GAO Technology Readiness Assessment Guide

NDIA Manufacturing Division Meeting
March 1, 2017

What is GAO?

- Background: Established in 1921, GAO is an independent, nonpartisan agency that is part of the legislative branch.
- Mission: Support Congress and improve performance and accountability of the federal government.
- Work: Most work done at the request of congressional committees or subcommittees or is mandated by public laws or committee reports; also done under the Comptroller General's authority.
- Authority: Broad authority to evaluate federal agency programs and investigate receipt, disbursement and use of public funds, with statutory right of access to agency records, including those considered pre-decisional.

GAO's Work on Defense Manufacturing

- "Drill down" reviews of individual major defense acquisition programs – Missile Defense, F-35, KC-46, LCS, etc.
- "Quick Look" – annual assessment of about 50 major defense acquisition programs and pre-major defense acquisition programs
- "Cross-cutting" reviews of issues that affect multiple programs, such as quality assurance, supply chain management, industrial base capabilities, and best practices for product development

GAO Guides and Best Practices

Currently Published Materials

- Purpose of these documents is two-fold:
  - Provide criteria for GAO audits
  - Provide guidance for agencies

- GAO has published the following guides:
  - Cost Estimating and Assessment Guide
    http://www.gao.gov/new.items/d093sp.pdf

  - Schedule Assessment Guide
    http://www.gao.gov/assets/680/674404.pdf

  - Best Practices for Analysis of Alternatives - Appendix 1 in GAO-16-22
    http://www.gao.gov/assets/680/673405.pdf

  - Technology Readiness Assessment Guide
    http://www.gao.gov/assets/680/679006.pdf

GAO Guides and Best Practices

Expert Group Process

- To develop these guides, GAO compiles a list of experts in that area to discuss topics

- For example, the Cost Expert Group was established in 2005 and has since grown to include experts on schedule analysis and earned value management
  - Group meets twice a year to discuss a variety of related issues
  - Contributions have been invaluable both in
    - Providing historical information and experience
    - Keeping the Guide current with industry trends

- GAO has currently assembled an Agile Expert Group
  - The group's first meeting occurred on August 30, 2016

Upcoming Guides: Federal Software Development Best Practices Guide and Update to the GAO Cost Guide

GAO Guides and Best Practices

How the Expert Group Works

Develop Initial Guides

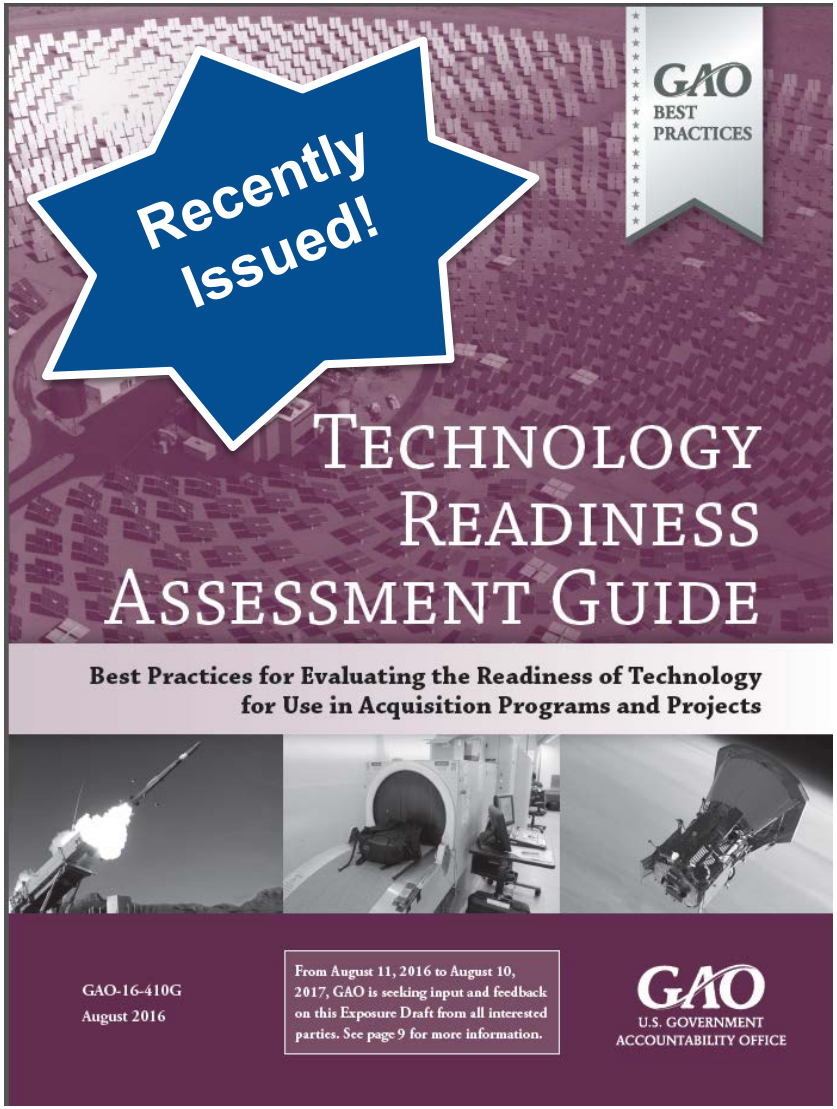
- Collect names to develop extensive contact list of experts in the field
- GAO researches various topics and develops drafts
- Expert Panel reviews drafts provided by GAO
- GAO vets comments to finalize Exposure Drafts
- Exposure Draft is published on the Internet and an open comment period is established
- GAO vets comments and incorporates them into the final version of the initial Guide

Updated Guides

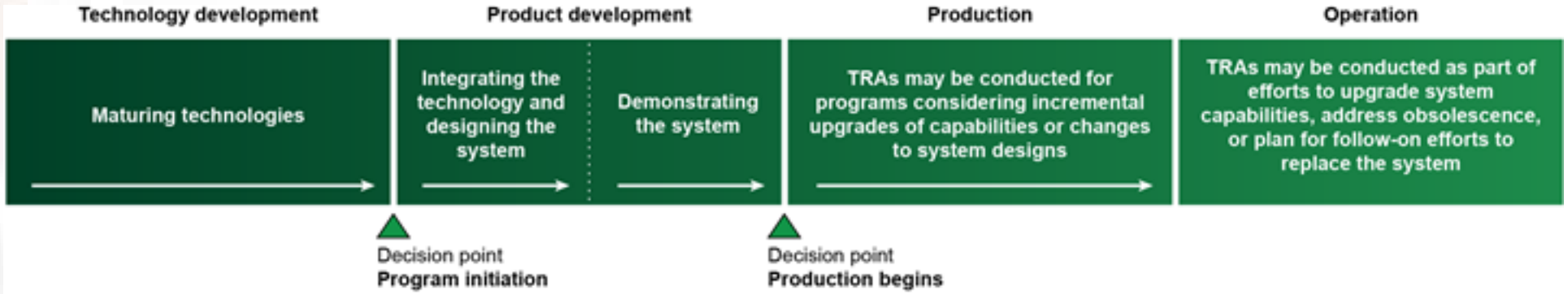
- GAO adds names to the contact list to ensure that the list of experts is inclusive
- GAO attends conferences/meetings to determine topics that should be discussed at meetings
- Broad Expert Meetings are held twice a year at GAO in March and September; agendas are sent out one month prior and GAO compiles and disseminates detailed meeting minutes
- GAO updates the chapters based on updated policies and research
- An open comment period is established and GAO vets and incorporates comments
- GAO issues an updated Guide

Technology Readiness Assessment Guide

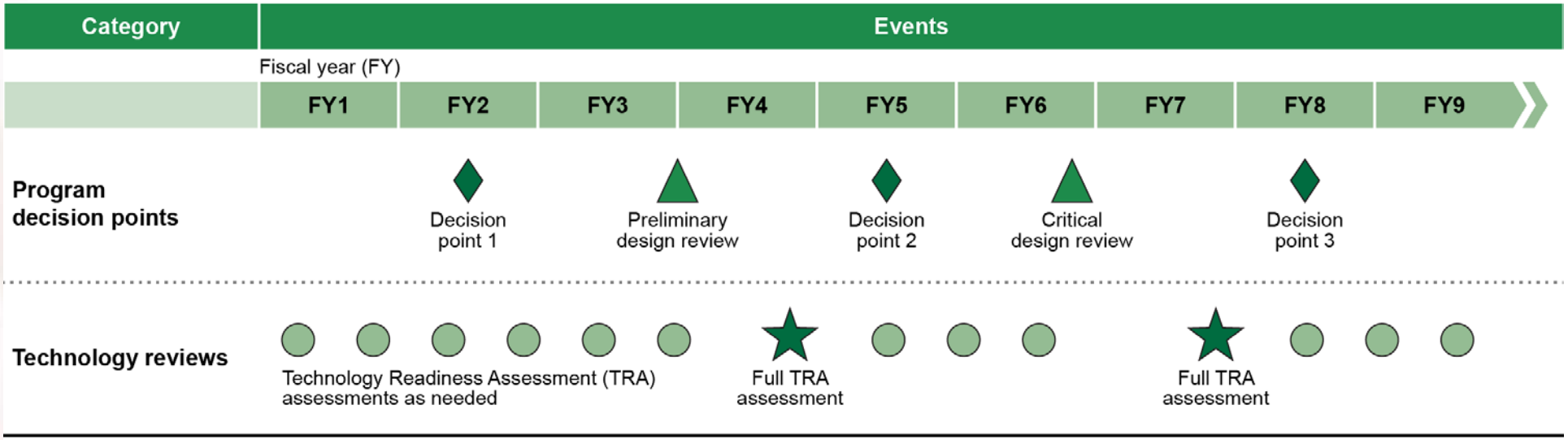
- Drafted 2015-2016, release of public exposure draft on August 11, 2016
- Outlines GAO's criteria for evaluating technological readiness assessments
- Contains 10 chapters with supporting appendixes
- Chapters 1 and 2 define TRAs and describe their importance and limitations
- Chapter 3 outlines a reliable process for conducting TRAs
- Chapters 4-10 address the associated best practices
- Provides case studies from prior GAO audits to show typical findings related to technology readiness assessment



Phased Acquisition Cycle with Decision Points



Source: GAO simplification of agency documents. | GAO-16-410G



Source: GAO analysis of agency documents. | GAO-16-410G

Technology Readiness Levels

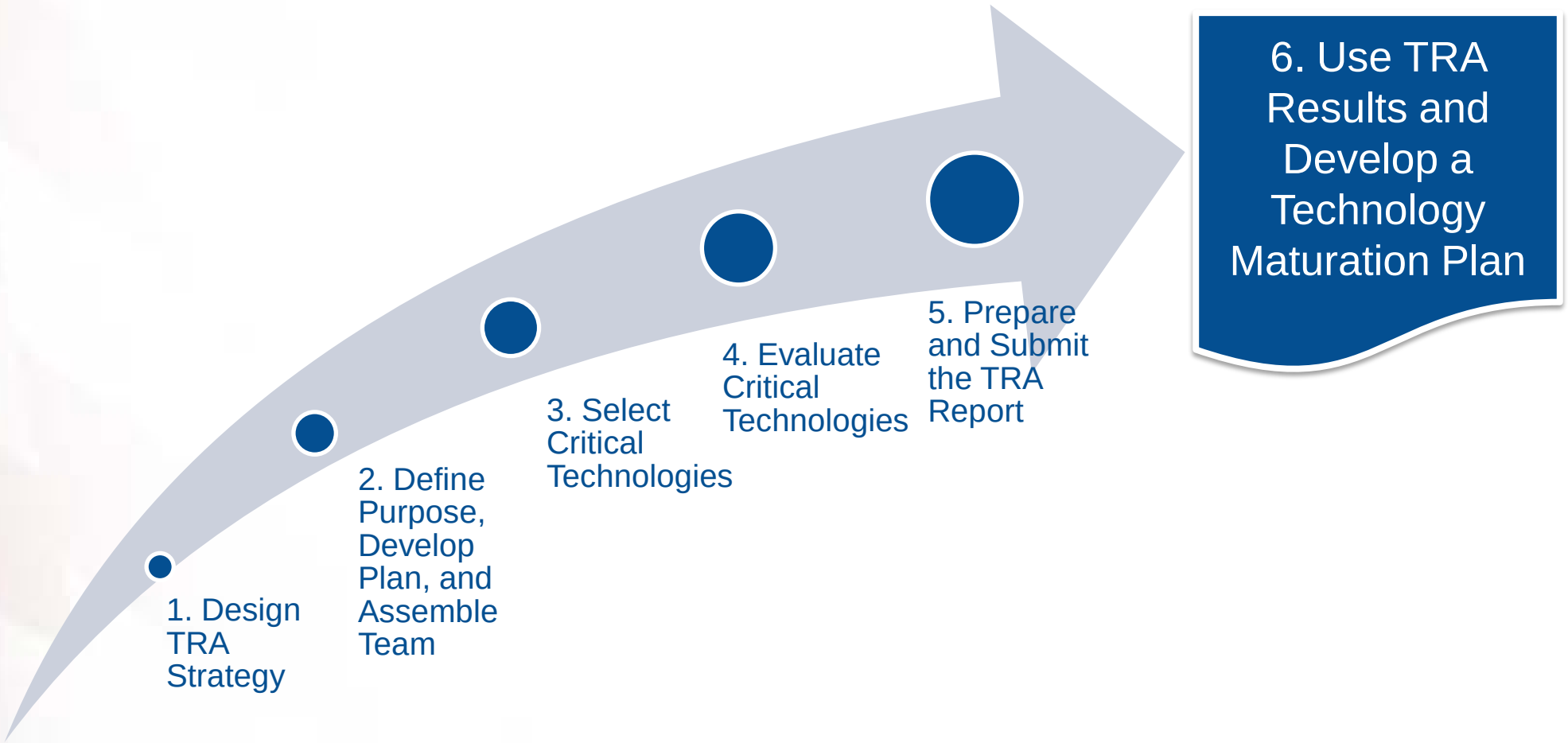
Technology readiness level (TRL)	Description
1 Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples include paper studies of a technology's basic properties.
2 Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic 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 the 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 they will work together. This is relatively low fidelity compared with the eventual system. Examples include integration of ad hoc hardware in the laboratory.
5 Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so they 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 that of TRL 5, is tested in its relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in a simulated operational environment.
7 System prototype demonstration in an operational environment	Prototype near or at planned operational system. Represents a major step up from TRL 6 by requirement demonstration of an actual system prototype in an operational environment (e.g., in an aircraft, a vehicle, or space).
8 Actual system completed and 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 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. Examples include using the system under operational mission conditions.

Source: GAO simplification of agency documents. | GAO-16-410G

Four Characteristics of a High Quality TRA

- **Credible** - Assessment design, execution, and reporting activity reflects understanding of requirements, critical technologies, relevant or operational environments; assessment team has right knowledge and expertise
- **Objective** - Assessment is based on objective, relevant and trustworthy data, analysis, and information; free from internal and external organizational bias or influence
- **Reliable** - Uses disciplined processes that facilitate repeatability, consistency, and regularity
- **Useful** – Stakeholders understand information; it has sufficient detail and is timely and can be acted upon

Six Steps to Develop a High Quality TRA



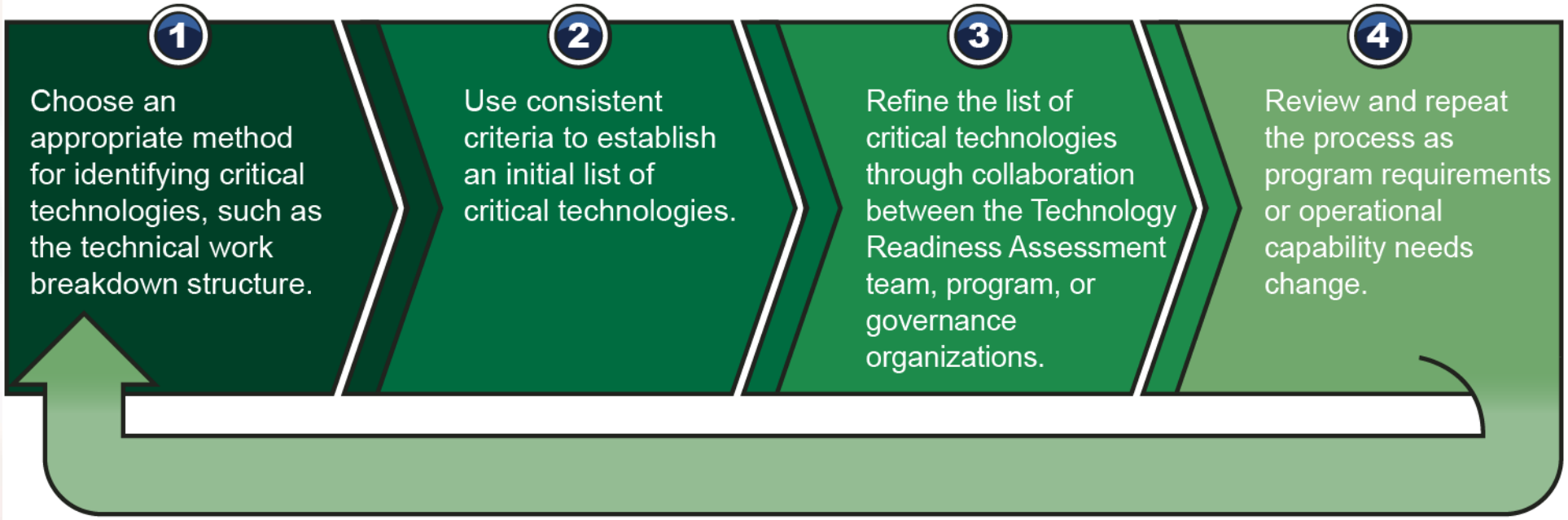
Six Steps to Develop a High Quality TRA

Develop TRA Strategy for Project	• Determine technology needs of a program and match up with assessment strategy • Document schedule for conducting assessments • Align assessment strategy to systems engineering management plan
Define Purpose, Develop Plan, and Assemble Team	• Determine purpose, level of detail, scope, TRL definition • Develop schedule and events • Determine specific team members and needed expertise • Outline the approach • Identify a plan for handling dissenting views
Select Critical Technologies	• Identify purpose, system, and performance characteristics in a technology baseline document • Use a Work Breakdown Structure that characterizes the system to select critical technologies • Use key questions and environment to determine if a technology is critical

Six Steps to Develop a High Quality TRA

Evaluate Critical Technologies	• Determine TRL definitions and required evidence prior to assessment • Determine acceptability of test articles and environments • Determine if testing results are sufficient and acceptable • Document all relevant information
Prepare and Submit the TRA Report	• Prepare an official report that documents actions from previous steps • Obtain report comments and explain dissenting views
Use TRA Results and Develop a Technology Maturation Plan	• Use TRA results to make decisions about the program's development priorities • Program management identifies TRA-related concerns and risks, including potential effects on cost and schedule estimates • Develop a technology maturation plan to track progress

Step 3: Select Critical Technologies



Source: GAO analysis and subject matter expert input. | GAO-16-410G

Best Practice Checklist: Selecting Critical Technologies

- A rigorous, objective, reliable, and documented approach, based on the WBS or other key program documents was used to initially identify critical technology candidates.
- The intended operational environment was considered, including potential adverse interactions with systems which the technology being developed must interface.
- A relevant environment was derived for each critical technology from those aspects of the operational environment that is determined to be a risk for the successful operation of that technology.
- Critical technologies were initially selected following a reliable process that is disciplined and repeatable with defined criteria using increasingly platform- or program-specific questions and requirements.
- Critical technologies were defined at a level that is testable, which could include the software needed to demonstrate their functionality.
- The assessment team documented the reasons why technologies were selected as critical, including reasons why other technologies were not selected.
- The number of critical technologies chosen for assessment was not arbitrary but was based on solid analysis using the WBS, process flows, or other technical documentation.
- When significant program changes occurred, critical technologies were reassessed possibly causing some to be added or removed from the list of critical technologies.
- Subject matter experts with appropriate and diverse knowledge selected and reviewed the critical technologies.

Uranium Processing Facility: Background

- The National Nuclear Security Administration (NNSA) conducts enriched uranium activities—including producing components for nuclear warheads and processing nuclear fuel for the U.S. Navy—at the Y-12 National Security Complex in Tennessee.
- NNSA has identified key shortcomings in the Y-12 plant's current uranium operations, including rising costs due to the facility's age. In 2004, NNSA decided to build a more modern facility—the UPF—which will use nine new technologies that may make enriched uranium activities safer and more efficient.

Uranium Processing Facility: Findings

New technology	Description	May 2013 TRL assigned by UPF contractor	August 2013 TRL assigned by UPF independent peer review report
Phase I			
Microwave casting	A process that uses microwave energy to melt and cast uranium metal into various shapes	6	Less than 6[a]
Special casting	A custom process for casting uranium into various shapes	3	3
Bulk metal oxidation	A process that converts bulk uranium metal to oxide	7	7
Uranyl nitrate hexahydrate (UNH) calcination	A process that converts impure solutions into a stable, storable condition	5	5[b]
Saltless direct oxide reduction[c]	A process that converts uranium dioxide into metal	6	4 or 5
Recovery extraction centrifugal contactors	A process that uses solvent to extract uranium for purposes of purification	7	Not above 6[d]
Phase II			
Agile machining	A system that combines multiple machining operations—for fabricating metal into various shapes—into a single process	5	4
Chip management	An automated process that reduces operator interactions with machining process and improves worker safety by minimizing exposure to radioactive metal chips. It is one of the multiple operations to be performed through agile machining	6	5
Alternate processing of pins	A process to form uranium metal into custom shapes	7	6

Uranium Processing Facility: Key Recommendations

- DOE should fully adhere to best practices in its technology development activities by achieving a TRL 7 – the level where a prototype is demonstrated in an operational environment, has been integrated with other key supporting subsystems, and is expected to only have minor design changes – at the start of construction.
- NNSA's oversight of technology development efforts should continue to include independent peer review to help identify and respond to some technology development issues.

Conclusions

- The GAO Cost Guide, Schedule Guide, and TRA Guide can provide criteria to evaluate many types of large technology-oriented and/or capital acquisition projects.
- Risk assessments such as technology readiness assessments, and independent cost and schedule assessments are often not performed – or are incomplete or lacking in independence, resulting in significant program risk and cost overruns.
- GAO recommendations have been aimed at improving oversight to keep projects on cost and schedule and to risk manage critical technologies in complex acquisitions.
- Programs/projects which do follow the best practices tend to demonstrate greater success in terms of outcomes and resource utilization.

Future GAO Work on Manufacturing

- What defense manufacturing issues should GAO be examining?

GAO Points of Contact

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- GAO Products
  - www.gao.gov