Technology Transition for Affordability

A Guide for S&T Program Managers

April 2001

Department of Defense
Deputy Under Secretary of Defense
(Science and Technology)

The Defense Department's Science and Technology (S&T) Program ensures that the warfighters today and tomorrow have superior and affordable technology to support their missions, and to give them revolutionary war-winning capabilities. S&T program products provide the technological edge that deters aggression and minimizes the endangerment of our young men and women in battle when deterrence fails. However, S&T needs to be more rapidly transitioned to an operational capability to compensate for constrained DoD budgets and to keep pace with commercial availability of advanced technologies. It is imperative that, to accelerate technology transition, the S&T community, acquisition staff, and military users work together to reduce development time for fielding critical technology while balancing cost with performance.

Our S&T Affordability Task Force (ATF) continues to promote activities that speed the transition of technologies from the laboratory to weapon systems. As a result of feedback from program managers in both the S&T and weapon system acquisition community, the ATF developed guidelines on "Technology Transition for Affordability."

This document is a guide that provides S&T program managers, particularly those involved in managing 6.3 advanced technology programs or other programs targeted for transition, with strategies for implementing best practices to achieve technology transition. Technology transition is the process of inserting critical technology into military systems to provide an effective weapon and support system at the best value, as agreed to by the developer, acquisition manager, user, and maintainer.

Technological superiority is a critical component to our national security. In peace, it provides deterrence; in crisis, it provides options; in war, it provides the necessary edge.

Delores M. Etter
Deputy Under Secretary of Defense
(Science & Technology)

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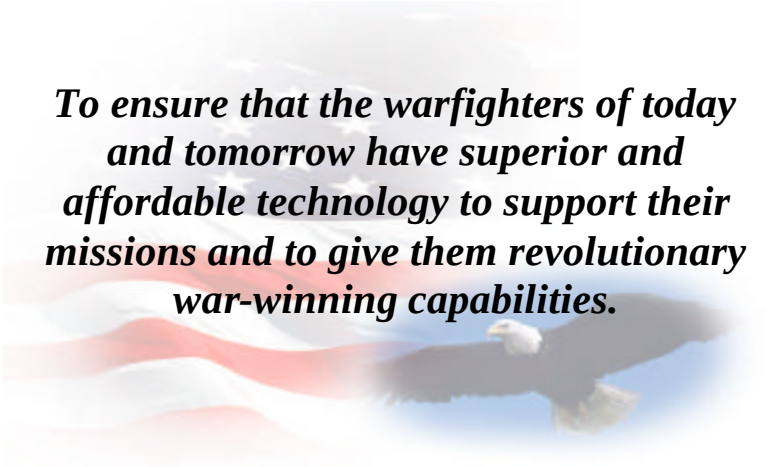
Introduction

This document provides S&T program managers – particularly those involved in managing 6.3 advanced technology development programs, e.g., Advanced Technology Demonstrations (ATDs), Advanced Concept Technology Demonstrations (ACTDs), and Experiments (both joint and Service-specific), with a guide for the implementation of best practices to achieve technology transition for affordability. Other S&T managers – those involved in managing Basic Research (6.1) and Applied Research (6.2) programs – may also improve transition of their technology into military systems, or to the next phase of development, with the adoption and application of selected practices within these guidelines. It is a brief compendium to assist in understanding what needs to be achieved and how to achieve it. Key resources available are also identified.

What is Technology Transition for Affordability?

The Defense Department has been very successful at producing highly effective military systems. However, to compensate for DoD diminishing resources and to keep pace with the commercial availability of advanced technologies, the DoD must reduce costs and field critical technology in a more timely manner by implementing affordability concepts. That is, the DoD must put into practice methods that lead to the best balance among a system's performance, life-cycle costs, and availability. Technology transition for affordability is the process of inserting critical technology into military systems to provide an effective weapon and support system – in the quantity and quality needed by the warfighter to carry out assigned missions – at the "best value" as measured by the warfighter. "Best value" refers to increased performance as well as reduced costs of development, production, acquisition, and life-cycle operations.

The rapid and affordable transition of new technologies into military systems is essential to ensure we stay ahead of potential adversaries who can readily obtain enhanced technology, such as weapons of mass destruction and state-of-the-art information technology from the global marketplace. Technology transition for affordability is an important element of the Defense Science and Technology Strategy, as well as the Under Secretary of Defense Acquisition, Technology, and Logistics goal to accelerate the Revolution in Business Affairs. The Defense S&T Strategy states that "DoD acquisitions will not meet the warfighters' needs within current budgets unless we achieve reduced costs of development, procurement, and life-cycle operation in the S&T program." The strategy includes technology transition as a key element to achieve the S&T mission that is:



The new DoD 5000-series documents (i.e., Defense Acquisition System), available at http://www.acq.osd.mil/ar/#5000, emphasize the evolutionary development of systems. The Policies and Principles section of DoDD 5000.1 discusses "Rapid and Effective Transition from Science and Technology to Products." This approach requires the S&T community to understand and respond to the time-phased requirements of the users of the technology. It requires the systems acquisition community to plan for initial system capability and incremental introduction of new technology and hence to have an intimate knowledge of the readiness of the technology for transition. The goal of the new policy is a significant reduction in technology cycle-time and cost, while increasing the ability to incrementally introduce new technologies to military systems. This evolutionary acquisition process provides risk mitigation by allowing phased integration of technologies into the product. Open systems architecture or the application of common components across multiple systems is also addressed as an enabling practice to increase affordability and facilitate evolutionary development.

Department of Defense Instruction (DoDI) 5000.2 includes a section on technology opportunity activities. This section details responsibilities of the Deputy Under Secretary of Defense for Science and Technology (DUSD(S&T)) and Component S&T Executives. The responsibilities that relate to transition are: supporting the use of commercial technologies and dual use technology development; advising program managers of new developments and providing technical advice throughout the acquisition process; and conducting and evaluating technology assessments to determine technology maturity for transition.

DoDD 5000.1

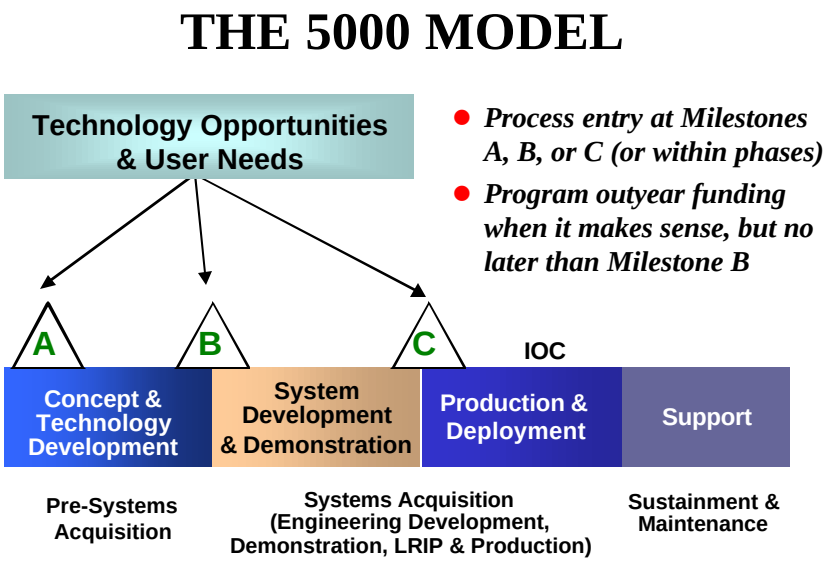
- **Rapid Transition From S&T to Products**
- **Emphasis on Affordability**

DoDI 5000.2

- **Focus on S&T Solutions in Pre-Acquisition**
- **Use Mechanisms with User & Acquisition Customer to Ensure Transition**

DoD 5000.2-R

- **Establish Technology Readiness Levels for Critical Technologies**



The S&T Role in Evolutionary Acquisition

Department of Defense Regulation 5000.2-R requires the major system acquisition program manager identify critical technologies and conduct technology assessments prior to milestone decision points B and C to assess technology maturity. Inherent in this process is the use of a technology readiness level (TRL) for each critical technology. Additional discussion on use of TRLs is included in the last section of the guidelines.

Although the S&T Program is viewed as pre-acquisition, its inclusion in the acquisition policy documents should serve to focus resources (i.e., people and dollars) on improving transition. The implementation of DoDI 5000.2 and DoD 5000.2-R will yield increased connectivity, visibility, and communication between the S&T community, the acquisition community, and the users — all of which are important for effective transition.

In the balance of this guidance document, affordability guidelines and criteria are reviewed and best practices for technology transition are provided to assist the S&T manager in achieving technology transition for affordability. The technology transition process for affordability contained in the handbook, "Addressing Affordability in Defense Science and Technology" is summarized. Key Service, Defense Advanced Research Projects Agency (DARPA), Defense Threat Reduction Agency (DTRA), Ballistic Missile Defense Organization (BMDO), and other OSD initiatives to improve technology transition are also discussed. Lastly, resources for information including training courses on Integrated Product and Process Development (IPPD) and acquisition management are provided.

What are the Key Elements to Achieve Technology Transition for Affordability?

- **Identify the Customer** – The S&T manager must understand the "real" needs and requirements of the customer for the technology. This begins with identification of the customer. For the S&T manager, the customer may be another S&T office or a weapon systems acquisition program office. In other cases, it may be a logistics support organization or even the end user (e.g., a warfighter). In any case, the communication with the customer must begin early so that user needs are considered in the S&T program.

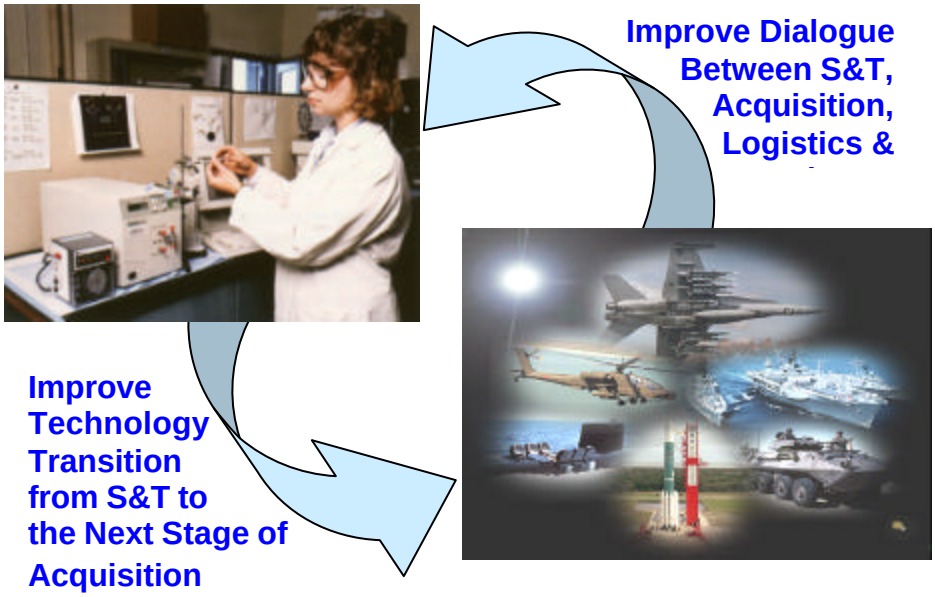
- **Team with the Customer** – The S&T manager must team with the customer (e.g., the acquisition program manager) to ensure technical attributes, schedules, costs, and other warfighter needs can be reasonably met. This team should also include S&T and acquisition contractors, government laboratories, test and evaluation personnel, and other appropriate government/industry stakeholders. The customer's definition of the readiness and timeliness of the technology for transition must be clearly understood and agreed upon by the team. Since the customer may not necessarily be the end user, it is important to communicate with the user to ensure the technology will, in fact, be a timely, usable, and affordable solution to the user's needs.

- **Consider Affordability Early On** – The S&T manager must recognize that decisions made during research and development (R&D) affect product affordability and must apply available tools and techniques to weigh the impact of each decision before it is made. The earlier affordability is considered, the more effectively the S&T manager can influence the life cycle costs and the affordability of products for insertion into military systems. Early implementation of tools such as IPPD coupled with the use of metrics (e.g., technical and programmatic goals) is important. An S&T integrated product team (IPT) consisting of the S&T manager, the S&T contractor, the customer and/or user and their contractors, and test and evaluation representatives is effective for addressing cost and performance trade-offs and for defining metrics.

- **Plan for Transition** – Technical, financial, and schedule issues must be agreed upon with the customer, and there must be clear assignment of responsibilities. The S&T manager will most successfully transition technology by working closely with the customer to plan for accepting and implementing the technology.

What are Some Guidelines for Technology Transition?

S&T program planning should focus on developing technology to meet the needs of the warfighter – in both the near term and far term. It is important for the S&T community – particularly those managing ATD, ACTD, and Experiments (joint and Service) – to be aware of system needs and to make 'choices' that favorably affect the utility and supportability of the final product. While the primary role of S&T managers is to develop technology not yet fully recognized or accepted by the acquisition community and warfighters (e.g. IR countermeasures for large aircraft), the S&T manager must also consider affordability and transition as R&D proceeds. Decisions made during S&T will have a dramatic impact on the ultimate affordability of the technology and, hence, on its eventual acceptance and implementation.



Communication is Key!

It is equally important for the customer to be aware of S&T and to be involved in planning the transition of technology across systems. Perhaps one of the best practices to achieve technology transition for affordability is for the customer – that is the DoD weapon system program office or systems integrator – to be involved early on in the development and planned transition of technology. System program managers are normally interested in communicating the attributes of their system and do not want to be surprised by new technology.

The handbook, "Addressing Affordability in Defense Science and Technology" published in October 1999, provides best practices and procedures captured in the form of criteria for S&T managers to address affordability and to ensure successful transition to acquisition. These criteria are summarized as follows:

- **Obtain Management Support to Meet Affordability Goals –** Top-level managers should motivate personnel at every level to clearly identify objectives and identify weapon system program office needs in order to plan an effective S&T program that focuses on technology transition. S&T program managers work most successfully in an environment that promotes goal setting, teamwork, and recognition of accomplishments from the management chain.

- **Implement the IPPD Methodology –** It is important to implement IPPD methods in which IPTs –government/industry multidisciplinary teams that include the "warfighter" customer – work together to ensure that customer needs are addressed during the technology development stage. IPTs should address life cycle and support issues early on in the design process to mature technologies that require fewer costly changes later in the product development process.

- **Develop and Execute a Training Plan –** An increasing number of courses and literature resources provide S&T managers with the skills, knowledge, and tools of how to transition technology. It is a best practice to conduct training as a team, including training of the industry partners and warfighters. S&T program managers are encouraged to take advantage of these resources as well as participate in the various Service, DARPA, DTRA, BMDO, and other OSD initiatives for technology transition outlined in the next section.

- **Establish and Track Affordability Metrics –** An S&T program manager must establish quantitative metrics to track the progress of an S&T program and set exit criteria to identify when a technology is ready to be transitioned. All stakeholders should agree upon metrics, especially the acquisition manager receiving the technology. By tracking technical performance and programmatic metrics, an S&T manager can identify actions and resources necessary to successfully satisfy requirements. Examples of metrics and/or exit criteria are unit cost, operating and support costs, life cycle cost savings or avoidance, lead-time reductions, and performance improvements resulting in a more affordable system.

- **Develop a Transition Strategy –** A clear commitment between the S&T program manager and the customer is the goal for implementing technology results. The best evidence of a transition commitment is the inclusion of funds in either the S&T budget or acquisition budget to bridge the gap from S&T to the next acquisition phase. Where this is not practicable, other actions impacting successful transition include: early identification of customer needs, formal program office support (with a memorandum of understanding or transition plan), development of affordability metrics against which to track progress, and addressing producibility and sustainability throughout the S&T program.

In addition to these criteria, there are additional affordability factors to consider while planning and conducting an S&T program. It is important to know when and how to "market" a technology that is ready for transition to a military system. Best practices for "marketing" a technology and successfully transitioning it include:

- **Block Improvement or Upgrade to Legacy System –** the technology feeds a weapon system block improvement that meets the operational need with greater return-on-investment (ROI) than the existing capability.

- **Fills Militarily Unique Need –** the new technology fills a specific defense need for which there are no existing technology alternatives (e.g., stealth).

- **Commercial-Off-The-Shelf –** COTS technology is adapted to reduce the overall life cycle cost of the military system.

- **Mature Technology "In-time" –** the technology for potential transition will be ready by the time the system program needs it – prototypes will have already been developed and/or the technology tested.

- **Customer Buy-In –** the customer or weapon systems acquisition program manager participates in the S&T program and is financially supportive of its insertion (e.g., through POM funding).

- **Industry Support –** the industry system integrator agrees to use the new technology and establishes an insertion process into the program acquisition strategy.

- **Application of Open Systems Concepts –** the technology improves affordability by extensive use of common components (including COTS) that may be applicable across multiple systems. Cost and manufacturability, as well as performance improvements, are addressed up-front in design.

- **Producibility –** the program addresses how to manufacture the product more efficiently and at a lower cost.

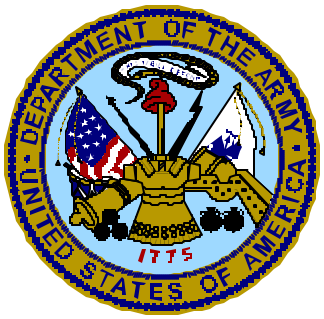
- **Total Ownership Cost (TOC) –** TOC has been addressed during program formulation, with identification of cost drivers, pursuit of unit price targets, and a mechanism to trace TOC.

- **Spiral Development –** there is a partnership between S&T, acquisition, contractor, and warfighter organizations to provide timely information on the development and implementation of new technology. System development is planned to allow the introduction of new technology during the development cycle.

What are the Key DoD Initiatives to Improve Technology Transition?

The Army, Navy, Air Force, DARPA, DTRA, BMDO, and OSD are pursuing initiatives that are resulting in transition improvements and facilitating insertion of technologies into weapon systems. Updates to these activities, as well as new Service actions, are routinely briefed and discussed at the DUSD (S&T) Affordability Conferences and workshops sponsored by the individual services. A brief overview of the current activities follows:

Army:



- The Army is placing emphasis on **ACTD/ATD programs** to help speed the maturation, assessment, and transition of advanced technologies through demonstrations conducted with the user. The tool for this transition process is the Master Plan (MP), an executive level document required from the Program Manager (PM) to ensure ACTD/ATD success. The MP embraces IPPD activities and addresses key areas, including objectives, program description, cost, schedule, exit criteria, risk, and transition. All major stakeholders are required to sign the MP, including the appropriate systems acquisition PM to whom the technology would transition if successful.

- **Technology Readiness Levels (TRLs)** are being implemented as a measure of technology maturity and its readiness to transition to the next acquisition phase. TRLs are becoming a critical consideration for technology transition and have been institutionalized for use throughout the Army S&T community. All S&T Objectives, Defense Technology Objectives, ATDs, and ACTDs incorporate TRLs. Inclusion of TRLs not only in the weapon systems program, but in all aspects of S&T technology development, ensures the Army S&T Community, Program Management offices, and industry have a common understanding of the exit criteria for program transition.

- The **Future Combat Systems (FCS)** is the Army's highest priority Transformation Campaign Plan program. The Army and DARPA seek greater technological innovation and leverage each other's investments in advanced technologies. In May 2000, DARPA awarded Section 845 agreements to four industry teams to develop design concepts for FCS. Through a series of competitions, at least one design will be selected and validated by a demonstration, leading to the System Development and Demonstration in FY2006 and fielding this decade. The Army has established a Task Force, led by a two-star general, to facilitate technology transition.

Navy:

- The Navy has invested in twelve **Future Naval Capabilities** (FNCs) that represent the highest priority clusters of technology needs of acquisition programs and operating forces. An IPT, composed of program managers from acquisition, OPNAV and S&T, oversees each FNC. In addition, a team consisting of a transition agent and personnel from both S&T and identified acquisition programs or System Commands, manages the S&T programs in each FNC.

- The Navy's **Chief Technology Officer** (CTO) is the senior advocate for the movement of technology, identifying emerging technologies of interest and mediating the transition of technology between the provider and the acquisition program. Assigned to the Office of Naval Research, the CTO focuses on matching acquisition

program needs with technology opportunities; provides independent, system-oriented technology assessments; and develops policies to improve utilization of technology.

- Responding to top-level requirements for affordability, the Navy's Corporate S&T Board designated reduction of **Total Ownership Cost** (TOC) an FNC. The IPT converged on a strong life cycle cost reduction S&T program that is fleet integrated, product focused, and project oriented. The TOC consists of four thrusts - Corrosion Technology to address long-life corrosion control technologies; Smart Systems for Condition Based Maintenance to reduce the fleet maintenance burden; Turbine Engine Technology to reduce turbine engine acquisition and maintenance costs; and Cost Analysis Tools for predicting weapon system design and manufacturing costs.

Air Force:

- The Commander, Air Force Research Laboratory (AFRL) published an affordability policy letter in February 2000 that requires the use of **IPPD on all transition programs** (ATDs and Integrated Technology Thrust Programs (ITTPs)), the calculation of return-on-investment (ROI), and tools and training to implement affordability metrics. An instruction and handbook are expected to follow. ITTPs are groupings of related, high visibility S&T programs focused on meeting critical Air Force operational capability needs.

- An **Affordability Council** has been formed with members from each of the AFRL technology directorates. The council identifies and shares best practices, reviews progress of affordability programs, develops affordability strategy and implementation plans, and monitors and supports the implementation of the S&T Affordability Program strategy.

- An **Applied Technology Council (ATC)** consisting of senior-level management from the MAJCOMS, Product Centers, and the Laboratory has been established to provide a forum to facilitate the timely and affordable transition of technology to improve warfighting capabilities. The ATC reviews all 6.3 ATD candidates, assesses warfighter support, and provides a plan and funding for Technology Transition.

Deputy Under Secretary of Defense (Advanced Systems & Concepts):

- The Deputy Under Secretary of Defense for Advanced Systems & Concepts manages and oversees Advanced Concept Technology Demonstrations (ACTDs), which are designed to **expedite the transition of maturing technologies from the developers to the users**. ACTDs emphasize technology assessment and integration rather than technology development. The goal is to provide a prototype capability to the warfighter and to support him in the evaluation of that capability.

- ACTDs are evaluated based on several criteria, including response to user needs, maturity of technologies, and potential effectiveness. A key goal is to **move ACTDs into the appropriate phase of formal acquisition without loss of momentum**, assuming the user makes a positive determination of military utility. Each ACTD has a clear acquisition goal for the post-ACTD phases. In addition, there must be provisions for the development of operational requirements, interoperability, life cycle cost, manning, and training; and preparations for supportability.

- Information concerning the process for nominating programs, success stories, and focal points for the ACTD program is available at http://www.acq.osd.mil/actd/

Defense Advanced Research Projects Agency (DARPA):

- DARPA programs **address affordability as one metric in the set of metrics and exit criteria** guiding each high risk, high payoff technology program. The relative emphasis of cost in each program depends on the desires of the transition partner and the program's technological maturity.

- Aggressive cost targets are often established in DARPA programs to reduce the life cycle cost of military systems to which the technology is being transitioned. For example, the **NetFires** program goal is to reduce operations and support costs by 85% and unit production costs by 33 percent. The overall objective of the NetFires program is to provide non line-of-sight tactical missile capability for future dominance on the battlefield, as articulated by the Future Combat Systems vision. NetFires will develop and demonstrate containerized, vertically launched missiles that can be remotely launched directly from the shipping container, fundamentally impacting the way small missiles are manufactured, transported, and used.

- One mechanism DARPA uses to improve affordability is through the use of conventional commercial-off-the-shelf components and processes. For example, the **Low Cost Cruise Missile Defense (LCCMD)** uses a commercial, composite-sheet molding process used by the automobile industry, a computer processor similar to those used in soda dispensing machines, and a commercially available Global Positioning System unit. The goal of the LCCMD program is to design, develop, demonstrate, and transition an affordable seeker for use on a missile interceptor system to defeat raids of unsophisticated air vehicles. The seeker subsystem is the predominant cost driver in an interceptor system and can account for over two-thirds the cost of the entire system.

Defense Threat Reduction Agency (DTRA):

- DTRA technology **development programs support and safeguard America and its allies from weapons of mass destruction (WMD)** – chemical, biological, radiological, nuclear and high explosives – by reducing the present threat and preparing for the future threat. DTRA conducts R&D that

transitions to military counterproliferation operations, such as the development of offensive and defensive tools to counter WMD threats, and creates and operates modeling and simulation tools for operations planning and hazards prediction.

- The **Threat Reduction Advisory Council (TRAC)** is a federally chartered advisory group that reviews DTRA strategic S&T investments for future WMD aspects and provides timely technical scientific and policy related advice to the SecDef, the DepSecDef, Under Secretary of Defense (Acquisition, Technology, and Logistics), and the Director of DTRA. The DTRA Corporate Council (DCC) provides a forum for DTRA strategic planning, business planning, and performance measurement. The DCC oversees all DTRA corporate activities to include the approval of investments in its S&T programs.

- Several key **technologies expected to transition to the warfighter** include the Counterproliferation ACTD Advanced Unitary Penetrator Hard Target Smart Fuse and Bomb Impact Assessment Module; the Counterproliferation Analysis and Planning System; and the Hard Target Defeat.

Ballistic Missile Defense Organization (BMDO):

- BMDO is investing to **build an integrated, affordable ballistic missile defense (BMD) architecture** that uses evolutionary acquisition and spiral development concepts to significantly reduce cycle time and costs while improving the ability to incrementally introduce new technologies into current and future BMD acquisition programs. Continuous phased integration of technologies into the BMD architecture provides a critical risk mitigation element to the Major Defense Acquisition Programs (MDAPs). A commitment to an open systems architecture approach, and maximum use of commercial-off-the-shelf components, increases affordability and facilitates technology infusion.

- BMDO **evaluates and manages technology development and transition through the use of TRLs** to ensure that technology is matured and tested before transition to systems acquisition. Throughout the acquisition life cycle, the BMDO Chief Scientist provides technical advice to the MDAPs and conducts technology assessments at milestone reviews to determine technology maturity prior to transition.

- **Key programs being transitioned include**: (1) the Gallium Arsenide (GaAs) Yield Improvement Advanced Radar Technology project to develop new designs that allow improved chip yields manufactured from high performance GaAs materials; and (2) the Advanced Master Frequency Generator (AMFG) Atmospheric Interceptor Technology project to conduct a form, fit, and function component redesign of the AMFG, a component of the PAC-3 missile's RF seeker.

ODUSD(S&T) Office of Technology Transition:

The DUSD(S&T)'s Office of Technology Transition provides management of several programs that are facilitating integration of commercial and military technologies into DoD weapon systems. These programs are developing dual use technologies, leveraging commercial technology for application to DoD products, establishing production capacity, and promoting technology exchange between DoD and the private sector. A brief description of key programs is found below, with additional details available at http://www.dtic.mil/ott/.

- **Dual Use Science and Technology (DUS&T)** partners with industry to jointly fund and develop dual use technologies and make this a normal way of doing business in the DoD.

- **Manufacturing Technology (ManTech)** nvests in new and improved defense-driven manufacturing techniques to acquire affordable equipment for the warfighter.

- **Commercial Operations and Support Savings Initiative (COSSI)** adapts commercial technologies for use in military equipment to reduce O&S costs and improve the performance of legacy systems.

- **Defense Production Act Title III** creates, modernizes, or expands domestic production capability and capacity for technology items, components, and industrial resources essential for national defense.

- **Technology Transfer (T2)** program provides a unique, noncompetitive avenue for DoD laboratories to work with private industry via various instruments, such as Cooperative Research and Development Agreements.

- **Small Business Innovative Research** harnesses the innovative talents of our nation's small technology companies to fund early-stage R&D projects that have a DoD need and the potential for commercialization in the private sector.

- **Independent Research & Development (IR&D)** ensures the DoD has superior and affordable technology by monitoring commercial industry R&D investments, and sharing the results of military technology with industry.

- The **North American Technology and Industrial Base Organization (NATIBO)** promotes a cost effective, healthy technology and industrial base that is responsive to the national and economic security needs of the United States and Canada.

How Can I Learn More about Technology Transition for Affordability?

There are a growing number of resources available to S&T program managers on the use of affordability tools, affordability best practices, and technology transition methods. The following list contains key resources available to the S&T program manager:

Education and Training

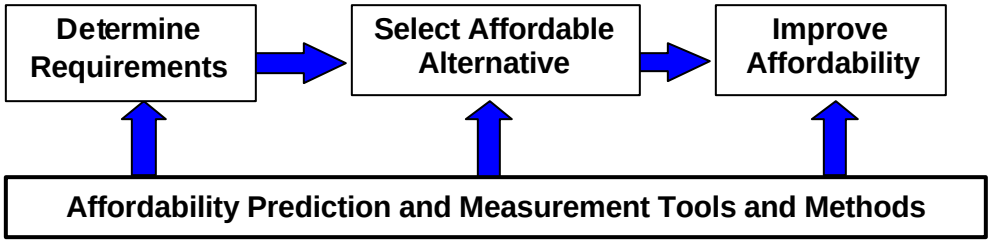
- **Addressing Affordability in Defense S&T: A Handbook for S&T Managers.** This handbook was published for S&T program managers in October 1999. It captures ideas, concepts, and best practices in implementing affordability concepts in S&T. This handbook provides guidelines on how to address affordability in an S&T program and is based on the principle that the earlier affordability is considered, the more effectively affordability and life cycle costs of products for insertion into military systems are impacted. A copy of the handbook is available at http://mtiac.iitri.org/.

- **Affordability in Science & Technology (S&T): An Introduction.** The Air Force Research Laboratory (AFRL) is investing in affordability training tools to characterize the risk and maturity of a technology and to assess its readiness for transition into product development. AFRL offers a 2-day S&T Affordability introduction course targeted for 6.2 and 6.3 program managers that emphasizes exposure to the IPPD/IPT process, including hands-on exercises for balancing performance, risk, and cost in S&T programs. A more extensive 4-day course is offered for affordability program managers and industry/government teams performing ATDs, ACTDs, and major 6.2/6.3 programs. More information can be found at http://www.affordability.com.

- **Introduction to Acquisition for S&T Managers.** The Office of Naval Research and the Office of the Assistant Secretary of the Army (Acquisition, Logistics, and Technology) have worked collaboratively with the Defense Systems Management College to develop a 3-day course entitled "Technology Insertion in Defense Systems Acquisitions". This session provides a basic overview of the mechanisms used to integrate advanced technologies into future warfighting systems. For more information on course offerings, contact Mr. Bill Lukens at DSMC, e-mail: bill.lukens@dau.mil.

- **Affordability Management Tools.** Additional courses are available that are aimed at the use of IPPD/ IPTs and affordability tools that S&T program managers may use to focus on customer needs and affordability. These include courses in Quality Function Deployment, Design of Experiments, Design for Six-Sigma, Cost as an Independent Variable, and Modeling and Simulation. A more detailed description of course offerings is described in the DoD handbook "Addressing Affordability in Defense S&T".

- **Affordability Modeling and Prediction.** The Office of Naval Research conducts the Affordability Measurement and Prediction (AMPP) program that develops advanced science-based tools to model and predict a system's affordability. These software tools enable the technologist to not only consider the performance benefits of developing a potential technology, but also to factor in life cycle cost impacts and the return-on-investment for a particular technology insertion. The eventual goal is to provide a web-based affordability toolkit for application by government and industry scientists and engineers to predict the overall affordability of a system. For more information, visit the program at http://www.onr.navy.mil/sci_tech/industrial/afford.htm.



Best Practices / Lessons Learned

- **S&T Affordability Conference.** This annual conference is held with senior laboratory, acquisition, and industry representatives to share best practices, discuss lessons learned, and improve the dialogue for affordability in the research and development community. Proceedings from past conferences are available at the National Center for Advanced Technologies (NCAT) web site, http://www.ncat.com/. Future Affordability Conferences will be announced on the following web site, http://www.affordability.org, and via notification from the Deputy Under Secretary of Defense (Science & Technology).

- **Technology Transition Strategy.** A written transition plan or a written commitment between the S&T program manager and the acquisition customer to implement a technology has been shown to improve the likelihood of transition. The transition plan provides clear assignment of responsibilities. Resource mechanisms for rapid acquisition and elements of a good technology transition plan are described in Section 2.2.5 of the DoD handbook, "Addressing Affordability in Defense S&T".

- **Virtual Technology Exposition (VTE).** Via the development of the VTE, the DUSD(S&T) has established a means for increasing the weapon system acquisition community's awareness of technology available to the warfighter via development of the VTE. The Web Site currently contains descriptions of more than 500 research efforts, which can be easily located by selecting subject areas associated with the Defense Technology Areas or the Joint Warfighting Capability Objectives. Work is ongoing to populate, update, and garner customer feedback on the database. Registered users of the Defense Technical Information Center (DTIC) and persons with a government or military email address may visit the Web site at https://vte.dtic.mil/.

- **Technology Readiness Levels (TRLs).** The Government Accounting Office report titled, "Better Management of Technology Development Can Improve Weapon System Outcomes", addresses how best practices offer improvements to the way the DoD incorporates new technology into weapon system programs. The report concluded that demonstrating a high level of maturity before incorporating new technologies into product development programs puts programs in a better position to succeed. The S&T manager should use TRLs as a guide to determine when a technology is ready to transition. It is crucial to approach TRLs together with the system program office targeted for transition and to apply TRLs as appropriate to the specific technology and application. A summary of the TRL levels follows:

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. Examples 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 reasonable 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.
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.