DARPA SBIR/STTR Programs

Transition Planning Guide

Prepared for: DARPA Small Business Program Office (SBPO)
Prepared by: The Foundation for Enterprise Development (FED)
FED Program Manager: Mary Ann Beyster
FED Transition Assistance Manager: June Chocheles
FED Senior Technology Consultant: Jim Russell

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1.0 Introduction

The Foundation for Enterprise Development (FED) prepared this Transition Planning Guide to assist companies participating in the Defense Advanced Research Projects Agency (DARPA) Small Business Innovation Research (SBIR) or Small Business Technology Transfer (STTR) programs with the planning and implementation of their SBIR/STTR Phase II technology transition activities.

Transition is the process by which a project moves beyond the SBIR/STTR Phase II activity and into additional research, development, and subsequent production activities in order for the technology to be fully matured, tested, and integrated for use in operational environments. There are a variety of approaches and methodologies that can be employed to support a company's transition activities. We encourage the SBIR/STTR companies to use this guide and also explore the myriad and variety of other resources available from both public and private sources to support transition activities. A sample set of resources is provided in section 6.0 Resources of this guide.

This guide was initially developed by the Foundation for Enterprise Development to support companies participating in DARPA's SBIR/STTR Transition Support Pilot Program and has been improved with feedback obtained during the Pilot implementation. The guide provides a transition planning framework, transition planning checklists and templates, and references to key resources for companies to use in developing a Phase III transition plan and implementation schedule, with a focus on identifying viable transition pathways for the technologies being developed into three primary markets—Department of Defense (DoD), other federal, and commercial.

The following definition of Phase III is found in the DoD SBIR/STTR Programs Desk Reference[1]:

> Phase III refers to work that derives from, extends, or logically concludes effort(s) performed under prior SBIR or STTR funding agreements, but is funded by sources other than the SBIR or STTR Programs. Phase III work is typically oriented towards commercialization of SBIR or STTR research or technology.

[1] U.S. Department of Defense SBIR/STTR: *SBIR Contracting & Payment Desk Reference* [document online]; [cited 2010 Feb 12]. Available from: http://www.acq.osd.mil/osbp/sbir/deskreference/13_phas3.htm

A Federal agency may enter into a Phase III SBIR or STTR agreement at any time with a Phase II awardee.

SBIR or STTR Phase III awards may be made without further competition. The competition for SBIR or STTR Phase I and Phase II awards satisfies any competition requirement when processing Phase III awards. Therefore, an agency is not required to conduct another competition in order to satisfy any statutory provisions for competition. Contract file documentation should demonstrate that the proposed Phase III award is derived from, extends or logically concludes efforts performed under prior SBIR or STTR funding agreements and is authorized under 10 U.S.C. 2304(b)(2) or 41 U.S.C. 253(b)(2). A separate J&A document is not required, pursuant to 10 U.S.C. 2304(b)(3) or 41 U.S.C. 253(b)(3).

There is no limit on the number, duration, type, or dollar value of Phase III awards made to a business concern. There is no limit on the time that may elapse between a Phase I or Phase II award and Phase III award or between a Phase III award and any subsequent Phase III award. Also, the small business size limits for Phase I and Phase II awards do not apply to Phase III awards.

The goal of the transition planning outlined in the guide is focused on assisting SBIR/STTR companies during their Phase II project to:

- Identify and vet potential end-user communities to understand potential applications and operational environments.
- Identify and position for Phase III funding (i.e., non-SBIR/STTR) sources to continue to mature and apply the technology.
- Identify experiment, exercise, test and evaluation, and benchmarking opportunities to demonstrate functionality and value to specific users and in specific operational environments.
- Identify potential partners and collaborators throughout specific supply chains.
- Identify thought leadership opportunities that can provide visibility to the company, the researchers, the technical challenge being addressed, and the innovative solution being developed under the DARPA-funded SBIR/STTR project.

Transition planning framework: This guide discusses the unique aspects of transitioning technology funded by the DARPA SBIR/STTR programs, and provides a planning framework that integrates three core components—technology, business, and market—for companies to augment the commercialization strategy that was outlined in their Phase II proposals into a transition plan for implementation.

Transition planning checklists, templates, and resources: In addition to the framework, the Foundation has developed a set of checklists, templates, and resource lists to assist companies in addressing and compiling the critical and interrelated pieces of information needed to determine which of the multiple available options to pursue within a specific transition path.

Transition planning and implementation schedule: The transition of innovative, often disruptive technology may take several years to complete, and may require significant resources before the technology can be both transitioned and fully integrated into an operational environment. This guide identifies and specifically focuses on key planning steps to be performed by companies, primarily during the Phase II project's period of performance, to assist them in positioning for—and implementing—ongoing activities to support successful transition beyond the Phase II SBIR/STTR project. While this guide is focused on transition planning and implementation during Phase II of a SBIR/STTR project, companies should initiate transition planning during their Phase I SBIR/STTR project activities to support development of a commercialization strategy for inclusion in a Phase II proposal.

Technology Transition at DARPA

The DARPA Strategic Plan document outlines technology transition as follows:

> Transitioning Technology—getting technology from research and into use—is a contact sport. Many different types of organizations may need to be involved, i.e., S&T [science and technology] organizations like DARPA, the acquisition community, the warfighting/requirements community, and the firms that actually produce the product. This involvement requires personal contact between the people developing the technology and those destined to receive it. The very nature of a technology strongly shapes how it transitions. For example, a component technology like a new material or microchip is likely to get to the warfighter when a prime contractor incorporates it into a system, without a Service acquisition program necessarily having decided on it *per se*. This means the key component decisions are made by industry—prime

> contractors and subcontractors. On the other hand, a large system development program such as Global Hawk requires the warfighting community to establish a formal requirement for the system, thereby charging the acquisition community with actually purchasing it. New systems simply do not diffuse their way into military use, like a new material might.[2]

Transition requires the identification and interaction of an evolving, integrated set of collaborators and partners to support transition activities. Identifying the programs and program managers within the S&T, acquisition, and warfighting/requirements communities along with those commercial entities that have roles in bringing the technology to the users is a key component to successful transition.

Upon award of their Phase II SBIR/STTR contract, we recommend that companies initially review the commercialization strategy outlined in the Phase II proposal, and using this guide along with other resources, identify gaps or areas that may require augmentation or modification to improve. As part of the Phase II project activities, companies can then begin to augment specific areas associated with transition. These areas may include:

- Identification and evaluation of potential transition pathways
- Applications
- Operational environments
- End user needs and requirements
- Partners and collaborators
- Experiments and exercises
- Risks and proposed mitigation
- Test and evaluation opportunities
- Manufacturing
- Funding sources, specifically Phase III funding sources (non-SBIR funds)
- Thought leadership opportunities

[2] DARPA Strategic Plan, February 2007. [document online]; [cited 2010 Feb 12]. Available from: http://www.darpa.mil/Docs/DARPA2007StrategicPlanfinalMarch14.pdf

The goal is for companies to develop a well-thought-out transition plan that they can implement during the Phase II project period of performance.

Table 1 provides a list of key factors in transition planning and implementation. The guide, especially section 4.0 Constructing the Transition Plan, provides more details on each factor.

Table 1: Key Factors in Transition Planning and Implementation

Factor	Details
Transition planning and implementation starts early.	▪ Begin transition planning early—ideally during Phase I—to identify key programs, program managers, and other entities and individuals, and to create a feedback loop among the research, development, integration, and end-user communities to support transition activities. ▪ Knowledge gained from ongoing interaction with individuals in these communities can help focus Phase II project tasking to meet mission needs and address technology and capability gaps. ▪ Identify and stay connected to individuals within the research, development, integration, and end-user communities during Phase II.
Transition requires an integrated team.	▪ Successful transition requires a variety of stakeholders, advocates, funding sources, and partners working in concert to shepherd the technology from the lab into operational environments. ▪ During Phase II, the company's technical, financial, and business team, the Program Director of DARPA Small Business Programs Office, and the DARPA program manager (PM) work together to support transition activities, which include identifying and connecting with DoD programs and program managers; and to identify experiment, test and evaluation, and benchmarking opportunities. ▪ These opportunities are focused on creating—within the research, development, and end-user communities—an awareness of the innovation being developed by the DARPA SBIR/STTR project, and helping the companies understand the requirements for new technologies to support specific applications and operational environments.

Factor	Details
Transition is a process—neither standard nor linear.	▪ The transition path a SBIR/STTR company initially defines to support its commercialization strategy is neither standard nor linear. It will evolve over time. ▪ A company will likely need to re-define and/or augment its transition plans during the project's lifecycle to best meet known or evolving needs and requirements within the acquisition, industry, and operational communities. ▪ Many issues must be addressed and re-addressed throughout the transition process. This requires companies to be flexible and agile in order to leverage information and rapidly respond to opportunities.
Technology Readiness Level (TRL) 6 or 7 is a key milestone achievement that supports transition.	▪ For many DARPA SBIR/STTR companies, securing Phase III funding to mature technology to TRL 6 *(System/subsystem model or prototype demonstration in a relevant environment)* or TRL 7 *(System prototype demonstration in an operational environment)* is a key milestone for increasing the probability of successful transition.
Transition requires effective communication to potential partners, collaborators, funding sources, and end users.	▪ Regardless of the transition pathway pursued, a set of core issues must be understood and communicated to potential partners, collaborators, funding sources, and end users: ◆ Value of the technology to the end user ◆ How the technology will be integrated into a system required to field the technology in an operational environment ◆ The existing or potential supply chain participants to integrate and deliver the technology to end users ◆ Advantages of the technology over the existing state-of-the-art and competing technologies ◆ Technical risk areas and how they are being addressed during the development activities ◆ Readiness of the company to meet the business, financial, and operational requirements to support and sustain the transition
Transition begins with innovative research, but that is not sufficient for success.	▪ Research must lead to practical applications for specific markets, customers, and end-user communities. ▪ Business and operational realities must be addressed to ensure sufficient resources for sustained profits. ▪ It is important to integrate the technology, market, and business components of a transition plan and assess the whole for its viability and feasibility.

For other DARPA SBIR/STTR companies, the Phase III transition plan may focus on identifying partners, such as defense suppliers (e.g., prime contractors), who can best integrate the enabling or component technology into an existing DoD system, or spiral it into a new system under development. These partners may potentially have funding and/or other resources—such as testing and evaluation environments—to further mature the technology through testing, evaluating, or benchmarking, so that it can be integrated into a larger system and then fielded to support one or several applications.

Accordingly, activities identified in the transition plan for securing Phase III funding needs to focus on identifying advocates—potential collaborators and partners in both the S&T and acquisition communities—who have the mission and resources to further mature the technology, and who also have links into the operational communities to support transition activities.

We envision that companies will be able to use this guide for their transition planning activities throughout their Phase II project, and into their Phase III project activities, regardless of the transition path they choose. The DARPA Small Business Programs Office looks forward to following the progress of the DARPA SBIR/STTR companies as they solve DARPA hard problems and bring innovative solutions to the warfighter, other federal applications, and into the commercial marketplace; and capturing transition success in DARPA's SBIR/STTR transition success reports.

2.0 Background

SBIR/STTR Program Overview

Congress established the SBIR program in 1982 and the STTR program in 1992 to provide opportunities for small businesses and research institutions to participate in government-sponsored research and development (R&D). The goals[3] of the SBIR and STTR programs are to:

- Stimulate technological innovation.
- Use small business to meet federal R&D needs.
- Foster and encourage participation by socially and economically disadvantaged small business concerns (SBCs), and by SBCs that are 51 percent owned and controlled by women, in technological innovation.
- Increase private sector commercialization of innovations derived from federal R&D, thereby increasing competition, productivity and economic growth.

The Small Business Administration (SBA) is responsible for administrative oversight of the federal SBIR and STTR programs, which includes developing policy and guidance, and reporting data and statistics to Congress. Each of the 11 federal agencies manages its SBIR and STTR programs independently in accordance with SBA policy. DARPA participates under DoD's SBIR and STTR program structure.

The DoD Office of Small Business Programs provides oversight of 12 DoD components to develop and execute three SBIR and four STTR solicitations each year. Eligible projects for funding consideration in the DoD SBIR/STTR program must serve a DoD R&D need and have potential to develop a product or service for defense and/or commercial or other federal markets.

Both of the SBIR and STTR programs use a three-phase program structure, reflecting the high degree of technical risk involved in developing and commercializing cutting-edge technologies.

[3] DARPA: Small Business Innovation Research Program [Internet]; [cited 2010 Feb 12]. Available from: http://www.darpa.mil/sbpo/sbir_program/

Phase I is a feasibility study that determines the scientific, technical, and commercial merit and feasibility of a selected concept. Phase I projects are competitively selected from proposals submitted against solicitations. Each solicitation contains topics seeking specific solutions to stated government needs. Phase I projects are typically six months in duration and funded up to $99,000.

Phase II represents a major research and development effort, culminating in a well-defined deliverable prototype (i.e., a technology, product, or service). The Phase II selection process is also highly competitive. Successful Phase I contractors are invited to submit Phase II proposals, as there are no separate Phase II solicitations. Phase II projects are typically 24 months in duration and funded up to $750,000. In many cases, companies are able to achieve the TRL 5 milestone *(Component and/or breadboard validation in relevant environment)* or TRL 6 milestone *(System/subsystem model or prototype demonstration in a relevant environment)*.

While achievement of TRL 5 or 6 during Phase II is a significant accomplishment—given the technical challenges addressed by many of the SBIR/STTR projects—it is important to note that there are still significant challenges yet to be addressed, and a substantial amount of work must be performed in order for the technology to achieve TRL 9—actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation—in order for the technology to make the final transition into the marketplace.

In Phase III, the small business or research institution is expected to obtain funding from the private sector and/or non-SBIR or non-STTR government sources to develop the prototype into a viable product or service for sale in the government or private sector markets.

The SBIR program is open to any small business, defined as a business having no more than 500 employees (including all affiliates), which is operated in the United States and at least 51 percent owned by a U.S. citizen or permanent resident alien. The small business may subcontract a portion of its work, as long as the small business "prime" performs at least two-thirds of the Phase I work and one-half of the Phase II work. For the purposes of determining compliance, percent of work is usually measured by both direct and indirect costs; however, the actual method of measurement will be verified during contract negotiations.

The STTR program is open to any team consisting of a small business (as defined previously) and a research institution. Central to the program is expansion of the public/private sector partnership to include the joint venture opportunities for small business and the nation's premier nonprofit research institutions. STTR's most important role is to foster the innovation necessary to meet the nation's scientific and technological challenges in the 21st century. The research institution may be any U.S.-based nonprofit research institution, federally funded research and development center (FFRDC), or university or college. The small business must perform at least 40 percent of the Phase I and Phase II work. The research institution must perform at least 30 percent of the Phase I and Phase II work. Up to 30 percent of the work may be subcontracted.

For SBIR program Phase I and II efforts, the primary employment of the principal investigator must be with the small business firm at the time of the award and for the duration of the proposed project effort. Primary employment means that more than one-half of the principal investigator's time is spent with the small business. For STTR program Phase I and II efforts, the principal investigator may be primarily employed with either the small business or the research institution.

In both SBIR and STTR programs, the Phase I and Phase II work must be performed in the United States, including the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, the Trust Territory of the Pacific Islands, and the District of Columbia.

DARPA's Mission and Operational Model

DARPA is the central research and development organization for the U.S. Department of Defense. DARPA's mission is to maintain the technological superiority of the U.S. military and prevent technological surprise from harming our national security. DARPA funds researchers in industry, universities, government laboratories, and elsewhere to conduct high-risk, high-reward research and development projects that will benefit U.S. national security.

DARPA research runs the gamut from conducting basic, fundamental scientific investigations in a laboratory setting to building full-scale prototypes of military systems. DARPA also funds research in a wide variety of scientific disciplines—biology, medicine, computer science, chemistry, physics, engineering, mathematics, material sciences, social sciences, neuroscience, and more.

DARPA was created in 1958 as the Advanced Research Projects Agency (ARPA). The political and defense communities recognized the need for a high-level defense organization to formulate and execute R&D projects that would expand the frontiers of technology beyond the immediate and specific requirements of the military services and their laboratories. A history of DARPA and its major achievements can be found at the DARPA Web site.

> Getting DARPA's scientific and technological achievements into the hands of the warfighters and peacekeepers who will use them is an exceptional challenge…The transition challenge is exacerbated for DARPA because its focus is on high-risk, revolutionary technologies and systems, which may have no clear home in a Service, are Joint, or threaten to displace current equipment or doctrine. Such factors tend to create resistance, or at least barriers to the use and adoption of a radical new technology.[4]
>
> DARPA invests about 97 percent of its funds at organizations outside DARPA, primarily at universities and in industry. Over time, this investment leads to new capabilities in industry and steadily reduces the risks of the underlying technology. At some point, a company becomes sufficiently confident of the capability, value, and technical maturity of a new technology for a predictable cost and schedule. It will then be willing to propose the technology to DoD users or acquisition programs. DARPA's investment reduces the risk of a technology to the point where firms themselves are willing to make it, use it, or otherwise bid it back to the rest of DoD.[5]

[4] DARPA: Technology Transition [Internet]; [cited 2010 Feb 12]. Available from: http://www.darpa.mil/techtrans.html

[5] DARPA: DARPA's Transition Strategy [Internet]; [cited 2010 Feb 12]. Available from http://www.darpa.mil/darpatrans.html

3.0 Transition Planning: From Research to Market

There are three main transition pathways for DARPA SBIR/STTR-funded technologies:

- Into the DoD Military Departments and other agencies
- Into other federal agencies, such as the Department of Homeland Security
- Into the commercial marketplace

An overview of each pathway is provided in this guide; however, since the DoD is the most typical end user of DARPA SBIR/STTR technology, the guide emphasizes preparation for that technology transition pathway.

According to the National Research Council's *SBIR and the Phase III Challenge of Commercialization: Report of a Symposium* report:

> Commercializing SBIR-supported innovation is necessary if the nation is to capitalize on its SBIR investments. This transition is, however, challenging because it requires a small firm with an innovative idea to evolve quickly from a narrow focus on R&D to a much broader understanding of the complex systems and missions of federal agencies as well as the interrelated challenges of managing a larger business, developing sources of finance, and competing in the marketplace.[6]

While the transition from Phase II to III is challenging, there are many SBIR/STTR companies that have successfully transitioned their technologies into the federal and commercial markets. Their success stories are documented on the following Web sites and provide real-world examples of transitions, challenges, and lessons learned.

- DARPA (http://www.darpa.mil/sbpo/success/index.html)
- U. S. Army (http://www.armysbir.com/commercialization/comm.htm)

[6] National Research Council. *SBIR and the Phase III Challenge of Commercialization—Report of a Symposium*. 2007, 5.

- U. S. Navy (http://www.navysbir.com/navsuccess.htm)
- U. S. Air Force (http://www.sbirsttrmall.com/Library/SBIRImpactStory.aspx)
- Special Operations Command (SOCOM) (http://www.socomsbir.com/success.asp)

Planning and implementation are critical components of transition success, as these mechanisms help companies manage the complexity of transition. Regardless of the transition pathway (DoD's military departments, other federal, or commercial markets for dual use technologies), in most cases companies will be pursuing transition within a competitive environment. Using the commercialization strategy outlined in their Phase II proposal as a starting point, companies can employ this guide to enhance or develop a transition plan. The transition plan includes the identification of a specific set of tasks and milestones, as well as a schedule, and identification and assignment of resources to support transition activities. We recommend that any enhancements or modifications to a company's transition plan be completed within the first three to four months of the SBIR/STTR Phase II project, so that tasks and related activities can be implemented in parallel with the technical tasking and activities being conducted. The plan should be agile enough to incorporate unanticipated opportunities arising throughout the Phase II project that have the potential to support transition.

Pathway #1—Into the DoD Military Departments

The DoD military departments acquire new and innovative technologies to support their mission and operational requirements via the Defense Acquisition Management System as well as through other procurement mechanisms. The SBIR/STTR topics that companies respond to are mechanisms for those companies to develop enabling technologies, a component of a solution, or a complete product or solution that can address potential areas of interest to these departments.

Figure 1 depicts the DoD Acquisition Management System. As detailed in DoD Instruction 5000.02, it:

> …establishes a simplified and flexible management framework for translating capability needs and technology opportunities, based on approved capability needs, into stable, affordable, and well-managed acquisition programs that include weapon systems, services, and automated information systems (AISs). Promising technologies shall be identified from all sources domestic and

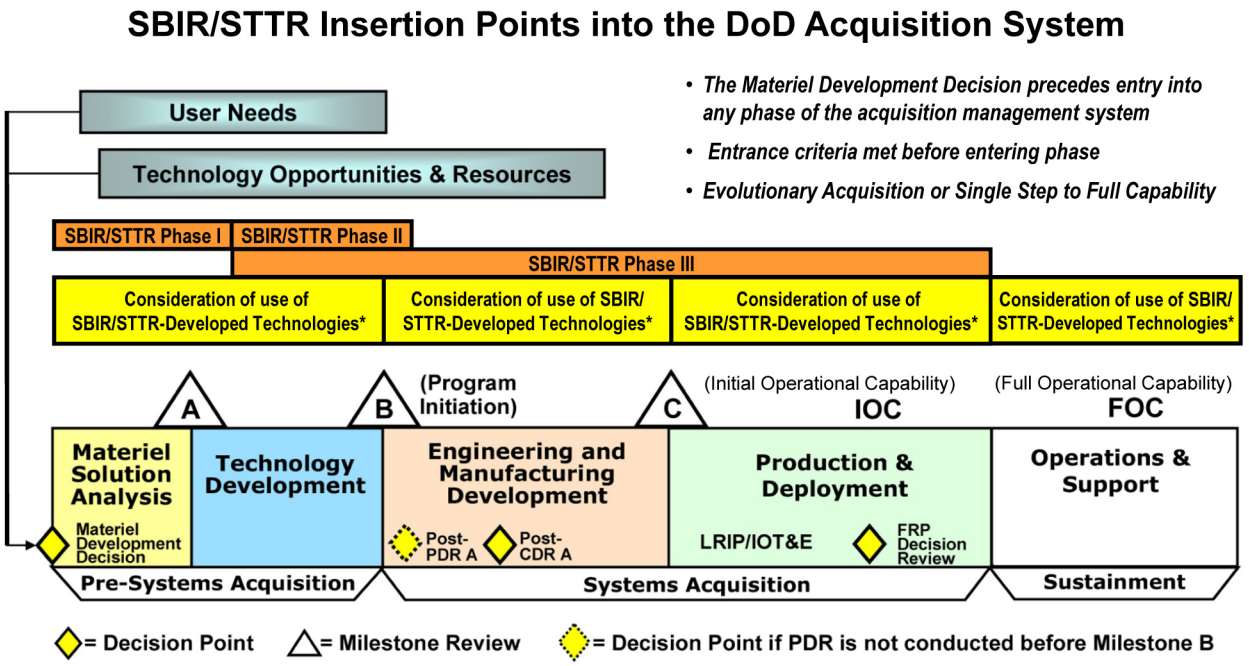
> foreign, including government laboratories and centers, academia, and the commercial sector. In addition, ***PMs shall consider the use of technologies developed under the Small Business Innovation Research (SBIR) program, and give favorable consideration to successful SBIR technologies***. The risk of introducing these technologies into the acquisition process shall be reduced; coordination, cooperation, and mutual understanding of technology issues shall be promoted. The conduct of Science and Technology (S&T) activities shall not preclude, and where practicable, shall facilitate future competition.[7]

Figure 1 illustrates the Defense Acquisition Management System's phases—Material Solution Analysis, Technology Development, Engineering and Manufacturing Development, Production & Deployment, and Operations & Support—and identifies where new technologies being developed under SBIR/STTR funding within the S&T community may be considered for transition by the acquisition community.

The DoD acquisition process is complex. Therefore, it is vital for Phase II SBIR/STTR companies to understand that the configuration of program teams should include both government and commercial participants—such as program managers, lead engineers, and existing or potential prime contractors and sub-contractors—to identify opportunities for participation to support transition. During the transition planning and implementation process, Phase II SBIR/STTR companies should identify existing programs and program managers that may have requirements for insertion of new technologies, as well as advocates and stakeholders who are building new programs, which are opportunities for insertion of the new technology being developed.

Additional resources on the DoD acquisition process are listed in section 6.0 Resources of this guide.

[7] Department of Defense. "DoD Instruction 5000.02." December 2008.



*Section 3, paragraph c. DoD Instruction number 5000.02, December 8, 2008

Source: http://www.dtic.mil/whs/directives/corres/pdf/500002p.pdf; original modified by FED to include SBIR/STTR insertion

Figure 1: DoD Acquisition Management System, including where promising SBIR/STTR developed Technologies may be considered

Pathway #2—Into Other Federal Agencies

Technologies and solutions developed under DARPA's SBIR/STTR program may also be of interest to other federal agencies. DARPA SBIR/STTR transitions can occur with a number of civilian agencies, including (but not limited to) the Department of Homeland Security, the Department of the Interior, and the National Institutes of Health.

Inter-agency technology transition can occur through the SBIR/STTR program or other programs established by the civilian agency or the DoD. For example, the DoD's 1401 program identifies, evaluates, deploys, and transfers to federal, state, and local first responders technology items and equipment in support of homeland security initiatives.

Figure 2 outlines the existing DoD to DHS technology transfer ecosystem.[8]

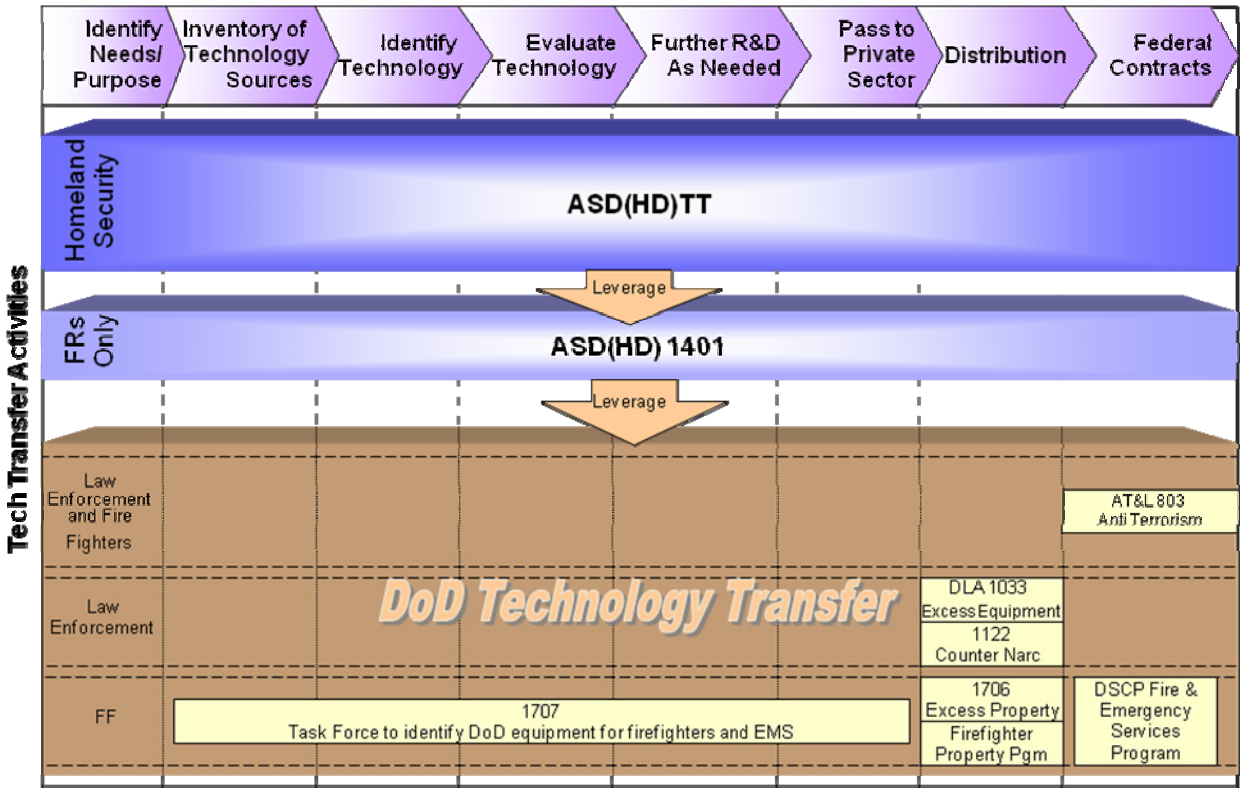


Figure 2: Existing DoD to DHS Technology Transfer Ecosystem

Additional resources on other federal agency transition programs are listed in section 6.0 Resources of this guide.

Pathway #3—Into Commercial Markets for Dual-Use Technologies

Technologies developed with DARPA SBIR/STTR funding may also have applications in the commercial marketplace. These technologies are frequently called "dual-use" technologies, as they address both federal and commercial markets. As with transitioning new technologies into federal markets, transitioning dual-use technologies into commercial markets is challenging.

[8] Department of Defense. Office of the Assistant Secretary of Defense. "1401 Technology Transfer Program." [document online]; [cited 2010 Feb 12]. Available from: http://www.dodtechmatch.com/DOD/ProgramBriefing.ppt

Many of the key issues that need to be addressed are typically the same. For example, a company still needs to identify its target market; the value proposition for the user; the business model to be employed; and how the company will enter and reach the market, including identification and engagement of partnering and collaboration entities. All are required to create and sustain a profitable business.

While many of the issues for transitioning into the commercial market may be the same as those for transitioning technology to the DoD or other federal users, the strategy and supporting tactics of addressing these issues are frequently different when specifically launching a new product into a commercial market. For example, buying behavior, procurement practices and durations, margins, price sensitivities, product and service requirements, and accounting practices can all be significantly different in the private sector, as compared with the DoD and other federal markets. These differences may be so significant that a company might decide to create a separate entity and specific product line that is structured, staffed, and financed differently than their government customer-based business.

Companies may find that securing financing is necessary to rapidly and strategically address and/or create opportunities in the commercial market. Meeting financing needs may involve expanding financing sources to include banks or external equity investors, such as angel and venture capitalists. If this is the case, the company must prepare to meet the standard due diligence performed by these types of investors. Thus, the development of the complete business plan (also frequently called the "roadshow" for venture capitalists) becomes a much higher priority during transition. Much has been written about this process, and many organizations can provide advice on the venture capital process. Resources can typically be found from national, regional, and local venture capital organizations, universities, and entrepreneurship centers.

There are many models to consider for commercializing government technologies into the private sector, with no single model being standard. Section 6.0 Resources of this guide provides helpful sources of information in this regard.

A Stage-Gate commercialization model may be useful for those companies with a strong interest in launching a product line or business focused on the private sector. This type of model has been used by the Department of Energy and other federal agencies. It presents a step-by-step process that minimizes risk by following an incremental product- and business-development strategy. The Stage-Gate method, from Robert G. Cooper—who developed the method in the 1980s, at which time it was based on experience with over 60

projects/firms—is an example approach that can be used for new product development. It defines predetermined steps, or stages, from developing an idea to launching a product. The gates control the process and serve to check readiness for moving forward with the product and business. An illustration of Cooper's Stage-Gate method is shown in Figure 3.[9]

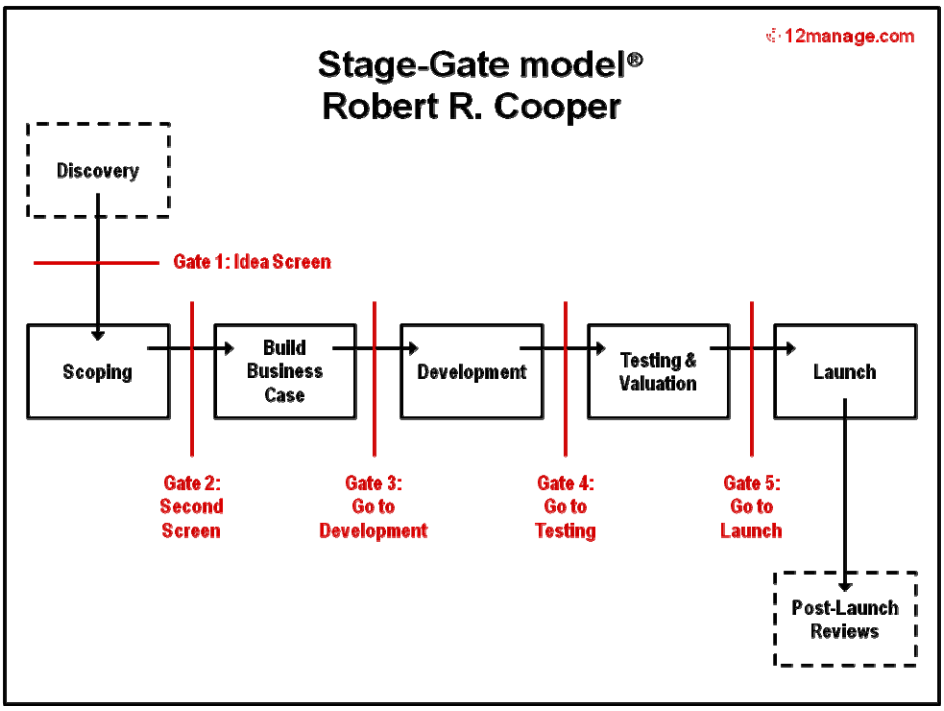


Figure 3: Example Stage-Gate Commercialization Process

Additional resources on the commercialization process, product development, technology project management, and small business management for technical entrepreneurs—especially for growing companies in the private sector—are listed in section 6.0 Resources of this guide.

[9] The term "Stage-Gate" is reported to have first appeared in an article by Cooper in *The Journal of Marketing Management*, 3, 3, Spring 1988. An even earlier version can be found in Cooper's book, *Winning at New Products*, published in 1986. Source: 12 Manage. "Managing product development. Explanation of the Stage-Gate model of Robert G. Cooper ('88)." [document online]; [cited 2010 Feb 12]. Available from: http://www.12manage.com/methods_cooper_stage-gate.html

4.0 Constructing the Transition Plan

Conducting innovative research and reaching targeted research milestones is not enough for transition success. The research must lead to a technology with practical applications for specific markets, customers, and end-user communities. The business realities of delivering that technology to the market, generating revenue, and sustaining a profitable business must all be addressed for successful transition to occur.

There is no doubt that transition momentum can start with an excellent technological solution to a challenging and significant national security problem. The SBIR/STTR-funded company must not only demonstrate a high level of technical and program management competence during its project, but must also have identified an innovative solution and application to a specific problem and created a plan for incremental development to apply that solution to a military services need. It is worth emphasizing that this statement has been the single most commonly shared "lesson learned" by DARPA SBIR/STTR companies that have successfully transitioned DARPA-funded technology.

The FED's planning approach to bringing technology to market requires an understanding of the relationships among the following:

- Technology that is being developed and offered
- Market that will be using and/or supporting the technology
- Business realities of getting the technology to market and making money

Figure 4 illustrates this concept for transition planning.

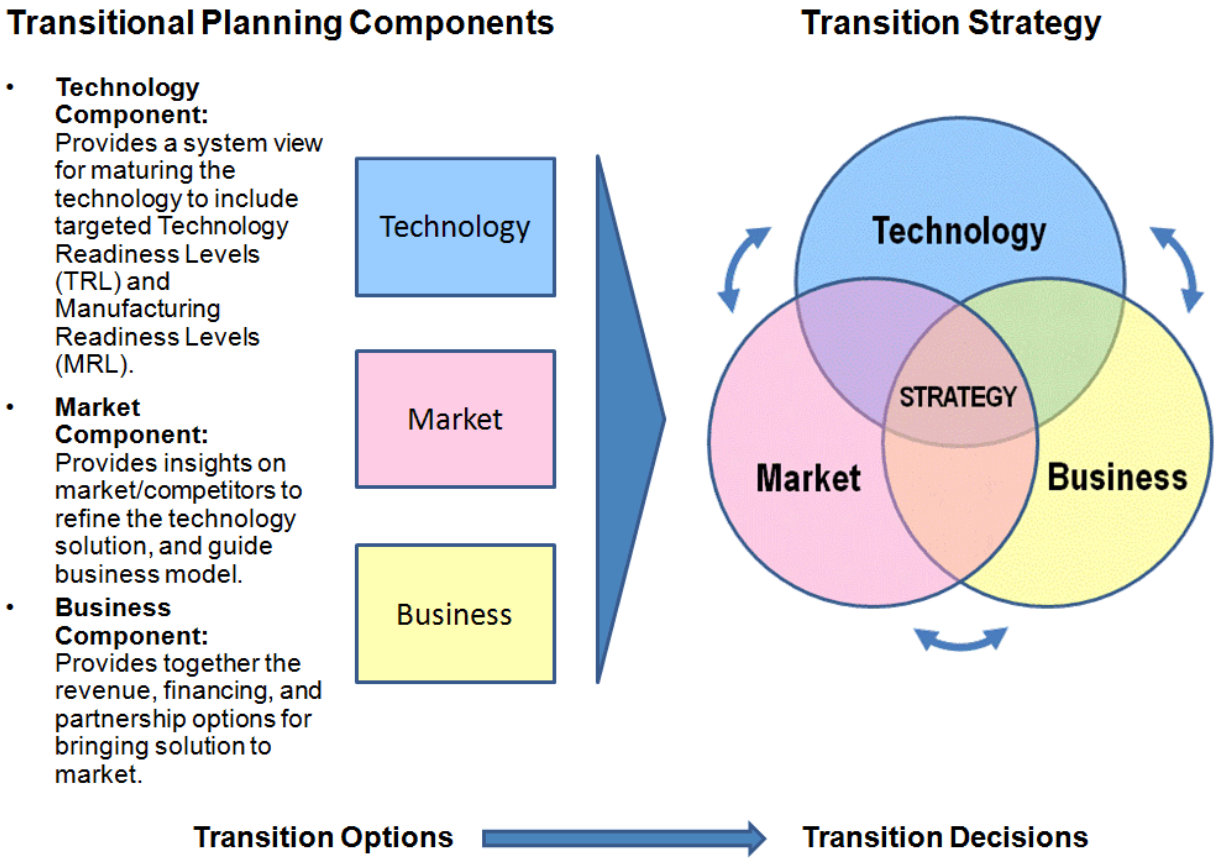


Figure 4: Transition Plan Components (Source: The Foundation for Enterprise Development)

As mentioned earlier in this guide, transition paths are neither standard nor linear. There are many elements and issues to be addressed. Most of these will need to be re-addressed throughout the development of technology during Phase II and beyond. Some companies may try to finalize an ideal commercialization solution and transition path, but this will likely be premature for companies funded by DARPA, which are involved in developing technologies that can be both broadly enabling and disruptive. Companies that adopt an agile approach to transition—one that focuses on testing, learning, and adjusting plans while working with the research community, end users, and integrators—will more likely identify and take advantage of unanticipated opportunities to move their technology along a transition path that will yield transition success.

The decisions regarding which options to select are influenced by many factors, including—but not limited to—availability of resources, experience base, contracting or sales history with the federal government or in the commercial

markets, manufacturing capabilities, and the company's overall business strategy and objectives.

Companies that have a vision for the future; support a culture for commercialization; create a learning organization; and implement processes and projects to move forward, measure progress and refine plans, and re-align as new information is learned can generate tangible returns on technological investment and position themselves to be government and/or industry leaders. This concept is illustrated as part of the TRL maturity lifecycle in Figure 5.

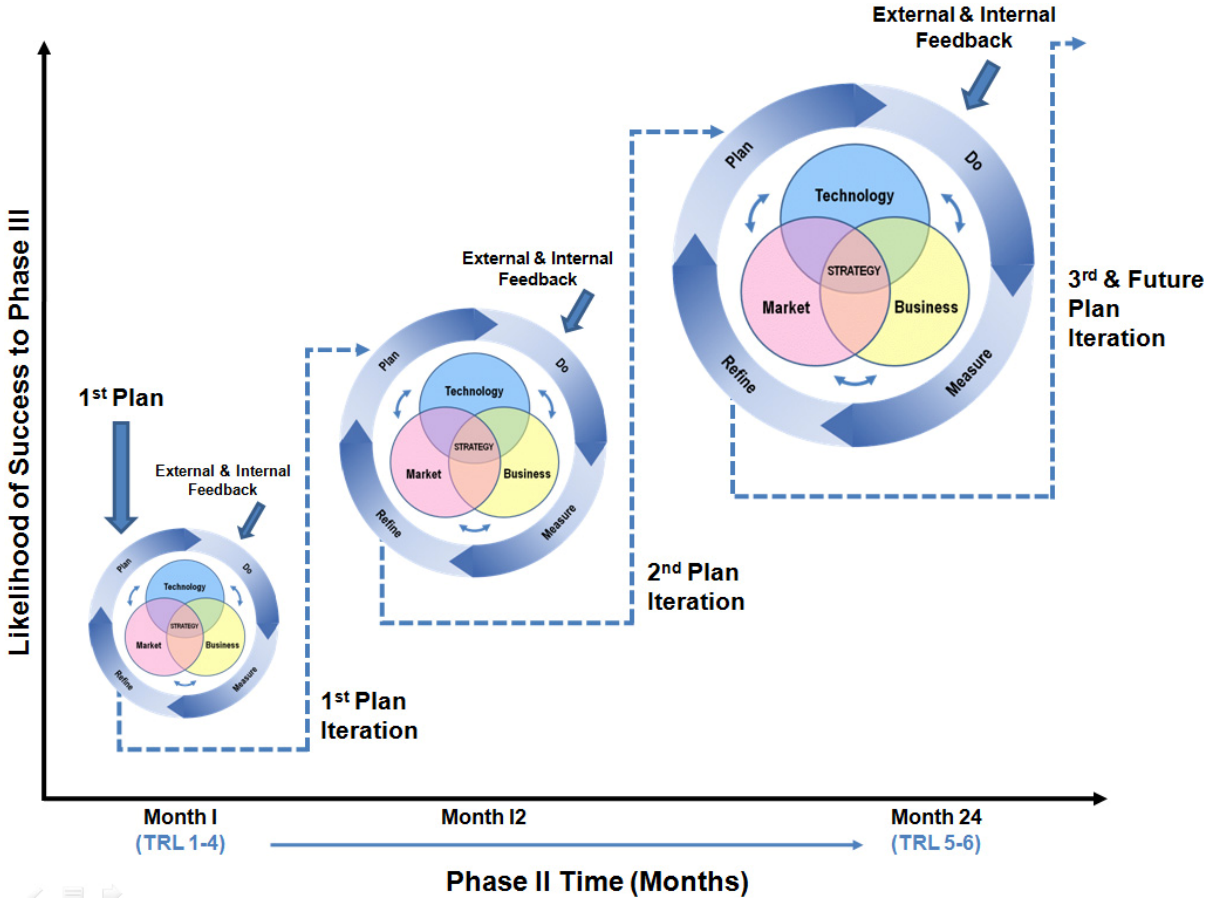


Figure 5: Illustration of Transition Planning Along the TRL Maturity Lifecycle (Source: The Foundation for Enterprise Development)

The best way to increase the likelihood of successful transition to Phase III is to start early and iterate on the plan for all three components—technology, business and market. This is important because there is an inter-play among the components, and decisions made on one component affect the other two components. For example, identifying an interested customer and application early under the market component will typically affect technology development

and the business model and value proposition under the business component. Similarly, deciding on the business model under the business component requires a consideration of factors from the other two components.

Transition planning is a process—not a point decision or solution. It requires continual investigation and fact finding from all three components, and iteration to weigh the options at several points during the 24 months of Phase II. This process is illustrated in Figure 5 to emphasize that the likelihood of success is improved and the risk of failure reduced by starting early and iterating.

The time and effort to do this can be adjusted to fit a SBIR company's circumstances and resources. It need not be overly time consuming or complex. We recommend the three check lists and strategy charts be used to aid preliminary (and ultimately final) decisions.

Very small companies can review these charts in an hour or two and jot down the most important next steps. Larger companies can use them to identify more elaborate steps requiring considerably greater time and effort. The important thing is to complete this review in the first few months of Phase II and iterate the review with 12 months and 24 months.

The plans arising from the findings and decisions resulting from the three components can also be as simple as a page or two or can be much more elaborate. Here again, the important point is to document the plan with supporting rationale.

The Technology Component

The technology component of the transition plan is focused on defining or identifying the key elements that influence or impact the technology issues associated with research and development, engineering and manufacturing development, software/systems development, and production and deployment activities that a company must address in order to mature and deploy technology in an operational environment. In this guide, the technology component includes defining the technical offering, the operational system and infrastructure in which it needs to function, the manufacturing and supply chain to support the offering, intellectual property, technology maturity, and technical risk management. Shortcomings in transition occur when companies do not address—or inadequately address—all the various technology elements that have a role in transitioning technology from the lab to the market.

Table 2, Technology Checklist, identifies the key technology elements that companies should review at the start of their Phase II project to identify any elements they have not yet addressed, or have addressed inadequately. Companies can then—in parallel with conducting their technical tasking—assign resources to address these business elements. Table 3, Defining the Technology, provides descriptions of three categories of technologies—enabling, component, and product—that may help companies think about the category of technology they are developing and how to provide it to the end user to make it operational (e.g., as part of a large solution, or a stand-alone solution).

The responses a company prepares during their Phase II project are focused on identification of, positioning for, and securing of Phase III funding to reach TRL 7, in which the prototype is near or at the planned operational system. This represents a major step up from TRL 6, which requires the demonstration of an actual system prototype in an operational environment, such as in an aircraft, vehicle, or space. Examples include testing the prototype in a test bed aircraft.

Table 2: Technology Checklist (See section 7.0 Templates)

Technology Checklist (Source: The Foundation for Enterprise Development)

#	Element	Priority (1-5)	Percent Completed
1	Define what you are developing under your SBIR/STTR Project (see Table 2 for definitions): ▪ Enabling technology ▪ Product ▪ Component		
2	Define related research projects that can leverage your Phase II SBIR/STTR project activities (other SBIRs/STTRs or internal research projects).		
3	Define Application(s): ▪ DoD ▪ Other government ▪ Other federal ▪ Commercial		
4	Define the end-to-end, high-level system that will incorporate the enabling technology component or product.		
5	Define "supply chain" for the high-level, end-to-end system including primes and other key suppliers.		
6	Define end users (programs, program managers).		
7	Define the infrastructure required to field the end-to-end system.		
8	Define the concept of operations for the end-to-end system to be fielded.		
9	Define intellectual property and protection status (patents, copyrights, trademarks).		
10	Identify operational requirements.		
11	Identify TRL requirements.		
12	Identify MRL requirements.		
13	Identify standards (including interfaces).		
14	Identify specifications (including engineering and testing).		
15	Identify tests.		
16	Identify certifications.		
17	Define required manufacturing processes.		
18	Define Phase III technology development plan (statement of work, schedule, budget, resources, team partners, TRL goals).		
19	Define risk areas associated with Phase III technology development plan.		
20	Identify Phase III technology development funding sources—agency, program, program manager: ▪ DoD ▪ Private—prime R&D ▪ Other federal ▪ Prime—venture capital. ▪ Other government		
21	Identify experiment, evaluation, exercise, and demonstration opportunities.		
22	Define pace of technology change affecting prospective application areas.		

Table 3: Defining the Technology

Definition	Role	Purpose	Example
Enabling Technology	Technologies that cannot stand alone and must be applied to perform a function	Work in combination with component technologies and can add value to the technologies they support.	Algorithms
Component	A constituent part of a system	Performs a specific function within a sub-system or system.	Microchip New materials
Product	An integrated set of components designed to perform a specific set of functions or satisfy a specific set of needs, and can be sold as a commodity	Stand-alone device or application that completes a discrete and complete set of functional requirements. Often requires integration into larger systems.	Battery Emergency planning system Autonomous micro-air vehicle

Manufacturing

During the research and development phase of the SBIR or STTR project, it is important that companies also address Manufacturing Readiness Levels (MRLs) in order for the technology to be considered a viable candidate for incorporation into a DoD Program of Record, other program, or for the company to independently successfully move the technology into production. The DoD has defined a set of 10 MRLs for companies to use in their project planning and implementation activities that covers nine specific manufacturing threads:

- Technology and Industrial Base
- Design
- Cost & Funding
- Materials (Raw Materials, Components, Sub-Assemblies and Sub-Systems)
- Process Capability & Control
- Quality Management

- Manufacturing Personnel
- Facilities
- Manufacturing Management

> Manufacturing readiness, like technology readiness, is critical to the successful introduction of new products and technologies [into DoD systems]. Consideration of manufacturing risks and issues should begin early in technology development and intensify as the technology matures so that manufacturing maturity is sufficient at the time of transition to support rapid and affordable system incorporation. Manufacturing Readiness Levels (MRLs) are designed to assess the maturity and risk of a given technology, weapon system or subsystems from a manufacturing perspective and guide risk mitigation efforts. MRLs are also intended to provide decision makes at all levels with a common understanding of the relative maturity and attendant risks associated with manufacturing technologies, products, and processes being considered to meet DoD requirements. They provide specific criteria to support decision-making based on knowledge of manufacturing status and risk.[10]

DoD Manufacturing Readiness references and corresponding links can be found at the DoD Manufacturing Readiness Level Web site: http://www.dodmrl.com.

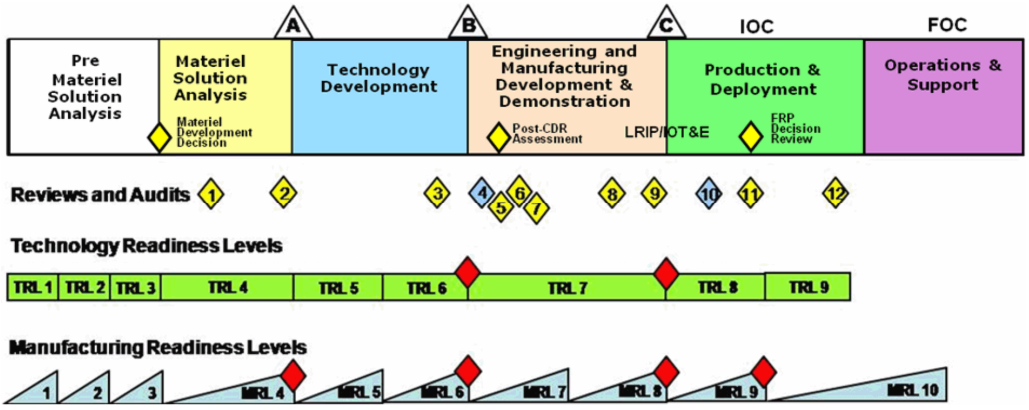


Figure 6: Relationship of MRLs to system milestones and TRLs

[10] Department of Defense, Joint Defense Manufacturing Technology Panel (JDMTP). *Manufacturing Readiness Assessment (MRA) Deskbook.* Draft Version 7.1, 2 May 2009.

See the DoD Manufacturing Readiness Level Definitions outlined in section 6.0 Resources of this guide. We recommend that you specifically reference the DoD *Manufacturing Readiness Assessment (MRA) Deskbook* (http://www.dodmrl.com/MRA_Deskbook_v7.1.pdf), which includes the DoD Manufacturing Readiness Level definitions as well as the detailed MRL definitions threads matrix.

Software and Systems Development

Companies that are engaged in software development or systems engineering/integration projects should apply proven software development and systems processes, such as those defined by the Software Engineering Institute (SEI). Government and—increasingly—commercial contracts for software and systems products now typically require companies to have certified software and systems engineering maturity models in place, as defined by SEI's *Capability Maturity Model Integration (CMMI)* Level model (http://www.sei.cmu.edu/cmmi/index.cfm). The maturity models reduce risk and ensure that the best methods and processes are used to develop and deliver a high quality product. They lower risk by reducing the variability of the schedule, budget, and performance in the design, development, delivery, and maintenance of integrated systems and software-based components and products, including development of prototypes.

These maturity models can be implemented in stages beginning at the project level, and certification can be sought at each maturity level. The higher maturity levels require processes to be instituted beyond the project level (e.g., at the line organization or enterprise level), and they also require methods for continuous improvement beyond a single project or product. Investments to develop and implement CMMI processes and training activities should be tailored and scaled to meet each company's requirements for existing and future projects. Once requirements are fully understood, an assessment of existing software development and systems engineering processes can be performed, followed by a gap analysis that maps existing processes to specific CMMI levels. When these activities are completed, the specific improvements and resources needed to achieve a particular CMMI level can be identified and integrated into a process improvement plan and schedule for implementation. Additional references are provided in section 6.0 Resources.

The Business Component

In this guide, the business component includes development of pricing and revenue models, financing, in-house resourcing, contracting and partnering, and business risk management. As with the technology component of the transition plan, the listed business elements also focus initially on issues associated with the advancing research and development, engineering and manufacturing development, and production and deployment activities that a company must address in order to mature and deploy technology in an operational environment.

Table 4, Business Checklist, identifies the key business elements that companies should review at the start of their Phase II project to identify any business elements they have not yet addressed, or have addressed inadequately. Companies can then—in parallel with conducting their technology development tasking—assign resources to address these business elements.

Table 4: Business Checklist (See section 7.0 Templates)

Business Checklist (Source: The Foundation for Enterprise Development)

#	Element	Priority (1-5)	Percent Completed
1	Define company's business model(s): ▪ Product ▪ Professional services ▪ Service ▪ Licensing		
2	Define the proposed commercialization models and critical contract/deal terms for bringing the technology to market: ▪ New company start up (spin-out) ▪ Productize in-house ▪ License (also includes potential for a services contract)		
3	Define value proposition for: ▪ Enabling technology ▪ Component ▪ Product		
4	Define pricing models and price points.		
5	Define stakeholders/advocates.		
6	Define business partners (primes, distributors).		
7	Define the financial analysis (profit and loss proforma, cash flow, operating expenses, financing requirements).		
8	Define business financing sources (public, private).		
9	Define company's transition project team (technology, business, marketing, finance domains).		
10	Define risk areas and mitigation, including the following identified in the National Research Council's "SBIR and the Phase III Challenge of Commercialization: Report of a Symposium", 2007 (p. 15): ▪ Ability to obtain funding to complete technology development ▪ Robustness of technology for integration into a DoD system ▪ Meeting DoD program schedule ▪ Meeting testing and engineering specs ▪ Ability to deliver on time and within budget ▪ Ability to scale		
11	Identify thought leadership opportunities (conference participation and publication opportunities).		
12	Identify networking opportunities (SBIR, DoD services, other federal agencies and trade organization meetings).		

Market Component

When the decision is made to continue the research that was proven to be viable during the SBIR/STTR Phase I project and award Phase II funding, one of the most important sets of activities is the analysis of the market and competition, which specifically identifies Phase III funding sources—public and/or private—that would have an interest in providing funding to fully mature the enabling technology, component, or product and then become a stakeholder or advocate in support the company's transition to the market. Regardless of the funding source—public or private—securing funding is competitive, and a company must understand its place within these "funding markets" early on to best position for securing funding.

Table 5, Market Checklist, identifies the key market elements that companies should review at the start of their Phase II project to identify any elements they have not yet addressed, or have addressed inadequately. Companies can then—in parallel with conducting their technology and business tasking—assign resources to address these market elements.

Table 5: Market Checklist (See section 7.0 Templates)

Market Checklist (Source: The Foundation for Enterprise Development)

#	Element	Priority (1-5)	Percent Completed
1	Define policy, legislation, and other new market drivers.		
2	Define and evaluate targeted markets (DoD, other federal, other government, commercial).		
3	Define and qualify targeted customers (agency, program, program manager): ▪ Technology Development phase ▪ Engineering and Manufacturing Development phase ▪ Production and Deployment phase		
4	Define current position within targeted customer sets: ▪ Current supplier ▪ Not a current supplier		
5	Define targeted federal acquisition and procurement models (RFP, BAA, IDIQ, GSA schedules).		
6	Define commercial sales models (direct sale, distributor).		
7	Define federal acquisition/procurement drivers: ▪ Meets requirements and specifications ▪ Price ▪ Best value ▪ Past performance ▪ Technical qualifications ▪ Team ▪ Other		
8	Define commercial purchasing drivers: ▪ Price ▪ Quality ▪ Support ▪ Other		
9	Identify competitors and assess positions.		
10	Define and implement needed business development capabilities (proposal development, costing, contracting, marketing).		
11	Perform self-analysis to understand strengths, weaknesses, opportunities, and threats (commonly referred to as a SWOT analysis).		

Companies should develop a project summary for distribution to potential advocates, partners, collaborators, and stakeholders—who also may be Phase III funding sources—to communicate information about the technology being developed. Companies must follow the DARPA process for public release, defined on the DARPA Web site, for review and approval of any materials that will be released to the public. For additional information on the DARPA public release process, see http://www.darpa.mil/tio. In addition, it is essential that companies address the protection of intellectual property

developed under the Phase II SBIR/STTR project prior to releasing or communicating information about the technology to others.

Table 6: Suggested Information to Include in a Project Summary

Suggested Information to Include in a Project Summary
▪ Technical challenge being addressed ▪ Applications/operational environments and scenarios ▪ Current state of the art and advantages of the technology over the existing state-of-the-art and competing technologies ▪ Company's innovative approach ▪ Proposed and demonstrated advantages ▪ Value to the end user ▪ How the technology will be integrated into a system required to field the technology in an operational environment ▪ Technical risk areas and how they are being addressed during the development activities ▪ Results from tests, experiments, and exercises ▪ Readiness of the company to meet the business, financial, and operational requirements to support and sustain the transition For DARPA review and approval process for any materials that will be released to the public see http://www.darpa.mil/tio

Currently there is no standard template for SBIR/STTR companies to prepare project descriptions to communicate—to potential transition partners, collaborators, or end users within the military services and other markets—detailed information about the technology or solutions under development. The SBIR/STTR project abstracts available on the publicly available www.dodsbir.net Web site provide a high-level project summary and approach overview, but do not include detailed information on potential applications, operational environments, integration requirements, the value proposition, or project results. In addition to the above suggested areas to cover in a project description, the following link to the Navy's Virtual Acquisition Showcase provides examples of project descriptions prepared by Navy SBIR/STTR funded companies: http://www.virtualacquisitionshowcase.com/browse09.php.

Selecting a Transition Pathway—Integration of Technology, Business, and Market Components

As companies work through the exercises and build on each component, viable transition pathways to move the technology from lab to fielding or the commercial market should become clear. The pathway is defined by integrating

the technology, business, and market components of the transition plan and assessing the whole for its viability and feasibility.

Figure 7, Technology Transition Strategy Table Legend, illustrates a way to document and think about the key technology options, business options, and market options that comprise potential paths a company may pursue to transition its technology.

Table 7: Technology Transition Strategy Table Legend

Transition Strategy	Definition
Technology Options	
Technology Solution	The offering the company is developing under the SBIR/STTR Phase II project—an enabling technology that may have a broad range of applications, a component that will require integration into a larger system for deployment in an operational environment, or a stand-alone product that may also be integrated into a larger system of systems configuration for deployment in an operational environment.
Business Options	
Business Model	The model the company plans to implement to generate revenue from the technology developed, including 1) sale of a product; 2) sale of professional services; 3) sale of a service; 4) licensing or sale of intellectual property. Companies may pursue multiple business models (e.g., license intellectual property and sell professional services or sell both a product and service). The business model also includes use of partners to support implementation of the model being pursued.

Transition Strategy	Definition
Transaction Model	How the company will implement the business model to sell it into various markets, including 1) in-house development and manufacturing of a product for delivery into the supply chain; 2) licensing the technology to another entity in the supply chain who will produce and sell a product; 3) selling the technology to an entity in the supply chain; 4) spinning out a new company to develop and manufacture and deliver a product into the supply chain.
Funding Sources	Funding sources used to support the various steps of technology transition into the marketplace, including 1) federal sources (DoD and other federal funding); 2) state and local sources; 3) private sources, including banks, internal and external investors, prime contractors, and other companies.
Market Options	
Procurement Channel	The vehicles available to end users to procure the company's products and services, including 1) DoD acquisition (including Programs of Record and other DoD programs and projects); 2) sales to end users via state and local procurement vehicles or federal procurement vehicles, such as GSA schedules; 3) direct sales to the private sector.
Markets and End User	The market(s) and end user(s) for the product or service, including 1) federal (DoD and other federal agencies and programs); 2) state and local organizations and programs; 3) commercial markets (e.g., healthcare, information security, telecommunications).

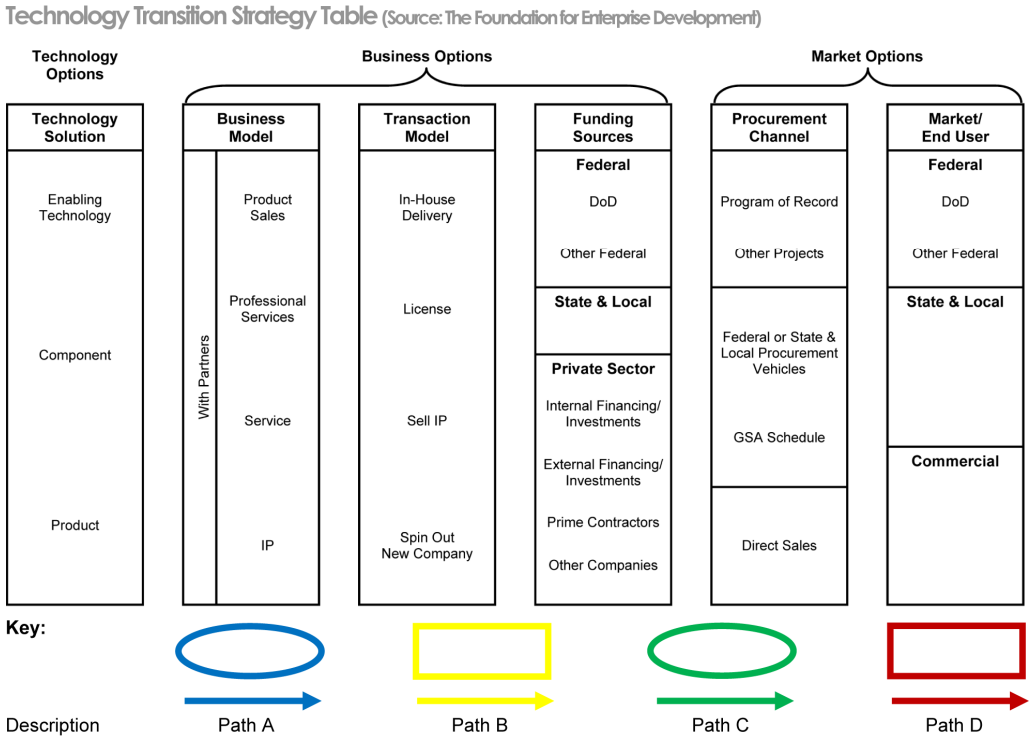


Figure 7: Technology Transition Strategy Table for Documenting Transition Pathways (See section 7.0 Templates)

Companies may have defined a priority transition pathway during the development of the commercialization strategy outlined in their Phase II proposal. However, we recommend that—after reviewing and addressing (or further addressing) the elements outlined in the technology, business, and market components of this guide—companies re-evaluate whether the pathways they have selected are still viable, or whether they should consider selecting alternative pathways that might result in a higher probability of transition success.

Uncertainties and unknowns of all types will surround the choices made for advancing new, innovative, and especially disruptive technology into the marketplace. This planning exercise is not meant to over-simplify those choices, but rather to provide a systems view of how those choices fit into an overall strategy. This exercise is also not meant to overly confine a company to one pathway, but it does encourage a company to limit the pathways pursued so that sufficient focus can be given and resources applied to executing specific transition activities. Undoubtedly, new information will be learned that requires some course correction throughout the process.

To help illustrate how Figure 7 can be used to document transition pathways, several examples are provided. First, Figure 8 shows how an enabling technology—an advanced algorithm funded by DARPA—has been transitioned into larger DoD systems, through licensing and partnering arrangements with primes. Figure 9 illustrates example pathways being explored for transitioning component technologies with applications into the DoD acquisition system and homeland security markets. Figure 10 illustrates example pathways that have been used for transitioning stand-alone devices and products into the DoD and commercial market.

Example A: Transition Pathway for an Enabling Algorithm Technology That Integrates into Larger Federal Systems

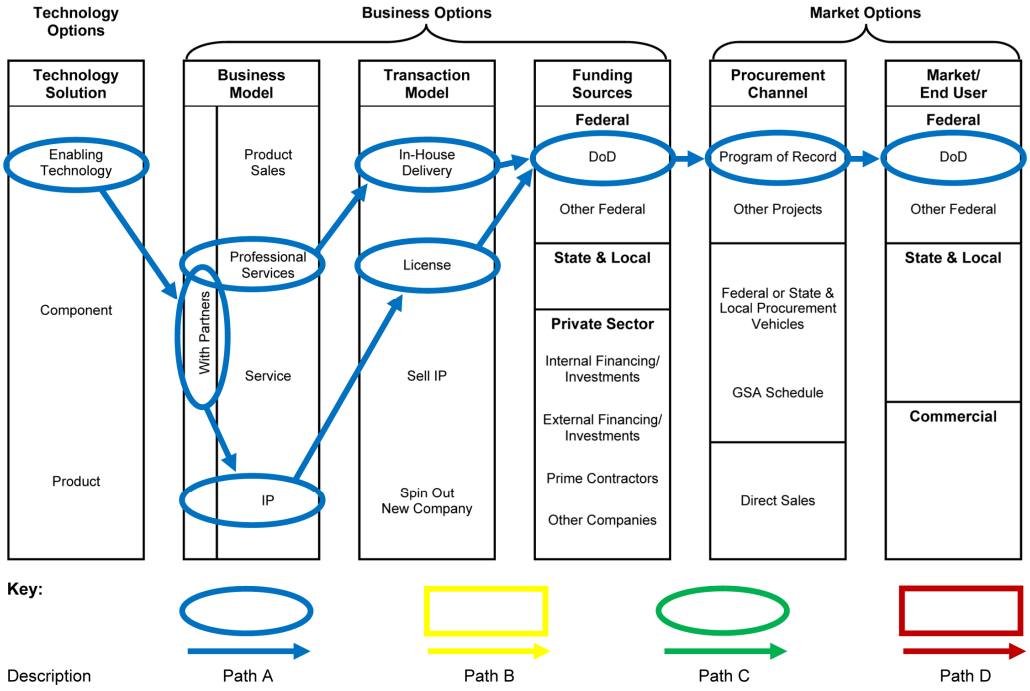


Figure 8: Example A Transition Pathways (Source: The Foundation for Enterprise Development)

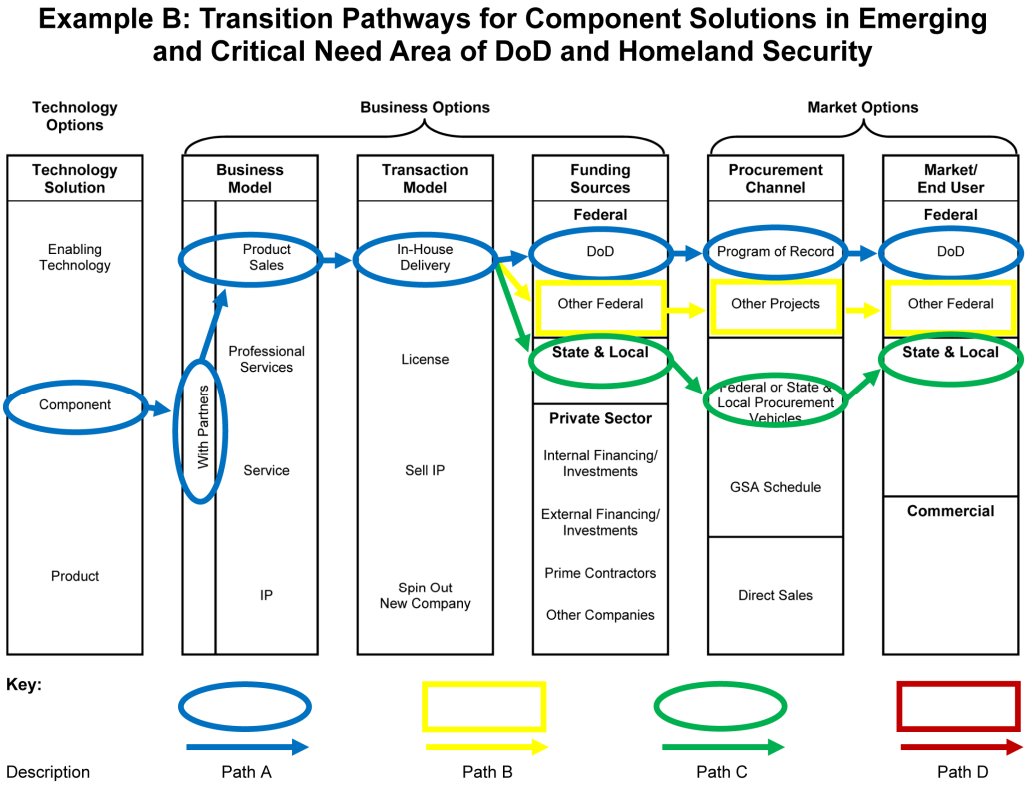


Figure 9: Example B Transition Pathways (Source: The Foundation for Enterprise Development)

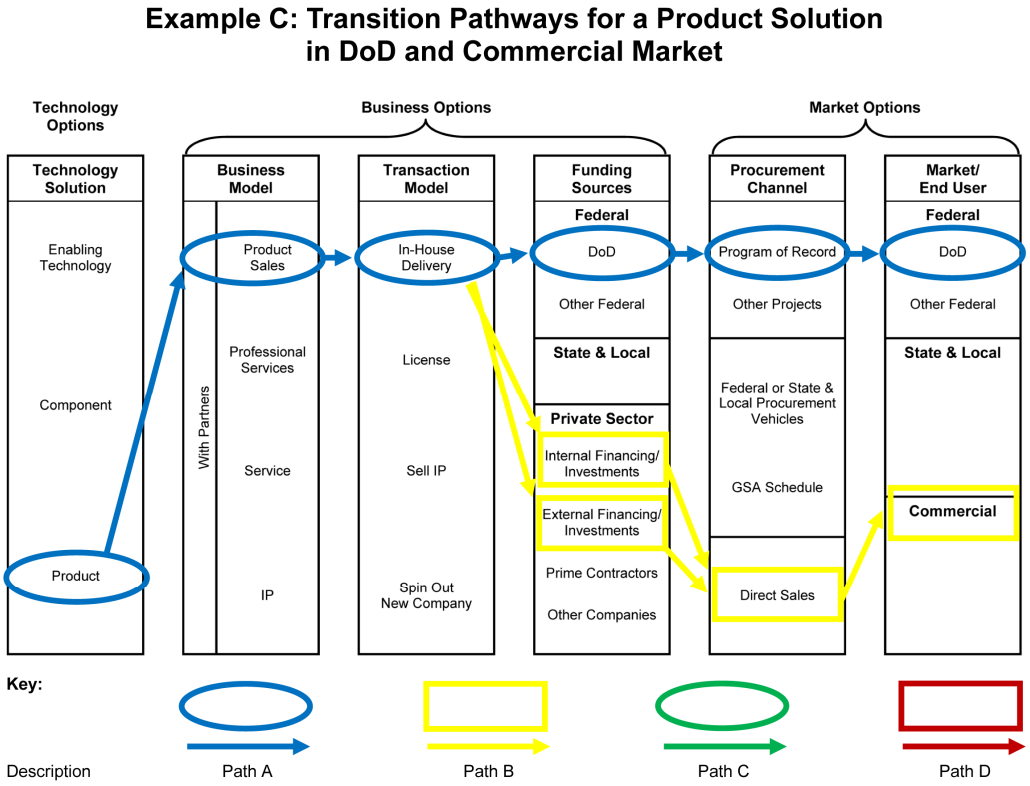


Figure 10: Example C Transition Pathways (Source: The Foundation for Enterprise Development)

5.0 Incremental Development and Implementation of the Transition Plan

The Phase III transition plan should be developed and implemented in conjunction with the Phase II SBIR/STTR and, for most companies, can be started by building upon the commercialization strategy outlined in the Phase II proposal. We anticipate that the transition plan will become more focused during the Phase II project and beyond as the result of the collection, review, and synthesis of all the information compiled during the transition plan development and associated activities.

Planning: Transition planning is a process, not a solution. The planning process should allow the company to develop awareness, make critical decisions, check assumptions and performance, and adjust and evolve throughout the project.

Program Management: As with any process or project, good project management is essential for managing transitions. Project management will help the company establish a set of tasks, schedule, and budget; identify key milestones and critical path tasks; maintain a schedule of detailed transition tasks for near-term completion; allocate and direct resources and budgets; measure performance against the plan; and report on transition status, accomplishments, and issues to be addressed by the team to ensure that transition activities stay focused an on plan.

Example checklists for tracking plan development and key transition milestones are provided in Table 8 and Table 9, respectively. The company should define clear roles and responsibilities of the transition team members and commit the required resources in order to optimize both individual and group efforts. Team members may be drawn from an existing pool of employees, consultants, and/or other trusted stakeholders outside the company.

Table 8: Transition Plan Components Development Checklist (See section 7.0 Templates)

Transition Plan Components Development Checklist
(Source: The Foundation for Enterprise Development)

Activity	Deliverable	Resources Assigned	Start Date	End Date
Define technology plan component.	Technology plan baseline			
Prepare business plan component.	Business plan baseline			
Define marketing and business development activities.	Marketing and business development plan			
Select transition path options.	Transition path baseline			
Implement transition plan.				

Table 9: Key Milestones for Transition (See section 7.0 Templates)

Key Milestones for Transition (Source: The Foundation for Enterprise Development)

	Phase II Key Milestones	Date Planned/Date Achieved
1	Technology Milestones (TRL)	
2	Manufacturing Milestones (MRL)	
3	Exercises (Agency, Program, PM)	
4	Experiments (Agency, Program, PM)	
5	Funding Milestone (Public and Private Sector)	
6	Thought Leadership Opportunities	

6.0 Resources

Department of Defense Technology Readiness Level Tables

Source: Department of Defense. *Defense Acquisition Guidebook*. Table 10.5.2 for TRL descriptions. [document online]; [cited 2010 February 15]. Available from: https://acc.dau.mil/CommunityBrowser.aspx?id=323139

Technology Readiness Level	Description
1. Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Example might include paper studies of a technology's basic properties.
2. Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.
3. Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4. Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of 'ad hoc' hardware in a laboratory.
5. Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include 'high fidelity' laboratory integration of components.
6. System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated operational environment.
7. System prototype demonstration in an operational environment	Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in an aircraft, vehicle or space. Examples include testing the prototype in a test bed aircraft.

Technology Readiness Level	Description
8. Actual system completed and 'flight qualified' through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.
9. Actual system 'flight proven' through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of true system development. Examples include using the system under operational mission conditions.

Hardware (HW) and Software (SW)

Technology Readiness Level	Description
1. Basic principles observed and reported	**HW/S:** Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties. **SW:** Lowest level of software readiness. Basic research begins to be translated into applied research and development. Examples might include a concept that can be implemented in software or analytic studies of an algorithm's basic properties.
2. Technology concept and/or application formulated	**HW/S/SW:** Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative and there may be no proof or de-tailed analysis to support the assumptions. Examples are limited to analytic studies.
3. Analytical and experimental critical function and/or characteristic proof of concept	**HW/S:** Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative. **SW:** Active research and development is initiated. This includes analytical studies to produce code that validates analytical predictions of separate software elements of the technology. Examples include software components that are not yet integrated or representative but satisfy an operational need. Algorithms run on a surrogate processor in a laboratory environment.

Technology Readiness Level	Description
4. Component and/or bread-board validation in laboratory environment	**HW/S:** Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of ad hoc hardware in the laboratory. **SW:** Basic software components are integrated to establish that they will work together. They are relatively primitive with regard to efficiency and reliability com-pared to the eventual system. System software architecture development initiated to include interoperability, reliability, maintainability, extensibility, scalability, and security issues. Software integrated with simulated cur-rent/legacy elements as appropriate.
5. Component and/or bread-board validation in relevant environment	**HW/S:** Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so it can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of components. **SW:** Reliability of software ensemble increases significantly. The basic software components are integrated with reasonably realistic supporting elements so that it can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of software components. System software architecture established. Algorithms run on a processor(s) with characteristics expected in the operational environment. Software releases are "Alpha" versions and configuration control is initiated. Verification, Validation, and Accreditation (VV&A) initiated.
6. System/subsystem model or prototype demonstration in a relevant environment	**HW/S:** Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in a simulated operational environment. **SW:** Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in software-demonstrated readiness. Examples include testing a prototype in a live/virtual experiment or in a simulated operational environment. Algorithms run on processor of the operational environment are integrated with actual external entities. Software releases are "Beta" versions and configuration controlled. Software support structure is in development. VV&A is in process.

Technology Readiness Level	Description
7. System prototype demonstration in an operational environment	**HW/S:** Prototype near, or at, planned operational system. Represents a major step up from TRL 6, requiring demonstration of an actual system prototype in an operational environment such as an aircraft, vehicle, or space. Examples include testing the prototype in a test bed aircraft. **SW:** Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in a command post or air/ground vehicle. Algorithms run on processor of the operational environment are integrated with actual external entities. Software support structure is in place. Soft-ware releases are in distinct versions. Frequency and se-verity of software deficiency reports do not significantly degrade functionality or performance. VV&A completed.
8. Actual system completed and qualified through test and demonstration	**HW/S:** Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications. **SW:** Software has been demonstrated to work in its final form and under expected conditions. In most cases, this TRL represents the end of system development. Examples include test and evaluation of the software in its in-tended system to determine if it meets design specifications. Software releases are production versions and configuration controlled, in a secure environment. Soft-ware deficiencies are rapidly resolved through support infrastructure.
9. Actual system proven through successful mission operations	**HW/S:** Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational mission conditions. **SW:** Actual application of the software in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last “bug fixing” aspects of the system development. Examples include using the system under operational mission conditions. Software releases are production versions and configuration controlled. Frequency and severity of software deficiencies are at a minimum.

Definitions for Terms Used in the TRL Tables

Breadboard: Integrated components that provide a representation of a system/subsystem and that can be used to determine concept feasibility and to develop technical data. Typically configured for laboratory use to demonstrate the technical principles of immediate interest. May resemble final system/subsystem in function only.

High fidelity: Addresses form, fit, and function. High-fidelity laboratory environment would involve testing with equipment that can simulate and validate all system specifications within a laboratory setting.

Low fidelity: A representative of the component or system that has limited ability to provide anything but first order information about the end product. Low-fidelity assessments are used to provide trend analysis.

Model: A functional form of a system, generally reduced in scale, near or at operational specification. Models will be sufficiently hardened to allow demonstration of the technical and operational capabilities required of the final system.

Operational environment: Environment that addresses all of the operational requirements and specifications required of the final system, including platform/packaging.

Prototype: A physical or virtual model used to evaluate the technical or manufacturing feasibility or military utility of a particular technology or process, concept, end item, or system.

Relevant environment: Testing environment that simulates the key aspects of the operational environment.

Simulated operational environment: Either (*a*) a real environment that can simulate all of the operational requirements and specifications required of the final system, or (*b*) a simulated environment that allows for testing of a virtual prototype. Used in either case to determine whether a developmental system meets the operational requirements and specifications of the final system.

Department of Defense Manufacturing Readiness Level Definitions

Source: Department of Defense, Joint Defense Manufacturing Technology Panel (JDMTP). *Manufacturing Readiness Assessment (MRA) Deskbook* (version 7.1). 2009, A1-A3. [document online]; [cited 2010 Feb 12]. Available from: http://www.dodmrl.com/MRA_Deskbook_v7.1.pdf

MRL	Definition	Description	Phase
1	Basic Manufacturing Implications Identified	This is the lowest level of manufacturing readiness. Basic research expands scientific principles that may have manufacturing implications. The focus is on a high level assessment of manufacturing opportunities. The research is unfettered.	Pre Materiel Solution Analysis
2	Manufacturing Concepts Identified	Invention begins. Manufacturing science and/or concept described in application context. Identification of material and process approaches are limited to paper studies and analysis. Initial manufacturing feasibility and issues are emerging.	Pre Materiel Solution Analysis

MRL	Definition	Description	Phase
3	Manufacturing Proof of Concept Developed	Conduct analytical or laboratory experiments to validate paper studies. Experimental hardware or processes have been created, but are not yet integrated or representative. Materials and/or processes have been characterized for manufacturability and availability but further evaluation and demonstration is required.	Pre Materiel Solution Analysis
4	Capability to produce the technology in a laboratory environment	Required investments, such as manufacturing technology development identified. Processes to ensure manufacturability, producibility and quality are in place and are sufficient to produce technology demonstrators. Manufacturing risks identified for prototype build. Manufacturing cost drivers identified. Producibility assessments of design concepts have been completed. Key design performance parameters identified. Special needs identified for tooling, facilities, material handling and skills.	Materiel Solution Analysis (MSA) leading to a Milestone A decision
5	Capability to produce prototype components in a production relevant environment	Mfg strategy refined and integrated with Risk Mgt Plan. Identification of enabling/critical technologies and components is complete. Prototype materials, tooling and test equipment, as well as personnel skills have been demonstrated on components in a production relevant environment, but many manufacturing processes and procedures are still in development. Manufacturing technology development efforts initiated or ongoing. Producibility assessments of key technologies and components ongoing. Cost model based upon detailed end-to-end value stream map.	Technology Development (TD) Phase
6	Capability to produce a prototype system or subsystem in a production relevant environment	Initial mfg approach developed. Majority of manufacturing processes have been defined and characterized, but there are still significant engineering/design changes. Preliminary design of critical components completed. Producibility assessments of key technologies complete. Prototype materials, tooling and test equipment, as well as personnel skills have been demonstrated on subsystems/systems in a production relevant environment. Detailed cost analysis include design trades. Cost targets allocated. Producibility considerations shape system development plans. Long lead and key supply chain elements identified. Industrial Capabilities Assessment (ICA) for MS B completed.	Technology Development (TD) phase leading to a Milestone B decision
7	Capability to produce systems, subsystems or components in a production representative environment	Detailed design is underway. Material specifications are approved. Materials available to meet planned pilot line build schedule. Manufacturing processes and procedures demonstrated in a production representative environment. Detailed producibility trade studies and risk assessments underway. Cost models updated with detailed designs, rolled up to system level and tracked against targets. Unit cost reduction efforts underway. Supply chain and supplier QA assessed. Long lead procurement plans in place. Production tooling and test equipment design & development initiated.	Engineering & Manufacturing Development (EMD) leading to Post CDR Assessment

MRL	Definition	Description	Phase
8	Pilot line capability demonstrated. Ready to begin low rate production	Detailed system design essentially complete and sufficiently stable to enter low rate production. All materials are available to meet planned low rate production schedule. Manufacturing and quality processes and procedures proven in a pilot line environment, under control and ready for low rate production. Known producibility risks pose no significant risk for low rate production. Engineering cost model driven by detailed design and validated. Supply chain established and stable. ICA for MS C completed.	Engineering & Manufacturing Development (EMD) leading to a Milestone C decision
9	Low Rate Production demonstrated. Capability in place to begin Full Rate Production	Major system design features are stable and proven in test and evaluation. Materials are available to meet planned rate production schedules. Manufacturing processes and procedures are established and controlled to three-sigma or some other appropriate quality level to meet design key characteristic tolerances in a low rate production environment. Production risk monitoring ongoing. LRIP cost goals met, learning curve validated. Actual cost model developed for FRP environment, with impact of Continuous improvement.	Production & Deployment leading to a Full Rate Production (FRP) decision
10	Full Rate Production demonstrated and lean production practices in place	This is the highest level of production readiness. Engineering/design changes are few and generally limited to quality and cost improvements. System, components or items are in rate production and meet all engineering, performance, quality and reliability requirements. All materials, manufacturing processes and procedures, inspection and test equipment are in production and controlled to six-sigma or some other appropriate quality level. FRP unit cost meets goal, funding sufficient for production at required rates. Lean practices well established and continuous process improvements ongoing.	Full Rate Production/ Sustainment

Definitions of Terms Found in Manufacturing Readiness Level Definitions

Production relevant environment – An environment normally found during MRL 5 and 6 that contains key elements of production realism not normally found in the laboratory environment (e.g. uses production personnel, materials or equipment or tooling, or process steps, or work instructions, stated cycle time, etc.). May occur in a laboratory or model shop if key elements or production realism are added.

Production representative environment – An environment normally found during MRL 7 (probably on the manufacturing floor) that contains most of the key elements (tooling, equipment, temperature, cleanliness, lighting, personnel skill levels, materials, work instructions, etc) that will be present in the shop floor production areas where low rate production will eventually take place.

Pilot line environment – An environment normally found during MRL 8 in a manufacturing floor production area that incorporates all of the key elements (equipment, personnel skill levels, materials, components, work instructions, tooling, etc.) required to produce production configuration items, subsystems or systems that meet design requirements in low rate production. To the maximum extent practical, the pilot line should utilize rate production processes.

Manufacturability – The characteristics considered in the design cycle that focus on process capabilities, machine or facility flexibility, and the overall ability to consistently produce at the required level of cost and quality. Activities can include some or all of the following activities:

- Design for commonality and standardization- fewer parts
- Perform comprehensive Technology Assessment, including commercial industrial applications and the supplier base
- Design for Multi-Use and Dual-Use applications
- Design for modularity and plug compatible interface/integration
- Design for flexibility, adaptability, and "robust design"
- Utilize reliable processes and materials

Producibility – Is the capability of an item to be produced, including some or all of the following activities:

- Design to specific Cp-CpK process control parameters- six sigma
- Perform material characterization analysis
- Perform variability reduction analysis- Taguchi, DOE
- Develop critical materials and processes before selecting product design
- Utilize pervasive modeling & simulation for product and process design tradeoffs
- Design and deployment of closed-loop process-control on critical items

RDT&E Budget Activities

Source: Department of Defense. "RDT&E Budget Activities" in *DoD Financial Management Regulation*. Volume 2B, Chapter 5. July 2008. [document online]; [cited 2010 Feb 12]. Available from: http://www.defenselink.mil/comptroller/fmr/02b/02b_05.pdf

A. The RDT&E budget activities are broad categories reflecting different types of RDT&E efforts. The definitions are provided below.

B. Budget Activity 1, Basic Research. Basic research is systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of

observable facts without specific applications towards processes or products in mind. It includes all scientific study and experimentation directed toward increasing fundamental knowledge and understanding in those fields of the physical, engineering, environmental, and life sciences related to long-term national security needs. It is farsighted high payoff research that provides the basis for technological progress. Basic research may lead to: (a) subsequent applied research and advanced technology developments in Defense-related technologies, and (b) new and improved military functional capabilities in areas such as communications, detection, tracking, surveillance, propulsion, mobility, guidance and control, navigation, energy conversion, materials and structures, and personnel support. Program elements in this category involve pre-Milestone A efforts.

C. Budget Activity 2, Applied Research. Applied research is systematic study to understand the means to meet a recognized and specific need. It is a systematic expansion and application of knowledge to develop useful materials, devices, and systems or methods. It may be oriented, ultimately, toward the design, development, and improvement of prototypes and new processes to meet general mission area requirements. Applied research may translate promising basic research into solutions for broadly defined military needs, short of system development. This type of effort may vary from systematic mission-directed research beyond that in Budget Activity 1 to sophisticated breadboard hardware, study, programming and planning efforts that establish the initial feasibility and practicality of proposed solutions to technological challenges. It includes studies, investigations, and non-system specific technology efforts. The dominant characteristic is that applied research is directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters. Applied Research precedes system specific technology investigations or development. Program control of the Applied Research program element is normally exercised by general level of effort. Program elements in this category involve pre-Milestone B efforts, also known as Concept and Technology Development phase tasks, such as concept exploration efforts and paper studies of alternative concepts for meeting a mission need.

D. Budget Activity 3, Advanced Technology Development (ATD). This budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment. ATD includes concept and technology demonstrations of components and subsystems or system models. The models may be form, fit and function prototypes or scaled models that serve the same demonstration purpose. The results of this type of effort are proof of technological feasibility and assessment of subsystem and component operability and producibility rather than the development of hardware for service use. Projects in this category have a direct relevance to identified military needs. Advanced Technology Development demonstrates the general military utility or cost reduction potential of technology when applied to different types of military equipment or techniques. Program elements in this category involve pre-Milestone B efforts, such as

system concept demonstration, joint and Service-specific experiments or Technology Demonstrations and generally have Technology Readiness Levels of 4, 5, or 6. Projects in this category do not necessarily lead to subsequent development or procurement phases, but should have the goal of moving out of Science and Technology (S&T) and into the acquisition process within the future years defense program (FYDP). Upon successful completion of projects that have military utility, the technology should be available for transition.

E. Budget Activity 4, Advanced Component Development and Prototypes (ACD&P). Efforts necessary to evaluate integrated technologies, representative modes or prototype systems in a high fidelity and realistic operating environment are funded in this budget activity. The ACD&P phase includes system specific efforts that help expedite technology transition from the laboratory to operational use. Emphasis is on proving component and subsystem maturity prior to integration in major and complex systems and may involve risk reduction initiatives. Program elements in this category involve efforts prior to Milestone B and are referred to as advanced component development activities and include technology demonstrations. Completion of Technology Readiness Levels 6 and 7 should be achieved for major programs. Program control is exercised at the program and project level. A logical progression of program phases and development and/or production funding must be evident in the FYDP.

F. Budget Activity 5, System Development and Demonstration (SDD). SDD programs have passed Milestone B approval and are conducting engineering and manufacturing development tasks aimed at meeting validated requirements prior to full-rate production. This budget activity is characterized by major line item projects and program control is exercised by review of individual programs and projects. Prototype performance is near or at planned operational system levels. Characteristics of this budget activity involve mature system development, integration and demonstration to support Milestone C decisions, and conducting live fire test and evaluation and initial operational test and evaluation of production representative articles. A logical progression of program phases and development and production funding must be evident in the FYDP consistent with the Department's full funding policy.

G. Budget Activity 6, RDT&E Management Support. This budget activity includes research, development, test and evaluation efforts and funds to sustain and/or modernize the installations or operations required for general research, development, test and evaluation. Test ranges, military construction, maintenance support of laboratories, operation and maintenance of test aircraft and ships, and studies and analyses in support of the RDT&E program are funded in this budget activity. Costs of laboratory personnel, either in-house or contractor operated, would be assigned to appropriate projects or as a line item in the Basic Research, Applied Research, or ATD program areas, as appropriate. Military construction costs directly related to major development programs are included.

H. Budget Activity 7, Operational System Development. This budget activity includes development efforts to upgrade systems that have been fielded or have received approval for full rate production and anticipate production funding in the current or subsequent fiscal year. All items are major line item projects that appear as RDT&E Costs of Weapon System Elements in other programs. Program control is exercised by review of individual projects. Programs in this category involve systems that have received Milestone C approval. A logical progression of program phases and development and production funding must be evident in the FYDP, consistent with the Department's full funding policy.

Resources for Small Business

The resources provided in this section are for information purposes only, are not intended to be an endorsement of any particular organization or agency, and do not reflect all possible sources of information to support transition and commercialization activities. We encourage all SBIR/STTR companies to continually seek out and employ a variety of resources available via the Internet and other sources to support their transition activities.

Sample of Federal Contracting, DoD, and Other Small Business Related Resource Sites

Federal Resources—Procurement Related

- Small Business Innovation Research Program Policy Directive http://www.sba.gov/idc/groups/public/documents/sba_program_office/sbir_policy_directive.pdf:

  See Section 8 for Information regarding "Rights In Data Developed Under SBIR Funding Agreement."

- U.S. General Services Administration:

  GSA awards contracts to responsible companies offering commercial items at fair and reasonable prices that fall within the generic descriptions in the GSA Schedule Solicitations.

  - "For Vendors - Getting on Schedule" http://www.gsa.gov/Portal/gsa/ep/contentView.do?contentType=GSA_OVERVIEW&contentId=8202
  - "Assistance for Small Businesses" http://www.gsa.gov/Portal/gsa/ep/contentView.do?contentType=GSA_OVERVIEW&contentId=25574

- GSA Schedules Training Webinar schedule http://www.gsa.gov/Portal/gsa/ep/contentView.do?eventId=5590&contentType=GSA_EVENTS&byEventId=y

DoD-Wide Resources

- Defense Contract Audit Agency http://www.dcaa.mil/:

  Under the authority, direction, and control of the Under Secretary of Defense (Comptroller), is responsible for performing all contract audits for the Department of Defense, and providing accounting and financial advisory services regarding contracts and subcontracts to all DoD Components responsible for procurement and contract administration. These services are provided in connection with negotiation, administration, and settlement of contracts and subcontracts. DCAA also provides contract audit services to some other Government Agencies.

  "Information for Contractors" is available via http://www.dcaa.mil/dcaap7641.90.pdf. This pamphlet has been prepared to assist contractors in understanding applicable requirements and to help ease the contract audit process. The models in this pamphlet are presented to illustrate some of the more frequent requirements that contractors encounter when working with DCAA auditors and in responding to the Government procurement and administrative process. Our examples are intended solely to provide better insight into the procurement process and should not be construed as uniform guides. Nor should this pamphlet be considered a substitute for the applicable rules and regulations, as not all requirements are contained herein. Each contractor must tailor its responses to its individual situation.

- Department of Defense Instruction 50000.02 (December 8, 2008), "Operation of the Defense Acquisition System" http://www.dtic.mil/whs/directives/corres/pdf/500002p.pdf
- Director of Administration & Management, "Organization and Functions Guide" (March 2008) http://www.defenselink.mil/odam/omp/pubs/GuideBook/ToC.htm
- Office of Small Business Programs, "Doing Business with the Department of Defense: The Basics" http://www.acq.osd.mil/osbp/doing_business/index.htm
- Office of Small Business Programs, "Guide to DoD Contracting Opportunities "A Step-by-Step Approach to the DoD Marketplace" http://www.acq.osd.mil/osbp/doing_business/DoD_Contracting_Guide.htm
- Office of Small Business Programs, "Marketing to the Department of Defense – The Basics" http://www.acq.osd.mil/osbp/doing_business/Marketing%20to%20DoD%20012007.pdf

- TechLink http://www.techlinkcenter.org/cgi-bin/techlink/index.html:

  TechLink helps the Department of Defense to commercialize leading-edge new technology by partnering DoD labs with private sector companies for technology licensing, transfer, and research and development.

- Defense Logistics Agency (DLA) http://www.aptac-us.org/new/index.php:

  There are over ninety Procurement Technical Assistance Centers (PTACs) with over 300 local offices that provide procurement support as an extension of DLA's mission of providing the best value goods and services to America's Armed Forces and other government agencies. PTACs procurement specialist provide contractors with knowledge of government contracting.

- Assistant Secretary of Defense for Networks and Information Integration/DoD CIO, DoD Information Assurance Certification and Accreditation Process (DIACAP) http://iase.disa.mil/diacap:

  DIACAP is the standard process under which all DoD information systems will achieve and maintain their Authority To Operate (ATO).

Transitioning Technology into First Responder Community

- Office of the Assistant Secretary of Defense, "1401 Technology Transfer Program" http://www.dodtechmatch.com/DOD/ProgramBriefing.ppt

- DoD First Link http://www.dodfirstlink.com:

  First National Center of Excellence for First Responder Technologies. Services are provided through a partnership with the United States Department of Defense Office of Technology Transition and the Air Force Research Laboratory (AFRL).

DoD Component Resources for Small Business (SBIR/STTR)

Defense Advanced Research Projects Agency (DARPA)

- DARPA Small Business Program Office (SBPO) http://www.darpa.mil/sbpo/
- DARPA Success Reports http://www.darpa.mil/sbpo/success/index.html

Army

- Army Phase II Technology Transition and Commercialization Strategy Components http://www.armysbir.com/sbir/07p2_instruct.htm
- Army Commercialization Pilot Program (CPP) http://www.armysbir.com/sbir/cpp_desc.htm
- Army's Small Business Portal http://www.armysbir.com/small_buss_portal.htm

- Joint Science and Technology Office for Chemical and Biological Defense http://www.armysbir.com/cbd/cbd.htm:

  The Joint Science and Technology Office for Chemical and Biological Defense (JSTO-CBD) provides the management for the Science and Technology component of the Chemical and Biological Defense program. Technologies developed under the SBIR program have the potential to transition to the Joint Program Executive Office for Chemical and Biological Defense (JPEO-CBD) if the appropriate level of technology maturity has been demonstrated. The JSTO-CBD Science & Technology programs and initiatives are improving defensive capabilities against Chemical and Biological Weapons.

Air Force

- Air Force SBIR/STTR Program http://www.sbirsttrmall.com/Overview/Default.aspx
- Air Force Small Business Innovative Research (SBIR) Commercialization Pilot Program (CPP) http://www.sbirsttrmall.com/CommercializationPilotProgram/default.aspx
- Air Force Small Business Portal http://www.selltoairforce.org/

Navy

- Navy SBIR/STTR Program http://www.navysbir.com/
- Navy Phase II STTR Transition Plan http://www.navysbir.com/Navy_STTR_Transition_Plan_for%20Phase_II_Update_12-08.pdf
- Navy SBIR Commercialization Pilot Program http://www.navysbir.com/navy_CPP.htm
- U.S. Navy. *Best Technology Transition Practices: The Navy Small Business Innovation Research Program.* (April 2008). http://www.navysbir.com/docs/Best_Practices_public3.pdf
- U. S. Navy. *Defense Contractors SBIR/STTR Partnering Manual: A Primer on Technology Risk Management and Partnering Strategies.* (August 1 2008). http://www.navysbir.com/docs/Navy_Partnering_Manual_public_release.pdf
- Center for Commercialization of Advanced Technology (CCAT) http://www.ccatsocal.org/index.html:

  Funded through the Office of Naval Research. "…employs an academic-industry-government collaborative process to define Department of Defense (DoD) priority requirements, identify candidate technology solutions, and promote their transition to both the commercial and government marketplaces, including government programs of record (POR)."

Special Operations Command (SOCOM)

- SOCOM Commercialization Pilot Program
  http://www.socomsbir.com/sbir_commercialization.asp

Missile Defense Agency (MDA)

- Doing Business with MDA http://www.winmda.com

Sample of Small Business Registration Sites and Points of Contact for Federal Prime Contractors

- Battelle Supplier Registration
  http://www.battelle.org/PRODUCTSCONTRACTS/small_business/opportunities.aspx
- Boeing Supplier Outreach https://app.suppliergateway.com/boeing/Login.aspx
- General Dynamics Supplier Diversity Program
  http://www.generaldynamics.com/supply_chain/bu-websites.htm
- Lockheed Martin Supplier Registration
  http://www.lockheedmartin.com/suppliers/supplier-diversity
- Northop Grumman Program
  http://www.ms.northropgrumman.com/about_us/suppliers/small_business.html
- QinetiQ-North America http://www.qinetiq-na.com;
  Suzan Zimmerman, Sr. Vice President Suzan.Zimmerman@QinetiQ-NA.com; and
  Michael Zatman, Senior Technical Fellow, Michael.Zatman@QinetiQ-NA.com
- Raytheon Supplier Registration https://app.suppliergateway.com/raytheon/Login.aspx
- Raytheon Supplier Diversity Program
  http://www.raytheon.com/connections/supplier/diversity
- Rockwell Collins Small Business Program
  http://www.rockwellcollins.com/suppliers/smallbusiness/index.html
- SAIC Supplier Registration http://contacts.saic.com/sbsExt.nsf/extSubmit?OpenForm

Sample of DoD Sites With Resources to Support Transition

Phase III funding includes funding from non-SBIR or non-STTR sources. In addition to various public and private sources of funding, the following provides links to specific programs providing sources of Phase III funding.

References Source:
U. S. Navy. *Defense Contractors SBIR/STTR Partnering Manual: A Primer on Technology Risk Management and Partnering Strategies.* (August 1 2008). [cited 2010 Feb 12]. Available from: http://www.navysbir.com/docs/Navy_Partnering_Manual_public_release.pdf

- Office of the Secretary of Defense (OSD) Defense Acquisition Challenge Program (DACP) https://cto.acqcenter.com/osd/portal.nsf/InfoDAC?ReadForm:

  The purpose is to identify, introduce, test, and procure innovative and cost-saving technology or products from within and outside DoD's S&T community. Proposals are accepted from commands in May only. Funding up to $2 million covers a two-year project, for ≈ six awards per year.

- OSD Technology Transition Initiative (TTI) http://www.acq.osd.mil/ott/tti:

  The purpose is to facilitate the rapid transition of new technologies from DoD S&T programs. Proposals are accepted from commands in May only. Funding up to $3 million covers a four-year project, for ≈four awards per year.

- OSD Foreign Comparative Testing Program (FCT) https://cto.acqcenter.com/osd/portal.nsf/InfoFCT?ReadForm:

  The purpose is to test and evaluate foreign non-development, or COTS equipment with demonstrated potential to satisfy warfighter and/or warfighter support requirements. Proposals are accepted from commands in May only. Funding up to $2 million covers a two-year project, for ≈six awards per year.

- OSD Quick Reaction Fund (QRF) http://www.onr.navy.mil/sci_tech/3t/transition/ti_qrf/default.asp, http://www.dod.mil/ddre/org_PandP_RTS_QRF.html:

  The purpose is to identify and rapidly field-test prototypes that respond to immediate and emerging warfighter needs. Proposals are accepted from commands on a rolling basis. Funding up to $3 million covers a one-year project, for ≈two awards per year.

- Navy Rapid Technology Transition (RTT) http://www.onr.navy.mil/sci_tech/3t/transition/ti_rtt/default.asp:

  The purpose is to rapidly transition technology into Navy Programs of Record to meet emergent/urgent Navy needs. Proposals are accepted from command CTOs in March only. Funding up to $2 million covers ≈15 two-year project awards per year.

- Navy Technology Insertion Program for Savings (TIPS) http://www.onr.navy.mil/sci_tech/3t/transition/ti_tips/default.asp:

  The purpose is to rapidly transition technology into Navy Programs of Record to significantly reduce operations and support costs. Proposals are accepted from command CTOs in March only. Funding up to $2 million covers ≈15 two-year project awards per year.

- Navy Rapid Development & Deployment (RDD) http://www.onr.navy.mil/sci_tech/3t/transition/ti_rdd/default.asp:

  The purpose is to rapidly develop and field prototype solutions to meet urgent Navy operational needs. Proposals are accepted from CNO N8 on a rolling basis. Funding up to $10 million covers ≈two one-year project awards per year.

Sample of Manufacturing Related Resource Sites

- DoD Manufacturing Readiness http://www.dodmrl.com:

  Manufacturing readiness, like technology readiness, is critical to the successful introduction of new products and technologies (into DoD systems). Consideration of manufacturing risks and issues should begin early in technology development and intensify as the technology matures so that manufacturing maturity is sufficient at the time of transition to support rapid and affordable system incorporation.

- DoD ManTech Program http://www.dodmantech.com:

  "The DoD Manufacturing Technology (ManTech) Program focuses on the needs of weapon system programs for affordable, low-risk development and production. It provides the crucial link between technology invention and development, and industrial applications. It matures and validates emerging manufacturing technologies to support low-risk implementation in industry and DoD facilities, e.g., depots and shipyards. The Program addresses production issues from system development through transition to production and sustainment. By identifying production issues early and providing timely solutions, the ManTech Program reduces risk and positively impacts system affordability by providing solutions to manufacturing problems before they occur."

  "For specific information on the Army, Navy, Air Force, and Defense Logistics Agency ManTech programs and how to work with those programs, and information on the technical areas within the ManTech Program, contact the service and agency members of the DoD ManTech community listed in the: Joint Defense ManTech Services/Agencies Directory."

- ManTech Success Stories https://www.dodmantech.com/successes/index.asp?main=success

- Defense Production Act Title III www.acq.osd.mil/ott/dpatitle3:

  The mission of the Defense Production Act (DPA) Title III Program (Title III) as outlined in Title III of the Defense Production Act of 1950 is to create assured, affordable, and commercially viable production capabilities and capacities for items essential for national defense. Title III promotes production capabilities that would otherwise be inadequate to support the material requirements of defense programs in a timely and affordable manner and focuses on materials and components that could be used in a broad spectrum of defense systems. The Title III program provides financial incentives to industry to make investment in production capabilities and resources; executes projects ranging from process

improvements to production plant construction; and targets the most important elements of production as they relate to both the nation's needs and industry business model.

- Best Manufacturing Practices Center of Excellence, "Program Manager's WorkStation (PMWS) Overview" http://www.bmpcoe.org/pmws/:

  "PMWS is an electronic suite of tools designed to provide timely acquisition and engineering information to the user. The main components of the PMWS are KnowHow, the Technical Risk Identification and Mitigation System (TRIMS), and the BMP Database. These tools complement one another and provide users with the knowledge, insight, and experience to make informed decisions through all phases of product development, production, and beyond."

- To locate other manufacturing related associations and standards organizations, see *Industry Week* Associations http://www.industryweek.com/associations/.

Sample of Resources on Commercialization, Technical Project Management, Business Planning for Entrepreneurs, and Start-Up Business

- For general business planning support, small businesses can contact their local Small Business Development Centers (SBDC), sponsored by the Small Business Administration. SBDCs offer one-stop assistance to individuals and small businesses by providing a wide variety of information and assistance in central and branch locations. Additional information can be found at http://www.sba.gov/aboutsba/sbaprograms/sbdc/index.html.

- To locate a SBDC in your state, see the SBDC locator http://www.sba.gov/aboutsba/sbaprograms/sbdc/sbdclocator/SBDC_LOCATOR.html.

- Entrepreneurship centers, many associated with universities, can provide useful articles, books, others materials, and assistance. A small business could access local entrepreneurial centers associated with universities by checking the Global Consortium of Entrepreneurship Centers (www.nationalconsortium.org). Suggested readings for entrepreneurs are provided by many of these centers and universities. Here are only a few examples of centers:

  - Ewing Marion Kauffman Foundation http://www.entrepreneurship.org/ResourcesCenter
  - George Mason University http://entrepreneurship.gmu.edu/entrepreneurs_resources.html
  - MIT Entrepreneurship Center http://entrepreneurship.mit.edu/booklist.php
  - San Diego State University Entrepreneurship Management Center http://www-rohan.sdsu.edu/dept/emc/resources/

- Stage-Gate Commercialization Method http://www.12manage.com/methods_cooper_stage-gate.html:

  Robert G. Cooper in *The Journal of Marketing Management*, 3, 3, Spring 1988. An even earlier version can be found in Cooper's book, *Winning at New Products*, published in 1986. Provided here as one example used to illustrate stage-gate commercialization method, focused on new products, and referenced in the planning section of this guide.

- New Product Development:

  There are many articles and books providing examples, advice, and frameworks on new product development, commercialization, and innovation. Although many are oriented toward helping large companies commercialize new products, small businesses could consider using some of the principles and adjust the frameworks to fit their circumstances. A few frequently referenced frameworks for commercialization of innovative or new products include:

  - Christensen, Clayton. *The Innovator's Dilemma*. Harvard Business School Press, 1997.
  - Moore, Geoffery. *Crossing the Chasm: Marketing and Selling High-Tech Products to Mainstream Customers*. HarperBusiness, 1991, revised 1999.
  - Ulrich, Karl T. and Steven D Eppinger. *Product Design and Development*. 3rd ed. McGraw-Hill/Irwin, 2004.
  - Wheelwright and Clark. *Revolutionizing Product Development: Quantum Leaps in Speed, Efficiency, and Quality*. The Free Press, 1992.

- Project Management Institute http://www.pmi.org/Resources/Pages/Default.aspx:

  This is a not-for-profit association for project management professionals, providing publications and training on a range of project management topics.

- Software Engineering Institute, Carnegie Mellon http://www.sei.cmu.edu/publications/:

  Provides training and publications to advance software/systems engineering and related disciplines to ensure the development and operations of systems with predictability and improved cost, schedule, and quality.

- State Science and Technology Institute (STTI) http://www.ssti.org/index.html:

  "SSTI is a national nonprofit organization that leads, supports and strengthens efforts to improve state and regional economies through science, technology and innovation."

Sample of National Security-Focused Organizations that Provide Training, Education, Thought Leadership, and Networking Opportunities for SBIR/STTR Companies

- National Defense Industries Association (NDIA) http://www.ndia.org:

  "NDIA is America's leading Defense Industry association promoting national security. NDIA is proud to provide a legal and ethical forum for the exchange of information between industry and government on national security issues. NDIA's members foster the development of the most innovative and superior equipment, training, and support for our warfighters and first responders through their divisions, local chapters, affiliated associations, and events."

- Armed Forces Communications and Electronics Association (AFCEA) International http://www.afcea.org/:

  "AFCEA International, is a non-profit membership association serving the military, government, industry, and academia as an ethical forum for advancing professional knowledge and relationships in the fields of communications, IT, intelligence, and global security."

7.0 Templates

Technology Checklist (Source: The Foundation for Enterprise Development)

#	Element	Priority (1-5)	Percent Completed
1	Define what you are developing under your SBIR/STTR Project (see Table 2 for definitions): ▪ Enabling technology ▪ Product ▪ Component		
2	Define related research projects that can leverage your Phase II SBIR/STTR project activities (other SBIRs/STTRs or internal research projects).		
3	Define Application(s): ▪ DoD ▪ Other government ▪ Other federal ▪ Commercial		
4	Define the end-to-end, high-level system that will incorporate the enabling technology component or product.		
5	Define “supply chain” for the high-level, end-to-end system including primes and other key suppliers.		
6	Define end users (programs, program managers).		
7	Define the infrastructure required to field the end-to-end system.		
8	Define the concept of operations for the end-to-end system to be fielded.		
9	Define intellectual property and protection status (patents, copyrights, trademarks).		
10	Identify operational requirements.		
11	Identify TRL requirements.		
12	Identify MRL requirements.		
13	Identify standards (including interfaces).		
14	Identify specifications (including engineering and testing).		
15	Identify tests.		
16	Identify certifications.		
17	Define required manufacturing processes.		
18	Define Phase III technology development plan (statement of work, schedule, budget, resources, team partners, TRL goals).		
19	Define risk areas associated with Phase III technology development plan.		
20	Identify Phase III technology development funding sources—agency, program, program manager: ▪ DoD ▪ Private—prime R&D ▪ Other federal ▪ Prime—venture capital. ▪ Other government		
21	Identify experiment, evaluation, exercise, and demonstration opportunities.		
22	Define pace of technology change affecting prospective application areas.		

Business Checklist (Source: The Foundation for Enterprise Development)

#	Element	Priority (1-5)	Percent Completed
1	Define company's business model(s): ▪ Product ▪ Service ▪ Professional services ▪ Licensing		
2	Define the proposed commercialization models and critical contract/deal terms for bringing the technology to market: ▪ New company start up (spin-out) ▪ Productize in-house ▪ License (also includes potential for a services contract)		
3	Define value proposition for: ▪ Enabling technology ▪ Component ▪ Product		
4	Define pricing models and price points.		
5	Define stakeholders/advocates.		
6	Define business partners (primes, distributors).		
7	Define the financial analysis (profit and loss proforma, cash flow, operating expenses, financing requirements).		
8	Define business financing sources (public, private).		
9	Define company's transition project team (technology, business, marketing, finance domains).		
10	Define risk areas and mitigation, including the following identified in the National Research Council's "SBIR and the Phase III Challenge of Commercialization: Report of a Symposium", 2007 (p. 15): ▪ Ability to obtain funding to complete technology development ▪ Robustness of technology for integration into a DoD system ▪ Meeting DoD program schedule ▪ Meeting testing and engineering specs ▪ Ability to deliver on time and within budget ▪ Ability to scale		
11	Identify thought leadership opportunities (conference participation and publication opportunities).		
12	Identify networking opportunities (SBIR, DoD services, other federal agencies and trade organization meetings).		

Market Checklist (Source: The Foundation for Enterprise Development)

#	Element	Priority (1-5)	Percent Completed
1	Define policy, legislation, and other new market drivers.		
2	Define and evaluate targeted markets (DoD, other federal, other government, commercial).		
3	Define and qualify targeted customers (agency, program, program manager): ▪ Technology Development phase ▪ Engineering and Manufacturing Development phase ▪ Production and Deployment phase		
4	Define current position within targeted customer sets: ▪ Current supplier ▪ Not a current supplier		
5	Define targeted federal acquisition and procurement models (RFP, BAA, IDIQ, GSA schedules).		
6	Define commercial sales models (direct sale, distributor).		
7	Define federal acquisition/procurement drivers: ▪ Meets requirements and specifications ▪ Price ▪ Best value ▪ Past performance ▪ Technical qualifications ▪ Team ▪ Other		
8	Define commercial purchasing drivers: ▪ Price ▪ Quality ▪ Support ▪ Other		
9	Identify competitors and assess positions.		
10	Define and implement needed business development capabilities (proposal development, costing, contracting, marketing).		
11	Perform self-analysis to understand strengths, weaknesses, opportunities, and threats (commonly referred to as a SWOT analysis).		

Transition Plan Components Development Checklist

(Source: The Foundation for Enterprise Development)

Activity	Deliverable	Resources Assigned	Start Date	End Date
Define technology plan component.	Technology plan baseline			
Prepare business plan component.	Business plan baseline			
Define marketing and business development activities.	Marketing and business development plan			
Select transition path options.	Transition path baseline			
Implement transition plan.				

Key Milestones for Transition (Source: The Foundation for Enterprise Development)

	Phase II Key Milestones	Date Planned/Date Achieved
1	Technology Milestones (TRL)	
2	Manufacturing Milestones (MRL)	
3	Exercises (Agency, Program, PM)	
4	Experiments (Agency, Program, PM)	
5	Funding Milestone (Public and Private Sector)	
6	Thought Leadership Opportunities	

Technology Transition Strategy Table (Source: The Foundation for Enterprise Development)