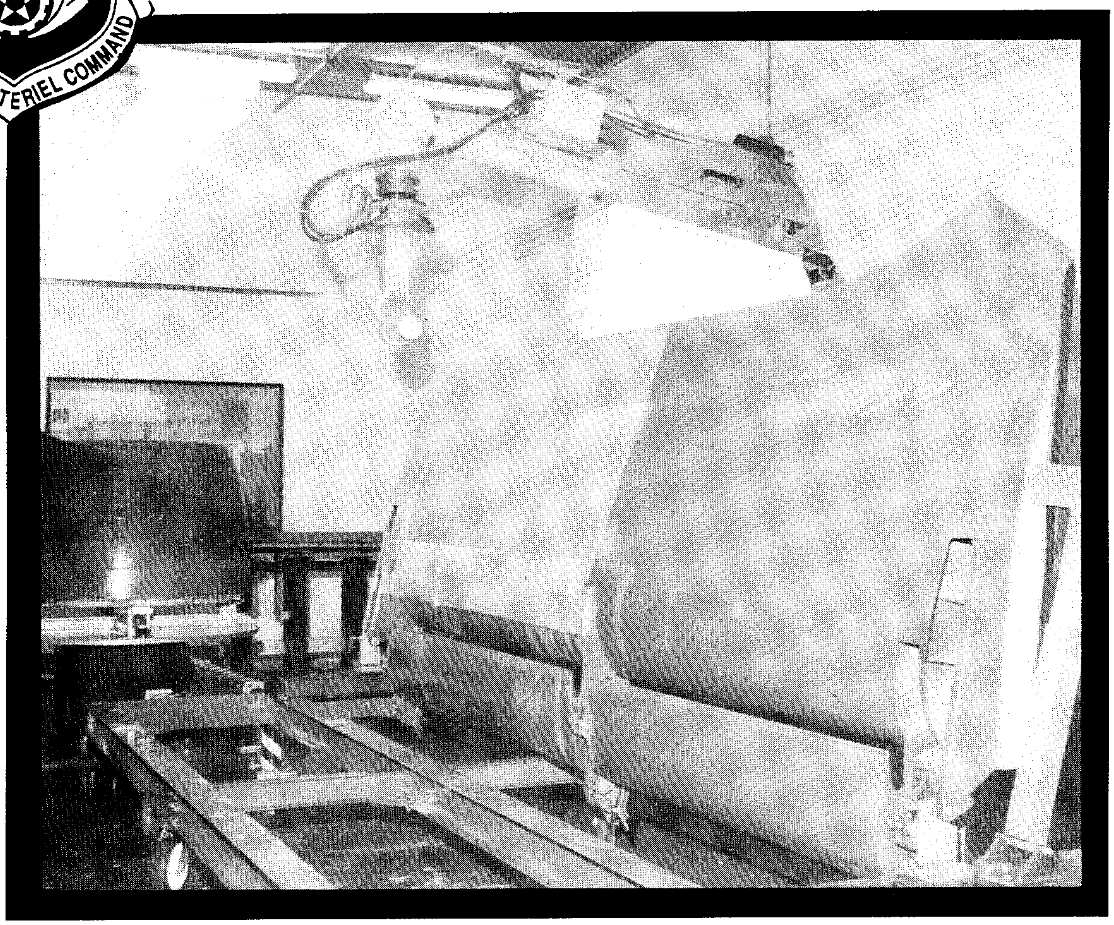
WL-TR-96-8000

FY96
MANUFACTURING SCIENCE AND TECHNOLOGY AREA PLAN



HEADQUARTERS AIR FORCE MATERIEL COMMAND
DIRECTORATE OF SCIENCE & TECHNOLOGY
WRIGHT-PATTERSON AFB, OHIO

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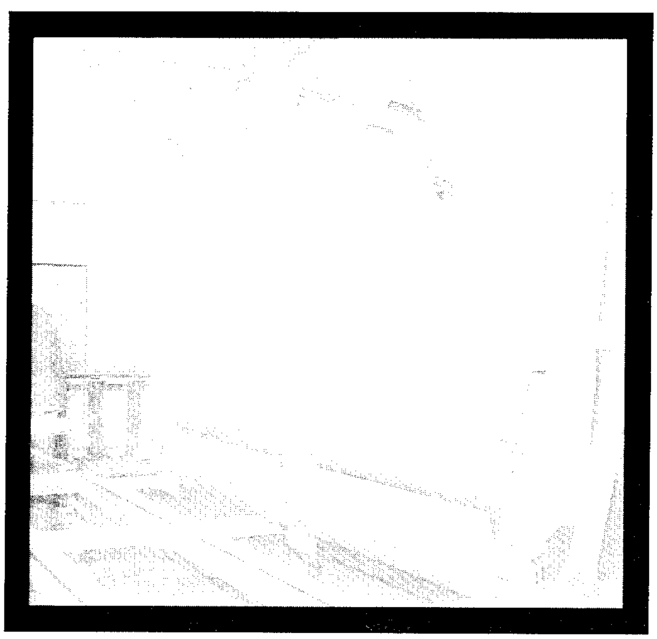
PREFACE

This Technology Area Plan (TAP) documents the Air Force Manufacturing Science and Technology (AF MS&T) Program's vision across four technology thrusts. The AF MS&T TAP is designed to demonstrate the technological opportunities that exist within the defense industrial base to establish vanguard industrial processes and enterprises capable of producing superior warfighting capabilities, in concert with significant reductions in cost.

The work discussed within this TAP is being performed by the AF MS&T Program, under the auspices of the Air Force Materiel Command (AFMC) Directorate of Science and Technology (DS&T). This TAP does not address projects being conducted by the Defense Production Act Program or the Wright Laboratory Manufacturing Technology Directorate Industrial Base Analysis Program since management oversight and funding for these activities fall outside the DS&T purview.

Note: This Technology Area Plan (TAP) is a planning document for the FY96-02 Air Force Science and Technology (AF S&T) Program, and is based on the President's FY96 Budget Request. It does not reflect the impact of the FY96 Congressional appropriations and the FY96-02 budget actions. You should consult WL/XP, (513) 255-4843, for specific impacts that the FY96 appropriations may have with regard to the contents of this particular TAP. This document is current as of 1 August 1995.



ABOUT THE COVER PHOTO

The MS&T Program extends its industrial process expertise beyond original manufacturing support requirements, introducing innovative capabilities into the air logistics centers to more affordably sustain existing weapon systems. The MS&T Program, in conjunction with the Oklahoma City Air Logistics Center (OC-ALC), is establishing the capability to eliminate reliance on manual chemical paint stripping operations in support of large aircraft. Depicted on the front cover is the MS&T Program's Aircraft Component Subsystem (ACS) that will enable protective coatings removal, using a high pressure water stream, from individual components while their host aircraft undergoes paint stripping operations. The ACS will support annual surface area workloads equivalent to 28 C-135s, removing protective coatings at 125 sq ft/hr without compromising the environment or the assigned workers' health and safety. This effort would not have been possible without supplemental funding support received from the Strategic Environmental Research and Development Program and the AFMC/CEV office.

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13. ABSTRACT (*Maximum 200 words*) The FY96 Air Force Manufacturing Science and Technology (AF MS&T) TAP highlights the Directorate's plans for enhancing/enabling weapon system (aircraft, spacecraft/C3I and launch, and/or missiles and munitions) affordability, producibility and sustainability. The MS&T TAP, one of thirteen TAPs generated annually, helps advocate the approved Air Force Science and Technology Program. The FY96 AF MS&T TAP defines an updated 21st-century industrial base vision that foresees being able to produce and sustain weapon systems at half the cost and in half the time. Achieving the vision is proposed by generating fundamental change in two areas, enterprise operations and technology. The AF MS&T TAP highlights three high-payoff areas that if correctly focused/emphasized can facilitate the 21st-century vision's achievement. These areas include 1) manufacturing and engineering systems, 2) processing and fabrication and 3) advanced industrial practices. The FY96 AF MS&T TAP defines specific investment strategies and goals, outlined according to four thrusts, for meeting stated user needs. Major thrust changes from last year's AF MS&T TAP are also described, as well as major thrust accomplishments.

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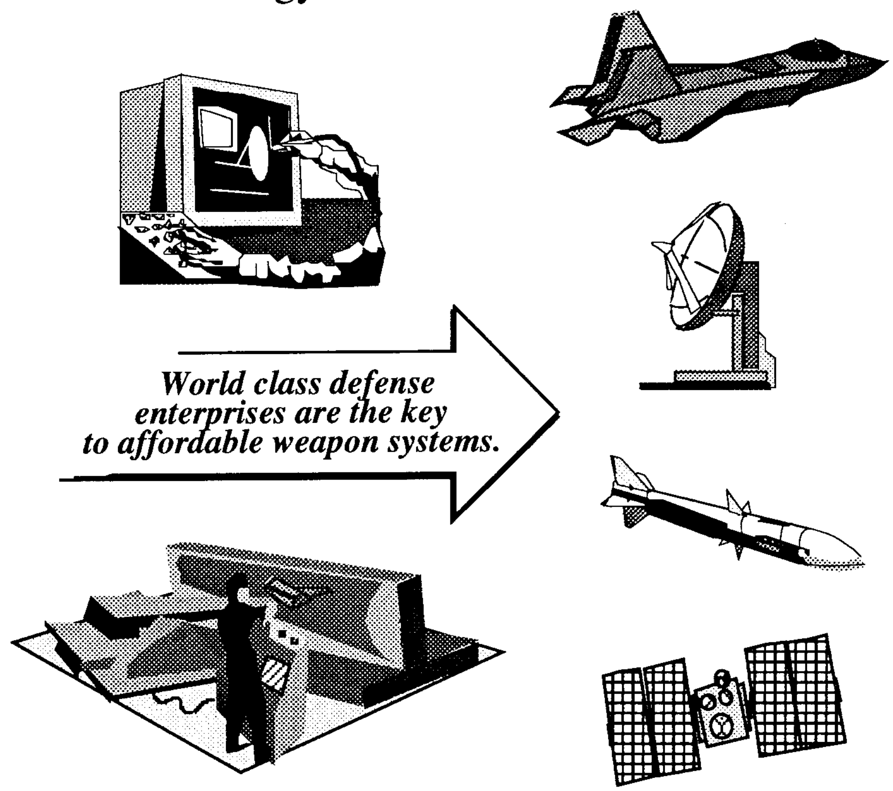
VISIONS and OPPORTUNITIES
Manufacturing Science and Technology (MS&T)



In the 21st Century, technologically superior Air Force weapons systems will be produced for half the cost and fielded in half the time through a fully integrated commercial, military and organic industrial base. The existing fleet will be upgraded and/or modified to maintain its superiority with the same reductions in cost and time. The Air Force is reliant on the Manufacturing Science and Technology (MS&T) Program to achieve this vision, looking to the Program to transform Air Force and defense industrial practices directly associated with the design and the production of superiority-edge capabilities for new systems and/or upgrades to existing systems.

These opportunities arise from proven approaches in highly-competitive manufacturing sectors that have realized the dramatic cost and the time improvement crucial to our manufacturing vision for the Air Force. The key areas for fundamental change are in:

- <u>Enterprise Operations</u> - viewing manufacturing, and its associated external relationships, as the entire enterprise and stressing comprehensive waste elimination at all levels through actions based on this holistic view of manufacturing. This key area for fundamental change impacts all elements of the enterprise, including product design and development, supplier and customer relations, organization, production, and workforce relations.

- <u>Technologies</u> - emphasizing product reliability, affordability and time to market. Expanded emphasis in this area will drive technology investment priorities toward low process variability, rapid product realization, organization streamlining, and intimate supplier involvement, in both design and production.

Successful manufacturers implementing and integrating these changes have achieved world class competitive-edge results, cutting time-to-market in half, doubling product reliability, cutting production cycle time by two-thirds, increasing output per employee by more than 50 percent, slashing inventories by more than two-thirds and cutting management levels in half. Moreover, they are continuing to improve on these dramatic gains by employing explicit strategies for continuous improvement, exemplified by formalized metrics that track change implementation. These world class firms have gained market share and improved their profitability, while at the same time, they have dramatically increased their workforces' contributions, skills and self-satisfaction.

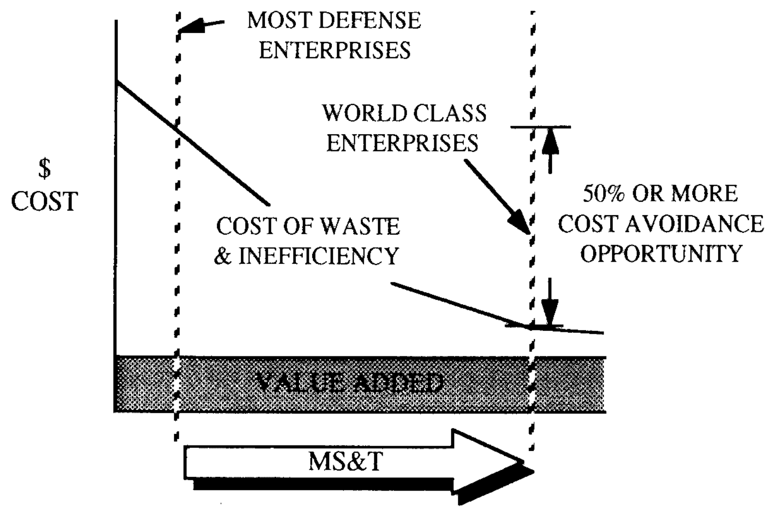
The Air Force weapon system design, manufacture and support environment has some distinctive differences in contrast with the commercial product world. Nevertheless, the enterprise operations and the technology changes successfully demonstrated by highly-competitive firms offer the enabling vehicles for achieving the stated MS&T vision.

The AF MS&T Program will provide the Air Force with the enabling mechanisms to tailor and to field successful industrial approaches in the affordable manufacture of defense systems and products, implementing them in Air Force design, production and sustainment efforts. The AF MS&T Program will spearhead efforts to mature vital new processes required by the Air Force, ensuring they possess world class manufacturing characteristics. We will achieve our defense manufacturing enterprise vision by vigorously focusing on the following three areas:

- **Manufacturing and Engineering Systems** - We will establish major advancements in the above-the-floor activities which plan, schedule and control the operations of any factory, fostering 1) integrated product and process development (IPPD) and supplier management environments, 2) techniques for ensuring released designs are manufacturable with six-sigma quality (less than four deficiencies per million like characteristics) and 3) the migration of the above listed improvements across the entire defense industrial enterprise. Our initiatives will dramatically reduce costs and shorten cycle times for transition to outsourcing and/or to onsite manufacturing.

- **Processing and Fabrication** - We will mature critical processes required to produce new superiority-edge military capabilities before they are committed to new systems or upgrades, enabling precise and repeatable processing of metals, ceramics and composites, and of electronics materials, devices and assemblies. Our efforts will lead to 1) high-quality, defect-free materiel, 2) rapid technology insertion and 3) reduction in cycle time and cost.

- **Advanced Industrial Practices** - We will closely couple integrated advancements from the other MS&T initiatives to weapon system programs and shift the industrial base towards adopting lean production characteristics. We will continue to generate pilot program efforts, linking and implementing new alternative manufacturing and business methods for enabling much lower cost, lower risk production of superiority-edge technologies. Our vanguard will be the lean manufacturing approach proven highly effective in the automotive industry. We will strive to enable the expanded production of required Air Force products across commercial lines.



We are transforming America's defense industrial base into a "lean" machine.

The AF MS&T Program is committed to ensuring the warfighter's materiel requirements can be affordably achieved in an accelerated manner, during initial acquisition, system sustainment and/or reconstitution.

This plan has been reviewed by all Air Force laboratory commanders/directors and reflects integrated planning. We request Air Force Acquisition Executive approval of the plan.

RICHARD R. PAUL
Brigadier General, USAF
Technology Executive Officer

DAVID A. HERRELKO
Colonel, USAF
Commander, Wright Laboratory

CONTENTS

INTRODUCTION
FY96 Manufacturing Science and Technology Area Plan

BACKGROUND

The Air Force Manufacturing Science and Technology (AF MS&T) Program, highlighted in Figure 1, is tasked to ensure America's defense aerospace industrial base is fully capable and responsive in supporting Air Force needs in the development, production, and sustainment of planned and existing weapon systems and components. Program successes frequently find broad application throughout defense and civil manufacturing sectors. The MS&T Technology Area Plan (TAP) identifies how this is accomplished.

The MS&T Program is committed to enhancing domestic productivity, increasing quality, and reducing weapon systems acquisition and life cycle costs. Sustained support is provided to all Air Force product and logistics centers in the areas of manufacturing and engineering systems; processing and fabrication (electronics, metals and nonmetals); advanced industrial practices; and development of viable domestic production capabilities in areas where critical voids exist. The Program's investment strategy emphasizes the selection of defense-essential projects that will have broad application across diversified systems.

An excellent example of how the Program can benefit a major weapon system program is the investment made in support of the F-16 program. To date, the MS&T Program has invested slightly over $162M in manufacturing technologies that were validated in the F-16 Program. This investment is expected to save the Air Force over $1 billion in life cycle costs, on the F-16 alone, through the year 2000. Two of the forty-five MS&T projects initiated in support of the F-16 program benefited <u>all</u> production aircraft and <u>all</u> of these technologies will benefit future aircraft.

Management of the MS&T Program is accomplished through the four technology thrusts listed on the front side of Figure 2. Major thrust goals are driven by user needs which are reevaluated annually in recognition of the aerospace industrial base dynamics, of changing force structure requirements, of emerging technology opportunities and of policy changes. The AF MS&T Program's primary goal is to provide advanced manufacturing leadership for enabling affordable, superior defense systems by:

- Executing a balanced customer driven-program
- Catalyzing beneficial change within the defense manufacturing enterprise
- Partnering and consulting with a comprehensive array of interested contributors
- Implementing the fundamentals of affordability, rapid technology insertion and reduced time to low risk production, while fostering a robust industrial base

This goal is achieved through the planning and executing of an integrated effort with the Joint Directors of Laboratories' (JDL) Project Reliance Panels, including the Manufacturing Science and Technology Panel.

The AF MS&T planning process is based on comprehensive analyses of force structure requirements, industrial base manufacturing issues, and technology opportunities. The overall emphasis is to focus on requirements and on those technologies which are applicable to multiple weapon systems. All AF MS&T planning activities are governed by the interactions of diverse requirements teams with four Technology Thrust

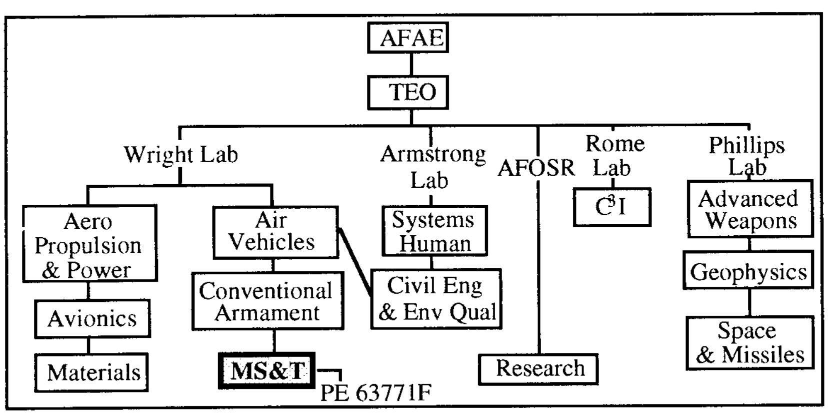


Figure 1. Air Force Science and Technology Program Structure

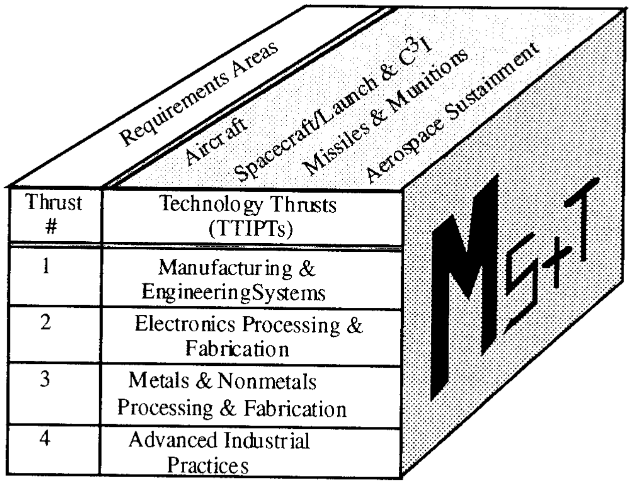


Figure 2. AF MS&T Program Planning Activities

Integrated Product Teams (TTIPTs), as shown in Figure 2. The requirements teams, individually aligned to specific mission areas, are focused on supporting a particular area's process and/or product technology needs, identifying manufacturing related deficiencies and/or opportunities which one or more of the MS&T TTIPTs could beneficially influence. The Manufacturing and Engineering Systems TTIPT is concerned with systems and information integration, integrated product/process development strategies, and manufacturing science. Both the Electronics and the Metals and Nonmetals Processing and Fabrication TTIPTs have similar product and/or process responsibilities, one being in electronics and the other in structures and propulsion, respectively. The Advanced Industrial Practices TTIPT addresses the issues of cost reduction, quality and cycle time through integration efforts involving infrastructure needs and business practices related to specific manufacturing technologies.

Each TTIPT and their associated thrust activities are described in expanded detail in the Program Description section. The MS&T Program's four thrusts are decentralized efforts focused on specific objectives, optimizing the Program's support to the Air Force product and logistics centers. These centers, in conjunction with the industrial base, are the MS&T Program's primary customers. The MS&T Program definition of "manufacturing" goes far beyond factory manufacturing processes, embracing every activity within an aerospace industrial activity's realm, including product development, inventory management, supplier relationships, environmental compliance, and product sustainment. Table 1 provides a representative listing of the diversified Air Force industrial needs that the MS&T Program currently has on its agenda.

Expansive MS&T needs, constrained by current budget realities, necessitate the Program having a highly integrated process for determining the Program's future course. Broad-based collaboration is required to achieve complementary and/or superior customer benefits. The following ground rules have been established to guide the Program's planning process, illustrated in Appendix 1 Figure A-2, ensuring customer requirements remain paramount.

- Focus on weapon systems affordability
- Emphasize technical and industrial base needs
- Pursue a requirements driven program
- Conduct proactive, joint planning
- Plan new projects using a disciplined process
- Nurture commercial--military integration and flexible manufacturing
- Maintain a continuous, evolving planning process

The MS&T Program planning process intersects the following key activities and/or functions during its planning cycle.

- The Director, Defense Research and Engineering communicates overall S&T strategy upon which product requirements are identified and communicated to the Joint Directors of Laboratories (JDL).
- The Air Force Acquisition Executive (AFAE) establishes broad guidance for planning and executing the Air Force Science and Technology Program strategies and programmatic emphasis areas.
- The JDL MS&T Reliance Panel develops joint plans for a cooperative and coordinated Triservice MS&T Program and transmits appropriate information to the TTIPTs.

Table 1. Representative MS&T Program Drivers

NEEDS CATEGORY	SPECIFIC NEEDS
Aircraft	• Lightweight, Affordable Structures for the F-22 • Affordable Engine Structures • Affordable Advanced Electronics for Radar and for Electronic Countermeasures Systems
Spacecraft/Launch and C^3I	• Gallium Arsenide (GaAs) Solar Cell Panel Assembly; Rapid Insertion for DSCS
Missiles and Munitions	• Infrared (IR) Detector Cryocooler Producibility • Affordable Millimeter Wave (MMW) Components for AGM-137, Joint Direct Attack Munitions (JDAM)
Aerospace Sustainment	• Economical Methods to Identify and Repair Hidden Corrosion • Compensating Capabilities for Parts Obsolescence • Environmentally Compatible Processes/Products
Manufacturing and Engineering Systems	• Manufacturing Systems Integration (Virtual Corporation/Collaborative Design and Production) • Simulation and Modeling (Automated Process Planning and Factory Simulation) • Manufacturing Engineering Support Tools (Interoperable Engineering Tools and Knowledge Bases)
Processing and Fabrication	• Risk Reduction of Defense-Essential Capabilities • Mission Enabling Processes, Emphasizing Affordability in Advanced Electronics and Composites • Economical Manufacture of Lighter Weight Metal Components Possessing Enhanced Structural Uniformity
Advanced Industrial Practices	• Military Electronic Products Produced Across Commercial Factory Lines • Military Structural Components Produced Across Integrated Commercial/Military Lines • Improved Affordability and Effectiveness within Production Operations

- The Air Force Technology Master Process, described in detail under Appendix 1, establishes the MS&T Program's working linkage to its Air Force customer base.

These activities and functions establish the framework used to guide future activities, ensuring investments are integrated into a highly coherent plan and are focused on the most important manufacturing challenges facing the Air Force.

The Program systematically gauges its progress through periodic self-assessments, ensuring the Program remains focused on attaining its long-term vision. Representative metrics applied by the Program to evaluate progress and to influence decision making include the following indicators.

- Implementation of a developed technology
- Increased process technology in advanced technology transition demonstrations
- Project-specific cost avoidance and/or cost reduction
- Engineering validated risk reduction (technology maturity)

This closed-loop process ensures the Program remains on course, facilitating expanded customer confidence in the Program's ability to effectively mature processes considered critical in enabling the affordable and/or successful exploitation of defense-essential capabilities.

To date, the Program has invested approximately $100M to support the affordable exploitation of several advanced technologies which could impact the F-22. Because of the MS&T Program's early involvement with the F-22, the opportunity window is much larger than experienced on similar weapon system programs such as the F-16 and the B-1B aircraft. Consequently, several cost-prohibitive, combat-superior technologies were rendered affordable and incorporated into the demonstration/validation (dem/val) configuration.

At present, the F-22 Program Engineering and Manufacturing Development and/or Production role is being developed, and additional investments can be anticipated to facilitate the affordable production and support of the F-22. The MS&T Program's "up front" involvement will enable a significant number of projects to beneficially impact all production aircraft, enhancing overall aircraft producibility. Many of the advanced capabilities earmarked for the F-22 are being considered for immediate insertion into existing platforms, demonstrating the "compounding effect" of MS&T matured technologies. For instance, potential F-15 and/or F-16 radar updates will have more affordable access to phased array technology

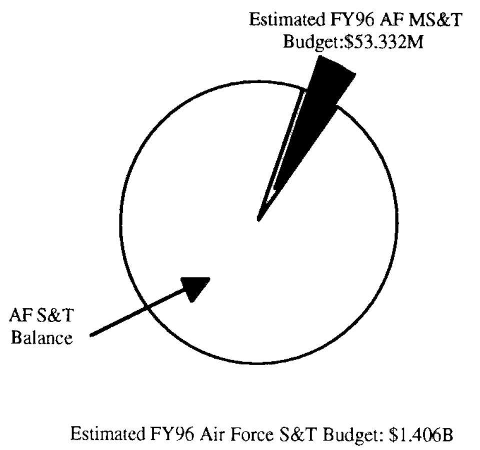


Figure 3. AF MS&T $ vs. AF S&T $

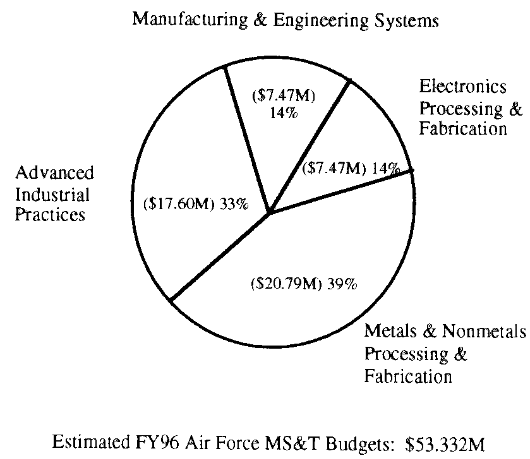


Figure 4. Major Technology Thrusts

because of cost reduction efforts achieved by the MS&T Program transmit/receive (T/R) module project.

The Program's ability to influence weapon system affordability is directly linked to its annual appropriation. Figure 3 illustrates the FY96 AF S&T President's Budget share that will be made available to the AF MS&T Program. Figure 4 shows the distribution of the AF MS&T President's Budget Request funds over the four MS&T technology thrusts.

RELATIONSHIP TO OTHER TECHNOLOGY PROGRAMS

The MS&T Program is comprehensive and broad based. It covers the entire spectrum of activities necessary to effectively and efficiently operate the industrial activities that produce and/or sustain weapon systems.

The MS&T Program is instrumental in transitioning technologies being generated by other MS&T entities within the DoD to affordable fruition. It also helps enable an array of technologies to be affordably incorporated into advanced weapon systems. As emphasis on process investment grows, the Program's association with all technology areas will expand. The range of the Program's requirements and technology thrusts (See Figure 2) is a clear indicator of the Program's technology diversification within the S&T community.

In an era of competing priorities, the successful exploitation of performance enabling technologies requires the establishment of comprehensive development strategies, extending beyond core technology dem/val efforts to include producibility. The MS&T Program continues to champion producibility across the S&T realm, as an advocate and as a hands-on contributor. Program initiatives are tailored to enable optimum industrial capabilities to be in place for accommodating significant advancements in such areas as electronics, propulsion and/or structures technology.

The MS&T Program is leading an AF S&T team in a command sponsored S&T Affordability initiative. Program electronics initiatives are enabling the Conventional Armament Directorate to incorporate more affordable guidance/sensor systems into the next-generation of standoff missile systems. Program producibility efforts in composites are assisting the Aero Propulsion and Power Directorate transition advanced propulsion technologies. Flat panel display Program efforts are enabling the Flight Dynamics Directorate to affordably upgrade cockpit technology. Multi-Bandgap Solar Cell producibility efforts will enable the Space and Missile Directorate equip defense satellites with expanded mission capabilities.

Based on historical and on anticipated funding, the FY 96 Program will leverage approximately $150M in external funds, orchestrating manufacturing technology and science efforts that range from infrastructure development for multi-chip modules to fast and flexible communications for engineering information within the aerospace industry. The Program specifically stresses multi-application potential during the project selection process, aiming to extend the resulting technology across a broader base. In addition, the MS&T Program performs the lead role in transforming technology into affordable, high-quality products and processes, and in controlling implementation risk.

CHANGES FROM LAST YEAR

The AF MS&T Program's emphasis on total quality management in pursuit of optimizing customer support necessitated a restructure in thrusts. The Program's total thrusts have been reduced from eight to four, consolidating common technology activities under specific thrusts. For instance, electronics MS&T needs previously addressed from a mission orientation are now worked under the Electronics Processing and Fabrication Thrust. Requirements teams have been established to accomplish needs identification tasks within specific mission areas. These teams will ensure the Program maintains an assertive mission/weapon system connection, cultivating customer requirements and making recommendations to the applicable technology thrusts. This realignment will help enable vertically integrated efforts aimed at solving common MS&T problems. The Program's restructure is part of a larger maturation process, establishing full integration with the Air Force Technology Master Process (TMP) and the Joint Directors of Laboratories' MS&T Panel. In November 1994, the MS&T Program completed its restructure upon the establishment of a documented planning process that is fully aligned with the TMP and the JDL.

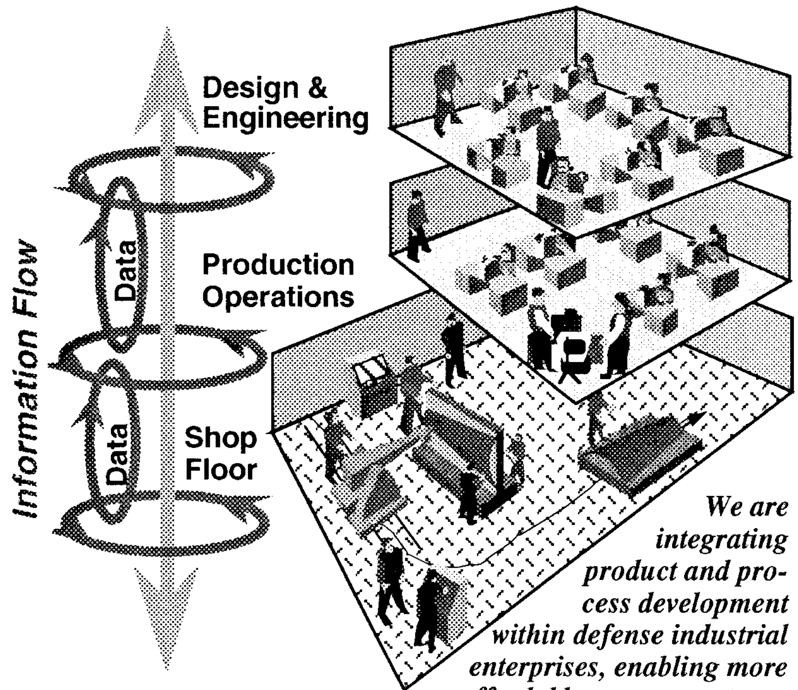
The MS&T Program spearheaded the establishment of the JDL's MS&T Panel, in concert with the other military services, the Defense Logistics Agency (DLA), and the Advanced Research Projects Agency (ARPA). During the past year, the panel established its technology taxonomy, dividing the JDL's MS&T Panel into three broad subareas, 1) Manufacturing and Engineering Systems, 2) Processing and Fabrication and 3) Advanced Industrial Practices. Roadmaps for each technology subarea were established and the performing activities identified, culminating in the generation of an integrated Technology Area Plan. Partially in response to the JDL MS&T Panel's subarea taxonomy, the AF MS&T Program restructured its thrusts to be comparable with the JDL's taxonomy, facilitating enhanced working relations with the panel's technology subareas.

The MS&T Program completed its assessment of the organic industrial base (OIB), now known as Sustainment 2005, extending the Manufacturing 2005 initiative to include the Air Force Air Logistics Centers. The MS&T led Sustainment 2005 initiative findings are generating significant change within the OIB, moving the OIB's management emphasis towards a workload sector perspective and away from an organizational concentration. In concert with the original Manufacturing 2005 initiative, the Sustainment 2005 initiative produced an abundance of technology and business policy and practice findings. Several findings will be used by the Program to document specific OIB needs requiring Program attention. Substantial emphasis will be placed on assisting the OIB's transition to becoming a "lean sustainment enterprise", concentrating on waste elimination and on rapid cycle time initiatives.

In response to the Program's declining budgets and increased earmarking, a general officer review was requested to assess the Program's future course and to establish a Program vote of confidence. Strong Program endorsement was achieved and a strategy was established to ameliorate the Program's fiscal ability to make meaningful Air Force contributions.

The Program's FY95 President's Budget Request was increased by the Appropriations Committee from \$58.2M to \$84.3M. However, only \$47.5M of this increased budget was discretionary, \$36.8M being directed to Congressional special interest topics. The Congressional-approved FY95 budget did enable the Program to restart 10 projects, placed on hold because of the original FY94 budget shortfall, and to initiate four new projects. The Program's FY95 funding source, as indicated in the FY95 AF MS&T TAP, was realigned away from the 78011F Program Element (PE) to 63771F. This move shifted the Program's funding source away from a consolidated Office of the Secretary of Defense budget line, aligning it with the AF S&T Program.

THRUST 1
Manufacturing and Engineering Systems



We are integrating product and process development within defense industrial enterprises, enabling more affordable weapon systems.

USER NEEDS

The defense manufacturing base's viability to meet future national security needs relies on technologically improved manufacturing and engineering systems. It demands a manufacturing research and development (R&D) base capable of supporting defense-unique requirements, including the affordable, low volume production of highly complex systems, many of which have no commercial counterpart.

The Manufacturing and Engineering Systems (M&ES) thrust is the leader in advancing methods, tools and information technologies for the Air Force MS&T Program. Driven by the need to achieve expanded weapon systems affordability, the M&ES thrust activities support a broad array of requirements. Unless major advances in manufacturing technology address these needs, minimal progress will be made in enabling affordable low-volume production of high-quality, technically-complex defense products.

In order to ensure the science and technology (S&T) culture addresses affordability during technology development, the M&ES thrust is leading an AF S&T team in a command-sponsored S&T Affordability Initiative. Initial funding is being provided by the AFMC/ST Directorate and its affiliated laboratories for establishing a process model and guide, explaining required tasks to address affordability in Advanced Technology Demonstration projects. Outyear funding for education, training and tools will be provided via a $10M FY96 Program Objective Memorandum (POM) initiative. The long-range goal is to change the S&T culture and its technology development practices, achieving balanced product and process maturation much earlier in technology development and reducing the cost and risk of transitioning laboratory-developed technology to weapon systems.

GOALS

Thrust success requires its activities focus on three key themes: 1) reduce weapon system life cycle costs through major improvements in above-the-shop floor manufacturing and engineering systems, tools and information integration, and in factory floor and design interfaces (integrated product and process development—IPPD); 2) migrate the above listed improvements across the entire defense industrial enterprise, including the air logistics centers; and 3) enhance technology transition from the S&T community into the acquisition and sustainment communities. Specific goals include the following:

- Achieve a 30-percent cost/time reduction in downstream operations with quantifiable risks and predictable manufacturing costs, linking key product attributes to process capabilities.
- Cut nonrecurring costs by 30 to 50 percent, achieving manufacturing efficiency in a lot size of one.
- Improve overall supplier responsiveness, achieving 1)

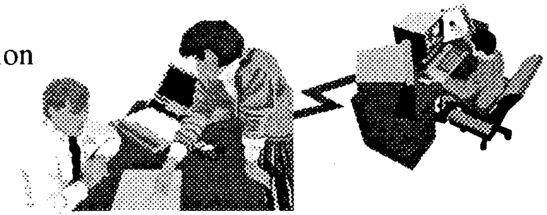
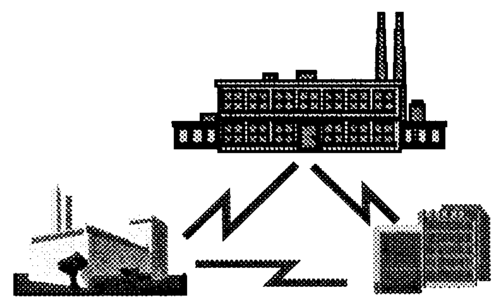
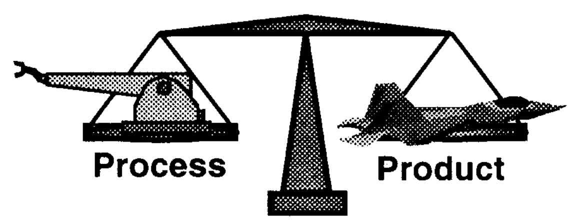
	MILESTONES	PAYOFFS	
Design for Affordability	• Link Mfg. Process Capability to Design Features (Six-Sigma Design) [FY97] • Characterize & Represent Processes (Electronic & Mechanical) [FY99-02]	• 30-Percent Cost/Time Reduction with Quantifiable Risks & Predictable Mfg. Costs • 50-Percent Design Time Reduction for Complex Electronic Assemblies	
Low-Rate Production Operations	• Prototype Manufacturing Tooling [FY97-99] • Deploy Soft Tooling [FY98-02]	• Affordable Low-Rate Production and Operating Prototypes • 30- to 50-Percent Reduction in Nonrecurring Costs, Achieving Mass Mfg. Efficiency in Small Volumes	
Supplier Partnering	• Expand Inter- and Intra-Supplier Electronic Commerce [FY96] • Initiate Federated Mfg. Pathfinders Across Multiple Enterprises [FY97-99]	• 30- to 50-Percent Reduction in Supplier Tansaction Time, Cost and Overhead • 30-Percent Inventory Cost Elimination with 100-Percent Electronic Integration of Key Primes—Suppliers	
Technology Transition Risk and Cost Reduction	• Conduct S&T Affordability Demonstrations [FY96-98] • Focus the Research Community on High-Cost Defense Manufacturing Needs [FY98-01]	• Reduced Transition Cost and Risk via Balanced Product and Process Development • Improved Technology Transition Risk and Cost Methods and Tools	

Figure 1.1. Manufacturing and Engineering Systems Thrust

30- to 50-percent reductions in transaction cost and time, 2) 30- to 50-percent reductions in supplier overhead, 3) 100-percent electronic integration of key prime suppliers and 4) 30-percent inventory cost reductions.

- Enhance industry abilities to develop and to transition affordable new technologies into weapon systems and into the factories that produce them.

- Establish a research community, in concert with the defense industrial base, to collaboratively resolve high-cost defense production problems.

The above goals are interrelated and, to some extent, support multiple Air Force needs. Achieving the M&ES thrust goals is critical to developing the underlying science base that will enable affordable, low-volume production for future weapon systems.

MAJOR ACCOMPLISHMENTS

Sustained FY95 efforts associated with the Electronic Product Data, the Virtual Test and the Simulatable Specifications projects achieved the following major accomplishments:

- Demonstrated a 15-percent reduction in redesign time for complex electronic systems.

- Demonstrated the feasibility of attaining a 50-percent component cycle time reduction, using electronic data representation and transfer.

- Validated the feasibility of applying "manufacturing in a computer" to real-world, defense-unique manufacturing scenarios.

- Demonstrated a 30-percent savings in electronic module assembly and test, using preliminary virtual test concepts.

- Led a major corporate S&T Affordability Initiative, enabling a more effective balance between performance and cost.

- Identified Advanced Technology Demonstration (ATD) projects and initiated a comprehensive education and training program for laboratory engineers.

- Initiated a collaborative effort with the National Science Foundation (NSF), utilizing university researchers to assess the underlying problems associated with new technology affordability.

The major FY95 accomplishments highlighted the need to nurture many of the underlying technologies essential to achieving FY96 thrust goals. Two major workshops paved the way for broad industry, government and academic collaboration in assessing manufacturing modeling and simulation applications and in facilitating future demonstration programs.

CHANGES FROM LAST YEAR

The MS&T Program merged the Manufacturing Systems and the Advanced Manufacturing thrusts into a single combined effort, now known as the M&ES thrust, facilitating a comprehensive agenda that emphasizes critical technologies and fills research voids in the defense manufacturing research and development base.

MILESTONES

Figure 1.1 illustrates four key M&ES thrust initiative areas, highlighting associated milestones and payoffs. Planned activities within each of these initiative areas are described in more detail below.

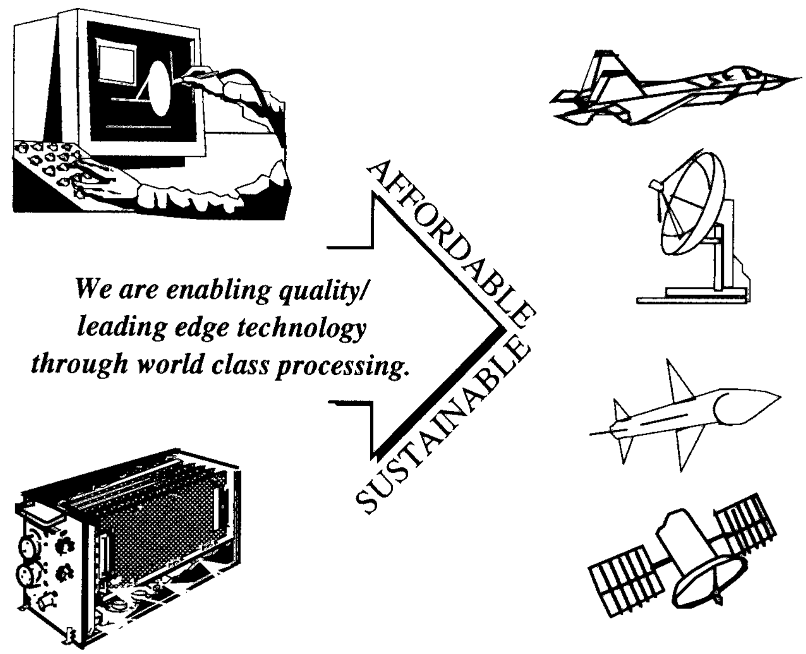
- <u>Design for Affordability</u>. Planned near-term activities will focus on the conceptual design stage, particularly for electronic and electro-mechanical systems and components. Longer range activities will address mechanical and structural components. A key goal is to develop models and tools, linking design features to manufacturing process capability and risk. The planned approach will pursue top-down, systems engineering design decomposition and synthesis, building on the results from existing thrust efforts that include the Continuous Electronics Enhancements Using Simulatable Specifications project and the Virtual Test project. Additional leverage will be achieved through the S&T Affordability Initiative.

- <u>Low-Rate Production Operations</u>. Planned activities will emphasize decoupling cost from volume, focusing specifically on reducing nonrecurring cost via "soft tooling" and on prototyping manufacturing tooling techniques.

- Supplier Partnering. Substantial industrial base improvement responsiveness in supporting defense needs will be pursued, building on the Agile and the Lean Manufacturing Initiatives' efforts to foster inter- and intra-supplier use of electronic commerce via pathfinders and focused technology developments.

- Technology Transition Risk and Cost Reduction. Today, an affordable, superiority-edge capability depends on effective technology transition from the laboratory to production, and into product support. This initiative area will pursue technology affordability, using S&T affordability demonstrations that effectively balance performance and cost during technology development. Other planned activities will support improved methods and tools to address transition costs and risks, leveraging on the AFMC/ST Directorate's Science and Technology Affordability Initiative and on the joint MS&T Program—NSF project that is investigating new approaches in estimating the cost of new technology. Cross-thrust coordination and cooperative efforts with the Program's Advanced Industrial Practices (AIP) thrust remain crucial towards achieving the needed payoffs. Therefore, sustained involvement with the AIP thrust Integrated Pilots will continue to be emphasized, providing industry with the mechanisms to alter their business processes and to enable them to incrementally implement far-reaching infrastructure changes that represent the most important M&ES output.

THRUST 2
Electronics Processing and Fabrication



USER NEEDS

The Electronics Processing and Fabrication (EP&F) Thrust focuses on developing reliable and repeatable manufacturing processes capable of producing electronic devices and components affordably, rapidly and with world class quality, facilitating the MS&T Program's four requirements areas (Aircraft, Spacecraft/Launch and C^3I, Missiles and Munitions, and Sustainment) access to electronic-based mission enabling capabilities. Thrust activities are customer driven and are nurtured through continual interaction with system and joint program offices, generating programs and projects responsive to user deficiencies and needs identified by the Technical Planning Integrated Product Teams (TPIPTs) and by the Mission Area Plans (MAPs) for inclusion in the Technology Investment Recommendations Report (TIRR). Figure 2.1 illustrates planned EP&F technology development milestones, leading to mission capability payoffs.

The initiatives and projects emerging from the thrust requirements-driven planning process address common, pervasive manufacturing process capability needs emanating from the user. The far-right subset in Figure 2.2 illustrates the processing of needs into technology focal areas. These focal areas target reducing manufacturing risk, accelerating the insertion of superiority edge technologies, reducing cycle time, desensitizing unit product cost from volume, increasing flexibility for multiple products, and facilitating lean factory operations. Weapon system manufacturers and their multitiered vendors and suppliers are the direct beneficiaries of these improvements.

GOALS

The thrust goals and the manufacturing technologies being pursued are integrated into three major initiative categories: 1) Transition of Emerging Technologies, 2) Process Improvement and Control and 3) Sustainability. The initiatives alignment with the user's needs is illustrated in Figure 2.2. Planned thrust benefits in meeting the user's most vigorous requirements are identified below according to the thrust major initiative categories.

Transition of Emerging Technologies

- Leading edge technologies successfully transitioned into affordable, producible manufacturing capabilities for advanced military products
- Risk reduction through process prototyping.

Process Improvement and Control

- Six-sigma process capability for world class quality
- Improved process capability metrices Cp and Cpk
- 50-percent reduction in cycle time
- 20-percent cost reduction
- Desensitized unit costs, irrespective of production volume.

Sustainability

- Expanded military-commercial integration, assuring critical process/

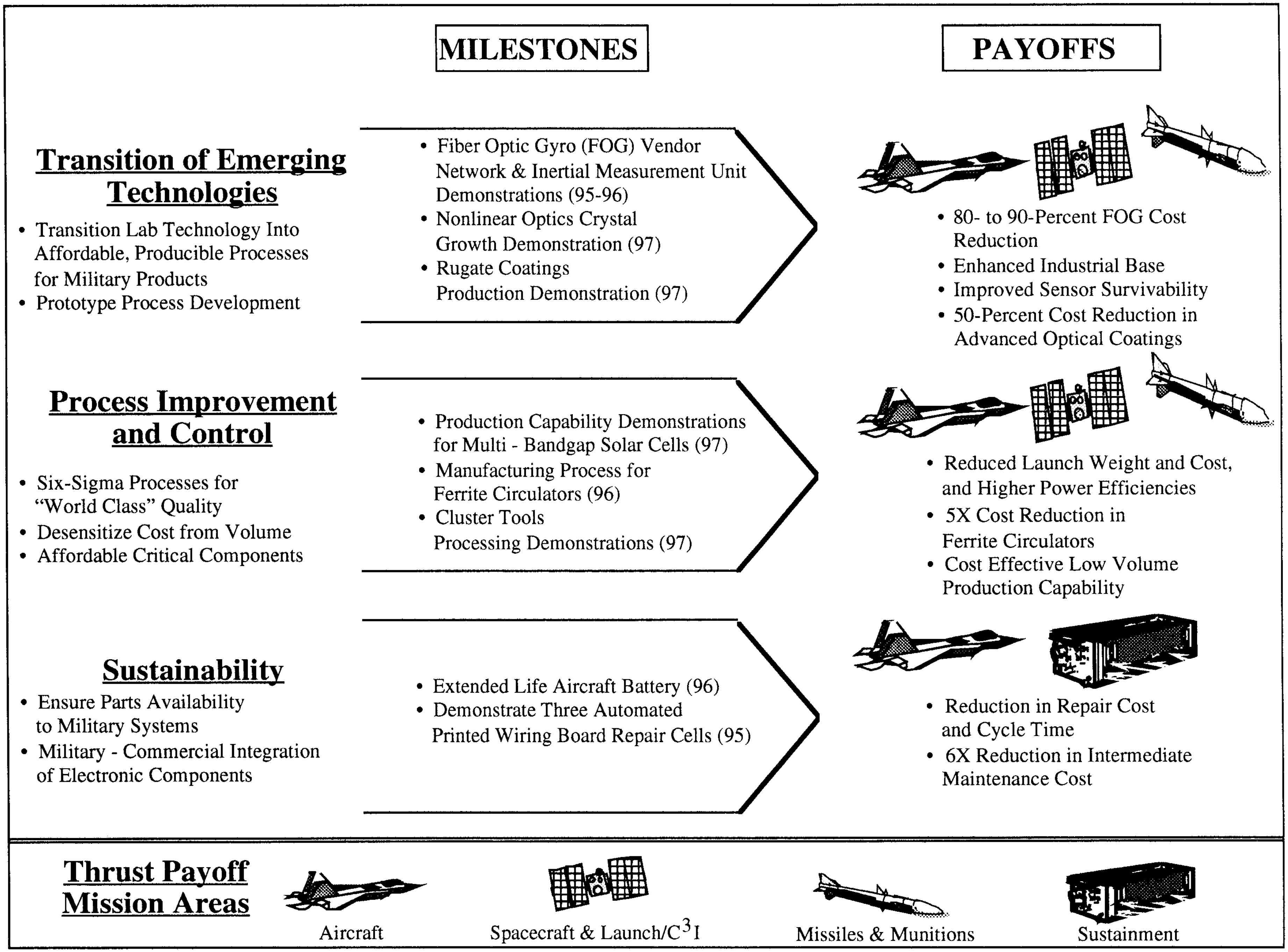


Figure 2.1. Electronics Processing and Fabrication Thrust

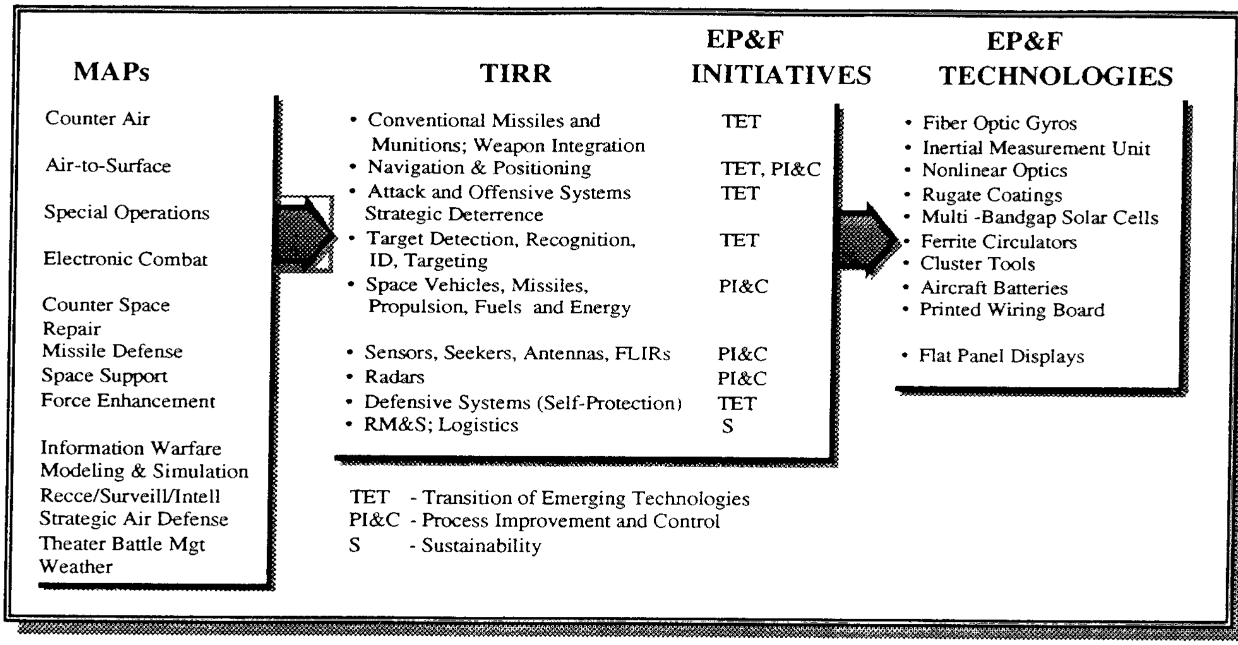


Figure 2.2. Consolidated Needs List and MAP References

component availability and affordability

- Cost-effective process capabilities for supplying critical components on fielded systems that are overtaken by parts obsolescence
- Reduced life cycle costs through environmentally conscious electronics manufacturing practices and processes.

Planned funding support for these three initiatives is shown in Figure 2.3.

MAJOR ACCOMPLISHMENTS

Major EP&F Thrust accomplishments, achieved in support of specific user needs, include the following:

- Tactical Grade Fiber Optic Gyros Established 1) a manufacturing technology vendor network base, assuring a robust fiber optic gyro (FOG) manufacturing capability, 2) an industrial review board, enabling real time FOG technology transfer to the industrial base and 3) a production cost model for tracking component and overall assembly costs. Planned task completion is scheduled for January 1998.

- High Voltage Power Supplies Successfully demonstrated quality function deployment techniques, generating a full set of design rules for producible, reliable high voltage power supplies (HVPS). Deployed program-developed design rules for use in the manufacture of the F-15 AN/ALQ-135 electronic countermeasures (ECM) system HVPS, enabling an 800-percent improvement in mean-time-between-failure rates, and exported the new design to the Advanced Medium Range Air-to-Air Missile (AMRAAM) program, enabling a 33-percent HVPS component count reduction.

- Silicon on Insulator Wafer Demonstrated 256K static random access memory (RAM) production capability at 16K static RAM wafer cost rates ($100 each), facilitating the establishment of a merchant vendor supplier for silicon on insulator wafers.

- Flat Panel Displays Successfully managed an FY95 Advanced Research Projects Agency (ARPA) funded pilot production demonstration effort ($9.6M), combined with other efforts involving focal plane arrays ($16M) and environmental needs ($3M), totaling $28.6M in ARPA funding. Technically sponsored a $20M Defense Production Act Title III effort for expanding military usage of flat panel displays.

CHANGES FROM LAST YEAR

The dominant changes from

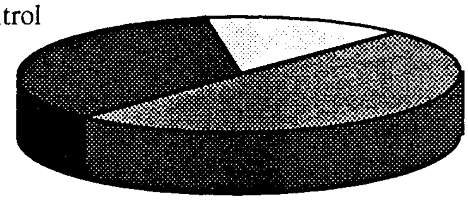


Figure 2.3. Electronics Processing and Fabrication Thrust Initiatives ($7.51M)

last year's plan stem from funding reductions and changes in program emphasis, necessitating 1) integrated requirements across multiple weapon systems and 2) intensified project emphasis on common manufacturing issues and solutions. To achieve these objectives, the thrust consolidated several projects, enabling two FY95 project restarts, the Cluster Tool Process Enhancements project and the Rugate Coating Producibility project. Three planned new starts, Lean Transmit/Receive Module Assembly, Flexible Manufacturing of Microwave Power Modules, and Metal Oxide on Substrate (MOS) Controlled Thyristor, were deferred because of unanticipated FY94/95 funding limitations. Four projects, 1) Whole Wafer Inspection of Gallium Arsenide, 2) Electronic Manufacturing Process Improvement (EMPI) for Sealed Fiber Nickel Cadmium Batteries (NiCd), 3) EMPI for Gallium Arsenide on Germanium Solar Cells and 4) Mid-Infrared Laser Frequency Conversion Materials (one of two projects), were stopped in FY94. The EP&F Thrust assumed technical responsibility for 1) an FY95 ARPA-funded Environmentally Conscious Electronic Systems Manufacturing Initiative, 2) collaboration on a tri-service effort entitled Affordable Multi-Missile Manufacturing and 3) a Title III funded flat panel display initiative.

MILESTONES

Figure 2.1 illustrates key milestones and payoffs for selected efforts associated with the Electronics Processing and Fabrication Thrust.

The FOG project will demonstrate Inertial Measurement Unit (IMU) application prototyping, comprised of three gyros and associated electronics, producing gyros at less than $1,000/axis with a goal of $500/axis. Lessons learned will be utilized to optimize manufacturing processes for an FY96 production demonstration, leading to an AMRAAM block upgrade that will leverage the project-established Phase 1 vendor base for critical components.

Improved sensor performance and survivability in nonlinear optics crystal growth and rugate coatings production will be demonstrated in FY96. Technology successfully demonstrated will be inserted into aircraft and missile applications.

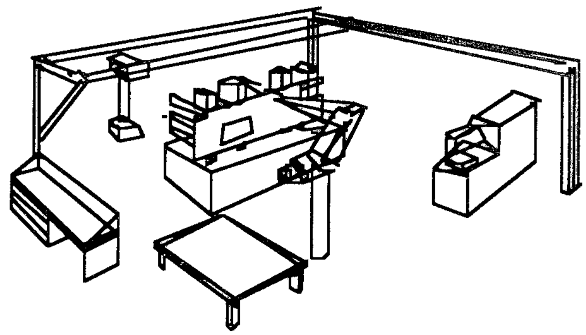
Four-port ferrite circulator affordability will be demonstrated in FY96, achieving an 80-percent unit cost reduction.

Multi-bandgap solar cell manufacturing technology will be demonstrated in FY97, enabling 1) a 400-percent increase in individual array surface area and 2) a 14-percent per watt cost savings.

Cluster tool processing demonstrations, in conjunction with SEMATECH and the supporting contractor, will continue, furthering Microelectronics Manufacturing and Science Technology (M&ST) project success, and will include process development for dry cleanup and for etching as part of the complete manufacturing capability for affordable, low-volume application specific integrated circuits (ASICs).

The EMPI for Sealed NiCd Batteries will demonstrate controlled processes in FY96, enabling further progress towards reducing the battery maintenance burden in aerospace applications. The thrust Printed Wiring Board (PWB) Repair Cell project will conclude in 1995 upon successful repair cell capability activation at the Warner Robins Air Logistics Center.

THRUST 3
Metals and Nonmetals Processing and Fabrication



We are establishing the quality/leading edge processes that will make advanced structures more affordable.

USER NEEDS

This thrust supports a diversified range of user requirements, and has been subdivided into four requirements areas to optimize the support provided in meeting the customer's stated MS&T needs. The four requirements areas, and their affiliated user needs, are discussed in the following subsections. The listed needs were identified through mission area plan reviews and interfaces with applicable Technical Planning Integrated Product Teams (TPIPTs). Table 3.1 correlates specific user needs with the generating activities' source documents.

Aircraft

The ongoing revolution in military technology continues to emphasize aircraft mission delivery systems (fighters, bombers and transports) as the backbone behind the Air Force's evolving force structure. Despite the Cold War conclusion, demands on the Air Force's shrinking aircraft fleets continue to grow. To successfully meet these demands, the warfighter is placing an expanded reliance on technology to achieve mission objectives. Given the fiscal constraints confronting the DoD, most emerging technologies will be inserted into existing systems or incorporated into new aircraft on a limited production basis. More than ever, fiscal constraints are making affordability the primary criteria for determining a mission-enabling technology deployment schedule. Innovative manufacturing methods and processes capable of slashing production costs and accelerating production rates have emerged as the fulcrum in establishing technology affordability.

Aerospace Sustainment

The Air Force aging force structure and associated support infrastructure necessitates innovative capabilities and practices be inserted into the sustainment industrial base, enabling the warfighter to be more affordably equipped with combat-superior assets. This subthrust leads the Air Force effort in applying advanced manufacturing technologies to the maintenance and repair needs of the Air Force and of the industrial base, and is uniquely postured to 1) assist the industrial base, the Air Force Materiel Command (AFMC) and the using commands in meeting this challenge by fielding innovative repair capabilities that drive down depot and industry support costs by 20 percent or more and 2) contribute towards making all industrial operations environmentally benign.

Spacecraft/Launch and C^{3}I

In response to the mission enabling capabilities rendered through space-based assets, the Air Force will require a steady stream of new spacecraft over the next several years, with most being of very low production quantities. Air Force Space Command is conducting a study to establish priorities, goals and milestones for upgrading space launch capabilities. The study conclusions will significantly influence future thrust activities in support of Spacecraft/Launch and C^{3}I requirements.

Missiles and Munitions

The killing power behind any future force structure will continue to be achieved primarily through air-to-air and air-to-surface weapons. To ensure the Program remains responsive to user requirements in this area, customer-driven interaction with such systems and/or joint program offices as the Advanced Medium Range Air-to-Air Missile (AMRAAM), the Joint Direct Attack Munitions (JDAM), the Joint Standoff Weapons (JSOW) and the AIM-9X Sidewinder Missile will be maintained. A Primary source for identifying the user's missiles and munitions needs are the Air-to-Surface and the Counter Air TPIPTs.

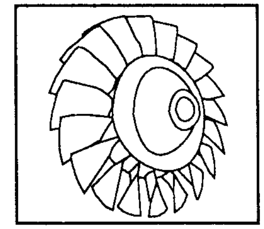
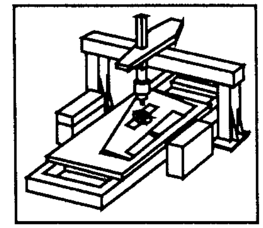
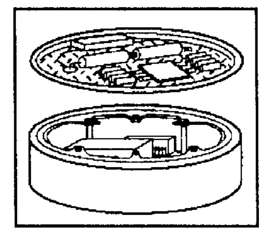
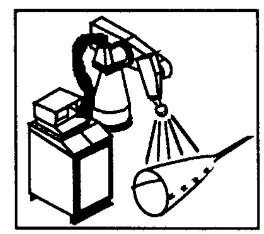
	MILESTONES	PAYOFFS	
Aircraft	• Improved Durability Radome (96) • Welded Titanium Structure (97) • Advanced High Temp Coatings (97) • Design For Manufacturing (98) • Thin Cast Structure (98) • Metal Matrix Engine Components (99) • Unitized Metallic Structure (00) • RTM For Composite Airframes (00) • Process For Affordable Prototypes (01) • Low Cost Investment Castings (01) • Composite For Electronics (02)	• Part Count Reduction • First Time Quality • 50-Percent Cost Reduction • Strategies For Prototyping • 40-Percent Engine Thrust Increase • Double The Cycle Maintenance Time • Enhanced Subtier Supplier Base	
Sustainment	• Large A/C Robotic Paint Stripping (95) • Chemical Tank Rejuvenation (95) • Flexible Automated Blade Tip Repair (96) • Manufacture Composite Preferred Spares (97) • Laser Cleaning (97) • Corrosion Control/Detection (00) • Lean Logistics (00)	• 75-Percent Work Reduction • Extended A/C Service Life • Hazardous Waste Reduction • Just In Time Manufacturing Capability	
C^3I/S&L	• NDE for Hidden A/C Corrosion (99) • Radome Fab. Improvement (99) • Russian Rocket Engine Manufacturing Capability Evaluation (99) • Initiative for Affordable Space Transportation (02)	• Life Extension/Improved Safety • Improved Quality/Reliability • Added Domestic Capability • Improved Affordability	
Missiles and Munitions	• Fill/Seal for Energetics (00) • Composite Gimbals (00) • High Performance Missile Radomes (00)	• Increased Lethality • Improved Stiffness/Lower Weight • Wide Band Performance	

Figure 3.1. Metals and Nonmetals Processing and Fabrication Thrust

Table 3.1. Customer Driven Requirements

CONSOLIDATED LIST OF NEEDS AND MAP REFERENCE	
USER DEFINED NEEDS	USING COMMAND AND MAP
AIRCRAFT	
Process Control/Quality of Cast Structures	ACC: Counter Air, Air-to-Surface SOC: Combat Support, Force Application
Affordable Signature Control	ACC: Counter Air, Air-to-Surface SOC: Combat Support, Force Application
Light Wt. Engine Efficiency/Thrust	ACC: Counter Air, Air-to-Surface SOC: Joint Battlefield
Improved Engine Efficiency	ACC: Counter Air
AEROSPACE SUSTAINMENT	
Responsive Depot Maintenance Cycle Times	All Commands: Combat Support, Force Application
Aging Aircraft Accommodations	All Commands: Combat Support, Force Application
System Signature Reductions	ACC: Counter Air, Air-to-Surface
Low Cost Training Drones	All Commands: Counter Air
SPACECRAFT/LAUNCH and C^3I	
Nondestructive Evaluation (NDE) for Hidden Aircraft Corrosion	ACC: Reconnaissance and/or Surveillance/Intel
Radome Fabrication Improvement	ACC: Reconnaissance/Surveillance
Russian Engine Assessment	AFSPACECOM: Spacelift
Affordable Space Transportation	AFSPACECOM: Spacelift
MISSILES and MUNITIONS	
High Performance Missile Radomes	ACC: Air-to-Air, Counter Air
Composite Gimbals	ACC: Air-to-Air, Counter Air
ACC: Air Combat Command SOC: Special Operations Command AFSPACECOM: Air Force Space Command	

GOALS

The thrust goals are focused on ensuring affordable manufacturing processes and systems aimed at resolving and/or supporting defined deficiencies and requirements affecting the aforementioned requirements areas. Specific goals, according to each requirement area, are listed in the following subsections.

Aircraft

- Enable the affordable/low risk exploitation of superiority-edge, mission enabling technologies in all Air Force systems.

- Accelerate the development and implementation of emerging advanced technologies essential to eliminating identified deficiencies and meeting Air Force system requirements.

- Improve the effectiveness, flexibility, and competitiveness of critical industrial base sectors essential to the Air Force and the Department of Defense (DoD) to meet system and mission requirements.

- Transition validated manufacturing capabilities to the factory environment.

- Transfer manufacturing technologies to and from the commercial sector, achieving economy of scale in the manufacture of affordable/low volume aircraft systems.

- Accelerate the development and affordable exploitation of titanium metal matrix composites (Ti-MMCs), enabling their low risk insertion into high performance engine structures at costs of $300 to $500 per pound.

Aerospace Sustainment

- Increase weapon system life cycle affordability through improved reliability, maintainability and supportability.

- Reduce weapon system repair and overhaul costs, curtailing risk for technology insertion and transitioning demonstrated benefits to all services for additional implementation.

- Demonstrate new and improved technologies to minimize, if not eliminate, hazardous wastes, implementing aggressive pollution prevention initiatives.

- Reduce lead times, work-in-progress, spare parts inventories, touch labor and process variability.

- Increase repair system throughput, productivity, product quality and responsiveness.

- Improve nondestructive inspection techniques for detecting aircraft corrosion.

Spacecraft/Launch and C^3I
- Facilitate affordable and/or upgraded quality in space system applications.

- Provide emerging and enabling technologies which are affordable for use in launch systems.

Missiles and Munitions
- Reduce missile system unit costs, independent of quantity.

- Maintain a responsive, competitive supplier base capable of producing technologically-superior, affordable tactical missile systems.

- Demonstrate automated fill/seal technology for energetic materials.

MAJOR ACCOMPLISHMENTS

Listed below, per the identified requirements areas, are the thrust's significant achievements since the FY95 MS&T TAP publication.

Aircraft
- The large aircraft wing program, utilizing the V-22 wing as a demonstration article, entered its final phase where its advanced design/ manufacturing approach will be validated, emphasizing risk and cost savings. Individual elements of the full size wing box were fabricated and are awaiting final assembly. Some cost savings measures have already been incorporated into the V-22 engineering and manufacturing development (EMD) program.

- Several structure design and manufacture trade studies were completed, involving the application of integrated process/product development (IP/PD). Structures involved included the advanced fighter wing, the advanced fighter forward fuselage, and the large aircraft wing and gas turbine engine duct. Each study generated innovative manufacture/design concepts, offering up to 50-percent potential cost savings. The methodologies for constructing integrated teams and conducting team activities were assessed within each trade study, emphasizing the Air Force drive towards new practices that enable decreased development cycles and increased affordability.

- Advanced technologies aimed at significantly reducing the acquisition and the support costs associated with composite structures continued to be pursued.

- The Welded Titanium Aircraft Structures project completed its Phase I technical effort. The project is establishing the capabilities to develop, demonstrate and implement improvements in the design and the manufacturing producibility required to affordably produce large and complex, high-quality welded titanium fighter airframe assemblies. Recent technical accomplishments have included 1) establishing a baseline, 2) assessing current welding state-of-the-art, finite element modeling and 3) identifying design and process improvements. The follow-on Phase II effort was initiated, stressing process maturation and scale-up and the demonstration, verification and enhancement of previously established process improvements.

- Phase I technical efforts were completed on the thermoplastic composite radome project, aiming to establish a rapid, low-cost manufacturing process for producing radomes fabricated with thermoplastic composite materials. Current fiberglass radomes absorb moisture, degrading radome electrical characteristics. Thermoplastic materials have significantly reduced moisture absorption characteristics, thereby allowing longer service life and reduced maintenance costs. This project demonstrates how the Program establishes innovative manufacturing processes to support the exploitation of alternative materials, accelerating the application of emerging technologies for solving Air Force system problems.

- The Program continues to elevate the affordability of advanced propulsion structures, developing and introducing innovative manufacturing processes that enable advanced materials to be more affordably utilized in high performance military gas turbine engines. Specific accomplishments included demonstrating process feasibility for the manufacture of titanium metal matrix composite components. The successful production and qualification testing of engine struts, of blades and of reinforced disks validated project-developed material forms and tooling concepts. Validated technology will enable increased service temperatures and component stiffness, contributing to improved efficiency and expanded range.

- Weight reduction is of paramount importance for both military and commercial engines. An effort was initiated to identify a cost-effective casting process, employing nickel-based alloy to support the affordable production of large and complex, thin-walled reproducible components. Early casting process development trials have been successful, demonstrating the developed process potential for attaining desired weight reductions. The Program is aiming to transition the developed technology into the F-119 engine, following successful qualification testing and the verification of predicted benefits.

Aerospace Sustainment

- The Large Aircraft Robotic Paint Stripping System (LARPS) project Aircraft Component Subsystem workcell (see front cover) was successfully installed and tested at the Air Force Oklahoma City Air Logistics Center (OC-ALC). The subsystem workcell, using an automated high-pressure water stream, removes protective coatings from small aircraft-removed components during host aircraft paint removal operations. During demonstration testing, the subsystem workcell efficiently removed protective coatings from numerous C-135 flaps without inflicting any component, personnel or environmental degradation. Upon full activation at the end of this year, the LARPS system and its subsystem workcell are projected to begin saving the OC-ALC $4.6M annually.

Spacecraft/Launch and C^3I

- An insufficient understanding exists on how variability in key manufacturing parameters affect the safety and reliability performance of composite overwrapped pressure vessels. Recent MS&T accomplishments in this area include the establishment of a relationship between manufacturing parameter variability and non-destructive inspection test results. Attempts are also being made to determine a numerical correlation of inspection results with pressure vessel burst pressure. Successful project completion will improve quality pressure vessels fabricated for space applications.

Missiles and Munitions

- The thrust has developed a proposed project for enabling automated fill/seal technology for energetic materials. There is currently no ongoing project activity in the area of missiles and munitions emanating from this thrust; however, recent Program funding restoration should enable renewed project activity.

CHANGES FROM LAST YEAR

Several projects associated with the aircraft and the sustainment areas were placed on hold due to Air Force MS&T funding reductions. Impacted projects involved efforts to 1) affordably produce composite structures, 2) develop prototype capabilities for engine blade tip repair, 3) perform sheet metal forming simulation, 4) economically manufacture thermoplastic preferred spares and 5) perform project concept and/or technology validation. Partial Program funding restoration has enabled these efforts to be restarted, necessitating renegotiated project technical content and schedules.

Reduced funding impacted the initiation of several key new starts, and continues to delay any contracting activity. Affected efforts include the following activities: 1) enabling the total enterprise to economically prototype airframe structures and to accommodate the new acquisition strategy, 2) developing innovative manufacturing processes to support the affordable production of low observable structures and 3) establishing high-speed machining capabilities for primary structures employed in large aircraft.

MILESTONES

Figure 3.1 illustrates the key milestones and payoffs of selected efforts associated with the Metals and Nonmetals Processing and Fabrication Thrust. Major milestones affecting specific requirements areas are discussed below.

Aircraft

- Successful completion of the proposed Lean Enterprise Initiative for Affordable Prototype/Aircraft in FY01 will reduce aircraft development cycle times by half.

- Development and activation

of emerging process and fabrication techniques, such as high speed machining of unitized primary structure, will be on line by FY00 if sufficient funding is made available, affording the Air Force a significant cost reduction against comparable structures manufactured in today's environment.

- Successful completion of the Manufacturing Initiative for Gas Turbine Engines in FY01 will define lean practices for advanced technologies, enhancing quality and reducing development time. In addition, this project will focus on gas turbine engine casting costs and associated lead times.

- Other propulsion structure milestones will enable a 90-percent improvement in first-time acceptance rates and an 80-percent reduction in product development costs.

Aerospace Sustainment

- Thrust emphasis in hazardous waste minimization and pollution prevention will continue.

- The LARPS and the Aqueous Based Cleaning System will be fully operational in late 1995.

- In conjunction with the AFMC sponsored 2005 Organic Industrial Base (OIB) Assessment, requirements-driven pathfinder projects will be initiated in FY96 to assess the feasibility of introducing "lean precepts" and/or "best practices" into the sustainment industrial base. If demonstrated feasible, a pilot project will be established in FY97/98 to help facilitate the organic industrial base's transition to becoming a lean sustainment enterprise.

- The Chemical Tank Rejuvenation project, scheduled for completion in FY96, will demonstrate the feasibility of reversing fluid contamination incurred in the cleaning of jet engine components. This process will alleviate the constant need for reconditioning resident fluids, historically incurred because 95 percent of all gas turbine engine components that undergo depot repair require cleaning. This effort is expected to result in a 10-year savings of $6M and eliminate a serious environmental problem, enabling AFMC's industrial operations to make additional progress towards becoming environmentally benign. Project results are expected to have tremendous technology transfer potential, benefiting similar industry processes and the nation's environment.

Spacecraft/Launch and C^3I

- At the end of 1995, significant economic and safety payoffs will be derived through the deployment of graphite/epoxy overwrapped pressure vessels. The shift from metal pressure vessels to composite overwrapped pressure vessels (COPVs) on satellites, upper stages and launch vehicles is expected to generate an effective payload weight reduction of nearly 5 percent. For new launch systems, this weight savings may be translated into a relative mix of increased payload capability, reduced vehicle size and/or decreased gross liftoff weight, enabling a total system cost reduction.

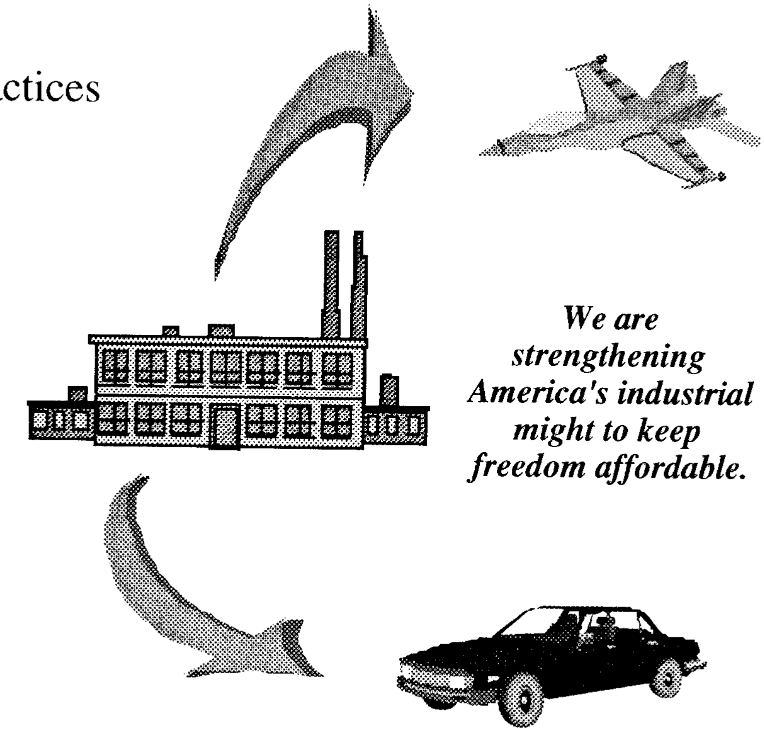
Missiles and Munitions

- The thrust will continue to cultivate opportunities for enhancing industrial operations associated with the production and/or upgrade of missiles and/or munitions.

- High performance missile radomes will achieve expanded affordability in FY00 because of planned thrust efforts.

- Two proposed projects, the fill/seal for energetics and the composite gimbals projects, should begin benefiting the affordable production of advanced missile systems at the start of FY00.

THRUST 4
Advanced Industrial Practices



USER NEEDS

Global political changes have enabled extensive restructuring in the US Armed Forces, facilitating significant reductions in defense spending in contrast to the Cold War years. Budget reduction realities are causing sweeping changes in how the Department of Defense (DoD), the Air Force and the aerospace industry all do business. Rapid consolidation is occurring across the aerospace industry. Aircraft, defense electronic, space and armament firms are merging or departing the defense market place. Shrinking production requirements are affecting the industrial base's ability to provide the Air Force with superior weapon systems at affordable and predictable costs. Weapon systems in development or in production, such as the F-22 fighter or the C-17 airlifter, are being impacted by downsizing cost pressures.

Force structure and downsizing reductions are also affecting the existing fleets' sustainability. In the past, unconstrained mission support was an Air Force depot maintenance infrastructure operating precept, making cost a secondary consideration. Current budget reductions, organization changes, and/or eliminations and workload competitions have focused the Air Force's attention on pursuing a balanced sustainment approach, integrating affordability with mission support requirements. These realities are now driving fundamental changes in weapon system requirements definition, development, acquisition and sustainment. The challenge is to achieve a smaller, more robust industrial base capable of providing the Air Force with a force structure composed of technologically superior, easily maintainable, and highly affordable systems in the context of these realities. The users need access to combat-superior systems, possessing affordable life cycle cost features, is driving thrust requirements.

The Advanced Industrial Practices (AIP) Thrust emerged from a joint Air Force and industry assessment of the commercial industrial base, known as *Manufacturing 2005*, and an Air Force organic industrial base technology assessment of the air logistics centers with their full participation, known as the *Sustainment 2005 Organic Industrial Base (OIB) Assessment.* The Manufacturing 2005 assessment reduced user requirements into two categories: affordability and technology superiority. The Sustainment 2005 Assessment identified over 100 major findings affecting the OIB's five major workload sectors: airframes, engines, electronics, software and commodities. Pervasive and/or systemic sector findings, involving more than one sector, were segregated according to one of two dominating characteristics, business practice and policy issues or technology needs.

The AIP Thrust is helping to resolve both assessments' generic findings and is advocating user access to a more robust industrial base, fully compatible with military and commercial requirements. The thrust is integrating advances from other MS&T thrusts into weapon system programs, linking and implementing new or alternative manufacturing and business methods leading to reduced costs, lower risk production and elevated technical superiority. The thrust change

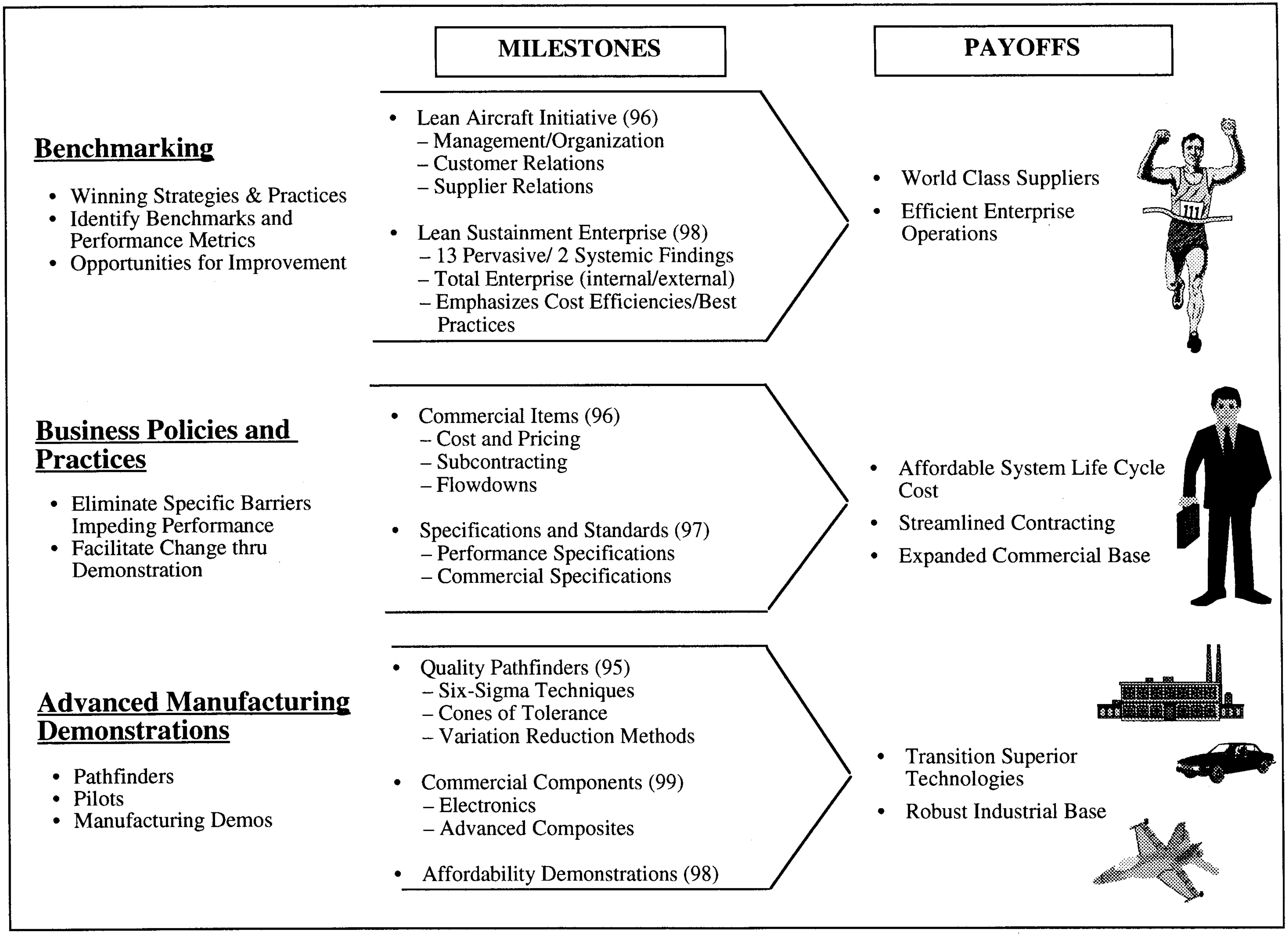


Figure 4.1. Advanced Industrial Practices Thrust

vehicle is the successful implementation of industrial base pilot projects, designed and intended as joint endeavors between manufacturing technology developers, system program offices (SPOs) and air logistics centers, all acting as implementing agents.

This multidimensional approach creates a science and technology (S&T) proving ground for validating other DoD activities' results (acquisition reform, product S&T, affordability and MS&T), involving such advanced practices as integrated product and process development (IPPD), six-sigma quality techniques, lean production and lean sustainment. A validated, integrated industrial strategy incorporating these practices will provide enormous potential benefits to the DoD, accelerating the adoption of enabling mechanisms and approaches capable of 1) reducing weapon system costs by half, 2) integrating common commercial/military production facilities, 3) expanding commercial application(s) of military technologies and 4) reducing technology insertion times by half.

The thrust is also communicating user needs to the Joint Directors of Laboratories' (JDL's) MS&T Panel, which has formed a subpanel on AIP to work common requirements amongst the military services and the Defense Logistics Agency. Figure 4.1 illustrates the key milestones and payoffs of selected efforts associated with the AIP Thrust.

GOALS

The AIP Thrust is chartered to establish and to validate new methodologies that could assist the DoD's acquisition and sustainment communities and their supporting industrial bases. This thrust will place major emphasis on weapons systems affordability, enabling weapon systems at half their current cost or less. In addition, the thrust is vigorously pursuing the below listed goals, emanating from the JDL's MS&T Panel:

- Set new benchmarks for cost, cycle time and quality.
- Define and exploit efficient best practices.
- Understand and demonstrate winning commercial strategies.
- Leverage/enable expanded MS&T applications within the industrial base.
- Transition improved product and process technologies for affordability.

In pursuing these goals, the AIP Thrust has accepted an expansive Air Force and industrial base needs agenda, addressing all technology, acquisition and sustainment process elements that add value in the product realization cycle or that enhance operational capabilities. AIP projects, initiated in response to these goals, follow a sequential approach, orchestrating three important activities to stimulate positive industrial base changes: 1) benchmarking, 2) business policies and practices (BP&P) upgrades and 3) advanced manufacturing demonstrations.

Benchmarking determines the best companies' current capabilities. Goals, objectives and program criteria are defined through surveys, visits, and assessments, involving leading companies and organizations. Different business practices, management tools and concepts, and metrics are then defined and adapted for insertion into existing fabrication lines or into developing manufacturing operations.

Business policies and practices initiatives appear as "needed" policy changes and waivers. BP&P issues arise throughout the commercial and the organic industrial bases. Examples include procurement regulations, environmental compliance, quality management, process control, accounting practices, inspection/oversight policies, standards and specifications, supplier management practices, and subcontracting methods. BP&P initiatives are structured to address specific barriers inhibiting improved performance and to concentrate on facilitating cultural change through demonstrating new methods.

Advanced manufacturing demonstration projects validate benchmarks and best practices, facilitating accelerated implementation within the Air Force's supporting industrial base and within supporting manufacturing enterprises. Planned as short duration pathfinders and as integrated industrial base pilot projects, Advanced Manufacturing Demonstrations concentrate on specific requirements in ways that result in direct implementation, impacting either a weapon system or, more broadly, the combined commercial-military industrial base.

MAJOR ACCOMPLISHMENTS

Fifteen new contracts, exceeding $60 million in combined value, were initiated by the AIP thrust. Included in these contracts are two major pilot efforts that will validate changes in business practices and manufacturing infrastructure, while addressing a specific manufacturing technology that benefits a program office. Pilots must be timely to impact a window of opportunity, yet not be on an acquisition program's critical path. Part of the aforementioned contracts include several pathfinder efforts designed to attack pervasive issues across industry sectors, demonstrating on a short-term basis beneficial business practice changes and/or evaluating analysis tools, technologies and applications methodologies to promote and advance one or more industrial base trends. Beneficial pathfinder results could lead to more complex efforts, such as industrial base pilots.

The two current industrial base pilot programs, Military Products from Commercial Lines and Military Products Using Best Commercial Military Practices, emphasize commercial-military integration, demonstrating the feasibility of producing military products across commercial lines. The first pilot program, awarded to TRW, is attacking commercial application of military technologies and affordability impediments, using a high volume commercial line to demonstrate affordable military electronics component production, irrespective of order quantity. The second pilot program, awarded to a McDonnell Douglas/Vought team, is incorporating best commercial practices into defense production facilities, expanding the potential for world class defense enterprises to provide more affordable weapon systems.

Two pathfinders categories (flexible and quality) achieved significant performance shifts, demonstrating more efficient management systems, improved factory operations, elevated product quality and reduced scrap and rework. Results from several pathfinders were briefed at the November 1994 Defense Manufacturing Conference. Results and demonstrations from the remaining quality pathfinders were presented at an Industry Day. One key effort, the Vertical Partnering Pathfinder, applied Contractor Integrated Technical Information Services (CITIS) concepts to the prime—subcontractor relationship, enabling more efficient, effective, and flexible vertical partnerships through the 1) sharing of design and manufacturing data, 2) automating of bidding procedures and 3) streamlining of contractual mechanisms, relating directly to the Lean Aircraft Initiative's (LAI's) supplier relationship focus area. Other pathfinders, including the Process Capability Methodology for Integrated Product Development (IPD), have demonstrated measurable success in controlling the F-18 manufacturing process, generating discussions focused on transitioning beneficial results directly into the C-17 pilot.

Successful demonstration efforts transitioned specific pathfinder results to members of the LAI consortium. The LAI involves approximately 20 leading aerospace organizations, participating in a cooperative research project led by the Massachusetts Institute of Technology (MIT). In regards to the LAI, research is being conducted in five focus areas: 1) product development, 2) factory operations, 3) policy, 4) human resources and 5) supplier systems. Several case studies and site surveys have been performed to help guide the initiative. Assessment tools are being developed to evaluate and guide industry, and will be distributed in 1995.

The Sustainment 2005 OIB Assessment was completed and the final report published in November 1994. Many concerns and issues found earlier in the commercial industrial base assessment apply to the sustainment base. However, there are additional issues associated with the OIB's commitment to sustaining an aging fleet, including 1) updating capabilities for restoring obsolete custom electronics, 2) developing inspection techniques for hidden corrosion and 3) establishing processes and inspection techniques to ensure low observable structures retain their original performance characteristics. The air logistic centers also are in need of adapting "lean" production concepts for sustainment applications. Lean sustainment and lean logistics practices will be incorporated into the depots, reducing costs and enabling accelerated repair cycle times.

CHANGES FROM LAST YEAR

The AIP Thrust is a bold new thrust, focusing on process insertion rather than on initial process development, the primary goal of the AF MS&T Program's other thrusts. This new thrust

Base Pilots Thrust, discussed in last year's TAP. AIP includes identifying and benchmarking world class best practices and then, transitioning them into the defense sector. An emphasis on both business and management inhibitors adds a totally new dimension to attacking affordability issues within defense enterprise operations. Strong ties to the user and to the aerospace industry are key to successfully transitioning new processes and practices, achieved through conducting up-front planning with the major weapon system programs and with the product and logistics centers.

The LAI's initial findings have been jointly prioritized by government and/or industry teams, establishing a new Lean Forum. High-risk, high-payoff findings are being targeted for accelerated resolution, using planned FY95 new starts, in conjunction with the Joint Advanced Strike Technology (JAST) program and the Lean Implementation Initiative, as demonstration vehicles. The Sustainment 2005 OIB Assessment's findings have expanded the AIP thrust focus to include the sustainment of an aging aircraft fleet. New efforts are now being initiated to address these issues, establishing integrated sector enterprises within the OIB and leveraging best practices under a Lean Sustainment Enterprise project. SPO participation in ongoing pilot programs have been formalized through signed Memoranda of Understanding with the F-22 SPO, the RAH-66 Comanche Program Management Office (PMO) and the C-17 SPO. These memoranda will speed the transition of demonstrated processes and practices, minimizing the cost and the risk of producing military hardware.

MILESTONES

The LAI's completion is scheduled for 1996. The effort will provide a set of identified best practices, measurable business changes, infrastructure improvements and demonstrated assessment tools.

A Lean Implementation Initiative, targeting the findings and recommendations emanating from the LAI, should be awarded not later than early FY96.

Several Pathfinders will be demonstrated, their results measured against original goals, and then documented for initial review in late 1995. Existing pathfinder and pilot efforts, demonstrating BP&P initiatives, will be expanded in 1996. Additional advancements from the flexible and the quality pathfinders are forecast, resulting in more efficient management systems, improved factory operations, elevated product quality, and reduced scrap and rework. Pilot programs are progressing satisfactorily and their validations are planned in the 1998/99 timeframe. The Military Products from Commercial Lines pilot program will continue to demonstrate "lean" principles, including 1) inventory reduction, 2) quality emphasis, 3) low volume production efficiency and 4) rapid product development cycles. Early pilot program demonstrations will also generate near-term improvements which can be applied throughout associated weapon system program offices and in many cases, transferred directly to the industrial base, as well as to the Lean Aircraft and the Lean Sustainment Initiatives.

The Military Products from Commercial Lines pilot program, in conjunction with similar efforts, is structured to demonstrate commercial production of communication, navigation and identification (CNI) modules, achieving reduced unit production costs and comparable quality with modules produced across a dedicated military line. The project testbed is CNI electronic board manufacturing for the F-22 Advanced Tactical Fighter and the RAH-66 Comanche Helicopter, using a regular commercial automotive manufacturing line. Cost savings to the F-22 and the RAH-66 programs are projected at the 30- to 50-percent range. The F-22 and RAH-66 Program Offices are part of the pilot program team, and will implement change(s) upon validation.

The Military Products Using Best Commercial and/or Military Practices pilot program will incorporate best commercial practices into defense production facilities, expanding the potential for flexible defense enterprises to provide more affordable weapon systems. Proven organic composite structures technology will be inserted into the low-risk fabrication of a C-17 horizontal stabilizer. Combining the best commercial/military practices and achieving equal or better quality composite components at reduced costs are the pilot project objectives. The pilot program is proceeding satisfactorily, and the C-17 SPO will implement the improvements as they occur.

GLOSSARY

A/C	Aircraft
ACC	Air Combat Command
AF	Air Force
AFAE	Air Force Acquisition Executive
AFMC	Air Force Materiel Command
A/I	Application Insertion
AIP	Advanced Industrial Practices
ALC	Air Logistics Center
AMC	Air Mobility Command
AMRAAM	Advanced Medium Range Air-to-Air Missile
ARPA	Advanced Research Projects Agency
ASIC	Application Specific Integrated Circuit
ATD	Advanced Technology Demonstration
B	Billion
BES	Budget Estimate Submission
BP&P	Business Policies and Practices
C^3I	Command, Control, Communications and Intelligence
CITIS	Contractor Integrated Technical Information Services
CNI	Communication, Navigation and Identification
COPV	Composite Overwrapped Pressure Vessel
CTC	Center Technology Council
DLA	Defense Logistics Agency
DoD	Department of Defense
DSCS	Defense Satellite Communications System
DemVal	Demonstration Validation
ECM	Electronic Countermeasures
EMD	Engineering and Manufacturing Development
EMPI	Electronic Manufacturing Process Improvement
EP&F	Electronics Processing and Fabrication
EV	Engineering Validation
FOG	Fiber Optic Gyro
GaAs	Gallium Arsenide
Ge	Germanium
HVPS	High Voltage Power Supplies
IMU	Inertial Measurement Unit
IPD	Integrated Product Development
IPPD	Integrated Product and Process Development
IP/PD	Integrated Process/Product Development
IR	Infrared
JAST	Joint Advanced Strike Technology
JDAM	Joint Direct Attack Munitions
JDL	Joint Directors of Laboratories
JSOW	Joint Stand-off Weapons
K	Thousand
LAI	Lean Aircraft Initiative
LARPS	Large Aircraft Robotic Paint Stripping System
M	Million
MAP	Mission Area Plan
MAT	Mission Area Team
MEB	Mission Element Board
M&ES	Manufacturing and Engineering Systems
MIT	Massachusetts Institute of Technology
MMW	Millimeter Wave
MOS	Metal Oxide on Substrate
MS&T	Manufacturing Science and Technology
NiCd	Nickel Cadmium
NDE	Nondestructive Evaluation
NSF	National Science Foundation
OIB	Organic Industrial Base
PGM	Product Group Manager
PMO	Program Management Office
POM	Program Objective Memorandum
PWB	Printed Wiring Board
RAM	Random Access Memory
R&D	Research and Development
RTM	Resin Transfer Molding
SOC	Special Operations Command
SPD	System Program Director
SPO	System Program Office
S&T	Science and Technology
TAP	Technology Area Plan
TC	Test Center
TEO	Technology Executive Officer
TIRR	Technology Investment Recommendations Report
Ti-MMC	Titanium Metal Matrix Composites
TMP	Technology Master Process
TPIPT	Technical Planning Integrated Product Team
T/R	Transmit/ Receive
TTIPT	Technology Thrust Integrated Product Team
TTO	Technology Transition Office

APPENDIX 1
Technology Master Process Overview

OVERVIEW

Part of the Air Force Materiel Command (AFMC) mission deals with maintaining technological superiority for the United States Air Force by:

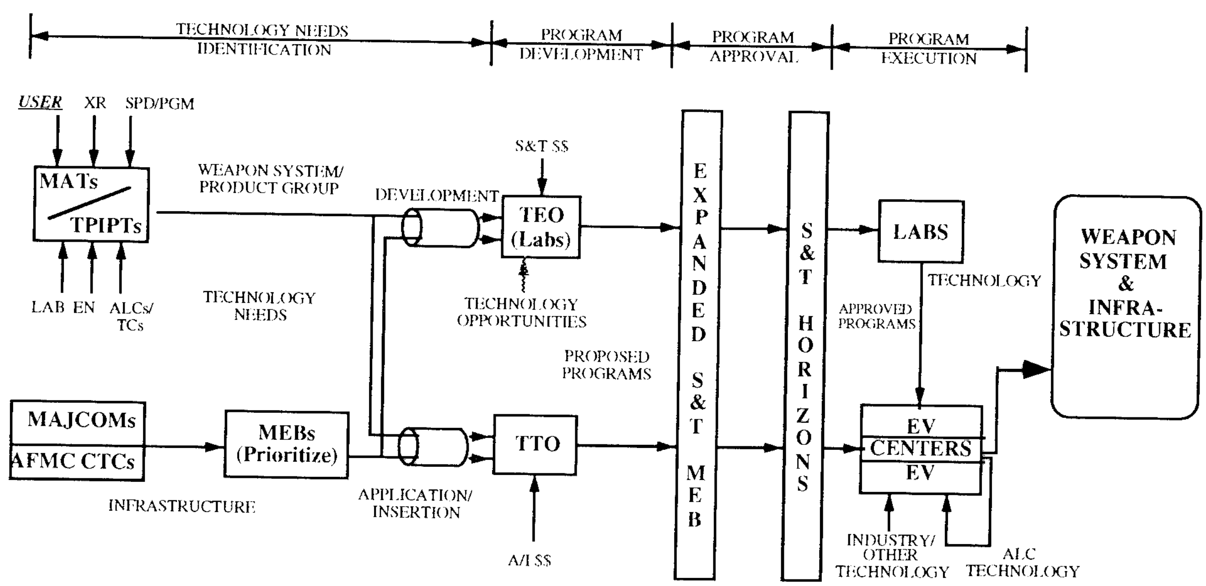
- Discovering and developing leading-edge technologies.
- Transitioning mature technologies to system developers and maintainers.
- Inserting fully developed technologies into our weapon systems and supporting infrastructure.
- Transferring dual-use technologies to improve economic competitiveness.

To ensure this mission is effectively accomplished in a disciplined, structured manner, the AFMC has implemented the Technology Master Process (TMP). The TMP is AFMC's vehicle for planning and executing an end-to-end technology program on an annual basis.

The TMP has four distinct phases, as shown in Figure A-1:

> Phase 1, Technology Needs Identification--Collects customer-provided technology needs associated with both weapon systems/product groups (via TPIPTs) and supporting infrastructure (via CTCs), prioritizes those needs, and categorizes them according to the need to develop new technology or apply/insert emerging or existing technology. Weapon system related needs are derived in a strategies-to-task framework via the user-driven Mission Area Planning process.

> Phase 2, Program Development--Formulates a portfolio of dollar constrained projects to meet customer-identified needs from Phase 1. The Technology Executive Officer (TEO), with the directorates, develops a set of projects for those needs requiring development of new technology, while the



AFMC	= Air Force Materiel Command	MEB	= Mission Element Board
CTC	= Center Technology Council	TEO	= Technology Executive Officer
EV	= Engineering Validation	TPIPT	= Technical Planning IPTs
MAT	= Mission Area Team	TTO	= Technology Transition Office

Figure A-1. Technology Master Process

Technology Transition Office (TTO) orchestrates development of a project portfolio for those needs which can be met by the application/insertion of emerging or existing technology.

Phase 3, Program Approval--Reviews the proposed project portfolio with the customer base via an expanded S&T Mission Element Board and, later, the AFMC Corporate Board via S&T HORIZONS. The primary products of Phase 3 are recommended submissions to the Program Objective Memorandum and/or Budget Estimate Submission (POM/BES) for the S&T budget and for the various technology application/insertion program budgets.

Phase 4, Program Execution-- Executes the approved S&T program and technology application and/or insertion program within the constraints of the Congressional budget and the budget direction from higher headquarters. The products of Phase 4 are validated technologies that satisfy customer weapon system and infrastructure deficiencies.

TMP IMPLEMENTATION STATUS

The Technology Master Process is in its third year of implementation. AFMC formally initiated this process at the beginning of FY94 following a detailed process development phase. During the FY96 cycle, AFMC will use the TMP to guide the selection of specific technology projects to be included in the Science and Technology FY98 POM and related President's Budgets.

The Air Force Manufacturing Science and Technology (AF MS&T) Program planning process is directly aligned with the TMP, emphasizing weapon systems and/or product groups/infrastructure support. In concert with the TMP, the MS&T Program has published a detailed guide, outlining the Program's planning procedures and integration with the TMP. Figure A-2 illustrates the Program's established planning process for supporting the customer's requirements.

ADDITIONAL INFORMATION

Additional information on the Technology Master Process is available by contacting the following offices:

HQ AFMC/STP, DSN 787-7850, (513) 257-7850.

WL/MTX, DSN 785-4623, (513) 255-4623.

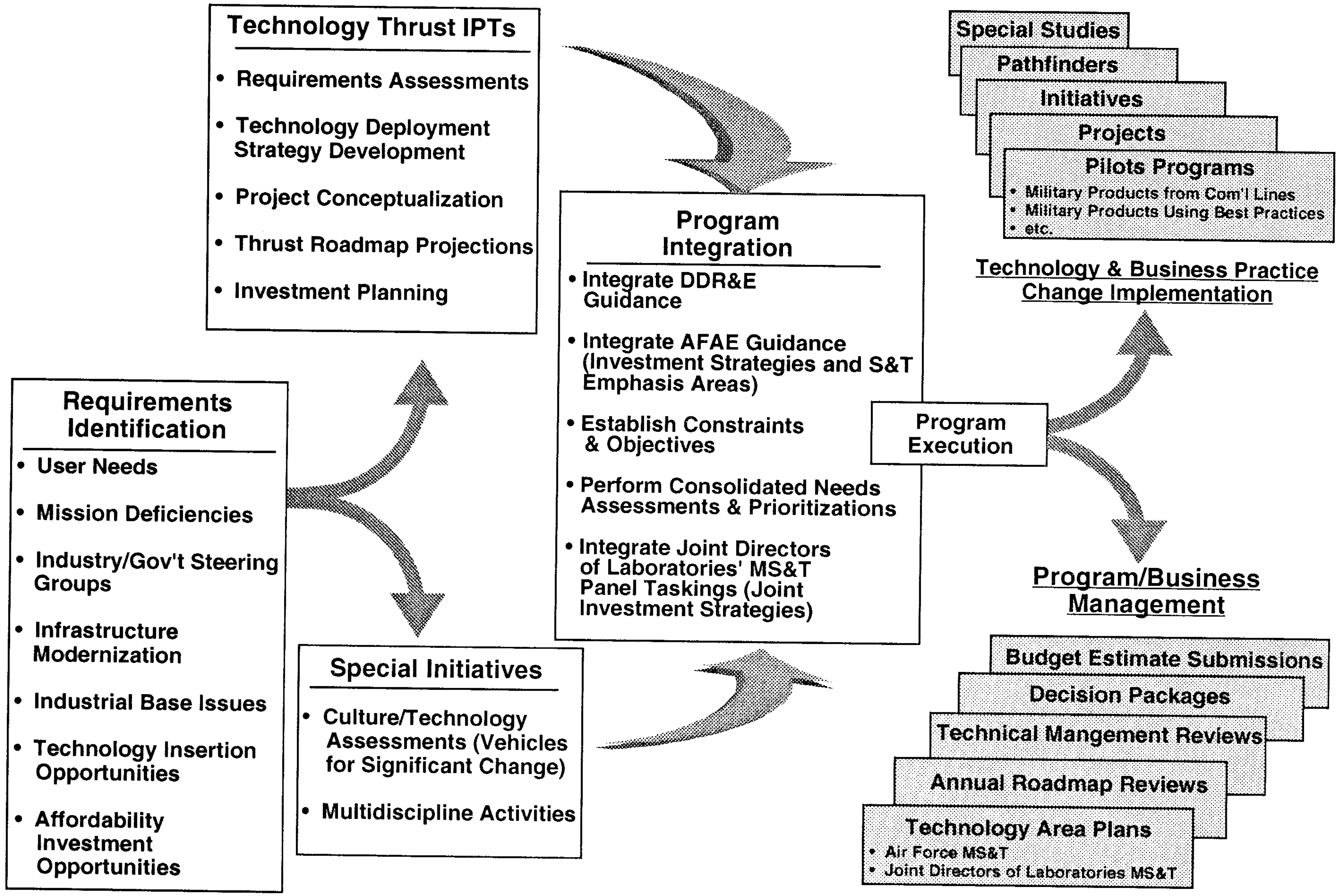


Figure A-2. AF MS&T Planning Process

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