The George Washington University

LOCKHEED MARTIN

A Review and Analysis of Maturity Assessment Approaches for Improved Defense Acquisition Decision Support

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Nazanin Azizian

Presentation Overview

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3. Knowledge Gaps
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    - *B. Consequences*
    - *C. How to Close*
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5. Technology Maturity
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    - *B. Technology Readiness Level (TRL)*
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6. Introduction to Other Tech Maturity Assessment Methods
7. SWOT (Strength, Weakness, Threat, Opportunity) Analysis
8. Conclusions & Recommendations

Introduction

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The Department of Defense (DoD) acquisition programs have a long history of experiencing various forms of risk

DoD is experiencing consequences of risk in the form of:

- **Cost overruns**
- ***Late deliveries***
- ***Failure to meet performance requirements***
- ***Program delays***
- ***Program cancellations***
- ***Failure to deliver promised capabilities***

Underlying causes of risk:

- **Unrealistic performance expectations**
- ***Unrealistic baseline estimates for cost or schedule***
- ***Immature technologies***
- ***Evolving requirements***
- ***Changes in procurement quantities;***
- ***Funding instability;***

GAO, "Defense Acquisitions: Assessments of Selected Weapon Programs," U.S. Government Accountability Office, vol. GAO-08-467SP, GAO, Ed, 2008

GAO Assessments and Findings

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GAO assessments of Acquisition Programs concluded that risk in poorly performing DoD programs result from not possessing the knowledge required to achieve a successful design at key points during development.

Knowledge gaps result in DoD programs moving forward without sufficiently:

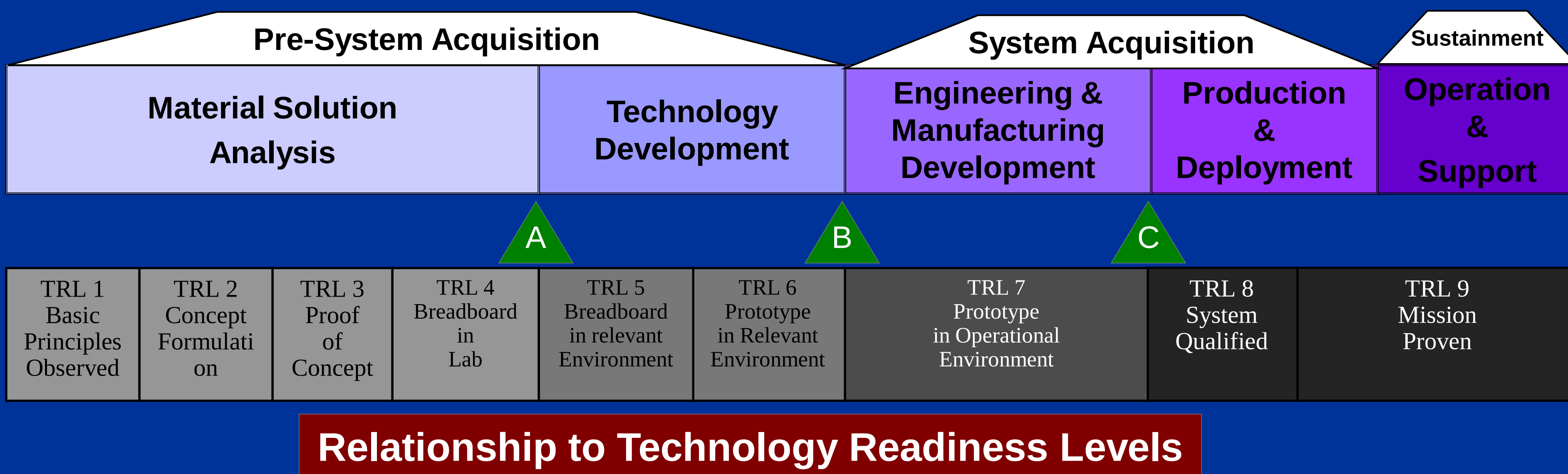
- *Maturing the new technologies,*
- *stabilizing the design, or*
- *maturing the manufacturing processes*

Multiple assessments (2000-2008) of the DoD acquisition portfolio concluded a strong correlation between delayed knowledge points and poor performance.

TRL Relationship to System Acquisition Milestones

DoD requires maturity assessment certification as entrance criteria for milestones B & C

Milestone B = TRL 6
Milestone C = TRL 7



2008 GAO Assessment of 72 Weapons Programs

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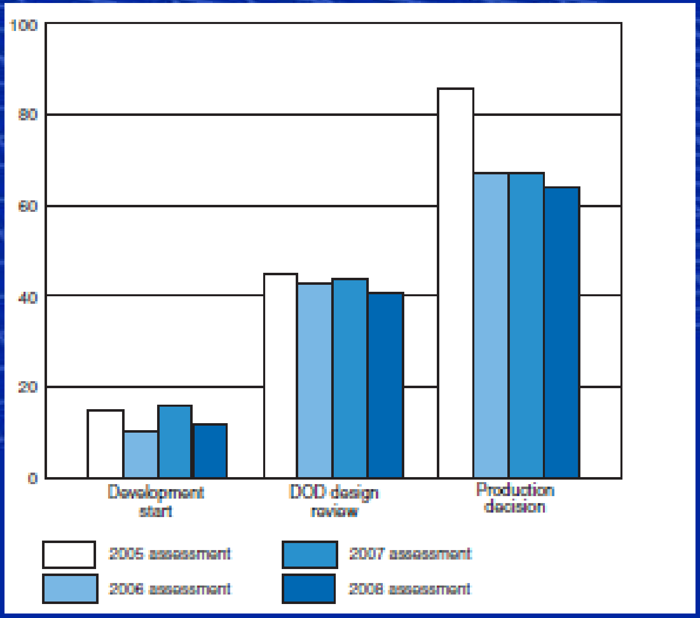
- **12%** began system development with fully mature critical technologies
- **4%** had demonstrated design stability before entering system demonstration phase
- **No** program had fully matured their production processes before entering production

Analysis of DOD Major Defense Acquisition Program
Fiscal year 2008

	Fiscal Year		
	2000 Portfolio	**2005 Portfolio**	**2007 Portfolio**
Number of Programs	75	91	95
Total Planned Commitments	$790 Billion	$1.5 Trillion	$1.6 Trillion
Commitments Outstanding	$380 Billion	$887 Billion	$858 Billion
	Portfolio Performance		
Change to total RDT&E costs from first estimate	27%	33%	40%
Change in total acquisition cost from first estimate	6%	18%	26%
Estimated total acquisition cost growth	$42 Billion	$202 Billion	$295 Billion
Share of programs with 25 percent or more increase in program acquisition unit cost	37%	44%	44%
Average schedule delay in delivering initial capabilities	16 Months	17 Months	21 Months



Percentage of Programs Achieving Technology Maturity at Key Junctures

Best Practices: Assessment of Selected Weapons Programs. GAO-08-467SP Washington, DC.: March 2008.

Basis of Knowledge Gaps

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Why do DoD programs enter various phases of acquisition and product development with knowledge gaps?

- Organizational drive for better, faster, cheaper warfare technologies
- Program risk management strategies allow for inherent risk
- Program financial methods punish delays in program start date

Why do DoD knowledge gaps result in design, technology, and production risks?

- Risk is typically underestimated by organizational leaders
- Programs take risk to maintain production start date to avoid political risks of delay (loss of funding)

System development challenges:

- ✓ Increasingly complex Systems
- ✓ Increased data demand requirements
- ✓ Operating in a net-centric environment
- ✓ System-of-System centric
- ✓ Rapid development cycle
- ✓ Rapid technology obsolescence
- ✓ Evolving/untradeable requirements

How to Close the Knowledge Gap

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1999 - GAO) stated in report that

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

2003 - DoDI 5000.02 (2003), para 3.7.2.2 required the inspection of technology maturity by stating

> ***"Objective assessment of technology maturity and risk shall be a routine aspect of DoD acquisition."***

2006 – Congressional legislation (Title 10, section)

- **Technology maturity must be assessed and certified to be adequate prior to MS B&C**

ACQUISITION TECHNOLOGY AND LOGISTICS

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3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

MAY 0 2 2006

MEMORANDUM FOR: SEE DISTRIBUTION

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

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

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

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

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

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

Attachment:
As stated

Technology Readiness Assessment (TRA)

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A TRA is a systematic, metrics-based process and accompanying report

The TRA assesses the Maturity of Critical Technology Elements

Critical Technology Elements (CTEs) are…

- *The system depends on this element to meet operational requirements*
- *The element or its application is either new or novel.*
- *Element poses major technological risk during detailed design or demonstration*

DoD standard tool for performing TRAs is Technology Readiness Level (TRL) metric

Technology Readiness Level (TRL)

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What is TRL?

- **Technology Readiness Level (TRL) is a 9 tier metric that systematically assess the maturity of a technology with respect to a particular use**

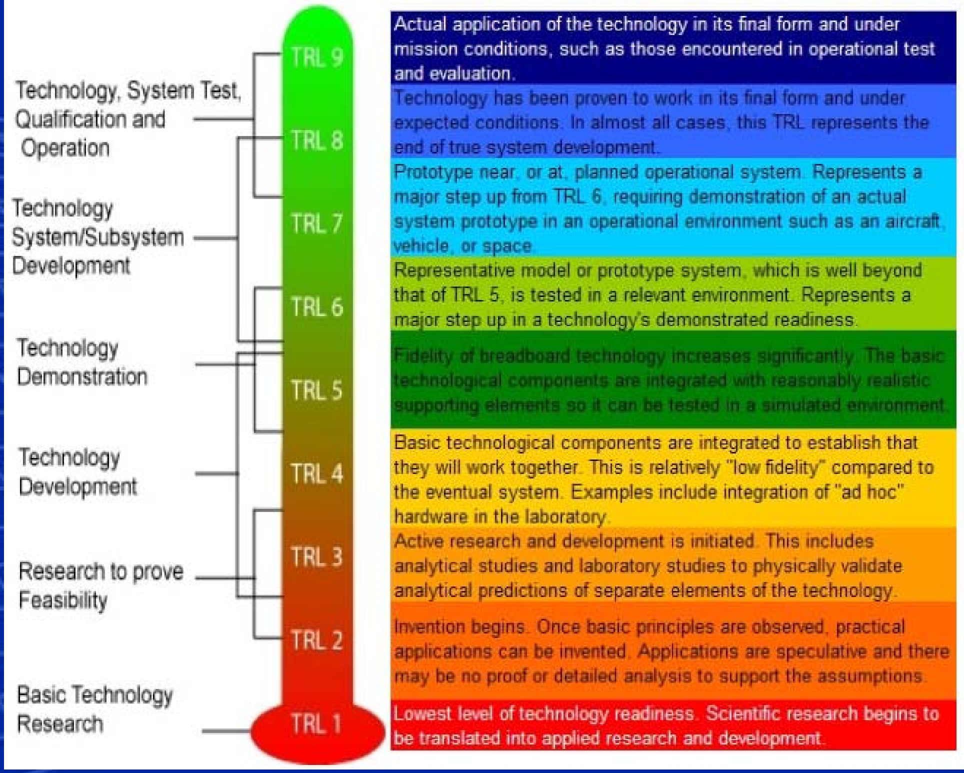
- **Pioneered by NASA in 1980's and adopted by the DoD in 2001**

Purpose of TRL

- **Provides a common language for understanding the developmental status of a technology to date**
- **Indicates the development maturity of a technology at a particular point in time**

TRL is *not for suitability*

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



Milestone B = TRL 6
Milestone C = TRL 7

TRL Limitations

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- Subjective Assessment - there exist no formal guideline of implementing TRLs; the TRL value is assigned to technology by a technology developer who may be biased; the definitions of each TRL level is prone to broad interpretation
- Not focused on system-to-system integration - TRLs focus on a component of a technology and when infusing the particular component with other in a larger scale, imperative integration concerns come forth
- Lacking in definition of terminology - the definitions of each TRL level can be ambiguous and reliant on an individual's interpretation
- Combines many dimensions of technology readiness into one metric
- Lacks accuracy and precision
- Conveys the status of technology readiness on a single scale at a particular point in time – does not foretell the possibility and difficulty of further maturing technology to higher TRL levels.

Rational for Other Methods

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TRLs are insufficient because they do not take into account many of DoD's system development needs

- ***large quantity manufacturing***
- ***Integration and rapid obsolescence***
- ***Increased system-of-system centricity***

To offset some of these issues, other models, tools, and methods have been developed

- ***GOAL - introduce objectivity and address the overlooked facets of technology maturity that have been omitted by the TRL***

Qualitative Techniques

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Tool	Description
Manufacturing Readiness Level (MRL)	The MRL is a 10 level scale used to define current level of manufacturing maturity , identify maturity shortfalls and associated risks, and provide the basis of manufacturing maturation and risk management (Cundiff 2003).
Integration Readiness Level (IRL)	The IRL is a 9 level scale intended to systematically measure the maturity, compatibility, and readiness of interfaces between various technologies and consistently compare interface maturity between multiple integration points. Further, it provides a means to reduce the uncertainty involved in maturing and integrating a technology into a system (Gove 2007).
TRL for non-system technologies	Expansion of the TRL definitions to account for non-system technologies such as processes, methods, algorithms, and architectures (Graettinger et al 2002).
TRL for Software	Expansion of the TRL metric to incorporate other attributes specific to software development (DoD TRA Deskbook 2005).
Technology Readiness Transfer Level (TRRL)	The TRRL is a 9 level scale describing the progress of technology transfer to a new application. It expands and modifies the TRL definitions to address the transfer to space technology into non-space system (Holt 2007) .

Tool	Description
Missile Defense Agency Checklist	A tailored verstion of the TRL metric specifically in support of hardware maturity through the development life-cycle of the product (Mahafza 2005).
Moorhouses Risk Versus TRL Metric	A 9 level metric mapping risk progression analogous to technology maturity progression. The TRL descriptions are tailored specifically toward UAV (Moorehouse 2002).
Advanced Degree of Difficulty (AD2)	Leveraging the concept of RD3, the AD2 augments TRLs by assessing the difficulty of advancing a technology from its current level to a desired level on a 9 tier scale (Bilbro 2007).
Research and Development Degree of Difficulty (RD3)	The RD3 is a 5 level scale intended to supplement the TRL by conveying the degree of difficulty involved in proceeding from the current TRL state to desired level, with 5 being very difficult and 1 being least difficult to mature the technology (Mankins 1998).

Quantitative Techniques

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Tool	Description
System Readiness Level (SRL)	The SRL is a normalized matrix of pair-wise comparisons of TRLs and IRL of a system. It is a quantitative method providing insight into system maturity as a product of IRL x TRL (Sauser et al. 2006, 2007, 2008) .
SRL Max	The SRL Max is a quantitative mathematical model aiming to maximize the SRL under constraint resources. The objective of the SRLmax is the achievement of the highest possible SRL based on the availability of resources such as cost and schedule (Ramirez-Marquez et al. 2009).
Technology Readiness and Risk Assessment (TRRA)	TRRA is a quantitative risk model that incorporates TRLs, the degree of difficulty (RD3) of moving a technology from one TRL to another, and Technology Need Value (TNV). The TRRA expands the concept of the risk matrix by integrating "probability of failure" on the y-axis and "consequence of failure" on the x-axis (Mankins 2007).
Integrated Technology Analysis Methodology (ITAM)	ITAM is a quantitative mathematical model that integrates various system metrics to calculate the cumulative maturity of a system based on the readiness of its constituent technologies. The system metrics include TRLs, delta TRL, R&D Degree of Difficulty (R&D3), and Technology Need Value (TND) (Mankins 2002).

Tool	Description
TRL for Non-Developmental Item (NDI) Software	A mathematical method to assess the maturity of Non-Developmental Item (NDI) software using orthogonal metrics in combination with a pair-wise comparison matrix to examine two equivalent technologies that are candidate for insertion into a system. Incorporate other attributes such as requirement satisfaction, environment fidelity, criticality, product availability, and product maturity (Smith
Technology Insertion (TI) Metric	TI involves the integration of various metrics that deal with insertion of technology and subsystems into a current system in order to develop an "enhanced system." The TI Metric is a high level metric computed from sub-metrics or dimensions intended to evaluate the risk and feasibility of technology insertion from a subsystem and a system level (Dowling and Pardo 2005).
TRL Schedule Risk Curve	This is a quantitative model that does not communicate the maturity of technology at a certain point in time but instead leverages the TRLs metric to identify the appropriate schedule margins associated with each TRL level in order to metigate schedule slipps (Dubos et al. 2007).

Automated Techniques

Tool	Description
Technology Readiness Level (TRL) Calculator	Microsoft excel based tool that enables the application of the TRL definitions to technology development. The calculator computes a TRL level based on the answers to a series of questions by the user and displays the output graphically (Nolte 2004).
Manufacturing Readiness Level (MRL) Calculator	Microsoft excel based tool that enables the application of the MRL definitions to technology development. Computes the MRL level based on answers to a series of questions in various threads related to manufacturing readiness.
Technology Program Management Model (TPMM)	TPMM is a technology-development activity model, partitioned into phases that are gate qualified using the TRLs. The model defines each TRL as a stage and establishes exit criteria (gate) for each stage of TRL. Each TRL stage has an associated checklist of activities that must be achieved before succeeding to the next stage. The TPMM is comprised of seven technology development phases (SMDTC 2006).
UK MoD Systrem Readiness Level	Captures key outputs from th nine levels of product development depicted by the Systems Engineering V-model in an excel-based tool. These outputs are confined and tracked in a matrix. Each output is evaluated on a 9 level SRL scale (http://www.ams.mod.uk/aofcontent/tactical/techman/content/srl_whatarethey.htm)

SWOT

(Strength, Weakness, Opportunity, Threat)

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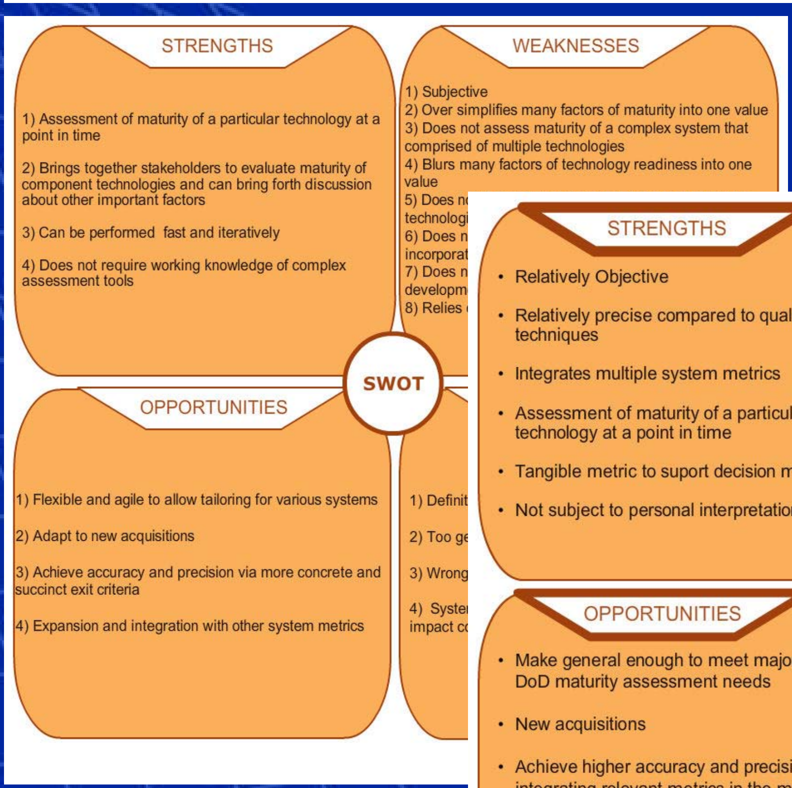
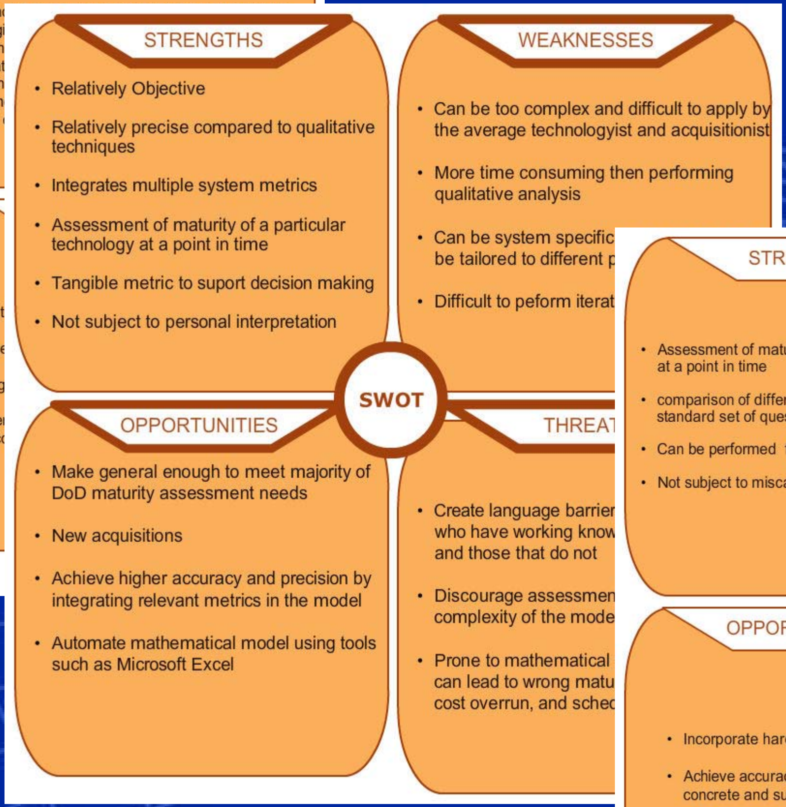
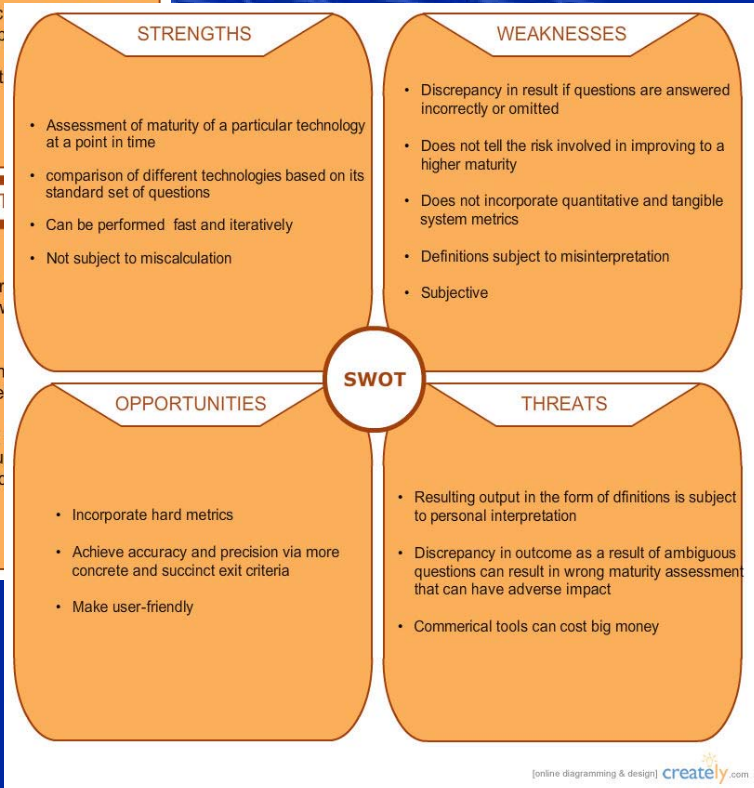
Qualitative Tools



Quantitative Tools



Auto Tools



Conclusion & Recommendations

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Evaluation of technology maturity is critical because it provides insight into technical and programmatic risk by:

- *Establishes milestones to track development progress*
- *Establishes entry and exit criteria for various milestones*
- *Provides direction for risk management and mitigation*

Objective and robust methods that can assess technology maturity accurately improve acquisition outcome

The success of programs depend on consistent and holistic evaluation of system maturity via a robust, repeatable and agile method

“Every dollar spent on inefficiencies in acquiring one weapon system is less money available for other opportunities.” (GAO 2006)