Defense Science Board
Task Force

on

The Manufacturing Technology Program:

A Key to Affordably Equipping the Future Force

February 2006

Office of the Under Secretary of Defense
for Acquisition, Technology and Logistics
Washington, D.C. 20301-3140

This report is a product of the Defense Science Board (DSB).

The DSB is a federal advisory committee established to provide independent advice to the secretary of defense. Statements, opinions, conclusions and recommendations in this report do not necessarily represent the official position of the Department of Defense.

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DEFENSE SCIENCE
BOARD

MEMORANDUM TO THE UNDER SECRETARY Of DEFENSE FOR
ACQUISITION, TECHNOLOGY AND LOGISTICS

SUBJECT: Report of the Defense Science Board Task Force on The Manufacturing Technology Program

I am forwarding to you the report of the Defense Science Board Task Force on The Manufacturing Technology (ManTech) Program.

This report underscores the longstanding concern of rising weapon systems costs, compounded by the challenges associated with rapid, efficient, and affordable low-volume production, and the need to reduce these costs in light of tighter economic constraints anticipated in the years ahead. The task force concluded that manufacturing technology, in general, must receive greater attention in the department—from the senior leadership in the Office of the Secretary of Defense to the managers of major weapons programs—as it is an important factor in weapon system affordability.

More specifically, in the judgment of the task force, the Manufacturing Technology Program can address critical acquisition challenges associated with advanced weapon systems. This report identifies specific actions that the task force believes will enhance and expand the impact of the ManTech program. I agree with the findings and recommendations of this report and commend them to your attention.

William Schneider, Jr.
Chairman

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DEFENSE SCIENCE
BOARD

MEMORANDUM TO THE CHAIRMAN OF THE DEFENSE SCIENCE BOARD

SUBJECT: Report of the Defense Science Board Task Force on the Manufacturing Technology Program

The challenge of designing and producing affordable weapon systems is longstanding. A March 2005 study by the U.S. Government Accountability Office, which reports on an assessment of 54 weapons programs, illustrates the pervasive nature of the problem and its relevance today. The study concluded that mature technology, stable designs, and *production processes that are mature and in control* are critical to reducing weapon system costs.

In this context, our task force was asked to evaluate DOD's Manufacturing Technology (ManTech) Program and to provide recommendations to strengthen and improve its benefits to the department.

The bottom line of our assessment is that ManTech can address critical development, acquisition, and sustainment problems associated with advanced weapon systems. The program impacts all phases of acquisition, facilitates technology transition, has demonstrated significant reductions in cost and cycle time, increases reliability, and has demonstrated tremendous return on investment.

It is important to recognize, however, that ManTech alone cannot solve all of DOD's acquisition problems associated with system cost, schedule, and quality. Broader changes—in reality, cultural changes—are needed in many areas: acquisition reform, the requirements process, the budget process, and legislation, for example.

While the ManTech program has been successful, the task force believes that its benefits can be enhanced. Toward that end, we identified ten areas that require action. These areas fall into three broad categories as follows:

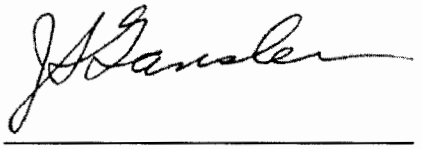
- **Leadership Emphasis**. The value of manufacturing technology is not well understood in DOD. Today's management approach will not lead to a coherent DOD manufacturing investment strategy, which is critical to weapon system affordability. Thus, the task force believes that senior leaders should **institutionalize the importance and value of manufacturing technology**, beginning with the publication of an **annual strategic plan and investment strategy** for the ManTech program. The plan should be based on **a balanced portfolio** that includes near- and longer-term investments to reduce technology risk, multi-service needs, and product and process disruptive

technologies. Furthermore, to be the most effective, manufacturing technology concerns must become **an integral part of the science and technology programs in the military services**.

- **New and Enabling Initiatives.** An advantage of the ManTech program is its ability to focus resources on areas of importance as they evolve over time. A major initiative developed by the ManTech community is **the Manufacturing Readiness Levels**, which the task force believes should be completed by 2005 year end and introduced into the 5000 series acquisition regulation. Another new initiative worthy of consideration is **software producibility**. Opportunities also exist to bolster initiatives that could further enhance investments and research in manufacturing technology. The task force identified two that are particularly promising: **expanding small-business participation** in the ManTech program by leveraging the Small Business Innovation Research program and **improving collaboration with industry**.

- **Essential Resources.** Without adequate resources, the ManTech program cannot realize its potential. Both expertise in the workforce and program funding have declined. The task force recommends that the Department develop strategies to **attract and retain needed manufacturing-related expertise,** including revitalizing the manufacturing career field that has been largely eliminated. Further, a **greater and more stable funding profile** should be establishes for the ManTech program, returning the total program investment to 1 percent of the research, development, test, and evaluation budget.

The time to act is now. In light of fiscal constraints in the coming years, reducing the cost of future weapon systems will be critical.



Hon Jacques S. Gansler
Chairman

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EXECUTIVE SUMMARY

Advanced weapon systems cost too much, take too long to field, and are too expensive to sustain. Systems proceed through the acquisition process with immature technology and unstable designs, which result in higher costs, longer development times, and even reduced order quantities—all detrimental to the ultimate goal of enhancing warfighting capabilities.

While these challenges have plagued the Department of Defense (DOD) acquisition process for decades, they remain relevant today—particularly given the level of current investment in weapon systems that rely on leading-edge technology. A March 2005 U.S. Government Accountability Office report, based on an assessment of 54 weapon programs, shows the pervasive nature of the problem. Among their conclusions is the need for mature technology, stable designs, and production processes that are mature and in control.

Because acquisition problems are often "designed in," the most successful programs are those where science and technology organizations are responsible for maturing technologies, rather than program or product development managers. Thus, more responsibility for this early effort should fall to the science and technology community. With the likelihood of tighter budgets on the horizon, reducing the cost of future weapons will become increasingly critical.

In this context, our task force was asked to evaluate DOD's Manufacturing Technology Program (ManTech) and to provide recommendations to strengthen and improve its benefits to the Department.

The bottom line of our assessment is that ManTech can address critical development, acquisition, and sustainment problems associated with advanced weapon systems. The program impacts all phases of acquisition, facilitates technology transition, has demonstrated significant reductions in cost and cycle time,

increases reliability, and has demonstrated tremendous return on investment.

The ManTech program is unique in its potential reach. ManTech invests in manufacturing research and development projects that can build capabilities to solve production challenges in weapon system development. But if properly funded and structured, the program can also positively impact the rate of technology transition, directly improve pre-acquisition processes for new systems, and impact sustainment.

ManTech can address future manufacturing technology challenges as well, such as challenges associated with rapid, efficient, and affordable low-volume production. In essence, ManTech has the capacity to have an impact on all phases of development activities and, as such, has a place in both the science and technology and acquisition communities —which sets the program apart.

Moreover, the Manufacturing Readiness Levels (MRLs), developed by the ManTech community and discussed in more detail later in this report, offer a tool to enhance visibility into technological maturity and production readiness—thus improving the knowledge on which program decisions are based. More specifically, implementation of the MRLs will

- Enhance transition of producible technologies into milestones B and C, in order to enter the production phase with an affordable, producible program
- Promote production-ready, cost-based prototypes
- Enable acquisition cost and cycle time reduction

It is important to recognize, however, that ManTech alone cannot solve all of DOD's acquisition problems associated with system cost, schedule, and quality. Broader changes—in reality, cultural changes—are needed in many areas to include acquisition reform, the requirements process, the budget process, and legislation.

The task force believes that the benefits of the ManTech program can be enhanced. In this report, we identify ten areas that require action. These areas fall into three broad categories, as summarized below—leadership emphasis, new and enabling initiatives, and essential resources.

LEADERSHIP EMPHASIS

The value of manufacturing technology is not well understood at all levels of management in DOD, which impacts the ManTech program directly. Today's management approach and program structure does not and will not lead to a coherent DOD manufacturing investment strategy. To be more effective, the ManTech program needs high-level attention in the Office of the Secretary of Defense (OSD) and in the military services, guided by a strategic plan that provides a coherent investment strategy for future manufacturing capability.

Importantly, because technology transition is a responsibility of the science and technology (S&T) community, manufacturing technology concerns must be addressed earlier in the design phases of a program. This requires a cultural change in DOD, where production and support costs become early design "requirements."

To improve program leadership, the task force recommends the following actions:

- The senior leadership in OSD and the military services should institutionalize the importance and value of manufacturing technology, including the ManTech program.
- The Under Secretary of Defense for Acquisition, Technology and Logistics (USD [AT&L])—with support from the Director of Defense Research and Engineering, the Service Secretaries, and Service Acquisition Executives—should publish an annual strategic plan and investment strategy for the ManTech program. A peer review process for

ManTech should be established to evaluate the program and provide recommendations to the USD (AT&L).

- The ManTech strategic plan should define a balanced portfolio that includes technology for cost and risk reduction of products, software, and processes; long-term, multi-Service needs; and disruptive technologies, both product and process.
- USD (AT&L) should set specific policy that manufacturing technology be an integral part of the overall science and technology program. The S&T leadership in the military services must be responsible and accountable for ensuring a robust ManTech program.

NEW AND ENABLING INITIATIVES

An advantage of the ManTech program is its ability to focus resources on areas of importance as they evolve over time—addressing both current needs and conducting research on next-generation manufacturing challenges. A major initiative developed by the ManTech community is the Manufacturing Readiness Levels, which can provide better visibility into and understanding of program manufacturing risks and ultimately speed technology transition. Another new initiative worthy of consideration involves software, given its importance and complexity—with focus on systems engineering, modeling, "production," and sustainment.

Opportunities also exist to bolster initiatives that could further enhance investments and research in manufacturing technology. One such initiative is to leverage small-business participation through the Small Business Innovation Research (SBIR) program. Another is to expand collaboration and cooperation with industry—efforts that are essential not only in effectively targeting DOD investments in advanced manufacturing technology, but also in leveraging industry process improvements and accelerating manufacturing technology transition.

Specifically, the task force recommends the following:

- The USD (AT&L) should require program managers to use the MRL tool on all programs. This tool should be completed by the end of 2005 and introduced into the 5000 series acquisition regulation.
- Because software is so important and complex, USD (AT&L) should direct a study of the future software development challenge as it relates to DOD and recommend specific actions to be taken.
- USD (AT&L) should direct the Services to expand small-business participation in the ManTech program through a shift of some of the SBIR program resources into ManTech.
- DOD should improve collaboration with industry through various mechanisms: adopt dual-use manufacturing; identify incentives for industry to incorporate and utilize manufacturing enhancements; develop roadmaps to direct research and development initiatives to critical areas; and sponsor manufacturing test beds.

ESSENTIAL RESOURCES

Without adequate resources, the ManTech program cannot realize its potential. Both expertise in the workforce and program funding have declined. The engineering and manufacturing talent in DOD, and in its supporting industrial base, is eroding—the career field has been largely eliminated in the Department and has weakened in industry. Fewer experts mean that fewer people understand the processes involved in developing and manufacturing defense systems and their importance in producing low-cost, high-quality, and reliable systems.

This in turn impacts policy and resource support for the ManTech program. The budget profile for ManTech in recent years, and over

the past few decades, does not reflect a well-planned and sustained strategic investment for more affordable acquisition, technology transition, and sustainment. The total planned investment, especially without the programs added by Congress, which are common, do not match the importance of the need to reduce weapon costs and cycle time.

In the area of resources, the task force recommends the following:

- The USD (AT&L), with the Under Secretary of Defense for Personnel and Readiness and Service Secretaries, must develop strategies to attract and retain needed manufacturing-related expertise.
- The USD (AT&L) should direct a greater and more stable funding profile for ManTech, returning the total program investment to one percent of the research, development, test, and evaluation (RDT&E) budget.
  - The ManTech program should include a budget line managed by OSD (a "D-line"), and executed by the Services, that focuses on multi-Service, multi-platform needs; increased investment of SBIR resources in manufacturing technology; and redirection of resources in the Defense Advanced Research Projects Agency for investment in disruptive manufacturing technology.

As stated at the outset, the ManTech program can address critical acquisition challenges associated with advanced weapon systems. This report identifies specific actions that the task force believes will enhance and expand the impact of the ManTech program. There is much to do, but with effective leadership, thoughtful planning, and adequate resources much can also be accomplished.

The time to act is now. Like many others, we believe the Department is likely to face tighter economic constraints in the years to come. In light of fiscal constraints, reducing the cost of future weapon systems will be critical.

CHAPTER 1. INTRODUCTION

The need for a cohesive manufacturing research and development investment program is fundamental to rapid acceleration of near-term technology capabilities to support warfighting operations and to long-term support for transition of revolutionary technologies. Warfighters need a responsive industrial base with advanced manufacturing technologies that reduce risks, costs, and lead times at every level and phase of the acquisition process, including design, development, production, and sustainment of fielded systems.

However, weapons acquisition in the Department of Defense (DOD) remains a high-risk area. Today's high-technology weapon systems cost too much to buy, take too long to field, and are expensive to sustain. Systems proceed through the acquisition process with immature technology and unstable designs, which result in higher costs, longer development times, and even reduced order quantities—all detrimental to the ultimate goal of enhancing warfighting capabilities.

As many acquisition problems emerge during the design process, and are thus "designed in," they must be addressed early in program development. As a result, more responsibility for this early effort should fall to the science and technology community. With the likelihood of tighter budgets on the horizon, reducing the costs of future weapons will become increasingly critical.

GAO STUDIES DOD ACQUISITION CONCERNS

The acquisition challenges facing the Department of Defense cannot be overstated, as reflected in a March 2005 report by the U.S. Government Accountability Office (GAO).[1] In its study, GAO notes that the DOD is investing heavily in technologically advanced weapon systems. Specifically, the study assessed 54 weapons

1. *Defense Acquisitions: Assessment of Selected Major Weapon Systems*, Washington, D.C.: U.S. Government Accountability Office, March 2005.

programs to gain a greater understanding of potential risks. Among its conclusions, the report identifies three characteristics of successful acquisition programs: mature technologies, stable designs, and production processes in control. Further, in successful programs, science and technology (S&T) organizations are responsible for maturing technologies rather than program or product development managers.

The impact of pushing immature technologies too quickly into development is significant, as shown in table 1. GAO reported that total research, development, test, and evaluation (RDT&E) costs for programs with immature technologies increased 41 percent, as compared to 9 percent for programs with mature technologies. Similarly, acquisition unit cost increased 21 percent and schedules slipped an average of 13 months. Not only are technologies immature, there is often little program visibility or knowledge of the maturity level. Thus, many programs are proceeding too quickly through the development process with immature technology, and there is not adequate understanding that this condition exists. It is this failure of knowledge that must be addressed.

Table 1. Impact of Immature Technology in System Development

	TECHNOLOGY STATUS AT BEGINNING OF DEVELOPMENT	
	MATURE	IMMATURE
RDT&E Cost Increase	9%	41%
Acquisition Unit Cost Increase	< 1%	21%
Average Schedule Delay	7 months	13 months

Source: U.S. Government Accountability Office, March 2005.

Design instability also leads to cost increases and schedule delays. Of the programs evaluated by GAO that had held design reviews, only 42 percent had design stability at that time. Programs that did not have stable designs experienced "combined development cost increase of 46 percent and an average schedule increase of 29 months since the first full estimate." Design stability cannot be attained without mature technologies. When looking ahead, among the nine

programs scheduled to hold design reviews next year, only two expect new technologies to be mature by that time.

HOW MANTECH CAN HELP—THE BOTTOM LINE

The Manufacturing Technology (ManTech) Program, chartered by Congress in title 10 U.S.C., can address multiple DOD acquisition challenges, as the program is unique in its potential reach. ManTech invests in manufacturing research and development projects that can build capabilities to solve production challenges in weapon system development. But if properly funded and structured, the program can also positively impact the rate of technology transition, directly improve pre-acquisition processes for new systems, and impact sustainment.

ManTech can address future manufacturing technology challenges as well, such as challenges associated with low cost, efficient, and rapid low-volume production. In essence, ManTech has the capacity to have an impact on all phases of development activities and, as such, has a place in both the science and technology and acquisition communities —which sets the program apart.

Moreover, the Manufacturing Readiness Levels (MRLs), developed by the ManTech community and discussed in more detail later in this report, offer a tool to enhance visibility into technological maturity and production readiness—thus improving the knowledge on which program decisions are based. More specifically, implementation of the MRLs will accomplish the following:

- Enhance transition of producible technologies into milestones B and C, in order to enter the production phase with an affordable, producible program
- Promote production-ready, cost-based prototypes
- Enable acquisition cost and cycle time reduction

It is important to recognize, however, that ManTech alone cannot solve all of DOD's acquisition problems associated with system cost, schedule, and quality. Broader changes—in reality, cultural changes—are needed in many areas to include acquisition reform, the requirements process, the budget process, and legislation.

THE DSB CHARTER

In recognition of the importance and potential contributions of the Manufacturing Technology Program, the Under Secretary of Defense for Acquisition, Technology and Logistics (USD [AT&L]) requested that the Defense Science Board convene a task force to evaluate the program.[2] In particular, the task force was asked to provide recommendations as to how the ManTech program can be strengthened to improve its benefits to the Department of Defense in general, and the military services in particular. Specifically, the task force was asked to evaluate the following areas:

- Investment strategy
- Program balance
- Programmatic and funding concerns
- Program ownership
- Acquisition impact

The remainder of this report details the results of the task force study. These recommendations evolved from information received during background briefings on the ManTech program and other related activities inside DOD and in commercial industry as well as from internal deliberations of the task force.[3] The report begins with a brief overview of the ManTech program followed by the detailed findings and recommendations of the task force.

2. Appendix A contains the complete terms of reference for the Defense Science Board Task Force on the Manufacturing Technology Program. Appendix B contains the task force membership.
3. Appendix C lists the presentations received by the task force.

CHAPTER 2. THE MANUFACTURING TECHNOLOGY PROGRAM: AN OVERVIEW

The ManTech program offers tremendous value to the Department of Defense. Program investments address many challenges involved in weapon system acquisition, technology transition, and manufacturing technology development.[4] The overall objective of the ManTech program is to enable DOD to obtain lower-cost, high-quality equipment more rapidly and in the smaller quantities likely to be ordered.

As established in title 10 U.S.C., the ManTech program was chartered to develop and apply advanced manufacturing technologies and processes that will accomplish the following:[5]

- Reduce the acquisition and supportability costs of defense weapon systems
- Reduce manufacturing and repair cycle times across the life cycle of such systems
- Improve the quality, productivity, technological capability, and practices of businesses and workers

To effectively accomplish these goals, manufacturing technology should be a key element of S&T responsibility for technology transition. By focusing on technology maturity earlier in program development, ease of production can be "designed in" enabling programs to stay on time and within budget.

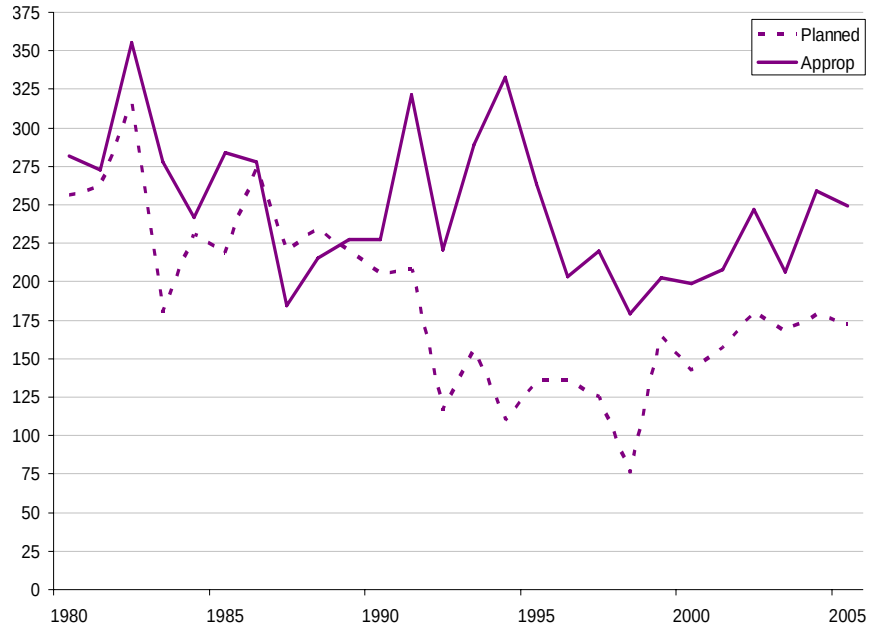
The success of the ongoing transformation effort in DOD depends on industry capability to rapidly develop and manufacture next-generation military systems at low cost, and (in most cases) in small quantities. ManTech is one of many activities that can help build needed capability in the industrial base. The program uses Service

4. The ManTech program is described in detail in Department of Defense Directive 4200.15, which can be referenced in appendix D.
5. Appendix E contains the title 10 language establishing the ManTech Program.

funding, leveraged by industry and other agency funding, to ensure that the U.S. industrial base can provide, in a timely, reliable and affordable manner, the military equipment needed by U.S. armed forces.

Appropriations for the ManTech program in fiscal year 2005 totaled $249.0 million. The Army has the largest portion of the program at $91.9 million. Investments total $60.4 million for the Navy, $57.5 million for the Air Force, and $39.5 million for the Defense Logistics Agency (DLA).[6] Over the past few decades, funding for the ManTech program has fluctuated significantly, with a generally downward trend as illustrated in figure 1. Further, the planned DOD ManTech budget has fallen significantly, with the program's top line bolstered, in some years by a considerable amount, during the Congressional appropriation process—with projects that may or may not serve the Department's interests well.

Figure 1. DOD ManTech Budget
(millions of constant fiscal year 2005 dollars)



6. Appendix F provides a brief overview of the Service ManTech programs.

As mentioned previously, there have been many successful outcomes from ManTech investments. Though these successes are often not well known, many ManTech projects have more than paid for themselves in return on investment. In its early years, ManTech investments laid the foundation for revolutionary manufacturing technologies such as numerically-controlled machine tools, microelectronics manufacturing, processes that led to precision laser-guided missiles and munitions and night vision capability.

ManTech investments also led to establishment of the Lean Aerospace Initiative—a consortium of DOD, industry, the Massachusetts Institute of Technology, and labor unions—that was instrumental in implementing and accelerating the use of lean manufacturing techniques in the defense industrial base.[7]

Program impacts include improvements in affordability, capability, reliability, and readiness. The following success stories are but a few examples of the impact of ManTech investments on warfighting capability.

- Affordability and Capability
  - Advanced, affordable lightweight body armor saving hundreds of lives in Operation Iraqi Freedom and Operation Enduring Freedom (Army)
  - Superior (longer range) night operations capability for hostile situations achieved with 60 percent cost savings (Navy)
  - Improved C-17 survivability for Operation Iraqi Freedom with large aircraft infrared countermeasures (LAIRCM) and 30 percent reduction in cost (Air Force)
  - Force multiplier for tank battles; 65 percent M-1 cannon accuracy improvement (Army)

7. Appendix G provides further discussion of these early program successes, lean manufacturing impacts on acquisition and depot repair, and describes numerous examples of successful ManTech projects.

  - 35 time cost reduction brought modern radar multi-target tracking capability to the battlefield (Air Force)
  - Reduced cost for Exoatmospheric Kill Vehicle structure by 46–60 percent (Missile Defense Agency)
- Readiness
  - Created replacements for obsolete microcircuits—375 systems helped (DLA)
  - Established JDAM thermal battery manufacturing capability for Operation Iraqi Freedom and Operation Enduring Freedom; 7,400 per month production increase (Navy)
  - Shorter depot repair time through lean manufacturing practices freed 22 F-15s (a squadron-equivalent) for mission duty (Air Force)

The ManTech program should serve as a complement to both science and technology and acquisition programs—addressing DOD and Service needs for manufacturing technology improvements. Its impact can begin early in research and extend throughout the many phases of a program's development. That said, ManTech cannot be the sole repository or sole bill payer for all matters of affordability and manufacturing. A focus of the program is to contribute to the development of manufacturing capabilities for key defense systems and components that are under development and can, with relatively low risk, rapidly and affordably transition into manufacturing. Still, responsibility exists throughout the program life cycle—from initial design and development through acquisition and long-term support—for ensuring that DOD programs are producible.

CHAPTER 3. FINDINGS AND RECOMMENDATIONS

The bottom line of our assessment is that the Manufacturing Technology Program can address critical development, acquisition, and sustainment problems associated with advanced weapon systems. The program impacts all phases of acquisition, facilitates technology transition, has demonstrated significant reductions in cost and cycle time, increases reliability, and has demonstrated tremendous return on investment. The task force believes that the benefits of the ManTech program can be enhanced. Ten areas require action:

1. **Leadership**
2. **Strategic planning**
3. **S&T responsibility**
4. **Balanced portfolio**
5. **Manufacturing readiness**
6. **Workforce expertise**
7. **Software**
8. **Small-business participation**
9. **Industrial leverage and incentives**
10. **Funding**

1. LEADERSHIP

For the ManTech program to be successful there needs to be clear recognition and action on the part of DOD leadership—in the Office of the Secretary of Defense and the Services—that the program is important and deserves attention. This is not the case today. In fact, the program receives inadequate attention at all management levels. As a result, there is a lack of understanding of what the program does, what it contributes to weapon system development, and, in particular, what it could contribute if the recommendations of this study are fully implemented. The ManTech program is often viewed as a production support program—a perspective that fails to realize its broader applications.

As a result of this view, the S&T community, in general, does not recognize cost and manufacturing technology as part of its core program, especially in its 6.1 (basic research), 6.2 (applied research), and 6.3 (advanced technology development) programs. Emphasis on cost as a program requirement and design driver has not been typically considered during the early stages of program development but must, through a major change in culture, become a concern long before a weapon reaches production. Such a change in culture must begin at the highest levels in the Department.

Certainly, the current approach to managing the ManTech program does not result in a coherent DOD manufacturing investment strategy. And the relative small size of the total investment—in spite of its large potential impact—makes the program easily overlooked in comparison to most acquisition programs.

Many of the recommendations discussed in the remainder of this chapter could help to enhance the leadership of the program. For example, by providing strategic guidance for the program and managing funding for multi-Service initiatives and for disruptive technologies, the Office of the Secretary of Defense (OSD) can better promote the importance and value of the program, encourage the same out of the Service leadership, and hold them accountable for results. Such leadership can enhance cohesion in the program while at the same time allow the individual Services to invest in unique needs.

However, ultimate success of the ManTech program will result from attention at the highest levels. Collectively, the Deputy Secretary of Defense; the Under Secretary for Acquisition, Technology and Logistics; the Director, Defense Research and Engineering (DDR&E); the Director, Defense Advanced Research Projects Agency (DARPA); the Assistant Secretary of Defense for Networks and Information Integration (ASD [NII]) as well as the Service Secretaries and Service Acquisition Executives (SAEs) should institutionalize the importance and value of manufacturing technology—including the ManTech program. With such support, it will be possible to attract the resources necessary to execute a

strategic investment plan that includes both Department- and Service-level manufacturing technology projects.

Evidence from the Army's experience shows that with high-level attention, the ManTech program is taken seriously. Encouraged by OSD, the Army leadership provided strategic focus, enhanced and protected program funding, and involved the warfighter in investment decisions—in all, leading to increased investments and a vastly improved program. Lessons from their experience can be of value to the other Services.

Leadership Recommendations

Collectively the Deputy Secretary of Defense, USD (AT&L), DDR&E, DARPA Director, ASD (NII), Service Secretaries, and SAEs should clarify the importance and value of manufacturing technology—including the ManTech program.

- **Implement a strategic plan and investment strategy for the ManTech program**
- **Establish responsibility, in the S&T community, for manufacturing technology and hold it accountable for results**
- **Define an integrated management structure and processes**
- **Maintain flexibility for Service-unique investments**
- **Ensure adequate resources to execute**
- **Lead cultural change in emphasizing the importance of designing for low acquisition cost early in development**

2. STRATEGIC PLANNING

DOD does not have a long-term strategic investment plan to provide for future manufacturing capability. As a result, the ManTech program lacks strategic focus and tends to be viewed as a grab bag of programs. The program is managed differently in each Service, so it is difficult for decision makers to understand the goals and benefits of the program. These circumstances often lead to

disconnects between the S&T community and the ManTech programs in the individual Services and agencies. In turn, the program suffers in the budget process within the Services and OSD.

Strategic and Investment Planning

More explicit strategic planning for the ManTech program is needed. In the past, DOD prepared a five-year plan for the ManTech program that served as strategic guidance and against which to measure program compliance. However, such a plan is no longer required. The task force recommends that the USD (AT&L) take the lead in publishing an annual strategic plan for the ManTech program, in collaboration with the Service components, defense agencies, and industry, and with the support of the DDR&E and the Service senior acquisition executives. Participation must include the technology, acquisition, and logistics communities.

The strategic plan must be accompanied by an investment strategy that reflects a balanced portfolio of individual and multi-Service programs, research in "disruptive" manufacturing technologies, as well as manufacturing programs that engage small business through the Small Business Innovation Research (SBIR) program. Overall, the ManTech program needs to balance projects that support current, near-term, and future needs as well as balance small and large firm participation.

The USD (AT&L) must not only publish a strategic plan, but also ensure its implementation with periodic reviews of the plan's execution.

Strategic Planning Recommendation

USD (AT&L), with support from the DDR&E, the Service Secretaries and Service SAEs, should publish an annual strategic plan and investment strategy for the ManTech program.

- **Collaborate with Service components, defense agencies, and industry.**

- **Include the technology, acquisition, and logistics communities.**
- **Define a balanced portfolio of individual and multi-Service programs, research in "disruptive" technologies, and SBIR programs. Balance current, near term, and future needs as well as small and large firm participation.**
- **Ensure implementation with periodic reviews of plan execution.**

Peer Review

As part of the process for developing a strategic plan and strategy, a capability is needed to ensure effective and efficient use of all ManTech funds—both those proposed by the DOD and by Congress. One approach is to establish a peer review process to evaluate the balance among the projects in the program's portfolio against the objectives set out in the strategic plan. In addition, this group should evaluate how well individual projects (including projects added by Congress) meet strategic and investment objectives. The group should report its findings and recommendations to the USD (AT&L).

The membership of the review group should include manufacturing experts from DOD, former defense industry experts, and representatives from commercial industry and academia.

Peer Review Process Recommendations

USD (AT&L) should establish a peer review process for the ManTech Program. The process should:

- **Evaluate the following**
  - **Balance among ManTech projects against the strategic plan**
  - **How well individual ManTech projects (including Congressional adds) meet overall program objectives**
- **Provide recommendations to the USD (AT&L)**

3. S&T RESPONSIBILITY

While the ManTech program is executed within the science and technology community, it is not viewed as an S&T program, nor does the S&T leadership generally take ownership of the program. While the reach of ManTech extends throughout the many phases of program development, and thus it is not purely focused on research, to be effective the program must have an anchor and legitimacy in the S&T community.

Technology transition is the responsibility of the science and technology community. Immature technologies and manufacturing challenges have a significant impact on the ability to rapidly and affordably transition technology to the warfighter. Furthermore, it is increasingly important for cost to be a real consideration early in program development. Therefore, the S&T community, including DARPA, must be responsible for "designing in" affordable production costs early in the design phases of a program.

Manufacturing technology must become an integral part of the overall science and technology program. Specific policy guidance is needed to clarify ownership of the ManTech program and its relationship to both the science and technology and acquisition communities. ManTech must become integrated within the S&T management process and linked to acquisition management—a responsibility, the task force believes, of the DDR&E and the Service S&T managers. In fact, the ManTech program should become a required tool to achieve rapid, affordable technology transition. In order for this to be realized the Service S&T leadership must be responsible and accountable for ensuring a robust ManTech program.

S&T Responsibility Recommendations

The USD (AT&L) should set specific policy that manufacturing technology be an integral part of the overall S&T program.

- **The ManTech program should become a required tool to achieve rapid, affordable technology transition**

- **DDR&E and the Service S&T managers must ensure that ManTech is integrated within the S&T management process and linked to acquisition management**
- **Service S&T leadership must be responsible and accountable for ensuring a robust ManTech program**

4. BALANCED PORTFOLIO

Because of resource constraints, ManTech program investments have been focused primarily on support for current programs and on manufacturing hardware and components. While these are important investments, the program needs a more balanced portfolio. Too little emphasis is placed on projects with a longer-term focus such as the following:

- Technology for cost and risk reduction of products, software, and processes
- Long-term multi-Service needs
- Disruptive technologies (both products and processes)

In general, the overall program lacks strategic perspective and integration.

Technology for Cost and Risk Reduction

In order to achieve the objective of lower cost equipment, manufacturing concerns must be addressed earlier in the program life cycle. Production and support costs need to become a component of key technical design requirements, before the final stages of development when technologies are released for prototyping. The importance of manufacturing concerns in prototype fabrication, as compared to rate production, is often not well understood or even recognized within the S&T and research, development, test, and evaluation communities.

S&T program managers often believe that affordability and manufacturing issues are not relevant concerns in 6.3 programs,

focusing instead on fabrication of test and evaluation and prototype articles. But this line of thinking leads to higher costs later in a program, when manufacturing concerns are addressed after technical designs are considered "ready." As a result, major programs risk formidable hurdles moving from design to prototype to production when there is less design flexibility to attack major cost or production problems, or insert new technology.

Essentially, at that point, a high-cost and difficult-to-produce solution has been "designed into" the system. It is not appropriate to rely on the ManTech program to "save the day" when affordability and manufacturing concerns have been ignored in the early development phases. What is needed is consideration, during new system design, of innovative strategies that can contribute to lower cost, faster response, and higher performance. Furthermore, programs in 6.3 need a manufacturing transition strategy; the Manufacturing Readiness Level tool (discussed below) can be used to define exit criteria and encourage the consideration of manufacturing concerns throughout program development.

Making unit production cost a key military "requirement" will encourage proper attention to affordability and producibility early in design and will align unit cost targets with small quantity production. In addition, "evolutionary acquisition" (also known as spiral development) will support more effective technology transition and bring the customer into the process—iterating with the customer to obtain feedback on prototypes and new technologies, and then quickly inserting them into a system.

While the Department has put greater emphasis on systems engineering, continued vigilance is needed. New systems—and, increasingly, new systems-of-systems—need to be initially analyzed from both a performance *and* total cost perspective. This practice is common in commercial industry, but needs to be applied in all DOD systems. Essentially, the concept is to take a broad, integrated view of cost and performance—a systems engineering view—when approaching a new system's (or system-of-system's) design, rather than a sub-optimization of each element of the system. The result can be a dramatic reduction in overall system cost, ease of production,

and a significant improvement in reliability and maintenance—often achieved in combination, through a simplification of the system's design, without any degradation in performance.

Technology for Cost and Risk Reduction Recommendations

To accelerate initial operational capability, the Milestone Decision Authority should enforce existing directives to

- **Make unit production cost a key military "requirement"**
  - **Encourage proper attention to affordability and producibility early in program design**
  - **Design for small-volume production**
- **Require "evolutionary acquisition" and use of manufacturing readiness levels**

USD (AT&L), along with the DDR&E, must establish systems engineering as a top acquisition priority

- **Require explicit production cost/performance trades as part of milestone exit criteria (especially milestones B and C)**

Long-Term, Multi-Service Needs

To support longer-term, multi-Service needs, a portion of the ManTech funding should be managed in the Office of the Secretary of Defense. Service ManTech funds would still pay for problems unique to an individual Service, but a "D-line" would exist to focus on manufacturing challenges with wider application, such as multi-Service, multi-platform programs. Funding for these programs would be added to current program funding levels, not conducted at the expense of current Service investments. As for execution, the task force believes that the individual Services should manage the projects selected for investment. Examples of such programs include batteries, radio-frequency identification devices, direct digital manufacturing, and standards and protocols.

Long-Term, Multi-Service Needs Recommendation

OSD should provide additional resources under the ManTech program (a "D-line") to fund multi-Service, multi-platform programs

- **Add resources to current ManTech funding levels**
- **Services execute projects**

Disruptive Technologies

ManTech funding should balance longer-term strategic requirements as well as near-term program requirements. Thus, greater emphasis is needed in research and development of disruptive technologies—both product and process.

The question of *how to affordably manufacture products based on next-generation disruptive technologies* is as important as establishing the technical capability. DOD invests far more on research and development of new product technologies as compared to its investments in process technologies. But investment is needed in the capability to manufacture products that incorporate emerging, disruptive technologies—such as nano-based products—which offer promise for a quantum difference in warfighting capability within the next decade. With more emphasis on production concerns early in development, such capabilities could be fielded quicker and more economically. Identifying such technologies is challenging, but could be informed by the peer review process previously mentioned.

In addition, *DOD needs to invest in disruptive manufacturing process technologies*—in particular, in timely access to affordable low-volume, state-of-the-art production capabilities. Solutions such as dual-use (civil and military) production or automated, multi-product "flexible manufacturing" need to be considered. Investments need to be made in prototypes and advanced concept technology demonstrations that address affordability (low cost) and rapid production of small-quantity production.

All 6.3 programs should have exit criteria based in part on manufacturing issues and 6.2 program managers should develop early strategies for manufacturing as well. The typical 6.1 project leader will be more concerned with technical feasibility, but a 6.1 program directed specifically at low-cost manufacturing research or science could provide great leverage.

The current 6.1 basic research program in DOD, the Services, and DARPA (in excess of $1 billion in annual investment) is essentially devoid of manufacturing research or science. At one time, DOD did support a 6.1 Manufacturing Science Program of approximately $10 million per year. The ability to cost-effectively manufacture disruptive technologies, such as nanotechnology, depends on basic research to lay the foundation that will enable technology and product development for affordable defense capabilities. The National Science Foundation sponsors a small 6.1-like manufacturing science program under its Manufacturing Process and Equipment Systems Cluster Investment initiative with selected investments in the following:

- Manufacturing machines and equipment innovations
- Materials and process manufacturing concepts
- Nanomanufacturing innovations

As it has with nanotechnology 6.1 investments, DOD could significantly leverage even a modest 6.1 manufacturing science investment (of perhaps $20–50 million per year). Several leading universities have the capability to conduct world-class, peer-reviewed research in this area and focus attention on basic problems of specific interest to the DOD.

Research on both aspects of disruptive technologies could appropriately be led by the DDR&E through DARPA. About a decade ago, DARPA made numerous investments in advanced manufacturing development programs, but such programs have declined as part of the DARPA portfolio in recent years. A portion of DARPA's investment portfolio should be redirected toward manufacturing research and development (R&D), as such

investments offer tremendous value to the defense and the national industrial base.

Disruptive Technology Recommendation

DDR&E should take the lead on research and development of manufacturing-related disruptive technology

1. **How to affordably manufacture products based on next-generation "disruptive" technologies**
2. **Disruptive *manufacturing process* technologies for faster and affordable low-volume production**

DDR&E should establish a separate 6.1 manufacturing science thrust within S&T

DARPA should reinstitute a significant advanced manufacturing technology program

5. MANUFACTURING READINESS

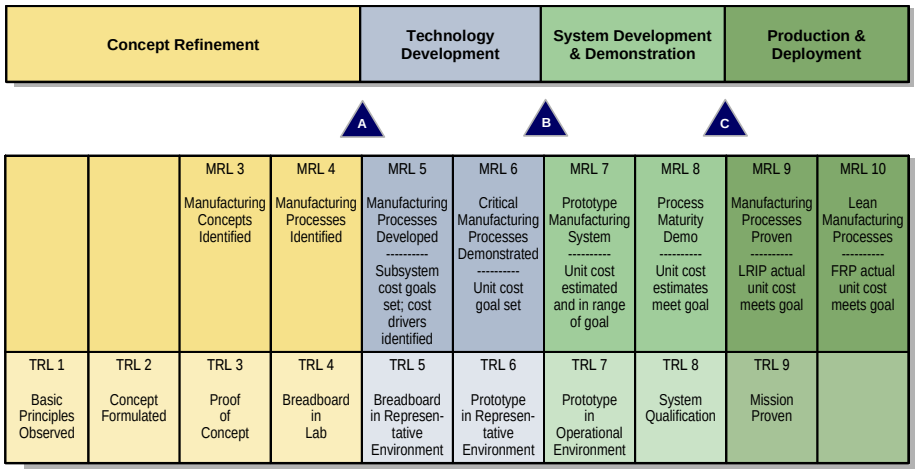
Better visibility into and understanding of program manufacturing risks is critical to rapid and affordable technology transition. Program managers often lack sufficient knowledge of program technologies, design, and production risks in assessing manufacturing readiness. Cost increases, schedule delays, and production shortfalls are a common result. A related concern in acquisition programs is facilitating technology transition during program development—being able to more rapidly move technology from the laboratory to the field. Today's high risk/high payoff systems require manufacturing breakthroughs alongside technology R&D solutions.

At milestone decision points, the level of manufacturing readiness is just as important as that of technology maturity or design stability. Determining that a technology can be produced on schedule, reliably, and affordably is as critical as determining that the technology can provide the desired warfighting capability. Similar to the Technology Readiness Level (TRL) concept that has helped to define the readiness

and risk associated with the introduction of new technology into weapon systems production, the Joint Defense Manufacturing Technology Panel (JDMTP) Manufacturing Readiness Levels are a major innovation for defining the maturity of manufacturing processes and techniques (including a focus on their affordability). [8]

Completion and introduction of the Manufacturing Readiness Level process can support the ManTech objective of achieving lower systems' cost. MRL assessments should be given the same degree of emphasis as given the TRL assessments in determining the readiness of a technology for transition and should be an integral part of weapon system program reviews. The MRL and TRL processes must work in parallel, as shown in figure 2, with the TRL technology assessments serving as key inputs to the MRL process in defining the need for ManTech investments.

Figure 2. Manufacturing Readiness Level Implementation



When completed, the MRLs will be a significant tool in assisting weapon system development managers in both DOD and industry to

- Reduce acquisition technical, cost, and schedule risk

8. An overview of the MRL process is in Appendix H.

- Define key ManTech investments needed for a weapon system program to proceed to full-scale development (during the pre-milestone B assessment)
- Identify, during pre-milestone C assessments, key risk areas and define the investments to manufacturing development required to reduce risks
- Foster technology transition

The USD (AT&L) should require program managers to use the MRL tool on all programs. In fact, MRLs should be explicit exit criteria for milestone decision points. In particular, 6.3 technology demonstrations within the S&T program should have specific exit criteria, at MRL level 5 or 6, before transition to a weapon program. MRLs can promote production-ready, cost-based prototypes; that is, prototypes that establish that a system is affordable and producible as well as demonstrate technical capability.

To institutionalize the use of MRLs, the task force recommends that the MRL tool be completed by the end of 2005 and introduced into the 5000 series acquisition regulation.

Manufacturing Readiness Recommendation

USD (AT&L) should require program managers to use the MRL tool on all programs

- **Establish as an explicit exit criteria for milestone decision points**
- **Clarify that prototyping includes affordability and producibility as well as technical capability**

Complete MRL tool by 2005 year end and introduce into the 5000 series acquisition regulation

- **Integrate into Technology Readiness Assessment document**
- **Ensure MRL process parallels TRL process**

6. WORKFORCE EXPERTISE

As responsibility for program risk has been increasingly transferred to industry contractors, robust in-house manufacturing-related expertise in OSD and the Services has diminished. As a result, engineering and manufacturing talent in the DOD workforce is declining; it is declining as well in the Department's supporting industrial base. What was once a promising career field in the military services—with promotion paths, training, and professional development—has been systematically eliminated over the past few decades. Manufacturing career paths in industry have similarly weakened.

Furthermore, not enough people—at both the working level and in leadership positions—understand the processes involved in developing and manufacturing defense systems, including software. Fewer people are capable of conducting production readiness reviews, evaluating industry's work on programs, and staying abreast of industry research and development.

This knowledge deficiency impacts many areas—policy support for programs such as ManTech; the ability to develop an effective strategic plan and investment strategy for manufacturing technology; the ability to implement the MRL tool; and the ability to effectively and affordably acquire low-cost, high-quality weapon systems.

The declining government skill base needs to be reversed, the importance of manufacturing expertise recognized, and staffing strategies developed to attract and retain needed expertise. Support for such efforts must come from the senior leadership in the Department, with efforts led by the Under Secretaries of Defense for Acquisition, Technology and Logistics and for Personnel and Readiness (USD [P&R]).

One near-term strategy that could be pursued is increased rotation between industry and government of personnel with required expertise, along the lines of the PL-313 program. Similar strategies should be pursued in the Services with rotations among the

ManTech program offices, the laboratories, and weapon program offices.

In addition, it is essential to revitalize the manufacturing career field by creating positions with promotion potential for people with manufacturing expertise. Further, as mentioned previously in this report, if ManTech begins to address software challenges, personnel with software expertise must be recruited into the program. In addition, the Defense Acquisition University needs to evaluate its curriculum to expand the focus on manufacturing technology.

Workforce Expertise Recommendations

USD (AT&L), together with the USD (P&R) and Service Secretaries, must develop recruiting strategies to attract needed expertise

- **In the near term, increase rotation of industry personnel with required expertise**
- **Implement similar rotation strategy in the Services between ManTech program and laboratories**
- **Charge the Defense Acquisition University to increase focus on manufacturing technology in curriculum**
- **Create positions with promotion potential for people with manufacturing expertise**
- **Recruit people with software expertise into the ManTech program**

7. SOFTWARE

Increasingly, major schedule, cost, performance, and reliability issues in DOD systems are being driven by software. The Future Combat System, for example, will have more than 35 million lines of code that is intensive, complex, and integral to system capability. To date, the Manufacturing Technology program has not traditionally addressed software, but could make a significant contribution. In the future, the task force believes that consideration should be given to include initiatives in the ManTech program to reduce software cost

and cycle time, as well as make it more producible. Such initiatives might include "software factories," automated programming, software self-testing, and open systems.

An example of the type of concept that could be funded under the ManTech program is a revolutionary concept called Model Driven Architecture (MDA). This emerging approach to the way modern systems are specified, designed, implemented, tested, and supported has the promise to realize significant reductions in both acquisition and life cycle costs, and order of magnitude reductions in cycle time. [9] ManTech should fund "pilot programs" to demonstrate the speed, cost, and interoperability benefits of this software development approach.

If software development becomes an explicit part of the ManTech program, sufficient expertise must exist in the staffs to assure adequate technical oversight.

Software Recommendations

Because software is so important and complex, USD (AT&L) should direct a study of the future software development challenge as it relates to DOD

- **Focus on systems engineering, modeling, "production," and sustainment aspects**
- **Determine appropriate manufacturing investments (and others) for DOD**
- **Recommend alternatives for ManTech (and other DOD R&D) activity**

Model-driven architecture provides an opportunity for big impact

- **Fund "pilot programs" to accelerate and expand applications of MDA to realize speed, cost, and interoperability benefits**

9. A summary of the model driven architecture concept is in Appendix I.

8. SMALL-BUSINESS PARTICIPATION

After nearly two years, the President's Executive Order directing manufacturing emphasis for the Small Business Innovation Research and the Small Business Technology Transfer (STTR) programs is not being adequately addressed.[10] Observed involvement by the DOD manufacturing community appears to be significantly short of that required to achieve executive intent. The current response is limited largely to database keyword searches that are not representative of the range of relevant manufacturing technologies. Nor does the manufacturing component of the SBIR/STTR program have adequate involvement by the Service and agency ManTech organizations.

To encourage small businesses to focus on the objectives of ManTech, a larger percentage of the SBIR program in DOD should be focused on ManTech objectives. Small and medium-sized companies tend to be hungrier and more competitively driven to succeed. They cannot afford to have too many failed projects or they risk going out of business. While utilizing small and medium-sized businesses, ManTech should be allowed and encouraged to leverage SBIR programs to reduce development, production, and support system costs and to promote state-of-the-art manufacturing technology.

Since the DOD SBIR annual program is now about $1 billion, the task force recommends that manufacturing technology projects grow to about $100 million per year. Furthermore, the ManTech community, in OSD and the Services, should have responsibility for selecting, planning, and executing the manufacturing-oriented SBIR topics. Such is not the case as the program is executed today, which hampers effective targeting of these investments.

10. Appendix J contains the Executive Order on Encouraging Innovation in Manufacturing.

Small-Business Participation Recommendation

USD (AT&L) should direct the Services to expand small-business participation in the ManTech program

- **Focus a larger percentage of the SBIR program in DOD on ManTech objectives (e.g., 10 percent)**
- **Assign ManTech community (OSD and Services) responsibility for selecting, planning, and executing the manufacturing-oriented SBIR topics**

9. INDUSTRIAL LEVERAGE

The Department of Defense needs to maintain effective coordination and collaboration with industry to leverage manufacturing process improvements, to better target its own investments in advanced manufacturing technology, and to rapidly meet surge requirements.

Yet, the extent to which DOD stays abreast of industry plans and investments and collaborates on technology transition is deficient. Today, industry process improvements are not effectively leveraged in developing defense acquisition and support programs. Moreover, investments are not being made in high-risk, high-cost projects related to disruptive technologies that could have significant leverage.

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.

The task force supports the intent of the proposed amendment drafted by the Senate Armed Services Committee to enhance manufacturing technology strategies (see appendix K), which calls for public-private partnership incentives, industry roadmaps for new manufacturing and technology processes, test beds for technology

transition, and other cooperative programs. While this proposal provides a starting point, it needs to go further to address the wider range of topics identified in this report.

An important area of exploration is dual-use manufacturing; that is, integrated civil and military operations. The ability to produce both civilian and military products on a single line should be adopted to the maximum extent possible. The potential rewards are many: increased responsiveness, lower costs for small-volume production, expanded surge capabilities, and the ability to leverage state-of-the-art manufacturing technologies and process improvements.

The task force encourages collaboration between DOD and industry in developing roadmaps that identify critical defense manufacturing areas. These roadmaps should be used by DOD to design its own research and development initiatives and, as appropriate, shared with industry as a basis for possible independent R&D or capital investments. This approach will assure ongoing manufacturing technology advances in critical and promising defense technology areas. Further, the military services could usefully sponsor manufacturing test beds to facilitate and support widespread development and deployment of innovative manufacturing technologies.

Industrial Leverage Recommendations

DOD should, to the maximum extent possible, adopt dual-use manufacturing

Identify incentives for defense manufacturing base contractors to incorporate and utilize manufacturing enhancements

Collaborate with industry to develop manufacturing technology roadmaps in order to ensure ongoing technology advances

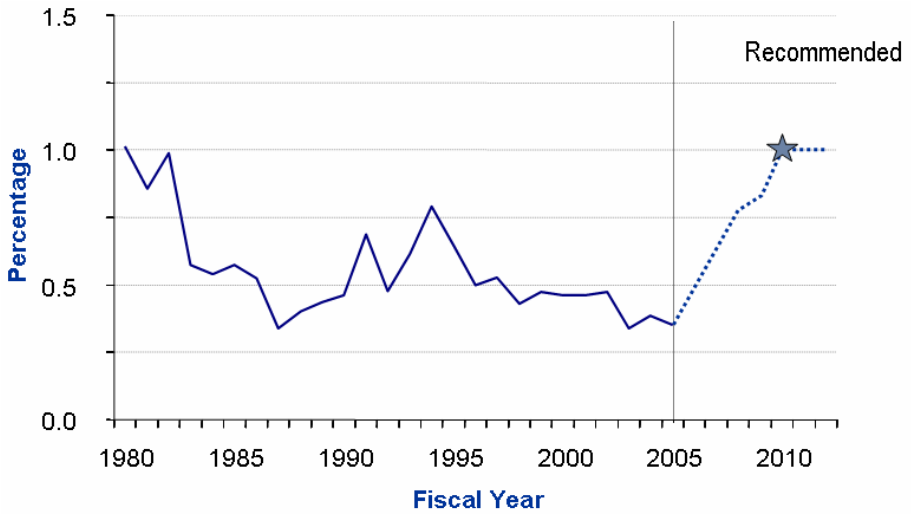
Sponsor manufacturing test beds to facilitate and support widespread development and deployment of innovative manufacturing technologies

10. PROGRAM FUNDING

The ManTech budget has fluctuated significantly over the past few decades, with a generally downward trend (see figure 1). In some of the Services—namely the Navy and Air Force—the ManTech budget has declined significantly; and the total appropriated budgets reflect significant funding added by Congress.[11] Overall, this budget profile does not reflect a well-planned and sustained strategic investment for more affordable acquisition, technology transition, and sustainment. The total ManTech investment, especially without the Congressional adds, does not match the importance of the need to reduce weapon costs and development cycle time.

In general, the program needs a greater and more stable funding profile within the Services and overall—funding that, over a five year period, returns ManTech-related investments to one percent of the RDT&E budget. As shown in figure 3, this increase aligns with the level of manufacturing technology investment in the early 1980s.

Figure 3. DOD ManTech Investment as a Share of RDT&E



[11] Appendix L contains funding profiles individual Service ManTech programs, both planned and appropriated.

The task force recommends increased investments in the following areas:

- A "defense-line" managed by OSD should be created, beginning with $50 million in fiscal year 2007.
- Funding for investments in manufacturing technology, within the overall SBIR program, should increase to $100 million by fiscal year 2010.
- By fiscal year 2010, DARPA should invest approximately $50 million in manufacturing research for disruptive technologies—investments in the manufacture of products using disruptive technologies as well as investments in disruptive manufacturing process technology. This amount reflects a redirection of less than two percent of the DARPA budget.

Table 2 shows the proposed ManTech budget profile from fiscal years 2006 through 2010. The 2010 profile reflects the task force recommended projections and a total program that is one percent of the planned RDT&E budget.[12]

Table 2. Proposed ManTech-Related Funding for Fiscal Years 2007–2010 (millions of dollars)

	2007	2008	2009	2010
Service ManTech	318	385	452	528
D-Line	50	50	50	50
SBIR*	60	80	100	100
Total	428	515	602	688
DARPA**	30	40	50	50

** Part of SBIR budget*
*** Part of DARPA program budget*

[12] Historical and projected funding profiles showing the ManTech budget as a percentage of RDT&E and S&T budgets are contained in Appendix M.

Funding Recommendations

USD (AT&L) should direct greater and more stable funding for the ManTech program in the individual Services and overall

- **Return total program investment to 1 percent of RDT&E budget**
- **Phase in over five-year period**

Add funding, beyond the current level of $249 million in fiscal year 2005, for the following:

- **Multi-Service, multi-platform initiatives (D-line)**
- **SBIR investments in manufacturing technology**
- **Service-unique projects**

Redirect part of DARPA program budget for investment in disruptive technologies—increasing to $50 million by 2010

CHAPTER 4. CONCLUSION

As stated at the outset of this report, advanced weapon systems cost too much, take too long to field, and are too expensive to sustain. In general, we believe that with high-level support, the ManTech program has the potential to significantly alleviate these problems. The program impacts all areas of acquisition, facilitates technology transition, has demonstrated significant reductions in cost and cycle time and increases in reliability, and has demonstrated tremendous return on investment. While the task force clearly recognizes that many broader actions are needed to address the depth of the Department's acquisition concerns, ManTech has an important contribution to make.

This report has identified specific actions in ten areas that the task force believes will enhance and expand the impact of the ManTech program: leadership, strategic planning, S&T responsibility, balanced portfolio, manufacturing readiness, workforce expertise, software, small-business participation, industrial leverage, and funding. There is much to do, but with effective leadership, thoughtful planning, and adequate resources much can also be accomplished.

The time to act is now. Like many others, we believe the Department is likely to face tighter economic constraints in the years to come. In light of fiscal constraints, reducing the cost of future weapon systems will be critical.

APPENDIX A. TERMS OF REFERENCE

THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

ACQUISITION,
TECHNOLOGY
AND LOGISTICS

SEP 17 2004

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference – Defense Science Board Task Force on the Manufacturing Technology Program

You are requested to form a Defense Science Board (DSB) Task Force to evaluate the Department of Defense (DoD) Manufacturing Technology (ManTech) Program. ManTech matures and validates manufacturing processes for emerging, defense-critical technologies, driving the timeline, affordability, and technology producibility level while shortening upgrade and deployment cycle time for key weapons, subsystems, and components.

The need for a cohesive manufacturing research and development investment program is fundamental to rapid acceleration of near-term technology capabilities to support warfighting operations, as well as long-term support for transition of revolutionary technologies. Warfighters need a responsive industrial base with advanced manufacturing technologies that reduce risks, costs, and lead times at every level and phase of the acquisition process, including design, development, production, and sustainment of fielded systems.

The Task Force should review the following and provide recommendations as to how the ManTech Program can be strengthened to improve its benefits to the DoD and the Military Services:

- Investment Strategy: Evaluate the extent to which ManTech investments and funding plans for each Military Service and the Defense Logistics Agency (DLA) support near-term, warfighting operations, the industrial base, and longer-range revolutionary technologies. Assess Service and DLA manufacturing process needs for military-driven requirements and impact on defense-unique industrial base capabilities.

- Program Balance: Assess the adequacy of technical investments across manufacturing process disciplines (e.g., processing and fabrication needs for electronics, metals, and composites) and support for both Joint Warfighting Capabilities and revolutionary technologies. Spiral integration of revolutionary technologies should include concurrent development of technologies, manufacturing processes, and related enterprise management improvements.

- Programmatic / Funding: Appraise funding for manufacturing research and development, including mechanisms to support both Service/Agency requirements (e.g., for ships, aircraft, tracked vehicles, logistics centers) and cross-cutting initiatives (for example, in power and battery technologies). For a level of investment,

identify how funding models and mechanisms utilized by commercial industry to speed transition of technology from laboratory to market might be utilized by DoD.

- Program Ownership: Evaluate relevant organizational structures to ensure the ManTech Program is appropriately postured both technically and resource-wise to mature and transition science and technology from the laboratory to the production floor.

- Acquisition Impact: Consider adequacy of manufacturing process guidelines for the 5000-series acquisition process. Assess mechanisms by which producibility issues are considered within the preferred approach of an evolutionary acquisition strategy.

The Study will be sponsored by me as the Acting Under Secretary of Defense (Acquisition, Technology, and Logistics), and the Deputy Under Secretary of Defense (Advanced Systems & Concepts). Dr. Jacques Gansler will serve as Task Force Chairman. Dan Cundiff, Oversight Executive for ManTech, ODUSD(Advanced Systems & Concepts), will serve as the Executive Secretary. LTC Scott Dolgoff, USA will serve as the DSB Secretariat representative.

The Task Force will operate in accordance with the provisions of P.L. 92-463, the "Federal Advisory Committee Act," and DoD Directive 5105.4, the "DoD Federal Advisory Committee Management Program." It is not anticipated that this Task Force will need to go into any "particular matters" within the meaning of section 208 of Title 18, U.S. Code, nor will it cause any member to be placed in the position of acting as a procurement official.

FOR Michael W. Wynne
Acting

APPENDIX B. TASK FORCE MEMBERSHIP

CHAIRMAN

NAME	AFFILIATION
Hon. Jacques Gansler	University of Maryland

TASK FORCE MEMBERS

Maj Gen Pat Condon, USAF (Ret)	Dayton Aerospace, Inc.
Dr. Lance Davis	National Academy of Engineering
Dr. Gary Denman	Private Consultant
Dr. Pamela Drew	Boeing
Mr. Noel Longuemare	Private Consultant
Mr. Jim Mattice	Universal Technology Corporation
Mr. Anthony Mulligan	Advanced Ceramics Research, Inc.
Mr. Herman Reininga	Rockwell Collins
Maj Gen Bill Usher, USAF (Ret)	Private Consultant

EXECUTIVE SECRETARY

Mr. Dan Cundiff	ODUSD (AS&C)
Ms. Adele Ratcliff	ODUSD (AS&C)

DSB REPRESENTATIVE

LTC Scott Dolgoff, USA	Defense Science Board

GOVERNMENT ADVISORS

Col Charles Bailey, USAF	Air Force Acquisition
Mr. John Carney	Office of Naval Research
Mr. John Christensen	Defense Logistics Agency
Ms. Carol Gardinier	Army Research, Development and Engineering Command
Mr. Steve Linder	Missile Defense Agency
Dr. Mike McGrath	DASN (RDT&E)
Ms. Mary Miller	Office of the Assistant Secretary of the Army, Acquisition, Logistics, and Technology
Mr. John Mistretta	Air Force Research Laboratory
Mr. James Reaser	Air Force Acquisition
Mr. Doug Schaefer	Missile Defense Agency/ Manufacturing and Producibility
Mr. John Todaro	ODUSD (AS&C), Director, Office of Technology Transition

STAFF

Ms. Barbara Bicksler	Strategic Analysis, Inc.
Ms. Julie Evans	Strategic Analysis, Inc.
Ms. Deborah Jermunson	Strategic Analysis, Inc.

APPENDIX C. PRESENTATIONS TO THE TASK FORCE

DECEMBER 17, 2004	
Name	*Topic*
Ms. Sue Payton *Deputy Under Secretary of Defense (DUSD), Advanced Systems & Concepts (AS&C), OSD*	Perspective on ManTech Program
Mr. Dan Cundiff *Associate Director, Office of DUSD, AS&C, OSD*	Transitioning Affordable Combat Power to Our Warfighters
Ms. Carol Gardinier *Program Manager, Army ManTech, Research, Development & Engineering Command*	Army ManTech Program Overview
Mr. John Carney *Acting Director, Navy ManTech, Office of Naval Research*	Navy ManTech Program Overview
Mr. John Mistretta, *Chief, ManTech Division, Air Force Research Laboratory*	Air Force ManTech Program Overview
Mr. John Mistretta *Chairman, Joint Defense Manufacturing Technology Panel*	Joint Defense ManTech Panel
FEBRUARY 16, 2005	
Dr. Lewis Sloter *Office of DUSD, Science & Technology (S&T)*	ManTech in Small Business Innovation Research
Mr. John Christensen *Chief, Industrial Capabilities, Defense Logistics Agency (DLA)*	DLA ManTech Perspective
Dr. Tony Tether *Director, Defense Advanced Research Projects Agency (DARPA)*	DARPA View on Manufacturing in R&D
Dr. Richard Mirsky *Program Manager, Defense Production Act III Program, OSD (AT&L)*	Title III of the Defense Production Act
Dr. Ann Marie Surprise *Director, Best Manufacturing Practices Center of Excellence*	Best Manufacturing Practices Center of Excellence

Mr. Dave Stieren *National Institute of Standards & Technology , Manufacturing Engineering Laboratory*	National Science & Technology Council Interagency Working Group on Manufacturing Research & Development
Mr. Doug Shaefer *Director, Producibility & Manufacturing, Missile Defense Agency (MDA)*	MDA Manufacturing Investments
MARCH 23-24, 2005	
Mr. Arun Seraphin *Member, Senate Armed Services Committee Staff*	ManTech Congressional Perspectives
Mr. Egils Milbergs *Center for Accelerating Innovation*	Innovation Ecosystems: Implications for the Defense Industrial Base
Mr. William Bonvillian *Chief Counsel, Senator Lieberman's Staff*	Defense Manufacturing Base Issues
Mr. Jean Reed *Member, House Armed Services Committee Staff*	Congressional Perspective on the Defense ManTech Program
Mr. Jack Taylor *Associate Director, Office of DUSD (S&T)*	Energy & Power Technology Initiative: Capacitor ManTech Program
Mr. Bart Moenster *Director, Advanced Manufacturing R&D, Boeing*	Boeing ManTech Program: Partnership for Technology Development & Insertion
Dr. Nancy Spruill *Director, Acquisition Resources & Analysis, Office of Under Secretary of Defense, Acquisition, Technology & Logistics*	Metrics & Performance Measures in the Acquisition Environment
Mr. Les Andersen *Joint Defense Manufacturing Technology Panel, Manufacturing Readiness Levels Development Working Group*	Current Status and Plans On the Evolution, Refinement, And Deployment Of DOD Manufacturing Readiness Levels
Mr. Jim Gucinski, *Naval Sea Systems (NAVSEA) Crane Power Systems Executive*	JDMTP Battery Manufacturing Gap Study
Dr. Dave Shaver *MIT Lincoln Laboratory*	Moving Technology from R&D to Military Systems
Mr. John McKeown *Technical Director, Joint Strike Fighter Program*	Joint Strike Fighter Program Overview
Dr. Toni Marechaux *Director, Board on Manufacturing and Engineering Design, The National Academies*	Manufacturing at the National Academies

MAY 24-25, 2005	
Dr. Ron Sega *Director, Defense Research & Engineering*	DDR&E Update
Mr. James Thompson *OUSD (AT&L)/Defense Systems*	Manufacturing in Acquisition: Guidelines & Mechanisms
Ms Dawn Vehmeier *Acting Director, Industrial Base Assessments, Office of DUSD (Industrial Policy)*	Defense Industrial Landscape
Maj Gen William Usher, USAF (Ret) *Private Consultant*	ManTech Study
Mr. John Mistretta *Chief, ManTech Division, Air Force Research Laboratory*	Case for Re-Building the Air Force Manufacturing and Quality Assurance Infrastructure
Mr. John Ouellette *Sustainment Project Coordinator, U.S. Army Unmanned Aircraft Technologies*	Army ManTech for Future Combat Systems
Lt Gen Richard Scofield, USAF, (Ret) *Private Consultant*	Delivering Combat Capability at Home & Abroad
Dr. Charles Holland *DUSD (S&T)*	Captive Foundry & Radiation Hardening
Dr. Gerry Graves *ATI*	Next Generation Manufacturing Technology Initiative
JULY 26, 2005	
Mr. Andy Summers *DD(X) Ship Design Manager, NAVSEA*	Japanese Kongo Class Comparison to USS Arleigh Burke
Mr. Bob Whalen *Chairman, Advanced Development Operations, Titan*	Titan Experience on Design Manufacturing of X-Craft, Affordable Weapon, & Affordable Phased Arrays
Mr. Jim Gucinski *NAVSEA Power Systems Executive*	Battery Brief
Mr. Steve Linder *Senior MDA Representative, Joint Defense ManTech Panel*	JDMTP MRL Update
Mr. Jack Harris *Director, Advanced ManTech, Rockwell Collins*	Predicting Manufacturing Performance
Dr. Mike McGrath *Deputy Assistant Secretary of Navy (RDT&E)*	Integration of Commercial & Military Manufacturing in 2010 and Beyond
SEPTEMBER 22, 2005	
CAPT Jeffery Wilson, USN *Technical Director, Joint Single Integrated Air Picture, System Engineering Organization*	Use of Model Driven Architecture in the Acquisition Process

APPENDIX D. DEPARTMENT OF DEFENSE DIRECTIVE 4200.15

Department of Defense

DIRECTIVE

NUMBER 4200.15

September 19, 2002

DDR&E

SUBJECT: Manufacturing Technology (ManTech) Program

(a) DoD Instruction 4200.15, "Manufacturing Technology Program," May 24, 1985 (hereby canceled)
(b) Section 2521 of title 10, United States Code
(c) Section 2374 of title 10, United States Code
(d) DoD 7000.14-R, "Department of Defense Financial Management Regulations," June 2000
(e) through (g), see enclosure 1

1. REISSUANCE AND PURPOSE

This Directive:

1.1. Cancels reference (a).

1.2. Implements references (b) and (c) to establish policy and assign responsibility for DoD Manufacturing Technology (ManTech) Program activities.

2. APPLICABILITY

This Directive applies to the Office of the Secretary of Defense, the Military Departments, the Chairman of the Joint Chiefs of Staff, the Combatant Commands, the Office of Inspector General of the Department of Defense, the Defense Agencies, the DoD Field Activities, and all other organizational entities within the Department of Defense (hereafter referred to collectively as the "DoD Components").

3. POLICY

It is DoD policy to rely on private sector investment and the "free enterprise" system to provide the manufacturing technology necessary to produce DoD materiel. There are cases, however, when qualified segments of industry cannot or will not commit private funds to establish manufacturing technology and make it available on a timely basis in support of DoD requirements. Accordingly, ManTech investments shall be directed at improving the quality, productivity, technology, and practices of businesses and workers providing goods and services to the Department of Defense. In addition, investments in ManTech shall:

3.1. Aid in the economical and timely acquisition and sustainment of weapon systems and components.

3.2. Ensure that advanced manufacturing processes, techniques, and equipment are available for reducing DoD materiel acquisition, maintenance, and repair costs.

3.3. Advance the maturity of manufacturing processes to bridge the gap from research and development advances to full-scale production.

3.4. Promote capital investment and industrial innovation in new plants and equipment by reducing the cost and risk of advancing and applying new and improved manufacturing technology.

3.5. Ensure that manufacturing technologies used to produce DoD materiel are consistent with safety and environmental considerations and energy conservation objectives.

3.6. Provide for the dissemination of Program results throughout the industrial base.

3.7. Sustain and enhance the skills and capabilities of the manufacturing work force, and promote high levels of worker education and training.

3.8. Meet other national defense needs within the guidance contained at enclosure 2.

4. RESPONSIBILITIES

4.1. The Director, Defense Research and Engineering under the authority, direction, and control of the Under Secretary of Defense for Acquisition, Technology, and Logistics, shall:

4.1.1. Provide centralized guidance and direction for the ManTech Program within the Department of Defense and ensure that it is executed in accordance with this Directive and references (b) through (g);

4.1.2. Develop and maintain a joint planning process, and use that process in preparing centralized program guidance.

4.1.3. Prepare an annual five-year plan as defined by reference (b).

4.1.4. Ensure coordination between the ManTech Program and industrial preparedness and similar manufacturing programs of the Department of Defense, other Departments and Agencies, and the private sector.

4.2. The Heads of the DoD Components shall:

4.2.1. Organize and execute a ManTech Program in accordance with the provisions of this Directive and supplemental guidance published by the Director, Defense Research and Engineering; and

4.2.2. Provide an adequately staffed ManTech Program management structure responsible for promoting and achieving ManTech Program objectives.

4.2.3. Ensure coordination between ManTech projects and industrial preparedness programs, and similar manufacturing projects of the Department of Defense, other Departments and Agencies, and the private sector.

5. INFORMATION REQUIREMENTS

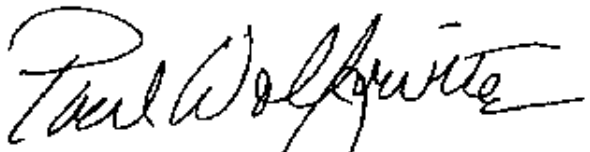
5.1. The DoD Components shall provide budget (detailed and summary) information to OSD in accordance with reference (c).

5.2. The DoD Components shall prepare a technical report describing deliverables received and activity conducted for each ManTech project for which funds have been expended. This report shall be submitted to the Defense Technical Information Center.

5.3. Each DoD Component shall submit ManTech Program information as needed to develop the annual five-year plan and to support other information requirements needed to satisfy reference (b).

6. EFFECTIVE DATE

This Directive is effective immediately.



Paul Wolfowitz
Deputy Secretary of Defense

Enclosures - 2
E1. References, continued
E2. Guidance for the ManTech Program

E1. ENCLOSURE 1

REFERENCES, continued

(e) DoD Directive 5000.1, "The Defense Acquisition System," October 23, 2000
(f) DoD Instruction 5000.2, "Operation of the Defense Acquisition System," April 5, 2002
(g) DoD 5000.2-R, "Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) Acquisition Programs," April 5, 2002

E2. ENCLOSURE 2

GUIDANCE FOR THE MANTECH PROGRAM

E2.1. INVESTMENTS

ManTech Program investments shall be directed toward areas of greatest need and potential benefit. Individual ManTech Program investments shall be selected by addressing the following:

E2.1.1. Projected requirements emerging from science and technology programs anticipated entering the systems acquisition process.

E2.1.2. Current industrial improvements in production, maintenance, repair costs, and industrial base responsiveness, including enhancement of in-house facilities, e.g., depots and shipyards.

E2.1.3. The potential to reduce costs, improve performance and responsiveness by advancing manufacturing technology. Maximum potential benefits from each ManTech Program investment shall be sought by ensuring that:

E2.1.3.1. There is a well-defined DoD requirement for the technology.

E2.1.3.2. The technology has been demonstrated in the laboratory environment as being feasible and can be delivered in time to meet the requirement.

E2.1.3.3. Anticipated investment results are applicable to more than one weapon system, component, or end item.

E2.1.3.4. There is a specific plan to implement, transition, and insert the results of the investment.

E2.1.3.5. The potential for multi-DoD Component-sponsored investments has been investigated.

E2.1.3.6. The proposed investment is not unnecessarily duplicative of other activities, both within and outside the ManTech Program.

E2.1.3.7. An assessment is made to determine if manufacturers of manufacturing equipment should be involved in projects.

E2.1.3.8. Competitive procedures shall be used in accordance with reference (d) for awarding all grants and entering into all contracts, cooperative agreements, and other transactions under the program. One of the evaluation factors shall be that the transaction provide for the proposed recipient to share in the cost of the project. For a project that the Government receives an offer from one offeror, the contracting officer shall negotiate a sharing ratio that represents the best value to the Government.

E2.2. RESTRICTIONS

ManTech Program funds may not be used for investments more appropriately funded by other means, such as:

E2.2.1. Routine application of existing technology for the production of specific equipment, manufacturing systems, or parts.

E2.2.2. Investments specifically intended to change an end item's design.

E2.2.3. Purchase of off-the-shelf capital equipment, unless it constitutes a minor portion of the investment and is required to establish the first-case application of the ManTech Program deliverable.

E2.2.4. Purchase of capital facilities.

E2.2.5. Implementation of manufacturing technology beyond the first-case application.

E2.2.6. A technology application unique to a single weapon system.

E2.3. REQUIREMENTS

The DoD Components shall clearly define project goals, objectives, milestones, and implementation plans for each project prior to project execution, and monitor the progress during project execution. Expected users of the technology or process shall participate in the project monitoring. ManTech Program effectiveness shall be evaluated by identifying and quantifying benefits resulting from the implementation of ManTech Program deliverables.

APPENDIX E. ESTABLISHING LEGISLATION FOR THE MANUFACTURING TECHNOLOGY PROGRAM

UNITED STATES CODE

TITLE 10--ARMED FORCES

Subtitle A--General Military Law

PART IV--SERVICE, SUPPLY, AND PROCUREMENT

CHAPTER 148—NATIONAL DEFENSE TECHNOLOGY AND INDUSTRIAL BASE, DEFENSE REINVESTMENT, AND DEFENSE CONVERSION

SUBCHAPTER IV--MANUFACTURING TECHNOLOGY

§ 2521. Manufacturing Technology Program

(a) ESTABLISHMENT.—The Secretary of Defense shall establish a Manufacturing Technology Program to further the national security objectives of section 2501(a) of this title through the development and application of advanced manufacturing technologies and processes that will reduce the acquisition and supportability costs of defense weapon systems and reduce manufacturing and repair cycle times across the life cycles of such systems. The Secretary shall use the joint planning process of the directors of the Department of Defense laboratories in establishing the program. The Under Secretary of Defense for Acquisition and Technology shall administer the program.

(b) PURPOSE OF PROGRAM.—The Secretary of Defense shall use the program—

(1) to provide centralized guidance and direction (including goals, milestones, and priorities) to the military departments and the Defense Agencies on all matters relating to manufacturing technology;

(2) to direct the development and implementation of Department of Defense plans, programs, projects, activities, and policies that promote the development and application of advanced technologies to manufacturing processes, tools, and equipment;

(3) to improve the manufacturing quality, productivity, technology, and practices of businesses and workers providing goods and services to the Department of Defense;

(4) to focus Department of Defense support for the development and application of advanced manufacturing technologies and processes for use to meet manufacturing requirements that are essential to the national defense,

as well as for repair and remanufacturing in support of the operations of systems commands, depots, air logistics centers, and shipyards;

(5) to disseminate information concerning improved manufacturing improvement concepts, including information on such matters as best manufacturing practices, product data exchange specifications, computer-aided acquisition and logistics support, and rapid acquisition of manufactured parts;

(6) to sustain and enhance the skills and capabilities of the manufacturing work force;

(7) to promote high-performance work systems (with development and dissemination of production technologies that build upon the skills and capabilities of the work force), high levels of worker education and training; and

(8) to ensure appropriate coordination between the manufacturing technology programs and industrial preparedness programs of the Department of Defense and similar programs undertaken by other departments and agencies of the Federal Government or by the private sector.

(c) EXECUTION.—

(1) The Secretary may carry out projects under the program through the Secretaries of the military departments and the heads of the Defense Agencies.

(2) In the establishment and review of requirements for an advanced manufacturing technology or process, the Secretary shall ensure the participation of those prospective technology users that are expected to be the users of that technology or process.

(3) The Secretary shall ensure that each project under the program for the development of an advanced manufacturing technology or process includes an implementation plan for the transition of that technology or process to the prospective technology users that will be the users of that technology or process.

(4) In the periodic review of a project under the program, the Secretary shall ensure participation by those prospective technology users that are the expected users for the technology or process being developed under the project.

(5) In order to promote increased dissemination and end use of manufacturing technology throughout the national defense technology and industrial base, the Secretary shall seek, to the maximum extent practicable, the

participation of manufacturers of manufacturing equipment in the projects under the program.

(6) In this subsection, the term `prospective technology users' means the following officials and elements of the Department of Defense:

(A) Program and project managers for defense weapon systems.

(B) Systems commands.

(C) Depots.

(D) Air logistics centers.

(E) Shipyards.

(d) COMPETITION AND COST SHARING.—

(1) In accordance with the policy stated in section 2374 of this title, competitive procedures shall be used for awarding all grants and entering into all contracts, cooperative agreements, and other transactions under the program.

(3) Under the competitive procedures used, the factors to be considered in the evaluation of each proposed grant, contract, cooperative agreement, or other transaction for a project under the program shall include the extent to which that proposed transaction provides for the proposed recipient to share in the cost of the project. For a project for which the Government receives an offer from only one offeror, the contracting officer shall negotiate the ratio of contract recipient cost to Government cost that represents the best value to the Government.

APPENDIX F. OVERVIEW OF SERVICE AND AGENCY MANUFACTURING TECHNOLOGY PROGRAMS

This appendix provides an overview of the military service and defense agency Manufacturing Technology Programs. Summaries cover the Army, Navy, Air Force, Defense Logistics Agency, and Missile Defense Agency.

ARMY MANTECH PROGRAM

The Army ManTech Program supports the development of essential manufacturing technologies that will enable more producible new technologies with reliable processes and higher yield, reduce the risk in transitioning military-unique manufacturing processes to production, and provide solutions enabling affordability of Future Force weapons systems.

The primary focus of the Army ManTech Program is the Future Combat Systems and the Future Force, through Manufacturing Technology Objectives that support Army Technology Objectives. The program also will continue to support other weapon system projects that are deemed high priority for the Army. The Army actively participates in the Department of Defense Joint Defense Manufacturing Technology Panel to coordinate ManTech efforts and maximize leverage of ManTech funding across the military services, Defense Logistics Agency, and Missile Defense Agency.

The Army ManTech Program supports process prototyping and pilot demonstration to develop or modify manufacturing technologies to support the production of Army weapon systems. Before Army ManTech funds are committed to an effort, the program manager of the target application weapon system must demonstrate that their acquisition strategy includes a realistic plan to implement the technology in the defense industrial base.

Organization

The Assistant Secretary of the Army for Acquisition, Logistics and Technology has overall responsibility for the Army ManTech Program. Within this office, the Director for Technology is charged with program oversight.

The Research, Development and Engineering Command (RDECOM), a subordinate command of the Army Materiel Command, has been further designated as the Army's ManTech Program Manager. The Systems of Systems Integration organization within RDECOM performs this function with a small staff that provides direction to the Army's four Research, Development and Engineering Centers (RDECs), the Natick Soldier Center (NSC), and the Army Research Laboratory (ARL). The ManTech managers at the RDECs, NSC, and ARL are responsible for detailed program management and execution of individual ManTech projects in coordination with the Army Technology Objective managers. This approach allows the Army to take advantage of technical expertise within the RDECs, NSC, and ARL and to maintain close contact with both the acquisition managers and the corresponding technology managers.

Investment Areas

The Deputy Assistant Secretary of the Army for Research and Technology has funded the most critical areas for ManTech investment to address Future Combat Systems/Brigade Combat Team requirements for the Future Force. The areas include the following:

- *Sensors*. To include dual-band cooled focal plane arrays, low-cost uncooled infrared sensors, and flexible display manufacturing.
- *Electronics and Power Systems*. To include pulsed power for advanced protection systems, compact power and energy storage, high current silicon carbide switches, phase shifters for phased radar arrays, and software defined radios.

- *Armor.* To include affordable lightweight structural and appliqué armor, and titanium for lightweight armament and ground vehicles.
- *Munitions*. To include low-cost, high-g force, high accuracy inertial measurement units based on microelectromechanical systems (MEMS) technology, durable gun barrels and armaments, and MEMS safe-and-arm for fuse technology.

The Army ManTech Program uses contracts with industry, cooperative research and development agreements, cost sharing arrangements, other transaction agreements, and DOD manufacturing centers of excellence to execute its manufacturing technology objectives.

Website

The URL for the Army Manufacturing Technology Program website is: http://www.armymantech.com.

NAVY MANTECH PROGRAM

Managed by the Office of Naval Research (ONR), the Navy ManTech Program provides a mechanism for developing enabling manufacturing technology and for implementing this technology for the production, repair, and maintenance of Navy weapon systems to support the fleet. The program is aimed at achieving affordability in weapon systems acquisition by inserting manufacturing process solutions early in the design phase in order to reduce life-cycle costs, improve schedules, and ensure quality.

By providing seed funding for the development of moderate to high-risk process and equipment technology, the ManTech Program permits contractors to upgrade their manufacturing capabilities. Working with defense contractors, the Naval Research Enterprise, and academia, the Navy ManTech Program promotes the development of improved processes and equipment, successful implementation on the factory floor for the affordable production of

defense materiel, and rapid transition to the fleet to support Navy warfighters. The program is structured to provide maximum dissemination of the results of manufacturing technology projects and to promote early implementation to strengthen the defense industrial base.

The Navy ManTech program supports the fleet by focusing resources on key, high-priority acquisition platforms; developing critical manufacturing, repair, and sustainment to support those platforms; involving relevant industry partners upfront to identify technical needs, schedule, and requirements for implementation; and focusing on transition as a key measure of success.

Objectives

The overall objective of the Navy ManTech Program is to significantly improve the affordability of Department of the Navy systems by engaging in manufacturing initiatives that address the entire weapon system life-cycle and to transition that technology to industry and the fleet. More specifically, DOD 4200.15 states investments should accomplish the following:

- Transition emerging S&T results to acquisition programs
- Improve industrial capabilities in production, maintenance, repair, and industrial base responsiveness
- Advance manufacturing technology to reduce cost, improve performance, and responsiveness

Customers of the Navy ManTech Program are many. They range from the acquisition system program executive officers and program managers responsible for transitioning major Navy weapon systems from development into production, to the logistics managers at the naval depots and shipyards responsible for repair, overhaul, and remanufacture of major weapon systems. Other customers of the Navy ManTech Program include the other Services, industry, and academia.

Centers of Excellence

The Navy ManTech Program has established centers of excellence (COEs) to provide focal points for the development and technology transfer of new manufacturing processes and equipment in a cooperative environment with industry, academia, and the Naval Research Enterprise. The COEs perform the following functions:

- Serve as corporate residences of expertise in particular technological areas
- Collaborate with the program executive offices and industry to identify and resolve manufacturing issues
- Develop and demonstrate manufacturing technology solutions for identified Navy manufacturing requirements
- Provide consulting services to naval industrial activities and industry
- Facilitate the transfer of developed manufacturing technologies

Planning and Execution

To support the evolving needs of naval forces and make wise investments, the ManTech Program Office restructured operations in fiscal year 2004. The ManTech Program implemented the Naval Integrated Systems Investment Strategy. The majority of yearly program resources support this new strategy, with the balance supporting diversified, long-term corporate investments. The Integrated Systems Investment Strategy ensures that the Navy ManTech investment aggressively addresses the highest priority manufacturing issues of select high-priority acquisition programs.

Investments are focused on those systems earlier in the development cycle for maximum impact. Rather than supporting every program with funding that falls short of the level where ManTech can be productive, ManTech now concentrates on a select few systems with a series of focused investments. While naval

weapon systems not included on the Navy ManTech investment list do have important manufacturing needs, there are insufficient resources to have maximum impact for all.

This sharply focused investment strategy will ensure that technology is transitioned to those higher priority systems to benefit Navy warfighters. Implementation of the new Integrated Systems Investment Strategy began in fiscal year 2004 concentrating on three initial program executive offices (PEOs) and platforms: PEO(Ships) for DD(X); PEO(Carriers) for CVN 21; and Joint Unmanned Combat Air System. For fiscal year 2005 the Littoral Combat Ship was added to the Integrated Systems Investment Strategy resulting in the configuration shown in figure F-1.

Figure F-1. Fiscal Year 2005 Navy ManTech Integrated Systems Investment Strategy

Additionally, ManTech will be working more closely with ONR's Future Naval Capabilities on requirements-driven, transition-oriented 6.3 and late stage 6.2 programs of interest to the targeted PEOs. Often these S&T programs have promising technology in need of process advancements before transition can be achieved. Where complementary, ManTech can provide expertise in solving these process technology issues associated with the new Future Naval

Capability products, particularly those issues with an impact on product affordability and, therefore, successful transition to the fleet.

To coordinate planning and execution efforts, Navy ManTech has identified ManTech liaisons for each PEO thrust area. These liaisons work closely with the PEO representatives and ONR S&T liaisons, as well as the centers of excellence and key system integrators (industry), to ensure that ManTech is focusing its investments on the highest priority needs and that progress is being made towards successful and timely transition to the fleet.

AIR FORCE MANTECH PROGRAM

The ManTech program is chartered by U.S.C. Title 10, section 2521 and implemented by DODD 4200.15. The purpose of the program is to enable a robust industrial base for affordable warfighter weapon systems, and provide advanced manufacturing capabilities to multiple weapon systems. The goals of the program are to reduce acquisition and sustainment costs; reduce cycle time for technology transition, manufacturing, and repair; and improve quality, productivity, and business practices. The program focuses investments on those beyond the normal risk for industry and system program offices. ManTech directly supports administration, Congressional, Secretary of Defense and Secretary of the Air Force industrial base policies.

Organization

The Deputy Under Secretary of Defense for Advanced Systems and Concepts provides DOD policy and program oversight for the ManTech program, on behalf of USD (AT&L). Within the Air Force, program management responsibility is assigned to Air Force Materiel Command (AFMC), with execution performed centrally by the Manufacturing Technology Division, Materials & Manufacturing Directorate, Air Force Research Laboratory (AFRL/MLM), Wright Patterson Air Force Base, Ohio. AFRL/MLM also executes OSD's Defense Production Act Title III program, Defense Production Act Title I, Air Force Industrial Base Assessments program, and AFMC

Diminishing Manufacturing Sources and Material Shortages program, as an integrated Air Force Industrial Preparedness Program.

Requirements and Planning

Technical requirements, priorities, and investment planning are developed in partnership with AFRL, Air Force program executive officers (PEO), ALCs, major commands, and industry. Technology transition requirements are identified and developed in partnership with AFRL. Acquisition and sustainment requirements are identified and developed through integrated product teams in each customer "sector": aeronautical; sustainment; armament; directed energy; command, control, intelligence, surveillance, and reconnaissance; and space. Key criteria for investment decision are warfighter capability impacts, pervasive system applications, and stakeholder implementation commitment. Requirements and plans are coordinated and approved by HQ AFRL, HQ AFMC, and SAF/AQR.

Future investments for the Air Force ManTech program will be focused in four key areas:

- Manufacturing readiness investments for advanced technology demonstration programs to expedite technology transition
- PEO program affordability and producibility investments to solve pervasive manufacturing issues and reduce acquisition program risk
- Sustainment and readiness investments to improve costs and cycle time for both repair and supply missions
- Industry partnership investments to resolve critical industrial base issues for entire industry segments throughout the acquisition life cycle

Recent Impacts for Air Force Warfighters

The ManTech program has had significant influence in the Air Force, improving warfighter capability in many areas, as the examples below illustrate.

- Enabled JDAM production to meet warfighter requirement by establishing "lean" efficiencies at several key JDAM suppliers. As a result surge production increased from 300 to 3,000 per month. This increased capability helped meet warfighter needs and improved quality.
- Increased number of F-15's and C-5's available for mission by reducing programmed depot maintenance cycle times at WR-ALC. As a result of the shorter maintenance time, an additional squadron of mission capable F-15s is now available to the warfighter. In addition, C-5 on time delivery increased from 25 to 100 percent. F-15 on-time delivery increased from 12 to 80 percent.
- Improved manufacturing of Viper Laser for Large Aircraft Infrared Countermeasures program enabled early fielding of 12 C-17s in direct support of Operation Iraqi Freedom. In addition, 28 million in savings were realized, with production costs reduced by 40 percent. In addition, improved power output and reliability increased aircraft survivability.
- Established second source for panoramic night vision goggles image intensifier tubes. The second source increased industrial base capacity to meet DOD demand. Goggle acquisition cost was reduced 20 percent.
- Partnered with program office to develop and implement lean production processes at Joint Programmable Fuze contractor facility. The process improvements that were implemented had a direct

impact on a successful first article acceptance test (before Air Force ManTech involved, prior 3 tests failed). Production ramped up to 500 per month providing the Air Force and Navy with more capable munitions (before Air Force ManTech involved, production was 0/month).

- Resolved JASSM production bottleneck by developing a new missile body process yielding 25 percent throughput increase as well as $19 million cost reduction.
- Resolved B-2 low observable coating issue, which eliminated the number one B-2 maintenance issue and increased fleet mission availability by 50 percent.
- Increased FOD damage resistance of F101 (B-1) and F119 (F/A-22) engines via new laser shock peening treatment for blades. This process reduced the risk of engine losses and reduced field inspections for F101 that powers the B-1B. As a result, a costly redesign of F119 engine that powers F/A-22 was avoided.

Examples of On-Going Investments

The following are examples of on-going investments in the Air Force ManTech program.

- *Active electronically scanned array radar*. Making next-generation radars affordable and reliable for air and space applications; $650M total cost reduction target across F/A-22, F-35, F-15, B-2, others.
- *Data links*. Developing production capability for affordable, highly-available ground stations, high band-width optical transceivers, and multi-access space terminals. Provides global situational awareness for existing and planned weapon systems

and simultaneous distribution of sensor data for shorter, more efficient kill chain.

- *Engine rotor life extension*. Establishing next-generation "retirement for cause" technology at depots, which will extend parts life to engine service life for over 45,000 F100 and F110 engine components; cost avoidance of ~$550 million over next 20 years.
- *Affordable precision guided munitions components*. Developing improvements for affordable and producible critical common components of next-generation precision guided munitions; targeting choke points such as thermal batteries, fuzes, guidance, and seeker systems.

DLA MANTECH PROGRAM

The Defense Logistics Agency is the DOD's combat support agency for logistics, providing the military services with food, clothing, medical, energy, barrier material, and weapon system spare parts. The agency's R&D program is aligned to the major supply chains that support these critical warfighting capabilities. The DLA Manufacturing Technology Program is organized along the different supply chains that provide materiel for the Services as shown in table F-1.

Table F-1. ManTech Program Supply Chain Alignment

Supply Chain	Clothing & Textiles	Subsistence	Const/ Equip	Maritime	Land	Aviation
ManTech Program	Apparel Research Network	Combat Rations Network		Electronics Acquisition		
			Castings			
			Forgings			

Each supply chain has its own particular manufacturing challenges and the programs are individually tailored to address these needs. Two of the chains, clothing and textiles and combat

rations, are supplied by industries that are totally dependent on DOD business. The castings and forgings supply chains are typically second- or lower-tier suppliers to the end item producers, who are often also small businesses. The DLA Electronics Availability program focuses on obsolescence mitigation by partnering with a U.S. microcircuit foundry to create a source for otherwise obsolete integrated circuits.

DLA's ManTech program has achieved great success since its inception, as described in the following examples:

- The *clothing and textiles* program has successfully integrated 3-D whole-body scanning into the recruit induction process as well as achieved complete supply-chain integration for recruit clothing. The result has been a dramatic increase in supply availability while achieving $87 million in inventory reductions.
- The *combat rations* program has significantly improved the delivery of rations by increasing quality, surge, manufacturability, and the cost effectiveness of an increasingly wide variety of rations.
- The *acquisition electronics* program has broken the obsolescence cycle that results when non-procurable microcircuits cause costly weapons system redesigns. ManTech developed a flexible manufacturing capability that has delivered over 75,000 form, fit, and function devices to 375 operating systems.
- The *castings* program has developed technology that has supported 96 weapon systems with over 950 part-types that, before ManTech, had extremely long production lead times. The program has directly supported 63 military program offices and laboratories with problem solving and education on the proper application of casting technology. It also

enjoys the strong support of every U.S. casting association.

- The *forgings* program has developed and populated a national commercial database of forging tools that are required to produce military spare parts. The availability of this data has resulted in significantly lower lead times and cost avoidance. It has also contributed to higher-level assembly forging issues at the weapons-system level.

The DLA ManTech Program has an excellent track record of providing solutions to difficult DLA supply-chain problems and supporting industries that are critical to DOD's warfighting capability.

MISSILE DEFENSE AGENCY MANUFACTURING TECHNOLOGY AND PRODUCIBILITY PROGRAM

The Directorate for Producibility and Manufacturing Technology (MDA/MP), in the Missile Defense Agency (MDA), is responsible for system-wide producibility analysis and manufacturing risk assessment and mitigation for the Ballistic Missile Defense System (BMDS). MP provides MDA a corporate organization that identifies common BMDS program risks and methods for reducing those risks and inserting lower-cost, more producible components into BMDS systems. The directorate's focus provides production-ready technologies to BMDS elements in support of the MDA's near term capabilities-based acquisition strategy.

MP's emphasis is on near-term measures that respond to changing BMDS requirements. With the initial deployment of the Ground Based Interceptor, there is a keener focus on BMDS element life cycle cost and on developing a BMDS with sufficient versatility to meet the evolving threat. This goal is achieved by concentrating on technologies that have demonstrated producibility, are applicable to multiple elements, have the potential to be inserted into elements in the near-term (one to three years), and support open system design

architecture. The Directorate also serves as the MDA focal point for manufacturing and industrial base issues.

Investment Strategy

MP provides manufacturing assurance to the BMDS. MP–funded and leveraged investments have helped reduce the cost and improve the quality and reliability of PAC-3, GMD, SM-3 and THAAD. MP plays an important role in National Security Space industrial base activities. Joint efforts with AF/SMC and OGA have identified top priority, common issues that will impact future space systems and formulated plans for the way ahead.

To achieve the mission set forth for the Directorate, MDA/MP has identified key investment areas where SBIR topics and MDA/MP core-funded projects are complemented. A process is in place that provides a continuous and stable budget for these key investment areas, while preserving the MDA/MP goal for near-term insertion and integration of mature projects into the BMDS.

By managing investments through the structured approach of key investment areas, MP can access, synthesize, and analyze data from various sources; identify and interact with key industry, Service and government laboratory participants; and formulate MP program guidance. The Engineering Manufacturing Readiness Levels (EMRLs), developed within MDA/MP, assist the key investment area teams in assessing the maturity of funded technologies in order to ensure the successful transition/insertion of the manufacturing improvement or technology into the BMDS.

MP has implemented incentives for improving quality and producibility. MDA and the BMDS elements now use Engineering Manufacturing Readiness Levels (EMRLs) as a program metric. MDA elements have also adopted the use of supply chain tools, web-based intelligent specifications and standards, and lean enterprise practices.

Small Business Innovation Research Leverage

MP has recognized that substantial benefits are gained by leveraging SBIR/STTR investment in manufacturing and producibility. MP is credited by many of the BMDS Elements as being responsive to their needs in supporting investments in areas that provide affordable solutions to common problems. The combination of using core funding with SBIR/STTR investment helps reduce risk and mature technology to increase the likelihood of technology/product transition to a prime or OEM is increased. MP will continue to use this model to help insure a viable industrial base with the ability to supply affordable, high quality products to the BMDS.

MDA/MP provides topics to the SBIR office to include in the overall MDA solicitation. The number of topics varies by offering year and the content of each topic is designed to complement the key investment areas. MDA/MP has a vested interest in this program as a promising source of technology and invites companies to share both Phase I and II projects with prime contractors at industry days, organized by MDA/MP. This venue provides a technical exchange between the small business and prime contractor that aids in facilitating the transition of SBIR projects into BMDS systems.

Summary

MDA's Manufacturing Technology and Producibility Directorate is a unique organization in the DOD. The small cadre of individuals which comprise MP provide vision and leadership, strategic planning, program/project architecture, and policies and procedures. MP's connections with BMDS element, prime and subcontractors, suppliers, and possible suppliers have taken years to develop. The key investment area approach of grouping issues and opportunities has allowed MP to make leveraged investments using both technology push and system demand pull to upgrade portions of the BMDS elements. Table F-2 shows the fiscal year 2005 program related to manufacturing technology and producibility for MDA/MP.

Table F-2. MP–Leveraged Budget for Fiscal Year 2005

BUDGET CATEGORY	MILLIONS OF DOLLARS
MP Core Funding	33.270
Congressional Adds	3.850
SBIR/STTR	35.000
Title III (Cost Match)	6.500 (27.0)
Other	22.500
Total	101.120

MP's key investment areas tackle the issues others are concerned about, but have difficulty dealing with across the entire manufacturing enterprise. Examples include batteries, production improvements, identifying alternative sources for lost manufacturing capability, and driving competition into all levels of BMDS acquisition.

APPENDIX G. IMPACT OF THE MANUFACTURING TECHNOLOGY PROGRAM: SELECTED SUCCESS STORIES

This appendix provides further detail on the impact of the Manufacturing Technology Program with brief summaries of selected success stories. It includes examples of Service and agency ManTech projects as well as examples of some of the successes achieved in the early years of the program that had major impact in both DOD and industry.

THE EARLY YEARS

A number of important advances in manufacturing technology began with ManTech Program investments. The following are a few examples:

- The *numerically-controlled machine tool industry*. In the 1950s, ManTech provided funding to the Massachusetts Institute of Technology to develop the first numerically-controlled machine tool and associated programming language. These machines are now vital to every weapon system.
- *Laid the foundation for the current microelectronics industry*. During the 1960s, ManTech funded key technologies that led to the production of Texas Instrument's first integrated circuit calculator. Other investments supported development of numerous key processes and equipment for microelectronics manufacture.
- *Accelerated the development of smart weapons*. ManTech teamed with the S&T community in the 1970s to develop processes that led to precision laser-guided missiles and munitions.

- *Night vision capability*. Early investments in image intensifier tubes led to a comprehensive night vision development program for surveillance, reconnaissance, and target acquisition.

Lean Manufacturing

The implementation of "lean manufacturing" in DOD and its supporting industrial base can trace its roots to ManTech investments. In 1993, Air Force ManTech collaborated with the Commander of the Aeronautical System Division, industry, and the Massachusetts Institute of Technology to establish the Lean Aircraft Initiative (LAI). The purpose of the initiative was to learn about, and adapt to aircraft development and production, the lean methods that Toyota had been using so successfully to reduce the cost and lead time for developing and producing high-quality automobiles.

LAI has been extremely successful in developing and adapting lean practices and tools and sharing lessons learned. Most members would credit LAI with accelerating by many years their progress in adopting lean techniques. LAI remains strong in 2005 and continues without ManTech funding.

Many projects have been funded by the Air Force and Navy ManTech programs to expand and validate lean practices in military applications. Investments exceed $70 million and have been beneficial to all of DOD and the defense industrial base. Success stories of lean manufacturing applications that benefited from ManTech investments, directly or indirectly, are numerous. The following are a few examples:

- The Navy's Lean Pathways program has successfully promoted lean practices in a variety of applications that range from on-board aircraft handling of spare parts to streamlining the supplier base for acquisition programs such as the SLAM-ER.
- JDAM has experienced a 63 percent reduction in cost as compared to initial estimates for a savings of $2.6

billion. In addition, surge capacity at nine key suppliers increased ten fold from 300 to 3,000 per month.

- For the F-15, shorter depot repair times returned 22 aircraft for mission duty (equivalent of one full squadron).
- M1 Main Battle Tank maintenance was 40 percent short of customer need (6 per week versus 10). With the application of lean techniques customer needs are being met and an 85 tank backlog eliminated within original budget estimates.
- C-17 unit price decreased 30 percent on final 80 aircraft ($6.5 billion savings).
- Recapitalization on the HMMWV line sped up sharply, from 12 to 200 vehicles per month.
- For the ATLAS program, launch vehicle lead time reduced 63 percent (from 48.5 to 18 months).

ARMY

Composite Body Armor

Army investments in the late 1990s enabled PM Soldier and the Marine Corps Systems Command to consider composite body armor as an affordable solution. The Army demonstrated processing of silicon and boron carbide materials, reducing plate cost (from $850 to $350) and improving manufacturing throughput. The weight of the armor was also reduced by 50 percent. Once the initial body armor system was fielded, demand for the system grew quickly; today, production is in the hundreds of thousands. The Army ManTech invested $450,000 in this program.

Affordable IR Sensors

The Army ManTech program has led to improved night vision capabilities that are important to the survivability and lethality of

deployed combat units. This work has had an impact on numerous systems, with examples as follows:

- The Long Range Advanced Scout Surveillance System (LRAS3) provides the ability to distinguish enemy vehicles beyond ranges of other systems. Improvements have been made in manufacturing processes and reliability for the Dewar and focal plan array subsystems, increasing identification range for targets and improving resolution. The system was reliable with most crews running it 24 hours a day for weeks at a time during Operation Iraqi Freedom.
- The Javelin command launch unit has been used as a primary surveillance and night vision device for light forces in Afghanistan. ManTech investments in the Standard Advanced Dewar Assembly and Linear Drive Coolers have doubled the reliability of Javelin coolers and reduced acquisition costs by an estimated $38 million.

For these initiatives, ManTech invested $9.7 million from 1990 through 1999. A more recent example is the Army ManTech work in the production of uncooled focal plane array, which has resulted in increased surveillance and target ranges at lower cost. Improved manufacturing processes are now being inserted directly into the lines producing Driver Vision Enhancer and Thermal Weapon Sights. These systems are in extremely high demand in the Afghanistan and Iraqi theater of operations and ManTech investments are significantly reducing the cost of these systems. The uncooled focal plane array cost is presently $4,000 and is on track to meet the goal of $2,000. Baseline cost is $16,000 per unit. The total ManTech investment for this focal plane array production effort is $15.3 million.

Stryker Turret Gunner Protection

With investments from the ManTech program, the Army has fielded titanium Stryker cupola shields to support operations in Iraq.

Funded from fiscal year 2001–2006 at $10.3 million, this project specifically addresses material cost and manufacturing processes for single-melt titanium, robotic welding, and laser hybrid welding. Using approximately 100,000 pounds of titanium plate and the technology advancements developed under the ManTech program, the Army RDECOM Armaments Research, Development and Engineering Center is manufacturing low-rate initial production quantities in house. A total of 406 sets, plus spares will outfit all six Stryker brigades. Without ManTech's investment, this solution would not have been affordable.

Cannon Tube Reshaping

Under the Cannon Tube Reshaping Manufacturing Technology Objective, the Army demonstrated a process to measure and straighten M1 tank barrels to a "fleet zero," that is accurate across the entire inventory of M1 tanks. With this improvement, the tanks can shoot rounds on target with much greater accuracy. This improvement has led to the greatest increase in the "loss-exchange ratio" (the ratio of enemy to friendly tanks destroyed) in more than 20 years—since the introduction of night vision technology in the 1980s. The program has developed a system that will be installed at Benet Labs/Watervliet Arsenal and a mobile system that will allow in-theater reshaping. The total Army ManTech investment was $7.4 million.

NAVY

PRC-112 Survival Radios

The AN/PRC-112 is a small, hand-held transceiver that provides voice and covert transponder identification and serves as well as a navigational aid. The modules were originally designed as throw-away items containing proprietary components, which was both expensive (at over $1,200 each) and led to delivery delays due to long lead times of four to six months. Difficulties in fielding the radios to Army and Navy units in Afghanistan led CECOM to request assistance from the Electronics Manufacturing Productivity Facility

(EMPF) to engineer a rework procedure for repairing faulty transmitter modules found in the radios.

With less than $5 in off-the-shelf replacement components and approximately $120 in labor (per module), radios with a faulty module were returned to the field at one-tenth the cost and much more rapidly than replacement through new module procurement. The identified rework procedure has become common practice at Tobyhanna Army Depot, and meets the 50 percent recovery goal for module refurbishment. Of 156 radios needing repair, 80 were successfully repaired in a two-month period; following that time about 50 percent of an additional 250 radios were successfully repaired. The procedure continued in use until the PRC-D model radio was made available.

Range Finder

The monoblock laser is a key enabling component in the U.S. Army's COBRA Multi-Function Laser System for the Land Warrior Program. The typical manufacturing process for laser transmitters incorporates a large number of components that are individually fabricated, machined, mounted, and precisely aligned by skilled labor—making these components highly costly and available in limited production quantities. In a joint Service effort with the Army, the Navy Electro-Optics Center optimized the manufacturing process critical to producing reliable and cost-effective monoblock laser assemblies. With this new process, the cost of the range-finder transmitter has been reduced by over 65 percent, from $6,300 to less than $2,000, with production quantities for new systems at 50,000. In addition, 25 units were successfully integrated on the M119A1 gun, providing range information that increased the percentage of first round hits. These systems have been sent to both Afghanistan and Iraq.

Night Vision

Night vision systems are limited in their effective range, requiring operators to get close to their target. A Navy ManTech project was

initiated to provide a longer-range capability for night vision systems with the goal of improving mission performance and optimizing manufacturing processes to reduce system costs. Optical Systems Technology, Inc., with guidance from the Electro-Optics Center, designed and developed three new night vision components; made manufacturing improvements for the Universal Night Sight; integrated a high-performance, uncooled infrared focal plane array into a hand-held shared aperture dual band sensor; and developed a long-range lightweight lens for use on nighttime surveillance systems for the next generation of components for night sight programs. The Universal Night Sight is now produced at 60 percent of its original cost and provides longer-range capability. This improved system is currently in use by special operations forces in both Afghanistan and in Iraq.

Thermal Batteries

The military uses thermal batteries to power sonobuoys, guided artillery, missiles, guidance systems, and countermeasure devices. Current thermal battery manufacturing practices do not meet the Navy's cost and production requirements, thereby limiting the number of weapon systems that can be purchased and deployed by the Navy. The objective of this ManTech project was to reduce the battery cost and improve the manufacturing process and quality.

Naval Surface Warfare Center Carderock, Eagle Picher, and the Navy Metalworking Center identified the cost drivers associated with manufacturing thermal batteries. Technologies that reduce cost and improve the manufacturing process and thermal battery quality were designed, manufactured, and implemented on the thermal battery that powers the JDAM guidance kit and other weapon systems. These included a battery cell component-stacking device, press features for improved die fill and reduced powder leakage, hopper system, tooling materials, and coatings. The estimated cost reduction per unit is 22 percent. This reduction translates into a cost avoidance of $29 million over a five-year period for the sonobuoy program and $24 million over the lifetime procurement of the JDAM, JSOW, and Paveway. In addition, the increased production capacity results in

availability of an additional 7,400 AN/SSQ-62E or 2,900 JDAM per month.

AIR FORCE

Anti-Missile System

Air Force ManTech, under contract with Northrop Grumman, has successfully developed and deployed significant cost saving procedures in the manufacture and assembly of the ViperTM Mid-Infrared (IR) Laser. The ViperTM Mid-IR Laser is one of the primary components in the Large Aircraft IR Countermeasures system, designed to protect C-17s, C-130s and other large aircraft from IR-guided surface-to-air missiles. The improvements are expected to result in a net savings of $4.2 million in the acquisition costs alone—a 200 percent return on the ManTech investment of $2.1 million. This cost savings is accompanied by reliability improvements and a dramatic increase in yield, which are expected to result in reductions in life cycle costs and increased system availability. Most important, ManTech investments made this LAIRCM capability upgrade available to outfit 12 C-17 aircraft in time for Operation Iraqi Freedom increasing the survivability of these critical assets and their crews.

C-17 Landing Gear Doors

An increase in failure rates for C-17 main landing gear doors has become a major contributor to reduced mission capability of the aircraft. The AFRL Materials and Manufacturing Directorate and Air Vehicles Directorate, in cooperation with The Boeing Company, have successfully developed and implemented a durable composite C-17 main landing gear door that resolves the C-17s number one airframe maintenance problem, saves more than $6 million in life cycle costs, and increases mission readiness days by 90 per year. A result of the Composites Affordability Initiative (CAI) C-17 technology transition demonstration program, the new main landing gear doors incorporate several advanced manufacturing technologies and an improved design that will increase reliability by 40 percent.

Turbine Engine Components

Historically, methods for predicting the life of gas turbine engine rotor components have resulted in a conservative estimate of useful life. The "retirement for cause" program developed, integrated, and deployed advanced inspection and life-estimating technologies that are in use today at Oklahoma City Air Logistics Center permitting longer service life for many safety-critical, high-value components on the F-15, F-16, B-1B, and B-2.

This program—a collaboration between Air Force ManTech, materials S&T, and logistics centers—is also credited with enhancing safety, increasing inspection throughput, and introducing damage tolerance and probabilistic concepts-of-life management for engines. The program has realized more than $1 billion in cost savings. A related ManTech effort, Engine Rotor Life Extension, is currently working to create and implement the technology to further extend the life of these components and address the more complex rotor geometries of advanced engines for the F/A-22 and F-35, for an additional $550 million in savings.

Active Electronically Scanned Array (AESA) Radar

Advanced aircraft require active array radar to detect and track multiple targets. These radars also offer improvements in reliability, lower maintenance cost, and reduced size and weight. Active element phased array systems using transmit/receive modules was a promising technology for ground-based, airborne, and space-based radar applications. Air Force ManTech investments with Hughes Aircraft accelerated the transition of this technology from S&T into production and fielding. The program reduced the transmit/receive module assembly time by a factor of 200, reduced the number of interconnects by almost 90 percent, and decreased test time from 17 hours to less than 10 minutes. Collectively, these improvements reduced the cost of the most expensive component of AESA radars by a factor of 35, making them practical for application to the F/A-22 and other DOD aircraft such as the F-15. Newer generations of AESA radar are now on the drawing board. A current ManTech effort is

working to assure that these technologies affordably move from laboratory to the field without delay.

Lean Depot Repair

The Lead Depot Repair project was established to determine whether lean methods could be adapted to the depot repair environment. Air Force ManTech partnered with Warner Robins Air Logistics Center to revolutionize the programmed depot maintenance lines for F-15 and C-5 aircraft, reducing cycle time and cost. As a result, critical warfighting assets are more quickly moved from maintenance to fully operational status.

Specifically, on-time return of C-5 aircraft increased from 25 percent in FY 2000 to 100 percent in FY 2004. The average flow time for depot maintenance on C-5s at the Air Mobility Command was reduced from 339 days in FY 2000 to an average of 240 days in FY 2004. On-time return of F-15 aircraft increased from 12 percent to 80 percent between FY 2000 to 2004. As a result, 22 additional F-15s (the equivalent of an additional squadron) were freed for operational use. Due to the success of this effort, lean depot practices are rapidly expanding across DOD, including Army arsenals and depots, Navy air depots, and shipyards.

DEFENSE LOGISTICS AGENCY

Acquisition Electronics

In 1985, DLA's Acquisition Electronics program began in an effort to meet logistics support requirements for electronics systems. Alternatives available to program managers to replace electronic systems—life-of-type buys, board-level redesign, or after market purchases—each had significant drawbacks that did not effectively meet requirements.

Working with Sarnoff Corporation, an integrated design and manufacturing system to provide a continuing source of form, fit, and function replacements for nonprocurable microcircuits was

developed and implemented. The system relies on a set of Bi-CMOS gate arrays and a single process line that is flexible and cost effective. Devices are manufactured to existing weapon system documentation and meet the specifications of the original devices, including physical, electrical, and environmental requirements. With this approach, parts can be used without time consuming and costly board-level qualification testing.

The F-15 program used this technology to keep mission readiness at acceptable levels as an older radar system was replaced with a new-generation radar. In all, the program has supplied over 75,000 failure-free devices to 375 weapon systems. As microcircuit technology continues to rapidly advance, the electronics acquisition program tracks new families of obsolescence, thereby assuring a continuing supply of qualified replacement parts into the future.

Combat Rations

The DLA Combat Rations Program has focused on improving meals, ready to eat (MRE), used primarily by ground forces when garrison feeding is not feasible. The production base for MREs is small and military specific. Companies do not have the incentive or resources to undertake the kind of manufacturing process development needed to meet military requirements for user acceptance.

In the past, MRE entrees were limited to "pumpables"—casserole-type foods such as beef stew, chicken a la king, and creamed beef—and could not include whole muscle meats, which would be preferable to soldiers. DLA's Combat Rations Program developed the horizontal "form, fill and seal" technology that allows whole muscle meats to be reliably included in the MRE menu. Current MREs now contain grilled beefsteak, pork chop, frankfurter, and chicken breast entrees.

The Combat Rations Program also developed equipment to automatically and reliably accomplish 100 percent inspection of MRE pouches, replacing an error-prone, labor-intensive, manual inspection. This process ensures that the meals are safe and

nutritious. The program works closely with the U.S. Army, the industrial base, and leading universities to continuously improve the quality and desirability of combat rations.

Castings Program

Castings are widely used in weapon systems whenever designers need a complex metal shape that is lightweight, durable, and cost effective. DLA's casting program is creating new technologies that will produce high-quality, cost-effective castings for replacement parts in older weapon systems, as well as new parts for emerging weapon systems. The program combines parts problem solving, research, and education in a comprehensive effort that helps the casting industry meet DLA and DOD requirements.

The program addresses metal casting procurement problems that threaten warfighter readiness. In the early phases of Operation Iraqi Freedom, demand for M1-A1 tank treads surged beyond any previous level. A key component of the tread is a die cast aluminum heat sink molded into the rubber shoe. The die for the heat sink would crack after 30,000 heat sinks were cast. The DLA Casting Program introduced a new, rapid tooling technology that reduced tooling lead time from 26 weeks to four and increased die life from 30,000 to 150,000 castings. With this new technology, DLA suppliers were able to meet the high demand for tank treads. Overall, the program has improved the reliability and lead time of over 950 DLA-managed parts, supporting 96 weapon systems.

APPENDIX H. MANUFACTURING READINESS LEVELS

Support to the warfighter is suffering as a result of consistent problems within the DOD acquisition process. The U.S. Government Accountability Office and other sources have pointed out that many program managers lack sufficient knowledge of their program's technologies, design, and production risks when making decisions to transition into production. As a result, programs experience cost increases, schedule delays, and production shortfalls. The Joint Defense Manufacturing Technology Panel (JDMTP) is developing a new tool that will give program managers better visibility into their program's risks before they have to make important decisions.

The DOD vision is to develop and institutionalize a set of Manufacturing Readiness Levels (MRLs), described in table H-1. This tool is consistent with current DOD 5000 acquisition doctrine, practice, and milestone decision points. These MRLs will be reconciled with DOD Technology Readiness Levels (TRLs), reconciled with MDA Engineering and Manufacturing Readiness Levels, and aligned with NASA TRL/MRL evolution. The potential is for DOD MRLs to serve as the basis for a government-wide standard.

The Technology Transition Working Group, comprised of government and industry representatives, developed an initial set of MRLs. In June 2004, the JDMTP chartered an MRL Working Group to refine initial definitions, evolve the supporting body of knowledge, and develop plans to institutionalize MRLs within the AT&L community.

To date the working group has developed the definitions of MRLs, how they interface with TRLs and milestone decisions points, and how they operate within the 5000 series process. The group has identified numerous key threads that transition through the manufacturing portion of the acquisition process and identified key risk identifiers at each MRL/milestone for each thread.

These threads cover such manufacturing transition topics as technology and the industrial base, design, materials, cost and funding, process capability and control, quality management, manufacturing personnel, facilities, and manufacturing management. These nine basic threads are further subdivided into twenty two sub-threads to allow visibility into risk areas. This approach provides risk visibility across the entire acquisition process schedule from the Pre Concept Refinement phase through the Production and Sustainment phase.

To enable the MRL concept, a web-based tool is being developed that can be used by a program office or acquisition official. The tool will allow program officials to pose appropriate manufacturing risk-related questions in order to gauge the risk potential against a standard, at any point within the acquisition process.

The tool in no way takes the authority away from decision makers but points out potential risks that exist and need to be taken into account during the decision-making process. The intent is to have the tool in the hands of program managers before the end of 2005.

Table H-1. Manufacturing Readiness Levels

MRL	DEFINITION	DESCRIPTION	PHASE
1-3	Manufacturing concepts identified.	Identification of current manufacturing concepts or producibility needs based on laboratory studies. Assumed that all corresponding TRL requirements are met for each MRL below.	Pre Concept Refinement
4	Manufacturing capability to produce the system, component, or item in a laboratory environment.	Conceptual design completed. Requirement validation underway and there are large numbers of engineering/design changes. Required investments, such as MANTECH identified. Component physical and functional interfaces have not been defined. Processes to insure producibility, manufacturability and quality are in place and are sufficient to produce technology demonstrators. Manufacturing cost drivers emerging. Producibility assessments have been initiated. Key technologies at least at TRL 4.	Concept Refinement leading to a Milestone A decision
5	Manufacturing capability to produce the system, component, or item in an initial production-representative environment.	Majority of manufacturing requirements have been preliminarily defined and validated, but there are still significant engineering/design changes. Component physical and functional interfaces have not yet been defined. Materials, machines and tooling, personnel skills, and inspection and test equipment have been demonstrated in a relevant environment but most manufacturing processes and procedures are in development (or MANTECH initiatives ongoing). Producibility assessments ongoing. Design-to-cost cost drivers identified.	Technology Development Phase

6	Manufacturing capability to produce the system, component or item in a production-representative environment.	Majority of manufacturing requirements have been preliminarily defined and validated, to include key characteristics, but there are still significant engineering/design changes. Preliminary design of critical components completed. Component physical and functional interfaces have not yet been defined. Materials, machines and tooling, personnel skills, and inspection and test equipment have been demonstrated in a relevant environment but most manufacturing processes and procedures are in development (or MANTECH initiatives ongoing). Producibility assessments ongoing. Production cost drivers/goals analyzed. System level design-to-cost goals set. Long-lead needs and key supply chain elements identified.	Technology Development leading to a Milestone B decision
7	Manufacturing capability maturing to produce actual system, component or item in low-rate initial production.	Engineering/design changes decreasing. Physical and functional interfaces clearly defined. All raw materials are fully understood, in production, and available to meet planned low-rate initial production (LRIP) schedule. Manufacturing processes and procedures in final validation test. Initial producibility improvements should be underway. Design-to-cost estimates and detailed production estimates being established. Producibility risk assessments ongoing and trade studies conducted. Supply chain being validated. System transitioned to formal configuration control. Long-lead readiness plans in place.	System Development & Demon-stration leading to Design Readiness Review

8	Manufacturing capability in place to begin low-rate initial production.	Design sufficiently stable to enter into low-rate initial production. Physical and functional interfaces clearly defined. All materials are in production and available to meet planned LRIP schedule. Manufacturing and quality processes and procedures have been proven, are under control and ready for low rate initial production. Initial producibility risk assessments completed. Production cost estimates meet design-to-cost goals. Supply chain established and stable. Key technologies at least at TRL 8.	System Development & Demon-stration leading to a Milestone C decision
9	Manufacturing capability in place to begin full-rate production.	During LRIP all systems engineering/design requirements are met and there are only minimal system engineering/design changes. Materials are in production and available to meet planned production schedules. Manufacturing processes and procedures are established and controlled in production to three-sigma or some other appropriate quality level. Personnel, machines and tooling, and inspection and test equipment deliver three-sigma or some other appropriate quality level in production. Production risk monitoring is ongoing. LRIP actual costs meet estimates	Production & Deployment leading to a Full-Rate Production Decision
10	Manufacturing capability in place to achieve lean production.	This is the highest level of production readiness. There are minimal engineering/design changes. System, component or item is in production or has been produced meeting all engineering, performance, quality and reliability requirements. All materials, manufacturing processes and procedures, inspection and test equipment, controlled in production to six-sigma or some other appropriate quality level in production. A proven, affordable product able to meet required schedule. Actual production costs meet estimates	Full-Rate Production/ Sustainment

APPENDIX I. MODEL DRIVEN ARCHITECTURE

INTRODUCTION

Model Driven Architecture (MDA) is a revolutionary approach to the way modern systems are specified, designed, implemented, tested, and supported. It affects all aspects of this process, and promises enormous reductions in both acquisition and life cycle costs, as well as orders of magnitude reduction in cycle time. Rarely has such a profound change in methodology emerged. The full impact of this revolution is just beginning to be realized and appreciated.

DESCRIPTION OF THE PROBLEM

Today's digitally enabled systems are becoming more and more dependent on software in virtually all of their functions. This phenomenon has resulted in vast improvements in performance, has enabled implementation of new capabilities, and is driving the trend toward network centric operations as the key discriminator on the battlefield. Software design, development, testing, and support are consuming an ever-larger share of DOD budgets. Model Driven Architecture is about to have a huge impact on this process.

In the classical approach to systems design, a set of paper requirements is developed that envision the desired system behavior and performance. These requirements are used by the system designer to formulate the necessary architecture, algorithms, and detailed signal and data flows. Models and simulations are often used to verify and optimize the detailed system design. Once this process is completed, the system design is provided to the software engineers who reduce the design to practice, generally employing a higher order language such as C++ or the like. Ultimately the engineers compile this into code for the host computing and processing platforms.

One of the most costly and often time-consuming steps in this process is systems test and integration, where the operation of the system is verified and compared with the desired behavior. A significant portion of the time is usually spent identifying discrepancies that have been introduced between the systems design specifications and implementation of the software design process.

THE MODEL DRIVEN ARCHITECTURE PROCESS

The MDA process changes this entire approach. Instead of paper specifications and requirements, the very first step generates a high-fidelity model of the desired system behavior, using an emerging tool known as Executable Universal Modeling Language (X-UML). This model is used to verify and optimize performance until the desired behavior is attained. So far, this approach is not too different from current practice. It is at the next step that the value of MDA emerges.

Once a suitable model has been constructed, a compiler is used to convert the UML model into software code in whatever language is appropriate to the host computing or processing platform chosen for the system. In most cases, there are other portions of the system with which the computing complex must interface. The model process is used to specify these details such that a complete description of the software functionality is captured. Once expressed in X-UML, the software is generated in a totally automated machine process.

Several advantages are immediately evident with this approach. Most significantly, the step of handing off the system design to a set of software engineers to redesign and manually convert into software is eliminated. Eliminating this step not only offers huge time and cost savings but also avoids the inevitable introduction of errors and "software designer's choice" discrepancies that are inherent to the manual process. Testing is also facilitated. Performance of the evolving software load can be readily verified using the faithful model representation that is fundamental to this approach. A significant issue in the current process is maintaining configuration control between the system designer's models and the actual system as it evolves. Since any design modifications based on MDA are first

performed by changing the X-UML model, one-to-one correspondence is assured.

SYSTEMS-OF-SYSTEMS NETWORKING AND INTEROPERABILITY

A significant and yet unsolved problem with today's vast array of military platforms is lack of true interoperability, which is fundamental to the concept of network centric operations. The emergence of MDA offers a method for achieving true network centric operations.

Rather than provide paper specifications to each participant in a system of systems to individually interpret and implement, an X-UML platform independent model (PIM) is generated that exhibits the desired network centric behavior. Once a suitable PIM is derived, it is provided to each participating platform design team, who in turn generate platform-specific versions applicable to their specific equipment and needs. An adaptation layer is generally used to adapt the core capability embodied in the PIM to each platform, addressing unique interface aspects and other platform peculiar needs. The key factor provided by MDA is that the same software code contained in the PIM core is essentially run on every member platform in the system-of-system's network, thus assuring data consistency and true interoperability.

SUPPORTABILITY BENEFITS

Not only is the initial design process greatly improved, there is even greater potential benefit in the software support area. Since system configuration control, when using MDA, revolves around a validated model rather than the software code, the impact of software changes and upgrades on the overall system and on system-of-systems performance can be readily verified at the design stage.

Further, as long as interfaces are not affected, changes can be disseminated to participating platforms in the form of changes to the PIM, which can then be incorporated into specific systems using the

machine code generation capabilities of MDA. Experience has shown that software changes that previously would take months and often years to manually develop and incorporate can be done in a matter of days. This is especially important for network centric systems, where an entire fleet of platforms can be modified or upgraded in a synchronized process at comparatively low cost. This approach also has implications for large savings in total ownership cost.

OTHER IMPLICATIONS OF APPLYING MDA

MDA is still at an early stage of development. Many of the X-UML tools required must be further refined and expanded to cover the needs of the myriad potential applications that are emerging. Industry has already recognized the benefits and is rapidly moving to exploit them. As software design migrates to an MDA approach for the various constituent parts of modern systems, modeling and simulation will take on a totally different and expanded role.

Classically, model generation has been a stand-alone effort generally funded as an adjunct task to the detailed design process, often performed by a separate group dedicated to modeling and simulation. Issues constantly arise as to how precisely the models represent an actual system. Quite often these models differ in substantive ways due to variations in the assumptions made, to simplifications introduced (to speed run time, for example), and to the practical problem of maintaining configuration control synchronization.

Almost all of these issues are avoided by using MDA. Models move from a side activity to the mainstream, since the basic, detailed designs are fundamentally one-to-one dependent on the models that specify them. No extra funding is required to generate models, since design funds are directly applied—and with reduced amounts being required. Model and system configuration synchronization is also assured at no extra effort.

A powerful new capability is possible once this process is implemented. Since in the limit every part of the software system is

described by high fidelity, interoperable models, the feasibility of readily putting together combinations of these models to emulate the behavior of a new system becomes practical. Thus, in the not too distant future, detailed behavior of complex new systems may well be modeled in an unprecedented short time and with a very high degree of fidelity. This capability can make it possible to rapidly field new capabilities and is a key to attaining true network centric operations.

SUMMARY

Model Driven Architecture is an emerging new process that affects virtually every stage of the system life cycle. The benefits in total ownership cost reduction and time to field are so significant that both government and industry are rapidly adopting and refining this process as they apply MDA to an increasing number of uses. Suppliers of Universal Modeling Language tools are also rapidly enhancing, broadening, and enriching the required tool sets and related compilers as the process is applied to an increasingly wide range of problems and domains. MDA represents a truly revolutionary improvement in the design of future systems. It supplies the key missing interoperability ingredient that will make complex network centric operations possible.

APPENDIX J. EXECUTIVE ORDER—ENCOURAGING INNOVATION IN MANUFACTURING

the White House
President George W. Bush

For Immediate Release
Office of the Press Secretary
February 24, 2004

Executive Order Encouraging Innovation in Manufacturing

By the authority vested in me as President by the Constitution and the laws of the United States of America, including the Small Business Act, as amended (15 U.S.C. 631 et seq.), and to help ensure that Federal agencies properly and effectively assist the private sector in its manufacturing innovation efforts, it is hereby ordered as follows:

Section 1. Policy. Continued technological innovation is critical to a strong manufacturing sector in the United States economy. The Federal Government has an important role, including through the Small Business Innovation Research (SBIR) and the Small Business Technology Transfer (STTR) programs, in helping to advance innovation, including innovation in manufacturing, through small businesses.

Sec. 2. Duties of Department and Agency Heads. The head of each executive branch department or agency with one or more SBIR programs or one or more STTR programs shall:

(a) to the extent permitted by law and in a manner consistent with the mission of that department or agency, give high priority within such programs to manufacturing-related research and development to advance the policy set forth in section 1 of this order; and

(b) submit reports annually to the Administrator of the Small Business Administration and the Director of the Office of Science and Technology Policy concerning the efforts of such department or agency to implement subsection 2(a) of this order.

Sec. 3. Duties of Administrator of the Small Business Administration . The Administrator of the Small Business Administration:

(a) shall establish, after consultation with the Director of the Office of Science and Technology Policy, formats and schedules for submission of reports by the heads of departments and agencies under subsection 2(b) of this order; and

(b) is authorized to issue to departments and agencies guidelines and directives (in addition to the formats and schedules under subsection 3(a)) as the Administrator determines from time to time are necessary to implement subsection 2(a) of this order, after such guidelines and directives are submitted to the President, through the Director of the Office of Science and Technology Policy, for approval and are approved by the President.

Sec. 4. Definitions. As used in this order:

(a) "Small Business Innovation Research (SBIR) program" means a program to which section 9(e)(4) of the Small Business Act (15 U.S.C. 638(e)(4)) refers;

(b) "Small Business Technology Transfer (STTR) program" means a program to which section 9(e)(6) of the Small Business Act (15 U.S.C. 638(e)(6)) refers;

(c) "research and development" means an activity set forth in section 9(e)(5) of the Small Business Act (15 U.S.C. 638(e)(5)); and

(d) "manufacturing-related" means relating to: (i) manufacturing processes, equipment and systems; or (ii) manufacturing workforce skills and protection.

Sec. 5. General Provisions. (a) Nothing in this order shall be construed to impair or otherwise affect the authority of the Director of the Office of Management and Budget with respect to budget, administrative, or legislative proposals.

(b) Nothing in this order shall be construed to require disclosure of information the disclosure of which is prohibited by law or by

Executive Order, including Executive Order 12958 of April 17, 1995, as amended.

(c) This order is intended only to improve the internal management of the executive branch and is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or in equity, against the United States, its departments, agencies, or other entities, its officers or employees, or any other person.

GEORGE W. BUSH
THE WHITE HOUSE,
February 24, 2004.

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APPENDIX K. PROPOSED LEGISLATION ON MANUFACTURING TECHNOLOGY

Subtitle D--High-Performance Defense Manufacturing Technology Research and Development

SEC. 231. RESEARCH AND DEVELOPMENT.

(a) IDENTIFICATION OF ENHANCED PROCESSES AND TECHNOLOGIES- The Under Secretary of the Defense for Acquisition, Technology, and Logistics shall identify advanced manufacturing processes and technologies whose utilization will achieve significant productivity and efficiency gains in the defense manufacturing base.

(b) RESEARCH AND DEVELOPMENT- The Under Secretary shall undertake research and development on processes and technologies identified under subsection (a) that addresses, in particular--

(1) innovative manufacturing processes and advanced technologies; and

(2) the creation of extended production enterprises using information technology and new business models.

(c) DEFENSE PRIORITIES- In undertaking research and development under subsection (b), the Under Secretary shall consider defense priorities established in the most current Joint Warfighting Science and Technology Plan.

SEC. 232. TRANSITION OF TRANSFORMATIONAL MANUFACTURING PROCESSES AND TECHNOLOGIES TO THE DEFENSE MANUFACTURING BASE.

(a) ACCELERATION OF TRANSITION FROM SCIENCE AND TECHNOLOGY-

(1) IN GENERAL- The Under Secretary of Defense for Acquisition, Technology, and Logistics shall undertake appropriate actions to accelerate the transition of transformational manufacturing technologies and processes (including processes and technologies identified under section 231) from the research stage to utilization by manufacturers in the defense manufacturing base.

(2) EXECUTION- The actions undertaken under paragraph (1) shall include a memorandum of understanding among the Director of Defense Research and Engineering, other appropriate elements of the Department of Defense, and the Joint Defense Manufacturing Technology Panel to accelerate the transition of technologies and processes as described in that paragraph.

(b) PROTOTYPES AND TESTBEDS-

(1) IN GENERAL- The Under Secretary shall, utilizing the Manufacturing Technology Program, undertake the development of prototypes and testbeds to promote the purposes of this section.

(2) COORDINATION OF ACTIVITIES- The Under Secretary shall coordinate activities under this subsection with activities under the Small Business Innovation Research Program and the Small Business Technology Transfer Program.

(c) DEVELOPMENT OF IMPROVEMENT PROCESS- The Under Secretary shall, in consultation with persons and organizations in the defense manufacturing base, develop and implement a program to continuously identify and utilize improvements and innovative processes in appropriate defense acquisition programs and by manufacturers in the defense manufacturing base.

(d) DIFFUSION OF ENHANCEMENTS INTO DEFENSE MANUFACTURING BASE- The Under Secretary shall ensure the utilization in industry of enhancements in productivity and efficiency identified by reason of activities under this subtitle through the following:

(1) Research and development activities under the Manufacturing Technology Program, including the establishment of public-private partnerships.

(2) Outreach through the Manufacturing Extension Partnership Program under memoranda of agreement, cooperative programs, and other appropriate arrangements.

(3) Coordination with activities under such other current programs for the dissemination of manufacturing technology as the Under Secretary considers appropriate.

(4) Identification of incentives for contractors in the defense manufacturing base to incorporate and utilize manufacturing enhancements in the manufacturing activities.

SEC. 233. MANUFACTURING TECHNOLOGY STRATEGIES.

(a) IN GENERAL- The Under Secretary of Defense for Acquisition, Technology, and Logistics may--

(1) identify an area of technology where the development of an industry-prepared roadmap for new manufacturing and technology processes applicable to defense manufacturing requirements would be beneficial to the Department of Defense; and

(2) establish a task force, and act in cooperation, with the private sector to map the strategy for the development of manufacturing processes and technologies needed to support technology development in the area identified under paragraph (1).

(b) COMMENCEMENT OF ROADMAPPING- The Under Secretary shall commence any roadmapping identified pursuant to subsection (a)(1) not later than January 2007.

SEC. 234. REPORT.

(a) IN GENERAL- Not later than December 31, 2007, the Under Secretary of the Defense for Acquisition, Technology, and Logistics shall submit to the congressional defense committees a report on the actions undertaken by the Under Secretary under this subtitle during fiscal year 2006.

(b) ELEMENTS- The report under subsection (a) shall include--

(1) a comprehensive description of the actions undertaken under this subtitle during fiscal year 2006;

(2) an assessment of effectiveness of such actions in enhancing research and development on manufacturing technologies and processes, and implementation of such within the defense manufacturing base; and

(3) such recommendations as the Under Secretary considers appropriate for additional actions to be undertaken in order to increase the effectiveness of the actions undertaken under this subtitle in enhancing manufacturing activities within the defense manufacturing base.

SEC. 235. DEFINITIONS.

In this subtitle:

(1) DEFENSE MANUFACTURING BASE- The term `defense manufacturing base' includes any supplier of the Department of Defense, including a supplier of raw materials.

(2) EXTENDED PRODUCTION ENTERPRISE- The term `extended production enterprise' means a system in which key entities, including entities engaged in product development, manufacturing, sourcing, and user entities, in the manufacturing chain are linked together through information technology and other means to promote efficiency and productivity.

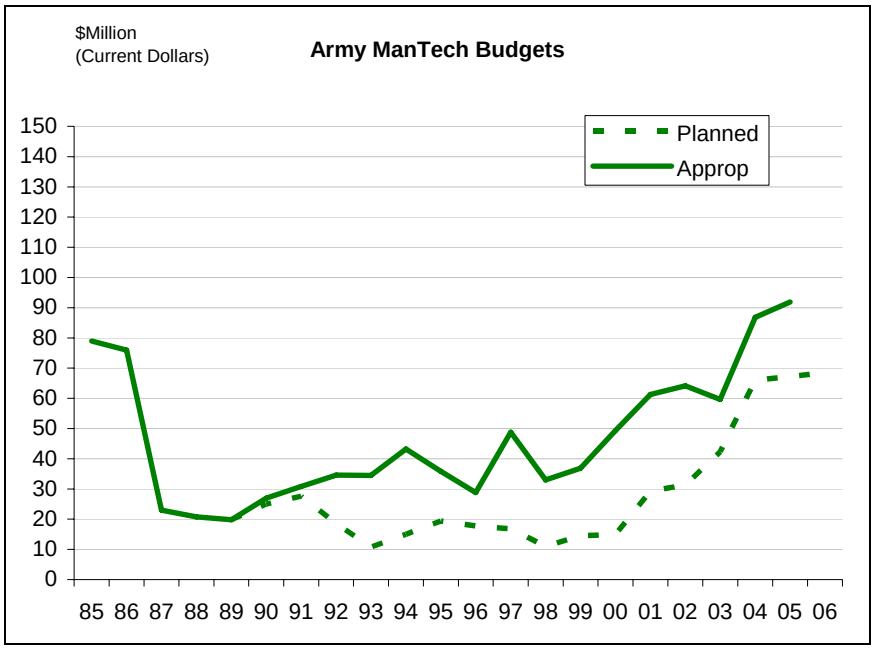
(3) MANUFACTURING EXTENSION PARTNERSHIP PROGRAM- The term `Manufacturing Extension Partnership Program' means the Manufacturing Extension Partnership Program of the Department of Commerce.

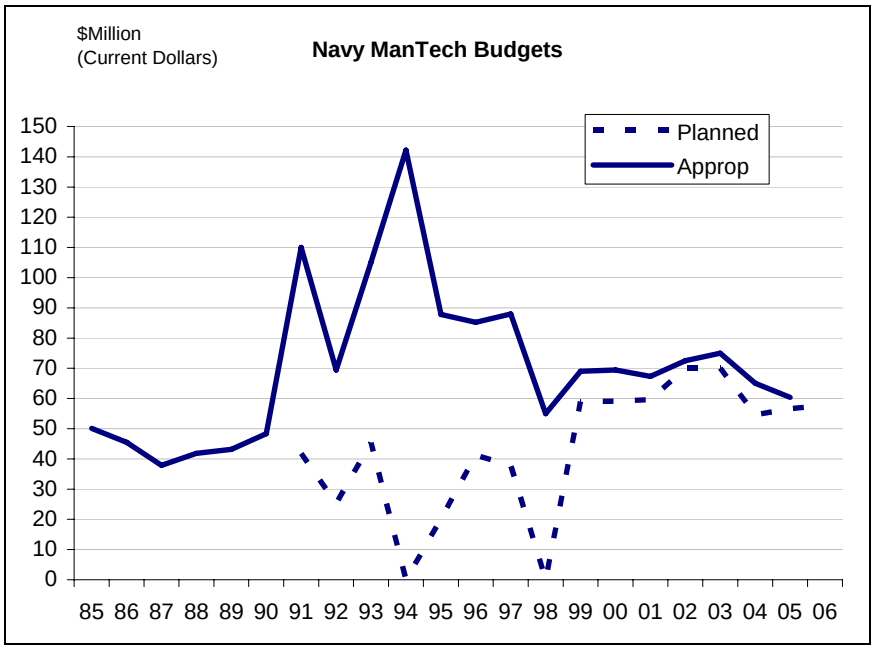
(4) MANUFACTURING TECHNOLOGY PROGRAM- The term `Manufacturing Technology Program' means the Manufacturing Technology Program under the Director of Defense Research and Engineering under section 2521 of title 10, United States Code.

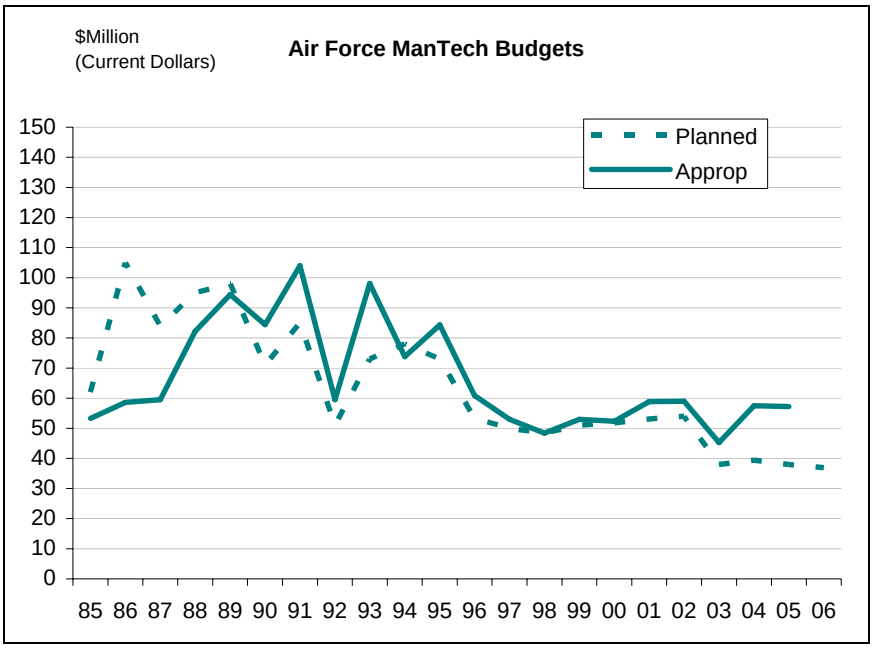
(5) SMALL BUSINESS INNOVATION RESEARCH PROGRAM- The term `Small Business Innovation Research Program' has the meaning given that term in section 2055 (11) of title 10, United States Code.

(6) SMALL BUSINESS TECHNOLOGY TRANSFER PROGRAM- The term `Small Business Technology Transfer Program' has the meaning given that term in section 2500 (12) of title 10, United States Code.

APPENDIX L. MANUFACTURING TECHNOLOGY PROGRAM BUDGET PROFILES






$Million
(Current Dollars)
Air Force ManTech Budgets
Planned
Approp
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120
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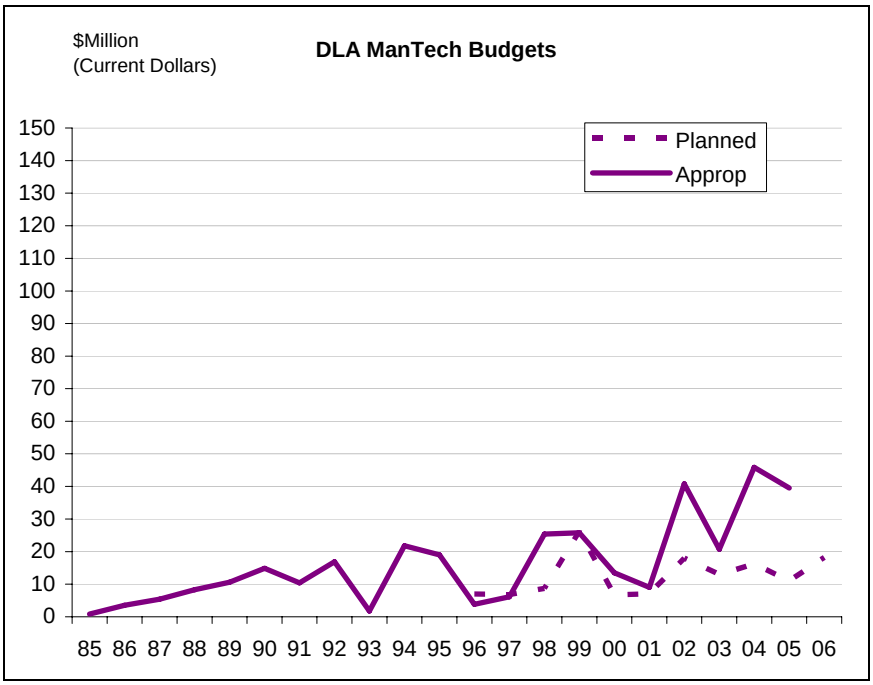
$Million
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APPENDIX M. COMPARISON OF MANTECH AND OTHER DOD BUDGETS

Figure M-1. DOD ManTech and Other Budget Comparisons
(millions of then year dollars)

	DOD MANTECH BUDGET	DOD R&D BUDGET	DOD MANTECH AS % OF R&D		DOD S&T BUDGET	DOD MANTECH AS % OF S&T
1980	142	14,021	1.01		2,885	4.92
1981	149	17,363	0.85		3,257	4.57
1982	206	20,848	0.98		3,757	5.48
1983	136	23,673	0.57		4,063	3.34
1984	151	27,935	0.54		4,394	3.43
1985	183	31,978	0.57		4,595	3.98
1986	184	35,000	0.52		4,780	3.84
1987	126	37,136	0.33		5,568	2.25
1988	153	38,126	0.40		5,720	2.67
1989	168	38,578	0.43		6,438	2.60
1990	175	37,869	0.46		5,843	2.99
1991	255	37,209	0.68		6,970	3.66
1992	180	37,779	0.47		7,181	2.51
1993	239	38,848	0.61		8,731	2.74
1994	281	35,510	0.79		7,660	3.66
1995	227	35,349	0.64		7,924	2.86
1996	179	35,783	0.49		7,534	2.37
1997	196	37,238	0.52		7,506	2.61
1998	162	37,569	0.43		7,715	2.09
1999	185	38,888	0.47		7,597	2.43
2000	185	39,960	0.46		8,269	2.23
2001	197	42,740	0.46		8,861	2.21
2002	236	49,877	0.47		9,874	2.39
2003	201	59,296	0.33		10,729	1.87
2004	255	65,948	0.38		12,081	2.11
2005	249	70,929	0.35		13,071	1.90
2006 (proj.)	694	69,356	1.00		13,500	5.13

APPENDIX N. GLOSSARY

AFMC	Air Force Materiel Command
AFRL/MLM	Air Force Research Laboratory, Materials & Manufacturing Directorate
ARL	Army Research Laboratory
ASD (NII)	Assistant Secretary of Defense for Networks and Information Integration
BMDS	Ballistic Missile Defense System
COE	Center of Excellence
DARPA	Defense Advanced Research Projects Agency
DDR&E	Director, Defense Research and Engineering
DLA	Defense Logistics Agency
DOD	Department of Defense
DSB	Defense Science Board
EMRL	Engineering Manufacturing Readiness Level
GAO	U.S. Government Accountability Office
JDMTP	Joint Defense Manufacturing Technology Panel
LAI	Lean Aircraft Initiative
LAIRCM	Large Aircraft Infrared Countermeasure
LRIP	Low-Rate Initial Production
ManTech	Manufacturing Technology
MDA	Missile Defense Agency
MDA	Model Driven Architecture
MDA/MP	Missile Defense Agency, Directorate for Producibility and Manufacturing Technology
MEMS	Microelectromechanical Systems
MRE	Meals Ready to Eat
MRL	Manufacturing Readiness Level
NSC	Natick Soldier Center
ONR	Office of Naval Research
OSD	Office of the Secretary of Defense
PEO	Program Executive Officer
PIM	Platform Independent Model
R&D	Research and Development
RDEC	[Army] Research, Development and Engineering Center
RDECOM	[Army] Research, Development and Engineering Command
RDT&E	Research, Development, Test, and Evaluation
S&T	Science and Technology

SAE	Service Acquisition Executive
SBIR	Small Business Innovation Research
STTR	Small Business Technology Transfer
TRL	Technology Readiness Level
USD (AT&L)	Under Secretary of Defense for Acquisition, Technology and Logistics
USD (P&R)	Under Secretary of Defense for Production and Readiness
X-UML	Executable Universal Modeling Language