Adapting Systems Engineering Best Practices to Technology Development in Applied Research

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Mr. Jeffrey Craver

Defense Acquisition University

Mr. Hossam Ahmed

DTRA-RD

Mr. Mike Ellis

DMD, LLC.

Overview

- *Introductions*
- *Problem Statement (GAO et al.)*
- *Identify Govt Orgs Using/Interested in the Technology Program Management Model (TPMM)*
- *Solution Implemented through collaborators/piloting*
- *Benefits of Rooting Tech Development in TPMM*
- *Conclusion - Way Forward .....*

Demonstrate how one solution developed out of necessity at the Army Space and Missile Defense Command has captivated the attention of the Defense Acquisition University and changed the landscape for S&T

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Quantifying the Effects of Immature Technologies

According to a GAO review in 2005 of 54 DoD programs:

- **Only 15% of programs began System Design Decision [beyond Milestone B] with mature technology (Technology Readiness Level (TRL 6-7))**
  - **Programs that *attempted to integrate with immature technologies* averaged *41% cost growth* and a *13 month schedule delay***
- **At Critical Design Review, 58% of programs demonstrated design instability (< 90% drawings releasable)**
  - ***Design stability not achievable with immature technologies***
  - **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

[Follow-up reports by GAO in subsequent years have not indicated any significant change in the Findings]

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Reasons Why This Happens

- ***Doctrine*** **Promotes delay**
  - **The DoD 5000 Directive calls for the first Assessment of the technology at MS-B (too late in the process to have any real effect on an immature technology)**
- ***Predisposition*** **of Viewpoints**
  - **Users know the requirements, Acquisition Managers know how to build things, and Technology Developers know how to invent.**
  - **A Forcing Function is needed to effectively cross those boundaries**
- ***Communications*** **Breakdown**
  - **Technology solutions selected to fill gaps need continual re-alignment to ensure development is on schedule and that the "right" problem is still being solved**
- ***Culture*** **Within the Technology Development Community**
  - **Tradition of Invention and scientific endeavor in the Technology Community *coupled with lack of Systems Engineering discipline* contributes to a lack of Transition Focus**
- ***Interpretation*** **Wide Enough to Drive a Humvee Through**
  - **TRL definitions are vague and sometimes too subjective which can lead to more questions than answers.**

One Conclusion: A System Engineering and Programmatic-based criteria set needs to be applied as a standard earlier in the process.

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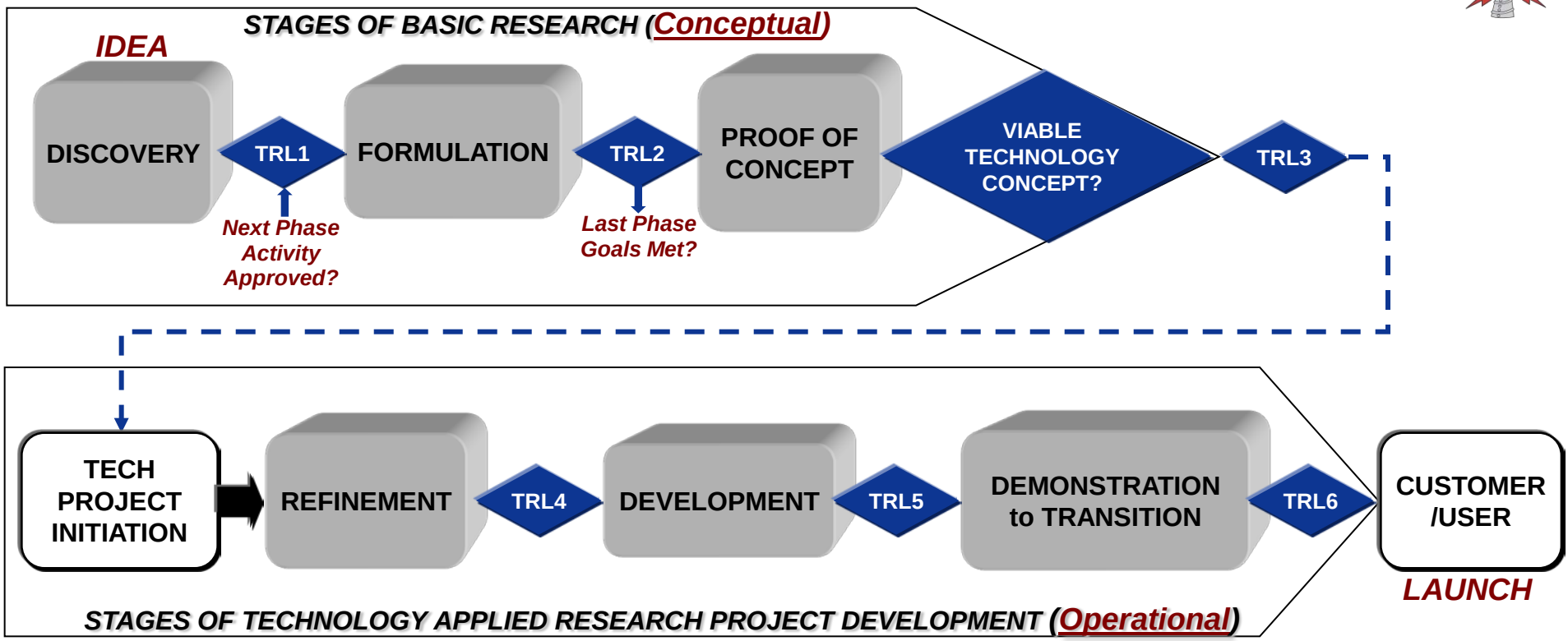
SE Rigor Using Stage-Gate



Process Represented by:

- Distinct Blocks for ***Conceptual*** and ***Operational*** development paths that when combined, traverse from ***Idea*** to ***Launch***.
- Managed process of ***Defined Stages*** composed of ***Activities/Tasks*** that are evaluated as input criteria for planning/approval to ***proceed to the next stage***.
- Stages culminate in ***Decision Gates*** of measurable Exit Criteria used to evaluate technical accomplishment and technology readiness/maturity.

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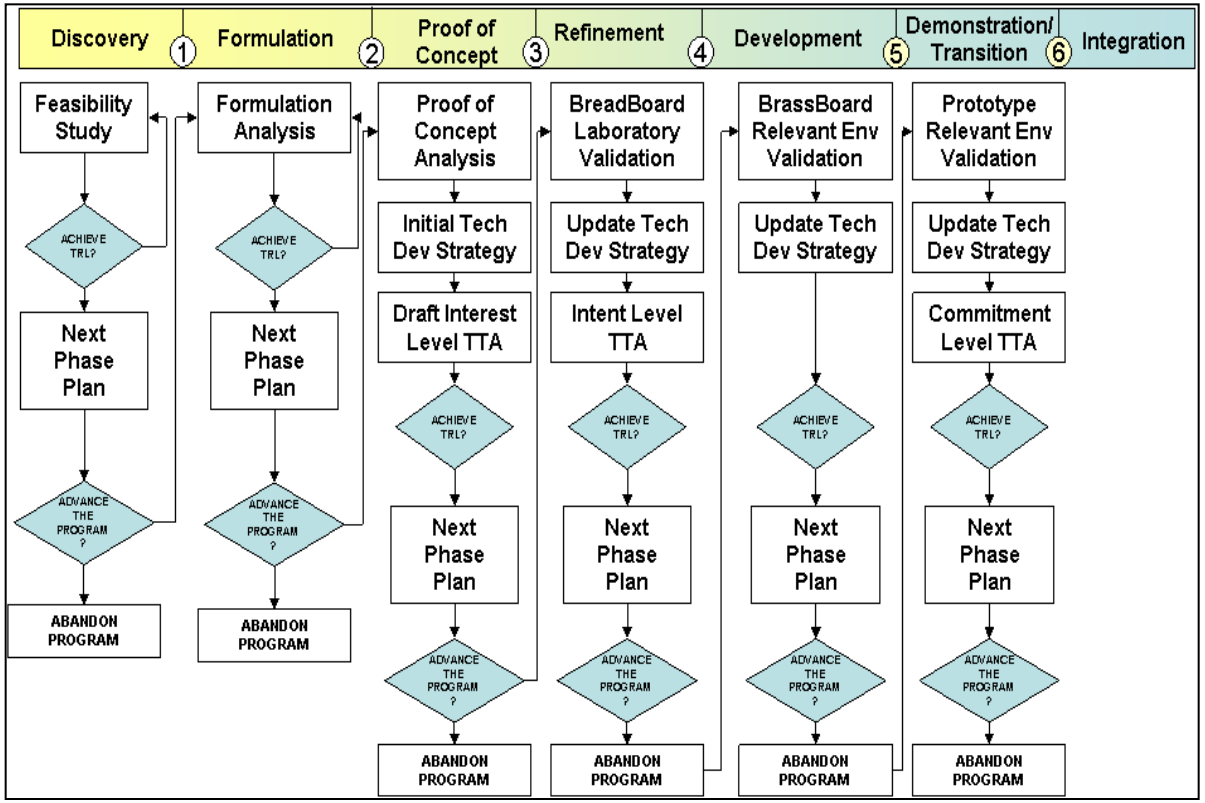
Functions Performed by TPMM

A TRL-Based, Stage Gate Model that:

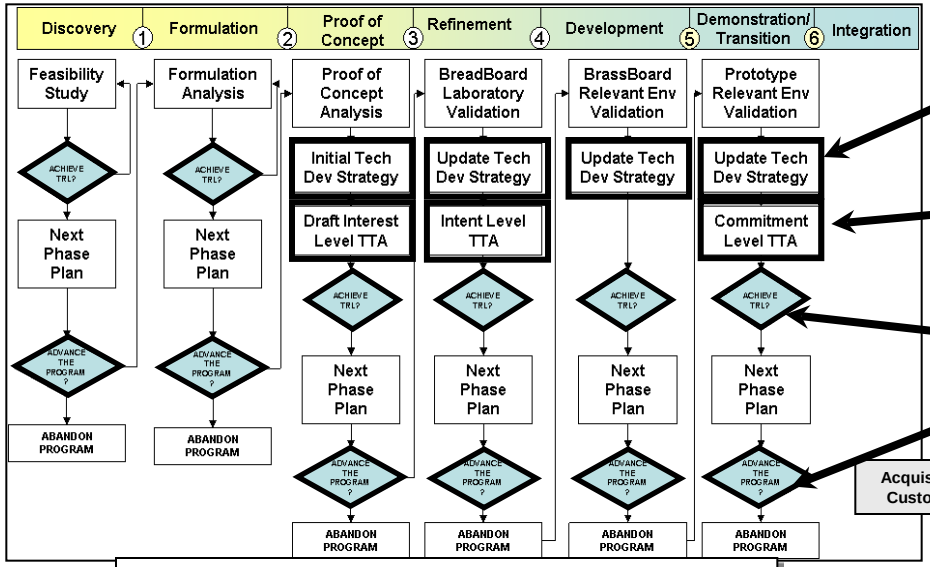
- **Program Definition**
  - Identify Activities to consider
  - Identify Deliverable Documents
  - Provide guidance for Tailoring
  - Employ "Best Practice" Tools
  - Identify and Mitigate Risk
- **Transition Management**
  - Technology Transition
  - Technology Transfer
  - Technology Marketing
- **Maturity Assessments**
  - Establishes Entry/Exit Criteria
  - Provides a Framework for Technology Maturity Assessments (TMA)



Legend:
TTA = Technology Transition Agreement
TDS = Technology Development Strategy

"TPMM: A Model Designed for Technology Development and Transition"

Key Features of TPMM



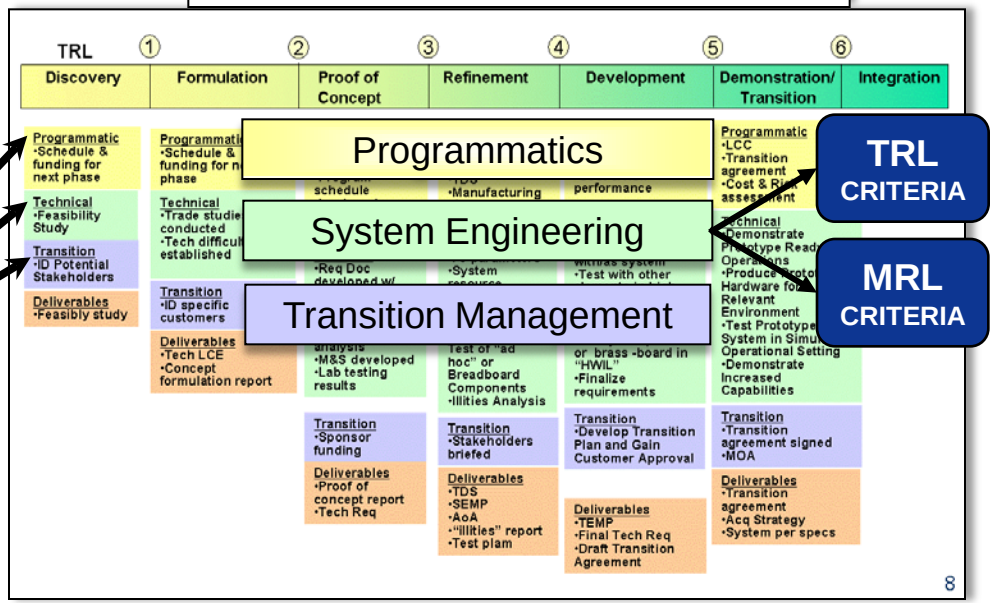
FUNCTIONAL VIEW

TDS establishes common language and vision

DAU adopted TTA

Program reviews include a TRA and a TAA

ARCHITECTURAL VIEW



Multi-Dimensional criteria set provides a comprehensive TRL Assessment

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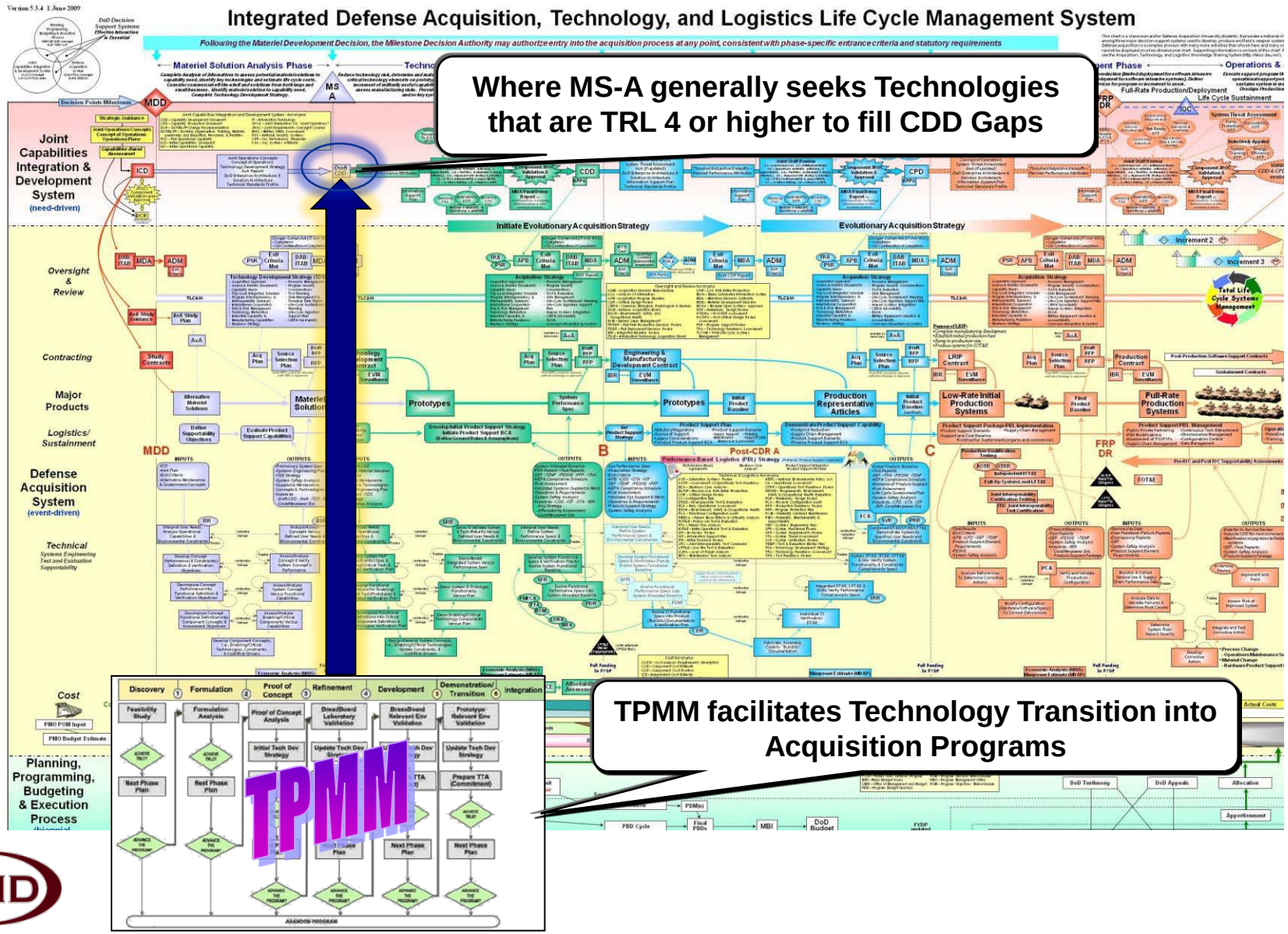
TPMM Facilitates DoDD 5000.1 Alignment



Where MS-A generally seeks Technologies that are TRL 4 or higher to fill CDD Gaps

TPMM facilitates Technology Transition into Acquisition Programs

Technology Transition Alignment Mechanisms

Legend:
TTA = Technology Transition Agreement
TDS = Technology Development Strategy
CFAR = Concept Formulation Analysis Report
PoCP = Proof of Concept Plan
PoCR = Proof of Concept Report

MDD

Material Solution Analysis Phase

MS A

USER

Technology Development Phase

MS B

PM

Engineering & Manufacturing Development Phase

ICD

CDD DRAFT

CDD FINAL

TDS DRAFT

TDS FINAL

AS DRAFT

AS FINAL

Alignment Mechanisms

TTA

TDS TTA

TDS TTA

TRA

TRL 3

TRL 4

TRL 5

TRL 6

PROOF OF CONCEPT

TMA

REFINEMENT

TMA

DEVELOPMENT

TMA

DEMONSTRATION/ TRANSITION

TMA

Technology Maturity Assessment (TMA)

Alignment Mechanisms

CFAR

TTA PoCP

TTA PoCR

TRL 1

TRL 2

TRL 3

DISCOVERY

TMA

FORMULATION (ANALYSIS OF ALTERNATIVES)

TMA

PROOF OF CONCEPT

TMA

Basic Research (6.1)

Applied Research (6.2)

Advanced Technology Development (6.3)

INDUSTRY

ACADEMIA

DoD USERS

BA S&T

TECH XFER

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TPMM Defines The Process And Transition Mechanisms To Help Align Tech Programs With Capability Needs

Technology Transition Best Practices

- Repeatable processes
- Demonstrated to produce the desired result in more than one environment
- Easily adapted to other organizations (tailorable)
- Focuses on needs of users/recipients of technology
- Produces credible data for decision makers

Level	Best Practice	Status	Where used	Benefits
Personal – project level tool	TRL Quicklook checklist	Available for deployment now – easily tailored	DTRA, similar tools used in USAF, NASA	Consistent, credible, more objective TRL assessment
S&T organization	Technology Program Management Model (TPMM)	Process is mature – tool (TurboTPMM) pending C&A	SMDC, MDA, DTRA	Provides consistent, credible, data for portfolio management at S&T org.
Enterprise (S&T and PEO)	Technology Assessment Transition Management (TATM)	Process is mature – tool in use, undergoing C&A	PEO Aviation/AMRDEC, PEO Soldier, (JPEO Robotics – past)	Provides PEO reliable data on status/scheduling of S&T projects that will transition to PEO programs

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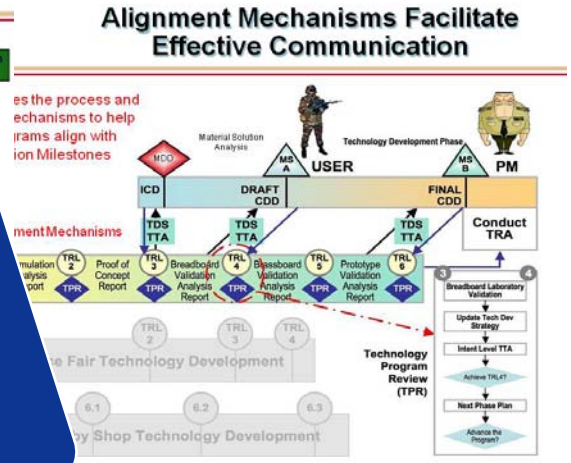
DAU Courseware includes Best Practice Methodologies and Tools

Technology Program Management Model

- U. S. Army Space and Missile Defense Technical Center
- Logical methodology to guide technology managers through the planning and development of their projects
- Seven phases with exit criteria and deliverables
- Technology process reviews after each phase
- Currently in use by Missile Defense Agency, Defense Threat Reduction Agency, Department of Homeland Security, Air Force Research Laboratory and Defense Threat Reduction Agency

TPMM

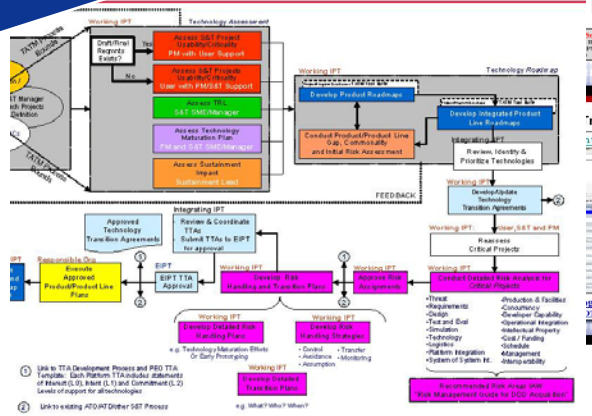


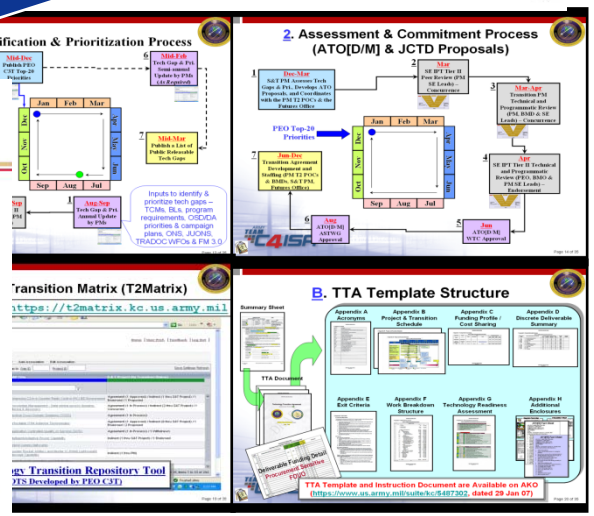
Technology Assessment and Tra… Management (TATM) Proces…

- Stable process agreed upon by AMRDEC and PEO Aviation
- User and sustainer are involved from start
- Technologies are judged on criticality and sustainability as well as technical maturity
- Identify where risk reduction efforts are needed
- Basis for Technology Transition Agreements

- DAU POC for TATM and TPMM: Mr. Jeff Craver, jeffrey.craver@dau.mil (256-895-3453) william.decker@dau.mil (256-895-3448)

TATM





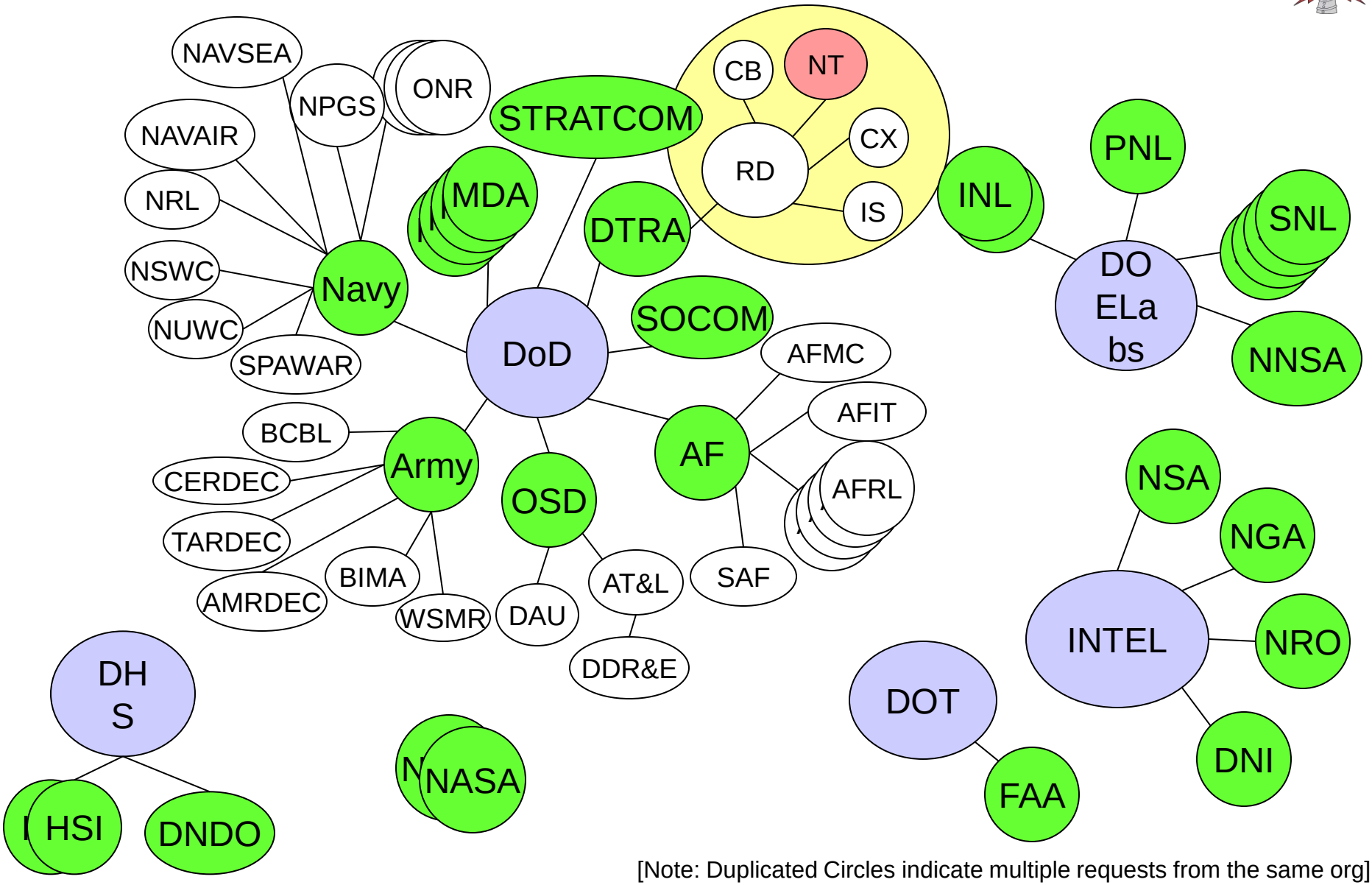
T2 MATRIX

Science and Technology Management

STM 202

Example content

Organizations Interested in TPMM



[Note: Duplicated Circles indicate multiple requests from the same org]

TPMM User Examples

Missile Defense Agency

- **Kill Assessment Technology Program used TPMM to broker the inclusion of their technology concept into the C2BMC Element of the BMDS.**

Department of Homeland Security

- **Provided Basic Research technology maturity data (Entry/Exit Criteria, Phase Deliverables, and Activities) used to populate the Exploratory portion of their draft S&T RDT&E Process.**

Air Force (AFMC at Wright-Patterson AFB)

- **Supporting TD-1-13 Initiative: High Confidence Technology Transition Planning Through the Use of Stage-Gates (More later)**

U.S. Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ARSTRAT)

- **Vertical/horizontal Integration of Space Technologies and Applications (VISTA) Program**
- **Distributed Imaging Radar Technology (DIRT)**
- **All Weather RF Launch Detection (AWRFLD)**

Defense Acquisition University (Huntsville Campus)

- **Developing an interface between Technology Assessment and Transition Management (TATM tool used at PEO Aviation) and TPMM.**

Defense Threat Reduction Agency (NTD Ft. Belvoir)

- **Providing Engineering Analysis to initiate collaboration on a Technology Management Process Improvement effort designed to implement the TPMM in their Division S&T.**

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DTRA RD
TPMM Implementation Pilot

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Technology Development Challenges Facing DTRA-RD

Consistent *technology development planning*

- Requirements definition and refinement not applied consistently and effectively.
- Lack a common set of tools and standards to gauge technology maturity.

Improve *transitioning of technologies*

- Transition not always considered as part of Technology Development
- Limited Customer/User identification/involvement

Establish **"a management methodology that balances the portfolio by *Imposing Structure and Rigor* *through the use of clear, well-defined and Measurable Metrics*!"**

J. Heusmann DTRA-RD *(7 May 09)*

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Desired Technology Management Environment

- **An environment that delivers technology-based solutions to a Program of Record in response to documented and validated capability gaps.**
- **An Environment where:**
  - **User capability needs are accurately and fully defined in the DTRA mission space and allocated to the appropriate directorate**
  - **Risk is reduced because the user is engaged at appropriate steps in the development process**
  - **Transition agreements and detailed roadmaps are jointly developed and committed to**
  - **Technologies/products are fully integrated, tested, and fielded**
  - **A set of common standards and metrics are established and applied to all technology development programs as applicable.**
  - **Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities (DOTMLPF) needs of our transition partners are addressed early in the development process.**

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DTRA-RD TPMM Training

TPMM Naked
Thurs, 28 Jan
0830-1000 hrs

TPMM and the Myth of the Grape Kool-Aid
Thurs, 25 Feb
1400-1530 hrs

TPMM - Combat Training
Weds, 17 Mar
1400-1530 hrs

Turbo TPMM
Weds, 3 Mar
1400-1530 hrs

Endorsed by Defense Acquisition University (DAU) as a "best practice"

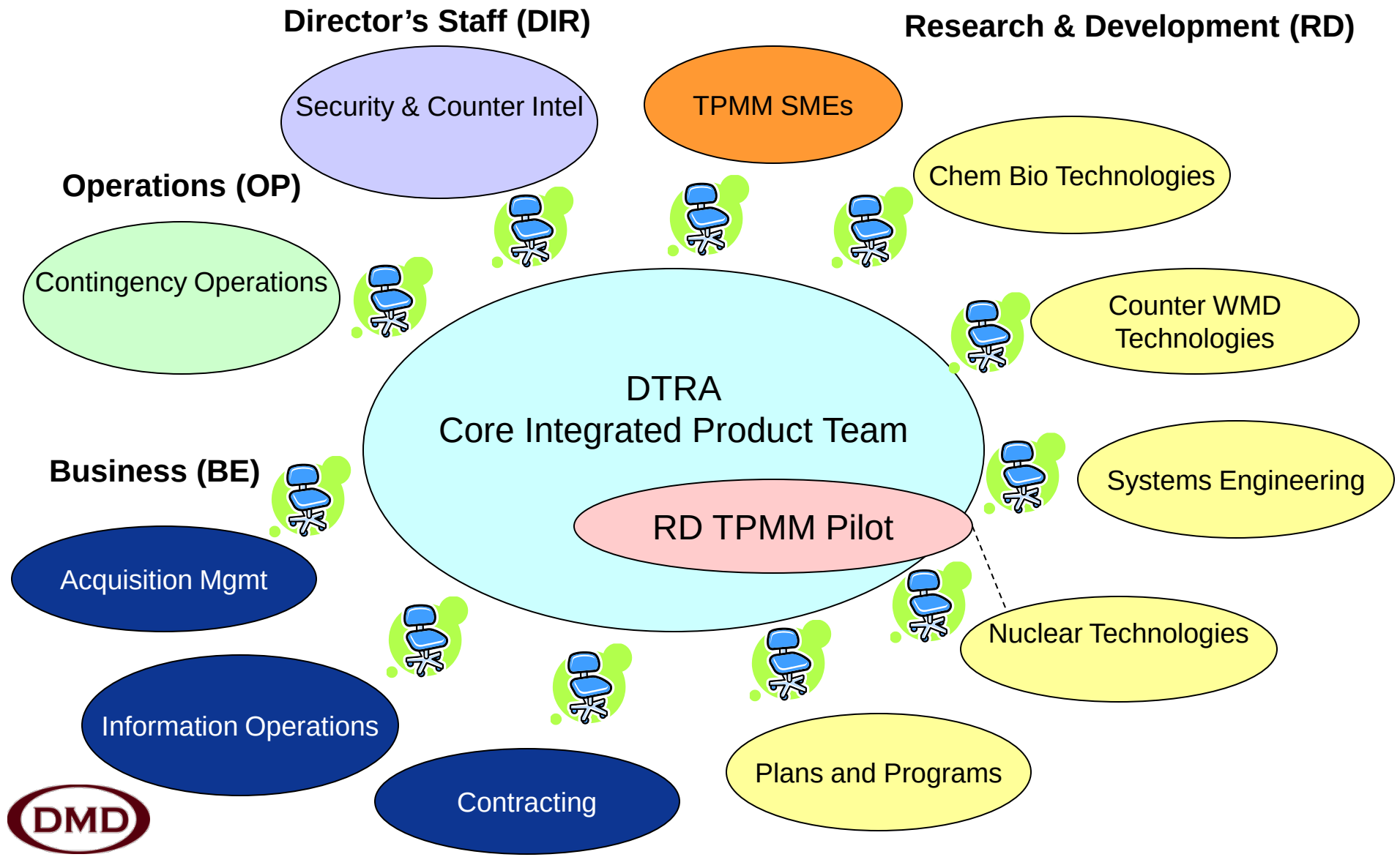
Technology Project Management Model (TPMM) Program

- Improves program execution
- Facilitates program review and prioritization
- Aligns capabilities and identifies gaps
- Reduces risk
- Improves investment decisions
- Can be tailored to meet organizational needs
- Defines key decision points to evaluate progress
- Incorporates organizational processes and systems
  Enhances documentation process
- Supports technology transition

Join Us As We Explore a Focused Approach To DTRA Technology Development

TPMM Pilot Underway in DTRA-RD-NT

DTRA TPMM IPT



TPMM Pilots at DTRA-RD

Basic Research

- BA to identify TRL 2/3 opportunities (1 or 2 projects) that BA and NTD will develop a transition plan for FY11 execution .

Division TPMM Pilot

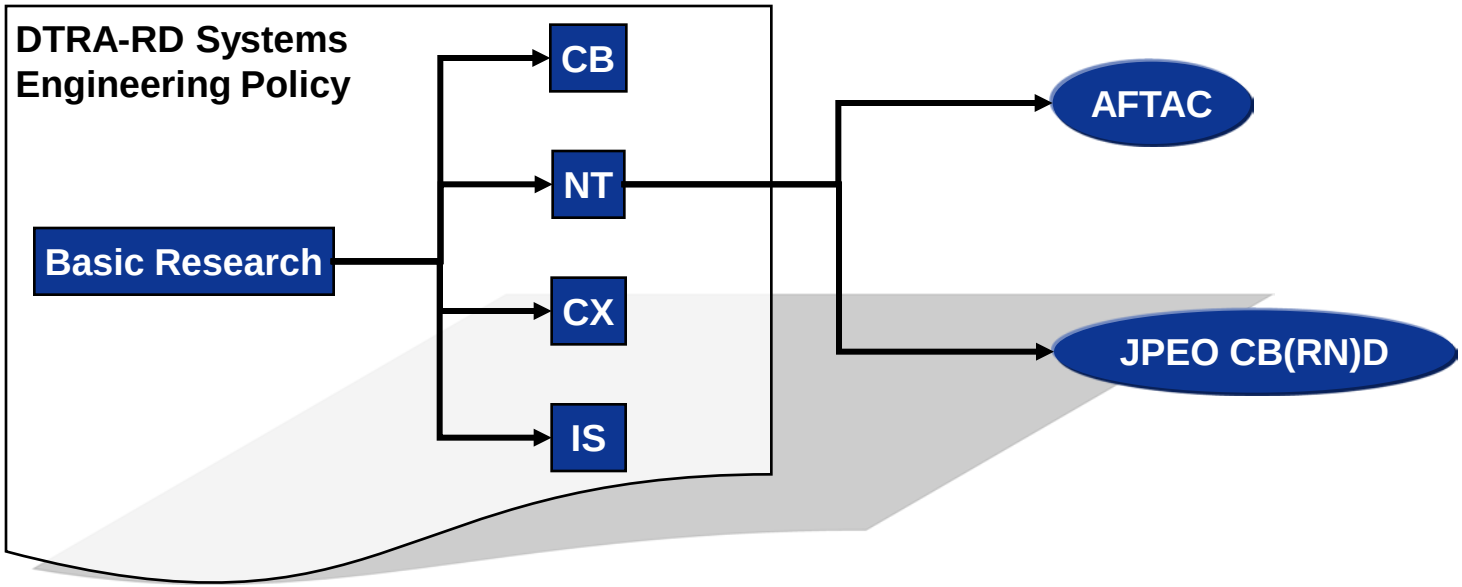
- Develop/Implement Standard Metrics for use in Measuring Progress using the DTRA/NTD Process. Perform ongoing Maturity Assessment for Detection Projects and Baseline in TPMM.

Systems Engineering

- Working DTRA-RD SE Policy and developing strawman Technology Maturity Assessment Process for in Formal Gate Reviews. Establishing DTRA Mission Space Requirements Pathway

Transition to Customer Pilot(s)

- Developing Generic Transition Process between JPEO CBD and DTRA-RD including Pilots
- Executing Technology Transition Agreement with AFTAC on a specific Technology Project



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Basic Research to Applied Research Technology Transition

Exercises in Technology Transition:

- BA to NTD Transition Process White Paper drafted
- "Interest" developed for six Grant projects will down-select to 2-3 that are "Intended" for Applied Research
- Developing process deliverables and evaluation tools
  - **Modified TRL 2 Checklist**
  - **Introduce Tailored TPMM Deliverables:**
    - Technology Transition Agreement
    - Concept Formulation Analysis Report
    - Proof of Concept Plan
    - Proof of Concept Report

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Technology Transition to JPEO-CB(RN)D

- **Exercises Planned in Technology Transition:**
  - First transition will be for a JCTD component system that is beyond MS-B that is ready for “leave behind” but *not presently sustainable*.
  - Assist JPM RN to provide for DOTMLPF
  - Follow-on Transitions will be more traditional and engage with the formal Acquisition process at or about MS-A (TRL 4).
- **Implementing TPMM process Transition Deliverables and evaluation tools**
  - Updated TRL 4, 5, & 6 Exit Criteria Checklists
  - Introduce Tailored TPMM Deliverables:
    - Technology Transition Agreement
    - Technology Development Strategy
    - Phase Validation Plans/Reports
  - Investigating Existing Criteria for IRL/SRL 7-8 for use with mature Projects

TPMM Phase Deliverables – Applied Research to EMD

INTERNAL TRANSITION

TMA

BASIC RESEARCH → APPLIED RESEARCH

TRL	1	2	3	4	5	6
	Discovery	Formulation	Proof of Concept	Refinement	Development	Demonstration/ Transition	Integration

Discovery

- Programmatic
  - Schedule & funding for next phase
- Technical
  - Tech Concept Developed
  - Industry Analysis
  - Academic Studies
- Transition
  - ID Potential Stakeholders

Deliverables

- Feasibility Study
- Formulation Plan

Formulation

- Programmatic
  - Schedule & funding for next phase
- Technical
  - Trade studies conducted
  - Tech difficulty established
  - Alternatives analyzed
- Transition
  - ID specific customers

Deliverables

- Analysis of Technical Alternatives
- Formulation Analysis Report
- Proof of Concept Plan

Proof of Concept

Programmatic
- Program cost Estimation
- Pgm Schedule developed
- Contract strategy

Technical
- Req Doc developed w/ (ICD)
- Cross tech
- Proof of concept analysis
- M&S developed
- Lab testing results

Transition
- Sponsor funding

Deliverables

- Proof of Concept Report
- Technology Development Strategy (TDS) Initial
- Technology Transition Agreement (TTA) (Interest)
- User Operational Requirements
- Breadboard Lab Validation Plan

Refinement

Programmatic
- WBS
- Cost Model
- TDS
- Manufacturing plan

Technical
- SEP
- F3 parameters
- System resource allocations
- Design constraints
- Integrated Lab Test of "ad hoc" or Breadboard Components
- Illities Analysis

Transition
- Stakeholders briefed (Customer/User)

Deliverables

- Breadboard Lab Validation Report
- TDS Update
- TTA (Intent)
- User Performance Requirements
- Brassboard Lab Validation Plan

Development

Programmatic
- LCCMP
- WBS (+)
- Cost & risk performance

Technical
- Demonstrate components work with/as system
- Test with other elements in HF Validation test
- Develop high fidelity component or Brassboard "HWIL"
- Final Requirements
- Manuf/Prod Anal
- Document ilities

Transition
- Detailed Transition Planning and Gain Customer Approval

Deliverables

- Brassboard Lab Validation Report
- TDS Update
- TTA Update (Intent)
- Manufacturing Plan [Draft]
- Production/ILS Plan [Draft]
- Prototype Relevant Env Lab Validation Plan

Demonstration/ Transition

Programmatic
- LCC
- Transition agreement
- Cost & Risk assessment

Technical
- Demonstrate Prototype Ready for Operations
- Produce Proto Hardware for a Relevant Env
- Test Prototype as System in Simulated Operational Setting
- Demonstrate Increased Capabilities

Transition
- Transition agreement signed
- MOA

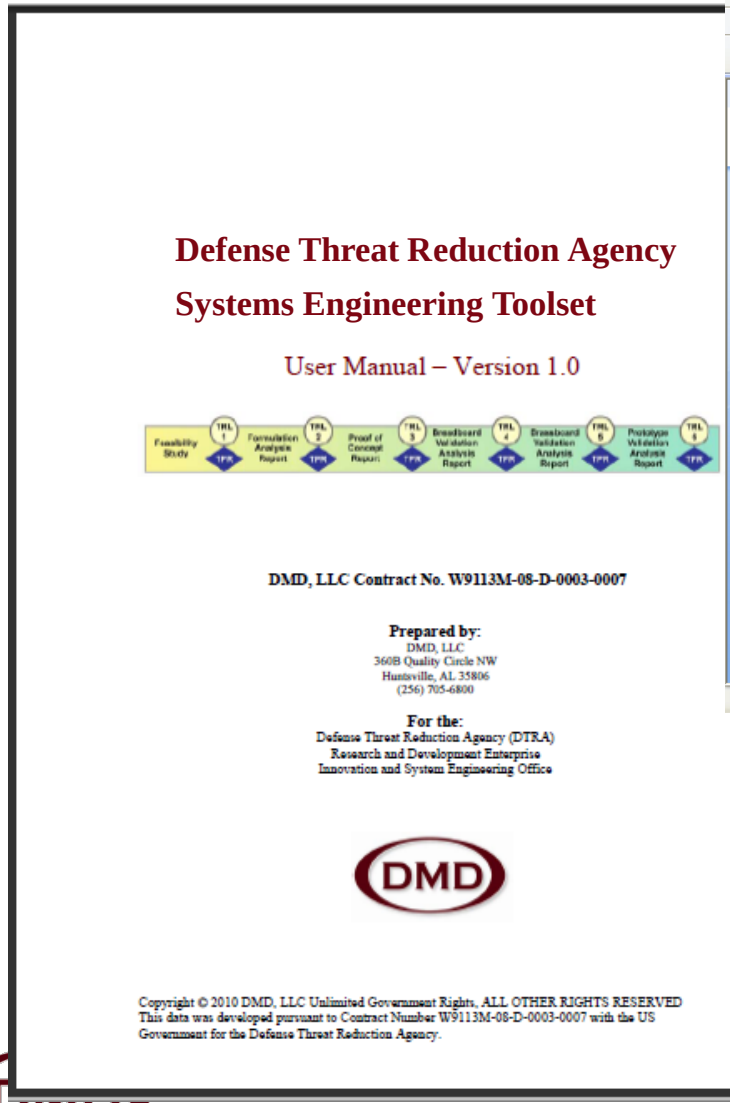
Deliverables

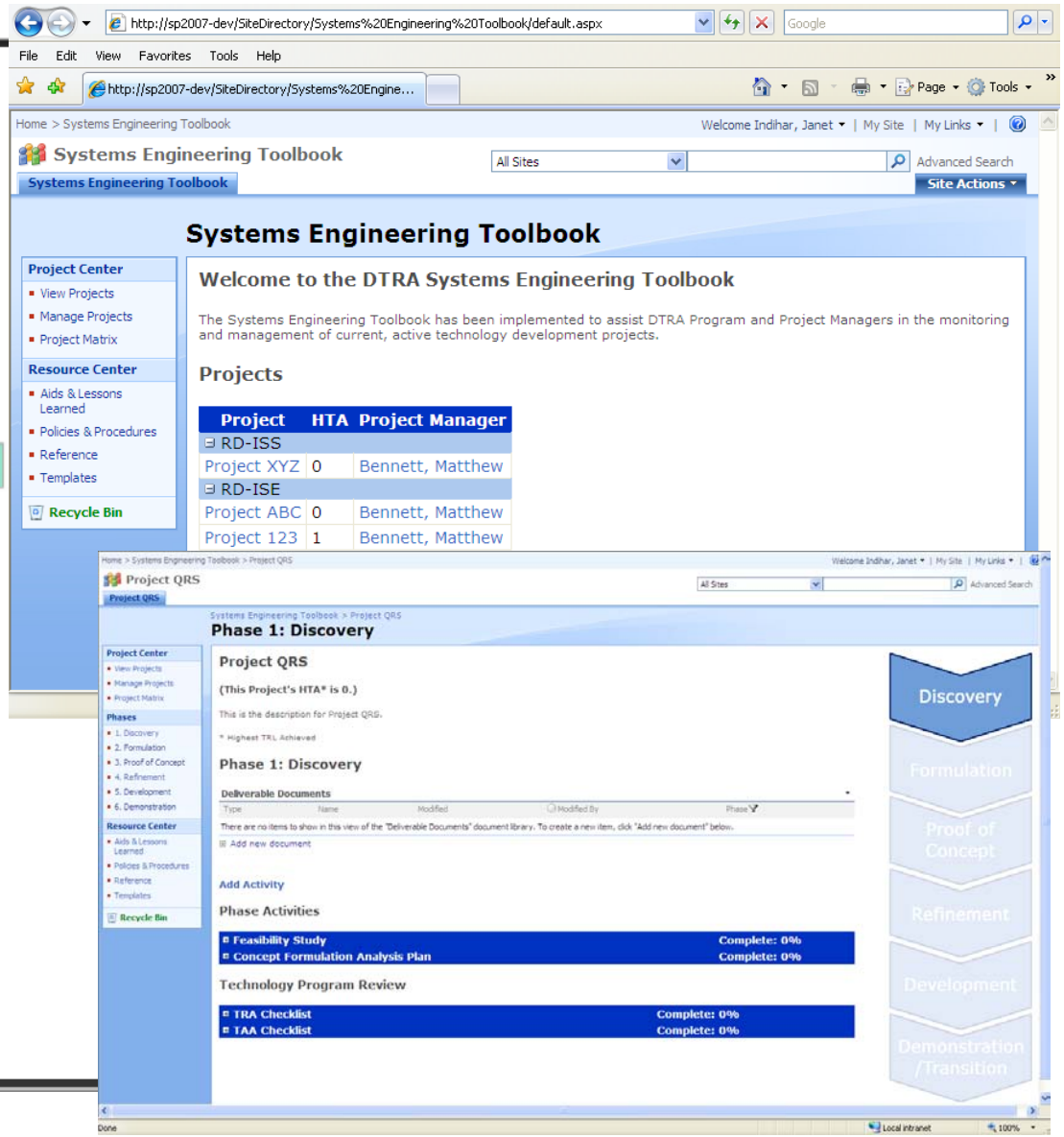
- Prototype Relevant Env Lab Validation Rpt
- TDS Final
- TTA Update (Commitment)
- Manufacturing Plan [Final]
- Production/ILS Plan [Final]
- Transition Support Plan

LEGEND

DTRA | JPEO | BOTH

DTRA-RD TPMM SharePoint Tool





TPMM Strategic Value

Status of Programs

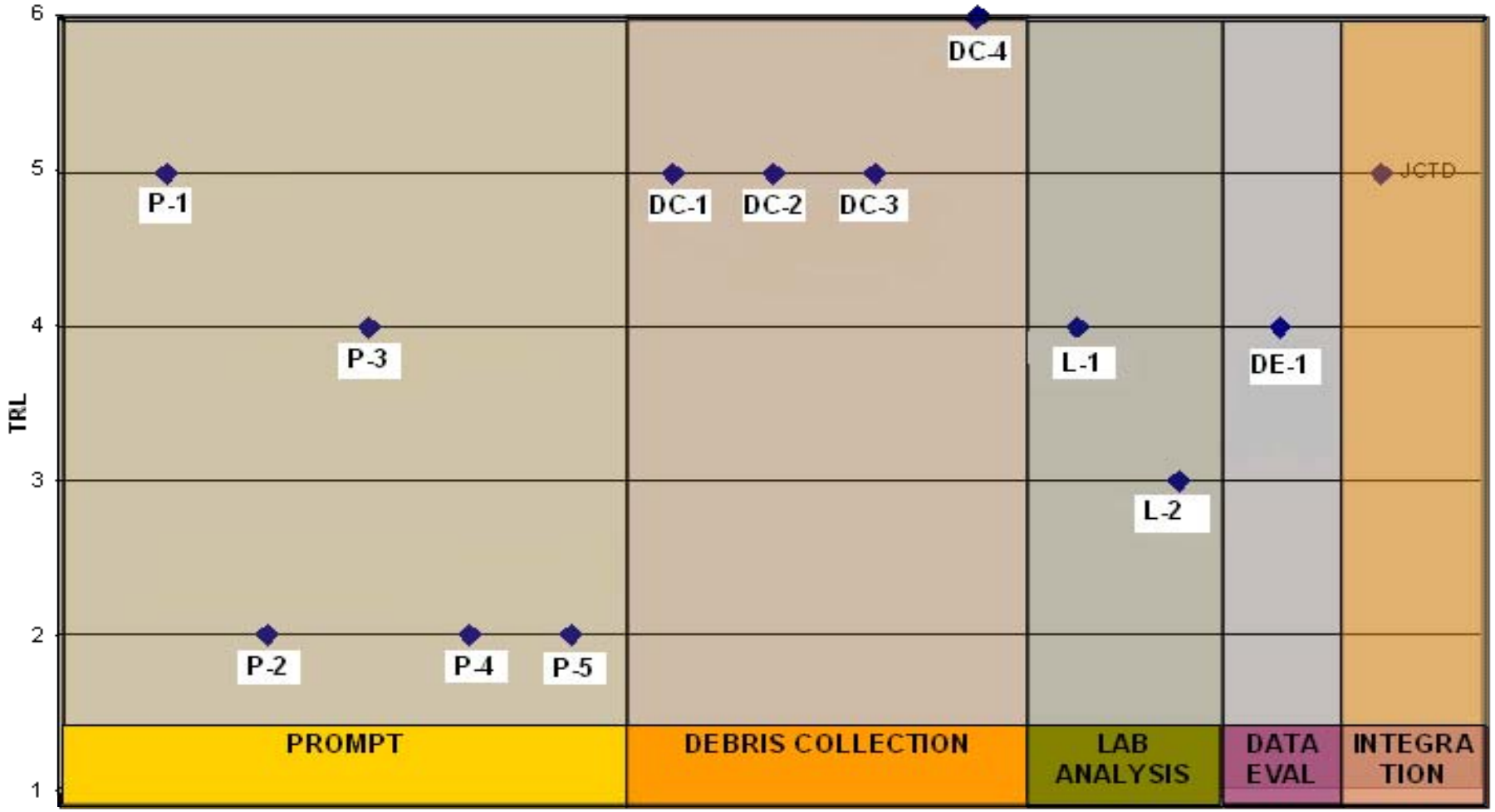
- Standardizes Progress in Meeting TRL Maturity Goals
- Transition Agreements in place
- Successful Transitions over time
- Program Distribution by
  - TRL
  - Technology Domain
    - •Science Discipline
    - •Sponsor
  - Acquisition Customer
  - Funding

Facilitate Strategic Planning

- Technology Distribution and Prioritization
- Technology Development Gap Analysis
- Domain Analysis
  - Skill gaps / recruiting needs (Develop/Maintain technical skill set)
  - Diversified Portfolio Analysis
    - •Sponsor
    - •Science Discipline
- TTA Migration Status
- Develop POM/Budget Inputs
  - Substantiates Technology maturity and value

TPMM Provides a Metrics-driven Process that Supports Strategic Decision Making

Technology Quicklook Maturity View: Forensics



TPMM Outputs Support Decision Making

TPMM Output	Priority	1	2	3	4	5
Technology Advancement Degree of Difficulty (TAD^2)	1	Well Within	Within	Pushing the Science	Hard Push on Science	Breakthrough Required
Risk	1	100% Mitigated	< 100% > 75% Mitigated	< 75% > 50% Mitigated	< 50% > 25% Mitigated	< 25% Mitigated
Next TRL Achievement	1	Imminent (0-6 months)	Soon (6-12 months)	Ranged (12-18 months)	Far (18-24 months)	Horizon (>24 months)
TRL Roadmap to Transition	1	1 Year	2 Years	3 Years	4 Years	>4 Years
Technology Transition Agreement (TTA) Initiated	1	Commitment	Intent	Interest	Under Development	None
Phase Cost (Funding Objectives and Threshold Minimum)	1	< $500K	>$500K <$1M	>$1M <$2M	>$2M <$3M	>$3M
Measure of Effectiveness as a % improvement over existing capability/performance	1	>100%	< 100% > 75%	< 75% > 50%	< 50% > 25%	< 25%
Requirements Trace	1	Traceable to DTRA Mission	Traceable to RD-NT	Traceable to RD-NT-NTD	Level DoD Source	Not Traceable

- **A priority can be set for any given factor when one has more influence with the decision than another (i.e., where MoE is more important than cost but equal in relevance to TAD^2)**
- **TPMM outputs can be used to support investment decisions applied as follows:**
  - **A Project that totals [≥ 33] is in need of review for continuation**
  - **A Project that ranks [≥ 21 but ≤ 32] needs Management Oversight**
  - **A Project that totals [≥ 11 but ≤ 20] has moderate risk**
  - **A Project that totals [≤10] should be considered as well targeted and relatively Low Risk**

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Summary

- TPMM is an ***activity model*** for technology development that is partitioned into phases and gate-qualified using ***TRL***.
- TPMM is a ***best practice standard*** that expands TRL understanding to include ***detailed activities, exit criteria, and deliverables***.
- TPMM is a ***toolset*** used by the Tech Manager to ***plan, guide and measure*** a technology program's development maturity.
- TPMM is an ***alignment mechanism*** that promotes early focus on ***transitioning the technology*** to Acquisition Program Customers.
- TPMM acts as a ***common yardstick*** and provides the criteria for evaluating the ***Technology Development Strategy*** earlier.
- TPMM model provides ***a standard TRL criteria set*** for performing effective ***Technology Readiness Assessments*** at MS B

Contact/Consultation Information

Mr. Jeffrey Craver
Defense Acquisition University
South Region
Huntsville, AL 35807
E-mail: **Jeffrey.Craver@dau.mil**

Mr. Hossam Ahmed
DTRA-RD
Ft. Belvoir, VA
E-mail: Hossam.Ahmed@dtra.mil

Mr. Mike Ellis
DTRA-RD
(USASMDC/DMD, LLC)
Ft. Belvoir, VA
E-mail: Michael.Ellis_contractor@dtra.mil

US Government Personnel can request a copy of TPMM V2.pdf file at:
http://www.tpmm.info

QUESTIONS?