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NAVAL AIR SYSTEMS COMMAND
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IN REPLY REFER TO

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NAVAIR INSTRUCTION 3910.1

From: Commander, Naval Air Systems Command

Subj: TECHNOLOGY READINESS ASSESSMENT PROCESS

Ref: (a) DoDD 5000.01 of 12 May 03
(b) DoDI 5000.02 of 8 Dec 08
(c) Defense Acquisition Guidebook of 8 Oct 04
(d) DoD Technology Readiness Assessment (TRA) Deskbook of Jul 09
(e) DoD Systems Engineering Plan Preparation Guide, Version 2.01 of Apr 08
(f) Section 2366a of Title 10, U.S. Code
(g) Section 2366b of Title 10, U.S. Code
(h) USD (AT&L) Memorandum, Prototyping and Competition of 19 Sep 07
(i) ASN (RDA) Memorandum, Prototyping and Competition of 27 Nov 07
(j) SECNAVINST 5000.2D of 16 Oct 08
(k) NAVAIRINST 4355.19D of 17 Apr 09
(l) NAVAIR TRA Chairman Designation Letter of 8 Jun 05
(m) ONR NAVAIR TRA Chairman Authorization Letter of 19 May 09

Encl: (1) Naval Air Systems Command (NAVAIR) Technology Readiness Assessment (TRA) Handbook, Version 1.0 of September 2009

1. Purpose. To outline the existing Naval Air Systems Command (NAVAIR) Technology Readiness Assessment (TRA) process, establish policy, and assign responsibilities for the planning, conduct and certification of TRAs for Acquisition Category (ACAT) I - IV programs aligned to NAVAIR.

a. The NAVAIR Systems Engineering Technical Review (SETR) Process was established by the NAVAIR Engineering community to provide a consistent, rigorous, and disciplined process for all NAVAIR acquisition programs (Major Defense Acquisition Programs (MDAPS) and non-MDAPS)), in support of the Milestone Decision Authority's (MDA)decision process. The SETR Process and the

TRA Process are complementary. The NAVAIR TRA Process was established by the NAVAIR Engineering community to also provide a consistent, rigorous and disciplined process for all NAVAIR acquisition programs (MDAPS and non-MDAPS), in support of the MDA's decision process.

b. The purpose of this TRA Process Instruction is to document the existing successful TRA Process and to disseminate enclosure (1) throughout the NAVAIR Community as guidance.

2. Scope and Applicability. This instruction applies to personnel supporting NAVAIR and Aviation Program Executive Officer (PEO) programs, and business units involved with the design, development, test and evaluation, and acquisition of Naval Aviation weapon systems and equipment.

a. This instruction applies to all Department of the Navy (DON) aviation ACAT designated programs under the cognizance of NAVAIR, the Marine Corps and affiliated PEOs.

b. TRA Definition. A TRA is a formal, systematic, metrics-based process and accompanying report that assesses the maturity of technologies called Critical Technology Elements (CTEs) to be used in systems. The CTEs can be hardware or software. An Independent Review Team (IRT) of subject matter experts (SMEs) uses Technology Readiness Levels (TRLs) as metrics to assess CTE maturity.

c. Terminology. Two terms, namely, TRA and Technology Maturity Assessment (TMA), when used in this instruction, signify the same rigorous and disciplined process, with the distinction that a TRA is in response to a regulatory requirement and a TMA is in response to a non-regulatory requirement.

3. Background. The 2003 version of Department of Defense Instruction (DoDI) 5000.02 established a regulatory requirement to conduct TRAs on MDAP programs, and subsequently the National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2006 established a statute for MDAPs that requires all immature technologies to be demonstrated in a relevant environment before Milestone (MS) B approval. Also in 2003, the Secretary of the Navy (SECNAV) made it regulatory to conduct TRAs on all Naval

Acquisition programs both MDAP and non-MDAP, applying the statutory requirement only to MDAPs.

a. In response, the Defense Acquisition Guidebook (DAG) included procedures for conducting a TRA and the Department of Defense (DoD) generated a TRA Deskbook, both as guidance for conducting TRAs. The DoD TRA Deskbook is generic in nature and applies to all the Services.

b. In response, in 2005 NAVAIR's Engineering Community, by letter of designation, established a single point of contact at NAVAIR for all programs to conduct TRAs. The designated NAVAIR TRA Chairman established a tailored NAVAIR-specific TRA Process based on the DoD TRA Deskbook as guidance. The established tailored NAVAIR-specific TRA Process has been very successful since its inception and endorsed by the Chief of Naval Research (CNR), the Assistant Secretary of the Navy (ASN) and the Office of the Secretary of Defense (OSD) as an example for all the Services.

4. Discussion. References (a) through (h) provide related policies, regulatory and statutory requirements, principles, and best practices applicable to all DoD acquisition programs. References (h) through (k) provide detailed NAVAIR process implementation and clarification consistent with DoD and Navy guidance for acquisition programs.

a. Specifically, reference (a) addresses an acquisition system emphasizing a central theme of employing mature technology. Reference (b) established the requirement for all acquisition programs to conduct TRAs, and states the purpose of the Technology Development (TD) Phase MS A is to reduce technology risk, determine and mature the appropriate set of technologies to be integrated into a full system, and to demonstrate critical technology elements (CTEs) (immature technology) on prototypes, and includes the requirement that acquisition programs shall begin Engineering and Manufacturing Development (EMD) with mature technology. To do so, the program technical risk shall be reduced, and enabling technologies determined to contain CTEs shall have been demonstrated at a system/subsystem level in a relevant environment for MS B, or an operational environment for MS C, with non-CTE fallback options identified where possible, prior to program initiation. Reference (c) provides members of the acquisition community and

our Industry partners with an interactive, on-line reference to defense acquisition policy and discretionary best practice.

b. The Deputy Under Secretary of Defense for Science and Technology (DUSD(S&T)) addresses policy and guidance provided by references (a), (b) and (c) in the form of a TRA Deskbook reference (d) applicable to all the Services.

c. Reference (d) states, "DoDD 5000.01 authorizes the publication of DoDI 5000.02. Together, these documents provide management principles and mandatory policies and procedures for managing all acquisition programs. The DoDI 5000.02 establishes a regulatory requirement for TRAs. *All* Department of Defense (DoD) acquisition programs must prepare a TRA at Milestone B and at Milestone C of the Defense Acquisition System. The TRA complements--but does not in any way preclude--the PM's responsibility to pursue all risk reduction efforts needed to ensure that adequate technological maturity is reached before Milestone B approval is sought. As an activity separate from the formal TRA, an early evaluation of technology maturity conducted shortly before Milestone A should be used to support the development of the Technology Development Strategy (TDS)."

d. Reference (e) addresses the need to discuss the relationship between the Systems Engineering Plan (SEP) and the documents developed during the TD phase, including the funding profile; draft Acquisition Strategy (AS); System Threat Assessment (STA); Preferred System Concept (PSC); draft TRA; draft Programmatic Environmental, Safety and Occupational Health (ESOH) Evaluation (PESHE); draft Information Support Plan (ISP); Initial Capabilities Document (ICD) and draft Capability Development Document (CDD); draft Program Protection Plan (PPP); Risk Management Plan (RMP); Technology Development Strategy (TDS); draft Integrated Master Plan (IMP) and Integrated Master Schedule (IMS); and the Test and Evaluation Strategy (TES).

e. Reference (f) Title 10 United States Code (U.S.C.) 2366a, states MDAPs may not receive MS B approval until the MDA can certify that all CTEs have been demonstrated in a relevant environment, technology readiness level (TRL) 6. Amended Title 10 U.S.C. 2366a addresses Changes to MS Certifications & the MDA's authority to withdraw or rescind MS B approval. Amended Title 10 U.S.C. 2366a also addresses the Review of Systemic Deficiencies on MDAPs and the need for the Under Secretary of

Defense for Acquisition, Technology, and Logistics (USD (AT&L)) to conduct an Annual Review for each FY in which three or more MDAPs experience a critical cost growth threshold break, have a certification withdrawn, or have a MS A approval rescinded by the MDA. Reference (g), Title 10 U.S.C. 2366b, addresses the requirement for MDAPs to receive certification before MS A or Key Decision Point A approval.

f. References (h) and (i) provide additional statutory and regulatory requirements for MDAPs to enter and conduct a TD phase where competitive prototyping of critical technologies occurs.

g. Reference (j) approved the Two-Pass/Six-Gate Process with phased development of a System Design Specification (SDS). This reference also established the requirement for Navy acquisition programs (All ACATs: I, II, III, and IV) to conduct TRAs, and reference (k) describes the NAVAIR SETR process, which addresses the timing of the TRA process in relation to other technical reviews. Reference (l) designated the NAVAIR TRA Chairman as the single focal point for all NAVAIR TRAs. Reference (m) recognizes the NAVAIR TRA Chairman "as having the authority to speak on behalf of the Science and Technology (S&T) Executive concerning the TRA process, training, and proper implementation in support of DoD and DON required TRA regulations and statutes". He is further "acknowledged by the Office of Naval Research (ONR) as a leader for the DON in the avocation and the implementation of proven TRA best practices".

h. Enclosure (1), The NAVAIR TRA Handbook, provides TRA processes for use in support of the acquisition of NAVAIR systems and products.

i. Figure 1 is a pictorial representation of the documents referenced above and the flow of authority.

j. The following table depicts review and approval authority as a function of MDAP and Non-MDAP.

Figure 1. Reference Documents

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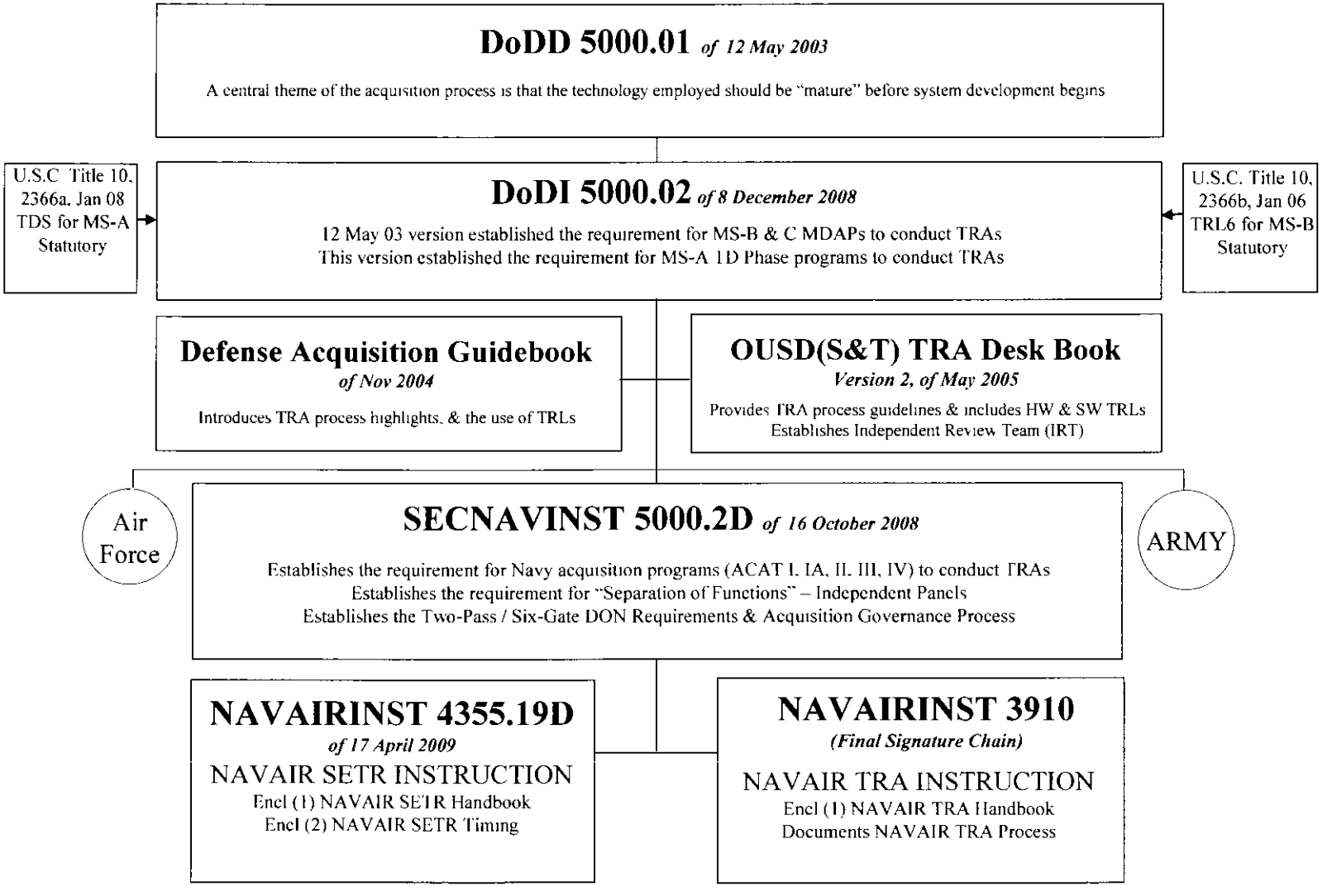

CATEGORY	MDAP		NON-MDAP	
ACAT	ID & IAM	IC	II	III, IV, IVM
MDA	DUSD (AT&L)	ASN (RDA)		PEO
NAVAIR TRA Chairman	TRA Report Signature	TRA Report Signature	TRA Report Signature	TRA Report Signature /Approval*
(CNR)	Signature/ Approval	Signature/ Approval	Signature/ Approval	
TRA SCHEDULE	10-14 months	7-10 months		4-6 months
MILESTONE A	Recommended TD TMA			
MILESTONE B	Regulatory TRA Statutory TRL 6 or better		Regulatory TRA Target TRL 6 or better	
MILESTONE C	Regulatory TRA Target TRL 7 or better		Regulatory TRA Target TRL 7 or better	

Table 1. Review and Approval vs. MDAP and Non-MDAP

5. Overall Acquisition Process. Reference (j) states, "Program Executive Officer (PEOs), Systems Command (SYSCOM) Commanders, Direct Reporting Program Managers (DRPMs), and Program Managers (PMs) shall ensure separation of functions so the authority to conduct oversight, source selection, contract negotiations/award does not reside in one person. As stewards of the national interest, all DON employees have an obligation to accept responsibility for ensuring the highest ethical conduct and shall question any perceived impropriety. These high ideals shall be continually emphasized to industry partners and within the acquisition community." The NAVAIR TRA Process as it exists today, and as defined in this instruction, "ensures separation of functions" by convening an independent review panel (IRP) of technical experts, independent from the program office and the program, to participate in the TMAs and TRAs and to render an objective unbiased assessment of the CTEs and their associated TRLs.

* NAVAIR Best Practice

6. Policy

a. Regulatory and Non-regulatory. To distinguish the regulatory requirement (MS A, MS B and MS C) from the non-regulatory requirement the NAVAIR Process utilizes the terms TRA and TMA, respectively.

b. The MDAP and non-MDAPs shall examine their technology needs and ensure that developmental efforts support the TRA process described herein. Programs shall ensure that planning for TRAs is fully integrated with the overall program plan for PEO and NAVAIR managed ACAT I through IV acquisition programs. TRA plans are further described in the program's SEP in accordance with reference (e).

c. For MDAPs (and non-MDAPs that are being conducted in accordance with "NAVAIR Best Practices"), TRAs and TMAs shall be accomplished in accordance with (IAW) enclosure (1) via an independent multi-discipline assessment of the program's enabling technologies and associated CTEs to determine technology maturity using the TRL index.

d. The ONR Point of Contact. The NAVAIR Chairman is the entry point for TRA coordination with the ONR.

e. The TRA Tailoring. The TRA process may be tailored to suit individual program scope and complexity as defined in the program SEP. Tailoring of the TRA process should be coordinated with the NAVAIR TRA Chairman in advance of SEP approval.

f. Technology Maturation Plans. As a "NAVAIR Best Practice", NAVAIR's existing TRA Process includes naval aviation acquisition programs, via the PM/Integrated Product Team (IPT)/Contractor, developing a Technology Maturation Plan (TMP) for each identified CTE. Reference (d) contains format and content for the TMP. The TMPs should be referenced within the SEP and coordinated with the NAVAIR Chairman or designee. An approved TMP provides a link between early technology assessments, system development planning and the TRA.

g. The Post MS A TRA. In accordance with reference (b) and this instruction, it is now a requirement that one or more TMAs be performed early in the formative stage of a program. The TD TMA can assist programs in identifying key or enabling

technologies and CTEs to be prototyped during TD, prior to preliminary design review (PDR).

h. Enclosure (1), The NAVAIR TRA Handbook, describes the procedures of the NAVAIR TRA Process and provides additional information concerning implementation of this instruction.

i. The TRA Participants. Independent technical area experts (TAEs) or subject matter experts (SMEs), together with government and contractor program IPT members, shall participate in the TRAs as coordinated with the TRA Chairman. Customer representatives and other stakeholders may be invited to provide the Warfighter's perspective with a clear linkage to their technical requirements.

j. The TRA Results Feed the Program Risk Process. Programs shall ensure TRA MS A, MS B, & MS C results are included in program risk assessments and are integrated into the program's risk process. The TRA process is not a risk assessment, but CTE maturity identified as a result of the TRA process is an element that the program should track within the risk management process. The TRA process does not assess the viability of system designs to achieve performance, cost or schedule, such as a risk assessment would, and therefore differs from the typical objectives or criteria associated with system design reviews.

k. Acquisition program plans such as a TDS and contract language shall support the conduct of TRAs as part of the acquisition process. TRAs do not:

(1) Constitute government approval of the design;

(2) Change the responsibility as set forth in the contract(s);

(3) Change or affect ownership of the design; or,

(4) Relieve the contractor from meeting specification requirements as set forth in the contract(s).

l. Availability of Data. The TRA process depends on the IPT and/or contractor/manufacturer to provide detailed quantitative technical information. Programs shall ensure technical information is available to support conduct of the

TRA. Enclosure (1) provides samples of the type of information typically required.

m. The TRA Results. The results of the TRA shall be summarized in a formal letter issued by the NAVAIR TRA Chairman. If security allows, a copy is provided for inclusion in the SETR archival database. "NAVAIR Best Practice", ensures TMPs are generated for each identified CTE with a copy provided to the TRA Chairman for submission with the TRA report. Post TRA TMP updates will be provided to the TRA Chairman when established. Only the TRA Chairman and independent panel can validate CTE TRL progression per TMP. All TRA documentation, with the exception of data requiring special security controls, shall be maintained and controlled in the TRA Chairman's Office database.

n. Conduct of the TRA. The NAVAIR TRA Chairman shall lead the TRA working closely with the ONR TRA Coordinator (TRAC). The NAVAIR TRA is conducted and approved by the NAVAIR TRA Chairman with concurrence from the ONR TRAC and the appointed TRA Panel Members. The TRA is conducted via a row by row review of each and every item listed on the technical work breakdown structure (TWBS). A consensus is arrived at identifying the CTEs and subsequently a TRL is assessed for each identified CTE. The TRA shall be formally completed by the TRA Chairman via a letter of closure. The TRA formal approval and endorsement staffing chain is dependent upon the ACAT level, as illustrated in the table below.

ACAT	MDA	Staffing Chain to MDA
ID and IAM	DUSD (AT&L)	• NAVAIR TRA Chairman • CNR • Deputy Assistant Secretary of the Navy (DASN) ~ Platform Specific (e.g., DASN(Air)) • DUSD(S&T)/Director, Defense Research & Engineering (DDR&E)
IC and II	ASN (RDA)	• NAVAIR TRA Chairman • CNR • DASN (Platform Specific) (e.g., DASN(Air))
III, IV	PEO/PM	• NAVAIR TRA Chairman ("NAVAIR Best Practice")

Table 2. Approval and Endorsement Staffing Chain

o. The MDA Tailoring. The NAVAIR TRA Process, as defined in this document and acknowledged by ASN(RDA) Chief Engineer (CHENG), stipulates that the TRA will be conducted via the NAVAIR TRA Chairman using an IRP for all ACAT level programs. DoDI 5000.02 "authorizes MDAs to tailor the regulatory information requirements and acquisition process procedures within DoDI 5000.02 to achieve cost, schedule and performance goals." The DoD TRA Deskbook which is linked to DoDI 5000.02 stipulates that "official" CTEs can only be identified by an IRP. At any time during the acquisition process, the S&T Principal Investigator (PI) or the PM can identify "preliminary" or "potential" CTEs to be validated by the IRP using the NAVAIR TRA process.

p. Joint Programs. In the case of Navy acquisition led Joint Programs, only one TRA is conducted, reviewed and approved by one Service S&T Executive. A recommended "Best Practice" to minimize staffing time for the TRA report is for the multiple Services to establish a Memorandum of Agreement (MOA) up-front. The MOA shall (when Navy is the executive agent) establish the NAVAIR Chairman, ONR, and ASN (RDA) as the responsible agent and approval chain (dependent upon ACAT level involved).

7. Action. The following responsibilities are assigned relative to the planning, conduct, and reporting of TRAs.

a. The PM is responsible for ensuring that program plans address the maturity of technology IAW statutory and regulatory direction as identified in referenced documents. The PM shall plan, program, budget, and fund the costs associated with identification of CTEs, execution of TMPs and conduct of required TRA events.

b. The NAVAIR TRA Chairman was appointed by reference (1). The NAVAIR TRA Chairman, or designated delegate, shall convene the TRA IRP. An integrated team participates in the TRAs consisting of the TRA core team members, IPT members, and independent Competency (internal) and independent external TAEs at the discretion of the TRA Chairman. The TRA Panel assesses the material presented to identify CTEs and to determine the TRLs for identified CTEs. The TRA Chairman is responsible for the final TRA Report, briefing the results, and obtaining final approval signatures.

c. The AIR-4.0 Competencies provide independent TAEs with acknowledged credentials, as required, to participate in the TRA process as a TRA independent panel member. These TAEs are independent from the program and provide expert technical assessments of the system technical baseline as to technology maturity and readiness. These TAEs must be Senior Engineers/Fellows with solid technical knowledge, experience, credentials, and acknowledgments relative to the critical technologies identified for each program.

d. Integrated Systems Evaluation Experimentation and Test Division Heads/Squadron Commanding Officers (AIR-5.0) provide independent TAEs with acknowledged credentials, as required, to participate in the TRA process as a TRA IRP member. These TAEs are independent from the program and provide expert technical assessments of the system technical baseline as to technology maturity and readiness. These TAEs must be Senior Engineers/Fellows with solid technical knowledge, experience, credentials, and acknowledgments. Reference (b) states that the Test and Evaluation Strategy document shall address Technology Development phase activity to include early demonstration of technologies in relevant environments. As such, the 5.0 TAE shall be the responsible TRA IRP member to validate that the "relevant environment" was appropriate for the respective CTE demonstration. The Test and Evaluation (T&E) methodology used to validate system performance should be considered to ensure no novel T&E process or technology is required. If new T&E technology is required, then it should be nominated as a CTE. However, it should be understood that the TRA is only assessing technology.

e. Logistics and Industrial Operations (AIR-6.0) provide independent TAEs with acknowledged credentials, as required, to participate in the TRA process as a TRA IRP member. These TAEs are independent from the program and provide expert technical assessments of the system technical baseline as to technology maturity and readiness. These TAEs must be Senior Logisticians with solid technical knowledge, experience, credentials, and acknowledgments.

f. Program IPT leads ensure program acquisition plans, strategies, resources, and budget are provided for the conduct of TRAs and that those assessments and any associated TMPs are available to inform the milestone decision-making process.

g. Program Assistant Program Manager for Systems and Engineering (APMSE):

(1) Coordinate across IPTs to ensure technology development activities are integrated with program cost and schedule plans. Ensure program documentation addresses identification of CTEs and technology maturation planning necessary to support conduct of technology assessments.

(2) Ensure in the development of the SEP, that technology maturity and TRAs are adequately addressed in that plan; and,

(3) Ensure the program contract; Statement of Work (SOW), Contract Data Requirements List (CDRL), and master schedule include provisions for TRAs and the documentation /data to support them.

(4) As a best practice and risk mitigation tool, coordinate with the TRA Chairman to conduct a TMA for Abbreviated Acquisition Programs (AAPs), Engineering Change proposals (ECPs) and other non-ACAT programs that develop or integrate new or novel technologies. The TMA is a streamlined TRA that applies the same rigor and discipline but is not mandated by a regulatory requirement. The TMA will be tailored based on program mitigation goals, available timeline, and budget. Its purpose is to identify and/or validate CTEs and maturation plans to mitigate program risk as part of a balanced systems engineering approach.

(5) Develop, coordinate, and execute, individual TRA arrangements in cooperation with the performing activity.

8. Review. This instruction will be reviewed by The NAVAIR TRA Chairman (AIR-4.0) annually and provide recommendations or cancellation to the Commander.

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NAVAIR

NAVAL AIR SYSTEMS COMMAND (NAVAIR)

Technology Readiness Assessment (TRA) Handbook

Version 1.0

September 2009

Prepared by the
Independent Technical Review Office
(ITRO)

This version of the TRA Handbook accounts for policy and guidance provided by Directive DoDD 5000.01 of 12 May 03; Instruction DoDI 5000.02 of 8 Dec 08; the Defense Acquisition Guidebook of Oct 04; and DoD TRA Best Practices.

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The NAVAIR TRA Handbook

1. Background. The National Aeronautics and Space Administration (NASA) first established the use of TRLs in the late 1980's, and initially TRLs were applied to Program Reviews. The actual number of TRL definitions evolved from the original seven levels to today's nine levels.

a. The DoD TRLs. The DoD adopted the use of TRLs for new Major programs in 2001 per a Deputy Under Secretary of Defense for Science and Technology/Director, Defense Research and Engineering (DUSD(S&T/DDR&E)) Memorandum, which was in response to a Government Accounting Office (GAO) report/recommendation to assess technology maturity prior to technology transition. The DoD established nine TRL levels modeled from the original NASA index. The DoD's TRL definitions are similar to, but different from NASA. The DoD's initial TRA guidance was published in 2003 in the form of a DoD TRA Deskbook. The TRA Deskbook established both System/HW TRLs and SW TRLs. The Deskbook is available at http://www.defenselink.mil/ddre/doc/tra_deskbook_2009.pdf.

b. Relevance. The DoD has referenced the importance of technology maturity in DoDD 5000.01, DoDI 5000.02, the DAG, and the DoD TRA Deskbook.

c. Why TRAs? The need for TRAs resulted from the statistics identified in the aforementioned GAO Report which cited the fact that most programs proceed with low levels of knowledge resulting in cost and schedule increases. In an annual review of 54 DoD programs they found that only 15% began System Development and Demonstration (SDD), now EMD with mature technology. Programs that started with mature technology averaged a 9% cost growth and a 7 month schedule delay and programs that did not have mature technologies averaged a 41% cost growth and 13 month schedule delay.

d. The NAVAIR TRA Process. The guidance offered via the existing tailored NAVAIR TRA Process, documented in this Handbook, is consistent with the guidance contained within the DoDI 5000.02, SECNAVINST 5000.2D, the DAG, and the DoD TRA Deskbook.

2. Purpose. The purpose of the TRA is to provide the information required by the Milestone Decision Authority (MDA) to enable execution of Title 10 responsibilities.

3. What is a TRA? A TRA is a formal, systematic, metrics based process and accompanying report that assesses the maturity of critical hardware, software, manufacturing, or life-cycle related technologies to be used in systems. It is conducted by an IRP of SMEs.

a. A TRA is regulatory for MS B, and MS C and is only conducted on the actual proposed threshold compliant design(s). However, as an activity separate from the formal TRA, an early evaluation of technology maturity conducted shortly before Milestone A should be used to support the development of the Technology Development Strategy (TDS).

b. The TRA is a regulatory requirement and applicable to all ACAT programs (I, II, III, and IV) per SECNAVINST 5000.2D of 16 Oct 08. For all ACAT programs, the PM is responsible for ensuring that a TRA is conducted. The NAVAIR venue for accomplishing the conduct of the TRA is via the NAVAIR TRA Chairman. The CNR is responsible for concurrence and approval of the TRA conducted in support of ACAT I and II programs and the PM is responsible for concurrence and approval of the TRA conducted in support of ACAT III and IV programs. The NAVAIR TRA Chairman is the entry point for program coordination with the ONR.

4. What is a CTE? 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, novel, or in an area that poses a major risk in completing technology maturation development. This revised DoD TRA Deskbook CTE definition explicitly focuses on technology development risk. The intent of Title 10 U.S.C. 2366b is to substantively complete technology development prior to EMD.

a. MDAPs. For MDAPs, per the Title 10 U.S.C. 2366b statutory requirement, the MDA must certify that all CTEs have been demonstrated in a relevant environment (TRL 6) before MS B approval can be granted.

b. Non-MDAPs. For non-MDAPs, the Title 10 U.S.C. 2366b statute does not apply. However, NAVAIR's MDAs have, to date, adopted a "NAVAIR Best Practice" of applying the intent of the statute as a chinning bar for non-MDAPs.

c. The CTE Terminology. In order to uniquely associate technology maturity from that of other similar references to technology, the term "CTE" strictly and solely applies to immature technologies. If a program has no CTEs, the program is, by definition, based solely on mature technologies.

d. A CTE Vice Standard Engineering Practice. It is important to ensure that the definition of a CTE is delineated clearly from that of standard engineering development practice. It is expected that during EMD technical challenges will arise typical to engineering development. When determining CTEs, especially at the stage approaching MS C, it is important to separate typical engineering challenges associated with integration into a platform with that which might be a technology limitation or barrier (i.e., CTE). If funding, time, and/or resources can be applied to resolve the problem, within the constraints of the official program of record, then the issue is likely a typical EMD challenge, and not a potential CTE.

e. Embedded Guidance. Extensive guidance for determining CTEs is embedded in the TRA CTE TWBS template provided to the IPT by the NAVAIR TRA Chairman's Office. The TRA CTE TWBS is a technical vice Contractual WBS (CWBS) containing levels of indenture for the various systems, subsystems and components, down to the lowest level that may contain a CTE.

f. Other Considerations. Manufacturing, Supportability, and T&E should also be considered to ensure no novel process or tooling is required to meet threshold expectations and therefore qualify as a CTE. It should be understood that the TRA is only assessing technology and is not the same as a Manufacturing Readiness Assessment (MRA) or Production Readiness Review (PRR). On the other hand, the TRA outcome may indeed feed MRA and PRR objectives.

g. Software Related Hardware. Software Engineering Environment (SEE) automated tools, model-based design environment, firmware devices, and hardware necessary to perform

software development will be assessed using DoD System/HW TRL definitions.

h. Software CTE Candidates. Any item that qualifies as a limiting technology, such that proposed software development rates are adversely impacted, or an item is considered new and implementing a non-standard approach, then that item is usually a CTE candidate.

i. Tools. Automated tools to consider may include, but not be limited to, model-based design tools including traceability databases, auto-coders, model checkers, automatic test vector generators, coverage verifiers, property proving tools, computer-aided software engineering tools, editors, compilers, assemblers, linkers, loaders, operating system, debuggers, simulators, emulators, and test tools.

j. Software. Computer software identified as dealing with new or novel air system, weapon system, sub-system, automatic test equipment, trainer, and/or mission planning applications, as well as new or novel algorithms or application of algorithms necessary to meet operational performance requirements will be assessed using the DoD software (SW) TRLs.

k. Software TRLs. The DoD SW TRLs typically are used to assess maturity of algorithms that apply such elements as mathematics, behavior models, or the like, that opens new improved frontiers to achieve novel system requirements. (Potential examples include: command and control, communications, target detection and tracking, automatic target recognition, navigation, flight control, fuel control, resource management, fusion, diagnostics, prognostics, etc.).

5. How does the TRA Identify CTEs? The TRA performs a detailed assessment of technical maturity by examining a program's intended or proposed system, subsystem, component, and where applicable, low level devices, via a detailed TWBS. The TWBS is documented using a standardized EXCEL spreadsheet template as shown in Figure 1.

Figure 1. Sample TRA CTE Technical WBS (TWBS) Spreadsheet Template

TWBS GUIDANCE LINK		NAVAIR Technology Readiness Assessment (TRA) Technical Work Breakdown Structure (TWBS) for *fill in Program Name*												
TWBS #	TWBS LEVEL	TWBS TITLE	TWBS MAPPING	TWBS ITEM DESCRIPTION	NEW TECHNOLOGY	NEW TECHNOLOGY	NEW APPLICATION	COTS + / COTS	REPACKAGED COTS	MODIFIED COTS	CHANGE DESCRIPTION	RECOMMENDED	ENABLING TECHNOLOGY (Note: complete this column only if a CTE has been identified for the row.)	CTE JUSTIFICATION NARRATIVE
Link	Link	Link	Link	Link	Link	Link	Link	Link	Link	Link	Link	Link	Link	Link
Top Level Program Background Information													Picture 1 - Top Level System	
Top Level Operational Environment Description		Describe here the CONOPS & what constitutes a relevant environment for your system, and the operational environmental boundaries for your system.											Picture 2 - System/Subsystem Architecture	
1	1	AIRCRAFT SYSTEM	This is a Level 1 roll-up: The program of record & threshold compliant design for this AIRCRAFT SYSTEM includes the Air Vehicle System, the Avionics Systems, the Crew Systems, the Propulsion Systems and the Stores System.											
1.1	2	Air Vehicle System	Aircraft System	This is a Level 2 roll-up: The Air Vehicle System includes Material and Structures.										Picture
1.1.1	3	Material	Air Vehicle System	**Technology:** describing the technology, including identifying sub-elements of this WBS item. **Function:** describing the functionality & operational expectations of the technology. **Platform Location:** describing how this technology fits into the platform. **Requirement Reference:** Citing the requirement from applicable specifications, ORD/CDD, & CONOPS, where applicable. **KPP:** traced to this technology.	N	N	N	N	N	N	If the answer to the "Repackaged Technology" or "Modified COTS or GOTS" columns is "Yes", then provide a detailed description here of the extent of the repackaging, of the modification incurred, and/or the new or novel environment.	N	**Critical Components:** that may drive technology maturity. An enabling technology element is "critical" if the system being acquired depends on this immature technology element to meet operational requirements. **Fallback Technology:** that could be used in place of the proposed enabling technology & still achieve a performance threshold compliant design. **External Dependency:** upon another program or investment to achieve the enabling technology maturity.	**Heritage/Pedigree:** of the design/development approach (include dates). **Quantitative Evidence:** it has been demonstrated in the intended relevant environment (include quantities & dates). **Quantitative Testing History:** (include platforms, flight hrs., & dates). **COTS Supplier/Part #:** **Conclusion:** This item is not a CTE because ... OR This item is a CTE because ...
1.1.2	3	Structures	Air Vehicle System	**Technology:** describing the technology, including identifying sub-elements of this WBS item. **Function:** describing the functionality & operational expectations of the technology. **Platform Location:** describing how this technology fits into the platform. **Requirement Reference:** Citing the requirement from applicable specifications, ORD/CDD, & CONOPS, where applicable. **KPP:** traced to this technology.	N	N	N	N	N	N	If the answer to the "Repackaged Technology" or "Modified COTS or GOTS" columns is "Yes", then provide a detailed description here of the extent of the repackaging, of the modification incurred, and/or the new or novel environment.	N	**Critical Components:** that may drive technology maturity. An enabling technology element is "critical" if the system being acquired depends on this immature technology element to meet operational requirements. **Fallback Technology:** that could be used in place of the proposed enabling technology & still achieve a performance threshold compliant design. **External Dependency:** upon another program or investment to achieve the enabling technology maturity.	**Heritage/Pedigree:** of the design/development approach (include dates). **Quantitative Evidence:** it has been demonstrated in the intended relevant environment (include quantities & dates). **Quantitative Testing History:** (include platforms, flight hrs., & dates). **COTS Supplier/Part #:** **Conclusion:** This item is not a CTE because ... OR This item is a CTE because ...
1.2	2	Avionics Systems	Aircraft System	This is a Level 2 roll-up: The Avionics Systems includes the Sensor Systems, Controls & Displays, & Core Processing.										Picture
1.2.1	3	Sensor Systems	Avionics Systems	This is a Level 3 roll-up: The Sensor Systems consists of the Hardware and Software for each sensor.										Picture
1.2.1.1	4	Hardware	Sensor Systems	**Technology:** describing the technology, including identifying sub-elements of this WBS item. **Function:** describing the functionality & operational expectations of the technology. **Platform Location:** describing how this technology fits into the platform. **Requirement Reference:** Citing the requirement from applicable specifications, ORD/CDD, & CONOPS, where applicable. **KPP:** traced to this technology.	N	N	N	N	N	N	If the answer to the "Repackaged Technology" or "Modified COTS or GOTS" columns is "Yes", then provide a detailed description here of the extent of the repackaging, of the modification incurred, and/or the new or novel environment.	N	**Critical Components:** that may drive technology maturity. An enabling technology element is "critical" if the system being acquired depends on this immature technology element to meet operational requirements. **Fallback Technology:** that could be used in place of the proposed enabling technology & still achieve a performance threshold compliant design. **External Dependency:** upon another program or investment to achieve the enabling technology maturity.	**Heritage/Pedigree:** of the design/development approach (include dates). **Quantitative Evidence:** it has been demonstrated in the intended relevant environment (include quantities & dates). **Quantitative Testing History:** (include platforms, flight hrs., & dates). **COTS Supplier/Part #:** **Conclusion:** This item is not a CTE because ... OR This item is a CTE because ...

Sample

The template allows for a systematic decomposition of the system threshold compliant technical baseline to its lowest level of indenture appropriate to maturity of the design. In-depth technical dialog between the program's IPT/Contractor and the independent TRA Panel members ensures a comprehensive thorough unbiased assessment of technical maturity.

a. Populating the TWBS. Programs identify *preliminary* or *potential* CTEs prior to scheduling and conduct of the TRA. These preliminary or potential CTEs are identified as such by the IPT with corresponding rationale while in the process of populating the TRA CTE TWBS EXCEL spreadsheet. The proposed threshold compliant technical design is delineated by levels of indenture representing the overall System and its corresponding subsystems, components and in some cases even devices depending upon their respective levels of maturity. Items of the design are listed on each row with corresponding columns requesting a TWBS number; TWBS Level; TWBS Title; TWBS Mapping; TWBS Item Description; a yes or no for if the item is Novel Technology, New Technology, a New Application of the Technology, Commercial off the shelf (COTS) or Government off the shelf (GOTS), Repackaged Technology, or Modified COTS or GOTS; a Change Description column; a yes or no for if it is Recommended To Be a CTE; an Enabling Technology column, and CTE Justification Narrative. All inputs are provided with respect to the system's intended relevant environment. The TRA is conducted via a row by row review of each and every item listed on the TWBS. A consensus is arrived at by the independent TRA Panel Members, convened by the NAVAIR TRA Chairman, identifying the CTEs and subsequently a TRL is assessed for each identified CTE.

b. The TRA and Program Risk. The TRA is not a risk assessment, but a valuable tool and an input for assessing program risk and the adequacy of technology maturation planning.

c. The TRA will assess the current technical maturity of the CTEs using DoD defined system/HW and SW TRLs, as defined by the DoD TRA Deskbook. The TRLs are only assessed on associated identified CTEs, not on programs or capabilities.

d. Current Data/Demonstrations. The TRA process establishes a baseline reference by "drawing a line in the sand" on the day of the TRA Scoring Event (SE) by making an assessment of technology maturity for the CTEs based on satisfactory

completion of demonstrations at some elemental level of integration.

e. Technology Maturation Plans. As a "NAVAIR Best Practice" a TMP should be generated by the IPT/Contractor, for each CTE identified in order to explain in detail when and how the subsequent maturity levels (i.e., TRLs) will be achieved. The maturation plan identifies all demonstrations to be accomplished throughout EMD, and any external leverage along a timeline that would substantiate maturity level progression.

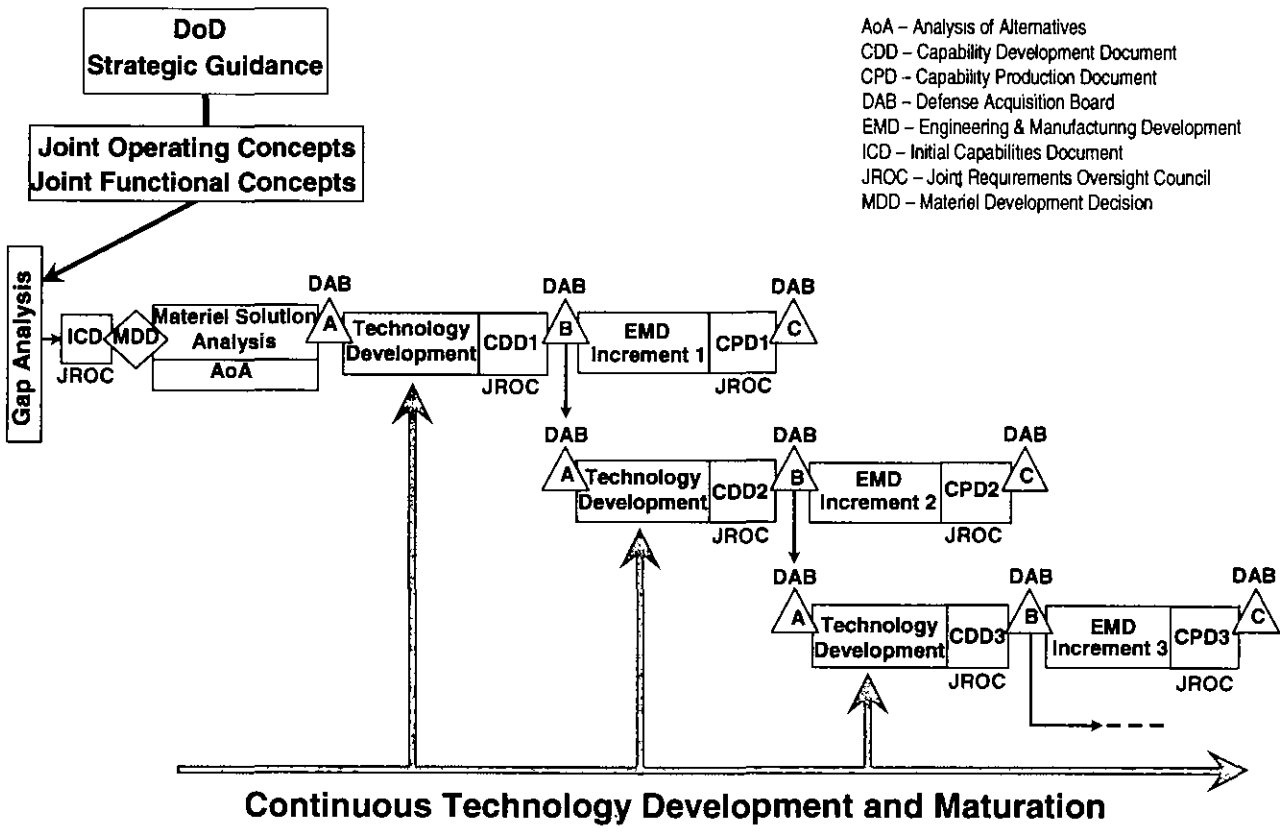
f. Watch Items. In addition to CTEs, the TRA also examines and, in some cases, discovers stressing technologies identified as "Watch Items" and other potential technology factors that require the Program Office's and TRA Chairman's continued attention. These "Watch Items" constitute technologies/technology areas that, depending on the actual design implementation realized, could become a CTE. All "Watch Items" should be included in the program risk management process.

6. Relationship to Acquisition Milestones

a. Evolutionary Acquisition. According to DoDI 5000.02, evolutionary acquisition is the preferred DoD strategy for rapid acquisition of mature technology for the user. An evolutionary approach delivers capability in increments, recognizing, up front, the need for future capability improvements. The objective is to balance needs and available capability with resources, and to put capability into the hands of the user quickly. The success of the strategy depends on a phased definition of capability needs and system requirements, and the maturation of technologies that lead to disciplined development and production of systems that provide increasing capability over time as shown in the figure below. Evolutionary acquisition requires collaboration among the user, tester, and developer. In this process, a needed operational capability is met over time by developing several increments, each dependent on available mature technology. The TD preceding initiation of an increment shall continue until the required level of maturity is achieved, and prototypes of the system or key system elements are produced. Successive TD Phases may be necessary to mature technology for multiple development increments. Each increment is a militarily useful and supportable operational capability

that can be developed, produced, deployed, and sustained. Each increment will have its own set of threshold and objective values set by the user. Block upgrades, pre-planned product improvement, and similar efforts that provide a significant increase in operational capability and meet an ACAT threshold shall be managed as separate increments.

Figure 2. Continuous Technology Development and Maturation



b. Technology Maturity. Technology maturity is a key attribute to consider during the formative stages of an ACAT program. Prior to MS A TD, enabling technologies and their associated preliminary or potential CTEs identified by the PM/Contractor/S&T PI provide the basis for a disciplined approach to measure and manage technology maturity. During TD and EMD, as a part of the overall systems engineering process, TRAs provide an independent (from the Program Office and the Program) assessment of enabling technologies and their associated official CTEs. The TRAs form the basis for establishing:

(1) CTEs;

(2) TRLs for CTEs;

(3) TMPs for CTEs; or,

(4) Certification in accordance with TRA related statutory and regulatory requirements.

c. Pre-MS A: Technology Projects. According to DoDI 5000.02, Joint Experimentation, Defense Advanced Research Projects Agency projects, the Technology Transition Incentive Program, Small Business Innovative Research (SBIR) and Small Business Technology Transfer Programs, the Joint Integration & Interoperability Program, Joint Capability Technology Demonstrations, the Coalition Warfare Program, the Quick Reaction Special Projects/Rapid Reaction Fund, Foreign Comparative Testing, the Defense Acquisition Challenge Program, the Joint Test & Evaluation Program, the Joint Improvised Explosive Devices Defeat Office, the Rapid Reaction Technologies Office, and Defense Biometrics are some of the activities that facilitate and provide early joint technology and capability definition, development, experimentation, refinement, testing, and transition. The USD (AT&L) shall be the MDA for those projects that, if successful, will likely result in an MDAP or Major Acquisition Information System (MAIS) program unless the USD (AT&L) delegates MDA for a MAIS program.

Upon PM request, the NAVAIR TRA Chairman will coordinate key IRP membership to review and comment on program TD Strategies and Pre-MS A Analysis of Alternatives (AoA) planning and results. In addition, CTE definition and maturation training can

be provided in support of Pre-MS A activity to programs upon request.

d. Pre-MS A: ICD. Representatives from multiple DoD communities shall assist in formulating broad, time-phased, operational goals, and describing requisite capabilities in the ICD document.

e. Pre-MS A: Materiel Development Decision (MDD). When the ICD demonstrates a need for a materiel solution, the DoD Component sponsor shall assess the potential level of investment and plan a MDD review with the appropriate decision authority. The Defense Acquisition Executive (DAE) or designee shall review potential ACAT I and ACAT IA materiel solutions; the Component Acquisition Executive (CAE) or the individual designated by the CAE shall review potential ACAT II and III materiel solutions. The MDA, working with appropriate stakeholders, shall determine whether there is sufficient information to proceed with a MDD. Promising technologies shall be identified from all sources domestic and foreign, including government laboratories and centers, academia, and the commercial sector.

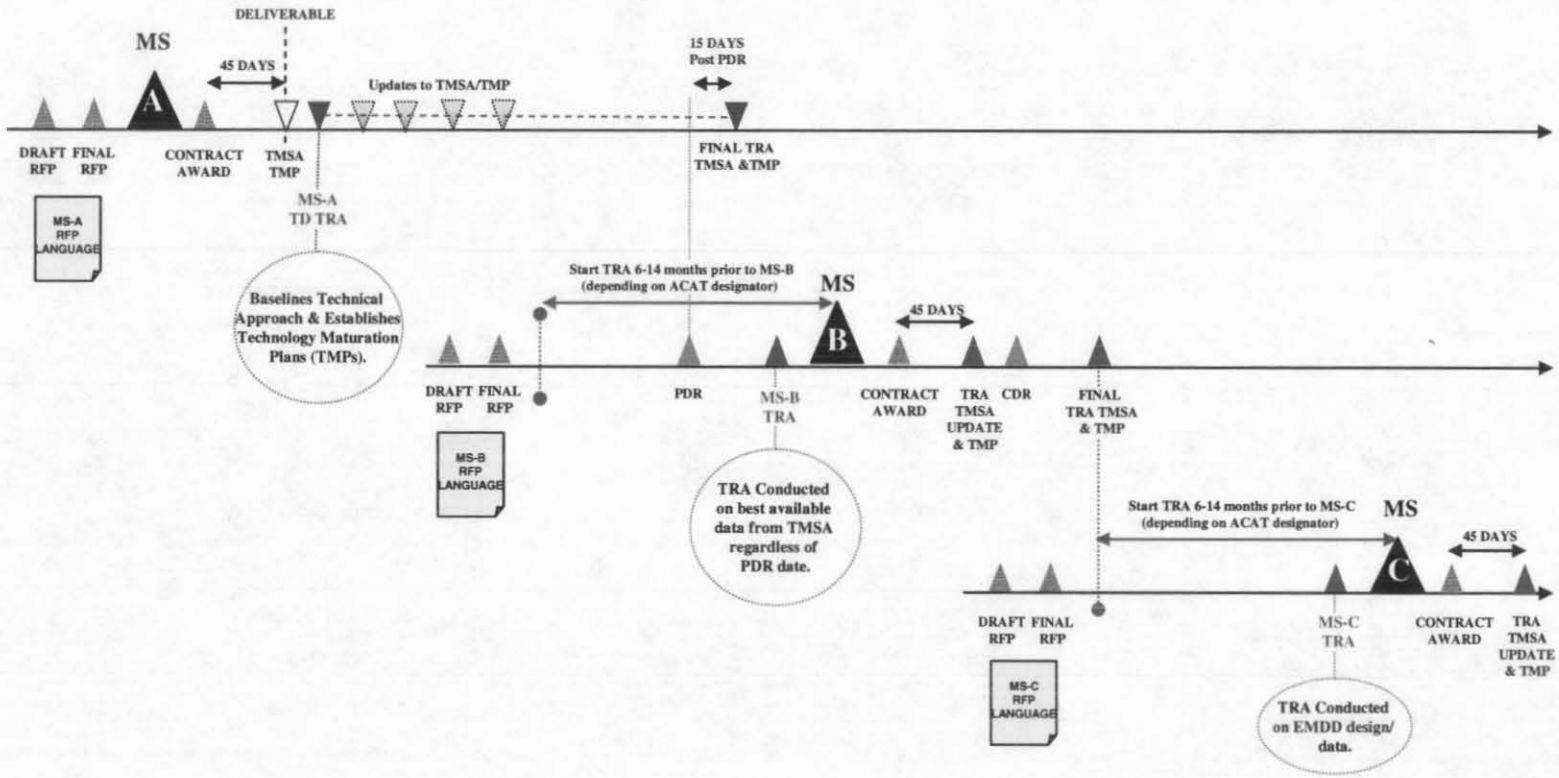
f. Pre-MS A: Materiel Solution Analysis (MSA). The purpose of this phase is to assess potential materiel solutions and to satisfy the phase-specific entrance criteria for the next program milestone designated by the MDA. Entrance into this phase depends upon an approved ICD resulting from the analysis of current mission performance and an analysis of potential concepts across the DoD Components, international systems from allies, and cooperative opportunities. The MSA Phase begins with the MDD review. The MDD review is the formal entry point into the acquisition process and mandatory for all programs. The MDA's decision to begin MSA DOES NOT mean that a new acquisition program has been initiated. Following approval of the study guidance, the lead DoD Component(s) shall prepare an AoA study plan to assess preliminary materiel solutions, identify key technologies, and estimate life-cycle costs. The purpose of the AoA is to assess the potential materiel solutions to satisfy the capability need documented in the approved ICD. The MSA Phase ends when the AoA has been completed, materiel solution options for the capability need identified in the approved ICD have been recommended by the lead DoD Component conducting the AoA, and the phase-specific entrance criteria for the initial review milestone have been satisfied.

g. Pre-MS A: Preliminary/Potential CTEs. The ICD and the AoA study guidance shall guide the AoA and MSA Phase activity. The AoA shall focus on identification and analysis of alternatives, measures of effectiveness, cost, schedule, concepts of operations, and overall risk. The AoA shall assess the critical technology elements (CTEs) associated with each proposed materiel solution, including technology maturity, integration risk, manufacturing feasibility, and, where necessary, technology maturation and demonstration needs. To achieve the best possible system solution, emphasis shall be placed on innovation and competition. Existing COTS functionality and solutions drawn from a diversified range of large and small businesses shall be considered. The CTEs in this quote refer to the preliminary, potential or unofficial CTEs identified as a super-set of potential materiel solutions during the MSA Phase categorized as a self-assessment on the part of the Contractor, Program Office, and/or the PI of an S&T Project. The identification of preliminary or potential CTEs forms the foundation for work in the TD phase of acquisition and subsequent evaluation of technology maturity.

h. MS A TMA. The previous version of DoDI 5000.02 along with SECNAVINST 5000.2D required a TRA be completed only in support of both MS B and MS C. The updated versions of DoDI 5000.02 along with SECNAVINST 5000.2D address the need for an activity separate from the formal TRA, an early evaluation of technology maturity conducted shortly before MS A to support the development of the Technology Development Strategy (TDS). A TD TMA update will be conducted approximately 45 days after the TD Phase contract is awarded, via a government provided TMSA EXCEL-based TWBS spreadsheet, which is submitted as an Annex to the TD proposal. Page 19, paragraph (4) of DoDI 5000.02 specifically states, "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. Technology readiness assessments, and where necessary, [independent technical assessments (ITAs) compiled and conducted by Office of the Secretary of Defense (OSD) if they disagree with the results of a TRA], 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 or engage the user in a

dialog on appropriately modifying the requirements." As per the following chart, the NAVAIR TRA Process includes a TMA during the TD phase of MS A as well as a TRA for MS B and MS C. The NAVAIR TRA Chairman's Office can provide the generic TMA/TRA request for proposal (RFP) language for each MS depicted in Figure 3.

Figure 3. MS A, MS B, and MS C TRAs



i. MS A TD TMA Updates. Updates to the TMA TMSA will be made routinely during the TD contract as a result of the prototype demonstrations culminating in a final TRA conducted approximately 15 days after the PDR. This TRA will serve as the technology maturity baseline for the MS B Technology Maturity Self-Assessment (TMSA) TRA and subsequent MS C TMSA TRA. A recommended "best practice" for all programs is that the PM/IPT requires the Contractor to provide a TMP for each identified CTE. A collection of TMPs is referred to as a Technology Maturation Roadmap (TMR). Progress on the TMPs is reviewed at each corresponding SETR event.

j. Official CTEs. The final or official CTEs accepted by CNR, Assistant Secretary of the Navy (ASN) and OSD can only be identified by an independent panel of recognized technical experts referred to as the IRT, IRP or TRA Panel Membership. Independence here is defined as one who has never been or is not intended to be a working member of the program or the Program Office.

k. TMSA. As shown in Figure 4, the TWBS utilized in conduct of the TMA/TRA has also been uniquely named as a TMSA to identify it with a version of the TWBS that is populated by a contractor/Offeror as an annex to their submitted proposal in response to a Request for Proposal (RFP). As shown below, the TMSA TWBS is identical to the non-source selection TMA/TRA TWBS version except that it contains three additional columns, namely, "Predicted TRL", "TRL Justification", and "CTE Maturation Roadmap".

Figure 4. Sample TMSA CTE Technical WBS (TWBS) Spreadsheet Template

OCT 21 2009

TWBS GUIDANCE LINE		NAVAIR Technology Maturity Self-Assessment (TMSA) Technical Work Breakdown Structure (TWBS) for *fill in Program Name*															
TWBS #	TWBS LEVEL	TWBS TITLE	TWBS MAPPING	TWBS ITEM DESCRIPTION	TECHNOLOGY	NEW TECHNOLOGY	NEW APPLICATION OF EXISTING TECHNOLOGY	COST	SCHEDULE	PERFORMANCE	CHANGE DESCRIPTION	TECHNOLOGY	ENABLING TECHNOLOGY (Note: complete this column only if a CTE has been identified for the row.)	CTE JUSTIFICATION NARRATIVE	PREDICTED TRL	TRL JUSTIFICATION	CTE MATURATION ROADMAP
LINK	LINK	LINK	LINK	LINK	LINK	LINK	LINK	LINK	LINK	LINK	LINK	LINK	LINK	LINK	LINK	LINK	LINK
Top Level Program Background Information													Picture 1 - Top Level System				
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1.1	2	Air Vehicle System	Aircraft System	This is a Level 2 roll-up: **The Air Vehicle System includes Material and Structures.**										Picture			
1.1.1	3	Material	Air Vehicle System	**Technology:** describing the technology, including identifying sub-elements of the WBS item. **Function:** describing the technical & operational expectations of the technology. **Platform Location:** describing how this technology fits into the platform. **Requirement Reference:** Citing the requirement from applicable specifications, ORD/CDD, & CONOPS, where applicable. **KPP:** tracked to this technology.	N	N	N	N	N	N	If the answer to the "Repackaged Technology" or "Modified COTS or GOTS" columns is "Yes", then provide a detailed description here of the extent of the repackaging, of the modification incurred, and/or the new or non-air environment.	N	**Critical Components:** that may drive technology maturity. Are enabling technology elements is "critical" if the system being acquired depends on this immature technology element to meet operational requirements. **Fallback Technology:** that could be used in place of the proposed enabling technology & still achieve a performance threshold compliant design. **External Dependency:** upon another program or investment to achieve the enabling technology maturity.	**Heritage/Pedigree:** of the design/development approach (include dates). **Quantitative Evidence:** it has been demonstrated in the intended relevant environment (include quantities & dates). **Quantitative Testing History:** (include platforms, flight hrs., & dates). **COTS Supplier/Part #:** **Conclusion:** This item is not a CTE because ... OR This item is a CTE because ...			
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1.2.1.1	4	Hardware	Sensor Systems	**Technology:** describing the technology, including identifying sub-elements of the WBS item. **Function:** describing the technical & operational expectations of the technology. **Platform Location:** describing how this technology fits into the platform. **Requirement Reference:** Citing the requirement from applicable specifications, ORD/CDD, & CONOPS, where applicable. **KPP:** tracked to this technology.	N	N	N	N	N	N	If the answer to the "Repackaged Technology" or "Modified COTS or GOTS" columns is "Yes", then provide a detailed description here of the extent of the repackaging, of the modification incurred, and/or the new or non-air environment.	N	**Critical Components:** that may drive technology maturity. Are enabling technology elements is "critical" if the system being acquired depends on this immature technology element to meet operational requirements. **Fallback Technology:** that could be used in place of the proposed enabling technology & still achieve a performance threshold compliant design. **External Dependency:** upon another program or investment to achieve the enabling technology maturity.	**Heritage/Pedigree:** of the design/development approach (include dates). **Quantitative Evidence:** it has been demonstrated in the intended relevant environment (include quantities & dates). **Quantitative Testing History:** (include platforms, flight hrs., & dates). **COTS Supplier/Part #:** **Conclusion:** This item is not a CTE because ... OR This item is a CTE because ...			

Sample

l. Technology Development Phase Exit. The project shall exit the TD Phase when an affordable program or increment of militarily useful capability has been identified. During TD, the user shall prepare the CDD to support initiation of the acquisition program or evolutionary increment, refine the integrated architecture, and clarify how the program will lead to joint warfighting capability. The CDD builds on the ICD and provides the detailed operational performance parameters necessary to complete design of the proposed system. A MS B decision follows the completion of TD.

m. MS B TRA. The purpose of the EMD Phase is to develop a system or an increment of capability; complete full system integration (technology risk reduction occurs during TD); develop an affordable and executable manufacturing process; ensure operational supportability with particular attention to minimizing the logistics footprint; implement HSI design for producibility; ensure affordability; protect Critical Program Items (CPIs) by implementing appropriate techniques such as AT; and demonstrate system integration, interoperability, safety, and utility. The CDD, AS, SEP, and Test and Evaluation Master Plan (TEMP) shall guide this effort. Entrance into this phase depends on technology maturity (including software), approved requirements, and full funding. Unless some other factor is overriding in its impact, the maturity of the technology shall determine the path to be followed. The TRA directly supports the MS decision. The EMD begins at MS B, which is normally the initiation of an acquisition program. There shall be only one MS B per program or evolutionary increment. Each increment of an evolutionary acquisition shall have its own MS B unless the MDA determines that the increment will be initiated at MS C. At MS B, the MDA shall approve the AS and the Acquisition Program Baseline (APB). The MDA decision shall be documented in an ADM. Final RFPs for the EMD Phase, or any succeeding acquisition phase, shall not be released, nor shall any action be taken that would commit the program to a particular contracting strategy, until the MDA has approved the AS. For MDAPs, the PM shall include language in the RFP advising Offerors that; (1) the government will not award a contract to an Offeror whose proposal is based on CTEs that have not been demonstrated in a relevant environment; and, (2) that Offerors will be required to specify the TRL of the CTEs on which their proposal is based and to provide reports documenting how those CTEs have been demonstrated in a relevant environment.

n. MS Certification and Program Changes. The MDA for an MDAP, without the authority to delegate, assesses the program business case and signs a certification memorandum prior to MS B approval. The memorandum includes the statements in 10 U.S.C. 2366b without modification. If the program is initiated at a later date, i.e. MS C, a similar memorandum is prepared as a matter of policy. The ADM includes the statement: "I have reviewed the program and the business case analysis and have made the certifications required, or executed a waiver of the applicability of one or more of the components of the certification required, as authorized by Section 2366b of title 10, U.S. Code." The PM shall immediately notify the MDA of any program changes that alter the substantive basis of the MDA certification or otherwise cause the program to deviate significantly from the material presented to the MDA in support of such certification.

o. MS C TRA. The purpose of the Production and Deployment Phase is to achieve an operational capability that satisfies mission needs. Operational test and evaluation shall determine the effectiveness and suitability of the system. The MDA makes the decision to commit the DoD to production at MS C and documents the decision in an ADM. The MS C authorizes entry into Low Rate Initial Production (LRIP) (for MDAPs and major systems), into production or procurement (for non-major systems that do not require LRIP) or into limited deployment in support of operational testing for MAIS programs or software-intensive systems with no production components. Entrance into this phase depends on the following criteria: acceptable performance in developmental test and evaluation and operational assessment (OSD operational test & evaluation (OT&E) oversight programs); mature software capability; no significant manufacturing risks; manufacturing processes under control (if MS C is full-rate production); an approved ICD (if MS C is program initiation); an approved Capability Production Document (CPD); a refined integrated architecture; acceptable interoperability; acceptable operational supportability; and demonstration that the system is affordable throughout the life cycle, fully funded, and properly phased for rapid acquisition. The CPD reflects the operational requirements, informed by EMD results, and details the performance expected of the production system. If MS C approves LRIP, a subsequent review and decision shall authorize full-rate production (FRP). The TRA directly supports the MS decision.

p. Relationship between TRLs and Acquisition Phases. The following two charts are an overlay of timelines and events for the DoDI 5000.02 Defense Acquisition Management System, the NAVAIR SETR Process, SECNAV's Two-Pass/Six-Gate DON Requirements and Acquisition Governance Process, and the TRA hardware (HW)/System TRLs and SW TRLs, respectively. The purpose of these charts is to show the associated TRLs as a function of the acquisition process. Title 10 U.S.C. 2366b established a line in the sand of a TRL 6 for MS B and these charts help to put into perspective the other TRLs throughout the acquisition process. It is important to note that S&T Projects are typically no higher than a TRL 4 when considered under the MSA phase.

Figure 5. DoDI 5000.02/2P6G/SETR/TRA HW TRLs Events & Timelines

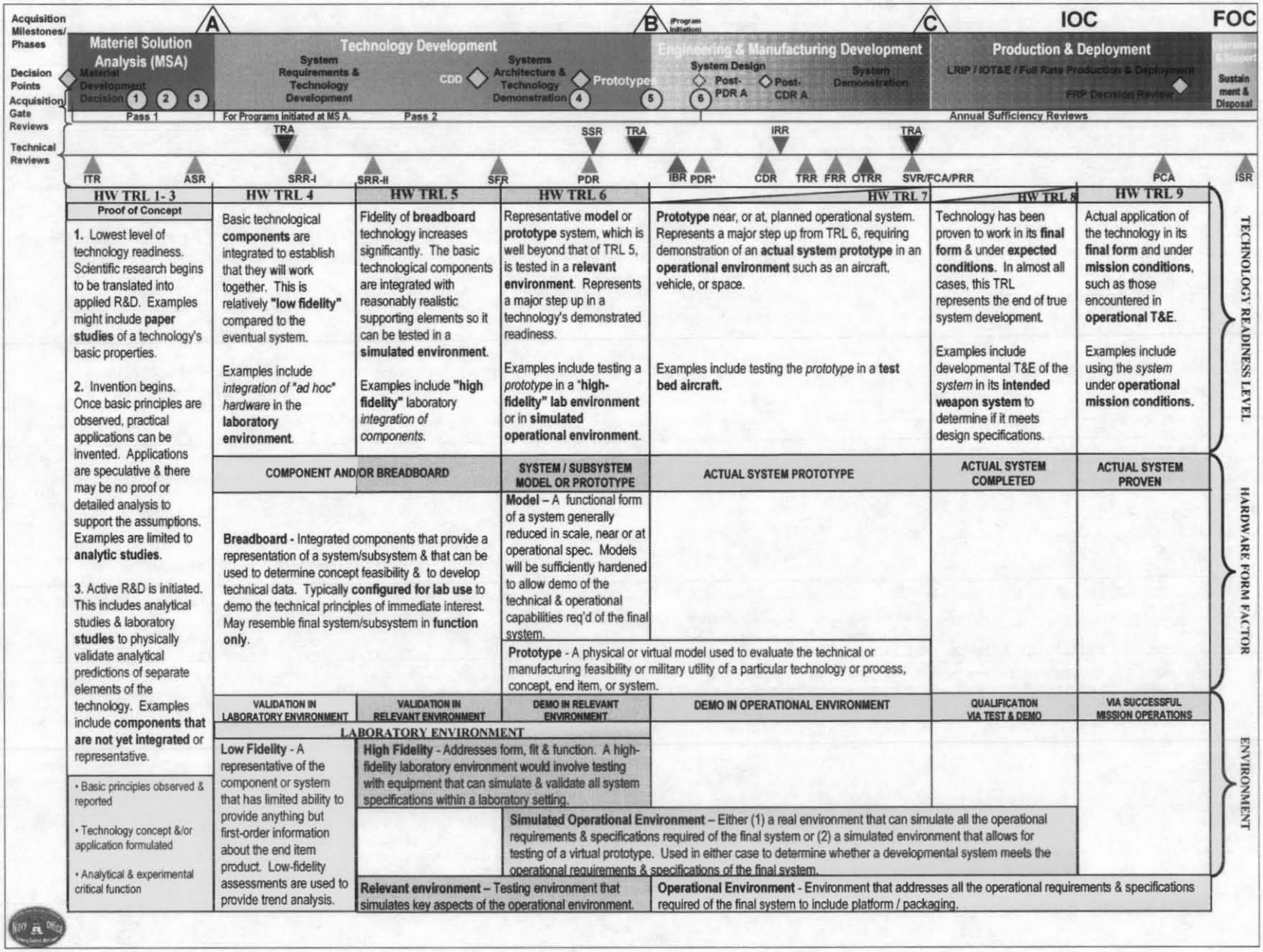
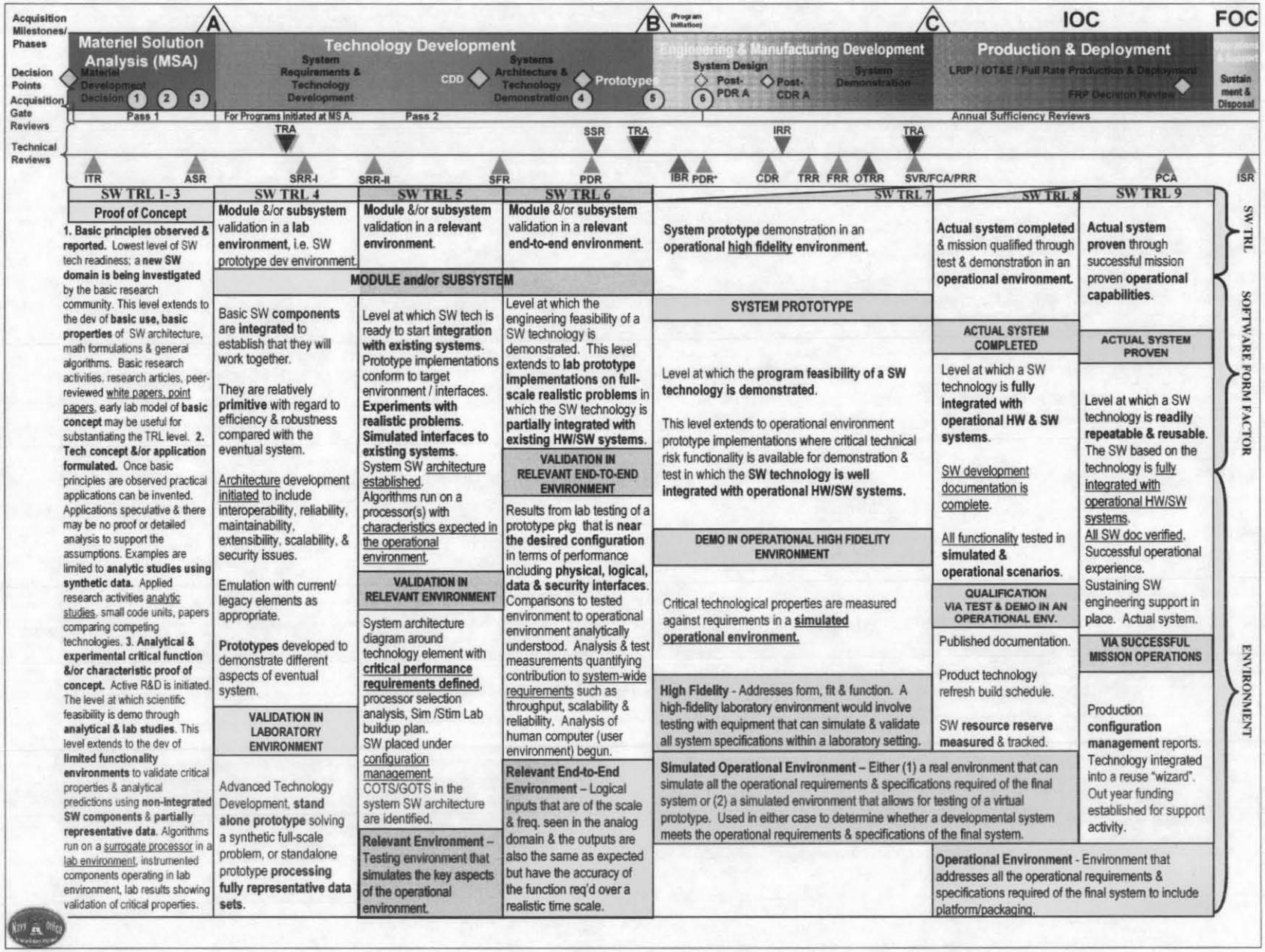


Figure 6. DoDI 5000.02/2P6G/SETR/TRA SW TRLs Events & Timelines OCT 21 2009



7. The Four Steps of the TRA Process. As documented in the TRA standard work package (SWP) 40TRA-001 PART 1 TRA Core Team Members Standard Work Package and the TRA SWP40TRA-002 PART 2 TRA Panel Members (Extended Team) Standard Work Package the four phases of a TRA are as follows.

Step 1 - Establishing the TRA

- An initial TRA discussion meeting is established.

Early in the establishment of a program and development of associated key documentation such as Technology Development Strategy (TDS), AS, System Development Specification (SDS), and CDD, it is the responsibility of the Program Manager - Air (PMA) and/or Assistant Program Manager for Systems Engineering (APMSE) to contact the NAVAIR TRA Chairman's office to initiate the TRA planning. This responsibility also applies for MS C, TRA Updates, and best practice TRA applications. The NAVAIR TRA Chairman's Office will also monitor program key milestones to proactively anticipate program initial contact. The initial meeting is used to introduce the program AS, scope, and requirements, as well as provide a short introduction to the TRA process and considerations towards TRA planning and budget.

- After the initial TRA discussion meeting the NAVAIR TRA Chairman's Office:

  — generates a Plan of Action and Milestones (POA&M) (based on the program ACAT level and MSs), which is forwarded to the IPT;

  — generates a rough order of magnitude (ROM) cost estimate for the entire effort spanned over the appropriate number of months, which is forwarded to the IPT;

  — creates a contact information list; and,

  — establishes an eRoom folder for the program where all TRA-related documentation is stored. Access info is forwarded to the IPT.

- Depending on the ACAT level, the POA&M may be briefed to OSD.

- Event dates from the POA&M and event locations are placed on the TRA Chair's calendar, the Core Team's calendar, and the IPT's calendar.
- As a result of the ROM, an initial funding increment is received.
- A Spend Plan is generated for the TRA Core Team by the TRA Core Team Budget Analyst.
- Based upon the technological needs of the program, TRA Panel Members or IRP are identified.
- Panel Members participation is confirmed with their respective competency.
- Other interested stakeholders may be invited to attend the events.
- The TRA kick-off meeting, as identified on the POA&M, is conducted.
- The TRA Chairman presents a TRA process tutorial brief.
- The IPT presents a short basic program overview brief.
- Meeting minutes are captured and placed in eRoom.
- The Program IPT Lead and/or APMSE should work with the TRA Chairman to ensure the program solicitation/contract (sections L & M) and necessary supporting documentation, such as the Statement of Objectives (SOO), Statement of Work (SOW), and CDRLs reflect the proper planning to support the TRA. It is recommended to the PM that the contractor/manufacturer be required to document in the IMP and IMS key TRA events consistent with the TRA POA&M in order to ensure the necessary contractor/manufacturer resources and priority will be applied.

Step 2 - CTE Reconciliation

- The IPT departs the kick-off meeting with instructions on populating the TRA CTE TWBS template spreadsheet that has been placed in the program eRoom folder and this begins the CTE Reconciliation (RECON) phase. In support of the TRA, the PM is

requested to provide, at a minimum, an electronic copy of the latest version for each of the following documents, if available:

— Analysis of Alternatives;
— Acquisition Strategy;
— Acquisition Plan;
— Initial Capabilities Document;
— Capability Development Document;
— Capability Production Document;
— System Performance Specification;
— Program Overview Brief;
— Technology Development Strategy;
— Master Program or Integrated Master Schedule; and,
— Current Program Risk Assessments.

• In addition, sufficient funding, resources, and contractual coverage should be in place to allow prime contractors and critical subcontractors to participate in the TRA activities, if applicable.

• In accordance with the POA&M, a series of informal CTE TWBS reviews will be scheduled between the TRA Core Team Action Officer and the IPT TRA Action Officer. The purpose of these informal reviews is to review progress and receive guidance from the NAVAIR TRA Chairman's Core Team towards successful completion of the CTE TWBS. Data/information requirements to support populating the TWBS include:

— equipment in-service heritage;
— product family pedigree;
— engineering analyses;
— any historical, relevant demonstration evidence; and,
— prior qualification test results and associated test environment definitions.

This information is inherently part of the engineering process. It documents the progress of a system's technical baseline and represents a "super-set" of potential threshold compliant design configuration options, dependent upon the development phase of the program.

• Each TRA begins with the IPT, with or without contractor assistance (dependent upon the development phase of the program), populating a TWBS, for the independent TRA Panel to review. The correctness and completeness of this information should be measured against clearly stated threshold compliant design requirements.

• The IPT initially concentrates on populating the first few vertical columns of the CTE TWBS spreadsheet and returns it by emailing it or updating it in the eRoom folder for the TRA Core Team to perform a quick sanity check to ensure population trend is correct.

• The CTE TWBS informal reviews between the TRA Core Team, the IPT Action Officer and any other IPT members are to review the draft CTE TWBS. Questions are asked and suggestions are given as to the kind of wording that is required in the spreadsheet.

• Depending upon the phase of the acquisition program, and usually for a MS B with a full and open competition, a CTE TWBS spreadsheet will be populated for each potential Offeror's technical approach. Even within a single Offeror, there may be more than one possible solution to the technical challenge. This is referred to as a CTE TWBS "Super-set" of possible technical solutions. This information allows the TRA Panel Members an opportunity to prepare for what to expect technologically plus it speeds up the process in the fact that once the actual Offeror's approach comes in, the Panel Members can focus more on the deltas. The goal of the TRA process is never to be the cause of an acquisition program not meeting their planned acquisition MSs.

• Once the informal CTE TWBS informal reviews have concluded, the next step is to prepare for the actual TRA CTE RECON event. Depending on the magnitude and scope of the program there may be more than one RECON, identified as "pre-RECONs" to facilitate the possible CTE screening process. It is not unusual for additional information to be required in a particular technological area.

• A CTE TWBS pre-RECON event is scheduled by the TRA Chairman to provide the program a forum to receive beneficial

early feedback on the CTE TWBS completeness from key independent TRA panel members. A pre-RECON may also be scheduled because the system baseline technical complexity requires early exposure to the independent TRA panel to allow the panel increased awareness for timely preparation and research.

- A CTE TWBS RECON event will be scheduled where the independent TRA panel members will conduct a row by row review of the CTE TWBS spreadsheet, in order to reconcile CTEs. The TRA Chairman with input from the TRA panel will reconcile with the program their recommendations with respect to the final official list of identified CTEs and "Watch Items". The TRA Chairman will make the final decision in all cases.

- In preparation for the TRA CTE RECON event the IPT owes the TRA Core Team a final read-ahead of the fully populated and corrected CTE TWBS. This read-ahead is shared with the chosen TRA Panel Members so that they can be prepared for the event.

- The construct of the TRA Panel does not include any pre-defined number of SMEs. The initial composition of the TRA Panel is at the discretion of the TRA Chairman, and is based on the technological disciplines involved in the program. CNR, ASN or OSD may recommend additional Panel members upon their review and approval of those compiled by the TRA Chairman.

- The RECON Phase and the RECON Event have been deemed the most important part of the overall TRA effort because this is where deep dives are conducted in various technological areas and the questions continue until the consensus of the empowered Panel Members agree on what is and what is not a CTE.

- If the RECON event determines that CTEs exist, a subsequent TRA SE is held to assign a maturity level to each identified CTE by using the DoD system/HW and SW TRLs. By default, a potential CTE is carried forward to the SE when insufficient information has been provided to adequately determine a technology's maturity.

- If the RECON event determines that there are no CTEs, the TRA process ends, and the TRA Chairman submits a letter to that effect. For ACAT III and IV programs, the TRA Chairman's letter is submitted directly to the MDA. In the case where this

outcome applies to ACAT I and ACAT II programs, the Chairman submits a completion letter signed by both the Chairman and the ONR TRAC, as well as a draft cover letter for CNR signature. The CNR submits the signed cover letter along with the report to the applicable MDA.

- The minutes of the RECON event are placed in the eRoom folder.

- The IPT departs the RECON event with a list of CTEs that they must now go and prepare additional information on each in preparation for the next step, the TRA SE.

Step 3 - Scoring

- Similar to the preparation for the RECON event, the IPT Action Officer will meet informally with the TRA Core Team to discuss the level of detail required for the TRA SE.

- Within a week before the planned TRA SE, the IPT owes the TRA Core Team a final read-ahead for the SE which includes the TWBS with only the previously identified CTEs and a briefing to accompany the individual CTE discussions.

- The TRA Chairman kick-offs the TRA SE with a brief explanation of the process for scoring and collection of the actual scoring documents.

- An IPT member will then walk everyone through the previously identified CTEs one-by-one. Questions will be asked at random by Panel Members and eventually the TRA Chairman asks if there are any more questions and if it is time for a vote.

- The voting is done anonymously and in writing along with written comments from the Panel Members as to what were the salient facts that influenced their vote. The process is followed for each and every CTE.

- The votes are recorded and tallied, in real time, by the event recorder.

- Once the discussions and voting have concluded, the TRA Chairman will present a summary only of the final scores. The

average scores are computed and rounded accordingly to arrive at a final TRL whole number.

- The SE minutes are placed in the eRoom folder.

Step 4 - Reporting

- Once the SE is over, the TRA Core Team focuses on preparing an initial TRA Results Power Point brief for the PMA, a TRA Results Power Point brief with notes for CNR, and a written draft TRA Report for OSD depending on the program ACAT and MS.

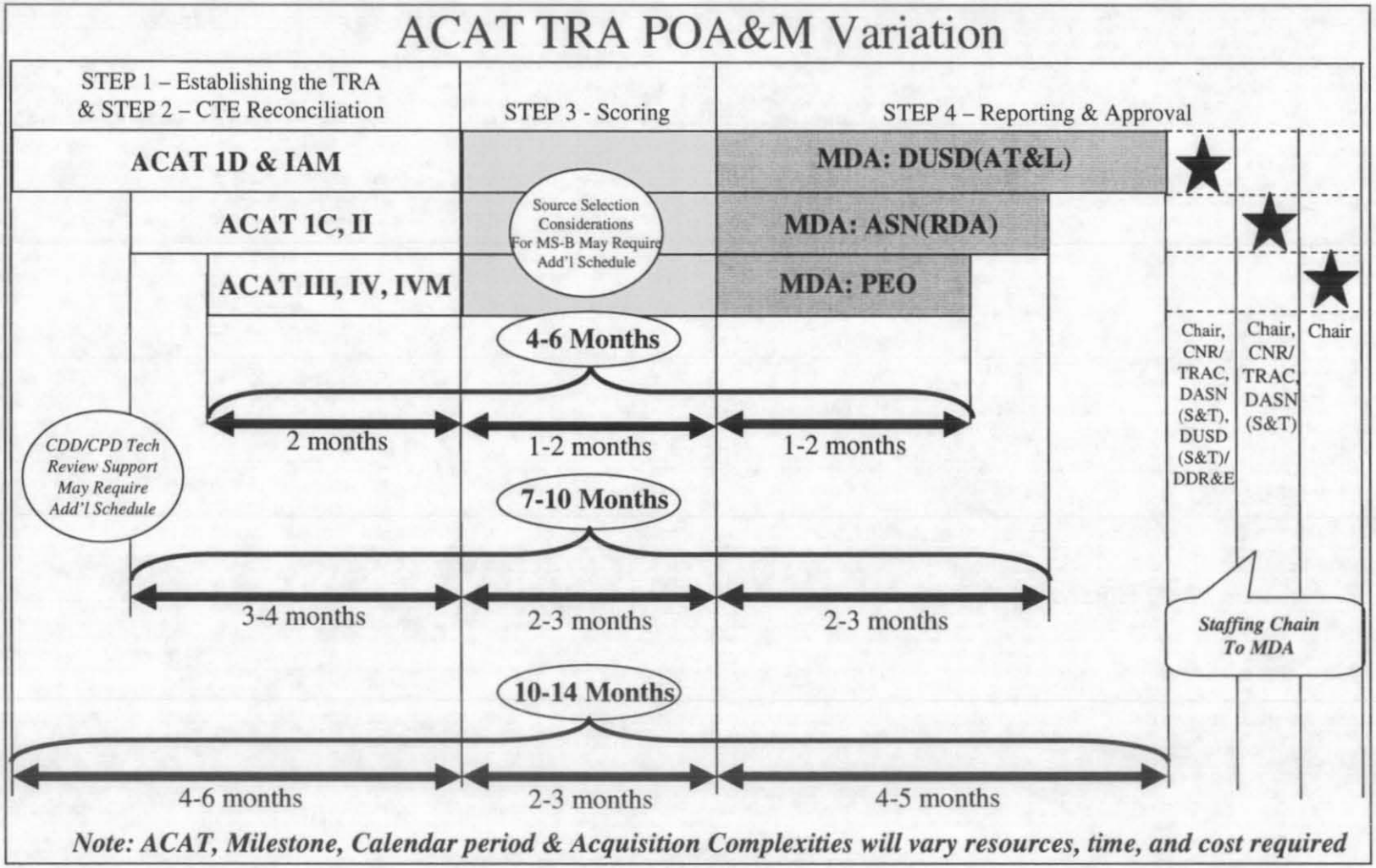
- Subsequent to the TRA SE, the program may generate TMPs for each CTE scored. The TMPs are customarily submitted to the TRA Chairman for review and incorporation into the final TRA Report.

- The reporting chain and typical flow time is dependent upon the ACAT level of the program.

Note: The same four steps apply whether the information is classified or unclassified, except when classified a separate and distinct TWBS is utilized, marked and handled appropriately and events are held in approved spaces. A classified TRA also impacts cost, and the logistics of information availability is the responsibility of the Program Office.

8. Planning/Scheduling/Staffing. Programs should initiate contact with the NAVAIR TRA Chairman's office early in the establishment/AS development phase of a program in order to initiate TRA planning (i.e., budget and scope of effort). The development of an AS or TDS should be closely coordinated with TRA scheduled activities in order to minimize both program schedule execution and cost risk. The following chart shows typical TRA duration estimates for ACAT levels delineating flow time vice touch time to allow risk free execution of the TRA process and consistency with OSD guidelines and/or historical trends.

Figure 7. TRA Timelines



a. Schedule Variations. Variations in schedule may be influenced by, but not limited to the following factors:

- number of Offerors/prototypes;
- number of supplier alternatives carried prior to prime down select;
- sole-source vs. competitive;
- contract vehicle in-place (or not) to facilitate the capture of technology information (populating the CTE TWBS);
- receipt of funding;
- ability to utilize non-government panel members during source selection; or,
- classified vs. unclassified

9. Roles and Responsibilities

a. Navy Science and Technology Executive. As the Navy's S&T Executive, the CNR is responsible for ensuring the integrity of the TRA process and provides concurrence with the TRA report content via cover letter to the applicable MDA.

b. Office of Naval Research TRA Coordinator. The TRAC is an appointed representative of the CNR, who is responsible for ensuring the integrity of the TRA process. The TRAC attends key TRA events and participates as a member of the independent TRA panel.

c. NAVAIR TRA Chairman. Designated by the Assistant Commander for Research & Engineering (AIR-4.0) as the TRA Chairman and principal TRA point-of-contact for all NAVAIR programs. The NAVAIR TRA Chairman is responsible for TRA coordination, planning, conducting, documenting, and reporting. In order to maximize TRA effectiveness and facilitate a CNR recommendation, the NAVAIR Chairman works closely with the appointed ONR TRAC. The TRA Chairman has an Action Officer; assigned to Program Executive Officer Air ASW, Assault and Special Mission Programs PEO(A), Program Executive Officer Unmanned Aviation and Strike Weapons PEO(U&W) programs, Program Executive Officer Tactical Aircraft Programs PEO(T) and Program Management (AIR-1.0) programs, to interface and coordinate TRA activities and events.

d. TRA Panel Members. For MS A TMAs and MS B and MS C TRAs, the TRA panel membership is comprised solely of independent, objective, unbiased, acknowledged TAEs. The independent membership can consist of TAEs from NAVAIR, ONR, national laboratories, other services, and academia depending on TRA Chairman and TRACs concurrence of necessary coverage and need for specialized experts. Panel members should have no direct affiliation with the program and are not an IPT member. Panel members have no special interest in the system, or any components therein, that would prevent the individual from providing a non-bias, solely objective assessment of the technology. The TAEs should be senior engineers/Fellows with solid technical knowledge, experience, and credentials, and acknowledgments. For MS C TRAs, the TRA panel membership is comprised of independent TAEs. Additional members from the Government IPT and Industry may also participate for additional perspective. The independent assessment constitutes the official score.

e. Program Office & IPT. The Program IPT interfaces with the NAVAIR TRA Chairman's Core Team to jointly support the completion of all required TRA tasks, attend TRA scheduled events, document results (e.g., CTE TWBS, maturation plans), and participate in reporting of results, as required. The Program Office provides the funding to the NAVAIR TRA Chairman's Office for the planning, execution, and reporting of the TRA, with the only exception that when a prime contractor/manufacturer or subcontractor is involved the Program Office will handle the funding of the contract. The Program Office will help facilitate all necessary security actions, where appropriate, and Non-Disclosure Agreements (NDAs) for government and contractor TRA support personnel. It is the responsibility of the Program Office to make all necessary documentation available and accessible to complete a comprehensive TRA.

10. Location of Events. The TRA and TRA-related events will be hosted by the TRA Core Team in the TRA Conference Room. This limited-access government facility has adequate capacity, resources, and safeguards to ensure complete participation by all panel members and adequate protection of proprietary, competition sensitive, and for official use only information.

11. Reporting and Approval. A final TRA report documents the findings of the assessment panel. For ACAT I and II programs, the final report is prepared and presented by the NAVAIR TRA Chairman, and consists of a Power Point briefing with embedded notes in a format outlined by ONR. For ACAT III and IV programs the final written report is signed by the NAVAIR TRA Chairman and forwarded to the PMA. Upon request of the PMA, an outbrief of the TRA results can be presented by the NAVAIR TRA Chairman.

a. Chief of Naval Research. For ACAT I and II programs, the final report is submitted and briefed by the NAVAIR TRA Chairman to CNR, or executive representative, usually with the TRAC, as well as a copy provided to the PMA. Upon CNR approval of the report, CNR provides the NAVAIR TRA Chairman the signed endorsement cover letter and forwards a copy of the report and letter to the applicable MDA.

b. An OSD Conducted ITA. If deemed necessary, the OSD, Director, Defense Research and Engineering can conduct another ITA in addition to, and totally separate from, the NAVAIR TRA, if the results of the CNR endorsed NAVAIR TRA report are deemed incomplete. An ITA is an exception and has been rarely exercised across the services and agencies within DoD.

c. Report Storage. When the TRA is complete and the report approved by CNR, the NAVAIR TRA Chairman prepares an electronic copy (in a searchable .pdf file format) of the signed CNR letter for the NAVAIR TRA Chairman's database. If security allows, a copy will also be forwarded for inclusion into the SETR archival database.

12. Point of Contact. For additional information about TRAs, contact the NAVAIR TRA Chairman's office at (301) 342-9154.

Table 1. DoD System/HW TRL Definitions

SYSTEM/HW TRL	Description	Supporting Information
1. Basic principles observed & reported.	Lowest level of technology readiness. Scientific research begins to be translated into applied R&D. Examples might include paper studies of a technology's basic properties.	Published research that identifies the principles that underlie this technology. References to who, where, when.
2. Technology concept and/or application formulated.	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative & there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.	Publications or other references that outline the application being considered & that provide analysis to support the concept.
3. Analytical & experimental critical function and/or characteristic proof of concept.	Active R&D is initiated. This includes analytical studies & lab studies to physically validate the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.	Results of laboratory tests performed to measure parameters of interest & comparison to analytical predictions for critical subsystems. References to who, where, & when these tests & comparisons were performed.
4. Component and/or breadboard validation in lab environment.	Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" HW in the lab.	System concepts that have been considered & results from testing lab scale breadboard(s). References to who did this work & when. Provide an estimate of how breadboard HW & test results differ from the expected system goals.
5. Component and/or breadboard validation in a 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" lab integration of components.	Results from testing a lab breadboard system are integrated with other supporting elements in a simulated operational environment. How does the "relevant environment" differ from the expected operational environment? How do the test results compare with expectations? What problems, if any, were encountered? Was the breadboard system refined to more nearly match the expected system goals?
6. System/ subsystem model or prototype demo in a relevant environment.	Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-	Results from lab testing of a prototype system that is near the desired configuration in terms of performance, weight, & volume. How did the test environment differ from the operational environment? Who performed the tests? How did the test compare

	fidelity lab environment or in simulated operational environment.	with expectations? What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems before moving to the next level?
7. System prototype demo in an operational environment.	Prototype near, or at, planned operational system. Represents a major step up from TRL 6 by requiring demo of an actual system prototype in an operational environment (e.g., in an A/C, in a vehicle, or in space.	Results from testing a prototype system in an operational environment. Who performed the tests? How did the test compare with expectations? What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems before moving to the next level?
8. Actual system completed & qualified through test & demo.	Technology has been proven to work in its final form & under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental T&E (DT&E) of the system in its intended weapon system to determine if it meets design specs.	Results of testing the system in its final configuration under the expected range of environmental conditions in which it will be expected to operate. Assessment of whether it will meet its operational requirements. What problems, if any, were encountered? What are/were the plans, options, or actions to resolve problems before finalizing the design?
9. Actual system proven through successful mission operations.	Actual application of the technology in its final form & under mission conditions, such as those encountered in operational T&E (OT&E). Examples include using the system under operational mission conditions.	OT&E reports.

Table 2. DoD SW TRL Definitions

SW TRLs	Description	Supporting Information
1. Basic principles observed & reported.	Lowest level of SW technology readiness. A new SW domain is being investigated by the basic research community. This level extends to the development of basic use, basic properties of SW architecture, mathematical formulations & general algorithms.	Basic research activities, research articles, peer-reviewed white papers, point papers, early lab model of basic concept may be useful for substantiating the TRL.
2. Technology concept and/or application formulated.	Once basic principles are observed, practical applications can be invented. Applications are speculative, & there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies using synthetic data.	Applied research activities, analytic studies, small code units, & papers comparing competing technologies
3. Analytical & experimental critical function and/or characteristic proof of concept.	Active R&D is initiated. The level at which scientific feasibility is demonstrated through analytical & lab studies. This level extends to the development of limited functionality environments to validate critical properties & analytical predictions using non-integrated SW components & partially representative data.	Algorithms run on a surrogate processor in a lab environment, instrumented components operating in a lab environment, lab results showing validation of critical properties
4. Module and/or subsystem validation in a lab environment (i.e., SW prototype development environment).	Basic SW components are integrated to establish that they will work together. They are relatively primitive with regard to efficiency & robustness compared with the eventual system. Architecture development initiated to include interoperability, reliability, maintainability, extensibility, scalability, & security issues. Emulation with current/legacy elements as appropriate. Prototypes developed to demo different aspects of eventual system.	Advanced technology development, stand-alone prototype solving a synthetic full-scale problem, or standalone prototype processing fully representative data sets.
5. Module and/or subsystem validation in a relevant environment.	Level at which SW technology is ready to start integration with existing systems. The prototype implementations conform to target environment/interfaces. Experiments with realistic problems. Simulated interfaces to existing systems. System SW architecture established. Algorithms run on a processor(s) with characteristics expected in the operational environment.	System architecture diagram around technology element with critical performance requirements defined. Processor selection analysis, Sim /Stim lab buildup plan. SW placed under configuration management. COTS/GOTS components in the system SW architecture are identified.

6. Module and/or subsystem validation in a relevant end-to-end environment.	Level at which the engineering feasibility of a SW technology is demonstrated. This level extends to lab prototype implementations on full-scale realistic problems in which the SW technology is partially integrated with existing HW/SW systems.	Results from lab testing of a prototype package that is near the desired configuration in terms of performance, including physical, logical, data & security interfaces. Comparisons between tested environment & operational environment analytically understood. Analysis & test measurements quantifying contribution to system-wide requirements such as throughput, scalability & reliability. Analysis of human-computer (user environment) begun.
7. System prototype demo in an operational high-fidelity environment.	Level at which the program feasibility of a SW technology is demonstrated. This level extends to operational environment prototype implementations, where critical technical risk functionality is available for demo & a test in which the SW technology is well integrated with operational HW/SW systems.	Critical technological properties are measured against requirements in a operational environment
8. Actual system completed & mission qualified through test & demo in an operational environment.	Level at which a SW technology is fully integrated with operational HW & SW systems. SW development documentation is complete. All functionality tested in simulated & operational scenarios.	Published documentation & product technology refresh build schedule. SW resource reserve measured & tracked.
9. Actual system proven through successful mission-proven operational capabilities.	Level at which a SW technology is readily repeatable & reusable. The SW based on the technology is fully integrated with operational HW/SW systems. All SW documentation verified. Successful operational experience. Sustaining SW engineering support in place. Actual system.	Production configuration management reports. Technology integrated into a reuse "wizard."

Table 3. Additional TRL-Related Definitions

The TRLs indicate to what level of technology readiness has been accomplished from several perspectives; theory to laboratory to field, relevant environment to operational environment, subscale to full scale, breadboard to brassboard to prototype, and partial performance to full performance. TRLs *do not* indicate that the technology is right for the job or that the application of the technology will result in successful development of the system and TRLs do not address risk, system integration, or capability readiness.

Term	Definition
Breadboard	Integrated components that provide a representation of a system/subsystem & that can be used to determine concept feasibility & to develop technical data. Typically configured for lab use to demo the technical principles of immediate interest. May resemble final system/subsystem in function only.
High Fidelity	Addresses form, fit & function. A high-fidelity lab environment would involve testing with equipment that can simulate & validate all system specs within a lab setting.
Low Fidelity	A representative of the component or system that has limited ability to provide anything but 1st-order information about the end product. Low-fidelity assessments are used to provide trend analysis.
Model	A functional form of a system generally reduced in scale, near or at operational spec. Models will be sufficiently hardened to allow demo of the technical & operational capabilities required of the final system.
Operational Environment	Environment that addresses all the operational requirements & specs required of the final system to include platform/packaging.
Prototype	A physical or virtual model used to evaluate the technical or manufacturing feasibility or military utility of a particular technology or process, concept, end item, or system.
Relevant Environment	Testing environment that simulates both the most important & most stressing aspects of the operational environment.
Simulated Operational Environment	Either (1) a real environment that can simulate all the operational requirements & specs required of the final system or (2) a simulated environment that allows for testing of a virtual prototype. Used in either case to determine whether a developmental system meets the operational requirements & specs of the final system.

(Source: July 2009 DoD TRA Deskbook)

Table 4. List of Acronyms

2P6G	Two Pass Six Gate
AAP	Abbreviated Acquisition Program
ACAT	Acquisition Category
ADM	Acquisition Decision Memorandum
AOA	Analysis of Alternatives
APB	Acquisition Program Baseline
APMSE	Assistant Program Manager for Systems and Engineering
AS	Acquisition Strategy
ASN	Assistant Secretary of the Navy
ASN(RDA)	Assistant Secretary of the Navy for Research, Development, & Acquisition
ASR	Alternative Systems Review
AT	Anti-tamper
AT&L	Acquisition, Technology, & Logistics
BAA	Broad Agency Announcement
CAE	Component Acquisition Executive
CDD	Capability Development Document
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CHENG	Chief Engineer
CNR	Chief of Naval Research
COTS	Commercial Off-The-Shelf
CPD	Capabilities Production Document
CPI	Critical Program Item
CTE	Critical Technology Element
CWBS	Contractual Work Breakdown Structure
DAB	Defense Acquisition Board
DAE	Defense Acquisition Executive
DAG	Defense Acquisition Guide
DASN	Deputy Assistant Secretary of the Navy
DASN(S&T)	Deputy Assistant Secretary of the Navy for Science & Technology
DAU	Defense Acquisition University
DDR&E	Director, Defense Research & Engineering
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DON	Department of the Navy
DRPM	Direct Reporting Program Manager
DUSD	Deputy Under Secretary of Defense

DUSD(S&T)	Deputy Under Secretary of Defense for Science and Technology
ECP	Engineering Change Proposal
EMD	Engineering and Manufacturing Development
ESOH	Environmental Safety & Occupational Health
FCA	Functional Configuration Audit
FOC	Full Operational Capability
FRP	Full Rate Production
FRR	Flight Readiness Review
FY	Fiscal Year
GAO	Government Accounting Office
GOTS	Government Off-The-Shelf
HSI	Human Systems Integration
HW	Hardware
IAW	In Accordance With
IBR	Integrated Baseline Review
ICD	Initial Capabilities Document
IMP	Integrated Master Plan
IMS	Integrated Master Schedule
IPT	Integrated Product Team
IRP	Independent Review Panel
IRR	Integration Readiness Review
IRT	Independent Review Team
ISP	Information Support Plan
ISR	In-Service Review
ITA	Independent Technical Assessment
ITR	Initial Technical Review
ITRO	Independent Technical Review Office
JCD	Joint Capabilities Document
JROC	Joint Requirement Oversight Council
LRIP	Low Rate Initial Production
MAIS	Major Acquisition Information System
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
MDD	Materiel Development Decision
MOA	Memorandum of Agreement
MRA	Manufacturing Readiness Assessment
MS	Milestone
MSA	Materiel Solution Analysis
NASA	National Aeronautics & Space Administration
NAVAIR	Naval Air Systems Command
NAVAIRINST	Naval Air Systems Command Instruction
NDA	Non-Disclosure Agreement
NDAA	National Defense Authorization Act

ONR	Office of Naval Research
OSD	Office of the Secretary of Defense
OT&E	Operational Test & Evaluation
OTRR	Operational Test Readiness Review
PCA	Physical Configuration Audit
PDR	Preliminary Design Review
PEO	Program Executive Officer
PEO(A)	Program Executive Officer Air ASW, Assault & Special Mission Programs
PEO(T)	Program Executive Officer Tactical Aircraft Programs
PEO(U&W)	Program Executive Officer Unmanned Aviation & Strike Weapons
PESHE	Programmatic Environmental Safety & Occupational Health Evaluation
PI	Principle Investigator
PM	Program Manager
PMA	Program Manager - AIR
POA&M	Plan of Action & Milestones
PPP	Program Protection Plan
Pre-RECON	Pre-Reconciliation
PRR	Production Readiness Review
PSC	Preferred System Concept
PWBS	Program Work Breakdown Structure
RDA	Research, Development, and Acquisition
RECON	Reconciliation
RFP	Request for Proposal
RMP	Risk Management Plan
ROM	Rough Order of Magnitude
S&T	Science and Technology
SBIR	Small Business Innovative Research
SDD	System Design and Development
SDS	System Design Specification
SDS	System Development Specification
SE	Scoring Event
SECDEF	Secretary of Defense
SECNAV	Secretary of the Navy
SECNAVINST	Secretary of the Navy Instruction
SEE	Software Engineering Environment
SEP	Systems Engineering Plan
SETR	Systems Engineering Technical Review
SFR	System Functional Review
SME	Subject Matter Expert
SOO	Statement of Objectives

SOW	Statement of Work
SRR	System Requirements Review
SSR	Software Specification Review
STA	System Threat Assessment
SVR	System Verification Review
SW	Software
SWP	Standard Work Package
SYSCOM	Systems Command
T&E	Test & Evaluation
TAE	Technology Area Expert
TD	Technology Development
TD TRA	Technology Development Technology Readiness Assessment
TDS	Technology Development Strategy
TEMP	Test and Evaluation Master Plan
TES	Test & Evaluation Strategy
TMA	Technology Maturity Assessment
TMP	Technology Maturation Plan
TMR	Technology Maturation Roadmap
TMSA	Technology Maturity Self-Assessment
TRA	Technology Readiness Assessment
TRAC	Technology Readiness Assessment Coordinator
TRL	Technology Readiness Level
TRR	Test Readiness Review
TWBS	Technical Work Breakdown Structure
U.S.C.	United States Code
USD(AT&L)	Under Secretary of Defense Acquisition, Technology & Logistics
WBS	Work Breakdown Structure