prompted by one or more followup telephone calls by NASA. NASA plans to continue to survey about 200 of its Phase II firms in each fiscal year. However, a given firm will not be surveyed in each of two successive fiscal years and generally will not be re-surveyed more frequently than once every three fiscal years. Firms are invited to voluntarily submit updated survey forms to NASA as frequently as they wish.

Survey and Metrics Principles Applied

All data must be auditable. Auditability is vital to the credibility of this study and to any strategic program decisions based on the study's results. Accordingly, every non-zero data point compiled in this study is supported by a survey form submitted by the chief executive of the SBIR firm or by his/her designee. In those cases where a chief executive acknowledged by telephone that a completed survey form for his firm would indicate zeros for all metrics, then a survey form containing all zeros was completed by NASA for the firm, with the telephone conversation and date cited, if the chief executive appeared reluctant to return a survey form containing all zeros. However, many firms reporting zero results have returned a completed survey form. NASA treats all survey responses as commercially sensitive and therefore does not disclose company-specific data to third parties. However, the data may be made available to the GAO under very controlled conditions and non-disclosure assurances by the GAO for the purposes of auditing aggregated survey results against raw data provided by respondents. Given its commercial sensitivity, company-specific data is exempt from Freedom of Information Act requests.

All data must be industry data provided directly by industry. No non-zero data points are recorded based on telephone conversations or on inputs other than a survey form completed and returned by a company chief executive or his/her designee. A potential source of error is that some companies may be tempted to report more positive commercial results than actually realized. NASA scrutinizes each returned survey form for internal consistency and reasonability in this regard. If NASA has any doubt, it follows up with a phone call to the company chief executive, requesting clarification.

A distinction between non-U.S. Government and U.S. Government markets is maintained. The survey form makes the distinction between resulting activity in commercial non-U.S. Government markets and follow-on Phase III funding by NASA or other U.S. Government agencies. This distinction is maintained so that results regarding the primary purpose of SBIR-funded technology for NASA mission needs can be assessed separately from those regarding the added benefit of SBIR technology providing a basis for commercial ventures targeting non-U.S. Government markets.

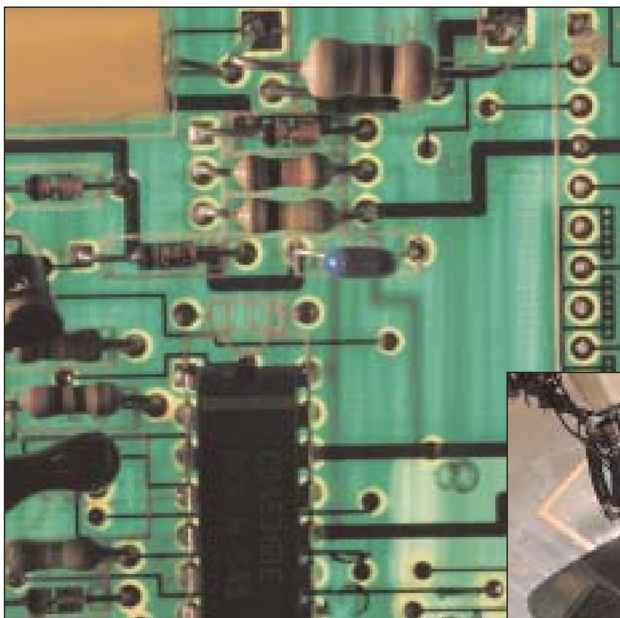
Resulting products/services are not counted unless they have generated revenues. If a responding firm reports that a commercial product or service has resulted that is at least partially based on NASA SBIR technology, NASA includes this information as a commercial application only if the firm also reports having realized revenues to date from the commercial application. Products and services for which the firm does not also report having realized revenues are not counted in compilation of survey results. In no case are company projections of revenues, market size, or expectations of any type included in survey results. If a commercial event has not already occurred (e.g., capital investment placed at risk, strategic partnership entered into), it is not counted in the survey results. Similarly, a firm's expectations regarding U.S. Government Phase III funding or Phase III contract amounts are not compiled in the survey results except to the extent that revenues are reported by the firm as having been realized (i.e., actually earned) as of the date of completion of the survey form.

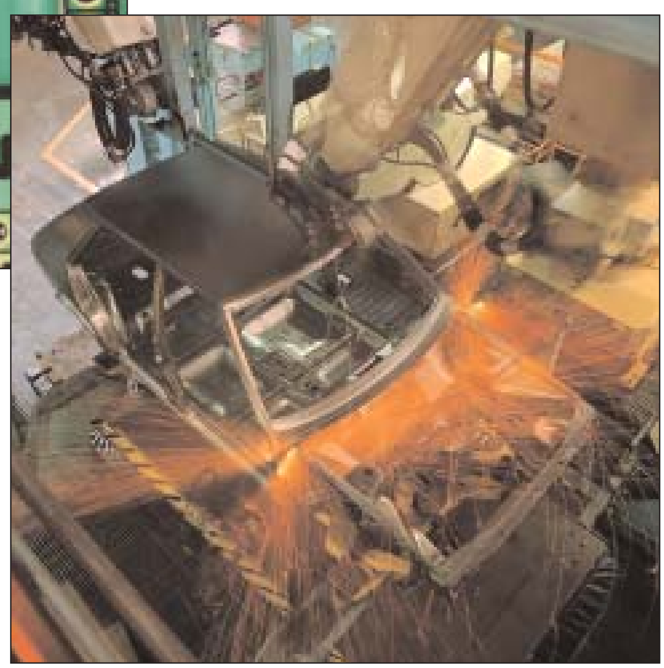
No estimation of net economic impact. No attempt is made to quantify a net contribution of NASA's SBIR program to U.S. economic productivity, growth, or job creation via econometric modeling or by other means. Realistically, given the size of the NASA SBIR investment over the period of study (i.e., $1.11 billion over the 1983–96 award year period) the program's relative effect on such macroeconomic measures is negligible by definition. Notwithstanding, given the numerous products and services in various industrial sectors that are at least partially based on NASA SBIR technology, as well as other measures such as involvement of hundreds of strategic alliance partner firms, the contribution of NASA SBIR technology to U.S. commercial activity is nevertheless significant and pervasive. Accordingly, the data are characterized in terms of various measures of "commercial activity associated with" NASA SBIR technology rather than "net economic impact of" NASA SBIR technology.

No statistical estimation, extrapolation, or application of econometric modeling. The entire 1983–96 universe of NASA SBIR Phase II companies was surveyed; thus, statistical random sampling was not employed. NASA recognizes that statistical sampling may have required less labor and a shorter timeframe to obtain insightful results. However, NASA considered it very unlikely that all of the selected firms in a random sample would have responded or that all of the firms in an appropriate subsample of nonrespondents would have eventually responded so that meaningful statistics and confidence intervals could be computed for each metric. Also, since the total 1983–96 universe of NASA Phase II firms is only 813 firms, NASA concluded that surveying the entire 1983–96 universe was a reasonable goal. Therefore, NASA has made simple compilations of the business data reported by the firms. Accordingly, the results represent minimums for each data category summed over all reporting firms. Total NASA SBIR program investment is used in the denominator to construct metrics representing various measures of commercial activity per NASA dollar invested. It is noteworthy that the methodology does not permit responding firms to implicitly represent nonresponding firms or to represent firms that NASA was unable to locate. Specifically, all firms in NASA's universe of Phase II companies for which a response was not received, for whatever reason, were assigned zeros regarding all metrics; these zero results were compiled with the results reported by responding firms. This approach produces conservative commercial activity and NASA mission use metrics, accordingly characterized as "minimums." To the extent that some of these firms might subsequently be located and/or elect to participate in the survey, any non-zero contribution to the survey results that they might provide will be included with amended survey results reported at some future time.

No representations of return on investment to the Government. Cumulative commercial activity results are compiled for each company (with zeros compiled in all data cells for other than responding firms) from the inception of the NASA SBIR program to the date the company completed the survey form. This approach produces "minimum" sums for each data category when aggregated over the universe of NASA Phase II firms. Although some "derived" metrics such as cumulative revenues generated per NASA SBIR dollar investment are computed because they may be somewhat insightful, there is no attempt to compute NASA's return on investment (ROI) in the SBIR program. Meaningful ROI computations must factor in time value of money and other considerations. However, NASA's successfully encouraging firms to provide cumulative (i.e., not by year) commercial activity data has proven to be a difficult enough challenge. In designing the survey, NASA decided that requesting commercial data broken out by year would have unreasonably burdened companies and discouraged them from responding to the survey. Also, NASA believes that it is easier for a company executive to think in terms of gross cumulative revenues generated by a particular current or previous venture. In this regard, NASA recognizes that the survey results may therefore be considered somewhat crude. However, NASA's approach is tempered by what it believes to be realistically achievable for the purposes of providing results that are reasonably revealing. Also, it is noteworthy that rigorous ROI computations are not appropriate for measuring the performance of a Government program in the same way that they are for measuring the performance of a private venture. Specifically, the primary purpose of the NASA SBIR program is to develop technology to meet NASA mission needs; commercial application of the technology is strictly a windfall benefit. However, NASA makes no claim that this windfall benefit has resulted in a net positive contribution to national economic growth. Conceivably, previously existing or innovative technologies alternative to NASA SBIR technology might have enabled very similar commercial applications. Accordingly, NASA takes no credit for any net positive economic impact of its SBIR Program. Finally, it is noteworthy that NASA's SBIR program has contributed to the quality of life of individuals in ways that cannot be meaningfully valued by dollars, ROI, or other commercial measures.

No allocation of commercial results over various supporting Federal agencies. Many of NASA's Phase II firms have received SBIR Phase II awards from more than one Federal agency. Thus, in some cases, a given firm's commercial application of SBIR technology incorporates technology developed under SBIR awards from NASA as well as from other Federal agencies. Based on NASA's internal deliberations and outside counsel, NASA does not allocate "credit" for SBIR-related commercial activity among the funding Federal agencies. Accordingly, resulting commercial activity is characterized as "at least partially based on" NASA SBIR technology.



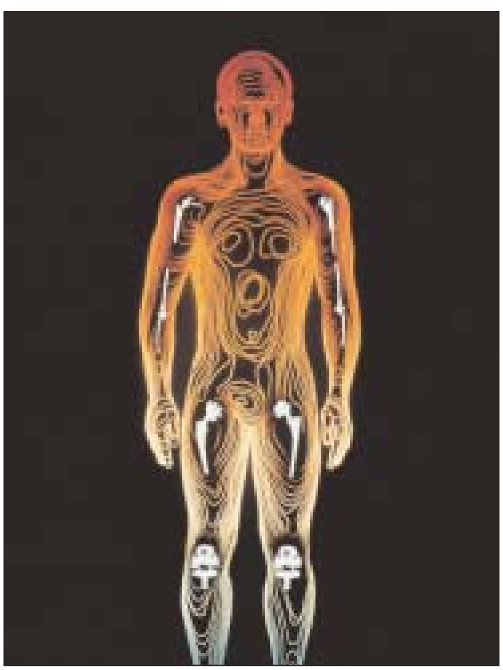


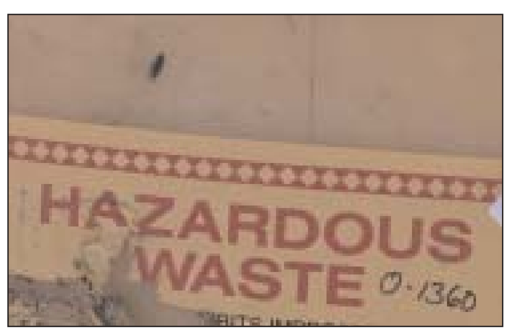
Survey Coverage

The totality of 830 firms receiving NASA SBIR awards from the inception of the SBIR program in 1983 through award year 1996 were targeted for survey. The targeted companies included all 813 firms in the universe of firms having received NASA Phase II awards over the 1983–96 period. The survey also included 17other firms that received NASA Phase I awards, but no NASA Phase II awards, and that were believed to have commercially applied NASA Phase I technology. However, NASA found that the relevant commercial activity of these Phase I firms was not significant.

Over five survey years, FY 1997–FY 2001, NASA has realized an overall response rate of more than 90 percent from the firms it has been able to locate. The FY 2002 survey effort is currently in process. For the purposes of this survey, NASA has never been able to locate approximately 14 percent of the universe of firms having received NASA SBIR Phase II awards over the 1983–96 period. NASA has surveyed approximately 200 of its SBIR firms in each of fiscal years 1997–2002, inclusive. Responding firms account for 1,452, or approximately 84 percent, of the 1,739 NASA Phase II awards made by NASA over the 1983–96 period. Nonresponding firms account for approximately 8 percent of all NASA Phase II awards made over that period; and firms which NASA has never been able to locate account for approximately 9 percent of all NASA Phase II awards made over the same period. (See figures 1 and 2.)

NASA found that top management of the SBIR companies recognized the importance of the survey effort in that it would enable NASA to evaluate the results of its investment in the SBIR program. However, it is NASA's observation that many of the executives who did respond would have preferred not to respond. In some cases, the top management of firms that received a significant number of NASA Phase II awards have thus far elected not to respond, notwithstanding extensive telephone followup by NASA. Some of these firms continue to apply for and receive NASA SBIR awards.





Some Observations

Commercial activity associated with NASA SBIR technology is significant.

A minimum of 612 products and services that are at least partially based on NASA SBIR technology have thus far generated revenues in non-U.S. Government markets. The trademark and other names of some of these products and services are given in Appendix C. The various types of these commercial applications are briefly described in Appendix D. The broad spectrum of industrial areas and types of products and services represented suggest that commercial activity associated with NASA's SBIR program is pervasive in the economy.

Responding firms reported a minimum of $2.28 billion in revenues generated by the 612 commercial products and services. Respondents also reported an additional $513 million in revenues generated in NASA and other U.S. Government markets regarding ventures associated with NASA SBIR technology. Accordingly, a minimum of $2.06 in revenues generated in non-U.S. Government markets is associated with each dollar of total NASA SBIR funding to all firms. Similarly, a minimum of $2.52 in revenues generated in non-U.S. Government and U.S. Government markets is associated with each dollar of total NASA SBIR funding. See figure 3.

For each dollar of NASA's total investment of $1.11 billion in the SBIR program over the 1983–96 period, at least 78 cents in private capital is placed at risk in ventures to produce commercial applications, in non-U.S. Government markets, that are at least partially based on technology developed under NASA's SBIR program.

Responding firms report a minimum of 6,888 full time job equivalents applied to ventures producing products and services that have generated revenues in non-U.S. Government and U.S. Government markets and that are at least partially based on NASA SBIR technology. This figure represents a minimum of about four full-time job equivalents per NASA Phase II award over the universe of all Phase II firms. However, the scope of this study provides no basis for claims that the NASA SBIR program has resulted in jobs created or jobs saved.

NASA SBIR firms report a significant amount of strategic alliance partnering with other private entities regarding ventures that are at least partially based on commercial application of NASA SBIR technology in non-U.S. Government markets. This industrial ripple effect involves at least 571 other U.S. private entities via joint venture partnerships, licensing agreements, royalty agreements, and other strategic alliance agreements with NASA SBIR firms. Accordingly, an average of about one U.S. private entity, in addition to the NASA SBIR firm developing the technology, is partnered in each venture commercially applying NASA SBIR technology in non-U.S. Government markets. Several firms entering into strategic alliances with SBIR companies regarding commercial application of NASA SBIR technology are Fortune 500 companies.

The incidence of commercial application of NASA SBIR technology in non-U.S. Government markets is significant.

At least 31 percent of NASA Phase II awards have produced technology upon which ventures generating revenues in non-U.S. Government markets have been at least partially based. Similarly, at least 36 percent of NASA Phase II awards have resulted in applications generating revenues in non-U.S. Government markets and/or in U.S. Government markets. See figure 4.

Three hundred and fifty-four of the 813 firms receiving NASA SBIR Phase II awards over the 1983–96 period have realized revenues from ventures, in non-U.S. Government markets, that are at least partially based on the NASA SBIR technology. Corresponding revenues realized by these firms are skewed toward amounts less than

$3 million per firm. Accordingly, about 69 percent of the 354 firms realized total revenues in non-U.S. Government markets of less than $3 million per firm from commercial application of NASA SBIR technology. Twenty-one firms realized revenues of at least $25 million from ventures, in non-U.S. Government markets, that are at least partially based on NASA SBIR technology. Corresponding revenues for three of those firms are in excess of $100 million for each firm. See figure 5.

The likelihood of commercial application of NASA-funded SBIR technology is not independent of technology area.

The Small Business Administration has defined seven major technology areas, along with detailed sub-categories for each major technology area. The SBA annually reports SBIR Phase I and Phase II award amounts for each Federal agency, by year, according to these technology areas (see Appendix B). Therefore, NASA has adopted the same technology areas for the purposes of computing certain metrics. The "Electronics," "Computer/Information Processing," and "Materials" technology areas collectively account for about 70 percent of the 612 products and services and about 77 percent of the $2.28 billion in revenues generated from commercial application of NASA SBIR technology in non-U.S. Government markets. The "Electronics" technology area alone accounts for about 42 percent of the $2.28 billion in revenues in non-U.S. Government markets. In contrast, the "Life Sciences" technology area accounts for only about 4 percent of the products and services and about 6 percent of the revenues generated from commercial application of NASA SBIR technology in non-U.S. Government markets (see figure 6). On a percentage of total NASA investment basis, ventures producing products and services at least partially based on "Electronics" types of NASA SBIR technology have generated the greatest cumulative revenues in non-U.S. Government markets. Specifically, revenues generated in non-U.S. Government markets are at a level that is at least 87 percent of NASA total SBIR program investment over the 1983–96 award year period. Second to the "Electronics" technology area in this regard is the "Materials" technology area showing non-U.S. Government revenues at a level that is about 47 percent of NASA total SBIR program investment (see figure 7).

NASA SBIR firms demonstrate significant commercial intent regarding application of NASA SBIR technology.

NASA's Phase II firms demonstrate strong commercial intent with respect to at least 38 percent of the Phase II awards made over the 1983–96 period. Specifically, in the case of at least 666 of the 1,739 Phase II awards made by NASA over that period, either the SBIR technology was commercially applied in non-U.S. Government markets or the firm took significant action to develop a commercial venture at least partially based on the NASA SBIR technology. Such action included the placing of private capital at risk, entering into strategic alliances with other private entities, and seeking patent protection of the SBIR technology. Regarding at least 34 other Phase II awards, the firms demonstrate some commercial intent by doing preliminary market research or engaging in other preliminary activities reflecting a lesser commitment to develop a commercial venture. Therefore, NASA's SBIR firms demonstrate some commercial intent regarding application of NASA SBIR technology in non-U.S. Government markets with respect to at least 40 percent of the NASA SBIR Phase II awards made over the 1983–96 period (see figure 8).

Growth in commercial and other Phase III activity appears to be significant.

For the 1983–94 Phase II award year universe of firms, a comparison of initial survey results with re-survey results shows a significant increase in commercial activity associated with ventures at least partially based on NASA SBIR technology. A comparison of results reported by first-time survey firms with the results reported by those firms in a re-survey approximately three to four years later shows a significant increase in such measures as 1) number of products and services incorporating NASA SBIR technology that have generated revenues in non-U.S. Government markets, 2) cumulative commercial revenues generated by those products and services, 3) cumulative private capital investment in ventures producing those products and services, and 4) number of NASA Phase II awards producing technology upon which the products and services are at least partially based. For example, cumulative revenues generated in non-U.S. Government markets by ventures incorporating NASA SBIR technology more than doubled over three to four calendar years from $1,015M to $2,178M, and private capital investment placed at risk in those ventures increased 84 percent over that period of time, from $448M to $825M (see figure 15). That a significant difference between initial survey and re-survey results exists on a per-NASA-dollar investment in the SBIR program basis is also noteworthy. Specifically, for the 1983–94 universe of Phase II firms, figure 16 shows that revenues generated in non-U.S. Government markets by ventures incorporating NASA SBIR technology increased about 115 percent, from $1.13 to $2.43 per NASA dollar investment in corresponding SBIR awards. Similarly, revenues generated in both non-U.S. Government and U.S. Government markets also increased by more than 100 percent, from $1.42 to $2.95 per NASA dollar investment in corresponding SBIR awards.

Differences between initial survey results and re-survey results are likely associated with the natural life cycle of the commercial ventures, as well as the creation of new ventures. Initial survey results and re-survey results would remain the same for ventures that were created and terminated prior to the initial survey year or that completed their natural life cycle prior to the initial survey year. Accordingly, the collection of venture life cycles associated with ventures incorporating technologies produced by the 1983–94 award year universe of SBIR contracts would generally be much more mature than those associated with applications of post-1994 SBIR award year technologies. Therefore, commercial activity generated by ventures incorporating post-1994 SBIR award year technologies would generally be expected to have greater upside potential than commercial activity generated by ventures incorporating 1983–94 SBIR award year technologies. Given that figures 15 and 16 show a significant increase in commercial activity of more than 100 percent over the three- to four-year period (i.e., roughly 30 percent per year) for a relatively mature collection of ventures incorporating NASA SBIR 1983–94 award year technologies, we would expect ventures incorporating post-1994 SBIR award year technologies to begin to generate commercial activity in excess of 30 percent per year over the next several years. Although re-survey data regarding commercial activity associated with more recent SBIR award year (i.e., 1996 and 1997) technologies is not yet available to confirm this expectation, figure 17 suggests an annual increase in commercial activity produced by relatively young (i.e., incorporating 1996 SBIR technologies) ventures of something well in excess of 30 percent per year. Specifically, figure 17 shows that commercial activity associated with ventures incorporating 1995 SBIR award year technologies is approximately three times the commercial activity associated with ventures incorporating 1997 SBIR award year technologies. Therefore, the accelerating trend suggested by the 200 percent additional amount of commercial activity corresponding to relatively young ventures (i.e., incorporating 1995 SBIR award year technology) having life cycles that are only about two years more mature than other young ventures (i.e., incorporating 1997 SBIR award year technology) may possibly be explained not only by the greater upside potential of young ventures, but also by NASA's placing a greater emphasis on eventual commercial application of the technology as part of its evaluation criteria beginning with selection of 1995 SBIR awards.

Note: Over the FY 1997–99 period, NASA surveyed almost the entire universe of firms that received NASA SBIR Phase II awards during the 1983–94 award year period. NASA obtained re-survey results for most of the 1983–94 award year Phase II awards in its FY 2000, FY 2001, and FY 2002 surveys. To the extent that firms did not respond to the FY 2000 through FY 2002 surveys, re-survey results regarding the 1983–94 universe of Phase II awards have not been obtained. Accordingly, figures 15 and 16 reflect comparative results to the extent that firms in the 1983–94 universe have responded to both initial survey and re-survey.

The effects of NASA's SBIR programmatic changes are just becoming apparent.

The survey methodology enables tracking the effects of NASA's SBIR programmatic changes that were implemented beginning with NASA's SBIR 1995 award year Solicitation by yielding comparisons for the purposes of assessing the effects of these changes. For example, although insufficient time has elapsed with respect to 1995–97 Phase II award year technologies for reasons discussed below, figure 17 illustrates the survey's ability to yield such comparisons. Accordingly, figure 17 suggests that technologies developed under 1995–97 Phase II awards appear to have resulted in less commercial and other Phase III activity to date on a per-NASA-dollar investment basis than did the 1983–94 universe of NASA Phase II awards. In particular, revenues generated in non-U.S. Government markets by ventures at least partially based on 1995 award year NASA Phase II awards thus far amount to $0.65 per dollar of NASA investment in the Phase II and corresponding Phase I versus $2.43 in non-U.S. Government revenues per dollar of NASA investment for the 1983–94 award year universe of Phase II awards. Similarly, 1995 Phase II awards have thus far attracted $0.08 in NASA Phase III development and procurement funding per NASA dollar investment in the Phase II and corresponding Phase I versus $0.22 per dollar of NASA investment for the 1983–94 award year universe of Phase II awards. When also considering non-NASA U.S. Government Phase III funding, the survey results show that 1995 award year Phase II awards have generated combined revenues in non-U.S. Government markets and U.S. Government markets of at least $0.91 per dollar of NASA investment in the Phase II and corresponding Phase I versus $2.95 in non-U.S. Government plus U.S. Government revenues per dollar of NASA investment for the 1983–94 award year universe of Phase II awards. Consistent with these findings, corresponding metrics for 1996 and 1997 Phase II awards are similarly less than those for 1995 Phase II awards.

However, survey results also reveal that at least 29 percent of the 1995 award year Phase II awards have produced technology incorporated in products and services generating revenues in non-U.S. Government markets versus a corresponding 32 percent for the much more mature database of 1983–94 award year Phase II awards. Also, at least 37 percent of 1995 Phase II awards produced technology incorporated in products and services generating revenues in either non-U.S. Government or U.S. Government markets compared to a corresponding 37 percent figure for the much more mature database of 1983–94 award year Phase II awards. Similarly, for the even less mature technologies created under the 1996 award year Phase II awards, the percentage of those awards producing technology incorporated in products and services generating revenues in non-U.S. Government or U.S. Government markets compares favorably with corresponding results for the mature 1983–94 database of Phase II awards. It is noteworthy that the NASA utilization rate of 1995 SBIR award year Phase II technologies already exceeds that of the much more mature 1983–94 database of Phase II awards (see figure 18). Also, the 28-percent figure for 1995 Phase II awards producing technology incorporated in products and services generating revenues in non-U.S. Government markets would not appear to be significantly different from the corresponding 32-percent figure for 1983–94 Phase II awards. This observation is particularly noteworthy when considering that survey results also reveal that private capital investment in ventures incorporating 1995 award year Phase II technology is about $0.17 per NASA SBIR investment dollar versus a corresponding $0.92 in private capital investment in ventures incorporating 1983–94 Phase II technology. Accordingly, the difference in private capital investment in ventures commercially applying 1995 Phase II technology (i.e., more recent technology) versus ventures commercially applying 1983–94 Phase II technology (i.e., less recent technology) may be a proxy for the maturation time required to engineer a technology for commercial application, as well as to finance and otherwise develop the corresponding business venture. Also, contracts for 1995 award year Phase II awards, for example, likely would not have been negotiated before the end of the FY 1995–early FY 1996 timeframe. Therefore, the two-year period of work to develop the Phase II technologies generally would not have begun prior to the early to mid-FY 1996 timeframe. That results for 1996 and 1997 Phase II awards are similarly less than those for 1995 Phase II awards may therefore also be partly explained by such time lags (see figure 17). Given the significant impact of maturation time evidenced in figures 15 and 16 regarding survey and resurvey results, approximately three to four years apart, regarding largely the same firms in the relatively mature 1983–94 Phase II universe, maturation time and other time lags likely would account for the significant difference between commercial and other Phase III survey results for 1995, 1996, and 1997 Phase II awards versus 1983–94 Phase II awards, as well as for the accelerating trend observable in the results for 1995 through 1997 Phase II awards.

This accelerating trend (see figures 17 and 18) in commercial and other Phase III activity may possibly be explained by the effects of NASA's greater emphasis on commercial potential, commercial capability, and commercial intent, as well as NASA's more closely aligning SBIR technology subtopics with the needs of its business unit Enterprises, beginning with NASA's 1995 SBIR Solicitation. Given subsequent re-survey results for 1995–97 Phase II awards, NASA should be able to confirm the effects of these programmatic changes on commercial and other Phase III activity.

Note: Just as the survey methodology enables NASA to specifically track results regarding PhaseII awards for individual award years 1995, 1996, and 1997, subsequent survey year efforts will enable NASA to track Phase II results for individual award years 1998, 1999, and so on.

The "mills" presumption does not apply to the NASA SBIR program.

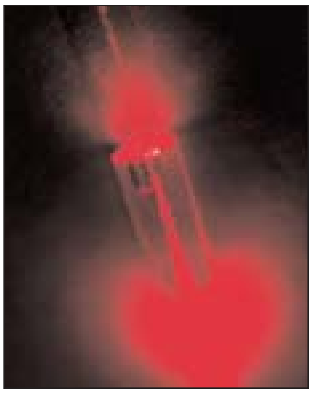
Critics sometimes refer to firms that have won several SBIR awards as SBIR "mills", particularly in those cases where the firm does not demonstrate a significant history of applying SBIR technology in U.S. Government or non-U.S. Government markets. Accordingly, the primary commercial intent of "mills" would appear to be that of generating SBIR contract revenues rather than developing products and services for sale to the Federal Government or to other entities. In the case of NASA's SBIR program, however, about 86 percent of all 1,040 firms winning NASA Phase II awards for award years 1983–01 have received a total of three or fewer NASA Phase II awards. Thus, about 86 percent of all firms winning NASA Phase II awards had previously won not more than two NASA Phase II awards (see figure 9). These firms received about 52 percent of the 2,410 Phase II awards made by NASA over the same period. Also, about 60 percent of all firms winning NASA Phase II awards for award years 1983–01 have won a total of only one NASA Phase II over this period. These firms received about 26 percent of all Phase II awards made by NASA over the period. Only 3.2 percent of NASA Phase II firms have won ten or more NASA Phase II awards, accounting for about 22 percent of all Phase II awards made by NASA over the 1983–01 period. Only six firms, or about 0.6 percent of all of NASA's Phase II firms, have won 20 or more NASA Phase II awards over award years 1983–01. These firms received about 7 percent of all Phase II awards made by NASA over this period (see figures 9 and 10). Also, over the past seven award years (1995–01), new entrant firms into the universe of NASA Phase II firms represent about 40 percent of all firms winning NASA Phase II awards over that period (see figure 14).

Total revenues generated from applications of NASA SBIR technology in non-U.S. Government and U.S. Government markets per NASA Phase II award appears to be significantly greater for firms having 6 or more NASA Phase II awards (see figure 11). Approximately 68 percent of total revenues generated in non-U.S. Government markets associated with NASA SBIR technology have been realized by firms having more than 3 NASA Phase II awards. Therefore, firms that have received a greater number of NASA Phase II awards would appear to demonstrate greater commercial results from NASA's SBIR program. However, statistical linear correlation coefficients regarding the association between number of Phase II awards and revenues generated per Phase II in non-U.S. Government and U.S. Government markets, by firm, are mildly positive (i.e., .3). Therefore, when the data are grouped, the positive association between commercial and other Phase III results and number of Phase II awards, by firm, appears stronger than it really is because a limited number of firms account for much of the success of each particular group. Also, 62 percent of the 714 firms having received 3 or fewer NASA Phase II awards over the 1983–96 award year period have not demonstrated any realized revenues from applications of NASA SBIR technology in non-U.S. Government markets or from U.S. Government Phase III funding. Accordingly, 96 percent of NASA Phase II firms not having realized any revenues from applications of NASA SBIR technology in non-U.S. Government or U.S. Government markets have received 3 or fewer NASA Phase II awards. About 18 percent of the 99 firms having received more than 3 NASA Phase II awards have not realized any revenues from applications of NASA SBIR technology in either non-U.S. Government or U.S. Government markets. Two of the 14 firms having 10 or more NASA Phase II awards have not realized revenues associated with NASA SBIR technology in either non-U.S. Government or U.S. Government markets. Again, nonresponding firms and firms which NASA has been unable to locate have been assigned "zero" results for the purposes of this study (see figure 13).

The data suggest that NASA appears to have had limited but increasing use for the technology it has funded under the SBIR program.

At least 10 percent of NASA Phase II awards have attracted NASA Phase III funding for either further development or purchase of product. Also, at least 15 percent of NASA Phase II awards have resulted in either Phase III funding from NASA or from other U.S. Government agencies (see figure 4). A minimum of 20 cents in NASA Phase III funding has resulted per dollar of NASA SBIR Phase I plus Phase II total program investment. Also, a minimum of 46 cents in total NASA Phase III funding plus Phase III funding from other U.S. Government agencies has resulted per dollar of NASA SBIR Phase I plus Phase II total program investment (see figure 3). Therefore, NASA's utility for the technology it has funded under the SBIR Program over SBIR award years 1983–96 appears to be limited when narrowly measured by dollar amounts of NASA Phase III funding. Some NASA SBIR firms report having sold products or services incorporating NASA SBIR technology, or the ownership or other rights to the technology itself, to other private entities that in turn incorporated the technology in deliverables to NASA under NASA procurements. The survey captures the corresponding sales by the SBIR firm exclusively as revenues realized in non-U.S. Government markets. However, since the SBIR executives surveyed were requested to report only on behalf of their own firms and not speculate for successive firms in the value-added chain, the utility to NASA of NASA-sponsored SBIR technology is thereby understated in the quantitative survey results. Also, several SBIR firms report that developing NASA SBIR technology contributed significantly to their knowledge base, enabling them to develop other technologies that they subsequently applied in non-U.S. Government and U.S. Government markets. The corresponding commercial activity attributed to this spillover effect is not captured in the survey's quantitative results. Similarly, to the extent that the knowledge base of NASA technical personnel has been extended by the innovative technology developed under NASA's SBIR program and applied in defining NASA requirements in non-SBIR NASA procurements, the utility to NASA of NASA SBIR technology is understated by the survey results.

That NASA's utility for technology developed under Phase II awards is increasing, as narrowly measured by NASA Phase III funding, is evident from a comparison of initial survey results for the 1983–94 universe of Phase II awards with re-survey results for virtually the same universe. NASA's survey effort has produced comparative survey and re-survey results only for the 1983–94 universe of Phase II awards thus far. Initial survey results for that universe showed NASA Phase III funding in the amount of $0.10 per dollar of NASA Phase I plus Phase II investment. Re-survey results for the same universe approximately three to four years later yields a corresponding figure of $0.22 in NASA Phase III funding per dollar of NASA Phase I plus Phase II investment, an increase of over 100 percent. It is noteworthy that the survey asks companies to report the more conservative (since contracts can be terminated prior to completion) metric of NASA Phase III "revenues received to date" rather than NASA Phase III "total contract amounts." Therefore, the maturing of NASA Phase III contracts as work is performed, revenues are earned, and NASA payments are received partly accounts for the more than 100-percent increase over the three- to four-year period. Since the conservative metric "revenues received to date" masks the value of NASA Phase III contracts awarded in recent years, contract values will be included in subsequent survey results as work under NASA Phase III contracts is completed.



Appendices

Appendix A

OMB No. 2700-0095

Date: _________

NASA SBIR Company - Commercial Metrics
(Commercially Sensitive Information)

Company: ______________________________ State: ___________

Company Contact Person: ______________ Title: ______________ Phone: ______________

Nondisclosure: *Unless you advise otherwise on this form, the information provided below will be considered by NASA as confidential commercial data and accordingly will not be disclosed for any purpose by NASA to non-NASA private or public parties, other than as part of data aggregated with that of other respondents, except for the compiling of this information by NASA subcontractor personnel for NASA program evaluation purposes.*

1. Regarding your firm's commercial products or services, currently or formerly generating revenues in non-USG markets, which are based on or partially based on technology developed under NASA SBIR awards to your firm:
   (Note: "**commercial**" is defined to be non-USG (non-USG) markets. Count a "product line" of products having varying attributes as a single product. "Best estimate" data is sufficient if the requested data is not available or unreasonably burdensome to obtain.)

			Cumulative Revenues ($ Millions) to Date Recognized by Your Firm from non-USG Sources			
Commercial Product or Service (include venture name, if different, and Reg. Trademark name, if any)	Briefly Identify Commercial Application	NASA SBIR Contract #'s Associated with Each Comm'l Product/Service	License Fees/ Sales	Royalties	Other (e.g. dividends; $ re: sell-off of technology)	Your Firm's No. of Full-Time Job Equivalents **Currently** Applied to Related Commercial Activities

(Please continue on reverse side, if additional space is necessary.)

2. Regarding your firm's efforts (successful or unsuccessful) & planning to date regarding commercial ventures to develop commercial products/services targeted to non-USG markets based on, or partially based on, technology developed under NASA SBIR Phase II awards(a) which were made to your firm, please provide the following information with respect to your firm:

(A commercial venture is defined to be 1) a separate profit center established by your firm; or, 2) a profit center of another private entity that is a source of royalties, licensing fees, or dividends for your firm or that has been established based on the outright purchase of NASA SBIR related technology from you firm.)

Venture Name	Associated NASA SBIR Contract Numbers	Cum. Priv. Cap. Investment by Your Firm & by Partner Firms ($ M)	No. of Spin Off Firms Formed (Names: Opt.*)	No. of Joint Partnerships (JV's) Entered	No. of Lic./ Roy. Agmts. Entered Entities	No. of Other Strategic Alliance Agrrements Entered W/Priv. JV's	No. of Other Firms Involved: (Names: Optional*) Lic./Roy.	No. of Other Firms Involved: (Names: Optional*) Other Agmts	No. of Patents	No. of Pat. Appl.	Other Significant Business Development Yes	Other Significant Business Development No	No Sig. Business Development; but Some Preliminary Planning (e.g. mkt. research) Yes	No Sig. Business Development; but Some Preliminary Planning (e.g. mkt. research) No

(Note: For those NASA SBIR contracts not associated with a commercial venture to date, please enter "NONE" in the "Venture Name" column. Please continue on reverse side, if additional space is necessary.)

3. NASA SBIR Phase II awards (a) made to your firm for which NASA and/or non-NASA USG agencies provided Phase III funding to your firm: (Note: USG Phase III funding is defined to be sales to NASA or to non-NASA USG agencies plus post-Phase II development funding awarded by NASA or by non-NASA USG agencies.)

NASA SBIR Phase II (a) Contract No.'s	Cumulative USG Phase III Funding (in $ Millions) Received by Your Firm To Date: Phase III Funding From NASA	Cumulative USG Phase III Funding (in $ Millions) Received by Your Firm To Date: Phase III Funding From non-NASA USG Agencies Related	Your Firm's No. of Full-Time Job Equivalents (not accounted for in Section 1 above) **currently** applied to Phase III activities in USG Markets

(Please continue on reverse side, if additional space is necessary.)

4. Comments: (* Optional names of any spin-off or partnering entities referred to above plus any other optional comments; use backside of this form, if necessary. Also, you may attach any marketing literature/other information on commercial applications of technology developed under NASA SBIR awards to your firm.)

[a] If commercial ventures or USG Phase III funding resulted from NASA Phase I awards for which there were no follow-on NASA Phase II awards, then please provide the requested information with respect to those NASA Phase I awards.

Appendix B

SBIR Technology Areas (Defined by the SBA)

Computer, Information Processing, Analysis

- *Computer and Communication Systems*—computer systems technology, communication and control systems, networks and architectures, computer security.
- *Information Processing and Management*—data and information processing, artificial intelligence, computer software, robotics and automation, man-machine interface.
- *Signal and Image Processing*—signal processing, image processing, navigation, guidance, positioning.
- *Systems Studies*—general studies, operations and systems analysis, safety systems, health and risk analysis.
- *Mathematical Science*—math fundamentals, numerical modeling, math modeling.

Electronics

- *Microelectronic*—microelectronics materials, concepts, and processing; compound semiconductors; photovoltaics; optoelectronics.
- *Electronics Device Performance*—electronic device performance, packaging, reliability; radiation damage and hardening; testability.
- *Electronic Equipment and Instrumentation*—electronic equipment and systems, data and information processing equipment, sensors, transducers, instrumentation.
- *Microwave and Millimeter Wave Electronics*—microwave electronics, millimeter wave electronics.
- *Optical Devices and Lasers*—optics and IR sensors, components; optical fiber technology; laser technology; higher frequency EM radiation.

Materials

- *Advanced Materials*—metallic, magnetic, high T, conducting and superconduction materials; polymers, ceramics; composites and lightweight materials; construction materials; fire, fabric, and insulation materials; biomaterials.
- *Materials Processing and Manufacturing*—materials processing, manufacturing methods, joining and welding technology, separation/characterization of multi-phases.
- *Coatings, Corrosion and Surface Phenomena*—corrosion, coatings, thin films and surfaces.
- *Materials Performance*—failure, fracture, fatigue; lubrication, wear and seals; repair; non-destructive evaluation.
- *Fundamentals and Instrumentation*—materials fundamentals; instrumentation.

Mechanical Performance of Vehicles, Weapons, Facilities

- *Hydrodynamics*—hydrodynamics, watercraft.
- *Aerodynamics*—fundamental aerodynamics; aerodynamic performance; aerodynamic facilities, instrumentation.
- *Acoustics*—underwater acoustic detection and communication, vibration-related acoustics.
- *Mechanical Performance of Structures and Equipment*—shock vibration and structural performance of vehicles, facilities, equipment; new structural concepts; performance of engine, equipment, mechanical components; weapons performance and effects.
- *Control*—control concepts, vehicle/weapon motion control, structural controls.
- *Mechanical Measurements*—mechanical measurements (pressure, velocity, etc.)

Energy Conversion and Use

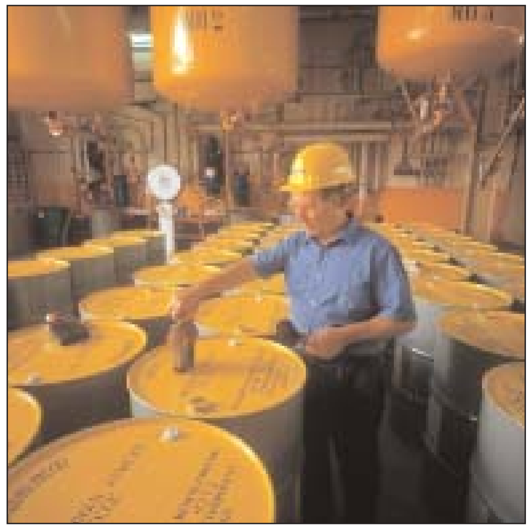
- *Transport Sciences*—fluid mechanics, flow/fluid measurement and enhancement, heat transfer, refrigeration/cryogenics.
- *Propulsion/Combustion Technology*—propulsion systems; propellants, fuels, explosives; combustion; fire detection; exhaust gases and analysis.
- *Large-Scale Energy Usage*—industrial energy processes and utilization; physics, nuclear physics, fusion and plasma; energy use in buildings.
- *Energy Conversion/Electric Power*—batteries, fuel cells, electrochemistry, energy storage; alternative energy conversion; electric power technology.

Environmental and Natural Resources

- *Ocean Science*—ocean science and instrumentation.
- *Atmospheric Sciences*—atmospheric science and monitoring, remote sensing, chemical and biological measurement, particulates and aerosols, pollution abatement and environment control.
- *Water Management*—water monitoring and characterization; water treatment; water management and utilization; ice, snow, frost detection.
- *Earth Sciences*—Earth sciences, soil measurement and manipulation.
- *Environment Protection*—nuclear, chemical, biological waste management; CBR defense.

Life Sciences

- *Medical Instrumentation*—medical measurements, measurements/techniques for radiation/imagery, medical devices, devices/systems for physically impaired.
- *Biotechnology and Microbiology*—biotechnology and genetic engineering; cellular biology; drugs, vaccines, toxicity, immunology; therapeutic agents; disease detection and screening.
- *Behavioral Sciences*—behavior, human factors, cognition; training, testing, simulation; social studies.
- *Physiology and Miscellaneous*—physiological mechanisms, injury, miscellaneous; dental; food, nutrition, agriculture; biotic resources; animal models and veterinary medicine; plant physiology.



Appendix C

Some Commercial Products and Services Generating Revenues in non-U.S. Government Markets

(At Least Partially Based on NASA SBIR Technology)

Java Beans	CFD-ACE(TM)	CFD-GEOM(TM)	Phoenix® ROV	PETI-5
CFD-FASTRAN(TM)	UNIC-2P	ZEUS(TM)	Phantom III®	T-SCANWHEEL
Crystal Score	XMT-145	Firefly®	IrDA(R)	3001 Front End Module
UNIC-CFD	GENOA-Probabilistic	VGA6	S-Tec	Process Advisor
OCRProof ™	HERMES ™	3 Dawn®	Thermal Radlad®	Black-Ice
SAM/OPTIMESH	PC SQUID	PB-1024	TEAMS-KB	WideGap ™
Thermalin	Phantom 150® ROV	MAMI	Qwikshot®	CLASS II
BitFLOW™	VelTherm	OBHMS	POLARBEAR	LoFLYTE ™
GENOA-PFA	Revtek	Thermal Desop®	Open Sesame! Mac	ProPHLEX ™
AGNC®	GURTA	OrthoSAR ™	ClearSat-15	FLODOME
AUTOSOLID	Redhawk/VIP 20	TEAMS®	PRM 1000	OMA
Spectrum ™	PB-300	KoolVest®	Spectra Temp ™	ICTT
AESOP®	Spectra Link	Site Planner	Avalance Diodes	Wireless PBX
ClearSite ™	SAVI	CARDIOCAM-SM	AMTEC	ModelQuest MarketMiner (MQMM)
Dragonfly® ROV	T3	AEROTEX	RotorCRAFT/AA	Data Broker®

Hawkes Sensory Manipulator	SINAPS Fluint	Smarts Engine	SIMS	O-Atom Facility
RGX®	LEPS	MetSensor	3000 Power Supply	SuperconTape
VelBlack	Airborne Multispectral Digital Cameral AA497	InPhotote™	4H Bipolar Power Devices	S+ Arc View
MSC	PHASE™	Superex	AF CVA	GmpSensors
63XX, 60XX Lasers	TEAMMATE	Pattern Recognition Toolbox(PRT)	GUST®	Delph
Test-Plan	IR Plex(R)2600	3002 Output Module	MV-200	F10 Laser Strobe
GRUPPA	QwikFind™	HyperXtrude™	HW CVA	Rampant(TM)
I*Sense 14000	Smart Sensor	MicroWIS™	RemoteGen™ RG-350 Power Generator	RotorCRAFT
SIRComm™	InSight	RFID	Costran2000	PMARC-EXPRESS/FPA
Vapor Sep®	NEUROCAM-SM	IFM	EVTS	TARGET
Vibromet-1000	AERO-CADD	Framework CT	DiComp	IR Plex® 2500
Rotapower	PYROGEL	BPS	BarrettHand BH8-255	LADARVision Excimer Laser
Finesse™	BarrettArm BA2-300	pH Optrode	Learn Sesame	DVET
PB-100	iVillage	Chlorine Electrolysis	ClearSat-ADOS	Qwikcheck®
FarLight	ClearSat-MBM	Ibridge®	Myo Monitor™	Sensor Skin
Fo Phase	Raman Probe™	JENTEK GridStation	Gas Sentry®	COBRA 2000 Laser
ControlShell	LAST®	Air 2000	Gas Ranger™	InQuisiX™
AgentBuilder	Component First™	TracePro	Phantom SPECTRUM® ROV	LIL JOE
RAPPID-RDA	Air Photocat	Lexitek PAPA Detector(LPD)	QwikBoost™	FIDAP
FlightScene	Patch Actuator	Serpentine Actuator	Compuglass	CVD Silicon Carbide®

AMP	KINEMOD	OPTIMOD	AHS - Model AA5201	G.A.-CAD
Fiber Sentry®	NEKTON3	MBO(N)D	Advaserve™	QuickPack®
R-Grid	LASERSCAPE	NEKTON2	Advaguard™	CRYOGEL
NOE Optimizer	CardiacVest	FAST Atom™	ORICA Controller	Scanalyzer™
TiNi™ Microvalve	IRMOLL	PowerSmart	AvroTec Flight Monitor	IA(X)
QASE®	S+SDK	HLMS	MCV®	ImageExpress™
Zeoponix-TeoPro™	PAE-COR	S+WAVELETS	PARSEC	T-Reaction Wheel
Windtracer®	Rad-View	EPHIC/HERO	PAE-TOR	FDP 3100 Frequence Domain Processor
SINAPS Plus®	Dexterous Master (DM)	THERMOPAD	TDK/SCAP	MDOF Load Cell
Wave Explorer	AOCI	FIELDVIEW 6	Acuity Autovision 100	XRD Spectrometer
LightCaster®	IsoLoop™	PRV 95	Cryocoolers for Satellites	GEM-3 Sensor
HCPEE	AGIS	Autostep®	Coolit®	Smart Deck™
Eschelles	York Service	S-Bond™	Model 102 Portable Spectrometer	CAD/Chem
GI-EYE	3Z Laser Strobe; 4Z Laser Strobe	NDPLAS	V8.5 FIDAP	Pyrograf-III
COMPASS/MARS	Fluent™	Stress Scanner Model SCA-1500	Rapid ToolMaker™	COPS
FOCUS™	CHARM	Ultrafast®	EPHIC	Magnepress®
Epigrade™ Reagents	ModelQuest Expert (MQX)	Cyberimpact 6-DOF	SMART LOAD	NNP®
TEAMS	GASP®	MIMVIS - Model AA5000	Diagnostician	EdgeNet
Network Linda	EZopt	Durango PMI Software	TwinSTAR	APA-100 Acutators
Mini-FTS	CLR-100	MRAM	CERACARB™	PhotoBubbles™

SIMION Software Analyzer	TCON	Map-X	Solar 1000™	ultraTOC 1500 Organic Carbon
Microllith™	VGRID3D	MEGA-BAC-TF™	Delta™	PHLEXsolid™
MSSCS S/W Upgrade	Safety Net	Daris	PlastiScan	FLOSTATION ©
Ikon B™	AOA Indicator	TNEX-2000	ImageLib™	Bearing Health Monitor
SpectraScan®	Spectr TRAK 600, 620,672,572,573	ProFlux	PICA Heatshield	GAPP
Porotec™	OpenWorlds Libraries	Holoscan	COMET	Phigs Tool
Active Stick	SWB-100	Star™ Motor	VSAERO	Accuheight
BeCOOL™	VLF-2 SFERICS	Input Shaping™	GENERATOR™	Tecplot®
Glasair™	EPIC	SC-4000 Deposition System	SpecTRM	Ped Alert™
Costran98	Biclops	DTI Virtual Window™	G-Logger-Model 3310/3320	Delta Therm 1000®

Appendix D

Some Commercial Applications of NASA SBIR Technology by Industry Sector

Aviation

- Detection of Aircraft Corrosion
- Non-Destructive Evaluation of Aircraft Fatigue, Corrosion, and Welds
- Sensors for General Aviation Collision Avoidance
- Aircraft Design Software
- Helicopter Design and Performance Software
- Jet Turbine Engine Performance Software
- Sensor for Measuring Aircraft Engine Temperature
- Wing Design Software
- Aircraft Lightning Protection Systems
- De-icing Systems
- Aircraft Icing Sensor
- Helicopter Blades
- Helicopter Stabilizers
- Flight Instrumentation
- Helicopter Navigation Sensors
- Flight Monitor Display for General Aviation
- Airport Security Scanning Systems
- Detection of Explosives in Baggage
- Corrosion Control Coatings for Aircraft Frames
- Aeroacoustics Analysis Software
- Aeroacoustics Noise Suppression

Agriculture

- Fertilizer
- Agricultural Mapping

Automotive Manufacturing

- High-Speed Flow Analysis
- Collision Avoidance Highway Systems
- Coatings for Brakes, Pistons, Valves
- Software for Design of Automotive Vehicles
- Electrodes for Automotive Applications
- Combustion Analysis
- Coatings for Automotive Assembly Fasteners
- Automotive Emissions Control Systems
- Catalytic Combustors for Automotive Engines
- Electrical Alternator Systems
- Motion Analysis Crash Worthiness Testing Software

Materials

- Thermal Spray Coatings
- Building Insulation
- Cryogenic Insulation
- Ceramic Materials
- Computer Modeling of Ceramic Materials
- Moisture Barrier Coatings
- Semiconductor Materials
- Software for Modeling Crystal Growth
- Processes for Separation and Purification of Organic Materials
- Polymeric Fibers, Films, Resins
- High-Temperature Ceramic Materials
- Computer Design of Ceramic Materials
- Thin Film Surface Area and Porosity Analysis
- Thermoplastic Materials
- Thin Film Deposition Systems
- Adhesives
- Coatings for Turbines
- Lubricants
- Thermal Materials for Electronics Applications
- Composite Materials for Structures
- Iridium TC Coatings

- High-Strength Copper
- Rhenium Coatings
- Carbon-Carbon Composites
- Bonding Solder for Joining of Metals, Ceramics, Glasses
- Clothing Insulation Fabric
- Metal Matrix Composites
- Oxidation-Resistant Coatings
- High-Barrier Food Packaging Materials
- Anti-Reflective Coatings

Communications

- High-Speed Modem for Digital Video Broadcast Networking
- Cellular System Electronic Devices
- Radar Signal Processing System
- Compression Modeling
- Signal and Image Processing
- Communications Satellite Antenna Reflector

Electrical/Electronics

- Spectrometer
- Tunable Solid State Lasers
- Spectrum Analysis Equipment
- Aluminum Electrolyte Capacitors
- Remote Power Sign Lighting
- Fiber Optic Accessories for Lab Spectrometers
- Semiconductors for Imaging and Sensing Applications
- X-Ray Equipment
- Software for Electronics Cooling
- Electron Beam Simulation Software
- Infrared Sensing
- Cryocooler Drive
- Semiconductor Thermal Detectors
- Electrical Generators
- Electronic Power and Switching Devices

- Oxide Cathode Phosphor for TV and Computer Monitors
- Cathode Ray Field Emission Display
- Electronics Cooling Systems
- Electrical Power Generation Diagnostics
- Satellite Solar Concentrators
- Mechanical Stress Measurement Instrumentation
- Laser Devices
- Organic Electrolytes for Capacitors
- Actuators for Valves and Switches
- Solar Cells
- Electronics Packaging
- Cryogenic Radiometers
- Laser Power Stabilizers
- Laser Power Converters
- Mercuric Iodine Semiconductors
- Heat Seal Flaw Detector
- Hydride Electrodes
- Lithium Cells for Powering Tools
- Coating Measurement Equipment
- Tunable Electronics Filter
- Shipping Vibration Recorder
- Identification of Defects in Printed Circuit Boards
- Electronics Cooling Devices

Environment

- Remotely Operated Vehicle for Nuclear Inspection
- Non-Destructive Evaluation of Refinery Piping and Welds
- Atmospheric Research Spectrometer
- Acoustic Emission Testing Equipment
- Treatment of Industrial Emissions
- Indoor Pollution Abatement Systems
- Lasers for Atmospheric Pollution Monitoring
- Detection of Hazardous Wastes
- Industrial Manufacturing Plant Emissions Control
- Gas Utility Inspection

- Hazardous Waste Handling
- Toxic Gas Monitoring of Chemical Processes
- Carbon Monoxide Measurement
- Drinking Water Purification Systems
- Electrometallurgy and Nuclear Waste Treatment
- Water Purification Monitoring
- Hydrazine Badges
- Waste Water Treatment
- Cloud Particle Analyzer
- Nuclear Power Plant Safety Systems
- Indoor Air Bacterial Measurement Device
- Environmentally Safe Refrigerant
- Removal of Contaminants from Soils
- Instrumentation for Sorting Recycled Plastics and Cans
- Disinfection Systems for Hot Tubs and Spas

Sensor Technology

- Moisture Sensors
- Pressure Vessel Scanning Equipment
- Optical Pressure Sensing
- Geophysical Survey Sensors
- Materials Stress Measurements
- Oxygen Sensors
- Contaminant Sensors
- Detection and Diagnosis of Structural Faults
- Security Sensors

Robotics

- Sensors for Robotic Arm Obstacle Avoidance
- Motion Control Systems
- Handcontroller for Robotics Equipment
- Manipulation of Underwater Equipment
- Robotics for Nuclear Power Plants
- Mine Clearance Robot

Medical Industry

- Kinematic Analysis of Human Motion
- DNA Electrophoresis Imaging
- Implantable Drug Delivery Systems
- Biomedical Load/Limb Monitor
- Medical Measurement Instrumentation
- Thin Film Materials for Medical Devices
- Ozone Generator for Medical Sterilization
- Medical Tubing Material
- Neural Network Health Monitoring System
- Computerized Health Management Systems
- High Speed Camera for Neuroscience
- High Speed Camera for Cardiac Research
- Biomedical Telemetry
- Eye Surgery Laser System
- Medical CAT Scan Systems
- Nuclear Medicine Equipment
- Low Pressure Oxygen Storage for Medical Equipment
- Aerosol Inhaler Design
- Biotechnology Processing Services
- Electrochromic Eyewear

Manufacturing Processes

- Chemical Identification Monitoring Systems
- Manufacturing Process Temperature Control in the Manufacture of Steel, Cement, Petroleum, Paper
- Control of Manufacturing Processes: Gauging, Inspection, Guidance, Verification
- Modeling of Chemical Reaction Flows
- Laser Strobe Systems for Control of Manufacturing Thermal Sprays
- Coolant Spray Quench Systems for Manufacturing Systems
- Laser Micromachining
- Semiconductor Manufacturing Equipment
- Separation and Purification of Organic Materials

Heating/Air Conditioning

- Heating and Refrigeration Compressor
- Heating and Refrigeration System Testing Additives
- Walk-in Freezers
- Gas-Fired Chillers
- Modeling of Heat Transfer Design
- Solar Concentrator
- Heat Pump
- Commercial Refrigeration

Optical Instrumentation

- Software for Optical Instruments Design
- Electro-Optic Devices
- Spectroscopy Instrumentation
- Autostereoscopic Visualization
- Optical Infrared Polarizer Filters
- Optical Fiber Laser
- Barcode Scanning
- Spectral Imaging
- Airborne Digital Camera
- Night Vision Inspection Laser Scanners
- Scanning of Heat Seal Quality
- Monitoring of Bridges, Tunnels, Pipelines, Floating Structures
- Toll Collection Mobile Speedpass

Other Software

- Software for Visualization of Multivariate Data
- Computer-Based Image Recognition
- Computational Fluid Dynamics Software
- Neural Network Processor
- Electromagnetic Actuator Control Software
- Fluid Analysis Software
- Thermal Simulation Software
- Speech and Image Processing Enhancements

- 3-D Motion Analysis System
- Software for Mathematical Data Analysis
- Rapid Prototyping Software
- Editing and Quality Control Software
- PC Videoconferencing Software
- Planning and Scheduling Software
- Data Mining Software
- Multimedia Applications Software
- Virtual Reality Display
- Tutoring Software

Other

- Magnetic Bearings
- Clean-Burning Gas Turbines
- Catalytic Combustors for Gas Turbines
- Electrochromic Eyewear
- Internal Inspection of Pipes and Circulation Pumps
- Vibration Control in Sporting Goods
- Oil Field Relief Valves
- Engines for Small Boats, Generators, Snowmobiles
- Traffic Control Systems

Appendix E

Some Commercial Applications of NASA SBIR Technology by SBA Technology Areas

Computer, Information Processing Analysis

Irvine Sensors Corporation (Costa Mesa, CA) currently sells several products which incorporate NASA-funded SBIR technology. For example, the company's SIRComm® SIR 2 receiver enables point-to-point wireless data transfer between computers. SIR2 is a 1996 Laser Focus World Commercial Technology Achievement award winner. MiniSIR® and SIRtel™ transceiver modules similarly enable cellular phone and pager communications, respectively. The company's Red Hawk ™ imaging technology and software provides digital enhancement of video data and extraction of high-quality images from any video source, including personal camcorders, the Internet, and broadcast media for uses by, for example, forensic and sports industry media professionals. The Red Hawk™ process reduces noise and enhances image color, detail, and resolution. The company also incorporates 3-D microelectronics technology developed under NASA's SBIR program in such products as desktop, laptop, and handheld computers, cellular phones, aircraft avionics, and satellites.

Qualtech Systems, Inc. (Storrs, CT) commercially markets its TEAMS™, TEAMS-RT™, and TEAMMATE® software tools which are based on technology developed by the firm under NASA's SBIR program. These software tools are commercially utilized to design, test, monitor, provide diagnostics, troubleshoot, and isolate failures in both hardware and software aspects of complex, autonomous systems from both onsite and remote locations. For example, the software tools are utilized in commercial and military aviation, including onboard, real-time applications, as well as in robotic exploration, communications networks, electronic equipment, transportations systems, automotive, and other safety-critical systems. Qualtech's customers for these software tools include several *Fortune 500* companies.

Barrett Technology, Inc. (Cambridge, MA) manufactures and markets the BarrettHand® and BarrettArm®, each of which is a pioneering product that was developed utilizing technology developed by the company under NASA SBIR contracts. The BarrettHand® is a three-fingered programmable grasper having two opposing fingers, each capable of 180 degrees of movement, with the dexterity to secure target objects of different sizes, shapes, and orientations. In assembly-line manufacturing applications, such as in the automotive industry, the BarrettHand® obviates the need, tools, downtime, and expense of switching out tasks as required in the use of less sophisticated robotics equipment. The BarrettArm® is a similarly dexterous item of robotics equipment offering revolutionary flexibility that makes it commercially useful for spraying, finishing, and contouring applications, and for mobile applications such as transporting hazardous material in nuclear power plants or weapons disposal sites, particularly in environments that are cluttered or dangerous to humans.

EMC Technology, Inc. (Cherry Hill, NJ) has incorporated NASA SBIR technology into two of its patented products, Thermopad® and SmartLoad®, which are currently sold worldwide. Thermopad® is a microwave attenuator that varies electrical power dissipation with shifts in temperature. This electronic device can be used in any application requiring a known amount of attenuation change for particular temperature shifts. This electronic device is particularly useful for maintaining the output of a multitude of electrical signal-processing components over varying temperatures. It can replace entire closed loop temperature compensation circuits with a single chip device that requires no controls. SmartLoad® is a temperature compensated thick film circuit that combines an RF termination and a signal detector into a single passive device. SmartLoad® provides highly linear responses (i.e., minimally distorted electrical signal outputs) over a wide range of frequencies. It is immune to damage from common levels of static electric discharge and radiation. Thermopad® and SmartLoad® are currently used in numerous military, aerospace, satellite communications, electrical test equipment, and telecommunications markets. For example, both products are utilized in personal computer systems, radar systems, altimeters, amplifiers, oscillators, and several other electronic systems.

Lightwave Electronics (Mountain View, CA) manufactures at least a dozen solid-state laser systems that incorporate NASA SBIR technology. Thousands of these laser products have been sold in telecommunications, semiconductor, electronic equipment, electronic assembly, medical equipment, holography, metrology, and R&D instrumentation markets for applications in fiber optic communications sensors, cable TV systems, remote antenna links, oscillators, semi-conductor marking and glass marking, surface inspection equipment, high-resolution spectroscopy, precision interferometry, micro machining, radar systems, and rapid prototyping. Key features of these products that offer unique competitive advantages include stable, narrow line width laser output, low noise, and direct conduction cooling.

Displaytech, Inc. (Longmont, CO) has developed LightCaster® microdisplay technology under NASA's SBIR program. LightCaster® provides revolutionary technology for consumer product developers by enabling the design of thinner, smaller, and lighter TVs, computer monitors, digital cameras, video camcorders, cellular phones with integrated video, video-ready front projectors for business settings, home theater, and video conferencing equipment, as well as wearable displays. LightCaster® generates a sharp, high-resolution, fingernail-size image of unmatched clarity, color, and intensity that can be enlarged for use in, for example, large screen, high-definition TV's. LightCaster's® small size means consumer products such as big-screen televisions can have slim profiles because conventional components (e.g., conventional tubes or plasma screens) are no longer necessary. The technology therefore enables greater simplicity of design and manufacture at significantly reduced production costs and operating power requirements. Displaytech sells LightCaster® technology to several consumer electronics companies and has entered into strategic alliances with Nissho Electronics Corp., Fuji Photo Optical Company, and Samsung Electronics regarding commercial applications of the technology.

Viking Instruments Corporation (Chantilly, VA) has developed it SpectraTrak™ series of commercial field portable gas chromatograph mass spectrometers based on technology developed under NASA's SBIR program for NASA's Viking Mars Mission. The company combined NASA-funded technology with miniaturization advances in mass spectroscopy, gas chromatography, ion optics technology, temperature control, vacuum technology, and computer technology to produce SpectraTrak™ instrumentation that can quickly detect and identify a vanishing, small quantity of a chemical compound. Commercial applications include environmental monitoring, chemical arms control, forensic analysis, chemical processing, and detection of illegal drugs. SpectraTrak™ portable instrumentation can analyze anything that bulky room-filling laboratory equipment can, and it does so in real time and on the real site. It therefore saves time andimproves accuracy. The technology can detect and identify chemical substances below the trillionth of a gram level in water, air, soil, and in other gas, liquid, and solid samples.

Materials

Materials and Electrochemical Research Corporation (Tucson, AZ) bases much of its composite materials business on technology developed under NASA's SBIR program. Specifically, the company developed carbon-carbon and metal matrix composite materials under NASA SBIR contracts. The carbon-carbon composite technology provides specialty properties at relatively low cost per pound. Commercial applications include automotive components such as pistons, cylinder wall liners, valves, and brakes. Other applications include furniture fixtures, heating elements, and all types of thermal management functions such as in electronics packaging and heat exchangers. The company's metal-matrix composites are reinforced with ceramic particles to yield materials with varying desired degrees of hardness, strength, elongation, and fracture toughness. The company's metal-matrix composites are utilized in engine components such as pistons, blocks, and valves, as well as in sporting goods such as golf clubs.

Morton International, Inc. (Chicago, IL) has incorporated NASA SBIR technology in the manufacturing of its commercial product, CVD Silicon Carbide®. CVD Silicon Carbide® is a ceramic material having a 99.9995% purity that is much greater than silicon carbide material produced under traditional state-of-the -art-processes. The greater purity achieved translates into superior chemical and physical characteristics such as homogeneity, nonporosity, chemical and oxidation resistance, cleanability, polishability, thermal conductivity, stability under thermal and cryogenic shock, and stiffness or dimensional stability. For example, due to its chemical inertness, CVD Silicon Carbide® components can be cleaned repeatedly in various acid solutions without loss of dimensional accuracy. CVD Silicon Carbide® material is commercially applied in semiconductor processing equipment, substrates for surveillance mirrors, wear components such as pump seals, information storage media, high-energy lasers, laser radar systems, large astronomical telescopes, weather satellites, and heat sinks for electronic packaging. The material generally excels in systems that require components of low mass, great chemical resistance, and extremely high temperature performance.

IAP Research, Inc. (Dayton, OH) has developed technology under NASA's SBIR program upon which its innovative Magnepress® system is partially based. Magnepress® uses pulsed magnetic forces to press, form, or join metals such as aluminum, steel, and copper including the joining of dissimilar materials (e.g. aluminum and steel). Magnepress® is also utilized to press powdered metal or ceramic and other powdered material into high-density, high-performance parts. The unique competitive advantages of the technology are: a) powdered metal can be compacted into higher densities than that possible using any other rapid production press methods for improved strength and performance; b) problems associated with heating metals before pressing are eliminated; c) metal sheets can be shaped into complex forms not possible through traditional metal forming methods; d) lower costs of high-volume production, particularly given that Magnepress® systems are smaller and more flexible than conventional hydraulic presses of comparable capacity. Parts produced by Magnepress® are utilized in the automotive industry (e.g., transmission gears, ignition cores, motor housings), food-processing industry (e.g., evaporator assemblies), as well as in military markets.

Energy Science Laboratories, Inc. (San Diego, CA) has developed technology under NASA's SBIR program upon which it has based two commercial products, Vel-therm™ and Vel-Black®, that the company manufactures and markets. Vel-Therm™ is a thermally conductive and compliant interface material useful for thermal attachment of electronic components to heatsinks and heatspreaders. Much of thermal management involves the transfer of heat from one element, such as an electronic component, to another (e.g., a heat sink). Of major concern in this process are high temperature drops at interfaces between elements, limiting overall performance of the thermal control system. Vel-Therm™ provides a thermal interface having very low thermal resistance. Its utilization results in weight reduction, improved performance, and longer lifetimes of electronic elements. Vel-Black® is an ultra-low reflectance coating that is useful for stray light suppression in optical systems.

Mechanical Performance of Vehicles

Deep Ocean Engineering (San Leandro, CA) has incorporated tractor drive thrusters, actuators, and composite structural frame materials developed under NASA's SBIR program in its Dragonfly®, Phantom®, Phoenix®, SPECTRUM, Hawkes, and Micro Pipeliner product lines of underwater remotely operated vehicles (ROV) and manipulators. These vehicles and manipulators are commercially utilized for inspection of boiling water and pressurized water nuclear reactors, tunnel inspections, in-vessel inspection, small object retrieval, deep oil field applications, pipeline inspection, dam and bridge footing inspection, contraband and evidence recovery, and underwater border patrol operations. This equipment is also utilized for military and research purposes. The unique advantage provided by NASA SBIR thruster technology is superior power and control relative to competing ROV technologies, particularly in adverse currents.

Digiray Corporation (San Ramon, CA) has commercially applied technology developed under NASA's SBIR program for the purposes of inspecting Space Shuttle tiles and welds, as well as locating hidden corrosion in NASA aircraft. The company's commercial product, RGX®, is based on this NASA SBIR technology. The RGX® system is commercially utilized for various purposes which include: a) nondestructive evaluation of oil refinery piping and piping welds; b) inspection for defects in nuclear reactor fuel rods; c) inspection for cracks and corrosion in petrochemical industry applications; d) detection of cracks and the presence of corrosion in commercial aircraft; c) defects in printed circuit boards; e) medical imaging; f) inspection of advanced composite materials; and, for g) security purposes such as baggage inspection, detection of explosives, and detection of contraband. RGX® provides several competitive advantages over existing state-of-the-art technologies. For example, RGX® enables commercial and military aircraft inspection to be faster, less expensive, and more reliable since it eliminates the need for slow, costly manual disassembly and reassembly of parts of the aircraft structure (e.g., the wings). RGX® provides 300 percent faster inspection of pipelines, and enables faster detection of corrosion under insulation by a factor of ten. RGX® provides significantly greater detail in medical imaging of bones, for example, than competing CAT technologies, and at reduced dosages. Generally, in addition to scanning large areas faster and providing greater detail than competing technologies, RGX® yields filmless images in real time, enables access to small, hard-to-reach areas, and detects defects that conventional systems cannot see.

Energy Conversion and Use

Materials and Electrochemical Research Corporation (Tucson, AZ) has developed lithium-ion rechargeable battery technology under the NASA SBIR program that has several advantages over present state-of-the-art technology. The NASA SBIR technology has resulted in lithium-ion batteries that are lower cost per watt-hour, lighter in weight, safer, and can be configured in thinner and more flexible shapes than competing commercial lithium-ion batteries. These attributes make the company's lithium-ion battery technology ideal for many consumer electronic applications, including portable consumer products such as cell phones and laptop computers. The technology can also be scaled up to high-capacity, high-voltage capabilities for electric vehicle applications. Government usage of the technology includes batteries for use in satellites and as a portable power source for various military applications.

Environmental and Natural Resources

Precision Combustion, Inc. (North Haven, CT) has developed its Microlith® technology, in part, under NASA's SBIR program. The technology has been developed for catalytic converter, fuel processor, fuel cell components, air cleaning systems, and chemical reactor exhaust applications. Microlith® technology commercial uses include automotive and other internal combustion engine after treatment applications, as well as air-cleaning systems for volatile organic compounds and other air pollutants from industrial manufacturing processes. The technology provides an order of magnitude improvement in performance as well as significant cost, size, weight, maintenance, required power, and shock tolerance advantages compared to state-of-the-art technologies.

Mainstream Engineering Corporation (Rockledge, FL) developed technology upon which its unique commercial product, QwikBoost™, is based under NASA's SBIR program. The technology was originally developed by the firm to improve efficiency of heat pumps used in NASA spacecraft and planetary heat rejection systems. QwikBoost™ is a low cost liquid refrigerant additive that increases the efficiency of commercial and residential air conditioners, heat pumps, refrigerators, and freezers from 10 percent to 20 percent. Once introduced into an air conditioning/refrigeration system, QwikBoost™ lasts for the life of the system. A side benefit of the product is that it improves the wear properties of compressors and other system components. QwikBoost™ increases the cooling capacity of automotive air-conditioning systems as well. The product also uniquely helps alleviate environmental problems. That is, when production of CFC-12 and other ozone-depleting refrigerants was halted in the U.S. by the Clean Air Act, industry switched to use of HFC-134a refrigerant, resulting in a reduction in vapor compression efficiencies of about 8 percent. Lower efficiencies meant more electrical consumption with a consequence of more power plant emissions. The contribution of QwikBoost™ is significant because it more than offsets the 8 percent loss in efficiency resulting from banning ozone depleting refrigerants in the U.S. while itself being environmentally safe with zero ozone-depletion potential. Other commercial applications by the company based on technologies it developed under NASA's SBIR program are: a) QwikCheck®, which is used to test refrigeration, air conditioning, and heat pump systems for the buildup of harmful acids; b) QwikShot®, which is used to remove the harmful acids before compressor, evaporator coil, and refrigerant are damaged; and, c) QwikFind™, a fluorescent leak-detection fluid that enables automotive technicians to find difficult-to-locate refrigeration system leaks.

EIC Laboratories, Inc. (Norwood, MA) has developed the commercial products Gas-Sentry® and Gas-Ranger™ based upon NASA SBIR technology. These products are utilized to detect natural gas, carbon monoxide, hydrogen sulfide, methane, oxygen, and other combustible gases in various applications which include a) testing and monitoring the safety of ambient air in confined and enclosed spaces; b) testing flue gas for carbon monoxide; c) testing residential units for carbon monoxide; d) locating propane and other combustible gas leaks in industrial and residential settings; e) checking for gas through holes in manhole covers; and, f) measuring methane and oxygen in landfill gas. Gas-Ranger™ detectors are specifically designed for gas and other utility personnel to monitor ambient air for natural gas and methane. The company has also developed its Raman spectroscopy equipment based upon NASA SBIR technology. Raman equipment is utilized to quickly identify chemicals in remote locations and other locations in the field. The identification of chemicals in remote locations utilizing conventional technology is extremely labor intensive since samples need to be collected, transported to the laboratory, and prepared prior to analysis. By enabling quick chemical analysis in the field, utilization of Raman equipment limits exposure of personnel to hazardous substances. Raman technology is also utilized to identify explosives, narcotics, and other illicit substances, as well as for industrial quality control in monitoring incoming materials and outgoing products.

Orbital Technologies Corporation (Madison, WI) has developed the commercial product PedAlert™ based on technology developed under NASA's SBIR program. PedAlert™ is commercially sold for use by patients with hip fractures, hip replacements, foot ulcers, and other conditions which limit weight bearing capability during and after the rehabilitation process. With PedAlert™, the weight placed on the lower limb is constantly monitored. A warning tone alerts the patient if the prescribed weight threshold is exceeded. The device is especially useful for patients whose cognitive status prevents self-monitoring. By lowering the risk of exceeding threshold weights, PedAlert™ reduces patient training time and otherwise simplifies rehabilitation procedures.

Alcorn Laboratories, Inc. (formerly **Autonomous Technologies Corporation**) (Orlando, FL) has developed LADARVision® technology under NASA's SBIR program. LADARVision® has received Food and Drug Administration (FDA) approval and is currently used to correct nearsightness, farsightness, and astigmatism by reshaping the cornea with a laser beam. Although alternative FDA-approved laser systems are currently employed to treat patients, the systems offer varying accuracy regarding their ability to track unavoidable, constant eye movements during laser surgery as well as the size and shape of the laser beam. If a laser system's tracker cannot keep up with the constant, involuntary motion of the eyes, the laser beam will not be directed to the exact spot on the cornea that needs reshaping. The FDA currently recognizes the LADARVision® tracker as offering the highest accuracy of any available system and therefore the accuracy with which the cornea is reshaped. LADARVision® tracks eyeball movements 4000 times per second during surgery. Also, not all laser eye surgery systems can correct astigmatism; however, given its superior technology, LADARVision® can correct astigmatism.

DelSys, Inc. (Boston, MA) utilizes technology developed in part under NASA's SBIR program in its commercial MyoMonitor® system. The enabling technology was originally developed for NASA to study the prolonged effects of zero gravity on the muscles of astronauts. MyoMonitor® is carried in a waist pack and is used for monitoring rehabilitative therapy, work place injury prevention, evaluation of recovery from physical injuries, ergonomics in the workplace, exercise training, motion studies, and for research in clinical environments. MyoMonitor® is uniquely suited for monitoring activities in remote or in constrained environments. Unique features of the technology include enabling the monitoring of muscle performance away from the laboratory. For example, MyoMonitor® makes it now possible to monitor muscle activity during a tennis serve, a baseball pitch, or a golf swing; recording electromyography (EMG) signals is no longer constrained by the necessity for immobile equipment. Also, significantly greater precision in measurement is achieved since the electrode-skin interface, which is compromised by movement of the skin and sweat during activity, is not a limiting factor in MyoMonitor® technology as it is in traditional EMG equipment.

Appendix F

Supporting Graphics

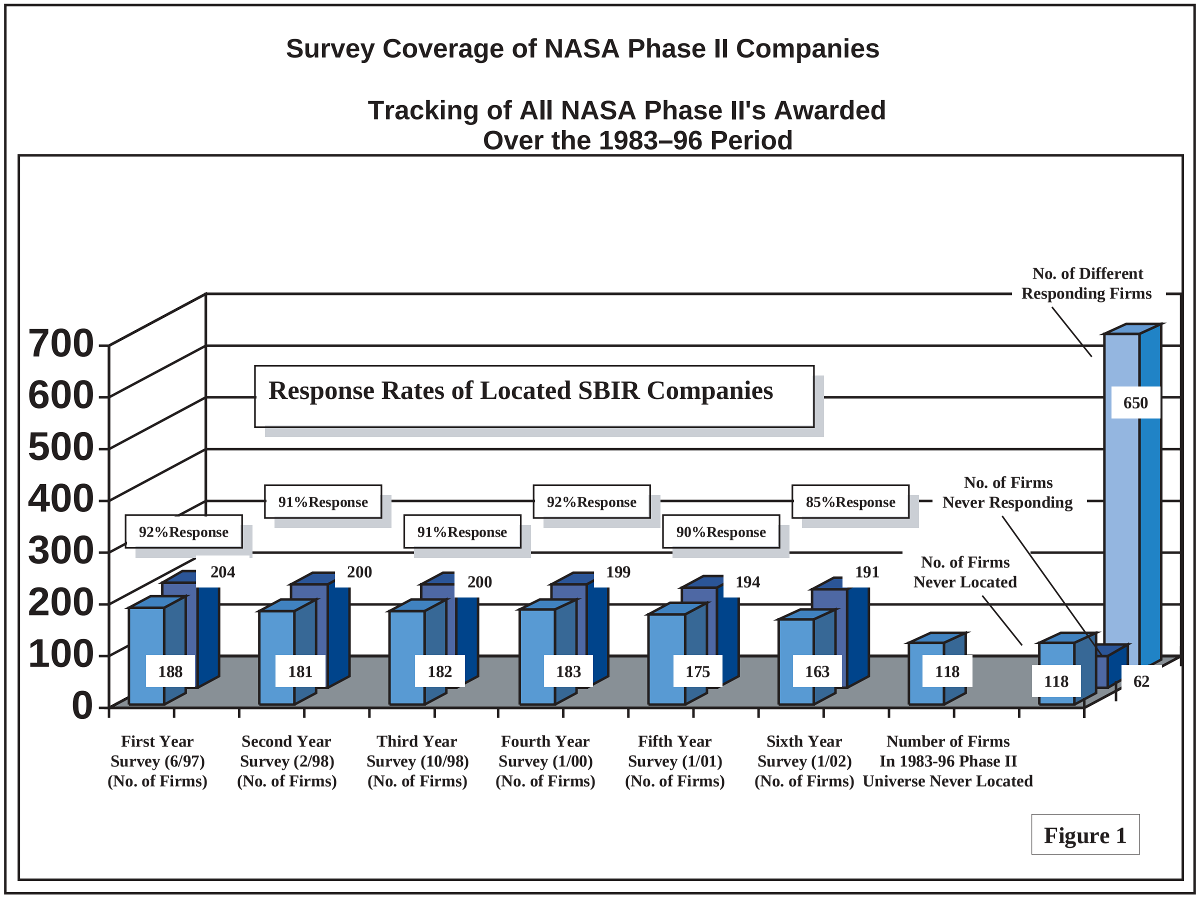
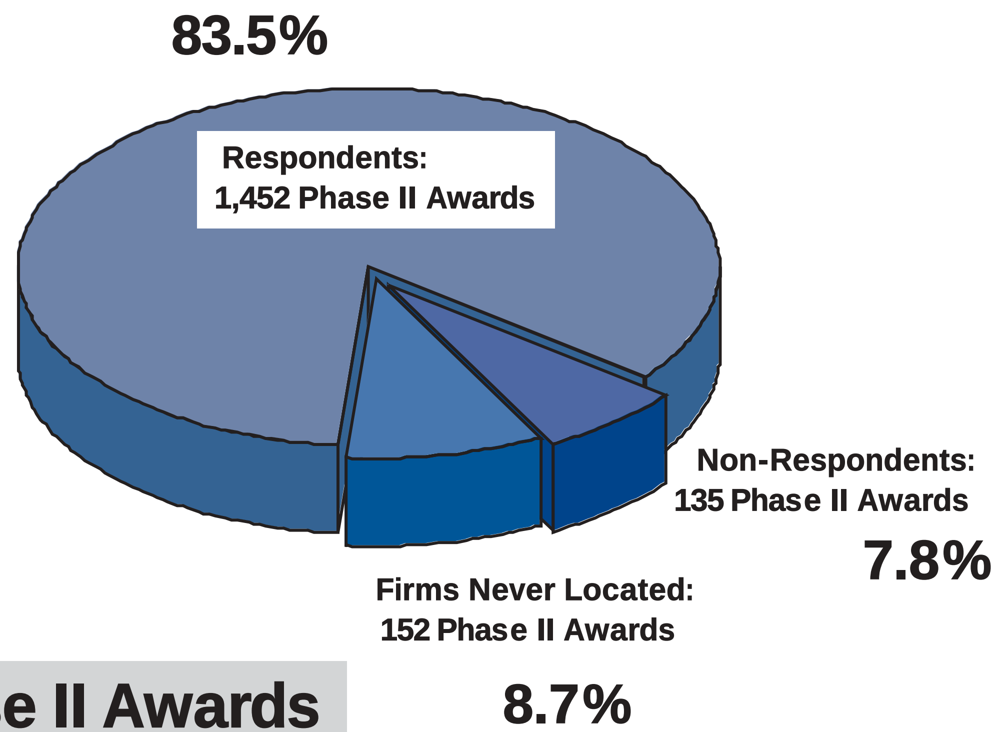


Figure 1

Survey Coverage of All 1,739 1983–96 NASA Phase II Awards



100% = 1,739 Phase II Awards

Figure 2

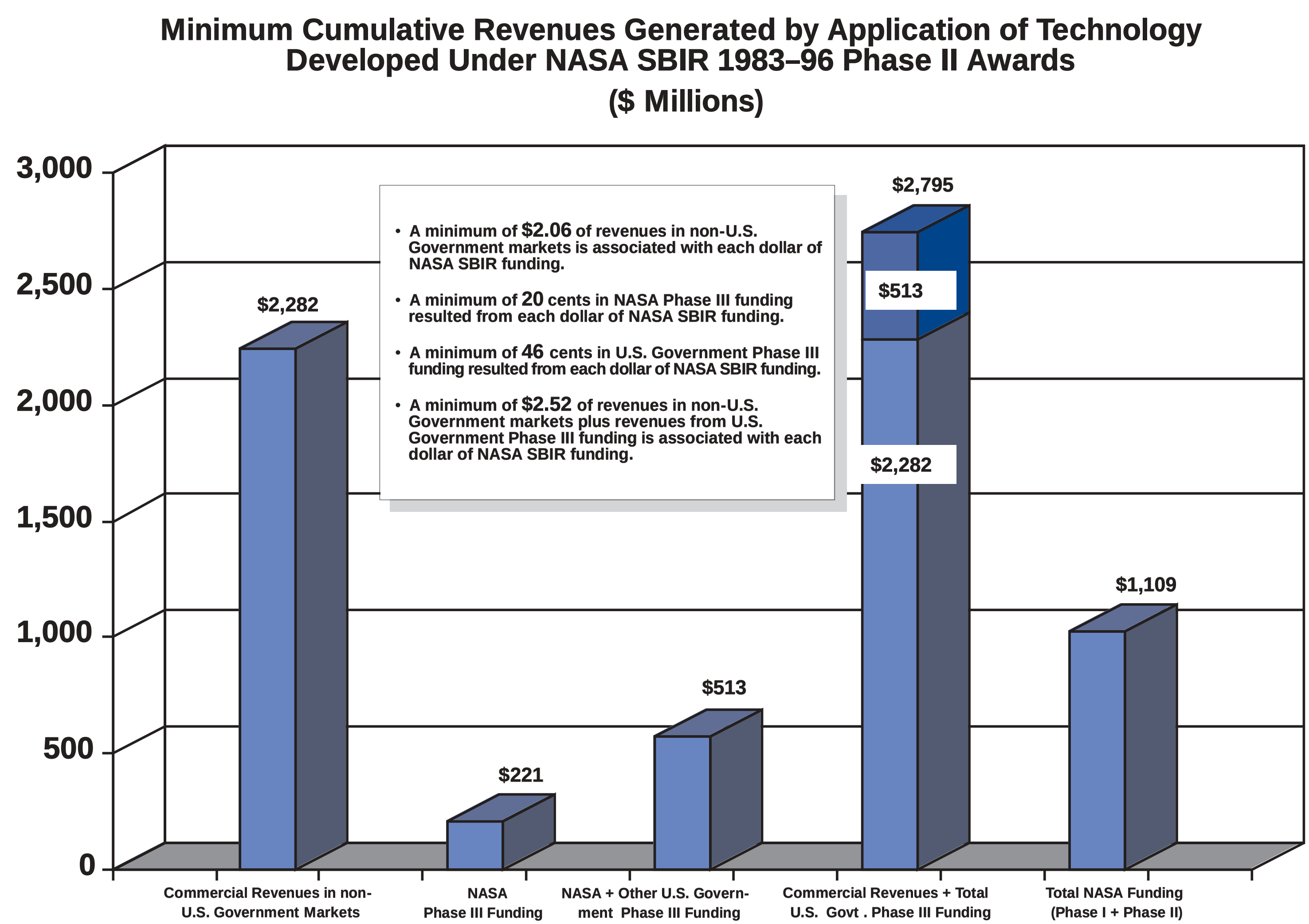

Minimum Cumulative Revenues Generated by Application of Technology Developed Under NASA SBIR 1983–96 Phase II Awards
($ Millions)
3,000
2,500
2,000
1,500
1,000
500
0
• A minimum of $2.06 of revenues in non-U.S. Government markets is associated with each dollar of NASA SBIR funding.
• A minimum of 20 cents in NASA Phase III funding resulted from each dollar of NASA SBIR funding.
• A minimum of 46 cents in U.S. Government Phase III funding resulted from each dollar of NASA SBIR funding.
• A minimum of $2.52 of revenues in non-U.S. Government markets plus revenues from U.S. Government Phase III funding is associated with each dollar of NASA SBIR funding.
$2,282
$221
$513
$2,795
$513
$2,282
$1,109
Commercial Revenues in non-U.S. Government Markets
NASA Phase III Funding
NASA + Other U.S. Government Phase III Funding
Commercial Revenues + Total U.S. Govt . Phase III Funding
Total NASA Funding (Phase I + Phase II)

Figure 3

Application of NASA SBIR Technology in Non-U.S. Government and U.S. Government Markets

Re: Tracking of Phase II Awards for Award Years FY 1983–96

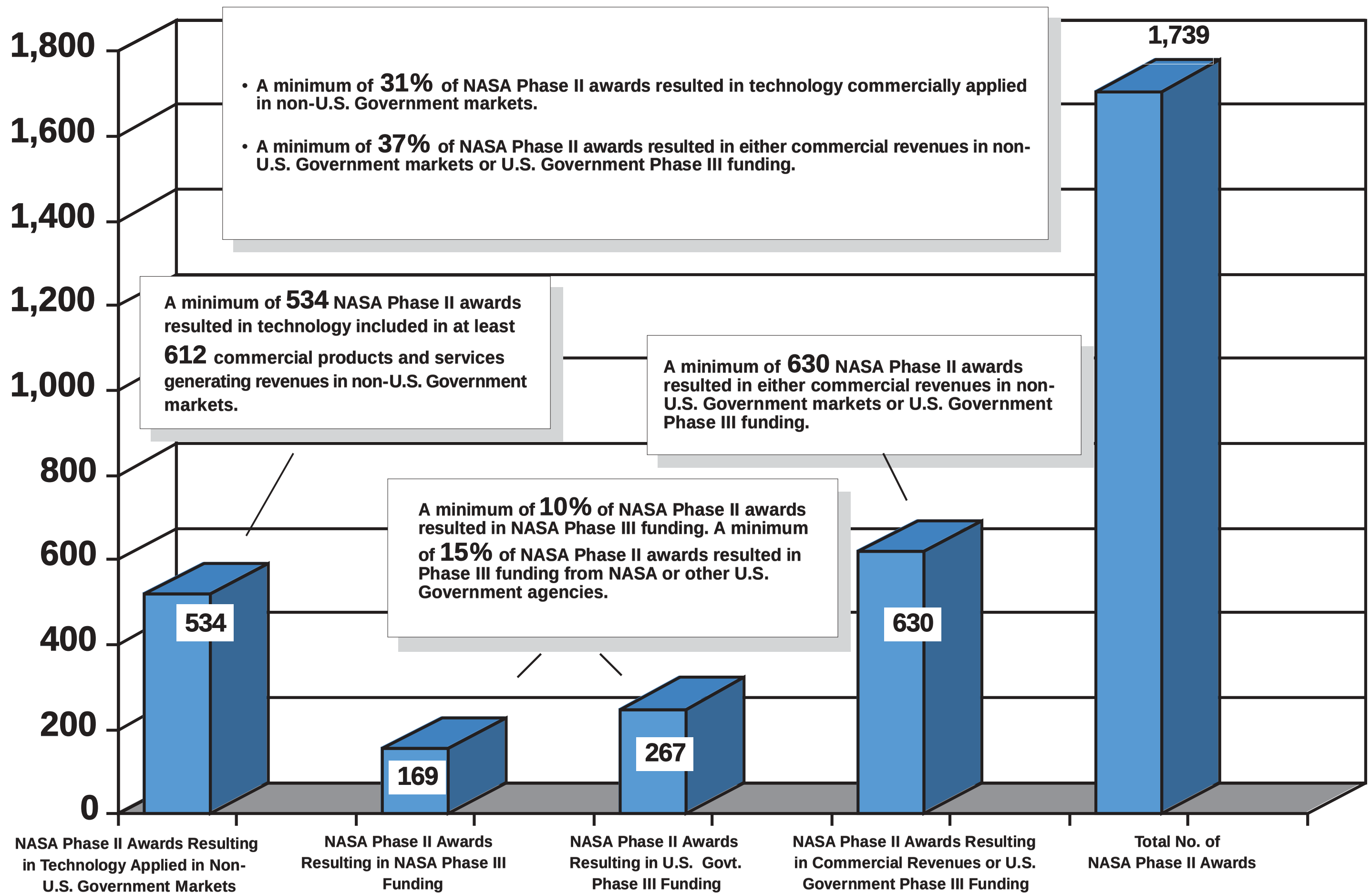


Figure 4

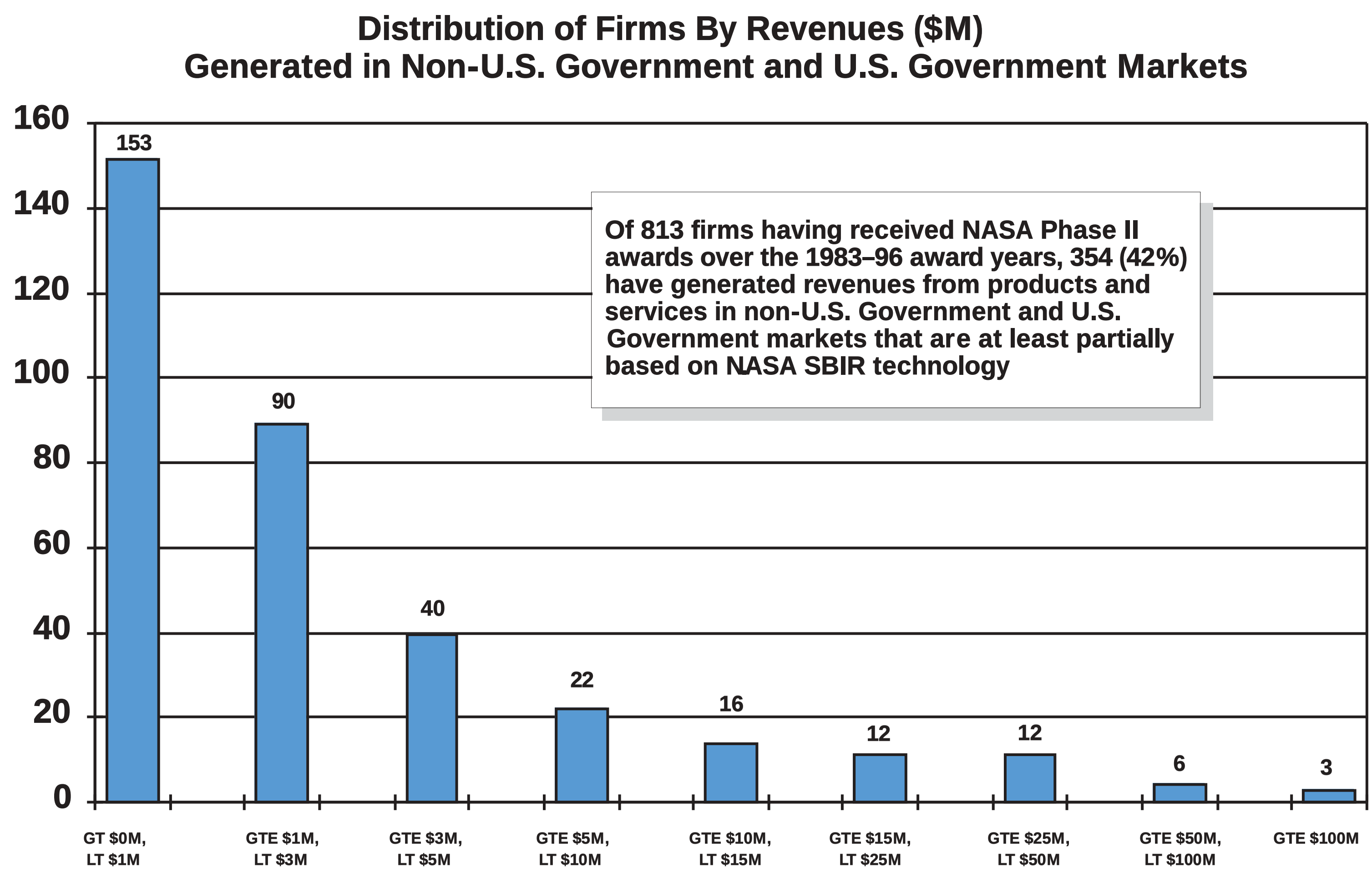

Distribution of Firms By Revenues ($M)
Generated in Non-U.S. Government and U.S. Government Markets
160
140
120
100
80
60
40
20
0
153
90
40
22
16
12
12
6
3
Of 813 firms having received NASA Phase II awards over the 1983–96 award years, 354 (42%) have generated revenues from products and services in non-U.S. Government and U.S. Government markets that are at least partially based on NASA SBIR technology
GT $0M, LT $1M
GTE $1M, LT $3M
GTE $3M, LT $5M
GTE $5M, LT $10M
GTE $10M, LT $15M
GTE $15M, LT $25M
GTE $25M, LT $50M
GTE $50M, LT $100M
GTE $100M

Figure 5

Commercial Products/Services at Least Partially Based on NASA-Funded Technology for the 1983–96 SBIR Award Years

Distribution by SBA Industrial Sectors

(All Numbers Are Minimums)

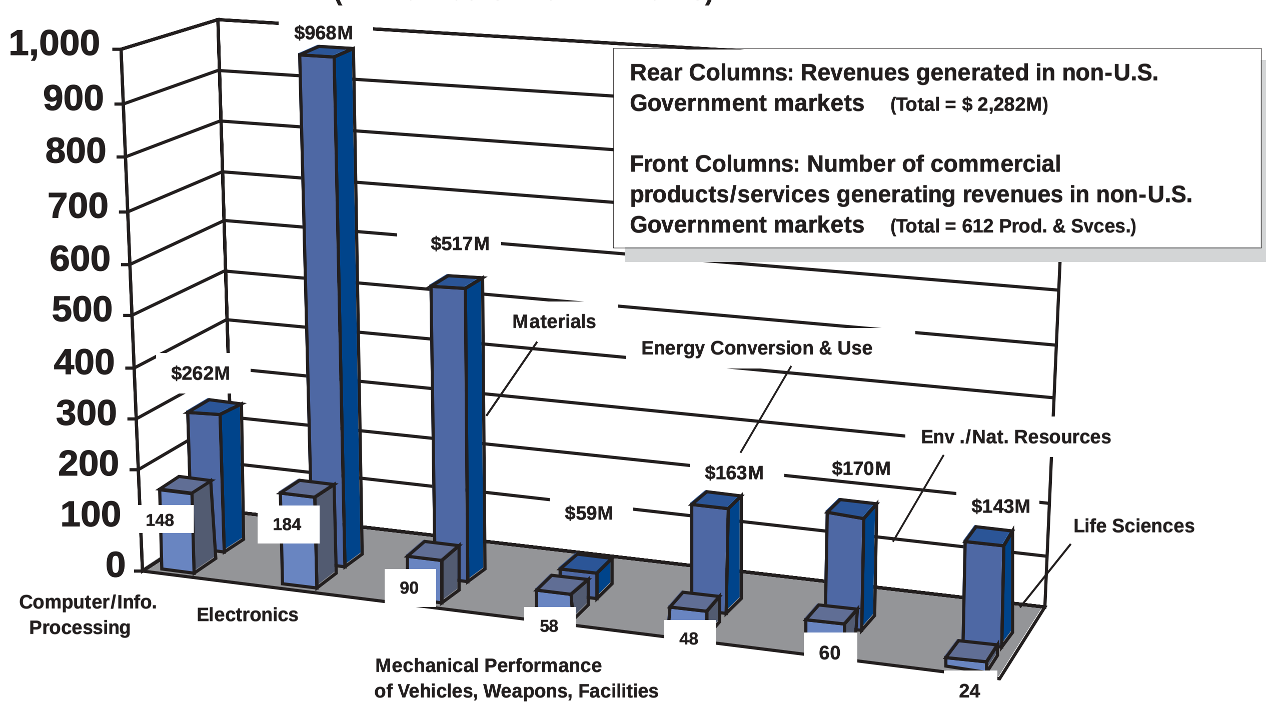


Figure 6

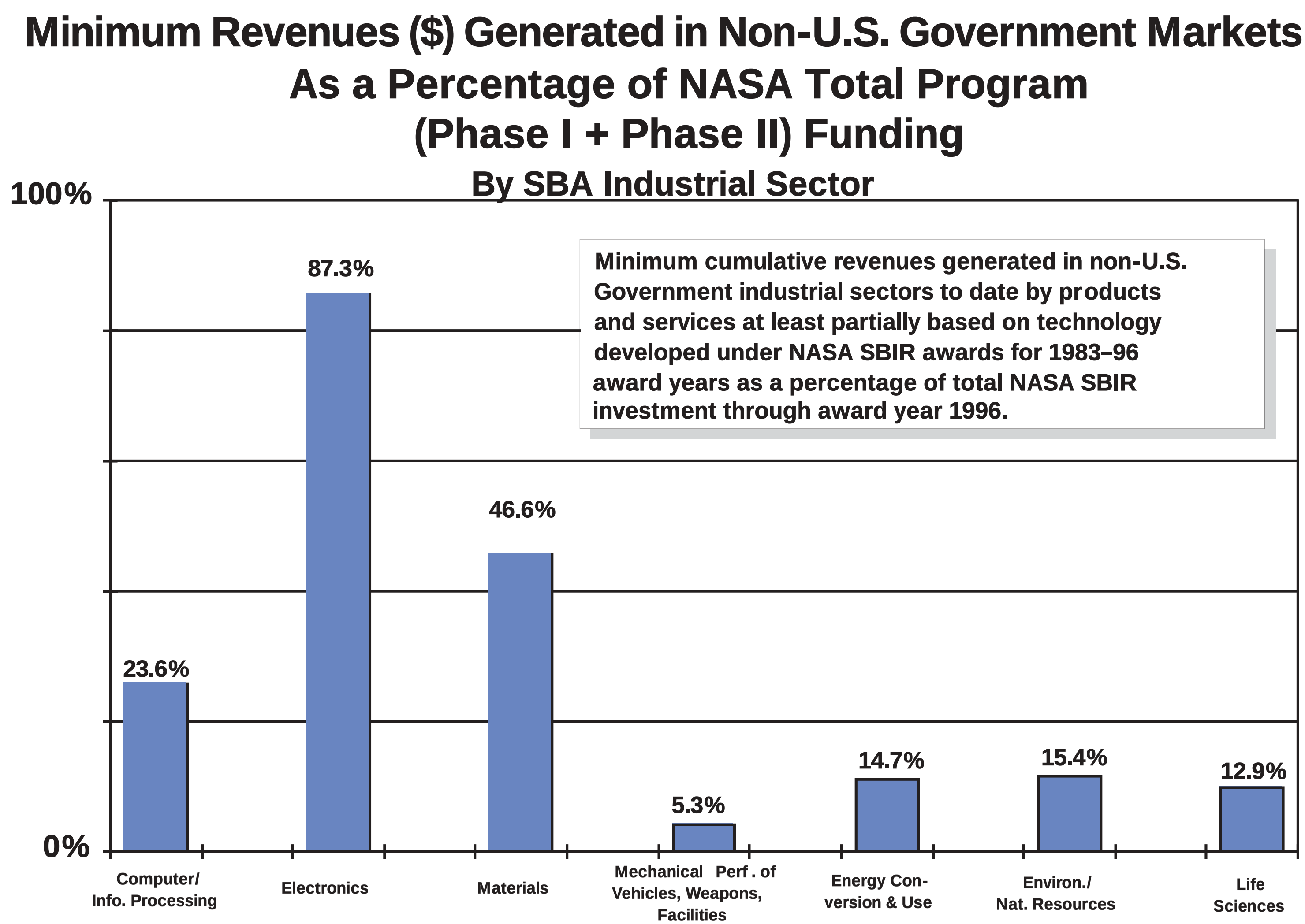

Minimum Revenues ($) Generated in Non-U.S. Government Markets
As a Percentage of NASA Total Program
(Phase I + Phase II) Funding
By SBA Industrial Sector
100%
0%
Minimum cumulative revenues generated in non-U.S. Government industrial sectors to date by products and services at least partially based on technology developed under NASA SBIR awards for 1983–96 award years as a percentage of total NASA SBIR investment through award year 1996.
23.6%
87.3%
46.6%
5.3%
14.7%
15.4%
12.9%
Computer/ Info. Processing
Electronics
Materials
Mechanical Perf . of Vehicles, Weapons, Facilities
Energy Con-version & Use
Environ./ Nat. Resources
Life Sciences

Figure 7

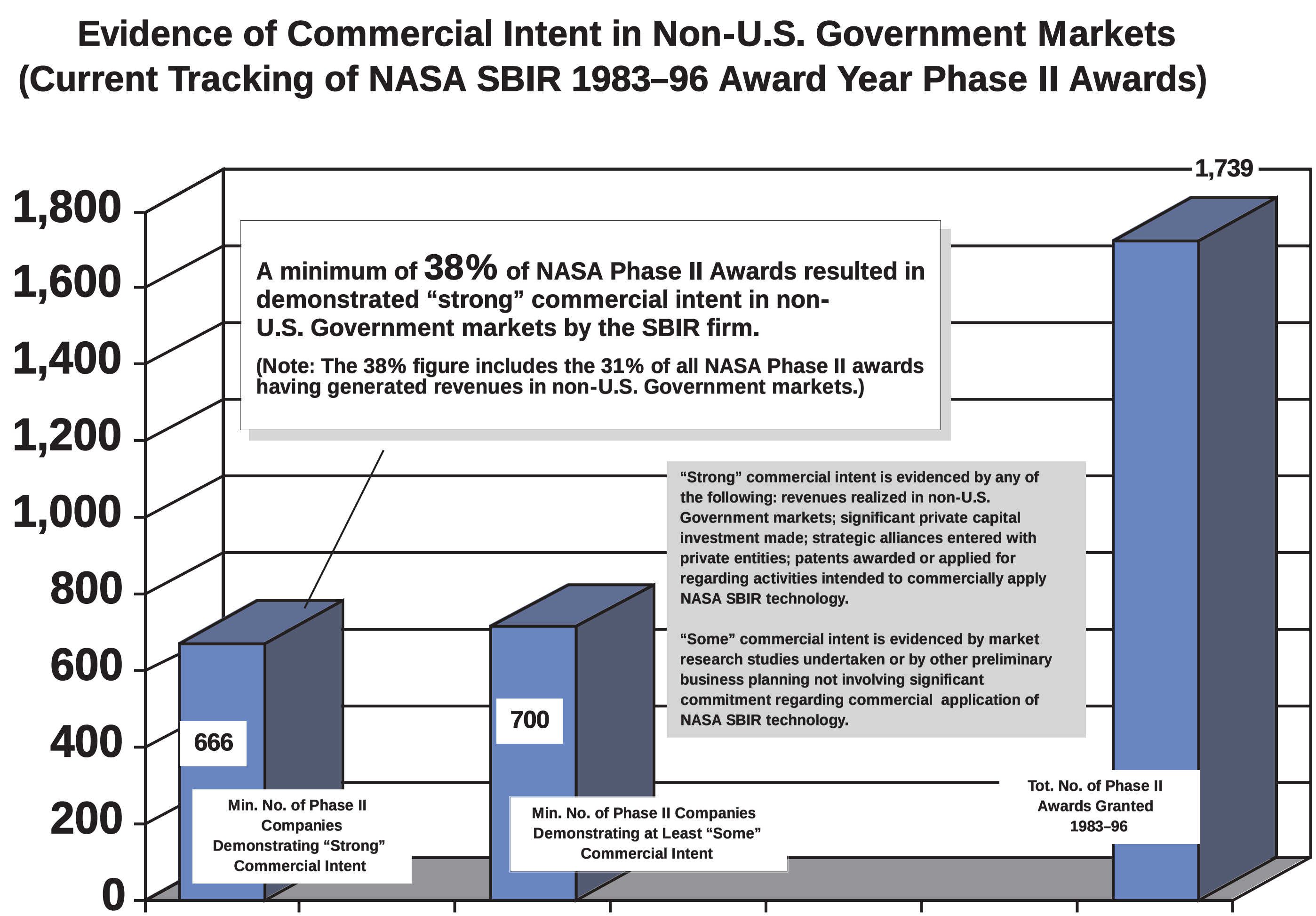

Evidence of Commercial Intent in Non-U.S. Government Markets
(Current Tracking of NASA SBIR 1983–96 Award Year Phase II Awards)
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1,739
A minimum of 38% of NASA Phase II Awards resulted in demonstrated "strong" commercial intent in non-U.S. Government markets by the SBIR firm.
(Note: The 38% figure includes the 31% of all NASA Phase II awards having generated revenues in non-U.S. Government markets.)
"Strong" commercial intent is evidenced by any of the following: revenues realized in non-U.S. Government markets; significant private capital investment made; strategic alliances entered with private entities; patents awarded or applied for regarding activities intended to commercially apply NASA SBIR technology.
"Some" commercial intent is evidenced by market research studies undertaken or by other preliminary business planning not involving significant commitment regarding commercial application of NASA SBIR technology.
666
700
Min. No. of Phase II Companies Demonstrating "Strong" Commercial Intent
Min. No. of Phase II Companies Demonstrating at Least "Some" Commercial Intent
Tot. No. of Phase II Awards Granted 1983–96

Figure 8

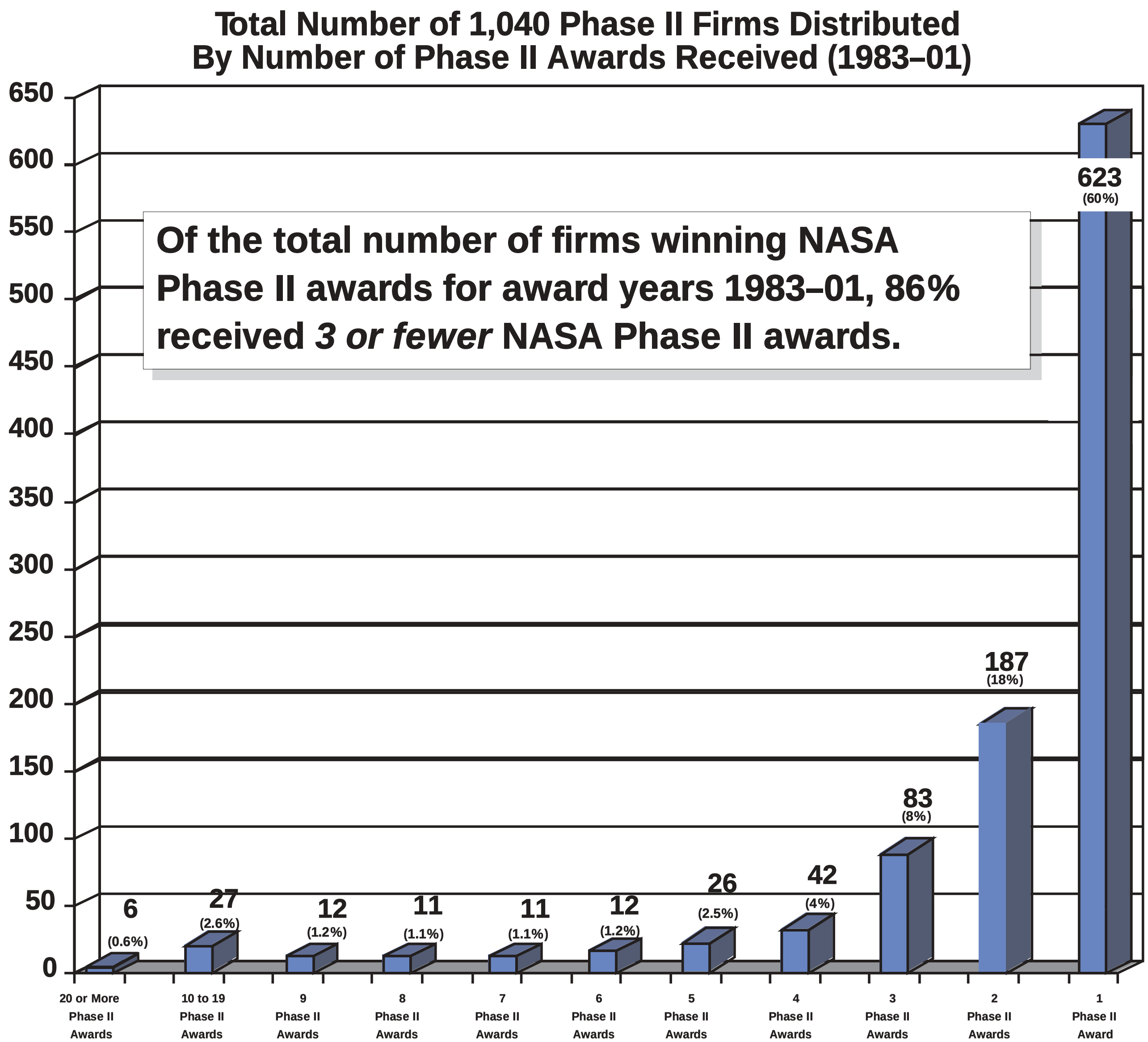

Total Number of 1,040 Phase II Firms Distributed
By Number of Phase II Awards Received (1983–01)
Of the total number of firms winning NASA Phase II awards for award years 1983–01, 86% received 3 or fewer NASA Phase II awards.
650
600
550
500
450
400
350
300
250
200
150
100
50
0
6 (0.6%)
27 (2.6%)
12 (1.2%)
11 (1.1%)
11 (1.1%)
12 (1.2%)
26 (2.5%)
42 (4%)
83 (8%)
187 (18%)
623 (60%)
20 or More Phase II Awards
10 to 19 Phase II Awards
9 Phase II Awards
8 Phase II Awards
7 Phase II Awards
6 Phase II Awards
5 Phase II Awards
4 Phase II Awards
3 Phase II Awards
2 Phase II Awards
1 Phase II Award

Figure 9

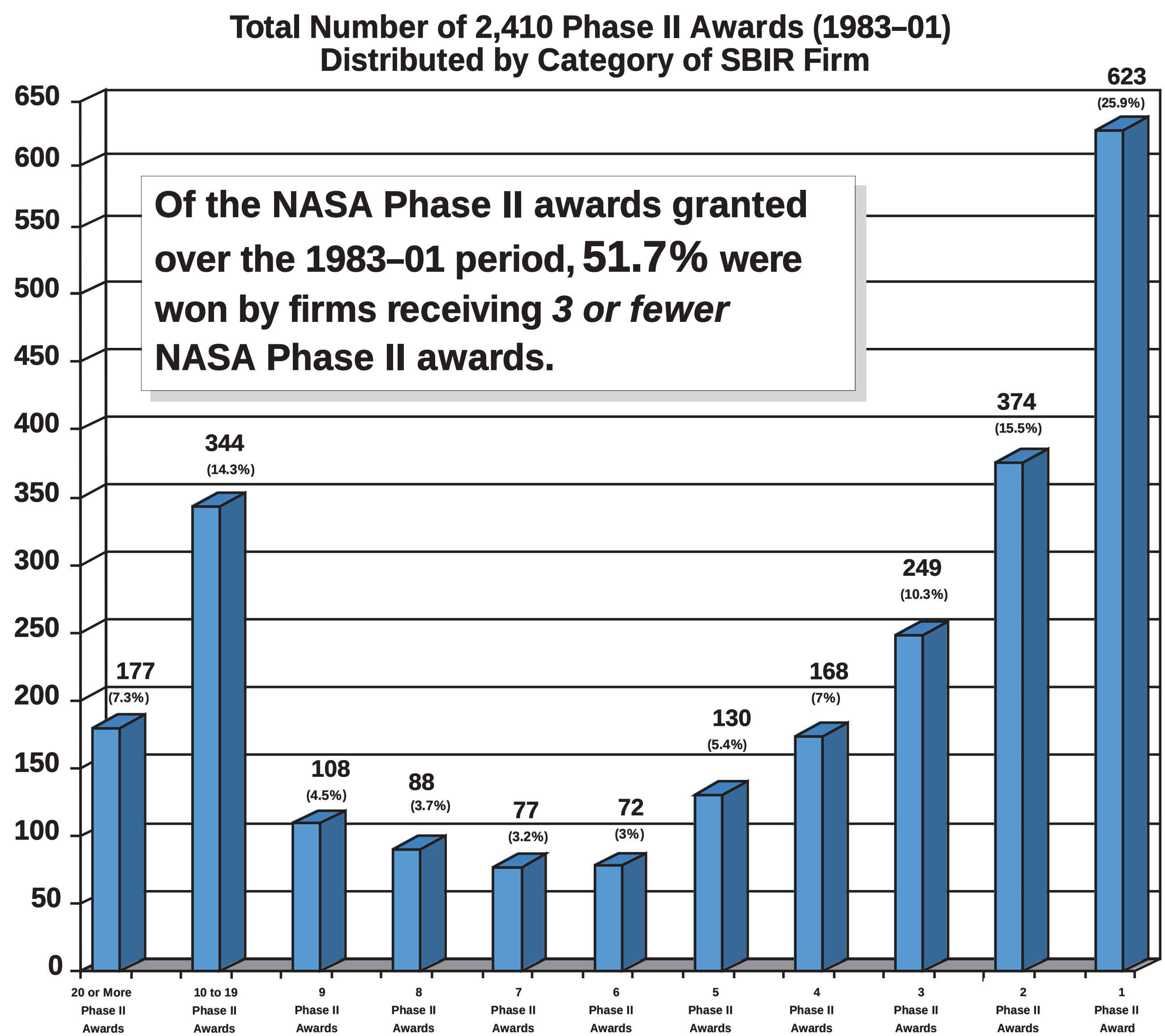
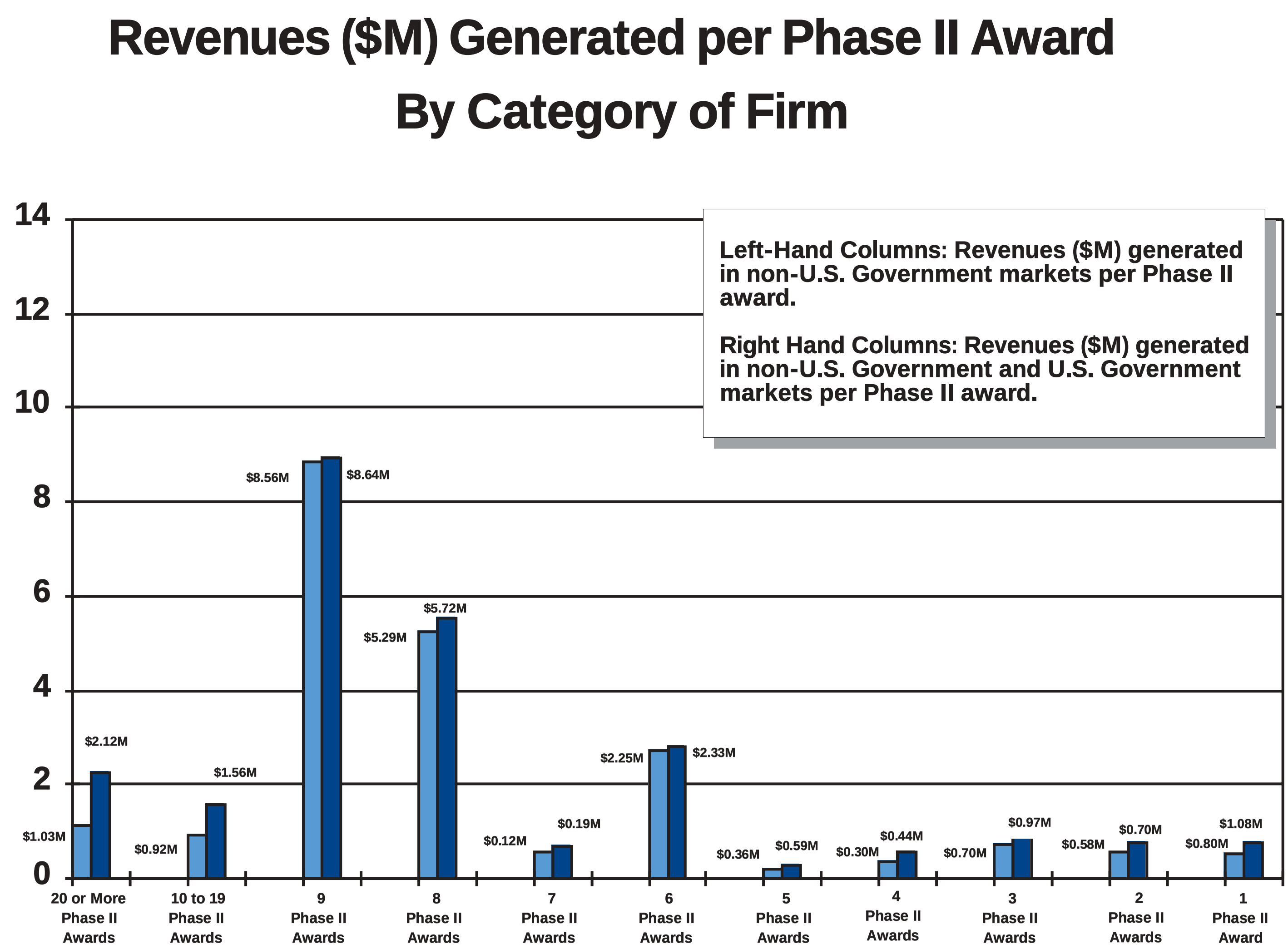

Total Number of 2,410 Phase II Awards (1983–01)
Distributed by Category of SBIR Firm
Of the NASA Phase II awards granted over the 1983–01 period, 51.7% were won by firms receiving *3 or fewer* NASA Phase II awards.
650
600
550
500
450
400
350
300
250
200
150
100
50
0
177
(7.3%)
344
(14.3%)
108
(4.5%)
88
(3.7%)
77
(3.2%)
72
(3%)
130
(5.4%)
168
(7%)
249
(10.3%)
374
(15.5%)
623
(25.9%)
20 or More Phase II Awards
10 to 19 Phase II Awards
9 Phase II Awards
8 Phase II Awards
7 Phase II Awards
6 Phase II Awards
5 Phase II Awards
4 Phase II Awards
3 Phase II Awards
2 Phase II Awards
1 Phase II Award

Figure 10



Revenues ($M) Generated per Phase II Award
By Category of Firm
Left-Hand Columns: Revenues ($M) generated in non-U.S. Government markets per Phase II award.
Right Hand Columns: Revenues ($M) generated in non-U.S. Government and U.S. Government markets per Phase II award.
0
2
4
6
8
10
12
14
$1.03M
$2.12M
$0.92M
$1.56M
$8.56M
$8.64M
$5.29M
$5.72M
$0.12M
$0.19M
$2.25M
$2.33M
$0.36M
$0.59M
$0.30M
$0.44M
$0.70M
$0.97M
$0.58M
$0.70M
$0.80M
$1.08M
20 or More Phase II Awards
10 to 19 Phase II Awards
9 Phase II Awards
8 Phase II Awards
7 Phase II Awards
6 Phase II Awards
5 Phase II Awards
4 Phase II Awards
3 Phase II Awards
2 Phase II Awards
1 Phase II Award

Figure 11

Revenues ($M) Generated in Non-U.S. Government Markets By Category of Firm

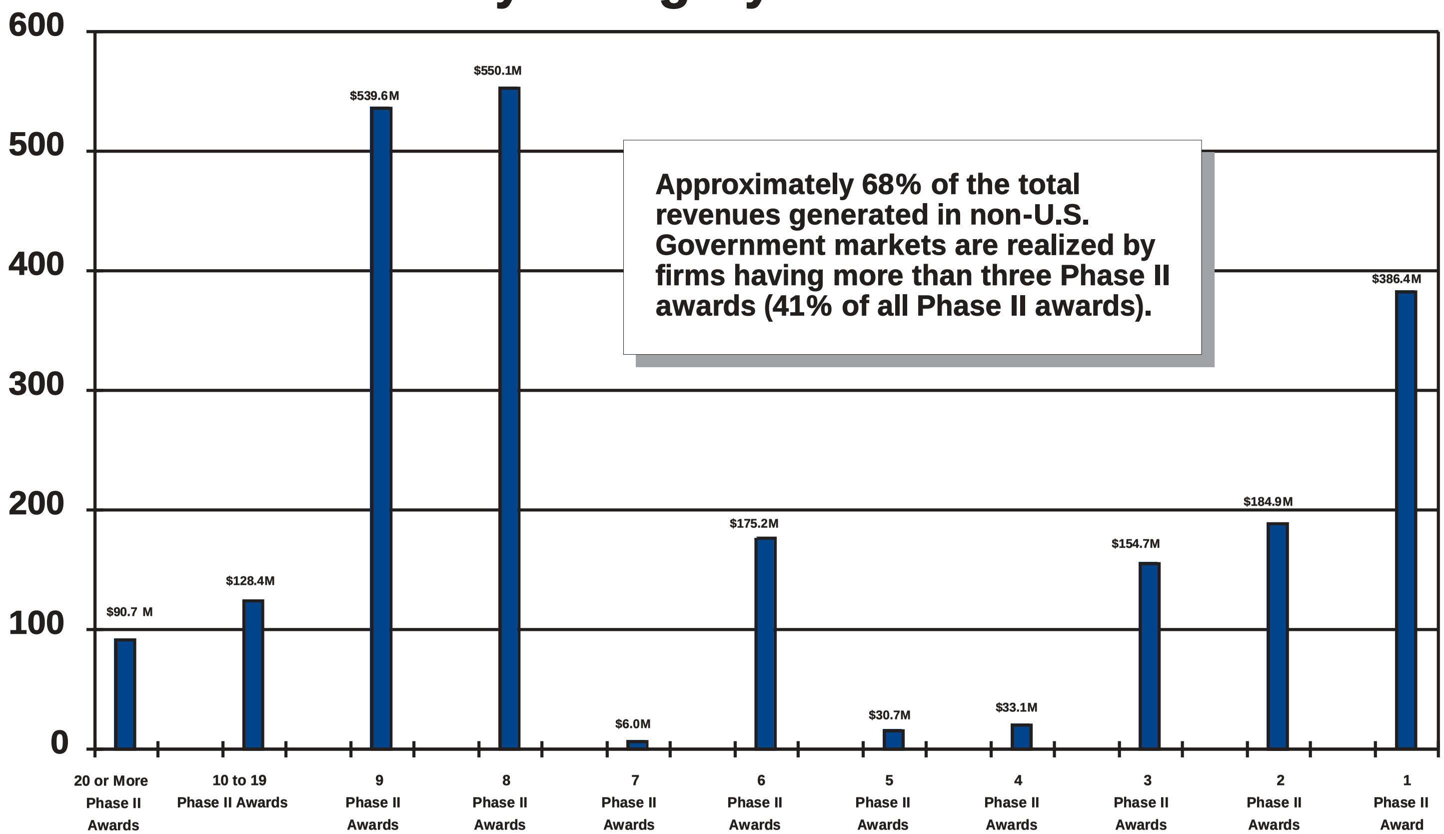


Figure 12

Number of Firms for Which Associated Total Revenues in Non-U.S. Government and U.S Government Markets = Zero By Category of Firm

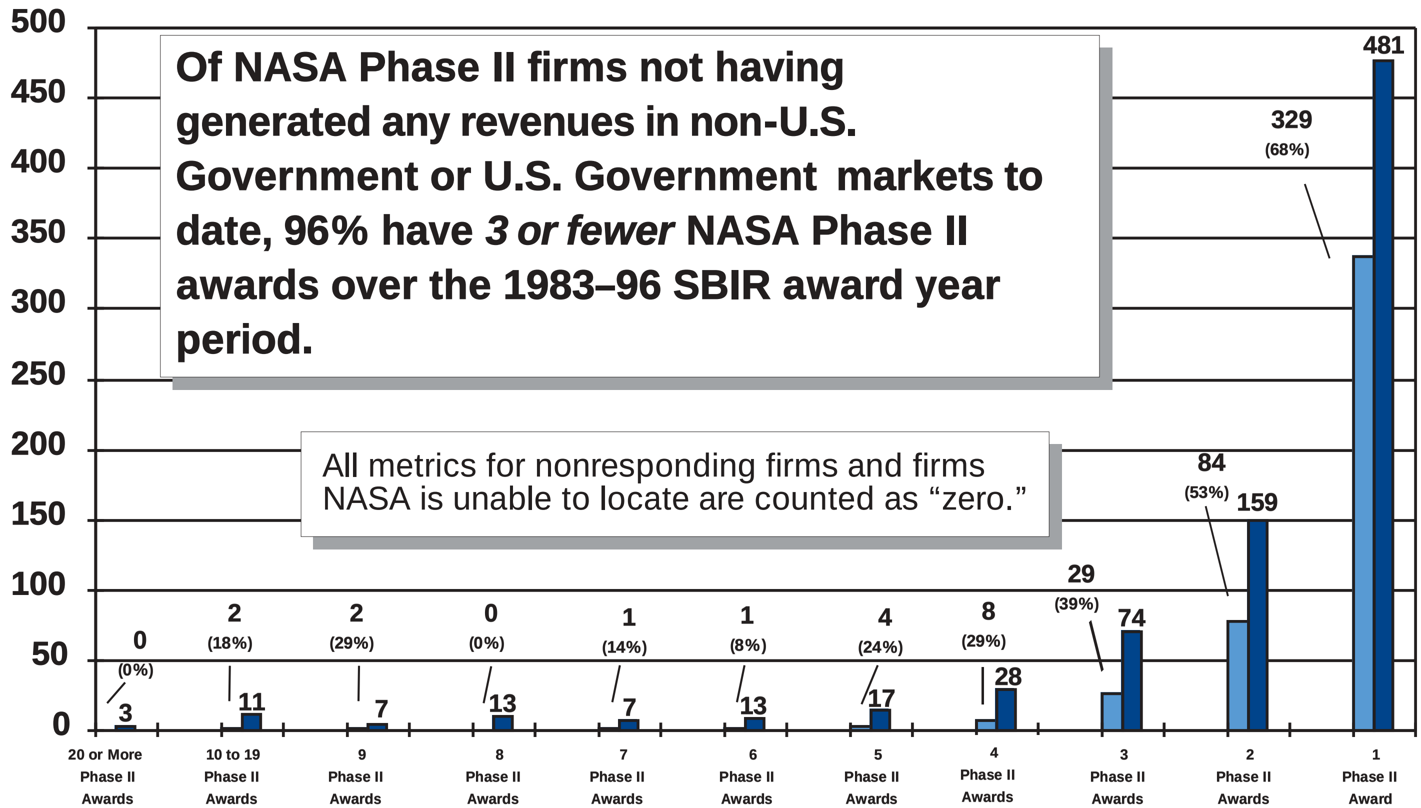


Figure 13

Percentage of Companies Receiving NASA Phase II Awards That Are First-Time Recipients of NASA Phase II Awards

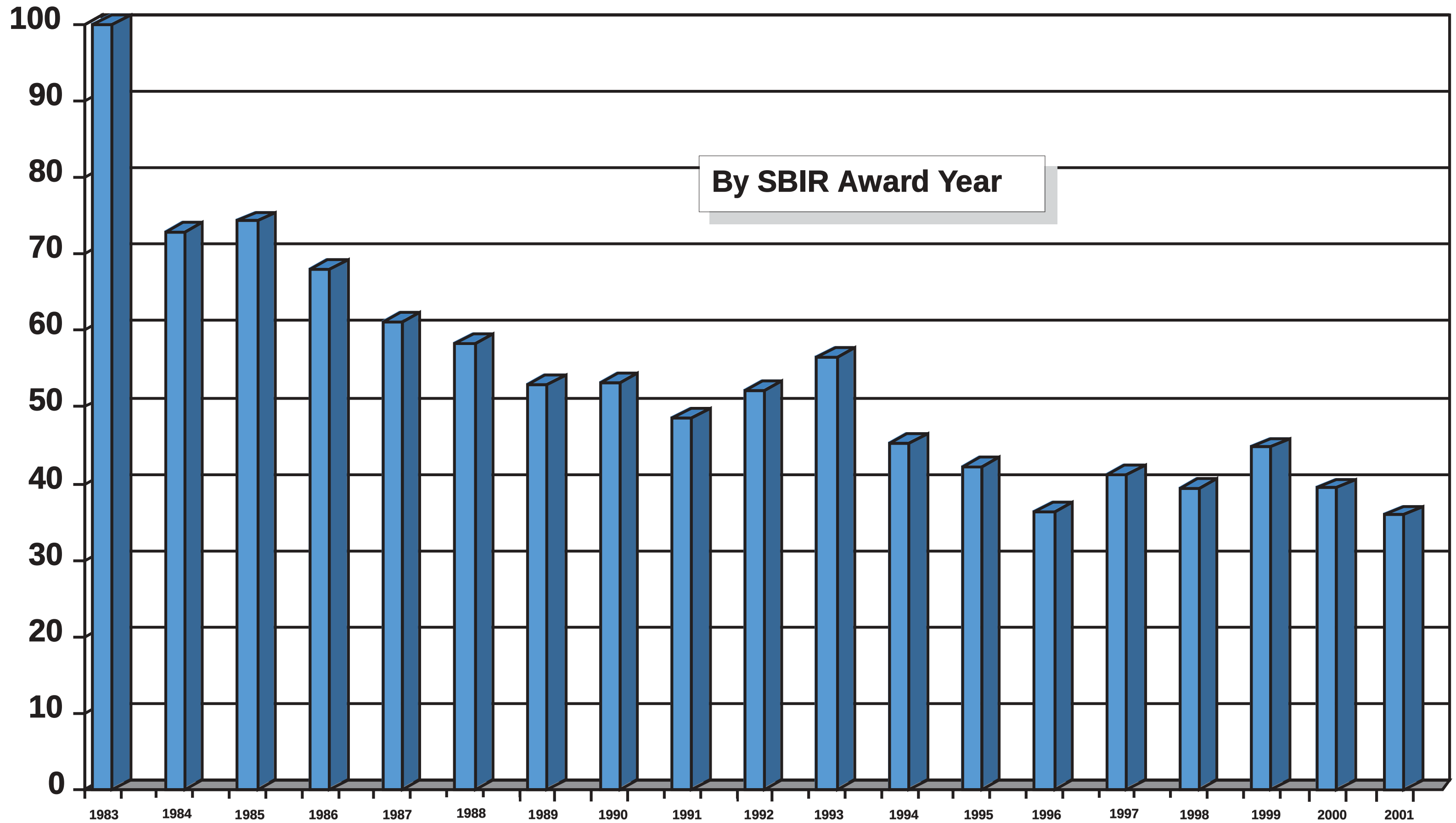


Figure 14

Tracking 1983–94 Phase II Awards:
Some Comparisons of Initial Survey Results With Re-survey Results

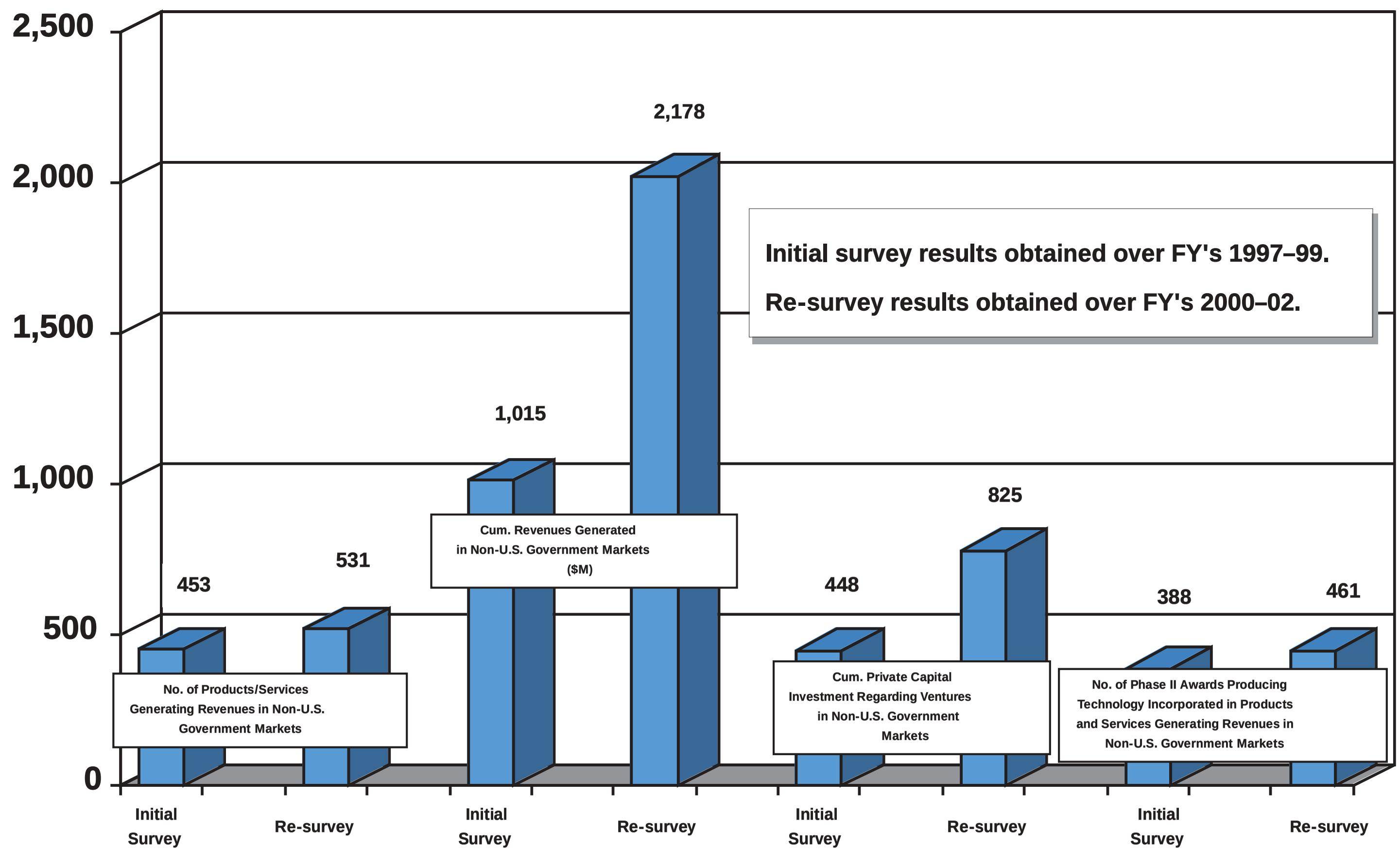


Figure 15

Tracking 1983–94 Phase II Awards:

Some Comparisons of
Initial Survey Results With Re-survey Results

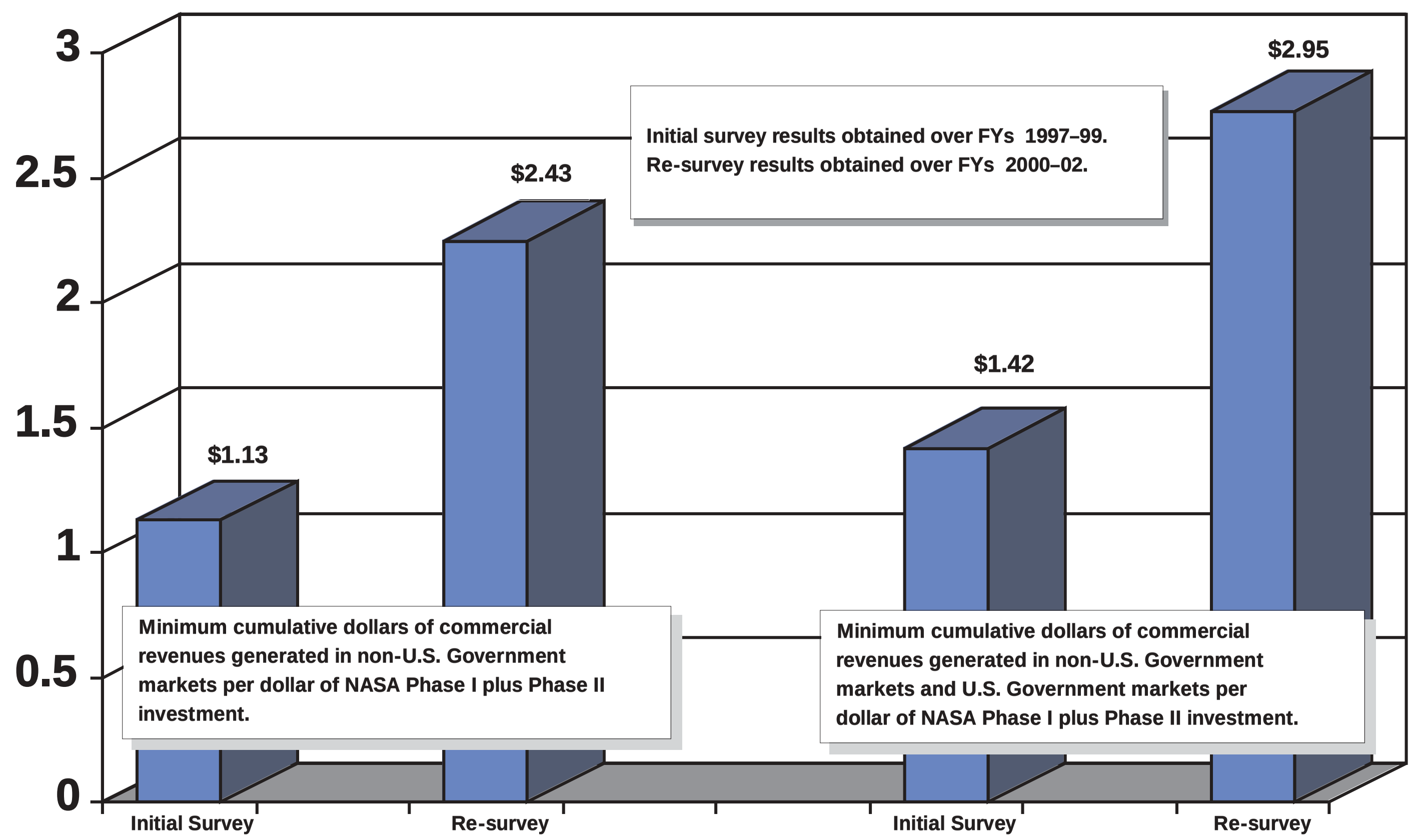
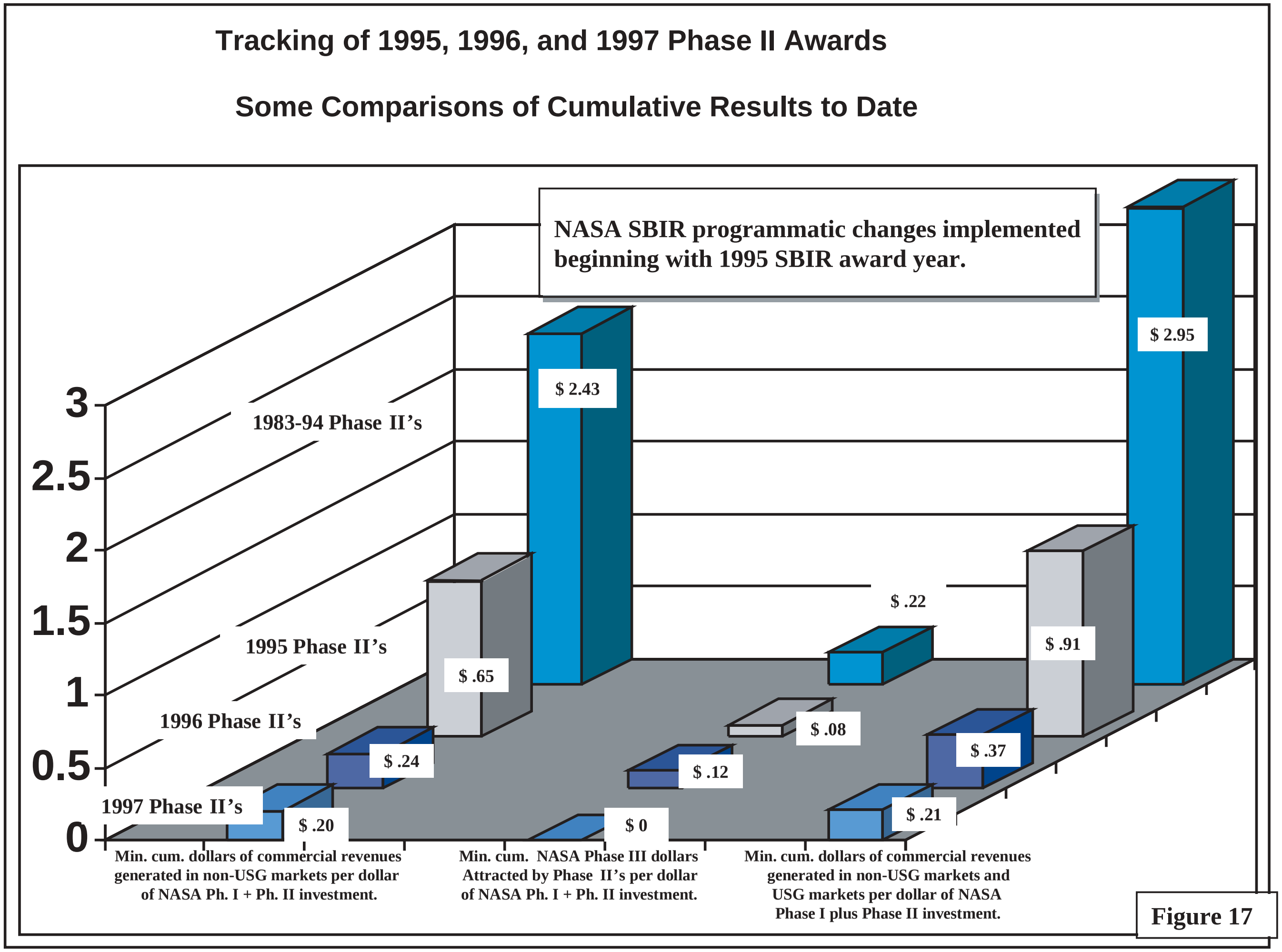


Figure 16



Tracking of 1995, 1996, and 1997 Phase II Awards
Some Comparisons of Cumulative Results to Date
NASA SBIR programmatic changes implemented beginning with 1995 SBIR award year.
3
2.5
2
1.5
1
0.5
0
1983-94 Phase II's
1995 Phase II's
1996 Phase II's
1997 Phase II's
$ 2.43
$ .65
$ .24
$ .20
$ .12
$ .08
$ .22
$ 0
$ 2.95
$ .91
$ .37
$ .21
Min. cum. dollars of commercial revenues generated in non-USG markets per dollar of NASA Ph. I + Ph. II investment.
Min. cum. NASA Phase III dollars Attracted by Phase II's per dollar of NASA Ph. I + Ph. II investment.
Min. cum. dollars of commercial revenues generated in non-USG markets and USG markets per dollar of NASA Phase I plus Phase II investment.
Figure 17

Figure 17

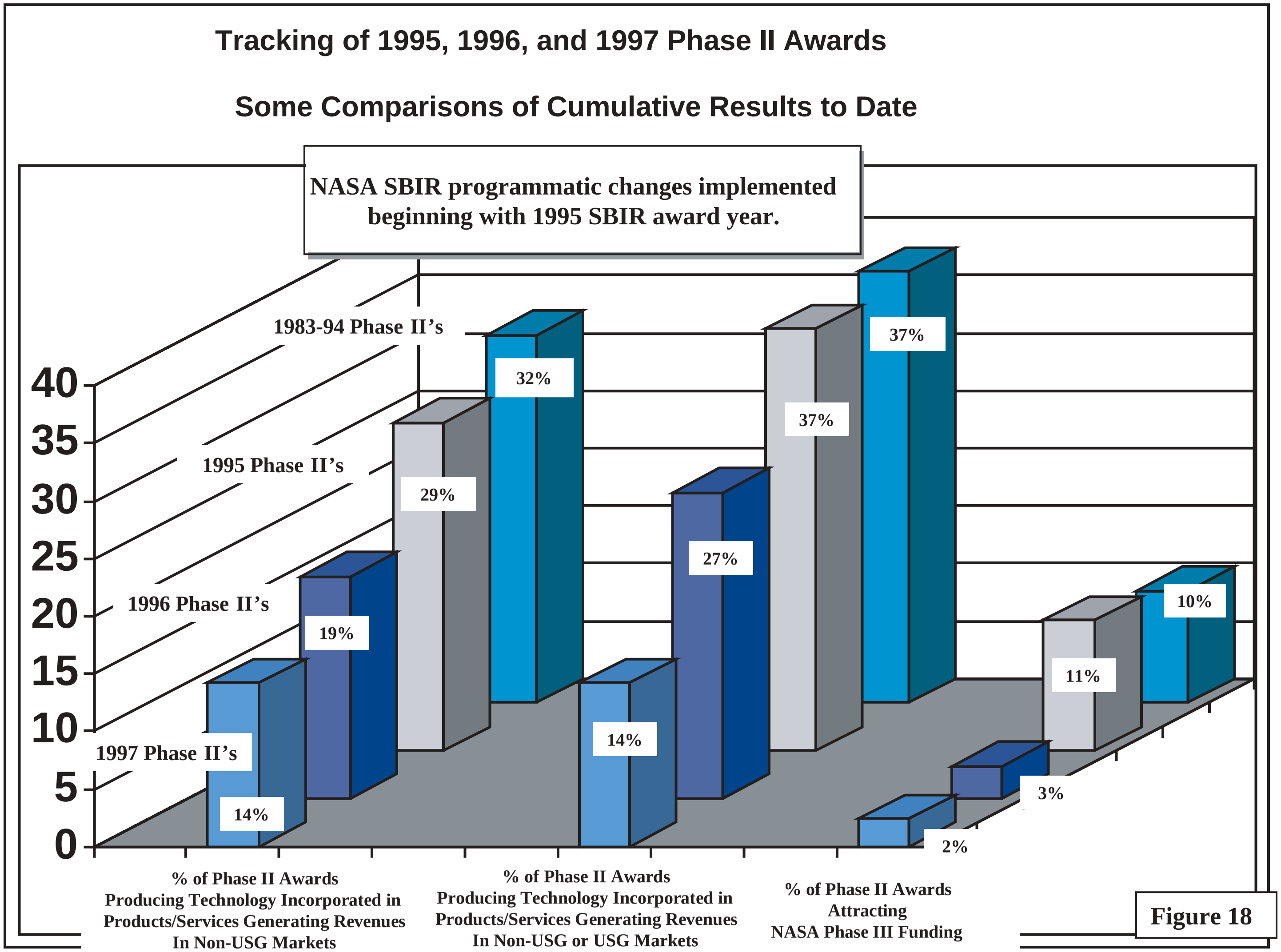

Tracking of 1995, 1996, and 1997 Phase II Awards
Some Comparisons of Cumulative Results to Date
NASA SBIR programmatic changes implemented beginning with 1995 SBIR award year.
1983-94 Phase II's
1995 Phase II's
1996 Phase II's
1997 Phase II's
40
35
30
25
20
15
10
5
0
14%
19%
29%
32%
14%
27%
37%
37%
2%
3%
11%
10%
% of Phase II Awards Producing Technology Incorporated in Products/Services Generating Revenues In Non-USG Markets
% of Phase II Awards Producing Technology Incorporated in Products/Services Generating Revenues In Non-USG or USG Markets
% of Phase II Awards Attracting NASA Phase III Funding
Figure 18

Figure 18

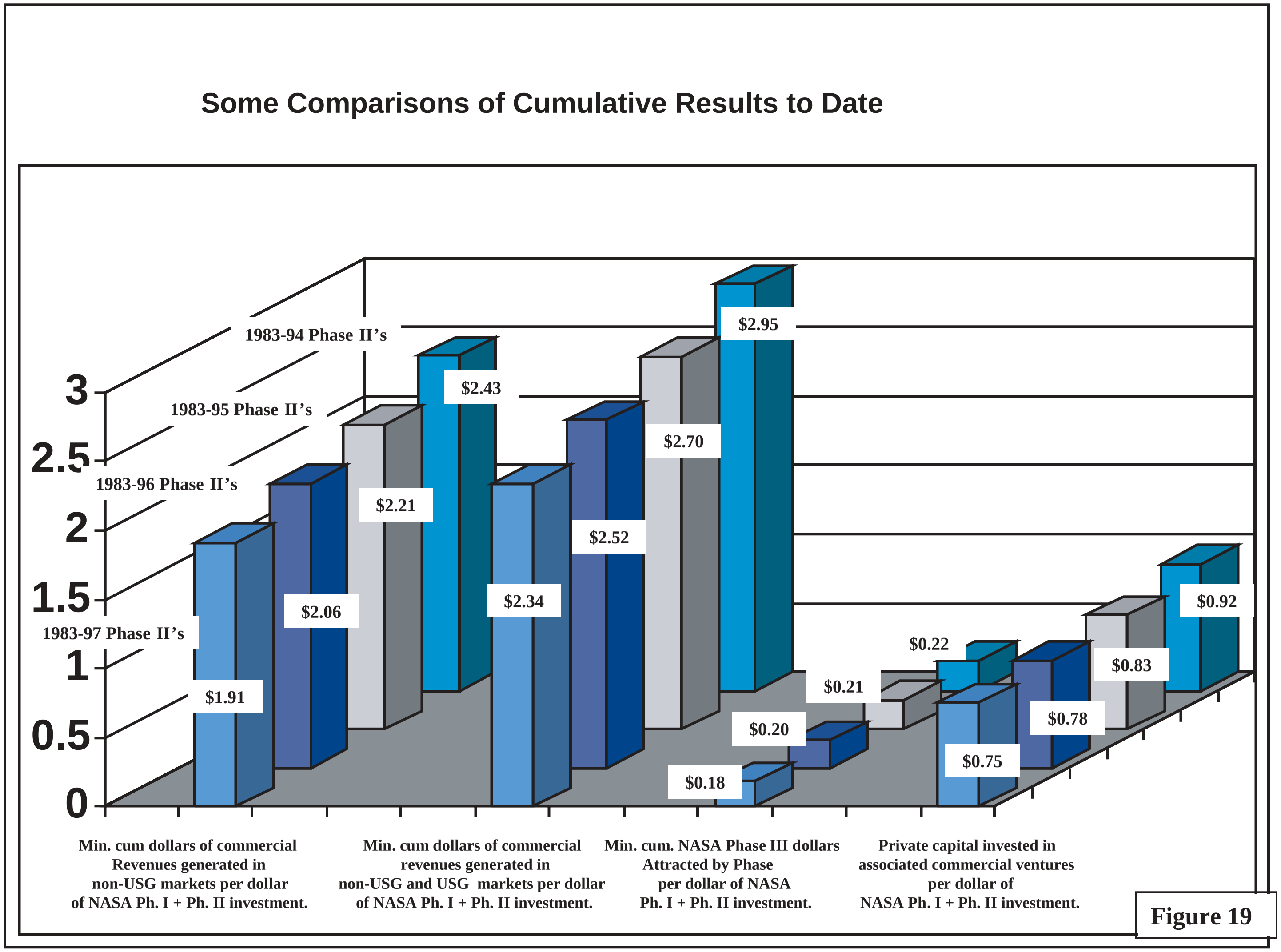

Some Comparisons of Cumulative Results to Date
3
2.5
2
1.5
1
0.5
0
1983-94 Phase II's
1983-95 Phase II's
1983-96 Phase II's
1983-97 Phase II's
$1.91
$2.06
$2.21
$2.43
$2.34
$2.52
$2.70
$2.95
$0.18
$0.20
$0.21
$0.22
$0.75
$0.78
$0.83
$0.92
Min. cum dollars of commercial Revenues generated in non-USG markets per dollar of NASA Ph. I + Ph. II investment.
Min. cum dollars of commercial revenues generated in non-USG and USG markets per dollar of NASA Ph. I + Ph. II investment.
Min. cum. NASA Phase III dollars Attracted by Phase per dollar of NASA Ph. I + Ph. II investment.
Private capital invested in associated commercial ventures per dollar of NASA Ph. I + Ph. II investment.
Figure 19

Figure 19