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A discrimination of success variables that indicate increased likelihood to achieve phase III commercialization or technology infusion from NASA funded phase II small business innovation research

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A DISCRIMINATION OF SUCCESS VARIABLES THAT INDICATE INCREASED LIKELIHOOD TO ACHIEVE PHASE III COMMERCIALIZATION OR TECHNOLOGY INFUSION FROM NASA FUNDED PHASE II SMALL BUSINESS INNOVATION RESEARCH

by

CARL A. ISE

A DISSERTATION

Submitted in partial fulfillment of the requirements
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We, the undersigned members of the Graduate Faculty of The University of Alabama in Huntsville, certify that we have advised and/or supervised the candidate on the work described in this dissertation. We further certify that we have reviewed the dissertation manuscript and approve it in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Industrial and Systems Engineering.

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ABSTRACT

The School of Graduate Studies
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Degree Doctor of Philosophy College/Dept. Engineering/Industrial & Systems Engineering and Engineering Management

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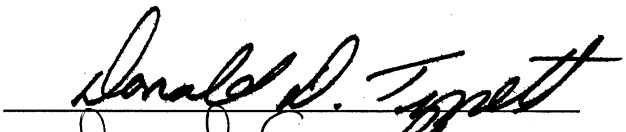
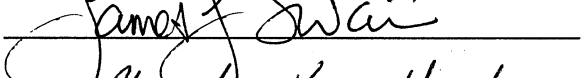
Title A Discrimination of Success Variables that Indicate Increased Likelihood to Achieve Phase III Commercialization or Technology Infusion from NASA Funded Phase II Small Business Innovation Research

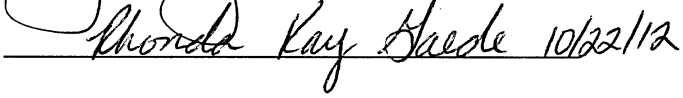
The Small Business Innovation Research program is a Federally funded effort to utilize small business commercialize innovations. The program is organized into three segments: a 6-month Feasibility Study (Phase I), 2-year Research and Development (Phase II), and Phase III Commercialization/Technology Infusion (not funded under the program). All Federally sponsored Small Business Innovation Research share the same structure but each Agency's implementation differs due to unique mission requirements. Previous research on Phase III has primarily occurred at the program level and has not considered the unique aspects of the implementing Agencies. Studies on NASA's program focused on program performance and did not identify factors that specifically contribute to achieving Phase III.

This study identifies success variables that increase the likelihood to achieve Phase III from NASA funded Phase II Small Business Innovation Research. These variables provide insight for small businesses so they can increase their ability to commercialize or infuse technologies. This study developed a comprehensive process to identify candidate critical success factors from two primary sources: the literature and a

structured interview process. These candidate critical success factor lists were merged with help of Small Business Innovation Research managers and subject matter experts. The list was used to develop a questionnaire which was then deployed across managers with experience executing Phase II projects. Considering the number of responses, techniques were used to reduce variables so statistical methods could be employed. The Primary Analysis identified two success variables for projects that achieved Phase III: they delivered a technology that solved the customer's problem and they were able to obtain post-Phase II funding from an external source. Secondary Analysis studied the influence of the type of technology and the type of Phase III (commercialization or technology infusion) on indicator variables. Technology Area results showed it was possible to discriminate variables based on the technology. Commercialization is influenced by internal company variables and Technology Infusion is influenced by external company variables. Tertiary Analysis indicated that Technology Area does not influence whether an innovation reaches Phase III or whether the innovation is commercialized or infused back into the government.

Abstract Approval: Committee Chair 

Department Chair 

Graduate Dean 

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I began this journey twelve years ago and was single with no real commitments. While conducting this research I met and married my lovely wife Dayna, went through three major work promotions (both with NASA and Air Force Reserves), and now have two wonderful sons, Aleksander (7) and Charles (5). I never gave up because of the continuous support from my wife, family, close friends, and coworkers. My wife, Dayna, deserves special thanks for everything she has done. A few close friends, coworkers, and extended family deserve mention for their support: Dr. James Isbell, Dr. Tim Reed, CAPT Milton Abner USN (Ret), Dr. John Olson, and my uncle, Fred Ise.

Special thanks go to my parents, Rein and Jerry Ann. They gave me the foundation and values to achieve and see success in life and its many challenges.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The following statement introduced the Small Business Innovation Development Act of 1982 and established a clear vision for the Small Business Innovation Research Program:

> "...to strengthen the role of the small, innovative firms in federally funded research and development, and to utilize Federal research and development as a base for technological innovation to meet agency needs and to contribute to the growth and strength of the Nation's economy." (Small Business Innovation Development Act 1982)

Congress recognized that small, entrepreneurial companies form the backbone of the U.S. economy by turning ideas into new products and introducing them into the market (Feldman et al. 2002, National Research Council 2007b). Almost half of U.S. workers are employed by small businesses, contributing to just over 50% of the U.S. Gross Domestic Product (Small Business Administration 2007). Additionally, studies have shown that research and development spending significantly contributes to economic growth (Solow 1957, National Science Board 2004). However, most small

companies lack the resources needed to develop and commercialize high technology innovations while also contending with the accompanying myriad of engineering and marketing obstacles (National Research Council 2008). The Small Business Innovation Research Program seeks to combine small business entrepreneurship with research and development investment to further economic growth.

The SBIR Program was established with four primary objectives (Small Business Innovation Development Act 1982):

1) to stimulate technological innovation

2) to use small business to meet federal research and development needs

3) to foster and encourage participation by minority and disadvantaged persons in technological innovation

4) to increase private sector commercialization derived from Federal research and development

Federal organizations that have at least a $100 million extramural research and development budget must allocate 2.5% of the extramural budget to the SBIR Program. This represents a significant Federal investment. As an example from the time-frame of this study, the Fiscal Year 2005 Federal SBIR investment was $1.85 billion (National Research Council 2007b).

The Small Business Innovation Research Program is organized into three phases. Phase I is a 6-month feasibility study funded up to $150,000. Phase II is a 2-year major research and development effort funded up to $1 million. Phase III is work that derives from, extends, or logically concludes effort(s) performed under prior SBIR funding

agreements, but is funded by sources other than the SBIR Program (Small Business Innovation Research Program Policy Directive 2002).

The overall Small Business Innovation Research Program is managed by the Small Business Administration but it is administered by each participating Federal organization. Each Federal organization is allowed flexibility to execute the SBIR Program to meet its unique requirements and needs (National Research Council 2008, Small Business Administration 2010). Examples of variations include accelerated funding, larger or smaller Phase I/II award amounts, duration of Phase I/II period of performance, broad versus focused topics, proposal review process, and post-Phase II bridge funding.

Small businesses that participate in the SBIR Program are defined as Small Business Concerns (SBC). SBCs must meet certain criteria to be eligible for participation. These criteria are (National Aeronautics and Space Administration 2006):

- Be organized for profit, operating primarily in the United States
- Be a company with majority ownership by U.S. citizens/permanent residents
- Have no more than 500 employees

1.2 NASA's SBIR Program

NASA's SBIR program is organized in three phases as described above. However, there are features of NASA's SBIR Program that differ from general SBIR guidance. NASA's program administratively differs in its funding award amounts and includes an optional subphase to provide post-Phase II bridge funding. Another feature

that differentiates NASA's program is the field of research and development. NASA develops technologies for aeronautical and space applications which tend to have limited general commercial viability. The Commercialization and Technology Infusion definitions are adapted from: United States Government Printing Office, "Small Business Innovation Research Program Policy Directive", Federal Register, Volume 67, Number 185, 2002, p. 60083

Phase I: 6-month feasibility study funded up to $100,000

Phase II: 2-year major research and development funded up to $600,000

Phase II enhanced option: bridge funding up to $750,000 (including Phase II)

Phase III:

- Commercialization - Revenue received from a private source that resulted from the sale, contract, or license of a Phase II innovation, or
- Technology Infusion - Revenue received from a Federal source that resulted from the sale, contract, or license of a Phase II innovation

NASA's SBIR program is an important player on the national stage. It is well funded relative to all participating organizations, awards contracts to a large number of companies each year, and has national impact. NASA's SBIR program is the fourth largest (out of eleven) with respect to funding. For example, during the selected sampling time-frame for this study, NASA's SBIR Fiscal Year 2005 funding was $103 million (National Research Council 2007a). Recent funding levels are slightly greater but consistent over the last several years (National Research Council 2009). In addition

to the large funding level, NASA's program has significant national impact. For a recent 4-year period, NASA awarded and average of one hundred forty-three Phase II contracts per year. The impacts reached nationally with Phase II contracts distributed across forty-two states. These characteristics identify NASA's SBIR Program as a significant funder of small business research.

1.3 The Difficulty of Achieving Phase III

One of the four goals of the Small Business Innovation Development Act (1982) is to increase private sector commercialization from research and development conducted under the SBIR Program. In support of this goal a primary concern for an SBC is to transition their technology to Phase III (substantiated through several interviews with SBC managers). However, factors that are keys to success for SBC managers participating in NASA's SBIR program are not well understood. Data on NASA Phase III success rates are inconsistent, with reports ranging from 6% to 46% (Small Business Administration 1991, United States Government Accounting Office 1998, Archibald & Finifter 2003, National Aeronautics and Space Administration 2002, National Research Council 2009). Studies have identified commercialization factors for the overall SBIR Program (Small Business Administration 1991, Berger et al 1992a, National Research Council 2007b, National Research Council 2008). However, evaluations at the participating program level are more appropriate than the overall SBIR Program level because of the unique features and differing implementations at each participating organization (Berger et al 1992, National Research Council 2009). Studies that evaluated

NASA's SBIR Program were primarily concerned with describing program attributes and evaluating program results, but were not focused on specific attributes enables SBCs to achieve Phase III. This research attempts to understand the critical factors for small business managers that lead to successful Commercialization or Technology Infusion from NASA funded Small Business Innovation Research.

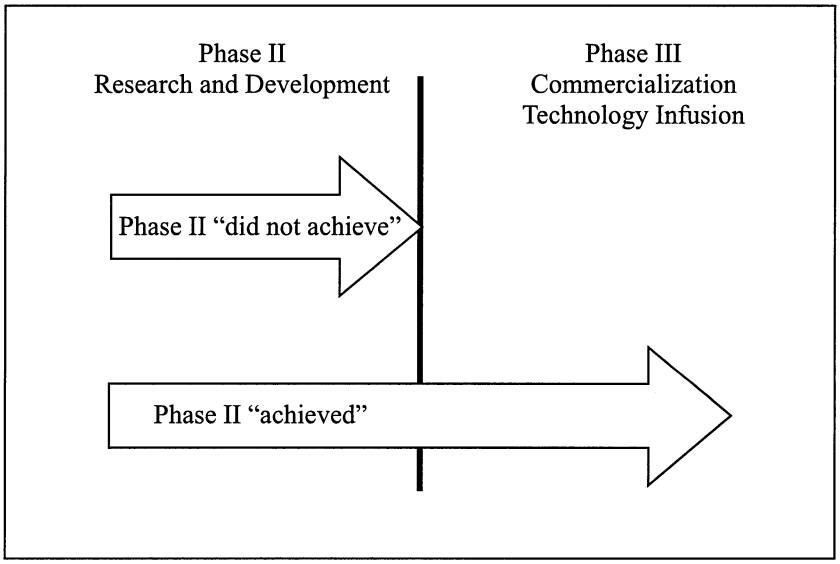
1.4 Measures of Success

Achieving Phase III Commercialization or Technology Infusion is a primary measure of success for a small business because of the potential revenue benefits to the company in Phase III. However, achieving Phase III is not the only measure of success for an SBC. Other potential success measures include (but are not limited to) new or enhanced business contacts, strengthening core capabilities within the company, gaining new knowledge or insight from the development effort, obtaining funds for additional research and development, learning how to navigate the federal contracting system, or obtaining intellectual property rights.

Previous studies have measured achieving Phase III by qualitative measures (Small Business Administration 1991); (Berger et al. 1992, Archibald and Finifter 2003, National Research Council 2007b, National Research Council 2009). Other studies have used quantitative (revenue-based) measures for projects that achieved Phase III (National Aeronautics and Space Administration 2002, National Research Council 2009). However, as the National Research Council (2009) found, the vast majority of Phase III's from NASA's SBIR Program were valued at less than $1 million, with the average

significantly less. From a practical standpoint, the above results indicate qualitative and quantitative success measures converge for NASA's SBIR projects. Therefore this study will establish "any revenue was received" as the Phase III success threshold. This success threshold breaks up SBIR projects into Phase II "did not achieve" and Phase II "achieved", as shown in Figure 1.1.

Figure 1.1 Phase II Project Comparison



Phase II "did not achieve" projects will be compared to Phase II "achieved" projects to identify Critical Success Factors for SBC managers to use as a management tool to increase the chance to achieve Phase III. Critical Success Factors are the attributes that Phase II projects should pay close attention for success. Critical Success Factors are not just 'best practices' or 'success factors' but are active management tools (Rockart 1979). Adapting the Rockart's definition to conform to the SBIR context, NASA SBIR Phase II "achieved" Critical Success Factors are:

"A few key areas where things must go right to achieve Phase III commercialization and/or technology infusion. If results in these areas are not adequate, the SBIR effort will be less than desired. As such, these areas of activity should receive constant and careful attention from management."

1.5 Significance of the Topic

Small business is a catalyst for innovation and economic growth. In addition, research and development spending greatly contribute to economic growth. However, small businesses have few resources to cope with development and marketing obstacles such as government red-tape, limited internal research and development funding, technology transition costs, or market penetration costs (National Research Council 2008). The Small Business Innovation Research Program is the largest Federal program to leverage small business to provide research and development to commercialize innovations. The SBIR Program provides Federal funding where small business can gain the greatest benefit.

NASA's SBIR Program has significant national impact. NASA's program is the fourth largest with respect to SBIR funding ($103 million Fiscal Year 2005) (National Research Council 2007b, National Research Council 2009). Not only is the funding significant, but NASA's SBIR Program provides a significant number of awards nationally. In a recent 4-year period, NASA awarded an average of one hundred forty-three Phase II contracts per year distributed across forty-two states. However, what it

takes to get to Phase III is not well understood. The best evidence to date are Phase III anecdotes shared between federal organizations (National Research Council 2007b, National Research Council 2009). However, these anecdotes may only be applicable to the specific organization's Program. Data on NASA Phase III success rates are inconsistent, with reports ranging from 6% to 46% (Small Business Administration 1991, United States Government Accounting Office 1998, Archibald & Finifter 2003, National Aeronautics and Space Administration 2002, National Research Council 2009). With (at most) less than half of Phase II projects achieving Phase III there is significant room for improvement. To successfully achieve Phase III, small business managers need practical information and tools within the scope of a single participating federal organization. Therefore, this research sets out to fill in a gap in the body of knowledge by identifying a set of Critical Success Factors related to improving an SBC's chances to achieve Phase III Commercialization or Technology Infusion from NASA funded Phase II SBIR projects.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter summarizes previous research that is relevant to this study and how it helped frame the methodology. First, the Small Business Innovation Research program is defined to provide an understanding of the larger Federal program, and then NASA's SBIR unique features are described. Two SBIR process models are compared showing how the theoretical [linear] model provides a basic process understanding, but in reality, the process to Phase III commercialization is nonlinear. SBIR commercialization studies are reviewed paying attention to previous measures of success, scope of previous commercialization studies, and potential impacts of technology type and technology market. Then the Critical Success Factor methodology will be defined with additional attention given to Critical Success Factor interview process and analysis.

2.2 Small Business Innovation Research Program

The Small Business Innovation Research program was created by the Small Business Innovation Development Act (SBIDA) (1982). The intent of the legislation was

to create an industry-government partnership with four goals (Small Business Innovation Development Act 1982).

1) to stimulate technological innovation

2) to use small business to meet federal research and development needs

3) to foster and encourage participation by minority and disadvantaged persons in technological innovation

4) to increase private sector commercialization derived from Federal research and development

The SBIR program has been favorably reviewed several times by the Government Accounting Office (GAO) (1987, 1989, 1992, 1995, 1998) leading to legislative program reauthorization in 1992 (Small Business Innovation Research Program Reauthorization Act 1992) and again in 2000 (Small Business Innovation Research Program Reauthorization Act 2000).

The SBIR program is implemented by Federal organizations that have at least a $100 million annual Research and Development (R&D) budget. These organizations must set aside and apply 2.5% of their extramural R&D budget to the SBIR program (Small Business Innovation Research Program Policy Directive 2002).

In addition to government participation criteria, small businesses must also meet certain thresholds to participate. Small businesses, defined as Small Business Concerns (SBC), must (Small Business Administration 2010):

1) Be organized for profit,

2) Operate primarily in the United States,

3) Be owned at least 51% by an individual

4) Have majority ownership by United States citizens or permanent residents

5) Have no more than 500 employees

The SBIR program is organized in three phases. Phase I is a 6-month feasibility study funded up to $150 thousand. Phase II is a 2-year major research and development effort funded by up to $1 million. Phase III is work that derives from, extends, or logically concludes effort(s) performed under prior SBIR funding agreements, but is funded by sources other than the SBIR Program (Small Business Innovation Research Program Policy Directive, 2002). The non-SBIR funding could be for a commercial application from non-Federal sources, for use in a Federal application from Federal sources, or for additional research and development (National Aeronautics and Space Administration, 2010). For this research, the specific definition of Phase III outcomes will be as defined below (adapted from "Small Business Innovation Research Program Policy Directive", Volume 67, Number 185, page 60083 2002).

- Commercialization -- Revenue received from a private source that resulted from the sale, contract, or license of a Phase II innovation, or
- Technology Infusion -- Revenue received from a Federal source that resulted from the sale, contract, or license of a Phase II innovation

The Small Business Administration was charged with overall SBIR management responsibility (Small Business Innovation Development Act 1982). The SBA establishes program guidance, however, each participating Federal organization may tailor implementation to meet the unique needs of their respective organization (Small Business Administration 2010, National Research Council 2008). Examples include accelerated funding, larger or smaller Phase I/II award amounts, duration of Phase I/II period of

performance, broad versus focused topics, proposal review process, and post-Phase II bridge funding.

2.2.1 NASA's Small Business Innovation Research Program Implementation

NASA's SBIR Program has significant national impact. It is the fourth largest with respect to SBIR funding ($103 million Fiscal Year 2005) (National Research Council 2007b, National Research Council 2009). Not only is the funding significant, but NASA's program awards a significant number of SBIR contracts nationally. In a recent 4-year period, NASA awarded an average of one hundred forty-three Phase II contracts per year distributed across forty-two states. However, what it takes to achieve Phase III is not well understood. The best evidence to date are Phase III anecdotes shared between federal organizations (National Research Council 2007b, National Research Council 2009). Furthermore, these anecdotes may only be applicable to a specific organization's program. Data on NASA Phase III success rates are inconsistent, with reports ranging from 6% to 46% (Small Business Administration 1991, United States Government Accounting Office 1998, National Aeronautics and Space Administration 2002, Archibald & Finifter 2003, National Research Council 2009). With (at most) less than half of Phase II projects achieving Phase III, significant improvement may still be possible. To successfully achieve Phase III, small business managers need practical information and tools to operate within the scope of a single participating federal organization.

NASA's SBIR program implementation follows the SBA's guidelines but is unique with respect to Agency award process, SBIR Phase implementation, and funding. Overall management for the SBIR Program is conducted through NASA's Innovative Partnership Program and implemented through NASA field centers (National Aeronautics and Space Administration 2010). SBIR project topics and sub-topics are generated at field centers and coordinated with NASA mission directorates. Sub-topics are assigned to a lead center and are awarded according to the assigned directorate: Aeronautics Research Mission Directorate, Exploration Systems Mission Directorate, Science Mission Directorate, or Space Operations Mission Directorate (National Aeronautics and Space Administration, 2010). A pending NASA organizational change would place the SBIR program in the Early Stage Innovation (ESI) Directorate under the Office of Chief Technologist (OCT) (National Aeronautics and Space Administration 2011).

NASA's SBIR structure is consistent with SBA guidance. However, NASA's implementation differs by having a lower Phase I and II award cap and an additional sub-Phase, Phase II Enhancement, is included. The Phase I award is capped at $100,000 (versus $150,000) the Phase II award is capped at $600,000 (versus $750,000) (National Aeronautics and Space Administration 2010). The NASA SBIR funding caps allow more Phase I and Phase II awards each year (Garrison, 2007). The Phase II Enhancement sub-phase was added in 2008 to act as a funding mechanism to help promising technologies reach Phase III (National Aeronautics and Space Administration 2010).

One additional NASA unique feature of the SBIR program is the emphasis on Phase III outcomes. As mention previously, NASA awards SBIR projects aligned to the

needs of the Aeronautics Research Mission Directorate, Exploration Systems Mission Directorate, Science Mission Directorate, or Space Operations Mission Directorate. This alignment is intended to encourage mission directorate usage of technology via Phase III Technology Infusion (Garrison 2007).

2.2.2 Small Business Innovation Research Models

The SBA and NASA processes described in the previous sections present a systematic, linear execution model. Under this model a technology concept is framed in the Phase I feasibility study, then matured during Phase II major research and development, and culminates in Phase III commercialization. Figure 2-1 summarizes the linear model as presented by NASA (2010).

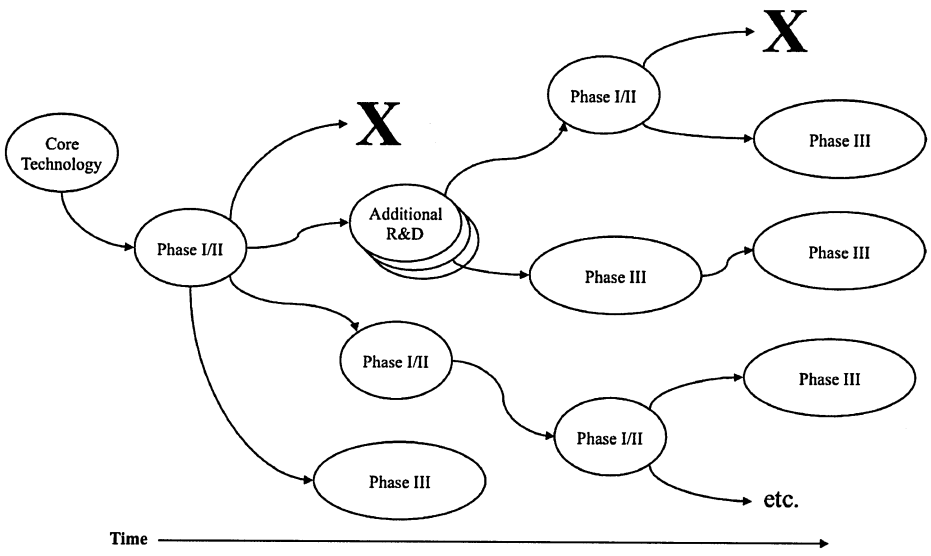
Figure 2.1 NASA SBIR Linear Process Model

Phase I	**Phase II**	Phase II Enhancement (option)	**Phase III**
• Feasibility Study	• Major Research and Development	• Additional Research and Development	• Commercialization
• Up to 6-months	• Up to 24-months	• Cost matching up to $150K	• Technology Infusion
• Funded up to $100K	• Funded up to $600K	not to exceed $750K including Phase II	• Additional Research and Development
Technologies awards tied to NASA mission areas:			
Aeronautics Research			
Exploration Systems			
Science			
Space Operations			

However, according to SBC manager interviews conducted during the Preliminary Study, the linear model is not an accurate representation of reality. SBC managers described a model wherein their company had a core technology that could meet the needs of a NASA SBIR solicitation and the core technology would be matured

during SBIR Phase I and Phase II, but then several alternatives could occur. The technology could ideally achieve Phase III (thus following the linear model), undergo additional research and development, result in another SBIR solicitation, or reach a dead-end. The process could then repeat itself in a variety of iterations. Essentially, SBC managers described a non-linear SBIR process model. This description was confirmed by a National Research Council (NRC) study evaluating NASA's SBIR program (National Research Council 2009). A representation of this model is shown in Figure 2.2.

Figure 2.2 NASA SBIR Actual Process Model



The most significant impact of the non-linear model is that the technology becomes extremely difficult to track in time from inception to Phase III. Tracking a large population of specific technologies using the NASA SBIR awards database and SBIR success story databases would be untenable.

2.2.5 Section Summary

This section describes how the SBIR program is organized and managed by the Small Business Administration. Each participating Federal organization meets certain basic program guidance but can employ the program differently to suit its unique mission needs. NASA's SBIR program is differentiated by awarding SBIR projects in line with NASA's unique mission areas and funds the program to offer more opportunities to develop technologies. The NASA SBIR process model is presented through official channels as a linear model but in reality, the process follows a non-linear model. This ultimately leads the researcher to rely on SBC managers for information about specific NASA SBIR projects in which they participated.

2.3 Evaluating Success in Small Business Innovation Research

As stated in Section 2.2, one of the legislative goals (Small Business Innovation Development Act 1982) is to commercialize technologies developed from SBIR funding. However, even with a well defined program structure and participation guidance, measuring success is challenging (Berger et al 1992); (National Research Council 2007b). Two constructs emerge from the literature to frame the problem of measuring SBIR success. The first construct uses qualitative criteria to measure SBIR commercialization and the second construct uses quantitative measures; both yield a measure of commercialization success. However, much of the literature evaluates the SBIR program and commercialization at the Federal level, which may be inappropriate (National Research Council 2007b); (National Research Council 2009). Studies looking

at the organizational participant level have identify unique characteristics, such as commercialization dependence on technology type and commercialization versus technology infusion. The culmination of these SBIR commercialization studies gives a broad understanding of how a participating organization's SBIR program is performing, but there is at best anecdotal evidence identifying factors that lead to Phase III (National Research Council 2008).

2.3.1 Qualitative versus Quantitative Measures of Success

Several studies have evaluated SBIR Phase III commercialization. These studies were attempting to demonstrate program results (National Aeronautics and Space Administration 2002), characterize program features (Small Business Administration 1991, Archibald and Finifter 2003, National Research Council 2007b, National Research Council 2009), or identify factors that led to commercialization (Small Business Administration 1991, Berger et al 1992a). These studies, which established criteria to measure commercialization success, can be grouped into qualitative measures and quantitative (revenue-based) measures.

The first study that evaluated SBIR commercialization success was published by the Small Business Administration (SBA) (1991). The SBA conducted a 3-year, multi-organization study to identify program features and identify factors leading to commercialization. A corollary study by Berger et al (1992a) evaluated SBIR commercialization features and factors 4-years after Phase II completed. These studies utilized a qualitative scale to measure commercialization success.

- Level 1 - Commercialization has occurred. Production and actual sales of product or service.
- Level 2 - Commercialization is likely. Some activity has occurred that demonstrates a move toward commercialization. Examples could include an acquisition, spin-off company, or financial commitments.
- Level 3 - Actively Pursuing Commercialization. The firm is seeking funding or other options to commercialize but no concrete outcomes have occurred.
- Level 4 - Interest in Commercialization. The company sees commercialization potential but requires further R&D.
- Level 5 - Commercialization Not Expected. A product or service is not expected as a result.

A study conducted by Archibald and Finifter (2003) examined SBIR awards at NASA's Langley Research Center to determine if changes brought about by the 1992 SBIR reauthorization (Small Business Innovation Research Program Reauthorization Act 1992) had noticeable impacts on SBIR commercialization. This study used a five tier qualitative scale to measure success.

- POTENTIAL - identification of commercial potential.
- COMMERCIAL - dates of commercial availability or expected availability.
- AVAILABLE - if technology is currently available.
- SALES - if any sales ever occurred with the technology.
- EVER_AVAILABLE - used to evaluated SALES and AVAILABLE together.

The National Research Council, based on direction from 2000 SBIR reauthorization legislation (Small Business Innovation Research Program Reauthorization Act 2000), conducted a series of studies to comprehensively evaluate the overall SBIR program and the five largest Federal SBIR programs. Two of the studies (National Research Council 2007b); (National Research Council 2009) utilized a six tier scale to measure success.

- No sales to date, but sales are expected

- No sales to date nor are sales expected
- Sales of product(s)
- Sales of process(es)
- Sales of services(s)
- Other sales (e.g. rights to technology, licensing, etc.)

However, the ultimate desire for stakeholders (e.g., Congress) is to understand the economic impact resulting from the SBIR program. A few studies have attempted to frame quantitative [revenue-based] measures to better understand commercialization impacts. Ultimately, the desire is to segregate commercialization 'home runs' from 'hits', although collecting revenue data is difficult at best (National Research Council, 2009).

Two studies collected revenue-based measures to provide a quantitative framework to evaluate commercialization success (National Aeronautics and Space Administration 2002, National Research Council 2009). The NASA study collected cumulative revenue data (from license fee/sales, royalties, etc.) over a 5-year period and grouped the data into the following categories.

- $0 to <$1M
- $1M to <$3M
- $3M to <$5M
- $5M to <$10M
- $10M to <$15M
- $15M to <$25M
- $25M to <$50M
- $50M to <$100M
- More than $10M

The National Research Council study also collected open ended revenue data on total sales dollars of Product(s), Process(es), or Service(s) and then presented the following categories.

- $0 to <$100K
- $100K to <$1M
- $1M to <$5M
- $5M to <$10M
- More than $10M

Another study, conducted by the National Research Council (2008), proposed using revenue-based measures of commercialization to better capture the various views of commercialization success. These measures, with descriptions were:

- Reaching the market—a finished product or service has reached the marketplace (Phase III),
- Reaching $1 million in cumulative sales (beyond SBIR Phases I and II)—the approximate combined amount of standard DoD Phase I and Phase II awards,
- Reaching $5 million in cumulative sales—a modest commercial success that may imply that a company has broken even on a project, and
- Reaching $50 million in cumulative sales—a full commercial success.

One of the results the National Research Council (2009) found from studying NASA's SBIR program (data collected for 1992-2001) was a significant majority (82.3%) of total sales from Phase III's were less than $1 million with the average significantly less ($127,000). This finding is significant because it supports the use of a unified (qualitative and quantitative) success measure scale of "achieving" Phase III Commercialization/Technology Infusion. This gave rise to the definition of Phase III used for this study as explained in Section 2.2.

2.3.2 Scope of Previous Small Business Innovation Research Studies

Many studies evaluating the SBIR program have reviewed the entire Program to include multiple government organizations. (Small Business Administration 1991,

Berger et al. 1992a, Berger et al 1992b, National Research Council 2007b). However, the National Research Council (2007b and 2009) recognized that it is at best difficult, even inappropriate, to draw specific conclusions that include multiple organizations due to each organization's unique program implementation. In fact, studies examining different government organizations produce different results (Berger et al 1992a, National Research Council 2007b, National Research Council 2008, National Research Council 2009). Congress also acknowledged each organization's uniqueness and requested the National Research Council to individually evaluate the SBIR programs largest participants in the 2000 SBIR legislative update (Small Business Innovation Research Program Reauthorization Act 2000).

The National Research Council studied NASA's SBIR Program in response to the above legislation. The NRC evaluated NASA's program to understand its effectiveness in commercializing technologies, how well the Program supported NASA's mission, the amount of innovation generated, the extent of support for minority and woman owned businesses, and how effective was NASA's management of its SBIR Program (National Research Council, 2009). The study drew data from different perspectives (NASA COTRs, SBC managers, and case studies) to provide a holistic view. Findings were generally positive with respect to NASA's program performance. The study recommended structural and procedural changes to improve the awards process, self evaluation, tracking, and reporting. The study focused on items within NASA's control and did not focus on specific factors that an SBC manager could do to increase his or her chances to achieve Phase III Commercialization or Technology Infusion.

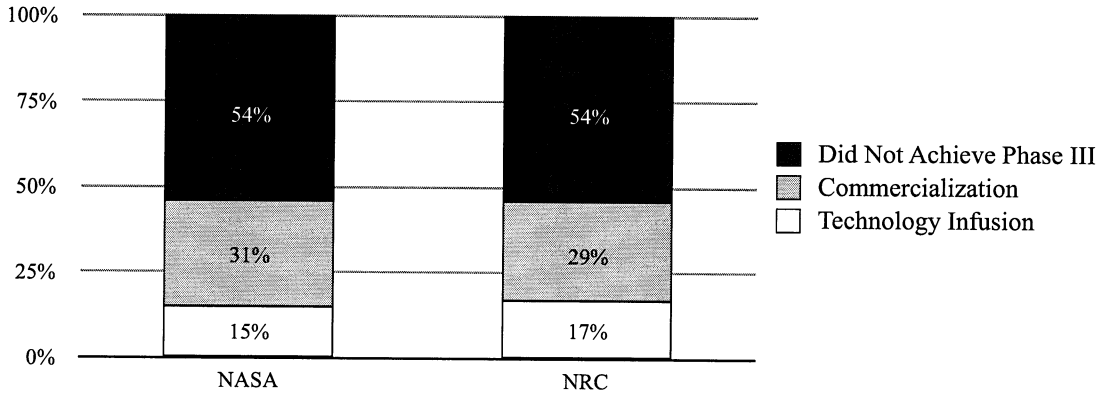
2.3.3 Commercialization Dependency on Technology Area

Recently, studies have begun looking at what effects the type of technology developed had on commercialization. NASA (2002) and the National Research Council (2009) found a correlation between the technology area and commercialization success. The NASA study found "Electronics" (Microelectronic, Electronics Device Performance, Electronic Equipment and Instrumentation, Microwave and Millimeter Wave Electronics, Optical Devices and Lasers) and "Materials" (Advanced Materials, Materials Processing and Manufacturing, Coatings, Corrosion and Surface Phenomena, Materials Performance, Fundamentals and Instrumentation) categories most productive while "Mechanical Performance of Vehicles, Weapons, Facilities" (Hydrodynamics, Aerodynamics, Acoustics, Mechanical Performance of Structures and Equipment, Control, Mechanical Measurements) was least productive (National Aeronautics and Space Administration 2002). The NRC study further indicated significant commercialization in the hardware category (final product, component, or intermediate hardware product) and other major commercialization in software, process technology, new or improved service capability, and research tool categories (National Research Council 2009). The technology area dependency was supported via discussions with SBC managers and NASA Subject Matter Experts (SMEs) during the Preliminary Study Phase of this research.

2.3.4 Commercialization versus Technology Infusion

Research conducted on SBCs that participated in NASA SBIRs during the 1990s indicated about 15% of Phase IIIs were Technology Infusion and 31% were Commercialization from a total of 1,739 Phase II awards (National Aeronautics and Space Administration 2002). More recently the National Research Council found 46% of Phase II projects have achieved Phase III (National Research Council 2009). Results are consistent between NASA and National Research Council studies. Of the 46%, Technology Infusion comprised 17% and Commercialization comprised 29%. Figure 2.3 shows the breakdown of Phase III data.

Figure 2.3 Phase III Breakdowns



A significant item to note from this evaluation is that over half (54%) of Phase II projects did not achieve Phase III. Significant room for improvement exists for businesses that participate in NASA's SBIR Program. However, companies face many challenges to improve their Phase III success rates. Difficulties could include a lack of institutional resources for the small business. Another difficulty specific to NASA's SBIR program is the uniqueness of space-related research and development (National Research

Council 2009). Hence, SBC managers need to better understand what it takes to achieve Phase III from NASA funded Phase II SBIRs.

2.3.5 Small Business Innovation Research Involving Phase III Success Factors

Three studies have taken a focused look at the factors that influenced commercialization. These studies provide a good indication of important factors but they were developed for the overall SBIR program, which has been shown (Chapter 2, Section 2.3.2) as problematic when applied to specific participating organizations. Additionally, the first two studies were conducted 20-years ago and much has changed and been learned since. The third study was more recent, but presented Phase III anecdotes for the overall SBIR program.

The first study was published by the Small Business Administration (1991) and evaluated SBCs over a 3-year period in the late 1980s. The study evaluated the Federal-wide SBIR program. The influencing factors the study identified were:

- Product orientation over research and development orientation
- Private sector orientation over government orientation
- Products over services
- Farthest along in product development
- Utilization of university resources
- Understanding the need for intellectual property protection
- Significant progress toward intellectual property protection
- Private focus had more commercialization success
- No need for outside resources
- Most progress on completing a marketing plan
- Actively implementing a marketing plan
- Obtaining follow-on funding commitments

A corollary study published by Berger et al (1992a) evaluated companies that participated in the SBIR program over a 4-year period. The factors were similar to the

SBA factors but were segregated into company related, technology related, and marketing related factors. The influencing factors in this study included the following.

Company Related:

- Product orientation over research and development
- Private sector orientation over government orientation

Technology Related:

- Products over services
- Utilization of university resources
- Understanding the need for intellectual property protection

Marketing Related:

- Private focus had more commercialization success
- Government focus had more sales to DoD and NASA
- No need for outside resources
- Actively implementing a marketing plan

In response to the 2000 SBIR legislative update (Small Business Innovation Research Program Reauthorization Act 2000), the National Research Council (2007b) conducted a symposium to gather Phase III anecdotes from government, prime contractors, and small businesses participants. The anecdotes led to recommendations to improve Phase III chances. The recommendations were:

- Better buy-in/alignment from the customer,
- Roadmap/funding integration with the customer/prime,
- Improved outreach and matchmaking services,
- Creative post Phase II funding,
- Aligning small business strategy with the technology, and
- Better prime contractor involvement with technology development.

2.3.6 Section Summary

One of the SBIR legislative goals is to commercialize technologies developed from SBIR funding (Small Business Innovation Development Act 1982). Additionally, SBC managers are highly interested in receiving revenue from sales of a technology developed from SBIR efforts. Both NASA and SBC managers are ultimately interested in reaching Phase III Commercialization or Technology Infusion from SBIR funded work. To assess reaching Phase III measurable criteria had to be established.

This section described the measures used to evaluate commercialization success. These measures were organized into qualitative and quantitative (revenue-based) criteria. Qualitative measures established criteria for a Phase III threshold by asking the respondent to assess a previous Phase II technology's likelihood of future sales, whether sales had occurred, or no sales had occurred. Alternatively, other studies asked respondents to evaluate sales from previous Phase II using revenue-based categories. For NASA Phase II technologies that achieved Phase III, the average revenue was relatively small based on the revenue scales ($127,000). This supported convergence of the qualitative and quantitative scales to establish a success threshold of "any revenue received" for Phase III Commercialization or Technology Infusion.

The scope of previous studies has primarily been conducted at the overall SBIR program level. However, with each participating organization having a unique implementation it is difficult (and possibly inappropriate) to draw conclusions outside of an organization's program. Therefore, this study evaluated only NASA funded SBIR Phase II projects.

Working in the space-related field poses unique challenges and opportunities. One of the challenges for an SBC is working in a niche market for most hardware related technologies. An opportunity could be the importance NASA has placed on linking missions to technologies to provide a stronger customer need. Previous research has indicated a link may exist between commercializing a technology and the type of technology produced. Because of the niche space market, technology infusion has occurred at about twice the rate of commercialization.

A few studies have attempted to understand the factors that influence achieving Phase III. However, these studies were conducted at the overall SBIR Program level and may not be applicable to NASA's program. Of the three studies documented, two were performed 20-years ago and may not have relevance to more recent SBIR Program implementation. The third study documented shared experiences between federal participating organizations. There is a clear gap in research to understand the factors important to an SBC manager to increase the probability to achieve Phase III Commercialization or Technology Infusion.

2.4 Critical Success Factors

This section describes the Critical Success Factor concept including its inception, evolution, and systemization. Daniel (1961) first coined the concept of "success factors" in the management literature. Rockart (1979) built upon Daniels work to define Critical Success Factors and provide a foundation for Critical Success Factor evaluation and analysis. Bullen and Rockert (1981) evolved the concept by providing context for how

Critical Success Factors fit within management structure and information needs. Pulling from Rockart's work, Pinto and his colleagues delved into the temporal nature of Critical Success Factors to show that Critical Success Factors are indeed dependent on the project phase (Pinto 1986, Slevin & Pinto 1986, Schultz, Slevin, & Pinto 1987, Pinto and Prescott 1988, Pinto and Slevin 1989). As part of his work, Pinot developed an instrument to identify Critical Success Factors for generalized product/project management. Dobbins (1999) refined Rockart's and Bullen's work to develop a systematic, repeatable, qualitative process to identify Critical Success Factors for specific projects. The Critical Success Factor literature was reviewed to identify the various methods (quantitative, mixed method, or qualitative) that have been used to determine Critical Success Factors. This review provides a basis for methodology selection for this research.

2.4.1 Critical Success Factor Methodology

Daniel (1961) was the first to identify "success factors" as a management concept. He proposed that each company has from three to six key factors that must be closely monitored and superbly executed to succeed in their respective market.

Rockart (1979) began where Daniel left off and refined the concept. Rockart developed a Critical Success Factor methodology to address a gap in available tools for managers to successfully achieve project goals. The problem Rockart viewed was that existing tools provided a wealth of data, but it was usually in a form where the manager

had to filter out the critical information. Rockart believed there were a 'critical few' items in which managers must concerned themselves. He thus envisioned,

> "Critical success factors thus are, for any business, the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization." and "As a result, the critical success factors are areas of activity that should receive constant and careful attentions from management.", (Rockart 1979, 85).

Adapting the Rockart's definition to conform to NASA's SBIR context:

A few key areas where things must go right to achieve Phase III commercialization and/ or technology infusion. If results in these areas are not adequate, the SBIR effort will be less than desired. As such, these areas of activity should receive constant and careful attention from management.

Rockart (1979) viewed four primary areas where Critical Success Factors originated.

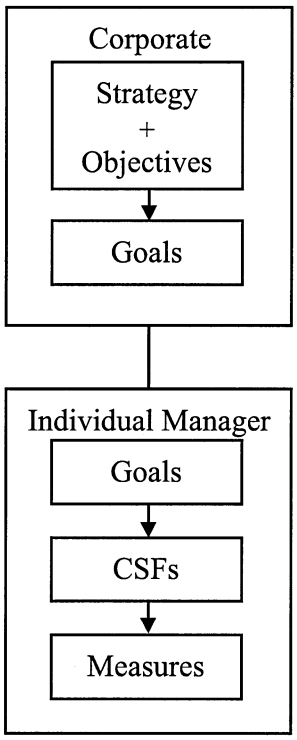
1) Structure of the particular industry - factors that any company in the industry must engage
2) Competitive strategy, industry position, and geographic location - factors tied more directly to the companies strategy and market position
3) Environmental factors - factors the company must respond to but which has no direct control
4) Temporal factors - time-based factors

Rockart (1979) proposed that Critical Success Factors should be developed via two or more interviews with prospective managers. The four primary Critical Success Factor (CSF) areas (above) are used in the interview to identify CSF information. The interviewer then analyzes the data and conducts one or more follow-on interviews to

validate the identified CSFs. A feature of the CSF validation is to develop specific measures (from one to three) to gauge the level of attainability of the CSF.

After Rockart (1979) established the Critical Success Factor methodology, Bullen and Rockart (1981) refined the methodology to help practitioners through the process of identifying Critical Success Factors and associated measures. Bullen and Rockart provided a construct to better define how Critical Success Factors fit within a management's information needs. From a corporate perspective, a company's strategy and objectives provide overall direction and anchor high-level goals. The corporate goals flow to individual managers who then have direct or derived goals to be achieved at some point in time. Critical Success Factors are derived from these management goals with each CSF having one to three measures. Figure 2.4 shows the construct relating Critical Success Factors to management and corporate performance hierarchy.

Figure 2.4 Critical Success Factor Hierarchy Construct



(Bullen and Rockart 1981)

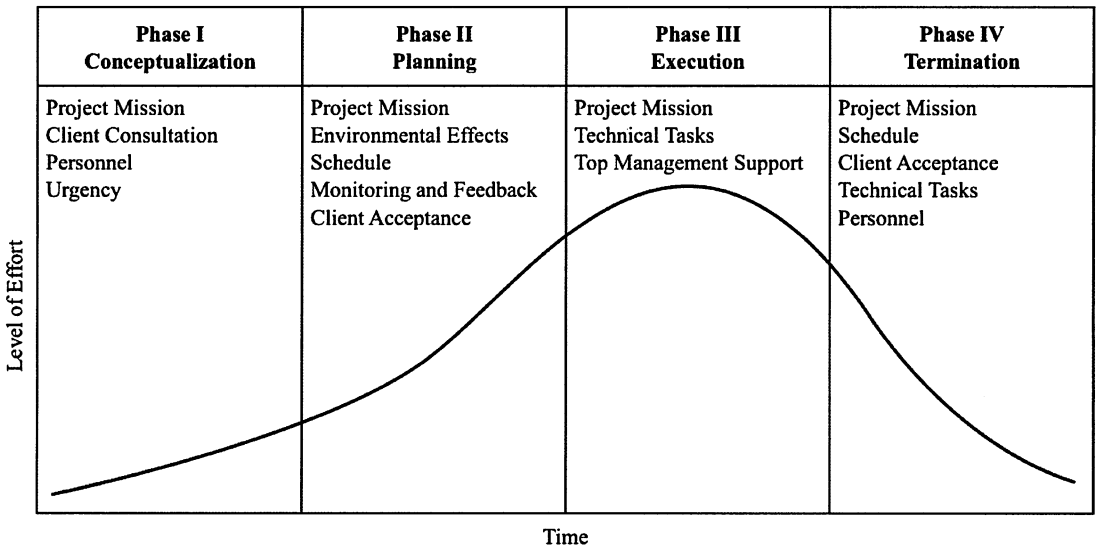
Bullen and Rockart (1981) also provided practical techniques to improve the interview process. Their paper documented guidelines to identify CSFs but did not define a systematic process.

2.4.2 Critical Success Factor Project Phase Dependence

Rockart (1979) identified temporal factors as a prime source of Critical Success Factors. A series of studies delved into, matured, and validated this concept. Pinto (1986) and Slevin and Pinto (1987) documented a study to determine critical success factors for project implementation. A primary contribution of his study was to develop the Project Implementation Profile (PIP) to determine critical success factors depending

on the project phase. The PIP is based on ten potential critical success factors for general project implementation. PIP development was high-lighted in a paper by Schultz, Slevin, and Pinto (1987). Later, Pinto and Prescott (1988) empirically demonstrated that critical success factors varied over a project life cycle. Then Pinto and Slevin (1989) presented how critical success factors vary over a life cycle for research and development projects. Figure 2.5 show the results, from Pinto and Slevin's paper (1989, 8), of the variation of critical success factors for research and development projects.

Figure 2.5 CSFs for a Generic Research and Development Project



(Pinto and Slevin 1989)

2.4.3 Generalized Critical Success Factor Process Model

Where Rockart (1979) initiated the Critical Success Factor concept and Bullen and Rockart (1981) provided structured methods for practitioners to identify Critical Success Factors, Dobbins (1999) took the next step to develop a systematic process for

Critical Success Factor analysis, identification, and measurement. Dobbins' research focused on developing a general process model for Critical Success Factor identification. He argued that previous studies that utilized Rockart's (1979) interview method only identified Critical Success Factors and did not explore other important factors such as Critical Success Factor constraints and measures. Additionally, he argued that studies that solely relied on empirical methods to identify Critical Success Factors provided results that were too generic and not contextually relevant. Dobbins developed his process to address these concerns as well as interview method and bias concerns noted by Davis (1979, 1980) and Munro (1983). Dobbins' structured interview method was designed to overcome short term memory issues and bring more objectivity to the process by not directly having the interviewee identify Critical Success Factors.

The process utilizes two interviews. In the first interview the business/project information is documented and then the interviewee assigns critical activities to each of ten categories.

1) Global or industry related
2) External influences
3) Internal influences
4) Current and future
5) Temporal and enduring
6) Risk abatement
7) Performance
8) Special monitoring
9) Quality
10) Modification management

After the interview, the analyst groups similar activities, checks for consistency and validity of the activities and then develops a candidate Critical Success Factor for each group. The activities then become the Critical Success Factor constraints. Once the

Critical Success Factors are determined, the analysis develops measures for each Critical Success Factor. Then the analyst checks for overall consistency of Critical Success Factors, constraints, and measures. The second interview is used to review and make any necessary changes. The results are detailed in a final document. In addition, Dobbins presented a method to associate risk (of achievement) for each Critical Success Factor. Dobbins determined that the generalized process produced objective, contextually-based Critical Success Factors, constraints, and measures that could be used by project managers as a management tool for success.

2.4.4 Critical Success Factor Research Methodologies

From the time Rockart (1979) developed the Critical Success Factor methodology, researchers evolved and expanded the interview-based, qualitative method to include quantitative, statistical analysis-based methods and a mixture of qualitative and quantitative methods, thus demonstrating the robustness of the Critical Success Factor concept. To select the most appropriate methodology for this research, the Critical Success Factor literature was reviewed and grouped into the predominate methodology utilized. The literature was organized into qualitative methods, quantitative methods, and mixed methods. Qualitative methods seek to understand and interpret the underlying context of a problem through observation or interview. Quantitative methods, meanwhile, seek to draw conclusions from objective analysis of measurable items (Brewerton and Millward 2001). Mixed methods combine features of qualitative and quantitative methods to triangulate on a solution (Tashakkori and Teddlie 1998).

The studies reviewed for research type were grouped based on the predominant methodology employed. The qualitative studies gathered data via a form of interview and utilized qualitative methods for analysis. Quantitive studies used the literature as a data foundation and utilized statistical analysis to draw conclusions. Mixed method studies used a combination of qualitative and quantitative methods to gather data, conduct analysis, and draw conclusions. Table 2.1 shows the Critical Success Factor study groupings by research method utilized.

Table 2.1 Critical Success Factor Methodologies

Time ↓

Qualitative	Mixed Method	Quantitative
Rockart, 1979		Davis, 1979
Munro and Wheeler, 1980	Davis, 1980	
Bullen and Rockart, 1981		
	Martin, 1982	
Munro, 1983		
Boynton and Zmud, 1984		
Shank, Boynton, and Zmud, 1985		
	Slevin and Pinto, 1986	
	Pinto, 1986	
		Pinto and Prescott, 1988
	Bergeron and Begin, 1989	Pinto and Slevin, 1989
	Cooper and Kleinschmidt, 1996	
	Rai, Borah, and Arkalgud, 1996	
	Tishler, et al., 1996	
	Wageman, 1997	
	Dobbins and Donnelly, 1998	
Dobbins, 1999		
	Bender et al, 2000	
Dyrhaug, 2002		
Dobbins & Donnelly, 2004		Lee and Osteryoung, 2004
Caralli, 2004		
		Watson, 2009

2.4.5 Section Summary

This section summarized the predominant research on the Critical Success Factor method. Daniel (1961) first identified "success factors" in the management literature. Building upon Daniel's work, Rockart (1979) developed the Critical Success Factor method. The method to identify Critical Success Factors was further refined by Bullen and Rockart (1981) to provide additional context for practitioners to identify Critical Success Factors. Pinto (1986) and colleagues evaluated the temporal nature of Critical Success Factors to show that Critical Success Factors change depending the phase of the project. Dobbins (1999) evolved the Critical Success Factor method to a repeatable, systematic process that minimized interview bias factors while maintaining the contextual nature of Critical Success Factors. Lastly, the Critical Success Factor literature was examined to determine the types of methods used to identify Critical Success Factors.

2.5 Chapter Summary

This chapter documented the operational framework for the Small Business Innovation Research program and high-lighted unique attributes of NASA's SBIR implementation. Models describing the SBIR process were examined. The NASA SBIR literature presents a linear model but in actuality the process is non-linear. SBIR 'success' literature was reviewed. Studies defined 'success' either qualitatively or quantitatively (revenue-based), however, each version of 'success' converged on receiving revenue. The scope of previous SBIR studies was primarily at the overall program level but there has more recently been a realization that it may be more

appropriate to scope studies at the implementing organization level. Some studies have indicated a dependency on SBIR commercialization with technology area and others have recognized an importance understand commercialization versus technology infusion. A few studies have attempted to identify SBIR success factors but either the scope was larger than NASA's SBIR program or the evidence was anecdotal. The Critical Success Factor methodology was examined from its inception, to refinement, through process systemization. The temporal nature of Critical Success Factors was studied and determined that Critical Success Factors are dependent on the phase of the project. The Critical Success Factor literature was examined to determine the predominant methods (qualitative, quantitative, or mixed method) used to identify Critical Success Factors. This review indicated no single method appeared to dominate.

CHAPTER 3

RESEARCH STATEMENT

3.1 Research Goal

The goal of this research was to determine the critical few factors required to achieve Phase III commercialization or technology infusion from NASA funded SBIR Phase II research and development projects. Other studies have identified necessary factors to achieve commercialization but multi-agency studies have been shown to be inappropriate due to the unique SBIR implementation at each participating organization. To accomplish the goal, this research compared Phase II projects that had not achieved Phase III to projects that achieved Phase III. However, it was likely that different factor structures existed for each case. Each factor structure would be compared to isolate the sufficient from the necessary Critical Success Factors. Factors unique to projects that achieved Phase III form the initial list of Critical Success Factors. Critical Success Factors common to both Phase II "did not achieve" and Phase II "achieved" would have their means tested to separate the sufficient factors from the necessary factors. The sufficient Phase II "achieved" factors would be added to the unique Phase II "achieved" factors to constitute the complete set of Critical Success Factors.

The research question was followed by the hypothesis test to determine differences between Phase II "did not achieve" and Phase II "achieved" SBIR projects.

Is there a difference between the factor structures of Phase II projects that have not achieved Phase III and Phase II projects that have achieved Phase III?

H_0: There is no significant difference between CSFs of Phase II projects that have not achieved Phase III and Phase II projects that have achieved Phase III

H_1: There is a significant difference between CSFs of Phase II projects that have not achieved Phase III and Phase II projects that have achieved Phase III

The inferences from this research are based upon the inputs from small business managers who have participated in NASA funded SBIR Phase II projects or those Phase II projects that achieved Phase III commercialization or technology infusion. The population was established by selecting companies with recent Phase II projects, allowing enough time where the innovation could have achieved Phase III. This established the minimum baseline. The small business manager had the ability to select a representative NASA funded Phase II project from his/her experience base.

3.2 Contribution

Small business drives innovation and economic growth in the United States. However, small businesses have limited resources to devote to the myriad of distractions that keep innovations from the market, such as government red-tape, limited internal research and development dollars, technology transition costs, or market penetration costs (National Research Council 2008). Additionally, small businesses that work with multiple government organizations must contend with each organization's unique

mission, environment, and needs (National Research Council 2007b, National Research Council 2009). The Small Business Innovation Research program is the largest government effort to leverage small, high-tech firms to deliver innovations to the public and private sectors (National Research Council 2007a). At the organizational level, NASA's SBIR program is the fourth largest with respect to SBIR funding (National Research Council 2009). Not only is the funding significant, but NASA's SBIR program spans the nation. In a recent 4-year period, NASA issued an average of one hundred forty-three Phase II awards covering forty-two states. However, the data on NASA Phase III outcomes is inconsistent with reports ranging from 6% to 46% of NASA SBIRs reaching Phase III (Small Business Administration 1991, United States General Accounting Office 1998, Archibald & Finifter 2003, National Aeronautics and Space Administration 2002, National Research Council 2009).

Previous studies evaluating 'best practices' or characteristics leading to Phase III have done so from the overall SBIR program level, which may be inappropriate (National Research Council 2007b, National Research Council 2009). Other studies have evaluated NASA's SBIR program but were primarily interested in characterizing societal benefits, program attributes, and improving program operations (National Aeronautics and Space Administration 2002, National Research Council 2009). No research has evaluated a participating organization to determine specific factors that lead to Phase III commercialization or technology infusion. Therefore, this research sets out to fill a research gap by identifying a set of Critical Success Factors to improve SBCs' chances to achieve commercialize technology from NASA funded SBIR Phase II projects.

CHAPTER 4

METHODOLOGY

4.1 Introduction

This chapter describes the research methodology. First, Critical Success Factor literature was reviewed to examine the type of methodologies used. A methodology was then selected that best supported the goals of this research. This chapter was organized into three major sections: the Preliminary Study, the Pilot Study, and the Primary Study. The Preliminary Study section discussed the process used to develop the Initial Consolidated Candidate Critical Success Factor list. The Pilot Study section described the methods and analysis used to develop the pilot questionnaire and Final Consolidated Candidate Critical Success Factor list. Finally, the Primary Study section discussed the methods and analysis used to test the study's hypothesis. The goal of this research was to identify Critical Success Factors related to achieving Phase III Commercialization/ Technology Infusion from NASA funded Phase II SBIR projects.

4.2 Critical Success Factor Development Process

The Critical Success Factor (CSF) development process was selected by reviewing the Critical Success Factor literature (discussed in Chapter 2, Section 2.4.4)

and choosing a method based on previous Critical Success Factor research. The literature was grouped into qualitative, quantitative, and mixed method. To ensure the largest sample of candidate Critical Success Factors could be collected, a mixed method approach was selected. A detailed research strategy was then formulated.

4.2.1 Selection of the Method to Determine Critical Success Factors

To select a methodology for determining Critical Success Factors to achieve Phase III from NASA funded Phase II SBIR projects, the literature was reviewed to identify previously used methodologies. Upon reviewing the CSF literature, three key features were identified that differentiated Qualitative, Quantitative, and Mixed Method CSF research. The three key features were Research Scope, CSF Sources, and Analysis Method.

Research Scope describes the focus of the research, which could be a manager, company, profession specialty, or a specific industry. The research scope was more narrowly focused for Qualitative research because it was focused on the individual manager (Rockart 1979), company (Rockart 1979, Shank 1985), or profession specialty (Dobbins 1999, Dyrhaug 2002). In Quantitative literature, the Research Scope was focused on the profession specialty (Pinto and Prescott 1988, Pinto and Slevin 1989) or specific industry (Lee 2004, Watson 2009). In Mixed Method literature, the Research Scope had a mid-range focus conducting an evaluation at the company level (Bergeron and Begin 1989, Wageman 1997), a profession specialty (Cooper and Kleinschmidt 1996,

Dobbins and Donnelly 1988), or specific industry (Rai et al. 1996, Tishler 1996, Bender et al. 2000).

CSF Sources describes the foundation used to formulate candidate CSFs. CSF sources could originate from structured interviews or the literature. Qualitative literature used structure interviews to formulate candidate CSFs. Quantitative literature used the literature for formulated candidate CSFs. Mixed Method literature used a combination of structured interview and literature data to formulate candidate CSFs.

Analysis Methods describes the way in which candidate CSFs were analyzed to draw conclusions about CSFs. Qualitative literature analysis methods used a structured process for the researcher to make interpretations and draw conclusions (Cresswell 2003). The findings may have validated results with additional reviews by the research subjects or subject matter experts. Quantitative studies were structured as experimental designs to test hypotheses using statistical analysis (Cresswell 2003). Mixed Method studies were much more varied in their structure and used a combination of qualitative and quantitative methods to conduct analysis and draw conclusions. Two studies employed data collection via structured interview followed by statistical analysis (Pinto 1986, Wageman 1997). Bender et al. (2000) and Dobbins and Donnelly (1998) used qualitative and quantitative data collection and analysis to compare results. Another method, employed by Rai, Borah, and Arkalgud (1996), used qualitative data collection and analysis to support quantitative data collection and analysis. Last, Bergeron and Begin (1989), Cooper and Kleinschmidt (1996), and Tishler et al. (1996) used qualitative and

quantitative data collection to triangulate a set of candidate Critical Success Factors that were then used in a questionnaire for statistical analysis.

Inherently, this research was an experimental design that would test a hypothesis using statistical analysis. Therefore, at least a portion of the research was Quantitative. Quantitative data and analysis would include broad application, objective findings that could be more generalizable to the industry (Cooper and Kleinschmidt 1996). However, Dobbins (1999) argued it is essential to develop Critical Success Factors directly from manager input via structured interviews rather than rely solely on the literature. Qualitative data and analysis would allow inclusion of rich, descriptive findings that would maintain the specific context applicable to candidate Critical Success Factors (Dobbins 1999). The triangulation method provides multiple viewpoints to confirm or converge on a solution (Cresswell, 2003). Therefore, the triangulation method was chosen as a method to include both Qualitative and Quantitative elements to mutually support and down-select the most important candidate Critical Success Factors. Table 4.2 shows the Critical Success Factor research methodologies.

Table 4.1 Critical Success Factor Research Methodologies

	Qualitative Methods	Mixed Methods	Quantitative Methods
Research Scope	• Manager • Company • Profession Specialty	• Company • Profession Specialty • Specific Industry	• Profession Specialty • Specific Industry
CSF Sources	• Structured Interview	• Structured Interview • Literature	• Literature
Analysis Method	• Inference with Subject Matter Expert (SME)/ Subject Validation	• Inference with SME/ Subject Validation • Experimental Design using Questionnaire/ Statistical Analysis • Qualitative findings compare, support, or triangulate Quantitative findings	• Experimental Design using Questionnaire/ Statistical Analysis

4.2.2 Development of the Research Process to Determine Critical Success Factors

Upon selecting the Mixed Method approach, the available sources and analysis methods had to be organized into a coherent research process. The different types of sources and analysis methods drove development of a multiphase research process. Three major phases were developed as shown in Figure 4.1: the Preliminary Study, the Pilot Study, and the Primary Study.

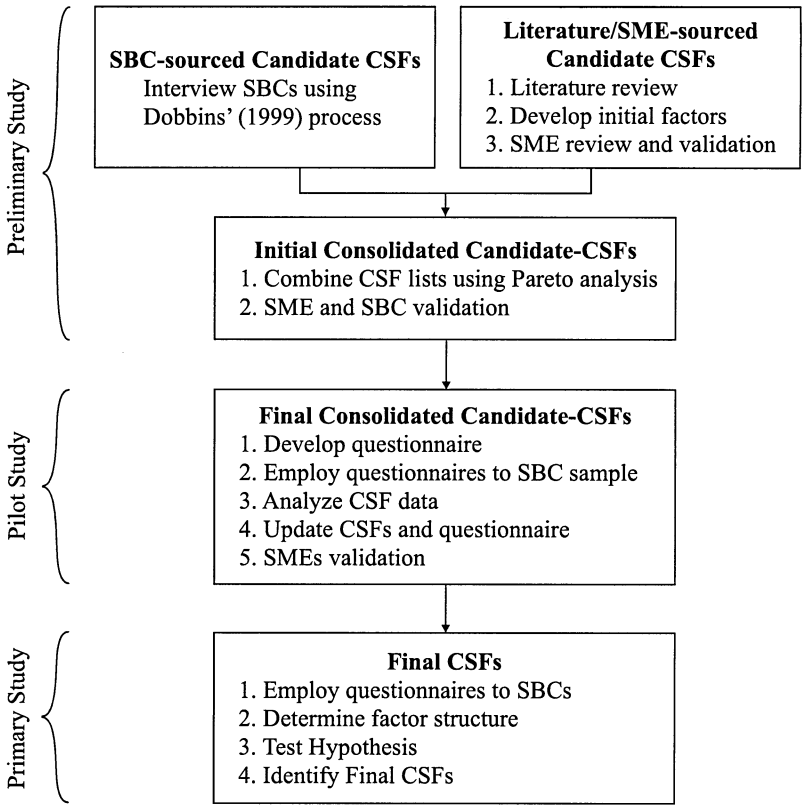
The Preliminary Study's goal was to identify a set of Initial Consolidated Candidate Critical Success Factors. The Preliminary Study was split into two sub-processes. The first sub-process developed a set of Candidate Critical Success Factors through SBC interviews. Dobbins' (1999) Generalized Process Model was followed for these interviews to maintain the context of the Critical Success Factor relevant to specific SBC managed Small Business Innovation Research projects. The second sub-process developed a set of Literature-based Candidate Critical Success Factors. NASA Small

Business Innovation Research Subject Matter Experts (SMEs) were to review and validate the development of the Candidate Critical Success Factors. The SBC-based Candidate Critical Success Factor list and Literature/SME-based Candidate Critical Success Factor lists were then combined using Pareto analysis with NASA Small Business Innovation Research SME and SBC manager review and validation to form the Initial Consolidated Critical Success Factor list.

The Pilot Study's goals were to pilot the questionnaire and reduce the Initial Consolidated Candidate Critical Success Factor list and thereby develop the set of Final Consolidated Candidate Critical Success Factors. A questionnaire was developed through a review of the underlying data forming the Initial Consolidated Critical Success Factor list. After SME and SBC review the questionnaire was piloted. The data was statistically analyzed to reduce the number of questionnaire descriptor statements and corresponding Candidate Critical Success Factors. The updated list was then used to form the Final Consolidated Candidate Critical Success Factor list.

The Primary Study's goal was to identify the set of Final Critical Success Factors. The updated questionnaire was employed on the defined SBC population. The plan was to develop a factor structure for Phase II "did not achieve" and Phase II "achieved" SBIR projects. These factor structures was compared to test the hypothesis and identify the Final Critical Success Factors.

Figure 4.1 Methodology Flow Diagram



It should be noted that NASA SMEs were selected based on their years of experience with NASA SBIRs, the type of experience, and mix of experience with projects completing Phase II with those that achieved Phase III. A pool of six SMEs were utilized for this research with their credentials shown in Table 4.2. The SME's experience averaged 14.7 years. All had experience as a Contracting Officer Technical Representative (COTR). The COTR was the contract monitor for an SBIR contract and had day-to-day technical interchange with the company performing the SBIR project. Two had experience as a Subtopic Manager. The Subtopic Manager helped create SBIR topics for annual solicitation. All had extensive experience working with Phase II projects and experience with at least one Phase III project.

Table 4.2 NASA SME Credentials

SME Number	Years Experience	Type of Experience	Mix of Experience
SME 1	20	COTR Subtopic Manager	10 Phase IIs 3 Phase IIIs
SME 2	13	COTR Resource Manager Asst. Program Manager SBIR Program Manager	>100 Phase IIs >100 Phase IIIs
SME 3	11	COTR	20 Phase IIs 3 Phase IIIs
SME 4	12	COTR	6 Phase IIs 1 Phase III
SME 5	18	COTR Subtopic Manager	>25 Phase IIs 3 Phase IIIs
SME 6	14	COTR	30 Phase IIs 1 Phase III

4.3 Preliminary Study

The purpose of the Preliminary Study was to define a set of Initial Consolidated Candidate Critical Success Factors to form a baseline to execute the rest of the study. The Initial Consolidated Candidate Critical Success Factors were formed by merging a set of Literature/SME-based Candidate Critical Success Factors and a set of SBC-based Candidate Critical Success Factors. The following sections describe the formulation of Literature/SME-based Candidate Critical Success Factors, the SBC-based Candidate Critical Success Factors, and the methods used to merge the two lists into an Initial Consolidated Candidate Critical Success Factor list.

4.3.1 Literature/Subject Matter Expert-based Candidate Critical Success Factors

A literature review was conducted to identify characteristics that could be used to formulate Candidate Critical Success Factors. Few sources were found that described success factors to achieve SBIR Phase III so the review was broadened to include commercialization and technology infusion best practices, success factors, and critical success factors in the innovation and technology transfer fields. Twenty-six sources were identified. For example, one commercialization success factor identified was "high level management support" (Balachandra 1997). Key words and phrases were documented for each source. Like-data references were grouped within a single source. Then like-data references were grouped across different sources. These natural groupings produced a list of thirty-four Literature-based Candidate Critical Success Factors. Five NASA Marshall Space Flight Center SBIR SMEs reviewed the list. Each SME individually reviewed each Candidate CSF and either validated the Candidate CSF, amended the Candidate CSF, eliminated a Candidate CSF, combined a Candidate CSF with one or more other Candidate CSFs, or added one or more new Candidate CSFs. Each SME list was then compared side-by-side and like Candidate CSFs were merged. Each SME then reviewed the updated Candidate CSF list again and had the option to validate, amend, eliminate, combine, or add Candidate CSFs. The SME review resulted in a set of twenty-six Literature/SME-based Candidate CSFs, as shown in Table 4.4. The detailed process to develop the Literature/SME-based Candidate CSF list is contained in Appendix A.

Table 4.3 Literature/SME-based Candidate Critical Success Factors

1	The SBC has the infrastructure to deliver the technology
2	The technology fills an identified market/user need
3	Open communication occurs between the user and SBC
4	The SBC is responsive to customer needs
5	SBIR project is aligned with a market-focused business strategy
6	SBC top management provides support for the SBIR project
7	The SBC actively pursues Phase III funding before Phase II completion
8	The SBC actively markets the technology
9	The SBIR project is integrated into the customer's planning
10	The SBC is product oriented
11	A champion exists within NASA that facilitates progress of the technology project
12	The SBC and user share responsibility to accomplish the technology project
13	The SBC has a high performing team working the SBIR project
14	The technology developed is mature
15	The customer likes the technology/product
16	NASA administrative processes are executed in a timely manner
17	The SBC actively pursues intellectual property protection during all Phases
18	The SBC has a private sector focus
19	The SBC can effectively manage external influences
20	NASA acts as an advertising mechanism for the technology/product
21	The SBC has a documented marketing/commercialization plan
22	NASA provides training to the SBC on the SBIR program/processes
23	The SBC's culture supports technology transfer
24	The SBC and NASA share personnel during the life of the technology development project
25	The rewards structure of the SBC supports technology transfer
26	The SBC has documented development & commercialization plans

4.3.2 Small Business Concern-based Candidate Critical Success Factors

Small Business Concern (SBC) managers who had experience with Phase III commercialization or technology infusion originating from NASA funded SBIR projects were interviewed to elicit Critical Success Factors. Dobbins' (1999) Generalized CSF Process Model, described in Chapter 2, was followed to conduct the interviews and analysis. The interview process had SBC manager's identify critical characteristics for ten areas related to the SBIR project: Global or Industry Related, External Influences, Internal Influences, Current and Future, Temporal and Enduring, Risk Abatement, Performance, Special Monitoring, Quality, and Modification Management. Five small businesses were selected based on input from the NASA's Marshall Space Flight Center SBIR Program Manager. Two face-to-face interviews were conducted and three phone interviews were conducted. An interview was conducted with each manager, followed by data analysis, then results were validated with each manager. The five Candidate CSF lists (Appendix B, Table B-1) were then merged, keeping all unique Candidate CSFs. Then each SBC manager was asked to review the complete list (Appendix B, Table B-2) and to vote which should be Candidate CSFs. All Candidate CSFs received at least one vote except "Develop technology/product utilizing concurrent systems engineering development process," so it was removed from the SBC-based Candidate CSF list. A set of nineteen SBC-based Candidate Critical Success factors resulted, as shown in Table 4.5. Each SBC manager reviewed the list and verified the results based on their NASA funded Small Business Innovation Research work experience. Five SBC-based Candidate CSFs

were the same as Literature/SME-based Candidate CSFs. The detailed process to develop the SBC-based Candidate Critical Success Factors is contained in Appendix B.

Table 4.4 SBC-based Candidate Critical Success Factors

1	Maintain regular and open communication with the customer
2	Begin project with a plan for post-Phase II activity
3	Deliver the technology/product within budget and schedule
4	Demonstrate the technology's capabilities to the customer
5	Ensure the technology/product meets customer needs
6	Manage personnel availability
7	Predict customer demand
8	Verify performance utilizing a rigorous test program
9	Develop a robust design
10	Develop and utilize lessons learned
11	Develop sources of funding to cover funding gaps
12	Ensure components are delivered within performance specifications through a rigorous quality system
13	Ensure the principle investigator has technical, communication, and business skills
14	Market the technology/product
15	Understand the underlying fundamentals of the technology's performance characteristics
16	Maintain rigorous configuration management process
17	Pursue SBIR projects that develop company expertise/intellectual property value
18	Maintain rigorous quality standards
19	Plan for technology obsolescence

4.3.3 Development of the Initial Consolidated Candidate Critical Success Factors

To develop the Initial Consolidated Candidate Critical Success Factor list, the Literature/SME-based Candidate CSF list and the SBC-based Candidate CSF list were compared side-by-side and evaluated using Pareto analysis. A Pareto score was developed for each list by counting the number of times a particular Candidate CSF

existed in the respective list. The factors from each list with a Pareto score of three or higher were kept and then like factors from each were matched for merger. The Candidate Critical Success Factor lists were merged. Following Dobbins' (1999) argument, the SBC-based Candidate CSFs were given priority because they better maintained the CSF context. The merged lists formed eighteen Initial Consolidated Candidate Critical Success Factors, as shown in Table 4.8. The SBC managers and NASA SMEs reviewed and validated the Initial Consolidated Candidate Critical Success Factor list. The detailed process to develop the Initial Consolidated Candidate Critical Success Factor list is contained in Appendix C.

Table 4.5 Initial Consolidated Candidate Critical Success Factors

1	Communication quality between the company's SBIR project team and your NASA customer
2	The degree to which your NASA customer's needs were met
3	Providing your NASA customer with a preview of the technology's capabilities
4	Your company's ability to manage personnel resources for the SBIR project
5	The depth of the innovation's verification program to substantiate performance
6	Understanding the intended application of the innovation once the SBIR project was complete
7	The SBIR project's performance against stated key performance parameters
8	Funding requirements beyond the completion of the SBIR project to bridge funding gaps
9	The degree of marketing activity for the innovation
10	The innovation's alignment with the company's business strategy
11	The degree of your company's management support for the SBIR project/innovation
12	The degree of integration the SBIR project had with your customer's planning
13	The type of development your company primarily pursued – product or process
14	The degree to which the SBIR project received support from NASA personnel
15	The ability of your company to predict the market/customer demand for the innovation
16	The degree your SBIR project team shared decision making responsibility with your customer
17	The level your SBIR project team's performance
18	The level of maturity the innovation achieved through the SBIR project

4.4 Pilot Study

The purpose of the Pilot Study was to pilot the questionnaire and reduce the initial list and thereby develop the set of Final Consolidated Candidate Critical Success Factors. To create the Final Consolidated Candidate Critical Success Factors, a questionnaire was developed based on the Initial Consolidated Candidate Critical Success Factors. The questionnaire and data analysis were then piloted to demonstrate the methodology's feasibility. Finally, lessons-learned were documented and incorporated. The following

sections describe the detailed steps to develop the Final Consolidated Candidate Critical Success Factor list.

4.4.1 Development of the Pilot Questionnaire

The basis for the hypothesis test was to compare differences between NASA SBIR Phase II projects that did not achieve Phase III and projects that achieved Phase III. Upon reviewing the literature, no instrument existed to gather data to support this test, so an original questionnaire had to be developed. The method to collect data required SBC managers to recall past events about SBIR projects in which they participated. Since the method to collect data was based on past events a questionnaire was an appropriate instrument.

To develop the pilot questionnaire, the underlying literature and interview data forming the eighteen Initial Consolidated Candidate Critical Success Factors were reviewed and analyzed. Sub themes within the Initial Consolidated Candidate Critical Success Factors were used to form descriptor statements. Three descriptor statements were developed for each Candidate CSF except Initial Consolidated Candidate CSF 17 (from Table 4.8), "The level of your SBIR project team's performance." Team performance is inherently a multi-factor phenomena and would require a validated survey instrument to adequately measure its contribution to this research. Therefore, the team performance-based Candidate CSF utilized an existing team performance survey instrument (Halfhill 2000). The details to develop the descriptor statements are contained in Appendix D. This gave the Initial Consolidated Candidate CSFs fifty-nine descriptor

statements. Two versions of the questionnaire were developed. One was written with a frame of reference for SBIR Phase II projects that did not achieve Phase III (Phase II "did not achieve"). The second was written with a frame of reference for SBIR Phase II projects that achieved Phase III (Phase II "achieved"). Each questionnaire's questions were the same except for an additional demographic question on the Phase II "achieved" questionnaire requesting information on the type of Phase III achieved. Instructions were provided to complete each questionnaire based on the SBCs experience with either Phase II "did not achieve" or Phase II "achieved" projects. The instructions and descriptor statements were subsequently reviewed and validated by the NASA SMEs and the SBCs that participated in the Preliminary Study. The pilot questionnaires and the letter allowing Halfhill's (2000) survey instrument questions are provided in Appendix E.

4.4.2 Pilot Study Implementation

Before implementing the pilot questionnaires a potential sample was identified. The NASA SBIR Phase II award database was reviewed and thirty-five SBCs were randomly selected from the 2001 through 2005 award periods. The SBCs were contacted via phone and asked to participate in the pilot study. Of the thirty-five SBCs, twenty-six were successfully contacted. Six responses were returned for the Phase II "did not achieve" questionnaire and five responses were returned for the Phase II "achieved" questionnaire resulting in approximately a 20% response rate.

4.4.3 Pilot Study Analysis

Objectives of the pilot study analysis were to determine whether descriptor statements were associated with their Initial Consolidated Candidate CSFs and eliminate multi-CSF dependent descriptor statements. With the small data set, Factor Analysis was not practical and an alternate method was selected. Goldstein (1982) presented a process to analyze multivariate data sets by direct inspection. The process allowed clustering data through visual means by creating categories based on quartiles or some other distinction. The data could then be sorted and grouped by category. For the pilot analysis, correlation strength was used as the discriminator. Table 4.6 presents correlation strength criteria to discriminate variable correlations, based on definitions provided by Jaisingh (2006) and Johnston (2000). The purpose of the groupings was to eliminate cross-factor correlated descriptor statements. An example section from the Phase II "did not achieve" matrix is shown in Table 4.7 and the complete correlation matrices are presented in Appendix F.

Table 4.6 Correlation Matrix Criteria

Correlation	Criteria	Marking
Strong	r >= 0.8 and -0.8 =< r	Dark Gray
Medium-Strong	0.8 > r <= 0.4 and -0.4 <= r > -0.8	None
Medium-Weak	0.4 > r < 0.1 and -0.1 < r > -0.4	Text Hidden
Weak	0.1 >= r =< -0.1	Hash

Table 4.7 Phase II Correlation Matrix, Selected Data

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1		0.633	1.000	0.858	0.858	0.773		0.552					0.633		
2	0.633		0.633	0.868	0.542	0.908	0.671	0.768	0.489				0.700		0.700
3	1.000	0.633		0.858	0.858	0.773		0.552					0.633		
4	0.858	0.868	0.858		0.647	0.947	0.728	0.871	0.492			0.000	0.542		0.542
5	0.858	0.542	0.858	0.647		0.492		0.417	0.038		0.647	0.420	0.868		
6	0.773	0.908	0.773	0.947	0.492		0.625	0.756	0.415		0.038		0.489		0.698
7		0.671		0.728		0.625		0.937	0.937	0.707	0.485	-0.433		0.707	0.671
8	0.552	0.768	0.552	0.871	0.417	0.756	0.937		0.756	0.552	0.417	-0.406		0.442	0.559
9		0.489		0.492	0.038	0.415	0.937	0.756		0.773	0.492	-0.406	0.070	0.884	0.698
10							0.707	0.552	0.773		0.858			0.500	
11					0.647	0.038	0.485	0.417	0.492	0.858		0.000	0.542		
12				0.000	0.420		-0.433	-0.406	-0.406		0.000		0.581		0.000
13	0.633	0.700	0.633	0.542	0.868	0.489			0.070		0.542	0.581			0.100
14							0.707	0.442	0.884	0.500					0.791
15		0.700		0.542		0.698	0.671	0.559	0.698			0.000	0.100	0.791	

The Phase II "did not achieve" and Phase II "achieved" data sets were evaluated individually. For each data set, a descriptor statement was evaluated one-for-one against all other descriptor statements. Descriptor statements with strong correlation patterns were grouped together. A descriptor statement with a strong correlation in more than one group was eliminated because its information was contained in each distinct group. Eleven Phase II "did not achieve" descriptor statements were eliminated and one Phase II "achieved" descriptor statement was eliminated using this method. The Phase II "did not achieve" and Phase II "achieved" descriptor statement lists were then matched so that each list matched the other one-for-one.

The descriptor statement analysis eliminated Initial Consolidated Candidate CSF 12 ("The degree of integration the SBIR project had with your customer's planning"). It merged Initial Consolidated Candidate CSFs 1 and 2 ("Communication quality between the company's SBIR project team and your NASA customer" and "The degree to which your NASA customer's needs were met"). It also merged Initial Consolidated Candidate CSFs 3 and 5 ("Providing your NASA customer with a preview of the technology's

capabilities" and "The depth of the innovation's verification program to substantiate performance"). The full correlation matrices are contained in Appendix F.

The descriptor statements were then reviewed by three NASA SMEs. The SMEs validated the groupings and then analyzed the grouped descriptor statements to determine if like statements could be merged. For statements to be merged, all three SMEs had to agree. Only one descriptor statement was reduced using this method. The Initial Consolidated Candidate CSF 1 descriptor statement "Project members developed a trusting relationship with their customer" was merged with "Project members' communication built the customer's confidence in the innovation." The results of the pilot analysis reduced Candidate CSFs from eighteen to fifteen and corresponding descriptor statements from fifty-nine to forty-six. Table 4.8 shows the Final Consolidated Candidate Critical Success Factors resulting from the pilot study analysis.

Table 4.8 Final Consolidated Candidate Critical Success Factors

1	Communication quality between the company's SBIR project team and the NASA/Phase III customer that influences the degree to which the customer's needs were met.
2	The depth of the innovation's verification program to substantiate performance
3	Your company's ability to manage personnel resources for the SBIR project
4	Understanding the intended application of the innovation once the SBIR project was complete
5	The SBIR project's performance against stated key performance parameters
6	Funding requirements beyond the completion of the SBIR project to bridge funding gaps
7	The degree of marketing activity for the innovation
8	The innovation's alignment with the company's business strategy
9	The degree of your company's management support for the SBIR project/innovation
10	The type of development your company primarily pursued – product or process
11	The degree to which the SBIR project received support from NASA personnel/Phase III customer
12	The ability of your company to predict the market/customer demand for the innovation
13	The degree your SBIR project team shared decision making responsibility with your customer
14	The level of maturity the innovation achieved through the SBIR project
15	The level your SBIR project team's performance

To demonstrate the analysis for identifying significant results, a Mann-Whitney test was conducted to compare medians between the Phase II "did not achieve" and Phase II "achieved" data sets. The hypothesis, below, used a significance of $\alpha = 0.05$. Figure 4.9 show the results of the means test.

H_0: Phase II "did not achieve" Candidate CSF = Phase II "achieved" Candidate CSF

H_1: Phase II "did not achieve" Candidate CSF $\neq$ Phase II "achieved" Candidate CSF

The pilot results show that 'communication', 'the depth of the verification program', and 'team performance' could be discriminated to show significant variables

that contribute to achieving Phase III. The small data set precluded analysis on Final Consolidated Candidate CSF 8. Note, no conclusions were drawn from these results as they were just to demonstrate the methodology.

Table 4.9 Pilot Study Results for the Final Candidate Critical Success Factors

	Final Candidate Critical Success Factors	p-value
1	Communication quality between the company's SBIR project team and the NASA/Phase III customer that influences the degree to which the customer's needs were met.	0.0004
2	The depth of the innovation's verification program to substantiate performance	0.0342
3	Your company's ability to manage personnel resources for the SBIR project	0.6532
4	Understanding the intended application of the innovation once the SBIR project was complete	0.1966
5	The SBIR project's performance against stated key performance parameters	0.3061
6	Funding requirements beyond the completion of the SBIR project to bridge funding gaps	0.2822
7	The degree of marketing activity for the innovation	0.3536
8	The innovation's alignment with the company's business strategy	N/A
9	The degree of your company's management support for the SBIR project/innovation	0.1851
10	The type of development your company primarily pursued – product or process	0.5653
11	The degree to which the SBIR project received support from NASA personnel/Phase III customer	0.0586
12	The ability of your company to predict the market/customer demand for the innovation	0.737
13	The degree your SBIR project team shared decision making responsibility with your customer	0.109
14	The level of maturity the innovation achieved through the SBIR project	0.2919
15	The level your SBIR project team's performance	0.0212

4.4.4 Pilot Study Summary and Lessons-Learned

The questionnaires and instructions were updated based on the pilot study results and lessons-learned (Section 4.4.4, lesson 4). NASA SMEs reviewed the updated questionnaire for face validity and content validity (Litwin 1995). Appendix G contains the instructions and questionnaires used for the Primary Study.

Four lessons-learned were developed during the course of the pilot study. Each lesson helped structure the methodology to enhance the execution of the primary study and avoid roadblocks.

The first lesson-learned was that the final factor structure must be determined during the primary study. The pilot study simply had too few data points to determine a factor structure.

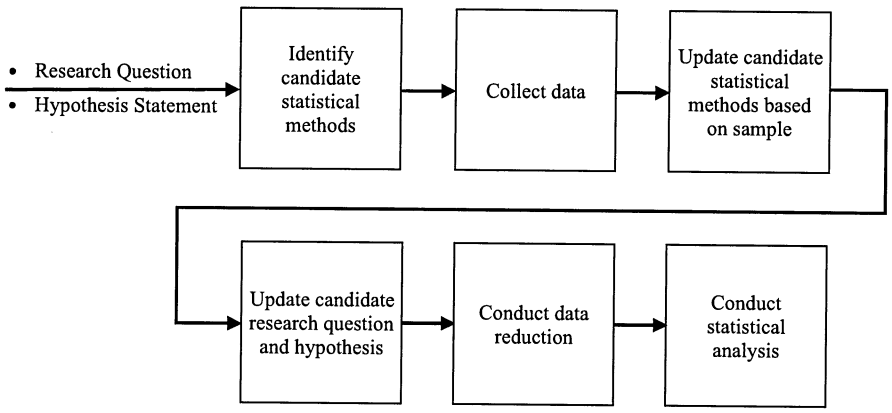
The second lesson-learned was that the primary study would likely need an alternative to factor analysis to determine the final factor structure. The population, 2002 to 2006 NASA Phase II awardees, was three hundred ninety-nine SBCs. If the primary study response rate was similar to the pilot study's (~20%) then there would not be enough data points to utilize factor analysis. A variable reduction method would be required and an alternative to factor analysis, such as logistic regression, should be reviewed.

The third lesson-learned was to look for additional ways to improve response rate. Two methods were identified and pursued. The first was to utilize multiple formats for questionnaire delivery and response, followed by recontact. The NASA SBIR Phase II database had SBC street addresses, company phone numbers, and an email contact. Therefore, a direct mailing followed by repeated email contact requesting research participation was chosen. SBCs would have the option to use multiple methods to respond via email or fax. Contact by phone was available if needed. The second method was to obtain NASA SBIR management endorsement or National Research Council endorsement for the study to emphasize the importance of the research.

4.5 Primary Study

The purpose of the Primary Study was to determine the Final Critical Success Factors to achieve Phase III from NASA funded SBIR Phase II projects. To accomplish this, statistical methods were defined that evaluated the research question and hypothesis. Data was collected via two questionnaires sent to three hundred ninety-nine SBCs identified from the NASA SBIR database. The limited data set precluded using the planned statistical analysis, so statistical methods were updated to enable production of research results consistent with the research goals. The research question was then updated to reflect what could be produced with the available data. The, variable reduction techniques were reviewed and employed to achieve a workable data set. The data was then analyzed to discriminate variables. The following sections describe the detailed steps to select an appropriate statistical test, review the data collected via the questionnaires, and update to an appropriate statistical test with respect to the available data to best achieve this study's research goals. Figure 4.2 shows the process to execute the Primary Study.

Figure 4.2 Primary Study Process



4.5.1 Candidate Method Selection to Test the Hypothesis

From Chapter 3, the research question and hypothesis for this study:

Is there a difference between Phase II "did not achieve" and Phase II "achieved" CSF factor structures?

> H_0: There is no significant difference between Phase II "did not achieve" and Phase II "achieved" CSFs
>
> H_1: There is a significant difference between Phase II "did not achieve" and Phase II "achieved" CSFs

The hypothesis statement would be tested by developing a factor structure for Phase II projects that did not achieve Phase III and for Phase II projects that did achieve Phase III and then comparing the two factor structures. For this study, data to conduct the factor analysis was gathered via two comparable questionnaires: one for Phase II "did not achieve" Phase III and one for Phase II "achieved" Phase III. Each questionnaire was identical except for the perspective from which one completed the questionnaire ("did not achieve" vs "achieved") and additional demographic questions about the type of Phase III ("Commercialization" / "Technology Infusion") for "achieved" projects.

Factor analysis would be used to develop Phase II "did not achieve" and Phase II "achieved" factor structures to allow comparison against one another. First, unique Phase II "achieved" factors would become CSFs. Second, like Phase II "did not achieve" and Phase II "achieved" factor means could be compared with the significant factors becoming CSFs. The following section reviews factor analysis for its intended purpose, assumptions for use, and implications for this research.

4.5.1.1 Factor Analysis

Factor analysis is a statistical tool used to determine the underlying factor structure starting from a proposed factor model. Essentially, factor analysis determines factor loading by maximizing and explaining the amount of common variance. Factor analysis utilizes a correlation matrix to determine maximum common variance (Grimm and Yarnold 1995).

The following assumptions need to be met to use factor analysis:

1. Each indicator and all linear combinations of indicators must have a normal distribution (Grimm and Yarnold 1995)
2. Factor analysis requires an adequate sample size. A guideline for the minimum samples-to-variable ratio is five to ten (Grimm and Yarnold 1995)

A significant issue to overcome is the sample-to-variable requirement. Because each questionnaire has forty-six descriptor statements (variables), at least two hundred thirty responses would be required for each questionnaire.

4.5.2 Primary Study Characteristics

The NASA SBIR contract award database was utilized to identify potential companies to sample (http://sbir.gsfc.nasa.gov/SBIR/awards.htm). The Pilot Study indicated companies that participated in NASA's SBIR program further back in time were less likely to provide reliable data and less likely to be contacted. On the other end of the time scale, enough time needed to have elapsed for companies to complete Phase II contracts with some additional time to achieve Phase III. These findings were consistent with findings from the National Research Council study (2009) of NASA's SBIR program. Therefore, companies awarded Phase II contracts from 2001 through 2006 were selected for the population to sample, producing a list of three hundred ninety-nine potential contacts.

Beginning in November 2010, a physical mailing was sent to the list of companies. The mailing included instructions for downloading Adobe Acrobat® versions of each questionnaire. Questionnaires could either be returned by email or fax. The physical mailing was followed by five additional emails from December 2010 to March 2011. The emails included Adobe Acrobat® versions of instructions and questionnaires.

Of the three hundred ninety-nine companies, seventy-nine companies had both physical mail returned-to-sender and emails bounced. These companies were removed from the population sample, leaving three hundred twenty companies.

Of the three hundred twenty companies contacted, sixty-two responded. Twenty-nine companies declined to participate. Most companies responded to either the Phase II "did not achieve" questionnaire or the Phase II "achieved" questionnaire. Forty-five

Phase II "did not achieve" questionnaires and twenty-seven Phase II "achieved" questionnaires were received. Ten companies completed both questionnaires for unique projects. This produced a total of seventy-two responses, giving a response rate of 22.5%. Table 4.10 shows the breakdown of responses with corresponding response rates. The detailed sampling data is contained in Appendix H.

Table 4.10 Primary Study Characteristics

	Number	Percentage
Companies included in sample	320	
Companies that responded	62	19.38%
Companies that declined to participate	29	9.06%
Responses for projects that did not achieve Phase III	45	14.06%
Responses for projects that achieved Phase III	27	8.44%
Total questionnaire responses	72*	22.5%

* Ten companies submitted a response for each questionnaire

4.5.3 Assessing Statistical Methods Based on Sample Characteristics

The samples-to-variable ratio was too small to conduct factor analysis. Variable reduction could not be considered in combination with factor analysis because of the small sample for Phase II "achieved" (N=26). For factor analysis to produce stable results at least three variables (five or more is recommended) must load on a single factor (Costello and Osborne 2005). The analysis becomes over constrained between the samples-to-variable ratio and the number of variables required to obtain valid factor

analysis results. Another statistical method, binary logistic regression, provided an alternative because a model could be formulated that would discriminate significant variables for the Phase II "achieved" condition. The ability to create a factor structure would be lost, but identifying a set of variables that predict increased likelihood of achieving Phase III was consistent with the research goals and a worthy outcome. A description of binary logistic regression is provided below.

4.5.3.1 Binary Logistic Regression

Binary logistic regression is a statistical tool that tests a model with a dichotomous predictor (dependent) variable and one or more predictor (independent) variables. The logistics regression model predicts the odds a variable belongs to one of two groups. The odds are expressed as a ratio of the probability of being in one group over the probability of being in the other group. When the odds ratio has a value of one the outcome of each group is equally likely. Odds ratio values greater than one indicate the outcome of the target group is more likely than the other group. Odds ratio values less than one indicate the outcome of the target group is less likely than the other group (Laurence 1995, Schwab 2005).

Several assumptions exist for logistic regression (Laurence 1995, Schwab 2005):

1. There must be a dichotomous dependent variable.
2. Cases represented must be independent.
3. The model must include all relevant predictors.
4. Categories must be mutually exclusive and collectively exhaustive. That is, a case under evaluation either fits in one group or the other, not both or neither.

5. Logistic regression requires a large sample size. A samples-to-variable ratio of at least ten but as high as fifty is recommended.

The issues relating to the use of logistic regression for this research relate to the sample size requirement. Since the questionnaires have forty-six descriptor statements (variables) a minimum of four hundred sixty responses would be required. This would indicate a need to conduct variable reduction prior to analysis. Three alternatives were considered to reduce the variables: Principal Component Analysis, Canonical Correlation, and Variable-to-Variable Group Comparison. Each tool's purpose, assumptions, and implications for this research is discussed below.

4.5.3.2 Principal Component Analysis

Principal Component Analysis provides a way to reduce a set of variables to its most important components. These explain most of the total variance. The method accomplishes this by utilizing a series of eigenvectors to explain total variance of a larger data set. The eigenvectors are the principal components (Laurence 1995, Schwab 2005).

Several assumptions must be met to utilize Principal Component Analysis (Laurence 1995, Schwab 2005):

1. There must be at least two variables.
2. To be included in the analysis, correlations of at least 0.3 must exist in the correlation matrix.
3. Variables must be metric or dichotomous nominal level.
4. A sampling adequacy of 0.5 is required. Variables less than 0.5 are removed.
5. The Bartlett test of sphericity must be significant.

6. A large sample size is required. At least five samples-to-variable, with a minimum of one hundred samples, is recommended.

The implication for this research is that this method cannot be used. The data set does not meet the sample size requirement (45 Phase II "did not achieve" and 27 Phase II "achieved") for the number of variables (46). For this study, two hundred thirty (230) variables would be required for each questionnaire version.

4.5.3.3 Canonical Correlation

Canonical Correlation is a tool that shows linear relationships between two sets of variables (Levine 1977, Hair et al. 2009). Canonical Correlation is similar to Principal Component Analysis, but with fewer restrictions on its application (Hair et al. 2009). For this research, Canonical Correlation would be used to determine relationships between Phase II "did not achieve" and Phase II "achieved" data sets. Variables that are the same between data sets could be set aside from further analysis.

Like other multivariate methods, Canonical Correlation has several assumptions (Hair et al. 2009):

1. Canonical Correlation is sensitive to missing data and outliers, so methods must be applied to mitigate these conditions.
2. There must be a linear relationship between variable pairs.
3. Variable normality is desired but not required.
4. Variable relationships need to be homoschedastic.
5. Variables should not have multicolinearity.
6. A large sample size. Ten observations per variable is recommended.

The implication for this research is that this method cannot be used. The data set does not meet the sample size requirement (45 Phase II "did not achieve" and 27 Phase II "achieved") for the number of variables (46). For this study, four hundred sixty (460) variables would be required for each questionnaire version.

4.5.3.4 Variable-to-Variable Comparison of Phase II Groups

An alternate method was evaluated because multivariate methods have a common samples-to-variable limitation. Therefore, an alternate method was evaluated for this research data set. Since the two questionnaires had identical descriptor statement structures, a descriptor statement-to-descriptor statement (variable-to-variable) comparison could be conducted to determine differences. Variables with no significant difference would not discriminate in further analysis. Since the questionnaire data is ordinal, the non-parametric Mann-Whitney Test is appropriate. The Mann-Whitney Test compares two sample's medians and distributions to determine whether they belong to the same group (Boslaugh and Waters 2009, CK-12 Foundation 2011).

To use the Mann-Whitney Test several assumptions about the data need to be met (Boslaugh and Waters 2009, CK Foundation 2011):

1. The data must have a continuous distribution.
2. There must be five or more samples. The groups to compare do not need the same number of observations.
3. The data must be numeric or ordinal, not categorical.

The assumption with the variable-to-variable comparison is that only significant results from the comparison could produce significant results with the logistic regression analysis.

4.5.4 Updating Definitions, Research Question, and Hypothesis

With binary logistic regression analysis and variable-to-variable variable reduction selected, additional definitions needed introduction, the research question and hypothesis statement required updating based on analytical limitations. Two additional definitions were introduced: the Success Variable and Success Indicator. In order of strength, the Critical Success Factor is the most robust, followed by the Success Variable, then the Success Indicator. Each are defined below:

- Critical Success Factor (CSF) (from Chapter 2, Section 2.4) - a few key areas where things must go right to achieve Phase III commercialization and/or technology infusion. (adapted from Dobbins, 1979)
- Success Variable (SV) - a variable discriminated for projects that achieved Phase III.
- Success Indicator (SI) - a variable discriminated that shows increased potential for contribution to achieve Phase III.

The primary research question and corresponding hypothesis statement was amended from:

Is there a difference between Phase II "did not achieve" and Phase II "achieved" CSF factor structures?

> H_0: There is no significant difference between Phase II "did not achieve" and Phase II "achieved" CSFs
>
> H_1: There is a significant difference between Phase II "did not achieve" and Phase II "achieved" CSFs

to:

Are there one or more variables that may be discriminated that show increased likelihood to achieve Phase III from NASA funded Phase II SBIR projects?

> H_0: There is no significant difference between Phase II "did not achieve" and Phase II "achieved" success variables
>
> H_1: There is a significant difference between Phase II "did not achieve" and Phase II "achieved" success variables

4.5.5 Variable Reduction

The variable-to-variable comparison variable reduction was conducted with the Mann-Whitney Test using Minitab 16 Statistical Software®. Table 4.11 shows the results of the Mann-Whitney Tests, with the significant ($\alpha = 0.05$) tests high-lighted in gray. Eight variables were identified as significant from the questionnaire's forty-six descriptor statements. These eight variables were retained for further analysis and the remaining variables were set aside.

Table 4.11 Mann-Whitney Test Variable Reduction

	Phase II "did not achieve" N = 45 Median	Phase II "achieved" N = 27 Median	p-value		Descriptor Statement
Q1	4.000	4.000	0.2943		
Q2	4.000	5.000	0.3997		
Q3	4.000	5.000	0.8313		
Q4	4.000	5.000	0.0006	Significant	The technology solved the customer's problem.
Q5	4.000	4.000	0.2050		
Q6	4.000	4.000	0.1767		
Q7	4.000	4.000	0.7825		
Q8	4.000	4.000	0.9001		
Q9	4.000	4.000	0.5253		
Q10	4.000	4.000	0.0251	Significant	Personnel were assigned to other projects when their services were no longer needed.
Q11	4.000	5.000	0.1519		
Q12	3.000	4.000	0.4034		
Q13	4.000	4.000	0.3743		
Q14	4.000	4.000	0.3569		
Q15	4.000	4.000	0.8757		
Q16	4.000	4.000	0.5397		
Q17	4.000	4.000	0.3454		
Q18	3.000	4.000	0.1667		
Q19	2.000	3.000	0.0043	Significant	The project received external funding to bridge any post-Phase II funding gaps.
Q20	4.000	4.000	0.2541		
Q21	3.000	4.000	0.3675		
Q22	4.000	5.000	0.0223	Significant	The innovation developed from the SBIR project supported the goals of the company.
Q23	4.000	4.000	0.1022		
Q24	4.000	5.000	0.1017		
Q25	4.000	5.000	0.0768		
Q26	4.000	4.000	0.7712		
Q27	3.000	3.000	0.7828		
Q28	4.000	4.000	0.7018		
Q29	4.000	4.000	0.9415		
Q30	3.000	4.000	0.2353		
Q31	4.000	4.000	0.0496	Significant	The company flexibly responded to customer priority changes.
Q32	4.000	4.000	0.3145		
Q33	4.000	4.000	0.3181		
Q34	4.000	4.000	0.1240		
Q35	4.000	4.000	0.4624		
Q36	4.000	4.000	0.3928		
Q37	4.000	4.000	0.1224		
Q38	2.000	2.000	0.5836		
Q39	4.000	5.000	0.1192		
Q40	4.000	5.000	0.0704		
Q41	4.000	5.000	0.0108	Significant	This group's work was always of the highest quality
Q42	5.000	5.000	0.1987		
Q43	4.000	4.000	0.4825		
Q44	4.000	5.000	0.0342	Significant	This work group should continue working together as a unit in the future.
Q45	5.000	5.000	0.0448	Significant	This group was not capable of working together as a unit.
Q46	5.000	5.000	0.3520		

From Section 4.5.3.1 one of the logistic regression assumptions was having a samples-to-variable ratio of at least ten. With eight variables and seventy-two subjects the variable ratio was a nine, still not meeting the recommended guideline. Therefore, further variable reduction was evaluated. Reviewing the significant variables from the variable-to-variable comparison, three significant variables (descriptor statement

questions 41, 44, and 45) were from Halfhill's (2000) team performance instrument. Since these three variables were validated measures of team performance, two of the three could be removed from further analysis. The two variables with the largest p-value were removed (questions 44 and 45). With the data reduced to six variables, a subject-to-variable ratio of twelve was attained. Table 4.12 shows the reduced data set ready for analysis.

Table 4.12 Reduced Data Set

	Phase II "did not achieve" N = 45 Median	Phase II "achieved" N = 27 Median	p-value	Descriptor Statement
Q4	4.000	5.000	0.0006	The technology solved the customer's problem.
Q10	4.000	4.000	0.0251	Personnel were assigned to other projects when their services were no longer needed.
Q19	2.000	3.000	0.0043	The project received external funding to bridge any post-Phase II funding gaps.
Q22	4.000	5.000	0.0223	The innovation developed from the SBIR project supported the goals of the company.
Q31	4.000	4.000	0.0496	The company flexibly responded to customer priority changes.
Q41	4.000	5.000	0.0108	This group's work was always of the highest quality
Q44	4.000	5.000	0.0342	This work group should continue working together as a unit in the future.
Q45	5.000	5.000	0.0448	This group was not capable of working together as a unit.

4.5.6 Demographics Analysis Methods

Demographics were collected in two areas: the type of technology developed and the type of Phase III, Commercialization and Technology Infusion. The literature stated Phase IIIs were dependent on the type of technology (National Aeronautics and Space Administration 2002, National Research Council 2009). As discussed in Chapter 2, the NASA study (2002) found the "Electronics" and "Materials" categories were most productive while the "Mechanical Performance of Vehicles, Weapons, Facilities" category was least productive. Similarly, although more generic, the National Research

Council study (2009) found a commercialization link with the "hardware", "software", "process technology", "new or improved service capability", and "research tool" categories. Since this research focused on NASA funded SBIR projects, the NASA SBIR success stories database technology categories were utilized (http://sbir.gsfc.nasa.gov/SBIR/successes/techcon.html). NASA collects voluntary Phase III data in thirty-two categories (as shown in the questionnaires in Appendix E and Appendix G) and SBIR developed technologies may fit into more than one category.

The second demographic collected, for Phase II "achieved" projects, was the Phase III category: Commercialization or Technology Infusion. Recent studies (discussed in Chapter 2) indicated 31% (National Aeronautics and Space Administration 2002) to 46% (National Research Council 2009) of Phase II projects have achieved Phase III. The NASA study (2002) Phase III breakdown was 15% Technology Infusion and 16% Commercialization while the National Research Council (2009) found 17% Technology Infusion and 29% commercialization.

The research plan followed the process used in the primary analysis. Considering the same analytical limitations, variables were discriminated for technology areas between Phase II "did not achieve" and Phase II "achieved" conditions. The results were evaluated with respect to the primary analysis results and the literature. Also, success variables were discriminated between Phase II "achieved" Commercialization and Technology Infusion. The results were evaluated with respect to the primary analysis results and the literature. Contingency Tables were used to determine if a particular type of technology had significantly more success (or failure) to achieve Phase III. In

addition, Contingency Tables were used to determine to see if a particular type of technology and significantly more Commercialization or Technology Infusion.

4.6 Summary

The methodology was executed in three stages: the Preliminary Study, the Pilot Study, and the Primary Study. The Preliminary Study defined a set of Initial Consolidated Candidate Critical Success Factors to form a baseline to execute the rest of the study. The Initial Consolidated Candidate Critical Success Factors were formed by merging a set of Literature/SME-based Candidate Critical Success Factors and a set of SBC-based Candidate Critical Success Factors.

The Pilot Study developed the set of Final Consolidated Candidate Critical Success Factors. To create the Final Consolidated Candidate Critical Success Factors, a pilot questionnaire was developed from the Initial Consolidated Candidate Critical Success Factors and was employed on a small group of small businesses that were previously awarded NASA Phase II SBIR contracts. The piloting of the questionnaire and data analysis demonstrated the methodology's feasibility. Lessons-learned were used to improve the questionnaire and processes for the Primary Study.

The Primary Study methodology was to determine the Final Critical Success Factors to achieve Phase III Commercialization or Technology Infusion from NASA funded Phase II SBIR projects. To accomplish this, the final questionnaires were employed on the selected population. Statistical methods were defined to test the research question and hypothesis. The amount of data gathered required an update to the

statistical approach with variable reduction techniques. Consequently, the research question and hypothesis statement were updated to discriminate variables indicating increased likelihood to achieve Phase III from NASA funded Phase IIs. This change provided an achievable answer that still met the goals of this research. Additionally, statistical tests were described for demographics gathered from the questionnaires. The Primary Study analysis and demographics analysis is discussed in Chapter 5.

CHAPTER 5

DATA ANALYSIS

5.1 Introduction

This chapter contains the data analysis as outlined in Chapter 4. The Primary Study data was analyzed using binary logistic regression to identify variables that increase the likelihood of achieving Phase III from NASA funded Phase II SBIR projects. Secondary analyses were conducted to identify indicators for each Technology Area and identify indicators between Technology Infusion and Commercialization. Tertiary analyses were conducted to determine whether a particular type of technology was related to achieving Phase III and whether a particular type of technology had significantly more Commercialization or Technology Infusion.

5.2 Primary Analysis to Discriminate Success Variables

As discussed in Chapter 4, binary logistic regression was chosen because it best supported the research goals within the limits of the data set. The six descriptor statements (variables) produced by the variable reduction (Chapter 4, Section 4.5.4) were used for the logistic regression analysis, as shown in Table 5.1. The table shows the descriptor statements that were carried forward to identify variables for discrimination.

The variables were identified using binary logistic regression. The descriptor statements represented the independent variables in the logistic regression analysis and the dichotomous dependent variable was Phase II "did not achieve" and Phase II "achieved." This was represented in the logistic model as a '0' for Phase II "did not achieve" and '1' for Phase II "achieved".

Table 5.1 Primary Study Data for Binary Logistic Regression

	Descriptor Statements	p-value
Q4	The technology solved the customer's problem.	0.0006
Q10	Personnel were assigned to other projects when their services were no longer needed.	0.0251
Q19	The project received external funding to bridge any post-Phase II funding gaps.	0.0043
Q22	The innovation developed from the SBIR project supported the goals of the company.	0.0223
Q31	The company flexibly responded to customer priority changes.	0.0496
Q41	This group's work was always of the highest quality.	0.0108

Minitab 16 Statistical Software® was used to test the binary logistic regression model with the confidence interval set to 95%. Several goodness-of-fit tests (i.e., Pearson, Deviance, and Hosmer-Lemeshow) were chosen to give multiple perspectives on model fit. The binary logistic regression results are shown in Table 5.2.

Table 5.2 Binary Logistic Regression Analysis

Predictor	Coef	SE Coef	Z	p-value	Odds Ratio	95% CI		
						Lower	Upper	
Constant	-9.10452	3.93236	-2.32	0.021				
Q4	1.22741	0.475588	2.58	0.01	3.41	1.34	8.67	Significant
Q10	-0.69727	0.35393	-1.97	0.049	0.50	0.25	1.00	Significant
Q19	0.680041	0.268354	2.53	0.011	1.97	1.17	3.34	Significant
Q22	-0.002687	0.50464	-0.01	0.996	1.00	0.37	2.68	
Q31	0.450624	0.424731	1.06	0.289	1.57	0.68	3.61	
Q41	0.567671	0.631821	0.90	0.369	1.76	0.51	6.09	

Goodness-of-Fit Tests			
Method:	**Chi-Square**	**DF**	**p-value**
Pearson	57.9955	53	0.296
Deviance	64.5946	53	0.132
Hosmer-Lemeshow	7.1059	8	0.525

Of the six variables analyzed, three were significant ($p < 0.05$). These were descriptor statements Q4 (The technology solved the customer's problem.), Q10 (Personnel were assigned to other projects when their services were no longer needed.), and Q19 (The project received external funding to bridge any post-Phase II funding gaps.). The goodness-of-fit tests were all rejected ($\alpha = 0.05$) indicating adequate fit for the model. Reviewing the significant coefficients, descriptor statements Q4 and Q19 were positively related to achieving Phase III. In other words, the stronger the agreement in Q4 and Q19, the more likely the technology achieved Phase III. Descriptor statement Q10 was negatively related to achieving Phase III. That is, the stronger the agreement that personnel were moved to other projects when no longer needed, the less likely the

technology achieved Phase III. Reviewing the Odds Ratios, Q4 and Q19 had large contributions. For the same level of agreement for Q4 between each Phase, the odds of achieving Phase III is 3.41 times more likely for a Phase II "achieved" technology. Similarly, for the same score for Q19, the odds of achieving Phase III is 1.97 times more likely for a Phase II "achieved" technology. For descriptor statement Q10, the odds ratio indicates a small detrimental to negligible contribution to achieving Phase III. The confidence interval for Q10 shows that 1.00 is included which indicates that it is possible there is no difference between Phases on the likelihood to achieve Phase III.

A sensitivity analysis was conducted to see the impact of Q41 versus Q44 and Q45 variables in the binary logistic regression analysis. The sensitivity analysis produced inconsistent results with respect to Q10 significance. Using Q44 instead of Q41 produced signifiant results for Q4, Q10, and Q19. However, using Q45 instead of Q41 produced significant results for just Q4 and Q19. The detailed analysis is contained in Appendix I. Additionally, the results of the logistic regression produced results contrary to the results of the Preliminary Study (Chapter 4, Section 4.3.3 and further detailed in Appendix D). Contrary to the results for Q10, the Preliminary Study results, supported by both SBCs and the literature, indicated that more successful projects effectively moved personnel on-and-off projects when needed. This contradiction indicates underlying issues that could be pursued in future research.

A review of the descriptive statistics (Appendix H, Table H.5) did not identify any overt characteristics that could explain the logistics regression results. In further detail, the Technology Area descriptive statistics were reviewed (Appendix I, Table I.5). Only

the Modeling, Simulation, Information Technology & Processing Technology Area was significant with respect to Q10. These results provide an opportunity for further research but a few potential explanations are offered. First, additional Phase II "achieved" data could have solidified the Q10's significance standing (significant or non-significant). Second, there may be an issue with the Q10 descriptor statement that needs deeper examination. Third, high technology personnel may require a different style of management than product team personnel, which could be pursued in future research. Ultimately, the results identified here must rely on the project manager to assess the team and keep the team together or move as needed based on the situation presented.

Next, the three variables were checked for independence calculating their Pearson correlations for Phase II "did not achieve" and Phase II "achieved." Minitab 16 Statistical Software® was used to calculate the Pearson correlations. The same criteria as Table 4.6 (Chapter 4, Section 4.4.3), and shown below in Table 5.3, was used to evaluate correlation strength. None of the variables had strong correlations and could be considered independent. Table 5.4 shows the Pearson correlation for Phase II "did not achieve" and Table 5.5 shows the Pearson correlation for Phase II "achieved."

Table 5.3 Correlation Matrix Criteria

Correlation	Criteria	Marking
Strong	r >= 0.8 and -0.8 =< r	Dark Gray
Medium-Strong	0.8 > r <= 0.4 and -0.4 <= r > -0.8	None
Medium-Weak	0.4 > r < 0.1 and -0.1 < r > -0.4	Text Hidden
Weak	0.1 >= r =< -0.1	Hash

Table 5.4 Pearson Correlations for Phase II "did not achieve"

	Q4	Q10	Q19
Q4		0.324	0.067
Q10	0.324		-0.009
Q19	0.067	-0.009	

Table 5.5 Pearson Correlations for Phase II "achieved"

	Q4	Q10	Q19
Q4		-0.092	-0.153
Q10	-0.092		0.314
Q19	-0.153	0.314	

The binary logistic regressions analysis produced a model with three variables (Q4, Q10, and Q19) that predicted likelihood of achieving Phase III. Pearson correlations were then reviewed to determine the independence of the three variables. The variable Q10 (Personnel were assigned to other projects when their services were no longer needed.) was significant but must be viewed with caution because the sensitivity analysis produced erratic results and were contrary to the literature/SME-based critical success factors and SBC-based critical success factors developed in Chapter 4, Section 4.3. Considering this analysis, two variables were identified that increased likelihood to achieve Phase III from NASA funded Phase II SBIR projects were:

Q4: The technology solved the customer's problem.

Q19: The project received external funding to bridge any post-Phase II funding gaps.

The descriptive statistics were reviewed to provide additional insight to interpret the results and are shown in Table 5.5. Descriptor statements Q4, Q10, and Q19 used a Likert scale scored as follows: 1 - Strongly Disagree, 2 - Disagree, 3 - Neutral, 4 - Agree, and 5 - Strongly Agree. These scores were used to evaluate the descriptive statistics.

Table 5.5 Descriptive Statistics for Significant Logistic Regression Results

	Phase II "did not achieve"				Phase II "achieved"			
	N	Mean	StDev	Median	N	Mean	StDev	Median
Q4: The technology solved the customer's problem.	45	3.867	0.757	4	27	4.481	0.700	5
Q19: The project received external funding to bridge any post-Phase II funding gaps.	45	2.244	1.190	2	27	3.148	1.292	3

The mean for Q4, Phase II "did not achieve" was 3.867 and the mean for Phase II "achieved" was 4.481. The results were consistent with the logistics regression analysis. Comparing the means indicated that achieved Phase III technologies were more likely to have solved the customer's problem or need.

The mean for Q19, Phase II "did not achieve" was 2.244 and the mean for Phase II "achieved" was 3.148. The results were consistent with the logistics regression analysis, comparing the means indicates technologies that did not achieve Phase III were less likely to have received funding to bridge post Phase II funding gaps.

The descriptive statistics for Phase II "did not achieve" and Phase II "achieved" were evaluated to identify qualitative themes for variables that were not significant. The list below describes the common features between Phase II "did not achieve" and Phase

II "achieved" projects, summarized from the detailed descriptive statistics in Appendix H.:

- Had effective communication with their customers, sought feedback, and felt they understood how the customer intended to use the technology.
- Demonstrated the innovations to their customers.
- Tested to a level between a breadboard and prototype in a relevant environment.
- Had robust verification and test programs.
- Valued multi-discipline workers over single-discipline workers.
- Researched and understood the intended market but less likely to build an early plan for Phase III or gather marketing data.
- Met project cost and schedule constraints.
- Required additional funding to mature the innovation, although it did not need further research and development.
- Were neutral to somewhat likely to receive internal research and development funds to bridge post-Phase II funding gaps.
- Developed business contacts for potential future sales.
- Were somewhat likely to have developed a marketing plan.
- Developed an innovation that supported the goals of the company.
- Supported by top management with goals of providing a revenue stream, increasing the innovation's maturity, and achieve a sale.
- Developed primarily product-based innovations and not process-based innovations.
- Received support from a technical authority to facilitate progress of the innovation but was only somewhat likely to receive fiscal support or active support from a NASA individual.
- Flexibly responded to customer priority changes.

- Were somewhat likely to receive customer input but included it in project decisions and gave feedback to the customer about including those inputs.
- Achieved maturity between a breadboard to prototype, and the innovation worked as intended at the conclusion of the project.
- Had high performing teams working on the project.

5.3 Secondary Analysis of Discriminate Success Indicators

To gain additional insight, the demographics were analyzed. The data was reviewed to determine how the data could be analyzed. The limited sample size and known dependence between variables within Technology Areas precluded the use of binary logistic regression (Laurence 1995, Schwab 2005). Therefore, analysis was conducted to determine increased potential for a variable's contribution, termed success indicator. Success indicators were identified using the Mann-Whitney test variable reduction technique (discussed in Chapter 4, Section 4.5.4). A summary of the analysis is presented in this section. A detailed analysis is located in Appendix I.

5.3.1 Discriminating Success Indicators within Technology Areas

The demographics were analyzed for the 33 Technology Areas. On the questionnaire, the respondents were asked to mark any Technology Areas that applied to the project for which they were completing a questionnaire. There was insufficient data to conduct tests for the 33 Technology Areas without violating Mann-Whitney assumptions (less than 5 responses) as stated in Chapter 4, Section 4.5.3.4 (Boslaugh and Waters 2009, CK-12 Foundation 2011). Therefore, with assistance from the MSFC SBIR Program Manager, the Technology Areas were consolidated to six Technology Areas.

The SBIR Program Manager used an internal NASA technology tree map to align SBIR technologies to the technology tree. The internal NASA technology tree is used by NASA management as a tool to identify technology gaps needing strategic investment. Technology categories that did not have adequate data were further consolidated into the "Other" category. The technology mapping shown in Table 5.6 and Appendix I.

Table 5.6 Technology Area Traceability Matrix

Grouped Technology Areas	As-collected Technology Areas
Aviation/Aeronautics	Acoustics/Vibroacoustics
	Aerodynamics
	Aeronautics
	Aerospace
	Aircraft Systems/Subsystem
	Aviation
	Test/Measurement
Space Power & Energy Storage	Energy
	Physics
	Power/Propulsion
	Space Systems
Science Instruments, Observatories & Sensor Systems	Chemistry
	Earth/Environmental Sciences
	Instrumentation
	Optics
	Sensors
Modeling, Simulation, Information Technology & Processing	Electronic Components
	Electronic Circuits
	Electronic Systems
	Information Sciences/Data Handling
	Software
Materials, Structures, Mechanical Systems & Manufacturing	Machinery/Automation
	Manufacturing/Fabrication
	Materials
	Mechanical
	Transportation
Other	Biological/Physical Sciences
	Biomedical/Medical
	Life Sciences
	Robotics
	Communications
	Nanotechnology
	Cryogenic Sciences

Responses that identified a particular Technology Area were grouped. Since a respondent could select more than one Technology Area for their project, the data for a single response could be allocated to more than one Technology Area. A hypothesis was formulated and then the Mann-Whitney test was used to test the hypothesis, as shown in Table 5.7. A hypothesis was formulated to test for significant success indicator variables in each Technology Area between the Phase II "did not achieve" and Phase II "achieved" cases for each Technology Area (1 to n):

> H_0: There is no significant difference between Technology Area (n) Phase II "did not achieve" and Phase II "achieved" success indicator variables
>
> H_1: There is a significant difference between Technology Area (n) Phase II "did not achieve" and Phase II "achieved" success indicator variables

Table 5.7 Mann-Whitney Test of Success Indicators for Technology Areas

	Aviation/ Aeronautics	Space Power & Energy Storage	Science Instruments, Observatories & Sensor Systems	Modeling, Simulation, Information Technology & Processing	Materials, Structures, Mechanical Systems & Manufacturing	Other
Q1	0.945	0.144	0.329	0.611	0.099	0.735
Q2	0.418	0.065	0.708	0.648	0.161	0.175
Q3	0.911	0.860	0.468	0.808	1.000	1.000
Q4	0.052	0.008	0.005	0.029	0.029	0.888
Q5	0.581	1.000	0.942	0.246	0.027	0.886
Q6	0.497	0.268	1.000	0.111	0.948	0.166
Q7	0.561	0.393	0.909	0.275	0.872	0.146
Q8	0.251	0.380	0.503	0.332	0.532	0.441
Q9	0.695	0.752	0.546	0.985	0.555	0.603
Q10	0.099	0.857	0.418	0.011	0.839	0.716
Q11	0.446	0.195	0.243	0.145	0.576	0.715
Q12	0.327	0.713	0.965	0.270	0.695	0.659
Q13	0.961	0.321	0.493	0.340	0.297	0.277
Q14	0.782	0.532	0.758	0.112	0.050	0.572
Q15	0.195	0.656	0.859	0.322	0.399	1.000
Q16	0.909	0.217	0.679	0.108	0.103	0.743
Q17	0.390	0.354	0.132	0.792	0.924	0.089
Q18	0.659	0.475	0.352	0.678	0.220	0.964
Q19	0.125	0.378	0.190	0.092	0.076	0.011
Q20	0.835	0.258	0.823	0.256	0.392	0.313
Q21	0.302	0.058	0.487	0.061	0.210	0.689
Q22	0.693	0.105	0.667	0.011	0.107	0.211
Q23	0.517	0.188	0.889	0.016	0.099	0.618
Q24	0.462	0.194	0.868	0.011	0.107	0.956
Q25	0.503	0.137	0.468	0.017	***	0.603
Q26	0.406	0.609	0.365	0.478	1.000	0.268
Q27	0.867	0.983	0.548	0.378	0.268	0.247
Q28	0.301	0.336	0.945	0.717	0.817	0.381
Q29	0.879	1.000	0.912	0.555	0.743	0.399
Q30	0.433	0.035	0.633	0.470	0.800	0.312
Q31	0.415	0.163	0.367	0.214	0.217	0.334
Q32	0.115	0.090	0.126	0.565	0.264	0.372
Q33	0.254	0.183	0.201	0.623	0.707	***
Q34	0.659	0.033	0.311	0.872	0.125	0.190
Q35	0.926	0.252	0.865	0.839	0.433	***
Q36	0.447	0.413	0.206	0.878	0.134	0.384
Q37	0.598	0.498	0.371	0.143	0.008	0.383
Q38	0.348	0.467	0.964	0.647	0.873	0.287
Q39	0.591	0.395	0.513	0.091	***	0.810
Q40	0.364	0.385	0.851	0.008	0.107	1.000
Q41	0.142	0.076	0.140	0.030	***	0.303
Q42	0.608	0.726	0.580	0.413	***	0.211
Q43	0.539	1.000	0.182	0.521	0.140	0.320
Q44	0.816	0.038	0.095	0.130	0.111	0.211
Q45	0.226	***	0.274	0.062	0.225	0.465
Q46	0.832	0.260	0.518	0.179	0.748	0.614

*** Mann-Whitney test could not calculate a solution due to equal values

Cells with significance ($\alpha = 0.05$) were colored gray to highlight patterns. Table 5.7 was then evaluated for patterns that supported or differed from the primary analysis. From Section 5.2 that Q4, Q10, and Q19 were discriminated as success variables.

Success indicators Q4 was significant across four of the six Technology Areas (Space Power & Energy Storage; Science Instruments, Observatories & Sensor Systems; Modeling, Simulation, Information Technology & Processing; Materials, Structures, Mechanical Systems & Manufacturing). Technologies within these four Technology Areas would likely have their chances increase to achieve Phase III by paying close attention to ensuring the technology solved the customer's problem. Q10 was only significant for the "Modeling, Simulation, Information Technology, & Processing" Technology Area. It is possible that technologies with the "Modeling, Simulation, Information Technology, & Processing" Technology Area are more well suited to maintaining a core team that stays with the technology as it progresses through development. Q19 was only significant for the "Other" Technology Area. It is possible that technologies in this category are more dependent on outside funding sources to bridge funding gaps on their way to Phase III. Technology Areas "Space Power, & Energy Storage" and "Modeling, Simulation, Information Technology, & Processing" had significant results for team performance. Otherwise, there were no recognizable variable patterns.

Technology Area variables were then reviewed, as shown in Table 5.8, based on their mean responses and associated descriptor statements. Technology Area "Aviation/ Aeronautics" had no significant success indicators. Technology Area "Space Power, & Energy Storage" success indicators show that no active support was provided from NASA yet customer input was included in project decisions. It is possible that projects sought input from their NASA contact and did not get any or projects used input from

non-NASA customers. Technology Area "Modeling, Simulation, Information Technology, & Processing" success indicators showed that the goals of the company and top management had significant influence on the success of the project. This indicates software-based technologies may be more dependent on a company's leadership and support to achieve Phase III. Technology Area "Materials, Structures, Mechanical Systems, & Manufacturing" success indicators showed that marketing research was important, the technology was demonstrated, and worked as intended. The long lead and capital intensive nature of materials and manufacturing technologies potentially drives the need for marketing research and demonstrating a working technology. Table 5.8 shows the results for the significant success indicators in each Technology Area between Phase II "did not achieve" and Phase II "achieved" cases.

Table 5.8 Phase II "achieved" Indicators for each Technology Area

	Phase II "dna" N = 22	Phase II "a" N = 10	Mann-Whitney	**Space Power & Energy Storage**
Variable	Mean	Mean	p-value	Descriptor Statement
Q4	3.955	4.700	**0.008**	The technology solved the customer's problem.
Q30	3.091	4.100	**0.035**	During the SBIR project, no active support was provided by any individual within NASA.
Q34	3.727	4.400	**0.033**	Customer input was included in project decisions.
Q44	4.273	4.800	**0.038**	This work group should continue working together as a unit in the future.

	Phase II "dna" N = 17	Phase II "a" N = 13	Mann-Whitney	**Science Instruments, Observatories & Sensor Systems**
Variable	Mean	Mean	p-value	Descriptor Statement
Q4	3.765	4.615	**0.005**	The technology solved the customer's problem.

	Phase II "dna" N = 20	Phase II "a" N = 14	Mann-Whitney	**Modeling, Simulation, Information Technology & Processing**
Variable	Mean	Mean	p-value	Descriptor Statement
Q4	3.950	4.500	**0.029**	The technology solved the customer's problem.
Q10	4.150	3.357	**0.011**	Personnel were assigned to other projects when their services were no longer needed.
Q22	4.100	4.786	**0.011**	The innovation developed from the SBIR project supported the goals of the company.
Q23	3.800	4.571	**0.016**	Top management believed the SBIR project should provide a revenue stream for the company.
Q24	4.000	4.786	**0.011**	Top management's desire was to increase the maturity of the innovation.
Q25	3.850	4.714	**0.017**	Top management's goal was to achieve sale to a customer from the innovation.
Q40	4.200	4.857	**0.008**	This group met all objectives for work completed.
Q41	4.400	4.786	**0.030**	This group's work was always of the highest quality.

	Phase II "dna" N = 20	Phase II "a" N = 6	Mann-Whitney	**Materials, Structures, Mechanical Systems & Manufacturing**
Variable	Mean	Mean	p-value	Descriptor Statement
Q4	3.850	4.667	**0.029**	The technology solved the customer's problem.
Q5	4.200	4.833	**0.027**	The innovation was presented to show it performed as required.
Q14	3.450	4.333	**0.050**	Project members gathered marketing data prior to end of Phase II.
Q37	4.000	4.833	**0.008**	At the conclusion of the SBIR Phase II project, the innovation worked as intended.

	Phase II "dna" N = 18	Phase II "a" N = 4	Mann-Whitney	**Other**
Variable	Mean	Mean	p-value	Descriptor Statement
Q19	2.278	3.750	**0.011**	The project received external funding to bridge any post-Phase II funding gaps.

5.3.2 Discriminating Indicators for Commercialization or Technology Infusion

Since the data could be segregated into two distinct groups, this analysis used a process similar to the primary analysis. Chapter 2, Section 2.3.4 documented the disparity between Commercialization and Technology Infusion. It was possible different success indicators could be attributed to Commercialization or Technology Infusion. A

hypothesis statement was established to test for significant variables between Commercialization and Technology Infusion within the Phase II "achieved" case.

> H_0: There is no significant difference between Phase II "achieved" Commercialization and Technology Infusion indicator variables
>
> H_1: There is a significant difference between Phase II "achieved" Commercialization and Technology Infusion indicator variables

The 10 to 1 samples-to-variables requirement precluded the use of logistic regression (only 24 samples with 46 variables) so the variable reduction analysis technique (Chapter 4, Section 4.5.4) was used to discriminate Commercialization and Technology Infusion indicators.

Similar to the method used to identify success indicators for each Technology Area (Chapter 5, Section 5.3.10), the Mann-Whitney test was then conducted between each variable from the Commercialization and Technology Infusion categories with the results shown in Table 5.9. Descriptor statements Q18, Q24, Q33, Q34, and Q40 were significant ($p < 0.05$). For Technology Infusion, the customer providing input (Q33) and using customer input in decisions (Q34) were significant indicators. The customer's relationship with the projects has a positive relationship for successful Technology Infusion. These indicators are more external to the company. For Commercialization, receiving internal research and development funds (Q18), top management support (Q24), and team performance (Q40) were significant indicators. Commercialization is more likely achieved based on funding, management support, and team performance indicators internal to the company.

Table 5.9 Phase II "achieved" Data

	Technology Infusion N = 16	Commercialization N = 8	Mann-Whitney	
Variable	Mean	Mean	p-value	Descriptor Statement
Q18	3.063	4.375	**0.012**	The project received internal research and development funds to bridge any post-Phase II funding gaps.
Q24	4.438	4.875	**0.049**	Top management's desire was to increase the maturity of the innovation.
Q33	4.000	3.000	**0.016**	The customer provided input for project decisions.
Q34	4.313	3.375	**0.030**	Customer input was included in project decisions.
Q40	4.375	4.875	**0.048**	This group met all objectives for work completed.

For projects that achieved Phase III, demographic inputs were evaluated to parse data between "Technology Infusion", "Commercialization", and "Both" categories to analyse overall trends and compare to the literature, as shown in Table 5.10. The "Both" category was created to segregate responses that had success with Commercialization and Technology Infusion. A separate "Both" category was required for categorical analysis of the types of Phase III in Section 5.4.2

Table 5.10 Type of Phase III Projects

	Projects	**Percent**
Phase II "did not achieve"	45	62.5%
Phase II "achieved"	27	37.5%

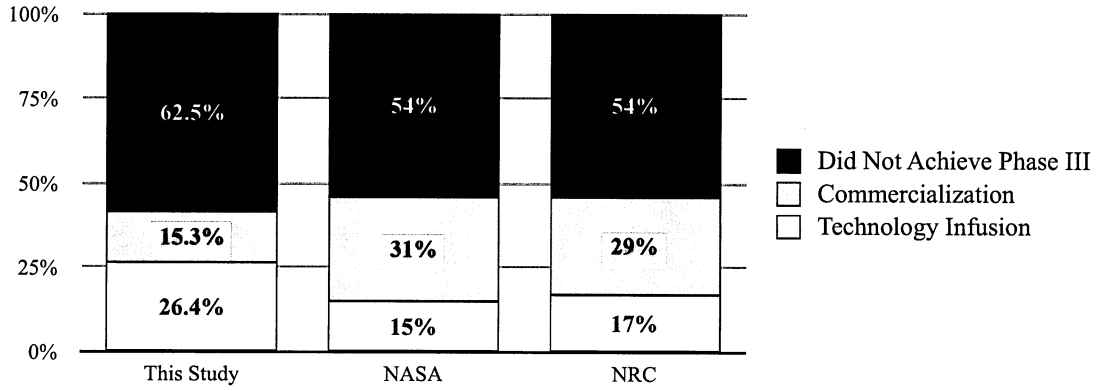
Phase II "achieved"	**Projects**	**Percent**	**Normalized**
Commercialization	8	29.6%	50.0%
Technology Infusion	16	59.3%	---
Both	3	11.1%	18.8%

Almost two-thirds of the responses were for projects that did not achieve Phase III while almost one-third achieved Phase III. Of the 27 projects that achieved Phase III about 30 percent (8 projects) were Commercialization, 59 percent (16 projects) Technology Infusion, and 11 percent (3 projects) experienced both.

Reviewing Figure 5.1 below, these results are broadly consistent with the literature with respect to the rate of Phase II "did not achieve" projects (National

Aeronautics and Space Administration 2002, National Research Council 2009). However, this study's results differ from the literature within the types of Phase IIIs. Considering the literature (documented in Chapter 2, Sections 2.3.4), Commercialization was approximately half of previous studies and Technology Infusion rates were about twice the literature's rates. The difference may be explained by the emphasis over the last several years to link SBIR awards to NASA mission needs, thus driving an increase in Technology Infusion (National Research Council 2009).

Figure 5.1 Phase Achieved Comparison Across Studies



5.3.3 Discriminating Indicators for each Technology Area

The data for each Technology Area was indexed to the type of Phase III. However, too few data points existed within each category to make an assessment.

5.4 Tertiary Demographics Analyses

Demographics were collected for thirty-three technology categories that are used by NASA to track SBIR success stories (http://sbir.gsfc.nasa.gov/SBIR/successes/

techcon.html). The first analysis of this data was a Contingency Table test on Technology Areas indexed to the Phase II (i.e., both "did not achieve" and "achieved") data. The second analysis was a Contingency Table test on Technology Areas indexed to the type of Phase III (Commercialization, Technology Infusion, or Both). However, the data set was too limited (too many categories with no data or less than five samples per category) to perform a Contingency Table analysis (Boslaugh and Waters 2009; CK Foundation 2011). As described in Chapter 5, Section 5.3.1, the 33 Technology Areas were consolidated into a set of six Technology Areas and then Contingency Table analysis was conducted using reduced categories. The details for the Technology Area grouping are also located in Appendix I.

5.4.1 Analysis of Technology Areas with Phase II "did not achieve"/"achieved"

Categorical data was analyzed to determine if a particular Technology Area had significant activity for either Phase II case (i.e., "did not achieve" or "achieved"). A hypothesis was formulated to evaluate the significance of Technology Area categories between the Phase II cases.

> H_0: There is no significant difference between Phase II "did not achieve" Technology Areas and Phase II "achieved" Technology Areas
>
> H_1: There is a significant difference between Phase II "did not achieve" Technology Areas and Phase II "achieved" Technology Areas

Reviewing the data in Table 5.11 shows a relatively uniform distribution for responses in Technology Areas for both Phases, except for the Phase II "achieved"

"Materials, Structures, Mechanical Systems & Manufacturing" and "Other" Technology Areas which had a drop-off in responses.

Table 5.11 Categorical Data for Technology Area versus Phase

	Phase II "did not achieve"	**Percent**	**Phase II "achieved"**	**Percent**
Aviation/Aeronautics	19	16.4%	12	19.7%
Space Power & Energy Storage	22	19.0%	12	19.7%
Science Instruments, Oberservatories & Sensor Systems	17	14.7%	13	21.3%
Modeling, Simulation, Information Technology & Processing	20	17.2%	14	23.0%
Materials, Structures, Mechanical Systems & Manufacturing	20	17.2%	6	9.8%
Other	18	15.5%	4	6.6%

The Contingency Table analysis using R (R Development Core Team 2011). The Fisher's Exact Test was used because it handles small data sets and missing data whereas the Chi Squared Test will break down or produce misleading results (Boslaugh and Waters 2009, CK Foundation 2011). The results are shown in Table 5.12. The p-value was 0.2982 so the null hypothesis could not be rejected. The test indicated the Technology Area did not have a discernible influence on whether a project achieved Phase III.

Table 5.12 Fisher's Exact Test for Technology Area versus Phase

Technology Area	Phase II "did not achieve"	Phase II "achieved"
Aviation/Aeronautics	19	12
Space Power & Energy Storage	22	12
Science Instruments, Observatories & Sensor Systems	17	13
Modeling, Simulation, Information Technology & Processing	20	14
Materials, Structures, Mechanical Systems & Manufacturing	20	6
Other	18	4
	p-value = 0.2982	

5.4.2 Analysis of each Technology Area with the Type of Phase III

Similar to the previous section, categorical data was analyzed to determine if a particular Technology Area had significant activity for the Phase II "achieved" cases for Commercialization, Technology Infusion, and Both. A hypothesis statement was formulated to evaluate the significance of Technology Area categories between the Commercialization, Technology Infusion, and Both cases.

> H_0: There is no significant difference between Phase II "achieved" Commercialization, Technology Infusion, and Both Technology Areas
>
> H_1: There is a significant difference between Phase II "achieved" Commercialization, Technology Infusion, and Both Technology Areas

The data in Table 5.13 shows responses for projects that achieved Phase III Commercialization or Technology Infusion. Technology Infusion occurred most frequently with a relatively uniform response, except for a small drop-off in the "Materials, Structures, Mechanical Systems & Manufacturing" and "Other" categories. For Commercialization, most responses occurred in the "Aviation/Aeronautics" and "Modeling, Simulation, Information Technology, & Processing" Technology Areas. Also, the Technology Area that had the largest success in Commercialization and Technology Infusion (Both) was in the "Science Instruments, Observatories, & Sensor Systems" category. Reviewing the normalized data, the "Modeling, Simulation, Information Technology, & Processing" Technology Area had the closest rates between Commercialization and Technology Infusion even though the overall Commercialization rate was just over 40 percent of the Technology Infusion rate.

Table 5.13 Categorical Data for Technology Area versus Type of Phase III

	Phase "achieved"				
	C	TI	B	C (Normalized)	B (Normalized)
Aviation/Aeronautics	4	7	1	57.1%	14.3%
Space Power & Energy Storage	2	9	1	22.2%	11.1%
Science Instruments, Oberservatories & Sensor Systems	2	8	3	25.0%	37.5%
Modeling, Simulation, Information Technology & Processing	6	7	1	85.7%	14.3%
Materials, Structures, Mechanical Systems & Manufacturing	2	3	1	66.7%	33.3%
Other	0	4	0	0.0%	0.0%
			Average	42.8%	18.4%

C = Commercialization; TI = Technology Infusion; B = Both

The Contingency Table results are shown in Table 5.14, below. The p-value was 0.7067 so the null hypothesis could not be rejected. This indicated the Technology Area had no discernible influence on a project reaching Commercialization, Technology Infusion, or Both.

Table 5.14 Fisher's Exact Test for Technology Area versus Phase III Type

Technology Area	Commercialization	Technology Infusion	Both
Aviation/Aeronautics	4	7	1
Space Power & Energy Storage	2	9	1
Science Instruments, Observatories & Sensor Systems	2	8	3
Modeling, Simulation, Information Technology & Processing	6	7	1
Materials, Structures, Mechanical Systems & Manufacturing	2	3	1
Other	0	4	0
	p-value = 0.7067		

5.4 Summary

Binary logistic regression analysis was used to discriminate variables that increase the likelihood to achieve Phase III funding for NASA funded Phase II SBIR projects. The analysis identified three discriminated variables: (1) The technology solved the customer's problem, and (3) The project received external funding to bridge any post-Phase II funding gaps. A third variable, Personnel were assigned to other projects when their services were no longer needed, was significant but not robust under sensitivity analysis.

Secondary analysis was conducted to identify success indicators based in demographic data. Success indicators were identified for each Technology Area indexed to the Phase II "did not achieve" and Phase II "achieved" cases. The success indicator, "The technology solved the customer's problem", had broad agreement as a significant indicator being identified for four of the six Technology Areas. No other discernible patterns emerged. However, a result of conducting this analysis was that unique success indicators could be identified thus providing a starting point for future research. Secondary analysis was also conducted to discriminate indicators for Phase II "achieved" Commercialization and Technology Infusion. Indicators for Commercialization were to receive internal research and development funds, have top management support, and high team performance. Indicators for Technology Infusion were to have strong customer relationships by getting and using customer input for project decisions.

Tertiary analysis was conducted on categorical demographic data. Contingency Tables were conducted on Technology Areas indexed to the Phase achieved and

Technology Areas indexed to the type of Phase III. Both tests indicated there was no difference between Technology Areas and the Phase achieved or Technology Areas and the type of Phase III. The next chapter will present conclusions drawn from this analysis.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The goal of this research was to identify Critical Success Factors to achieve Phase III Commercialization or Technology Infusion from NASA funded Phase II Small Business Innovation Research. The Critical Success Factor concept was based on Rockart's (1979) definition. The goal of the research was to evaluate differences between Phase II "did not achieve" and Phase II "achieved" projects. The methodology used a mixed method approach to formulate and test initial candidate Critical Success Factors. The initial candidate Critical Success Factors were from two sources: literature data reviewed by NASA SBIR subject matter experts and interviews with Small Business Concern managers using Dobbins' (1999) Critical Success Factor interview process. These two sets of initial candidate Critical Success Factors were merged to form a set of candidate Critical Success Factors. The candidate factors were operationalized, piloted, and refined into two identical forty-six item questionnaires, one for Phase II "did not achieve" projects and one for Phase II "achieved" projects. A limited data set precluded formulating a Critical Success Factor structure. Therefore, the research question and hypothesis were amended to discriminate variables. Then, the data was reduced and

binary logistic regression used in the primary analysis to create a model that discriminated variables. Secondary analysis was conducted to identify success indicators for each Technology Area and for the type of Phase III, using the same data reduction technique as the primary analysis. A tertiary analysis was conducted to determine whether a particular Technology Area was important to the Phase achieved or with the type of Phase III awarded.

6.2 Primary Analysis Conclusions

The methodology provided a comprehensive, structured approach to develop a set of candidate Critical Success Factors. The methodology was structured for a large data set but was adapted to a smaller data set to discriminate variables showing increased likelihood to achieve Phase III. The results from this research suggest that to improve the likelihood of achieving Phase III: (1) companies need to focus on delivering the specific technology the customer needs, (2) companies should assess how best to manage personnel during the life cycle of a team, and (3) companies need to pursue outside funding to bridge post Phase II funding gaps.

The first success variable, "The technology solved the customer's problem.", was aligned with the research literature and interview data supporting effective communication between the project and the customer. Communication is a key ingredient to ensure the technology or product fulfills customer requirements and buy-in. This is particularly important for space-related technologies because of the small market size which is one reason for recent emphasis by NASA to link future Mission Directorate

needs to SBIR topic generation. Other participating organizations have similar initiatives to match technologies to potential customers (National Research Council, 2008). For technologies that are more applicable to a wider market (i.e., software), delivering the right technology to the customer is important if the company is to successfully compete.

The second success variable, "The project received external funding to bridge any post-Phase II funding gaps," is consistent with overall SBIR program concerns and confirms the need to continue research and identify ways to obtain bridge funding. Bridge funding initiatives have been discussed in the literature (e.g., extra large Phase II awards, transition assistance funding, and other government sponsored venture capital funding) (National Research Council 2008). NASA began the Phase II enhanced option in 2008 to address the bridge gap funding issue (NASA 2010). Increased access to these types of initiatives could give companies the needed resources to achieve Phase III funding. Otherwise, companies need to work avenues for post-Phase II funding as early as possible.

A third success variable, "Personnel were assigned to other projects when their services were no longer needed.", is more difficult to explain based on its erratic response under sensitivity analysis and divergence from the SBC-based input and the literature with SME-based input. The statistical analysis indicates successful Phase III projects were more likely to keep team members together rather than move personnel in-and-out during a project's life. This is contrary to SBC-based input and the literature with SME-based input. Two reasons are offered as potential explanations, but ultimately this is left for further study. First, there may be an underlying issue with the Q10 descriptor

statement that needs deeper examination. Second, high technology personnel may require a different style of management than product team personnel. Expanding on this second possibility, the specialized nature of state-of-the-art space technologies may require keeping a core team in place to mature a technology to the point of commercialization or infusion. Many of these teams are formed by experts in-their-field and cannot be phased in-and-out. For technologies being developed with broad application, resource constraints and schedule demands may require phasing workers in-and-out to control costs and balance resources. Ultimately, a company's management needs to assess how manpower will be utilized to best accomplish work goals.

6.3 Secondary Analysis Conclusions

Secondary analysis produced results for Technology Area indicators and indicators for Commercialization and Technology Infusion. An indicator was a measure of increased potential for a variable's contribution. Although not conclusive, indicators provide insight into potential contributions and starting points for future research.

Success indicators were found within Technology Areas to achieve Phase III. Most notable was the wide ranging consistency between the Technology Area success indicator and primary analysis variable Q4, "The technology solved the customer's problem." However, variables Q10, "Personnel were assigned to other projects when their services were no longer needed" and Q19, "The project received external funding to bridge any post-Phase II funding gaps." were significant indicators in only one Technology Area each. Additional data might have expanded results. Other success

indicators show no discernible pattern and were not supported by the primary study results. However, the analysis showed that variables could be discriminated within different technology areas and could provide a starting point for future research.

Indicators were found for the types of Phase III: Commercialization and Technology Infusion. These indicators were variables that offered potential to explain why a project achieved Phase III Commercialization or Technology Infusion. For Commercialization three indicators were found. First, the project was more likely to receive internal research and development funds to bridge any post-Phase II funding gaps. Second, top management more likely desired to increase the maturity of the innovation. Third, this team was more likely to have met all its work objectives. Note, these three indicators were related to internal company variables. For Technology Infusion two indicators were found. First, the customer was more likely to provide input for project decisions. Second, customer input was included in project decisions. Note, these indicators were related to external variables, specifically the customer of the technology.

6.4 Tertiary Analysis Conclusions

No single Technology Area had significant results for either Phase II "did not achieve" or Phase II "achieved". Basically, no Technology Area had a discernible influence for technologies that achieved Phase III. Similarly, no Technology Area had significant results for Phase III Commercialization, Technology, or Both. No Technology Area had a discernible influence on whether a technology experienced

Commercialization and/or Technology Infusion. However, success rate responses suggests the "Materials, Structures, Mechanical Systems & Manufacturing" and "Other" Technology Areas offer a slightly lower success rate than other Technology Areas. Also, a qualitative evaluation of the type of Phase III data suggests Technology Infusion occurred at twice the rate of Commercialization.

6.5 Implications for NASA and Other Government Sponsors

This research provided implications for NASA and other government sponsors. The Contracting Officer Technical Representative (COTR) provided a key interface to the SBC and this interface should be paid special attention from both the government side and the small business. Response data indicated the technical representative (i.e., the COTR) provided support to facilitate progress of the innovation. The COTR's role is to evaluate the the technology and communicate customer requirements and objectives. Communication is an important ingredient to support the SBC and ensure the technology will meet customer needs for infusion. The COTR represents this important link. Furthermore, the COTR can also be an advocate for the SBC to the mission end-user for post-Phase II funding thus increasing the technology's chance to reach Phase III.

6.6 Recommendations for Future Research

Having presented these results, one must consider potential structural and programmatic changes that may influence or alter these study results. For example, Congress could enact legislative changes that increase the allowed venture capital

ownership of an SBC. This additional venture capital funding to offset problems obtaining post-Phase II bridge funding. Another possible example is NASA instituting an initiative to build SBIR projects and planning into major program schedules (similar to a DoD initiative), which could increase the likelihood the technology being developed would have customer buy-in. The results certainly apply to the sampled population and, from a practical standpoint, appear enduring. However, any legislative or programmatic changes would likely require a reevaluation of the results of this study.

Several related threads exist for future research. First, the results of this research was to provide useful information to Small Business Concern managers to gain additional insight to achieve Phase III. Another valuable perspective would be to conduct this Critical Success Factor research from the perspective of the NASA Contracting Officer Technical Representative (COTR). The COTR is the SBIR's day-to-day point of contact in NASA for whom the SBC is ultimately accountable. Gaining additional insight to what NASA COTRs deem Critical Success Factors would provide valuable information to SBC managers about their SBIR customer.

Second, this research could be extended to other participating SBIR organizations (e.g., Army, Navy, Air Force, Department of Energy, National Institute of Health). The results would be valuable for SBCs participating in those organizations and also could be compared/contrasted to the results from this study.

A third area for study could be a more detailed evaluation of the demographics collected in this research. The literature identified a link between Technology Area and Phase III funding. This study provided broad understanding of technology area

distribution but no detailed understanding causation or correlation to Phase III funding. Similarly, Technology Infusion and Commercialization of technologies could be more fully studied. A question that could be answered is whether the technology itself or the needs of the customer correlate to Phase III funding. How much market forces influence Technology Infusion versus Commercialization. How much of an influence does venture capital or bridge funding contribute to Technology Infusion versus Commercialization.

Fourth, a longitudinal study could be conducted on projects moving through NASA's SBIR program. Critical Success Factors could be determined at each Phase similar to Pinto's study (Pinto, 1986). The results could potentially show that SBC managers must pay attention to different Critical Success Factors depending on the SBIR Phase they are in.

Fifth, just as important to discovering factors to achieve Phase III, is to discover factors that caused SBIR Phase II projects to fail. This research compared Phase II "did not achieve" projects to Phase II "achieved" projects. Based on that comparison, it was impossible to determine if a Phase II "did not achieve" project was doing something 'wrong'. A focused study evaluating the 'failure' factors would be extremely valuable to both NASA and SBC managers. Anecdotally, several SBC managers provided feedback, "bureaucratic contracting process", "COTRs that didn't care about the technology", or "unfair process."

Last, the Project Implementation Profile (PIP) (Slevin and Pinto, 1987) could be validated as an instrument to measure Critical Success Factors for NASA (or other) SBIR

projects. The results from the PIP could be compared to results from this study for Phase II "did not achieve" or Phase II "achieved" projects.

APPENDICES

APPENDIX A

DEVELOPMENT OF LITERATURE/SUBJECT MATTER EXPERT-BASED INITIAL CANDIDATE CRITICAL SUCCESS FACTORS

A literature review was conducted to identify critical success factors in NASA's Small Business Innovation Research. No sources were found specific to critical success factors for NASA's SBIR commercialization or technology infusion so the review was broadened to include Phase III/commercialization/technology infusion 'best practices', 'success factors', and 'critical success factors' in NASA and high technology-related technology transfer, innovation, general Small Business Innovation Research. This broadened literature review identified one hundred eighty-six individual data references from twenty-six sources, as shown on Table A.1.

Each like data reference within a source was grouped. For example, "Publishing technologies through various media", "not-for-profit intermediaries", "technology ferrets (i.e., a gatekeeper for industry rather than the lab", and "technology brokers" were grouped from the same literature source (Carr, 1992b). Then like data references between sources were grouped. For example, "top management support - getting adequate resource/authority/power" (Pinto and Slevin, 1989), "high level management support" (Balachandra, 1997), and "management support" (Tan, 1996) were all grouped.

These cross-source groupings formed the foundations for the Literature-based Candidate Critical Success Factors. Thematic descriptions were created for each set of cross-source groups, as shown in Table A.2. This process created an initial list of thirty-four initial Literature-based Candidate Critical Success Factors, as shown in Table A.3.

Five NASA Marshall Space Flight Center SMEs individually reviewed and amended the initial Literature-based Candidate Critical Success Factor list. Each SME-reviewed list is shown in Table A.4. Then a combined list was created by comparing each SME's list side-by-side with like factors being merged. Each SME then reviewed and validated the combined list to form a twenty-six item Literature/SME-based Candidate Critical Success Factor list, as shown in Table A.5.

Table A.1 Literature-based Candidate Critical Success Factor Data

Chakrabarti and Rubenstein, 1976	Bush, 1996	Horsham, 1999	NASA, 2004a	NAPA, 2004	Grimes, Metzger, and Kim, 1993	Archibald and Finifter, 2003
Top management support	Internal Champion	Align Center resources to technology development	Using multiple methods of outreach	Leadership commitment to technology transfer	Technical monitor believes development is high quality	More commercialization focus correlated to
Tying a technology to a recognized problem	External Champion	Align Center resources to technology partnering	Sharing resources between developer and user	Relocate Technology Transfer Administration to		
Quality of information from the innovation	Government Funding		Publishing results via New Technology Reports	Hold Mission and Center Directors accountable for		
	Equivalent Technology		Personal awards tied to technology transfer	Streamline the outreach functions		
	License		Patent awards	Improve web site design to facilitate outreach		
				Improve processing time for patent applications, licenses,		
				Use Balanced Scorecard to measure transfer		

Table A.1 Literature-based Candidate Critical Success Factor Data (cont'd)

GAO, 1998	NRC, 2000	NMAB, 2001	Segel, 2001	Pretorius, 2004	SBA, 1991 / Berger, Little, and Saavedra, 1992	Pinto and Slevin, 1989
Some Agencies developed "Fast Track" processes to mitigate	DoD's "Fast Track" processes developed to mitigate funding gaps	Assign an SBIR liaison	Provide interagency access to SBIR awards	Company's long term strategy for dealing with obstacles	Product oriented companies have higher commercialization	Project Mission - clarity of goals
Improve outreach through annual conferences and use of		Link program needs to SBIR solicitations	Use standardized criteria for measuring commercialization		Private sector oriented companies have higher commercialization	Top Management Support - getting adequate
Improve results through commercialization		Link SBIR contractors to prime contractors	Reduce Agency duplication by developing common		Companies that produce products have more	Project Schedule/Plans detailed plans/schedule
		Senior acquisition officers direct including SBIR as part			Awardees that are farthest along in product development	Client Consultation - communication/active listening
		Institute metrics to measure progress			Awardees that know they need to legally protect their	Personnel - recruitment, training, & selection
					Awardees that have mode the most progress towards	Technical Tasks - availability of technology and
					Awardees that do not need outside support have higher	Client Acceptance - "selling" the technology
					The more progress on a completed marketing plan the more	Monitoring and Feedback - systematic feedback control
					The more progress toward implementing the marketing plan the	Environmental Events - external factors
					Awardees that have obtained follow-on funding commitments	Urgency - perceived importance

Table A.1 Literature-based Candidate Critical Success Factor Data (cont'd)

Carr, 1992b	Souder, 1990	Ransley and Rogers, 1994	Tan, 1996	Cooper and Kleinschmidt, 1996 [2007]	Balachandra and Friar, 1997	Martyniuk, Jain, and Stone, 2003
Management Encouragement and Support	Technologies with tangible value	Technology Strategies - tie corporate/business strategies to R&D	Technical Characteristics	A high-quality new product process	High level management support	No other competition: market pull
Formal Recognition of Technology Transfer Activities	Technologies that could be incrementally adopted	Program Selection and Management - Involve all departments in	User Involvement	New product strategy for the business unit	Probability of technical success	Regulatory driver [specific case studies dealing with
Formal & Informal Technology Transfer Networks	Technologies that are adaptable to various applications	Core Strengths - Integrate core technologies into	Communication	Resource availability	Market existence	Field test and pilot scale operational data
Changing the Culture	Conduct passive outreach	Effectiveness - Results measure against business objectives	Management Support	R&D spending levels	Availability of raw materials	Direct human health impacts
An Inventor-Friendly Disclosure and Patenting Process	Form partnerships to develop technologies	External Awareness - conduct strategic analysis on	Project Team Characteristics		Need to lower cost	Technology benefits matching market needs
Incentives for Inventors	Cost sharing	Technology Transfer - use cross-functional teams, job rotation,	Difference between Technology Provider and Receiver		Timing	Novelty
Responsiveness to Inventors	Joint transfer teams	Personnel - career development	Incentives		Commitment of project staff	Technology Champions
Technology Ferrets (i.e., a Gatekeeper for Industry rather than the	Personnel transfers (temporary & permanent)		Infrastructure Support		Emphasize marketing	
Evaluation of marketability by the Inventors	Funding loans to build commitment		Obstacles		Marketing and technology are strengths	
Evaluation by Technology transfer Office Personnel	Technology consulting				Competitive environment	
Consultation with Cooperating Firms	Open interactions				Technology strategy tied to business strategy	
Labs either perform or enlist help to conduct Market Research					R&D process well planned	
Patenting Committees					Create, make, market interphase	
Target firms for First Contact Marketing					Training and experience of own people	
Focused Publicity for Marketing Technologies						
Internal Maturation Funds						
External Maturation Funds						
Maturation by External R&D Organizations						
Cooperative R&D						
Location Incentives in Licenses						
Technical Assistance to Local Industry						
Not-for Profit Intermediaries						
Industry Associations						
Venture Capital Firms						
Technology Brokers						
Publishing Technologies Through Various Media						

Table A.1 Literature-based Candidate Critical Success Factor Data (cont'd)

Franza and Grant, 2007	Gutwein and Montoya, 1978	NPR, 1993	McMillan, 2006	NRC, 2007b
The developer establishes a dedicated technology transfer	Purpose and Direction	Protect sensitive information on cooperative projects	Mission-Directorate Technology Need Identification	Align SBIR to programs
The transfer agent is located close to the developing	Resources and Productivity	Technology Transfer Training	Local Program Manager (PM) - Level 2 buy-in or	More mature technologies
The developing organization targets advertising to relevant	Product Effectiveness & Value	NASA wide dedicated tech transfer funding	External Partner Involvement via Leveraged Resources,	Document SBIR firm capability to deliver
The acquiring organization facilitates informal transfer	Control and Accountability	Executive support for cooperative arrangements that may	Agency IPPO/Technology Transfer Organization	Work SBIR projects into budget estimates
The acquiring organization funds the transfer project	Organizational Unity	NASA Centers provide dedicated funding & resources for tech		Train senior management on SBIR program
The acquiring organization has a business plan for	Human Resource Development	Establish tech transfer metrics		Program/directorate buy-in by emphasizing spin-in potential
Both the developing and the acquiring organizations share		Contracts should address technology transfer plans		SBIR can fill R&D gaps in acquisition programs
		Evaluate RFPs based on the tech transfer objectives		Roadmap Integration
		Partner with small businesses		Outreach and Matchmaking
		NASA's strategic plan should address technology transfer's		Improve SBIR tracking
				Designated liaison for SBIR
				More Funding for Outreach
				Small Phase III Awards
				Larger Phase II Awards
				Unbundling Larger Phase III Awards
				Redefining SBIR program scope
				Matchmaking databases
				Keep SBIR off the critical path
				Place milestones that trigger initial Phase III funding
				Aligning Small Business Strategy
				Specific Phase III funding from prime contractors
				Assurances from prime contractors on Phase III plans with
				Help primes learn how SBIR can meet requirements
				Show prime contractors advantages of sole-source SBIR

Table A.2 Literature-based Candidate Grouped Critical Success Factor Data

	Chakrabarti and Rubenstein, 1976	Bush, 1996
Top management provides support	Top management support	
Project is aligned with the business strategy		
Metrics are used to measure performance		
The developer has the infrastructure to deliver the technology		
The developer obtains outside funding		
A technology broker/matchmaker is used to find a suitable customer		
Agency utilizes outreach tools/activities to promote research opportunities		
The technology fills an identified market/user need	Tying a technology to a recognized problem	
Open communication occurs between the user and developer	Quality of information from the innovation	
The developer and user share responsibility to accomplish the technology project		
The developer has a documented marketing/commercialization plan		
The developer markets the technology		
The technology has unique/novel qualities		
Agency administrative processes are executed in a timely manner		
The developer pursues intellectual property protection		License

Table A.2 Literature-based Grouped Candidate CSF Data (cont'd)

	Chakrabarti and Rubenstein, 1976	Bush, 1996
The developer has a high performing team		
The technology developed is mature		Equivalent Technology
A liaison is assigned to the developer		
The developer's project is integrated into the customer's planning		
The Agency provides training to the developer on the SBIR program/processes		
The rewards structure of the developer supports technology transfer		
The developer can effectively manage external influences		
A dedicated organization is established within the developer to facilitate transfer		
Agency provides technology consulting		
The developer has a documented technology development plan		
The developer and user share personnel		
The developer has a private sector focus		
Career development is important		
A champion exists that facilitates progress of the technology project		Internal Champion External Champion
The developer's culture supports technology transfer		
The developer is product oriented		
Agency provides the benefits of the SBIR program to stakeholders & customers		
The developer participates in industry technology transfer networks		
The developer protects its technology development processes		
Not Applicable as a candidate CSF for the NASA SBIR Program		Government Funding
Not enough information to classify		

Table A.2 Literature-based Grouped Candidate CSF Data (cont'd)

	Horsham, 1999	NASA, 2004a
Top management provides support		
Project is aligned with the business strategy	Align Center resources to technology development Align Center resources to technology partnering	
Metrics are used to measure performance		
The developer has the infrastructure to deliver the technology		
The developer obtains outside funding		
A technology broker/matchmaker is used to find a suitable customer		Publishing results via New Technology Reports
Agency utilizes outreach tools/activities to promote research opportunities		Using multiple methods of outreach
The technology fills an identified market/user need		
Open communication occurs between the user and developer		
The developer and user share responsibility to accomplish the technology project		Sharing resources between developer and user
The developer has a documented marketing/commercialization plan		
The developer markets the technology		
The technology has unique/novel qualities		
Agency administrative processes are executed in a timely manner		
The developer pursues intellectual property protection		Patent awards

Table A.2 Literature-based Grouped Candidate CSF Data (cont'd)

	Horsham, 1999	NASA, 2004a
The developer has a high performing team		
The technology developed is mature		
A liaison is assigned to the developer		
The developer's project is integrated into the customer's planning		
The Agency provides training to the developer on the SBIR program/processes		
The rewards structure of the developer supports technology transfer		Personal awards tied to technology transfer
The developer can effectively manage external influences		
A dedicated organization is established within the developer to facilitate transfer		
Agency provides technology consulting		
The developer has a documented technology development plan		
The developer and user share personnel		
The developer has a private sector focus		
Career development is important		
A champion exists that facilitates progress of the technology project		
The developer's culture supports technology transfer		
The developer is product oriented		
Agency provides the benefits of the SBIR program to stakeholders & customers		
The developer participates in industry technology transfer networks		
The developer protects its technology development processes		
Not Applicable as a candidate CSF for the NASA SBIR Program		
Not enough information to classify		

Table A.2 Literature-based Grouped Candidate CSF Data (cont'd)

	NAPA, 2004	Grimes, Metzger, and Kim, 1993
Top management provides support	Hold Mission and Center Directors accountable for technology spin-in Leadership commitment to technology transfer	
Project is aligned with the business strategy		
Metrics are used to measure performance	Use Balanced Scorecard to measure transfer	
The developer has the infrastructure to deliver the technology		
The developer obtains outside funding		
A technology broker/matchmaker is used to find a suitable customer		
Agency utilizes outreach tools/activities to promote research opportunities	Improve web site design to facilitate outreach Streamline the outreach functions	
The technology fills an identified market/user need		
Open communication occurs between the user and developer		
The developer and user share responsibility to accomplish the technology project		
The developer has a documented marketing/commercialization plan		
The developer markets the technology		
The technology has unique/novel qualities		Technical monitor believes development is high quality
Agency administrative processes are executed in a timely manner	Improve processing time for patent applications, licenses, and partnership agreements	
The developer pursues intellectual property protection		

Table A.2 Literature-based Grouped Candidate CSF Data (cont'd)

	NAPA, 2004	Grimes, Metzger, and Kim, 1993
The developer has a high performing team		
The technology developed is mature		
A liaison is assigned to the developer		
The developer's project is integrated into the customer's planning		
The Agency provides training to the developer on the SBIR program/processes		
The rewards structure of the developer supports technology transfer		
The developer can effectively manage external influences		
A dedicated organization is established within the developer to facilitate transfer		
Agency provides technology consulting		
The developer has a documented technology development plan		
The developer and user share personnel		
The developer has a private sector focus		
Career development is important		
A champion exists that facilitates progress of the technology project		
The developer's culture supports technology transfer		
The developer is product oriented		
Agency provides the benefits of the SBIR program to stakeholders & customers		
The developer participates in industry technology transfer networks		
The developer protects its technology development processes		
Not Applicable as a candidate CSF for the NASA SBIR Program	Relocate Technology Transfer Administration to NASA HQ for better visibility	
Not enough information to classify		

Table A.2 Literature-based Grouped Candidate CSF Data (cont'd)

	Archibald and Finifter, 2003	GAO, 1998
Top management provides support		
Project is aligned with the business strategy		
Metrics are used to measure performance		
The developer has the infrastructure to deliver the technology		
The developer obtains outside funding		
A technology broker/matchmaker is used to find a suitable customer		
Agency utilizes outreach tools/activities to promote research opportunities		Improve outreach through annual conferences and use of the internet
The technology fills an identified market/user need		
Open communication occurs between the user and developer		
The developer and user share responsibility to accomplish the technology project		
The developer has a documented marketing/commercialization plan		
The developer markets the technology		
The technology has unique/novel qualities		
Agency administrative processes are executed in a timely manner		Some Agencies developed "Fast Track" processes to mitigate funding gaps
The developer pursues intellectual property protection		

Table A.2 Literature-based Grouped Candidate CSF Data (cont'd)

	Archibald and Finifter, 2003	GAO, 1998
The developer has a high performing team		
The technology developed is mature		
A liaison is assigned to the developer		
The developer's project is integrated into the customer's planning		
The Agency provides training to the developer on the SBIR program/processes		Improve results through commercialization training
The rewards structure of the developer supports technology transfer		
The developer can effectively manage external influences		
A dedicated organization is established within the developer to facilitate transfer		
Agency provides technology consulting		
The developer has a documented technology development plan		
The developer and user share personnel		
The developer has a private sector focus	More commercialization focus correlated to higher commercialization rate	
Career development is important		
A champion exists that facilitates progress of the technology project		
The developer's culture supports technology transfer		
The developer is product oriented		
Agency provides the benefits of the SBIR program to stakeholders & customers		
The developer participates in industry technology transfer networks		
The developer protects its technology development processes		
Not Applicable as a candidate CSF for the NASA SBIR Program		
Not enough information to classify		

Table A.2 Literature-based Grouped Candidate CSF Data (cont'd)

	NRC, 2000	NMAB, 2001
Top management provides support		
Project is aligned with the business strategy		Link program needs to SBIR solicitations
Metrics are used to measure performance		Institute metrics to measure progress
The developer has the infrastructure to deliver the technology		
The developer obtains outside funding		
A technology broker/matchmaker is used to find a suitable customer		Link SBIR contractors to prime contractors
Agency utilizes outreach tools/activities to promote research opportunities		
The technology fills an identified market/user need		
Open communication occurs between the user and developer		
The developer and user share responsibility to accomplish the technology project		
The developer has a documented marketing/commercialization plan		
The developer markets the technology		
The technology has unique/novel qualities		
Agency administrative processes are executed in a timely manner	DoD's "Fast Track" processes developed to mitigate funding gaps	
The developer pursues intellectual property protection		

Table A.2 Literature-based Grouped Candidate CSF Data (cont'd)

	NRC, 2000	NMAB, 2001
The developer has a high performing team		
The technology developed is mature		
A liaison is assigned to the developer		Assign an SBIR liaison
The developer's project is integrated into the customer's planning		Senior acquisition officers direct including SBIR as part of program planning
The Agency provides training to the developer on the SBIR program/processes		
The rewards structure of the developer supports technology transfer		
The developer can effectively manage external influences		
A dedicated organization is established within the developer to facilitate transfer		
Agency provides technology consulting		
The developer has a documented technology development plan		
The developer and user share personnel		
The developer has a private sector focus		
Career development is important		
A champion exists that facilitates progress of the technology project		
The developer's culture supports technology transfer		
The developer is product oriented		
Agency provides the benefits of the SBIR program to stakeholders & customers		
The developer participates in industry technology transfer networks		
The developer protects its technology development processes		
Not Applicable as a candidate CSF for the NASA SBIR Program		
Not enough information to classify		

Table A.2 Literature-based Grouped Candidate CSF Data (cont'd)

	Segel, 2001	Pretorius, 2004
Top management provides support		
Project is aligned with the business strategy		Company's long term strategy for dealing with obstacles significant to commercialization success
Metrics are used to measure performance	Use standardized criteria for measuring commercialization success	
The developer has the infrastructure to deliver the technology		
The developer obtains outside funding		
A technology broker/matchmaker is used to find a suitable customer	Provide interagency access to SBIR awards	
Agency utilizes outreach tools/activities to promote research opportunities		
The technology fills an identified market/user need		
Open communication occurs between the user and developer		
The developer and user share responsibility to accomplish the technology project		
The developer has a documented marketing/commercialization plan		
The developer markets the technology		
The technology has unique/novel qualities		
Agency administrative processes are executed in a timely manner		
The developer pursues intellectual property protection		

Table A.2 Literature-based Grouped Candidate CSF Data (cont'd)

	Segel, 2001	Pretorius, 2004
The developer has a high performing team		
The technology developed is mature		
A liaison is assigned to the developer		
The developer's project is integrated into the customer's planning		
The Agency provides training to the developer on the SBIR program/processes		
The rewards structure of the developer supports technology transfer		
The developer can effectively manage external influences		
A dedicated organization is established within the developer to facilitate transfer		
Agency provides technology consulting		
The developer has a documented technology development plan		
The developer and user share personnel		
The developer has a private sector focus		
Career development is important		
A champion exists that facilitates progress of the technology project		
The developer's culture supports technology transfer		
The developer is product oriented		
Agency provides the benefits of the SBIR program to stakeholders & customers		
The developer participates in industry technology transfer networks		
The developer protects its technology development processes		
Not Applicable as a candidate CSF for the NASA SBIR Program	Reduce Agency duplication by developing common tools	
Not enough information to classify		

Table A.2 Literature-based Grouped Candidate CSF Data (cont'd)

	SBA, 1991 / Berger, Little, and Saavedra, 1992	Pinto and Slevin, 1989
Top management provides support		Top Management Support - getting adequate resources/authority/power
Project is aligned with the business strategy		
Metrics are used to measure performance		Monitoring and Feedback - systematic feedback control
The developer has the infrastructure to deliver the technology	Awardees that do not need outside support have higher commercialization success	Personnel - recruitment, training, & selection Technical Tasks - availability of technology and expertise
The developer obtains outside funding	Awardees that have obtained follow-on funding commitments have higher commercialization success	
A technology broker/matchmaker is used to find a suitable customer		
Agency utilizes outreach tools/activities to promote research opportunities		
The technology fills an identified market/user need		
Open communication occurs between the user and developer		Client Consultation - communication/active listening
The developer and user share responsibility to accomplish the technology project		
The developer has a documented marketing/commercialization plan	The more progress on a completed marketing plan the more commercialization success	Project Schedule/Plans - detailed plans/schedule
The developer markets the technology	The more progress toward implementing the marketing plan the more commercialization success	Client Acceptance - "selling" the technology
The technology has unique/novel qualities		
Agency administrative processes are executed in a timely manner		
The developer pursues intellectual property protection	Awardees that have mode the most progress towards intellectual property protection have higher commercialization success Awardees that know they need to legally protect their technology have higher commercialization success	

Table A.2 Literature-based Grouped Candidate CSF Data (cont'd)

	SBA, 1991 / Berger, Little, and Saavedra, 1992	Pinto and Slevin, 1989
The developer has a high performing team		Project Mission - clarity of goals Urgency - perceived importance
The technology developed is mature	Awardees that are farthest along in product development have higher commercialization success	
A liaison is assigned to the developer		
The developer's project is integrated into the customer's planning		
The Agency provides training to the developer on the SBIR program/processes		
The rewards structure of the developer supports technology transfer		
The developer can effectively manage external influences		Environmental Events - external factors
A dedicated organization is established within the developer to facilitate transfer		
Agency provides technology consulting		
The developer has a documented technology development plan		
The developer and user share personnel		
The developer has a private sector focus	Private sector oriented companies have higher commercialization success	
Career development is important		
A champion exists that facilitates progress of the technology project		
The developer's culture supports technology transfer		
The developer is product oriented	Product oriented companies have higher commercialization success Companies that produce products have more commercialization success	
Agency provides the benefits of the SBIR program to stakeholders & customers		
The developer participates in industry technology transfer networks		
The developer protects its technology development processes		
Not Applicable as a candidate CSF for the NASA SBIR Program		
Not enough information to classify		

Table A.2 Literature-based Grouped Candidate CSF Data (cont'd)

	Carr, 1992b	Souder, 1990
Top management provides support	Management Encouragement and Support	
Project is aligned with the business strategy		
Metrics are used to measure performance		
The developer has the infrastructure to deliver the technology		
The developer obtains outside funding	Venture Capital Firms Internal Maturation Funds External Maturation Funds	Cost sharing
A technology broker/matchmaker is used to find a suitable customer	Publishing Technologies Through Various Media Not-for Profit Intermediaries Technology Ferrets (i.e., a Gatekeeper for Industry rather than the Lab) Technology Brokers	
Agency utilizes outreach tools/activities to promote research opportunities	Target firms for First Contact Marketing	Conduct passive outreach
The technology fills an identified market/user need	Evaluation of marketability by the Inventors	
Open communication occurs between the user and developer		Open interactions
The developer and user share responsibility to accomplish the technology project	Cooperative R&D	Funding loans to build commitment Form partnerships to develop technologies Joint transfer teams
The developer has a documented marketing/commercialization plan	Labs either perform or enlist help to conduct Market Research	
The developer markets the technology	Focused Publicity for Marketing Technologies	
The technology has unique/novel qualities		Technologies that could be incrementally adopted Technologies that are adaptable to various applications Technologies with tangible value
Agency administrative processes are executed in a timely manner	Responsiveness to Inventors An Inventor-Friendly Disclosure and Patenting Process	
The developer pursues intellectual property protection	Location Incentives in Licenses Patenting Committees	

Table A.2 Literature-based Grouped Candidate CSF Data (cont'd)

	Carr, 1992b	Souder, 1990
The developer has a high performing team		
The technology developed is mature		
A liaison is assigned to the developer		
The developer's project is integrated into the customer's planning		
The Agency provides training to the developer on the SBIR program/processes		
The rewards structure of the developer supports technology transfer	Incentives for Inventors	
The developer can effectively manage external influences		
A dedicated organization is established within the developer to facilitate transfer	Evaluation by Technology transfer Office Personnel Formal Recognition of Technology Transfer Activities	
Agency provides technology consulting	Technical Assistance to Local Industry Consultation with Cooperating Firms	Technology consulting
The developer has a documented technology development plan		
The developer and user share personnel		Personnel transfers (temporary & permanent)
The developer has a private sector focus		
Career development is important		
A champion exists that facilitates progress of the technology project		
The developer's culture supports technology transfer	Changing the Culture	
The developer is product oriented		
Agency provides the benefits of the SBIR program to stakeholders & customers		
The developer participates in industry technology transfer networks	Industry Associations Formal & Informal Technology Transfer Networks	
The developer protects its technology development processes		
Not Applicable as a candidate CSF for the NASA SBIR Program	Maturation by External R&D Organizations	
Not enough information to classify		

Table A.2 Literature-based Grouped Candidate CSF Data (cont'd)

	Ransley and Rogers, 1994	Tan, 1996
Top management provides support	Program Selection and Management - Involve all departments in technology development, get buy-in	Management Support
Project is aligned with the business strategy	External Awareness - conduct strategic analysis on threats/opportunities Technology Strategies - tie corporate/business strategies to R&D strategy	Difference between Technology Provider and Receiver
Metrics are used to measure performance	Effectiveness - Results measure against business objectives	
The developer has the infrastructure to deliver the technology		Infrastructure Support
The developer obtains outside funding		
A technology broker/matchmaker is used to find a suitable customer		
Agency utilizes outreach tools/activities to promote research opportunities		
The technology fills an identified market/user need		
Open communication occurs between the user and developer	Technology Transfer - use cross-functional teams, job rotation, communication, and trust	Communication
The developer and user share responsibility to accomplish the technology project		
The developer has a documented marketing/commercialization plan		
The developer markets the technology		
The technology has unique/novel qualities		Technical Characteristics
Agency administrative processes are executed in a timely manner		
The developer pursues intellectual property protection		

Table A.2 Literature-based Grouped Candidate CSF Data (cont'd)

	Ransley and Rogers, 1994	Tan, 1996
The developer has a high performing team		Project Team Characteristics
The technology developed is mature		
A liaison is assigned to the developer		User Involvement
The developer's project is integrated into the customer's planning	Core Strengths - Integrate core technologies into business plan	
The Agency provides training to the developer on the SBIR program/processes		
The rewards structure of the developer supports technology transfer		Incentives
The developer can effectively manage external influences		Obstacles
A dedicated organization is established within the developer to facilitate transfer		
Agency provides technology consulting		
The developer has a documented technology development plan		
The developer and user share personnel		
The developer has a private sector focus		
Career development is important	Personnel - career development	
A champion exists that facilitates progress of the technology project		
The developer's culture supports technology transfer		
The developer is product oriented		
Agency provides the benefits of the SBIR program to stakeholders & customers		
The developer participates in industry technology transfer networks		
The developer protects its technology development processes		
Not Applicable as a candidate CSF for the NASA SBIR Program		
Not enough information to classify		

Table A.3 Literature-based Initial Candidate Critical Success Factors

1	Top management provides support to the SBIR project
2	SBIR project is aligned with the business strategy
3	The SBC utilizes metrics to measure performance
4	The SBC has the infrastructure to deliver the technology
5	The SBC obtains funding outside of SBIR program
6	A technology broker/matchmaker is used to find a suitable customer
7	NASA utilizes outreach tools/activities to promote SBIR opportunities to potential applicants
8	The technology fills an identified market/user need
9	Open communication occurs between the user and SBC
10	The SBC and user share responsibility to accomplish the technology project
11	The SBC has a documented marketing/commercialization plan
12	The SBC markets the technology
13	The characteristics of the technology promote user acceptance
14	NASA administrative processes are executed in a timely manner
15	The SBC pursues intellectual property protection with respect to commercialization/infusion
16	The SBC has a high performing team working the SBIR project
17	The technology developed is mature
18	A NASA liaison is assigned to the SBC to facilitate interactions/expectations/achieving goals
19	The SBIR project is integrated into the customer's planning
20	NASA provides training to the SBC on the SBIR program/processes
21	The rewards structure of the SBC supports technology transfer
22	The SBC can effectively manage external influences
23	A dedicated organization is established within the SBC to facilitate commercialization/infusion
24	NASA provides technology consulting to SBCs during the SBIR project
25	The SBC has a documented technology development plan
26	The SBC and NASA share personnel during the life of the technology development project
27	The SBC has a private sector focus
28	Career development is an important aspect of participating in the SBIR project
29	A champion exists that facilitates progress of the technology project
30	The SBC's culture supports technology transfer
31	The SBC is product oriented
32	NASA provides the benefits of the SBIR program to potential stakeholders & customers
33	The SBC participates in industry technology transfer networks
34	The SBC protects its intellectual property with respect to the technology development process

Table A.4 SME-reviewed, Literature-based Candidate Critical Success Factors

	SME 1
1	SBIR project is aligned with a market-focused business strategy
2	SBC top management provides support for the SBIR project
3	The SBC actively pursues Phase III funding before Phase II completion
4	The SBC has the infrastructure to deliver the technology
5	The technology fills an identified market/user need
6	The SBC actively markets the technology
7	Open communication occurs between the user and SBC
8	The SBIR project is integrated into the customer's planning
9	The SBC actively pursues intellectual property protection during all Phases
10	The SBC has a high performing team working the SBIR project
11	The technology developed is mature
12	The SBC can effectively manage external influences
13	The SBC is product oriented
14	NASA provides the benefits of the SBIR program to potential stakeholders & customers
15	A champion exists within NASA that facilitates progress of the technology project
16	The SBC is responsive to customer needs

	SME 2
1	The SBC actively pursues Phase III funding prior to Phase II completion
2	The SBC has the physical and human infrastructure to deliver the technology
3	The technology fills an identified market/user need
4	The SBC actively markets the technology
5	Open communication occurs between the user and SBC
6	A champion exists that facilitates progress of the technology project
7	The SBC understands its customer/market
8	The SBC has documented development & commercialization plans

	SME 3
1	SBIR project is aligned with the business strategy
2	Top management provides support to the SBIR project
3	The SBC has the infrastructure to deliver the technology
4	The technology fills an identified market/user need
5	The SBC and user share responsibility to accomplish the technology project
6	Open communication occurs between the user and SBC
7	The customer likes the technology/product
8	NASA administrative processes are executed in a timely manner
9	The SBIR project is integrated into the customer's planning
10	The SBC has a high performing team working the SBIR project
11	The technology developed is mature
12	The SBC's culture supports technology transfer
13	The SBC and NASA share personnel during the life of the technology development project
14	The SBC has a private sector focus
15	The rewards structure of the SBC supports technology transfer
16	The SBC can effectively manage external influences
17	The SBC is product oriented
18	NASA acts as an advertising mechanism for the technology/product
19	The COTR champions the technology project
20	The SBC responsive its customer/market

	SME 4
1	SBIR project is aligned with the business strategy
2	Top management provides support to the SBIR project
3	The SBC actively pursues Phase III funding before Phase II completion
4	The SBC has the infrastructure to deliver the technology
5	The technology fills an identified market/user need
6	The SBC and user share responsibility to accomplish the technology project
7	The SBC actively markets the technology
8	Open communication occurs between the user and SBC
9	The customer likes the technology/product
10	NASA administrative processes are executed in a timely manner
11	The SBIR project is integrated into the customer's planning
12	The technology developed is mature
13	The SBC has a private sector focus
14	The SBC is product oriented
15	A champion exists that facilitates progress of the technology project
16	The SBC responsive its customer/market

	SME 5
1	SBIR project is aligned with NASA objectives
2	Top management within the SBC champions the SBIR project
3	The SBC actively pursues Phase III funding before Phase II completion
4	The SBC has the infrastructure to deliver the technology
5	The technology fills an identified market/user need
6	The SBC and user share responsibility to accomplish the technology project
7	The SBC markets the technology
8	Open communication occurs between the user and SBC throughout the life of the project
9	The SBIR project is integrated into the customer's planning
10	The SBC pursues intellectual property protection with respect to commercialization/infusion
11	The SBC has a high performing team working the SBIR project
12	NASA provides training to the SBC on the SBIR program/processes
13	The SBC is product oriented
14	The SBC is customer focused

Table A.5 Literature/SME-based Candidate Critical Success Factors

1	The SBC has the infrastructure to deliver the technology
2	The technology fills an identified market/user need
3	Open communication occurs between the user and SBC
4	The SBC is responsive to customer needs
5	SBIR project is aligned with a market-focused business strategy
6	SBC top management provides support for the SBIR project
7	The SBC actively pursues Phase III funding before Phase II completion
8	The SBC actively markets the technology
9	The SBIR project is integrated into the customer's planning
10	The SBC is product oriented
11	A champion exists within NASA that facilitates progress of the technology project
12	The SBC and user share responsibility to accomplish the technology project
13	The SBC has a high performing team working the SBIR project
14	The technology developed is mature
15	The customer likes the technology/product
16	NASA administrative processes are executed in a timely manner
17	The SBC actively pursues intellectual property protection during all Phases
18	The SBC has a private sector focus
19	The SBC can effectively manage external influences
20	NASA acts as an advertising mechanism for the technology/product
21	The SBC has a documented marketing/commercialization plan
22	NASA provides training to the SBC on the SBIR program/processes
23	The SBC's culture supports technology transfer
24	The SBC and NASA share personnel during the life of the technology development project
25	The rewards structure of the SBC supports technology transfer
26	The SBC has documented development & commercialization plans

APPENDIX B

DEVELOPMENT OF SMALL BUSINESS CONCERN-BASED INITIAL CANDIDATE CRITICAL SUCCESS FACTORS

The NASA Marshall Space Flight Center SBIR manager provided a list of companies who had Phase III experience to be subjects for interview to develop Critical Success Factors. Five Small Business Concern (SBC) managers agreed to participate in the process. Dobbins' (1999) Generalized CSF Process Model (detailed in Chapter 2) was followed to identify a set of Critical Success Factors for a NASA funded SBIR project that achieved Phase III. Two face-to-face interviews were conducted and three phone interviews were conducted.

Each SBC manager was asked to select a NASA funded Phase II SBIR project that achieved Phase III and answer a series of questions. Based on Dobbin's (1999) process, the manager was asked to identify critical characteristics for ten areas related to the SBIR project: Global or Industry Related, External Influences, Internal Influences, Current and Future, Temporal and Enduring, Risk Abatement, Performance, Special Monitoring, Quality, and Modification Management. The data from the interviews are shown for each SBC on pages B-3 through B-12. The critical characteristics were then analyzed to grouped according to common themes. Each of these themes formed a

Critical Success Factor with the underlying critical characteristics forming constraints for the CSF. Measures were then developed for each Critical Success Factor. The results were reviewed and validated with each SBC manager. The Dobbins' (1999) Critical Success Factor results for each SBC are shown on pages B-13 through B-30. Critical Success Factor lists for each SBC are shown in Table B.1.

The Critical Success Factors for each SBC was then compared side-by-side and combined. Like CSFs were merged and all unique CSFs were included. Each SBC manager reviewed the combined list. One factor, "Develop technology/product utilizing concurrent systems engineering development process," was eliminated during this review. The process identified nineteen SBC-based Candidate Critical Success Factors, as shown in Table B.2.

Small Business Concern 1 Critical Success Factors Interview Data

Global or Industry Related
- Market your Phase II technology/product
- Develop contacts to further business development opportunities

External Influences
- Definite need for the technology
- Availability of funding from potential customers
- Responding to NASA priorities
- Competitive strength of the technology

Internal Influences
- Availability of internal research and development funding to complete the SBIR.

Current and Future

Long Term:
- Marketing your Phase II product
- Developing business contacts during technical exchange meetings

Current:
- Making the technology work before the end of the project period of performance
- Being responsive to solving unexpected technical problems
- Focus on developing the technology

Temporal and Enduring

Temporal:
- Supporting technical presentations on short notice
- Ensuring required technical staff was available

Enduring:
- Delivering a product within technical and budget constraints

Risk Abatement
- Ensuring required parts were available on schedule
- Managing parts procurement so that parts arrive within specifications
- Managing personnel staffing - people are available when needed and go away when not needed

Performance
- Tracking laser performance versus requirements
- Tracking drawing package relative to milestone deliveries
- Tracking design process against delivery goals

Special Monitoring

- Not applicable

Quality

- Tracking compliance of mechanical and optical parts in a cost effective manner
- Setting up inspection processes to catch defects for mechanical and optical components

Modification Management

- Regular and open dialogue with customer about real status of program
- Getting feedback from the customer
- Dealing with customer requirements changes
- Build trust by establishing a good working relationship with customer

Small Business Concern 2 Critical Success Factors Interview Data

Global or Industry Related

- Managing the technology to fit within size, weight, and power constraints for installation on an existing airframe
- Developing a technology/product that gives a competitive advantage for Phase III award (project in response to Columbia accident)

External Influences

- People internal to NASA that had experience working with the SBC
- Providing the best value to the customer

Internal Influences

- Capability to handle program management issues, a short schedule, with no up front specifications
- Capability to derive requirements concurrently with the design
- Constant communication with the customer
- Establishing tight cost control
- Having a solid management system in place
- Having a solid quality system in place

Current and Future

Current:

- Managing schedule successfully
- Ability to manage material procurement to pass NASA standards while still meeting schedule

Future:

- None

Temporal and Enduring

Temporal:

- Getting NASA contracting in place
- Responding to technical direction within financial constraints

Enduring:

- Ensuring a quality product
- Producing a design optimized for size, weight, and power
- Building a reliable design
- Successfully managing cost

Risk Abatement

- Use of the newest parts to achieve power, size, and weight
- Managing cost, schedule, and performance within requirements

Performance

Technical:

- Ability to manage concurrent design/specification development -- Data used to derive requirements for a specification

Programmatic:

- Communicate regularly with the customer to build and maintain confidence
- Worked with customer to meet requirements at lower cost

Special Monitoring

Technical:

- Followed progress of new processor with less risky backup processor
- Closely followed testing
- Diversified system design to build in redundancy

Programmatic:

- Dispel rumors within the customer by offering prompt design reviews

Quality

- Utilized internal manufacturing system like customer's
- Customer quality personnel involved in manufacturing

Modification Management

- No change management needed

Small Business Concern 3 Critical Success Factors Interview Data

Global or Industry Related

- Dealing with limited funding from Phase II to produce prototype.
- Sell back to the government since it has funding for additional R&D to reach higher maturity, then look for commercial market.
- Dealing with limited resources and funding to realize a useful product.

External Influences

- Be flexible and responsive to government customer development/demand cycles.
- Be able to predict if or how well a Phase II will fit with the demand at the end of Phase II.
- Integrate the Phase I with the customer's acquisition program.

Internal Influences

- Develop a good understanding of the SBIR project's intended use by the customer.
- Develop a good working relationship with prime contractors.
- Involve the customer with the SBIR development.
- Get the customer's buy-in.
- Have a Principle Investigator with good non-technical/business knowledge.
- Be focused on solving the customer's problem and not just developing technology.
- Communicate openly and often with the customer.

Current and Future

Current:

- Be focused on solving the customer's problem.
- Develop a unique solution that can produce intellectual property.
- Focus on the project itself.

Future:

- Have support infrastructure in place.
- Establish the proper intellectual property protection.
- Provide adequate customer support.
- Establish quality processes.
- Understand what you plan to do once the project's period of performance is over.
- Produce a unique product that has long-term intellectual property value.

Temporal and Enduring

Temporal:

- Focus on the project itself.
- Be focused on solving the customer's problem.

Enduring:

- Focus development activities to produce a product (not just technology).

- Being responsive to requirements differences between government and commercial customers.

Risk Abatement

- Dealing with a customer that is not interested in the technology.
- Focusing on solving the customer's problem.
- Ensuring that you communicate often with the customer.
- Communicate with the principle investigator to ensure he/she is focused on the right issues.
- Holding regular project reviews with project and technical parties.
- Evaluate to see if prime contractors can help with success.
- Have external observers that can evaluate processes for process improvement.
- Be in a position for Phase III when the Phase II is over.

Performance

- Establish principal investigator competencies for both the technical and business side.
- Developing measurable data for a marketing plan.

Special Monitoring

- Not applicable.

Quality

- Implementation of a rigorous software configuration management process.
- Continuous improvement for project processes.

Modification Management

- Implementation of a rigorous software configuration management process.
- Recognize the importance of rigors configuration management.

Small Business Concern 4 Critical Success Factors Interview Data

Global or Industry Related

- Information technology obsolescence before achieving Phase III.
- Responding to different information technology standards within the agency.
- Communication with NASA prior to SBIR topic announcement.

External Influences

- Dealing with significant and sudden funding priority changes.
- Responding to administrator priority changes.
- Being able to anticipate and plan responses to changes.

Internal Influences

- Protecting intellectual property.
- Retaining the best talent during times of lower activity.
- Being flexible with your workforce.
- Helping managers develop skills, both technical and people.

Current and Future

Current:

- None

Future:

- Obtaining funding to continue Phase II work to achieve Phase III.

Temporal and Enduring

Temporal:

- Communication with your customer to build their confidence in your product.

Enduring:

- Overcoming your customer's resistance to change.
- Planning for information technology obsolescence.

Risk Abatement

- Being able to anticipate what the Phase III needs will be.
- Planning for Phase III at project inception.
- Obtaining feedback from your customer.

Performance

- Developing voice over internet protocol encryption.
- Speed and responsiveness of the software.
- Delivering the product on schedule.

Special Monitoring

- Giving the customer software features that provided administrative control.
- Having close communication with your customer.
- Providing the customer a single point of contact or support.
- Developing trust between the company and the customer.

Quality

- Clear, traceable, and specific requirements from both NASA and the initial proposal.
- Having tight controls during beta-testing.
- Documenting the software code.

Modification Management

- Being flexible and responsive to contracting changes.
- Having people who are multi-disciplined.
- Having financial flexibility to bridge Phase II to Phase III.
- Being flexible with your workforce.

Small Business Concern 5 Critical Success Factors Interview Data

Global or Industry Related

- A defined need for the technology exists from the NASA customer
- A clear path exists to develop the technology
- Both NASA and the small business define common goals for the technology
- Clearly articulate the technology development path to the customer
- Show immediate benefits to the customer

External Influences

- The availability of NASA funding
- Be ready to seize emerging technology infusion opportunities

Internal Influences

- Engage the customer
- Understand your technologies capabilities -- find a balance between overselling and underselling capabilities
- Demonstrate the technology's capabilities -- sell the capabilities
- Establish expectations with your customer
- Look for business/technology opportunities and applications

Current and Future

Near Term:

- Demonstrate the capabilities of the technology to show it behaves as needed
- Predict how the technology might be used by the customer

Long Term:

- Accurately predict the location and position of the mast

Temporal and Enduring

Short Term:

- Build and demonstrate that the technology meets requirements
- Demonstrate the capabilities of the technology to show it behaves as needed

Life:

- Develop a comprehensive understanding of the technology's performance
- Develop repeatable performance with the technology

Risk Abatement

- Understand the full set of requirements
- Ensure people are available when needed
- Control precise fabrication techniques

Performance

- Build and demonstrate the technology to pass precise verifications
- Ensure structural stiffness meets predictions via test
- Correlate models to test results

Special Monitoring

- None

Quality

- Control build-up of truss members to meet very high accuracy requirements
- Verify performance with utilizing a build-up approach
- Understand the hardware performance characteristics

Modification Management

- Develop and act on lessons learned
- Be flexible to market conditions
- Be responsive to customer needs

Critical Success Factor Results for SBC 1

Phase II Project description: Develop an injection seated single frequency laser that would operate in an airborne vibration environment. Design intended to be scalable to space-based applications.

CSF #1. Market the technology/product

Constraints:

- Develop contacts to further business development opportunities.
- Develop business contacts during technical exchange meetings.
- Market your Phase II technology/product.
- Market your Phase II product.

Measures:

1. A marketing plan been developed
2. Potential customers are contacted with regular follow-up
3. Meeting opportunities are identified to market potential customers

CSF #2. Ensure the technology/product meets customer needs

Constraints:

- Develop a technology with high competitive strength.
- Develop a technology that has a definite need.
- Respond to NASA priorities.
- Deal with customer requirements changes.

Measures:

1. The market has been evaluated for potential sales opportunities
2. The company has a technology that fills an identified market/customer need
3. The company is organized to quickly respond to changes in priorities

CSF #3. Deliver the technology/product within budget and schedule

Constraints:

- Ensure required parts are available on schedule.
- Track drawing package relative to milestone deliveries.
- Track design process against delivery goals.
- Deliver a product within technical and budget constraints.
- Make the technology work before the end of the project period of performance.
- Focus on developing the technology.

Measures:

1. A detailed integrated master schedule (IMS) has been developed
2. The IMS is resource loaded to track funding expenditures over time
3. The IMS is monitored closely and reported to management

CSF #4. Maintain regular and open communication with the customer

Constraints:

- Build trust by establishing a good working relationship with customer.
- Get feedback from the customer.
- Have regular and open dialogue with customer about real status of program.
- Support technical presentations on short notice.

Measures:

1. Regular meetings are held with customer
2. The company supports meetings as required by the customer

CSF #5. Ensure components are delivered within performance specifications through a rigorous quality system

Constraints:

- Set up inspection processes to catch defects for mechanical and optical components.
- Track compliance of mechanical and optical parts in a cost effective manner.
- Manage parts procurement so that parts arrive within specifications.
- Track laser performance versus requirements.

Measures:

1. A quality plan has been developed to describes detailed quality processes
2. Tight controls are maintained over component compliance

CSF #6. Develop sources of funding to cover funding gaps

Constraints:

- Have funding available from potential customers.
- Have internal research and development funding available to complete the SBIR.

Measures:

1. Funding sources are developed prior to Phase II completion
2. Management has allocated budget to cover post-Phase II funding gap

CSF #7. Manage personnel availability

Constraints:

- Ensure required technical staff is available.
- Manage personnel staffing - people are available when needed and go away when not needed.
- Be responsive to solving unexpected technical problems.

Measures:

1. A plan has been established to apply manpower when needed
2. Company processes allow for flexible manpower changes

Critical Success Factor Results for SBC 2

Phase II Project description: Wireless precision data acquisition system for space flight applications.

CSF #1. Delivering a technology/product that meets customer needs

Constraints:

- Develop a technology/product that gives a competitive advantage for Phase III award.
- Provide the best value to the customer.
- Use the newest parts to achieve power, size, and weight.
- Manage the technology to fit within size, weight, and power constraints for installation on an existing airframe.

Measures:

1. The market has been evaluated for potential sales opportunities
2. The company has a technology that fills an identified market/customer need
3. Technology/product features are matched to customer requirements
4. Customer feedback is sought on technology/product features

CSF #2. Manage project to deliver technology/product within cost and schedule constraints

Constraints:

- Capability handle program management issues, a short schedule, with no up front specifications.
- Follow progress of circuits with less risky backup circuits.
- Have a solid management system in place.
- Manage cost, schedule, and performance within requirements.
- Respond to technical direction within financial constraints.
- Establish tight cost control.
- Get NASA contracting in place.

Measures:

1. A detailed integrated master schedule (IMS) has been developed
2. The IMS is continuously updated

3. The IMS is resource loaded to track funding expenditures over time
4. The IMS is monitored closely and reported to management

CSF #3. Maintain regular and open communication with the customer

Constraints:

- Develop recurring relationship with people internal to NASA.
- Communicate regularly with the customer to build and maintain confidence.
- Worked with customer to meet requirements at lower cost.
- Dispel rumors within the customer by offering prompt design reviews.

Measures:

1. Regular meetings are held with customer
2. The company supports meetings as required by the customer

CSF #4. Maintain rigorous quality standards

Constraints:

- Manage material procurement to pass NASA standards.
- Involve customer's quality personnel in manufacturing processes.
- Utilize internal manufacturing system like the customer's.
- Ensure a quality product.
- Have a solid quality system in place.
- Follow testing closely.

Measures:

1. A quality plan has been developed to describes detailed quality processes
2. Tight controls are maintained over component compliance
3. Customer quality personnel are integrated into manufacturing processes

CSF #5. Develop a robust design

Constraints:

- Design diversified system to build in redundancy.
- Build a reliable design.

Measures:

1. System design has built-in redundancy
2. Highly reliable parts are built into the design

CSF #6. Develop technology/product utilizing concurrent systems engineering development process

Constraints:

- Derive requirements concurrently with the design.
- Manage concurrent design/specification development – Analysis data used to derive requirements for a specification.

Measures:

1. Systems engineering process is established to utilize technical analysis feedback to validate derived requirements

Critical Success Factor Results for SBC 3

Phase II Project description: Computational Fluid Dynamics (CFD) six degree of freedom flow solver

CSF #1. Develop sources of funding to cover funding gaps

Constraints:

- Deal with limited funding from Phase II to produce prototype.
- Deal with limited resources and funding to realize a useful product.
- Evaluate to see if prime contractors can help with success.

Measures:

1. Funding sources are developed prior to Phase II completion
2. Management has allocated budget to cover post-Phase II funding gap

CSF #2. Predict customer demand

Constraints:

- Be flexible and responsive to government customer development/demand cycles.
- Predict how well a Phase II will fit with the demand at the end of Phase II.

Measures:

1. Up front analysis has been conducted to evaluate customer/market demands

CSF #3. Maintain regular and open communication with the customer

Constraints:

- Develop a good working relationship with prime contractors.
- Involve the customer with the SBIR development.
- Get the customer's buy-in.
- Communicate openly and often with the customer.
- Ensure that you communicate often with the customer.
- Hold regular project reviews with project and technical parties.
- Deal with a customer that is not interested in the technology.
- Have support infrastructure in place.

- Provide adequate customer support.

Measures:

1. Regular meetings are held with customer
2. The company supports meetings as required by the customer
3. Customer is actively involved with SBIR development

CSF #4. Ensure the technology/product meets customer needs

Constraints:

- Be focused on solving the customer's problem and not just developing technology.
- Focus on the project itself.
- Focus development activities to produce a product (not just technology).
- Develop a good understanding of the SBIR project's intended use by the customer.

Measures:

1. The company has a product that fills an identified market/customer need
2. Product features are matched to customer requirements
3. Customer feedback is sought on product features

CSF #5. Pursue SBIR projects that develop company expertise/intellectual property value

Constraints:

- Develop a unique solution that can produce intellectual property.
- Establish the proper intellectual property protection.
- Produce a unique product that has long-term intellectual property value.
- Develop knowledge/expertise within the company

Measures:

1. The intellectual property value of the technology/product has been evaluated
2. Intellectual property protection has been sought for the technology/product

CSF #6. Maintain rigorous configuration management process

Constraints:

- Implement a rigorous software configuration management process.
- Recognize the importance of rigorous configuration management.

Measures:

1. A configuration management plan has been developed
2. A rigorous configuration management process is being followed

CSF #7. Maintain rigorous quality standards

Constraints:

- Implement continuous improvement for processes.
- Establish quality processes.
- Have external observers that can evaluate processes for process improvement.

Measures:

1. A quality plan has been developed to describes detailed quality processes
2. Tight controls are maintained over component compliance
3. Customer quality personnel are integrated into manufacturing processes

CSF #8. Ensure the principle investigator has technical, communication, and business skills

Constraints:

- Communicate with the principle investigator to ensure he/she is focused on the right issues.
- Have a Principle Investigator with good non-technical and business knowledge.
- Establish principle investigator competencies for both the technical and business side.

Measures:

1. The principle investigator has multi-discipline experience, particularly business skills
2. Mandatory competencies have been established for future principle investigators
3. The company provides mentoring, resource assistance, and training for skills development

CSF #9. Begin project with a plan for post-Phase II activity

Constraints:

- Understand what you plan to do once the project's period of performance is over.
- Be responsive to requirements differences between potential government and commercial customers.
- Develop measureable data for a marketing plan.
- Sell back to the government since it has funding for additional R&D to reach higher maturity and then look for commercial market.
- Be in a position for Phase III when the Phase II is over.
- Integrate the Phase I with the customer's acquisition program.

Measures:

1. A plan has been developed for post-Phase II activity at the project's inception
2. Efforts have been conducted to integrate the project into the customer's/prime contractor's planning cycle

Critical Success Factor Results for SBC 4

Phase II Project description: Voice over internet protocol (VOIP) communications system for communicating between ground and on-orbit astronauts.

CSF #1. Deliver the technology/product within schedule

Constraints:

- Deliver the product on schedule.

Measures:

1. A detailed integrated master schedule (IMS) has been developed
2. The IMS is monitored closely and reported to management

CSF #2. Maintain rigorous configuration management process

Constraints:

- Have tight controls during beta-testing.
- Document the software code.

Measures:

1. A software configuration management plan has been developed
2. A rigorous software configuration management process is being followed

CSF #3. Plan for technology obsolescence

Constraints:

- Plan for information technology obsolescence before achieving Phase III.

Measures:

1. An evaluation has been conducted on technology trends within the project's field

CSF #4. Predict customer demand

Constraints:

- Deal with significant and sudden funding priority changes.
- Respond to NASA administrator priority changes.
- Be able to anticipate and plan responses to changes.
- Be flexible and responsive to contracting changes.

Measures:

1. Up front analysis has been conducted to evaluate customer/market demands

CSF #5. Pursue SBIR projects that develop company expertise/intellectual property value

Constraints:

- Protect intellectual property.
- Develop voice over internet protocol encryption.
- Deliver software that is speedy and responsive.
- Give the customer software features that provide administrative control.

Measures:

1. The intellectual property value of the technology/product has been evaluated
2. Intellectual property protection has been sought for the technology/product

CSF #6. Manage personnel availability

Constraints:

- Help managers develop skills, both technical and people.
- Retain the best talent during times of lower activity.
- Be flexible with your workforce.
- Have people who are multi-disciplined.

Measures:

1. A plan has been established to apply manpower when needed
2. Company processes allow for flexible manpower changes
3. The company encourages it's employees to develop multiple skill sets

CSF #7. Develop sources of funding to cover funding gaps

Constraints:

- Obtain funding to continue Phase II work to achieve Phase III.
- Have financial flexibility to bridge Phase II to Phase III.

Measures:

1. Funding sources are developed prior to Phase II completion
2. Management has allocated budget to cover post-Phase II funding gap

CSF #8. Maintain regular and open communication with the customer

Constraints:

- Communicate with NASA prior to SBIR topic announcement.
- Communicate with your customer to build their confidence in your product.
- Overcome your customer's resistance to change.
- Obtain feedback from your customer.
- Have close communication with your customer.
- Develop trust between your company and the customer.
- Provide the customer a single point of contact or support.

Measures:

1. Regular meetings are held with customer
2. The company supports meetings as required by the customer
3. Customer is actively involved with SBIR development

CSF #9. Begin project with a plan for post-Phase II activity

Constraints:

- Be able to anticipate what the Phase III needs will be.
- Plan for Phase III at project inception.

Measures:

1. A plan has been developed for post-Phase II activity at the project's inception
2. Efforts have been conducted to integrate the project into customer planning cycles

CSF #10. Ensure the technology/product meets customer needs

Constraints:

- Respond to different information technology standards within the agency.
- Determine clear, traceable, and specific requirements from both NASA and the initial proposal.

Measures:

1. The company has a product that fills an identified market/customer need
2. Product features are matched to customer requirements
3. Customer feedback is sought on product features

Critical Success Factor Results for SBC 5

Phase II Project description: Develop an articulating, deployable mast for precise po-tion space-based application.

CSF #1. Ensure the technology/product meets customer needs

Constraints:

- A defined need for the technology exists from the NASA customer.
- Be responsive to customer needs.
- Establish expectations with your customer.
- A clear path exists to develop the technology.
- Both NASA and the small business define common goals for the technology.
- Clearly articulate the technology development path to the customer.

Measures:

1. The market has been evaluated for potential sales opportunities
2. The company has a technology that fills an identified market/customer need
3. The company is organized to quickly respond to changes in priorities
4. The development path for the technology has customer buy-in

CSF #2. Predict customer demand

Constraints:

- Be ready to seize emerging technology infusion opportunities
- Look for business/technology opportunities and applications
- Be flexible to market conditions
- Predict how the technology might be used by the customer
- The availability of NASA funding

Measures:

1. Up front analysis has been conducted to evaluate customer/market demands

CSF #3. Maintain regular and open communication with the customer

Constraints:

- Engage the customer.

Measures:

1. Regular meetings are held with customer
2. The company supports meetings as required by the customer

CSF #4. Understand the underlying fundamentals of the technology's performance characteristics

Constraints:

- Understand your technologies capabilities -- find a balance between overselling and underselling capabilities.
- Understand the hardware performance characteristics.
- Understand the full set of requirements.
- Develop a comprehensive understanding of the technology's performance.

Measures:

1. A deep understanding of the technology's performance characteristics has been developed

CSF #5. Demonstrate the technology's capabilities to the customer

Constraints:

- Show immediate benefits to the customer.
- Demonstrate the technology's capabilities -- sell the capabilities.
- Demonstrate the capabilities of the technology to show it behaves as needed.
- Build and demonstrate that the technology meets requirements.

Measures:

1. The technology's/product's capabilities have been demonstrated to the customer

CSF #6. Verify performance utilizing a rigorous test program

Constraints:

- Accurately predict the location and position of the mast.
- Build the technology to pass precise verifications.
- Ensure structural stiffness meets predictions via test.
- Correlate models to test results.
- Develop repeatable performance with the technology.
- Verify performance with utilizing a build-up approach.

Measures:

1. A test plan has been developed to describes detailed test procedures and objectives
2. Test procedures require testing from component to system
3. Prediction models have been anchored to test results

CSF #7. Ensure components are delivered within performance specifications through a rigorous quality system

Constraints:

- Control precise fabrication techniques.
- Control build-up of truss members to meet very high accuracy requirements.

Measures:

1. A quality plan has been developed to describes detailed quality processes
2. Tight controls are maintained over component compliance

CSF #8. Develop and utilize lessons learned

Constraints:

- Develop and act on lessons learned.

Measures:

1. A lessons learned database has been developed
2. Lessons learned are applied to the current project

CSF #9. Manage personnel availability

Constraints:

- Ensure people are available when needed.

Measures:

1. A plan has been established to apply manpower when needed
2. Company processes allow for flexible manpower changes

Table B.1 SBC-based Candidate Critical Success Factors Compared

	SBC 1
1	Develop sources of funding to cover funding gaps
2	Ensure the technology/product meets customer needs
3	Market the technology/product
4	Maintain regular and open communication with the customer
5	Deliver the technology/product within budget and schedule
6	Ensure components are delivered within performance specifications through a rigorous quality sys-
7	Manage personnel availability

	SBC 2
1	Ensure the technology/product meets customer needs
2	Maintain regular and open communication with the customer
3	Manage project to deliver technology/product within cost and schedule constraints
4	Maintain rigorous quality standards
5	Develop a robust design
6	Develop technology/product utilizing concurrent systems engineering development process

	SBC 3
1	Begin project with a plan for post-Phase II activity
2	Develop sources of funding to cover funding gaps
3	Ensure the technology/product meets customer needs
4	Maintain regular and open communication with the customer
5	Maintain rigorous quality standards
6	Predict customer demand
7	Pursue SBIR projects that develop company expertise/intellectual property value
8	Maintain rigorous configuration management process
9	Ensure the principle investigator has technical, communication, and business skills

	SBC 4
1	Begin project with a plan for post-Phase II activity
2	Develop sources of funding to cover funding gaps
3	Ensure the technology/product meets customer needs
4	Maintain regular and open communication with the customer
5	Deliver the technology/product within schedule
6	Manage personnel availability
7	Predict customer demand
8	Pursue SBIR projects that develop company expertise/intellectual property value
9	Maintain rigorous configuration management process
10	Plan for technology obsolescence

	SBC 5
1	Ensure the technology/product meets customer needs
2	Maintain regular and open communication with the customer
3	Manage personnel availability
4	Ensure components are delivered within performance specifications through a rigorous quality sys-
5	Predict customer demand
6	Understand the underlying fundamentals of the technology's performance characteristics
7	Demonstrate the technology's capabilities to the customer
8	Verify performance utilizing a rigorous test program
9	Develop and utilize lessons learned

Table B.2 SBC-based Candidate Critical Success Factors

1	Maintain regular and open communication with the customer
2	Begin project with a plan for post-Phase II activity
3	Deliver the technology/product within budget and schedule
4	Demonstrate the technology's capabilities to the customer
5	Ensure the technology/product meets customer needs
6	Manage personnel availability
7	Predict customer demand
8	Verify performance utilizing a rigorous test program
9	Develop a robust design
10	Develop and utilize lessons learned
11	Develop sources of funding to cover funding gaps
12	Ensure components are delivered within performance specifications through a rigorous quality system
13	Ensure the principle investigator has technical, communication, and business skills
14	Market the technology/product
15	Understand the underlying fundamentals of the technology's performance characteristics
16	Maintain rigorous configuration management process
17	Pursue SBIR projects that develop company expertise/intellectual property value
18	Maintain rigorous quality standards
19	Plan for technology obsolescence
20	Develop technology/product utilizing concurrent systems engineering development process

Table B.3 SBC-based Candidate Critical Success Factors

1	Maintain regular and open communication with the customer
2	Begin project with a plan for post-Phase II activity
3	Deliver the technology/product within budget and schedule
4	Demonstrate the technology's capabilities to the customer
5	Ensure the technology/product meets customer needs
6	Manage personnel availability
7	Predict customer demand
8	Verify performance utilizing a rigorous test program
9	Develop a robust design
10	Develop and utilize lessons learned
11	Develop sources of funding to cover funding gaps
12	Ensure components are delivered within performance specifications through a rigorous quality system
13	Ensure the principle investigator has technical, communication, and business skills
14	Market the technology/product
15	Understand the underlying fundamentals of the technology's performance characteristics
16	Maintain rigorous configuration management process
17	Pursue SBIR projects that develop company expertise/intellectual property value
18	Maintain rigorous quality standards
19	Plan for technology obsolescence

APPENDIX C

DEVELOPMENT OF INITIAL CONSOLIDATED CANDIDATE CRITICAL SUCCESS FACTORS

To develop an Initial Consolidated Candidate Critical Success Factor list the Literature/SME-based Candidate CSF list and the SBC-based Candidate CSF lists were combined using Pareto analysis. A Pareto score was developed for each Candidate CSF list by adding the number of times a particular Candidate CSF occurred in an individual list. For example, a Literature/SME-based Candidate CSF was assigned a 5 if it occurred in all Literature/SME-based lists, or an SBC-based Candidate CSF was assigned a 2 if it occurred in two of the five SBC-based Candidate CSF lists. Using this process, all Candidate CSFs on each Candidate CSF list could be assigned a score 1 through 5. For the Pareto analysis, factors with scores 3 and higher were kept while factors with scores 2 or less were discarded. Table C.1 shows the Pareto scores for each Candidate CSF list with the cut-off line.

The Literature/SME-based Candidate CSF list and SBC-based Candidate CSF list were then compared side-by-side to align like Candidate CSFs. The side-by-side Candidate CSF alignment is shown in Table C.2. The Candidate Critical Success Factor lists were then merged with the SBC-based Candidate CSFs taking priority for matched

factors. The SBC-based Candidate CSFs were given priority to better maintained CSF context, as argued by Dobbins (1999). The merged lists formed eighteen Initial Consolidated Candidate Critical Success Factors, as shown in Table C.3. The SBC managers and NASA SMEs reviewed and validated the Initial Consolidated Candidate Critical Success Factor list.

Table C.1 SBC-based and Literature/SME-based Candidate CSFs with Pareto Scores

SBC	SBC-based CSFs	Literature/SME-based CSFs	SME
5	Maintain regular and open communication with the customer	Open communication occurs between the user and SBC	5
4	Ensure the technology/product meets customer needs	The technology fills an identified market/user need	5
4	Demonstrate the technology's capabilities to the customer	The SBC is responsive to customer needs	5
4	Begin project with a plan for post-Phase II activity	The SBC has the infrastructure to deliver the technology	5
4	Deliver the technology/product within budget and schedule	The SBC actively pursues Phase III funding before Phase II completion	4
3	Manage personnel availability	The SBC actively markets the technology	4
3	Verify performance utilizing a rigorous test program	SBIR project is aligned with a market-focused business strategy	4
3	Predict customer demand	SBC top management provides support for the SBIR project	4
		The SBIR project is integrated into the customer's planning	4
		The SBC is product oriented	4
		A champion exists within NASA that facilitates progress of the technology project	4
		The SBC and user share responsibility to accomplish the technology project	3
		The SBC has a high performing team working the SBIR project	3
		The technology developed is mature	3
2	Ensure components are delivered within performance specifications through a rigorous quality system	The customer likes the technology/product	2
2	Develop sources of funding to cover funding gaps	NASA administrative processes are executed in a timely manner	2
2	Market the technology/product	The SBC actively pursues intellectual property protection during all Phases	2
2	Develop a robust design	The SBC has a private sector focus	2
2	Develop and utilize lessons learned	The SBC can effectively manage external influences	2
2	Ensure the principle investigator has technical, communication, and business skills	NASA acts as an advertising mechanism for the technology/product	2
2	Understand the underlying fundamentals of the technology's performance characteristics	The SBC and NASA share personnel during the life of the technology development project	1
1	Maintain rigorous configuration management process	The SBC has documented development & commercialization plans	1
1	Maintain rigorous quality standards	The SBC has a documented marketing/ commercialization plan	1
1	Pursue SBIR projects that develop company expertise/intellectual property value	NASA provides training to the SBC on the SBIR program/processes	1
1	Plan for technology obsolescence	The SBC's culture supports technology transfer	1
		The rewards structure of the SBC supports technology transfer	1

Table C.2 Combined SBC-based and Literature/SME-based Candidate CSFs

SBC-based CSFs	Literature/SME-based CSFs
Maintain regular and open communication with the customer	Open communication occurs between the user and SBC
Ensure the technology/product meets customer needs	The technology fills an identified market/user need
	The SBC is responsive to customer needs
Begin project with a plan for post-Phase II activity	
Deliver the technology/product within budget and schedule	
Demonstrate the technology's capabilities to the customer	The SBC has the infrastructure to deliver the technology
Manage personnel availability	
Verify performance utilizing a rigorous test program	
	The SBC actively pursues Phase III funding before Phase II completion
	The SBC actively markets the technology
	SBIR project is aligned with a market-focused business strategy
	SBC top management provides support for the SBIR project
	The SBIR project is integrated into the customer's planning
	The SBC is product oriented
	A champion exists within NASA that facilitates progress of the technology project
Predict customer demand	
	The SBC and user share responsibility to accomplish the technology project
	The SBC has a high performing team working the SBIR project
	The technology developed is mature

Table C.3 Initial Consolidated Candidate Critical Success Factors

1	Communication quality between the company's SBIR project team and your NASA customer
2	The degree to which your NASA customer's needs were met
3	Providing your NASA customer with a preview of the technology's capabilities
4	Your company's ability to manage personnel resources for the SBIR project
5	The depth of the innovation's verification program to substantiate performance
6	Understanding the intended application of the innovation once the SBIR project was complete
7	The SBIR project's performance against stated key performance parameters
8	Funding requirements beyond the completion of the SBIR project to bridge funding gaps
9	The degree of marketing activity for the innovation
10	The innovation's alignment with the company's business strategy
11	The degree of your company's management support for the SBIR project/innovation
12	The degree of integration the SBIR project had with your customer's planning
13	The type of development your company primarily pursued – product or process
14	The degree to which the SBIR project received support from NASA personnel
15	The ability of your company to predict the market/customer demand for the innovation
16	The degree your SBIR project team shared decision making responsibility with your customer
17	The level your SBIR project team's performance
18	The level of maturity the innovation achieved through the SBIR project

APPENDIX D

MAPPING DESCRIPTOR STATEMENTS TO THE INITIAL CONSOLIDATED CANDIDATE CRITICAL SUCCESS FACTORS

A literature review was conducted to determine if an instrument existed that could measure critical success factors or elements of the Initial Consolidated Candidate Critical Success Factor list. One instrument was identified that measured Critical Success Factors, the Project Implementation Profile (PIP) (Pinto 1986). However, the PIP was designed to measure Critical Success Factors for general project management applications. Since this research was examining a specific application of Critical Success Factors, the PIP would have needed validation prior to use and so was discounted.

Specific attention was placed on finding an existing instrument to measure team performance, one of the Initial Consolidated Candidate Critical Success Factors. Team performance has been greatly studied and any original questions or instrument would require validation, which was out of scope for this research. Requirements to use an existing team performance instrument was conciseness and accessibility. A team performance instrument by Halfhill (2000) was previously used in a recent department dissertation (Benfield 2005). This team performance instrument was concise, with eight

questions, and Dr. Halfhill explicitly provided approval for fair use of his instrument (contained in Appendix E).

This study required SBC managers to recall past events about SBIR projects in which they participated. Since the data is based on past events a questionnaire was an appropriate instrument to gather data.

The other seventeen Initial Consolidated Candidate Critical Success Factors required formulation of descriptor statements for measurement. The research plan was to utilize Factor Analysis to determine factor structures for Phase II "did not achieve" Phase III and Phase II "achieved" Phase III cases. Factor Analysis requires at least three variables (descriptor statements) per factor to calculate a factor structure (Grimm and Yarnold 1995). The underlying data that formed the Literature/SME-sourced Candidate CSFs and SBC-sourced Candidate CSFs were used to formulate descriptor statements. Tables were built for each Initial Consolidated Candidate CSF using the Literature/SME-sourced Candidate CSF data and SBC-sourced Candidate CSF measurement data, as shown in Table D.1. Three descriptor statements were then formulated according to major theme within each Candidate CSF. No more than three descriptor statements were developed per Candidate CSF to keep the questionnaire to a manageable size (to increase the likelihood for completion) while still meeting Factor Analysis requirements. This resulted in fifty-one descriptor statements, not counting the team performance measures. These fifty-one descriptor statements were reviewed and validated by each NASA SME and SBC manager that participated in developing the Literature/SME-sourced Candidate

CSFs and SBC-sourced Candidate CSFs. This resulted in the pilot questionnaire contained in Appendix E.

Table D.1 Underlying CSF Data to Form Descriptor Statements

SBC-sourced and Literature/SME-sourced Candidate CSFs with Underlying Data
Maintain regular and open communication with the customer • Build trust by establishing a good working relationship with customer • Obtain feedback from your customer • Regular meetings are held with customer • The company supports meetings as required by the customer • Customer is actively involved with SBIR development Open communication occurs between the user and SBC • Quality of information from the innovation • Client Consultation - communication/active listening • Open interactions • Technology Transfer - use cross-functional teams, job rotation, communication, and trust • Communication • The acquiring organization facilitates informal transfer processes The SBC and NASA share personnel during the life of the technology development project • Personnel transfers (temporary & permanent) • Both the developing and the acquiring organizations share personnel over the life of the transfer project
Ensure the technology/product meets customer needs • The company has a technology that fills an identified market/customer need • The company is organized to quickly respond to changes in priorities • Technology/product features are matched to customer requirements • Product features are matched to customer requirements • Customer feedback is sought on technology/product features • The market has been evaluated for potential sales opportunities • The development path for the technology has customer buy-in The technology fills an identified market/user need • Tying a technology to a recognized problem • Evaluation of marketability by the Inventors • Market existence • Technology benefits matching market needs • Direct human health impacts • No other competition: market pull • Product Effectiveness & Value • Mission-Directorate Technology Need Identification The SBC is responsive to customer needs • Introduced during SME review

SBC-sourced and Literature/SME-sourced Candidate CSFs with Underlying Data
Demonstrate the technology's capabilities to the customer • The technology's/product's capabilities have been demonstrated to the customer Manage personnel availability • A plan has been established to apply manpower when needed • Company processes allow for flexible manpower changes • The company encourages it's employees to develop multiple skill sets Verify performance utilizing a rigorous test program • A test plan has been developed to describes detailed test procedures and objectives • Test procedures require testing from component to system • Prediction models have been anchored to test results Ensure components are delivered within performance specifications through a rigorous quality system • A quality plan has been developed to describes detailed quality processes • Tight controls are maintained over component compliance Maintain rigorous configuration management process • A configuration management plan has been developed • A rigorous configuration management process is being followed • A software configuration management plan has been developed • A rigorous software configuration management process is being followed Maintain rigorous quality standards • A quality plan has been developed to describes detailed quality processes • Tight controls are maintained over component compliance • Customer quality personnel are integrated into manufacturing processes The SBC has the infrastructure to deliver the technology • Awardees that do not need outside support have higher commercialization success • Personnel - recruitment, training, & selection • Technical Tasks - availability of technology and expertise • Infrastructure Support • Resource availability • Availability of raw materials • Training and experience of own people • Resources and Productivity • Document SBIR firm capability to deliver
Begin project with a plan for post-Phase II activity • A plan has been developed for post-Phase II activity at the project's inception • Efforts have been conducted to integrate the project into the customer's/prime contractor's planning cycle The SBC has documented development & commercialization plans • A high-quality new product process • R&D process well planned The SBC has a documented marketing/commercialization plan • The more progress on a completed marketing plan the more commercialization success • Project Schedule/Plans - detailed plans/schedule • Labs either perform or enlist help to conduct Market Research • The acquiring organization has a business plan for commercializing the technology • Evaluate RFPs based on the tech transfer objectives • Contracts should address technology transfer plans
Deliver the technology/product within budget and schedule • A detailed integrated master schedule (IMS) has been developed • The IMS is resource loaded to track funding expenditures over time • The IMS is monitored closely and reported to management • The IMS is continuously updated

SBC-sourced and Literature/SME-sourced Candidate CSFs with Underlying Data
Develop sources of funding to cover funding gaps • Funding sources are developed prior to Phase II completion • Management has allocated budget to cover post-Phase II funding gap The SBC actively pursues Phase III funding before Phase II completion • Awardees that have obtained follow-on funding commitments have higher commercialization success • Venture Capital Firms • Internal Maturation Funds • External Maturation Funds • Cost sharing • The acquiring organization funds the transfer project adequately • NASA Centers provide dedicated funding & resources for tech transfer • Small Phase III Awards • Larger Phase II Awards • Unbundling Larger Phase III Awards • Specific Phase III funding from prime contractors
Market the technology/product • A marketing plan been developed • Potential customers are contacted with regular follow-up • Meeting opportunities are identified to market potential customers The SBC actively markets the technology • The more progress toward implementing the marketing plan the more commercialization success • Client Acceptance - "selling" the technology • Focused Publicity for Marketing Technologies • Emphasize marketing • Marketing and technology are strengths • The developing organization targets advertising to relevant industries
SBIR project is aligned with a market-focused business strategy • Align Center resources to technology development • Align Center resources to technology partnering • Link program needs to SBIR solicitations • Company's long term strategy for dealing with obstacles significant to commercialization success • External Awareness - conduct strategic analysis on threats/opportunities • Technology Strategies - tie corporate/business strategies to R&D strategy • Difference between Technology Provider and Receiver • New product strategy for the business unit • Technology strategy tied to business strategy • NASA's strategic plan should address technology transfer's role • Aligning Small Business Strategy • Align SBIR to programs

SBC-sourced and Literature/SME-sourced Candidate CSFs with Underlying Data
SBC top management provides support for the SBIR project • Top management support • Hold Mission and Center Directors accountable for technology spin-in • Leadership commitment to technology transfer • Top Management Support - getting adequate resources/authority/power • Management Encouragement and Support • Program Selection and Management - Involve all departments in technology development, get buy-in • Management Support • High level management support • Executive support for cooperative arrangements that may result in tech transfer • Local Program Manager (PM) - Level 2 buy-in or Concurrence • Program/directorate buy-in by emphasizing spin-in potential
The SBIR project is integrated into the customer's planning • Senior acquisition officers direct including SBIR as part of program planning • Core Strengths - Integrate core technologies into business plan • Assurances from prime contractors on Phase III plans with execution • Roadmap Integration • Keep SBIR off the critical path • Work SBIR projects into budget estimates
The SBC is product oriented • Product oriented companies have higher commercialization success • Companies that produce products have more commercialization success
A champion exists within NASA that facilitates progress of the technology project • Internal Champion • External Champion • Technology Champions
Predict customer demand • Be flexible and responsive to government customer development/demand cycles • Predict how well a Phase II will fit with the demand at the end of Phase II • Up front analysis has been conducted to evaluate customer/market demands
The SBC and user share responsibility to accomplish the technology project • Sharing resources between developer and user • Cooperative R&D • Funding loans to build commitment • Form partnerships to develop technologies • Joint transfer teams • Partner with small businesses • External Partner Involvement via Leveraged Resources, Innovative Ideas, and Capabilities
The technology developed is mature • Equivalent Technology • Awardees that are farthest along in product development have higher commercialization success • Field test and pilot scale operational data • More mature technologies

APPENDIX E

PILOT STUDY QUESTIONNAIRES

Dear Madam or Sir:

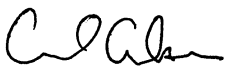
I am a doctoral student researching critical success factors to achieve Small Business Innovation Research (SBIR) Phase III commercialization or technology infusion. I am in the pilot study phase of my research and need your help to collect data that will form a final set of critical success factors to proceed into the final study phase. Ultimately, the benefits for your business will be to highlight critical areas where management should focus efforts to achieve commercialization or techcology infusion of NASA funded SBIR innovations.

I am requesting your participation to complete the following questionnaire. This questionnaire consists of fifty-none questions, however, if your company has ever commercialized or infused innovations from a NASA SBIR effort, I request you fill out a second questionnaire. Each questionnaire should take approximately 20 - 30 minutes to complete. Since only a select set of company's have been selected for this pilot questionnaire, you participation is crucial to the succes of my research.

Information specific to your company will remain confidential and interviewee anonymity will be maintained. Once my study is complete I will send you a summary of the findings. If you have any questions please contact me at my work number below.

If you would like inquire about credentials for this research please contact Dr. Don Tippett at 256-824-6895.

Thank you.



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Questionnaire to determine Critical Success Factors for NASA originated SBIR projects

Definitions:
Critical Success Factor (CSF) – A few key areas where things must go right to achieve Phase III Commercialization/Technology Infusion. If results in these areas are not adequate, the SBIR effort will be less than desired. As such, these areas of activity should receive constant and careful attention from management.
Phase II – Funded NASA SBIR. Up to 2-year focused research and development with results being demonstration and delivery of the innovation.
Phase III Commercialization -- Revenue received from a private source that resulted from the sale, contract, or license of a NASA SBIR Phase II innovation.
Phase III Technology Infusion -- Revenue received from a Federal source that resulted from the sale, contract, or license of a NASA SBIR Phase II innovation.

Instructions:
Answer the questionnaire based on your knowledge of your company's participation in NASA's SBIR program and any follow-on business activities. Please evaluate the criteria below to determine how to proceed.

Your company's innovations have only completed Phase II (none have achieved Phase III):
You are requested to complete one questionnaire with respect to a specific innovation that only completed Phase II.

Your company had an innovation that achieved Phase III:
You are requested to complete two questionnaires. Answer the first questionnaire for a specific SBIR project/innovation that achieved Phase III. Then, complete a second questionnaire for another specific SBIR innovation that has only completed Phase II (not achieved Phase III).

Phase II project description: _____

For each item, select the best answer that describes your project/innovation.

Communication quality between the company's SBIR project team and your NASA customer					
1. Project members' communication built the customer's confidence in the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
2. Project members sought feedback from their customer.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
3. Project members developed a trusting relationship with their customer.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
The degree to which your NASA customer's needs were met					
4. The project members understood customer requirements.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
5. The technology solved the customer's problem.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
6. Project members understood how the customer intended to use the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
Providing your NASA customer with a preview of the technology's capabilities					
7. A demonstration was conducted for the customer to exhibit the innovation's benefits.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
8. The innovation was presented to show it performed as required.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
9. The customer received a hands-on preview of the innovation's capabilities.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

Your company's ability to manage personnel resources for the SBIR project					
10. Workers were available for assignment to the project when needed.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
11. Personnel were assigned to other projects when their services were no longer needed.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
12. Multi-disciplined workers were valued more than single-discipline workers.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
The depth of the innovation's verification program to substantiate performance					
13. The highest level of testing the innovation received is best described by:	Did not test or achieve at least a breadboard maturity ☐	Breadboard testing in a laboratory environment ☐	Breadboard testing in a relevant environment ☐	Testing in a relevant environment ☐	Testing in its operational environment ☐
14. Analytical predictions were followed up with empirical testing.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
15. The innovation's verification methodology followed a build-up approach (i.e., component > assembly > subsystem > system).	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
Understanding the intended application of the innovation once the SBIR project was complete					
16. The project members developed a plan for Phase III at project's inception.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
17. The project members understood the intended market for the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
18. Project members gathered marketing data prior to end of Phase II.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The SBIR project's performance against stated key performance parameters					
19. Your company delivered the innovation within schedule constraints.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
20. Your company delivered the innovation within budget constraints.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
21. The innovation met key technical performance measures.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
Funding requirements beyond the completion of the SBIR project to bridge funding gaps					
22. The project required additional funding, beyond the SBIR Phase II funding, to mature the innovation for use by a customer.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
23. The project received internal research and development funds to bridge any post-Phase II funding gaps.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
24. The project received external funding to bridge any post-Phase II funding gaps.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
The degree of marketing activity for the innovation					
25. The project members developed business contacts during the SBIR project for future sales opportunities.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
26. The innovation's benefits were advertised to potential customers.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
27. A marketing plan was developed describing how the innovation would be introduced into its intended market.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The innovation's alignment with the company's business strategy					
28. The innovation developed from the SBIR project supported the goals of the company.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
29. The innovation was intended for:	Solely the Federal government ☐	Mostly the Federal government ☐	Federal government and commercial market ☐	Mostly the commercial market ☐	Solely the commercial market ☐
30. At the time of the this SBIR project, the company's business strategy was focused on:	Solely the Federal government ☐	Mostly the Federal government ☐	Federal government and commercial market ☐	Mostly the commercial market ☐	Solely the commercial market ☐
The degree of your company's management support for the SBIR project/innovation					
31. Top management believed the SBIR project should provide a revenue stream for the company.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
32. Top management's desire was to increase the maturity of the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
33. Top management's goal was to achieve sale to a customer from the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
The degree of integration the SBIR project had with your customer's planning					
34. SBIR project milestones were incorporated into customer planning.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
35. The SBIR project was integrated into customer's funding cycle.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
36. The SBIR project was integrated into customer's schedule.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The type of development your company primarily pursued – product or process					
37. At the time of the SBIR project, the company was primarily focused on developing product-based innovations.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
38. At the time of the SBIR project, the company was primarily focused on developing process-based innovations	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
39. At the time of the SBIR project, the company did not focus on a particular type of innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
The degree to which the SBIR project received support from NASA personnel					
40. An individual with technical authority provided sustained support that facilitated progress of the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
41. An individual with fiscal authority provided sustained support that facilitated progress of the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
42. During the SBIR project, no active support was provided by any individual within NASA.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
The ability of your company to predict the market/customer demand for the innovation					
43. The company flexibly responded to customer priority changes.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
44. The company researched demand for the innovation before the start of the project.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
45. At the conclusion of the Phase II project, the predicted demand for the innovation was realized.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The degree your SBIR project team shared decision making responsibility with your customer					
46. The customer provided input for project decisions.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
47. Customer input was included in project decisions.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
48. The customer was notified if inputs were included in project decisions.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
The level of maturity the innovation achieved through the SBIR project					
49. Based on completion of the Phase II project, the innovation's maturity was:	An analytical or experimental proof of concept ☐	A breadboard in a laboratory environment ☐	A breadboard in a relevant environment ☐	A prototype ☐	Fully operational ☐
50. At the conclusion of the SBIR Phase II project, the innovation worked as intended.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
51. The innovation required additional research and development at the conclusion of the SBIR Phase II project.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

With respect to the SBIR project identified above, please indicate your level of agreement by selecting the appropriate button:

The level your SBIR project team's performance					
1. This group understood how to accomplish its tasks	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
2. This group met all objectives for work completed	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
3. This group's work was always of the highest quality	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
4. This group took initiative in solving problems and decision making	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
5. This group was very good at planning how to accomplish their work objectives	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
6. This work group should continue working together as a unit in the future	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
7. This group was not capable of working together as a unit	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
8. As a work unit, this group showed signs of falling apart	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

Phase III project description: _____

For each item, select the best answer that describes your project/innovation.

Communication quality between the company's SBIR project team and your Phase III customer					
1. Project members' communication built the customer's confidence in the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
2. Project members sought feedback from their customer.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
3. Project members developed a trusting relationship with their customer.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
The degree to which your Phase III customer's needs were met					
4. The project members understood customer requirements.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
5. The technology solved the customer's problem.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
6. Project members understood how the customer intended to use the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
Providing your Phase III customer with a preview of the technology's capabilities					
7. A demonstration was conducted for the customer to exhibit the innovation's benefits.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
8. The innovation was presented to show it performed as required.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
9. The customer received a hands-on preview of the innovation's capabilities.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

Your company's ability to manage personnel resources for the SBIR project					
10. Workers were available for assignment to the project when needed.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
11. Personnel were assigned to other projects when their services were no longer needed.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
12. Multi-disciplined workers were valued more than single-discipline workers.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
The depth of the innovation's verification program to substantiate performance					
13. The highest level of testing the innovation received is best described by:	Did not test or achieve at least a breadboard maturity ☐	Breadboard testing in a laboratory environment ☐	Breadboard testing in a relevant environment ☐	Testing in a relevant environment ☐	Testing in its operational environment ☐
14. Analytical predictions were followed up with empirical testing.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
15. The innovation's verification methodology followed a build-up approach (i.e., component > assembly > subsystem > system).	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
Understanding the intended application of the innovation once the SBIR project was complete					
16. The project members developed a plan for Phase III at project's inception.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
17. The project members understood the intended market for the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
18. Project members gathered marketing data prior to beginning of Phase III.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The SBIR project's performance against stated key performance parameters					
19. Your company delivered the innovation within schedule constraints.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
20. Your company delivered the innovation within budget constraints.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
21. The innovation met key technical performance measures.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
Funding requirements beyond the completion of the SBIR project to bridge funding gaps					
22. The project required additional funding, beyond the SBIR Phase II project funding, to mature the innovation for use by a customer.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
23. The project received internal research and development funds to bridge any pre-Phase III funding gaps.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
24. The project received external funding to bridge any pre-Phase III funding gaps.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
The degree of marketing activity for the innovation					
25. The project members developed business contacts during the SBIR project for future sales opportunities.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
26. The innovation's benefits were advertised to potential customers.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
27. A marketing plan was developed describing how the innovation would be introduced into its intended market.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The innovation's alignment with the company's business strategy					
28. The innovation developed from the SBIR project supported the goals of the company.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
29. The innovation was intended for:	Solely the Federal government ☐	Mostly the Federal government ☐	Federal government and commercial market ☐	Mostly the commercial market ☐	Solely the commercial market ☐
30. At the time of the this SBIR project, the company's business strategy was focused on:	Solely the Federal government ☐	Mostly the Federal government ☐	Federal government and commercial market ☐	Mostly the commercial market ☐	Solely the commercial market ☐
The degree of your company's management support for the SBIR project/innovation					
31. Top management believed the SBIR project should provide a revenue stream for the company.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
32. Top management's desire was to increase the maturity of the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
33. Top management's goal was to achieve sale to a customer from the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
The degree of integration the SBIR project had with your customer's planning					
34. SBIR project milestones were incorporated into customer planning.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
35. The SBIR project was integrated into customer's funding cycle.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
36. The SBIR project was integrated into customer's schedule.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The type of development your company primarily pursued – product or process					
37. At the time of the SBIR project, the company was primarily focused on developing product-based innovations.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
38. At the time of the SBIR project, the company was primarily focused on developing process-based innovations	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
39. At the time of the SBIR project, the company did not focus on a particular type of innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
The degree to which the SBIR project received support from your Phase III customer					
40. An individual with technical authority provided sustained support that facilitated progress of the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
41. An individual with fiscal authority provided sustained support that facilitated progress of the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
42. During the SBIR project, no active support was provided by any individual within your Phase III customer.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
The ability of your company to predict the market/customer demand for the innovation					
43. The company flexibly responded to customer priority changes.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
44. The company researched demand for the innovation before the start of the project.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
45. At the time the Phase II was achieved, the predicted demand for the innovation was realized.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The degree your SBIR project team shared decision making responsibility with your customer					
46. The customer provided input for project decisions.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
47. Customer input was included in project decisions.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
48. The customer was notified if inputs were included in project decisions.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
The level of maturity the innovation achieved through the SBIR project					
49. Based on achieving the Phase III, the innovation's maturity was:	An analytical or experimental proof of concept ☐	A breadboard in a laboratory environment ☐	A breadboard in a relevant environment ☐	A prototype ☐	Fully operational ☐
50. At the time the Phase III was achieved, the innovation worked as intended.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
51. The innovation required additional research and development at the conclusion of the SBIR Phase II project.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

With respect to the SBIR project identified above, please indicate your level of agreement by selecting the appropriate button:

The level your SBIR project team's performance					
1. This group understood how to accomplish its tasks	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
2. This group met all objectives for work completed	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
3. This group's work was always of the highest quality	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
4. This group took initiative in solving problems and decision making	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
5. This group was very good at planning how to accomplish their work objectives	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
6. This work group should continue working together as a unit in the future	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
7. This group was not capable of working together as a unit	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
8. As a work unit, this group showed signs of falling apart	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

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Michael P.J. Benfield
158 Stone Meadow Lane
Madison, AL 35758

Mike,

The purpose of this letter is to formally state that you and your entire department may use any of the performance measures used in the Auburn BET project. Also, since the measures are published (in-press) they are considered public domain and available for public use.

If you have any questions please do not hesitate to contact me.

Sincerely,
Terry Hamhill

(724) 334-6715

APPENDIX F

PILOT STUDY DATA AND ANALYSIS

Objectives for the pilot study analysis were to determine whether the descriptor statements were truly associated with their Initial Candidate-CSFs and to eliminate multi-CSF dependent descriptor statements. The completed questionnaires from the pilot study were six responses for Phase II "did not achieve" and five responses for Phase II "achieved". The raw data collected from the pilot study is shown in Table F.1. With the extremely small data set the samples-to-variables ratio could not be met, so Factor Analysis could not be utilized (Laurence 1995). Therefore, an alternative method was selected to evaluate strength of relationship between descriptor statements (variables). Goldstein (1982) presented a process to analyze multivariate data sets by direct inspection. The process allowed clustering data through visual means by creating categories based on quartiles or some other distinction. The data could then be sorted and grouped by category. For the pilot analysis, correlation strength was used as the discriminator. Table F.2 presents correlation strength criteria to discriminate variable correlations, based on definitions provided by Jaisingh (2006) and Johnston (2000). A correlation matrix was developed for the data from each questionnaire (using JMP®

8.0.2). The Phase II "did not achieve" correlation matrix is shown in Table F.3 and the Phase II "achieved" correlation matrix is shown in Table F.4.

For the Phase II "did not achieve" data set, an iterative pair-wise comparison was conducted for each descriptor statement. Descriptor statements with strong correlations were grouped together. Then, descriptor statements strongly correlated in more than one group were eliminated because their information was contained in other unique groups. Eleven Phase II descriptor statements were eliminated using this method. This process was repeated for the Phase II "achieved" data set and one descriptor statement was eliminated. The Phase II "did not achieve" and Phase II "achieved" descriptor statement lists were then aligned to enable a one-to-one comparison of Phase II "did not achieve" and Phase II "achieved" descriptor statements. The eliminated descriptor statements are shown in Table F.5.

The descriptor statement analysis eliminated Initial Candidate-CSF 12 ("The degree of integration the SBIR project had with your customer's planning") because all three associated descriptor statements were eliminated. Additionally, Initial Candidate-CSFs 1 and 2 ("Communication quality between the company's SBIR project team and your NASA customer" and "The degree to which your NASA customer's needs were met") were grouped together and Initial Candidate-CSFs 3 and 5 ("Providing your NASA customer with a preview of the technology's capabilities" and "The depth of the innovation's verification program to substantiate performance") were grouped together. The grouped Initial Candidate -CSF descriptor statements are shown in Table F.6.

The grouped descriptor statements were then reviewed by three NASA SMEs. The SMEs validated the groupings and then analyzed the grouped descriptor statements determine descriptor statement uniqueness. For statements to be merged, all three SMEs had to agree. Only one descriptor statement was reduced using this method. The Initial Candidate-CSF 1 descriptor statement "1. Project members developed a trusting relationship with their customer." was merged with "3. Project members' communication built the customer's confidence in the innovation." The results of the pilot analysis reduced CSFs from eighteen to fifteen and corresponding descriptor statements from fifty-nine to forty-six, as shown in Table F.7.

Table F.1 Pilot Study Raw Data

	Phase II "not successful"					
	SBC 1	SBC 2	SBC 3	SBC 4	SBC 5	SBC 6
Q1	4	4	5	4	5	4
Q2	4	4	5	5	5	3
Q3	4	4	5	4	5	4
Q4	4	4	5	4	5	3
Q5	4	3	5	4	5	4
Q6	3	4	5	4	5	2
Q7	5	4	5	4	4	2
Q8	5	4	5	4	5	2
Q9	5	4	5	4	3	2
Q10	5	4	5	4	4	4
Q11	5	3	5	4	4	4
Q12	2	3	5	5	4	5
Q13	3	2	4	4	4	3
Q14	4	4	4	4	3	3
Q15	3	4	4	4	3	2
Q16	4	3	4	4	1	2
Q17	4	4	5	4	3	3
Q18	4	3	5	4	1	4
Q19	5	2	5	4	4	4
Q20	5	4	5	4	4	4
Q21	5	4	5	4	4	3
Q22	4	2	5	4	1	2
Q23	4	2	1	4	4	2
Q24	4	2	1	4	1	2
Q25	5	3	5	4	1	3
Q26	4	3	5	4	4	4
Q27	4	3	2	4	4	4
Q28	5	4	5	4	4	4
Q29	3	2	3	3	2	2
Q30	3	2	3	3	3	2
Q31	4	4	5	4	4	4
Q32	5	4	5	5	4	4
Q33	5	4	5	5	5	3
Q34	5	4	5	4	3	2
Q35	5	2	5	4	3	2
Q36	5	2	5	4	3	2
Q37	4	4	5	4	5	2
Q38	2	2	2	3	5	2
Q39	2	2	1	4	1	4
Q40	4	3	4	3	4	4
Q41	3	3	3	4	3	3
Q42	2	3	2	2	1	2
Q43	4	4	5	4	3	3
Q44	5	4	5	4	4	4
Q45	4	3	2	3	4	4
Q46	4	4	5	4	3	3
Q47	4	4	5	4	3	3
Q48	4	4	5	4	3	3
Q49	4	2	4	4	2	3
Q50	5	3	5	4	4	3
Q51	4	4	5	4	4	4
Q1	5	4	5	4	4	4
Q2	5	3	5	4	4	4
Q3	5	4	5	4	4	4
Q4	5	4	5	4	4	4
Q5	5	3	5	4	4	4
Q6	5	4	5	3	4	3
Q7	1	1	1	2	2	2
Q8	1	1	1	2	1	1

	Phase II "successful"				
	SBC 1	SBC 2	SBC 3	SBC 4	SBC 5
Q1	5	5	5	5	5
Q2	5	5	5	5	4
Q3	5	5	5	5	5
Q4	5	5	5	5	4
Q5	5	4	5	4	5
Q6	5	5	5	5	4
Q7	5	5	5	4	4
Q8	5	5	5	4	5
Q9	5	5	5	4	4
Q10	5	4	5	4	4
Q11	5	3	5	4	4
Q12	2	3	5	4	5
Q13	4	3	4	2	4
Q14	4	5	4	4	5
Q15	4	5	5	3	5
Q16	4	4	5	2	4
Q17	4	5	5	4	4
Q18	4	4	5	1	3
Q19	5	4	5	4	5
Q20	5	4	5	3	5
Q21	5	4	5	4	4
Q22	4	4	5	2	4
Q23	4	4	1	4	3
Q24	4	4	1	2	3
Q25	5	5	5	3	4
Q26	4	5	5	2	4
Q27	4	5	4	1	3
Q28	5	5	5	5	5
Q29	3	2	3	3	3
Q30	3	2	3	3	4
Q31	5	4	5	4	5
Q32	5	4	5	4	5
Q33	5	5	5	4	5
Q34	5	4	5	3	3
Q35	5	4	5	2	3
Q36	5	4	5	2	3
Q37	4	4	4	4	3
Q38	2	2	2	3	4
Q39	2	2	1	3	2
Q40	5	5	5	2	4
Q41	4	5	5	2	4
Q42	1	1	2	5	2
Q43	4	4	5	3	4
Q44	4	4	5	4	2
Q45	4	4	5	4	3
Q46	5	5	5	3	4
Q47	4	5	5	3	4
Q48	4	5	5	3	4
Q49	4	4	5	2	4
Q50	5	4	5	4	4
Q51	4	4	4	4	4
Q1	5	5	5	4	5
Q2	5	4	5	2	4
Q3	5	5	5	3	4
Q4	5	5	5	4	4
Q5	5	4	5	4	5
Q6	5	5	5	4	4
Q7	1	1	1	1	2
Q8	1	1	1	1	1

Table F.2 Correlation Matrix Criteria

Correlation	Criteria	Marking
Strong (p <= 0.05)	r >= 0.8 and -0.8 =< r	Dark Gray
Medium-Strong	0.8 > r <= 0.4 and -0.4 <= r > -0.8	None
Medium-Weak	0.4 > r < 0.1 and -0.01 < r > -0.4	Text Hidden
Weak	0.1 >= r =< -0.1	Hash

Table F.3 Phase II "did not achieve" Correlation Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1		0.633	1.000	0.858	0.858	0.773		0.552					0.633	
2	0.633		0.633	0.868	0.542	0.908	0.671	0.768	0.489				0.700	
3	1.000	0.633		0.858	0.858	0.773		0.552					0.633	
4	0.858	0.868	0.858		0.647	0.947	0.728	0.871	0.492			0.000	0.542	
5	0.858	0.542	0.858	0.647		0.492		0.417	0.038		0.647	0.420	0.868	
6	0.773	0.908	0.773	0.947	0.492		0.625	0.756	0.415		0.038		0.489	
7		0.671		0.728		0.625		0.937	0.937	0.707	0.485	-0.433		0.707
8	0.552	0.768	0.552	0.871	0.417	0.756	0.937		0.756	0.552	0.417	-0.406		0.442
9		0.489		0.492	0.038	0.415	0.937	0.756		0.773	0.492	-0.406	0.070	0.884
10							0.707	0.552	0.773		0.858			0.500
11					0.647	0.038	0.485	0.417	0.492	0.858		0.000	0.542	
12				0.000	0.420		-0.433	-0.406	-0.406		0.000		0.581	
13	0.633	0.700	0.633	0.542	0.868	0.489			0.070		0.542	0.581		
14							0.707	0.442	0.884	0.500				
15		0.700		0.542		0.698	0.671	0.559	0.698			0.000	0.100	0.791
16				0.000		0.000	0.577		0.812	0.612	0.420		0.000	0.919
17		0.434		0.412	0.059	0.417	0.728	0.492	0.871	0.686	0.412	0.000		0.858
18					-0.096				0.434	0.562	0.482		0.000	0.562
19					0.728	0.000				0.707	0.970		0.671	0.000
20							0.707	0.552	0.773	1.000	0.858			0.500
21		0.542		0.647		0.492	0.970	0.871	0.947	0.858	0.647	-0.420		0.686
22	0.000		0.000				0.589		0.773	0.750	0.686			0.750
23				0.033	0.033	-0.022			-0.022		0.033			-0.097
24	-0.756		-0.756	-0.454	-0.454	-0.459		-0.042		0.095				0.473
25		0.000		-0.088	-0.088		0.482		0.733	0.766	0.613		0.000	0.766
26	0.612		0.612	0.420	0.840					0.612	0.840	0.500	0.775	0.000
27	-0.463		-0.463	-0.476		-0.511	-0.436		-0.511	-0.463			0.000	-0.463
28							0.707	0.552	0.773	1.000	0.858			0.500
29	0.000	0.447	0.000				0.667	0.469	0.781	0.707	0.728	0.000	0.447	0.707
30	0.500	0.791	0.500	0.686	0.686	0.552	0.707	0.773	0.552	0.500	0.686	0.000	0.791	
31	0.633	0.400	0.633	0.542	0.542	0.489	0.447		0.489	0.633	0.542		0.400	
32	0.000	0.447	0.000				0.667	0.469	0.781	0.707	0.728	0.000	0.447	0.707
33	0.463	0.878	0.463	0.794	0.476	0.716	0.873	0.920	0.716	0.463	0.476		0.586	0.463
34		0.489		0.492	0.038	0.415	0.937	0.756	1.000	0.773	0.492	-0.406	0.070	0.884
35		0.533		0.482	0.482		0.795	0.683	0.807	0.843	0.867		0.533	0.562
36		0.533		0.482	0.482		0.795	0.683	0.807	0.843	0.867		0.533	0.562
37	0.707	0.894	0.707	0.970	0.485	0.937	0.833	0.937	0.625				0.447	
38	-0.533	-0.539	-0.533	-0.512	-0.512	-0.518	0.000			0.426			-0.539	0.533
39	-0.756	-0.478	-0.756	-0.843	-0.454	-0.710	-0.668	-0.793	-0.459	-0.473				-0.095
40	0.500		0.500		0.686		0.000			0.500	0.686	0.000		-0.500
41		0.400				0.070	0.000	-0.070	0.070				0.400	
42	0.612		0.612	0.420	0.840		0.000			0.000	0.420		0.775	-0.612
43		0.434		0.412	0.059	0.417	0.728	0.492	0.871	0.686	0.412	0.000		0.858
44							0.707	0.552	0.773	1.000	0.858			0.500
45		-0.500		-0.434		-0.559	-0.447		-0.559					-0.633
46		0.434		0.412	0.059	0.417	0.728	0.492	0.871	0.686	0.412	0.000		0.858
47		0.434		0.412	0.059	0.417	0.728	0.492	0.871	0.686	0.412	0.000		0.858
48		0.434		0.412	0.059	0.417	0.728	0.492	0.871	0.686	0.412	0.000		0.858
49				-0.045					0.551	0.657	0.766		0.415	0.525
50	0.433	0.548	0.433	0.594	0.594		0.817	0.765	0.765	0.866	0.891		0.548	0.433
51	0.633	0.400	0.633	0.542	0.542	0.489	0.447		0.489	0.633	0.542		0.400	
52							0.707	0.552	0.773	1.000	0.858			0.500
53					0.647	0.038	0.485	0.417	0.492	0.858	1.000	0.000	0.542	
54							0.707	0.552	0.773	1.000	0.858			0.500
55							0.707	0.552	0.773	1.000	0.858			0.500
56					0.647	0.038	0.485	0.417	0.492	0.858	1.000	0.000	0.542	
57	0.433		0.433	0.594			0.817	0.765	0.765	0.866	0.594	-0.530	0.000	0.433
58	0.000	0.000	0.000				0.667	0.469	0.781	0.707		-0.577	-0.447	0.707
59		-0.400				-0.070	0.000	0.070	-0.070				-0.400	

Table F.3 Phase II "did not achieve" Correlation Matrix (cont'd)

15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
							0.000		-0.756		0.612	-0.463		0.000
0.700		0.434				0.542				0.000				0.447
							0.000		-0.756		0.612	-0.463		0.000
0.542	0.000	0.412				0.647		0.033	-0.454	-0.088	0.420	-0.476		
		0.059	-0.096	0.728				0.033	-0.454	-0.088	0.840			
0.698	0.000	0.417		0.000		0.492		-0.022	-0.459			-0.511		
0.671	0.577	0.728			0.707	0.970	0.589			0.482		-0.436	0.707	0.667
0.559		0.492			0.552	0.871			-0.042				0.552	0.469
0.698	0.812	0.871	0.434		0.773	0.947	0.773	-0.022		0.733		-0.511	0.773	0.781
	0.612	0.686	0.562	0.707	1.000	0.858	0.750		0.095	0.766	0.612	-0.463	1.000	0.707
	0.420	0.412	0.482	0.970	0.858	0.647	0.686	0.033		0.613	0.840		0.858	0.728
0.000		0.000				-0.420					0.500			0.000
0.100	0.000		0.000	0.671						0.000	0.775	0.000		0.447
0.791	0.919	0.858	0.562	0.000	0.500	0.686	0.750	-0.097	0.473	0.766	0.000	-0.463	0.500	0.707
	0.581	0.759				0.542	0.474		0.060		0.000	-0.586		0.447
0.581		0.840	0.803		0.612	0.630	0.919		0.579	0.938			0.612	0.866
0.759	0.840		0.675		0.686	0.765	0.858	-0.433	0.065	0.788	0.420	-0.794	0.686	0.728
	0.803	0.675			0.562		0.843	-0.491		0.909	0.459	-0.434	0.562	0.662
					0.707	0.485	0.589			0.482	0.866	0.000	0.707	0.667
	0.612	0.686	0.562	0.707		0.858	0.750		0.095	0.766	0.612	-0.463	1.000	0.707
0.542	0.630	0.765		0.485	0.858		0.686	0.033		0.613	0.420	-0.476	0.858	0.728
0.474	0.919	0.858	0.843	0.589	0.750	0.686				0.936	0.612	-0.463	0.750	0.943
		-0.433	-0.491			0.033			0.587			0.809		
0.060	0.579	0.065			0.095			0.587		0.483		0.525	0.095	0.535
	0.938	0.788	0.909	0.482	0.766	0.613	0.936		0.483		0.417		0.766	0.843
0.000		0.420	0.459	0.866	0.612	0.420	0.612			0.417			0.612	0.577
-0.586		-0.794	-0.434	0.000	-0.463	-0.476	-0.463	0.809	0.525				-0.463	
	0.612	0.686	0.562	0.707	1.000	0.858	0.750		0.095	0.766	0.612	-0.463		0.707
0.447	0.866	0.728	0.662	0.667	0.707	0.728	0.943		0.535	0.843	0.577		0.707	
			0.000	0.707	0.500	0.686	0.500	0.486			0.612	0.000	0.500	0.707
0.400		0.759	0.533	0.447	0.633	0.542	0.633	-0.676	-0.478	0.485	0.775	-0.878	0.633	0.447
0.447	0.866	0.728	0.662	0.667	0.707	0.728	0.943		0.535	0.843	0.577		0.707	1.000
0.586		0.476	-0.087	0.436	0.463	0.794	0.463	0.450					0.463	0.655
0.698	0.812	0.871	0.434		0.773	0.947	0.773	-0.022		0.733		-0.511	0.773	0.781
	0.688	0.675	0.474	0.795	0.843	0.867	0.843			0.718	0.688		0.843	0.927
	0.688	0.675	0.474	0.795	0.843	0.867	0.843			0.718	0.688		0.843	0.927
0.671		0.485				0.728				0.000		-0.436		
0.067	0.653	0.512	0.839	0.000	0.426		0.533	-0.580		0.762	0.000		0.426	
					-0.473	-0.648	0.000		0.571	0.097		0.525	-0.473	0.000
-0.633			0.000	0.707	0.500		0.000	-0.097		0.000	0.612	0.000	0.500	0.000
0.400				0.000				0.430	0.598		0.000			0.447
	-0.500	-0.420	-0.459	0.577	0.000	0.000		0.476		-0.417	0.500		0.000	0.000
0.759	0.840	1.000	0.675		0.686	0.765	0.858	-0.433	0.065	0.788	0.420	-0.794	0.686	0.728
	0.612	0.686	0.562	0.707	1.000	0.858	0.750		0.095	0.766	0.612	-0.463	1.000	0.707
-0.800	-0.581	-0.868	-0.533	0.000		-0.434	-0.633	0.614		-0.485		0.878		-0.447
0.759	0.840	1.000	0.675		0.686	0.765	0.858	-0.433	0.065	0.788	0.420	-0.794	0.686	0.728
0.759	0.840	1.000	0.675		0.686	0.765	0.858	-0.433	0.065	0.788	0.420	-0.794	0.686	0.728
0.759	0.840	1.000	0.675		0.686	0.765	0.858	-0.433	0.065	0.788	0.420	-0.794	0.686	0.728
	0.804	0.586	0.812	0.743	0.657	0.495	0.919	0.026	0.546	0.872	0.643		0.657	0.929
	0.530	0.594		0.817	0.866	0.891	0.722			0.590	0.707		0.866	0.817
0.400		0.759	0.533	0.447	0.633	0.542	0.633	-0.676	-0.478	0.485	0.775	-0.878	0.633	0.447
	0.612	0.686	0.562	0.707	1.000	0.858	0.750		0.095	0.766	0.612	-0.463	1.000	0.707
	0.420	0.412	0.482	0.970	0.858	0.647	0.686	0.033		0.613	0.840		0.858	0.728
	0.612	0.686	0.562	0.707	1.000	0.858	0.750		0.095	0.766	0.612	-0.463	1.000	0.707
	0.612	0.686	0.562	0.707	1.000	0.858	0.750		0.095	0.766	0.612	-0.463	1.000	0.707
	0.420	0.412	0.482	0.970	0.858	0.647	0.686	0.033		0.613	0.840		0.858	0.728
		0.594		0.408	0.866	0.891	0.433			0.442		-0.535	0.866	0.408
0.447	0.577	0.728		0.000	0.707	0.728	0.471	-0.412	0.000	0.602	0.000	-0.655	0.707	
-0.400				0.000				-0.430	-0.598		0.000			-0.447

Table F.3 Phase II "did not achieve" Correlation Matrix (cont'd)

30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
0.500	0.633	0.000	0.463				0.707	-0.533	-0.756	0.500		0.612		
0.791	0.400	0.447	0.878	0.489	0.533	0.533	0.894	-0.539	-0.478		0.400		0.434	
0.500	0.633	0.000	0.463				0.707	-0.533	-0.756	0.500		0.612		
0.686	0.542		0.794	0.492	0.482	0.482	0.970	-0.512	-0.843			0.420	0.412	
0.686	0.542		0.476	0.038	0.482	0.482	0.485	-0.512	-0.454	0.686		0.840	0.059	
0.552	0.489		0.716	0.415			0.937	-0.518	-0.710		0.070		0.417	
0.707	0.447	0.667	0.873	0.937	0.795	0.795	0.833	0.000	-0.668	0.000	0.000	0.000	0.728	0.707
0.773		0.469	0.920	0.756	0.683	0.683	0.937		-0.793		-0.070		0.492	0.552
0.552	0.489	0.781	0.716	1.000	0.807	0.807	0.625		-0.459		0.070		0.871	0.773
0.500	0.633	0.707	0.463	0.773	0.843	0.843		0.426	-0.473	0.500		0.000	0.686	1.000
0.686	0.542	0.728	0.476	0.492	0.867	0.867				0.686		0.420	0.412	0.858
0.000		0.000		-0.406						0.000			0.000	
0.791	0.400	0.447	0.586	0.070	0.533	0.533	0.447	-0.539			0.400	0.775		
		0.707	0.463	0.884	0.562	0.562		0.533	-0.095	-0.500		-0.612	0.858	0.500
	0.400	0.447	0.586	0.698			0.671	0.067		-0.633	0.400		0.759	
		0.866		0.812	0.688	0.688		0.653				-0.500	0.840	0.612
	0.759	0.728	0.476	0.871	0.675	0.675	0.485	0.512				-0.420	1.000	0.686
0.000	0.533	0.662	-0.087	0.434	0.474	0.474		0.839		0.000		-0.459	0.675	0.562
0.707	0.447	0.667	0.436		0.795	0.795		0.000		0.707	0.000	0.577		0.707
0.500	0.633	0.707	0.463	0.773	0.843	0.843		0.426	-0.473	0.500		0.000	0.686	1.000
0.686	0.542	0.728	0.794	0.947	0.867	0.867	0.728		-0.648			0.000	0.765	0.858
0.500	0.633	0.943	0.463	0.773	0.843	0.843		0.533	0.000	0.000			0.858	0.750
0.486	-0.676		0.450	-0.022				-0.580		-0.097	0.430	0.476	-0.433	
	-0.478	0.535							0.571		0.598		0.065	0.095
	0.485	0.843		0.733	0.718	0.718	0.000	0.762	0.097	0.000		-0.417	0.788	0.766
0.612	0.775	0.577			0.688	0.688		0.000		0.612	0.000	0.500	0.420	0.612
0.000	-0.878			-0.511			-0.436		0.525	0.000			-0.794	-0.463
0.500	0.633	0.707	0.463	0.773	0.843	0.843		0.426	-0.473	0.500		0.000	0.686	1.000
0.707	0.447	1.000	0.655	0.781	0.927	0.927			0.000	0.000	0.447	0.000	0.728	0.707
		0.707	0.926	0.552	0.843	0.843	0.707	-0.426				0.612		0.500
		0.447		0.489	0.533	0.533	0.447		-0.478			0.000	0.759	0.633
0.707	0.447		0.655	0.781	0.927	0.927			0.000	0.000	0.447	0.000	0.728	0.707
0.926		0.655		0.716	0.780	0.780	0.873		-0.525	0.000			0.476	0.463
0.552	0.489	0.781	0.716		0.807	0.807	0.625		-0.459		0.070		0.871	0.773
0.843	0.533	0.927	0.780	0.807		1.000	0.530						0.675	0.843
0.843	0.533	0.927	0.780	0.807	1.000		0.530						0.675	0.843
0.707	0.447		0.873	0.625	0.530	0.530		-0.452	-0.802	0.000	0.000		0.485	
-0.426							-0.452					-0.783	0.512	0.426
	-0.478	0.000	-0.525	-0.459			-0.802				0.598			-0.473
		0.000	0.000				0.000				-0.633	0.612		0.500
		0.447		0.070			0.000		0.598	-0.633		0.000		
0.612	0.000	0.000						-0.783		0.612	0.000		-0.420	0.000
	0.759	0.728	0.476	0.871	0.675	0.675	0.485	0.512				-0.420		0.686
0.500	0.633	0.707	0.463	0.773	0.843	0.843		0.426	-0.473	0.500		0.000	0.686	
	-0.800	-0.447		-0.559			-0.447						-0.868	
	0.759	0.728	0.476	0.871	0.675	0.675	0.485	0.512				-0.420	1.000	0.686
	0.759	0.728	0.476	0.871	0.675	0.675	0.485	0.512				-0.420	1.000	0.686
	0.759	0.728	0.476	0.871	0.675	0.675	0.485	0.512				-0.420	1.000	0.686
0.525	0.415	0.929		0.551	0.812	0.812	0.000	0.448			0.415	0.000	0.586	0.657
0.866	0.548	0.817	0.802	0.765	0.973	0.973	0.612	0.000	-0.491	0.433	0.000		0.594	0.866
	1.000	0.447		0.489	0.533	0.533	0.447		-0.478			0.000	0.759	0.633
0.500	0.633	0.707	0.463	0.773	0.843	0.843		0.426	-0.473	0.500		0.000	0.686	1.000
0.686	0.542	0.728	0.476	0.492	0.867	0.867				0.686		0.420	0.412	0.858
0.500	0.633	0.707	0.463	0.773	0.843	0.843		0.426	-0.473	0.500		0.000	0.686	1.000
0.500	0.633	0.707	0.463	0.773	0.843	0.843		0.426	-0.473	0.500		0.000	0.686	1.000
0.686	0.542	0.728	0.476	0.492	0.867	0.867				0.686		0.420	0.412	0.858
0.433	0.548	0.408	0.535	0.765	0.649	0.649	0.612		-0.818	0.433	-0.548	0.000	0.594	0.866
0.000	0.447			0.781				0.603	-0.535	0.000	-0.447	-0.577	0.728	0.707
		-0.447		-0.070			0.000		-0.598	0.633	-1.000	0.000		

Table F.3 Phase II "did not achieve" Correlation Matrix (cont'd)

45	46	47	48	49	50	51	52	53	54	55	56	57	58	59
					0.433	0.633						0.433	0.000	
-0.500	0.434	0.434	0.434		0.548	0.400							0.000	-0.400
					0.433	0.633						0.433	0.000	
-0.434	0.412	0.412	0.412	-0.045	0.594	0.542						0.594		
	0.059	0.059	0.059		0.594	0.542		0.647			0.647			
-0.559	0.417	0.417	0.417			0.489		0.038			0.038			-0.070
-0.447	0.728	0.728	0.728		0.817	0.447	0.707	0.485	0.707	0.707	0.485	0.817	0.667	0.000
	0.492	0.492	0.492		0.765		0.552	0.417	0.552	0.552	0.417	0.765	0.469	0.070
-0.559	0.871	0.871	0.871	0.551	0.765	0.489	0.773	0.492	0.773	0.773	0.492	0.765	0.781	-0.070
	0.686	0.686	0.686	0.657	0.866	0.633	1.000	0.858	1.000	1.000	0.858	0.866	0.707	
	0.412	0.412	0.412	0.766	0.891	0.542	0.858	1.000	0.858	0.858	1.000	0.594		
	0.000	0.000	0.000					0.000			0.000	-0.530	-0.577	
				0.415	0.548	0.400		0.542			0.542	0.000	-0.447	-0.400
-0.633	0.858	0.858	0.858	0.525	0.433		0.500		0.500	0.500		0.433	0.707	
-0.800	0.759	0.759	0.759			0.400							0.447	-0.400
-0.581	0.840	0.840	0.840	0.804	0.530		0.612	0.420	0.612	0.612	0.420		0.577	
-0.868	1.000	1.000	1.000	0.586	0.594	0.759	0.686	0.412	0.686	0.686	0.412	0.594	0.728	
-0.533	0.675	0.675	0.675	0.812		0.533	0.562	0.482	0.562	0.562	0.482			
0.000				0.743	0.817	0.447	0.707	0.970	0.707	0.707	0.970	0.408	0.000	0.000
	0.686	0.686	0.686	0.657	0.866	0.633	1.000	0.858	1.000	1.000	0.858	0.866	0.707	
-0.434	0.765	0.765	0.765	0.495	0.891	0.542	0.858	0.647	0.858	0.858	0.647	0.891	0.728	
-0.633	0.858	0.858	0.858	0.919	0.722	0.633	0.750	0.686	0.750	0.750	0.686	0.433	0.471	
0.614	-0.433	-0.433	-0.433	0.026		-0.676		0.033			0.033		-0.412	-0.430
	0.065	0.065	0.065	0.546		-0.478	0.095		0.095	0.095			0.000	-0.598
-0.485	0.788	0.788	0.788	0.872	0.590	0.485	0.766	0.613	0.766	0.766	0.613	0.442	0.602	
	0.420	0.420	0.420	0.643	0.707	0.775	0.612	0.840	0.612	0.612	0.840		0.000	0.000
0.878	-0.794	-0.794	-0.794			-0.878	-0.463		-0.463	-0.463		-0.535	-0.655	
	0.686	0.686	0.686	0.657	0.866	0.633	1.000	0.858	1.000	1.000	0.858	0.866	0.707	
-0.447	0.728	0.728	0.728	0.929	0.817	0.447	0.707	0.728	0.707	0.707	0.728	0.408		-0.447
				0.525	0.866		0.500	0.686	0.500	0.500	0.686	0.433	0.000	
-0.800	0.759	0.759	0.759	0.415	0.548	1.000	0.633	0.542	0.633	0.633	0.542	0.548	0.447	
-0.447	0.728	0.728	0.728	0.929	0.817	0.447	0.707	0.728	0.707	0.707	0.728	0.408		-0.447
	0.476	0.476	0.476		0.802		0.463	0.476	0.463	0.463	0.476	0.535		
-0.559	0.871	0.871	0.871	0.551	0.765	0.489	0.773	0.492	0.773	0.773	0.492	0.765	0.781	-0.070
	0.675	0.675	0.675	0.812	0.973	0.533	0.843	0.867	0.843	0.843	0.867	0.649		
	0.675	0.675	0.675	0.812	0.973	0.533	0.843	0.867	0.843	0.843	0.867	0.649		
-0.447	0.485	0.485	0.485	0.000	0.612	0.447						0.612		0.000
	0.512	0.512	0.512	0.448	0.000		0.426		0.426	0.426			0.603	
					-0.491	-0.478	-0.473		-0.473	-0.473		-0.818	-0.535	-0.598
					0.433		0.500	0.686	0.500	0.500	0.686	0.433	0.000	0.633
				0.415	0.000							-0.548	-0.447	-1.000
	-0.420	-0.420	-0.420	0.000		0.000	0.000	0.420	0.000	0.000	0.420	0.000	-0.577	0.000
-0.868	1.000	1.000	1.000	0.586	0.594	0.759	0.686	0.412	0.686	0.686	0.412	0.594	0.728	
	0.686	0.686	0.686	0.657	0.866	0.633	1.000	0.858	1.000	1.000	0.858	0.866	0.707	
	-0.868	-0.868	-0.868			-0.800							-0.447	
-0.868		1.000	1.000	0.586	0.594	0.759	0.686	0.412	0.686	0.686	0.412	0.594	0.728	
-0.868	1.000		1.000	0.586	0.594	0.759	0.686	0.412	0.686	0.686	0.412	0.594	0.728	
-0.868	1.000	1.000		0.586	0.594	0.759	0.686	0.412	0.686	0.686	0.412	0.594	0.728	
	0.586	0.586	0.586		0.682	0.415	0.657	0.766	0.657	0.657	0.766			-0.415
	0.594	0.594	0.594	0.682		0.548	0.866	0.891	0.866	0.866	0.891	0.750	0.408	0.000
-0.800	0.759	0.759	0.759	0.415	0.548		0.633	0.542	0.633	0.633	0.542	0.548	0.447	
	0.686	0.686	0.686	0.657	0.866	0.633		0.858	1.000	1.000	0.858	0.866	0.707	
	0.412	0.412	0.412	0.766	0.891	0.542	0.858		0.858	0.858	1.000	0.594		
	0.686	0.686	0.686	0.657	0.866	0.633	1.000	0.858		1.000	0.858	0.866	0.707	
	0.686	0.686	0.686	0.657	0.866	0.633	1.000	0.858	1.000		0.858	0.866	0.707	
	0.412	0.412	0.412	0.766	0.891	0.542	0.858	1.000	0.858	0.858		0.594		
	0.594	0.594	0.594		0.750	0.548	0.866	0.594	0.866	0.866	0.594		0.817	0.548
-0.447	0.728	0.728	0.728		0.408	0.447	0.707		0.707	0.707		0.817		0.447
				-0.415	0.000							0.548	0.447	

Table F.4 Phase II "achieved" Correlation Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1		.	.	.	.	.	.	.	.	.	.	.	.	.
2	.		.	1.000	-0.408	1.000	0.612		0.612	0.408		-0.515		-0.612
3	.	.		.	.	.	.	.	.	.	.	.	.	.
4	.	1.000	.		-0.408	1.000	0.612		0.612	0.408		-0.515		-0.612
5	.	-0.408	.	-0.408		-0.408		0.612		0.667	0.764		0.919	
6	.	1.000	.	1.000	-0.408		0.612		0.612	0.408		-0.515		-0.612
7	.	0.612	.	0.612		0.612		0.612	1.000	0.667		-0.490	0.408	
8	.		.		0.612		0.612		0.612	0.408		-0.086	0.875	0.408
9	.	0.612	.	0.612		0.612	1.000	0.612		0.667		-0.490	0.408	
10	.	0.408	.	0.408	0.667	0.408	0.667	0.408	0.667		0.873		0.612	-0.667
11	.		.		0.764					0.873		0.046	0.535	-0.764
12	.	-0.515	.	-0.515		-0.515	-0.490	-0.086	-0.490		0.046		0.086	
13	.		.		0.919		0.408	0.875	0.408	0.612	0.535	0.086		
14	.	-0.612	.	-0.612		-0.612		0.408		-0.667	-0.764			
15	.		.		0.408		0.408	0.875	0.408				0.688	0.612
16	.		.		0.667		0.667	0.919	0.667	0.583			0.868	
17	.	0.408	.	0.408		0.408	0.667	0.408	0.667					
18	.		.		0.542		0.843	0.885	0.843	0.662		-0.076	0.774	0.060
19	.	-0.408	.	-0.408	1.000	-0.408		0.612		0.667	0.764		0.919	
20	.		.		0.919		0.408	0.875	0.408	0.612	0.535	0.086	1.000	
21	.	0.408	.	0.408	0.667	0.408	0.667	0.408	0.667	1.000	0.873		0.612	-0.667
22	.		.		0.667		0.667	0.919	0.667	0.583			0.868	
23	.	0.086	.	0.086	-0.560	0.086				-0.490	-0.504	-0.706	-0.515	
24	.	-0.086	.	-0.086		-0.086					-0.413	-0.765	0.086	0.490
25	.		.		0.408		0.919	0.875	0.919	0.612			0.688	
26	.	0.000	.	0.000		0.000	0.745	0.913	0.745		0.000	0.000	0.685	
27	.		.				0.843	0.885	0.843		-0.079		0.590	
28	.	.	.	.	.	.	.	.	.	.	.	.	.	.
29	.		.		0.612		-0.408		-0.408	0.408	0.802			-0.612
30	.	-0.791	.	-0.791	0.646	-0.791	-0.646	0.000	-0.646	0.000	0.423	0.542		0.000
31	.	-0.408	.	-0.408	1.000	-0.408		0.612		0.667	0.764		0.919	
32	.	-0.408	.	-0.408	1.000	-0.408		0.612		0.667	0.764		0.919	
33	.		.		0.612		0.612	1.000	0.612	0.408		-0.086	0.875	0.408
34	.	0.559	.	0.559	0.456	0.559	0.913	0.559	0.913	0.913	0.598		0.559	-0.456
35	.		.		0.560		0.910	0.772	0.910	0.840	0.504		0.729	
36	.		.		0.560		0.910	0.772	0.910	0.840	0.504		0.729	
37	.	1.000	.	1.000	-0.408	1.000	0.612		0.612	0.408		-0.515		-0.612
38	.	0.875	.	0.875		0.875	0.919		0.919	0.612		-0.557	0.063	-0.408
39	.	0.000	.	0.000	-0.646	0.000	-0.646	-0.791	-0.646	-0.646	-0.423		-0.791	0.000
40	.	0.086	.	0.086	0.490	0.086	0.840	0.943	0.840	0.560			0.772	
41	.	0.000	.	0.000		0.000	0.745	0.913	0.745		0.000	0.000	0.685	
42	.	-0.068	.	-0.068	0.444	-0.068	0.722	0.953	0.722		0.036		0.749	
43	.	0.000	.	0.000	0.646	0.000	0.646	0.791	0.646	0.646	0.423		0.791	0.000
44	.	0.919	.	0.919		0.919	0.667		0.667	0.583				-0.667
45	.	0.791	.	0.791	0.000	0.791	0.646	0.000	0.646	0.646	0.423	0.000	0.000	-0.646
46	.		.		0.408		0.919	0.875	0.919	0.612			0.688	
47	.		.				0.764	0.802	0.764		-0.071	0.046	0.535	
48	.		.				0.764	0.802	0.764		-0.071	0.046	0.535	
49	.		.		0.667		0.667	0.919	0.667	0.583			0.868	
50	.	0.408	.	0.408	0.667	0.408	0.667	0.408	0.667	1.000	0.873		0.612	-0.667
51	.	.	.	.	.	.	.	.	.	.	.	.	.	.
52	.		.		0.612		0.612	1.000	0.612	0.408		-0.086	0.875	0.408
53	.	0.000	.	0.000	0.745	0.000	0.745	0.913	0.745	0.745	0.488		0.913	0.000
54	.		.		0.408		0.919	0.875	0.919	0.612			0.688	
55	.	0.612	.	0.612		0.612	1.000	0.612	1.000	0.667		-0.490	0.408	
56	.	-0.408	.	-0.408	1.000	-0.408		0.612		0.667	0.764		0.919	
57	.	0.612	.	0.612		0.612	1.000	0.612	1.000	0.667		-0.490	0.408	
58	.	1.000	.	1.000	-0.408	1.000	0.612		0.612	0.408		-0.515		-0.612
59	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table F.4 Phase II "achieved" Correlation Matrix (cont'd)

15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		0.408		-0.408		0.408		0.086	-0.086		0.000		.	
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		0.408		-0.408		0.408		0.086	-0.086		0.000		.	
0.408	0.667		0.542	1.000	0.919	0.667	0.667	-0.560		0.408			.	0.612
		0.408		-0.408		0.408		0.086	-0.086		0.000		.	
0.408	0.667	0.667	0.843		0.408	0.667	0.667			0.919	0.745	0.843	.	-0.408
0.875	0.919	0.408	0.885	0.612	0.875	0.408	0.919			0.875	0.913	0.885	.	
0.408	0.667	0.667	0.843		0.408	0.667	0.667			0.919	0.745	0.843	.	-0.408
	0.583		0.662	0.667	0.612	1.000	0.583	-0.490		0.612			.	0.408
				0.764	0.535	0.873		-0.504	-0.413		0.000	-0.079	.	0.802
			-0.076		0.086			-0.706	-0.765		0.000		.	
0.688	0.868		0.774	0.919	1.000	0.612	0.868	-0.515	0.086	0.688	0.685	0.590	.	
0.612			0.060			-0.667			0.490				.	-0.612
	0.868	0.612	0.774	0.408	0.688		0.868	-0.515	0.086	0.688	0.913	0.774	.	
0.868		0.583	0.963	0.667	0.868	0.583	1.000	-0.665	-0.035	0.868	0.932	0.813	.	
0.612	0.583		0.662				0.583	-0.490		0.612	0.745	0.662	.	-0.612
0.774	0.963	0.662		0.542	0.774	0.662	0.963	-0.556	0.051	0.958	0.942	0.891	.	
0.408	0.667		0.542		0.919	0.667	0.667	-0.560		0.408			.	0.612
0.688	0.868		0.774	0.919		0.612	0.868	-0.515	0.086	0.688	0.685	0.590	.	
	0.583		0.662	0.667	0.612		0.583	-0.490		0.612			.	0.408
0.868	1.000	0.583	0.963	0.667	0.868	0.583		-0.665	-0.035	0.868	0.932	0.813	.	
-0.515	-0.665	-0.490	-0.556	-0.560	-0.515	-0.490	-0.665		0.765		-0.470		.	
0.086	-0.035		0.051		0.086		-0.035	0.765				0.430	.	-0.515
0.688	0.868	0.612	0.958	0.408	0.688	0.612	0.868				0.913	0.958	.	
0.913	0.932	0.745	0.942		0.685		0.932	-0.470		0.913		0.942	.	-0.456
0.774	0.813	0.662	0.891		0.590		0.813		0.430	0.958	0.942		.	-0.590
.	.	.	.	.	.	.	.	.	.	.	.	.		.
		-0.612		0.612		0.408			-0.515		-0.456	-0.590	.	
0.000	0.000	-0.646		0.646		0.000	0.000					-0.466	.	0.791
0.408	0.667		0.542	1.000	0.919	0.667	0.667	-0.560		0.408			.	0.612
0.408	0.667		0.542	1.000	0.919	0.667	0.667	-0.560		0.408			.	0.612
0.875	0.919	0.408	0.885	0.612	0.875	0.408	0.919			0.875	0.913	0.885	.	
	0.685	0.456	0.824	0.456	0.559	0.913	0.685		0.000	0.839	0.612	0.659	.	0.000
0.515	0.840	0.490	0.936	0.560	0.729	0.840	0.840	-0.412		0.943	0.783	0.809	.	-0.086
0.515	0.840	0.490	0.936	0.560	0.729	0.840	0.840	-0.412		0.943	0.783	0.809	.	-0.086
		0.408		-0.408		0.408		0.086	-0.086		0.000		.	
0.063		0.612	0.590		0.063	0.612		-0.086	0.086	0.688	0.456	0.590	.	
-0.791	-0.968	-0.646	-0.933	-0.646	-0.791	-0.646	-0.968	0.814		-0.791	-0.866	-0.699	.	0.000
0.772	0.910	0.560	0.961	0.490	0.772	0.560	0.910			0.986	0.939	0.961	.	
0.913	0.932	0.745	0.942		0.685		0.932	-0.470		0.913	1.000	0.942	.	-0.456
0.749	0.806		0.843	0.444	0.749		0.806	-0.093	0.560	0.919	0.870	0.943	.	-0.408
0.791	0.968	0.646	0.933	0.646	0.791	0.646	0.968	-0.814		0.791	0.866	0.699	.	0.000
		0.583				0.583							.	
0.000		0.646	0.466	0.000	0.000	0.646		-0.542	-0.542				.	0.000
0.688	0.868	0.612	0.958	0.408	0.688	0.612	0.868			1.000	0.913	0.958	.	
0.869	0.873	0.873	0.906		0.535		0.873	-0.504	0.046	0.869	0.976	0.906	.	-0.535
0.869	0.873	0.873	0.906		0.535		0.873	-0.504	0.046	0.869	0.976	0.906	.	-0.535
0.868	1.000	0.583	0.963	0.667	0.868	0.583	1.000	-0.665	-0.035	0.868	0.932	0.813	.	
	0.583		0.662	0.667	0.612	1.000	0.583	-0.490		0.612			.	0.408
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0.875	0.919	0.408	0.885	0.612	0.875	0.408	0.919			0.875	0.913	0.885	.	
0.685	0.932		0.942	0.745	0.913	0.745	0.932	-0.470		0.913	0.833	0.808	.	0.000
0.688	0.868	0.612	0.958	0.408	0.688	0.612	0.868			1.000	0.913	0.958	.	
0.408	0.667	0.667	0.843		0.408	0.667	0.667			0.919	0.745	0.843	.	-0.408
0.408	0.667		0.542	1.000	0.919	0.667	0.667	-0.560		0.408			.	0.612
0.408	0.667	0.667	0.843		0.408	0.667	0.667			0.919	0.745	0.843	.	-0.408
		0.408		-0.408		0.408		0.086	-0.086		0.000		.	
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table F.4 Phase II "achieved" Correlation Matrix (cont'd)

30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
-0.791	-0.408	-0.408		0.559			1.000	0.875	0.000	0.086	0.000	-0.068	0.000	0.919
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
-0.791	-0.408	-0.408		0.559			1.000	0.875	0.000	0.086	0.000	-0.068	0.000	0.919
0.646	1.000	1.000	0.612	0.456	0.560	0.560	-0.408		-0.646	0.490		0.444	0.646	
-0.791	-0.408	-0.408		0.559			1.000	0.875	0.000	0.086	0.000	-0.068	0.000	0.919
-0.646			0.612	0.913	0.910	0.910	0.612	0.919	-0.646	0.840	0.745	0.722	0.646	0.667
0.000	0.612	0.612	1.000	0.559	0.772	0.772			-0.791	0.943	0.913	0.953	0.791	
-0.646			0.612	0.913	0.910	0.910	0.612	0.919	-0.646	0.840	0.745	0.722	0.646	0.667
0.000	0.667	0.667	0.408	0.913	0.840	0.840	0.408	0.612	-0.646	0.560			0.646	0.583
0.423	0.764	0.764		0.598	0.504	0.504			-0.423		0.000	0.036	0.423	
0.542			-0.086				-0.515	-0.557			0.000			
	0.919	0.919	0.875	0.559	0.729	0.729		0.063	-0.791	0.772	0.685	0.749	0.791	
0.000			0.408	-0.456			-0.612	-0.408	0.000				0.000	-0.667
0.000	0.408	0.408	0.875		0.515	0.515		0.063	-0.791	0.772	0.913	0.749	0.791	
0.000	0.667	0.667	0.919	0.685	0.840	0.840			-0.968	0.910	0.932	0.806	0.968	
-0.646			0.408	0.456	0.490	0.490	0.408	0.612	-0.646	0.560	0.745		0.646	0.583
	0.542	0.542	0.885	0.824	0.936	0.936		0.590	-0.933	0.961	0.942	0.843	0.933	
0.646	1.000	1.000	0.612	0.456	0.560	0.560	-0.408		-0.646	0.490		0.444	0.646	
	0.919	0.919	0.875	0.559	0.729	0.729		0.063	-0.791	0.772	0.685	0.749	0.791	
0.000	0.667	0.667	0.408	0.913	0.840	0.840	0.408	0.612	-0.646	0.560			0.646	0.583
0.000	0.667	0.667	0.919	0.685	0.840	0.840			-0.968	0.910	0.932	0.806	0.968	
	-0.560	-0.560			-0.412	-0.412	0.086	-0.086	0.814		-0.470	-0.093	-0.814	
				0.000			-0.086	0.086				0.560		
	0.408	0.408	0.875	0.839	0.943	0.943		0.688	-0.791	0.986	0.913	0.919	0.791	
			0.913	0.612	0.783	0.783	0.000	0.456	-0.866	0.939	1.000	0.870	0.866	
-0.466			0.885	0.659	0.809	0.809		0.590	-0.699	0.961	0.942	0.943	0.699	
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0.791	0.612	0.612		0.000	-0.086	-0.086			0.000		-0.456	-0.408	0.000	
[redacted]	0.646	0.646	0.000				-0.791	-0.791	0.000				0.000	-0.646
0.646	[redacted]	1.000	0.612	0.456	0.560	0.560	-0.408		-0.646	0.490		0.444	0.646	
0.646	1.000	[redacted]	0.612	0.456	0.560	0.560	-0.408		-0.646	0.490		0.444	0.646	
0.000	0.612	0.612	[redacted]	0.559	0.772	0.772			-0.791	0.943	0.913	0.953	0.791	
	0.456	0.456	0.559	[redacted]	0.959	0.959	0.559	0.839	-0.707	0.767	0.612	0.609	0.707	0.685
	0.560	0.560	0.772	0.959	[redacted]	1.000		0.729	-0.814	0.912	0.783	0.794	0.814	0.490
	0.560	0.560	0.772	0.959	1.000	[redacted]		0.729	-0.814	0.912	0.783	0.794	0.814	0.490
-0.791	-0.408	-0.408		0.559			[redacted]	0.875	0.000	0.086	0.000	-0.068	0.000	0.919
-0.791				0.839	0.729	0.729	0.875	[redacted]		0.557	0.456	0.408		0.868
0.000	-0.646	-0.646	-0.791	-0.707	-0.814	-0.814	0.000		[redacted]	-0.814	-0.866	-0.646	-1.000	
	0.490	0.490	0.943	0.767	0.912	0.912	0.086	0.557	-0.814	[redacted]	0.939	0.957	0.814	
			0.913	0.612	0.783	0.783	0.000	0.456	-0.866	0.939	[redacted]	0.870	0.866	
	0.444	0.444	0.953	0.609	0.794	0.794	-0.068	0.408	-0.646	0.957	0.870	[redacted]	0.646	-0.028
0.000	0.646	0.646	0.791	0.707	0.814	0.814	0.000		-1.000	0.814	0.866	0.646	[redacted]	
-0.646				0.685	0.490	0.490	0.919	0.868				-0.028		[redacted]
-0.500	0.000	0.000	0.000	0.707	0.542	0.542	0.791	0.791	-0.500			0.000	0.500	0.968
	0.408	0.408	0.875	0.839	0.943	0.943		0.688	-0.791	0.986	0.913	0.919	0.791	
-0.423			0.802	0.598	0.733	0.733		0.535	-0.845	0.871	0.976	0.764	0.845	
-0.423			0.802	0.598	0.733	0.733		0.535	-0.845	0.871	0.976	0.764	0.845	
0.000	0.667	0.667	0.919	0.685	0.840	0.840			-0.968	0.910	0.932	0.806	0.968	
0.000	0.667	0.667	0.408	0.913	0.840	0.840	0.408	0.612	-0.646	0.560			0.646	0.583
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0.000	0.612	0.612	1.000	0.559	0.772	0.772			-0.791	0.943	0.913	0.953	0.791	
0.000	0.745	0.745	0.913	0.817	0.939	0.939	0.000	0.456	-0.866	0.939	0.833	0.870	0.866	
	0.408	0.408	0.875	0.839	0.943	0.943		0.688	-0.791	0.986	0.913	0.919	0.791	
-0.646			0.612	0.913	0.910	0.910	0.612	0.919	-0.646	0.840	0.745	0.722	0.646	0.667
0.646	1.000	1.000	0.612	0.456	0.560	0.560	-0.408		-0.646	0.490		0.444	0.646	
-0.646			0.612	0.913	0.910	0.910	0.612	0.919	-0.646	0.840	0.745	0.722	0.646	0.667
-0.791	-0.408	-0.408		0.559			1.000	0.875	0.000	0.086	0.000	-0.068	0.000	0.919
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table F.4 Phase II "achieved" Correlation Matrix (cont'd)

45	46	47	48	49	50	51	52	53	54	55	56	57	58	59
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0.791					0.408	.		0.000		0.612	-0.408	0.612	1.000	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0.791					0.408	.		0.000		0.612	-0.408	0.612	1.000	.
0.000	0.408			0.667	0.667	.	0.612	0.745	0.408		1.000		-0.408	.
0.791					0.408	.		0.000		0.612	-0.408	0.612	1.000	.
0.646	0.919	0.764	0.764	0.667	0.667	.	0.612	0.745	0.919	1.000		1.000	0.612	.
0.000	0.875	0.802	0.802	0.919	0.408	.	1.000	0.913	0.875	0.612	0.612	0.612		.
0.646	0.919	0.764	0.764	0.667	0.667	.	0.612	0.745	0.919	1.000		1.000	0.612	.
0.646	0.612			0.583	1.000	.	0.408	0.745	0.612	0.667	0.667	0.667	0.408	.
0.423		-0.071	-0.071		0.873	.		0.488			0.764			.
0.000		0.046	0.046			.	-0.086			-0.490		-0.490	-0.515	.
0.000	0.688	0.535	0.535	0.868	0.612	.	0.875	0.913	0.688	0.408	0.919	0.408		.
-0.646					-0.667	.	0.408	0.000					-0.612	.
0.000	0.688	0.869	0.869	0.868		.	0.875	0.685	0.688	0.408	0.408	0.408		.
	0.868	0.873	0.873	1.000	0.583	.	0.919	0.932	0.868	0.667	0.667	0.667		.
0.646	0.612	0.873	0.873	0.583		.	0.408		0.612	0.667		0.667	0.408	.
0.466	0.958	0.906	0.906	0.963	0.662	.	0.885	0.942	0.958	0.843	0.542	0.843		.
0.000	0.408			0.667	0.667	.	0.612	0.745	0.408		1.000		-0.408	.
0.000	0.688	0.535	0.535	0.868	0.612	.	0.875	0.913	0.688	0.408	0.919	0.408		.
0.646	0.612			0.583	1.000	.	0.408	0.745	0.612	0.667	0.667	0.667	0.408	.
	0.868	0.873	0.873	1.000	0.583	.	0.919	0.932	0.868	0.667	0.667	0.667		.
-0.542		-0.504	-0.504	-0.665	-0.490	.		-0.470			-0.560		0.086	.
-0.542		0.046	0.046	-0.035		.							-0.086	.
	1.000	0.869	0.869	0.868	0.612	.	0.875	0.913	1.000	0.919	0.408	0.919		.
	0.913	0.976	0.976	0.932		.	0.913	0.833	0.913	0.745		0.745	0.000	.
	0.958	0.906	0.906	0.813		.	0.885	0.808	0.958	0.843		0.843		.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0.000		-0.535	-0.535		0.408	.		0.000		-0.408	0.612	-0.408		.
-0.500		-0.423	-0.423	0.000	0.000	.	0.000	0.000		-0.646	0.646	-0.646	-0.791	.
0.000	0.408			0.667	0.667	.	0.612	0.745	0.408		1.000		-0.408	.
0.000	0.408			0.667	0.667	.	0.612	0.745	0.408		1.000		-0.408	.
0.000	0.875	0.802	0.802	0.919	0.408	.	1.000	0.913	0.875	0.612	0.612	0.612		.
0.707	0.839	0.598	0.598	0.685	0.913	.	0.559	0.817	0.839	0.913	0.456	0.913	0.559	.
0.542	0.943	0.733	0.733	0.840	0.840	.	0.772	0.939	0.943	0.910	0.560	0.910		.
0.542	0.943	0.733	0.733	0.840	0.840	.	0.772	0.939	0.943	0.910	0.560	0.910		.
0.791					0.408	.		0.000		0.612	-0.408	0.612	1.000	.
0.791	0.688	0.535	0.535		0.612	.		0.456	0.688	0.919		0.919	0.875	.
-0.500	-0.791	-0.845	-0.845	-0.968	-0.646	.	-0.791	-0.866	-0.791	-0.646	-0.646	-0.646	0.000	.
	0.986	0.871	0.871	0.910	0.560	.	0.943	0.939	0.986	0.840	0.490	0.840	0.086	.
	0.913	0.976	0.976	0.932		.	0.913	0.833	0.913	0.745		0.745	0.000	.
0.000	0.919	0.764	0.764	0.806		.	0.953	0.870	0.919	0.722	0.444	0.722	-0.068	.
0.500	0.791	0.845	0.845	0.968	0.646	.	0.791	0.866	0.791	0.646	0.646	0.646	0.000	.
0.968					0.583	.				0.667		0.667	0.919	.
		0.423	0.423		0.646	.	0.000			0.646	0.000	0.646	0.791	.
		0.869	0.869	0.868	0.612	.	0.875	0.913	1.000	0.919	0.408	0.919		.
0.423	0.869		1.000	0.873		.	0.802	0.732	0.869	0.764		0.764		.
0.423	0.869	1.000		0.873		.	0.802	0.732	0.869	0.764		0.764		.
	0.868	0.873	0.873		0.583	.	0.919	0.932	0.868	0.667	0.667	0.667		.
0.646	0.612			0.583		.	0.408	0.745	0.612	0.667	0.667	0.667	0.408	.
.	.	.	.	.	.		.	.	.	.	.	.	.	.
0.000	0.875	0.802	0.802	0.919	0.408	.		0.913	0.875	0.612	0.612	0.612		.
	0.913	0.732	0.732	0.932	0.745	.	0.913		0.913	0.745	0.745	0.745	0.000	.
	1.000	0.869	0.869	0.868	0.612	.	0.875	0.913		0.919	0.408	0.919		.
0.646	0.919	0.764	0.764	0.667	0.667	.	0.612	0.745	0.919			1.000	0.612	.
0.000	0.408			0.667	0.667	.	0.612	0.745	0.408				-0.408	.
0.646	0.919	0.764	0.764	0.667	0.667	.	0.612	0.745	0.919	1.000			0.612	.
0.791					0.408	.		0.000		0.612	-0.408	0.612		.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	

Table F.5 Correlation Analysis: Eliminated Descriptor Statements

Phase II "not successful" Eliminated Descriptor Statements
4. The project members understood customer requirements.
7. A demonstration was conducted for the customer to exhibit the innovation's benefits.
9. The customer received a hands-on preview of the innovation's capabilities.
21. The innovation met key technical performance measures.
26. The innovation's benefits were advertised to potential customers.
29. The innovation was intended for:
30. At the time of the this SBIR project, the company's business strategy was focused on:
35. The SBIR project was integrated into customer's funding cycle.
36. The SBIR project was integrated into customer's schedule.
39. At the time of the SBIR project, the company did not focus on a particular type of innovation.
45. At the conclusion of the Phase II project, the predicted demand for the innovation was realized.
Phase II "not successful" Eliminated Descriptor Statements
34. SBIR project milestones were incorporated into customer planning.

Table F.6 Correlation Analysis: Grouped Descriptor Statements

Grouped Descriptor Statements
Communication quality between the company's SBIR project team and your NASA customer. The degree to which your NASA customer's needs were met. 1. Project members' communication built the customer's confidence in the innovation. 2. Project members sought feedback from their customer. 3. Project members developed a trusting relationship with their customer. 5. The technology solved the customer's problem. 6. Project members understood how the customer intended to use the innovation.
Providing your NASA customer with a preview of the technology's capabilities. The depth of the innovation's verification program to substantiate performance. 8. The innovation was presented to show it performed as required. 13. The highest level of testing the innovation received is best described by: 14. Analytical predictions were followed up with empirical testing. 15. The innovation's verification methodology followed a build-up approach (i.e., component > assembly > subsystem > system).

Table F.7 Final Consolidated Candidate Critical Success Factors

1	Communication quality between the company's SBIR project team and the NASA/Phase III customer that influences the degree to which the customer's needs were met.
2	The depth of the innovation's verification program to substantiate performance
3	Your company's ability to manage personnel resources for the SBIR project
4	Understanding the intended application of the innovation once the SBIR project was complete
5	The SBIR project's performance against stated key performance parameters
6	Funding requirements beyond the completion of the SBIR project to bridge funding gaps
7	The degree of marketing activity for the innovation
8	The innovation's alignment with the company's business strategy
9	The degree of your company's management support for the SBIR project/innovation
10	The type of development your company primarily pursued – product or process
11	The degree to which the SBIR project received support from NASA personnel/Phase III customer
12	The ability of your company to predict the market/customer demand for the innovation
13	The degree your SBIR project team shared decision making responsibility with your customer
14	The level of maturity the innovation achieved through the SBIR project
15	The level your SBIR project team's performance

APPENDIX G

PRIMARY STUDY QUESTIONNAIRES

SBIR Research Introduction

Dear Respondent:

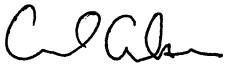
I am a doctoral candidate at The University of Alabama in Huntsville conducting research to identify critical success factors for a small business to achieve Small Business Innovation Research (SBIR) Phase III commercialization or technology infusion. I am in the primary study phase and need your help to collect data to formulate the set of critical success factors to achieve Phase III. It is hoped that businesses like yours will ultimately benefit from learning the critical areas in which management should focus its efforts to enhance the likelihood to achieve Phase III commercialization or techcology infusion from NASA-funded SBIR innovations.

Based on your company's experience with NASA-funded SBIR Phase II's, I am requesting you complete one of two questionnaires (instructions on the following page). A questionnaire should take from 5 - 10 minutes to complete. Your participation is crucial to the success of this research.

Information specific to your company will remain confidential and respondent anonymity will be maintained. Once my study is complete I will make available a summary of the principal findings. If you have any questions please contact me at my work phone number below.

If you would like inquire about credentials for this research please contact my research advisor, Dr. Don Tippett, Associate Professor, The University of Alabama in Huntsville, 256-824-6895 or Dr. Nicholaos Jones, IRB Chair, <irb@uah.edu>, 256-824-2338.

Thank you.



Carl A. Ise
Doctoral Candidate
The University of Alabama in Huntsville

and

Subsystem Manager
Ares I Upper Stage Project Office/JP30
NASA/Marshall Space Flight Center
(256) 617-3826

SBIR Research Introduction

Questionnaire Instructions

Questionnaire to determine Critical Success Factors for NASA originated SBIR projects

Definitions:
Critical Success Factors (CSFs) – A few key areas where things must go right to achieve Phase III Commercialization/Technology Infusion. If results in these areas are not adequate, the SBIR effort will be less than desired. As such, these areas of activity should receive constant and careful attention from management.
Phase II – Funded NASA SBIR. Up to 2-year focused research and development with results being demonstration and delivery of the innovation.
Phase III Commercialization -- Revenue received from a private source that resulted from the sale, contract, or license of a NASA SBIR Phase II innovation.
Phase III Technology Infusion -- Revenue received from a Federal source that resulted from the sale, contract, or license of a NASA SBIR Phase II innovation.

Instructions:
Answer the questionnaire based on your knowledge of your company's participation in NASA's SBIR program and any follow-on business activities. Please evaluate the criteria below to determine how to proceed.

Your company has an innovation that only completed Phase II (did not achieve Phase III):
You are requested to complete Questionnaire 1 and answer the questions with respect to the specific innovation that only completed Phase II.

Your company had/has an innovation that achieved Phase III originating from a NASA funded SBIR Phase II:
You are requested to complete Questionnaire 2 and answer the questions with respect to a specific Phase II project that achieved Phase III.

If you had projects that meet both criteria please fill out both questionnaires.

Each questionnaire is an Adobe Acrobat form (http://get.adobe.com/reader/).

Please fill in the title of the SBIR project at the top of the first page. Each questionnaire has forty-six questions and each question requires a mutually exclusive response -- click a box that is the most appropriate response for the question. Once complete, click the "Submit" button at the bottom of the questionnaire to email the form to me (iseca@mac.com) -- the completed form should automatically attach to a pre-addressed email. You must complete all questions to 'Submit'. You also have the option to submit a hard copy; print completed questionnaire and fax to 1-888-866-4579.

Questionnaire Instructions

Demographics:

1. Phase II project name/description: _____

2. Please select the technology category(ies) (more than one may apply) that describes your SBIR project/innovation:
   - ☐ Acoustics/Vibroacoustics
   - ☐ Aerodynamics
   - ☐ Aeronautics
   - ☐ Aerospace
   - ☐ Aircraft Systems/Subsystem
   - ☐ Aviation
   - ☐ Biological/Physical Sciences
   - ☐ Biomedical/Medical
   - ☐ Chemistry
   - ☐ Communications
   - ☐ Cryogenic Sciences
   - ☐ Earth/Environmental Sciences
   - ☐ Electronic Components
   - ☐ Electronic Circuits
   - ☐ Electronic Systems
   - ☐ Energy
   - ☐ Information Sciences/Data Handling
   - ☐ Instrumentation
   - ☐ Life Sciences
   - ☐ Machinery/Automation
   - ☐ Manufacturing/Fabrication
   - ☐ Materials
   - ☐ Mechanical
   - ☐ Nanotechnology
   - ☐ Optics
   - ☐ Physics
   - ☐ Power/Propulsion
   - ☐ Robotics
   - ☐ Sensors
   - ☐ Software
   - ☐ Space Systems
   - ☐ Test/Measurement
   - ☐ Transportation

For each item, select the best answer that describes the Phase II project/innovation.

Communication quality between the company's SBIR project team and your customer that influenced the degree to which the customer's needs were met.					
1. Project members' communication built the customer's confidence in the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
2. Project members sought feedback from their customer.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
3. Project members understood how the customer intended to use the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
4. The technology solved the customer's problem.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The depth of the innovation's verification program to substantiate performance					
5. The innovation was presented to show it performed as required.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
6. The highest level of testing the innovation received is best described by:	Less than Breadboard ☐	Breadboard in Lab ☐	Breadboard in Relevant Environment ☐	Testing in Relevant Environment ☐	Testing in Operational Environment ☐
7. Analytical predictions were followed up with empirical testing.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
8. The innovation's verification methodology followed a build-up approach (i.e., component > assembly > subsystem > system).	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

Your company's ability to manage personnel resources for the SBIR project					
9. Workers were available for assignment to the project when needed.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
10. Personnel were assigned to other projects when their services were no longer needed.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
11. Multi-disciplined workers were valued more than single-discipline workers.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

Understanding the intended application of the innovation once the SBIR project was complete					
12. The project members developed a plan for Phase III at project's inception.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
13. The project members understood the intended market for the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
14. Project members gathered marketing data prior to end of Phase II.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The SBIR project's performance against stated key performance parameters					
15. Your company delivered the innovation within schedule constraints.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
16. Your company delivered the innovation within budget constraints.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

Funding requirements beyond the completion of the SBIR project to bridge funding gaps					
17. The project required additional funding, beyond the SBIR Phase II funding, to mature the innovation for use by a customer.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
18. The project received internal research and development funds to bridge any post-Phase II funding gaps.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
19. The project received external funding to bridge any post-Phase II funding gaps.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The degree of marketing activity for the innovation					
20. The project members developed business contacts during the SBIR project for future sales opportunities.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
21. A marketing plan was developed describing how the innovation would be introduced into its intended market.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The innovation's alignment with the company's business strategy					
22. The innovation developed from the SBIR project supported the goals of the company.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The degree of your company's management support for the SBIR project/innovation					
23. Top management believed the SBIR project should provide a revenue stream for the company.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
24. Top management's desire was to increase the maturity of the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
25. Top management's goal was to achieve sale to a customer from the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The type of development your company primarily pursued – product or process					
26. At the time of the SBIR project, the company was primarily focused on developing product-based innovations.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
27. At the time of the SBIR project, the company was primarily focused on developing process-based innovations.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The degree to which the SBIR project received support from your customer					
28. An individual with technical authority provided sustained support that facilitated progress of the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
29. An individual with fiscal authority provided sustained support that facilitated progress of the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
30. During the SBIR project, no active support was provided by any individual within NASA.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The ability of your company to predict the market/customer demand for the innovation					
31. The company flexibly responded to customer priority changes.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
32. The company researched demand for the innovation before the start of the project.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The degree your SBIR project team shared decision making responsibility with your customer					
33. The customer provided input for project decisions.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
34. Customer input was included in project decisions.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
35. The customer was notified if inputs were included in project decisions.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The level of maturity the innovation achieved through the SBIR project					
36. Based on completion of the Phase II project, the innovation's maturity was:	Analytical or experimental proof of concept ☐	Breadboard in lab environment ☐	Breadboard in relevant environment ☐	Prototype ☐	Fully operational ☐
37. At the conclusion of the SBIR Phase II project, the innovation worked as intended.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
38. The innovation required additional research and development at the conclusion of the SBIR Phase II project.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The level your SBIR project team's performance					
39. This group understood how to accomplish its tasks.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
40. This group met all objectives for work completed.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
41. This group's work was always of the highest quality.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
42. This group took initiative in solving problems and decision making.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
43. This group was very good at planning how to accomplish their work objectives.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
44. This work group should continue working together as a unit in the future.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
45. This group was not capable of working together as a unit.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
46. As a work unit, this group showed signs of falling apart.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

Demographics:

1. Phase III project name/description: _____

2. Please select the technology category(ies) (more than one may apply) that describes your SBIR project/innovation:
   - ☐ Acoustics/Vibroacoustics
   - ☐ Aerodynamics
   - ☐ Aeronautics
   - ☐ Aerospace
   - ☐ Aircraft Systems/Subsystem
   - ☐ Aviation
   - ☐ Biological/Physical Sciences
   - ☐ Biomedical/Medical
   - ☐ Chemistry
   - ☐ Communications
   - ☐ Cryogenic Sciences
   - ☐ Earth/Environmental Sciences
   - ☐ Electronic Components
   - ☐ Electronic Circuits
   - ☐ Electronic Systems
   - ☐ Energy
   - ☐ Information Sciences/Data Handling
   - ☐ Instrumentation
   - ☐ Life Sciences
   - ☐ Machinery/Automation
   - ☐ Manufacturing/Fabrication
   - ☐ Materials
   - ☐ Mechanical
   - ☐ Nanotechnology
   - ☐ Optics
   - ☐ Physics
   - ☐ Power/Propulsion
   - ☐ Robotics
   - ☐ Sensors
   - ☐ Software
   - ☐ Space Systems
   - ☐ Test/Measurement
   - ☐ Transportation

3. At the time the Phase III was awarded, how did the innovation reach the market?
   - ☐ Commercialization
   - ☐ Technology Infusion

For each item, select the best answer that describes the Phase III project/innovation.

Communication quality between the company's SBIR project team and your customer that influenced the degree to which the customer's needs were met.					
1. Project members' communication built the customer's confidence in the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
2. Project members sought feedback from their customer.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
3. Project members understood how the customer intended to use the innovation.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
4. The technology solved the customer's problem.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

The depth of the innovation's verification program to substantiate performance					
5. The innovation was presented to show it performed as required.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
6. The highest level of testing the innovation received is best described by:	Less than Breadboard ☐	Breadboard in Lab ☐	Breadboard in Relevant Environment ☐	Testing in Relevant Environment ☐	Testing in Operational Environment ☐
7. Analytical predictions were followed up with empirical testing.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
8. The innovation's verification methodology followed a build-up approach (i.e., component > assembly > subsystem > system).	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

Your company's ability to manage personnel resources for the SBIR project					
9. Workers were available for assignment to the project when needed.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
10. Personnel were assigned to other projects when their services were no longer needed.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
11. Multi-disciplined workers were valued more than single-discipline workers.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

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15. Your company delivered the innovation within schedule constraints.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
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34. Customer input was included in project decisions.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
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37. At the conclusion of the SBIR Phase II project, the innovation worked as intended.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
38. The innovation required additional research and development at the conclusion of the SBIR Phase II project.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

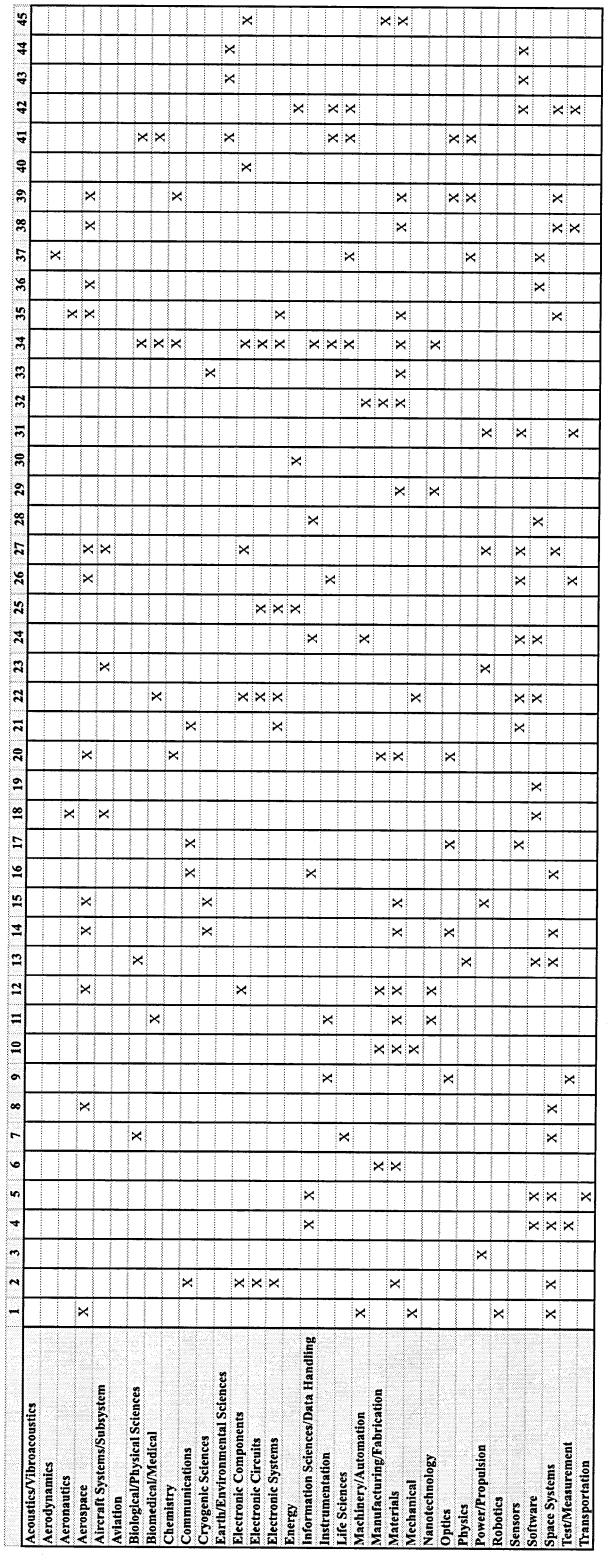
The level your SBIR project team's performance					
39. This group understood how to accomplish its tasks.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
40. This group met all objectives for work completed.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
41. This group's work was always of the highest quality.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
42. This group took initiative in solving problems and decision making.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
43. This group was very good at planning how to accomplish their work objectives.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
44. This work group should continue working together as a unit in the future.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
45. This group was not capable of working together as a unit.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐
46. As a work unit, this group showed signs of falling apart.	Strongly Disagree ☐	Disagree ☐	Neutral ☐	Agree ☐	Strongly Agree ☐

APPENDIX H

PRIMARY STUDY DATA

Appendix H contains the raw sampling data from the Primary Study. Table H.1 shows the Phase II "did not achieve" demographic data. Table H.2 shows the Phase II "did not achieve" questionnaire scores. Table H.3 shows the Phase II "achieved" demographic data. Table H.4 shows the Phase II "achieved" questionnaire scores. Last, Table H.5 shows the descriptive statistics for both Phase II "did not achieve" and Phase II "achieved" projects.

Table H.1 Phase II "did not achieve" Demographics



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Acoustics/Vibroacoustics																																													
Aerodynamics																																					X								
Aeronautics		X																																										
Aerospace								X				X			X					X						X	X								X	X								
Aircraft Systems/Subsystem														X				X					X				X								X			X					
Aviation																																												
Biological/Physical Sciences							X						X																															
Biomedical/Medical											X											X												X						X			
Chemistry																	X			X															X					X			
Communications		X														X	X																										
Cryogenic Sciences														X	X																			X								
Earth/Environmental Sciences																																									X	X		
Electronic Components		X										X										X					X														X		
Electronic Circuits		X																				X												X								X
Electronic Systems		X																			X	X			X									X								
Energy																					X				X									X								
Information Sciences/Data Handling				X	X											X								X			X															
Instrumentation									X		X															X																	
Life Sciences							X																																					
Machinery/Automation		X																														X											
Manufacturing/Fabrication						X				X		X								X				X								X									X	X	
Materials			X			X				X	X	X		X	X					X							X					X									X	X	
Mechanical		X								X												X						X															
Nanotechnology											X																																	
Optics									X				X				X			X								X												X			
Physics																																					X				X			
Power/Propulsion			X												X								X						X							X				X			
Robotics		X																				X																					
Sensors																	X				X	X		X																		X	X	
Software				X	X													X	X		X			X																		X	X	
Space Systems		X		X	X		X	X					X	X		X						X				X										X	X						
Test/Measurement				X					X				X																										X	X				
Transportation					X																																							

Table H.2 Phase II "did not achieve" Raw Data

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Q1	4	4	4	4	4	4	4	5	5	4	4	4	4	4	5	4	5	3	4	4	4	3	5	5	4	5	4	5	3	3	3	4	5	5	5	4	4	3	4	1	4	4	5	5	5
Q2	5	3	4	4	5	4	4	5	3	4	4	5	4	4	4	4	5	4	4	5	4	5	5	4	3	5	4	5	4	3	5	4	5	5	5	4	5	4	5	1	4	4	5	4	5
Q3	4	5	5	5	4	4	4	5	5	5	5	5	4	5	4	3	5	4	4	4	4	4	4	4	4	5	3	5	4	5	4	5	5	5	5	4	3	5	5	1	4	4	5	5	5
Q4	4	4	5	4	4	4	4	5	4	4	4	4	3	3	4	4	5	3	4	4	4	3	3	3	3	4	4	5	3	4	3	2	3	5	5	4	4	5	5	5	3	4	3	3	4
Q5	3	4	4	3	5	4	4	5	5	4	4	5	5	5	4	5	5	4	4	4	4	4	4	4	4	4	4	5	3	4	4	4	4	5	5	5	4	4	5	1	5	4	4	4	4
Q6	3	3	2	2	4	4	2	3	5	4	2	4	2	3	4	4	3	5	4	4	4	4	2	4	2	2	2	4	2	2	5	2	4	2	5	4	4	5	4	5	3	5	5	2	5
Q7	4	4	3	4	3	3	4	5	5	4	4	2	4	5	5	4	5	4	3	4	4	4	4	5	4	5	3	4	3	4	4	5	4	5	5	4	3	5	3	5	4	5	5	4	4
Q8	5	5	4	4	4	4	5	5	2	3	3	4	4	5	4	4	3	4	3	3	4	4	3	5	4	5	4	2	3	3	4	5	4	5	5	4	3	4	5	3	4	5	5	4	4
Q9	5	4	5	5	5	4	4	5	4	4	5	5	4	3	4	2	4	4	4	4	4	5	5	3	4	5	4	4	4	3	4	5	4	5	5	4	5	5	5	5	5	4	5	5	5
Q10	4	4	4	4	2	4	4	5	4	5	5	5	4	2	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	5	4	4	5	5	5	5	1	4	5	5	5
Q11	5	2	5	4	3	4	4	5	3	5	5	5	4	4	3	4	4	4	3	5	4	4	5	2	4	3	4	5	4	5	3	4	4	3	5	3	5	5	5	3	5	2	4	5	5
Q12	4	2	4	4	4	4	3	5	2	1	4	4	4	4	1	1	2	3	2	4	3	1	2	4	3	5	2	2	3	4	1	2	3	5	5	4	2	4	4	1	4	4	3	2	5
Q13	4	4	5	4	3	4	3	5	4	3	5	4	4	4	3	4	4	4	4	4	4	4	2	4	4	5	4	3	4	4	5	4	3	5	5	4	3	4	4	5	4	4	5	5	5
Q14	4	2	4	3	3	4	3	5	1	1	4	3	4	3	2	4	4	2	3	4	4	4	2	2	2	5	4	4	4	2	3	4	3	5	4	4	4	5	4	1	4	3	2	2	4
Q15	4	2	5	4	5	4	4	5	3	5	4	5	4	3	4	2	4	2	4	5	4	4	3	4	4	5	4	5	3	4	3	3	4	2	4	5	5	4	5	5	4	4	5	5	5
Q16	2	4	5	4	5	3	4	5	5	5	4	5	4	4	5	1	3	4	4	5	4	4	2	5	4	5	4	5	3	4	5	4	4	5	5	5	5	4	5	3	3	4	5	5	4
Q17	5	4	4	5	2	4	5	2	5	3	5	4	4	2	5	5	4	4	3	4	4	4	2	5	4	5	5	4	4	5	2	5	3	3	4	4	4	2	5	5	4	2	5	5	5
Q18	5	2	3	2	3	2	2	5	5	1	2	3	4	1	2	5	4	4	2	4	2	2	1	2	4	3	5	1	2	2	1	4	3	5	4	5	5	4	5	5	4	2	3	2	1
Q19	3	2	2	1	3	2	2	5	5	1	2	2	2	1	3	1	4	2	2	2	2	2	1	2	2	3	5	1	2	3	1	2	3	1	3	1	4	2	1	1	3	2	1	5	1
Q20	4	2	4	3	3	3	4	5	5	4	4	4	2	4	4	5	5	3	2	3	3	4	2	3	2	5	4	4	4	1	4	3	3	5	4	4	5	4	4	1	4	2	3	3	5
Q21	2	2	3	2	3	4	3	5	1	2	3	3	2	4	3	4	5	2	2	4	3	3	2	2	3	5	3	4	4	4	2	3	3	5	3	4	4	4	4	5	4	2	2	2	5
Q22	5	3	5	4	5	4	4	5	5	4	5	4	4	5	4	4	5	4	4	4	4	4	4	2	4	5	5	2	4	4	3	4	4	5	5	4	5	5	5	5	4	5	5	5	5
Q23	2	2	5	3	5	4	4	5	4	4	4	4	4	5	5	2	5	4	4	4	4	4	4	2	4	3	5	3	4	3	3	4	4	5	4	3	4	5	4	5	4	4	5	5	5
Q24	5	4	5	4	5	4	4	5	5	2	4	5	4	5	4	4	5	4	4	4	4	4	4	1	3	5	5	1	4	5	4	4	4	5	5	4	4	5	5	5	4	4	5	5	5
Q25	5	2	5	5	5	3	5	5	4	4	5	4	5	4	5	3	5	4	3	5	4	4	4	2	3	5	5	1	4	5	3	4	4	5	5	4	4	5	4	5	4	4	5	5	4
Q26	3	4	3	3	2	4	4	5	2	4	5	4	3	5	5	5	4	4	3	5	4	4	4	4	4	5	5	1	3	4	2	4	4	5	5	4	4	2	5	5	4	4	4	5	4
Q27	1	4	1	2	2	2	2	4	4	2	3	2	3	1	2	5	2	3	3	3	4	4	3	3	2	3	5	5	2	4	4	2	2	4	3	2	4	4	1	1	2	3	5	5	1
Q28	4	4	5	4	5	3	4	5	5	4	2	5	4	5	2	4	5	4	4	4	2	4	3	5	4	5	3	5	2	4	5	4	5	4	5	4	3	4	5	1	4	2	5	5	5
Q29	3	4	5	4	3	3	5	5	5	4	2	5	4	5	1	4	4	4	4	3	2	4	2	4	4	5	1	3	2	3	5	4	4	3	4	4	1	4	4	1	3	4	5	5	4
Q30	4	2	3	4	5	3	5	1	3	5	3	5	4	3	2	2	4	3	2	4	3	3	4	5	2	5	4	5	3	2	2	3	5	4	2	2	4	4	5	1	2	2	5	5	3
Q31	5	4	4	3	4	4	4	3	3	3	3	5	4	4	3	4	4	4	4	5	4	3	3	5	4	3	3	5	3	3	3	3	5	5	4	4	4	4	3	4	4	4	4	4	5
Q32	2	2	5	4	3	4	4	5	2	4	4	4	4	4	4	4	4	3	4	4	3	3	4	3	4	5	5	1	4	4	5	4	3	5	5	4	4	3	5	5	4	4	3	4	4
Q33	4	4	4	4	4	4	4	1	2	4	2	2	4	5	3	2	4	4	4	4	3	4	4	5	4	4	3	5	3	3	1	3	4	4	4	4	3	3	5	1	3	4	3	3	4
Q34	5	3	4	4	4	4	4	3	4	4	3	2	4	5	2	3	4	4	4	4	4	4	4	5	4	5	4	5	3	4	3	3	4	5	4	4	4	4	5	1	3	2	3	3	4
Q35	5	4	4	4	4	4	4	5	3	4	4	2	4	4	2	4	4	4	4	4	4	4	4	5	4	5	4	5	3	4	5	3	4	4	4	3	4	4	5	1	3	2	3	3	4
Q36	4	3	1	4	5	4	4	4	4	4	2	4	1	3	4	5	2	4	5	4	4	4	2	3	2	2	2	4	1	3	4	2	4	4	4	5	4	4	5	5	3	4	4	2	4
Q37	3	4	3	5	4	4	4	5	2	4	4	5	4	4	4	4	4	3	4	4	4	3	4	3	4	4	4	5	4	3	4	3	4	5	5	4	4	4	5	5	4	4	3	3	4
Q38	5	4	2	3	2	2	1	5	1	4	2	2	2	1	2	2	1	3	3	4	2	2	4	1	2	1	2	1	1	1	2	2	3	4	3	2	1	2	2	5	1	1	2	2	1
Q39	5	4	5	5	5	4	5	5	5	3	5	5	4	5	5	3	4	5	4	5	4	4	4	4	4	5	4	5	4	5	4	4	4	5	5	4	5	4	5	5	4	4	4	4	5
Q40	3	3	4	5	5	4	4	5	5	4	5	5	4	5	5	3	4	2	4	4	4	4	4	4	4	5	4	5	4	3	4	4	4	5	5	4	5	4	5	4	5	4	4	4	5
Q41	5	4	4	5	5	3	5	5	4	4	5	5	4	5	4	4	4	4	4	5	4	4	4	4	4	5	4	5	4	5	4	4	3	4	5	4	4	5	4	5	5	4	4	4	5
Q42	5	4	5	5	5	4	5	5	5	3	5	5	4	5	4	3	4	5	4	5	4	4	4	5	4	5	4	5	4	4	5	4	4	5	5	4	5	5	5	5	4	4	4	3	5
Q43	5	3	5	5	5	4	5	5	4	3	5	5	4	5	4	2	4	4	4	5	4	4	4	4	4	5	3	5	3	5	4	3	4	4	5	4	4	5	5	4	4	4	3	3	5
Q44	5	4	4	5	5	4	5	5	5	4	5	5	3	5	5	4	4	4	4	5	4	4	4	4	4	5	3	5	4	4	4	4	4	5	4	5	3	4	5	4	4	4	3	3	5
Q45	5	4	5	5	5	4	5	1	5	4	5	5	3	5	5	5	4	4	4	4	5	4	5	4	5	4	5	4	5	4	5	5	5	2	4	5	5	5	5	5	5	4	4	4	4
Q46	5	4	5	5	5	4	5	1	5	5	5	5	3	5	5	5	4	4	5	4	5	4	5	4	4	5	5	5	4	5	5	5	5	4	5	5	5	5	3	5	5	4	5	5	5

Table H.3 Phase II “achieved” Demographics

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Acoustics/Vibroacoustics																											
Aerodynamics																										X	
Aeronautics																										X	
Aerospace	X																X			X		X	X	X			
Aircraft Systems/Subsystem	X									X					X						X					X	
Aviation																	X				X					X	
Biological/Physical Sciences									X																		
Biomedical/Medical																											
Chemistry					X																		X		X		
Communications																											
Cryogenic Sciences																											
Earth/Environmental Sciences													X														
Electronic Components																		X									X
Electronic Circuits						X								X													X
Electronic Systems		X				X														X							
Energy											X														X	X	
Information Sciences/Data Handling				X			X																				
Instrumentation								X	X			X													X	X	
Life Sciences					X																				X		
Machinery/Automation																											
Manufacturing/Fabrication														X													X
Materials									X							X							X				X
Mechanical																											
Nanotechnology									X																		
Optics		X	X					X						X					X								
Physics					X																						
Power/Propulsion											X																
Robotics																								X			
Sensors												X	X		X				X							X	
Software				X			X			X					X	X	X				X			X			
Space Systems	X			X	X	X					X				X				X	X		X	X				
Test/Measurement								X														X			X	X	
Transportation				X																							
Commercialization							X	X		X			X	X	X	X		X				X				X	X
Technology Infusion	X	X	X	X	X	X			X		X	X	X	X			X		X	X	X		X	X	X	X	

Table H.4 Phase II “achieved” Raw Data

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Q1	4	5	5	4	5	2	5	4	5	4	5	4	4	5	4	4	4	3	5	5	4	4	5	4	2	5	5
Q2	4	5	5	5	4	5	5	5	5	4	5	4	2	5	4	4	4	2	5	5	4	5	5	3	2	5	5
Q3	4	5	5	3	4	3	5	5	5	4	5	4	5	5	4	4	4	1	5	5	4	5	5	5	2	5	5
Q4	4	5	5	4	4	5	5	5	5	5	5	4	4	5	5	4	5	3	5	5	4	5	5	3	3	5	5
Q5	5	5	4	5	4	4	5	5	5	4	4	4	3	5	4	5	4	4	4	5	5	4	4	4	4	5	5
Q6	4	5	3	4	2	4	5	5	2	3	2	2	5	2	4	4	5	5	4	5	5	4	4	3	3	4	5
Q7	3	5	4	3	3	4	4	5	4	4	4	4	5	5	4	5	3	5	5	5	5	4	3	3	4	5	4
Q8	3	5	4	4	5	4	5	2	3	4	4	4	3	4	4	4	4	4	4	5	4	3	4	3	4	5	5
Q9	5	5	4	5	4	5	4	5	5	4	4	3	4	4	4	5	4	2	4	5	4	4	5	5	4	4	4
Q10	4	1	4	2	4	4	4	4	5	2	4	4	4	4	4	4	2	4	4	4	4	4	5	4	4	4	4
Q11	5	3	4	3	4	5	5	3	5	3	5	5	5	5	5	3	4	4	4	5	5	5	5	5	2	5	5
Q12	3	5	4	4	3	5	4	3	4	4	4	2	4	3	4	4	2	1	3	3	4	4	3	2	2	3	5
Q13	4	5	4	3	4	5	5	4	5	5	5	4	4	5	4	4	2	2	4	5	4	4	4	4	4	4	5
Q14	4	5	4	4	3	5	4	1	4	5	3	2	2	5	2	4	2	2	4	3	4	4	4	4	2	4	5
Q15	4	5	4	5	3	4	4	5	3	5	4	4	2	4	5	4	4	1	3	4	5	4	5	5	4	4	5
Q16	4	5	4	5	3	5	4	5	4	5	4	4	2	5	5	5	4	1	5	5	5	4	5	4	4	4	5
Q17	5	5	4	2	5	5	3	5	5	4	4	5	4	5	4	4	4	5	5	4	3	3	5	5	4	5	2
Q18	3	1	4	2	4	4	3	5	2	4	2	1	4	4	5	5	3	5	4	4	4	4	5	2	4	4	4
Q19	3	1	2	2	3	1	4	5	4	4	4	4	2	5	1	3	2	5	4	4	2	3	2	4	4	5	2
Q20	4	5	2	3	3	5	4	4	4	4	4	4	4	4	4	4	2	2	5	4	4	4	4	4	2	5	5
Q21	4	3	2	3	2	5	4	1	4	4	3	2	2	3	4	4	2	4	4	5	4	4	4	4	2	4	5
Q22	4	5	4	5	5	5	5	5	5	5	5	4	5	5	5	5	4	4	5	5	4	5	4	5	4	5	5
Q23	3	5	4	5	4	5	5	4	4	3	5	4	4	5	5	5	3	4	3	5	4	5	4	5	4	5	5
Q24	4	5	4	5	4	5	5	5	4	5	5	4	4	5	5	5	4	4	4	5	4	5	5	5	4	5	5
Q25	5	5	4	5	5	5	5	4	5	4	5	2	5	5	5	5	4	5	4	5	4	4	5	4	4	5	5
Q26	3	5	3	2	4	5	4	2	4	5	5	4	3	5	5	4	2	4	4	5	4	2	5	2	4	4	4
Q27	2	3	2	2	1	4	4	5	3	3	3	4	4	3	5	1	4	2	4	2	2	4	1	2	2	2	1
Q28	4	5	4	4	5	1	4	5	4	4	5	4	2	4	5	4	5	2	4	5	4	4	5	4	4	5	5
Q29	4	5	4	2	5	1	4	5	4	4	5	2	2	4	4	3	4	2	2	5	4	3	4	3	4	4	5
Q30	4	5	4	4	5	2	4	4	5	3	5	3	3	3	5	4	5	2	5	4	2	5	2	4	2	4	3
Q31	4	5	4	5	4	4	4	3	5	1	4	4	3	5	4	4	5	4	4	5	5	4	3	4	4	5	5
Q32	3	3	4	4	4	4	4	3	4	5	3	3	4	5	3	4	4	2	4	4	5	4	3	3	2	3	5
Q33	4	5	4	4	4	2	4	4	4	1	5	4	2	4	4	3	4	1	4	4	4	4	4	4	4	4	3
Q34	5	5	4	5	5	3	4	4	4	1	5	4	3	5	4	4	4	2	4	4	4	4	5	4	4	4	4
Q35	4	5	4	5	4	4	4	4	4	1	5	4	2	4	4	4	4	2	4	4	4	5	4	4	4	4	4
Q36	4	4	4	5	4	3	4	4	2	3	2	3	5	5	4	4	4	4	4	4	4	4	4	3	3	3	5
Q37	4	5	4	5	4	4	5	2	5	5	4	3	4	5	4	4	4	2	3	5	5	4	5	4	4	4	5
Q38	3	1	4	2	1	3	1	2	1	4	2	2	2	2	1	2	4	1	2	4	3	3	5	2	2	1	3
Q39	5	5	4	5	5	5	5	5	5	4	5	4	4	5	4	5	5	5	4	5	5	4	5	4	4	5	5
Q40	4	5	4	5	4	4	5	5	4	5	5	3	2	5	5	5	4	5	4	5	5	4	5	5	4	5	5
Q41	4	5	4	5	5	4	5	5	5	5	5	4	4	5	5	5	4	4	5	5	5	5	5	5	4	5	5
Q42	5	5	4	5	5	4	5	5	5	5	5	5	4	5	4	5	3	4	4	5	5	4	5	5	4	5	5
Q43	5	5	4	5	5	3	5	4	5	4	4	4	4	5	4	5	2	3	4	5	5	4	5	4	4	5	4
Q44	5	5	4	5	5	5	5	5	5	4	5	3	4	5	4	5	4	4	5	5	5	4	5	5	4	5	4
Q45	5	5	4	5	5	5	5	5	5	5	5	5	3	5	5	5	5	4	5	5	5	5	5	5	4	5	4
Q46	5	5	4	5	5	5	5	5	5	5	5	5	4	5	5	5	4	5	5	5	5	5	4	5	4	5	4

Table H.5 Descriptive Statistics for Phase II "did not achieve" and Phase II "achieved"

		Phase II "did not achieve" (N=45)			Phase II "achieved" (N=27)		
		Mean	StDev	Median	Mean	StDev	Median
Q1	Project members' communication built the customer's confidence in the innovation.	4.111	0.804	4	4.259	0.859	4
Q2	Project members sought feedback from their customer.	4.244	0.802	4	4.296	0.993	5
Q3	Project members understood how the customer intended to use the innovation.	4.356	0.802	4	4.296	1.031	5
Q4	The technology solved the customer's problem.	3.867	0.757	4	4.481	0.700	5
Q5	The innovation was presented to show it performed as required.	4.178	0.747	4	4.370	0.565	4
Q6	The highest level of testing the innovation received is best described by:	3.444	1.139	4	3.815	1.111	4
Q7	Analytical predictions were followed up with empirical testing.	4.089	0.763	4	4.148	0.770	4
Q8	The innovation's verification methodology followed a build-up approach (i.e., component > assembly > subsystem > system).	3.978	0.839	4	3.926	0.730	4
Q9	Workers were available for assignment to the project when needed.	4.356	0.712	4	4.296	0.724	4
Q10	Personnel were assigned to other projects when their services were no longer needed.	4.133	0.815	4	3.778	0.934	4
Q11	Multi-disciplined workers were valued more than single-discipline workers.	4.044	0.928	4	4.333	0.920	5
Q12	The project members developed a plan for Phase III at project's inception.	3.111	1.265	3	3.407	1.010	4
Q13	The project members understood the intended market for the innovation.	4.044	0.706	4	4.148	0.818	4
Q14	Project members gathered marketing data prior to end of Phase II.	3.289	1.100	4	3.481	1.122	4
Q15	Your company delivered the innovation within schedule constraints.	4.022	0.917	4	4.037	0.980	4
Q16	Your company delivered the innovation within budget constraints.	4.156	0.952	4	4.222	0.974	4
Q17	The project required additional funding, beyond the SBIR Phase II funding, to mature the innovation for use by a customer.	3.978	1.055	4	4.333	0.832	5
Q18	The project received internal research and development funds to bridge any post-Phase II funding gaps.	3.067	1.405	3	3.444	1.281	4

		Phase II "did not achieve" (N=45)			Phase II "achieved" (N=27)		
		Mean	StDev	Median	Mean	StDev	Median
Q19	The project received external funding to bridge any post-Phase II funding gaps.	2.244	1.190	2	3.111	1.340	3
Q20	The project members developed business contacts during the SBIR project for future sales opportunities.	3.533	1.079	4	3.815	0.921	4
Q21	A marketing plan was developed describing how the innovation would be introduced into its intended market.	3.200	1.079	3	3.407	1.083	4
Q22	The innovation developed from the SBIR project supported the goals of the company.	4.311	0.763	4	4.704	0.465	5
Q23	Top management believed the SBIR project should provide a revenue stream for the company.	3.978	0.892	4	4.333	0.734	4
Q24	Top management's desire was to increase the maturity of the innovation.	4.222	0.951	4	4.593	0.501	5
Q25	Top management's goal was to achieve sale to a customer from the innovation.	4.178	0.960	4	4.519	0.700	5
Q26	At the time of the SBIR project, the company was primarily focused on developing product-based innovations.	3.911	0.996	4	3.815	1.075	4
Q27	At the time of the SBIR project, the company was primarily focused on developing process-based innovations.	2.867	1.236	3	2.778	1.219	3
Q28	An individual with technical authority provided sustained support that facilitated progress of the innovation.	4.000	1.066	4	4.111	1.013	4
Q29	An individual with fiscal authority provided sustained support that facilitated progress of the innovation.	3.600	1.195	4	3.593	1.118	4
Q30	During the SBIR project, no active support was provided by any individual within NASA.	3.378	1.230	3	3.741	1.095	4
Q31	The company flexibly responded to customer priority changes.	3.822	0.716	4	4.111	0.892	4
Q32	The company researched demand for the innovation before the start of the project.	3.822	0.912	4	3.630	0.792	4
Q33	The customer provided input for project decisions.	3.467	1.014	4	3.667	1.000	4
Q34	Customer input was included in project decisions.	3.733	0.889	4	4.000	0.920	4
Q35	The customer was notified if inputs were included in project decisions.	3.800	0.869	4	3.889	0.892	4
Q36	Based on completion of the Phase II project, the innovation's maturity was:	3.467	1.140	4	3.741	0.764	4
Q37	At the conclusion of the SBIR Phase II project, the innovation worked as intended.	3.933	0.688	4	4.111	0.847	4

		Phase II "did not achieve" (N=45)			Phase II "achieved" (N=27)		
		Mean	StDev	Median	Mean	StDev	Median
Q38	The innovation required additional research and development at the conclusion of the SBIR Phase II project.	2.222	1.204	2	2.259	1.163	2
Q39	This group understood how to accomplish its tasks.	4.444	0.586	4	4.667	0.480	5
Q40	This group met all objectives for work completed.	4.222	0.704	4	4.481	0.753	5
Q41	This group's work was always of the highest quality.	4.356	0.570	4	4.704	0.465	5
Q42	This group took initiative in solving problems and decision making.	4.444	0.624	5	4.630	0.565	5
Q43	This group was very good at planning how to accomplish their work objectives.	4.178	0.777	4	4.333	0.784	4
Q44	This work group should continue working together as a unit in the future.	4.267	0.654	4	4.630	0.565	5
Q45	This group was not capable of working together as a unit.	4.444	0.841	5	4.778	0.506	5
Q46	As a work unit, this group showed signs of falling apart.	4.578	0.783	5	4.815	0.396	5

APPENDIX I

PRIMARY STUDY ANALYSIS

Appendix I contains a sensitivity analysis on the Primary Analysis, the detailed descriptive statistics for the Primary Analysis, Secondary Analyses, and shows the Technology Area mappings. Table I.1, I.2, and I.3 show the sensitivity analysis for the Team Performance variables (Q41, Q44, and Q45). Additional Binary Logistic Regression analysis was conducted using Q44 or Q45 instead of Q41 to see if they had an effect on the Primary Analysis results. Then all three variables were included to examine effects. The sensitivity analysis further shows that variable Q10 has questions about being included as a Success Variable. This leads the to a recommendation that the SBIR project manager must determine the optimal team makeup and strategy: keep the core team together if it makes sense in the context of the project and business or move team member on and off the project if that makes the most sense in the context of the project and business.

Table I.4 shows the information used to interpret the Mann-Whitney tests for the Primary Analysis. Table I.5 shows the information used to interpret the Mann-Whitney tests for the Secondary Analysis for success indicators in the six Technology Areas and indicators for Commercialization and Technology Infusion. Table I.6 shows a traceability

matrix the SBIR Program Manager developed to group 33 Technology Areas to 10 Technology Areas. Five of the grouped Technology Areas were further grouped due to limited data to allow contingency table analysis. An new Technology Area category "Other" was created from "Human health, Life Support & Habitation Systems", "Robotics, Tele-Robotics & Autonomous Systems", "Communication & Navigation", "Nanotechnology", and "Thermal Management Systems". Tables I.7 and I.8 show the grouping of Technology Areas from thirty-three categories to six categories. Table I.4 is for Phase II "did not achieve" and Table I.5 is for Phase II "achieved". Note, when grouping Technology Areas, responses for multiple technologies grouped together were consolidated into a single response to eliminate bias since categories did not have necessarily have the same number of technologies within groups.

Table I.1 Binary Logistic Regression for Primary Analysis

Predictor	Coef	SE Coef	Z	p-value	Odds Ratio	95% CI Lower	95% CI Upper	
Constant	-8.54826	3.73061	-2.29	0.022				
Q4	1.25436	0.472407	2.66	0.008	3.51	1.39	8.85	Significant
Q10	-0.714292	0.353792	-2.02	0.043	0.49	0.24	0.98	Significant
Q19	0.661981	0.267510	2.47	0.013	1.94	1.15	3.27	Significant
Q22	0.0944978	0.491160	0.19	0.847	1.10	0.42	2.88	
Q31	0.461780	0.418429	1.10	0.270	1.59	0.70	3.60	
Q44	0.349656	0.485636	0.72	0.472	1.42	0.55	3.67	

Goodness-of-Fit Tests			
Method:	**Chi-Square**	**DF**	**p-value**
Pearson	57.8171	54	0.336
Deviance	64.8887	54	0.147
Hosmer-Lemeshow	12.4776	8	0.131

Table I.2 Binary Logistic Regression for Primary Analysis

Predictor	Coef	SE Coef	Z	p-value	Odds Ratio	95% CI Lower	95% CI Upper	
Constant	-9.79284	4.13086	-2.37	0.018				
Q4	1.27022	0.479032	2.65	0.008	3.56	1.39	9.11	Significant
Q10	-0.634925	0.358293	-1.77	0.076	0.53	0.26	1.07	
Q19	0.716258	0.275003	2.60	0.009	2.05	1.19	3.51	Significant
Q22	0.0857645	0.490343	0.17	0.861	1.09	0.42	2.85	
Q31	0.467139	0.426102	1.10	0.273	1.60	0.69	3.68	
Q45	0.493884	0.450465	1.10	0.273	1.64	0.68	3.96	

Goodness-of-Fit Tests			
Method:	**Chi-Square**	**DF**	**p-value**
Pearson	63.6396	53	0.150
Deviance	66.8941	53	0.095
Hosmer-Lemeshow	8.3081	8	0.404

Table I.3 Binary Logistic Regression for Primary Analysis

Predictor	Coef	SE Coef	Z	p-value	Odds Ratio	95% CI		
						Lower	Upper	
Constant	-11.1242	4.59372	-2.42	0.015				
Q4	1.22510	0.485465	2.52	0.012	3.40	1.31	8.82	Significant
Q10	-0.627146	0.358469	-1.75	0.080	0.53	0.26	1.08	
Q19	0.724258	0.279352	2.59	0.010	2.06	1.19	3.57	Significant
Q22	-0.005221	0.507857	-0.01	0.992	0.99	0.37	2.69	
Q31	0.419831	0.430135	0.98	0.329	1.52	0.65	3.54	
Q41	0.419155	0.741025	0.57	0.572	1.52	0.36	6.50	
Q44	0.0901949	0.567011	0.16	0.874	1.09	0.36	3.33	
Q45	0.440674	0.450210	0.98	0.328	1.55	0.64	3.75	

Goodness-of-Fit Tests			
Method:	**Chi-Square**	**DF**	**p-value**
Pearson	64.6395	55	0.175
Deviance	66.2975	55	0.141
Hosmer-Lemeshow	14.2958	8	0.074

Table I.4 Descriptive Statistics for Primary Analysis

	Phase II "did not achieve"			Phase II "achieved"			Mann-Whitney
Variable	N	Mean	StDev	N	Mean	StDev	p-value
Q1	45	4.111	0.804	27	4.259	0.859	0.294
Q2	45	4.244	0.802	27	4.296	0.993	0.400
Q3	45	4.356	0.802	27	4.296	1.031	0.831
Q4	45	3.867	0.757	27	4.481	0.700	**0.001**
Q5	45	4.178	0.747	27	4.370	0.565	0.205
Q6	45	3.444	1.139	27	3.815	1.111	0.177
Q7	45	4.089	0.763	27	4.148	0.770	0.783
Q8	45	3.978	0.839	27	3.926	0.730	0.900
Q9	45	4.356	0.712	27	4.296	0.724	0.525
Q10	45	4.133	0.815	27	3.778	0.934	**0.025**
Q11	45	4.044	0.928	27	4.333	0.920	0.152
Q12	45	3.111	1.265	27	3.407	1.010	0.403
Q13	45	4.044	0.706	27	4.148	0.818	0.374
Q14	45	3.289	1.100	27	3.481	1.122	0.357
Q15	45	4.022	0.917	27	4.037	0.980	0.876
Q16	45	4.156	0.952	27	4.222	0.974	0.540
Q17	45	3.978	1.055	27	4.333	0.832	0.345
Q18	45	3.067	1.405	27	3.444	1.281	0.167
Q19	45	2.244	1.190	27	3.111	1.340	**0.004**
Q20	45	3.533	1.079	27	3.815	0.921	0.254
Q21	45	3.200	1.079	27	3.407	1.083	0.368
Q22	45	4.311	0.763	27	4.704	0.465	**0.022**
Q23	45	3.978	0.892	27	4.333	0.734	0.102
Q24	45	4.222	0.951	27	4.593	0.501	0.102
Q25	45	4.178	0.960	27	4.519	0.700	0.077
Q26	45	3.911	0.996	27	3.815	1.075	0.771
Q27	45	2.867	1.236	27	2.778	1.219	0.783
Q28	45	4.000	1.066	27	4.111	1.013	0.702
Q29	45	3.600	1.195	27	3.593	1.118	0.942
Q30	45	3.378	1.230	27	3.741	1.095	0.235
Q31	45	3.822	0.716	27	4.111	0.892	**0.050**
Q32	45	3.822	0.912	27	3.630	0.792	0.315
Q33	45	3.467	1.014	27	3.667	1.000	0.318
Q34	45	3.733	0.889	27	4.000	0.920	0.124
Q35	45	3.800	0.869	27	3.889	0.892	0.462
Q36	45	3.467	1.140	27	3.741	0.764	0.393
Q37	45	3.933	0.688	27	4.111	0.847	0.122
Q38	45	2.222	1.204	27	2.259	1.163	0.584
Q39	45	4.444	0.586	27	4.667	0.480	0.119
Q40	45	4.222	0.704	27	4.481	0.753	0.070
Q41	45	4.356	0.570	27	4.704	0.465	**0.011**
Q42	45	4.444	0.624	27	4.630	0.565	0.199
Q43	45	4.178	0.777	27	4.333	0.784	0.483
Q44	45	4.267	0.654	27	4.630	0.565	**0.034**
Q45	45	4.444	0.841	27	4.778	0.506	**0.045**
Q46	45	4.578	0.783	27	4.815	0.396	0.352

Table I.5 Descriptive Statistics for Secondary Analysis

Aviation/Aeronautics

	Phase II "did not achieve"			Phase II "achieved"			Mann-Whitney
Variable	N	Mean	StDev	N	Mean	StDev	p-value
Q1	19	4.158	0.688	12	4.083	0.793	0.945
Q2	19	4.474	0.612	12	4.167	0.937	0.418
Q3	19	4.368	0.684	12	4.333	0.888	0.911
Q4	19	4.000	0.667	12	4.500	0.798	0.052
Q5	19	4.263	0.653	12	4.417	0.515	0.581
Q6	19	3.737	1.147	12	4.083	0.793	0.497
Q7	19	4.158	0.898	12	4.000	0.853	0.561
Q8	19	4.105	0.875	12	3.750	0.866	0.251
Q9	19	4.474	0.612	12	4.417	0.515	0.695
Q10	19	4.211	0.713	12	3.750	0.866	0.099
Q11	19	4.105	0.994	12	4.333	1.073	0.446
Q12	19	3.368	1.300	12	3.083	0.793	0.327
Q13	19	4.000	0.745	12	4.000	0.739	0.961
Q14	19	3.421	1.121	12	3.250	1.215	0.782
Q15	19	4.053	0.911	12	4.500	0.522	0.195
Q16	19	4.368	0.955	12	4.500	0.522	0.909
Q17	19	3.737	1.284	12	4.250	0.754	0.390
Q18	19	3.474	1.541	12	3.917	0.900	0.659
Q19	19	2.474	1.429	12	3.250	1.288	0.125
Q20	19	3.842	0.898	12	3.750	0.866	0.835
Q21	19	3.105	1.150	12	3.500	1.168	0.302
Q22	19	4.474	0.612	12	4.583	0.515	0.693
Q23	19	3.947	0.848	12	4.167	0.835	0.517
Q24	19	4.526	0.513	12	4.667	0.492	0.462
Q25	19	4.526	0.612	12	4.417	0.515	0.503
Q26	19	4.000	1.106	12	3.583	1.311	0.406
Q27	19	2.842	1.167	12	2.833	1.337	0.867
Q28	19	4.053	1.026	12	4.500	0.522	0.301
Q29	19	3.632	1.422	12	4.000	0.603	0.879
Q30	19	3.316	1.204	12	3.667	1.155	0.433
Q31	19	3.789	0.787	12	3.917	1.165	0.415
Q32	19	4.000	0.943	12	3.500	0.905	0.115
Q33	19	3.368	1.165	12	3.750	0.866	0.254
Q34	19	3.789	0.976	12	3.917	0.996	0.659
Q35	19	3.842	1.015	12	3.833	0.937	0.926
Q36	19	3.737	0.872	12	3.667	0.492	0.447
Q37	19	4.053	0.780	12	4.167	0.835	0.598
Q38	19	2.421	1.305	12	2.833	1.267	0.348
Q39	19	4.684	0.478	12	4.583	0.515	0.591
Q40	19	4.368	0.831	12	4.667	0.492	0.364
Q41	19	4.474	0.513	12	4.750	0.452	0.142
Q42	19	4.737	0.452	12	4.583	0.669	0.608
Q43	19	4.474	0.612	12	4.250	0.866	0.539
Q44	19	4.474	0.697	12	4.583	0.515	0.816
Q45	19	4.579	0.961	12	4.917	0.289	0.226
Q46	19	4.526	1.020	12	4.750	0.452	0.832

Table I.5 Descriptive Statistics for Secondary Analysis (Continued)

Space Power & Energy Storage

	Phase II "did not achieve"			Phase II "achieved"			Mann-Whitney
Variable	N	Mean	StDev	N	Mean	StDev	p-value
Q1	22	4.045	0.575	10	4.300	0.949	0.144
Q2	22	4.227	0.685	10	4.700	0.483	0.065
Q3	22	4.273	0.703	10	4.300	0.823	0.860
Q4	22	3.955	0.722	10	4.700	0.483	**0.008**
Q5	22	4.273	0.631	10	4.300	0.483	1.000
Q6	22	3.227	1.152	10	3.700	0.949	0.268
Q7	22	4.045	0.722	10	3.800	0.789	0.393
Q8	22	4.227	0.685	10	4.000	0.667	0.380
Q9	22	4.318	0.839	10	4.500	0.527	0.752
Q10	22	3.864	0.990	10	3.900	0.738	0.857
Q11	22	4.136	0.990	10	4.600	0.699	0.195
Q12	22	3.227	1.270	10	3.600	0.699	0.713
Q13	22	3.909	0.750	10	4.200	0.632	0.321
Q14	22	3.364	0.953	10	3.600	0.843	0.532
Q15	22	3.909	0.868	10	4.100	0.738	0.656
Q16	22	4.000	1.113	10	4.500	0.707	0.217
Q17	22	3.727	1.279	10	4.200	1.033	0.354
Q18	22	3.227	1.478	10	3.700	1.059	0.475
Q19	22	2.364	1.217	10	2.700	1.160	0.378
Q20	22	3.455	1.143	10	4.000	0.667	0.258
Q21	22	3.091	0.921	10	3.800	0.919	0.058
Q22	22	4.409	0.666	10	4.800	0.422	0.105
Q23	22	3.909	1.019	10	4.400	0.843	0.188
Q24	22	4.409	0.590	10	4.700	0.483	0.194
Q25	22	4.318	0.894	10	4.800	0.422	0.137
Q26	22	3.864	1.037	10	4.000	1.247	0.609
Q27	22	2.818	1.296	10	2.800	1.398	0.983
Q28	22	4.000	0.926	10	4.200	1.229	0.336
Q29	22	3.545	1.299	10	3.500	1.434	1.000
Q30	22	3.091	1.231	10	4.100	1.197	**0.035**
Q31	22	3.773	0.612	10	4.100	0.568	0.163
Q32	22	4.000	0.873	10	3.600	0.516	0.090
Q33	22	3.455	1.057	10	3.900	0.738	0.183
Q34	22	3.727	0.827	10	4.400	0.699	**0.033**
Q35	22	3.955	0.785	10	4.300	0.483	0.252
Q36	22	3.409	1.182	10	3.800	0.789	0.413
Q37	22	4.045	0.575	10	4.200	0.632	0.498
Q38	22	2.318	1.211	10	2.600	1.265	0.467
Q39	22	4.500	0.598	10	4.700	0.483	0.395
Q40	22	4.227	0.752	10	4.500	0.527	0.385
Q41	22	4.455	0.510	10	4.800	0.422	0.076
Q42	22	4.500	0.598	10	4.600	0.516	0.726
Q43	22	4.318	0.839	10	4.400	0.699	1.000
Q44	22	4.273	0.703	10	4.800	0.422	**0.038**
Q45	22	4.545	0.963	10	5.000	0.000	***
Q46	22	4.500	1.012	10	4.900	0.316	0.260

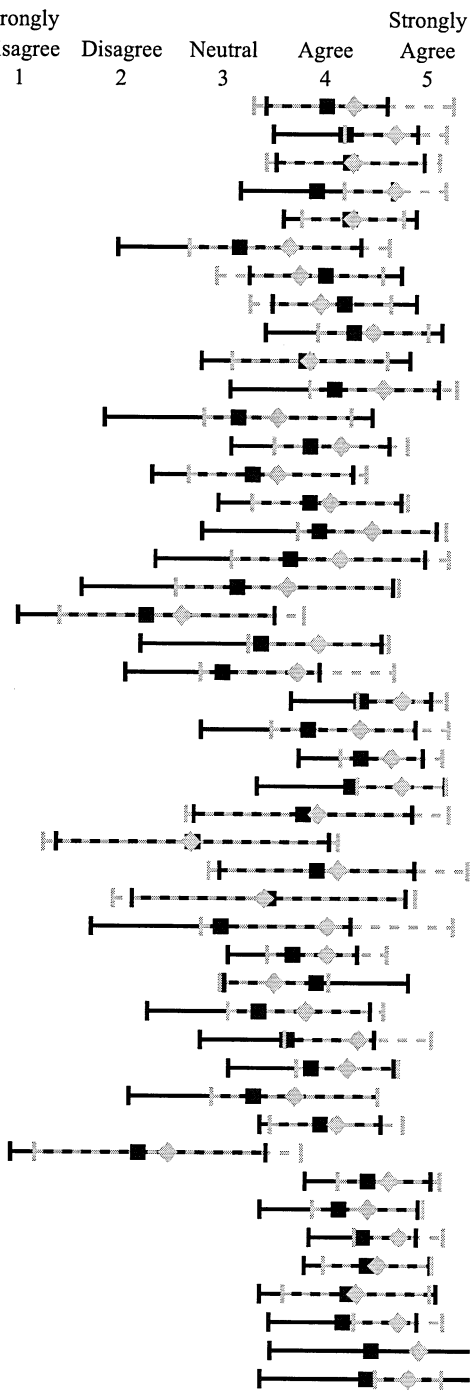


Table I.5 Descriptive Statistics for Secondary Analysis (Continued)

Science Instruments, Observatories & Sensor Systems

	Phase II "did not achieve"			Phase II "achieved"			Mann-Whitney
Variable	N	Mean	StDev	N	Mean	StDev	p-value
Q1	17	4.294	0.686	13	4.462	0.877	0.329
Q2	17	4.412	0.618	13	4.308	1.109	0.708
Q3	17	4.471	0.624	13	4.538	0.877	0.468
Q4	17	3.765	0.752	13	4.615	0.650	**0.005**
Q5	17	4.353	0.493	13	4.308	0.630	0.942
Q6	17	3.471	1.179	13	3.462	1.198	1.000
Q7	17	4.353	0.702	13	4.308	0.751	0.909
Q8	17	4.118	0.928	13	3.923	0.862	0.503
Q9	17	4.353	0.702	13	4.231	0.599	0.546
Q10	17	4.059	1.088	13	3.923	0.954	0.418
Q11	17	3.824	1.015	13	4.231	1.013	0.243
Q12	17	3.176	1.286	13	3.308	0.855	0.965
Q13	17	4.353	0.493	13	4.231	0.439	0.493
Q14	17	3.412	1.121	13	3.231	1.301	0.758
Q15	17	4.000	0.866	13	3.923	0.954	0.859
Q16	17	4.412	0.712	13	4.231	0.927	0.679
Q17	17	4.059	1.144	13	4.692	0.480	0.132
Q18	17	3.059	1.435	13	3.615	1.387	0.352
Q19	17	2.471	1.463	13	3.231	1.481	0.190
Q20	17	3.824	0.883	13	3.846	0.987	0.823
Q21	17	3.176	1.237	13	2.846	1.068	0.487
Q22	17	4.471	0.874	13	4.692	0.480	0.667
Q23	17	4.118	0.857	13	4.231	0.599	0.889
Q24	17	4.353	0.996	13	4.462	0.519	0.868
Q25	17	4.294	0.849	13	4.462	0.877	0.468
Q26	17	4.235	0.970	13	4.000	0.913	0.365
Q27	17	3.294	1.263	13	3.000	1.354	0.548
Q28	17	4.118	1.166	13	4.308	0.855	0.945
Q29	17	3.765	1.251	13	3.769	1.092	0.912
Q30	17	3.647	1.115	13	3.846	1.144	0.633
Q31	17	3.824	0.728	13	4.077	0.760	0.367
Q32	17	3.941	0.899	13	3.462	0.776	0.126
Q33	17	3.471	1.125	13	3.923	0.641	0.201
Q34	17	3.882	0.928	13	4.231	0.599	0.311
Q35	17	3.882	0.857	13	3.923	0.641	0.865
Q36	17	3.294	0.985	13	3.769	0.832	0.206
Q37	17	3.765	0.752	13	4.000	0.913	0.371
Q38	17	2.000	1.225	13	2.000	1.225	0.964
Q39	17	4.412	0.507	13	4.538	0.519	0.513
Q40	17	4.412	0.507	13	4.231	0.927	0.851
Q41	17	4.412	0.507	13	4.692	0.480	0.140
Q42	17	4.471	0.624	13	4.615	0.506	0.580
Q43	17	4.118	0.697	13	4.462	0.519	0.182
Q44	17	4.118	0.697	13	4.538	0.660	0.095
Q45	17	4.529	0.514	13	4.692	0.630	0.274
Q46	17	4.529	0.624	13	4.692	0.480	0.518

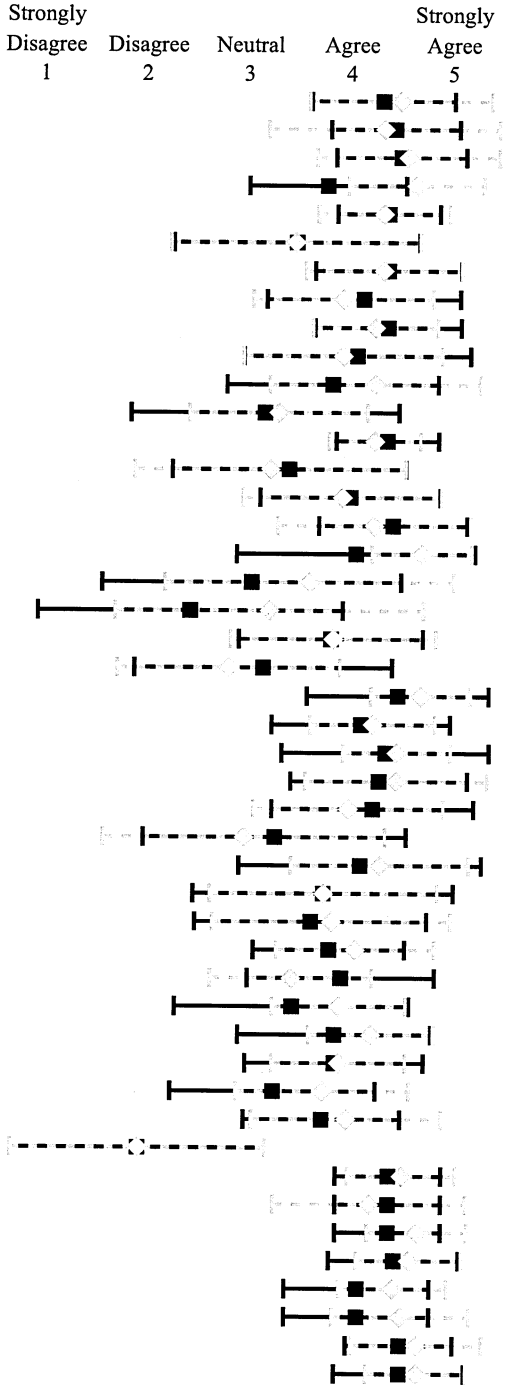


Table I.5 Descriptive Statistics for Secondary Analysis (Continued)

Modeling, Simulation, Information Technology & Processing

	Phase II "did not achieve"			Phase II "achieved"			Mann-Whitney
Variable	N	Mean	StDev	N	Mean	StDev	p-value
Q1	20	4.000	0.918	14	4.143	0.864	0.611
Q2	20	4.150	0.988	14	4.286	0.914	0.648
Q3	20	4.050	0.999	14	4.071	1.141	0.808
Q4	20	3.950	0.686	14	4.500	0.760	**0.029**
Q5	20	4.200	0.951	14	4.571	0.514	0.246
Q6	20	3.650	1.089	14	4.214	0.975	0.111
Q7	20	3.900	0.788	14	4.214	0.802	0.275
Q8	20	3.950	0.759	14	4.214	0.579	0.332
Q9	20	4.300	0.801	14	4.286	0.825	0.985
Q10	20	4.150	0.671	14	3.357	1.082	**0.011**
Q11	20	3.800	0.951	14	4.286	0.914	0.145
Q12	20	3.050	1.356	14	3.571	1.222	0.270
Q13	20	4.050	0.605	14	4.143	1.099	0.340
Q14	20	3.300	1.031	14	3.857	1.167	0.112
Q15	20	3.950	1.099	14	4.286	1.069	0.322
Q16	20	4.200	0.951	14	4.500	1.092	0.108
Q17	20	4.100	0.788	14	3.929	1.072	0.792
Q18	20	3.300	1.455	14	3.571	1.222	0.678
Q19	20	2.000	1.076	14	2.857	1.460	0.092
Q20	20	3.400	1.188	14	3.857	0.949	0.256
Q21	20	3.200	1.056	14	3.857	0.864	0.061
Q22	20	4.100	0.912	14	4.786	0.426	**0.011**
Q23	20	3.800	1.005	14	4.571	0.756	**0.016**
Q24	20	4.000	1.170	14	4.786	0.426	**0.011**
Q25	20	3.850	1.182	14	4.714	0.469	**0.017**
Q26	20	3.850	1.040	14	4.000	1.177	0.478
Q27	20	3.100	1.252	14	2.714	1.204	0.378
Q28	20	3.950	1.050	14	4.000	1.177	0.717
Q29	20	3.350	1.182	14	3.571	1.222	0.555
Q30	20	3.250	1.251	14	3.571	1.089	0.470
Q31	20	4.100	0.718	14	4.286	1.069	0.214
Q32	20	3.700	1.031	14	3.929	0.917	0.565
Q33	20	3.600	0.995	14	3.357	1.216	0.623
Q34	20	3.800	0.951	14	3.786	1.122	0.872
Q35	20	3.800	0.894	14	3.786	1.051	0.839
Q36	20	3.800	1.105	14	4.000	0.679	0.878
Q37	20	4.150	0.671	14	4.429	0.852	0.143
Q38	20	2.150	0.933	14	2.357	1.151	0.647
Q39	20	4.450	0.605	14	4.786	0.426	0.091
Q40	20	4.200	0.834	14	4.857	0.363	**0.008**
Q41	20	4.400	0.503	14	4.786	0.426	**0.030**
Q42	20	4.500	0.607	14	4.643	0.633	0.413
Q43	20	4.100	0.788	14	4.214	0.975	0.521
Q44	20	4.300	0.657	14	4.643	0.497	0.130
Q45	20	4.500	0.607	14	4.857	0.363	0.062
Q46	20	4.600	0.598	14	4.857	0.363	0.179

Table I.5 Descriptive Statistics for Secondary Analysis (Continued)

Materials, Structures, Mechanical Systems & Manufacturing

	Phase II "did not achieve"			Phase II "achieved"			Mann-Whitney
Variable	N	Mean	StDev	N	Mean	StDev	p-value
Q1	20	4.150	0.671	6	4.667	0.516	0.099
Q2	20	4.450	0.605	6	4.833	0.408	0.161
Q3	20	4.600	0.503	6	4.500	0.837	1.000
Q4	20	3.850	0.813	6	4.667	0.516	**0.029**
Q5	20	4.200	0.616	6	4.833	0.408	**0.027**
Q6	20	3.600	0.995	6	3.500	1.225	0.948
Q7	20	4.050	0.887	6	4.000	0.894	0.872
Q8	20	4.200	0.768	6	4.000	0.632	0.532
Q9	20	4.450	0.686	6	4.667	0.516	0.555
Q10	20	4.150	0.875	6	4.000	1.095	0.839
Q11	20	4.100	1.021	6	4.333	1.033	0.576
Q12	20	3.400	1.314	6	3.833	0.753	0.695
Q13	20	4.000	0.649	6	4.333	0.816	0.297
Q14	20	3.450	1.050	6	4.333	0.516	**0.050**
Q15	20	3.950	0.945	6	4.333	0.816	0.399
Q16	20	4.250	0.851	6	4.833	0.408	0.103
Q17	20	3.900	1.071	6	3.833	1.472	0.924
Q18	20	2.850	1.348	6	3.667	1.366	0.220
Q19	20	2.000	0.725	6	3.000	1.265	0.076
Q20	20	3.700	0.733	6	4.000	0.632	0.392
Q21	20	3.300	0.923	6	3.833	0.753	0.210
Q22	20	4.300	0.801	6	4.833	0.408	0.107
Q23	20	4.000	0.973	6	4.667	0.516	0.099
Q24	20	4.200	1.056	6	4.833	0.408	0.107
Q25	20	4.200	0.951	6	5.000	0.000	***
Q26	20	4.050	0.945	6	4.000	1.095	1.000
Q27	20	2.400	1.046	6	1.833	0.983	0.268
Q28	20	4.050	1.050	6	4.333	0.516	0.817
Q29	20	3.500	1.000	6	3.667	1.033	0.743
Q30	20	3.650	1.089	6	3.500	1.049	0.800
Q31	20	4.000	0.858	6	4.500	0.837	0.217
Q32	20	3.700	0.865	6	4.167	0.753	0.264
Q33	20	3.750	0.851	6	3.667	0.516	0.707
Q34	20	3.850	0.933	6	4.500	0.548	0.125
Q35	20	3.850	0.813	6	4.167	0.408	0.433
Q36	20	3.600	0.995	6	4.167	1.169	0.134
Q37	20	4.000	0.649	6	4.833	0.408	**0.008**
Q38	20	2.400	1.231	6	2.500	1.378	0.873
Q39	20	4.500	0.607	6	5.000	0.000	***
Q40	20	4.350	0.671	6	4.833	0.408	0.107
Q41	20	4.350	0.671	6	5.000	0.000	***
Q42	20	4.550	0.605	6	5.000	0.000	***
Q43	20	4.300	0.801	6	4.833	0.408	0.140
Q44	20	4.400	0.598	6	4.833	0.408	0.111
Q45	20	4.450	0.759	6	4.833	0.408	0.225
Q46	20	4.550	0.605	6	4.667	0.516	0.748

Table I.5 Descriptive Statistics for Secondary Analysis (Continued)

Other

	Phase II "did not achieve"			Phase II "achieved"			Mann-Whitney
Variable	N	Mean	StDev	N	Mean	StDev	p-value
Q1	18	4.111	0.583	4	4.000	1.414	0.735
Q2	18	4.333	0.594	4	3.500	1.291	0.175
Q3	18	4.278	0.669	4	4.000	1.414	1.000
Q4	18	3.778	0.647	4	3.750	0.957	0.888
Q5	18	4.278	0.669	4	4.250	0.500	0.886
Q6	18	3.222	0.943	4	2.500	0.577	0.166
Q7	18	4.056	0.802	4	3.500	0.577	0.146
Q8	18	4.111	0.758	4	3.750	0.957	0.441
Q9	18	4.222	0.808	4	4.500	0.577	0.603
Q10	18	3.944	0.998	4	4.250	0.500	0.716
Q11	18	3.944	0.938	4	4.000	1.414	0.715
Q12	18	3.000	1.237	4	2.750	0.957	0.659
Q13	18	3.889	0.583	4	4.250	0.500	0.277
Q14	18	3.556	0.784	4	3.250	0.957	0.572
Q15	18	3.667	0.907	4	3.750	0.957	1.000
Q16	18	3.778	1.060	4	3.750	0.500	0.743
Q17	18	3.944	0.938	4	4.750	0.500	0.089
Q18	18	3.056	1.349	4	3.000	1.155	0.964
Q19	18	2.278	0.895	4	3.750	0.500	**0.011**
Q20	18	3.778	1.003	4	3.250	0.957	0.313
Q21	18	3.278	0.958	4	3.000	1.155	0.689
Q22	18	4.333	0.594	4	4.750	0.500	0.211
Q23	18	3.889	0.963	4	4.250	0.500	0.618
Q24	18	4.278	0.461	4	4.250	0.500	0.956
Q25	18	4.222	0.808	4	4.500	0.577	0.603
Q26	18	4.111	0.676	4	3.500	1.000	0.268
Q27	18	2.778	1.166	4	2.000	0.816	0.247
Q28	18	3.611	1.145	4	4.250	0.500	0.381
Q29	18	3.333	1.283	4	4.000	0.816	0.399
Q30	18	3.333	1.085	4	4.000	1.414	0.312
Q31	18	3.889	0.676	4	4.250	0.500	0.334
Q32	18	3.667	0.767	4	3.250	0.957	0.372
Q33	18	3.444	0.856	4	4.000	0.000	***
Q34	18	3.556	0.984	4	4.250	0.500	0.190
Q35	18	3.611	0.850	4	4.000	0.000	***
Q36	18	3.333	1.138	4	3.000	0.816	0.384
Q37	18	4.000	0.485	4	4.250	0.500	0.383
Q38	18	2.167	1.150	4	1.500	0.577	0.287
Q39	18	4.389	0.608	4	4.500	0.577	0.810
Q40	18	4.222	0.732	4	4.250	0.500	1.000
Q41	18	4.444	0.511	4	4.750	0.500	0.303
Q42	18	4.333	0.594	4	4.750	0.500	0.211
Q43	18	4.056	0.802	4	4.500	0.577	0.320
Q44	18	4.333	0.594	4	4.750	0.500	0.211
Q45	18	4.389	0.850	4	4.750	0.500	0.465
Q46	18	4.556	0.616	4	4.750	0.500	0.614

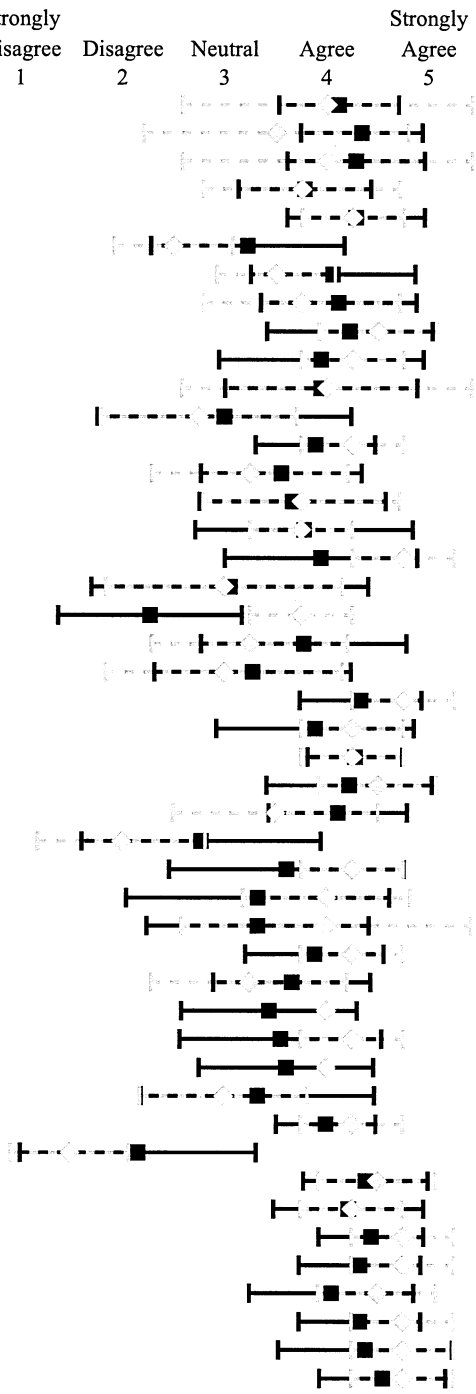


Table I.5 Descriptive Statistics for Secondary Analysis (Continued)

	Technology Infusion			Commercialization			Mann-Whitney
Variable	N	Mean	StDev	N	Mean	StDev	p-value
Q1	16	4.250	1.000	8	4.125	0.641	0.401
Q2	16	4.375	0.885	8	4.250	1.035	0.811
Q3	16	4.250	0.931	8	4.125	1.356	1.000
Q4	16	4.438	0.727	8	4.625	0.744	0.476
Q5	16	4.375	0.500	8	4.500	0.535	0.591
Q6	16	3.563	1.153	8	4.375	0.744	0.103
Q7	16	3.875	0.806	8	4.375	0.518	0.138
Q8	16	4.000	0.632	8	3.875	0.991	0.945
Q9	16	4.438	0.629	8	4.000	0.926	0.246
Q10	16	3.688	1.078	8	3.750	0.707	0.872
Q11	16	4.313	0.946	8	4.125	0.991	0.661
Q12	16	3.313	1.014	8	3.625	1.188	0.351
Q13	16	4.125	0.806	8	4.125	0.991	0.865
Q14	16	3.563	0.964	8	3.375	1.506	0.974
Q15	16	4.125	0.719	8	4.125	1.356	0.486
Q16	16	4.375	0.619	8	4.250	1.389	0.585
Q17	16	4.375	0.885	8	3.750	1.035	0.122
Q18	16	3.063	1.237	8	4.375	0.744	**0.012**
Q19	16	2.875	1.147	8	3.375	1.408	0.373
Q20	16	3.688	1.014	8	3.875	0.835	0.705
Q21	16	3.313	1.078	8	3.750	1.165	0.277
Q22	16	4.563	0.512	8	4.875	0.354	0.144
Q23	16	4.188	0.750	8	4.500	0.756	0.319
Q24	16	4.438	0.512	8	4.875	0.354	**0.049**
Q25	16	4.438	0.814	8	4.625	0.518	0.724
Q26	16	3.813	1.109	8	3.750	1.165	0.923
Q27	16	2.563	1.031	8	3.125	1.642	0.394
Q28	16	4.188	0.981	8	4.125	0.991	0.918
Q29	16	3.625	1.258	8	3.750	1.035	0.974
Q30	16	3.813	1.223	8	3.750	1.035	0.798
Q31	16	4.313	0.602	8	3.625	1.188	0.118
Q32	16	3.563	0.727	8	3.750	1.035	0.599
Q33	16	4.000	0.632	8	3.000	1.309	**0.016**
Q34	16	4.313	0.602	8	3.375	1.188	**0.030**
Q35	16	4.188	0.403	8	3.500	1.309	0.182
Q36	16	3.563	0.814	8	4.000	0.535	0.202
Q37	16	4.250	0.683	8	3.875	1.246	0.666
Q38	16	2.563	1.209	8	2.125	1.126	0.429
Q39	16	4.688	0.479	8	4.625	0.518	0.793
Q40	16	4.375	0.619	8	4.875	0.354	**0.048**
Q41	16	4.625	0.500	8	4.875	0.354	0.228
Q42	16	4.625	0.619	8	4.625	0.518	0.882
Q43	16	4.313	0.873	8	4.125	0.641	0.383
Q44	16	4.688	0.602	8	4.375	0.518	0.130
Q45	16	4.875	0.342	8	4.750	0.463	0.477
Q46	16	4.750	0.447	8	4.875	0.354	0.514

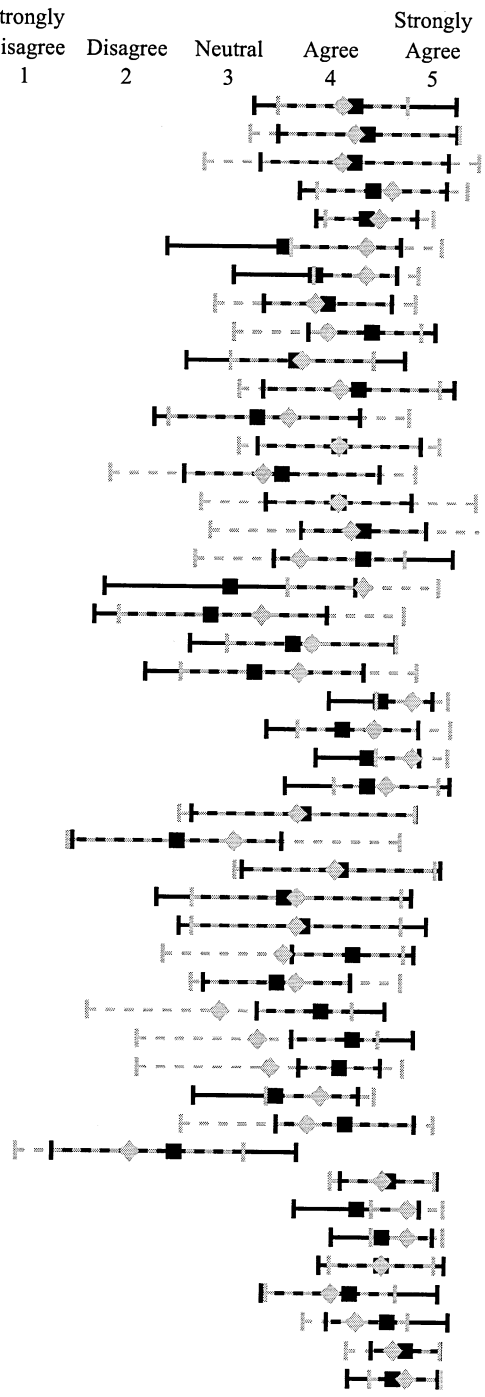


Table I.6 Technology Area Grouping Trace

Technology Areas as Collected	Grouped Technology Areas
Acoustics/Vibroacoustics	Aviation/Aeronautics
Aerodynamics	
Aeronautics	
Aerospace	
Aircraft Systems/Subsystem	
Aviation	
Test/Measurement	
Energy	Space Power & Energy Storage
Physics	
Power/Propulsion	
Space Systems	
Robotics	Robotics, Tele-Robotics & Autonomous Systems*
Communications	Communication & Navigation*
Biological/Physical Sciences	Human health, Life Support & Habitation Systems*
Biomedical/Medical	
Life Sciences	
Chemistry	Science Instruments, Observatories & Sensor Systems
Earth/Environmental Sciences	
Instrumentation	
Optics	
Sensors	
Nanotechnology	Nanotechnology*
Electronic Components	Modeling, Simulation, Information Technology & Processing
Electronic Circuits	
Electronic Systems	
Information Sciences/Data Handling	
Software	
Machinery/Automation	Materials, Structures, Mechanical Systems & Manufacturing
Manufacturing/Fabrication	
Materials	
Mechanical	
Transportation	
Cryogenic Sciences	Thermal Management Systems*

*Additional grouping, "Other", created due to limited data to allow contingency table analysis.

Table I.7 Phase II "did not achieve" Technology Area Mapping

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	Total
Aviation/Aeronautics	Acoustics/Vibroacoustics																																														0
	Aerodynamics																																					X									1
	Aeronautics																		X																	X											2
	Aerospace	X							X				X		X	X					X						X	X								X	X		X	X							12
	Aircraft Systems/Subsystem																		X					X				X																			3
	Aviation																																														0
	Test/Measurement				X					X																	X					X							X				X				6
Space Power & Energy Storage	Energy																									X					X												X				3
	Physics													X																								X		X		X					4
	Power/Propulsion			X												X								X				X				X															5
	Space Systems	X	X		X	X		X	X					X	X		X											X								X			X	X			X				14
Science Instruments, Oberservatories & Sensor Systems	Chemistry																				X														X					X							3
	Earth/Environmental Sciences																																									X		X	X		3
	Instrumentation									X		X															X								X							X	X				6
	Optics									X					X			X			X																			X		X					6
	Sensors																	X				X	X		X		X	X				X											X	X	X		10
Modeling, Simulation, Information Technology & Processing	Electronic Components		X										X										X					X							X						X					X	7
	Electronic Circuits		X																				X			X									X												4
	Electronic Systems		X																			X	X			X									X	X											6
	Information Sciences/Data Handling				X	X											X								X				X						X												6
	Software				X	X								X					X	X			X		X				X								X	X									10
Materials, Structures, Mechanical Systems & Manufacturing	Machinery/Automation	X																							X								X														3
	Manufacturing/Fabrication						X				X		X								X												X													X	6
	Materials		X				X				X	X	X		X	X					X									X			X	X	X	X			X	X						X	16
	Mechanical	X									X												X																								3
	Transportation					X																																									1
Other	Biological/Physical Sciences							X						X																					X							X					4
	Biomedical/Medical											X											X												X							X					4
	Communications		X														X	X				X																									4
	Cryogenic Sciences														X	X																		X													3
	Life Sciences							X																											X			X				X	X				5
	Nanotechnology											X	X																	X					X												4
	Robotics	X																																													1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	Total
Aviation/Aeronautics	X			X				X	X			X		X	X			X		X			X			X	X				X				X	X	X	X	X			X				19
Space Power & Energy Storage	X	X	X	X	X		X	X					X	X	X	X							X		X		X			X	X				X		X	X	X		X	X				22
Science Instruments, Oberservatories & Sensor Systems									X		X			X			X			X	X	X		X		X	X				X			X					X		X	X	X	X		17
Modeling, Simulation, Information Technology & Processing		X		X	X							X	X			X		X	X		X	X		X	X		X	X						X	X	X	X			X					X	20
Materials, Structures, Mechanical Systems & Manufacturing	X	X			X	X				X	X	X		X	X					X		X		X					X			X	X	X	X			X	X						X	20
Other	X	X					X				X	X	X	X	X	X	X				X	X							X				X	X			X				X	X				18

Table I.8 Phase II "achieved" Technology Area Mapping

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Total	C	TI	B
Aviation/Aeronautics	Acoustics/Vibroacoustics																												0	0	0	0
	Aerodynamics																										X		1	0	0	1
	Aeronautics																										X		1	0	0	1
	Aerospace	X																X			X		X	X	X				6	1	5	0
	Aircraft Systems/Subsystem	X									X					X						X					X		5	2	2	1
	Aviation																	X				X					X		3	0	2	1
	Test/Measurement								X														X			X	X		4	2	1	1
Space Power & Energy Storage	Energy											X														X	X		3	0	2	1
	Physics					X																							1	0	1	0
	Power/Propulsion											X																	1	0	1	0
	Space Systems	X			X	X	X					X				X				X	X		X	X					10	2	8	0
Science Instruments, Oberservatories & Sensor Systems	Chemistry					X																		X		X			3	0	3	0
	Earth/Environmental Sciences													X															1	0	0	1
	Instrumentation								X	X			X													X	X		5	1	3	1
	Optics		X	X					X						X					X									5	1	3	1
	Sensors												X	X		X				X							X		5	1	2	2
Modeling, Simulation, Information Technology & Processing	Electronic Components																		X									X	2	2	0	0
	Electronic Circuits						X								X													X	3	1	1	1
	Electronic Systems		X				X														X								3	0	3	0
	Information Sciences/Data Handling				X			X																					2	1	1	0
	Software				X			X			X					X	X	X				X			X				8	4	4	0
Materials, Structures, Mechanical Systems & Manufacturing	Machinery/Automation																												0	0	0	0
	Manufacturing/Fabrication														X													X	2	1	0	1
	Materials									X							X							X				X	4	2	2	0
	Mechanical																												0	0	0	0
	Transportation				X																								1	0	1	0
Other	Biological/Physical Sciences									X																			1	0	1	0
	Biomedical/Medical																												0	0	0	0
	Communications																												0	0	0	0
	Cryogenic Sciences																												0	0	0	0
	Life Sciences					X																				X			2	0	2	0
	Nanotechnology									X																			1	0	1	0
	Robotics																								X				1	0	1	0
	Commercialization							X	X		X			X	X	X	X		X				X				X	X	11			
	Technology Infusion	X	X	X	X	X	X			X		X	X	X	X			X		X	X	X		X	X	X	X		19			

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Total	C	TI	B
Aviation/Aeronautics	X							X		X					X		X			X	X	X	X	X	X	X		12	4	7	1
Space Power & Energy Storage	X			X	X	X					X				X				X	X		X	X		X	X		12	2	9	1
Science Instruments, Oberservatories & Sensor Systems		X	X		X			X	X			X	X	X	X				X				X		X	X		13	2	8	3
Modeling, Simulation, Information Technology & Processing		X		X		X	X			X				X	X	X	X	X		X	X			X			X	14	6	7	1
Materials, Structures, Mechanical Systems & Manufacturing				X					X					X		X							X				X	6	2	3	1
Other					X				X															X	X			4	0	4	0

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