Lesson 17: Science and Technology in the Acquisition Process

U.S. Technology Posture

Defining Science and Technology

Science is the broad body of knowledge derived from observation, study, and experimentation. It includes:

- Physics
- Biology
- Material sciences
- Chemistry
- Geophysics
- Mathematics

Technology is the practical application of scientific knowledge.

Science and Technology Base

Many past technological advances were linked to defense development. Several "firsts" were developed to ensure national security in times of crisis or warfare. Such advances include:

- Telegraph
- Mass-produced jet aircraft
- Stealth technology
- Atomic power
- Laser
- RADAR

To ensure dominance in future warfare, the United States is committed to maintaining a solid and strong science and technology program. This technology base is the nation's premier combat force multiplier.

Technology Transition

Technology transition is a function/goal of the Systems Engineering Process.

- In peacetime, technological superiority is a key element for deterrence of conflict.
- During crisis, technological superiority provides a wide range of options to the Combatant Commanders, while providing confidence to our allies.
- In war, technological superiority enhances combat effectiveness, reduces casualties, and minimizes equipment loss.
The Military's Changing Role in Science and Technology

In the mid-1970's, there was a shift in the origin of new technology breakthroughs. No longer was the defense establishment the primary source of new technology. Commercial consumer technology began to provide many "firsts." The military emphasis shifted from developing new technologies to leveraging commercially developed applications.

Defense Science and Technology Program Foundations

The Defense Science and Technology program:

- Needs to be grounded in a deep understanding of fundamental science and technology.
- Uses this understanding to create new military capabilities to counter security threats.
- Responds to what the warfighters need.
- Does not duplicate what the commercial marketplace can produce cheaper and faster.

Remember that science and technology play a critical role in peacetime as well as during times of conflict. Our technology base is our foremost force multiplier and an important national economic asset.

Science and Technology Continuum

Research, Development, Test, and Evaluation (RDT&E) Budget Activities

The science and technology program is managed in the following three (RDT&E) budget activities:

- Basic Research
- Applied Research
- Advanced Technology Development

Research, Development, Test, and Evaluation (RDT&E) budget activities are separately funded but related. The difference in funding between acquisition programs and science and technology can be explained by reviewing the RDT&E appropriation.

Research, Development, Test, and Evaluation (RDT&E) Appropriation

The chart below shows the seven RDT&E Budget Activities (BA) implemented in the Future Year Defense Program (FYDP).
Basic Research

Basic research includes scientific studies that increase fundamental knowledge in fields such as computer science, chemistry, electronics, and materials. The objective is to create or exploit scientific breakthroughs and guard against technological surprise.

Colleges and universities conduct 60% of DOD's basic research; DOD and Federal Labs conduct 25%; and industry and nonprofit organizations conduct 15%.

Applied Research

Applied research:

- Focuses on maturation of technologies before they are considered for transition to advanced development.
- Includes applying basic research to solving specific military problems.
- Concepts proving to have merit are formulated into possible technological solutions. These solutions are evaluated based on the feasibility and practicality of their technological application.

Twelve Key Areas of Importance to Future Military Needs

Applied research focuses on those technologies in the 12 key areas, as reflected in the Defense Technology Area Plans (DTAPs) that have the highest relative importance to future military needs. The following areas are described in 12 Technology Areas Plans (TAPs):

- Air Platforms  
- Battlespace Environments  
- Ground and Sea Vehicles  
- Biomedical  
- Human Systems  
- Chemical/Biological Defense  
- Materials/Processes  
- Sensors and Electronics  
- Weapons  
- Information Systems Technology  
- Nuclear Technology
Advanced Technology Development

This category focuses on the development of components, subsystems, and advanced technology demonstrations with potential application to a variety of similar products rather than application to one specific system.

Technology Progression

The F-117, B-2, and other stealth aircraft provide an excellent example of how technology progresses through basic research, applied research, advanced technology development, and finally into system development.

Basic Research

Basic research efforts are conducted to create scientific breakthroughs. Basic research efforts were conducted in the late 60's and early 70's dealing with mathematical analysis of radar wave reflectivity from various geometric shapes. Other efforts studied the absorption/reflection characteristics of various materials.

Applied Research

The basic research efforts led to applied research investigations. The mathematical analysis of geometric shapes evolved into studies of how low-reflectivity shapes could serve as aerodynamic components (airfoils, fuselage). Work continued to determine if low absorption materials could serve as structural components of an airframe or be applied to structural components.

Advanced Technology Development

Finally, a technology demonstrator was built. Initially, this demonstrator was highly classified. This demonstrator ultimately led to operational aircraft such as the F-117 and B-2.

Introducing Technology into Acquisition Phases

Research Application

DOD funds basic research institutes in a dozen Science and Engineering Disciplines, but only a small portion of research findings is incorporated into military or defense systems.
Research is often found to be infeasible for application or not mature enough to be incorporated into the acquisition process. A program manager must decide when it is appropriate to incorporate new technology into an acquisition program.

**Twelve Basic Research Science and Engineering Disciplines**

The 12 Basic Research Science and Engineering Disciplines funded by the DOD include:

- Physics
- Chemistry
- Mathematics
- Computer Science
- Electronics
- Materials Science
- Mechanics
- Terrestrial Science
- Ocean Sciences
- Atmospheric and Space Sciences
- Biological Sciences
- Cognitive and Neutral Science

**When To Incorporate Technology**

The decision to transition new technology into an acquisition program requires:

- An objective assessment of the maturity level of a given technology.
- Cooperation, understanding, and effective communications among the users, acquirers, and Science and Technology managers.

**Determination of Mission Needs**

Science and Technology managers and users focus on new ideas that could meet the warfighters needs during the Functional Area Analysis. If the analysis shows that a materiel solution is needed, an Initial Capabilities Document is prepared, and the acquisition process is begun.

**Materiel Solution Analysis and Technology Development**

As concepts are considered, the benefits and risks of the candidate technologies are reviewed to understand the impact of each approach.

- Selecting unproven technology can introduce significant risk.
- Selecting proven or mature technology can pay off in cost, schedule, and performance.
Engineering and Manufacturing Development and Demonstration

As the design matures, introducing new technology can occur during System Development and Demonstration:

• New technology can often be inserted into the ongoing increment of capability.
• Technologies involving new manufacturing techniques are often incorporated into the design during this phase.

Insertion of technology into parallel system modifications and Service Life Extension Programs can be planned based on changing user needs, such as:

• Changing threats
• The need for more cost-efficient systems
• New technological opportunities

Production and Deployment

During the Production and Deployment phase, new technologies are typically introduced as part of a pre-planned product improvement or evolutionary development.

Operations and Support

During the Operations and Support phase, system modifications may be developed that inject new technology into the system throughout its life. These are typically managed as new or distinct programs.

It may be many years between the development of a system and its demilitarization and disposal. New technologies can be used to dispose of these systems properly. Often new technologies are needed to comply with current requirements:

• Legal
• Environmental
• Safety

Principles for Successful Technology Integration

Program managers can reduce the risk associated with integrating technology by adhering to four underlying principles that govern the successful transition of technology into military systems. The underlying principles for successful technology integration are:

• Ensure technology is focused on critical military needs.
• Establish a technology transition approach to define tasks and resources needed to accomplish the transition.
• Define transition criteria and the implementation method for incorporating technology.
• Conduct periodic reviews in conjunction with laboratories, users, and maintainers.
A program office should develop criteria for incorporating advanced technology into an acquisition. The office may consider several criteria, but there are three criteria that have proven to increase success and reduce risk and therefore should be included.

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<th>CRITERION</th>
<th>DESCRIPTION</th>
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<tr>
<td>Clear military need</td>
<td>The technology should demonstrate a significant improvement in the defense system.</td>
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<tr>
<td>Fully demonstrated, evaluated, and tested</td>
<td>The more information there is about the proposed technology, the less risk will be involved.</td>
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<tr>
<td>Cost-effective</td>
<td>Anything that drives down the cost of the weapon system has a far greater chance of success.</td>
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Advanced Technology Demonstrations

Advanced Technology Demonstrations (ATDs)

Direct application of efforts in basic and applied research to systems application may be marginal. The technology produced in these two areas is not mature enough to transition directly to systems development. ATDs reduce the risk in transitioning from technology to systems.

Advanced Technology Demonstrations (ATDs) are:

- Projects funded using RDT&E Budget Activity 3 (Advanced Technology Development).
- Intended to demonstrate technology feasibility and maturity.
- Designed to reduce technical risks and uncertainties at the relatively low cost of informal processes.

Uses of ATDs

ATDs are hardware and software prototypes used for:

- Testing and evaluating non-system-specific solutions to refine basic and applied research.
- Preparing technology for systems development by demonstrating the feasibility and maturity of an approach at a relatively low cost.
Managing and Funding ATDs

Following are important points to remember about ATDs. ATDs:

- Demonstrate technology before transitioning to an engineering community or program office.
- Are funded by Advanced Technology Development funds.

Advanced Technology Development Funds

This Budget Activity (BA) that 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. Results of these efforts include proof of technological feasibility and assessment of subsystem and component operability and producibility. Both ATDs and ACTDs are funded with BA3 funds.

Joint Capabilities Technology Demonstrations (JCTDs)

Joint Capabilities Technology Demonstrators (JCTDs):

- Can be fielded and used by operational forces.
- A means of demonstrating the use of emerging or mature technology to address critical military needs in a short period of time; 3 months to 1 year
- Not acquisition programs, although they are designed to provide annual deliverables and,
- Assess transition potential based on JROC validation
- Funded with Advanced Technology Development (ATD) funds.

JCTD Characteristics

JCTDs have the following characteristics:

- candidates are nominated by the services and selected by the Director, Defense Research and Engineering (DDRE)
- focus on the military utility and transition of the technology.
- Synchronization with Combatant Command (COCOM) experimentation
ATD and JCTD Objectives

The objectives of each type of demonstration are shown below:

- ATD Objective: To assess and demonstrate technology feasibility and maturity
- JCTD Objective: To decide whether to invest resources based on military utility and requirements

JCTD Key Points

- Are selected at a very high Office of the Secretary of Defense (OSD) level, by DDRE.
- Have a review panel.
- Emphasize parallel technology development and refinement of operational concepts in the field.
- Do not require all of the documentation that usually applies to acquisition programs.
- Require a Management Plan.
- Require a Transition Plan
# Comparison ACTD - JCTD

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<th>Performance Metric</th>
<th>ACTD</th>
<th>JCTD</th>
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<td>Project Selection Focus</td>
<td>Threat Based: Shared Military Service and CoCom influence</td>
<td>Capability Based: Greater CoCom influence looking at nearer term joint/coalition needs.</td>
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<tr>
<td>Spiral Technologies</td>
<td><strong>No Metric currently established</strong></td>
<td>Initial Technology available within one year of JCTD initiation.</td>
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<td>Final Demonstration Completed (Starting Point: Approved ID)</td>
<td>3 to 4 years after initiation (Implementation Directive (ID) Signed)</td>
<td>50% completed by the end of the 2(^{nd}) year. All JCTDs completed by the end of the 3(^{rd}) year</td>
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<td>Shared Funding and Visibility of resources</td>
<td>OSD provides no more than 30% of the budgeted resources. Funding provided from many different program elements.</td>
<td>OSD provides significantly more funding (more than 50% depending on cost of the JCTD), especially in the first two years.</td>
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<td>Military Utility Assessment (MUA) conducted by an independent activity</td>
<td>MUA traditionally tied to a specific planned exercise for evaluation</td>
<td>JCTDs not necessarily tied to an exercise. Greater flexibility to establish military utility via operational “real-world” demonstration or specifically designed test/venue</td>
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<td>Transition of technology</td>
<td>70% of ACTDs transition at least one product to sustainment</td>
<td>80% of JCTDs transition at least 50% of their products to sustainment</td>
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