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Missile Defense Technology Initiatives

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Abstract	
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PURPOSE

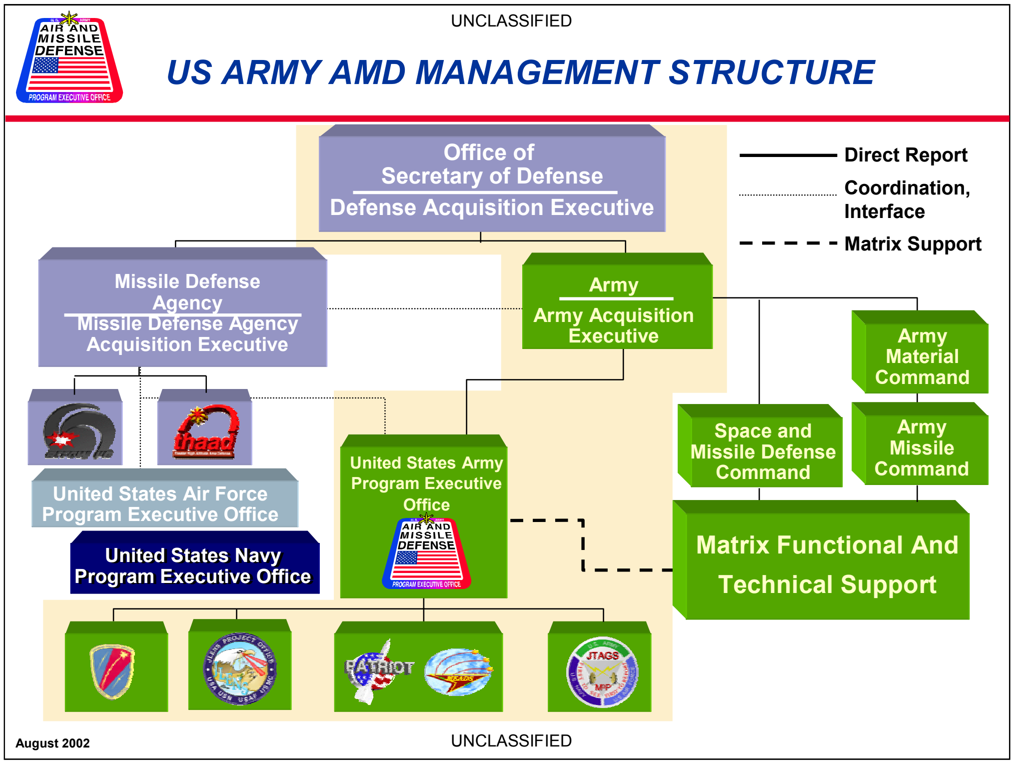
The Purpose Of This Paper:

To Describe How The Missile Defense Technology Initiatives Process Supports Capability–Based Acquisition

PURPOSE

To Describe The Technology Program Management Model Used in Conjunction with the Technology Initiatives Process,

Used By The US Army Program Executive Office, Air and Missile Defense (PEO AMD)



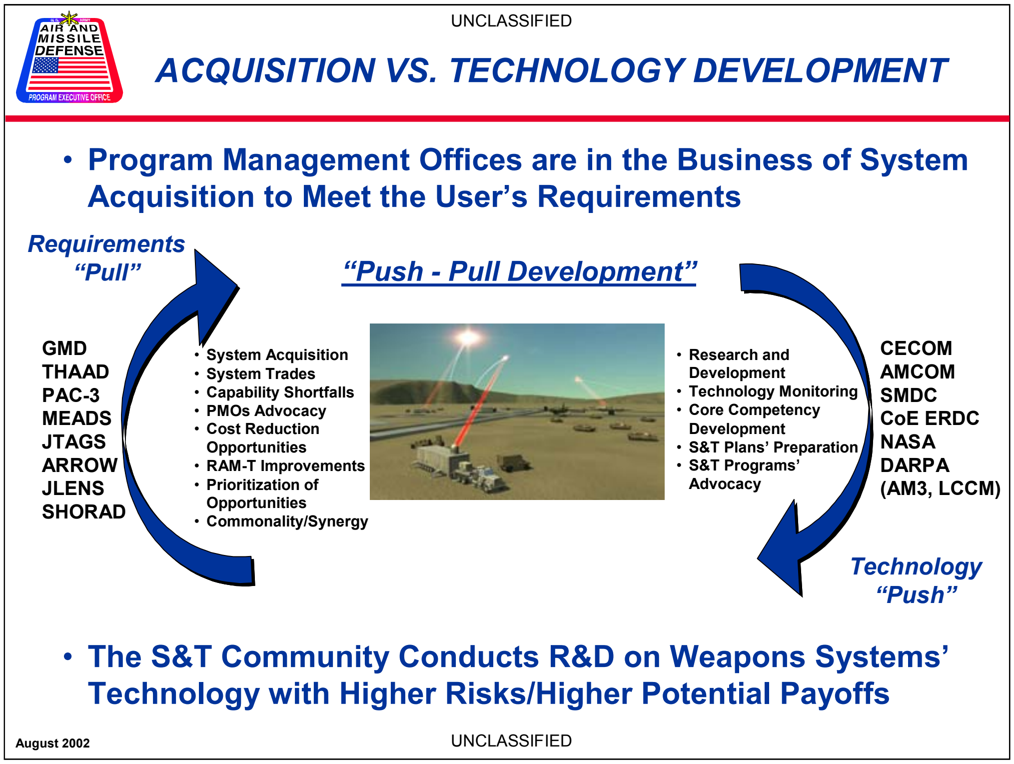
US ARMY AMD MANAGEMENT STRUCTURE

The PEO AMD is organized in the Office of Secretary of Defense under the US Army Acquisition Executive. The actions and activities of Ballistic Missile Defense are coordinated with the Ballistic Missile Defense Organization. PEO AMD specifically covers the Theatre Missile Defense Systems; the National Missile Defense, or NMD System, is under the auspices of the NMD Joint Program Office.

PEO AMD planning includes forecasting via analysis, upgrades to current weapons systems while developing concepts for the next generation systems. PEO AMD then integrates the S&T technology development program schedule with the MDAP's acquisition schedule, resolving conflicts through planning the timely technology insertion into the program(s). PEO AMD becomes a primary advocate for funding the technology development program, assisting with budgetary programming processes with the respective S&T labs, corporations and other government agencies.

What the PEO AMD does not do, is operate in a vacuum removed from daily contact with MDAPs. Personnel within PEO AMD are matrixed from within the US Army S&T base, such as from the Space and Missile Defense Command (SMDC) and the Army Aviation and Missile Command (AMCOM). This cross-matrix of personnel offer a tremendous cross-program ability to analyze and recommend technologies for insertion opportunities.

The US Army AMD Management structure is such that the PEO is directed by the Office of the Secretary of Defense (OSD) to oversee and direct the offices associated with programs like: Army Lower Tier Program Office (ALTPO), The Joint Tactical Ground Station (JTAGS) – multi-mission Mobile Processor (M3P), Joint Land Attack Cruise Missile Elevated Sensor



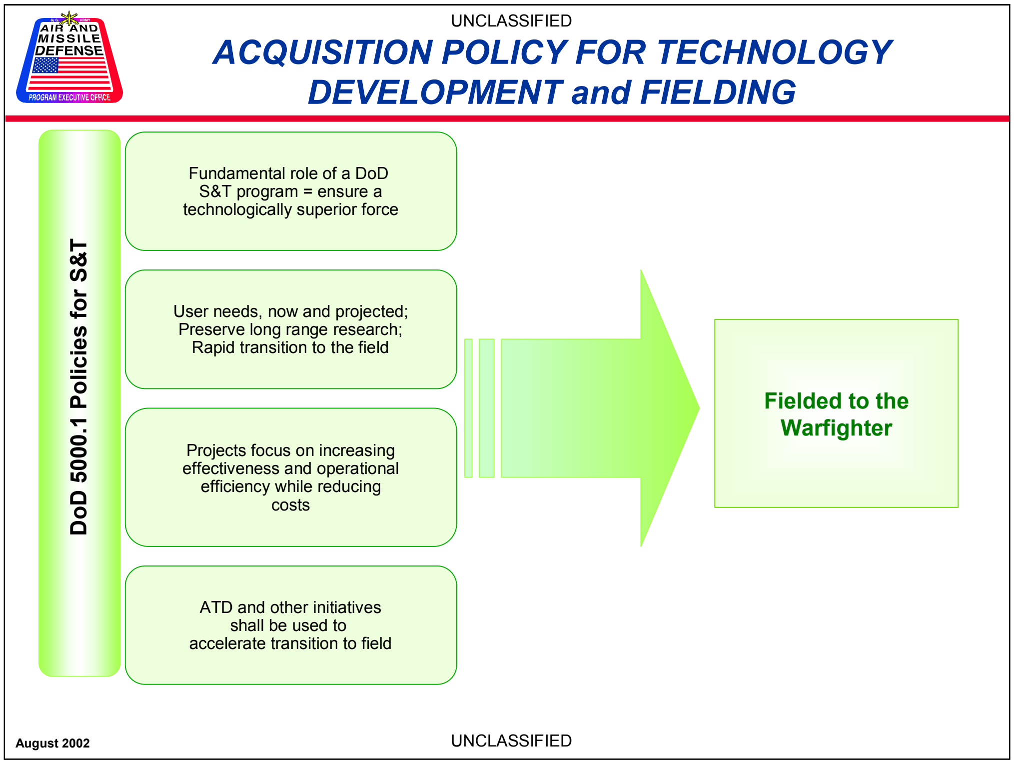
ACQUISITION VS. TECHNOLOGY DEVELOPMENT

There is a difference in how the U.S. acquires weapons systems and how we develop technology. We refer to this as the "*Push-Pull Development*" process.

The PEO AMD and its PMOs are in the business of system acquisition to meet the users' requirements, which constitutes the requirements 'pull' for new technology: The PMO and its prime contractor working within ORD constraints, trading off design alternatives, overcoming ORD shortfalls, focusing on near-term milestones, and the PEO AMD looking 'outside of the box' for ways to improve performance, reduce risk, reduce cost and improve R&M.

Meanwhile, the S&T community is engaged in research and development (R&D) to advance weapons systems' technology with higher risk/higher potential pay offs. This constitutes the technology 'push' for development: each government laboratory monitors progress in specific technical areas, has it's own core competencies and functions as a particular 'center of excellence' in a specific field of technology, such as guidance and control.

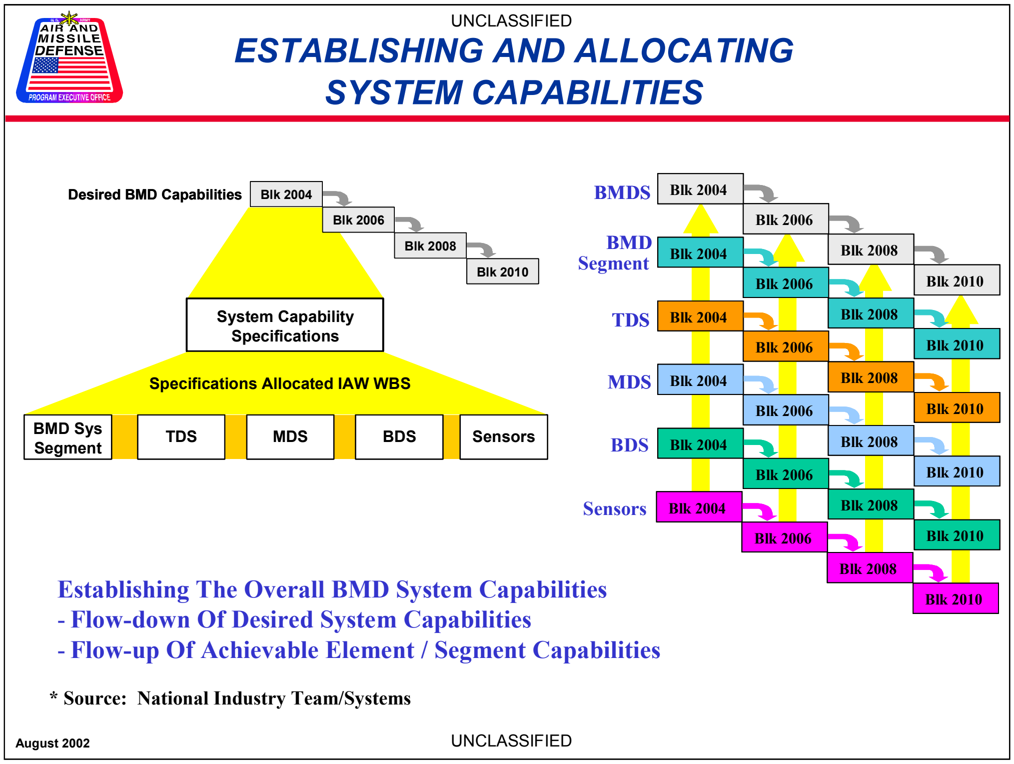
The S&T community is responsible for preparing the future years S&T Plan, and in conjunction with the acquisition proponents, advocates program funding. Through this 'Push-Pull' process, appropriate technologies are developed and transitioned to weapons systems' acquisition.



ACQUISITION POLICY FOR TECHNOLOGY DEVELOPMENT and FIELDING

The first principle of the TPMM is that it is consistent with DoD acquisition processes and policies.

The Figure above illustrates the DoD Acquisition Policy pertaining to four science and technology principles within the DoD 5000.1 document. Documents DoD 5000.1 and 5000.2 are extremely specific to the use of additional and projected technology insertion opportunities into an established MDAP. Thus, the Milestone Decision Authority (MDA) must be comfortable that not only does a proposed technology meet the requirements for insertion, but also satisfies the policies accompanying such acquisition.



The above figure depicts the acquisition foundation on which the TPMM Guidebook is established. The TPMM offers Technology Development PM's and MDAP PM's guidelines to ensure policies are met, while examining relevant Technology Readiness Levels (TRLs) peculiar to the effort.

The circular arrows indicate that there is cohesion and consistency between established policy and the TPMM tool.

PROCESS

The Technology Initiatives process begins with the identification of the various weapons systems' technology needs.

PEO AMD collects, catalogs and disseminates these needs to the Science and Technology (S&T) community, searching for the best solutions, which are typically developing or emerging technologies from the S&T Labs.

PEO AMD plans the upgrade of current weapons systems and develops concepts for next generation systems.

PEO AMD then integrates the S&T technology development program schedule with the weapons systems' acquisition schedules, resolving schedule conflicts and planning the timely insertion of the technology into the weapons system programs.

And finally, PEO AMD becomes a primary advocate for funding the technology development program and assists in the budget programming process with the respective S&T labs, corporations and other government agencies.

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RATIONALE

Why Do This?

To:

- **Improve Performance (P_{ssk}) vs. Baseline (Threshold), Emerging, Advanced (Objective), and Responsive (Countermeasures) Threats**
- **Reduce System Life Cycle Cost (LCC)**
- **Improve Producibility**
- **Improve Reliability, Availability, Maintainability and Testability**
- **Resolve Parts Obsolescence Problems, Implement COTS**
- **Reduce Weapon Systems' Risks**
- **Develop Plans for Upgrading Current Weapon Systems and Concepts for Next Generation Systems**

Technology Insertion Helps Mitigate Evolving Threats, Solve Difficult Technical Problems And Reduce Cost

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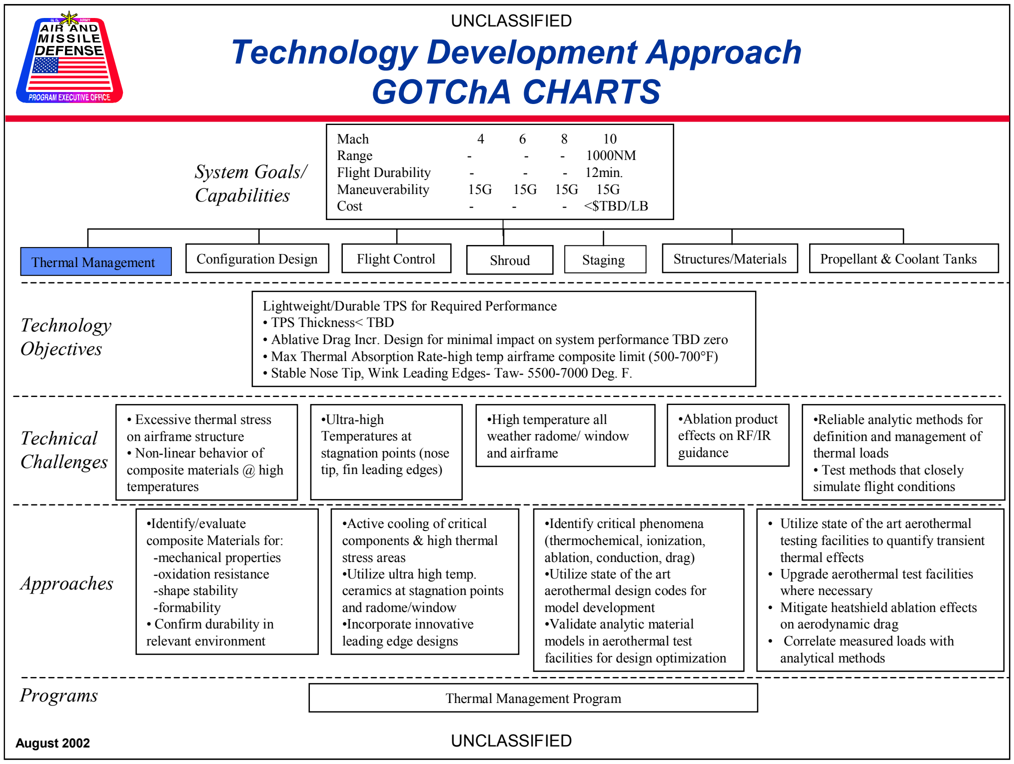
RATIONALE

The question arises, why change the design baseline with technology insertion?

The answers are obvious. Often times, some time has passed since the weapons system ORD was approved, sent out in the form of request for proposal, and a contract was awarded. During that time, the threat has advanced to what the objective system was designed to meet, threats have emerged and countermeasures to the fielded system have been identified. The performance of the baseline design needs to be improved to satisfy the customer.

Other system attributes such as life cycle cost, producibility, reliability, and maintainability are measured and goals identified. During the MDAP cycle, parts obsolescence becomes an issue, for example, in system electronics, thanks to Moore's Law. This can often be alleviated by commercial-off-the-shelf (COTS) material. Overall, systems' risks can be reduced and plans for upgrading the current weapon systems or next generation systems concepts can be developed. Technology Insertion helps mitigate evolving threats, solve difficult MDAPs technical problems and reduce system cost, which becomes the primary driver in the acquisition cycle.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Technology Development Approach
GOTChA CHARTS
System Goals/ Capabilities
Mach 4 6 8 10
Range - - - 1000NM
Flight Durability - - - 12min.
Maneuverability 15G 15G 15G 15G
Cost - - - <$TBD/LB
Thermal Management
Configuration Design
Flight Control
Shroud
Staging
Structures/Materials
Propellant & Coolant Tanks
Technology Objectives
Lightweight/Durable TPS for Required Performance
• TPS Thickness< TBD
• Ablative Drag Incr. Design for minimal impact on system performance TBD zero
• Max Thermal Absorption Rate-high temp airframe composite limit (500-700°F)
• Stable Nose Tip, Wink Leading Edges- Taw- 5500-7000 Deg. F.
Technical Challenges
• Excessive thermal stress on airframe structure
• Non-linear behavior of composite materials @ high temperatures
•Ultra-high Temperatures at stagnation points (nose tip, fin leading edges)
•High temperature all weather radome/ window and airframe
•Ablation product effects on RF/IR guidance
•Reliable analytic methods for definition and management of thermal loads
• Test methods that closely simulate flight conditions
Approaches
•Identify/evaluate composite Materials for:
-mechanical properties
-oxidation resistance
-shape stability
-formability
• Confirm durability in relevant environment
•Active cooling of critical components & high thermal stress areas
•Utilize ultra high temp. ceramics at stagnation points and radome/window
•Incorporate innovative leading edge designs
•Identify critical phenomena (thermochemical, ionization, ablation, conduction, drag)
•Utilize state of the art aerothermal design codes for model development
•Validate analytic material models in aerothermal test facilities for design optimization
• Utilize state of the art aerothermal testing facilities to quantify transient thermal effects
• Upgrade aerothermal test facilities where necessary
• Mitigate heatshield ablation effects on aerodynamic drag
• Correlate measured loads with analytical methods
Programs
Thermal Management Program
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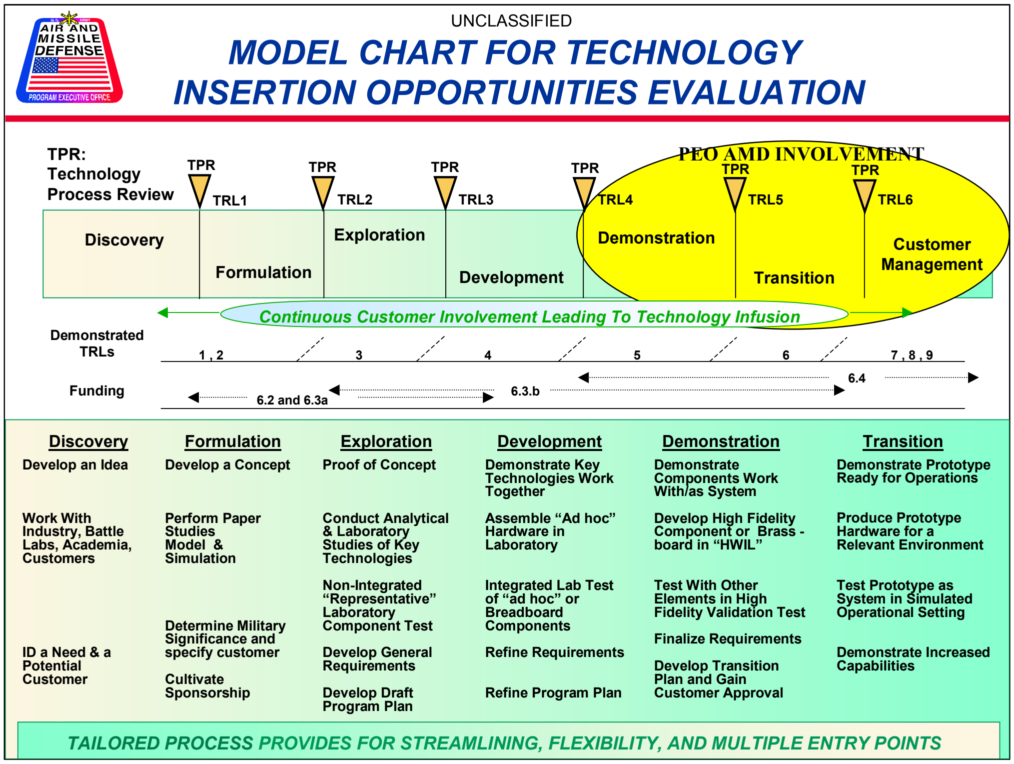

MODEL CHART FOR TECHNOLOGY INSERTION OPPORTUNITIES EVALUATION

Here we see a timeline coupled with technology readiness levels used as a guide for technology evaluation. This is discussed within the paper in the section, **The TPMM, TRLs, and Policy**. As an introduction to the fundamentals of the overall process, the TRLs need to be introduced here as they are a part of the evaluation criteria for insertion discussions.

All technologies, which are candidates for insertion opportunities, need to be scrutinized according to the TRL system and connected to a certain milestone for decision-making. Each TRL phase has a specific set of criteria to be satisfied prior to proceeding to the next phase of the project. This is the essence of the TPMM evaluation process.

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TECHNOLOGY MATURITY DETERMINES INSERTION TIMING

Technology Readiness Levels - TRLs

Level	Description
1. Basic principles observed and reported.	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a 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 a 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 TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a "high 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 TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in an aircraft, vehicle or space. Examples include testing the prototype in a test bed aircraft.
8. Actual system completed and "flight qualified" through test and demonstration.	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL 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 specifications.
9. Actual system "flight 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. In most cases, this is the end of the last "bug fixing" aspects of true system development. Examples include using the system under operational mission conditions.

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TECHNOLOGY MATURITY DETERMINES INSERTION TIMING

When evaluating technologies in the past, three levels of subjective risk analysis were used: low, medium and high risk. Only technologies deemed low or medium risk were considered viable for insertion planning. High risks were relegated to the S&T community for further development to reduce the risk before re-consideration for insertion planning.

Today, a broader scale for technology maturity evaluation is embraced within DoD: TRLs. These wee developed by and borrowed from the National Aeronautic and Space Administration (NASA). There are 9 TRLs, each with its own objectively-defined level of technical accomplishment, defined and described in this slide.

Before a technology can be considered for insertion, a level of maturity must be demonstrated. PEO AMD requires technologies to achieve TRL 6 before they are considered ready to transition into a weapons system. At TRL 7, the MDAP is intimately involved in the technology insertion effort. All test results pertinent to the technology being evaluated must be forwarded to the Technology Development PM's, the MDAP PM's, or a specific Program Management Office (PMO), to augment decisions relevant to the MDAP and insertion opportunities.

Within the guidelines of the TPMM, technology readiness levels provide for adequate evaluation and determination of the usability of the technology under consideration. There is a specific set of questions to be answered before a technology is perceived to be beyond a certain TRL, and its benefit for the targeted system must be well-understood and viable for utilization consideration. Therefore, development and insertion considerations are not carried out isolated from the many other factors affecting an MDAP. Thus, Technology Development PM's and MDAP PM's have a useful tool to assist with crucial decisions as the project moves forward.

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TAILORED TRLs

Verification / Validation		
TRL Level	Tailored Criteria	Validation
1	Conduct literature search on candidate technology	Develop technology utility concepts
2	Develop requirements for using a system flow-down process	Develop application conceptual design
3	Validate performance of all components of conceptual design	Conduct laboratory experiments validating component performance
4	Validate performance of partial breadboard	Conduct hardware feasibility tests in Lab or field
5	Develop and test complete breadboard in simulated environment	Conduct high-fidelity field experiments
6	Develop brassboard with required performance and weight traceability	Test brassboard on ground or in airborne demonstrations
7	Development test flight unit integratable in interceptor	Flight test in space environment
8	First production unit flight test	Fly production unit in actual interceptor in a C2 demo
9	Flight test against C2+ threats	Fly production unit against C2 + threats

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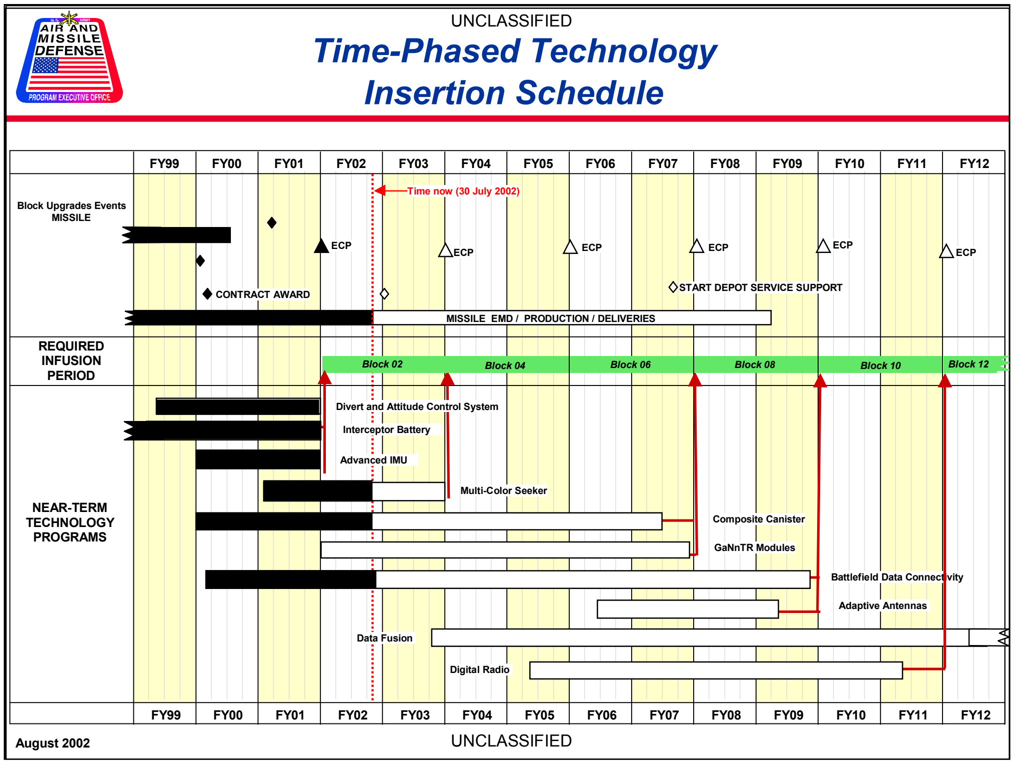
TAILORED TRLs

PEO AMD realizes that technologies vary from hardware, software, phenomenology, algorithms, etc., and that TRLs should be tailored for each type of technology, with specific tailoring to specific efforts.

For example, consider a technology that enhances a given system, such as a new type of sensor. Using guidelines set forth in the TPMM, tailored TRLs peculiar to this technology must be addressed in a step-wise fashion, progressing from one to the next in sequence. This slide lists the validation and verification steps required for this respective sensor technology.

Observe that ‘brassboard’ development and testing is required in TRL 6 before transition consideration.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Time-Phased Technology
Insertion Schedule
FY99 FY00 FY01 FY02 FY03 FY04 FY05 FY06 FY07 FY08 FY09 FY10 FY11 FY12
Time now (30 July 2002)
Block Upgrades Events
MISSILE
ECP
CONTRACT AWARD
START DEPOT SERVICE SUPPORT
MISSILE EMD / PRODUCTION / DELIVERIES
REQUIRED
INFUSION
PERIOD
Block 02
Block 04
Block 06
Block 08
Block 10
Block 12
NEAR-TERM
TECHNOLOGY
PROGRAMS
Divert and Attitude Control System
Interceptor Battery
Advanced IMU
Multi-Color Seeker
Composite Canister
GaNnTR Modules
Battlefield Data Connectivity
Adaptive Antennas
Data Fusion
Digital Radio
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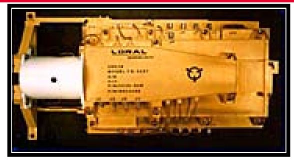
PEO AMD SUCCESS STORIES

- Advanced Master Frequency Generator
  - PAC-3 Specific Application
  - 10:1 Cost Benefits



- Lithium Oxyhalide Batteries
  - THAAD, NMD EKV*
  - Performance Improvement (Non-Thermal)/Weight Reduction (50%)

- Composite DACS Bulkhead
  - THAAD , NMD EKV*
  - Cost/Weight Reduction (50%/30%)

Composite Alum

** Potential Application*

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PEO AMD SUCCESS STORIES

Here are a few of the PEO AMD Technology Initiatives success stories.

First, we have the Advanced Master Frequency Generator, developed by the Atmospheric Interceptor Technology (AIT) Program for specific application to the PAC-3 weapons system. This effort brought a 10:1 return on investment in Life Cycle Cost.

Next, is the development of the Lithium Oxyhalide Batteries, developed by a cooperative effort of Lockheed-Martin, the THAAD Program Office and the AIT Program. This light-weight, non-thermal battery has application in THAAD and the NMD-EKV, or any other interceptor program for that matter, where parasitic heat is an issue.

The Composite Divert and Attitude Control System bulkhead was developed by the Space and Missile Defense Command for THAAD, with potential application to the NMD-EKV. This program replaced bulk-machined aluminum with light-weight, low-cost composites.

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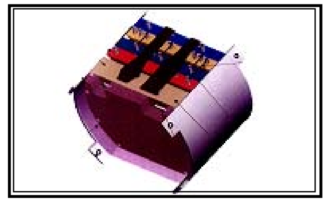
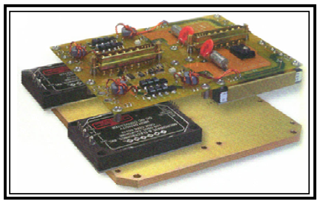
PEO AMD SUCCESS STORIES

- **Multiband Radio Frequency Data Link**
  - **PAC-3 Specific Application, MEADS***
  - **Enhance Performance**





- **High Density Module**
  - **Patriot Launcher**
  - **Cost Reduction, Increase Reliability and Maintainability**

- **Militarized Analog/Digital Converter**
  - **Patriot**
  - **Enhance Performance**

**** Potential Application***

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WORK-IN-PROGRESS

Examples From Over 100 Technologies In Progress:

- Silicon Carbide Composite Thrust Chambers (THAAD, GMD-EKV*)
- Cobalt Disulfide Thermal Batteries (PAC-3, THAAD, ARROW*)
- Gallium Nitride Power Amplifiers for Radar Transmit/Receive Modules (THAAD, GMD GBR*, MEADS*)
- Advanced A/D Converters for Radar (PAC-3)
- Low Voltage Power Supply (PAC-3)
- Global Positioning System Shield (PAC-3)
- Transmit/Receive Electronics Assembly (THAAD, GMD-GBR*, MEADS)
- Low Cost Composite Canisters (THAAD, PAC-3, MEADS)
- Tactical Telemetry (PAC-3)
- Composite Canister (PAC-3*, MEADS*, THAAD*)

*** Potential Application***

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WORK-IN-PROGRESS

PEO AMD has numerous (over 100) other technologies in progress for technology insertion, to include:

1. The Multi-Band Radio Frequency Data Link, which will allow PAC-3 and MEADS interoperability.

2. Silicon Carbide Composite Thrust Chambers, which can replace Columbium metals used on THAAD and potentially NMD-EKV thrusters, with lower cost, lighter weight composites.

3. Cobalt Disulfide Thermal Batteries, which can provide longer-life batteries in applications where excess thermal energy is not an issue, for PAC-3, THAAD and potentially ARROW

4. Solid State Transmitter for the PAC-3 and potentially NAD.

5. Tactical Fiber Optic Gyroscope Evaluation, which can replace higher cost ring laser gyro-based IMUs in PAC-3 and potentially ARROW

6. Gallium Nitride Power Amplifiers for radar transmit/receive modules in potentially all ground based radar to provide more power.

7. Advanced A/D converters for the PAC-3 radar with more dynamic range and through-put.

8. Low Voltage Power Supply for PAC-3, which is more reliable, lower cost.

9. Global Positioning System Shield for PAC-3 to prevent service interruption.

10. Transmit/Receive Electronics Assembly for THAAD, NMD-EKV, and MEADS to reduce cost.

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KEY ENABLERS

- Research and Development funding must be available at the appropriate level to address the MDAP Technology needs across the board.
- An appropriate balance between near-term and far-term technologies must be reached to ensure current problems are solved and future technologies will be available.
- Innovative science and technology programs, like the Small Business Innovative Research (SBIR) program, must be focused on Missile Defense Systems Applications.
- Novel contracting arrangements need to be explored allowing cooperative participation among competing contractors.

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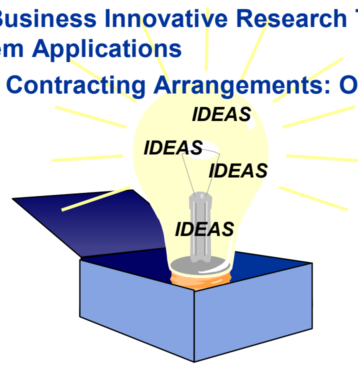
KEY ENABLERS

PEO AMD identified key enablers necessary for technology insertion.

THE ROAD AHEAD

These 'Enablers' are Necessary for Technology Insertion Success:

- Increase R&D Funding
- Find an 'Appropriate' Balance Between Near-Term And Far-Term Technologies
- Focus Small Business Innovative Research Toward Missile Defense System Applications
- Explore Novel Contracting Arrangements: Overcome Obstacles



PEO AMD Technology Initiatives Allows PMO To Focus On Program Milestones While Still Reaping The Benefits Of "Thinking Outside-the-Box"

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Thanks for your attention. Are there any questions?