The Air Force
Manufacturing Technology Program
Vision

Attaining Next Generation
Agile Manufacturing

September 2010
The Air Force Manufacturing Technology (ManTech) program is an Air Force corporate Science and Technology (S&T) activity and supports the overall Air Force S&T Strategy. This document describes this Air Force-wide role and the associated top level plans guiding ManTech program strategy implementation.

In that context, this vision charts an ambitious course. The hypercompetitive economic and technological environment of the 21st century has introduced vast new challenges for our defense technology and industrial bases. The pressures to develop, produce, and sustain world-class weapon systems across air, space, and cyberspace domains—and do so affordably, at ever-increasing response rates—are immense. Air Force system modernization and sustainment needs continue to accumulate, and a strained defense acquisition system coupled with heavy budget pressures further narrows leadership’s decision options. Additionally, there is a growing need to provide affordable technology to sustain the existing fleet, both at the Air Logistics Centers and in the field.

This is precisely the type of environment in which the Air Force ManTech program can deliver its greatest value to the Air Force and its supporting industrial base. The mission of Air Force ManTech—to strengthen defense manufacturing capabilities—and its force multiplier impact have never been more crucial than now. Further, the call to rapidly deliver affordable, pervasive manufacturing technology solutions focused on Air Force capability needs will only grow as the forms of conflict continue to multiply and technology challenges become more complex. These operational and industrial environments clearly demand innovation, speed, and agility at unprecedented levels.

Viewing these challenges as opportunity, the Air Force ManTech community energized a year-long strategic analysis effort that culminated in the enclosed vision. It is bold yet pragmatic in its approach as a useful, technology focused planning document. It will effectively guide ManTech investment over the next 15 years and beyond, while influencing near-term plans to ensure responsiveness to today’s fight as well as tomorrow’s. Regardless of your role within the defense manufacturing enterprise, this plan has relevance for you, and we welcome your engagement!

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Executive Summary

**Purpose.** For over sixty years since the birth of the US Air Force in 1947, the Air Force Manufacturing Technology (ManTech) program has played a pivotal role in developing and transitioning advanced manufacturing technologies to enable the delivery of critical capabilities to the warfighter, both in the acquisition and sustainment phases of a system’s life. This vision is a vehicle to help unify, align, and guide the AF ManTech program and its stakeholders in support of the program’s longstanding mission to make weapon systems more affordable and producible.

**Strategic Context.** The 2010 Quadrennial Defense Review Report describes the complex and evolving warfighter environment and then prominently discusses the need for a robust industrial base with sufficient manufacturing capability and capacity to preserve America’s technological edge and support the force. This continues the important industrial themes from the seminal 2006 Defense Science Board (DSB) Task Force Report on the DoD ManTech program and the DSB’s 2008 *Report on Defense Industrial Structure for Transformation*. Both reports drive home the imperative to transform the 20th century industrial base to meet 21st century modernization and sustainment challenges. An effective ManTech capability is clearly key to enabling that industrial base transformation which underpins corporate AF strategies (including the AF S&T Strategy) to fully enable AF Service Core Functions.

**The Mission.** The USC Title 10-derived mission of Air Force ManTech—*strengthening defense manufacturing capabilities*—is clear, vital, and enduring. Only through a strong and progressive US industrial base can the AF achieve more affordable and producible systems. This mission focus is enabled by a set of five “enduring mission priorities” namely, (1) *Manufacturing Assurance*, (2) *Manufacturing Innovation*, (3) *Affordable Acquisition*, (4) *Affordable Sustainment*, and (5) *Quality People and Infrastructure*. These priorities are brought to life in a dynamic and collaborative organization that is outwardly focused on a diverse stakeholder base.

**The Vision.** ManTech’s vision of *attaining next-generation agile manufacturing* is the heart of the program. The vision is both expansive and ambitious and reflects a studied review of stakeholder needs and AF priorities, coupled with a growing national consensus that an aggressive and transformative approach is necessary to meet 21st century industrial imperatives supporting AF capabilities. Four strategic thrusts summarize and embody this vision; namely: (1) *Moving Manufacturing Left*, (2) *A Cradle-to-Cradle Digital Thread*, (3) *A Responsive, Integrated Supply Base*, and (4) *Factory of the Future*. More specifically, the ManTech vision represented by these thrusts calls for the following: a greater awareness up front of manufacturing readiness issues and opportunities; highly innovative approaches to overcoming defense-unique production challenges across S&T, design, production, and sustainment phases of a system’s life cycle, seamlessly supported by world class digital information systems; the ability to rapidly produce smaller and smaller lots of more specialized systems, affordably, across globally interconnected supplier networks; as well as highly advanced physical manufacturing operations that intelligently manage environmental footprints and long term impacts. The agile manufacturing base defined by these strategic thrusts is not solely focused on affordability or speed of delivery, but more broadly, on pervasive and continuous adaptation in an environment of accelerating change and increasing complexity. Taken together, these thrusts form a mosaic of long-term influences shaping the program’s manufacturing technology roadmaps—roadmaps that represent critical implementation pathways to fully enable achievement of the vision.
Introduction

It is difficult to overstate the importance—to the Air Force and to this nation’s security—of a healthy and resilient defense manufacturing capability. Further, an effective manufacturing technology program that constantly hones the leading edges of that capability is vital to its future. Manufacturing technology overcomes the challenges of making affordable new defense products, or of making them within stringent budgets and schedules in-spite of demanding product performance characteristics. Additionally, ManTech provides affordable technologies for sustaining the existing fleet. Doing these well is paramount to the USAF in its role of equipping air, space and cyberspace forces. The following statement, taken from the seminal 2006 Defense Science Board (DSB) Task Force report on the Manufacturing Technology (ManTech) program, states the case this way:

...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.1

This statement not only underscores ManTech’s enormous—and proven—leveraging potential in support of the Air Force’s core science and technology development, system acquisition, and sustainment missions, but it implicitly challenges leaders, at all levels across the defense manufacturing enterprise, to aggressively capitalize on ManTech’s strengths. Indeed, the confluence of several major trends impacting defense manufacturing and the broader industrial base has now created the imperative, as never before, to maximize and leverage ManTech’s critical capabilities. In its 2008 task force report on Defense Industrial Structure for Transformation, the DSB captured the essence of this new environment and grand challenge when it stated that “the last two decades have seen a consolidation of the defense industry around 20th Century platforms. Looking ahead, the critical challenge for DoD is to employ its leadership and influence in transforming the defense industry around a 21st Century National Security Industrial structure.”2

A central objective of this vision is to define the technological underpinnings of a new, 21st century industrial vision3 and then map key transformational pathways to enable leadership at all levels within the Air Force and across industry to realize it. Achieving true industrial base transformation like that called for in the 2008 DSB report is daunting. Nonetheless, the 2009 DoD ManTech program Strategic Plan conceded that “manufacturing is so important to the nation that the ManTech community is sometimes looked to as the champion not only for defense manufacturing technologies, but for the entirety of the defense manufacturing enterprise or even for enhancing US global manufacturing competitiveness,” adding that these topics form an important strategic context for ManTech planning.4 Thus, while ManTech cannot single-handedly lead such a transformation; it is a vital component of any strategy to do so.

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1 DSB Study on Manufacturing Technology Program, 2006, pg iii.
3 The lead-off recommendation in the 2008 DSB task force report on Defense Industrial Structure for Transformation is to “Articulate a National Security Industrial Vision; adopt government policies to implement the Vision; structure incentives for industry to achieve the Vision; and monitor ongoing industrial dynamics to ensure its realization.”
4 DoD Manufacturing Technology Program Strategic Plan, March 2009, pg.1.
ManTech’s pivotal role for the Air Force and US industry is consistently demonstrated by the heritage of the program’s 60+ years of innovation and delivery of critical capabilities to the warfighter. Since the creation of the Air Force in 1947, ManTech has been a key force multiplier focused on advanced manufacturing processes and technology transition. Air Force ManTech was an early enabler for Air Force and DoD mobilization planning, critical / strategic materials / diminishing source remediation, and both government depot and private sector defense-unique industrial base capability creation. These early successes were followed by key transitions for composites manufacturing in the 1980s and beyond, “Lean” processes and high temperature turbine engines in the 1990s, and advanced radar components in the 2000s. The many Air Force ManTech program capability “firsts,” shown in the adjacent inset, reveal a nearly continuous output of innovations since WWII that in many cases have transformed entire defense industrial sectors and have spun off to other military and commercial applications with sometimes incalculable benefit.

Although the Air Force ManTech program has enjoyed remarkable success through the years, the success trend line must turn upward even more; the USAF’s future needs are too great, and ManTech’s importance in meeting them is too central. To this end, this vision, which represents the culmination of an intensive, one-year effort of stakeholder engagements, environmental surveys, data collection and trend analysis, and critical portfolio reviews, ensures that Air Force ManTech continues to deliver. The planning effort was one of serious program introspection and dialogue across the defense manufacturing community, leading to convergence on a disciplined--and exciting--path forward for the Air Force ManTech program. This path is defined by the new vision of Next Generation Agile Manufacturing and a supporting set of strategic thrusts that provide broad direction for the program’s technical investment roadmaps. This construct is designed to best position the Air Force 5, 10, and 15 or more years into the future, while creating the very real potential to drive dramatic, game-changing improvements to Air Force and broader industrial base capabilities. A positive transformational change can only occur, however, through leadership’s keen understanding of ManTech’s capabilities and potential, developed against the backdrop of today’s extremely dynamic global economic, technological, and industrial environments.

**Air Force ManTech “Firsts”**

**1950s**
- Numerical controlled (NC) machine tool (world premier, all modern AF and DoD weapon systems)
- Development of automatically programmed machine tool industry-wide standard language (APT)

**1960s**
- “Net-shape” manufacturing of aluminum, titanium, super alloy and depleted uranium parts
- Rapid, 3-D nondestructive inspection of large rocket motors (advanced Minuteman and later strategic and tactical missiles)

**1970s**
- Integrated Computer-Aided Design (ICAD) and Manufacturing (ICAM) concepts and methods
- Integrated Graphics Exchange Specifications (IGES) and Integrated Definition (IDEF) architecture and other standards

**1980s**
- Environmentally safe paint removal for aircraft maintenance
- ALC “retirement-for-cause” inspection of critical aircraft engine components, now widely deployed across the turbine engine sector
- Automated manufacturing process for advanced composite structures fabrication and repair; spin-off to sports and automotive industries

**1990s**
- Industry-wide (defense and commercial) definition and implementation of “Lean” concepts and practices
- Manufacture of titanium metal matrix composites
- Manufacture of enhanced yield solar cells

**2000s**
- Manufacture of microelectromechanical systems (MEMS) for inertial measurement units (IMU)
- Development of Engine Rotor Life Extension (ERLE) Program
- Key manufacturing improvements to active electronically scanned array (AESA) radar
- Innovative, laser shock peening surface treatment techniques
- Affordable, advanced ceramic matrix composite applications
- DoD leader in development and use of Manufacturing Readiness Levels (MRLs)
Strategic Context

America’s security and prosperity are increasingly linked with the health of our technology and industrial bases. In order to maintain our strategic advantage well into the future, the Department requires a consistent, realistic, and long-term strategy for shaping the structure and capabilities of the defense technology and industrial bases—a strategy that better accounts for the rapid evolution of commercial technology, as well as the unique requirements of ongoing conflicts.

- 2010 Quadrennial Defense Review (QDR) Report⁵

Understanding the layered complexity of the strategic environment and ManTech’s role within it is critical to effectively advancing the Air Force ManTech program’s mission toward its strategic vision, in concert with DoD and Air Force goals, direction, and resources. The 2010 QDR Report sets the current stage by describing the ongoing reform and reshaping of America’s military and then emphasizes the imperative to “have a robust industrial base with sufficient manufacturing capability and capacity to preserve our technological edge and provide for the reset and recapitalization of our force.”⁶ Advanced manufacturing technologies and capabilities supporting US military forces are thus prominently recognized for their considerable strategic importance to our national defense and military strategies.

The 2006 DSB study entitled The Manufacturing Technology Program: A Key to Affordably Equipping the Future Force was central to fostering this important, enterprise-wide refocusing on ManTech’s value. The report advocated for a strong ManTech program and called for a strategic plan and coordinated investment strategy.⁷ It noted that ManTech creates significant benefits for system affordability and timely delivery. It also recommended that ManTech activities become an integral part of the Science and Technology (S&T) programs within the military departments, confirming that manufacturing should be a central consideration in the systems engineering process.

The US Defense Manufacturing Environment

The strategic environment in which the Air Force operates is under constant change—from technology advances, the shifting global industrial base, or updates to defense policy guidance. The ManTech Strategic Vision was created to take full advantage of the current and future trends in the DoD and industrial base environment and deliver robust manufacturing capabilities in the midst of change. Recent modifications to the Defense Acquisition System shift the manufacturing focus earlier in the acquisition process, and the ManTech program has a key responsibility to help the defense acquisition enterprise sharpen that focus by assessing manufacturing readiness and closing technology gaps.

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⁵ QDR Report, February 2010, Executive Summary, Strengthening the Industrial Base, pg xv.
⁶ QDR Report, February 2010, pg 103.
⁷ DSB Study on Manufacturing Technology Program, 2006, pg v.
Key examples of this shift in defense guidance can be shown relative to the new Defense Acquisition Framework (see Figure 1) in which additional manufacturing activities are explicitly aligned with specific acquisition phases. During the Material Solution Analysis phase, the Analysis of Alternatives is now required to assess the “manufacturing feasibility” of each proposed solution. Further, the exit criteria for the Technology Development phase requires that “…manufacturing processes for that program or increment have been assessed and demonstrated in a relevant environment,” which matches the definition of Manufacturing Readiness Level 6. New guidance for the Engineering and Manufacturing Development (EMD) phase similarly calls for additional program management attention on manufacturing, with a stated purpose to “…develop an affordable and executable manufacturing process…,” requiring the Critical Design Review (CDR) to demonstrate “the maturity of critical manufacturing processes,” and the EMD exit criteria calling for “…manufacturing processes being effectively demonstrated in a pilot line environment.” These substantial changes to foundational DoD acquisition policy demonstrate a growing focus on early manufacturing efforts. Before considering DoD and Air Force guidance, a review of the key global and technological trends is in order.

**Strategic Trends: A Global Perspective**

Globalization increasingly impacts the fielding and sustainment of military systems. The offshore flight of many manufacturing sectors leaves the domestic manufacturing capability small or nonexistent, and the US is no longer the global leader in all military technologies. For example, the US share of printed circuit boards has fallen from 30 percent to seven percent in one decade, and the DoD share of electronics components in 2006 was less than one percent. This situation forces the US military to either adopt COTS strategies or invest in lengthy development programs with small lot sizes and no dual use partners, driving cost exponentially. In many cases, COTS solutions represent greater capabilities due to the rapid cycle time of commercial technologies but don’t meet military unique requirements. A critical need to combat this trend are manufacturing technologies which level the playing field and enable domestic manufacturing of advanced technologies in small lots and custom configurations.

Another global trend with significant strategic impact for the Air Force is the growing, worldwide focus on environmental issues and the associated government regulations and mandates. The European Union mandated lead-free electronics creating a global electronics marketplace with lead-free components not suitable for defense applications. This highlights the impact of being dependent upon global supply chains which cannot be controlled by domestic policy or requirements.

To be responsive to Air Force needs and to gain access to the best manufacturing technologies, the ManTech program must understand the global economy and industrial base capabilities and then selectively reinforce or develop US-based industrial capabilities as needed. The key for success is to be fully

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cognizant of the dynamics of globalization and its effects, and take full advantage of its benefits while mitigating potential vulnerabilities and risks to the US industrial base and military systems.

**Strategic Trends: Technological Challenges**

Today, innovation has never been more crucial for fielding new capabilities, particularly considering the need to rapidly deliver technologies to warfighters to match the quick cycle of today’s forms of warfare. The Air Force is experiencing increasing demands on its various core functions, and rapid-response technology solutions are necessary. Ten- and 15-year development cycles are unacceptable. Today’s environment demands quick, innovative solutions and, specifically, technology-driven solutions. Whether these responses result in dramatic surges to unmanned aerial vehicle (UAV) production, persistent ISR sensors, or long range precision munitions, Air Force leadership is looking to remove the traditional barriers slowing technology advances that could be used to provide affordable capabilities for the warfighter.

Technical manufacturing challenges are ever-evolving and may be linked to advanced materials, processes, components, sensors, advanced warfighter technologies, or fabrication and assembly processes as part of factory operations. In order to take advantage of research in advanced sciences and technologies, such as nanomaterial, high temperature ceramic matrix composite, hybrid- and metal-matrix material, multifunctional material, or low-temp cure composite components, sensors and structures, considerable technical barriers in producing, processing and even handling these materials and commodities must be overcome. Similarly, warfighter-driven advanced weapon systems such as UAVs, directed energy systems, long-range strike or persistent ISR systems all present significant fabrication and assembly challenges before development and affordable production can be successful. Sustainment of legacy systems with more affordable manufacturing/repair/overhaul processes will remain a top AF priority.

Finally, factory operations and system assembly represent a wide range of opportunities to apply manufacturing technologies in order to meet service needs, spanning future production approaches to distributed, network-centric manufacturing, direct-digital production tooling, energy lean factories, and tool-less assembly. Manufacturing technologies also represent vital enablers for longer-range next-generation Air Force capabilities, as described in the 2010 USAF “Technology Horizons” study, including hyperprecision munitions, cybertechnology, hypersonics, microinertial navigation systems, and spectrum management. Central to all of these technical challenges is determining the extent to which manufacturing processes or industrial base capabilities are needed to resolve them.

**Strategic Planning Guidance and Influences**

As depicted in Figure 2, the AF ManTech Vision is guided and influenced by many inputs: Congressional and Administration intent, relevant higher-level strategic plans (in particular, the DoD ManTech program, US Air Force, and AFRL strategic plans), and an extremely diverse stakeholder base, including the R&D enterprise, acquisition and logistical & sustainment customer programs, the operational community, and numerous interests across industry and academia. This landscape forms the complex set of inputs that the Air Force ManTech program must effectively assess and respond to when shaping investment decisions. This landscape is presented in more detail next.

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Key Linkages to Strategic Guidance

The DoD ManTech program published its strategic plan in March 2009, establishing a vision appropriate for the overall mission of the Defense Manufacturing Technology program as established by Title 10 and comprised of the component ManTech programs from OSD, the military departments, and participating defense agencies. In describing the program’s mission, the plan states that ManTech anticipates and closes gaps in manufacturing capabilities for affordable, timely, and low-risk development, production and sustainment of defense systems. Although the plan, consistent with the Title 10 mandate, set guidelines for the components to refine their own ManTech programs, a unique aspect of the DoD ManTech strategy was in the definition of four strategic thrusts which lead to the realization of its vision. The core thrust called for effective management and delivery of processing and fabrication solutions. However, three additional thrusts support a highly connected defense manufacturing enterprise, a strong institutional focus on manufacturability and process maturity, and an effective manufacturing infrastructure and workforce. These strategic thrusts are also consistent with the recently stated objectives for the industrial base in the 2010 QDR Report. The Air Force ManTech Vision implements and complements the relevant elements of the DoD thrusts while focusing particularly on the on the air, space, and cyber-space industrial base requirements.

The corporate Air Force Strategic Plan establishes a vision for the US Air Force as a trusted and reliable joint partner, providing compelling air, space, and cyber capabilities. The Air Force will excel as stewards of resources while providing precise and reliable Global Vigilance, Reach and Power for the Nation. The plan sets five priorities: 1) Reinvigorate the Air Force Nuclear Enterprise, 2) Partner with the Joint and Coalition Team to Win Today’s Fight, 3) Develop and Care for Airmen and Their Families, 4) Modernize Our Air and Space Inventories, Organizations and Training, and 5) Acquisition Excellence. Although the Air Force Strategic Plan does not describe specific manufacturing capabilities required from AF ManTech, it does present a set of AF Core Functions that AF ManTech must strive to support and a clear set of priorities which heavily influence the AF S&T Strategy and ManTech Vision. In particular, priorities four and five will depend a great deal on the technical capabilities and manufacturing knowledge of the acqui-

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10 Title 10 USC, Subtitle A, Part IV, Chapter 148, Sec. 2521, “Manufacturing Technology Program.”
sition corps and the industrial base. Specifically, modernization of air and space inventories place a compelling significance on rapid and affordable production, the stalwarts of effective manufacturing capability.

Acquisition Excellence is also a priority for the Air Force, (and DoD), leading to significant revisions in the DoDI 5000.02 defense acquisition regulation, as discussed previously. The purpose behind this revision was to reduce the record cost growth experienced by Major Defense Acquisition Programs (MDAPs), since immature technology and lack of manufacturing readiness were identified as a root cause. These improvement efforts clearly shift manufacturing focus to earlier in the acquisition process, and the ManTech program’s ongoing focus on closing manufacturing technology capability gaps is thus a critical element of DoD’s solution to its growing affordability and acquisition timeliness challenges. The AF ManTech strategy encourages partnering with S&T programs to align manufacturing development with ongoing technology development as well as direct engagement with acquisition programs of record to apply pervasive manufacturing technological solutions. Further, the ManTech community has led the development of Manufacturing Readiness Levels (MRLs), backed by timely Manufacturing Readiness Assessments (MRAs), providing a clearer path to effective acquisition strategies, sound source selection, and realistic estimates of cost and schedule.

The Air Force Science and Technology (S&T) Vision is to “create compelling air, space, and cyber capabilities for precise and reliable Global Vigilance, Reach and Power for our Nation.” Associated with this vision, AF leadership has established several tenets and priorities that serve as direct guidance for the AF S&T program. These priorities are readily supported by the Title 10 ManTech charter that drives ManTech to be both a powerful S&T transition partner and a driver of S&T advances for US manufacturing capability. For example, the draft AF S&T Strategy places specific emphasis on improving affordability of AF assets and legacy weapon systems, reducing cyber vulnerabilities, enabling long-range precision and persistent strike and surveillance, reducing energy dependency, accelerating technology transition, and assessing technology maturity. All of these priorities are supported explicitly by the current ManTech program, and this vision will serve to further advance them over the long term. Additionally, high priority warfighter materiel gaps will be addressed by AFRL’s emerging Flagship Capability Concepts, and the ManTech Vision supports that construct well. The Air Force ManTech Vision will remain carefully aligned with the AF S&T strategy and will help set the balance of emerging manufacturing technology requirements from other laboratory, acquisition, and sustainment programs.

**Stakeholder Needs and Priorities**

The Air Force ManTech program uniquely supports and collaborates with a broad population of stakeholders within the government and industry, including higher headquarters, S&T programs, acquisition programs, air logistics centers, joint service programs, industry contractors and original equipment manufacturers, and academia; in fact, the entire defense supply chain. The Air Force ManTech community actively engages with various customer and stakeholder communities throughout the year on a continual basis to gather requirements and opportunities. Examples of these engagements include MRAs on selected Advanced Technology Demonstrations (ATDs) and acquisition programs of record, industry IR&D plan reviews, technology maturation/transition studies and analyses, Industrial Base Assessments, and AFMC Product/Logistic Center S&T/ManTech site visits.

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In an attempt to efficiently gather a broad representation of aerospace industry perspectives and priorities, AFRL’s Manufacturing Technology Division (AFRL/RXM) organized and conducted a three-day, industry-government-academia workshop to help shape this vision. The workshop, held in March 2009, involved nearly 120 invited participants. Analysis of the workshop results yielded 15 high-level trends spanning topics from globalization of supply chains to increasingly crucial technologies to emerging manufacturing approaches affecting the defense industrial base. A final synthesis of the workshop outputs identified several emerging, strategic manufacturing opportunities that could enhance AF industrial base capabilities over the next 15 years. A more complete description of the derived trends and opportunities is provided in Annex C.

The workshop results, coupled with the National Security, DoD and Air Force guidance and influences, converged on a targeted set of pervasive, strategic issues facing the manufacturing community. These vital issues, consisting of global trends, Air Force priorities, customer requirements, and technical challenges, were synthesized to form the basis for the strategy presented herein.
The Mission

The Secretary of Defense shall establish a Manufacturing Technology Program to further the national security objectives ... 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.

- Title 10 United States Code (USC), Section 2521
  “Manufacturing Technology Program”

Air Force ManTech’s Mission: Strengthening Defense Manufacturing Capabilities

Chartered under USC Title 10, the mission of the Air Force Manufacturing Technology program can be distilled down to: “Strengthening defense manufacturing capabilities.” Central to this mission is development of pervasive, multi-application technologies focused on Air Force capability needs. Delivering on this vital mission requires a robust and resilient program that will not only lead in the discovery of new manufacturing capabilities and efficiencies for defense systems, but ultimately lead in transitioning those discoveries to the factory floor rapidly and affordably. These projects typically represent a higher risk than industry is prepared to accept, making Air Force investment appropriate.

Department of Defense Directive 4200.15 further defines this essential, continuing mission by requiring the Department and its component ManTech programs to:

- Aid in the economical and timely acquisition and sustainment of weapon systems and components
- Ensure that advanced manufacturing processes, techniques, and equipment are available for reducing DoD materiel acquisition, maintenance and repair costs
- Advance the maturity of manufacturing processes to bridge the gap from research and development advances to full scale production
- 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
- Ensure that manufacturing technologies used to produce DoD materiel are consistent with safety and environmental considerations and energy conservation objectives
- Provide for the dissemination of program results throughout the Industrial Base
- Sustain and enhance the skills and capabilities of the manufacturing work force, and promote high levels of worker education and training
The Air Force ManTech program is structured to be able to address all of these requirements if adequate resources are available. Resource adequacy entails extensive requirements analysis, business case-based investment planning, compelling advocacy, and rigorous program/project management discipline for realizing advertised returns on investment for achieving timely, high quality, affordable production and sustainment of Air Force systems.

**Enduring Mission Priorities**

Underpinning Air Force ManTech’s mission are five enduring mission priorities that embody the long term purposes of the ManTech program. These priorities are Manufacturing Assurance, Manufacturing Innovation, Affordable Acquisition, Affordable Sustainment, and Quality People and Infrastructure. Each one is briefly summarized next.

**Manufacturing Assurance**

Ensure aerospace industrial and manufacturing readiness for warfighter access to affordable, quality, and reliable warfighting materiel. This priority points to the essential need to maintain constant situation awareness of the present and future industrial base needs of the AF and develop investments to address them. This priority requires ManTech to develop and implement pervasive manufacturing technologies (such as for evolving directed energy or unmanned air systems) at various levels in the supply chain and foster the development of alternative competitive new sources for advanced weapon systems. This is accomplished through systematic application of industrial readiness best practices and ManTech manufacturing readiness technical and analytical competencies.

**Manufacturing Innovation**

Pursue game-changing manufacturing technologies which have the potential to transform aerospace industrial base capabilities. This priority calls for ManTech to pursue disruptive, revolutionary manufacturing technologies to produce affordable, timely weapon systems and components. These technologies are often high-risk, pervasive industrial base advances that require ManTech leadership. Some example areas expected to be pursued include virtual manufacturing, model based enterprise advancements, and novel manufacturing processes for nano-scale and bio-inspired technologies. In order to be ready for the next revolutionary & evolutionary technology changes, AF ManTech must aggressively engage in technology exploration early in the S&T innovation/maturation process and become an integral part of it.

**Affordable Acquisition**

Shift manufacturing considerations earlier in the acquisition framework and be a transition catalyst for S&T. This priority is focused on encouraging application of quantitative Manufacturing Readiness Assessments earlier in the acquisition cycle (pre-Milestone A & B) to identify key manufacturing risks as well as investing in transition of key S&T technologies that are high impact, particularly for larger ACAT programs. ManTech partnering with PEO programs of record on pervasive, strategic manufacturing is-
Sues and opportunities that affect cost, schedule, performance, and sustainability will be key to success. Recent examples of these types of investments include transition of more durable, lighter weight ceramic matrix composites for turbine engines and microelectromechanical systems for lower cost, smaller package guidance components. Expected investments in this area include maturing direct digital manufacturing, rapid prototyping for airframe structures, and advanced solar cells for space systems.

**Affordable Sustainment**

**Develop manufacturing technologies to increase affordability, availability and performance of fielded systems.** This priority is the analog of the affordable acquisition one, as applied to legacy (sustainment) systems. Technology advances in manufacturing or re-manufacturing, repair, and overhaul of legacy systems must be brought to bear to greatly control the life cycle cost and cycle time of depot overhaul and maintenance processes, on-system, such as aircraft repair. This can take the form of S&T transition or process improvement initiatives tailored to limited numbers of discreet systems and/or subsystems and their components. A recent example of this was the application of lean principles to WR-ALC C-5 and F-15 programmed depot maintenance lines. Expected investments in this area include transition of embedded system health monitoring sensors and condition based maintenance prognostics to both the system in-depot and the ALC infrastructure for subsequent broad applicability.

**Quality People & Infrastructure**

**Develop and maintain a right-sized, competent workforce; efficient business practices; and quality facilities.** Similar to the diversity of its organization, the AF ManTech program requires a diverse blend of technical competencies to perform its mission. Its workforce manufacturing skills and experience are overlaid on a knowledge base of classical science, technology and engineering disciplines like physics, chemistry, mechanical/chemical/electrical materials engineering and industrial engineering and industrial enterprise operations research, etc. In the aggregate, these skills and knowledge reflect a unique set of S&T core technical competencies to carry out the Air Force ManTech mission and strategic vision. This priority reflects ManTech’s commitment to develop the workforce in concert with the technological needs represented in the other priorities. In addition, ManTech will maintain leading edge MRA and industrial base analysis processes to ensure superior industrial capability situation awareness and application to Air Force systems.

The Air Force ManTech program’s priority focus on quality people and skills directly relates to a required supporting organizational structure. The Manufacturing Technology Division in AFRL’s Materials and Manufacturing Directorate (AFRL/RXM) has assigned overall program execution responsibilities, under the oversight of the Air Force Research Laboratory and the office of the Deputy Assistant Secretary of the Air Force for Science, Technology, and Engineering (SAF/AQR). The program features active partnership with the Joint Defense Manufacturing Technology Panel (JDMTP, a DoD chartered Joint Service coordinating body of peer service/agency ManTech program directors), with appointed industry and academic representation. Residing within the ManTech Division of the AFRL Materials and Manufacturing Directorate and consisting of three branches (Integration and Technology, Processing and Fabrication, and Electronics), the organization’s manufacturing skills and experience are uniquely situated to leverage related S&T programs, disciplines and skills. A more comprehensive description of the ManTech program, organizational structure and technical competencies, can be found in Annex A.
The Vision…and Pathways to Achieve It

The Air Force ManTech Vision: Attaining Next Generation Agile Manufacturing

The Air Force vision, to be a trusted and reliable joint partner and provide compelling air, space, and cyber capabilities, directly hinges upon the capabilities of the defense industrial base. The AF ManTech program is a key investment program ranging across the entire industrial base. This wide influence affords substantive opportunities to transform the industrial base. In this role, the AF ManTech program is in a unique position to realize a vision of attaining next generation agile manufacturing.

This expansive vision contains several components, each of which is critical to the future manufacturing enterprise. An agile manufacturing base does not solely emphasize speed of delivery, but also the capability within the manufacturing community to quickly react to changing conditions or requirements. Flexibility in system alternatives and lower technology transition risk is aided through constant monitoring of new emerging technologies and innovative procedures. Next generation manufacturing is as much about the discovery of advanced technologies, such as virtual manufacturing, as innovative approaches to overcome defense-unique production challenges, such as low-volume, high-mix fabrication or modeling surge responses for supplier networks.

Tomorrow’s Air Force will operate in an increasingly information-intensive world, and capturing salient aspects of S&T, design, production, and sustainment in a seamless digital thread environment ensures agile, efficient life cycle management of products delivered to the warfighter. The product realization enterprise will face increasing pressure to maintain financial viability while producing smaller lots of more specialized systems in a globally interconnected network of suppliers. Manufacturing enterprises must understand and manage their environmental footprint, and designers will be constrained to utilize material systems for which the long-term impacts can be quantified. An industrial base with these traits will be strong and robust enough to weather global trends and affordably and rapidly equip the future Air Force.
Strategic Thrusts

The Air Force ManTech Vision is predicated upon a set of strategic thrusts which are immutable with respect to industrial base transformation to agility. Yet, while each of these thrusts is necessary, they alone are not sufficient to achieve the vision. Air Force and industry leadership, as well as considerable technical effort, investment, and acceptance throughout the defense manufacturing enterprise will be required to completely realize this vision.

Moving Manufacturing Left

In response to the overwhelming mandate from DoD and the Air Force leadership—to get the up-front system engineering correct, and only allow development to proceed when the design, technologies, and manufacturing have been sufficiently established and demonstrated—moving manufacturing left captures a philosophical change in the way manufacturing implications are regarded during acquisition and support. To adequately control integration risk, concept development must give ample consideration to downstream manufacturing cost and schedule, and manufacturing technology activities should parallel ongoing laboratory research and development in such a manner that technologies are delivered to programs “ready for insertion.” A significant portion of cost and schedule overruns on major DoD programs when entering LRIP can be reduced or avoided altogether by earlier consideration of manufacturing ramifications (cost, quality, supply chain). This thrust has two distinct elements: 1) Application of tools and expertise that promote early consideration of manufacturing implications during selection of major design solutions and 2) Concurrent identification of promising manufacturing processes for S&T discovery, followed by rapid, parallel maturation. The former is dominated by a need for better decision support during analysis of alternatives, the latter by a widening of the aperture for ManTech planning.

ManTech will promote early development of game-changing manufacturing technologies through partnerships with academia and small business on high-risk/high-payoff opportunities, and will sponsor collaborative, rapid prototyping capabilities for manufacturing research. The near-term objectives will build upon the existing manufacturing readiness competency to develop design tools that support manufacturability trades and feasibility assessment during pre-Milestone A activities and energize a manufacturing research component within the AF program.

A Cradle-to-Cradle Digital Thread

A core element of the future industrial base is the concept of a digital thread, defined as technologies that enable all participants and contributors to the weapon system, at any point of the life-cycle, to access the same computer-based technical description of the product. This technical description refers pertinent product and process data, such as design concept, 3-D geometry, material specifications, manufacturing tool paths, simulation performance, engineering analysis, logistics activities, or reliability estimates. Cradle-to-cradle refers to a design and development philosophy that considers the en-
tire product life cycle value stream, including the potential reusability of each material and component and the impact on the environment. Thus, the core goal of this thrust is the ever-present access to a single, digital representation of a system design throughout all potential uses and re-uses of the material.

The agile industrial base of tomorrow will be fueled by information. The digital definition of the product and all knowledge created during the design, fabrication, assembly, test, operation, maintenance, and disposal must become a single “thread” connecting all of these lifecycle stages and the disparate entities that execute during those stages. Constant access to a single, digital definition that can be used in various levels of modeling and simulation will drive huge decreases in cost and time and allow better optimization of highly complex tradeoffs. The integrity of data supporting sustainment, modification, and reuse will have huge payoffs through the lifecycle.

Essential attributes to be pursued include a commitment to capturing, organizing, and storing relevant data (e.g., product lifecycle management), physics based models for manufacturing technologies developed and demonstrated for all life cycle aspects of performance and material reuse, and the capability for distributed, multipurpose collaboration. Required tools must be developed for capture of utilization data, including as-designed, as-built materials, and service/operational environment history traced to the component level. These models and information can be closely linked to improved analysis of alternatives prior to Milestone A and are essential for long-term sustainment objectives such as health monitoring and condition-based maintenance.

**A Responsive, Integrated Supply Base**

The vision of an agile manufacturing base embraces the notion that the product realization enterprise can be assembled relatively quickly, possibly across sectors and international boundaries. The defense industrial base consists of a very few prime contractors whose role has become focused on formation of partnerships and systems integration, while the great many second and third-tier suppliers, all of which require the ability to operate collaboratively, handle more and more detailed design and component/subsystem manufacturing. The Air Force as a customer requires a new toolset featuring the capabilities for analyzing, identifying, and managing risks and critical issues in tomorrow’s responsive, integrated industrial base.

Delivering rapid response requires that the Air Force have manageable access to and management of the future industrial base, with capability to identify and form agreements quickly with suppliers whose capabilities and availability are known. Underpinning this agility will be tools and resources for better insight into suppliers’ self-declared process capabilities, certification of those capabilities, cost models, and quality data. A new set of supply chain management principles will lend structure and accountability to relationships from the warfighter to the smallest supplier, and furnish predictive models for the life cycle. Supply chains for new product development can be evaluated and designed as part of the product to avoid unforeseen capability issues or material shortages. Risk analysis through the supply chain will be a regular and valued exercise shared by prime contractors, acquiring offices, and the sustainment community.
Factory of the Future

Each of the thrusts provides a contextual element to meet the vision; "moving manufacturing left" provides the early manufacturing design rigor, the "digital thread" provides the single-point access to anyone needing to conceive, model or manufacture components, and the "responsive supply base" can provide a door to an integrated and visible network of qualified suppliers. The final link is the ability to most effectively produce items using the most advanced processing, fabrication and assembly processes. This is the "factory of the future," and it embraces the vital 21st century ideal of economy of scope: insensitive to production volume or specific product characteristics. This factory leverages advanced technologies to be platform flexible with real integration of above-shop-floor information.

This thrust attacks a key cost and schedule driver of defense manufacturing: small production volume of highly tailored components. It delivers agility by leveraging lot-size neutral fabrication processes; tool-less processes; and reconfigurable tools, fixtures, and assembly jigs. Teams of smaller, multifunctional robotic fixtures will provide precision featuring and control of machine operations. Factory floor execution will be highly autonomous, based on controls built into the build package and available via the "digital thread." Quality and cost will be highly predictable, through modeling of the manufacturing processes and supply base. Machines will use direct digital manufacturing where possible. After proving these capabilities, parts design can be self-located, allowing wide application of self-correction assembly processes with no loss of precision. Machines will be capable of monitoring their own performance, self-correcting where necessary, and scheduling their own preventive maintenance. Sustainable manufacturing technologies will be implemented at both the shop-floor and enterprise level to optimize energy footprints and use environmentally sustainable processes. Small-lot size manufacturing capability will allow the factory of the future to quickly respond to acquisition requirements and turnaround replacement parts for legacy systems.

Operational Pathways: Manufacturing Technology Roadmaps

The lifeblood of the Air Force ManTech program is its exceptional experience and knowledge across a broad range of technologies. Operationalizing this expertise in a way that both accomplishes today's mission and anticipates the future requires a detailed, robust planning process and a sustained commitment to pushing the envelope. Central to this planning process is the construction and constant review of manufacturing technology roadmaps, which capture the ManTech Vision and goals for ManTech's chosen technology application areas (see inset for listing). They represent, necessarily, the most dynamic content of this plan in that they must be agile, accounting for updated strategic

<table>
<thead>
<tr>
<th>Air Force Manufacturing Technology Roadmaps</th>
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<tbody>
<tr>
<td>Advanced Manufacturing Enterprise</td>
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<tr>
<td>o Virtual Manufacturing</td>
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<tr>
<td>o Integrated Enterprise--complex, market-level information</td>
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<tr>
<td>o Advanced manufacturing operations</td>
</tr>
<tr>
<td>Propulsion Manufacturing</td>
</tr>
<tr>
<td>o High perf. turbines, increased fuel efficiency</td>
</tr>
<tr>
<td>o Ramjet, Scramjet, Pulsed Detonation</td>
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<tr>
<td>o Advanced UAV, launch vehicle applications</td>
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<tr>
<td>Aerospace Structures Manufacturing</td>
</tr>
<tr>
<td>o Reduced aero structure manufacturing costs and lead times</td>
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<tr>
<td>o Raise Manufacturing Readiness Levels</td>
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<tr>
<td>o Scale-up innovative and/or advanced airframe materials and manufacturing processes</td>
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<tr>
<td>C4ISR Manufacturing</td>
</tr>
<tr>
<td>o Closing C4ISR technology manuf. gaps</td>
</tr>
<tr>
<td>o Radar, datalinks, communications systems, solar cells, optical interconnects, sensors</td>
</tr>
<tr>
<td>o Airborne &amp; Space platforms; manned/unmanned platforms</td>
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(continued on next page)
context, technology breakthroughs, etc. Each roadmap serves as a pathway to accomplish the broad technological goals within various manufacturing sectors and represents a roughly 15-year integrated view of the manufacturing technology goals, investments, partnerships, and transitions.

Core manufacturing technology roadmap areas include: Advanced Manufacturing Enterprise (AME), Propulsion, Aerospace Structures, C4ISR, Armament, and Sustainment / Readiness. The specific roadmaps and more detailed narrative explanations of each are included in Annex B.

Toward the Vision: An Integrated View

The core focus of the vision begins with deploying the vision and thrusts through strategic communications and other means. The thrusts provide a steady and guiding influence on program planning and execution through manufacturing roadmaps and subsequently the annual business plan, as shown in Figure 3:

- **Armament Manufacturing**
  - Hard Target Defeat—new/hardened materials, fuzing, enhanced penetrators
  - Advanced Dual Role Missiles
  - Mini/Micro Precision Strike—maximum lethality, minimum collateral damage
- **Sustainment / Readiness**
  - Increased maintenance efficiencies, decreased down time
  - Innovative energy solutions
  - Processes to enhance the High Velocity Maintenance (HVM) Program

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**Figure 3: Strategic Linkage across Vision, Mission, and Manufacturing Technology Roadmaps**
3. Additionally, the thrusts have a cross cutting linkage with the mission, with opportunities to realize the vision associated with each of the enduring mission priorities. The cycle is completed through periodic assessment and adjustment, in which leadership reviews progress towards desired outcomes and proposes adjustments in program plans or roadmap objectives. This process highlights the enduring and pervasive nature of the thrusts, which will gradually become “filters” through which the roadmaps shape the technical objectives and scope of individual projects. Through this process, the long-term vision is realized, fully enabling the delivery of specific results to S&T, acquisition, and sustainment customers.

**Influence on Roadmaps**

An important element of this vision is the influence of the strategic thrusts on future program plans. Just as the vision is linked to (enabled by) the thrusts, an important relationship exists between the strategic thrusts and the technical goals and projects within the manufacturing technology roadmaps. The strategic thrusts provide broad direction for the roadmaps. The roadmaps enable delivery of capabilities aligned to the thrusts, hence driving the program toward attainment of the vision. Each roadmap will be shaped by the thrusts diversely, with some aligned with all four strategic thrusts, while others have more pronounced dependencies on particular thrusts.

**Advanced Manufacturing Enterprise.** AME developments are central to the four strategic thrusts. Conceptualization and design advisor tools enable manufacturing consideration during early design when potential cost savings are greatest. A cradle-to-cradle approach requires lifecycle management that can only be achieve through advanced modeling. Cost, risk, data integrity, process repeatability, and environmental impacts must all be modeled and optimized in a multivariate, dynamic environment which is the foundation for the “digital thread.” AME tools are required to provide real-time collaboration between the entire AF supply network. Risks will need to be modeled with costs and lead times, and supply base capabilities must be transparent to accurately assess agility. Rapid response operations require high levels of production flexibility, adaptive control of processes and robotics, and increased direct digital manufacturing, all of which heavily rely upon advanced modeling capabilities.

**Propulsion Manufacturing.** Moving manufacturing left in the propulsion arena involves investing in the science basis for additive manufacturing technologies as well as consideration of affordability and producibility during new propulsion technology development, including improved manufacturing readiness of ceramic matrix composites and ceramic bearings. The digital thread will be augmented by physics-based modeling of propulsion system manufacturing issues linking performance improvements directly to cost models. The responsive, integrated supply base must include affordable industrial base capability for ramjet, scramjet, and pulse detonation engine technologies. The factory of the future will be capable of high precision control of small hole drilling.

**C4ISR Manufacturing.** The C4ISR roadmap supports the larger ManTech strategic thrusts to move manufacturing to the left, develop next generation manufacturing technologies, and develop intelligent supplier networks. A concerted investment will be necessary in manufacturing technology for solar cell production and optical interconnects affordability and producibility. The digital thread demands models for design of hybrid communications systems, electronics computer-aided design supporting advanced radar designs, and physics models for integrated structures. C4ISR efforts include management of critical industrial base needs in solar cell production and development of multiple sources for affordable common datalinks. The factory of the future will include the ability for direct write technologies for advanced structures (e.g., mini-RPA).
Armament Manufacturing. Moving manufacturing left invokes a need for manufacturing research to improve armament affordability and producibility. Modular designs that enable multiple, customizable roles for weapon platforms (e.g., directed energy, reconfigurable fuzing) will be key aspects of the cradle-to-cradle digital thread for munitions. Activity supporting creation of a responsive, integrated supply base will entail management of critical industrial base concerns in important component areas, including directed energy, fuzing, batteries, and seekers. The need for direct digital manufacture capability for missile bodies and other components will be part of the factory of the future for weapons. A key component to the vision of deploying micro/mini-munition systems is the ability to rapidly produce highly customizable sensor/structure/warhead combinations to meet the ever shifting requirements in the urban battlefield. Enabling this flexibility will require modular systems designs and manufacturing facilities that employ emerging technologies as direct digital manufacturing and robotic assembly.

Structures Manufacturing. Moving manufacturing left in the design and production of advanced structures requires investigating the science basis and improved manufacturing readiness for additive manufacturing technologies, multifunctional materials, hot structures, and integrated structures. The cradle-to-cradle digital thread demands improved producibility modeling for multifunctional materials, designs supporting unitized structures, and model-based approaches for a rapid airframe production demonstration. The responsive, integrated supply base requires collaboration models for design and fabrication of large, multifunctional structures to maintain advantageous industry partnerships. Structures imperatives for the factory of the future include direct digital manufacturing capabilities, flexible, affordable tooling; adaptive machining and metrology; and improved robotic accuracy.

Sustainment/Readiness. Through the use of high fidelity modeling and simulation techniques, advanced manufacturing methods, the use of lean principles, and green energy usage, the Sustainment/Readiness roadmap reflects the ManTech strategic thrusts of moving manufacturing left. It focuses on earlier consideration of sustainment issues, particularly in design; and repair technology/repair science addressed early to need. The cradle-to-cradle digital thread for expedited maintenance activities is facilitated by integrated system health monitoring data collection and analysis; 3D tech data package; and physics-based life prediction models; a responsive integrated supply base includes high velocity maintenance (HVM) concepts featuring world-class supply chain integration and a capability for rapid acquisition of spares. The factory of the future must include advanced NDI capabilities and lean repair processes.

Strategic Partnerships and Collaboration

Continual contact with AF priorities and customer needs (S&T, acquisition, sustainment) and subsequent periodic adjustment of strategy and plans is critical. Additionally, a fundamental imperative for realizing an agile and next generation industrial base is to create and leverage strategic partnerships with stakeholders across government, industry, and academia. One key partner is the Joint Defense Manufacturing Technology Panel (JDMTP), tasked with joint service coordination of ManTech investments. JDMTP is the body responsible for implementing the DoD ManTech strategy, and common elements of both plans form the basis for collaboration and further definition of common investment goals. Another crucial partner is the Small Business Innovative Research (SBIR) program, which is currently required by executive order to engage small business in manufacturing topics to the greatest extent practical. Partnering with the SBIR community to define topics in support of the manufacturing roadmaps topics represents an effective arrangement; SBIR funding will support roadmap objectives, and ManTech personnel will manage SBIR projects in concert with OEM needs. Finally, industry must remain engaged as perhaps ManTech’s most crucial partner to achieve full success. Industry must feel ownership and be actively engaged in this implementation, through strategy-related conferences, symposia, and workshops as well as routine program
level planning and execution. Other collaborations will be determined by exploring common objectives with other manufacturing technology efforts at AFOSR, DARPA, NSF, Department of Commerce, the National Defense Industrial Association, and many others.

**Periodic Assessment and Adjustment**

Change-inducing forces internal and external to the ManTech program will affect this vision almost as soon as it is published, but it is important that the ManTech program assess its ongoing progress in achieving its vision and mission goals. The various elements of this vision will be reviewed at various management levels during each annual PPBE cycle, and adjustments made to the investment portfolio. The attainment of the ManTech Vision in support of Service Core Functions will be the main overarching indicator of success. The four strategic thrusts are considered pervasive in nature and long term in realization. Despite changes in strategic context, AF ManTech expects to continue its course pursuing these thrusts for the foreseeable future and the roadmaps are a key tool in that effort. To this point, perhaps the most enduring, visible codification of this plan is represented in the manufacturing roadmaps which possess a direct correlation to the Air Force’s six core functions (Figure 4). The roadmaps are living documents that are updated by revisions to higher-HQ strategies, PPBE guidance, technical discovery and evolutions, and customer requirements. Therefore, roadmap content and progress towards developing technologies and products relating to the four thrusts will be reviewed annually as the roadmaps and program-specific plans are reviewed by management during formulation of the annual Business Plan, coming year’s Buy Plan, and POM updates. In addition, at a lower level, technical objectives relating to the thrusts and other technical goals defined in the Roadmaps will be driven into specific programs through pre-cursor studies, the Phase 0 formulation and approval process, and subsequent Laboratory Management Reviews of new and on-going ManTech projects.

![Figure 4: Manufacturing Roadmap Correlation to AF Core Functions](image-url)
Conclusion: Always Forward

The security of this nation is firmly tied to the health and capabilities of the US defense industrial base. This requires robust access to advanced technologies and assured delivery of materiel in support of the warfighter. The 2010 QDR Report and other national assessments make this clear. Pressure from global economic and technological forces, and trends in the defense acquisition system, serve to increase the need for an already essential ManTech program. Put simply, the Air Force ManTech program must continue delivering leading edge industrial and technical capabilities that are directly tied to Air Force Service Core Functions, and it must do so even more affordably, at greater delivery rates, and at higher levels of performance.

In response to this call to action, the vision presented in this plan provides the technological underpinnings of a new 21st century manufacturing capability for the Air Force, introduces strategic thrusts which enable the realization of that vision, and maps key transformational pathways for implementation across the spectrum of near-, mid- and far-term horizons. Considering the legacy of past ManTech accomplishments, and our military’s inescapable dependence on the defense industrial base, the vision positions the ManTech program to substantively enable industrial base transformation required by Air Force capability needs in the 21st century. Indeed, the vision of attaining next generation agile manufacturing cannot be met without the explicit focus of the four strategic thrusts and their influence on the program’s manufacturing technology roadmaps.

The success of this vision and its impact on Air Force capability needs depends heavily on the active engagement of every member of Air Force ManTech and senior leadership. Achieving this expansive vision is no small task, but doing so carries enormous benefits for our Airmen. This requires active collaboration with the various S&T communities, engaged partnership with AF/DoD and industry stakeholders, and a keen and constant attention to technology transition needs of the warfighter. This also requires taking stock of the program on a regular basis while keeping an outward orientation to assess the broader effects that Air Force ManTech program investments are having on the defense industrial base. Such collective leadership and actions will help ensure the “always forward” orientation of the Air Force ManTech program, providing vital support to the warfighter and to our nation.
Annex A:
Program Organization and Technical Competencies

Similar to the cross-cutting nature of its mission, Air Force ManTech’s organizational structure embodies active partnership, collaboration, and outreach across the defense manufacturing enterprise, both within the Air Force, and across the joint community, industry, and academia. The Manufacturing Technology Division in AFRL’s Materials and Manufacturing Directorate (AFRL/RXM) has overall program execution responsibilities in close partnership with the office of the Deputy Assistant Secretary of the Air Force for Science, Technology, and Engineering (SAF/AQR). This blend of operational execution performed in concert with the S&T policy arm of the Air Force Secretariat staff affords ManTech a very wide field of view--and potential for broad impact--across the Air Force and joint S&T, acquisition, and operational and sustainment communities. Put another way, Air Force ManTech is a corporate program, the domain and rightful concern of the entire Air Force and DoD, and the program is optimally organized to serve this broad constituency.

In that same vein, the Joint Defense Manufacturing Technology Panel (JDMTP) is a key coordination body that has served the DoD ManTech program well for many years. Component ManTech programs, including Air Force ManTech, collaborate and coordinate their efforts through the JDMTP, which operates under a charter signed by the Director of Defense Research and Engineering (DDR&E) and the S&T executives of the military departments. The JDMTP, therefore, serves to communicate component ManTech initiatives across traditional component program boundaries in an inter-agency/joint-service environment. The JDMTP coordinates ManTech investment topics within technology subpanels (the current subpanels are Electronics, Metals, Composites, and the newly established Advanced Manufacturing Enterprise Subpanel), to maximize opportunities for shared investment in initiatives with joint application, and to avoid duplication of effort. The JDMTP also recognizes the advanced manufacturing interests of other defense organizations such as DARPA and other federal agencies such as NIST, DoE, and NSF, all of whom are afforded ex-officio status in JDMTP activities. Air Force ManTech is an active participant at all levels of the JDMTP.

This broad and vibrant organizational enterprise is summarized in Figure A-1. As seen, robust and continuous collaboration exists across this enterprise, and this collaboration can be thought of as the “lifeblood” of the Air Force ManTech program. As seen in the figure, AFRL’s Manufacturing Technology Division consists of three branches: Integration and Technology, Processing and Fabrication, and Electronics.

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15 Recognizing the enduring value of the JDMTP, Congress recently codified its existence in the FY10 National Defense Authorization Act (PL 111-84, Sec 212).
16 The 2009 DoD ManTech Program Strategic Plan draws a similar, appropriate analogy for JDMTP coordination (page 18).
Similar to the diversity of its organization, the AF ManTech program requires a diverse blend of technical competencies to perform its mission. Its workforce manufacturing skills and experience are overlaid on a knowledge base of classical science and engineering disciplines like physics, mechanical/chemical/electrical materials engineering, industrial engineering and operations research, etc. In the aggregate, these skills and knowledge reflect a unique core technical competency to carry out the Air Force ManTech mission and strategic vision. “Manufacturing Technology” as a core competency can be more broadly described as comprehensive knowledge and skills related to the establishment and optimization of manufacturing process capability and industrial readiness for improved production capacity, availability, and life cycle cost. This top level competency can be divided into two complementary, but distinct sub-competencies: Manufacturing Readiness and Industrial Readiness. Figure A-2 depicts these components. These competencies, exercised through the program structure described next, ensure the ManTech program has the broad situation awareness of manufacturing issues and opportunities across the AF as well as the skills to innovatively respond with needed manufacturing technology solutions.
A deliberate planning process based on industrial base assessments helps identify prioritized program investments to pursue for greatest warfighter benefit. Customer requirements are derived from all Air Force domains including: Aeronautical; Armament; Directed Energy Systems; Command, Control, Communications & Computers Intelligence, Surveillance & Reconnaissance (C4ISR), Electronics; and Space Systems. These requirements, together with “tech push” opportunities, are organized and executed within six key manufacturing roadmaps presented in detail in Annex B.
Annex B:
Manufacturing Technology Roadmap Descriptions

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Overview

Manufacturing technology roadmaps capture the ManTech Vision and goals for ManTech’s chosen technology application areas. They represent, necessarily, the most dynamic content of this plan in that they must be agile, accounting for updated strategic context, technology breakthroughs, etc. There are six roadmaps: Advanced Manufacturing Enterprise, Propulsion Systems, Aerospace Structures, C4ISR Hardware, Armament Systems, and Sustainment/Readiness. These roadmaps represent detailed key long-term planning resources for the ManTech Program, and flow down program vision and strategy to FYDP investment portfolios and current year buy plans. These roadmaps are critical for coordinating with stakeholder requirements to meet narrow and shifting transition schedules. Further, the roadmaps provide an integrated view of multiple investment sources, including S&T, Title III, SBIR, OSD and PEO projects. This long-term and highly-integrated view allows the manufacturing roadmaps to function as a planning, implementation, and communication tool. Figure B-1 outlines the taxonomy used to develop and convey the key information in the roadmaps.
AFRL/RXM Manufacturing Readiness
Roadmap Legend

Examples of Program Designations Based on Funding Type

AF Manufacturing Technology (AF ManTech)
- MT Pgm
- MT UFR
- AF ManTech Program Name

OSD Manufacturing S&T (DoD MS&T)
- MS&T
- MS&T UFR
- MS&T Program
- OSD MS&T (DoD MT) Pgm Name

Industrial Base Planning / Industrial Base Analysis
- IBP
- UFR

AF SBIR
- SBIR-I/-II
- UFR

Manufacturing SBIR / SPO Funded SBIR Phase III
- SBIR Mfg
- UFR

RXM Managed Funds (CIIs, External/Incoming Funds)
- RXM Other
- UFR

Non RXM Funds Managed Elsewhere (RXM Receives Input From, Or RXM Output To External Effort)
- Non RXM Other
- UFR

Examples of Input and Output From Mfg Program

Input From Another Organization (ex. RY)

Ref RXM Roadmap

Transition System (ex. F-35, …)

Proposed Transition System

Technical Goal / Component

Device Application / Capability

Future “Destination” (BHAG, Holy Grail)

What Is Striving To Be Achieved

Examples of AFRL Connection

Discovery

ProactiveISR

Affordable Mission Generation & Sustainment

Figure B-1: Manufacturing Roadmap Legend
Advanced Manufacturing Enterprise (AME)

The AME roadmap illuminates the technology developments necessary to provide the right design and manufacturing information to the right decision markers – at the right time – in a system’s lifecycle. AME is industrial infrastructure and as such application is pervasive across weapon systems. AME activities typically consist of creating models and simulating scenarios to optimize a design, process, organization, or operation. AME efforts can be divided into three core areas based on the nature and scale of the information handled: Virtual Manufacturing (VM) deals with physical products/systems information, Integrated Enterprise (IE) with complex, market-level information, and Advanced Operations (AO) with information pertaining to specific equipment and facilities. Due to the nature of AME tools, their need for widespread adoption in industry, and their large potential impact on industry, the Air Force’s AME goals are in line with industry’s goals. The combined vision of AME can be described through the following list of attributes and capabilities: integrated, robust, smart product & process models; intelligent design and analysis advisors; M&S to be a real-time enterprise controller; open, shared repositories and validation centers; real-time, interactive performance models; and seamless interoperability.
Figure B-2: AME Roadmap Part 1 – Virtual Manufacturing
AFRL/RXM Advanced Manufacturing Enterprise

**Integrated Enterprise**

**Supply Chain Networks**
- Leading SCM Practices
  - RANGER
  - FES
- NCM for Remfg
- Net Centric Pilots
- IB War Gaming / Sim Capability
- Proactive SC Risk Mgmt
- Network Mfg Protocols
  - Technology & Practices For Rapid Enterprise Alignment
  - Standards Framework For Plug n’ Play

**Service Oriented Architecture**
- Social Networking for Supplier Exchange
  - Service / Capability Modeling
- Service-Oriented Mfg Architect
- Mfg Extension Partnership (NIST)
- GCMA

**Lifecycle Support**
- MBE: TDP Enhancements (Army)
- MBE: TDP Policy
- PMI Rich Models
- Model Standardization/Interoperability
- Feature Based Interoperability
- Global Mfg Service Ontology (MySpace For Manufacturers)

Figure B-3: AME Roadmap Part 2 – Integrated Enterprise
AFRL/RXM Advanced Manufacturing Enterprise

Advanced Operations

AME Advanced Operations – Perfect Execution

Smart Machining / Intelligent Assembly

- SMR (Army)
- Smart Machine Platform Initiative: Notification Alarm
- System Process Planning
- Autonomous Control & Online Correction
- Remote Production Monitoring
- Elastic Assembly Modeling
- Human Resource Modeling
- Low Cost, Flexible Metrology
- Adv. Robotics

Agile Production

- Modular, Reusable Tooling
- Tooling Library & Auto-simulation
- Prepositioned Maintenance (PILOT)
- Structural Health Monitoring
- DDM, Direct CAD Import (Metallic)
- Direct Write Technologies
- Troublesh. Advisor

Low Impact Operations

- Energy Phase 1 & 2
- Energy-Based Scheduling
- Form & Fab. Energy Model
- SC monitoring/Integration

Model-based Operations Systems That Control Production And Sustainment

Highly Flexible Shop Floor Resources Configured To, And Directed By The Design

Digital Integration Of Business, Product Realization, And Operations Functions

Minimizing Resource Consumption And Environmental Impact

Figure B-4: AME Roadmap Part 3 – Advanced Operations
Propulsion Systems

The Propulsion roadmap outlines the maturation of manufacturing technologies which enable increased fuel efficiency…first in high-performance turbine engines for defense such as the F135/F136 and T700, and later in turbine engines for commercial applications and power production. For the far-term, developmental engines from the Propulsion Directorate and alternate engines such as ramjet, scramjet, and pulsed detonation may provide opportunities for transitioning manufacturing technologies. Applications such as UAVs and launch vehicles should also benefit from these technologies. The propulsion program aims to improve manufacturing readiness of emerging technologies such as ceramic matrix composites, ceramic bearings, high temperature polymeric composites and additive manufacturing. For more mature technologies such as casting, small-hole drilling and machining, the propulsion program aims are to increase affordability.
Figure B-5: Propulsion Roadmap Part 1 – Top Level Roadmap Summary
AFRL/RXM Mfg of Propulsion Systems

Ceramics Matrix Composites

Page 2 of 4

Ceramic Matrix Composites for Propulsion

- AMPI SiC Fabric Coating
- AMPI CMC Matrix Densification
- Fiber/Matrix Opt
- Adv Mach. CMC
- Effects of Defects
- Production NDE for CMCs
- Vanes+Exhaust Nozzle
- In Line Tow Coating of SiC
- 3-D Airfoil Inspection
- MS&T for SiC Fibers
- SiC Fiber Processing Science
- 2700°F SiC Mfg Base
- AMPI CMCs
- Ceramics Afford.

Figure B-6: Propulsion Roadmap Part 2 – Ceramic Matrix Composites
AFRL/RXM Mfg of Propulsion Systems

Ceramic Bearings, OMCs & Additive Mfg

Page 3 of 4

Figure B-7: Propulsion Roadmap Part 3 – Ceramic Bearings, OMCs & Additive Mfg
Figure B-8: Propulsion Roadmap Part 4 – Casting, Machining & Small Hole Drilling

- **Advanced Castings for Propulsion**
  - Foam Patterns
  - Ceramic Cores
  - FOPAT Demo
- **Advanced Machining for Propulsion**
  - Low Cost IBRs
  - SAM
  - Super Abrasive Machining
- **Small Hole Drilling (SHD) for Propulsion**
  - SHD Industrial Base Assessment
  - 3D Airfoil Insp.
- **Casting, Machining & Small Hole Drilling**
  - RXM Metals Productivity Roadmap
  - VAATE, ADVENT & HEETE
  - In or. Small Hole Drilling Throughput By 50%, Reduce Scrap By 25%
  - Affordable Adaptive Drilling Of Cooling Holes
  - Increase Cooling Efficiency & Reduce Scrap Rate Through Rapid, Accurate Drilling of Small Holes
Aerospace Structures

The overall objectives of the Structures roadmap are to reduce the manufacturing costs and lead times of current and future aerospace structures, raise MRL of new technologies for production to at least four/five, and scale-up innovative and/or advanced airframe materials and manufacturing processes that can be readily incorporated into aerospace structures. Current Structures roadmap topics include: large multi-functional structures, hot aero-structures, and rapid/responsive manufacturing of structures. Man-Tech's structures roadmap is pervasive across the airframe industry and includes applications such as UAVs and long range strike. The Structures roadmap includes and targets pervasive near, mid and far term technologies.
AFRL/RXM

Mfg of Aerospace Structures

Page 1 of 4 (Top Level Roadmap Summary)

01-Jul-10

Figure B-9: Aerospace Structures Roadmap Part 1 – Top Level Roadmap Summary
AFRL/RXM Mfg for Aerospace Structures

Large Multifunctional Structural Mfg

Page 2 of 4

13-Jul-10

AF MT Core
SBIR MFG / -III
SBIR-I / -II
OSD MS&T (MT)
IBP: IBA
RXM Other
Non RXM Other
AFRL Mid Term Demo

ASI: Advanced Structures Initiative
Large Multi-Functional Structures Manufacturing

ACCA Ph 3
ACCA Ph 4

Optimized Use Of Flexible Automation
Intelligent Integration of Components
Joint Future Tactical Lift Design AoA

M3 Tactical X-Plane [7.5.1]

Conformal Load-bearing Antenna Structures (CLAS)

Sensorcraft

Modular Embedded Devices:
- Durable Antennas, Power,
- Structural Health Monitoring

Figure B-10: Aerospace Structures Roadmap Part 2 – Large Multifunctional Structural Mfg
AFRL/RXM Mfg for Aerospace Structures

Hot Aero-Structure Manufacturing

Page 3 of 4

Systems Technology/ Technology Transition
Force Projection – All Weather Global Transonic Lift

ASl: Advanced Structures Initiative
Hot Aero-Structures Manufacturing

Low Cost, Shape Stable Materials and Structures
Efficient, LO Compatible Inlet / Exhaust Systems and Aero Configurations

Integration of Shielded High-Bypass Engines
Exhaust Washed Flaps For Short Field Landing
Joint Future Tactical Lift

Incr. Durability of Exhaust Impinged Components

Propulsion: AMPI -AFR-PE-4 Cure Cycle Reduction

Hybrid (RXB)
Alt. Monomers

High Temp OMC

CMC Hybrids (RXB, RXL)
Thermal Prot (RXB, RXL)
2700F CMCs (RXL)

Large Area Ceramic Matrix Composites

Supersonic Cruise [4.2.1]
Reusable Space Launch [7.3.2]

Trans-atmospheric Aero-structures

Incr. Durability of Exhaust Impinged Components

Figure B-11: Aerospace Structures Roadmap Part 3 – Hot Aero-Structure Mfg
Figure B-12: Aerospace Structures Roadmap Part 4 – Rapid/Responsive Mfg
C4ISR Hardware

The C4ISR roadmap defines the path to close manufacturing gaps created by the rapid emergence of C4ISR technologies such as radar, datalinks and communications systems, solar cells, and optical interconnects. The C4ISR roadmap identifies ManTech programs that will benefit sensor development programs, current airborne and space platforms, and future manned and unmanned platforms as well. This initiative will improve manufacturing readiness of emerging technologies supporting C4ISR.
AFRL/RXM Mfg of C4ISR Hardware

Radar

Page 1 of 4

01-Jul-10

Figure B-13: C4ISR Hardware Roadmap Part 1 – Radar
## AFRL/RXM Mfg of C4ISR Hardware

### Communications / Datalinks

**Figure B-14: C4ISR Hardware Roadmap Part 2 – Communications/Datalinks**

<table>
<thead>
<tr>
<th>FY10</th>
<th>FY11</th>
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**DCA: Datalink Component Affordability**

- **SDB-II, JSOW, Harpoon, SLAM-ER**
- **Common Data Links Afford. Pgm (CDAP)**
- **Miniaturization, Embedded, Passive, Increased Yield**
- **$\leq$10K Per Common Datalink**
- **Force Projection**

**ACA: Advanced Communication Affordability**

- **Airborne Optical Comm. Systems**
- **V & W Band Comm. System**
- **High Band-width Miniature Optical Transceivers and Multi-access Space Terminals**
- **Transformational Communication via Real Time Audio / Video / SAR and Autonomous Processing Capability**
- **Simultaneous Distribution of Sensor Data for Shortened Kill Chain, Single Integrated Air Picture (SIAP), and Global Situational Awareness**

**AF MT Core**

- SBIR MFG / -III
- SBIR-I / -II
- OSD MS&T (MT)
- IBP: IBA
- RXMO ther
- Non RXM Other
- AFRL Mid Term Demo
**AFRL/RXM Mfg of C4ISR Hardware**

**Solar Cells**

Page 3 of 4

**Figure B-15: C4ISR Hardware Roadmap Part 3 – Solar Cells**
**AFRL/RXM Mfg of C4ISR Hardware**

**E&O Producibility: MWIR Optics**

Page 4 of 4

01-Jul-10

**E&O Mfg of Mid-wave Optics / IR Windows**

- **MT CII: EFG Sapphire**
  - 16” x 30” x 0.75”

- **SBIR Mfg: Sapphire Sheet Scale Up**
  - 18” x 35” x 2”
  - 32” x 32” x 0.8”

- **AF MT: Sapphire Sheet Scale Up**
  - 14” x 20” x 0.75”
  - 32” x 32” x 0.8”

- **Spinel**
  - 12” x 18” x 0.25”
  - 16” x 18” x 0.6”
  - 15” x 20” x 0.8”
  - 16” x 40” x 0.75”

- **T-III: ALON & Spinel**
  - 17” x 30” x 0.5”

- **Edge Bonding Process Development**
  - 23.5” x 27” x 0.8”

- **Edge Bonding (USN SBIR)**
  - 32” x 32” x 0.8”

- **Planar IR Window Polishing**

- **Planar IR Window Coating**

- **Transparent Armor**

- **1-D Conformal IR Window Productionization**

- **2-D Conformal IR Window Productionization**

- **2-D Conformal Window**

- **2-D Conformal Window Polishing**

- **Conformal Windows To Incr. Sensor Field Of View & Ease Integration Into The Outer Mold Line**

- **1-D Conformal Window**

- **1-D Conformal IR Window Polishing**

- **32” x 32” Planar Window**

- **32” x 32” x 0.8”**

- **DDG-1000**

- **Edge Bonding for Large Windows**

- **Edge Bonding (USN SBIR)**

- **24” x 60” Planar Window**

- **Figure B-16: C4ISR Hardware Roadmap Part 4 – E&O Producibility: MWIR Optics**
Armament Systems

The Armament roadmap focuses on technology maturation which improves manufacturing readiness and rapid insertion of emerging technologies in three major weapons’ areas: Mini/Micro Munitions, Selectable Effect Munitions, Hard Target Defeat, Hypersonic Strike, and Directed energy Components. Investment in Hard Target Defeat technologies will ultimately lead to the implementation of new hardened materials and fuzing/GN&C (guidance, navigation and control) technologies enabling penetrators to kill deeply buried reinforced targets. Investment in Missile Technologies will focus on the Joint Dual Role Air Dominance Missile (JDRADM), which combines the capabilities of AIM-9, AMRAAM, Maverick, and HARM, providing a single solution for air-to-air and air-to-ground engagement. Mini and Micro Munitions will provide the warfighter with a revolutionary precision strike capability, maximizing lethality with little or no collateral damage, and the ability to act in networked swarms in a dense urban battle environment Directed energy activities will help build an industrial base capable of affordably producing DE components including low and high power applications.
Figure B-17: Armament Systems Roadmap Part 1 – Top Level Summary
AFRL/RXM Mfg of Armament Systems

PGM Mini/Micro Munitions & Selectable Effects

Armament Page 2 of 4 (PGM Detailed Roadmap #1 of 2)

Figure B-18: Armament Systems Roadmap Part 2 – PGM Mini/Micro Munitions & Selectable Effects
AFRL/RXM Mfg of Armament Systems

PGM Hard Target & Hypersonic Strike

Armament Page 3 of 4 (PGM Detailed Roadmap #2 or 2)

Figure B-19: Armament Systems Roadmap Part 3 – Next Generation Missile Components
AFRL/RXM Mfg of Armament Systems
VCSEL & DE Components

Page 4 of 4

Systems Technology/Technology Transition
Target Engagement – Small, Stealthy, High Speed Precision Effects On-Demand

Vertical Cavity Surface Emitting Laser (VCSEL) Producibility
- Proximity Sensors; Laser Illuminators, Rangefinders & Designators
- >1kW/cm² Power Density with >40% Efficiency for >9000 hours at <$1/Watt
- Hi Power VCSEL

Directed Energy Component Affordability
- AFRL/RW
- VCSEL (SBIR-II)
- RW
- AFRL/RWGD
- RFI
- DE Phase 0

DE Affordability for Laser
- Electric Laser on Large Aircraft (ELLA) [3.5.2.1]
- Multi-Sortie High Power Microwave RPA [3.5.5.1]
- Counter HPM Electronics Adv Missile Project (CHAMP) [3.5.4.1]

DE Affordability for RF (HPM)
- Electric Laser on Small Aircraft (ELSA) [3.5.3.1]
- Electronic Attack, CounterElectronic Warfare

DE Component Affordability
- MRA
- Electric Laser for Counter Electronics & Weaponry
- Flight Weight 100kW Laser
- High Power Microwave & Lasers for Counter Electronics & Weaponry

Figure B-20: Armament Systems Roadmap Part 4 – DE Components
Sustainment / Readiness

The Sustainment/Readiness roadmap aims to introduce new technologies and processes in order to increase maintenance efficiencies, decrease down time, and extend life of AF legacy systems. This includes candidate technologies which will address and aid the High Velocity Maintenance (HVM) program that is currently being rolled out across the depots. The end goal would be quick “pit stops” for aircraft in order to greatly increase aircraft availability and boost mission readiness.
**AFRL/RXM**

**Mfg for Sustainment / Readiness**

*Page 1 of 2 (HVM)*

**High Velocity Maintenance Manufacturing Processes**

Integration of System Component Design and Configuration Control with On Demand Fabrication and Repair of Components to Reduce Manufacturing & Processing Cycle Time

- Rapid Fabrication & Repair Utilizing Smart Materials, Processes & Tools
- Precision Robotic Drilling
- Additive Mfg Technologies
- Advanced Curable Coatings
- Laser Material Removal Process
- Lean Scheduling

**Systems Technology / Technology Transition**

Mission Generation & Sustainment – Rapid Return To Service

**Depot Transition**

- Contractor MRO Transition

**Figure B-21: Mfg for Sustainment/Readiness Roadmap Part 1 – HVM**
Figure B-22: Mfg for Sustainment/Readiness Roadmap Part 2 – ERLE and IHM
Annex C: Trends and Opportunities – Outcomes from the March 2009 Industry Workshop

The Manufacturing Technology (ManTech) Division in the Air Force Research Laboratory’s Materials and Manufacturing Directorate (AFRL/RXM) organized and conducted a three-day, industry-government-academia workshop to help shape this Air Force ManTech Vision. The Workshop was held in San Antonio, Texas from 24 to 26 March 2009, and involved nearly 120 invited participants. Below are the workshop’s key outcomes\textsuperscript{17} and an overview of promising Air Force ManTech program opportunities.

The following emergent opportunities, or investment themes, were crafted from a broad synthesis of the analyses. Every attempt was made to ensure these opportunities flow as directly as possible from the outcomes of the workshop, which were grouped, prioritized, and analyzed to best distill the sense of the industrial base manufacturing community in a practical form. These opportunities represent both financial investments as well as initiatives that may not drive significant financial outlays. The opportunities were developed by considering the workshop derived technical and program needs in the context of high-level trends (again, workshop derived), leading to an emergent picture of high-leverage opportunities, both now and into the future.

Before crafting the final set of investment opportunities, the high-level trends were further categorized in several ways. This was done to help align capabilities and needs to yield opportunities that would clearly: (1) exploit a positive trend, (2) react in an appropriate way to ameliorate the impact of a negative trend, or in some cases, even (3) influence the direction or intensity of a trend. Of special interest was whether a trend was mostly external, outside the control or influence of the Air Force, or an internal one, primarily within the Air Force’s influence. A second categorization important to the formulation and alignment of opportunities was whether the trend affects the defense enterprise broadly or whether the effect is focused on a specific platform or technical domain (electronics, for instance). Finally, trends were categorized by whether they are primarily aligned with technical aspects of defense systems or aligned with managerial, policy or resourcing aspects of the defense acquisition system. This distinction assisted in determining the most effective type and scope of initiatives (a policy initiative for example) to address a particular trend. The 15 trends were categorized according to these factors, and the results are provided in Table C-1.

<table>
<thead>
<tr>
<th>Trend No.</th>
<th>High-Level Trend</th>
<th>Rank Order</th>
</tr>
</thead>
</table>
| T12      | Increased focus on more intelligent, sustainable designs yielding lower total life cycle cost and improved mission / energy / environmental performance  
- Response to greater demand for multi-functional, readily certifiable systems that are morphing, self-healing, and can monitor in-service health  
- Designs which increasingly utilize lightweight structures for affordability, performance, and energy conservation | 1          |

\textsuperscript{17} The complete report was prepared by AFRL/RXM and is available along with a limited-distribution “Proceedings” CD, both of which AFRL/RXM maintains.
<table>
<thead>
<tr>
<th>Trend No.*</th>
<th>High-Level Trend</th>
<th>Rank Order</th>
</tr>
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<tbody>
<tr>
<td>T10</td>
<td>Increased leveraging of product and process modeling &amp; simulation methodologies</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>• Growing need to address tech / process data standardization, transfer, and archiving</td>
<td></td>
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<tr>
<td></td>
<td>• Availability of increasingly elaborate virtual modeling &amp; simulation methods to address both component / product and system / enterprise manufacturing issues</td>
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<tr>
<td></td>
<td>• Growing interest in value of industrial base war gaming and exercises to yield insight and innovation</td>
<td></td>
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<tr>
<td>T8</td>
<td>Demand for rapid and agile acquisition capabilities to match reduced technology refresh cycles</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>• Shorter technology life cycles, higher technology refresh rates, driving shorter upgrade cycles and need for more agile acquisition capabilities</td>
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<tr>
<td></td>
<td>• Faster paced technology deployment by adversaries putting higher value on rapid acquisition response</td>
<td></td>
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<tr>
<td></td>
<td>• Increasing frequency of disruptive technology events requiring more agile acquisition processes to exploit opportunities</td>
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<tr>
<td>T5</td>
<td>“Green consciousness” becoming a global / societal mandate</td>
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<tr>
<td></td>
<td>• Growing global support for conservation (e.g. clean air, water, energy); increased regulations</td>
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<td>• Growing use of goals for net-zero (&quot;green&quot;) and near-net-zero facilities and deployments</td>
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<td></td>
<td>• Reduction of waste streams and use of environmentally friendlier processes</td>
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<td>T1</td>
<td>Supply chains increasingly dynamic, global, evolving</td>
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<tr>
<td></td>
<td>• Increasing rates of change, sector clock speeds</td>
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<td></td>
<td>• Much greater global connectivity, interactivity, dispersion</td>
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<tr>
<td></td>
<td>• Global sourcing and COTS use continuing to expand</td>
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<tr>
<td>T14</td>
<td>Accelerated introduction of new / emergent materials driving more elaborate manufacturing requirements</td>
<td>6</td>
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<tr>
<td></td>
<td>• New / emergent materials increasingly driving need for rapid, innovative, and often complex manufacturing solutions</td>
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<td>• Continued growing focus on nanotechnology materials and manufacturing solutions</td>
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<td></td>
<td>• New / emerging lightweight (including light structural) materials and approaches driving manufacturing requirements</td>
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<tr>
<td>T13</td>
<td>Increased need for small lot size, more agile, and more affordable defense manufacturing methods / processes</td>
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<tr>
<td></td>
<td>• Pervasive focus on affordable tools, tooling, and tool-less manufacturing</td>
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<td></td>
<td>• Increased use of Direct Digital Manufacturing methods and capabilities</td>
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<td>T2</td>
<td>Growing tension between globalization and the maintenance of a secure US industrial base</td>
<td>8</td>
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<tr>
<td></td>
<td>• Shrinking domestic defense industrial / manufacturing base capacity and capability in several sectors (e.g., electronics)</td>
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<td>• Growing demand for a national strategy to maintain an effective US industrial base amidst new / emerging 21st century global dynamics</td>
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<td>• Many regulations at odds with increasingly global dynamics surrounding flow of information and technology, e.g. ITAR, IP regulations, etc.</td>
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<td>• Increasing risk in ability to acquire COTS and other hardware from foreign sources</td>
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<tr>
<td>T4</td>
<td>Diminishing supply of qualified, educated workers</td>
<td>9</td>
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<td>• Skill set availability increasingly driven by diminishing supply of qualified, educated workers to replace the aging workforce</td>
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<td>• Growing need for new technology-enabled employees</td>
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<td>• Large and increasing percentage of post-graduate students are non-US citizens</td>
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<tr>
<td>T9</td>
<td>Growing call for effective systems engineering and life cycle management, increasingly driven by affordability challenges</td>
<td>10</td>
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</table>
Continued strong and growing DoD and national focus on defense acquisition reform
Growing federal / DoD budget pressures; less tolerance for cost overruns / non-productive investments; more intense competition for DoD investment funding

Growing focus on alternate energy solutions
- Growing interest in use of biomass
- Increased use of Synthetic fuels (e.g. coal to liquid)
- Increased focus on distributed and renewable power generation (e.g. photovoltaic, biomass)
- Increased need for energy robustness - being prepared for national emergencies

Emergence of new innovation dynamics and sources
- Innovative capability shifting from OEM layer to supply tiers due to heavy outsourcing
- Growing paradox between need for corporate IP protection and generation of innovation through open collaboration and transparency

Enormous increases in system automation and IT sophistication (for both manufacturing and weapon systems)
- Automation of processes and information management increasing at nearly exponential rates
- Greatly expanding use of UAS / autonomous operations (air, land, sea)
- Continued strong increases in IT performance requirements, bandwidth needs, throughput
- High growth in available, internet-based, open-source software

Increased reliance on miniaturization in defense systems
- More embedded technology (miniaturization)
- More component miniaturization
- Electronics getting smaller and lower-powered with every short-lived generation of packaging

Increased power and energy requirements for weapon systems
- Increased energy densities
- Increased energy conversion efficiencies
- Increased mission duration requirements (mobile, wearable)
- Growing requirements for lightweight power sources (e.g., wearable)
- Increasing fuel efficiency for gas turbines

* Note: The trend numbers in the left column are for trend identification only and do not reflect a prioritized or rank ordering (see right column for rank order).

Investment themes were iteratively refined through multiple views and adjustments, leading to the following eight, workshop-derived investment opportunities for consideration during development of this vision. These opportunities are not listed in any particular order.

**Establishing Network Centric Capabilities for Agile Manufacturing.** The maturation and use of Network Centric Manufacturing capabilities was a strong, common theme in three technical sessions and one topical session. Investment projects under this opportunity include modeling and simulation capabilities for manufacturing, technical data standardization and interoperability, and tools to push advanced materials and processes into a risk-averse supply chain. These technical approaches are key elements of agile manufacturing, which is a critical enabler of a rapid, agile acquisition system. Pursuing this opportunity would specially respond to Trends T8, demand for rapid, agile acquisition, and T10, leveraging of modeling and simulation, by enabling network centric manufacturing for defense systems, and tapping into the broad domestic manufacturing capabilities within multiple tiers of the supply chain. Such initiatives could help significantly address, in appropriate ways, both the positive and negative attributes of
Trend T1, *dynamic supply chains*, impacting the defense industrial base. Additionally, this opportunity and Opportunity 3, *eliminating tooling as a cost driver*, are mutually supportive and help adjust to the realities of Trend T13, *affordable, small lot size manufacturing*.

**Making the Clear Business Case for Manufacturing Investment.** This opportunity is driven by Trend T9, *call for more effective systems engineering*, and represents the establishment and validation of an operational business case model that would highlight the need for an overall AF institutional focus on system manufacturability and producibility across the life cycle. Workshop participant comments made clear that too often, the ability to manufacture a working prototype component is mistaken for system producibility, and investment in manufacturing technology is pushed off or eliminated. However, a large driver of system cost is manufacturing, and the business case for this category of investment needs to be modeled, validated, understood, and accepted by senior stakeholders. This business case would go further than the standard Return on Investment (ROI) model and would capture the effects of possessing knowledge of a system’s producibility at key acquisition gates, as well as quantify impacts on cycle time and mission assurance. This business case can then be adequately compared against other investment options and trades which may increase performance but lengthen the schedule or decrease mission assurance. Pursuing this opportunity would have a broad, positive effect on many of the trends by providing a comprehensive instrument for program advocacy which also helps to navigate the challenges inherent in Trend T2, *tension between globalization and the domestic industrial base*.

**Eliminating Tooling as a Manufacturing Cost Driver.** This opportunity is about investments in manufacturing processes to avoid reliance on, or help to eliminate, capital-intensive, long lead-time tooling. The theme of tooling can be traced throughout multiple workshop sessions and responds to the need for *affordable, small lot size manufacturing* (Trend T13). This opportunity would be classified as a mid- to far-term initiative to substantially impact the cost and time required for tooling at the OEM and sub-tier supplier level. The scope of this initiative does not include assembly jigs when required for final system assembly at the prime. Capitalizing on this opportunity could create a substantial, positive impact within industrial base sectors relying on lower component production rates or high-mix ratios of subsystem production, such as electronics and propulsion. Investment topics within this opportunity include tool-less processes, low cost reconfigurable tooling, Direct Digital Manufacturing (DDM), functional (certifiable) prototyping processes, and disposable tooling. This opportunity should be able to exploit Trend T3, *emerging new innovation sources*.

**Moving Manufacturing “Left” (Earlier in the Acquisition Framework).** This opportunity recognizes that the time is right, and strong justification exists, to work to shift the consideration of system producibility and manufacturing technologies earlier in the design and development process. The theme of early involvement of manufacturing was present in virtually every technical and topical session at the workshop, and it directly aligns with Trend T9, *call for more effective systems engineering*. The opportunity requires a combination of policy, practices, and tool development in concert with the Air Force Systems Engineering community. One objective of the initiative would be more effective preliminary design reviews by providing the required knowledge of manufacturing capabilities associated with advanced technologies, thus reducing the negative impacts of Trend T14, *new materials driving manufacturing requirements*. This requires an acquisition framework which considers producibility on par with performance, together with policies and processes enabling early identification of needed facilities and long-lead, critical materials. The outcome of this initiative would be a more complete Milestone (MS) B review and greatly increased cost and schedule assurance at Critical Design Review and MS C. Required efforts under this opportunity would include establishing or refining policy on Manufacturing Readiness and System Engineering, construction of models of manufacturing capability gaps for use in design trades, simulation tools
to war-game development options, and concurrent maturation of technology and manufacturing processes.

**Making Next Generation Structures a Reality.** This investment opportunity combines workshop derived issues and capabilities to target affordable production of large-scale, lightweight structures with embedded sensors. Next generation structures are multi-functional and will require specialized manufacturing processes, such as low temperature curing, unitized forms, and dissimilar materials joining. In Trend T14, *new materials driving manufacturing requirements*, workshop participants described advanced structural technologies as having the greatest potential for dramatic shifts in performance, and they are absolutely dependent upon manufacturing technologies. Making next generation structures a reality would have a dramatic effect upon many Air Force Systems and substantially influence system affordability. Investment topics under this opportunity include out-of-autoclave lightweight structural curing, metal-composite joining, multifunctional, unitized structures, and readily certifiable structures with embedded sensors, conformal arrays, and NDE processes. This opportunity directly relates to and leverages Trend 12, *increasing focus on intelligent designs for improved cost and performance*.

**Delivering Energy Density and Efficiency.** This opportunity reflects clear mandates from the workshop, found in Trends T7, *increased power and energy needs*, and T6, *growing focus on alternative energy*, to deliver solutions for the ever-increasing energy demands of defense systems, enabling alternative generation and storage technologies. Each new generation of defense systems requires more (or more diverse types of) power with little room for increased size or weight. Pursuit of this opportunity would focus on closing this highly fluctuating capability gap by producing high density energy sources and technologies for greater system efficiency. This dual approach, i.e., increasing supply and decreasing need, allows for multiple paths for success, and suggests the need to carefully balance the mix of near and far term investments. Investment topics under this opportunity would encompass manufacturing processes for high density energy sources, including scale-up of next generation chemistries such as lithium-ion polymers and solar cell materials. It also suggests investments for improving the efficiency of major systems, such as CMC and OMC components for propulsion systems and silicon carbide components for electronic systems.

**Closing Manufacturing Gaps Created by the Rapid Change of C4ISR Technologies.** Arguably an “imperative” as much as it is an "opportunity," this investment theme focuses on the producibility of materials and components to meet the ever-accelerating growth of requirements for C4ISR capabilities and the associated mission architectures. As captured in Trend T11, *increases in automation and IT sophistication*, Air Force C4ISR systems rely on high-bandwidth components to capture, transmit, and disseminate digital information from high resolution sensors, all around the globe and in space. Additionally, sensor fusion and integrated command are keys to understanding and managing these enormous amounts of information. Next generation C4ISR and cyber system capabilities will depend upon the speed and assurance of data transmittal from source to user. The Air Force needs the ability to manufacture defense-unique, high bandwidth components required for sensors, affordable RF and photonic transmitters, and C4ISR systems being developed by defense laboratories. Pursuing this investment opportunity also exploits Trend T15, *increased miniaturization*, and it supports the delivery of associated capabilities. Focused investments under this opportunity include miniaturization of electrical components including manufacturing at the nanotechnology-based scale, photonic components, SiC material maturation, optical interconnects, and affordable RF datalinks.

**Realizing Green Manufacturing.** Capitalizing on this opportunity entails development of “green”, sustainable manufacturing processes and facilities to satisfy the growing, global trend of conservation. Doing so also leads to investments which fill gaps in response to continuing legislative restrictions on materials
or manufacturing processes, such as lead-free electronics. A specific objective of this initiative is for the defense manufacturing base to measurably decrease the use of hazardous or non-renewable materials, including energy, without affecting the quality or performance of defense systems. A second objective is to pursue mitigating solutions and strategies when the use of hazardous materials is essential to mission assurance. Mature, proven manufacturing processes with wide utility are becoming obsolete due to restrictions such as REACH (Registration, Evaluation, Authorization, and restriction of Chemical substances), and alternatives are required to fill the resultant gaps in manufacturing capability. While this opportunity arose primarily from discussions in the energy and electronics technical sessions, the effects are broadly applicable. Investment topics under this opportunity include alternative lead-free manufacturing processes, development of "net-zero" facilities, reduction of waste streams, reduction or recovery of energy, and alternate corrosion protection materials. This opportunity is a focused response to Trend T5: mandate for "green facilities", and it also helps to diffuse negative effects of Trend T2, tension between globalization and the domestic defense industrial base.

The above eight opportunities represent the distilled set of investment thrusts traceable to the views and recommendations of the workshop participants.
Annex D: References

Program Directives and Governance Documents


Published Plans and Strategy Documents Influencing the AF ManTech Program


Recent Reports and Studies


Annex E: Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>1-D</td>
<td>One dimensional</td>
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<tr>
<td>2-D</td>
<td>Two dimensional</td>
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<tr>
<td>3D</td>
<td>Three dimensional</td>
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<td>AAC</td>
<td>Army Aviation Center</td>
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<td>ACAT</td>
<td>Acquisition Category</td>
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<td>ACCA</td>
<td>Advanced Composite Cargo Aircraft</td>
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<td>Adv</td>
<td>Advanced</td>
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<td>ADVENT</td>
<td>Adaptive Versatile Engine Technology</td>
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<tr>
<td>AEHF</td>
<td>Advanced Extremely High Frequency</td>
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<tr>
<td>AESA</td>
<td>Active Electronically Scanned Array</td>
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<tr>
<td>AF</td>
<td>Air Force</td>
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<tr>
<td>AFR-PE-4</td>
<td>An ultra-high temperature polyimide</td>
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<tr>
<td>APT</td>
<td>Automatically programmed machine tool</td>
</tr>
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<td>Aff</td>
<td>Affordable</td>
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<td>Air intercept missile</td>
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<td>Air Force Materiel Command</td>
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<td>Air Force Research Laboratory</td>
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<tr>
<td>AFRL/RX</td>
<td>Office symbol for AFRL Materials and Manufacturing Directorate</td>
</tr>
<tr>
<td>AFRL/RXM</td>
<td>Office symbol for AFRL Manufacturing Technology Division</td>
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<td>AFRL/RZ</td>
<td>Office symbol for AFRL Propulsion Directorate</td>
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<td>Air logistics center</td>
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<td>ALON</td>
<td>Aluminum Oxynitride</td>
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<td>Alt</td>
<td>Alternative</td>
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<td>Advanced Manufacturing Enterprise</td>
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<td>AMPI</td>
<td>Advanced Manufacturing Propulsion Initiative</td>
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<td>AMRAAM</td>
<td>Advanced, Medium-Range Air-to-Air Missile</td>
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<td>Army Missile Research, Development and Engineering Center</td>
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<td>AO</td>
<td>Advanced Operations</td>
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<td>AoA</td>
<td>Analysis of Alternatives</td>
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<tr>
<td>APCMP</td>
<td>Alternate Penetrator Case Manufacturing Process</td>
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<tr>
<td>ARRA</td>
<td>American Recovery and Reinvestment Act</td>
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<td>ASI</td>
<td>Aircraft systems interface, Army Space Institute, Advanced Structures Initiative</td>
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<tr>
<td>ATD</td>
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<td>AWDI</td>
<td>Affordable Weapons DataLink Initiative</td>
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<td>BLU</td>
<td>Bomb Live Unit</td>
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<td>BMI</td>
<td>Bismaleimide</td>
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<td>Br</td>
<td>Branch</td>
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<tr>
<td>C4ISR</td>
<td>Command, Control, Communications &amp; Computers, Intelligence, Surveillance &amp; Reconnaissance</td>
</tr>
<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
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<tr>
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<td>Composites Affordability Initiative</td>
</tr>
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<td>Condition-Based Maintenance</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>CC</td>
<td>Commander</td>
</tr>
<tr>
<td>CDAP</td>
<td>Common Datalinks Affordability Program</td>
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<td>CHAMP</td>
<td>Counter HPM Electronics Advanced Missile Project</td>
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<tr>
<td>CII</td>
<td>Compatibility, interoperability, and integration</td>
</tr>
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<td>CIP</td>
<td>Component Improvement Program</td>
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<td>CLAS</td>
<td>Conformal Load-bearing Antenna Structures</td>
</tr>
<tr>
<td>cm²</td>
<td>Centimeter squared</td>
</tr>
<tr>
<td>CMC</td>
<td>Ceramic matrix composite</td>
</tr>
<tr>
<td>COMET</td>
<td>Cost Modeling for Enterprise Transformation</td>
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<td>Conv</td>
<td>Conventional</td>
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<td>COTS</td>
<td>Commercial off-the-Shelf</td>
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<tr>
<td>CSAF</td>
<td>Chief of Staff of the Air Force</td>
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<tr>
<td>CT</td>
<td>Casting technology</td>
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<td>DARPA</td>
<td>Defense Advanced Research Projects Agency</td>
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<tr>
<td>DDM</td>
<td>Direct Digital Manufacturing</td>
</tr>
<tr>
<td>DDR&amp;E</td>
<td>Director, Defense Research and Engineering</td>
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<tr>
<td>DE</td>
<td>Directed Energy</td>
</tr>
<tr>
<td>DfA</td>
<td>Design for Affordability</td>
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<tr>
<td>DfM</td>
<td>Design for Manufacturing (or Manufacturability)</td>
</tr>
<tr>
<td>D/L</td>
<td>Datalink</td>
</tr>
<tr>
<td>DL</td>
<td>Depot level</td>
</tr>
<tr>
<td>DLA</td>
<td>Defense Logistics Agency</td>
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<td>DMS&amp;T</td>
<td>Defense-wide Manufacturing Science &amp; Technology</td>
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<tr>
<td>DMSMS</td>
<td>Diminishing Manufacturing Sources and Material Shortages</td>
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<td>DoD</td>
<td>Department of Defense</td>
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<td>DoE</td>
<td>Department of Energy</td>
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<tr>
<td>DoDD</td>
<td>Department of Defense Directive</td>
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<tr>
<td>DREX</td>
<td>Digital Receiver Exciter</td>
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<td>DSTAG</td>
<td>Defense Science and Technology Advisory Group</td>
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<td>DW CLAS</td>
<td>Direct Write Conformal Load-bearing Antenna Structures</td>
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<td>E&amp;O</td>
<td>Electronics and Optics</td>
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<td>EBAM</td>
<td>Electron beam additive manufacturing</td>
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<td>ECAD</td>
<td>Electrical Computer Aided Design</td>
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<td>EFG</td>
<td>Edge-defined Film-fed Growth</td>
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<tr>
<td>ELLA</td>
<td>Electric Laser on Large Aircraft</td>
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<tr>
<td>ELSA</td>
<td>Electric Laser on Small Aircraft</td>
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<td>EMD</td>
<td>Engineering and Manufacturing Development</td>
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<tr>
<td>EO</td>
<td>Electro-optical</td>
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<td>EOTS</td>
<td>Electro-optical Targeting System</td>
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<td>ERLE</td>
<td>Engine Rotor Life Extension</td>
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<td>FAST</td>
<td>Fast Access Spacecraft Test-bed</td>
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<td>FES</td>
<td>Flow Equivalent Servers (DMS&amp;T supply chain modeling project)</td>
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<td>FLTC</td>
<td>Focused Long Term Challenge</td>
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<td>FOC</td>
<td>Full operational capability</td>
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<td>FOPAT</td>
<td>Foam Patterns</td>
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<tr>
<td>FY</td>
<td>Fiscal Year</td>
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<tr>
<td>FYDP</td>
<td>Future Years Defense Program/Plan</td>
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<tr>
<td>Acronym</td>
<td>Full Form</td>
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<tr>
<td>GAO</td>
<td>Government Accountability Office</td>
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<tr>
<td>GE</td>
<td>General Electric</td>
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<td>GEAE</td>
<td>General Electric Aircraft Engines</td>
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<td>Gen</td>
<td>Generation</td>
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<tr>
<td>GCMA</td>
<td>Global Collaborative Manufacturing Architecture</td>
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<tr>
<td>GNC</td>
<td>Guidance, navigation, control</td>
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<tr>
<td>GPS</td>
<td>Global Positioning System</td>
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<td>HALE</td>
<td>High Altitude Long Endurance</td>
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<td>GN&amp;C</td>
<td>Guidance, navigation and control</td>
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<td>HARM</td>
<td>High-speed Anti-Radiation Missile</td>
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<td>HBGW</td>
<td>Hypersonic Boost Glide Weapon</td>
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<td>HEETE</td>
<td>Highly Efficient Embedded Turbine Engine</td>
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<td>HiFi</td>
<td>High Fidelity</td>
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<td>Hi-g</td>
<td>High Gravity</td>
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<td>HOB</td>
<td>Height of Burst</td>
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<td>HPM</td>
<td>High-Power Microwave</td>
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<td>HPSA</td>
<td>High Power Solar Array</td>
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<td>HQ</td>
<td>Headquarters</td>
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<tr>
<td>HT</td>
<td>High temperature</td>
</tr>
<tr>
<td>HTD</td>
<td>Hard Target Defeat</td>
</tr>
<tr>
<td>HTVS</td>
<td>Hard target void sensor</td>
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<tr>
<td>HTVSF</td>
<td>Hard target void sensing fuse</td>
</tr>
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<td>HVM</td>
<td>High Velocity Maintenance</td>
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<td>IB</td>
<td>Industrial base</td>
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<tr>
<td>IE</td>
<td>Integrated enterprise</td>
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<tr>
<td>IBA</td>
<td>Industrial base assessment</td>
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<tr>
<td>IBP</td>
<td>Industrial base planning</td>
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<tr>
<td>IBRs</td>
<td>Integrally bladed rotors</td>
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<td>ICAD</td>
<td>Integrated Computer Aided Design</td>
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<tr>
<td>ICAF</td>
<td>Industrial College of the Armed Forces</td>
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<tr>
<td>IDEF</td>
<td>Integrated definition</td>
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<td>IDEV</td>
<td>International development</td>
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<tr>
<td>IGES</td>
<td>Integrated graphics exchange specifications</td>
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<tr>
<td>IMU</td>
<td>Inertial measurement unit</td>
</tr>
<tr>
<td>IOC</td>
<td>Initial operational capability</td>
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<tr>
<td>IP</td>
<td>Industrial Policy, intellectual property</td>
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<tr>
<td>IR&amp;D</td>
<td>Independent research &amp; development</td>
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<tr>
<td>ISR</td>
<td>Intelligence, Surveillance &amp; Reconnaissance</td>
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<tr>
<td>IT</td>
<td>Information technology</td>
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<tr>
<td>ITAR</td>
<td>International Trafficking in Arms Regulations</td>
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<td>JASSM-ER</td>
<td>Joint Air-to-Surface Standoff Missile - Extended Range</td>
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<td>JCTD</td>
<td>Joint Capability Technology Demonstration</td>
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<td>JDAM-ER</td>
<td>Joint Direct Attack Munition - Extended Range</td>
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<td>JDMP</td>
<td>Joint Defense Manufacturing Technology Panel</td>
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<td>JDRADM</td>
<td>Joint Dual-Role Air Dominance Missile</td>
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<tr>
<td>JFTL</td>
<td>Joint Future Theater Lift</td>
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<td>JPF</td>
<td>Joint Programmable Fuze</td>
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<tr>
<td>JSOW</td>
<td>Joint Standoff Weapon</td>
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<tr>
<td>kW</td>
<td>Kilowatt</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>LADAR</td>
<td>Laser detection and ranging</td>
</tr>
<tr>
<td>Lbs</td>
<td>Pounds</td>
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<tr>
<td>LO</td>
<td>Low observable</td>
</tr>
<tr>
<td>LRIP</td>
<td>Low Rate Initial Production</td>
</tr>
<tr>
<td>LRS</td>
<td>Long Range Strike</td>
</tr>
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<td>M4I</td>
<td>Mini/Micro Munitions Manufacturing Initiative</td>
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<td>M&amp;S</td>
<td>Modeling and simulation</td>
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<td>MALD</td>
<td>Miniature Air Launched Decoy</td>
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<td>ManTech</td>
<td>Manufacturing Technology</td>
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<td>MBE</td>
<td>Model Based Enterprise</td>
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<td>MCAD</td>
<td>Manufacturing Computer Aided Design</td>
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<td>Missile Defense Agency</td>
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<td>Major Defense Acquisition Program</td>
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<td>MEMS</td>
<td>Micro-electro-mechanical systems</td>
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<td>Mfg</td>
<td>Manufacturing</td>
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<td>MISPI</td>
<td>Mono-pulse information signal processing</td>
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<td>MRA</td>
<td>Manufacturing Readiness Assessment</td>
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<td>MRL</td>
<td>Manufacturing Readiness Level</td>
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<td>MRO</td>
<td>Maintenance, Repair and Overhaul</td>
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<td>Milestone</td>
</tr>
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<td>MS&amp;T</td>
<td>Manufacturing Science &amp; Technology</td>
</tr>
<tr>
<td>MT</td>
<td>Manufacturing Technology, Mechanical timer (armaments)</td>
</tr>
<tr>
<td>MWIR</td>
<td>Mid-wavelength infrared</td>
</tr>
<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
</tr>
<tr>
<td>NAVAIR</td>
<td>Naval Air Systems Command</td>
</tr>
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<td>Network Centric Manufacturing</td>
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<td>Non-Destructive Examination/Evaluation</td>
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<td>National Defense Industrial Association</td>
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<td>Nano Electro-Mechanical Systems</td>
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<td>Nickel</td>
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<td>National Science Foundation</td>
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<td>Oklahoma City Air Logistics Center</td>
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<td>OEM</td>
<td>Original equipment manufacturer</td>
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<td>OMC</td>
<td>Organic matrix composite</td>
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<td>Out-of-Autoclave</td>
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<td>OO-ALC</td>
<td>Ogden Air Logistics Center</td>
</tr>
<tr>
<td>Ord</td>
<td>Ordinance</td>
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<tr>
<td>OSD</td>
<td>Office of the Secretary of Defense</td>
</tr>
<tr>
<td>PDM</td>
<td>Programmed depot maintenance</td>
</tr>
<tr>
<td>PEO</td>
<td>Program Executive Office</td>
</tr>
<tr>
<td>Pgm</td>
<td>Program</td>
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<tr>
<td>PGM</td>
<td>Precision guided munition</td>
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<tr>
<td>Ph</td>
<td>Phase</td>
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<tr>
<td>Pkg</td>
<td>Package</td>
</tr>
<tr>
<td>PLM</td>
<td>Product Lifecycle Management</td>
</tr>
</tbody>
</table>

E-4
PM Program manager
POM Program Objective Memorandum
PPBE Planning, Programming, Budgeting and Execution
Prop Proposal
Prot Protection
QDR Quadrennial Defense Review
QNT Quint Networking Technology
QRC Quick Response Capability
Qual Qualification
RANGER Risk Assessment for Next Generation Supply Chain Readiness
RAPID Rapid Airframe Production Implementation Demonstration
RB Shorthand for Air Force Research Laboratory Air Vehicles Directorate
RDT&E Research, Development, Test and Evaluation
Remfg Re-manufacturing
REACH Registration, Evaluation, Authorization and restriction of Chemical substances
RF Radio frequency
RFI Request for information
RI Shorthand for AFRL’s Information Directorate
ROI Return on investment
RPA Remotely piloted aircraft
RR Rolls Royce
RV Shorthand for AFRL’s Space Vehicles Directorate
RXB Shorthand for AFRL’s Nonmetallic Materials Division
RXL Shorthand for AFRL’s Metals, Ceramics & Nondestructive Evaluation Division
RXM Shorthand for AFRL’s Manufacturing Technology Division
RY Shorthand for AFRL’s Sensors Directorate
RZ Shorthand for AFRL’s Propulsion Directorate
S&T Science and Technology
SAF Secretary of the Air Force
SAF/AQ Office symbol for Assistant Secretary of the Air Force for Acquisition
SAF/AQR Office symbol for Deputy Assistant Secretary of the Air Force for Science, Technology, and Engineering Leadership
SAF/IE Office symbol for Assistant Secretary of the Air Force for Installations, Environment & Logistics
SAF/OS Office symbol for Secretary of the Air Force
SAM Surface-to-air missile, Super Abrasive Machining
SAR Search and Rescue
SBIR Small Business Innovation Research
SC SensorCraft
SCM Supply Chain Management
SCRAMJet Supersonic Combustion RAMjet
SDB-II Small Diameter Bomb - II
SECAF Secretary of the Air Force
SES Senior Executive Service
SHD Small Hole Drilling
SHM Structural Health Monitoring (System Health Management)
SIAP Single Integrated Air Picture
SiC Silicon Carbide
Sim Simulation
The Air Force
Manufacturing Technology Program
Vision

Attaining Next Generation
Agile Manufacturing

September 2010

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