**Summary of Selected Technology Project Management Tools, as addressed in STM202 and the prerequisites.**

As part of the preparation to attend STM303, all participants must review this material, as a refresher from the course prerequisites, in preparation for the 1st exercise, which starts immediately after the introduction on the first day of class. Additional information is available in the PRIMARY course references indicated in the primary file of advanced assignments, downloaded from the DAU Pre-Course Website, http://www.dau.mil/registrar/_pre-courses.asp.

All others are available from the DoD "AT&L Knowledge Support System", https://akss.dau.mil/default.aspx or the DAU Acquisition Community Connection, https://acc.dau.mil/CommunityBrowser.aspx?id=18479

## 1. S&T Linkage to the Defense Acquisition Management System, as defined in the DoDD 5000.1 and DoDI 5000.02.

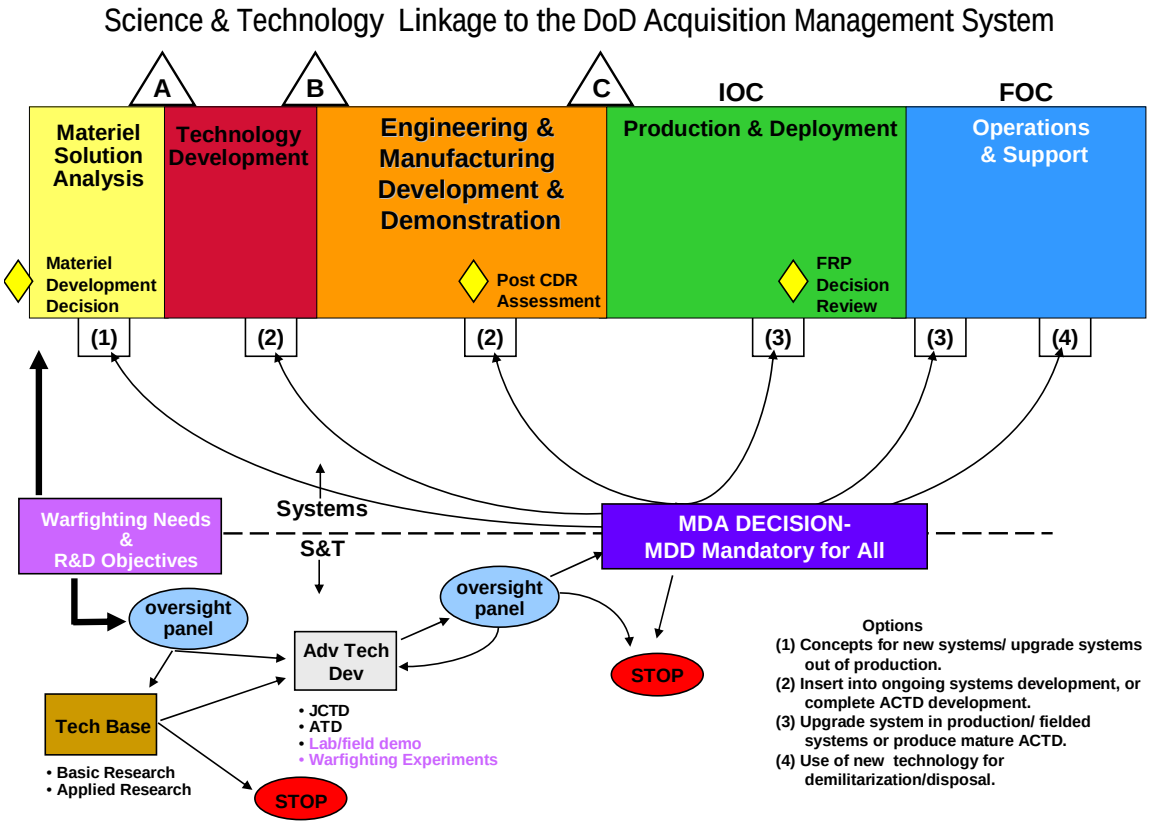



Figure 1. First, the top shows the new DoD Acquisition Management process, as defined in the **JUST RELEASED** DoDI 5000.02, 2 December 2008. A deeper review of the process is available in the Introduction to Defense Acquisition Management booklet, and the 5000 series, which is on the STM303 pre-course website.

Secondly, this shows conceptually how advanced technology, developed by any of the DoD and Service organizations, flows to an acquisition program, which can

occur at any time in the acquisition management system. Some technologies may have been developed by industry or academia under a DoD funded effort, or developed commercially, and will support the critical technology's function in the developing system.

Ideally, the earlier a technology is mature enough and planned for insertion into an acquisition program, the better. As part of the Analysis of Alternatives (AoA) conducted during the Material Solution Analysis Phase (formerly entitled the Concept Refinement Phase), DoDI 5000.02 states that the "AoA shall assess the critical technologies associated with these concepts, including technology maturity, technical risk, and, if necessary, technology maturation and demonstration needs."

## 2. TECHNOLOGY TRANSITION AGREEMENT (TTA)

As described in the DoD Technology Readiness Assessment Deskbook, June 2005, "A TTA documents the commitment of the requirements/resource sponsor, the science and technology (S&T) activity (developer and provider of the technology / product), and the Acquisition Program Office ([***one of the***] intended receiver of a technology or capability development) to develop, deliver, and integrate a technology/product into an acquisition program. The following elements should be considered for inclusion in the TTA. Not every one of these elements is appropriate for every agreement, but each element should be considered for inclusion.

Agreements, to be effective, must be reviewed periodically with each of the key partners: the requirements/resource sponsor, S&T activity and the Acquisition Program Office representatives. These reviews should address technical progress and future directions."

**Elements To Be Provided by the [Acquisition] Program Office**

**A. Target acquisition program.** Provide a brief description of the acquisition program to receive the technology/product. Include the

Major program objectives, their current acquisition life cycle phases and projected initial operational capability date.

**B. Program Manager (PM)/ Project Officer (PO).** Identify personnel responsible for day-to- day program/project management.

**C. Acquisition program technology need.** Identify the technology needs of the acquisition program that S&T is expected to provide. Briefly describe the benefit that the technology/product will bring to the acquisition program.

1. Relate the benefit to the Initial Capabilities Document (ICD), Capability Development Document (CDD), key performance parameters (KPPs), and so forth.
2. Include need dates for specific capabilities.
3. Provide an estimate of the Technology Readiness Levels (TRL)

**D. Integration strategy.** Describe the process for integrating the technology/product into the acquisition program including the evolutionary acquisition block upgrade, required contractor-to-contractor agreements., acquisition program element (PE) numbers funding the transition, annual PE funding levels committed to the transition program, transition Fiscal Year (FY) and statement conveying the level of commitment.

**For example,**
**i. Commitment:** "Upon successful demonstration of key performance requirements (*exit criteria*), PM XXX (*Acquisition Program Office*) will integrate YYY *(technology product delivered*) into XXX (*acquisition program that will integrate the technology deliverable*) commencing in FYXX (*transition year*)." This integration effort will be funded under PE XXXXXXX, Project XXXX (*FYDP budget profile for this acquisition line should be included*).
**ii. Intent:** "Upon successful demonstration of key performance requirements *(exit criteria)*, PM XXX *(Acquisition Program Office)* intends to integrate *YYY (technology product to be delivered)* into XXX *(acquisition program that will integrate the technology deliverable)* commencing in FYXX *(transition year)* under PE XXXXXXX Project XXXX *(FYDP budget profile).*
"

**Elements To Be Provided by the S&T Activity**
**A. Development.** What the S&T activity intends to develop for transition to the acquisition program. Include capability delivery dates.

**B. Technology manager**. Identify the individual designated by the S&T activity to coordinate day-to-day management of the technology/product development and list contact information.

**C. Current status of technology/product.** Show Status summary, current state of development, primary areas where additional development is required, estimate of current TRL, a risk analysis, and planned mitigation activities to address technical risk (e.g., producibility, affordability, sustainability).

**D. Acquisition Program Technology Development Strategy (TDS).** Outline the planned approach. Including efforts required beyond those currently underway, integration plans if multiple projects are planned and planned Advanced Technology Demonstration (ATD) or Joint Technology Capability Demonstration (JCTD) developments, if applicable.

**E. Exit criteria** (key technical measures of readiness) for transition. Identify quantifiable criteria that will be used to measure whether the technology/product development effort is proceeding appropriately. Provide:

1. Definitive, complete, measurable parameters to be tracked, to include performance, physical attributes.
2. Conditions under which technology/product will be tested/demonstrated before delivery to acquisition.
3. Current performance of the technology/product.
4. Minimum acceptable performance threshold.
5. Desired final goal/objective.
6. Estimate of the transition TRL, coordinated with the program office.

**F. Program plan.** Show major activities/efforts planned for the technology/product development with acquisition and S&T milestones.

**Elements To Be Provided by Resources/Requirements Code**

**A. Capability requirement basis.** Identify the governing source of the capability requirement (the official reference documenting the capability need).

**B. Resource sponsor/requirements officer.**

**Signatures and Dates** TTAs should be signed to commit participating organizations to the plan outlined in the agreement.

## 3. TECHNOLOGY READINESS ASSESSMENTS (TRA) **"**An acquisition TRA is a systematic, metrics-based process and accompanying report that assesses the maturity of certain technologies [called Critical Technology Elements (CTEs)] used in systems. The [TRA] report includes information about how the CTEs are identified, why they are important to the program, and an *independent* (from the [acquisition] program) assessment of their maturity. The purpose of the TRA is to surface data and assess information relevant to the maturity of the CTEs in acquisition programs.

This assessment does not predict future performance of the technologies or the system nor does it assess the quality of the system architecture, design, or integration plan. It is simply a report on what has been accomplished to date for an important subset of technologies in the program. The TRLs reported in the TRA are part of the program's technical risk assessment. Elements of technical risk also include design, architectures, interoperability, cost, schedule, manufacturability and producibility, and so forth. Thus, although the [acquisition] PM should find the output of a disciplined TRA process useful in highlighting technology items and shaping the risk mitigation plans, the TRA should not be the sole means of discovering technology risk." TRA Deskbook, 2005.

# 4. CONTRACTING & ASSISTANCE INSTRUMENTS

Contracts put into place between the government and suppliers generally fall under the rules of the Federal Acquisition System, as legally documented in the Federal Acquisition Regulations (FAR).

The Federal Acquisition System satisfies the customer in terms of cost, quality, and timeliness of the delivered product or service by, for example --
(i) Maximizing the use of commercial products and services;
(ii) Using contractors who have a track record of successful past performance or who demonstrate a current superior ability to perform; and

For small supply items a contract can be fairly simple. For larger items, and items developed specifically to the unique needs of the department of Defense, as acquisition contract can be billions of dollars over decades of time. Basically, there are 2 broad types of contracts, as defined below and categorized in the following figure.

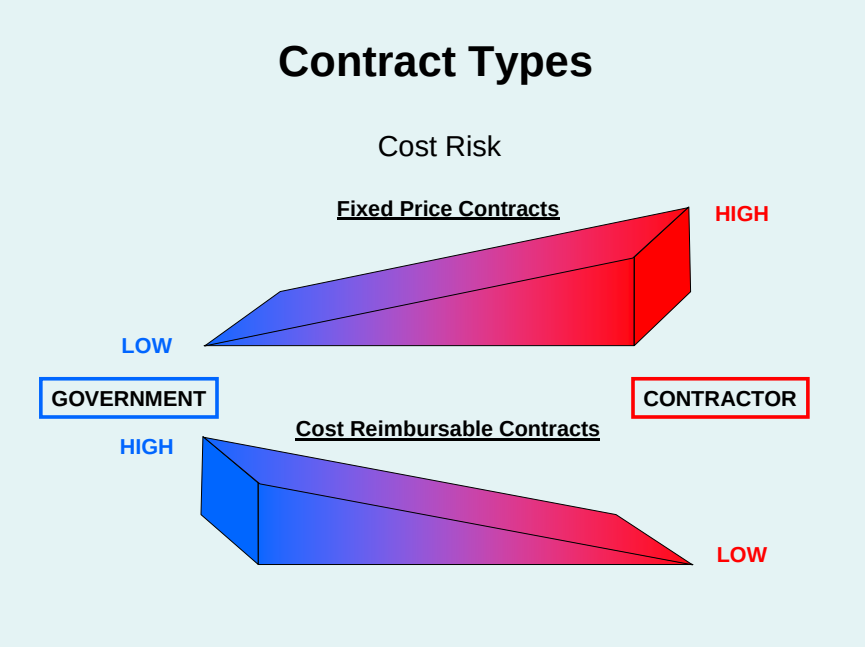
**CPIF = Cost Plus Incentive Fee.** A cost-reimbursement contract that provides for the initially negotiated fee to be adjusted later by a formula based on the relationship of total allowable costs to total target costs. This contract type specifies a target cost, a target fee, minimum and maximum fees, and a fee adjustment formula. After contract performance, the fee payable to the contractor is determined in accordance with the formula. The formula provides, within limits, for increases in fee above target fee when total allowable costs are less than target costs, and decreases in fee below target fee when total allowable costs exceed target costs. This increase or decrease is intended to provide an incentive for the contractor to manage the contract effectively. When total allowable cost is greater or less than the range of costs within which the fee-adjustment formula operates, the contractor is paid total allowable costs, plus the minimum or maximum fee.

**CPFF = Cost Plus Fixed Fee:** Fee does not vary with actual costs

**CPAF = Cost Plus Award Fee** Permits a subjective unilateral decision for amount of fee to be awarded. Must have award fee plan, evaluators. Fee pool determined up front. May have a base fee and the award is in addition to the base.

**FFP = Firm Fixed Price.** Provides for a price that is not subject to any adjustment on the basis of the contractor's cost experience in performing the contract. This type of contract places upon the contractor maximum risk and full responsibility for all costs and resulting profit or loss. Provides maximum incentive for the contractor to control costs, and imposes a minimum administrative burden on the government.

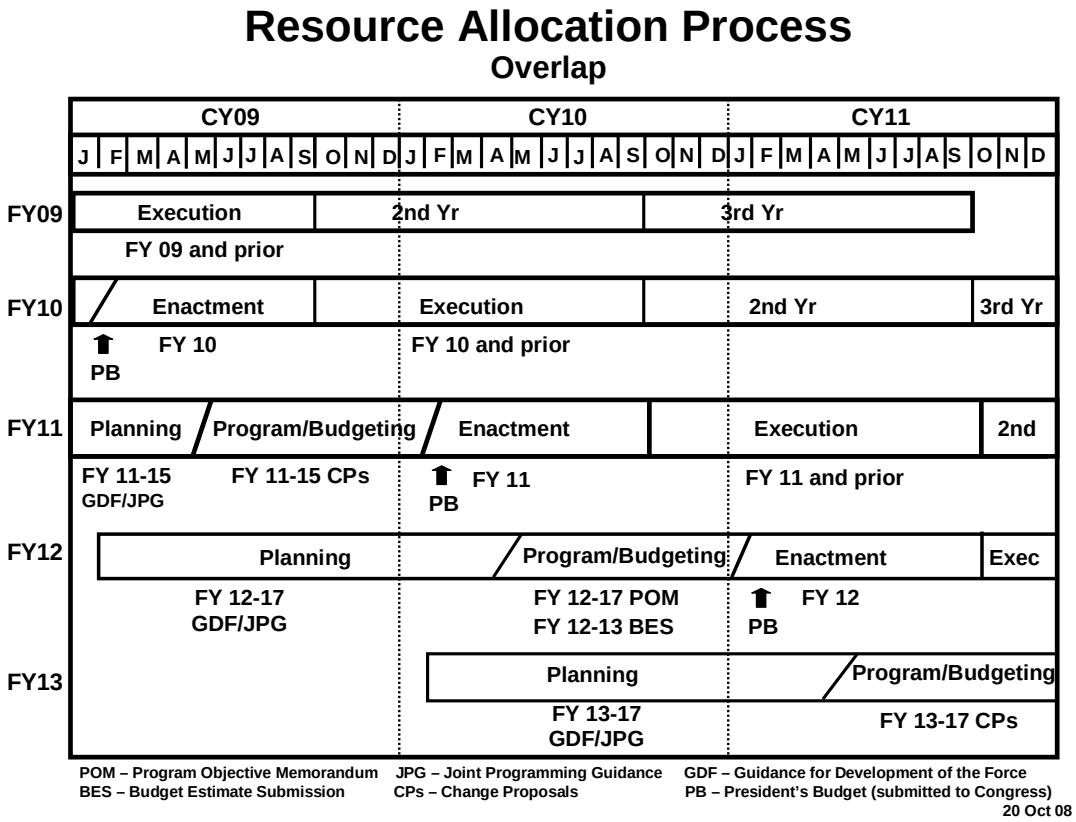
There are other contract variations besides these… Award Term, Fixed Price Incentive, etc. A table of other variations will be provided during the course, or go to the DAU ACC Contracting Community of Practice.




**ASSISTANCE INSTRUMENTS** consist of special contracting mechanisms used primarily in S&T for pure research, university activities, and others, which will be discussed during the course. Type of assistance instruments are grants, other transactions, Cooperative R&D Agreements (CRADA)

## 5. PLANNING, PROGRAMMING, BUDGETING & EXECUTION (PPBE) PROCESS, as demonstrated in the Five-year Resource Allocation Process:

The Resource Allocation Process shows the ongoing PPBE process across the DoD Five-Year Defense Plan (FYDP). Developing future year budgets while updating near term budgets and managing present-year activities can be confusing and seemingly chaotic. When done in the context of technology programs, the risk of unknown technology complications makes it even more of an art, but an essential component of any government activity.




(Go to the Introduction to Defense Acquisition Management, DAU Press, 2005, for a detailed explanation of the RAP. Available on the STM303 pre-course site.)

## 7. THE COLOR OF $

When appropriated by Congress thru the PPBE process for DoD, funding is generally broken down into specific major appropriation categories. Category 6 is military Research, Development, Test & Evaluation (RDT&E) funding, which consists of all funding authorized for Science & Technology activities and the acquisition of all military equipment. Category 6 has 7 budget activities (BA); BA1 thru BA7, or also 6.1 through 6.7, as further explained below. S&T is defined as BA 1 through BA 3. Acquisition is BA 4 through BA 7.

- **Basic Research (6.1)** is a systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts. E.g. research into the basic properties of a material, or an effect, such as properties of microwaves, charge in a silicon microchip foundation or new radar signal generation

- **Applied Research (6.2)** is systematic study to gain knowledge or understanding necessary to determine the means by which a recognized or specific need may be met. E.g. applying the gained knowledge to develop a prototype, such as a laboratory microwave generator, silicon microchip with

limited transistors to evaluate the new properties, or a new radar emitter in the lab

- **Advanced Technology Development (6.3)** includes all efforts that have moved into the development and integration of hardware for field experiments and tests. E.g. developing a prototype microwave generator for field testing, full 64Kb packaged microchip or a field radar test. Essentially taking existing technologies and integrating them for a new application or capability.

- **Advanced Component Development and Prototypes (6.4**) E.g. efforts necessary to evaluate integrated technologies, representative modes or prototype systems in a high fidelity and realistic operating environment are funded in this budget activity. Emphasis is on proving component and subsystem maturity prior to integration in major and complex systems and may involve risk reduction initiatives involving efforts prior to Milestone B.

- **System Development and Demonstration (6.5)** Funding for programs that have passed Milestone B approval and are conducting engineering and manufacturing development tasks for meeting validated requirements prior to FRP. Characterized by major line item projects and program control is exercised by review of individual programs and projects. Prototype performance is near or at planned operational system levels.

- **Operational System Development (6.7)** E.g. budget activity includes development efforts to upgrade systems that have been fielded or have received approval for full rate production and anticipate production funding in the current or subsequent fiscal year. All items are major line item projects that appear as RDT&E Costs of Weapon System Elements in other programs and have received Milestone C approval.

- **RDT&E Management Support (6.6)** E.g. RDT&E efforts and funds to sustain and/or modernize the installations or operations required for general research, development, test and evaluation. Test ranges, military construction, maintenance support of laboratories, operation and maintenance of test aircraft and ships, and studies and analyses in support of the RDT&E program are funded in this budget activity, including military contruction (MilCon) related to major development programs. BA 6.6 can be applied across the acquisition processes which are primarily funded by 6.4 thru 6.7.

## 8. EARNED VALUE MANAGEMENT PRINCIPLES

“Earned value is a management (EVM) technique that relates resource planning to schedules and to technical cost and schedule requirements. All work is planned, budgeted, and scheduled in time-phased "planned value" increments constituting a cost and schedule measurement baseline. There are two major

objectives of an earned value system: to encourage contractors to use effective internal cost and schedule management control systems; and to permit the customer to be able to rely on timely data produced by those systems for determining product-oriented contract status." (DAU EVM Community of Practice, https://acc.dau.mil/evm) EVM is required in all DoD acquisition programs as part of its business management, and has been found to be an increasingly useful tool by the technical side of program management.

The following DAU "EVM Gold Card" is a handout used in many DAU courses (and usually printed on gold card stock). It summarizes the principles of the EVM system (EVMS). Any project has a budget and schedule based on the plan of tasks to get accomplished and sequence in which they must be accomplished. Planning is critical, and the resources, manpower, knowledge skills and abilities, equipment, facilities, test ranges, laboratory test equipment, etc., must all be planned for and properly resourced. Once that is done, then the sequencing of what must happen, and the funding necessary to make it happen can be determined. Once the plan is complete, the EVMS concepts of planned value, earned value and actual costs (BCWS, BCWP and ACWP, respectively, as explained on the Gold Card.) Since all activities, resources and project progress are summarized into financial terms, and equated onto an easy to read scale, in its strategic form, technical managers can use EVM to monitor their project's performance and engineers find it a way to understand what the business managers are tracking, and the project progresses better.

## 9. TECHNOLOGY READINESS LEVELS

**DEFINITION:** Technology Readiness Level (TRL): A measure used to assess the maturity of evolving technologies (materials, components, devices, etc.) prior to incorporating that technology into a system or subsystem. Once the technology is sufficiently proven, it can be incorporated into a system/subsystem.

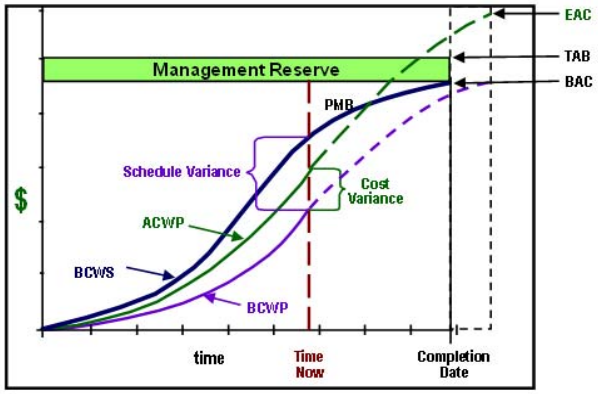
**Primary Purpose**: to help management make decisions concerning the development and transition of technology.

**Uses of Technology Readiness Levels (TRLs):**

a. Provides a common understanding of technology status (maturity)
b. Conveys what has been accomplished (demonstrated) with the technology
c. Used as a factor in technical risk management
d. Used to make decisions concerning technology funding
e. Used to make decisions concerning transition of technology
f. Used to scope acquisition programs and their requirements
g. Used as a basis for certification under statute

# Earned Value Management
# 'Gold Card'

Defense Acquisition University




**VARIANCES** Favorable is Positive, Unfavorable is Negative

| | | | |
|---|---|---|---|
| Cost Variance | CV | = BCWP – ACWP | CV % = (CV / BCWP) * 100 |
| Schedule Variance | SV | = BCWP – BCWS | SV % = (SV / BCWS) * 100 |
| Variance at Completion | VAC | = BAC – EAC | |

**OVERALL STATUS**

| | |
|---|---|
| % Schedule | = ($BCWS_{CUM}$ / BAC) * 100 |
| % Complete | = ($BCWP_{CUM}$ / BAC) * 100 |
| % Spent | = ($ACWP_{CUM}$ / BAC) * 100 |

**DoD TRIPWIRE METRICS** Favorable is > 1.0, Unfavorable is < 1.0

| | | |
|---|---|---|
| Cost Efficiency | CPI | = BCWP / ACWP |
| Schedule Efficiency | SPI | = BCWP / BCWS |

**BASELINE EXECUTION INDEX (BEI) (Schedule Metric)**

BEI = # of Baseline Tasks Actually Completed / # of Baseline Tasks Scheduled for Completion

**CRITICAL PATH LENGTH INDEX (CPLI) (Schedule Metric)**

CPLI = (Critical Path Duration + Float Duration $_{\text{(to baseline finish)}}$) / Critical Path Duration

**TO COMPLETE PERFORMANCE INDEX (TCPI) # §**

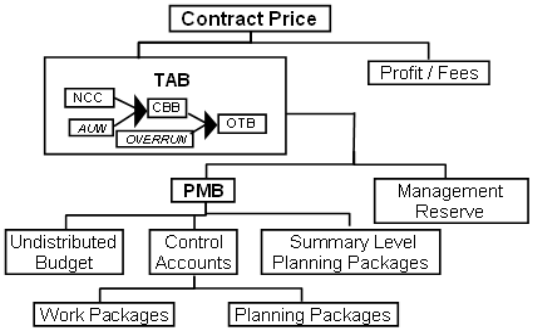
$TCPI_{EAC}$ = Work Remaining / Cost Remaining = (BAC – $BCWP_{CUM}$) / (EAC – $ACWP_{CUM}$)

**ESTIMATE AT COMPLETION** #

| | | |
|---|---|---|
| EAC | = Actuals to Date | + [(Remaining Work) / (Efficiency Factor)] |
| $EAC_{CPI}$ | = $ACWP_{CUM}$ | + [(BAC – $BCWP_{CUM}$) / $CPI_{CUM}$] = BAC / $CPI_{CUM}$ |
| $EAC_{Composite}$ | = $ACWP_{CUM}$ | + [(BAC – $BCWP_{CUM}$) / ($CPI_{CUM}$ * $SPI_{CUM}$)] |

# To Determine a Contract Level TCPI or EAC; You May Replace BAC with TAB

§ To Determine the $TCPI_{BAC\ or\ LRE}$ Replace EAC with either BAC or LRE




**TERMINOLOGY**

| | | |
|---|---|---|
| **NCC** | Negotiated Contract Cost | Contract price less profit / fee(s) |
| **AUW** | Authorized Unpriced Work | Work contractually approved, but not yet negotiated / definitized |
| **CBB** | Contract Budget Base | Sum of NCC and AUW |
| **OTB** | Over Target Baseline | Sum of CBB and recognized overrun |
| **TAB** | Total Allocated Budget | Sum of all budgets for work on contract = NCC, CBB, or OTB |
| **BAC** | Budget At Completion | Total budget for total contract thru any given level |
| **PMB** | Performance Measurement Baseline | Contract time-phased budget plan |
| **MR** | Management Reserve | Budget withheld by Ktr PM for unknowns / risk management |
| **UB** | Undistributed Budget | Broadly defined activities not yet distributed to CAs |
| **CA** | Control Account | Lowest CWBS element assigned to a single focal point to plan & control scope / schedule / budget |
| **WP** | Work Package | Near-term, detail-planned activities within a CA |
| **PP** | Planning Package | Far-term CA activities not yet defined into WPs |
| **BCWS** | Budgeted Cost for Work Scheduled | Value of work planned to be accomplished = PLANNED VALUE |
| **BCWP** | Budgeted Cost for Work Performed | Value of work accomplished = EARNED VALUE |
| **ACWP** | Actual Cost of Work Performed | Cost of work accomplished = ACTUAL COST |
| **EAC** | Estimate At Completion | Estimate of total cost for total contract thru any given level; may be generated by Ktr, PMO, DCMA, etc. = $EAC_{Ktr\ /\ PMO\ /\ DCMA}$ |
| **LRE** | Latest Revised Estimate | Ktr's EAC or $EAC_{Ktr}$ |
| **SLPP** | Summary Level Planning Package | Far-term activities not yet defined into CAs |
| **TCPI** | To Complete Performance Index | Efficiency needed from 'time now' to achieve an EAC |

**EVM POLICY:** **DoDI 5000.2, Table E3.T2 . EVMS in accordance with ANSI/EIA-748 is required for cost or incentive contracts, subcontracts, intra-government work agreements, & other agreements valued ≥ $20M (Then-Yr $). EVMS contracts ≥ $50M (TY $) require that the EVM system be formally validated by the cognizant contracting officer. Additional Guidance in Defense Acquisition Guidebook and the Earned Value Management Implementation Guide (EVMIG). EVMS is discouraged on Firm-Fixed Price, Level of Effort, & Time & Material efforts regardless of cost.**

**EVM CONTRACTING REQUIREMENTS:**

**Non-DoD FAR Clauses – Solicitation – 52.234-2 (Pre-Award IBR) or 52.234-3 (Post Award IBR)**
**– Solicitation & Contract – 52.234-4**

**DoD (≥ $20M) DFAR Clauses - 252.234-7001 for solicitations and 252.234-7002 for solicitations & contracts**

**Contract Performance Report – DI-MGMT-81466A*** 5 Formats (WBS, Organization, Baseline, Staffing & Explanation)

**Integrated Master Schedule – DI-MGMT-81650*** (Mandatory for DoD EVMS contracts)

**Integrated Baseline Review (IBR) - Mandatory for all EVMS contracts**

* See the EVMIG for CPR and IMS tailoring guidance.

**EVM Home Page = https://acc.dau.mil/evm eMail Address: EVM.dau@dau.mil**
**DAU POC: (703) 805-5259 (DSN 655)**
**Revised April 2008**

**Other technical measures are also important, which MAY NOT be part of a TRL determination:**

| | |
|---|---|
| Performance envelope of the technology | Systems engineering and technology integration |
| Difficulty of work to be done | Technology usefulness or appropriateness |
| Systems Design | |

The TRL value **DOES NOT indicate** that the technology is right for the job or specific application**, only that, by itself, it has a certain level of maturity,** without regard to its ability to integrate or interface with something else, an operating environment or operating constraints. (Maturity, e.g. stability, reliability of its technology application and degree of understanding of the principles.)

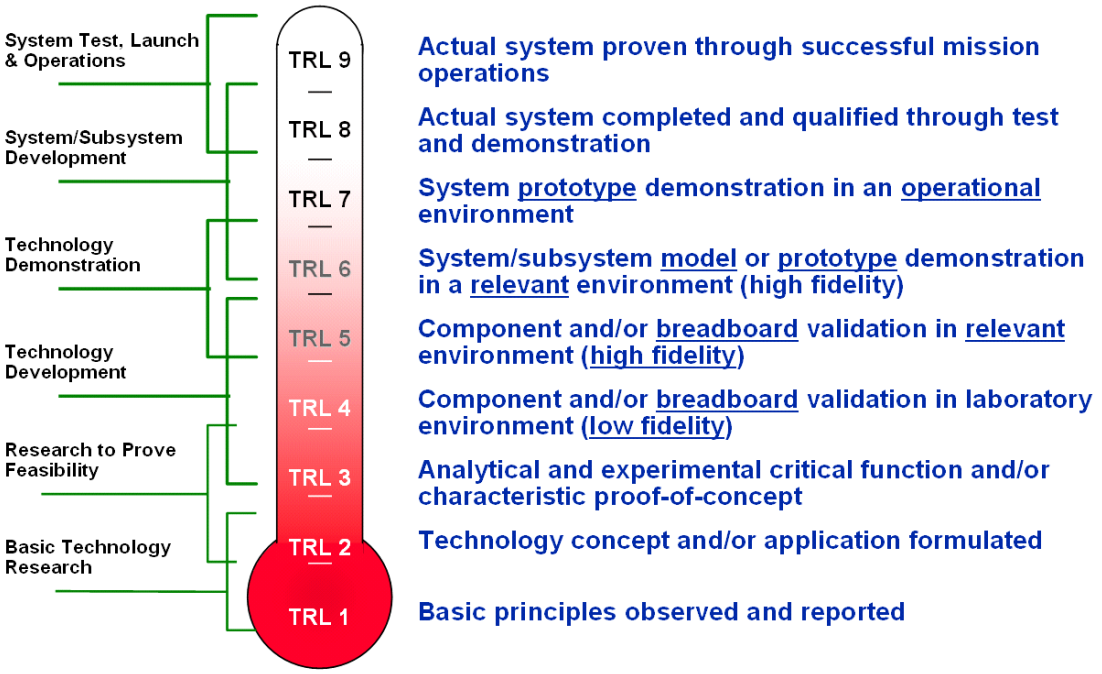
**9. THE NINE-POINT TRL SCALES FOR HARDWARE AND SOFTWARE** as defined and discussed in the DoD Technology Readiness Assessment Deskbook, June 05 and the Defense Acquisition Guidebook (DAG).

**TRL Definitions:**

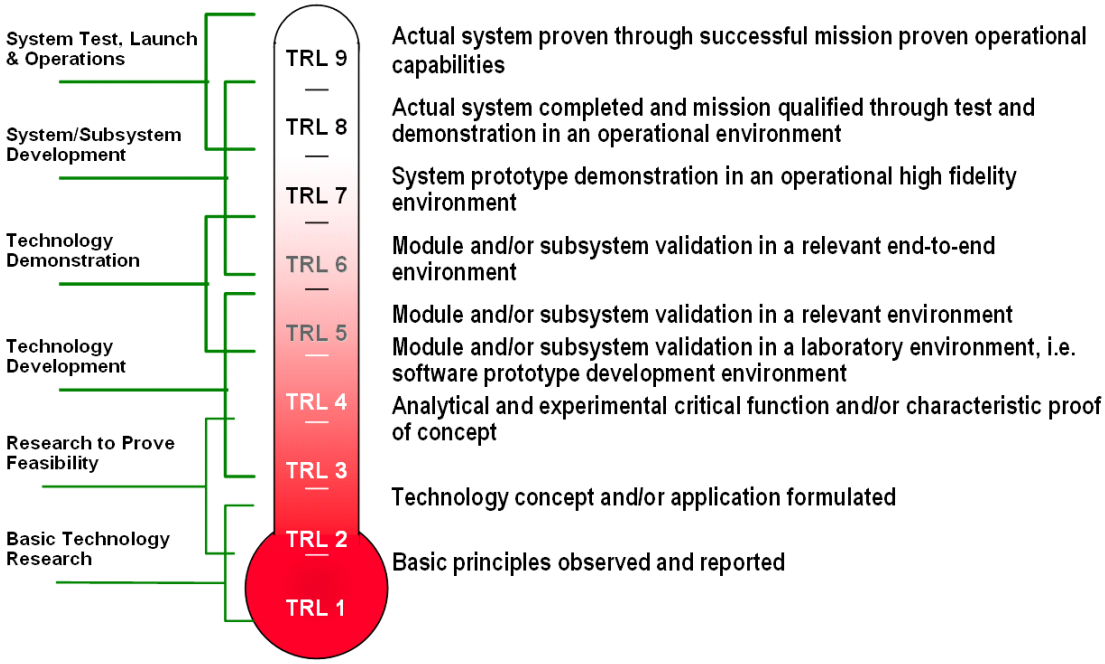
**BREADBOARD**: Integrated components that provide a representation of a system/subsystem and which can be used to determine concept feasibility and to develop technical data. Typically configured for laboratory use to demonstrate the technical principles of immediate interest. May resemble final system/subsystem in function only, since the use of a breadboard is to allow temporary wiring and position of components to achieve functionality only.

**BRASSBOARD**: A level of integration above bread boarding, where an actual crude prototype is fabricated. Electronic circuit boards would be etched and actual metal would be bent. Called a brass board because of the ease of machining brass for a low-cost initial prototype part.

**"HIGH FIDELITY**": Addresses form, fit and function. High fidelity laboratory environment would involve testing with equipment that can simulate and validate all system specifications within a laboratory setting.




**Measuring Hardware Technology Maturity**




**Measuring Software Readiness Maturity**

**"LOW FIDELITY"**: A representative of the component or system that has limited ability to provide anything but first order information about the end product. Low fidelity assessments are used to provide trend analysis.

**MODEL**: A reduced scale, functional form of a system, near or at operational specification. Models will be sufficiently hardened to allow demonstration of the technical and operational capabilities required of the final system.

**OPERATIONAL ENVIRONMENT**: Environment that addresses all of the operational requirements and specifications required of the final system to include platform/packaging.

**PROTOTYPE**: The first early representation of the system which offers the expected functionality and performance expected of the final implementation. Prototypes will be sufficiently hardened to allow demonstration of the technical and operational capabilities required of the final system.

**RELEVANT ENVIROMENT**: testing environment that simulates the key aspects of the operational environment.

## 11. MANUFACTURING READINESS LEVELS

**DEFINITION:** Manufacturing Readiness Level (MRL): In a like manner a measure used to assess the maturity of evolving manufacturing capability required to produce the article defined by the technologies TRL description e.g. as the TRL level rises so must the corresponding MRL.

**Purpose:** Assess the readiness of the system for manufacturing. Manufacturing Readiness Levels (MRLs) Modeled after TRL's, except 10 levels of readiness assessing 9 area / functional "threads."

**Benefits:**

Identification of Production Risks & development of Risk Mitigation Plans.

Implementation of Manufacturing Planning and Process Improvement Activities

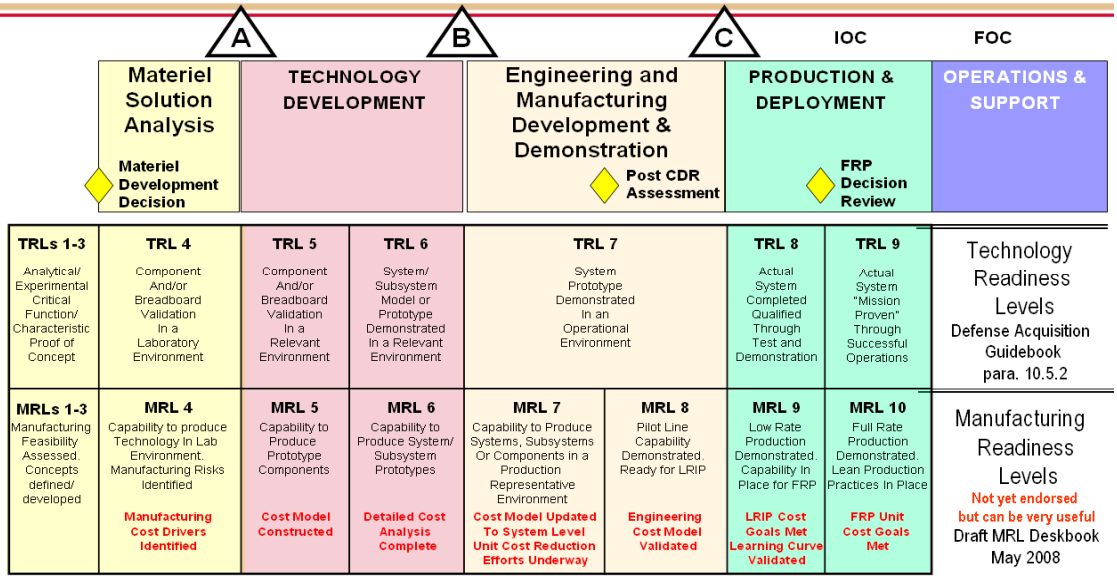
# MRL Levels & Definitions

| MRL | Definition | Phase |
|---|---|---|
| 1-4 | Manufacturing concepts identified in a laboratory | Pre Concept Refinement |
| 5 | Manufacturing capability maturing to production representative environment. | Tech. Development |
| 6 | Manufacturing capability in a production-representative environment. | TD - MS B decision. |
| 7 | Manufacturing capability maturing towards LRIP | SDD / DRR |
| 8 | Manufacturing capability ready for LRIP | SDD - MS C |
| 9 | Manufacturing capability ready for FRP | P&D - FRP |
| 10 | Manufacturing capability in ready for lean production. | FRP Sustainment |

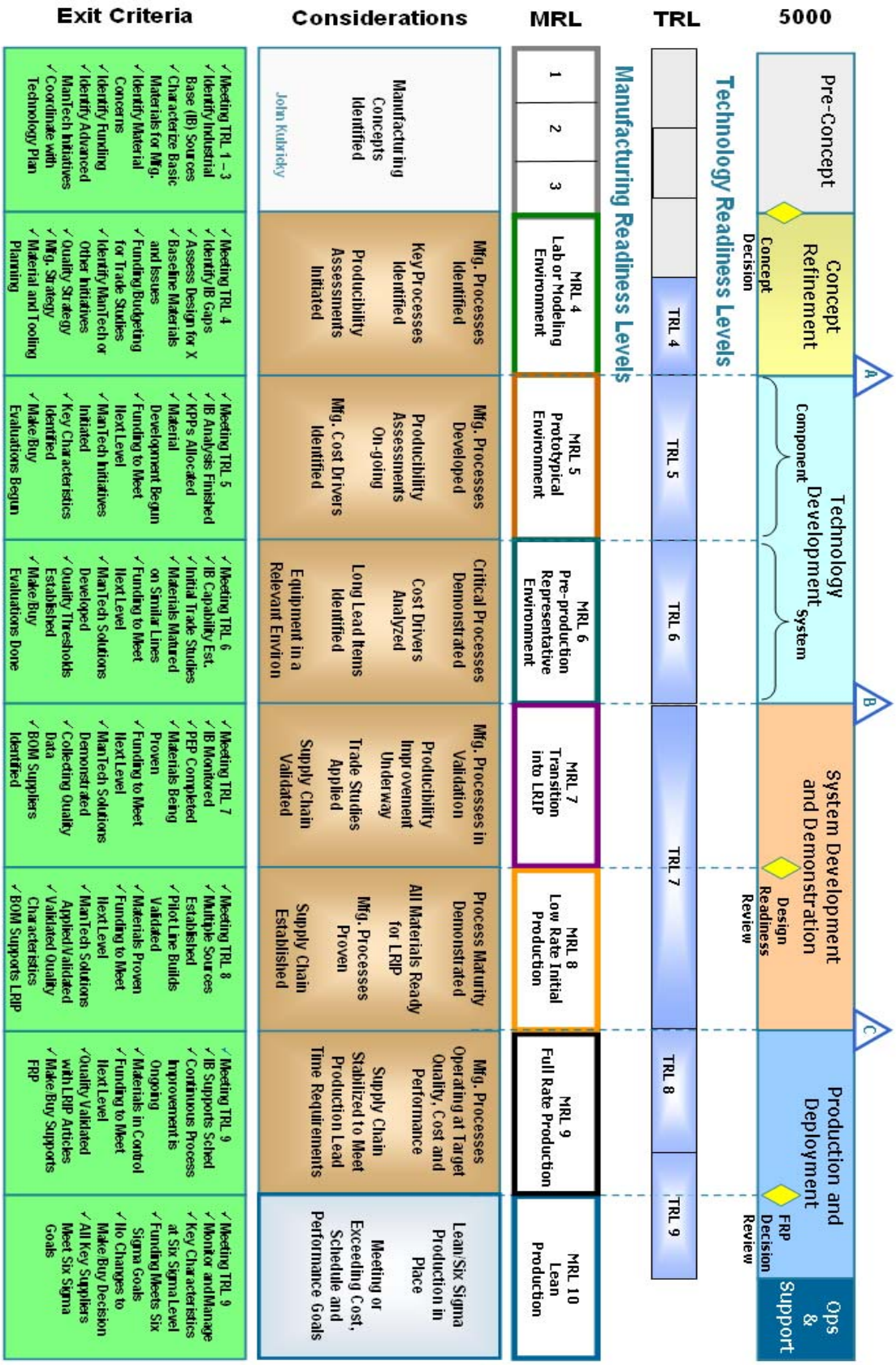
As introduced in the DoD TRA Deskbook, June 2005, and developed in the Manufacturing Readiness Assessment (MRA) Deskbook, 29 May 2008,
by the Joint Defense Manufacturing Technology Panel (JDMTP).

## Technology and Manufacturing Readiness

Defense Acquisition University




Section 2366a of Title 10, United States Code, requires certification that: the **technology** in the program has been demonstrated in a **relevant** environment to enter Milestone B. [TRL 6]


5000
TRL
MRL
Considerations
Exit Criteria
Pre-Concept
Concept Refinement
Technology Development
System Development and Demonstration
Production and Deployment
Ops & Support
Concept Decision
Component
System
Design Readiness Review
FRP Decision Review
A
B
C
Technology Readiness Levels
Manufacturing Readiness Levels
TRL 4
TRL 5
TRL 6
TRL 7
TRL 8
TRL 9
1
2
3
MRL 4 Lab or Modeling Environment
MRL 5 Prototypical Environment
MRL 6 Pre-production Representative Environment
MRL 7 Transition into LRIP
MRL 8 Low Rate Initial Production
MRL 9 Full Rate Production
MRL 10 Lean Production
Manufacturing Concepts Identified
Key Processes Identified
Producibility Assessments Initiated
Mfg. Processes Identified
Producibility Assessments On-going
Mfg. Cost Drivers Identified
Mfg. Processes Developed
Cost Drivers Analyzed
Long Lead Items Identified
Equipment in a Relevant Environ
Critical Processes Demonstrated
Producibility Improvement Underway
Trade Studies Applied
Supply Chain Validated
Mfg. Processes in Validation
All Materials Ready for LRIP
Mfg. Processes Proven
Supply Chain Established
Process Maturity Demonstrated
Supply Chain Stabilized to Meet Production Lead Time Requirements
Mfg. Processes Operating at Target Quality, Cost and Performance
Meeting or Exceeding Cost, Schedule and Performance Goals
Lean/Six Sigma Production in Place
John Kukwicky
✓Meeting TRL 1 – 3
✓Identify Industrial Base (IB) Sources
✓Characterize Basic Materials for Mfg.
✓Identify Material Concerns
✓Identify Funding
✓Identify Advanced ManTech initiatives
✓Coordinate with Technology Plan
✓Meeting TRL 4
✓Identify IB Gaps
✓Assess Design for X
✓Baseline Materials and Issues
✓Funding Budgeting for Trade Studies
✓Identify ManTech or Other Initiatives
✓Quality Strategy
✓Mfg. Strategy
✓Material and Tooling Planning
✓Meeting TRL 5
✓IB Analysis Finished
✓KPPs Allocated
✓Material Development Begun
✓Funding to Meet NextLevel
✓ManTech Initiatives Initiated
✓Key Characteristics Identified
✓Make Buy Evaluations Begun
✓Meeting TRL 6
✓IB Capability Est.
✓Initial Trade Studies
✓Materials Matured on Similar Lines
✓Funding to Meet NextLevel
✓ManTech Solutions Developed
✓Quality Thresholds Established
✓Make Buy Evaluations Done
✓Meeting TRL 7
✓IB Monitored
✓PEP Completed
✓Materials Being Proven
✓Funding to Meet NextLevel
✓ManTech Solutions Demonstrated
✓Collecting Quality Data
✓BOM Suppliers Identified
✓Meeting TRL 8
✓Multiple Sources Established
✓Pilot Line Builds Validated
✓Materials Proven
✓Funding to Meet NextLevel
✓ManTech Solutions Applied/Validated
✓Validated Quality Characteristics
✓BOM Supports LRIP
✓Meeting TRL 9
✓IB Supports Sched
✓Continuous Process Improvement is Ongoing
✓Materials in Control
✓Funding to Meet NextLevel
✓Quality Validated with LRIP Articles
✓Make Buy Supports FRP
✓Meeting TRL 9
✓Monitor andManage
✓Key Characteristics at Six Sigma Level
✓Funding Meets Six Sigma Goals
✓No Changes to
Make Buy Decision
✓All Key Suppliers Meet Six Sigma Goals

The above figure is a Lifecycle Comparison of TRL and MRL against the DoD Acquisition Management System by the Joint Defense Manufacturing Technology Panel (JDMTP). This figure still shows the Concept Refinement and System Development & Demonstration Phases, now called the Material solution Analysis and Engineering & Manufacturing Development (EMD) Phases under the new DoDI 5000.02.

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## Emerging Transition Tools

**INTEGRATION READINESS LEVEL (IRL) A technology readiness level** only indicates the isolated maturity of a technology, not whether it will fit or work in a specific system or operational environment. With the increasing complexity of modern systems, INTEGRATION is becoming a critical issue, once the technology itself is mature, i.e. stable, reliable and understood to a sufficient degree for use in a deployed manner. The concept of developing a similar scale for integration has been under study in DoD and NASA for a number of years. Still very much only an initial concept, IRLs have not yet been even postulated in DoD, and therefore not mature enough to use as a transition tool.

**IRL DRAFT DEFINITION**: When the TRL of an evolving technology is raised to a point where it can be produced under a corresponding MRL level and is ready to be incorporated into an existing system or subsystem, the measure of maturity of each to accept the other and be fully mission integrated. This capability is an integration readiness level.

**A System Readiness Level (SRL)** scale is also being postulated in NASA, which integrates individual systems or extensive elements of a system into its full operating system, such as a satellite constellation and its requisite ground stations.

IRLs and SRLs are **not** used in this course, but refer to when the system is operationally ready and ready for deployment and its manufacturability is verified.

Anyone interested in more information on IRL or SRL should Google these concepts. Some research is already documented, especially in NASA and its supporting research at the Stevens Institute of Technology.

--- **End of Summary of Selected Technology Project Management Tools ---**