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Technology Program Management Model (TPMM) Overview

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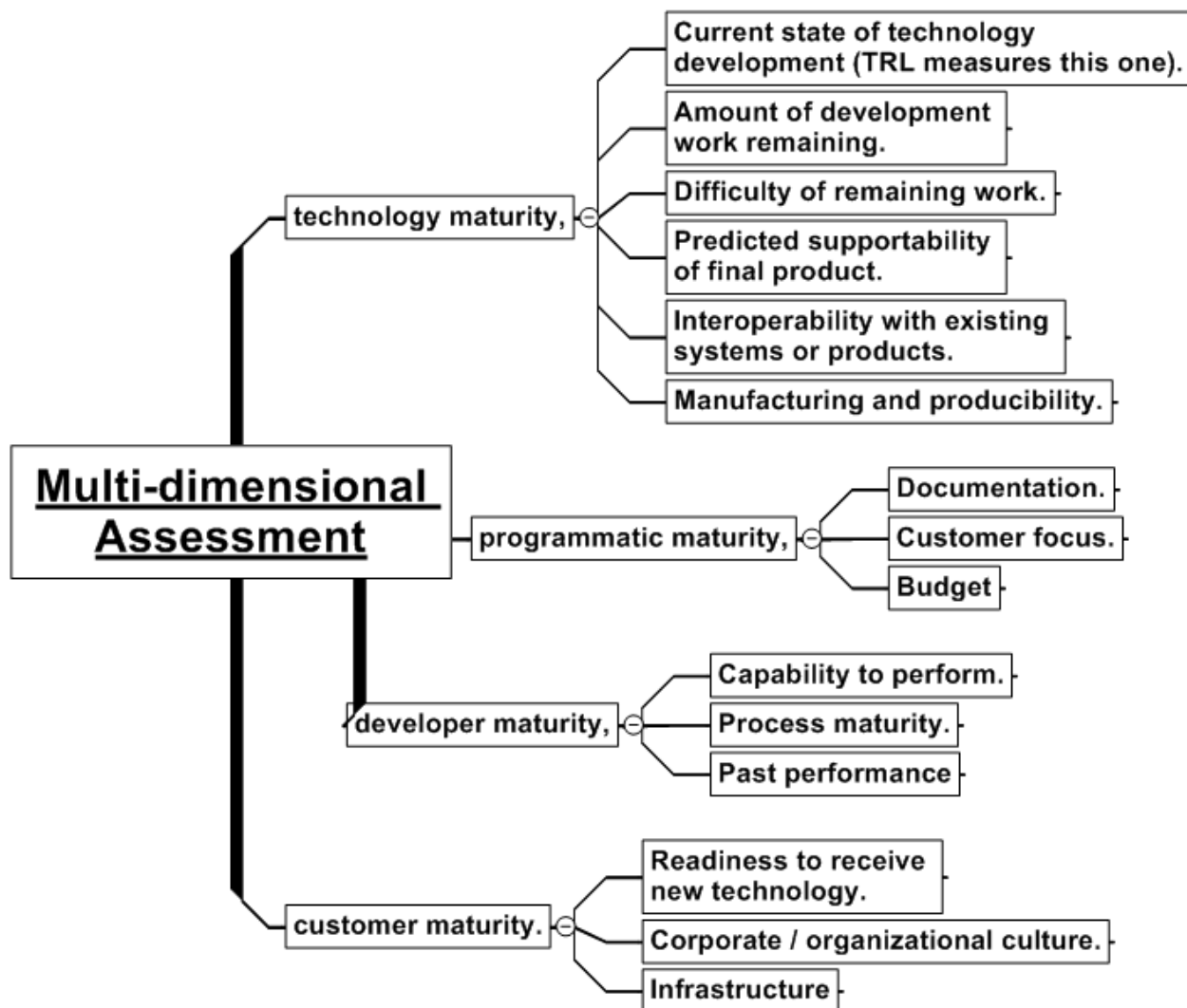
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Space and Missile Defense, Technical Center

Mission is to “Successfully *support the transition* of evolving and mature technologies to customers.”

Technology Program Management Model (TPMM)





Quantifying the Effects of Immature Technologies



According to a GAO review of 54 DoD programs:

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

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



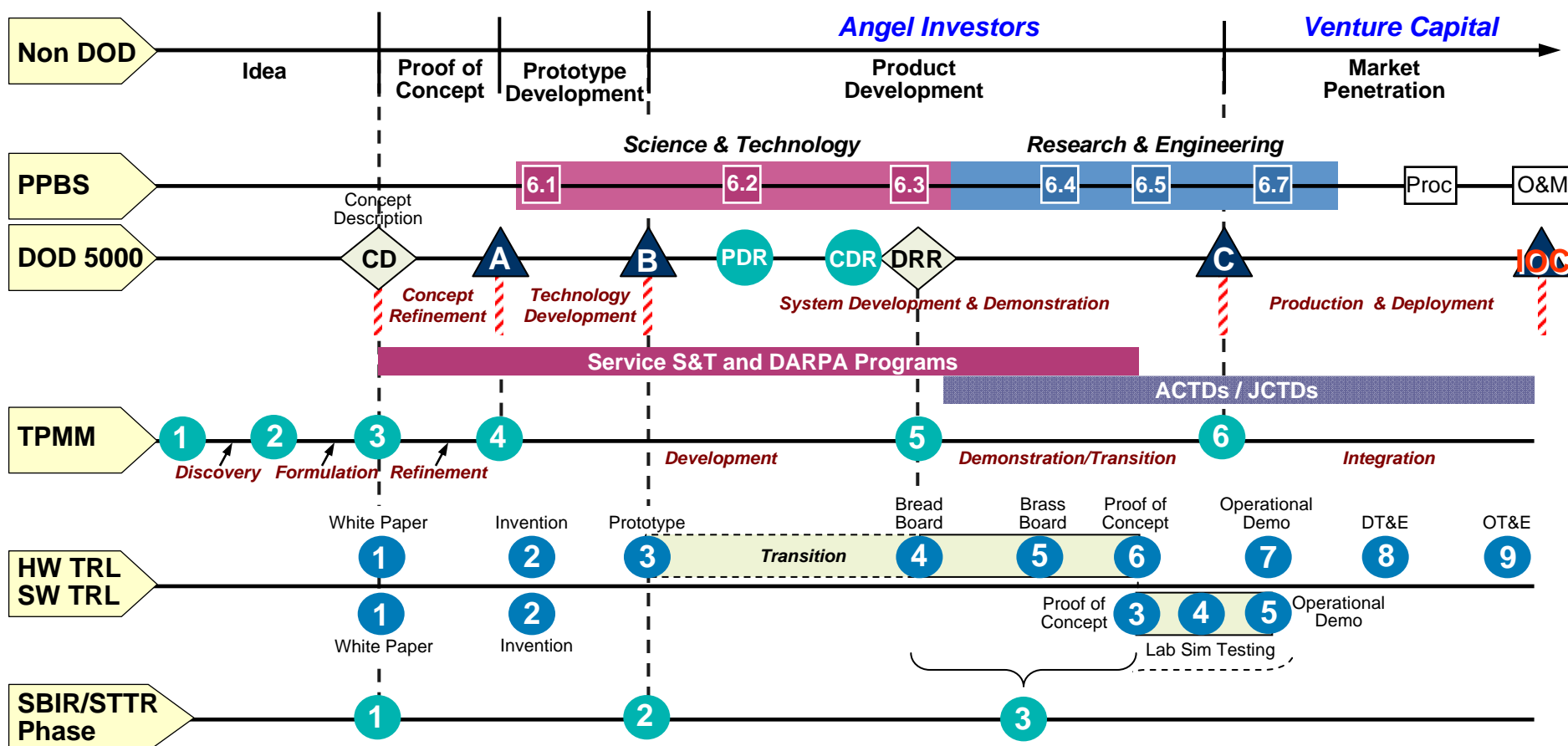
Competing Metrics in Program Development: Crosswalk



Technological Risk

Note: Relationships Are Approximations

Capital Requirements



LEGEND

SBIR - Small Business Innovative Research

TRL - Technology Readiness Level

TPMM - Technical Program Management Model

STTR - Small Business Technology Transition Research

PPBS - Planned Program Budget Execution System



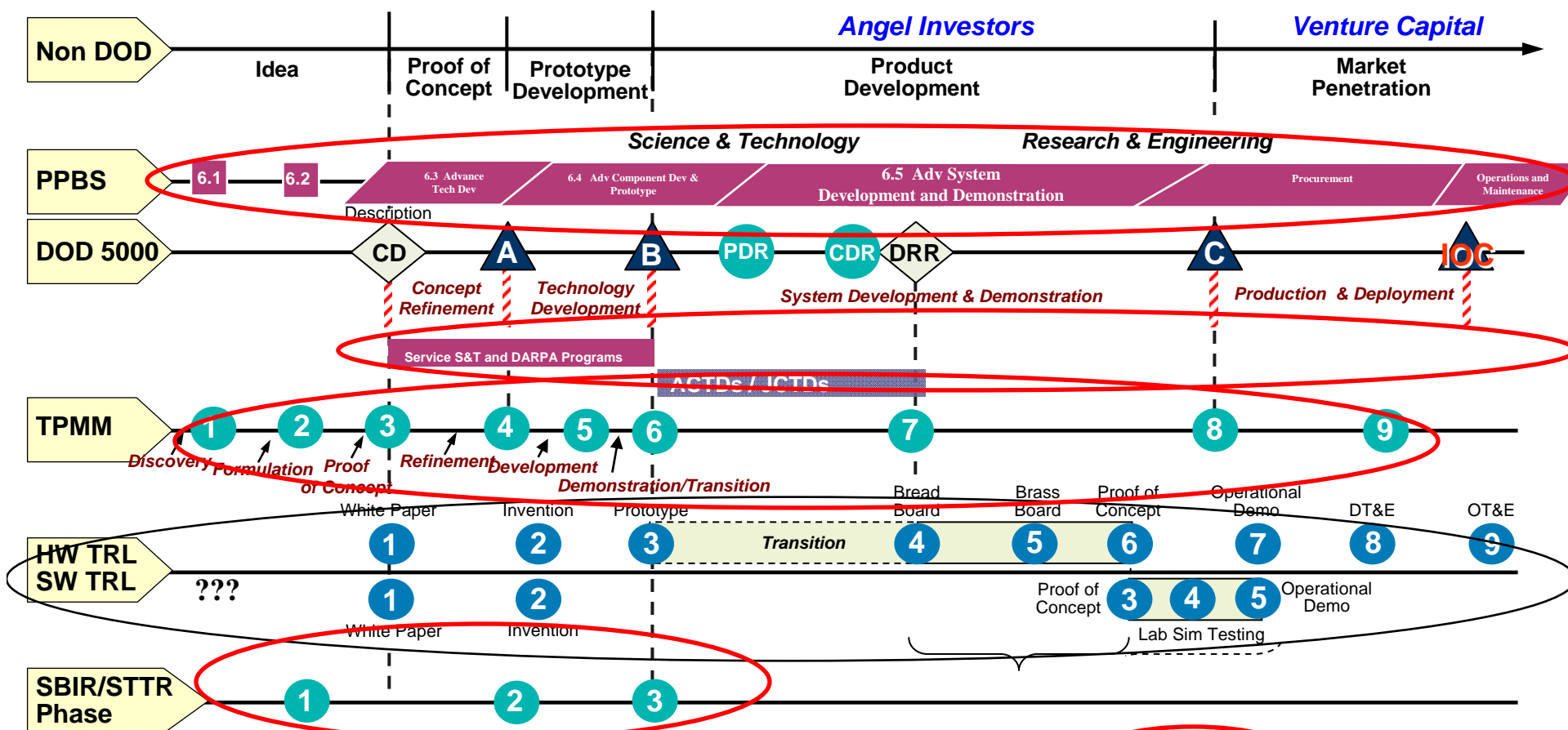
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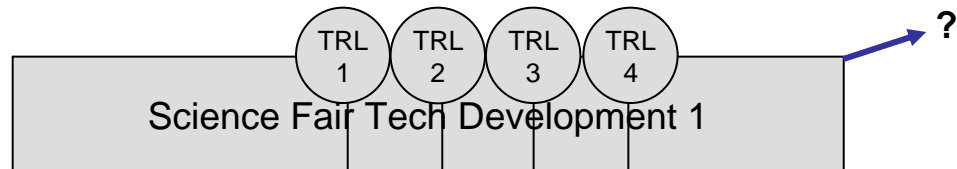
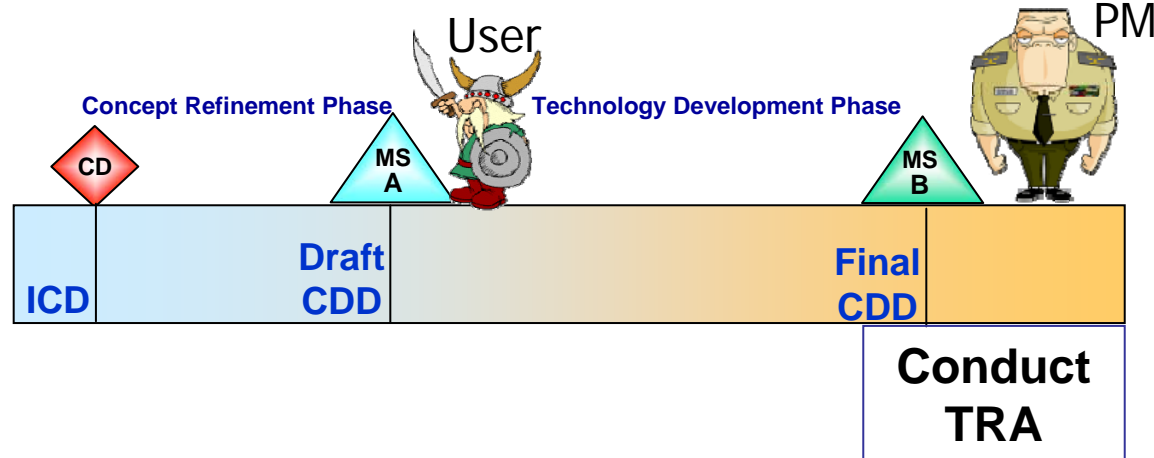
TPMM - **Technology** Program Management Model

STTR - Small Business Technology Transition Research

PPBS - Planned Program Budget Execution System



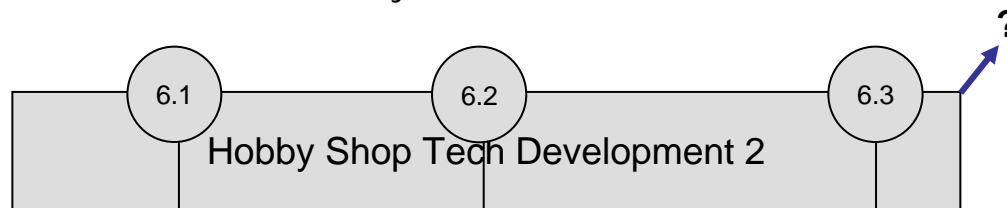
Why Do Immature Technologies Transition?



Unstandardized maturity assessment



S&T



Funding-driven maturity assessment



“Perspective of the USER”



Hey Buddy - I OWN The Requirements!

I Want it All!!
I Want it Cheap!
I Want it Now!

Gotta be small,
lightweight,
and 99.99% reliable

I am understaffed
to do that

I'm governed by
the JCIDS

USER

- Threat Driven
- Soldier-Proof
- Fieldable
- Meets Mission Needs
- **DOTMLPF**



“Perspective of PM”

I am governed by
DoD 5000.



Your next chance for
funding is 5 years
down the road – stud!

I NEED a
REQUIREMENT
(CDD)!

My prime
can do that!!

You forgot about
the “illities”!!!



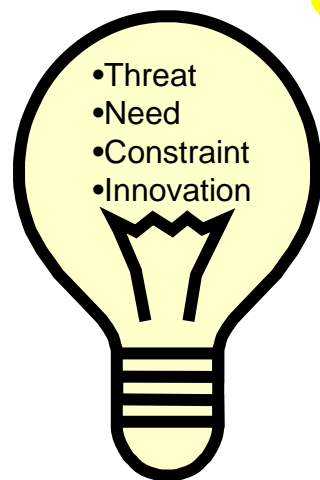
PM

- | | | |
|------------------|-------------------|----------------------------|
| •Reliability | •Affordability | •Producibility |
| •Availability | •Interoperability | •Technical Data |
| •Survivability | •Transportability | •Safety And Health Hazards |
| •Maintainability | •Environmental | •Supportability |
| •Deployability | •Maintainability | •Supply |
| •Sustainability | •Manufacturing | •Equipment |
| •Human Factors | | •Manpower And Personnel |

- Value Added
- Capability
- Probability of Success
- Acquisition Strategy
- Budget (LLC/POM)
- Schedule - WBS
- The System “ approach”



“Perspective of S&T”



S&T Project

- Technical “break-thru”
- Performance Goals
- Risk
- Cost Estimate.
- Program Plan
- Build a prototype

**You don’t understand -
This project is different
from everyone else**

**My S&T job is my
life - If I finish it –
then what?**

**S&T does not require
a process – I have
been doing it for years**

**Customer role
is to integrate**

**Marketing is not
part of S&T**

**If you “Push” long
enough – they will
come!**





Transitioning Technology



Technology Management vs. Transition Management



"Secure the High Ground"



Technology Readiness Levels

DoD 5000.2-R



1. Basic principles observed and reported.	Lowest level of technology readiness. Scientific research begins to be translated into technology's basic properties.
2. Technology concept and/or application formulated.	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.
3. Analytical and experimental critical function and/or characteristic proof of concept.	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4. Component and/or breadboard validation in laboratory environment.	Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in a laboratory.
5. Component and/or breadboard validation in relevant environment.	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in simulated environment. Examples include "high fidelity" laboratory integration of components.
6. System/subsystem model or prototype demonstration in a relevant environment.	Representative model or prototype system, which is well beyond the breadboard tested for level 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 fidelity laboratory environment or in simulated operational environment.
7. System prototype demonstration in an operational environment.	Prototype near or at planned operational system. Represents a major step up from level 6, requiring the demonstration of an actual system prototype in an operational environment. Examples include testing the prototype in a test bed aircraft.
8. Actual system completed and qualified through test and demonstration.	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this level represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specs.
9. Actual system proven through successful mission operations.	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational mission conditions.

"Secure the High Ground"



Technology Readiness Levels



DoD

In what way will this technology Add Value to the End User?

What Programmatic & System Engineering tasks should be performed during each Stage of Development?

When should I know who my Customer is?

When should I know what the requirements for the technology are?

At what point will the technology be transitioned to a Customer?

How will my progress be measured?

What are the criteria for completing a TRL?

What is the definition of a success?

1. Basic principles and concepts are established. The technology is at the level of a concept. The technology is at the level of a concept. The technology is at the level of a concept.
2. Technology is defined in terms of its basic principles and concepts. The technology is at the level of a concept. The technology is at the level of a concept. The technology is at the level of a concept.
3. A technology plan is developed. The technology is at the level of a concept. The technology is at the level of a concept. The technology is at the level of a concept.
4. Component and/or breadboard validation is performed. The technology is at the level of a concept. The technology is at the level of a concept. The technology is at the level of a concept.
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6. System prototype demonstration is performed. The technology is at the level of a concept. The technology is at the level of a concept. The technology is at the level of a concept.
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8. Technology is defined in terms of its basic principles and concepts. The technology is at the level of a concept. The technology is at the level of a concept. The technology is at the level of a concept.
9. Actual system demonstration through successful mission operations. The technology is at the level of a concept. The technology is at the level of a concept. The technology is at the level of a concept.

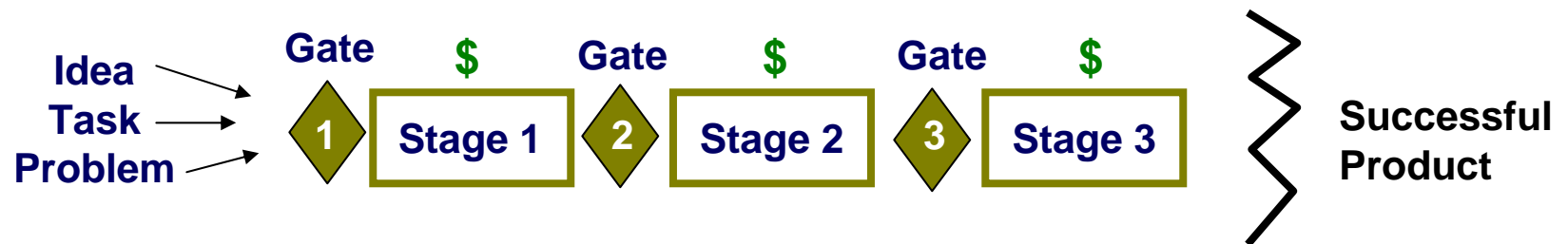
"Secure the High Ground"



Basic Stage Gate Process



Stage – Gate Type Process – all businesses have “a process”



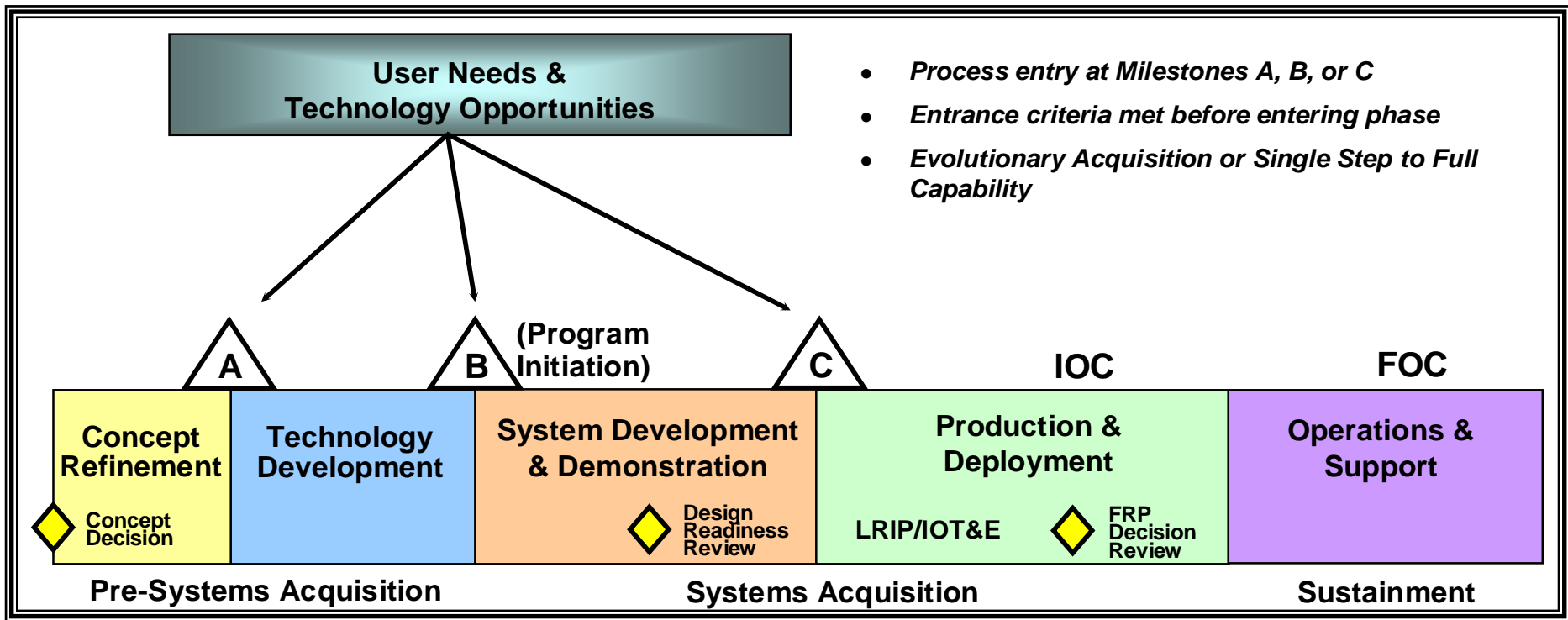
- Each Gate is a decision point for the program to move to the next stage.
 - Decision to Go / Kill / Hold / Recycle
- Each Stage is measured by:
 - Metrics Goals
 - Deliverables
 - (Exit Criteria)
 - Funding allocation

Everything We Do is a Process

“Secure the High Ground”



First TRA Requirement



DoD 5000 Metric

- **Technology Readiness Assessment (TRAs) - Required at MS B**
- **TRAs using Technology Readiness Levels (TRLs)**



Solution?



According to a GAO review of 54 DoD programs:

- Only 15% of programs began SDD (after MS B1 with mature technology)
 - **A standardized assessment process based upon a System Engineering- and Programmatic-based TRL criteria set applied earlier in the process.**
- At design completion:
 - Design stability not achievable with immature technologies
 - Programs with stable designs at CDR averaged 6% cost growth
 - Programs without stable designs at CDR averaged 46% cost growth and a 29 month schedule delay

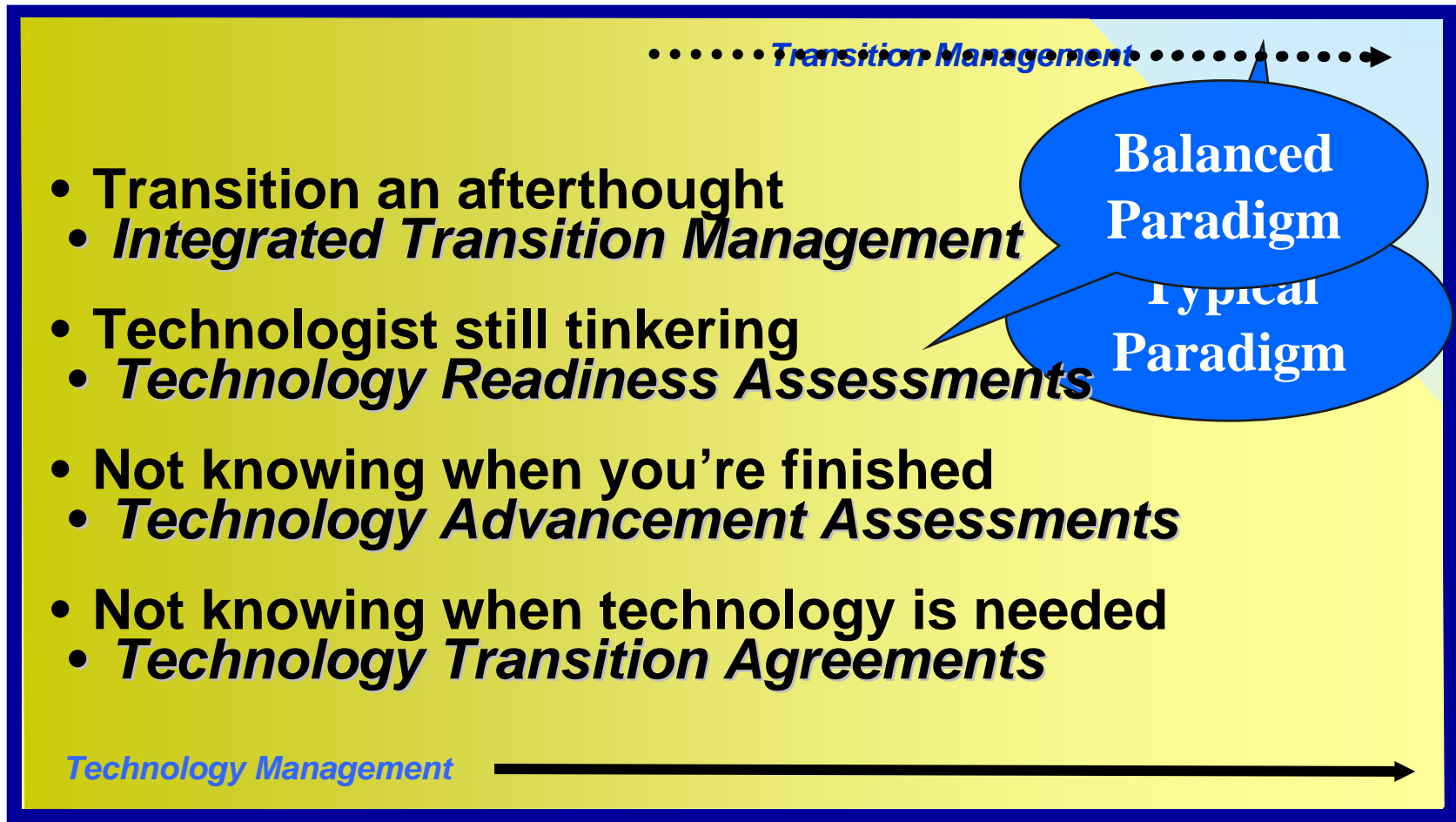
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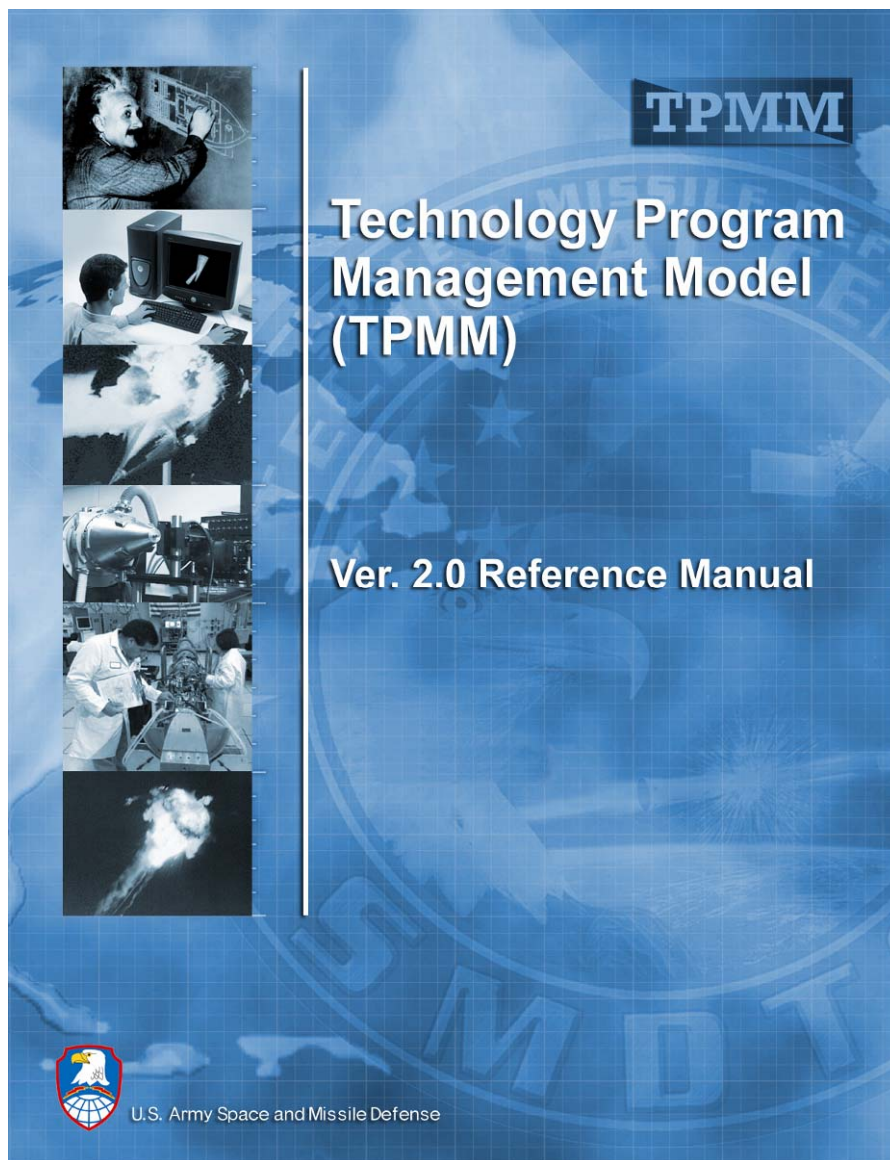


Transitioning Technology



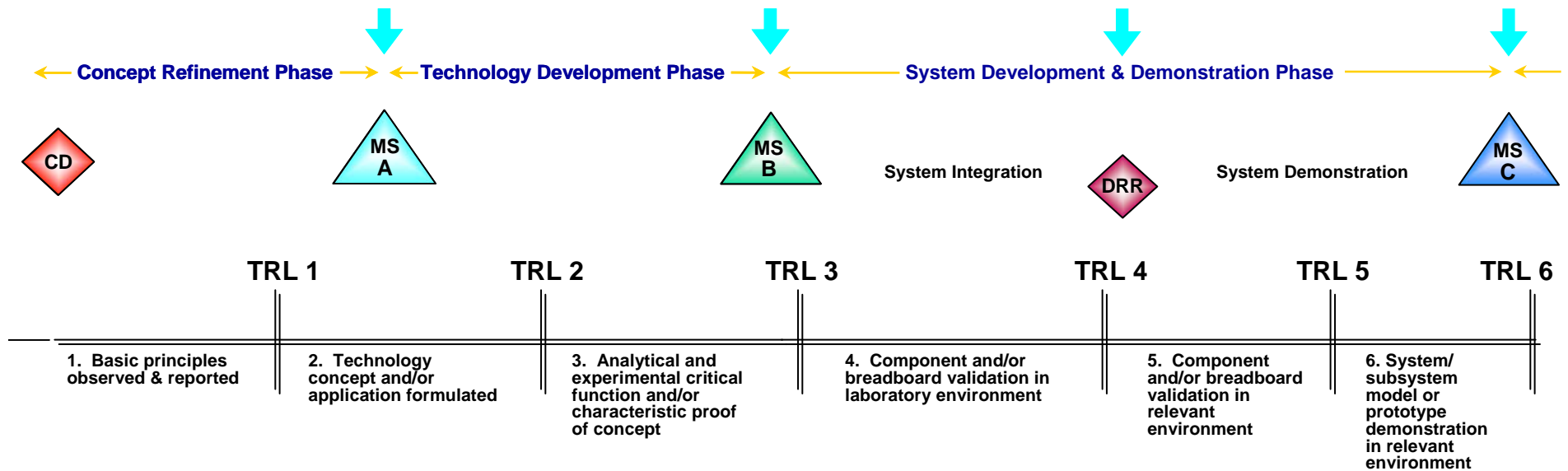
Technology Management vs. Transition Management







Aligning TRLs & DoD 5000



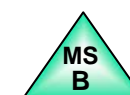
S&T Community Activities



Aligning TRLs & DoD 5000



← Concept Refinement Phase → Technology Development Phase →



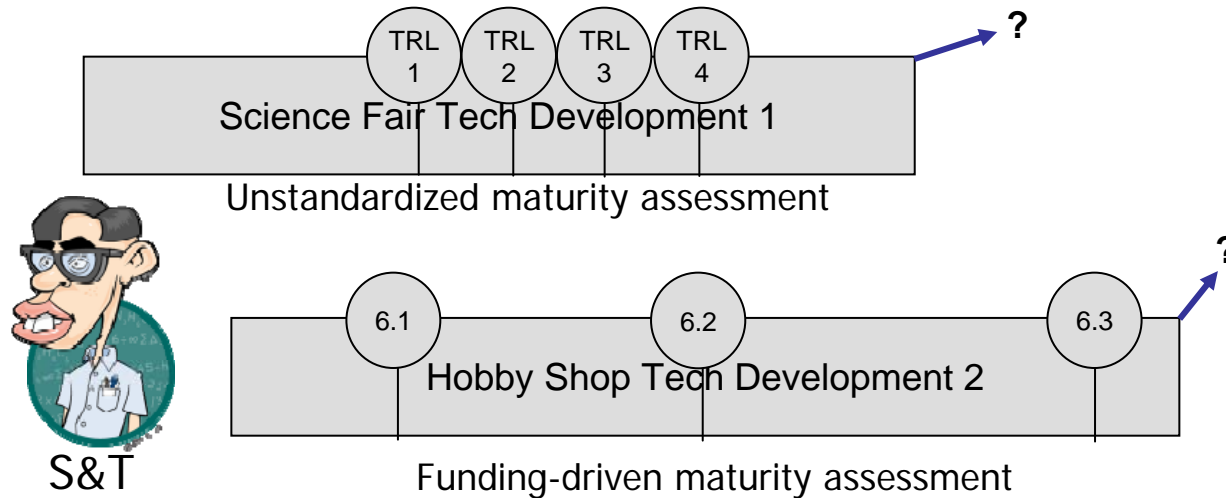
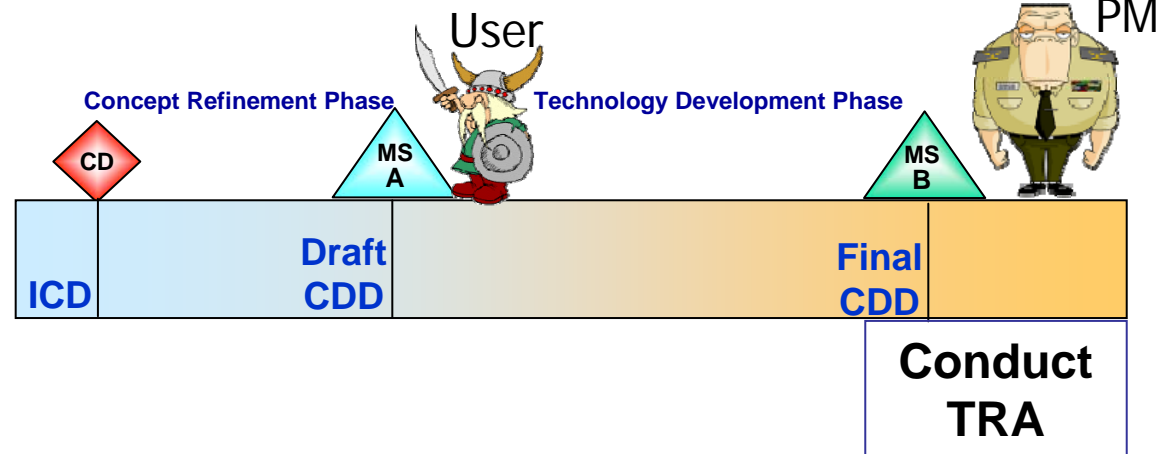
TPMM Criteria

TRL 1	TRL 2	TRL 3	TRL 4	TRL 5	TRL 6
1. Basic principles observed & reported	2. Technology concept and/or application formulated	3. Analytical and experimental critical function and/or characteristic proof of concept	4. Component and/or breadboard validation in laboratory environment	5. Component and/or breadboard validation in relevant environment	6. System/subsystem model or prototype demonstration in relevant environment
<u>Discovery</u>	<u>Formulation</u>	<u>Proof of Concept</u>	<u>Refinement</u>	<u>Development</u>	<u>Demonstration Transition</u>
Develop an Idea Based on Threat, need, User Rqmt, Other Identify Pertinent Military Application & a Potential Customer(s)	Develop a Concept Conduct Trade Studies Perform Military Utility Analysis Perform Paper Studies Identify specific customer(s) Analysis of Alternatives	Proof of Concept and approach Develop General Technical Requirements ID cross technologies Develop Draft Tech Development Strategy TTA - Interest	Demonstrate Key Technologies Work Together Refine Requirements System Eng Plan Update Tech Development Strategy TTA -Intent	Demonstrate Components Work With/as System Finalize Requirements Develop Transition Plan and Gain Customer Approval	Demonstrate Prototype Ready for Operations Demonstrate Increased Capabilities Develop Transition Agreement Acquisition Strategy TTA - Commitment

"Secure the High Ground"



Why Do Immature Technologies Transition?

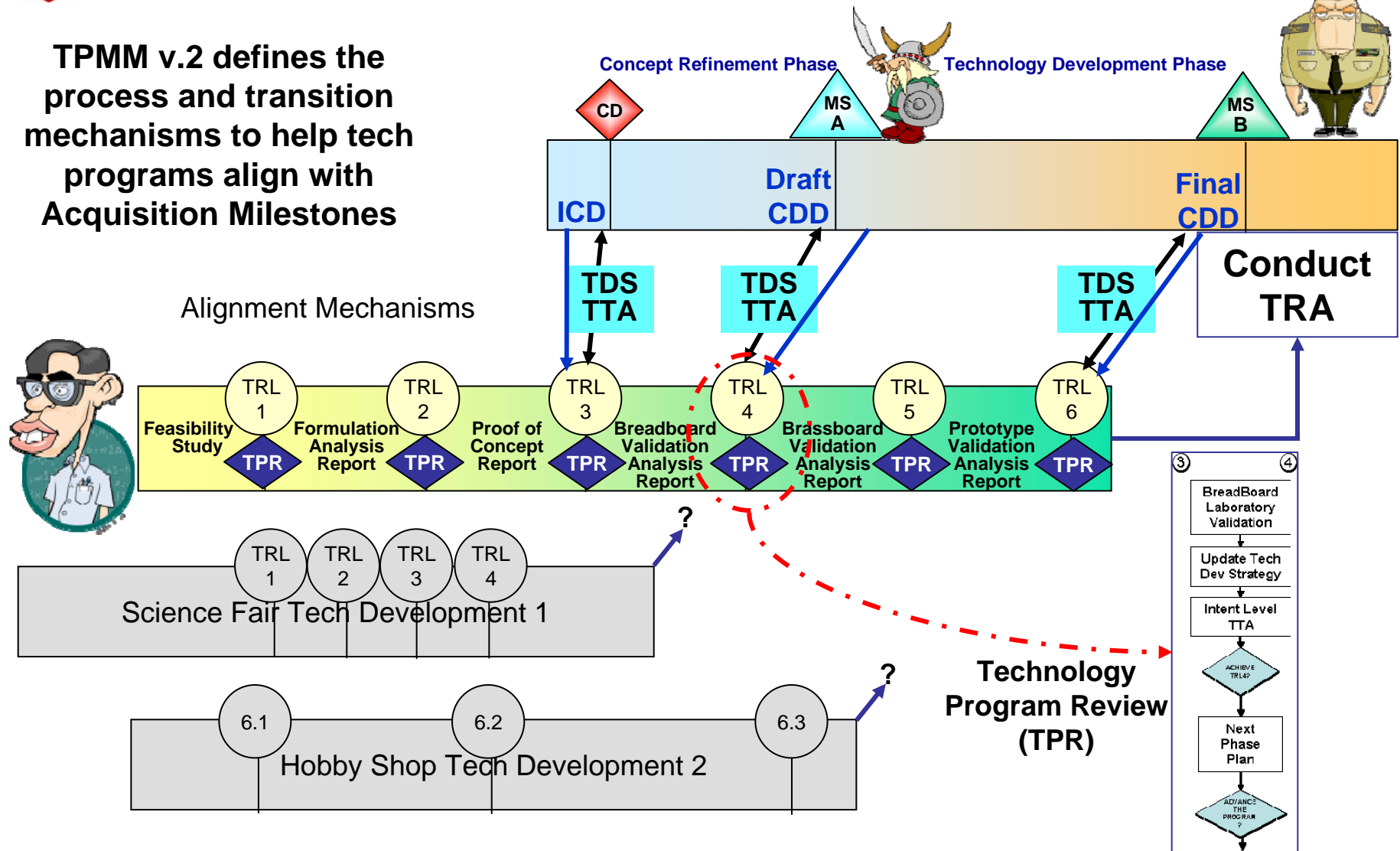




Aligning the Technology with DoD 5000 MS's



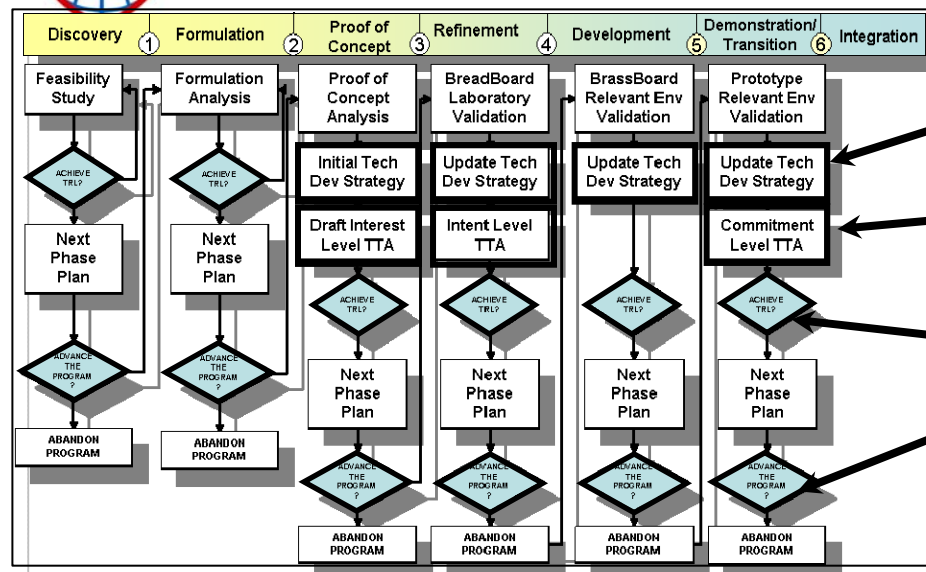
TPMM v.2 defines the process and transition mechanisms to help tech programs align with Acquisition Milestones



"Secure the High Ground"



Systematic Development Process

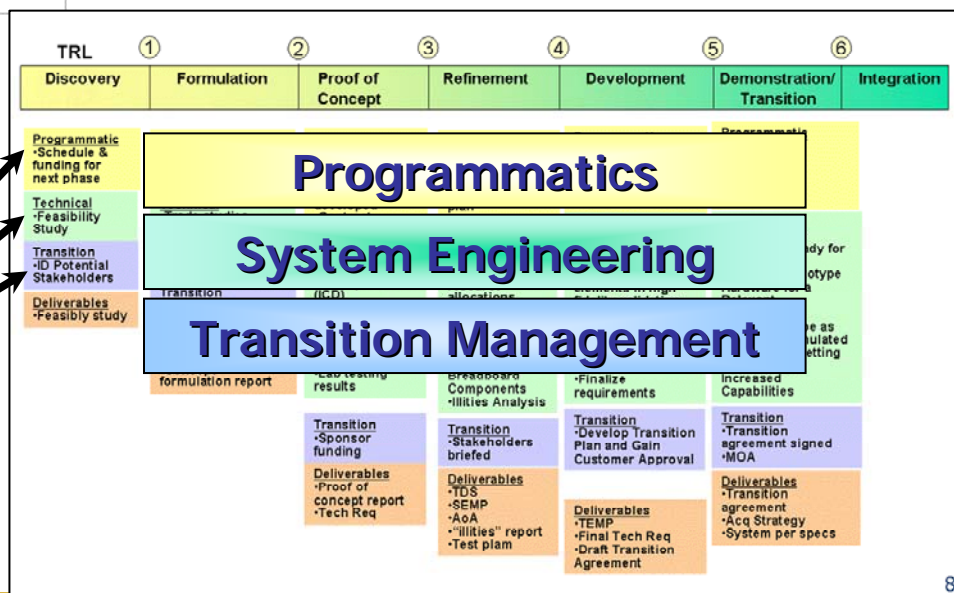


- TDS establishes common language and vision

- DAU adopted TTA

- Program reviews include a TRA and a TAA

- Multi-Dimensional criteria set provides a comprehensive TRL Assessment





Implement New Technology Transition Agreement (TTA)



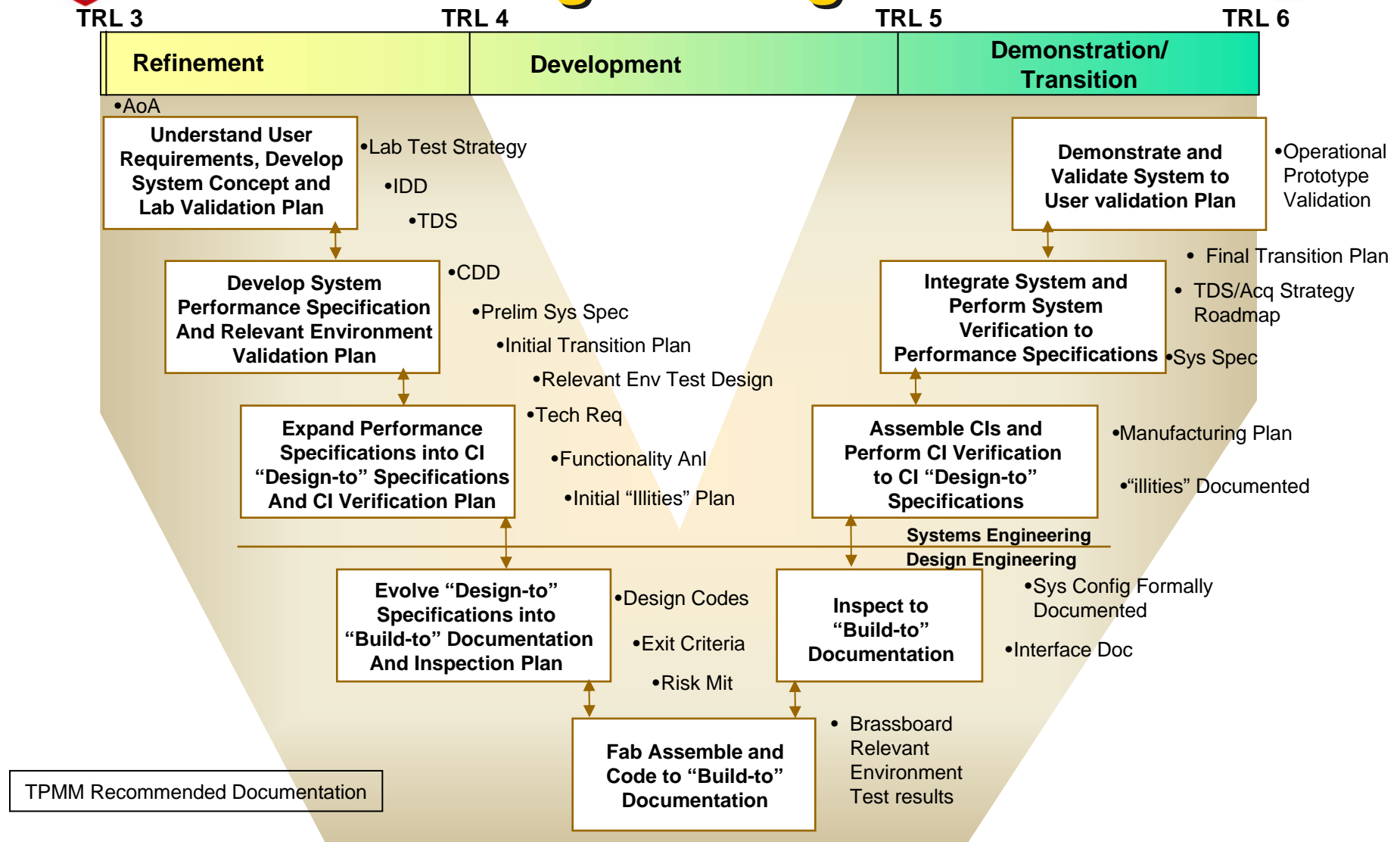
Helping manage the Technology Transition by

- formalizing development requirements
- establishing timelines for technology insertion
- establishing plans for integration into target Acquisition environment

Key Indicators	Description	TTA Version		
		Interest	Intent	Commitment
Performance Requirements	Definitive, complete, measurable performance & physical attributes parameters to be tracked.	Not Likely	Yes	Yes
Performance Thresholds	Minimum acceptable performance threshold has been identified	Not Likely	Yes	Yes
Performance Demonstrated	Current performance of the technology/product	Maybe (Simulated)	Yes - Lab	Yes - Relevant Environ
Test Planning	Conditions under which technology/product will be tested/demonstrated prior to delivery to acquisition	Not Likely	Yes - Lab	Yes - Relevant Environ
Operational Environment	The environment in which the technology will operate has been defined	Maybe	Yes	Yes
TRL at Transition	Estimate of the transition TRL coordinated with the program office	Maybe	Yes	Yes

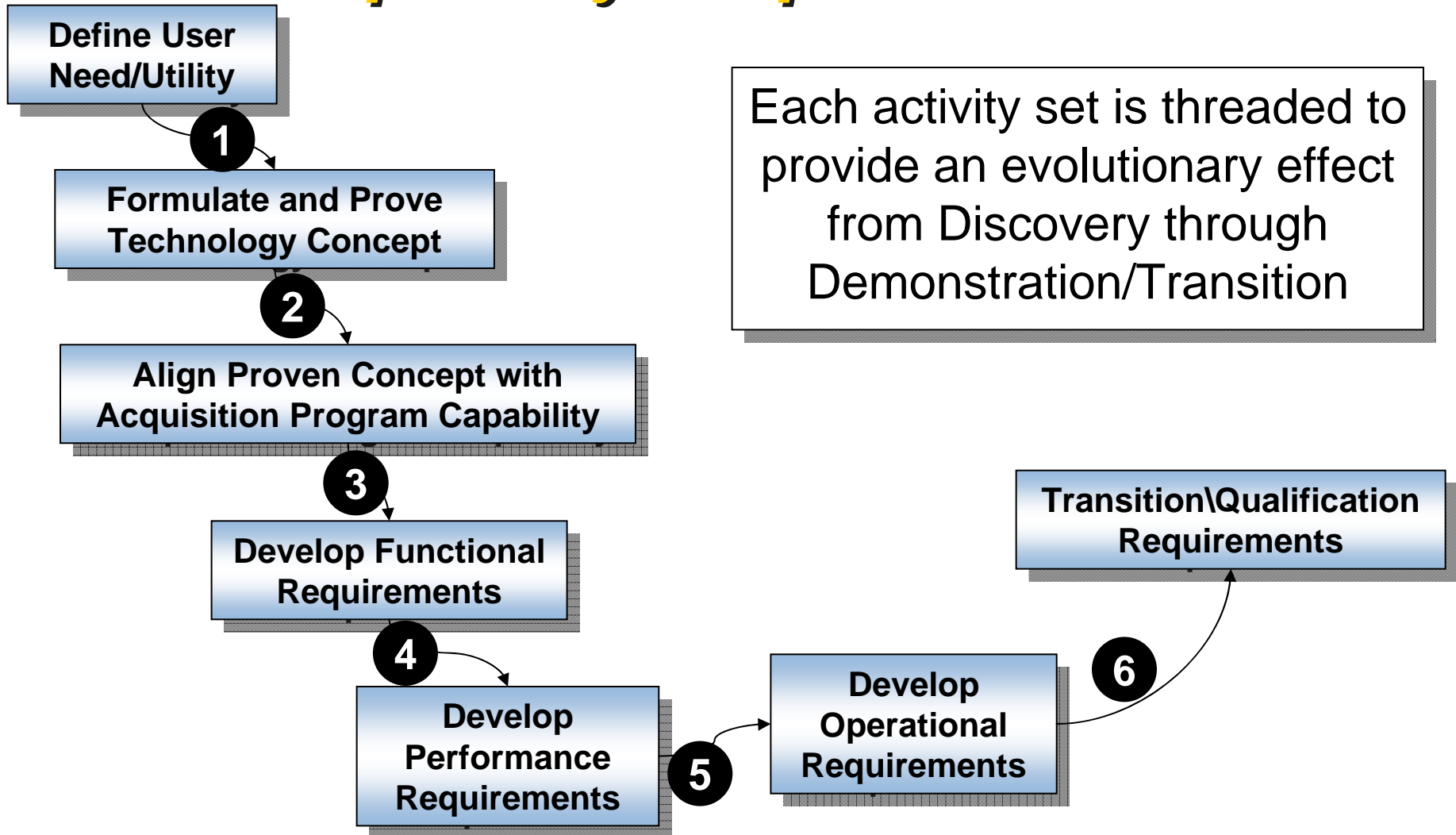


TPMM v.2 & the System Engineering V





Example Thread - Capability/Requirement





System Engineering Threads



TPMM Administration Tool

File Import Export View Help

Graph Activities

Include Dep Threads: Yes
Include Pred Threads: No
Include Orphans: Yes

Systems Engineering

- Conduct a functional analysis flowdown of the technology system.
- Define how and where the system will be used and potential applications
- Define Key Technology Requirements And Specifications
- Define measures of effectiveness
- Define the system element(s).
- Define the system interface requirements for the technology.
- Define the system performance requirements for the technology.
- Define the system physical requirements.
- Describe any other considerations included during the analysis and evaluation p
- Describe conclusions from the analysis and evaluation of each solution alternati
- Describe the analysis and evaluation of feasible solution alternative
- Describe the analysis results of each solution alternative/architecture.
- Describe the analytical tools, study results, and processes used for the assessm
- Describe the architectural synthesis process leading to optimization.
- Describe the criteria used in the selection process, including key performance p
- Describe the utility analysis results (Mil or other), including user benefits and prel
- Identify Preliminary "ilities" Requirements
- Refine the constraints
- Refine the operational and mission requirements/objectives
- Refine The Operational Concept
- Refine the system functional requirements
- Specify the technology advancement degree of difficulty index for the selected

Transition Management

1. Identify technology capabilities

2. Define the system performance requirements for the technology.

3. Refined System Performance Requirements

3. Develop Technology Performance goals

Selection Information

Deliverable: Proof of Concept Report 2.h v1 (Proof Of

Cat/Sub-cat: Technical : Systems Engineering



TPMM supports RL integration



TRL ②

③

Proof of Concept

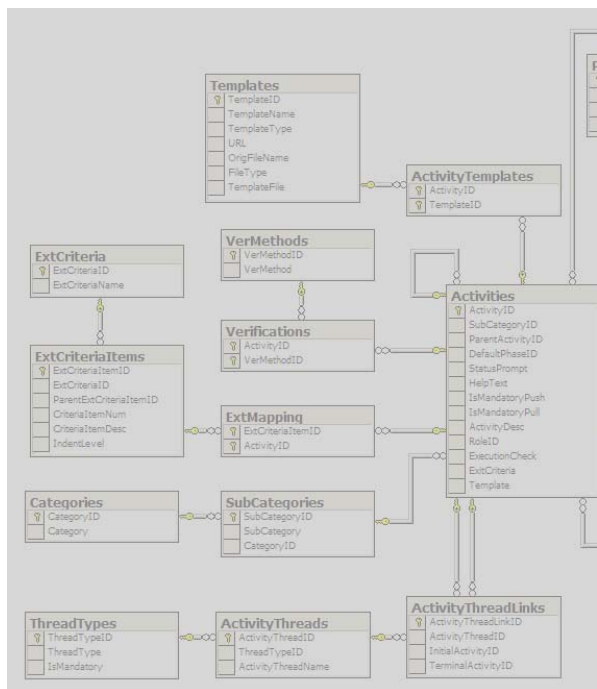
TPMM Activities

Technical

- Describe The Analytical Studies Conducted
- Describe The Laboratory Test(s) Conducted
- Describe the results and scenarios of the modeling and simulation studies
- Refine the System Physical Requirements
- Define the system interface and performance requirements
- Identify HTI opportunities
- Models And Simulations Develop/Update/Validate

MDA/AS EMRL for TRL 3

3.1.a	Performance predictions of elements of technology capability validated by Analytical Studies details
3.1.b	Performance predictions of elements of technology capability validated by Laboratory Experiments details
3.1.c	Performance predictions of elements of technology capability validated by Modeling and Simulation details
3.2	Scaling studies have been started. Define the goals of the studies and how the goals relate to the BMDS mission.
3.3	Preliminary performance characteristics and measures have been identified and estimated. Quantify level of performance.
3.4	Cross technology effects (if any) have begun to be identified. Identify other new or in development technology that could increase performance and reduce risk.
3.5	Design techniques/codes have been identified and defined to the point where small applications may be analyzed/simulated. Provide details.





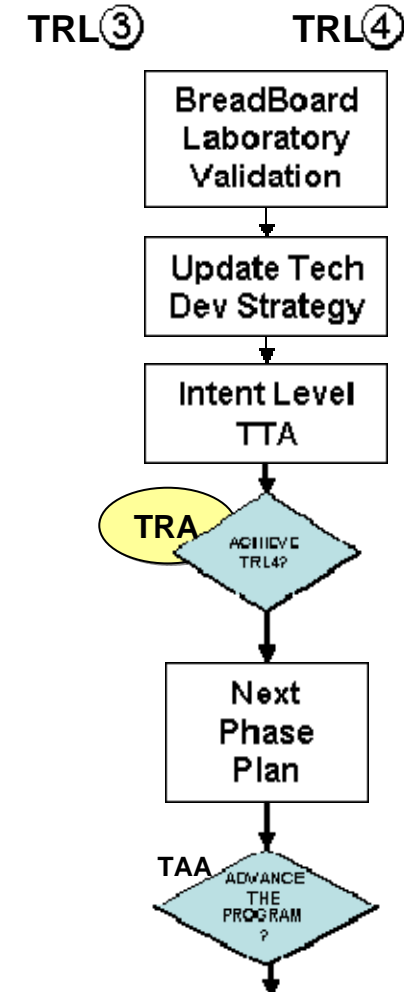
TPMM v.2

Technology Readiness Assessment Criteria



Refinement Phase (TRL 4) Assessment Criteria Checklists

A Breadboard Laboratory Validation Report Was Completed		Check
The explanation of objectives of the breadboard laboratory validation analyses and testing are sufficient.		<input type="checkbox"/>
The various test configurations were adequately explained and the key functions and subsystems of each were identified.		<input type="checkbox"/>
Items to be tested		<input type="checkbox"/>
The Technology Development Strategy was Updated (Part 1)		Check
The mission	A project organization has been documented that includes roles and responsibilities	<input type="checkbox"/>
All external	A sponsor for this technology development been identified	<input type="checkbox"/>
All organizational	A Customer (acquisition program) for this technology development been identified	<input type="checkbox"/>
Anomalies	An end user	<input type="checkbox"/>
A schedule	Other organizations	<input type="checkbox"/>
The Technology Transition Agreement was Updated		Check
The results	The status to the current state of the technology development and transition activity is provided.	<input type="checkbox"/>
Breadboard	The current state of development has been Summarized	<input type="checkbox"/>
Results	The appropriate version of TTA has been developed	<input type="checkbox"/>
Recommendations	Exit Criteria for Transition Has been determined	<input type="checkbox"/>
Development	A Requirements Officer and Capability Requirement Basis have been identified.	<input type="checkbox"/>
Preliminary	Major program objectives have been developed	<input type="checkbox"/>
A Performance	Projected initial operational capability date is reasonable and has been coordinated with the Target Acquisition Program	<input type="checkbox"/>
A Breadboard	Identify personnel responsible for day-to-day program/project management	<input type="checkbox"/>
Prototypes	The technology needs of the acquisition program that S&T is expected to provide have been identified	<input type="checkbox"/>
Describe	Relative benefit to meeting specific Acq Program Capability has been shown	<input type="checkbox"/>
Risk Management	Realistic Need Dates for meeting Specific Capabilities were developed	<input type="checkbox"/>
Production	The estimated Technology Readiness Level (TRL) for each technology/product need identified was Valid and has been Effectively Coordinated between the S&T group and the Acquisition Program.	<input type="checkbox"/>
Transition	The process for integrating the technology/product into the acquisition program was adequately described.	<input type="checkbox"/>
A contract	Identify the Sustainment officer responsible for identifying resourcing and executing Sustainment after transition. Include contact information.	<input type="checkbox"/>
Customer	The present version of TTA has been approved and signed by all necessary parties.	<input type="checkbox"/>
A plan for		
An accurate		
An approved		



the High Ground™



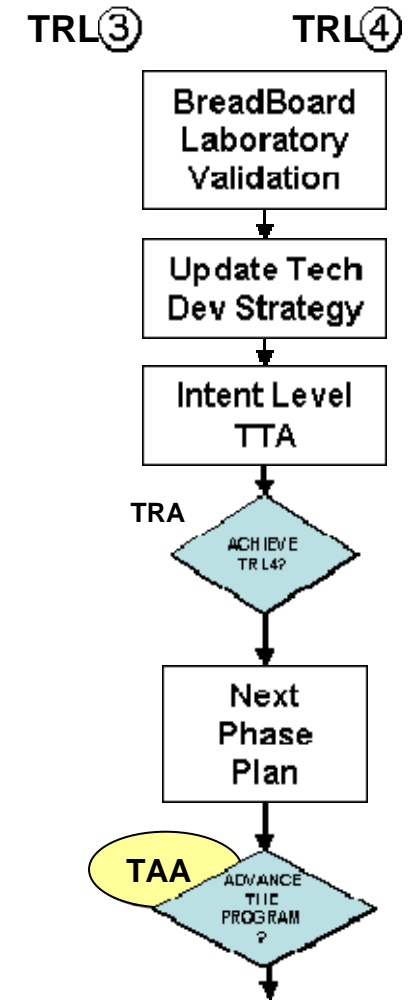
TPMM v.2

Technology Advancement Assessment Criteria



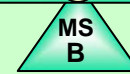
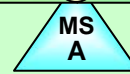
Development Phase (TRL 5) Entry Criteria Checklist (partial)

Develop a Brassboard Laboratory Validation Plan for use in Development	Check
A Brassboard Laboratory Validation Plan was developed	<input type="checkbox"/>
The purpose described for validation testing is adequate	<input type="checkbox"/>
The explanation of objectives of the Brassboard laboratory validation analyses and testing are sufficient.	<input type="checkbox"/>
The key performance parameters of the system that will be validated were properly identified	<input type="checkbox"/>
The various test configurations were adequately explained and the key functions and subsystems of each were identified.	<input type="checkbox"/>
Items to be tested in the Brassboard Laboratory Validation were identified	<input type="checkbox"/>
The Testing environment was sufficiently described	<input type="checkbox"/>
All external systems participating in the test were identified	<input type="checkbox"/>
All organizations participating in the tests to include any external organizations were identified.	<input type="checkbox"/>
A schedule which shows a timeline for each planned test was provided.	<input type="checkbox"/>
All operational considerations for each test were described.	<input type="checkbox"/>
The methods for determining results based on content, quality, quantity, completeness, were described.	<input type="checkbox"/>





TPMM Value-added



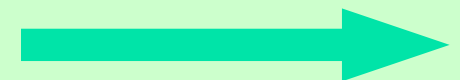
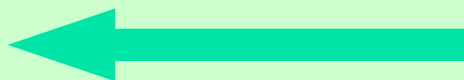
Continuous Customer Involvement Leading To Technology Infusion

Transition Management

- Defines activity-based phases and gate reviews for each TRL (TPR)
- Establishes exit criteria & deliverables for each phase (TRA)
- Reinforces System Engineering and Programmatic Principles (TAA)
- Facilitates alignment of S&T with Acquisition Programs
- Early focus on successful transitioning (Evolutionary TTA)

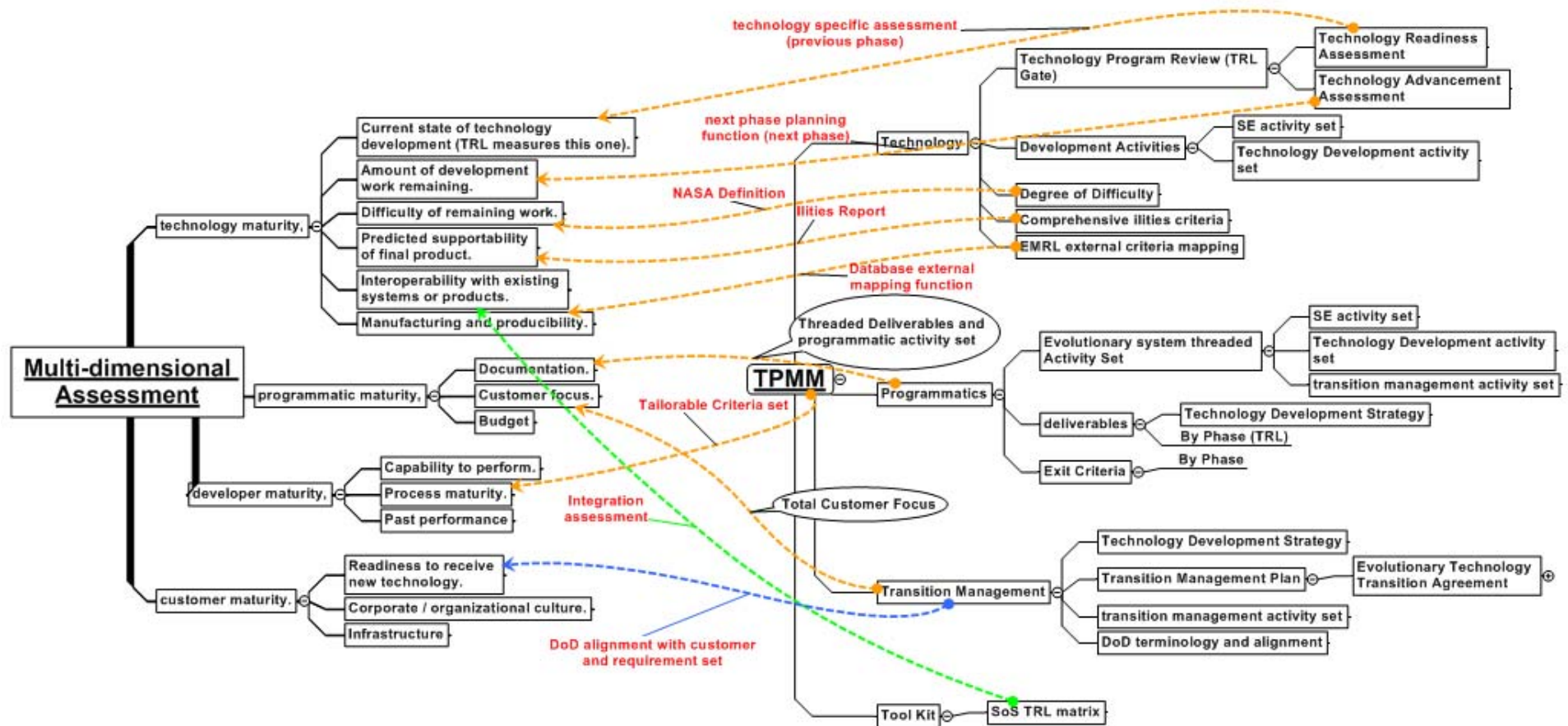
Technology Management

Standardized Management Model
For Technology Maturation





TPMM Related to MDA TM





TPMM Summary



Increases the probability of successfully fielding the right technology solution at the right time by:

- Standardized process based on a validated development model
 - Provides a system-engineered activity set consisting of technical, programmatic, and transition management activities
 - Establishes common language
 - Supports continuous improvement through incorporation of lessons learned across enterprise
 - Reduces gaps in program execution to successful transition
- Standardized TRL-based Technology Readiness Assessment
- Provide consistency in Development method and execution

Increases productivity of program management enabling an S&T Organization to be more responsive to emerging needs such as:

- Fulfillment of the DoD 5000 technology development & assessment process
- Real-time enterprise-level TRL-based metrics for all S&T Programs
- Visibility into all aspects of the program portfolio execution
 - Program Justification (Auditing)
- Answer Maturity Trade-off requests
 - Tools for self-assessment of technology maturity for down selection



Q&A

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256-337-6557

<http://www.tpmmm.info>

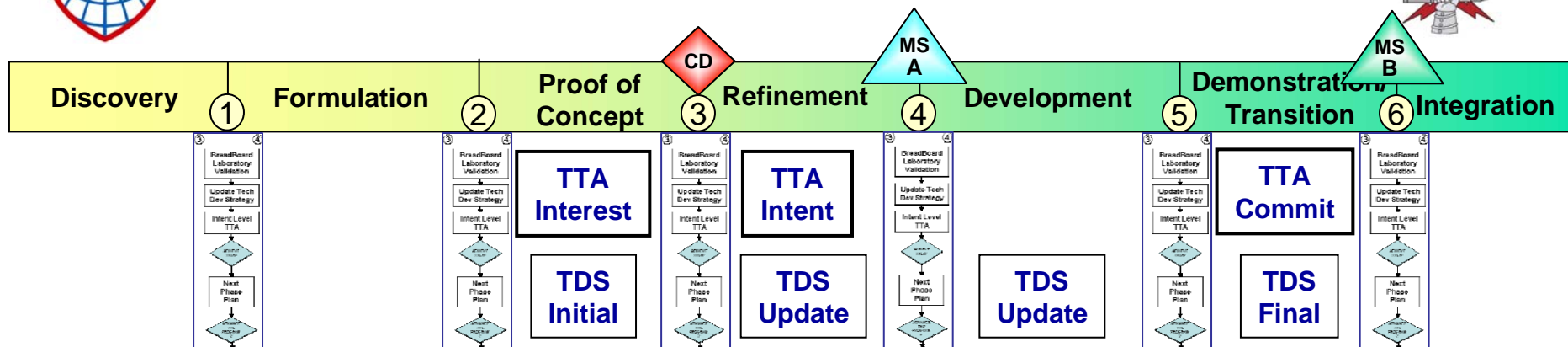
"Secure the High Ground"



Additional Info



TPMM is an **ACTIVITY** model



- Show a Capability
- Identify Pertinent Military Application & Potential Customer

- Identify specific customer(s)
- Perform Military Utility Analysis
- Cultivate Sponsorship

- Develop Initial Operational Req's (ICD)
- Customer & USER briefed

- Refine Operational Req.
- Funding obtained for Dev & Demo

- Develop Transition Plan and Gain Customer Approval

- Final Req (CDD)
- PM's Acquisition Strategy Roadmap
- Demonstrate Prototype Ready for Operations

Transition Management

- Develop an Idea Based on Threat, need, User Rqmt, Other

- Develop a Concept
- Conduct Trade Studies
- Perform Paper Studies

- Proof of Concept and approach
- Analysis of Alternatives
- ID cross technologies

- Demonstrate Key Technologies Work Together
- System Eng Plan

- Demonstrate Components Work With/as System
- Finalize Requirements

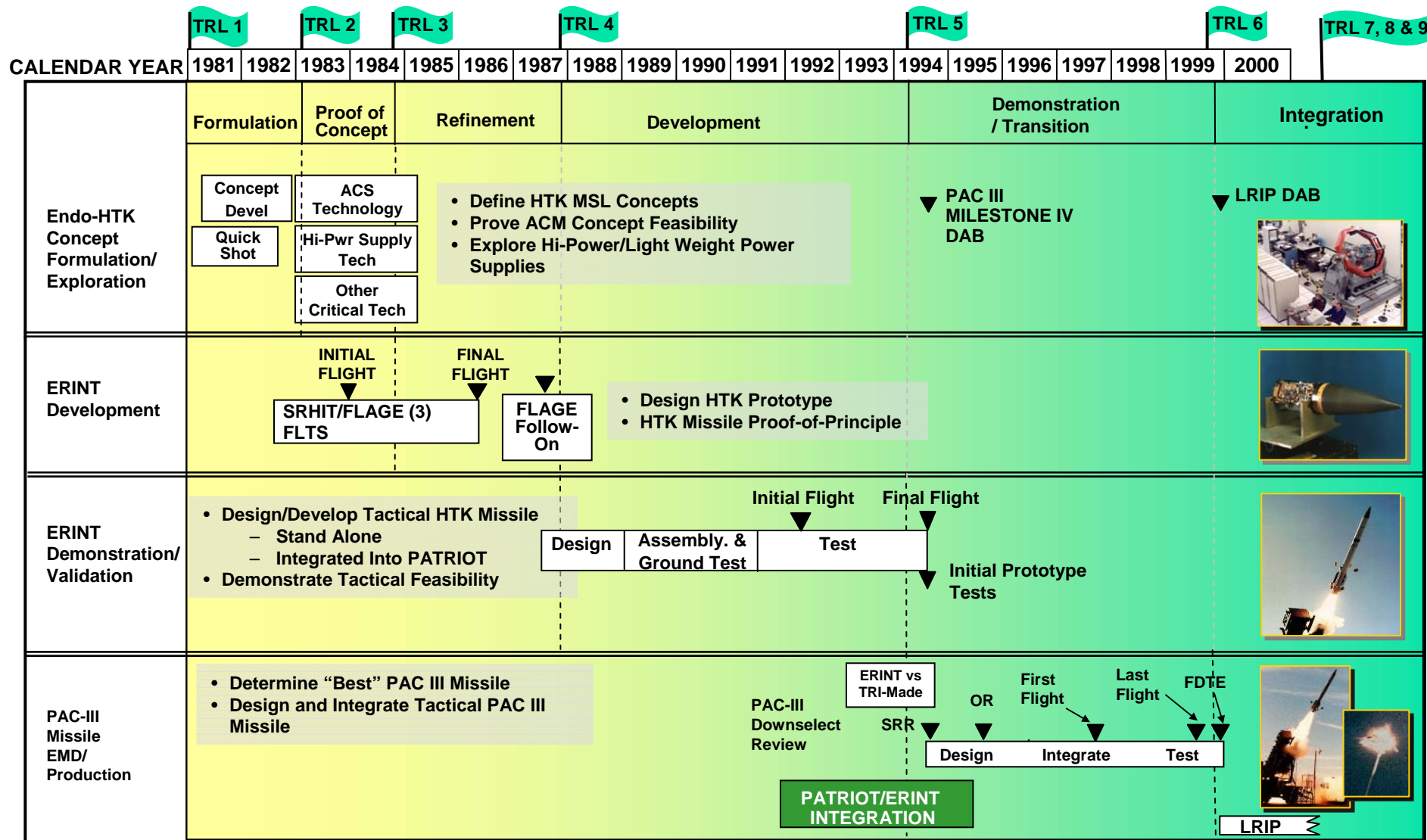
- Demonstrate Increased Capabilities

Technology Management

Program Management
Develop and Manage Program Plan



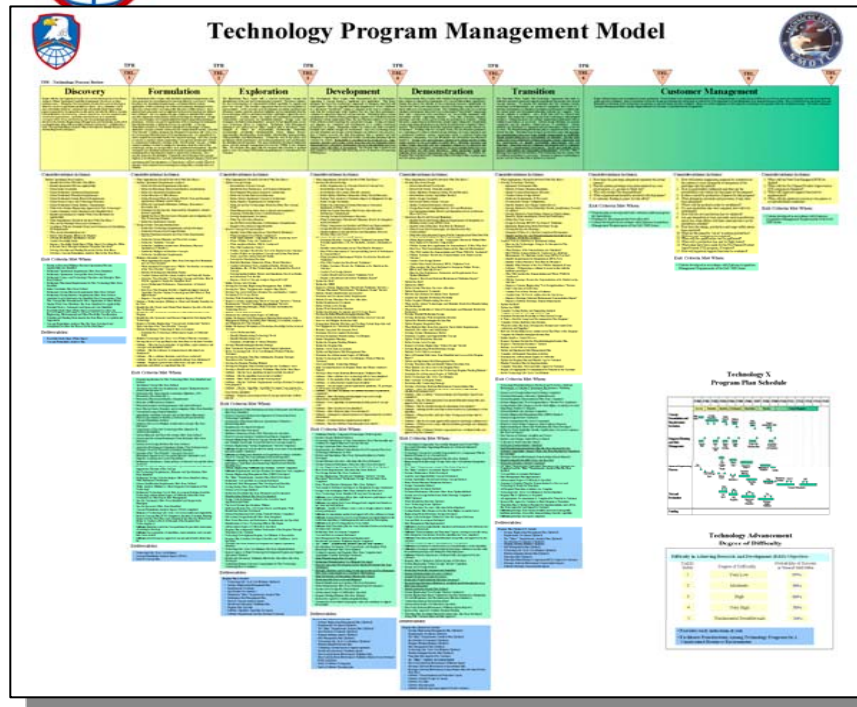
ERINT Program Plan Schedule w/ TPMM Overlay



“Secure the High Ground”



What's New in Version 2

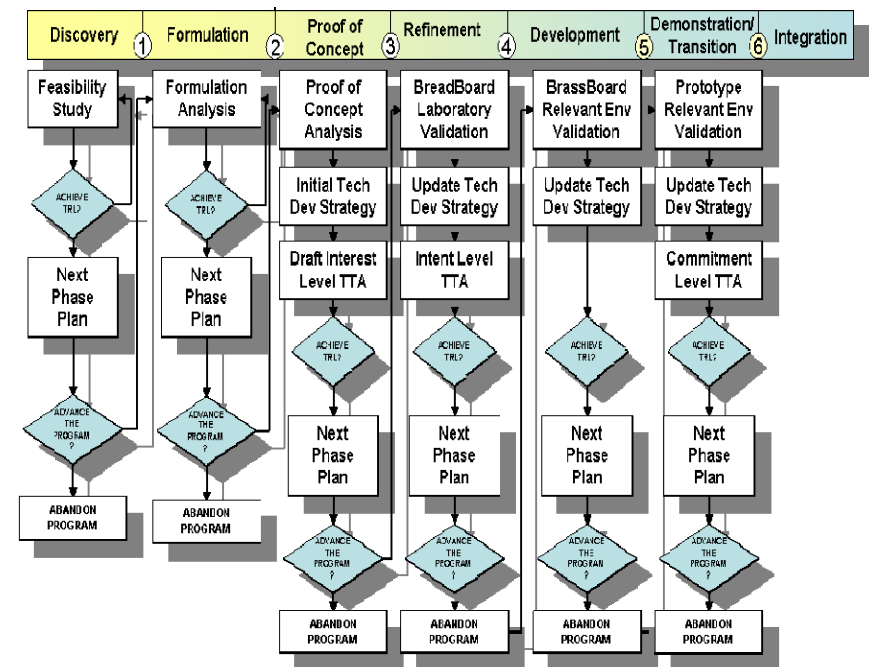


New Features:

- Tailorable and Flexible –
- Updated and aligned Exit Criteria and Deliverables
- Focused on Transition and Requirements
- Activity set developed in database in prep for automation
- Integrating Customer Requirements and other Readiness levels

Structural Differences:

- TRL phases have been redesigned
- Deliverables have been adapted and expanded to align to DoD 5000.2
- Systems Engineering Activities has been expanded with detailed fidelity and task breakdown
- Activities have been classified by category and threaded



"Secure the High Ground"



Technology Management Using TPMM v.2



TPMM v.2 provides *standardized*:

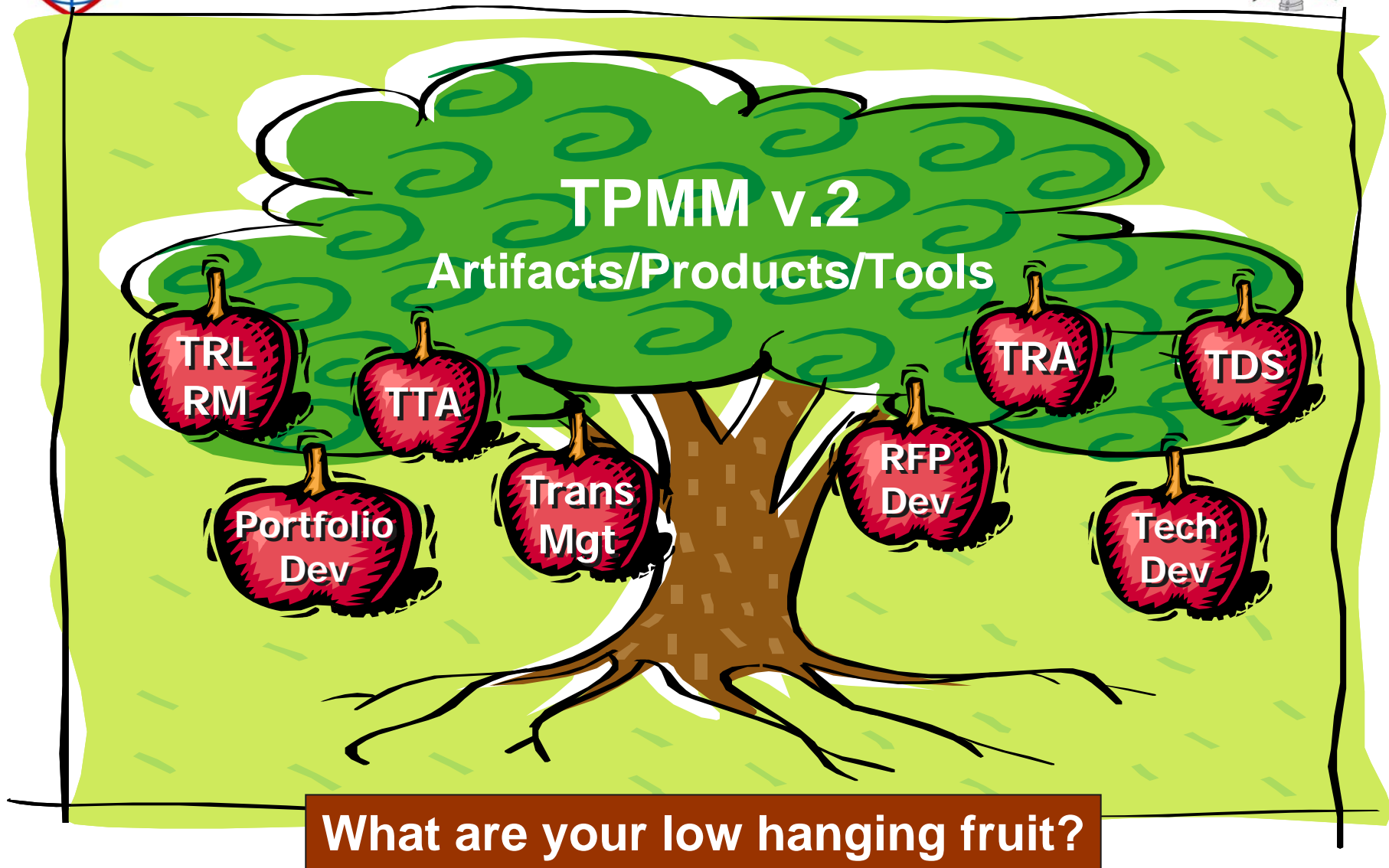
- Planning – Provides tailorable activity set for each phase
 - RFP Development
 - TRL Roadmap
- Management – Executing tailored criteria set –
 - Deliverables
 - Exit criteria
 - Mechanism – transition and DoD 5000 alignment (TTA & TDS)
- Assessment – Evaluating data from tailored metric set
 - Technology Readiness Assessment
 - Gap Analysis (Risk Assessment)
 - Technology Advancement Assessment
- Deliverables – final product
 - Deliverable correlation
 - Templates & Examples

TPMM v.2 is a common yard stick to plan and measure technology
development and transition

“Secure the High Ground”



TPMM-based Point Solutions



"Secure the High Ground"



TPMM v.2 Adoption



Increases the probability of successfully fielding the right technology solution at the right time by:

- Standardized process based on a validated development model
 - Programmatic, and
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 - Re
- Standard
- Provide

***S&T Shops Must
Preserve Their
Knowledge Base***

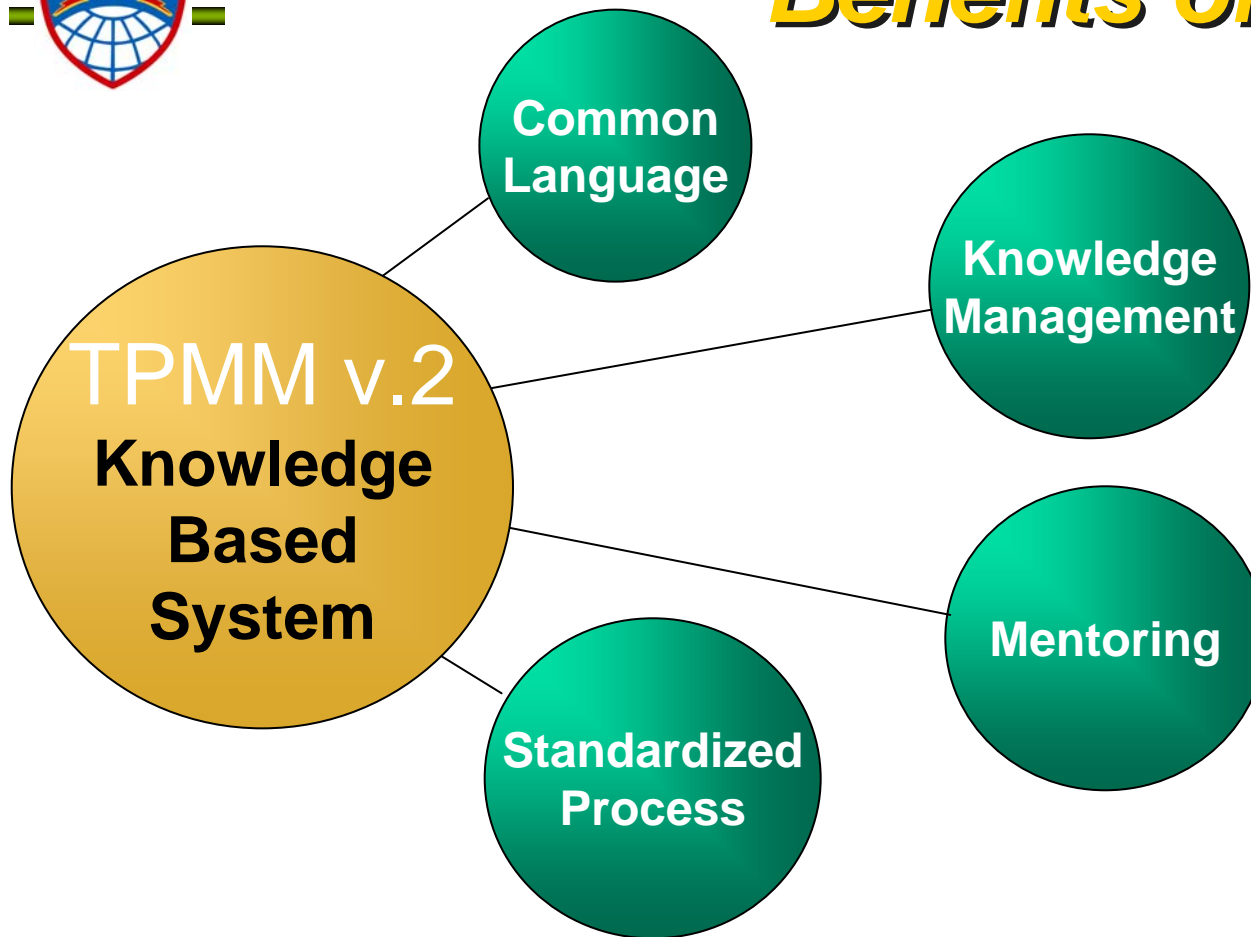
***Increases
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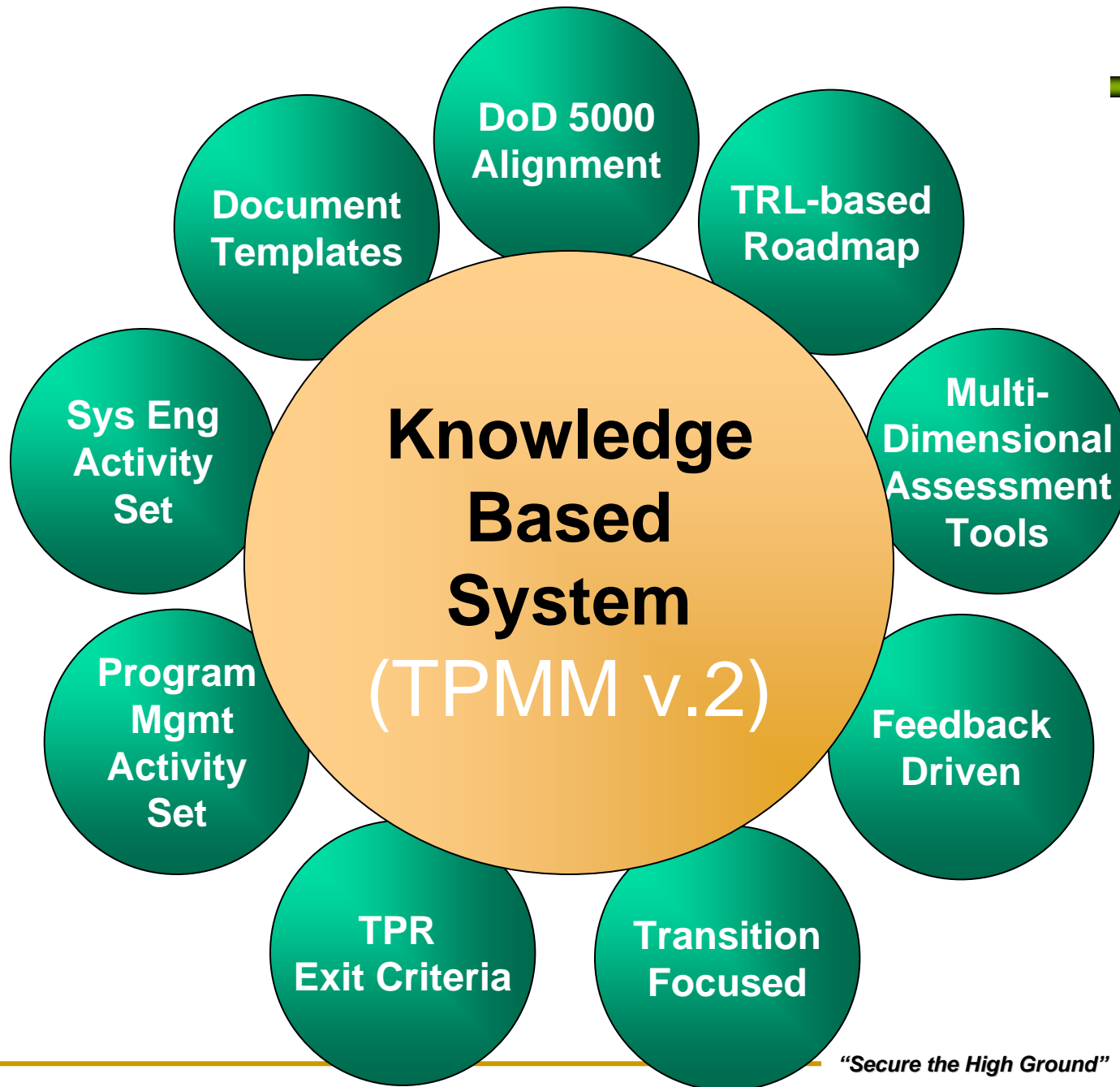
- Fulfillment of the DoD 5000 technology development & assessment process
- Real-time enterprise-level TRL-based metrics for all S&T Programs
- Visibility into all aspects of the program portfolio execution
 - Program Justification (Auditing)
- Answer Maturity Trade-off requests
 - Tools for self-assessment of technology maturity for down selection



Benefits of a KBS



Provides a means to re-apply known solutions to current problems which can be used by others, less experienced in the problem area





TPMM/T3 Collaborator Base



❖ **Department of Homeland Security**

- Exploratory Program Process
- DHS customized TPMM application

❖ **SOCOM**

- TPMM flow process
- TTA/TDS Development

❖ **Defense Threat Reduction Agency**

- Web-based Tech Tran Agreement
- DTRA customized TPMM application

❖ **Defense Acquisition University**

- Best Practice classes
- Speaker at workshops

❖ **MDA**

- Kill Assessment Technologies (KA)
- QS

❖ **UAH**

- Guest speaker at SE Short Course

❖ **NASA**

- TRLs Definitions



TECHNICAL PROGRAM MANAGEMENT MODEL



- **Focused on providing a tailorable model for Technology Development.**
 - **TRL Assessment – Validated Exit Criteria**
 - **System Engineering Process - Aligned To TRLs**
 - **Programmatic Planning**
 - **MDA Criteria (HW/SW/EM) Readiness Assessments**
 - **Focused on Successful Transition**
- **Increases Probability of Customer Acceptance and Funding Support**
- **Improves Documentation Process to Support STO / ATD / ACTD Nomination Process or Transition to an Acquisition Program**

“TPMM: A Model for Technology Development and Transition”