The Need for Manufacturing Innovation and Readiness

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Topics

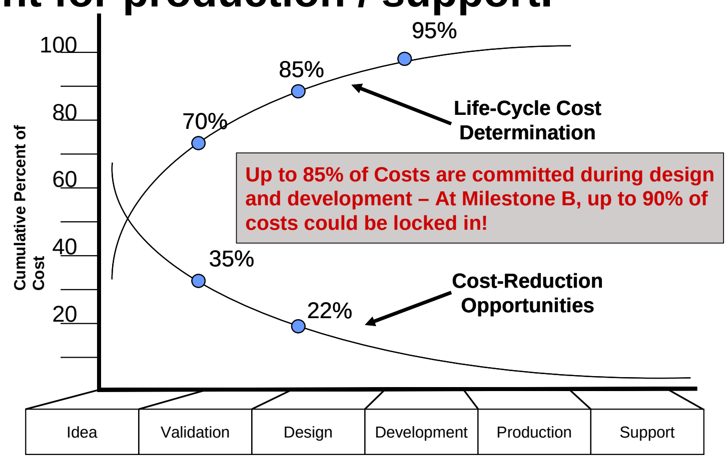
- Why Manufacturing is Key to Technology Transition
- The DoD Manufacturing Technology Program
- Current ManTech Priorities
  - Manufacturing Science and Technology
  - Manufacturing Readiness Levels
- MRL Implementation & Policy
- Questions

Why Consider Manufacturing In Transition?

- **The ability to manufacture a component:**
  - Is not subservient to technology development cycle, but central to it.
  - Determines a large percentage of the total cost and schedule.
  - Can in itself bring about innovative technologies (MEMS, LAM, Flexible Displays, Complex Dimensional Composites, CMCs)

- **The capability to produce a technology/material is often not seen as part of technology transition or innovation, and may be ignored by the Science and Technology community.**
  - However, it is a core focus in highly competitive commercial markets (Aerospace, Automotive, IT, & Transportation.)
  - System engineering models require the maturation of technology along with the ability to manufacture, support, and test.

- **In Defense, practice is often to demonstrate the performance of complex systems, then change the design late in development for production / support.**
  - Customer priorities requirements.
  - Contracting structure allows cost increases.



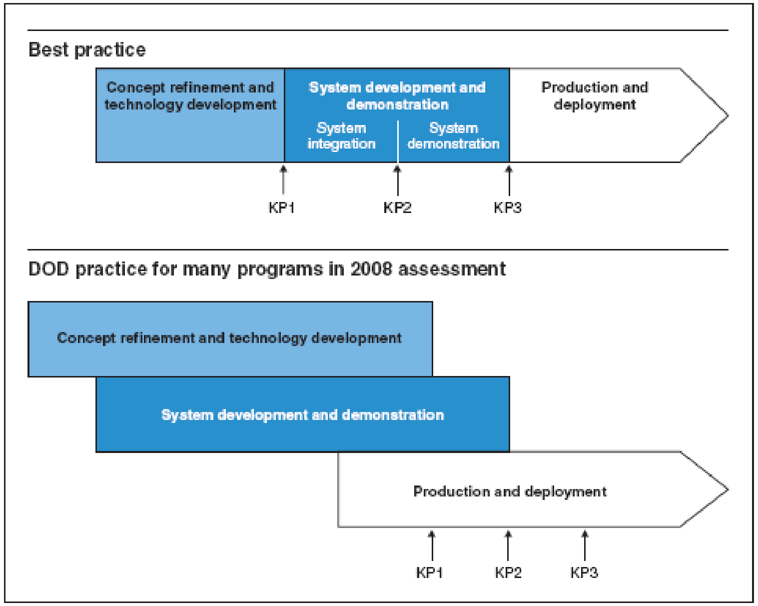
Source: DARPA Rapid Design Exploration and Optimization (RaDEO) Project

The foundation of affordable transition is the access for program manager to technology with demonstrated levels of performance, producibility and support. These attributes allow for effective design trades with knowledge about cost.

GAO: Knowledge Based Acquisition

- During GAO assessments of Acquisition Programs, a disturbing trend of growing cost and schedule overruns led to a conclusion that poorly performing DoD programs did not possess the knowledge required to achieve a successful design at key points during development.
- **$135B in Cost Growth (2004-2007)**
- They determined best practices in successful DoD and commercial development and defined three Knowledge Points:
  - **Knowledge point 1: Resources and needs match [Best practice: MS B]**
  - **Knowledge point 2: Product design is stable [Best practice: CDR]**
  - **Knowledge point 3: Production processes are mature [Best Practice: MS C]**
- In multiple assessments (2000-2008) of the DoD acquisition portfolio, there was found to be was a strong correlation between delayed knowledge points and poor performance.
- In typical defense program practices, these knowledge points were achieved significantly later in the development process, meaning that system design changes continued far into integration and production.
- Reversing this practices resulted in a strong policy requiring Technology Readiness at MS B, Configuration Control Boards and increasing use of Prototypes in competition.

Figure 6: Best Practices Compared to DOD Practices for Programs in 2008 Assessment



Source: GAO.

Finding: Most Programs Proceed With Low Levels of Knowledge Resulting in Cost/Schedule Increases

In a recent annual review of DoD programs (n=62), GAO found:

- Only 16% of programs achieved mature technology at MS B.
  - programs that demonstrated mature technologies averaged 2.6% cost growth and a 1 month schedule delay
  - programs that did not have mature technologies averaged 32% cost growth and a 20 month schedule delay
- At critical design review:
  - 44% of programs achieved technology maturity
  - 27% of programs demonstrated design stability (90% drawings releasable)
- At MS C, the start of Production:
  - Only 67% of programs achieved technology maturity
  - 33% of programs had still not achieved design stability
  - 10% of programs were collecting data on process control. (0% in control)
  - 47% reported they have already conducted or planned to conduct a developmental test of a production representative article (i.e., prototype)

Based on 62 programs	Technology Status at Beginning of Development	
	Mature	Immature
RDT&E Cost Increase	2.6%	32.3%
Acquisition Unit Cost Increase	<1%	>30%
Average Schedule Delay	1 month	20 months

Defense Acquisitions: Assessments of Selected Major Weapon Programs. GAO-07-406. Washington, DC.: March 2007.

The DoD Manufacturing Technology Program

- ManTech is critical for moving disruptive technologies into disruptive capabilities
- If you can't build it, build it affordably, reliably, and in a timely manner, you don't have IT.
- To have true capability, must be able to move beyond the prototype "One-Off"

  - Operates Under Title 10 (Section 2521)
    - Manufacturing process investments that provide product performance, operational, & affordability improvements
  - All About Affordable & Timely Equipping of the Warfighter
    - Defense essential needs beyond normal risk / interest of industry
    - Pervasive needs across systems, platforms, or components
  - Transition of Validated Technology
    - Scale-up of processes for S&T, ATDs, IR&D, & ACTD products
    - Focus: Manufacturing process investments

ManTech Addresses Major QDR Issues – Affordability, Sustainability, Decreased Logistical Footprint

Joint Defense ManTech Panel - (JDMTP)

ManTech Principals
(Army, Navy, AF, DLA, MDA)

Ex Officio:
- OSD, Army, Air Force Staff
- Agencies, Dept of Energy, Dept of Commerce (NIST)
- Industry

Metals Processing & Fabrication
- Specialty Materials
- Processing & Joining
- Inspection & Compliance

Composites Processing & Fabrication
- Performance Improvements
- Life Cycle Affordability

Electronics Processing & Fabrication
- Packaging & Assembly
- RF Electronics
- Electro-Optics

Sustainment

Focus – Joint Collaboration

Manufacturing Technology Program Examples

Warfighter Relevance

(U.S. Air Force)

Solved #1 B-2 Mission Capable MX Issue New capability will have the greatest impact on B-2 Fleet Availability

Developed new LO Magnetic Radar Absorbing Material (MagRAM) for B-2, reduced mx downtime for LO materials from 36 hrs to 7 hrs.

Solved #1 C-17 MX Issue – Structural Damage to Doors on undeveloped runways

AF – ManTech developed new stitched resin infusion process to prevent delamination.

Met Tank Tread Demand Surge for OIF

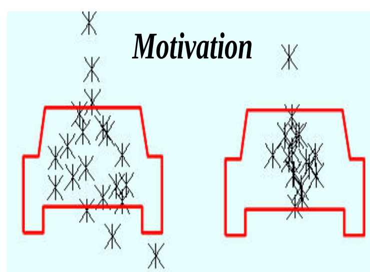
- Vital Track component experienced accelerated failures
- Advanced casting tooling method enabled industry to meet surge and demand

Created force multiplier for battle tanks

- Improved Accuracy through Cannon Tube Reshaping

- 20 fold tighter tolerance; 65% reduction of shot group dispersion;

- Resulted in greatest increase in "loss exchange ratio" in 20-plus years



Before After

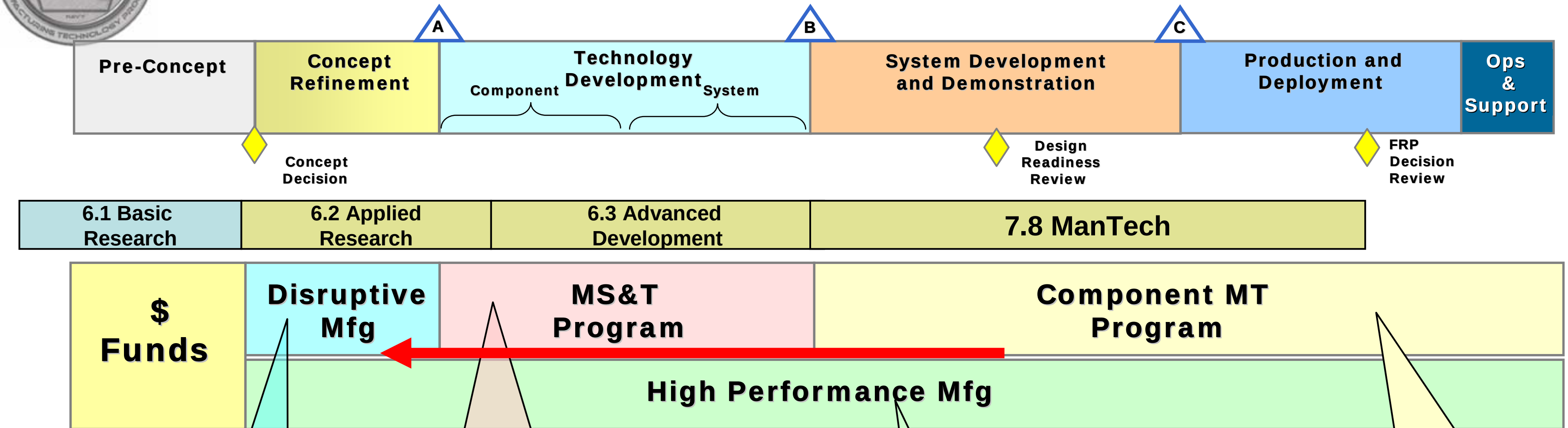
Developed New Capability - New Marine Composite-to-Steel Joining Capability - Reduces Logistics Footprint and enables DD(X) to meet Program Requirements

New Adhesive Joint replaces 5120 bolts that failed to meet technical req'ts of DD(X)

Manufacturing Technology Program
Top Priorities

- OSD Manufacturing S&T Program
- SBIR- Manufacturing
- MRL/MRA Implementation
- Strategic Planning

Pulling Manufacturing Back into S&T



<u>Manufacturing Science and Technology:</u>
Concurrently develop and mature cross-cutting manufacturing processes with new and emerging technologies.

- **Align R&D** investments
- **Accelerate** Transition

<u>Traditional ManTech:</u>
Develop and mature manufacturing processes for acquisition programs, and specifically for **affordable production and capacity**.

<u>Disruptive Manufacturing Technology:</u>
Radically alter the defense industrial base through development of “disruptive” manufacturing processes. Provide **faster and more affordable access** to low-volume production capabilities for **defense unique** technologies. Transition emerging, disruptive technologies

<u>High Performance Manufacturing:</u>
Identify and transition advanced manufacturing processes. Includes development of **test beds and prototypes**, and creation of **technology roadmaps**.

MRL: Background

- *Immature technology and unstable manufacturing processes are major acquisition drivers*
- *Manufacturing Readiness Levels (MRL) Developed*
  - In collaboration with industry
  - Common Standard and framework for identifying, communicating, and managing manufacturing risks
  - Reconciled with TRLs
- *Policy Required*
  - Establish and promote manufacturing risk management as basic principal of technology development and acquisition programs
  - Plan and budget for incorporating manufacturing readiness to support successful transition
  - Establish DoD standard for manufacturing readiness at key milestones
    - Milestone A – MRL4
    - Milestone B – MRL 6
    - Milestone C – MRL 8
    - FRP Decision – MRL 9
  - Support the development and maintenance of necessary knowledge and skills within the DoD workforce to support this best practice already used by key U.S. defense industries
  - Provide guidance for the new DoD standard
- *MRL Process Owner: DDR&E*

Equip the DoD Enterprise with Knowledge Based Approach to Manufacturing Risk Management - Standard, Policy, Tools, and Training

MRL Definitions & Descriptions

MRL	Definition
1	Manufacturing Feasibility Assessed
2	Manufacturing Concepts Defined
3	Manufacturing Concepts Developed
4	Capability to produce the technology in a laboratory environment.
5	Capability to produce prototype components in a production relevant environment.
6	Capability to produce a prototype system or subsystem in a production relevant environment.
7	Capability to produce systems, subsystems or components in a production representative environment.
8	Pilot line capability demonstrated. Ready to begin low rate production.
9	Low Rate Production demonstrated. Capability in place to begin Full Rate Production.
10	Full Rate Production demonstrated and lean production practices in place.

MRL	Definition	Description	Phase
	Production.	monitoring ongoing. LRIP cost goals met, learning curve validated. Actual cost model developed for FRP environment, with impact of Continuous improvement.	Production (FRP) decision
10	Full Rate Production demonstrated and lean production practices in place.	This is the highest level of production readiness. Engineering/design changes are few and generally limited to quality and cost improvements. System, components or items are in rate production and meet all engineering, performance, quality and reliability requirements. All materials, manufacturing processes and procedures, inspection and test equipment are in production and controlled to six-sigma or some other appropriate quality level. FRP unit cost meets goal, funding sufficient for production at required rates. Lean practices well established and continuous process improvements ongoing.	Full Rate Production/ Sustainment

MRL Criteria Matrix / Threads

MRL Criteria Matrix Threads

- Technology and Industrial base
- Design
- Cost and Funding
- Materials (Raw Materials, Components, Sub-assemblies and Sub-systems)

Producibility assessments of key technologies/components and producibility trade studies completed. Results used to shape System Development Strategy and plans for SDD or technology insertion.

Threads ↓

…ty	Evaluate product lifecycle requirements and product performance requirements.	Systems E… the Test a… recognize… establishm… manufactu… managem… risk for the… Initial Key… Paramete…				…ct …s …ta … Major … are …hat key …cesses … those …hange …ntly …cteristics …n … r …gram.	Major product design features are stable and LRIP produced items are proven in product testing. Design change traffic is limited to minor configuration changes. All KC's are controlled in production to three sigma or other appropriate quality levels.	Product design is stable. Design changes are few and generally limited to those required for continuous improvement or in reaction to obsolescence. All KCs are controlled to six sigma or other appropriate quality levels.
…t …st	Technology cost models developed for new process steps and materials based on engineering details at MRL 1-2. High-level process chart cost models with major production steps identified at MRL 3.	Detailed process chart cost models driven by key characteristics and process variables. Manufacturing, material and specialized reqt. cost drivers identified.	Detailed end-to-end value stream map cost model for major system components includes Materials, Labor, Equipment, Tooling/STE, setup, yield/scrap/rework, WIP, and capability/capacity constraints. Component simulations drive cost models.	Cost model inputs include design requirements, material specifications, tolerances, integrated master schedule, results of system/subsystem simulations and production relevant demonstrations.	Cost models updated with detailed designs and features, collected quality data, plant layouts and designs, obsolescence solutions.	Engineering cost model driven by detailed design and validated with data from relevant environment.	Actual cost model developed for FRP environment. Variability experiments conducted to show FRP impact, potential for continuous improvement.	Cost model validated against actual FRP cost.
Cost & F…	Sensitivity, Pareto analysis to find cost drivers and production representative scenario analysis to focus S&T initiatives and address scale-up issues.	Material, manufacturing, and specialized reqt. costs identified for design concepts. Producibility cost risks assessed and manufacturing technology initiatives identified to reduce costs.	Current state analysis of cost of design choices, make/buy, capacity, process capability, sources, quality, key characteristics, yield/rate, and variability.	Cost analysis of mfg future states, design trades, supply chain/yield/rate/SDD/technology insertion plans. Allocate cost targets. Cost reduction and avoidance contract incentives identified.	Costs rolled up to system level and tracked against targets. Detailed trade studies and engineering change requests supported by cost estimates. Cost reduction efforts underway, incentives in place.	Cost analysis of proposed changes to requirements or configuration.	LRIP cost goals met, learning curve validated.	FRP cost goals met. Cost reduction initiatives ongoing.
…ring …t Budget	Program/ projects have budget estimates for reaching MRL of 4.	Program has budget estimate for reaching MRL 5. All Risk Mitigation Plans required to raise deficient elements to MRL of 4 are fully funded.	Program has budget estimate for reaching MRL 6 by MS B. Estimate includes capital investment for Production-representative equipment. All Risk Mitigation Plans required to raise deficient elements to MRL of 5 are fully funded.	Program has budget estimate for reaching MRL 7 by CDR. All Risk Mitigation Plans required to raise deficient elements to MRL of 6 are fully funded.	Program has budget estimate for reaching MRL 8 by MS C. Estimate includes investment for Low Rate Initial Production. All Risk Mitigation Plans required to raise deficient sub systems to MRL of 7 are fully funded.	Program has budget estimate for reaching MRL 9 by the FRP decision point. Estimate includes investment for Full Rate Production. All Risk Mitigation Plans required to raise deficient sub systems to MRL of 8 are fully funded.	Program has budget estimate for lean implementation during FRP. All Risk Mitigation Plans required to improve deficient subsystems to MRL of 9 during FRP are fully funded.	Production budgets sufficient for production at required rates and schedule.

Implementation: MRL/MRA Experience in Industry

- Industry Associations and companies are supportive of DoD Manufacturing Readiness efforts and support policy
  - Participated in Three DoD-Industry Workshops

- OEMs and Second Tier Suppliers are using the first or second generation definitions, published in the Technology Readiness Assessment Guide

- Many companies have developed their own manufacturing maturity measures.
  - Rockwell Collins Manufacturing Maturity Index
  - Sikorsky Production Readiness Index

- Other companies have adopted our MRLs, and are using them within the company's gated development process.
  - **Lockheed Martin Missiles and Fire Control**
  - **Raytheon (Tuscon)**
  - **Pratt & Whitney**
  - **General Electric Power Systems**
  - **Boeing (EMRLs for MDA, MRLs for FCS)**
  - **Goodrich**
  - **… and the list is growing**

Implementation: MRL/MRA Experience in DoD

- Air Force
  - MRAs completed on 21 Air Force Advanced Technology Demonstrations using the manufacturing readiness level (MRL) criteria; additional 12 are in process
  - Used MRL criteria to perform MRAs on two ACAT 1 Programs
- Army
  - Uses MRLs on all 6.3 Programs that have manufacturing or producibility issues tied to Army Technology Objectives- Manufacturing (ATO-M)
  - Army also uses MRLs and MRAs on selected SBIR Projects
  - Army to incorporate MRLs and MRAs into the management aspect of planned Commercialization Pilot Program.
- MDA
  - Applies related scale (EMRLs) to manage high risk prototype- production technologies.

Implementation – Statute and Policy

- **Manufacturing Readiness Levels**
  - Definitions and framework developed, socialized with industry, Services
  - Criteria Matrix developed, piloted, revised, and posted (Version 6.5, April 2008)
- **Developed AT&L Policy**
  - Coordinating with DAU on Defense Acquisition Guidebook Inputs
  - Signed Policy triggers 5000 updates
- **Manufacturing Readiness Guidebook** – "Why" posted 2006
- **Manufacturing Readiness Deskbook** - "How"
  - Piloted under AF
  - Lessons Captured
  - DoD MRA Deskbook Developed
  - DoD MRA Deskbook Red Teamed
    - SOO/SOW language
  - DoD MRA Deskbook – Post on DAU Website – April 2008
- **Coordination with TRA**
  - Incorporated MRL into TRA Deskbook Revision – Appendix I
  - Mapping MRA Deskbook to TRA Deskbook – Coordinating with OSD
  - De-conflicting existing policies

Summary

- **Manufacturing is a <u>core attribute</u> for transition of Innovative Technology<u>, particularly for affordability!</u>**
- **There is an obvious need for <u>pacing development and demonstration</u> of manufacturing processes concurrent with technology.**
  - **Targets $135B cost growth in Defense System Costs.**
- **DoD ManTech Program is <u>shifting forward</u> to include disruptive / high performance topics.**
- **Manufacturing Readiness Levels represent a <u>stable, proven tool</u> for tracking either a technology's or system's manufacturing maturity, and <u>will be adopted by DoD Policy</u> this year.**

Questions?

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