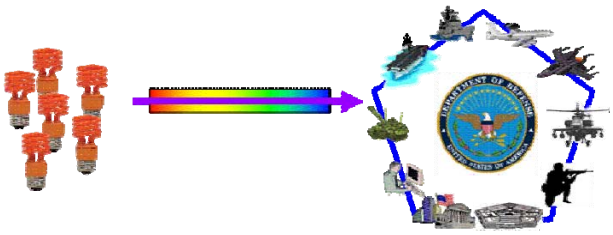
DEPARTMENT OF DEFENSE

INCENTIVES WHITE PAPERS FOR ADVANCED MANUFACTURING TECHNOLOGY



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Overview of Incentives White Papers for Advanced Manufacturing Technology

1.0 THE CHALLENGE

Technological superiority continues to be a critical foundational element for the U.S. military and the U.S. Warfighter. Virtually every facet of mission success depends on fielding of advanced technologies supporting superior capabilities of speed, agility, intelligence gathering, communications, strategic and tactical mission planning, coordination and execution, force application, and safety and force protection. In February 2006, the Defense Science Board Task Force reviewed the DoD Manufacturing Technology Program report[1] which documented – among other issues – that *the introduction of immature technology typically increases the cost of new weapon systems by 41%.* New technologies improve the effectiveness of weapon and support systems, enhance how well the Warfighter is protected, and enable more efficient production and life-cycle management of these systems. However, there is a strong need to improve the technology management process so that it delivers better value to DoD while also avoiding the problems caused by premature deployment of new technologies – both in the products being developed and the processes being developed to manufacture them.

These challenges apply not only to new weapon systems, but those in the field that must be sustained, supported, and technologically refreshed over years – or decades – of operation.

DoD and industry find themselves with a dilemma. New technologies are imperative for more efficient production and more effective and affordable weapon systems. However, since new technologies introduce risk and potentially higher acquisition costs, Service program managers are motivated to avoid risk by not asking for technology "stretch" in design or manufacture. Similarly, industry is motivated through acquisition processes to only apply proven technologies that minimize the risk of cost and schedule overruns and performance shortfalls.

Resolving this dilemma requires multiple actions: 1) spend the requisite resources to mature new technologies *before* introducing them into the critical path of the products and their manufacturing processes; 2) mitigate the attendant risks by executing a reliable, repeatable technology insertion process and supporting system of tools; and 3) strongly ***motivate and incentivize*** the development and deployment of new technologies offering significant performance and cost improvements in design and manufacture.

In addressing these challenges, the key questions are:

1. *What needs to be incentivized* – to encourage faster development, maturation, insertion, and adoption of advanced manufacturing technologies for the Warfighters and their weapon systems?
2. *How can incentives be effectively implemented* – to achieve the needed impacts with a clear and compelling business case for investment by both DoD and the defense industrial base?

[1] Defense Science Board Task Force on the Manufacturing Technology Program: *A Key to Affordably Equipping Future Forces*, February 2006.

2.0 BACKGROUND & RESULTS

In response to these challenges, government and industry stakeholders conducted two forums to explore incentives concepts and possible strategies:[2]

- An Incentives Brainstorming session in Washington, DC on August 14, 2008 in concert with the National Defense Industrial Association (NDIA) Manufacturing Committee meeting.
- An Incentives for DoD Manufacturing Technology Workshop at Fort Belvoir, VA on January 13 and 14, 2009.

Through these forums, more than 70 participants from across DoD, industry, and academia discussed issues, identified needs, and developed proposed solutions related to incentivizing the development and insertion of advanced manufacturing technology. Three tracks were followed to focus the discussions:

- Manufacturing technology development
- Insertion of new manufacturing technology to support existing and legacy systems
- Insertion of new manufacturing technology into new and future (planned) systems.

These forums identified key actions that, if taken, will accelerate delivery and mitigate risk in developing and deploying new technology in new and improved weapon systems. These key actions were prioritized and further developed in the form of white papers to define specific incentives initiatives to address the business case for moving forward with implementation of the key actions.

The following provides a brief synopsis of the positional white papers (shown by priority rank as determined by the workshop participants) that constitute the recommended 'go forward' initiatives.

Rank	Recommended Incentive Initiative
1	**Establishment of a Focal Point for DoD Manufacturing Technology** The creation of a single point of leadership for defense manufacturing technology will provide critically needed coordination for more effective manufacturing technology development and deployment and will incentivize government, industry, and academia to work together for the common cause.
2	**Funding Practices for Manufacturing Technology Development and Insertion** Implement coherent, multiyear funding planning and practices for DoD system acquisitions that 1) minimize the cost and risk associated with the timely maturation and transition of manufacturing technologies into production programs; and 2) permit more flexible funding to incentivize industrial commitments to meet DoD program goals.
3	**Incentives for Collaborative Teaming** The increasing complexity of defense systems, coupled with increasing intensity of competition across the defense supply base, has made collaboration a critical success factor for DoD programs. By promoting new models and tools for industry-wide collaboration within and across supply chains and with the commercial sector, DoD can reduce the time and cost of moving major system acquisitions from concept to deployment.

[2] For more information about the Incentives White Papers and the Incentives forums, contact Charlie Neal, IMTI, Inc at 865-862-5667 or charlieneal@imti21.org

Rank	Recommended Incentive Initiative
4	**Creating A Focused DoD Manufacturing Technology Community** A unified community and coordinated support mechanisms for defense manufacturing technology will facilitate rapid, lower-risk development of warfighting capabilities while strengthening our industrial base, increasing cooperation between defense suppliers, and ensuring greater responsiveness to Warfighter needs. This cooperative environment will provide better solutions for the Warfighter at lower cost, and will provide incentives for consistent excellence in the industrial base.
5	**Strategic Imperatives for Manufacturing Technology Insertion** To improve critical-path technology development and insertion, broad adoption of a highly structured technology maturation process is encouraged. We propose that DoD implement a formal strategic approach for technology portfolio management. This approach includes technology planning and development projects guided by technology roadmaps, and programs with performance-based contracts tied to technology maturation milestones. The roadmaps will define requirements for progression to higher technology readiness levels, and project continuation will be based on phase gate/stage gate processes.
6	**Incentives for Infrastructure and Production Capability** A much stronger and more responsive defense industrial base can be achieved by reinstating and innovatively applying incentive programs currently and formerly used by DoD. These programs support the assessment of business and manufacturing processes, implementation of streamlining actions, and modernization and improvement of defense manufacturing facilities and infrastructure.
7	**Enabling Fast Track Requalification and Recertification** Expanded use of modeling and simulation technologies, leveraged sharing, and use/reuse of those technologies will improve the timeliness and reduce the cost of requalification and recertification to extend the useful life of DoD systems, quickly insert new capabilities to counter changing threats, and much more effectively address obsolescence and diminishing manufacturing source issues.

3.0 STRATEGIC CONTEXT & CONSIDERATIONS

The participants in the initial brainstorming session and subsequent workshop realize the challenges posed by the numerous facets and complexities of the DoD acquisition environment and weapon system life-cycle processes. The following key strategic themes were identified by the participants and used to guide the development process for the subject white papers:

- Leadership focus and communications, both internal and external to DoD
- Rigor in funding and strategic planning for technology maturation and insertion
- Defense manufacturing infrastructure revitalization and productivity improvements
- Lessening of barriers for improvements to existing systems.

Although each white paper recommends actions that can be implemented to deliver direct benefits to DoD, they were developed from an overarching strategic context of needs that would best be met by implementing all of the recommendations as an integrated set. They are a collection of high-priority, "game changing" pragmatic efforts to improve the application of incentives for DoD ManTech and the defense industrial manufacturing base.

A strategic implementation of the full suite of proposed initiatives is strongly recommended to yield far greater and synergistic benefits. The anticipated results are the differences between point solutions offering tens of millions in annual savings versus 'pervasive' implementation delivering hundreds of millions in savings, and much stronger leveraging of advanced manufacturing technologies to benefit the Warfighter and our national security missions.

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Establishment of a Focal Point for DoD Manufacturing Technology

A White Paper Supporting Incentives for Advanced Manufacturing Technology

The creation of a single point of leadership for defense manufacturing technology will provide critically needed coordination for manufacturing technology development and deployment and will incentivize government, industry, and academia to work together for the common cause.

1.0 STATEMENT OF CHALLENGE

The Department of Defense needs a common point of responsibility and leadership for its manufacturing base. For the required credibility, the position should to be that of Deputy Undersecretary for Manufacturing, reporting to the Under Secretary of Defense for Acquisition, Technology and Logistics (AT&L). This position will function as a Chief Manufacturing Officer (CMO) and will have responsibility for DoD manufacturing (including depot activities), the ManTech program, DoD manufacturing supply chain issues, industrial policy, Title III programs, and linkage to Small Business Innovative Research (SBIR) programs.

Manufacturing of the equipment and weapons needed by the Warfighter is a huge challenge, yet the responsibility for maintaining the infrastructure to provide the needed technologies to support that manufacturing base is widely distributed across System Program Offices (SPOs), Program Executive Offices (PEOs), the Services, depot maintenance and repair organizations (MROs), and various other activities. The responsibility for assuring the ability to manufacture needed products is likewise distributed across the various organizations and offices, without a unified focus. As a result, the DoD manufacturing infrastructure and core capabilities are not well supported, resulting in a long history of cost overruns, delays, and sub-optimal performance. It is time to raise the manufacturing challenges to a common point of visibility to champion and drive the creation and widespread implementation of next-generation design and manufacturing systems. Only by focusing the authority and responsibility for the defense manufacturing base can we ensure our ability to produce what is needed, when it is needed, at far lower cost, and with higher performance and greater responsiveness to urgent national security challenges.

This study focuses on incentives for the manufacturing technology community. Establishing a focal point for DoD manufacturing may not be readily evident as an incentive for industry and government to work together to meet the compelling needs. However, the real objective is to improve the performance of the defense manufacturing base. The root cause of many current issues in defense acquisition is a lack of cooperative, coordinated execution of the DoD manufacturing mission. In the workshops and research done to support this study, one of the greatest frustrations of industry is the inability to receive consistent guidance and direction. In fact, the highest-ranked recommendation of the study participants was to establish focused leadership. Such a point of synergy would incentivize and energize the defense industrial base.

Many mechanisms exist for incentivizing excellence, but they are not well utilized. From the government side, the Joint Defense Manufacturing Technology Panel (JDMTP) works across agencies and the Services to collaborate, but their sphere of influence and participation is, in the main, limited to focused programs, and they have limited visibility across all programs and weapon systems. There is a positive trend in ManTech toward crosscutting programs, but Man-

Tech is only part of the total manufacturing equation. The ability to look across programs and drive solutions from research to development, deployment, and life-cycle support is lacking.

Manufacturing is often a secondary concern in the present environment, although this has not always been the case. In the 1980s, the industrial base received high priority under the leadership of the Undersecretary of Defense for Acquisition. This office established a Defense Manufacturing Board (similar to the Defense Science Board), mandated the creation of defense industrial strategic plans, and implemented several programs to strengthen our manufacturing capability.[3] Reenergizing this level of support by elevating manufacturing direction and oversight to a cross-Service senior position, with requisite budget authority, would send an important message that DoD is serious about fixing the problems that impede our defense industrial base.

2.0 OPPORTUNITY AND IMPACT

"DoD's investment in weapon systems represents one of the largest discretionary items in the budget. The department expects to invest about $900 billion…over the next 5 years on development and procurement, with more than $335 billion invested specifically in major defense acquisition programs. Every dollar spent inefficiently in acquiring weapon systems is less money available for other budget priorities."[4]

DoD's huge investment in new weapon systems, and the manufacturing challenges that have to be addressed across these programs, reinforces the need for top-level oversight. The new administration is promising stimulating investments in the SBIR programs, in ManTech, and in other R&D arenas. This is a great opportunity to gain a fresh start in defense manufacturing and create coordinated plans that help our existing and potential new investments deliver systemic, sustainable, and game-changing improvements in supporting the needs of the Warfighter and protecting our nation. A coordinating position is mandatory to ensure these results. Specifically, the recommended DoD manufacturing executive position is required for the following reasons.

1. Weapon systems cost too much and take too long to deploy. The 2008 GAO study found that of the 95 programs in the 2007 portfolio with a total planned commitment of $1.6 trillion, there was a total acquisition cost growth of $295 billion. Some 44% of the programs had cost escalation of more than 25%, and the average schedule delay in delivering the initial capabilities was 21 months.[5] The overruns and delays are due to a number of factors. One of the most important is the inability to manufacture what is designed, on time and within budget. An office charged with managing manufacturing core competencies and maturing critical manufacturing technologies would address this compelling need.

2. New manufacturing technology is needed for multiple weapon systems, but the development efforts are program-specific. The practices of the past will not suffice for the challenges of the future. It is mandatory that DoD stay at the fore in the capabilities, the design, and the manufacture of weapon systems. The defense industrial community is, more and more, a globally competitive environment. The ability of the U.S. to have affordable F-35 fighters is greatly influenced by the ability of the prime contractor and SPO to sell these planes to our allies. To do

[3] Testimony before the Subcommittee on Innovation, Technology, and Productivity, Committee on Small Business, United States Senate, 1 March 1988. http://www.cherry.gatech.edu/mod/modarchive/statement%20mar1,88,%20costello.pdf

[4] Testimony Before the Committee on Oversight and Government Reform and the Subcommittee on National Security and Foreign Affairs, House of Representatives, Defense Acquisitions - Results of Annual Assessment of DoD Weapon Programs, Statement of Michael J. Sullivan, Director of Acquisition and Sourcing Management, 29 April 2008.

[5] Ibid.

so, the manufacturing base must be second to none in affordability as well as capability. To ensure the strength of our manufacturing base, industry and government must work together to ensure that the very best in technology is available. This must not be in isolated areas of excellence, but rather as a "tide that raises all ships" – ***jointly invested, jointly shared, and individually exploited for competitive advantage.*** A focal point for DoD manufacturing can expedite the development and deployment of a new, game-changing generation of design and manufacturing capabilities that support the coming wave of new defense systems.

3. Technology maturation is a major issue in cutting cost and ensuring capability. Technology Readiness Levels (TRLs), Manufacturing Readiness Levels (MRLs), Engineering and Manufacturing Readiness Levels (EMRLs), are all useful tools to ensure that technologies deployed are mature and that the weapon systems can be delivered on time, as budgeted, with the needed capability. Various Government Accountability Office (GAO) studies have found that acquisition costs increase substantially when immature technologies are included in the designs. The Defense Science Board on the ManTech program reported that total research, development, test, and evaluation (RTD&E) cost was 32% higher for programs with immature technologies compared to those with mature technologies. Perhaps more telling, acquisition unit cost increased by 21% and average schedule delay was 7 months longer.[6] MRLs are being used across DoD, but implementation varies with the Services and the programs. While it is perhaps not yet possible to totally unify maturation strategies across Services and major programs, a common language and structure are essential to support crosscutting activities. The way to ensure unification of strategies is through a single point of focus – a Chief Manufacturing Officer (CMO) and supporting staff.

4. DoD does not collaborate effectively with other agencies or with industry. Various government agencies share common manufacturing needs, but collaboration efforts across agencies at present are insufficient to realize the significant potential benefits. DoD has the largest manufacturing investment and thus the most to gain from collaboration. However, there is no consensus regarding collaboration, and there is no clear point of synergy. DoD can reap great rewards from asserting stronger leadership in cross-agency collaboration.

The relationship of DoD with the defense industrial base is highly structured, contractually defined, and Congressionally influenced. However, there is great value in working together in more flexible ways to achieve "grand challenge" manufacturing goals. Establishing a DoD CMO provides an mechanism to broaden the relationship to include far greater collaboration across industry and with academia and with other agencies, and to provide a counterpart and ally to the Department of Commerce Assistant Secretary for Manufacturing and Services.

5. Limited use of commercial systems in military applications creates unnecessary supply and cost crises. Military specifications are often complex and in areas restrictive, which limits the use of commercial solutions for defense applications. The market for many defense system components is not sufficient to sustain a supply base, and older parts often lack readily available or competitive sources. Leadership is needed to remove the barriers to rapid and affordable application of commercial or derivative products to meet military needs.

6. Accountability for manufacturing excellence is often missing. Studies by GAO, the Defense Science Board, and others point to the shortfalls defense manufacturing. The Secretary of

[6] Defense Science Board Task Force on The Manufacturing Technology Program: *A Key to Affordably Equipping the Future Force*, Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, Washington, DC, February 2006.

Defense is regularly charged by the Congress to deliver improvements in efficiency of weapon system production. The orders flow down through the system, but there is no "desk where the buck stops." A CMO would provide that designated point of responsibility and accountability.

3.0 BENEFITS TO BE ACHIEVED

The goal of this effort is to incentivize industry, research organizations, and universities to work with government to deliver improvements in fulfilling the mission of the DoD. No single action by the nation's leaders would accomplish more towards this end than the establishment of a strong focal point that would elevate design and manufacturing issues to the needed level of visibility and coordinate collaborative solutions.

The benefits will be measured in improved delivery of defense products, faster and at lower cost. The ability to coordinate investments across the Services and across industry and the entire manufacturing R&D community will eliminate duplication of effort and provide needed synergy and leverage. The ability to coordinate and focus investments on a large scale will allow the DoD to bring large problems – those not solvable by a single organization or by diverse programs that are not connected – to solution. For example, new process technologies can be matured and deployed to deliver disruptive change. Direct digital manufacturing and friction stir joining are just two examples of technologies that can have impact across multiple platforms, but the R&D is being done piecemeal. Enterprise technologies that support globally competitive manufacturing and model-based enterprise (MBE) concepts can only provide point solutions without focus and coordination, and that focus and coordination best comes through a point of senior authority. Major defense contractors who are members of the U.S. MBE team agree that realization of the Model-Based Enterprise will cut costs by 50% and reduce time to market by 45%[7]. However, realizing these aggressive goals requires coordination of major investments.

The benefits also will be realized in consistent and workable policy. There are many tough policy issues facing the defense industrial base. A point of synergy will enable a strong and consistent message to be delivered to all stakeholders, leading to policy modifications that support the balanced win/win relationships that must be foundational to our national strategies.

The final benefit is advocacy. The defense manufacturing community shares common goals of cost-effective delivery of quality products in a sustainable business environment. Manufacturing excellence is imperative for national security. That message needs to be communicated and supported at the highest levels of the DoD and in interactions with Congress and the Administration.

4.0 SOLUTIONS AND PATH FORWARD

With this paper, the participants in the DoD Manufacturing Technology Incentives Workshop call on the defense community and industry stakeholders to gain consensus on a plan and to petition the Administration, the House of Representatives Armed Services Committee, and the Senate Committee on Armed Services to endorse this proposal.

To unify the DoD leadership, a Defense Science Board study of the DoD manufacturing infrastructure should be undertaken to gain visibility and support for the proposed solution. The envisioned position is an appointed Deputy Undersecretary of Defense for Manufacturing, reporting to the Undersecretary of Defense for Acquisition, Technology and Logistics. This person should

[7] From presentations at the MBE session at the Defense Manufacturing Conference, Las Vegas, Nevada, December 2007.

be selected for a deep understanding of the DoD manufacturing community and the challenges that are faced, and should be given authority and budget to implement needed changes.

The CMO will perform functions in three basic areas:

1. **Analysis** – Perform top-level business case analysis and industrial base assessments, and ensure that the manufacturing requirements of DoD Instruction 5000.2, Operation of the Defense Acquisition System, are satisfied. Ensure the integration of strategic plans and technology roadmaps to guide manufacturing technology investments and technology insertion initiatives.
2. **Policy** – Perform the dual function of implementation and adaptation of policies to establish and maintain more effective manufacturing capabilities and performance.
    - Establish a strategic investment strategy for developing and deploying critical technologies as a foundation for technology portfolio management – at both program levels and DoD-wide.
    - Guide incentive alternatives by providing awareness of options, building programs, and ensuring the needed incentives are in place. Conduct assessments of past and existing incentive programs, recommend changes, and put effective programs in place. Specifically, the workshop participants recommend the reinstatement of a new and effective Industrial Modernization Incentive Program (IMIP) with shared access to results.
    - Advocate for important programs now in place, such as the Militarily Critical Technologies List, and ensure that identified priorities are implemented in programs.
    - Coordinate implementation and ensure compliance with executive orders and policy directives (e.g., Executive Order 13329) encouraging innovation in manufacturing and mandating that SBIR and other programs support manufacturing.[8]
3. **Portfolio Development** – Integrate the presently disparate elements of the manufacturing technology development and deployment investment (ManTech, Title III, Manufacturing Science & Technology, SBIR, acquisition program investments, etc.).
    - Ensure that the major issues are addressed in a coordinated and integrated fashion.
    - Fulfill the intent of statutory requirements for a National Technology and Industrial Base (the framework now specified in law).
    - Be responsible for three key functional areas of Policy, Analysis, and Investment.
    - Implement strategic guidance and investment planning for manufacturing, including provision of technology roadmaps and strategic investment plans for providing critical capabilities and meeting the needs of specific acquisition programs.
    - Define an integrated management structure and processes to ensure that the functions of the office are properly executed.
    - Lead a cultural change in DoD by emphasizing an integrated, systems approach to product conceptualization and development, including requirements-based product and process development.

[8] Executive Order 13329, Encouraging Innovation in Manufacturing, Federal Register, 26 February 2004.

- Provide a central focus for maximizing the crosscutting value of manufacturing functions while maintaining the flexibility needed by the Services to meet their individual national security mission requirements.
- Maintain an expert staff of manufacturing professionals capable of supporting the functions of the office, and ensure adequate funding to perform the functions.
- Serve as a point of unification of programs across various funding sources to build and execute programs across the product development cycle.
- Hold Service acquisition and S&T executives accountable for manufacturing efficiency and excellence.
- Establish and manage a peer review process for DoD manufacturing technology programs. The process will evaluate:
  - The balance of manufacturing programs across the investment strategy
  - How well projects and programs (including congressional adds) align with the strategic and investment objectives
  - The investment portfolio and will provide guidance concerning adjustments to the existing portfolio and areas for future focus – including gap analysis and identification of critical voids.

Funding Practices for Manufacturing Technology Development and Insertion

A White Paper Supporting Incentives for Advanced Manufacturing Technology

Implementation of multiyear funding planning and practices for DoD system acquisitions will 1) minimize the cost and risk associated with the timely maturation and transition of manufacturing technologies into production programs; and 2) increase funding flexibility to incentivize industrial commitments to meet program goals.

1.0 STATEMENT OF CHALLENGE

DoD has widely documented problems in weapon system acquisition, with cost overruns, schedule delays, and product performance shortfalls common in every area of the defense industry.[9] One cause of problems is the funding constraints imposed by acquisition processes and the attendant lack of flexibility in contracting approaches. Contractors at every level of the supply chain express frustration over the expectation of contracting officers for ever-lower pricing and ever-higher performance, without allowing contractors to temper the additional risk that comes with investing in the new product and process technologies needed to meet these expectations.

In addressing technology incentivization at the recent Manufacturing Technology Incentives workshop, Eleanor Spector, Vice President of Contracts for Lockheed Martin, said there is constant downward pressure on negotiated profit by DoD contracting officers to get ever-lower costs, past reasonable expectations.[10] For defense contractors, the greatest incentive for incorporating new manufacturing technologies is the potential for long-term buys and, in the case of aircraft, missiles, and other equipment, for follow-on foreign military sales to allied nations. However, cost growth, schedule slips, and budget changes frequently result in only a fraction of the end-item quantities originally projected. These uncertainties make contractors increasingly reluctant to invest in new technologies that might lead to manufacturing performance improvements and ultimately, better products at lower cost.

No incentives in the technology development phase of a new system can make up for a lack of adequate funding. Conversely, if adequate funding were provided, no additional incentives would be needed to encourage manufacturing technology investments. The weighted guidelines of the Defense Federal Acquisition Regulations Supplement (DFARS) already allow contracting officers to provide up to 4% extra profit to incentivize contractor investments, including manufacturing technology improvements, that benefit the customer. The contracting officer has flexibility in evaluating the potential benefits to the government and the contractor's potential reward for cost reduction efforts, but these incentives are rarely used. They are even less likely to be applied to stimulate manufacturing technology improvements. The participants at the workshop agreed that while some new guidelines and incentives might stimulate greater industry investments in manufacturing technology, DoD would see significant improvement if contracting officers would use the flexibility already available in the DFARS.

[9] GAO-05-301, *Assessments of Selected Major Weapon Programs*; GAO-06-883, DoD Technology Transition.
[10] Eleanor Spector, "Contract Incentives for Manufacturing Technology," keynote presentation to DoD workshop on *Incentivizing Advanced Manufacturing Technologies for the Warfighter*, 13 January 2009.

2.0 OPPORTUNITY AND IMPACT

A major problem associated with current DoD contracting practices is that the acquisition process for new production programs results in multiple stops and starts of funded work, and underfunding of the full scope of requirements and opportunities. The programs tend to be front-loaded, with insufficient consideration of downstream costs and issues. Contractors need economic order quantities to ensure a reasonable return on manufacturing technology investments. Therefore, they are reluctant to invest in significant improvements without better certainty regarding future orders. Funding constraints and risk aversion drive short-sighted decision making, increasing life-cycle costs and discouraging innovation in longer-term capability improvements.

Industry representatives are united in their desire for stable funding profiles and assured minimum production quantities over multiyear contracts that enable them to realize economic order quantities and a more stable workload.

Another problem exacerbated by funding constraints is the inclusion of immature technologies in complex systems. Failure to fully mature a new technology prior to its inclusion in the system or manufacturing baseline usually causes significant cost overruns and schedule delays, leading to performance shortfalls and drastic reductions in production quantities. The "Valley of Death" between initial development of a technology and its ultimate maturing into production status often kills key technologies that could provide significant benefits in life-cycle cost or operational capability.

There is a great need to incentivize key stakeholders (technology developers, prime manufacturers, and government program managers) to plan for implementation of new manufacturing technologies to benefit one or more systems, new or already fielded. These plans should address technology development, maturation, and system insertion as discrete elements. While an individual system acquisition program may have difficulty justifying the investment for a new manufacturing technology, the opportunity to benefit multiple systems makes a much stronger business case.

Program managers on both the contractor and government sides of the equation are also reluctant to accept the cost and schedule risk of introducing a new manufacturing technology unless it is core to the program requirements. Hence, **the best way to stimulate manufacturing technology improvements is for DoD to provide contract funding specifically for these improvements.** Contractors would propose their ideas to DoD, which would fund promising concepts to be matured and validated for insertion in subsequent system procurements for one or more programs. Manufacturing technology investments are currently piecemealed across so many organizations and funding streams that it is extremely difficult to deliver major impacts.

There should be distinct and adequate funding for identification, development, and implementation of advanced manufacturing technologies. This would require synchronized technical activities and coherent multiyear funding plans, which would be enabled by an ability to **integrate funding over multiple life-cycle phases and across multiple programs**. This is particularly important in sectors such as shipbuilding, where a single system acquisition cannot justify ManTech funding. Implementing coherent, multiyear planning and funding practices in DoD acquisitions will enable a more robust and capable supplier base, with improved competitive advantage in the global market.

3.0 BENEFITS TO BE ACHIEVED

A number of benefits will be realized through coherent multiyear planning and funding of weapon systems and of the manufacturing technologies needed to produce them.

Manufacturing technology insertion is a central element of strategic business planning for DoD contractors, and should receive much greater focus from DoD and System Program Offices (SPOs). Adoption of a more systematized approach will mitigate technical and financial risk, supporting consistently successful technology insertions. The uneven acquisition performance of DoD will be greatly improved.

A higher percentage of programs will successfully transition to production due to improved planning, reduced development time, and more efficient use of resources. With a better understanding of total life-cycle cost under the coherent funding plans, there will be less cost growth.

Suppliers will have greater incentive to invest in manufacturing capability improvements, both independently and in collaboration with government, academia, and the science and technology (S&T) community. Enhanced participation in improving manufacturing technology will improve DoD's ability to solve obsolescence and diminishing manufacturing source (DMS) issues, helping provide more affordable products for the Warfighter. It will also help stabilize and maintain critical competencies and support the overall modernization of the U.S. defense industrial base.

Comprehensive manufacturing technology development and deployment plans facilitated by stable, longer-term funding will assure focused investment in bringing innovative, game-changing technologies to maturation. Improved and shared awareness of the technology landscape will eliminate waste in the form of unfocused and duplicated effort.

4.0 SOLUTIONS AND PATH FORWARD

1. Engineer Systems for Full Life Cycle: *Incentivize early systems engineering activities to include consideration of total life-cycle performance, affordability/cost optimization, and technology insertion plans, including full support for associated manufacturing processes.*

- Fund product design/development improvement initiatives for new and existing systems, addressing design for manufacture (producibility), design for maintenance, etc., in the context of total life-cycle costs.
- Leverage world-class manufacturing technology development processes from outside of DoD to benefit defense manufacturing programs.
- Provide mechanisms to incentivize collaboration between DoD platform sponsors, S&T organizations, and prime contractors to address life-cycle cost as a core element of all major acquisition programs.
- Require plans for technology maturation and insertion across the product life cycle.

2. Separate Manufacturing Technology Development: *Adjust the acquisition process to enable long-term commitments enabling separate, up-front investment in new manufacturing technologies.*

- Establish manufacturing technology development (and technology insertions) as a funding requirement separate from weapon system development and production.

- Make the case to Congress to remove restrictions on the "color of money" when multi-year lot quantities are purchased.
- Provide systems that improve awareness of advanced manufacturing technologies, and support collaboration in widespread implementation across multiple programs.
- Support policy that allows funding to cross engineering manufacturing design and development/system design and development (EMDD/SDD) boundaries.
- Provide the flexibility to obligate funds across multi-year fiscal periods.

3. Strategic Support for the National Industrial Base: *Provide funding and incentives for establishing and assuring a qualified supplier base, including stable base contracts – to create a sustainable business model for developing and deploying new product and process technologies.*

- Develop incentive-based contracts that allow wins across the supply chain and across multiple programs based on deployment of innovative manufacturing technologies. Include mechanisms to subsidize initial implementation (including, for example, technology licensing) where the near-term business case is marginal.
- Incentivize DoD contracting officers to use the full flexibility available in the DFARS to incentivize contractors to pursue new technology developments and other process or efficiency improvements.
- Promote identification and pursuit of multi-use (DoD, foreign military sales, commercial) production line opportunities wherever possible.
- Establish multi-year contracting methods with guaranteed minimum production quantities and mechanisms for ameliorating investment risk if production commitments are canceled or significantly curtailed.
- Implement standard source selection criteria that place emphasis on manufacturing technology investment and life-cycle costs in overall evaluation of "best value" and Total Evaluated Price (TEP) for production contracts.
- Incentivize innovation by tying a percentage of fee on cost-type contracts specifically to the success of the contractor in implementing advanced manufacturing technologies that benefit product performance, quality, cost, and other factors such as energy/environmental conservation.
- Incentivize technology investment by providing separate incentive fees for cost reductions related directly to implementation of new manufacturing technologies.
- Establish a Value Manufacturing Change Proposal (VMCP) program to encourage implementation of manufacturing technology advances by sharing projected cost savings between the contractors and the government.
- Develop an improved and streamlined VECP/VMCP process that supports multiple DoD product lines and includes provisions for bridge agreements at the Service or DoD level involving different contracts and contract types across multiple Services.
- Enhance current tax incentives and DoD funding vehicles for internal research and development (IR&D) programs to stimulate manufacturing capability investments. Consider establishing a separate Manufacturing component for industry-wide IR&D programs.

Incentives for Collaborative Teaming

A White Paper Supporting Incentives for Advanced Manufacturing Technology

The increasing complexity of defense systems, coupled with increasing intensity of competition across the defense supply base, has made collaboration a necessary success factor for many DoD programs. By promoting new models and tools for industry-wide collaboration within and across supply chains and with external organizations and the commercial sector, DoD can reduce the time and cost of moving major system acquisitions from concept to deployment.

1.0 STATEMENT OF CHALLENGE

The defense industrial base has changed radically over the past 15 years. No longer do individual companies compete alone for major contracts; rather, competition now is between supply chain-centric organizations that create teams to pursue each new opportunity. There are several reasons for this shift. Industry consolidation and acquisitions have reduced the number of large prime contractors to the point where a large procurement only has two or three viable competitors instead of the five or six common a decade ago. Changes in defense acquisition strategy have reduced the quantity of large contract opportunities and raised the bar of competition, threatening the sustainability of the supply base.

The coming generation of defense systems are "systems of systems," all integrated and coordinated in their production and deployment. These programs, such as the F-35 Joint Strike Fighter (JSF) and Future Combat Systems (FCS), involve large and complex teams, the members of which may work together on several programs and compete against each other on many others.

This new environment presents significant challenges for the defense industrial base. Arguably, the largest is in fostering an environment in which companies can simultaneously collaborate and compete while maintaining and exploiting their intellectual property and core competencies. The challenge is amplified when the reality of increasingly global supply chains is considered. No longer are contractors "one-stop shops" in which products are designed, built, assembled, tested, delivered, and supported under one roof. Instead, major systems are produced through a complex interrelationship of technology vendors, component suppliers, subsystem assemblers, and system integrators.

Multinational programs with global supply chains are an increasingly important part of the procurement equation, facilitating the production of high-cost systems in quantities sufficient that the large investment in development can be recovered through international as well as domestic sales. To secure global markets, contractors must usually provide a level of production in each customer's country, and provide access to new technologies. The result is a global collaborative network wherein, in theory, everyone wins.

However, the risk equation has changed as well. Complex supply chains are vulnerable to breakage due to the many interdependencies among its members, and the failure of any one link can cause the entire chain to break down. Control of technology is also a concern. Intellectual

property rights and other restrictions – such as ITAR[11] and its counterparts in other countries – commonly limit the sharing of technology, which complicates collaboration.

The challenge to the DoD is clear. The Department must incentivize industry to work together more efficiently and effectively with other industry members, technology vendors and suppliers, and research and development organizations to deliver the best weapon systems possible. These systems must be delivered at reasonable cost, with full assurance that national security needs will be met.

There are successful collaboration models in today's competitive environment. Boeing's 787 Dreamliner proves that organizations around the globe can come together to achieve success for all parties. In the Boeing model, collaboration is defined as "a collection of interdependent companies that engage in shared creation of value, often in real time." These concepts enabled Boeing to bring 70 companies from 20 different countries together to develop and deliver one of the most technologically advanced commercial aircraft in the world. Organizations within our defense supply networks must also adopt these principles to create an environment where "a rising tide lifts all ships," and work in concerted efforts that benefit DoD and the entire defense manufacturing community.

The need for industry collaboration is further emphasized in a study by Science Applications International Corporation (SAIC): "The traditional contracting process may not result in win-win solutions because it lacks the collaboration required to mutually achieve program goals. Traditional approaches to the application of contractual incentives must change..."[12] As indicated by this statement, it will be difficult to change the mindset of industry leaders and encourage greater collaboration. Many contractors and technology providers feel that sharing knowledge with other industry participants reduces their competitive advantage. Other challenges include trust and the need to ensure that critical information is not distributed outside of the collaborative environment.

To promote increased levels of and effectiveness in collaboration, DoD must take an active role in addressing the needs of industry. As stated in the SAIC report, "Understanding the motivation of the parties is critical…and aligning the motivations of the subcontractor with the goals of the prime contractor, and its government customer, is critical if the incentive structure is to be successful." DoD needs to work with industry leaders – including all stakeholders in the defense supply network – to determine the best approach to incentivize each group to pursue and participate in collaborative efforts. Incentives need to align with the needs of each stakeholder segment and ensure that government requirements for technical performance, cost, and schedule are improved through the adoption of collaboration incentive programs.

2.0 OPPORTUNITY AND IMPACT

Better collaboration is critical to improving the ability of the defense industrial base to meet increasingly complex national security challenges while improving affordability, reducing costs, and shortening timelines from development to deployment. The impact will only be realized through the development and deployment of a new technology toolset that supports more effective collaboration in development and production. Key opportunities are as follows.

[11] International Traffic in Arms Regulations.

[12] SAIC Corp., *Constructing Successful Business Relationships – Innovation in Contractual Incentives.* p. 8.

1. Reduced Time to Market – Global collaboration will not deliver the needed impact without a more capable technology toolset for product and process development. In the example of the 787, Boeing imposed common tools and methods on the supply base and invested heavily in modeling and simulation tools across the enterprise. Simply providing a common toolset is not enough; extensive training is required to ensure each tool is used in a way that delivers a compatible result. For the collaborative network to be effective, DoD must incentivize the development of interoperable systems that work together. When the compatible toolset is in place, products will be designed and problems solved in a virtual environment, and product and process development times can be slashed.

2. Fewer Changes and Interruptions in the Production Cycle – For collaboration to work well, it must be technology enabled. The pieces must all fit in a way that ensures continuity of activities and operations through the life cycle of the product and "gets it right" the first time. An integrated collaborative network supports requirements-based conceptualization and design. The requirements drive the design process and flow through the downstream applications, throughout the supply network. The technologies that support the integrated design and development process allow the thorough modeling of each function and of the resulting impact on the product. This collaborative, model-based system ensures that all of the pieces fit together, resulting in a product that meets all requirements from the first article forward. The production processes likewise will be fully tested in virtual space before any products are made, resulting in fewer change orders and minimal interruptions.

3. Sprint Capability – Perhaps the most valuable opportunity in establishing a collaborative environment is the ability to provide unprecedented sprint capability to meet urgent operational requirements driven by changes in threats or threat tactics. In many cases, the members of the supply networks have the capacity and capability to respond to a time-critical DoD need – but complex contracting and startup processes prevent rapid response. Improving the ability to collaborate in both the technical and business areas can drastically reduce the time required to move from identified requirement to delivered capability.

4. Higher-Quality Systems at Lower Cost – The theory in technology-enabled global collaboration is that the up-front investment pays off in lower life-cycle cost and higher-quality products. The investment to create industry-wide collaboration systems is not small. It is expensive to develop a complex weapon system design, build its supply base, equip that supply base with the needed technology, ensure that the training and support is in place, and operate the supply network. With global networks come global markets with added production volume, allowing the initial investment to be recovered over many units/variants and ultimately delivering products at a much lower unit cost.

Additional Opportunities

In its current state, industry cooperation is typically limited to contractual arrangements that define work scope and working relationships between a prime contractor and its partners, subcontractors, and suppliers. These agreements are almost always associated with an individual contract, and although they often meet the short-term goals of the participating organizations, they seldom provide the long-term benefits available through wider collaboration. Opportunities exist for our defense manufacturing community to pursue more aggressive paths in developing collaborative relationships that include government agencies, large contractors, small businesses, research organizations, and the supply chains supporting these operations. These efforts need to

go beyond a limited number of companies working together in a contractor/supplier relationship and be expanded – without limiting competition – to engage a more robust and diverse set of team members with unique capabilities and strengths. Without this broad-based approach to collaboration, manufacturing innovations will continue to be limited to incremental advances.

There is value and added incentive in creating collaborative environments that make doing the right thing more expedient. While abiding by all contractual necessities, organizations such as the Composites Affordability Initiative (CAI) and the Metals Affordability Initiative (MAI) work within the ManTech community to solve tough problems and deliver solutions that benefit the entire community. Wider use of such models presents dramatic opportunities for impact. However, funding for these types of programs typically comes from Congressional plus-ups. It is difficult to obtain long-term support for development of solutions that have wide benefit, but such programs are needed in addition to more specific collaborations around a single contract.

Opportunities for collaboration exist in all facets of defense manufacturing. DoD needs to pursue cross-agency/cross-service collaboration to enhance leverage of resources and reduce duplication of effort. Corporations need to pursue business-to-business relationships that improve technology transition, leverage limited resources, and share knowledge to drive innovation and capability enhancement. Universities and other research organizations should be heavily involved in collaborative efforts to move ideas from conceptualization to development. All of these relationships can benefit from better collaboration, and each stakeholder of the defense community must work to ensure that these opportunities are pursued.

Collaborative relationships benefit the small-business sector as well. Collaborative teaming allows small companies to participate in larger programs, and provides a better mechanism for advancing Small Business Innovative Research (SBIR) activities for manufacturing technology. In many SBIR programs with promising technologies, there is little or no connection with the potential end users. The lack of support beyond Phase II results in a low percentage of programs maturing to the point of implementation. By improving collaboration between government agencies, large contractors, and small business participants, SBIR activities can move beyond the short-term focus of Phase I and Phase II, and yield a higher percentage of implementation.

3.0 BENEFITS TO BE ACHIEVED

The benefits associated with improved collaboration will impact our entire manufacturing base. By increasing communication between organizations, developing cross-functional integrated product/process teams, and proactively working as a unified team to exploit collective key competencies, our manufacturing community can drive innovation, improve technical capabilities, and ensure excellence across the entire industry.

Increased collaboration will also improve the global competitiveness of our U.S. industrial base. As manufacturing capabilities continue to globalize, overseas sources have become significant suppliers of technology-based products. To remain competitive, the U.S. manufacturing community must work as a team to reduce costs, improve performance, shorten design and development timelines, and enhance capabilities. Increased funding for new technology development among government agencies, industry leaders, research facilities, and members of the supply chain will empower our manufacturing technology community to better share ideas, award workload to the most capable sources, and sharpen our competitive advantage. As a result, our manufacturing base will be well enabled to continue leading the design, development, and deployment

of future weapon systems for our military and for our allies. The opportunity to harmonize equipment solutions across allied forces will increase foreign military sales and provide the revenue streams essential to sustain and advance the defense industrial base.

Better collaboration across industry will also stimulate greater innovation and more efficient technology implementation. As relationships are expanded beyond the manufacturer-supplier network to more effectively include other research and technology organizations, industry will see a significant increase in technology transfer. By working with these organizations to develop future technology concepts, manufacturers will gain valuable insight that promotes investment in new ideas, which helps ensure the needed production capabilities are available as new concepts become reality.

Collaboration also reduces risk associated with innovation development. By identifying key competencies within the team, each member organization can perform work that aligns with their specific strengths, and rely on other team members to address areas in which they need support. Through continued interaction, companies can learn from one another to build new capabilities within their own organizations.

4.0 SOLUTIONS AND PATH FORWARD

The globally collaborative environment is the environment of the future, and DoD needs to incentivize the tools, technologies, processes, and culture that make that environment work in order to preserve a strong and capable defense supply network. Specific actions recommended include:

1. **Tools and Technologies** – Support the development of model-based enterprise capabilities. The globally collaborative enterprise must be model-rich in product, process, and enterprise management. The tools and technologies for this environment are maturing quickly. However, there are voids in the toolset, and the challenges of interoperability and product definitions to enable transparent collaboration in engineering and manufacturing are yet to be met. Interoperability is a key enabler, and the lack of interoperability is a key barrier, to effective collaboration.
2. **Strategic Investment Planning** – Conduct benchmarking studies of existing collaborative relationships and methods to define best practices, tools, and problem areas. Build technology roadmaps and strategic investment plans to identify the areas where investment is needed and to ensure that the investments are made. Incentivize participation in these planning activities by providing funding for government, industry, and academia.
3. **Business Process Management** – Present contracting methods present a challenge in dealing effectively with networks of suppliers. When global suppliers and diverse organizations (such as universities and research institutions) are involved, intellectual property issues and other business management challenges can pose intractable barriers. DoD should conduct a study of contractual issues in global collaboration with the intent of identifying solutions to resolve them.
4. **Incentives for Collaboration** – DoD should commission a study by the National Research Council's Board on Manufacturing and Engineering Design, the National Academy of Sciences, and the National Academy of Engineering to evaluate mechanisms for

stimulating and facilitating collaboration. This study should address incentives for every member of the supply network.

To promote a higher level of collaboration within the defense manufacturing community, DoD must take an active role in establishing goals and monitoring progress of collaborative activities. To accomplish this, we recommend that DoD establish a Manufacturing Technology Advisory Board that works with industry leaders to identify opportunities for collaboration, promote incentives available to these participants, support the needs of collaborative teams, and monitor the effectiveness of the initiatives. In doing so, DoD needs to ensure participation from all levels of the supply chain. In many cases, contract incentives benefit the prime contractor and do not reach their lower-tier suppliers. Through improved mechanisms for collaboration, DoD should ensure that all partners within these collaborative teams are properly incentivized with shared risks and rewards.

DoD should work with stakeholders to address the competitive concerns of industry participants. For many organizations, intellectual property represents a significant competitive advantage. According to the SAIC report, "Rather than rewarding the innovative company that initiates a new idea, the government tends to limit innovative thinking by assuring that everyone has an equal chance to pursue someone else's good idea." This situation needs to be evaluated to ensure that innovators can be adequately compensated for their design activities, while continuing to ensure adequate competition for the production and use of these technologies. This is another area where a cooperative study should be done to assess risk/reward mechanisms and more flexible and standardized contractual agreements.

In responding to these recommended actions, we encourage the DoD to evaluate and leverage ongoing efforts that can be used to support industry collaboration. For example, efforts are being made today to develop a Global Collaborative Manufacturing Architecture (GMCA) to support the manufacturing industry, and several companies (including defense contractors and commercial companies like Procter & Gamble) are participating in large-scale collaborative programs that support open communication of innovative technologies. By working with these organizations, DoD can develop a core set of best practices and lessons learned to apply within the defense community.

Creating A Focused DoD Manufacturing Technology Community

A White Paper Supporting Incentives for Advanced Manufacturing Technology

A unified community and coordinated support mechanisms for Department of Defense manufacturing technology will facilitate faster, lower-risk development of warfighting capabilities while strengthening our industrial base, increasing cooperation between defense suppliers, and ensuring greater responsiveness to Warfighter needs. This cooperative environment will provide better solutions for the Warfighter at lower cost, and will provide incentives for consistent excellence in the industrial base.

1.0 STATEMENT OF CHALLENGE

The challenges faced by our defense industry as we move deeper into the 21st century are substantial. Asymmetric warfare and the ability of our enemies to rapidly change tactics makes it essential that we improve our ability to rapidly and cost-effectively devise, produce, and deliver immediate counter responses. As our weapon systems become more complex and diverse, the manufacturing solutions that produce these systems must also keep pace. A culture of responsiveness, enabled by advanced manufacturing technologies, will make the industrial base more agile, adaptive, and cost-effective. Closer and more responsive working relationships across programs, funding elements, Services, and all defense industry stakeholders is essential to transforming the current culture of many diverse participants, not working together, to a unified manufacturing community. As a team, the manufacturing community must come together to create a truly cooperative environment wherein systemic barriers are broken down and urgent Warfighter requirements are met with fast responses – optimized for total value.

Significant challenges are engrained in the current acquisition culture. The challenges that each Service faces are generally solved within the bounds of their organizations and their supply base, and broad collaboration in technology development is not the norm. For example, DARPA works on high-risk, high-impact concepts, and has a broad view of technologies – not focused on manufacturing. The Science and Technology (S&T) programs fund ensuing development and demonstrations. ManTech fills a gap for critical manufacturing technologies and has a relatively broad span, from development through early deployment. Programs such as Title III are designed to move technology to commercialization and broader deployment. SBIR programs support all of these activities with a phased approach from research to deployment, but experience has shown that the progression is often lacking.

The challenge is to create a synergistic and better-integrated community wherein all players work together to move needed technologies rapidly and effectively through development and to productive use. A number of organizations provide a foundation for a more coherent and responsive manufacturing community. ManTech is an excellent model in that multiple Services work together in a shared environment, and their crosscutting activities are increasing. The Services hold conferences in which their needs and directions are shared, including the SBIR Opportunity Forums and other activities. However, there is no location where all players regularly come together to discuss common needs and plan for common solutions. The Defense Manufacturing Conference offers the closest fit. However, DMC is chiefly a ManTech conference. The

organizers of DMC have worked hard to embrace other organizations and agencies as participants. Continued pressure toward a comprehensive conference that brings the entire manufacturing community together is encouraged. Associations and societies also play a role. The Aeronautics Industries Association (AIA), the National Defense Industries Association (NDIA) and others are becoming more active as forums for manufacturing success. The NDIA Manufacturing Committee has become an effective focal point for an action agenda, and its newly formed partnership with the Systems Engineering Committee offers great promise.

All of these organizations and programs are delivering tremendous value to our national security. However, it is clear that a new paradigm of cooperation, collaboration, and synergy is critically needed to address the challenges that are facing our nation today.

2.0 OPPORTUNITY AND IMPACT

The opportunity offered by the Manufacturing Technology Community (MTC) concept is its ability to provide far sharper focus and rapid reaction in solving challenges that face each Service and the entire defense industrial base. The impact will be faster delivery of more capable solutions to manufacturing technology challenges, resulting in better warfighting solutions, sooner, and at far lower cost than is possible in today's environment. Specific areas of opportunity are addressed below.

1. Collaboration and Teamwork – The MTC will be a powerful forum and enabler for increased collaboration. Participants will be continually aware of problems that need solutions, and every member of the community will be encouraged to participate in the pursuit of those solutions. Focus on the precompetitive environment ensures ample opportunity and space for working together. Best practices will be shared in an open environment, and assistance in adoption will be provided. The DoD will work with this community to make better use of existing mechanisms and to create new incentive programs that reward collaborative solutions.

2. Technology Innovation, Assessment, and Maturation – The MTC will facilitate the development, implementation, and adoption of game-changing manufacturing technologies across the entire defense industry. The community environment will stimulate innovation and provide a fertile ground for collaboration that goes beyond the identification of the potential solution, to managing the solution to maturity and deployment.

3. Global Competitiveness – As in commercial industry, the world is the marketplace for the U.S. defense industry. Trade in defense products is a strong pillar of our national economy as well as our national security strategy, and is vital to sustaining our defense industrial base. Foreign sales also make it feasible to provide new weapon systems at a much more affordable cost by spreading the nonrecurring manufacturing costs across larger production quantities. Economies of scale also deliver benefits in production. With the growing trend of globalization, it has become much easier for international firms to compete with U.S. firms for defense system sales. By establishing the MTC, the U.S. defense industry will create a far more powerful ability to leverage shared resources to maintain, grow, and protect its competitive position.

4. Supplier and Research Community Engagement – Present mechanisms are not as effective as they should be in engaging small manufacturers and the research community. DMC, for example, is dominated by prime contractors. Small businesses rarely have the resources to engage in open-ended programs, although they arguably represent the most innovative segment of the manufacturing community. The MTC concept will aid and incentivize the smaller technology

suppliers and manufacturers to better participate as members of the larger DoD manufacturing solutions community. A similar argument can be made for the research community. Providing greater visibility of what is being done across the entire R&D spectrum and leveraging that work for defense applications offers tremendous potential for accelerating innovation in the design and manufacture of defense systems.

3.0 BENEFITS TO BE ACHIEVED

Despite strong efforts towards acquisition reform, the development, maturation, and production of defense systems remains a long and costly process with many risks. It is imperative that actions be taken to improve on-time delivery of systems within budget constraints. Through development of a focused, collaborative manufacturing technology community, many of the issues leading to cost/schedule overruns and performance shortfalls can be addressed. The MTC can transform our current manufacturing technology community into a more focused and cooperative team to move our industrial base to a position of unprecedented power and responsiveness to the nation's needs. Principal benefits of the MTC are as follows.

- Through increased interaction and knowledge sharing, industry participants will benefit from lessons learned and best practices. This improved "cultural exchange" will deliver improvements in development and implementation of new and more capable – and more cost-effective – manufacturing technologies.
- Knowledge is one of the most valuable of all resources, yet one that is not well managed. The knowledge sharing that comes from a collaborative community will be invaluable in solving entrenched problems that cannot be solved without collective efforts.
- As participants collaborate on related developments, redundancy of effort will be reduced, helping all stakeholders make more effective use of their resources. The improved ROI from coordinated technology investments will result in better solutions that are proven mature and ready for deployment. This improved development process will dramatically reduce the risks associated with technology insertion and enable faster implementation to benefit defense production programs.
- The MTC will provide far better visibility of new developments and emerging technologies across the defense stakeholder community, stimulating cooperation and technology transfer. This increased awareness and interaction will promote the development of innovative products and systems throughout the industry.

The benefits of the MTC can be extended beyond manufacturing technology to include business practices. By extending the focus to broader issues, the community can promote and encourage adoption of "green" technology that supports energy efficiency, conservation, and environmental sustainability. It can share business practices that support integration of enterprise systems and improved management. It can build a foundation for safer and more productive work environments. It can deliver training programs to prepare our workforce for future technologies.

4.0 SOLUTIONS AND PATH FORWARD

Based on input from the participants in the workshop, we encourage DoD to facilitate the creation of the Manufacturing Technology Community. The MTC will provide mechanisms that support improved industry collaboration, knowledge transfer, and the development of standard-

ized tools and policies that enhance manufacturing capability and performance. DoD should leverage available incentive programs to encourage participation in this program and promote widespread utilization of the tools, processes, and knowledge repositories developed by the community.

The goal of the MTC is to encourage open communication throughout the manufacturing industry and ensure that design teams, program managers, and industry leaders are clearly aware of emerging capabilities and innovations. An MTC advisory board should be established to provide program direction and interface with government and industry leaders to seek and manage opportunities for community interaction. Periodic forums and web-based interchanges should also be used to bring community members together to discuss issues, share knowledge, create plans, and establish collaborative development and implementation activities.

Key actions that should be considered in development of the MTC concept include:

1. **Develop mechanisms to promote industry collaboration and knowledge transfer for solving manufacturing problems and extending the knowledge base.**
    - Develop industry-wide collaborative teaming agreements to enable open information exchange.
    - Establish focused programs to collect and share lessons learned and best practices from industry leaders and innovators. The MTC must take an active role in establishing these partnerships, and take responsibility for collecting and distributing knowledge and tools to participating members. Working with existing organizations is encouraged.
    - Evaluate other activities such as the DOE Interagency Manufacturing Operations Group (IMOG) as potential models for a DoD program.
    - Implement mechanisms to connect end users with manufacturing solution providers to improve product support and sustainability.
    - Establish communities of practice that allow practitioners from across the manufacturing continuum to exchange information and work together to solve problems.
    - Extend the community of practice beyond technology to address business practice and business culture issues.
    - Provide training opportunities for knowledge extension.
    - Continue to extend the scope and inclusiveness of DMC to provide a common forum for all defense manufacturing organizations and participants.
2. **Open the MTC scope to encourage participation from other government agencies, small businesses, research institutions, universities, and other organizations that support the defense supply chain.**
    - Establish relationships with other agencies possibly by rejuvenating and redefining the Interagency Working Group (IWG) for Manufacturing R&D.

3. **Support the standardization of design and production tools to provide a common, interoperable defense industrial base toolkit for development and production.**
   - Define common design and manufacturing needs that exist across the defense industrial base. Define needed tools and classes of tools to address these needs.
   - Develop common workflow models for each application area and process type for which shared tools would be of value.
   - Establish certification requirements that ensure compatibility of similar and interrelated tools, including the ability to create, manipulate, and share product and process models.
   - Disseminate the certification requirements to the technology vendor community and establish timetables for participating companies to complete the certification process.
   - Promote the availability of interoperable tools and encourage their use in defense programs.
   - Define modeling tools that support defense needs, and establish and maintain shared model libraries.

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Strategic Imperatives for Manufacturing Technology Insertion

A White Paper Supporting Incentives for Advanced Manufacturing Technology

To achieve critical path technology development and insertion and to incentivize, broad adoption of a fully structured technology maturation process is encouraged. We propose that DoD develop and operate its technology programs using a formal strategic approach for technology portfolio management. This approach includes technology planning and development projects guided by technology roadmaps, and programs with performance-based contracts tied to technology maturation milestones. The roadmaps will define requirements and metrics for progression to higher technology readiness and manufacturing readiness levels (TRLs/MRLs), and project continuation will be based on phase gate/stage gate processes.

1.0 STATEMENT OF CHALLENGE

DoD has a long history of projects that have large cost overruns, significant schedule delays, or other major program performance issues. A 2005 study of 26 major weapon system programs found that, on average, costs increased by 42% and schedule increased by nearly 20% from initial estimates.[13] As a result, order quantities for 10 of the programs were reduced and unit cost increased, sometimes drastically. This less than desirable performance was blamed on failure to demonstrate at key "knowledge points" (or stage gates) that the required technologies were sufficiently mature, that designs were stable, and that production processes were in control. Only 15% of the assessed programs demonstrated mature technologies at the start of system development; these programs experienced lower development time/cost and lower unit cost increases. In a larger review of 52 major weapon programs in 2006, 90% of the programs started with immature technologies; more than half were working with immature technologies at the Critical Design Review milestone, and when production began, one-third of the programs still had immature technologies. Programs that started with mature technologies averaged a modest 4.8% cost growth above initial estimate, while programs starting with immature technologies averaged about 35% cost growth.[14]

With ever-increasing competition for limited funds – an even stronger imperative to use funds wisely – DoD must take the appropriate corrective action. This means the adoption and operation of a more disciplined and strategically focused methodology to ensure its ability to fulfill its commitments. Technology development investments must be aligned using strategic technology roadmaps, and targeted to the highest-priority technologies. As a step in the right direction, a May 2003 revision of DoD acquisition policy recommends the separation of technology development from product development, and requires the demonstration of technologies to high readiness levels before insertion into production programs.[15] This change brings DoD more in line with commercial best practices, and should reduce risk and improve project performance. The guidance also provides a mandate for implementation of a technology development and maturation methodology.

[13] GAO-05-301, Assessments of Selected Major Weapon Programs, p. 5.
[14] GAO-06-883, DoD Technology Transition, p. 8.
[15] GAO-05-301, p. 8.

This white paper supports the creation of a formal, strategic approach to guide the development, maturation, and insertion of high-priority manufacturing technologies into DoD production programs. To improve returns on technology investments and ensure performance of the technologies in DoD systems, disciplined strategic planning and adherence to gated reviews and decisions based on technology and manufacturability readiness assessments is essential. Key stakeholders (technology developers, industry partners, and government program managers) must work together to implement improved or new manufacturing technology in planned or currently fielded systems. The gated technology maturation process is not limited to the lower TRLs and MRLs, but should guide the development process all the way through to deployment, including insertion in new systems and technology refresh for existing systems.

Strategic technology management is also vital for addressing obsolescence and diminishing manufacturing source (DMS) issues. Current-generation military systems are increasingly reliant on commercial off-the-shelf (COTS) technologies and components to reduce acquisition costs and increase commonality. However, commercial technologies evolve rapidly and generally become obsolete within a few years, while most defense systems must be supported for 20 years or more. Understanding technology development and deployment opportunities and planning for the insertion of available, mature solutions is the best method for addressing obsolescence. Equally important is assuring a source of long-term supply for high-purity specialty materials (e.g., for optical windows, radomes, and electronic components) and specialized commodity components (e.g., titanium fasteners for aircraft structures).

Since this white paper is focused on manufacturing issues, the importance of Manufacturing Readiness Levels (MRLs) and assessments must be emphasized. The strategic management of the technology development and insertion cycle must be based on proving that the new manufacturing technology is viable, and that the manufacturing systems and processes are in place to deliver and support the components or products. The phase/stage processes work just as well for Manufacturing Readiness assessment as they do for Technology Readiness assessment.

2.0 OPPORTUNITY AND IMPACT

Current acquisition practices allow too many immature technologies, or technologies not yet matured to production readiness, to slip through what should be key decision points in weapon system production and sustainment programs. In new programs this leads to significant delays and cost overruns. In existing systems, the opportunity for strategic management of technology refresh is lost. The present acquisition system uses a push-pull strategy, with DoD defining requirements that must be met, and industry having intellectual property that they want to exploit for competitive advantage. The disconnect comes when what industry is pushing is not what DoD needs and when the pull creates pressure for technology deployment before it is sufficiently mature. The issue of technology maturity and manufacturing readiness is often treated very optimistically. The resulting cost overruns often result in reduced order quantities or canceled programs, which slashes industry's return on investment and provides a strong disincentive for them to cooperate with the government in moving the best technologies forward.

Many innovative technologies fall into the "Valley of Death" between early development and proveout for insertion into production systems. DoD funding sources and acquisition organizations are not well aligned to a cohesive roadmap or set of roadmaps to move effectively through the innovation process to deployment. Tools and mechanisms (such as MRL/TRL management, stage gate maturation management, and technology roadmaps) are being used, but there is no

systematic, strategic approach that makes the application of these methods consistent and effective, and no agreement within DoD as to what constitutes an effective technology roadmap. Only with a systematic application can we effectively coordinate investments in high-priority technologies.

3.0 BENEFITS TO BE ACHIEVED

The disciplined strategic approach to technology management will better align manufacturing technology development and investment with the highest-priority needs of defense programs and will mitigate risk in delivering the needed capabilities to the Warfighter. The result will be reduced cost and reduced "reprogramming" of weapon system programs. Fewer changes mean faster to the field with more responsive and cost-effective solutions. Whether solving problems and addressing obsolescence in existing systems, or building challenging new high-performance systems, strategic management of technology maturation will be a repeatable success model that supports the modernization and competitiveness of our defense industrial base.

Timely development and insertion of mature manufacturing technologies into the industrial base will reduce costs and improve the ability to deliver and deploy systems on schedule. This will provide continuity of manufacturing technology development from the science and technology environment into programs/platforms, bridging the "Valley of Death." Because the technology management process continues with technology refreshes strategically planned and executed, improved cost control over the entire life cycle will be achieved along with optimal use of capital resources, resulting in improved total value.

4.0 SOLUTIONS AND PATH FORWARD

The following actions are required to establish a coordinated strategic approach to manufacturing technology management. Where similar or related efforts are under way, these should be encouraged and leveraged for maximum benefit.

1. **Utilize existing information to develop and maintain a "critical technologies list" and an "emerging technologies list" and manage the maturation of the identified technologies at a DoD level to support current and future acquisition programs.**[16]
2. **Develop a unified technology roadmap (or set of roadmaps) across multiple Service components for important crosscutting technology areas and to meet specific program needs.**
   - Identify a single point of responsibility within DoD for creating and managing unified technology roadmaps.
   - Create a common framework for all roadmaps that addresses the critical and emerging technologies, and implement that structure across DoD.
   - Assess existing Service and program technology roadmaps, and move appropriate information to the common structure.

[16] A Critical Technologies List is maintained today; however, better visibility and utilization and linkage to technology plans and investments is recommended.

- Create and maintain technology roadmaps and strategic investment plans, using a common MRL assessment system. Include the requirement to provide and manage a Manufacturing Technology Roadmap for every key technology incorporated into a new weapon system.
- Continuously map activities and projects to the roadmap to ensure maximum synergy across DoD and with external leverage of commercial sectors.

3. Assess existing mechanisms for strategic technology management and modify as needed.

- Ensure appropriate criteria are in place for uniform MRL implementation.
- Define a DoD-wide strategy for phase gate/stage gate implementation across the defense industrial base for all DoD funded programs.
- Establish a plan for strategic technology management and an approach for auditing results.

4. Develop a strategic guidance framework for technology insertion.

- Target manufacturing technology development projects according to roadmap priorities.
- Promote the stage gate model with Go/No Go decisions for all projects to readiness of mature manufacturing processes and technologies at key need points.
- Institutionalize manufacturing readiness assessments 'early on' (i.e., during conceptualization and design) in new systems, with linkage between capability, maturity, and risk.

5. Establish manufacturing technology development as a funding requirement separate from weapon system development.

- Based on the critical technology and emerging technology assessments, promote funding for projects to develop and mature high-priority manufacturing technologies.
- Support policy that allows funding across program and Service boundaries to ensure that the needed technologies are developed and matured.

6. Develop technology insertion processes and guidelines.

- Require the establishment and management of manufacturing technology insertion plans for systems and critical subsystems.
- Make provisions to fund and support the insertion of new manufacturing technology into relevant system acquisition programs.
- Develop shared risk and staged implementation strategies to incentivize technology insertion.

7. Define compliance requirement levels for all acquisitions.

- Facilitate collaboration between government agencies, contractors, trade associations, technical societies, and academia to leverage investments to achieve technology development goals.
- Investigate reward mechanisms to encourage compliance with strategic technology management approaches (stage gates, etc.).

8. Test and refine the strategic management process with pilot projects.

- Implement pilot projects, structured in accordance with the new strategic management requirements.
- Capture lessons learned for the benefit of current and future systems; refine process requirements as needed.

9. Exercise existing contractual mechanisms and implement new or modified vehicles that support performance-based contracts tied to technology roadmaps and maturation plans.

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DoD Manufacturing Technology Incentives for Infrastructure and Production Capability

A White Paper Supporting Incentives for Advanced Manufacturing Technology

A much stronger and more responsive defense industrial base can be achieved by reinitiating and innovatively applying incentive programs currently and formerly used by DoD. These programs support the assessment of business and manufacturing processes, implementation of streamlining actions, and modernization and improvement of defense manufacturing facilities and infrastructure.

1.0 STATEMENT OF CHALLENGE

The weapon systems of today and tomorrow demand excellence and affordability in design and manufacture. Although industry is putting selected new capabilities in place to support high-profile acquisition programs, the current defense manufacturing infrastructure is aging and in need of modernization. DoD and industry must work together to implement specific manufacturing capability enhancements and infrastructure modernization to meet these challenges across the defense supply base. New manufacturing technologies and processes are needed to provide game-changing improvements in cost and performance, benefitting current production programs and laying the foundation for the radical capability improvements needed to support the next generation of advanced warfighting systems.

The participants in the Incentives for DoD Manufacturing Technology Workshop identified the provision of programs that support the nation's defense manufacturing capabilities as a high priority, with emphasis on three specific programs: Value Engineering, Single Process Initiative, and the Industrial Modernization Incentives Program. These programs are not new; rather, the challenge is to learn the lessons from past application and apply these lessons to create better programs that deliver significant impact across the entire defense industrial base.

2.0 OPPORTUNITY AND IMPACT

> *"No matter how much education or R&D a nation funds, if industry does not invest in advanced manufacturing processes and integrate them onto their factory floors, our productivity relative to competing nations will suffer. It is in capital investment that the federal government takes its most laissez-faire approach. This…approach is inappropriate, especially for the defense industry, for several reasons:*
>
> - *'defense' market forces and government contracting policies do not provide the incentives for capital investment or productivity growth*
> - *without manufacturing innovation, industry will not be able to produce the weapon systems of the 21st century*
> - *production disadvantages can negate any technical advantage in weapon system design"*[17]

[17] *The Industrial Base and National Security A New Strategy*; an Executive Research Project by LTC Garry C. Varney, U.S. Air Force, 1993.

> *"The Department expends little effort to provide incentives that will speed manufacturing technology transition. DoD needs to identify incentives for defense manufacturing base contractors to incorporate and utilize manufacturing enhancements. Programs such as value engineering proposals and single-process initiatives, for example, should be reinstituted"* [18]

Sobering observations, made years apart yet clearly appropriate given the challenges faced by DoD programs and the U.S. manufacturing industry today. Some of the observations of the Incentives workshop participants include:

- The U.S. manufacturing base is losing ground as foreign industry and their supportive governments provide investment capital to modernize facilities and infrastructure.
- Except in isolated instances, the DoD manufacturing infrastructure is not keeping current with advanced manufacturing technologies.
- Current DoD procurements are largely awarded based on lowest cost, which does not support investment in advanced manufacturing technologies.
- Advanced warfighting products and technologies need commensurately advanced manufacturing technologies and processes to enable cost-effective, high-performance production.

From the existing systems perspective, baseline DoD product designs are in place, production facilities are in place, and production methods are in place, and there is reluctance to change. The existing capital base and the acquisition cost of upgrades limits the ability to implement improvements that would lower costs, improve quality and throughput, and better integrate the supply network. This static situation is at odds with warfighting requirements and mission capability needs, which continue to evolve in response to new threats and growing adversarial capabilities.

In collaboration with industry, DoD must support the systematic determination of the best opportunities for maximizing the benefits of capital investments in the defense manufacturing base. This systematic approach should be applied to industrial facilities, infrastructure, advanced manufacturing technologies, and in streamlining government and industry "business-of-manufacturing" practices. In response to this critical need, the Incentives workshop participants identified three methodologies and programs that meet offer great promise in assuring strong return on infrastructure investments: Value Engineering (VE); Single Process Initiative (SPI); and the Industrial Modernization Incentives Program (IMIP).

Value Engineering[19,20,21]

Developed at General Electric Corp. during World War II, value engineering (VE) is widely applied in the defense, transportation, construction, and healthcare sectors. VE is defined as "an analysis of the functions of a program, project, system, product, item of equipment, building, facility, service, or supply of an executive agency, performed by qualified agency or contractor

[18] The *Manufacturing Technology Program: A Key to Affordably Equipping the Future Force*, Defense Science Board Task Force, February 2006.

[19] *A Strategic Plan for Value Engineering in DoD*, December 2008.

[20] *R-TOC in DoD Systems Status Report*, Spiros Pallas, Principal Deputy, OSD/Defense Systems; PEO/SYSCOM Commanders' Conference, November 2002.

[21] OMB Circular A-131 Value engineering, 21 May 1993. http://www.whitehouse.gov/omb/circulars/a131/a131.html#4

personnel, directed at improving performance, reliability, quality, safety, and life cycle costs." VE is an effective technique for reducing costs, increasing productivity, and improving quality. It can be applied to hardware and software; development, production, and manufacturing; specifications, standards, and contract requirements; and facility design and construction.

The application of VE is required by law (41 USC 432), and the Office of Federal Procurement Policy (OFPP) Act requires every Federal agency to maintain a Value Engineering program. The DoD VE program is an analytical system aimed at improving performance and costs by incentivizing government and industry participants to achieve best-value solutions in their business relationships. This is a shared value proposition as illustrated in Figure 1.

Figure 1. Value Engineering benefits both DoD and the supplier.

VE's focus on quality and cost-saving acquisition practices helps ensure that a viable supply base, including a diverse array of small business suppliers, is ready to meet the needs of DoD. The DoD and its industry partners (both prime contractors and their supply chains) depend on each other for the creation of value and achievement of success. Based on partnering, communicating, establishing trust, and assuring mutual understanding of the acquisition business case, strategies such as the Value Engineering Change Proposal (VECP) process (Table 1) can be applied to incentivize contractors to better meet DoD's objectives.

Table 1. VE Phases and Activities

Phase	Activity
I. Information	Study documents, learn background, identify functions, and identify cost/worth of functions
II. Speculation	Identify what else can do what must be done (free use of imagination with no judgment is essential)
III. Analysis	Rank alternative solutions in terms of quality with realistic judgment
IV. Development	Develop the best alternatives into written proposals
V. Implementation	Include accepted proposals in the project/program plans

Despite its close tie-in with other DoD priorities such as reducing total ownership costs (R-TOC) and despite ample evidence that VE is highly cost-effective, its use has diminished in recent years for several reasons. The VCEP process can be cumbersome, and program managers are

increasingly reluctant to divert their limited engineering resources to activities that are not core to meeting their contractual technical, cost, and schedule requirements. VECPs are also more useful in high-volume production programs where a small improvement can deliver large pay-back through unit cost savings. With fewer DoD procurements and less assurance of quantity buys over multiple years, the incentive for contractors to pursue improvements through VE is greatly reduced.

Single Process Initiative[22,23]

The purpose of the Single Process Initiative (SPI), originated in 1996, is to remove customer-unique requirements from contracts and enable the use of a single, common process proposed by the contractor. For example, if a contractor is allowed to use a single soldering standard for all work at its facility, costs to all affected customers should be reduced, while maintaining or even enhancing quality.

Because the various military services and federal agencies have their own unique requirements, a contractor may have several very similar systems or processes set up to accommodate each customer. Many of the differences may be procedural and without impact on product or process quality. This is inefficient and costly to both the contractor and the government. SPI transitions contractor facilities to common, facility-wide processes used on all applicable contracts, rather than tailoring on a contract-by-contract basis.

The overall goal is to eliminate unique processes/systems unless they are essential to mission safety and reliability. This often allows contractors to use best commercial practices. SPI improves process efficiencies, improves product quality, reduces operating costs, and, reduces acquisition costs.

There are three basic steps to the SPI process:

1. Identification of proposed common processes for implementation across the contractor's facility. These processes are documented in concept papers submitted to the local Management Council.
2. Joint evaluation and approval by the Management Council.
3. Execution of a block change modification to implement the approved process(es) across all applicable contracts.

According to the Defense Contract Management Agency (DCMA), the most frequent proposed SPI process changes address quality system requirements, electronic manufacturing, configuration management, calibration standards, material review, cost data reporting, soldering, subcontractor approval, property management, and test requirements.

Industrial Modernization Incentives Program[24,25]

The Industrial Modernization Incentives Program (IMIP), initiated in 1978 and closed down in 1992, was designed to encourage contractor investment in more efficient production equipment

[22] http://nawctsd.navair.navy.mil/Resources/Library/Acqguide/spi.htm

[23] Single Process Initiative (SPI) Guidance for Army Component Team Leaders - A Practical Guidebook & Lessons Learned For Army Team Leaders and Team Members, September 2003.

[24] *DoD's Industrial Modernization Incentives Program: An Evolving Program Needing Policy and Management Improvement*, GAO/NSIAD-85-131, September 1985.

[25] Varney, 1993.

and processes as well as management and other software systems to increase productivity and reduce weapon system acquisition costs. Program objectives also included improving product quality, shortening lead times, reducing life-cycle costs, and increasing surge and mobilization capability.

IMIP addressed two DoD acquisition conditions that inhibit contractor investments in modern plant equipment: 1) directly basing profit on costs incurred, and 2) the uncertainty inherent to incremental annual buys for weapons and other defense equipment. The two primary incentives used were payments based on cost reductions, and governmental investment protection guarantees if affected weapon programs were terminated prematurely.

An IMIP effort could be initiated in a number of ways, ranging from a requirement in a weapon system request for proposal to an unsolicited proposal from a contractor. An IMIP effort is normally accomplished in three phases (Table 2).

Table 2. IMIP Phases

Phase	Contractor Actions	Results
I	Top-down factory or product line analysis	Proposal for Phase II and/or III
II	Develop and validate engineering applications of new technology	Capital investment proposal
III	Investment in and installation of capital equipment	Cost reductions, other benefits, and incentive payments

Phase I is a structured analysis of the contractor's factory operation. It results in a plan to modernize the entire facility or a single product line by identifying contractor projects to be integrated into the factory. The plan identifies those investments that will reduce costs but not give the contractor an adequate return on investment. Phase II designs, develops, and validates the new manufacturing system. During this phase, DoD funds may be used to develop technology for a production application but not to purchase capital equipment. At the conclusion of Phase II, the contractor may submit a capital investment proposal that specifies the type, cost, and timing of contractor investments and incentives desired. During Phase III, the contractor buys and installs the capital equipment. Weapon system program offices pay incentives in accordance with prior agreements.

In its application, IMIP reenergized capital investment in the defense industrial base and created a culture in which government and industry sought better way to do things. However, there were weaknesses of complexity, duration, validation of savings, adequate commitment of funding and resources, and, after initial successes, dwindling priority in the acquisition process:

> *"Incentives focused on specific programs and integrated into the life cycle of those programs make more sense than broader based incentives. For example, the government invested heavily in the F-16 Tech Mod program. There was a lot of focus on the program, and every dollar placed on the program was highly visible. Follow-on programs in the Industrial Modernization Incentives Program (IMIP) have not been as successful – probably because there has been less emphasis and exposure. It might be good to create an incentives program similar to that of the F-16 for the F-35 (JSF)."*[26]

[26] Michael McGrath, Group Presentation/Discussion during the DoD Incentives Brainstorming session, 14 August 2008.

3.0 BENEFITS TO BE ACHIEVED

The DoD will realize an increasingly more reliable, capable, and responsive defense manufacturing base along with numerous direct benefits through reenergized and focused VE, SPI, and IMIP initiatives:

- More equipment and systems delivered to the warfighter at lower cost
- Higher-quality products and reduced lead times from streamlined, modernized processes
- Increased surge capability from increased automation for improved production capability.

The potential savings from reinvigorating these programs is huge based on prior experience:

VE: During 2006, 3,473 DoD VE proposals and contractor-initiated VECPs were accepted, with projected savings/cost avoidance in excess of $1.6 billion.[27]

SPI: There have been 201 facility conversions to commercial quality standards; 21 conversions to commercial Earned Value Management Systems; 23 conversions to commercial parts management practices; 47 conversions to commercial soldering standards; and 27 conversions to commercial calibration standards in the past 30 months. Negotiated savings to existing contracts are $30 million, and cost avoidance is $444 million.[28]

IMIP: At the height of the IMIP, the Air Force had more 60 contractors involved. Combined resources committed included more than $530 million for the Air Force and more than $1.3 billion for industry, with a total estimated cost savings exceeding $4.5 billion.[29]

4.0 SOLUTIONS AND PATH FORWARD

Based on input from the Incentives workshop participants, we encourage the DoD, in concert with industry, to pursue the following recommendations. Further, we recommend DoD implement an internal program for identifying, developing, and managing methods and tools for improving manufacturing technology with a companion incentives approach that promotes the widespread and effective use of those improvement tools and techniques.

1. **Form a VE/SPI/IMIP organization to pursue and promote advanced manufacturing technology opportunities within the defense manufacturing base.**
   - Form an internal DoD Program Group involving ManTech, Program Executive Offices and System Program Offices (PEOs/SPOs), and the Office of Management and Budget plus existing VE and SPI program offices and Defense Acquisition University faculty.
   - Form an Industry/Academia Outreach Office.
   - Utilize these bodies to review existing programs, make recommendations for change, and champion utilization of the enhanced programs.

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[27] *Department of Defense Announces Value Engineering Achievement Award Winners*, Department of Defense Office of the Assistant Secretary of Defense (Public Affairs) News Release No. 255-07, 7 March 2007. http://www.defenselink.mil/releases/release.aspx?releaseid=10583

[28] *Acquisition Reform - Gansler Endorses Single Process Initiative Throughout DoD-Industry*; PM, September-October 1998. http://www.dau.mil/pubs/pm/pmpdf98/gansl1so.pdf

[29] Department of Defense Authorization For Appropriations For Fiscal Years 1990 and 1991, Senate Committee On Armed Services, 101st Congress, SHrg 101-251. GPO, 1989.

2. Re-instate IMIP.

- Create a Reinstatement Panel to review the prior implementation of IMIP and recommend changes for a revamped program. Guidelines to consider are:

  Involve more than one weapon system program and one Service

  Have a principal goal of reducing lead time and expanding surge capability

  Involve subcontractors and vendors as well as system prime contractors

  Strengthen the visibility of benefits and ensure consistency in reporting.

  Put in place technology transfer programs to assure that value gained in individual programs is shared across multiple programs.

  Develop lessons learned from prior implementation.

- Initiate discussion/involvement regarding IMIP with acquisition professionals, PEOs/SPOs, ManTech Offices, and industry.

3. Assess the current state of VE and SPI.

- Conduct sponsored meetings involving Services, industry, and other stakeholders to assess the methodologies for VE and SPI and make recommendations for improvement.
- Review existing applicable FAR and DFAR provisions.
- Review the contractual language in selected programs for VE and SPI provisions.
- Review current implementation and coordination as well as plans and budgets, handbooks, guidelines, and instructional media.

4. Modify/develop funding, contractual, and incentive structures supportive of VE/SPI/IMIP programs.

- Assess incentives and options for use of direct government funds and use of contractor funds
  - Provide direct IMIP funding for more thorough factory analyses.
  - Provide direct government funding for VE and SPI proposals.
- Establish mechanisms for flexible sources of funding for VE/SPI/IMIP projects to provide start-up funds for engineering and other efforts needed to implement such initiatives.

5. Develop and implement a strategic plan for an integrated VE/SPI/IMIP approach.

- Implement pilot projects structured in accordance with the new strategic requirements.
- Capture lessons learned for implementation; refine requirements and implementation process as needed.

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Enabling Fast-Track Requalification and Recertification

A White Paper Supporting Incentives for Advanced Manufacturing Technology

Expanded use of modeling and simulation(M&S) technologies, leveraged sharing, and use/reuse of those technologies will improve the timeliness and reduce the cost of product and process re-qualification and recertification for existing and legacy DoD systems, ensuring their ability to reliably perform their missions over the full span of their operational life.

1.0 STATEMENT OF CHALLENGE

Finding innovative approaches that enable 'fast tracking' of requalification and recertification of existing and legacy[30] components, equipment, and systems is critical when new manufacturing sources, technologies, or processes are implemented to sustain operational systems for all of the military Services. Increasing use of commercial off-the-shelf (COTS) equipment in military systems presents significant obsolescence and diminishing manufacturing source (DMS) issues, since commercial hardware typically goes out of production within a few years. Commercial manufacturers lack incentive to preserve production capability for specialized defense products due to the small order quantities. Dual sourcing, end-of-production lifetime buy (LTB), and other strategies can help protect the spares pipeline, but the long operational lives of military systems present challenges in ensuring long-term availability of replacement components and subsystems. Storage and support limitations, particularly for life-limited components, complicate the process of ensuring spares availability over many years. Such strategies must also consider the need to upgrade weapon systems at multiple points over their life to improve performance, add new mission capabilities, or address reliability, maintainability, or supportability needs.

The Manufacturing Technology Incentives workshop identified two potential high-return, innovative approaches to mitigate these challenges:

1. Using modeling and simulation (M&S) techniques to reduce the time and cost of qualification and certification of proposed changes in the product and/or its manufacturing system. Models can be applied to test and validate expected performance, cost, and reliability.
2. Leveraging multiple-use and reuse of requalification and recertification capabilities across existing, similar products and processes through:
   - Qualification by similarity
   - Increased commonality of qualification requirements across the Services and across families of systems
   - Sharing and reuse of models and simulations for similar capabilities.

[30] 'Existing' refers to military systems still in production; 'legacy' refers to systems in use, but out of production.

2.0 OPPORTUNITY AND IMPACT

Legacy platforms (ships, aircraft, and ground vehicles) comprise the core of DoD's operational equipment assets and require ever-increasing investment for maintenance and repair as operating lifetimes and conditions are pushed beyond their original design intent. The shift to operations against increasingly fluid threats has greatly increased the need for faster response to changing operational capability requirements. Countering these changing threats – while maintaining in-theater operational capabilities – dictates multiple technology insertions over the life cycle of the systems. Technology insertion into older systems is often complicated by physical space and power constraints, legacy software architectures, proprietary interfaces, and the unique differences of individual platforms having multiple variants.

Short refresh cycles and narrow windows of market availability for commercial hardware further complicate the challenge. Depending on the technology, the cycle time (window of opportunity) for new capabilities is quite short. This is especially true of electronics, which typically have a 6- to 18-month commercial refresh cycle and a 10-year or less window of market availability (Figure 1). [31]

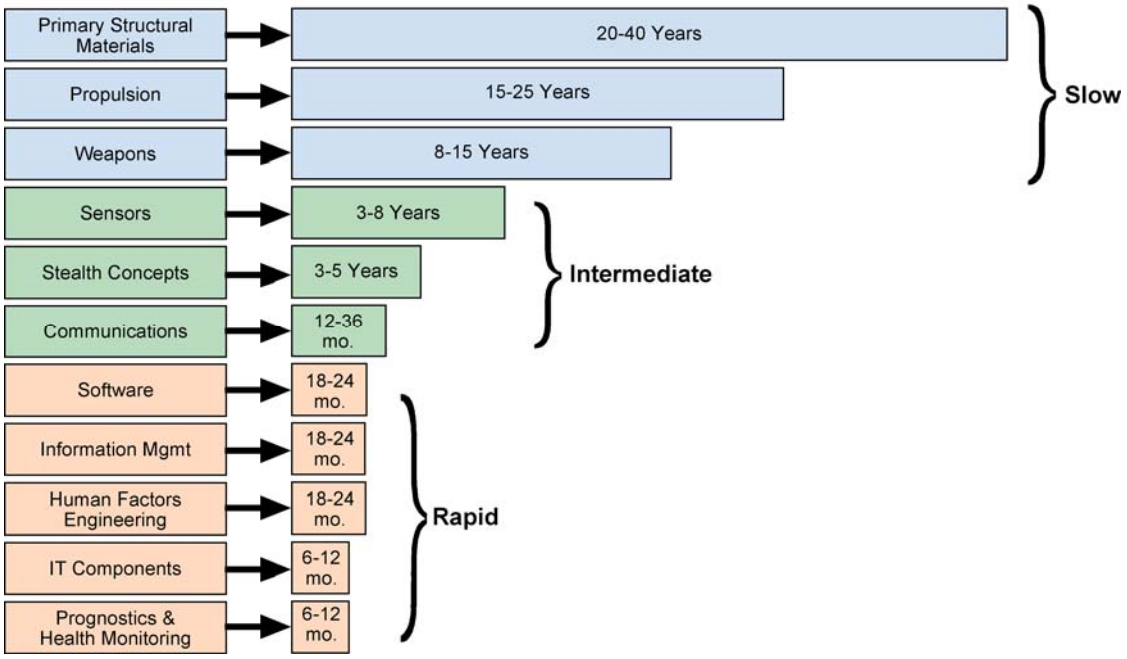

Figure 1. Technology Refresh Cycle Times for Military Systems[32]

These short cycles of availability present manufacturing and technology insertion challenges for weapons platforms having a long operational life – ships/submarines, aircraft, and missile systems – as indicated in Figure 2. A primary platform may have to accommodate dozens to hundreds of technology upgrades or refits over its life to address obsolescence issues, life extensions, or capability improvements.

[31] *Aging Avionics in Military Aircraft*, Committee on Aging Avionics in Military Aircraft, Air Force Science and Technology Board, National Research Council, 2001.

[32] Navy Research Advisory Committee Report: Life Cycle Technology Insertion, July 2002.

Significant impediments in responding to these needs include the requalification and recertification actions to ensure properly integrated insertion at all levels of a platform (Figure 3). There is often a 'roll-up' effect when inserting technology at a lower level that requires requalification and recertification of a higher level of the system.

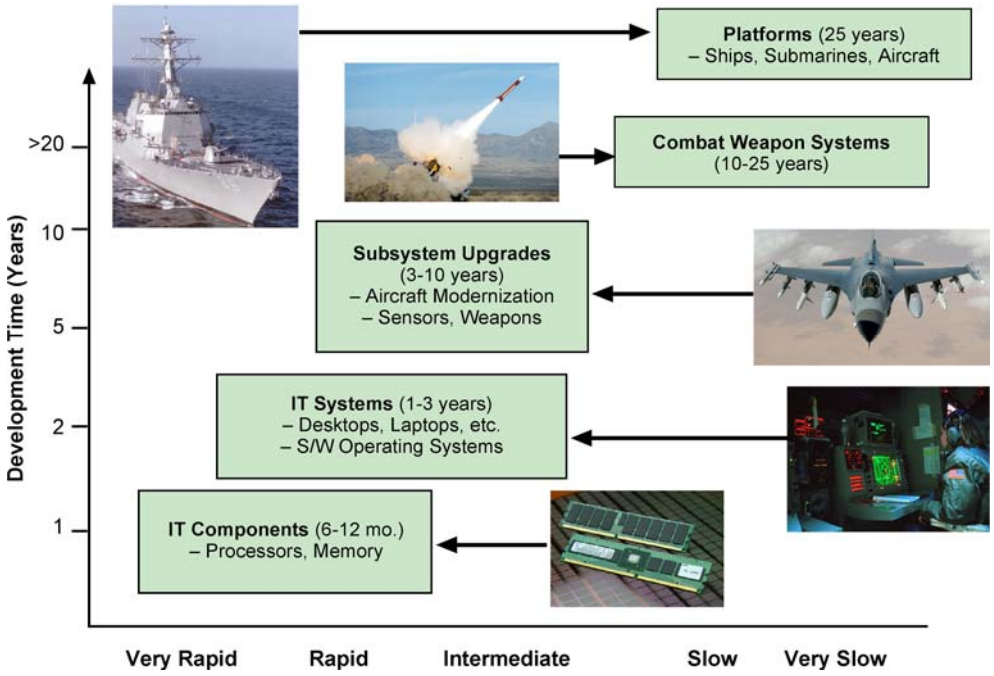

Figure 2. Technology vs. Platform Cycle Times[33]

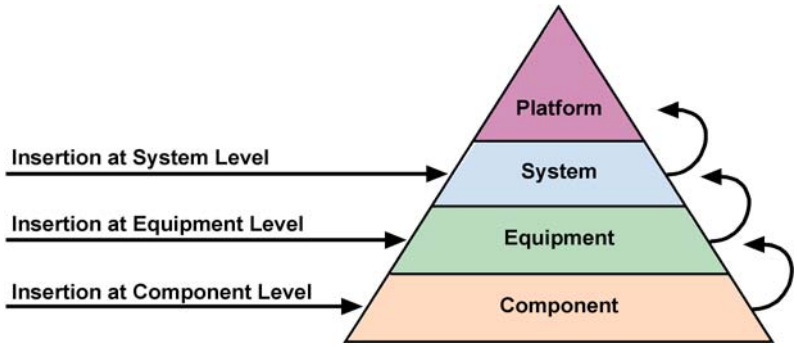

Figure 3. Technology Insertion Hierarchy[34]

The current approach to qualify/requalify and certify/recertify parts and processes is expensive and time-consuming, which discourages the insertion of potential alternatives – including new, more cost-effective manufacturing technology as well as substantially new hardware designs. There are numerous examples of the inefficiencies and problems that can result. Materials with known long-term deficiencies have been used in several cases (e.g., 7075T6 aluminum on aircraft wing skins) because of the unacceptable time and cost of qualifying a better replacement

[33] Ibid.

[34] *Technology insertion in the defence industry: a primer*, C.I.V. Kerr, R. Phaal, and D.R. Probert, Centre for Technology Management, University of Cambridge, UK; Proc. IMechE, Vol. 222 Part B: J. Engineering Manufacture; JEM1080; IMechE 2008.

material.[35] Qualification of new shipboard engine controllers, as another example, can take longer than the entire design and build of the first-unit hardware itself.

To support long-lived defense systems, the management, development, and insertion of new product and process technologies must be integrated in a coordinated manner. In some cases, manufacturing technology changes are driven by manufacturers' desires to continually lower costs, improve quality, increase throughput, or support new product lines. As a result, the manufacturing capability cycles may be shorter than the product cycles. DoD looks to industry to preserve qualified manufacturing lines for out-of-production weapons still in inventory, but without specific funding for the purpose industry cannot maintain mothballed facilities indefinitely. Setting a good precedent, the Air Force has streamlined some updates to engine components based on extensive industry analysis and proven operational experience in the commercial arena. Leveraging COTS upgrades based on analysis and limited qualification testing (where necessary to address risks) should move from an isolated best practice to a DoD-wide standard practice.

One of the best examples of short technology cycles coupled with insertion of new capabilities and advanced manufacturing technologies is in the avionics arena. When avionic systems are modified, the systems must be tested to prove compatibility with existing onboard hardware and software, validate required performance, and ensure safety-of-flight for continued airworthiness certification. Requalification and recertification testing incurs a significant share of the costs for both obsolescence fixes and system upgrades. For aircraft software, certification testing accounts for nearly 40% of development costs. Each software refresh cycle requires regression testing and flight testing, training updates for pilots and maintainers, and configuration change management, which all add to the cost.

The lack of a truly efficient strategy for recertification of avionics is a major problem. One solution is to use advanced modeling tools to provide high-fidelity emulation of circuit operation. With some additional development, these tools could be applied to create complete, stand-alone digital models of the product. The ability to complete all but the final verification tests in the virtual realm would greatly reduce the overall time and cost of testing.[36]

Performance models and associated software also offer the potential for shared reuse with similar components, equipments, and systems. To reduce time and cost in getting commercial avionics to market, the Federal Aviation Administration (FAA) has developed robust guidelines and methodologies for software reuse.[37] A procedure is being established to give credit for full or partial certification compliance for software components that were originally certified for a prior application. Under this arrangement, total system testing can take credit for earlier tests on the reused module, and so concentrate on end-to-end performance verification and operational safety assessment. The commercial sector has developed modeling, simulation, and diagnostic tools to ensure the integrity of certification processes and shorten the cycle time of avionics testing. These processes could be used as a model for a similar DoD strategy for requalification testing.

Leveraging advanced modeling and simulation (M&S) tools – applied specifically for avionics but also extended to a broader range of electronic systems – is a major opportunity for DoD to use commercial practices to streamline the verification and validation process and reduce cycle times in the electronics arena. Core capabilities in generic modeling and simulation tools are in

[35] From Robert Schafrik, GE Aviation.

[36] *Aging Avionics in Military Aircraft*, 2001.

[37] *Reusing Safety-Critical Software Components*, COTS Journal, August 2005.

place. These could be enhanced and more broadly applied to better support technology insertion for all of the Services.

3.0 BENEFITS TO BE ACHIEVED

The core benefits to be realized for DoD by implementing a well-architected and robust M&S environment are reductions in the time and cost of requalification and recertification, including user training – especially for the fast paced technology cycles of avionics and other electronic systems. Participants in the Incentives workshop commented that Australia has demonstrated that an entire ship can have a single physics-based operating model, which is now enabling 24/7 crew training ashore. The shipboard fuel savings have been enormous, and crew proficiency has significantly increased.

Additional benefits can be realized by leveraging commercial M&S practices for the requalification and recertification of military systems and by developing a share and reuse environment for the modeling and simulation codes:

- Systematic technology management for existing and legacy platforms including streamlined recertification/requalification processes will yield more efficient technology insertion and refresh and more robust system performance over the entire life cycle.
- Deliver new capabilities at lower cost through the use of comprehensive, physics-based system operating models.
- Lower barriers for inserting new manufacturing technology to better manufacture both existing and new products, helping mitigate obsolescence and DMS issues.
- Lower the life-cycle cost of platforms and other major weapon systems.
- Use and reuse validated models for requalification and recertification and during design, manufacture, and post-delivery training, thus multiplying the total overall savings.

4.0 SOLUTIONS AND PATH FORWARD

With this paper, the participants in the DoD Manufacturing Technology Incentives Workshop recommend the following actions:

1. **Provide DoD-wide direction and support for demonstration/validation of modeling & simulation concepts supporting requalification and recertification.**
   - Form a board of experts under the authority of the Under Secretary of Defense for Acquisition, Technology and Logistics (AT&L) to develop a DoD ‘enterprise’ strategy for M&S for Manufacturing Technology and specifically for requalification and recertification. This activity should involve major system program offices, prime contractors, and research organizations.
   - Demonstrate and implement M&S tools for requalification and recertification of product classes of high interest to DoD (e.g., avionics, guided weapons, propulsion/power systems) on a case-by-case basis; expand deployment over time across the Services and major programs.

- Provide oversight at the AT&L level to ensure that the program offices and cognizant technical authorities agree on and fully implement the enhanced requalification and recertification process.
- Strengthen the systems engineering process for technology insertion by developing, deploying, and using toolkits of validated systems M&S applications.
- Enhance, expand, and use the M&S toolset as "corporate resources" available to the entire U.S. defense industry.

2. Initiate a ManTech-led assessment of requalification and recertification factors for key manufacturing technologies supporting Technologies of Critical Interest.

- Identify Key Manufacturing Technologies of Critical Interest; e.g., suggest cross-cutting categories supported by the Joint Defense Manufacturing Technology Panel (OSD and Service ManTech offices, Service program offices).
- Identify the requalification and recertification considerations and issues at the intersection of the current DoD Technologies of Critical Interest and the new Key Manufacturing Technologies categories.
- Identify specific M&S areas of excellence for potential requalification and recertification use, and recommend actions to improve the use of M&S across DoD.

4. Baseline current M&S use in DoD programs and wider industry.

- Identify current DoD organizations and contractors involved in M&S applicable to certification and qualification, and benchmark significant relevant system/program M&S use within the contractor supply chains.
- Identify and benchmark current M&S usage in selected commercial arenas that are closely aligned to DoD programs (e.g., avionics, shipboard controls) and having applicability to certification and qualification.
- Based on these findings, recommend actions to improve the use of M&S across DoD.

5. Implement requirements and incentives for use of M&S by contractor/government teams.

- For every major system acquisition, include from inception the requirement to develop and validate the models needed to create accurate, high-fidelity simulations for production, operational use, and support. Include requirements to provide training in use of the models/simulations and to maintain the model databases over the life of the system.
- Establish technology refresh and insertion as a standard element of program plans for all military systems, including the development of product/system performance models that can be used for requalification and recertification.
- Examine the feasibility of requiring, as a standard contract deliverable for different types of systems, contractor-maintained high-fidelity simulation models as a tool for minimizing future requalification/recertification testing.
- Using the guidance resulting from the Critical Technologies Assessment and benchmarking activities, explore opportunities to streamline requirements for requalification and recertification processes.