How the S&T Community Can Best Support the Technology Readiness Assessment (TRA) Process

Do's and Don'ts

2007 Technology Maturity Conference
September 11-13, 2007

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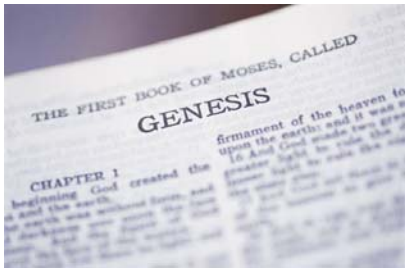
Outline

- **Introduction**
  - **What is a TRA**
  - **Why it is important**
- **Overview of Technology Considerations During Systems Acquisition**
- **Synopsis of the TRA Process**
  - **Identifying Critical Technology Elements (CTEs)**
  - **Assessing CTE Readiness**
- **Pre-Milestone B Technology Maturation Policy**
- **How the S&T Community Can Best Support the TRA Process**
  - **Do's and Don'ts**
- **References and Resources**

How TRAs Got Started

- **"Program managers' ability to reject immature technologies is hampered by (1) untradable requirements that force acceptance of technologies despite their immaturity and (2) reliance on tools that fail to alert the managers of the high risks that would prompt such a rejection."** ***GAO/NSIAD-99-162***

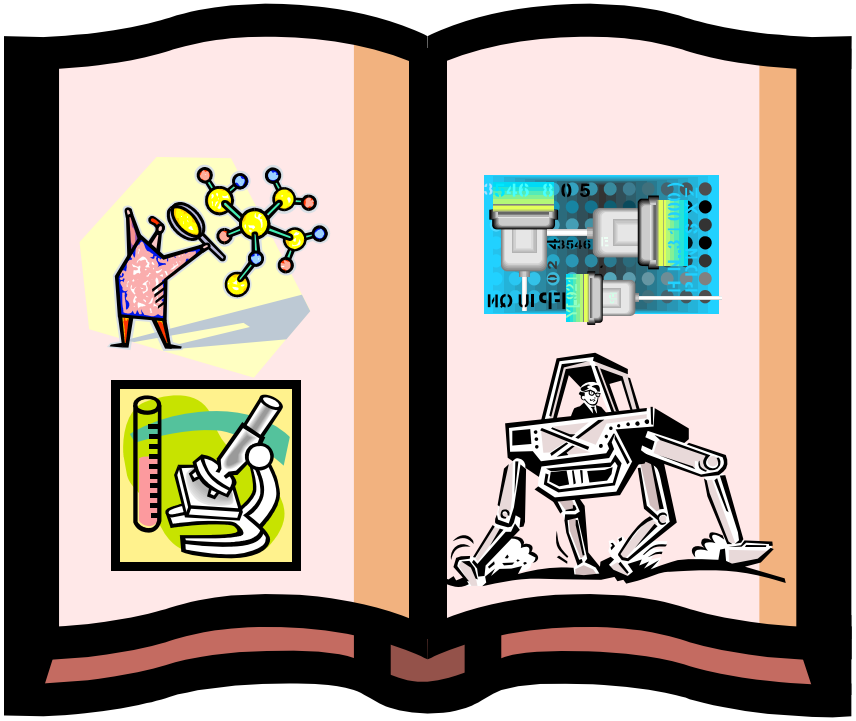


- **"Identify each case in which a major defense acquisition program entered system development and demonstration … into which key technology has been incorporated that does not meet the technology maturity requirement … and provide a justification for why such key technology was incorporated and identify any determination of technological maturity with which the Deputy Under Secretary of Defense for Science and Technology did not concur and explain how the issue has been resolved."** ***National Defense Authorization Act for Fiscal Year 2002***
- **"The management and mitigation of technology risk, which allows less costly and less time-consuming systems development, is a crucial part of overall program management and is especially relevant to meeting cost and schedule goals. Objective assessment of technology maturity and risk shall be a routine aspect of DoD acquisition."** ***DoDI 5000.2, paragraph 3.7.2.2***

Stop launching programs before technologies are mature

What is a TRA?

- **Systematic, metrics-based process that assesses the maturity of Critical Technology Elements (CTEs)**
  - **Uses Technology Readiness Levels (TRLs) as the metric**
- **Regulatory information requirement for *all* acquisition programs**
  - **Submitted to DUSD(S&T) for ACAT ID and IAM programs**



≠ Not a risk assessment

≠ Not a design review

≠ Does not address system integration

Critical Technology Element (CTE) Defined

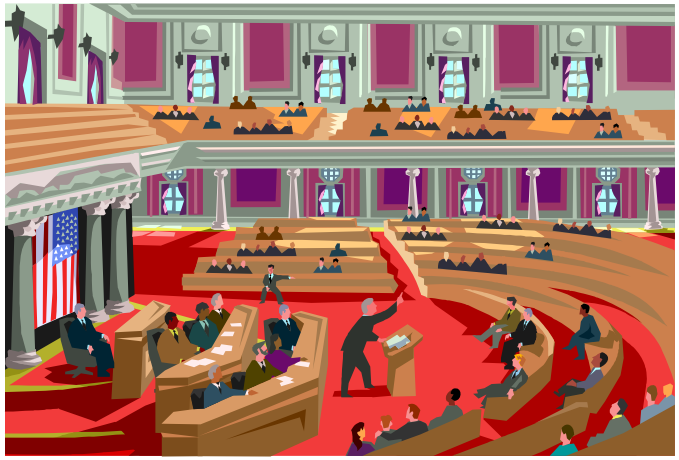
A technology element is "critical" if the system being acquired depends on this technology element to meet operational requirements with acceptable development cost and schedule and with acceptable production and operation costs *and* if the technology element or its application is either new or novel.

Said another way, an element that is new or novel or being used in a new or novel way is critical if it is necessary to achieve the successful development of a system, its acquisition or its operational utility.

CTEs may be hardware, software, manufacturing, or life cycle related at the subsystem or component level

Why is a TRA Important? (1 of 2)

- **The Milestone Decision Authority (MDA) uses the information to support a decision to initiate a program**
  - **Trying to apply immature technologies has led to technical, schedule, and cost problems during systems acquisition**
  - **TRA established as a control to ensure that critical technologies are mature, based on what has been accomplished**



- **Congressional interest**
  - **MDA must certify to Congress that the technology in programs has been demonstrated in a relevant environment at program initiation**
  - **MDA must justify any waivers for national security to Congress**

Quantifying the Effects of Immature Technologies (1 of 2)

According to a *2005* GAO review of 54 DoD programs:

- **Only 15% of programs began SDD with mature technology (TRL 7)**
  - **Programs that started with mature technologies averaged 9% development cost growth, a 7 month schedule delay, and a 1% acquisition unit cost growth**
  - **Programs that did not have mature technologies averaged 41% development cost growth, a 13 month schedule delay, and a 21% acquisition unit cost growth**
- **At critical design review, 42% of programs demonstrated design stability (90% drawings releasable)**
  - **Design stability not achievable with immature technologies**
  - **Programs with stable designs at CDR averaged 6% development cost growth**
  - **Programs without stable designs at CDR averaged 46% development cost growth and a 29 month schedule delay**

Source: Defense Acquisitions: Assessments of Selected Major Weapon Programs, GAO-05-301, March 2005

Quantifying the Effects of Immature Technologies (2 of 2)

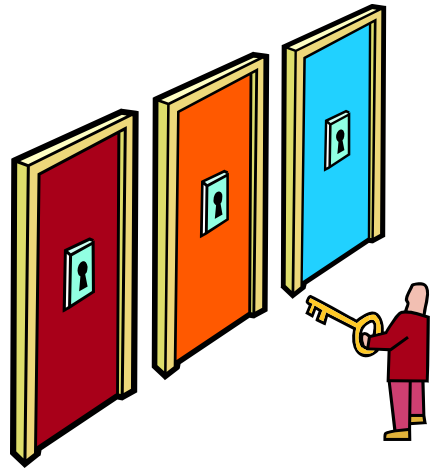
According to a *2006* GAO review of 52 DoD programs:

- **Only 10% of programs began SDD with mature technology (TRL 7)**
  - **Programs that started with mature technologies averaged 4.8% development cost growth and a 1% acquisition unit cost growth**
  - **Programs that did not have mature technologies averaged 34.9% development cost growth and a 27% acquisition unit cost growth**
- **Only 23% of programs began SDD with DoD's standard for mature technology (TRL 6)**
  - **Programs that started with mature technologies averaged 18.8% development cost growth**
  - **Programs that started with mature technologies averaged 34.6% development cost growth**

Source: Defense Acquisitions: Assessments of Selected Major Weapon Programs, GAO-06-391, March 2006

Why is a TRA Important? (2 of 2)

- **The PM uses the expertise of the assessment team and the rigor and discipline of the process to allow for:**
  - **Early, in depth review of the conceptual product baseline**
  - **Periodic in-depth reviews of maturation events documented as verification criteria in an associated CTE maturation plan**
  - **Highlighting *(and in some cases discovering)* critical technologies and other potential technology risk areas that require management attention (and possibly additional resources)**
- **The PM, PEO, and CAE use the results of the assessment to:**
  - **Optimize the acquisition strategy and thereby increase the probability of a successful outcome**
  - **Determine capabilities to be developed in the next increment**
  - **Focus technology investment**



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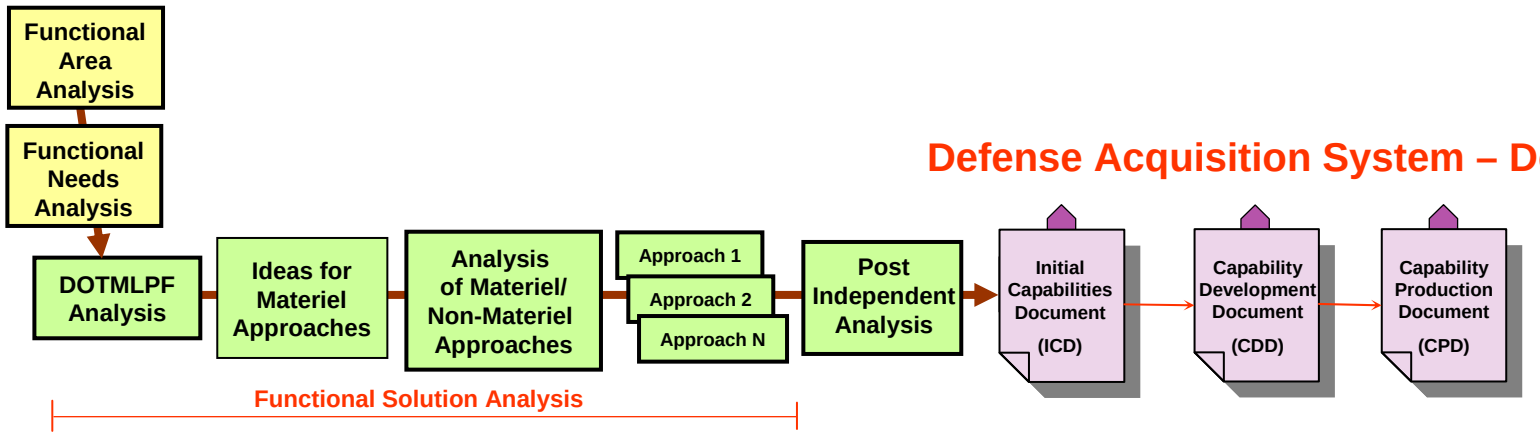
Joint Capabilities Integration and Development System (JCIDS)

Strategic Guidance --
National Security Strategy/National Defense Strategy/National Military Strategy

Family of Joint Future Concepts
Concepts of Operations
Joint Tasks

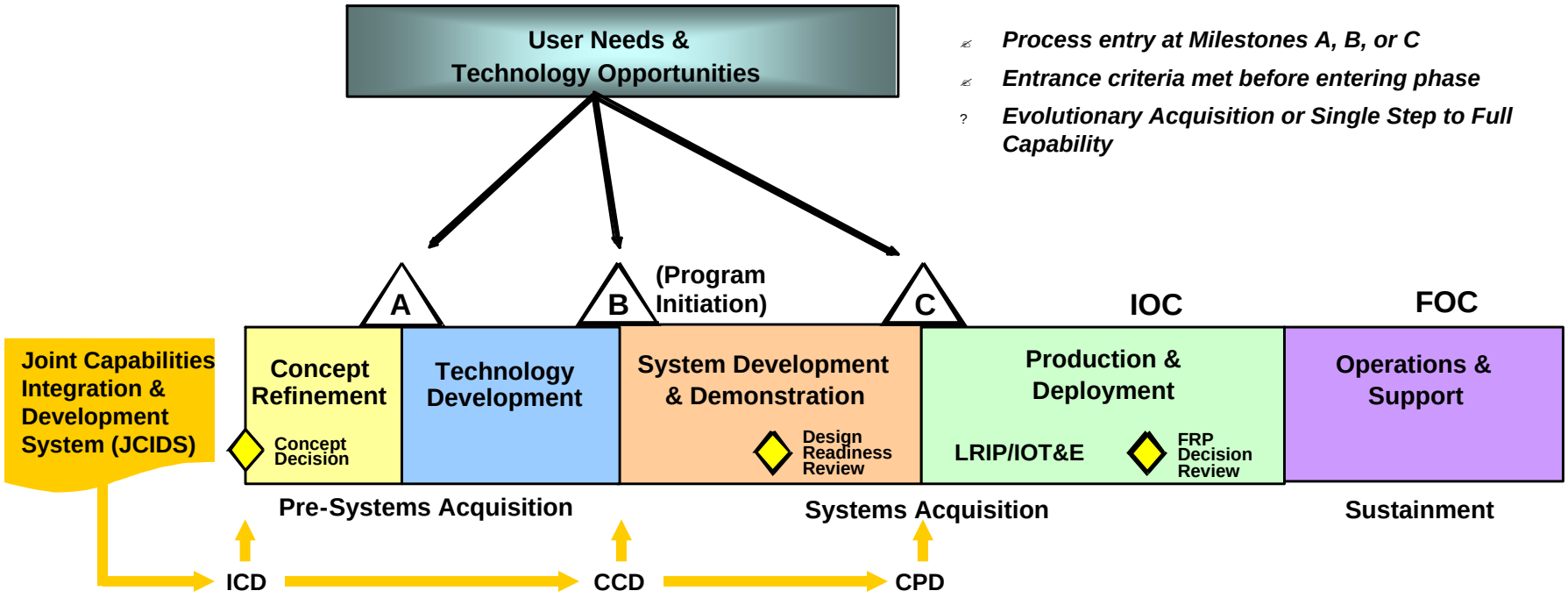
Integrated Architectures



Defense Acquisition System – DoD 5000

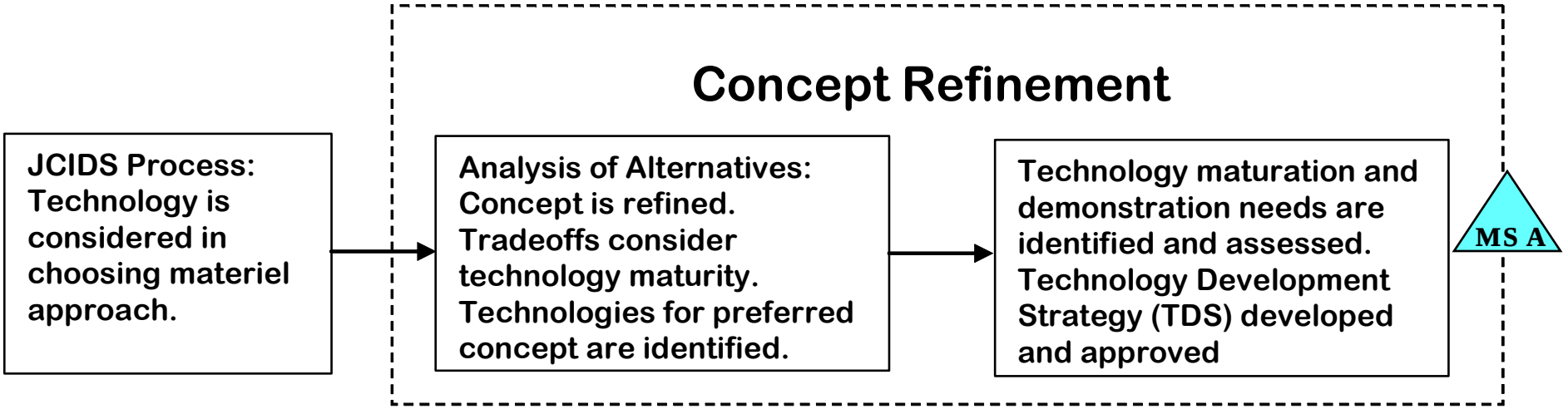
JCIDS governed by -- CJCSI 3170

Overview of Technology Considerations During Systems Acquisition



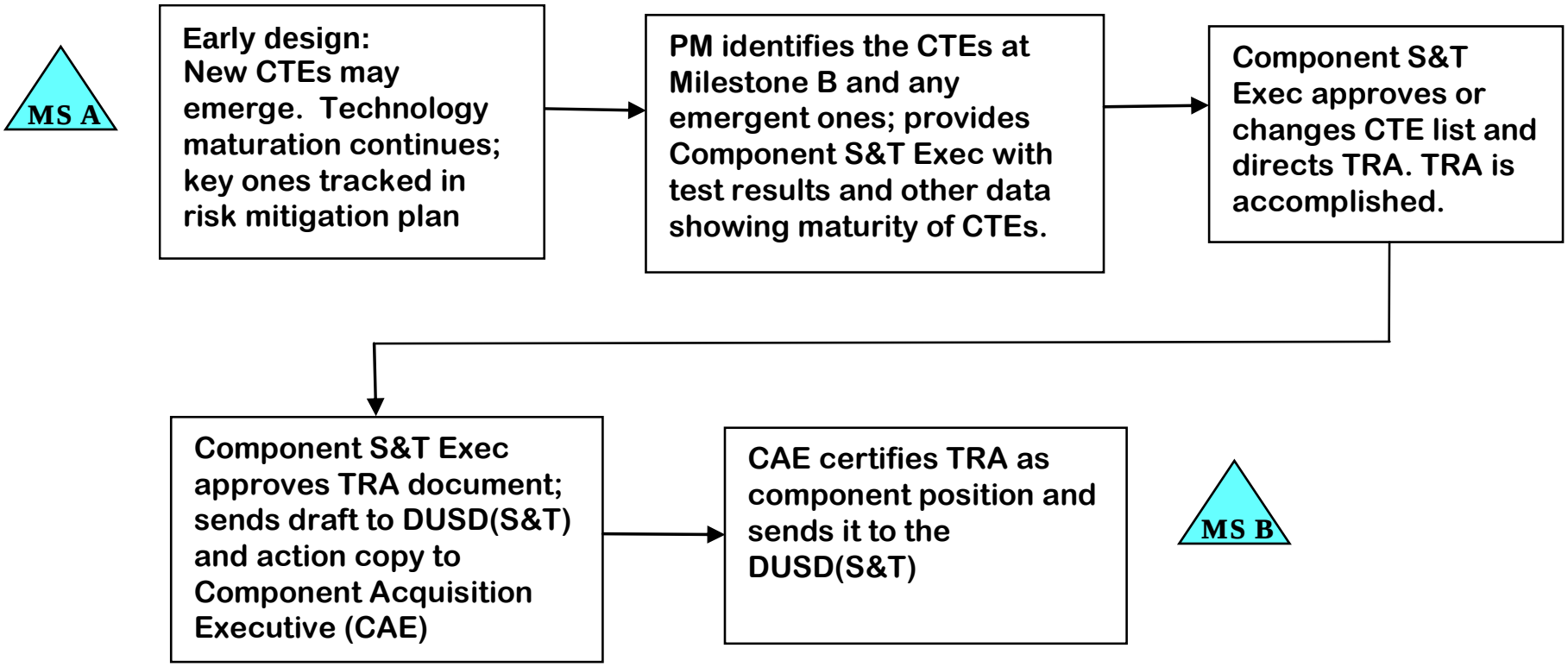
TRAs required at MS B, MS C, and program initiation for ships (usually MS A).

Technology Considerations Pre Milestone A



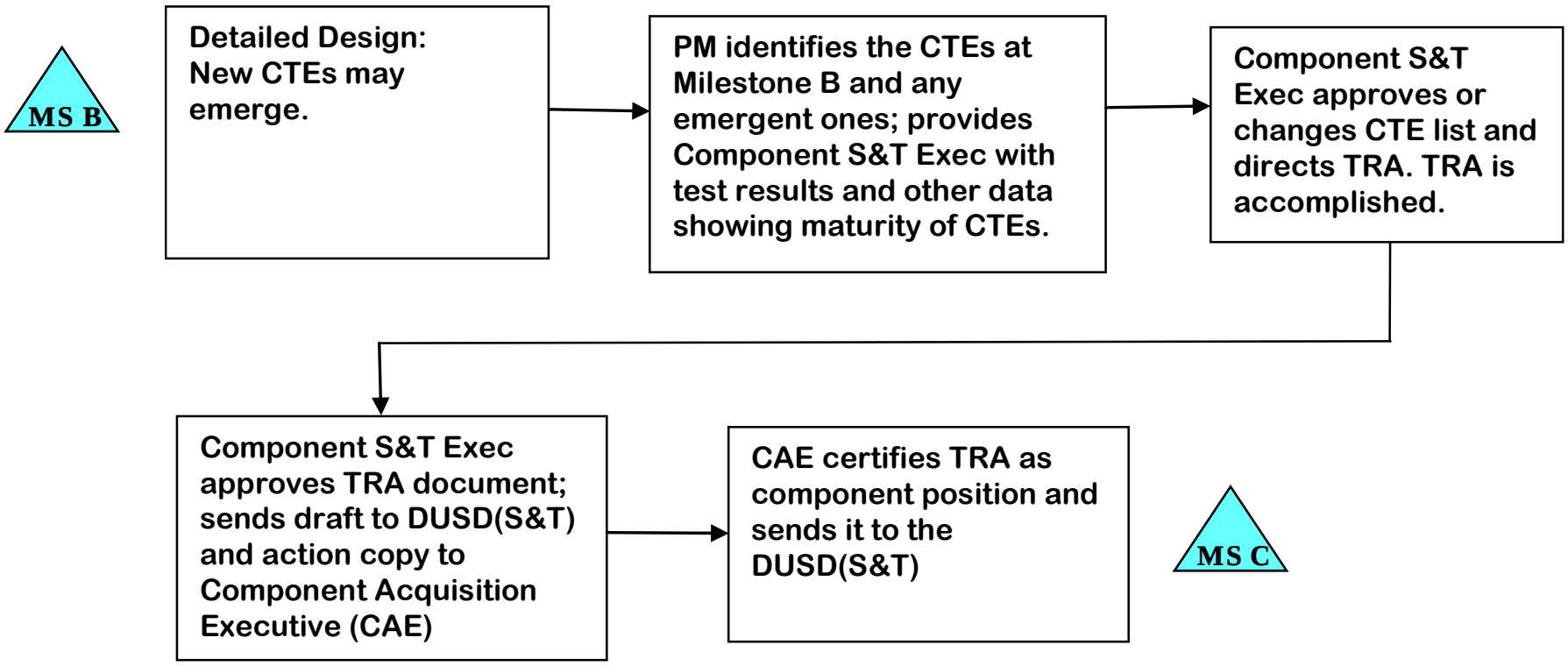
CTE identification begins in JCIDS process.
By MS A, CTE component should be demonstrated in a laboratory.

Technology Considerations During the Technology Development Phase



By MS B, CTE subsystem should be demonstrated in a relevant, preferably operational environment.

Technology Considerations During the System Development and Demonstration Phase



By MS C, system prototype should be demonstrated in an operational environment.

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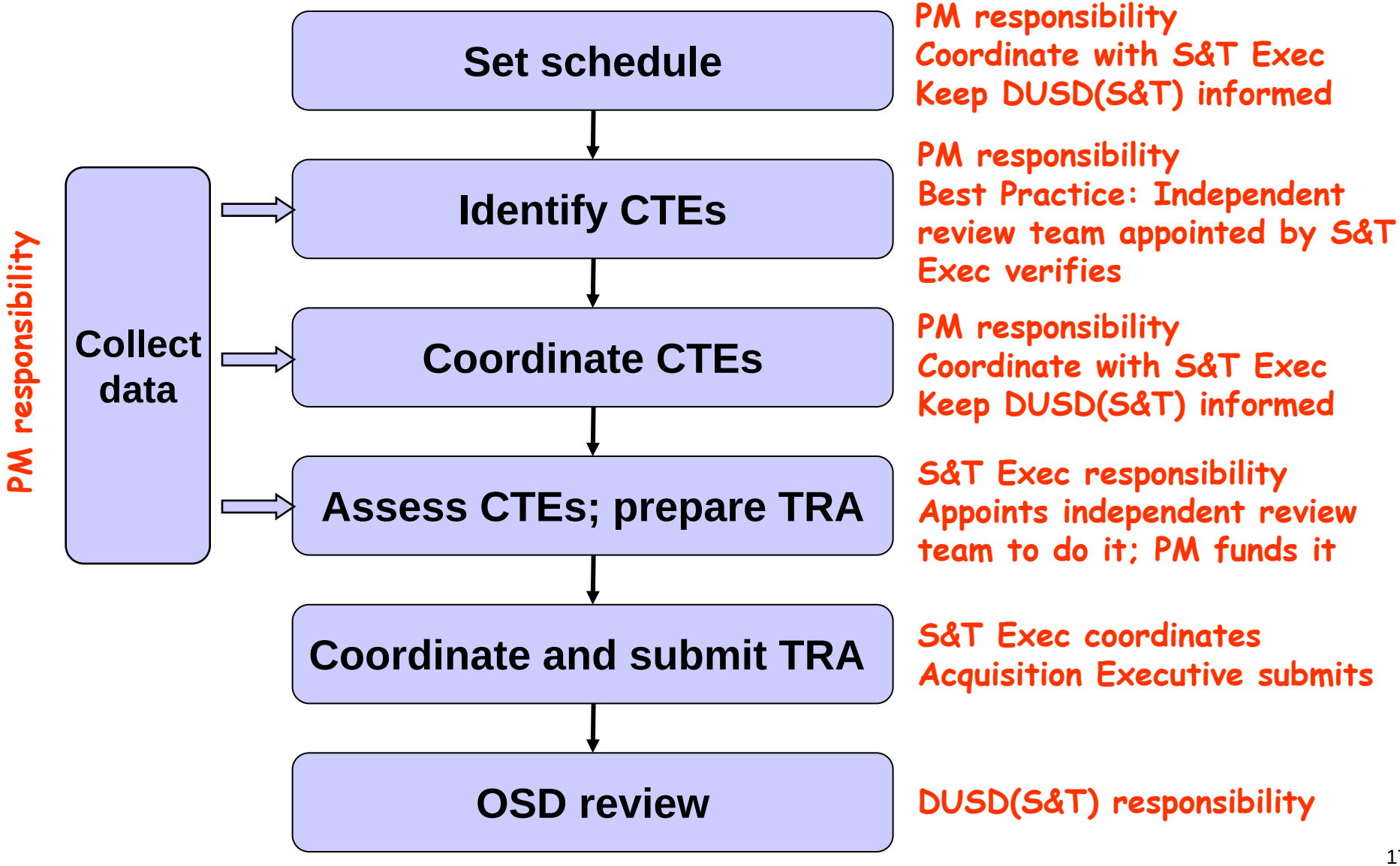
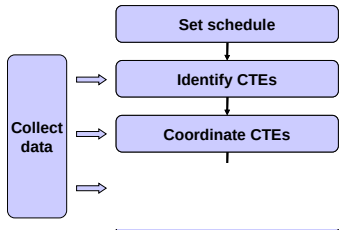
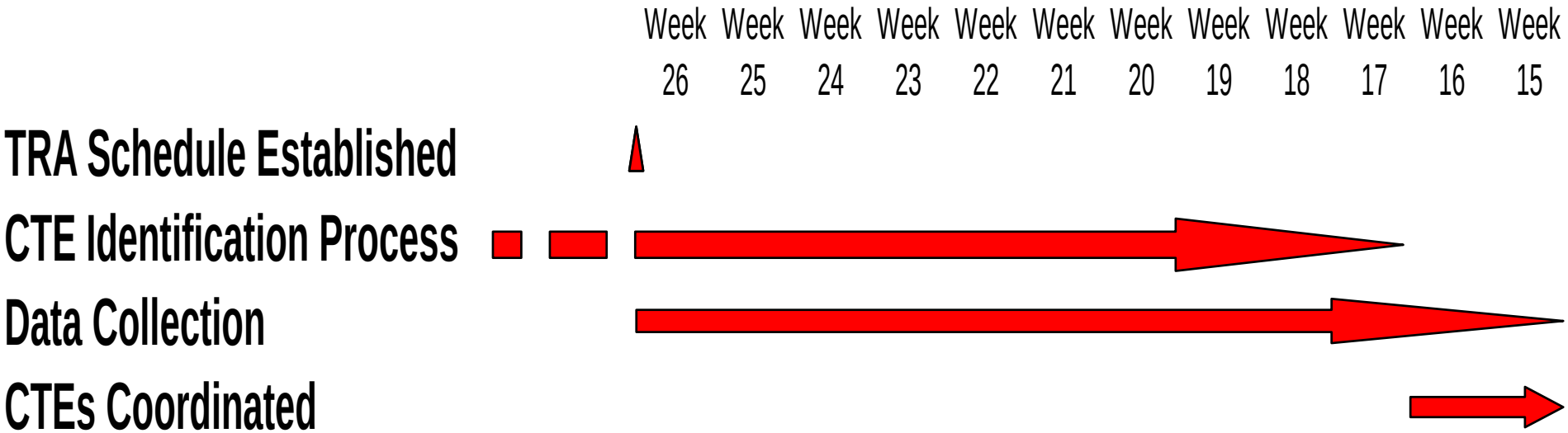
Process Overview



PM Responsible; Ind Review Team Verifies

Identifying CTEs





Schedule should be set 6-12 months before the Milestone Review depending on the complexity of the program.

PM Responsible; Ind Review Team Verifies

CTE Identification: Management Process

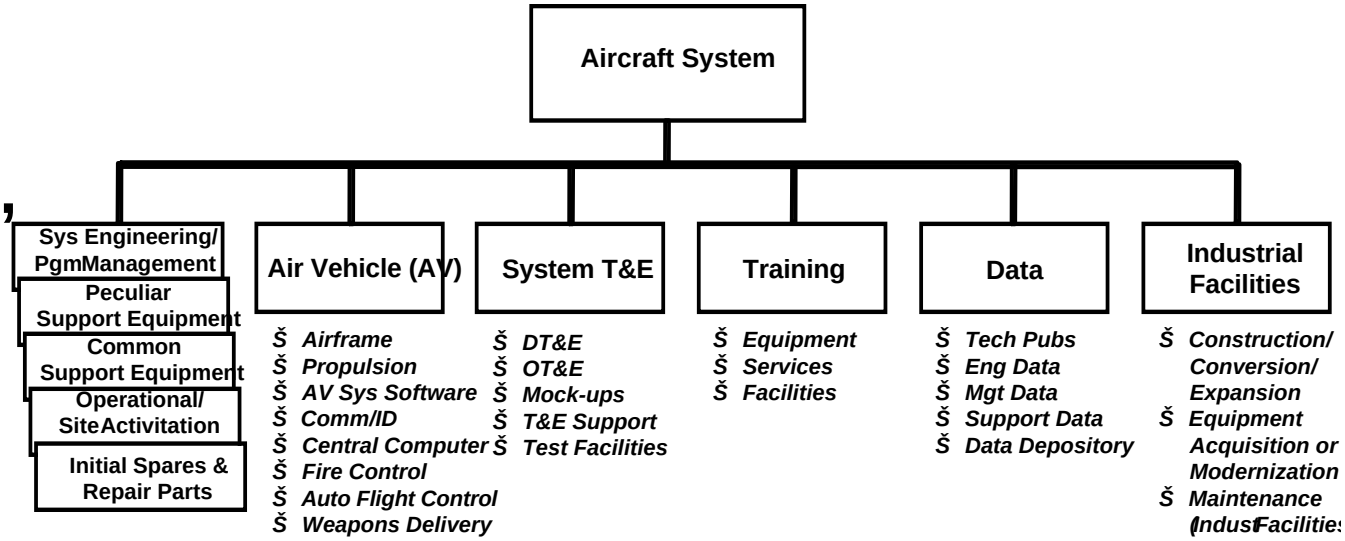
- **Initial review**
  - **PM led with program office, system contractors, and Govt labs**
  - **Thorough, disciplined and conservative approach**
  - **Identifies longer list of candidates to ensure that no potential CTE is overlooked**
  - **Identifies information needed to determine whether the candidates meet the criteria in the CTE definition**

- **Independent review**
  - **Conducted by independent review team of experts**
  - **Resolves status based on data and expertise**
  - **Makes recommendations whether candidates meet the criteria**

PM Responsible; Ind Review Team Verifies

CTE Identification: Technical Process (1 of 3)

- **Utilize the work breakdown structure (WBS), or system architecture for IT systems, to identify CTE candidates by:**
  - **Establishing the functions to be performed by each system, subsystem, or component throughout the WBS**
  - **Determining how the functions will be accomplished**
  - **Identifying the technologies needed to perform those functions at the desired level**



Adapted from MIL-HDBK-881

PM Responsible; Ind Review Team Verifies

CTE Identification: Technical Process (2 of 3)

- **Criticality to the program criteria**
  - **Does the technology directly impact an operational requirement?**
  - **Does the technology have a significant impact on an improved delivery schedule?**
  - **Does the technology have a significant impact on the affordability of the system?**

At least one answer must be "yes"

Aircraft example

Networked communication system example

Manufacturing example

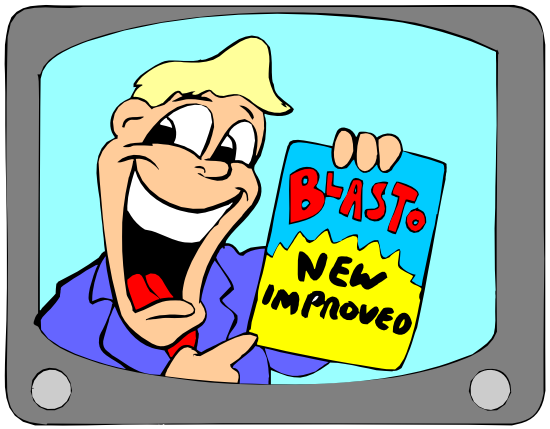
See section D.4 of the Deskbook for other examples

PM Responsible; Ind Review Team Verifies

CTE Identification: Technical Process (3 of 3)

- **New or novel criteria**
  - **Is the technology new or novel?**
  - **Is the technology modified?**
  - **Has the technology been repackaged such that a new relevant environment is realized?**
  - **Is the technology expected to operate in an environment and/or achieve a performance beyond its original design intention or demonstrated capability?**

At least one answer must be "yes"



Environment key to "new or novel"

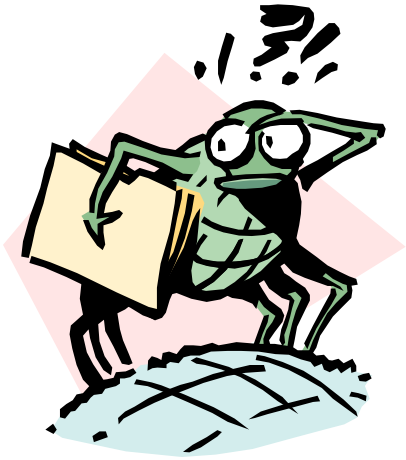
Environment Examples

- **Physical Environment**, for instance Mechanical Components, Processors, Servers and Electronics; Kinetic and Kinematic; Thermal and Heat Transfer; Electrical and Electromagnetic; Climatic−Weather, Temperature, Particulate; Network Infrastructure
- **Logical Environment**, for instance, Software (Algorithm) Interfaces; Security Interfaces; Web-enablement
- **Data Environment**, for instance, Data Formats and Databases; Anticipated Data Rates, Data Delay and Data Throughput; and Data Packaging and Framing
- **Security Environment**, for instance, Connection to Firewalls; Security Appliqués; Rates and Methods of Attack
- **User and Use Environment**, for instance, Scalability; Upgradeability; User Behavior Adjustments; User Interfaces; Organization Change/Realignments with System Impacts; Implementation Plan

Others may be relevant

Sample Questions to Determine if Environment is New or Novel

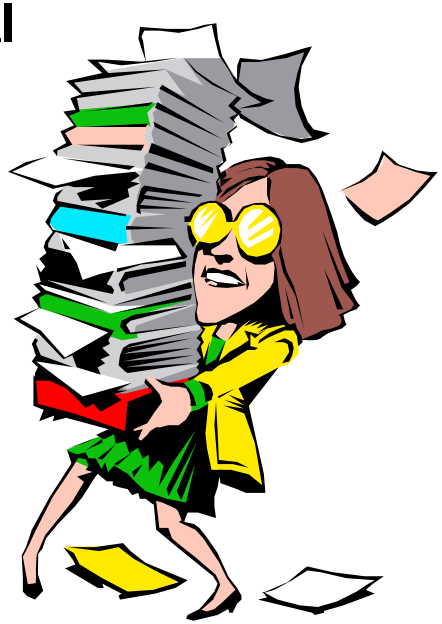
- **Is the physical/logical/data environment in which this CTE has been demonstrated similar to the intended environment? How is it different? Is the difference important?**
- **Is the CTE going to be operating at or outside of the usual performance envelope? Do specifications address the behavior of the CTE under these conditions? What is unique or different about the proposed operations environment?**
- **Do test data, reports or analysis that compare the demonstrated environment to the intended environment exist? If modeling and simulation is an important aspect of that comparison, are the analysis techniques common and generally accepted?**



See Section D.3.2 of the Deskbook for more questions

CTE Coordination and Data Collection

- PM submits list to the Component S&T Executive and requests a TRA
- S&T Executive may add CTEs if it is felt that special attention is warranted
- PM collects evidence of CTE maturity
  - Ongoing process throughout CTE identification
  - May include component and subsystem test descriptions, analyses, environments, and results
  - Best Practice: evidence should be as objective as possible and align with current technology maturation plan's documented verification criteria for achieving the next level



Keep DUSD(S&T) informed; may suggest additional CTEs

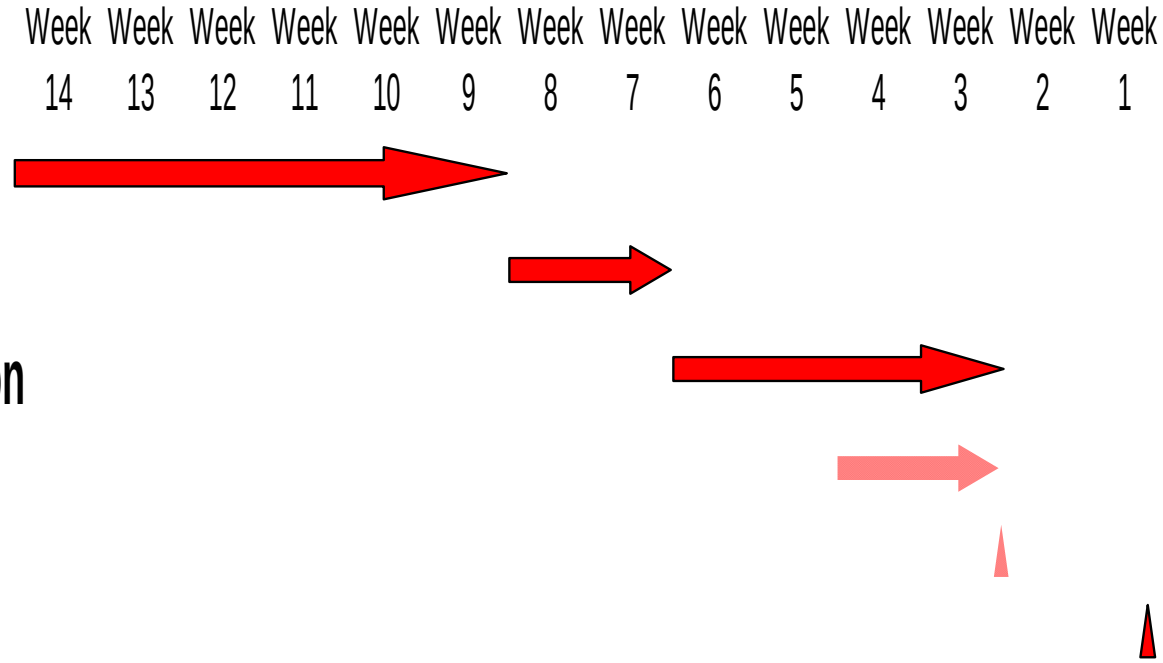
Component S&T Exec Responsible

Assessing CTE Readiness

Assess CTEs; prepare TRA

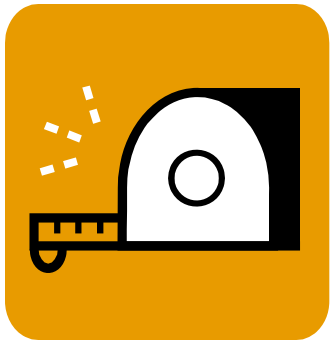
Coordinate and submit TRA

OSD review



TRL Overview

- **Measures technology maturity**
- **Indicates what has been accomplished in the development of a technology**
  - **Theory, laboratory, field**
  - **Relevant environment, operational environment**
  - **Subscale, full scale**
  - **Breadboard, brassboard, prototype**
  - **Reduced performance, full performance**



- **Does not indicate that the technology is right for the job or that application of the technology will result in successful development of the system**

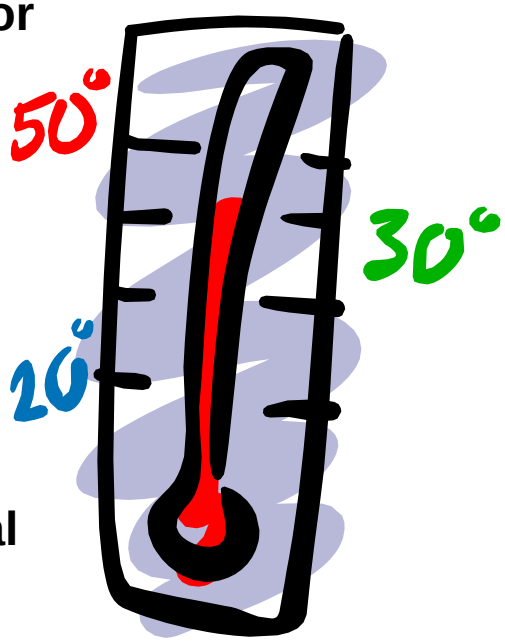
Hardware and Manufacturing TRLs

Increasing maturity

1. Basic principles observed and reported
2. Technology concept and/or application formulated
3. Analytical and experimental critical function and/or characteristic proof of concept
4. Component and/or breadboard validation in a laboratory environment
5. Component and/or breadboard validation in a relevant environment
6. System/subsystem model or prototype demonstration in a relevant environment
7. System prototype demonstration in an operational environment
8. Actual system completed and qualified through test and demonstration
9. Actual system proven through successful mission operations

Software TRLs

1. Basic principles observed and reported.
2. Technology concept and/or application formulated.
3. Analytical and experimental critical function and/or characteristic proof of concept
4. Module and/or subsystem validation in a laboratory environment, i.e. software prototype development environment
5. Module and/or subsystem validation in a relevant environment
6. Module and/or subsystem validation in a relevant end-to-end environment
7. System prototype demonstration in an operational high fidelity environment
8. Actual system completed and mission qualified through test and demonstration in an operational environment
9. Actual system proven through successful mission proven operational capabilities



TRA Performed

- **Program responsible for funding, *BUT* most of the work has already been done**
- **Independent team trained and convened by the Component S&T Executive to**
  - **Make the assessments**
  - **Write the report**
- **Multiple TRAs should be conducted if multiple systems still in competition**

Contact DUSD(S&T) with any issues (e.g., CTE uncertainty) early in the process

Hardware assessment criteria

See additional hardware examples in Section C.2 of the Deskbook

Software assessment criteria

See additional software examples in Section C.3 of the Deskbook

Manufacturing assessment criteria

See additional manufacturing examples in Section C.4 of the Deskbook

Contents

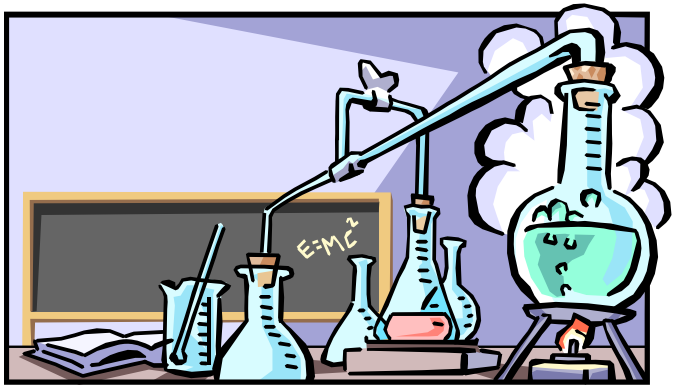
20%

- 1.0 Purpose of This Document
- 2.0 Program Overview
  - 2.1 Program Objective
  - 2.2 Program Description
  - 2.3 System Description

Focus is not programmatic

80%

- 3.0 Technology Readiness Assessment
  - 3.1 Process Description
  - 3.2 Critical Technologies
  - 3.3 Assessment of Maturity
    - 3.3.1 First CTE or Category of Technology
    - 3.3.2 Next CTE or Category of Technology
  - 3.4 Summary of TRLs by Technology
- 4.0 Conclusion



TRA is a technical report with references

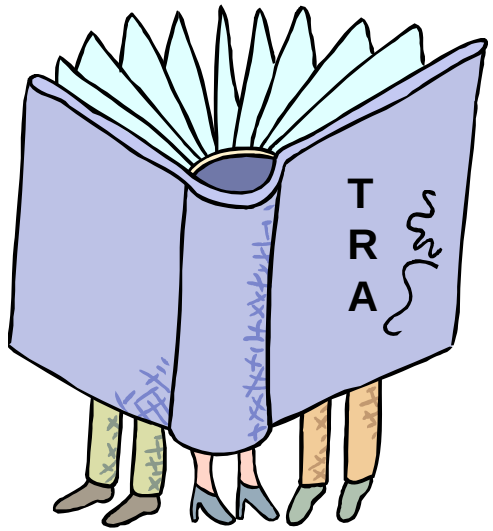
Component TRA Coordination

- **Identified CTEs and assessed TRL**
  - **Component TRA approval is an agreement on its accuracy only**
- **Maturity requirements:**
  - **Subsystem demonstrated in relevant environment (TRL 6) for MS B**
  - **Prototype (TRL 7) or actual system for manufacturing CTEs (TRL 8) demonstrated in an operational environment for MS C**
- **Three options if a technology is not mature**
  - **Request a delay for the Milestone review until all CTEs are at the requisite maturity level**
  - **Utilize alternative, mature technologies**
  - ***As a last resort*, carry immature technologies into the Milestone review and prepare a waiver, based on inability to meet national security objectives, for the MDA to submit to Congress**

Acquisition Executive submits the TRA to DUSD(S&T)

DUSD(S&T) TRA Review

- **Results of initial review**
  - **Concur**
  - **Request revisions**
- **Results of final review**
  - **Concur**
  - **Concur with reservations**
  - **Perform independent technical assessment**



DUSD(S&T) informs Milestone Decision Authority of the results

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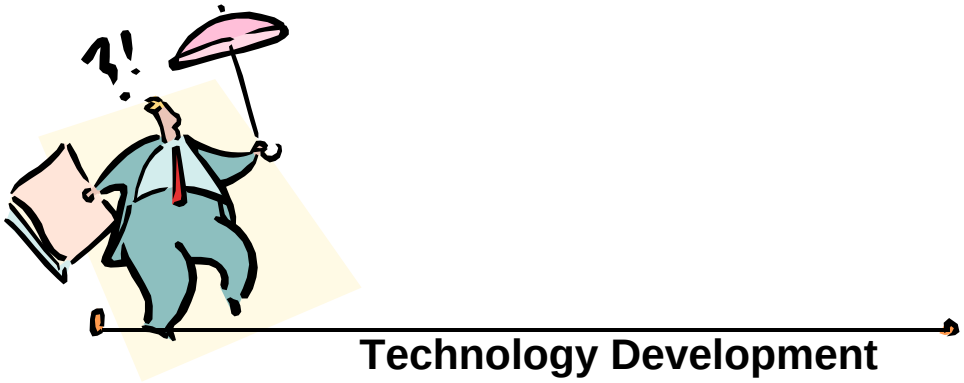
Technology Maturation Policy Leading to Milestone B is Unambiguous

"The project shall exit Technology Development when an affordable increment of militarily-useful capability has been identified, the technology for that increment has been demonstrated in a relevant environment, and a system can be developed for production within a short timeframe (normally less than five years); or when the MDA decides to terminate the effort. …. A Milestone B decision follows the completion of Technology Development." (DoDI 5000.2, paragraph 3.6.7)



Technology Maturation Policy Leading to Milestone B is Unambiguous (cont'd)

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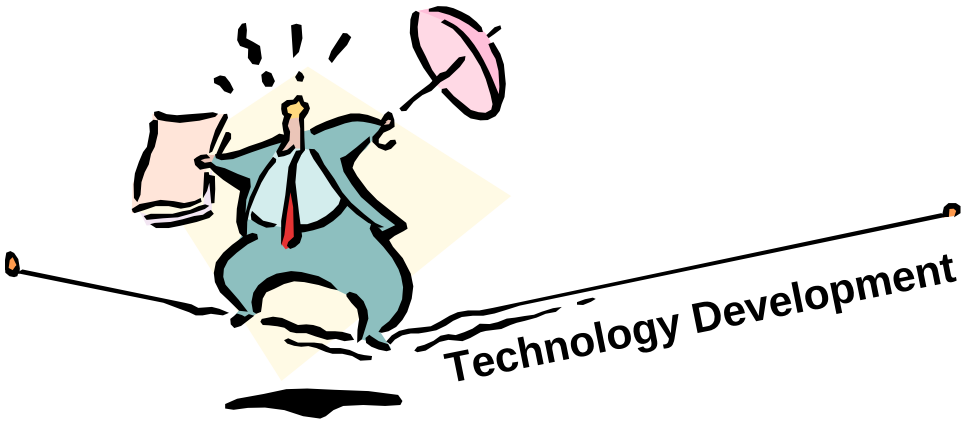


Objective assessment of technology maturity and risk shall be a routine aspect of DoD acquisition. Technology developed in S&T or procured from industry or other sources shall have been demonstrated in a relevant environment or, preferably, in an operational environment to be considered mature enough to use for product development in systems integration. Technology readiness assessments, and where necessary, independent assessments, shall be conducted.

If technology is not mature, the DoD Component shall use alternative technology that is mature and that can meet the user's needs." (DoDI 5000.2, paragraph 3.7.2.2)

and • • •

• • • The Policy is Reflected as a Title 10 Requirement for Certification

10 USC §2366a states

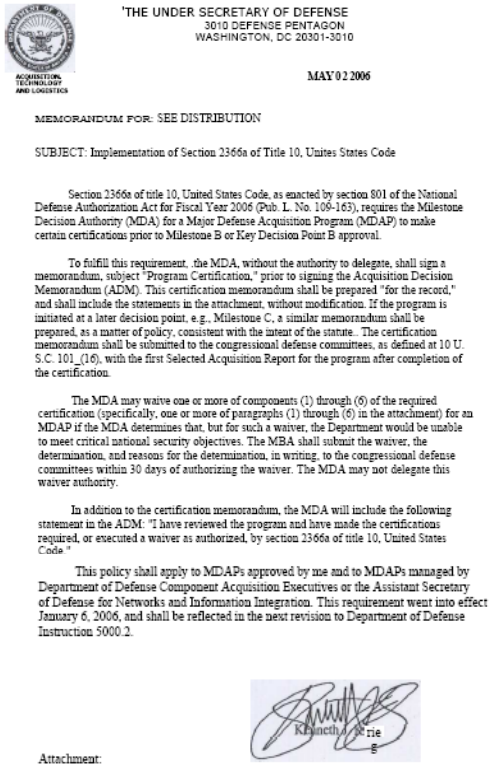
Major defense acquisition programs: certification required before Milestone B or Key Decision Point B approval:

(a) CERTIFICATION. A major defense acquisition program may not receive Milestone B approval, or Key Decision Point B approval in the case of a space program, until the milestone decision authority certifies that –

(2) the technology in the program has been demonstrated in a relevant environment;

. . .

(10) the program complies with all relevant policies, regulations and directives of the Department of Defense



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WASHINGTON, DC 20301-3010

MAY 02 2006

MEMORANDUM FOR: SEE DISTRIBUTION

SUBJECT: Implementation of Section 2366a of Title 10, Unites States Code

Section 2366a of title 10, United States Code, as enacted by section 801 of the National Defense Authorization Act for Fiscal Year 2006 (Pub. L. No. 109-163), requires the Milestone Decision Authority (MDA) for a Major Defense Acquisition Program (MDAP) to make certain certifications prior to Milestone B or Key Decision Point B approval.

To fulfill this requirement, the MDA, without the authority to delegate, shall sign a memorandum, subject "Program Certification," prior to signing the Acquisition Decision Memorandum (ADM). This certification memorandum shall be prepared "for the record," and shall include the statements in the attachment, without modification. If the program is initiated at a later decision point, e.g., Milestone C, a similar memorandum shall be prepared, as a matter of policy, consistent with the intent of the statute. The certification memorandum shall be submitted to the congressional defense committees, as defined at 10 U. S.C. 101_(16), with the first Selected Acquisition Report for the program after completion of the certification.

The MDA may waive one or more of components (1) through (6) of the required certification (specifically, one or more of paragraphs (1) through (6) in the attachment) for an MDAP if the MDA determines that, but for such a waiver, the Department would be unable to meet critical national security objectives. The MBA shall submit the waiver, the determination, and reasons for the determination, in writing, to the congressional defense committees within 30 days of authorizing the waiver. The MDA may not delegate this waiver authority.

In addition to the certification memorandum, the MDA will include the following statement in the ADM: "I have reviewed the program and have made the certifications required, or executed a waiver as authorized, by section 2366a of title 10, United States Code."

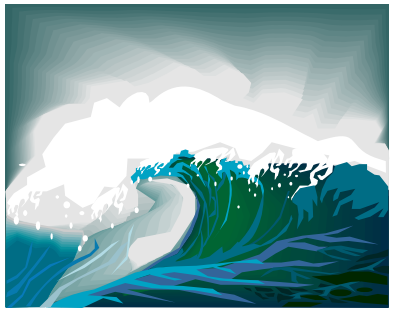
This policy shall apply to MDAPs approved by me and to MDAPs managed by Department of Defense Component Acquisition Executives or the Assistant Secretary of Defense for Networks and Information Integration. This requirement went into effect January 6, 2006, and shall be reflected in the next revision to Department of Defense Instruction 5000.2.

Attachment:
As stated

Certification Submitted with the First Selected Acquisition Report for the Program

• • • But Waivers Are Allowed

(c) WAIVER FOR NATIONAL SECURITY. The milestone decision authority may waive the applicability to a major defense acquisition program of one or more components (as specified in paragraph (1), (2), (3), (4), (5), (6), (7), (8), or (9) of subsection (a)) of the certification requirement if the milestone decision authority determines that, but for such a waiver, the Department would be unable to meet critical national security objectives. Whenever the milestone decision authority makes such a determination and authorizes such a waiver, the waiver, the determination, and the reasons for the determination shall be submitted in writing to the congressional defense committees within 30 days after the waiver is authorized.



Changes Made to Meet the Statutory Requirements

- **USD(AT&L) policy determinations**
  - **Programs will no longer be initiated with immature technologies**
  - **The same standards apply to all acquisition programs**
- **DDR&E will provide technical advice in support of certification**
  - **TRA will be the basis of that advice**

Desired Outcomes from Process Changes in Support of the New Situation

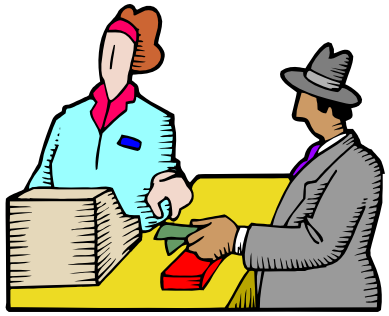
- **Safeguards in place to provide the DDR&E with the confidence necessary to assure the MDA that certification can be made**
  - **To make the TRA support the certification, it must draw upon the best technical information available prior to source selection**
- **Assurance that technologies have been demonstrated in a relevant environment by the winning SDD Phase contractor**
  - **To initiate programs with mature technologies, the source selection process should include a focus on technical maturity**

Outline

- Introduction
  - What is a TRA
  - Why it is important
- Overview of Technology Considerations During Systems Acquisition
- Synopsis of the TRA Process
  - Identifying Critical Technology Elements (CTEs)
  - Assessing CTE Readiness
- Pre-Milestone B Technology Maturation Policy
- How the S&T Community Can Best Support the TRA Process
  - Do's and Don'ts
- References and Resources

Use of TRA and TRL Terminology

Acquisition Community



- **TRAs help ensure the technology being used in acquisition programs is mature**
  - **Use of immature technologies leads to cost growth and schedule slippage**
- **TRAs provide the basis for DDR&E to advise the MDA on 10 USC 2366a certification for technology maturity at Milestone/KDP B**
- **TRLs are the maturity metric for CTEs in TRAs; TRLs 5-9 are applicable**
  - **Environments and the performance requirements defined by a program of record**
- **TRAs performed at Milestones B and C and program initiation for ships**

Use of TRA and TRL Terminology

S&T Community

- **TRAs are an acquisition construct**
  - **They are not performed on an S&T project**
- **TRLs may be used as a maturity metric for technologies in a technology development project; TRLs 1-6 are applicable**
  - **TRL definitions and descriptions successively spell out progress (as measured by tests) toward a goal**
- **TRLs may be used as part of a technology managers' ongoing assessment of a technology or technologies**

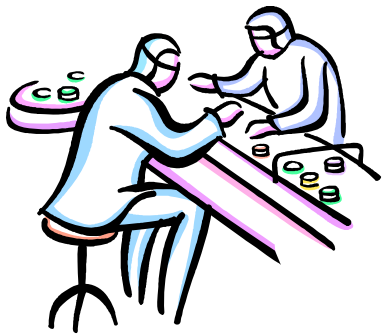
Use of TRLs 5 and 6 overlaps with the acquisition community

Issues Arising from Overlap in Terminology

- **Normally demonstrating a technology beyond TRL 4 requires more resources than maturing the technology through TRLs 1-3**
  - **Higher level assemblies needed**
  - **More refined components needed**
  - **More broad scale tests needed**
- **Such resources often obtained from programs of record as activities shift from the realm of technology advancement to technology transition and insertion**
- **Misunderstanding of TRLs 5-6 has led to misuse of the terminology when competing for these resources**
  - **May damage the S&T program and/or the TRA process**
  - **May create the wrong impression with leadership**

Misuse of TRA and TRL terminology and concepts may lead to negative unintended consequences

TRL 4 is the Breakpoint between Invention and Application (1 of 3)



- **TRLs 1-3 involve development of functionality, mostly independent of the application**
- **To achieve TRL 4**
  - **Must begin integration of components to represent how they would be used in a fieldable application**
  - **Must have a generic application in mind without knowing exactly how that application will be used**

TRL 4 is the Breakpoint between Invention and Application (2 of 3)

- To achieve TRL 5 or higher
  - Must be in the context of an application for a program of record
    - The application provides the both the metric (speed, energy density…) and the threshold (10 m/s; 100J/g…)
  - Must have an understanding of the relevant environment
    - The relevant environment cannot be determined without an understanding of requirements and intended operational use defined in programmatic documents

TRL 4 is the Breakpoint between Invention and Application (3 of 3)

- **Gun propellant example**
  - **TRL 1: Theoretical studies and computer models lead to synthesis and characterization of a new energetic material for a propellant**
  - **TRL 2: New material synthesized, characterized and potential performance of propellants mapped via computer codes**
  - **TRL 3: New propellants prepared at small scale and performance, processing, and physical properties characterized**
  - **TRL 4: Based on TRL 1-3 data propellant designed for a specific application and near full scale tests performed to confirm computer modeling**
  - **TRL 5: New propellant produced in quantity and evaluated in near-final system configuration**

MS B Requirement: Demonstration or Validation in a Relevant Environment (TRL 6)

<u>Relevant Environment</u>: a *set of stressing conditions representative of the full spectrum of relevant operational employments*, which are applied to a CTE as part of a component (TRL 5) or system/subsystem (TRL 6) model or prototype in order *to identify whether any design changes or fixes are needed to support the required (threshold) functionality*

Demonstration or Validation of a Technology in a Relevant or Operational Environment

- **Requires successful trial testing that either:**
  - **Shows that the technology satisfies functional need across the full spectrum of operational employments, or**
  - **Shows that the technology satisfies the functional need for some important *(stressing)* operational employment and uses accepted techniques to extend confidence over all required operational employments**

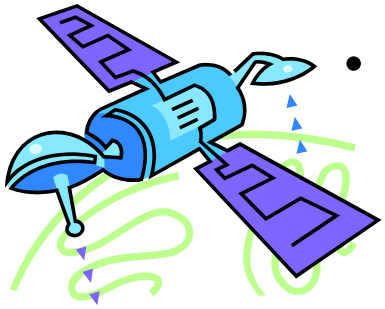
S&T Practices to Better Support TRAs and the Acquisition Process (1 of 7)

- **Not labeling the technology assessments performed by the S&T community as a TRA**
  - **Misuses the term in a way that misleads stakeholders**
  - **May damage both TRA and technology proponent's reputation**
- **Not justifying the need for research (dollars) based on achieving TRL 5/6 without the metrics and the threshold provided by a program of record**

S&T Practices to Better Support TRAs and the Acquisition Process (2 of 7)

- **Applying judgment when determining the relevant environment from the operational environment to maximize test efficiency**
  - **Environments tested should be stressing enough to be persuasive**
    - **Being exhaustive is usually too expensive**

Example



- **Launching a satellite should not be on critical path for design and demonstration**
- **Relevant environment depends on what is stressing**
  - **E.g., thermal load, radiation in space, g-forces during launch**
  - **May be tested and demonstrated in the lab**
- **Technical expertise ensures stressing portion of the environment is demonstrated; no expensive, exhaustive tests applied to non-critical element**

S&T Practices to Better Support TRAs and the Acquisition Process (3 of 7)

- **Continuing promising technology development at TRL 4 when there is no program of record**
  - **While TRLs 5/6 are achieved with a successful demonstration, there are a large number of useful activities that could take place at TRL 4**

  - **It is helpful to complete an extensive performance characterization rather than a "point demonstration"**
    - **Provides information on how to incorporate the technology into a design**
    - **Enables more rapid insertion**
    - **Supports knowledge-based acquisition decisions**
  - **A technology's capability may be advanced using metrics of interest without knowing the particular thresholds**
  - **Improvements may be planned on the basis on draft requirements**

Continuing development applies to TRL 5/6 as well

S&T Practices to Better Support TRAs and the Acquisition Process (4 of 7)

- **Preparing to help programs of record achieve TRLs 5/6 via expertise with the technology itself and test design as they reach back to the tech base for solutions**
  - **Neither labs nor program offices are organized or staffed to conduct the realistic demonstrations of highly integrated components need to mature technologies to TRL 5/6 on their own**
  - **S&T personnel (and institutions) should transition into a supporting role**

Example

- **Armor piercing, fin stabilized discarding sabot (APFSDS) had nearly maxed performance capabilities**
- **Armament Enhancement Initiative in 1984 established to reduce sabot weight (partnership between S&T and acquisition)**
- **By 1987, requirement established for new composite sabot; fielded in 1992**
- **Cycle repeated itself for fielding more advanced sabot in 2003**

S&T Practices to Better Support TRAs and the Acquisition Process (5 of 7)

- **Differentiating proof of principle demonstration (TRL 3) from demonstration in a (requirements defined) relevant environment TRL 5/6**
  - **For TRL 3, do not need to have an application in mind**
    - **Acquisition customer may say "If you make it work, I'll use it"**
  - **For TRL 5, there must be an application and components must be representative of use in intended application**
  - **For TRL 6, ready to turn it over to a design engineer**

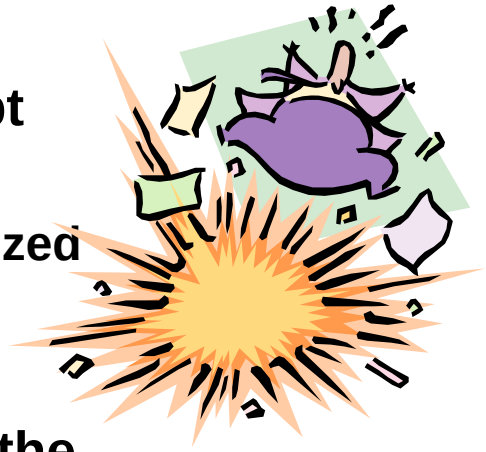
Overselling technology readiness damages the S&T community credibility as much as overselling technology performance. May lead to • • •

S&T Practices to Better Support TRAs and the Acquisition Process (6 of 7)

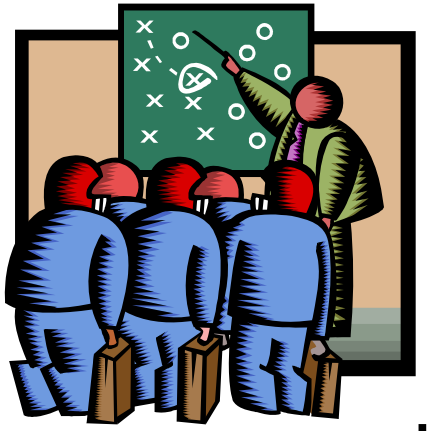
• • • acquisition problems if program initiated with immature technology

Example

- **Regenerative Liquid Propellant Gun ultimately became the CRUSADER program**
  - **When program transitioned from S&T, the concept was proven**
    - **All technology issues were reasonably well recognized**
    - **Plan was to solve the problems in engineering**
  - **Eventual failure (program cancellation) was associated with the difficulties when transferring the technology to practical hardware**



S&T Practices to Better Support TRAs and the Acquisition Process (7 of 7)



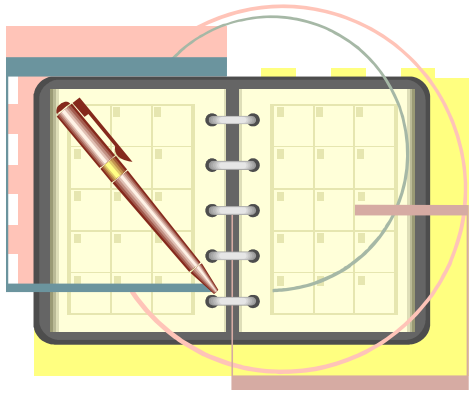
- **Avoiding the use of TRLs as a sole and governing measure for managing S&T programs**
  - **TRLs are a static metric; represent snapshot in time; they do not assess difficulty of advancement**
  - **TRLs lack high specificity; much more information needs to be conveyed**
    - **Should lay out specific technical goals to evaluate technology status / progress**
  - **Could lead to a premature stoppage of development efforts as soon next TRL is reached**
- **Using TRLs a high-level metric for managing a balanced portfolio of investments from basic research to exploratory development of components**
  - **Helps avoid under emphasis on basic principles or concept formulation (TRLs 1 and 2) in favor of research on proof of principle or demonstration in lab (TRLs 3 and 4)**

Acquisition Practices to Improve Linkages with S&T (1 of 2)

- **Developing (in conjunction with the S&T community) a technology maturation plan to identify how technologies will be demonstrated in a relevant environment by Milestone B**
- **Establishing measurable technical performance requirements as technology transition exit criteria to achieve TRL 6 for CTEs**
  - **Fully describe the relevant environment in technology transition agreements**
  - **Include metrics and thresholds in a relevant environment**
  - **Do not specify TRL 6 as an exit criterion**

Acquisition Practices to Improve Linkages with S&T (2 of 2)

- **Shifting necessary resources (funding and personnel) to the technology development phase**
- **Accounting for the event-driven nature of S&T processes when developing schedules**
  - **Applying schedule-driven constraints may compromise technology development and lead to immature technologies at Milestone B**
  - **Backup plans and alternatives to technologies less than TRL 6 are advisable**



Outline

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- Overview of Technology Considerations During Systems Acquisition
- The TRA Process
  - Identifying Critical Technology Elements (CTEs)
  - Assessing CTE Readiness
- Technology Maturation
- References and Resources

References and Resources

- **Defense Acquisition Resource Center http://akss.dau.mil/darc/darc.html**
  - **DoD Directive 5000.1 (DoDD 5000.1), *The Defense Acquisition System*, dated May 12, 2003**
  - **DoD Instruction 5000.2 (DoDI 5000.2), *Operation of the Defense Acquisition System*, dated May 12, 2003**
  - ***Defense Acquisition Guidebook***
- ***DAU Continuous Learning Module CLE021***
  - **https://learn.dau.mil/html/clc/Clc.jsp to browse it**
- ***TRA Deskbook***
  - **http://www.defenselink.mil/ddre/doc/tra_deskbook_2005.pdf**
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