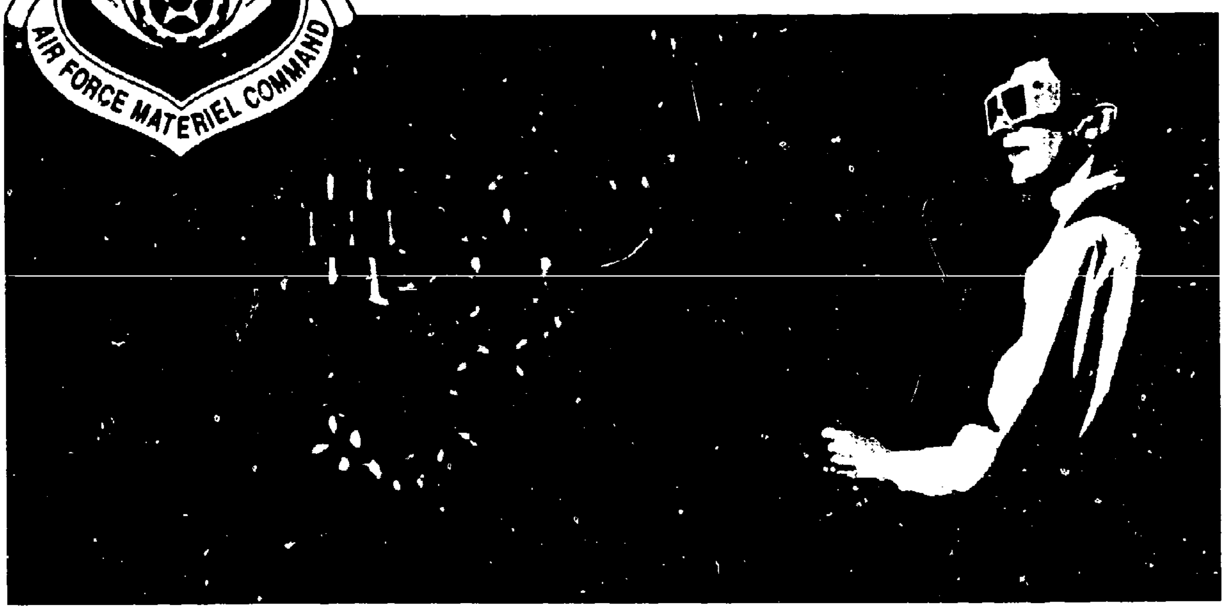
WL-TR-97-4000

FY97
MATERIALS & PROCESSES TECHNOLOGY AREA PLAN

AD-A286 908

96-02310



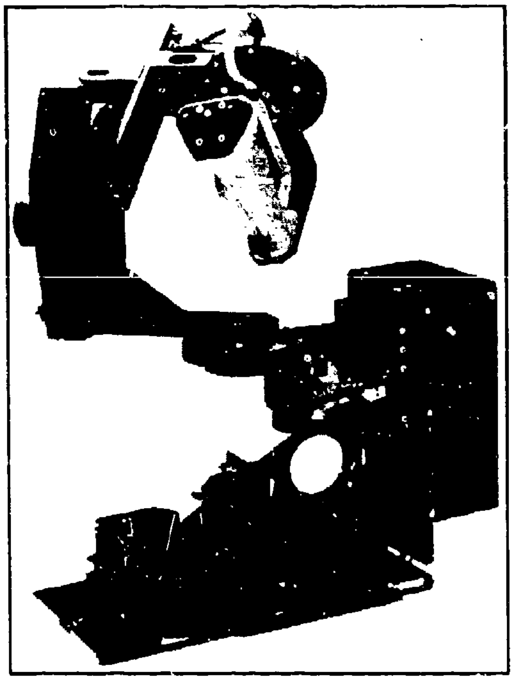
HEADQUARTERS AIR FORCE MATERIEL COMMAND
DIRECTORATE OF SCIENCE AND TECHNOLOGY
WRIGHT-PATTERSON AFB, OHIO

Approved for Public Release: Distribution is Unlimited

Note: This Materials and Processes Technology Area Plan (M&P TAP) is a planning document for the FY97-02 Science and Technology (S&T) program and is based upon the President's FY97 Budget Request. It does not reflect the impact of the FY97 Congressional appropriations and FY97-02 budget actions. You should consult WL/MLI, (513) 255-7174, for specific impacts that the FY97 appropriation may have had with regard to the contents of this particular TAP. Additional copies of this document can be obtained via the Internet at "http://stbbs.wpafb.af.mil/STBBS/" where comments can also be made. This document is current as of 1 May 1997.

... about the cover

Pictured on the cover is a representation of the "Molecular Docking Facility" which is a virtual reality based molecular interaction simulator operated by the M&P Technology Area. The facility is being used to aid in optimizing novel material designs with controlled properties. It allows chemist and material scientist to manually explore the reactive nature of molecules via a real-time force feedback modeling system with a three dimensional (3-D) display. This man-machine interaction in molecular design provides "sense of touch" by tactile "forced reflection" through a robotic arm with a wide range of motion so that the best position for docked molecules can be found. This manipulation of a structure on the screen is a more efficient molecular designing method than performing the traditional systematic search. The facility has a six-degree-of-freedom Cybernet PER-Force force-reflective manipulator (the robotic arm pictured on the cover and to the right). Crystal Eyes liquid-crystal shutter goggles for 3 dimensional viewing and a video data / graphics 3-gun projection system to project 2 dimensional images onto a large screen. The system is part of our extensive and very fruitful utilization of the Department of Defense (DoD) High Performance Computing (HPC) capabilities.



The PER-Force Handcontroller

The use of the "Molecular Docking Facility" to optimize new material designs is only one way the M&P Technology Area is implementing the use of advanced computer and information processing technology. The Materials & Processing Technology Area has also been actively implementing the use of information processing technology to advance the state of the art and to optimize material selection, material processing, designing tooling parts, fabrication processes, inspection and failure testing of materials and components. The use of computers will enhance the quality of the components to be fabricated while decreasing the time and cost of those components thereby enabling the material scientist to provide rapid response to the design engineer whether the need is for a retrofit to a current systems or a conceptual design for a future system.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	SEP 1996	FINAL 10/01/95--09/30/96

4. TITLE AND SUBTITLE
FY97 MATERIALS & PROCESSES TECHNOLOGY AREA PLAN

5. FUNDING NUMBERS
C
PE
PR 9993
TA 00
WU 00

6. AUTHOR(S)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
MATERIALS DIRECTORATE
WRIGHT LABORATORY
AIR FORCE MATERIEL COMMAND
WRIGHT PATTERSON AFB OH 45433-7734

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
MATERIALS DIRECTORATE
WRIGHT LABORATORY
AIR FORCE MATERIEL COMMAND
WRIGHT PATTERSON AFB OH 45433-7734

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
WL-TR-97-4000

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED.
Joe Burke
DSN: 785-5197
5766

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)

14. SUBJECT TERMS

15. NUMBER OF PAGES
38

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR

GENERAL INSTRUCTIONS FOR COMPLETING SF 298

The Report Documentation Page (RDP) is used in announcing and cataloging reports. It is important that this information be consistent with the rest of the report, particularly the cover and title page. Instructions for filling in each block of the form follow. It is important to ***stay within the lines*** to meet ***optical scanning requirements***.

Block 1. Agency Use Only *(Leave blank)*.

Block 2. Report Date. Full publication date including day, month, and year, if available (e.g. 1 Jan 88). Must cite at least the year.

Block 3. Type of Report and Dates Covered. State whether report is interim, final, etc. If applicable, enter inclusive report dates (e.g. 10 Jun 87 - 30 Jun 88).

Block 4. Title and Subtitle. A title is taken from the part of the report that provides the most meaningful and complete information. When a report is prepared in more than one volume, repeat the primary title, add volume number, and include subtitle for the specific volume. On classified documents enter the title classification in parentheses.

Block 5. Funding Numbers. To include contract and grant numbers; may include program element number(s), project number(s), task number(s), and work unit number(s). Use the following labels:

C	- Contract	**PR**	- Project
G	- Grant	**TA**	- Task
PE	- Program Element	**WU**	- Work Unit Accession No.

Block 6. Author(s). Name(s) of person(s) responsible for writing the report, performing the research, or credited with the content of the report. If editor or compiler, this should follow the name(s).

Block 7. Performing Organization Name(s) and Address(es). Self-explanatory.

Block 8. Performing Organization Report Number. Enter the unique alphanumeric report number(s) assigned by the organization performing the report.

Block 9. Sponsoring/Monitoring Agency Name(s) and Address(es). Self-explanatory.

Block 10. Sponsoring/Monitoring Agency Report Number. *(If known)*

Block 11. Supplementary Notes. Enter information not included elsewhere such as: Prepared in cooperation with ...; Trans. of...; To be published in.... When a report is revised, include a statement whether the new report supersedes or supplements the older report.

Block 12a. Distribution/Availability Statement. Denotes public availability or limitations. Cite any availability to the public. Enter additional limitations or special markings in all capitals (e.g. NOFORN, REL, ITAR).

DOD - See DoDD 5230.24, "Distribution Statements on Technical Documents."
DOE - See authorities.
NASA - See Handbook NHB 2200.2.
NTIS - Leave blank.

Block 12b. Distribution Code.

DOD - Leave blank.
DOE - Enter DOE distribution categories from the Standard Distribution for Unclassified Scientific and Technical Reports.
NASA - Leave blank.
NTIS - Leave blank.

Block 13. Abstract. Include a brief *(Maximum 200 words)* factual summary of the most significant information contained in the report.

Block 14. Subject Terms. Keywords or phrases identifying major subjects in the report.

Block 15. Number of Pages. Enter the total number of pages.

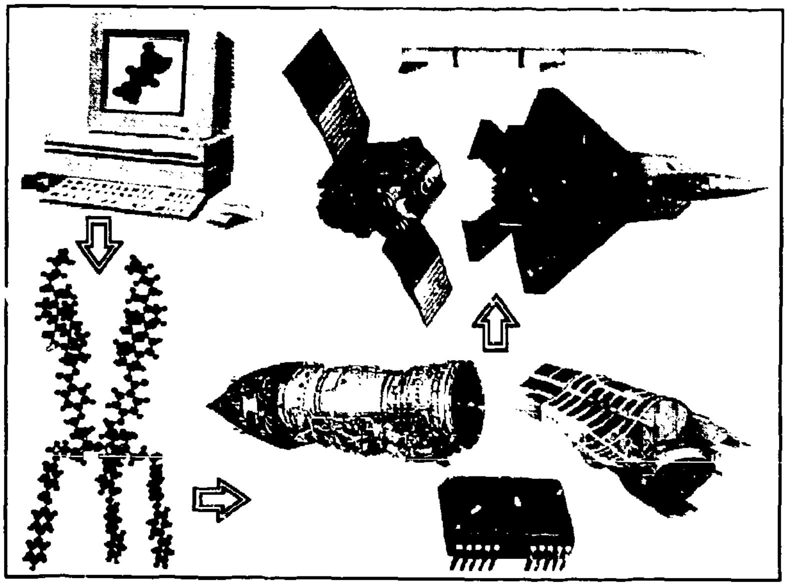
Block 16. Price Code. Enter appropriate price code *(NTIS only)*.

Blocks 17. - 19. Security Classifications. Self-explanatory. Enter U.S. Security Classification in accordance with U.S. Security Regulations (i.e., UNCLASSIFIED). If form contains classified information, stamp classification on the top and bottom of the page.

Block 20. Limitation of Abstract. This block must be completed to assign a limitation to the abstract. Enter either UL (unlimited) or SAR (same as report). An entry in this block is necessary if the abstract is to be limited. If blank, the abstract is assumed to be unlimited.

VISIONS & OPPORTUNITIES
Materials & Processes

The Materials & Processes Technology Area Plan addresses materials and processes (M&P) research, development and support for all Air Force current and future systems. The impact of these technologies is pervasive to all systems. More importantly, M&P often represent the limiting factors in system cost, performance, and risk. The importance of this area is reflected in Department of Defense (DoD) priorities. The Undersecretary of Defense for Research and Engineering (USD / DDRE), Dr. Anita Jones, has stated that "the top four priorities for DoD Science and Technology (S&T) are Information Technologies, Materials, Sensors and Affordability." While materials are specifically identified, materials development and processing technologies are also critical elements for each of the other priority areas. The importance of this area is further reinforced by analysis of Mission Area Plan's (MAP) deficiencies, Technology Planning Integrated Product Team's (TPIPT) concepts and Customer Focus Integrated Product Team's (CFIPTs) and Center Technology Council (CTC) technology needs. The CFIPT leaders have identified 11 Air Force pervasive technology needs, all of which are dependent upon or impacted by M&P being developed under this area.



"MATERIALS AND PROCESSES TO MEET THE CHALLENGE"

The challenge is to provide better and more affordable materials and material processing support to operations and maintenance, while developing the materials and processes to help meet potential readiness problems in 5 to 10 years. The opportunities lie in responding to the need to replace hardware in aging systems, in the modifications / upgrades that will occur and in critical environment issues such as pollution prevention. We can use these lower risk applications to qualify and gain production experience on new M&P and thus reduce their risk in 21st century systems. Whether the challenge is aging systems or preparation for next century systems, our vision is that we will have "the materials and processes to meet the challenge."

We will accomplish this by:

- •Conducting near-, mid-, and far-term, high payoff M&P research and development, and implementing technologies wherever possible on nearer term modifications / upgrades / sustainment activities.
- •Developing M&P technologies directly related to improved maintenance of existing systems that, in themselves, become baseline technologies for improved sustainability in next generation systems.
- •Providing in-house expertise and systems support for the Air Force Product Centers and maintenance and repair centers.

To respond to our customer's needs in a period of downsizing, we will:

- •Maintain a world-class research organization in a selected number of M&P areas vital to future Air Force capability needs and be "one phone call away" from national and international experts in other areas.
- •Have quality facilities in which to perform the excellent work expected of us.

Our philosophy in achieving the above will be to:

- Continue to make our customers aware of new M&P that solve their current problems or meet their future needs.
- Maintain a cognizance of Mission Area Plans and direct involvement in the Technology Planning Integrated Product Teams to ensure that we can insert new technology when needed into new / upgraded weapon concepts.
- Work with Wright Laboratory Customer Focus Integrated Product Teams to maintain a balanced program that addresses priority needs across all Product Centers.
- Track Center Technology Council technology needs and conduct programs to meet priorities of the Air Logistic, Flight and Test Centers.
- Advocate materials and processes to enable New World Vista concepts.
- Collocate engineers with system program offices (SPOs) to:
  - identify system technology needs to the Materials Directorate (WL/ML) for M&P technology planning,
  - identify opportunities in preplanned product improvements to WL/ML, and
  - provide expert consultation to the SPOs in M&P.
- Interact with other service science and technology organizations to:
  - exploit opportunities for cooperation, and
  - provide technology development leadership in areas where we have the sole expertise or technical lead.
  - avoid duplication,
- Contract with industry to ensure that industry possesses technology essential to the Air Force and to help maintain a vital industrial base.
- Conduct in-house research in order to:
  - pursue technologies beyond the risk of industry or that industry does not see a large enough market,
  - pick the right technologies to exploit with industry, and
  - be educated buyers of contracted technology.
- Focus three areas for increased materials and processing special emphasis:
  - Aging Aircraft Systems
  - Space
  - Pollution Prevention
- Address affordability issues as key evaluation criteria in the development of all materials and processes. Material and processing cost, performance and risk attributes of affordability will be provided to Air Force users and industry.
- Support areas of special interest: unmanned aerial vehicles, hypersonics and information warfare.

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

SIGNED

RICHARD W. DAVIS, Colonel, USAF
Commander
Wright Laboratory

SIGNED

RICHARD R. PAUL
Major General, USAF
Technology Executive Officer

CONTENTS

INTRODUCTION
Materials & Processes

BACKGROUND

The Materials and Processes Technology Area, highlighted in **Figure 1**, is that part of the Air Force Science and Technology (AF S&T) program responsible for developing materials, cost-effective processes, nondestructive evaluation technology and repair / maintenance techniques of advanced materials to support the entire Air Force mission.

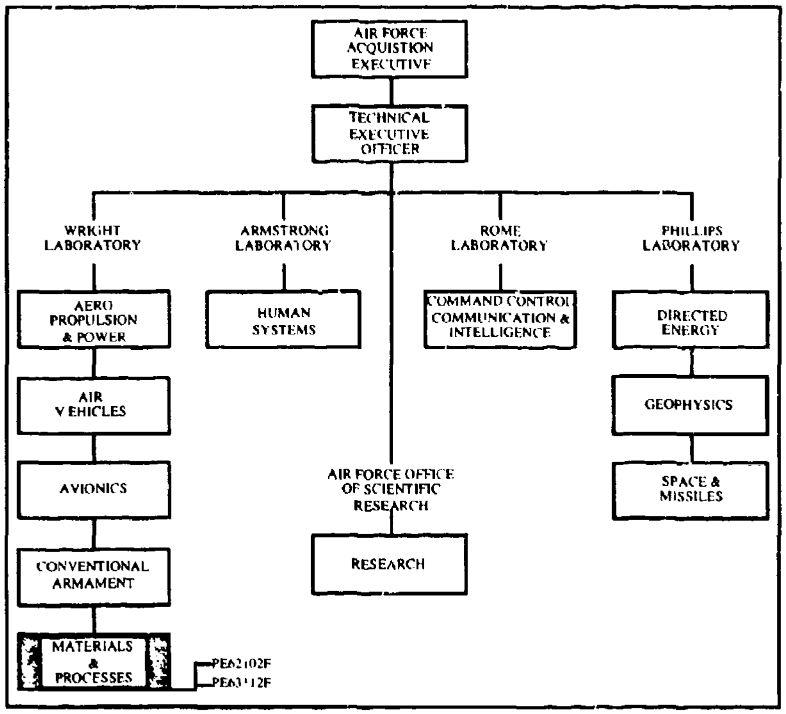


Figure 1: Air Force Science & Technology Program Structure

Over the years many outstanding contributions have been made by this area including superalloys for high-temperature turbine engines; ultra-high purity silicon for infrared detectors; permanent magnets for microwave sources, power generation and conditioning applications; advanced composites for aerostructures; carbon-carbon nozzles and nosetips for missiles; high temperature lubricants and thermal control coatings for spacecraft. Over the past year, this area continued to provide outstanding contributions to the Air Force and many of these are highlighted under the three thrust areas. Particular noteworthy contributions are the development and transition of diamond coated ball bearings that last 100X longer than steel ball bearings, the first use ever of gamma Titanium Aluminide was approved for the F119 engine inner shroud, a new ceramic matrix composite with the potential to increase exhaust nozzle component life 900%, and successful operational assessment of holographic laser protection spectacles for helicopter crew with and without night vision goggles.

Since materials and processing (M&P) technology is often a limiting factor in achieving mission capabilities, close working relationships are necessary to define user needs and to supply the level of user support required. To achieve these relationships, we are actively working within the Technology Master Process and we maintain collocated engineers at Systems Program Offices (SPOs). In addition, we provide quick reaction support to resolve operational field maintenance problems as they occur. These activities help us to identify technology needs of current systems and for next generation systems.

The current research and development program is focused on providing the M&P technologies needed for both system upgrades or modifications and advanced systems, including propulsion, structures, electronics, optics and electro-optics, all with an emphasis on affordability attributes of performance, cost and risk. These system concepts evolve informally through direct user interactions and formally through the Technology Master Planning (TMP) process. The TMP process has Center Technology Council (CTCs) technology needs submitted by the Air Logistic Centers and Air Force Test and Engineering Centers, Mission Area Plans (MAPs) deficiencies prepared by the Major Commands, Technology Planning Integrated Product Teams (TPIPTs) concepts prepared by the Air Force Materiel Command in cooperation with Air Force users, and Customer Focus Integrated Product Teams (CFIPTs) technology needs developed by Wright Laboratory.

Air Force S&T funds are allocated to the M&P Technology Area as shown in **Figure 2**. All funding figures reflect the President's FY97 Budget Request. The program defined in this M&P Technology Area Plan is subject to change based upon possible congressional action.

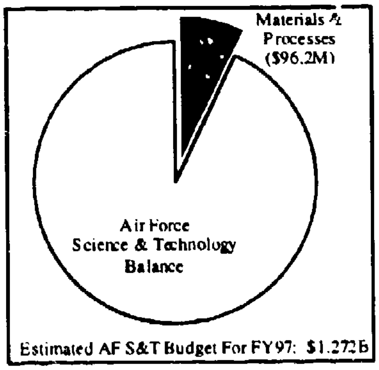


Figure 2: Materials & Processes S&T vs. Air Force S&T

To meet systems requirements that drive materials and material processing research and development, the M&P Technology Area is organized into three key Technology Thrust Integrated Product Teams (TTIPTs) listed in **Table 1**.

Table 1: Major M&P Technology Thrusts

Technical Thrust No. And Title
1. M&P For Structures, Propulsion And Subsystems
2. M&P For Electronics, Optics And Survivability
3. M&P Technology For Sustainment

From review of the CTC, MAP, TPIPT and CFIPT documents the vast majority of identified user deficiencies, concepts and technology needs are dependent upon or are impacted by the M&P being developed by the M&P Technology Area. A summary of the number and types of user needs identified as they correlate to the three M&P TTIPTs is presented in **Table 2**.

The TPIPTs (and corresponding MAPs) that have the most needs that are being tracked by the M&P Technology Area are: Air-to-Surface, Aerospace Control, Special Operations, Mobility, Force Enhancement, Strategic Deterrence, Space Control, Information Warfare and Environmental Safety & Occupational Health. All of the needs documented by this area were identified by the appropriate Product Centers and an illustration of the breakout of user needs being tracked by the M&P Technology Area by Product Center is presented in **Figure 3**.

Table 2: Overview Of User Needs By M&P Technology Thrusts

1: M&P For Structures, Propulsion and Subsystems	<u>Structures</u> 111 Needs Covering: • Lightweight • Conformal Fuselage & Carriages • Low Observable • Lower Cost & Longer Life Higher Specific Strength • Lightweight High Temperature • Lightweight Dimensionally Stable • Thermal Management Of Electronics And Structures • Thermal Protection Systems • Smart / Adaptive Structures	<u>Nonstructural</u> 31 Needs Covering: • Reduced Maintenance Through Longer Life Solid & Liquid Lubes, Seals • Fire / Explosion Resistance • Thermal And Signature Control Coatings • Environmental Exposure • No Outgassing • Lower Cost • Wide Temperature Range	<u>Propulsion</u> 73 Needs Covering: • Dual / Multi-mode Engine • Nozzle Integration • Reduced Signature • Improved Thrust-To-Weight • Reusable Rockets • Lower Cost • Longer Life • Less Maintenance • Reduced Size • Higher Efficiency
2: M&P For Electronics, Optics and Survivability	<u>Sensors & Countermeasures</u> 285 Needs Covering: • UV, Visible, EO, Laser & IR Sensors For Satellite, Missile, & Aircraft • IR, EO & Laser (Counter) Countermeasures • All Weather, 4 Pi, Through Obscurents Capability • Miniaturization, Lighter Weight • Wider Area Coverage At Longer Range • Multipurpose • Ability To Function At High Mach	<u>Laser Protection</u> 48 Needs Covering: • Aircraft, Satellite, & Missile Sensor Hardening • Personnel Eyes, Visors • Critical Structures • Low Cost • Lightweight • Min. Performance Impact • No Mission Denial • Day & Night Protection • Fixed, Broadband & Agile Laser Protection	<u>Electronics</u> 299 Needs Covering: • Enhanced Avionics • Offboard Datalinks • Integrated Optics • Optical Interconnects • Secure, Jam Resistant • Higher Speed, Mass Storage, Reliability Temp., & Power • Lower Weight, Cost, Cooling & Complexity • Miniaturization
3: M&P Technology For Sustainment	<u>Pollution Prevention</u> 117 Needs Covering: • ODC Free Fire Suppressants and Refrigerant • VOC-Free Cleaning & Degreasing • Processing Methods To Reduce / Eliminate Metal Bearing Waste • Low Emission Protective Coatings • Decrease / Eliminate Paint Stripping HazTox Materials • Reduce / Eliminate Air Force Use Of 17 Targeted EPA Chemicals	<u>Systems Support</u> 79 Needs Covering: • Logistics Support To Aging Systems • Design Handbooks & Aids • Technology Transfer • Worldwide Crash / Failure Analysis • Corrosion • Enhanced RM&S • Depot & Field Repair • LO Repairs	<u>Nondestructive Evaluation (NDE)</u> 75 Needs Covering: • Corrosion • Structural Degradation • Life Prediction • Multi-Site Damage • Large Area • Multi-Contoured • Heat Damage • Aging Systems • Bonded Repairs • Non-contact Ultrasonics

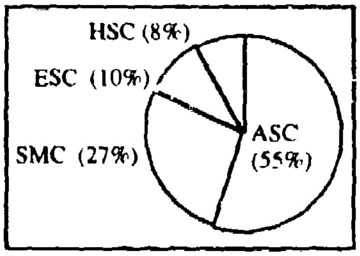


Figure 3: Distribution Of M&P User Needs By AFMC Product Centers

Along with identifying the breadth of MAP deficiencies and TPIPT technology needs dependent upon or impacted by M&P being developed by the M&P Technology Area, special emphasis is given to those needs identified as critical or high priority by the MAPs, TPIPTs, CTC and CFIPTs. From the CFIPT Customer Focus Investment Strategy Guidance report, 72% (98 of 136) high priority or critical technology needs are dependent upon or impacted by the M&P being developed in this area. The M&P Technology Area has a role in all 11 pervasive technology needs identified by the CFIPTs. This is illustrated in **Table 3** which lists the CFIPT pervasive technology needs across the Air Force and cross references the identified need with the M&P TTIPTs. Specific information about the M&P technologies being developed for each of these eleven needs can be found in the three TTIPT program descriptions of this document.

The difficult task that lies ahead is in selecting the distribution of limited funds on those needs most critical and / or have the broadest impact across the Air Force. The M&P TTIPTs are structured to meet Air Force capability needs and are reviewed and revised periodically to reflect changing priorities. **Thrust 1** is the largest effort in the M&P Technology Area and covers development of M&P for a wide range of aircraft, space, and missile applications requiring characteristics such as load bearing, thermal management, lightweight, reduced life cycle cost, signature control and lubrication. **Thrust 2** includes electronic and optical materials and material processes to meet requirements for advanced avionics, communications, reconnaissance, surveillance, intelligence and electronic combat as well as electromagnetic materials for transparencies and laser hardening for personnel eye protection, sensors, and aircraft and spacecraft structures. **Thrust 3** is the primary interface between the M&P Technology Area and users. It provides nondestructive inspection / evaluation (NDI/E) techniques and devices, on-site personnel in SPOs, component material failure analyses, and develops data to transition materials to those organizations that develop, operate, and maintain systems. This thrust also has the lead to reduce by 50% the use of hazardous toxic materials in material processing. **Figure 4** shows the relative emphasis of these thrusts by distribution of M&P S&T funds.

Table 3: Correlation Of Pervasive Air Force Needs To M&P Technology

Pervasive Air Force Technology Needs Documented By The Customer Focus Integrated Product Teams	M&P Technology Thrusts: 1: M&P For Structures, Propulsion & Subsystems	2: M&P For Electronics, Optics & Survivability	3: M&P Technology For Sustainment
• Structural Corrosion / Fatigue and Repair	■		■
• Affordable, Supportable Stealth (All Spectrum)	■		
• Low Cost, Light Weight, High Strength Structures	■		
• Turbine Engine Durability, Incr. Efficiency and Endurance	■	■	
• Affordable, All Weather Targeting & Precision Munitions Delivery		■	
• IR/EO/Laser Threat Detection, Warning & Countermeasures		■	
• Cost Effective Avionics, Commonality, Obsolescence		■	
• Battle Management / Information Technologies (RTIC for Manned Systems & C4I for Unmanned Systems)		■	
• Affordable, Low Cost Processing Techniques and Materials	■	■	■
• Maintainability, Reliability, and Repairability Improvements	■	■	■
• Environmentally Compliant Materials and Processes	■	■	■

RELATIONSHIP TO OTHER TECHNOLOGY PROGRAMS

Relationship To Other Air Force TAPs - Since the M&P Technology Area is broadly based and supports the entire Air Force, it is closely related to many other S&T technology areas. For example, this Area has joint initiatives with the **Aero Propulsion & Power** Area (WL/PO) for the Hypersonic Technology (HyTech) and Integrated High Performance Turbine Engine Technology (IHPTET) programs, the **Avionics** Area (WL/AA) in M&P for electronic and electro-optic materials, the **Air Vehicle** Area (WL/FI) in structural materials design and validation, the **Space & Missiles** Area in space structures, coatings and propulsion M&P, the **Armament** Area (WL/MN) in M&P for hardening sensors and seekers, and the **Research** Area in basic materials.

Industrial Programs - The Air Force provides leadership and vision for the aerospace industry investment in M&P research. This is stimulated in part by de-

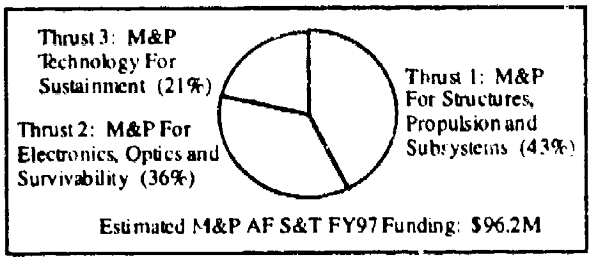


Figure 4: Major M&P Technology Thrust Funding

voting a great deal of energy interfacing with industry to provide direction and focus. The M&P Technology Area leverages industry investment to maximize return on Air Force investment and ensure critical mass funding levels. Typically, industry investment is more production driven while Air Force investment addresses research and development needs of new and fielded systems. The M&P Technology Area strategy is to be in the "high risk" innovative or breakthrough technologies and to reduce investment in areas where there already is considerable industry investment. Thrust 1, M&P for Structures, Propulsion and Subsystems, has demonstrated this strategy by providing international leadership in technology insertion of organic composites for the last two decades but focusing on only key issues such as affordability as industry investment has increased. In areas such as laser hardening, industry investment is small resulting in a considerably larger investment being needed within the M&P Technology Area to meet future requirements. To assist in transitioning of M&P technology into industry this area currently has 18 active Cooperative Research and Development Agreements (**CRDAs**) with 7 more in negotiation and 11 completed. The CRDAs underway cover such areas as scale-up of processing techniques, publishing engineering data, and making computer models user friendly for wider distribution. Of significance was the transfer of software, data, material testing techniques and advanced process engineering procedures to a network of five aluminum extrusion and 16 die-making companies.

Also, the M&P Technology Area has four educational partnership agreements with regional schools from which scientists and students are collaborating on research. The universities represented are Dayton, Wright State, Northern Kentucky & Cincinnati.

The M&P Technology Area also actively supports small businesses through actively awarding small business set-asides, small business innovation research (SBIR) and small business technology transfer (STTR) contracts. This approach leverages M&P Technology Area funding in seeking unique breakthrough technologies to fulfill Air Force technical and mission needs. Of particular emphasis are the areas of environmental compliance, modeling and simulation, novel processing methods, biological films for optical coatings, nondestructive inspection, superconducting M&P, electronic packaging, and biodegradable paint removal materials. **Table 4** lists the number and total funding of ongoing Phase I SBIRs and **Table 5** does the same for Phase II SBIRs. There is one STTR Phase II program of $300,000 in forming of Titanium Aluminide with automotive applications. Total on contract SBIR Phase I, Phase II, and STTRs in FY95 equaled $21,420,127. Awards for FY96 SBIRs are still in process as of

Table 4: Summary Of On-Going FY94 & FY95 Phase I SBIRs By M&P Technology Thrust

M&P Thrust	No SBIRs Phase I	Funding ($)
1. Structures Propulsion And Subsystems	18	$1,385,564
2. Electronics Optics And Survivability	9	$712,254
3. Technology For Sustainment	4	$318,436
Total	31	$2,416,254

Table 5: Summary Of On-Going FY94 & FY95 Phase II SBIRs By M&P Technology Thrust

M&P Thrust	No. SBIRs Phase II	Funding ($)
1. Structures Propulsion And Subsystems	19	$11,421,314
2. Electronics Optics And Survivability	7	$4,507,906
3. Technology For Sustainment	4	$2,774,653
Total	29	$18,703,873

submittal of this Technology Area Plan (TAP).

International Programs - The M&P Technology Area actively works with international partners by co-chairing international symposiums and having 14 international agreements. There are two international exchange agreements (IEA), one for advanced organic matrix composites and their application in aircraft structures and the other covering laser hardening. Under two Four Powers project arrangements the M&P Technology Area is collaborating on tactical laser hardened materials and nondestructive evaluation (NDE). Four Data Exchange Agreements (DEA) exist in the following areas: 1) behavior of advanced fluids and lubricants, 2) composite materials and structures, 3) material measurements and characterization, and 4) materials and processes for military applications. The other six efforts cover data exchange agreements regarding electronic materials, Carbon-Carbon (C-C) composites for dual use applications and C-C ablation models for thermal protection. All of these areas are high priority that support related Air Force needs and enable the M&P Technology Area to follow international developments in these areas and bring these technologies to Air Force systems.

Other DoD and Government Agencies - The M&P Technology Area is thoroughly coordinated through the Department of Defense (DoD) Joint Directors of Laboratory Technology Panel for Advanced Materials (JDL/TPAM). The Air Force chairs 2 of the 11 subpanels and is represented on 8 of the other 9 subpanels. The Air Force does not participate on the Armor Subpanel. The panels chaired by the Air Force are the Special Functional Materials and Biomolecular M&P panels. Even though coordination already existed among the services, a more comprehensive coordination has been realized through the JDL.

We are also actively working with the National Materials Advisory Board and National Science and Technology Council to identify critical national M&P issues. This ensures that critical Air Force M&P are included in the national investment strategy.

CHANGES FROM LAST YEAR

During strategic planning activities, three areas were identified for increased special emphasis. These three Special Emphasis Areas (SEAs) will focus and prioritize activities across the M&P Technology Area to provide demonstratable near-term benefits for our highest priority customers, be the areas in which the M&P Technology Area will add resources, and assure the technology area's presence in DoD and national arenas is recognized. The three SEAs are:

- M&P for Space and Missile Systems
- M&P for Life Management of Aging Systems
- M&P for Pollution Prevention

The Space and Missile SEA established a partnership with the Phillips Laboratory (PL) in which 20% of the M&P Technology Area's 6.2 core technology budget is to be dedicated to support the space and missile sector by FY97. Additionally, a joint investment / program strategy was established and an organizational infrastructure was implemented to ensure the continued health of the partnership.

The Life Management of Aging Systems SEA covers a broad range of technologies such as corrosion detection, characterization and protection; durable composite patch repair of cracked metallic structures; long life coatings for infrared windows and domes; and alternate heatshield materials and booster inspection methods to enable Air Force systems to be maintained in the active inventory beyond their planned service life. A focus area with the aging aircraft systems SEA is for improved High Cycle Fatigue (HCF) of propulsion systems where the M&P Area is addressing life prediction. Existing predictive methods / analytical tools are only valid for perfect materials under ideal conditions. Also, improved, environmentally compliant, long-lasting M&P for painting and depainting is a specific technology that will be provided.

The Pollution Prevention SEA has a goal to reduce the purchase of 17 Environmental Protection Agency (EPA) toxins by 50% by the end of 1996 from the 1992 baseline for all Air Force operations and their contractors. Another goal for the Pollution Prevention SEA is to reduce hazardous material waste disposal 25% from the 1992 baseline by 1996 and by 50% by the end of 1999. Particular focus is on cleaning and degreasing volatile organic compounds (VOCs), ozone depleting chemicals (ODCs), paint stripping, protective coatings, and metal bearing waste.

Other areas of special interest in the M&P Technology Area are unmanned aerial vehicles, information warfare and hypersonics. For hypersonics two major changes have occurred: the termination of the Hypersonic System Technology Program (HySTP), the National Aerospace Plane (NASP) follow-on, and the Secretary of the Air Force direction to develop an integrated follow-on generic hypersonic program. In response, the HyTech program was started with the primary goal to develop critical enabling technologies for hypersonic systems. In support of HyTech, this area is managing $1M/year for WL/PO to address M&P of propulsion components operating for extended periods above Mach 4. Materials screening and development fabrication processes, joining, inspection and design allowable properties will be completed in parallel with other HyTech subtasks to support demonstration hardware fabrication. Materials testing will be completed by 1999 with full scale inlet and combustor components demonstrated by 2001.

PROGRAM DESCRIPTION

Thrust 1: Materials & Processes for Structures, Propulsion And Subsystems

The overall objectives of this thrust are to provide new materials and processes (M&P) for:

1) Aircraft, missiles, launch systems and satellite structures,
2) Propulsion structures and
3) All Air Force systems nonstructural applications.

A roadmap for Thrust 1 is presented in **Figure 5** and the correlation between Thrust 1 technologies and Air Force missions is presented in **Table 6**.

M&P currently under development or transition includes carbon-carbon (C-C) for thermal management, lightweight satellites and for reentry vehicle (RV) nosetips, and heatshields; an aluminum alloy for reduced aircraft and spacecraft weight; advanced titanium alloys for hypersonic vehicles, advanced engines, and improved system reliability; self-improving process design and control cost of advanced nonmetallic/organic matrix composites, as well as higher temperature composites to replace metallics for weight savings; and advanced hydraulic fluids, low friction films for bearings, advanced lubricants for mechanical subsystems and thermal control coatings for space vehicles.

This area is coordinated with the other services through the Joint Directors of Laboratory (JDL). Specific subpanels involved include structural, high temperature, special function, bimolecular, processing and low observable (LO) materials.

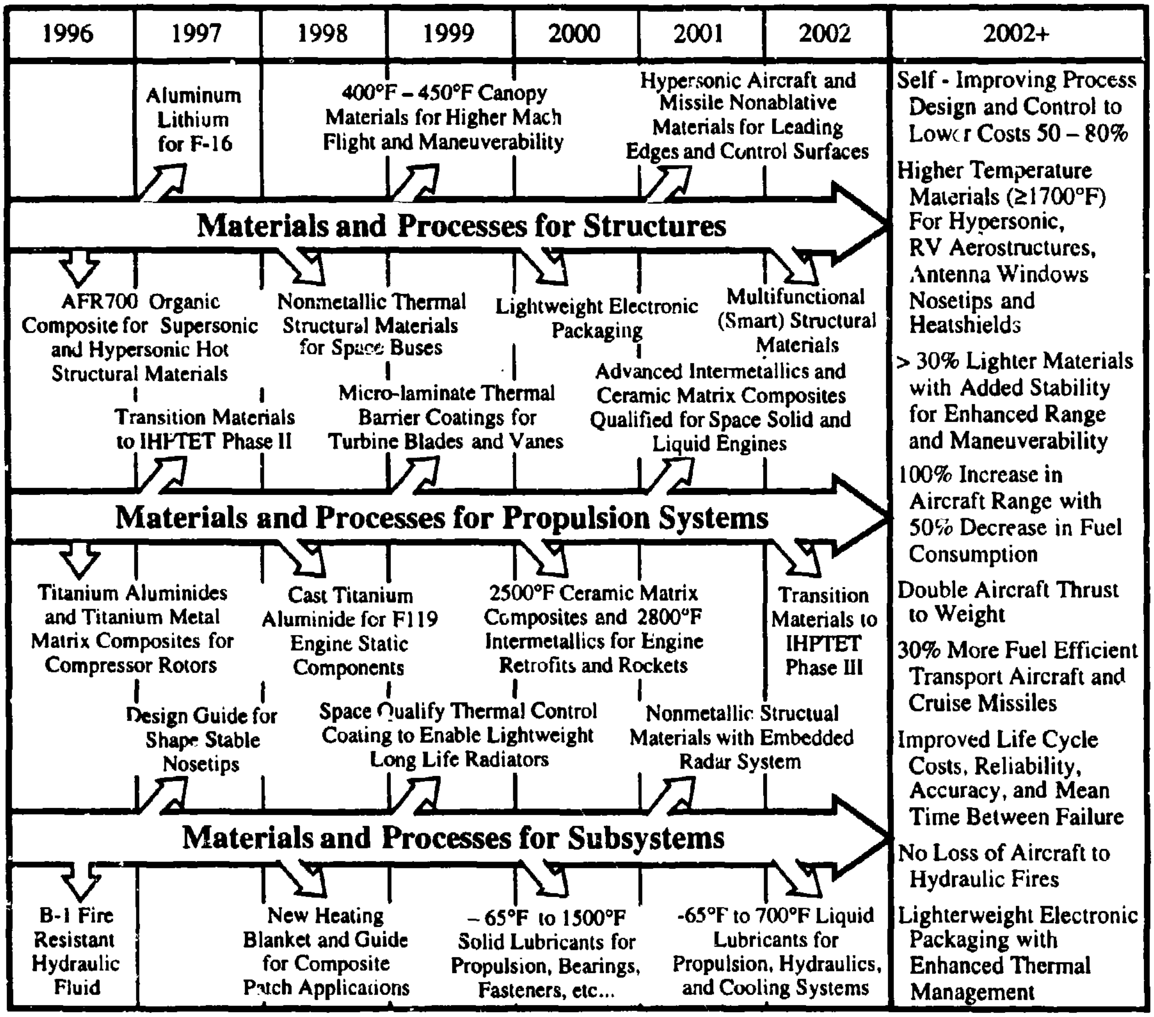


Figure 5: Thrust 1 – Materials And Processes For Structures, Propulsion, And Subsystems

USER NEEDS

The largest percentage of identified user needs which Thrust 1 supports are for far-term aircraft, spacecraft, and engine applications requiring range, speed, fuel efficiency, and weight. These broadly based needs are from a majority of Technology Planning Integrated product Teams (TPIPTs) and Mission Area Plans (MAPs). There are fewer, but still a significant number of user needs supported by Thrust 1 technologies for new missiles, satellites, engine modifications, unmanned aerial vehicles (UAVs), and preplanned product improvements (P3I) in the near- to mid-term. The role of the M&P Technology Area is to develop the necessary materials and materials processes, not the specific structures, engines or their integration. Specific concepts and missions identified in which the M&P Technology Area support are as follows.

Across the Air Force a drive is for lightweight systems to increase range, thrust-to-weight (TTW) ratio, maneuverability, and survivability for aircraft and missiles; enable conformal fuselages and weapon carriages; increased throw weight for launch vehicles; all while decreasing life cycle cost (LCC) of aircraft and launch cost of satellites. **M&P for lightweight structures** will address all of these issues. Lightweight structures are required for Air Force missions of Aerospace Control, Air-to-Surface, Mobility, Special Operations, Rescue, Force Enhancement, Space Control and Space Support. In responding to these identified needs, this area is developing organic matrix composites (OMCs), C-C composites and lightweight metal alloys that will be more affordable giving lower acquisition and maintenance cost while increasing the structure's life.

Table 6: Thrust 1 Key Technologies Per Air Force Mission

Primary TPIPTs (Mission Categories)	M&P For Lightweight Structures	M&P For Lightweight High Temperature Structures	M&P For Propulsion Systems	M&P For Nonstructural Applications	M&P For LO / Signature Control Technologies	M&P For Smart / Adaptive Structures	M&P Lightweight, Dimensionally Stable Space Structures	M&P For Thermal Management	M&P For Thermal Protection Systems	M&P For Antenna And Apertures
Aerospace Control	■	■	■	■	■	■		■	■	■
Air-To-Surface	■	■	■	■	■	■		■	■	■
Mobility	■		■		■					■
Special Operations	■		■	■	■					
Rescue	■		■							
Air Base Systems					■					
Training	■									
Force Enhancement	■		■		■		■	■		■
Space Control	■		■							
Strategic Deterrence			■	■	■			■	■	■
Space Support	■		■	■					■	
Information Warfare										■

Ultralightweight composite concepts are being developed to provide 50% weight savings over traditional aircraft aluminum while also being more damage tolerant. A near-term priority application of advanced composites is the F-22, where composites are projected to account for at least 26% of the airframe structural weight. Advanced M&P now under development will increase the usage of composites by 2005, but at a lower acquisition cost for longer range MAP/TPIPT needs.

Aluminum (Al) and Titanium (Ti) alloys comprise 90% of the airframe materials in the Air Force fleets. Wrought and cast products of these two alloy systems are ready and can be easily designed into any system to provide significant cost savings over historical fabrication processes. "Boutique" or "niche" materials for special applications are also available, such as Aluminum-Lithium (Al-Li) which can potentially provide design weight savings of up to 20% for space tankage applications. Al-Li is also a strong contender for the Joint Strike Fighter (JSF) and because of its durability characteristics could be used in replacement parts on the F-16.

To accelerate transfer of lightweight structural materials to system applications, advanced simulation, optimization and control methods and software are being developed and transferred to industry which will allow for more reliable, lower cost and less conservative designs.

M&P for lightweight high temperature structures was initiated by the M&P Technology Area in support of the National Aero Space Plane (NASP) in the late 1980s and continues to support 21st century systems requiring higher mach flight, angle of attack (AOA), payload and maneuverability for faster response times and increased mission capability. Concepts identified that will require lightweight high temperature structures are the hypersonic bomber and attack aircraft; next generation stealth attack and Forward Air Control (FAC) / spotter aircraft; glide weapons; and mach 4-6, mach 8-10, dual range and 4-pi missiles. These concepts support Air Force missions of Aerospace Control and Air-to-Surface.

In meeting lightweight high temperature structural needs the M&P Technology Area is developing nonablative primary airframe structural materials [metals, OMCs and ceramic matrix composites (CMCs)] to satisfy a two-fold objective. First, lower the structural weight and complexity of current material designs while maintaining same temperature capability. Second, the ability to operate uncooled (or with minimal cooling) with hotter exterior and interior structures. The end result will be structures that are inherently able to operate at higher temperatures, that are easier to fabricate, maintain and inspect than state-of-the-art (SOTA) methods requiring excessive cooling mechanisms, coatings, tiles and / or ablative structures such as the F-117 and B-2 exhaust washed structures.

AFR700 developed by the M&P Technology Area is a high temperature OMC (700°F) that is being used to replace heavier aluminum and titanium structures. AFR700 was implemented in a retrofit for the F-117A at Sacramento Air Logistics Center resulting in reduced acquisition cost of trailing edge components by 50%, while providing a three-fold extension in component life.

Another nonmetallic material under development to meet extreme high temperature lightweight structural needs with dramatic cost savings over current capabilities is the development of a net-shape carbon foam. This foam will exploit carbon's unique extreme tailorability, but at one-tenth the cost of C-C composites for hot internal structures.

The M&P Technology Area is evaluating the Titanium alloy Ti-62222 which is the baseline for components in the F-22 aft section. Efforts are focused on heat treatment processing techniques of the qualified material to increase long term durability, lower cost and gain the ability to reclaim damaged components.

Other M&P for high temperature structures include the development of oxidation resistant intermetallic alloys for 2400°F applications. Also, lower cost, more durable CMCs are being developed for exhaust heated structures [B-2, F-117, and JSF] and other hot aerostructures such as the Hypersonic Technology (HyTech) program. Recently, a newly developed CMC potentially could extend the life of an exhaust nozzle component 900%.

M&P for propulsion systems are critical to meeting Air Force mission needs for aircraft, missiles and space launch vehicles. Air Force missions that have propulsion deficiencies documented are Aerospace Control, Air-to-Surface, Mobility, Special Operations, Rescue, Force Enhancement, Strategic Deterrence, Space Control and Space Support. These missions have identified propulsion concepts ranging from dual / multi-mode engines, hybrid rocket / ramjet / scramjet / turboramjet engines to reusable rockets amongst others. Requirements for these propulsion systems include high cycle fatigue, high efficiency fans, integrated nozzles, multi-use without refurbishment, reduced observability, improved thrust management / directional control, reduced size and weight, extended life, lower cost, increased TTW. Increased TTW requirements are being addressed by two technology demonstrator programs: Integrated High Performance Turbine Engine Technology (IHPTET) and Integrated High Performance Rocket Propulsion technology (IHPRPT). Lightweight high temperature engine materials [advanced metallics and intermetallics, C-C, OMCs, metal-matrix composites (MMCs) and CMCs] as well as nonstructural materials (fluids, lubricants and seals) are being developed to support these technology demonstrator programs. Also being developed are high temperature inorganic semiconductors to enable electronic control of engines and nanoscale thin films to provide thermal barriers for turbine blades and zero gradient thin films for corrosion and wear properties. The primary M&P Technology Area emphasis is balanced between far-term development for supersonic / hypersonic propulsion systems and mid to near-term production of missile engines and aircraft engine modifications, retrofits and P3I.

To obtain weight savings in propulsion systems, high temperature C-C and OMCs are replacing traditional titanium nonrotating structures. High temperature resins are enabling composite materials to compete for lower temperature engine applications (compressor frames, ducts) with 30% weight savings. The high temperature resins also offer improvements in cost, durability, and low observability. An OMC demonstration program is underway to replace titanium at 35% weight savings with the technology transitioning to the F119 engine and its derivatives. C-C composites are being developed for high temperature engine bearing retainers. Also this area is supporting transition of environmentally protected C-C to WL/PO (funded by WL/PO) for the demonstration of expendable turbine engines.

Higher TTW requires operations at higher temperatures and current lubrication systems cannot operate at the desired high temperature. Also, in engine areas that operate at high temperatures (above 850°F), fastener seizure severely impedes disassembly. Pratt & Whitney estimates that $24 M/yr is lost due to the scrapping of parts and increased maintenance time because of this problem. The M&P Technology Area is demonstrating an enhanced lubricant / seal system and will transition through WL/PO for application to current propulsion systems. Also a new contract is developing high temperature seals with 700°F sustained use capability and a seal modification program to alleviate high maintenance seal leak problems is underway. Far-term activities including the development of a single fluid to act as both a fuel and engine lubrication will provide over 100 lbs per engine weight savings.

Titanium Metal Matrix Composites (Ti MMCs) are being developed to replace heavier superalloy vanes, shrouds, compressor blades and low pressure turbine blades for improved TTW in high temperature areas of engines such as the F119. A near term goal for Ti MMCs is to aid their transition to commercial applications including the P&W4000 and GE90 engines. Efforts in this area involve the proactive support of a recently-signed cooperative agreement between the Air Force and the Ti MMC Turbine Engine Component Consortium. Additionally, the M&P Technology Area is providing mechanical testing and life prediction modeling of Ti MMCs for the MMC Life Prediction Cooperative team.

The current CMC program is balanced to address the pacing issues for continued application of CMCs in Air Force systems and addresses dual use through strong interaction / collaboration with customers, technical leadership and joint activities with other government / industry / university organizations. CMCs are being pursued to replace metal components in fielded and developing air and space systems to provide greater temperature capability, durability and maintainability while having lower weight and signature. Uncooled turbines will become possible through the use of ceramic matrix components with reinforced oxide fibers. Fibers will be "made to order" (tailored to specific component or system needs) and components with tailored properties will be possible. Plans underway are to insert CMCs as preferred spares into the F100 engine and B-2, and as bill of materials for the F-22 and demonstration hardware (IHPTET and IHPRPT).

High Cycle Fatigue (HCF) has become a serious problem in advanced highly stressed engine designs and several engine failures have occurred costing millions of dollars. For improved HCF, the M&P Area is addressing life prediction. The development of damage tolerant life prediction methods for HCF of turbine engine components is based on fracture mechanics or other fundamental principles. Current crack inspection methods are adequate to detect low cycle fatigue (LCF) crack growth. For HCF, most crack lengths are below current nondestructive evaluation (NDE) detectability limits. Also, existing predictive methods / analytical tools are only valid for perfect materials under ideal conditions. Models to account for foreign object damage (FOD), LCF damage, creep, fretting, corrosion pitting and thermal mechanical fatigue are being developed as well as NDE methods to detect 10 - 100 micrometer cracks of parts with variable surface finishes.

In addition to high temperature gas turbine engine oils and seals, other **M&P for nonstructural applications** are needed for Air Force systems including hydraulic fluids; solid lubricants for bearings, gyros and electromechanical actuators; and thermal control coatings (TCC) for spacecraft. Also considered under this area is the development of inherently conducting polymer lightweight wiring to replace copper. Aircraft paints are covered under pollution prevention in Thrust 3. Air Force missions identified with these needs are Aerospace Control, Air-to-Surface, Special Operations, Strategic Deterrence and Space Support.

The M&P Technology Area is transitioning fire resistant hydraulic fluids through a SPO flight test program. Nonstructural materials have been identified as enabling technologies for future space surveillance systems. Long-life lubrication, in particular, is critical to the improved performance of momentum gyros and gimbaled sensors by eliminating outgassing around optics. Ultra-low friction solid lubricants and wear resistant coatings are being transitioned through Phillips Laboratory at the Space and Missile Center (SMC/PL), Aerospace Corporation, and prime contractors. Additionally for space, TCC developments will reduce radiator size and lower space launch cost.

Coatings and high strength, lightweight OMCs / CMCs with inherent LO properties to reduce systems detection are needed for retrofits and new systems capability. **M&P for LO / signature control technologies** are required for concepts such as 21st century fighter; dual role missile; UAV/RPV (remotely piloted vehicle); next stealth attack, FAC, airlift and special operations aircraft; and satellites. Air Force missions with LO requirements are: Aerospace Control, Air-to-Surface, Mobility, Special Operations, Force Enhancement, Strategic Deterrence and Air Base Systems.

To reduce weight and signatures, OMCs will be used to replace metal components while CMCs will be used for higher temperatures. Specialty materials are being developed as improved gap treatments but smart / multifunctional materials with inherently conducting polymers will offer a far-term, high payoff solution to gaps on LO aircraft. Their tailorable dielectric and electronic properties reduce observability by allowing the system to have its signature characteristics changed to meet real-time requirements. These M&P will be transitioned through SPOs, prime contractors, and the operating commands.

M&P for smart / adaptive structures will revolutionize how systems are designed and used in warfighting. Multifunctional materials (conductive and ordered polymers) and embedded (parasitic) sensors will enable closed-loop feedback health monitoring between a system and the pilot for enhanced flight maneuvers, in-field structural analysis, ability to detect directed energy weapon (DEW) threat engagement and damping of satellite vibration among others. Concepts identified for smart / adaptive structures are air-to-surface aircraft with reconfigurable flight controls, mach 8-10 global response system (GRS), the 21st century fighter and satellites for missile warning from Air Force Aerospace Control and Air-to-Surface missions.

Conducting polymers will be incorporated into composite structural elements. Such material configurations will allow the incorporation of electronic, sensor and actuating functionalities or components into lightweight, high strength smart structures.

Space surveillance and communication satellites have utilized advanced structural and non-structural materials (lubricants and thermal control coatings) for years. To exploit space in the future, the Air Force will have to rely on lower cost, more reliable means of placing satellites in orbit. **M&P for lightweight, dimensionally stable space structures** will improve the mass fraction of the spacecraft by decreasing structural weight thus enabling increased payload / reduced launch cost. Lower inertial weight in orbit, combined with high modulus, low thermal expansion OMCs and MMCs, and C-C can significantly increase the on-orbit performance of space based communication and surveillance platforms. These materials will also lower spacelift vehicle (rockets and single stage to orbit) costs by reducing overall payload system weight and volume. Also, C-C, OMCs and MMCs used in optical benches for precise sensor targeting, satellite radiators, and solar cells will be survivable to the nuclear threat, and thermal control coatings for these materials may be required to reduce weight (as opposed to thermal blankets and insulation). Concepts identified for these M&P are missile warning, GPS IIF, Milstar III as well as for those deficiencies identified for missions of Force Enhancement and Space Control.

For both space and tactical systems, **M&P for thermal management** of structures and electronics is a critical need. Lightweight (un)cooled structures of C-C, conductive ordered polymers and MMCs will allow innovative heat dissipation designs. Concepts with thermal management issues are hypersonic bomber and attack aircraft, mach 4-6 and 8-10 missiles, GRS and 21st century fighter. Similar technology is needed for small, lightweight high power density batteries for space systems such as Milstar III. Air Force missions that have thermal management needs which will require the new structural materials and coolants are Aerospace Control, Air-to-Surface Force Enhancement and Strategic Deterrence.

The thermal management capability of OMC and C-C composites will provide significant performance enhancements with major weight reductions for future applications such as heat exchangers thermal planes, radiators, electronic packaging for high temperature applications without cooling, and Sodium Sulfur (NaS) battery cases. The C-C thermal planes for electronics act as heat exchangers and are to replace heavier and less efficient Aluminum thermal planes on the Space Shuttle in FY98. In FY99 NaS battery cases are being transitioned to automobile and space applications. A joining and attachment program has already influenced the transition of thermal plane technology through primes (e.g. Titan IV).

Hypersonic and reentry structures (nosetips, and heat shields) require **M&P for thermal protection systems** (TPS) with high temperature structural materials (advanced metallics, metal, C-C and CMCs). System performance needs are for reduced weight, cost, cooling, complexity, length-to-diameter (L/D) design ratios, and installation requirements while increasing range, AOA and durability. Specific concepts with these performance needs are hypersonic bomber and attack aircraft, GRS (semi-orbital UAV), dual role missile, RV and spacelift vehicles. Air Force missions with TPS requirements are: Aerospace Control, Air-to-Surface, Strategic Defense and Space Support.

C-C materials were originally developed by the M&P Technology Area for reentry nosetips because of their extraordinary thermal shock resistance and temperature capabilities (up to 6000°F) enabling RVs to reach their targets with controllable loss in precision due to geometry changes of nosetips and heat shields. This unique class of materials offers other dramatic capabilities; i.e., C-C is 40% lighter than aluminum and has a specific thermal conductivity exceeding copper. In addition, C-C offers a near zero coefficient of thermal expansion and no outgassing allowing the material to be used around optics. C-C composites continue to be enabling for strategic missile applications in both the RV and propulsion areas. This area is the only supporter of RV C-C and thermal protection materials and life management / extension are critical opportunities along with enhanced materials for global reach and precision strike. The primary effort now is the evaluation, replacement, and retrofit of materials for the aging Intercontinental Ballistic Missile (ICBM) fleet. The materials for RVs will transition to Phillips Laboratory, Silo Based (SB) ICBM SPO, and the Department of Defense (DoD) RV Applications Program. The nosetip, heatshield and antenna window programs will transition to the SB ICBM SPO 6.3B flight tests after materials ground testing. Programs are closely coordinated with the ICBM long range planning team and Navy to provide a coordinated position for the DoD; the Navy has offered flight test opportunities. Additionally, support continues for the ICBM community to maintain the existing fleet.

Along with the increasing need for supersonic / hypersonic flight and very high AOA is the need for continuous, accurate, targeting and communication. **M&P for antennas and apertures,** being developed (C-C, CMCs, and OMCs with highly conductive fibers) for larger more advanced antennas and apertures, that have LO characteristics, and are conformal allowing real-time, continuous tracking and data relay, ground uplink-downlink telemetry, global positioning satellite (GPS) update, and synthetic aperture radar (SAR) tracking. Concepts identified for antenna and aperture materials technology are the next stealth attack and FAC aircrafts, hypersonic bomber and attack aircrafts, hypersonic attack and standoff fast reaction weapons, UAV decoy, kinetic energy weapons, dual role, mach 4-6 and mach 8-10 missiles, glide weapons, MILSATCOM, ultra high frequency (UHF) adaptive arrays, RVs, and mobility multiband antennas and radios. These concepts are from the Air Force missions of Aerospace Control, Air-to-Surface, Mobility, Force Enhancement, Strategic Defense and Information Warfare.

Structural polymers under development will improve compression strength of lightweight aircraft radomes. Also, CMCs are being developed for near-term high performance interceptor missile and RV applications such as the Mk21 RV window which has a 3-inch diameter and 3-inch thickness. Currently have processed 1ft^3 of a CMC (3DQ Di100) that reduces cost 30% and will be flight tested in FY97 on the Army's PAC-3 missile. Mid-term CMC development is targeted towards aging issues such as environmental resistance and enabling a GPS capability. Far-term developments are to provide lower cost, 5+ inch diameter conformal antenna windows.

GOALS

The goal of Thrust 1 is to provide new M&P for aircraft, spacecraft, launch vehicles, missiles, propulsion systems, and related subsystems. Specific goals evolve around improved affordability, maintainability, and enhanced performance of current and future systems and are addressed below:

- Develop a family of affordable lightweight materials, including metals, metallic and nonmetallic composites, carbon-carbon and ceramics that can provide upgrade capability for existing aircraft, spacecraft and missile systems, and that can meet challenges for new systems beyond the year 2000. Included are enabling materials:

- ••To dramatically decrease the LCC of aircraft from 50-80% lower cost structures to improved durability and reliability while increasing performance for enhanced maneuverability, range, speed and survivability.
- ••To meet 1700°F – 2800°F requirements for engines to double thrust-to-weight ratios of 1986 engine performance baseline.
- ••For spacecraft that are lightweight, environmentally dimensionally and stable (to radiation, atomic oxygen, moisture temperature) and noncontaminating to meet improved surveillance and communication needs.

•Provide the fluids, lubricants, seals, greases, coatings, insulations and other nonstructural materials for the subsystems on aircraft, spacecraft, missiles and their propulsion systems.

MAJOR ACCOMPLISHMENTS

•Demonstrated C-C battery sleeves that are 40% lighter than steel with 25X specific conductivity and longer life. Also resists corrosion and denting with over 400% increase in power efficiency. For geosynchronous earth orbit (GEO) satellites, decreased battery weight 67% (870 kgs).

•C-C electronic thermal planes accepted as bill of materials for Titan IV, replaces aluminum. Could double electronics reliability and save millions of dollars (>150% electronic reliability, < 50% temperature rise in circuit boards, 30% weight savings over Al and could save $360M for F-15 fleet alone).

•Demonstrated effectiveness of polysilazanes as waterproofing agents for antenna windows (SOTA 6% absorption unacceptable, new agent limits it to 2%, a 66% reduction).

•Low cost, high K, lightweight C-C structures were flight tested on SCARLET (Solar Concentrator with Refractive Linear Element Technology).

•Produced and tested ultra low cost C-C high-modulus graphite foams for structures.

•Developed 90 ksi compression strength C-C. Has high thermal conductivity, high modulus and will be used as thermal doublers under avionics and equipment modules for the Mars Global Surveyor.

•Processed large area CMC antenna window material (1f[3] "3DQ Di100") with 30% cost savings. Will be flight tested by the Army in FY97 on the PAC-3 missile.

•Developed internally cooled missile nosetip that withstands frictional heat at hypersonic velocities (wing swept 60°, velocity of 7 km/s and times of >20 min). Enabling technology for hypersonic and endoatmospheric interceptors and will be used in Army's Advanced Interceptor Technology (AIT) program.

•New CMC potentially increases operating life of exhaust nozzle component 900%.

•Verified new process design and control method for forging a near net-shape integral bladed rotor (IBR) from a gamma TiAl alloy (Ti-48Al-2V) which was a difficult-to-process material with a prescribed microstructure. Was first success in forging a large integral component with desired microstructure.

•First gamma TiAl component selected for application. F-22 will use as F119 inner shroud.

•Ti MMC hydraulic actuator rods [Trimarc/Ti-6242, (Ti-6Al-2Sn-4Zr-2Mo)] have been selected for up to twso flight test engines and are under consideration for preproduction verdsion engines. Trimarc is 40% lighter than stainless steel saving 7.4 lbs for the F22 and can also be used as acuators for ailerons, flaps and landing gear components. First made in 1994 and now qualifying first DoD application. Nonfracture-critical application helps gain Ti MMC experience, confidence, production volume. Integrated Product Team has led selection of Ti MMCs as bill-of-material up to 2 flight test engines. Ultimate goal is the substitution of Ti MMC into all actuators on the F-22 saving 42.2 lbs/aircraft.

•Successfully demonstrated the proper chemistry and processing to manufacture an isotropic wrought Al-Li product with superior properties to current versions of these alloys. Registered "AF/C486" with the Aluminum Association.

•Conducted field evaluation of nonflammable hydraulics for the KC-135.

•Delivered requalified spacecraft TCC to SMC SPO.

•Converted F-15 and F-15 ground support equipment dielectric coolant to improve moisture sensitivity, crude / corrosion properties. Also approved for B-2.

•Developed diamond coated ball bearings that last 100 times longer than steel bearings.

•"Auto-Inspect," an automated eddy-current inspection process design and test of the design system, was adopted for use on all future engine components to identify problems which previously could not be found until much later in the development process. The software code will significantly reduce time and cost of inspecting engine components by producing computerized low cycle fatigue "scan-plans."

•Conducted joint flight and ground test of advanced materials for RVs with Phillips Lab.

CHANGES FROM LAST YEAR

The Life Management of Aging Systems and Space SEAs have had the most impact on Thrust 1. These new efforts include:

•The initiation of a High Cycle Fatigue effort to develop predictive models for realistic operating conditions and inspection techniques to detect smaller cracks in key engine components.

•With the successful demonstration of the proper chemistry and processing to manufacture a superior isotropic wrought Al-Li, the M&P Technology Area is preparing a demonstration of the technology and technology transition strategy for space tankage.

•Investigation of thermal conducting enhancements to OMCs to minimize heating loads on spacecraft.

•Development of M&P for precision assembly / fabrication to eliminate fit-up mismatched and uneven surfaces.

•Initiation of a study to identify the M&P applicable for advanced liquid and solid engines in support of IHPRPT, Enhanced Expendable Launch Vehicle (EELV) and Reusable Launch Vehicle (RLV).

MILESTONES

•Demonstrate efficient carbon-carbon joining and attachment methods by 1997.

•Develop net-shape process for carbon-carbon that reduces scrap 50% by 1997.

•Develop a comprehensive guide for optimal application of fast and low cost composite patches for aircraft by 1998.

•A new composite patch curing heating blanket system that will cure faster, at high temperatures, more uniformly, and produces a higher quality patch / bond by 1998.

•Provide environmentally compliant high performance powder based paints by 1998.

•Demonstrate affordable structural OMC that meet spacecraft thermal requirements by 1998.

•Fabricate lightweight (-30%), dimensionally stable materials for space surveillance by 1998 (C-C, OMC).

•Develop orthorhombic Ti MMC for 1400°F advanced turbine engine components (bladed ring – bling) with 50% weight savings over Ni-based superalloys by 1998.

•Demonstrate a variant of the isotropic wrought AF/C486 Al-Li alloy that is weldable for space tankage by 1998.

•Verify antenna window material transmission characteristics for advanced RVs by 1998 with flight demonstrations by 2000.

•Demo 30% weight and cost savings of OMCs for aircraft and engine structures by 1999.

•Space qualified thermal control coatings to enable lighter weight, longer life radiators with improved reliability and performance by 1999.

•Scale-up and transition environmentally compliant LO aircraft paint by 1999.

•Field and depot level repair techniques for ceramic matrix composite engine exhaust components by 1999.

•Structural ceramics for IHPRPT initiative by 1999.

•HyTech > 1700°F materials (ceramics, C-C, and titanium aluminides) available by 1999 for full scale scramjet demonstration of inlet and combustors by 2001.

•High temperature (–65°F to 1500°F) solid lubricants for propulsion bearings, fasteners, etc. by 2000.

•Advanced metallic materials by 2000 for improved performance, reliability and affordability of cryogenic rocket engines.

•Low cost thermoset composites for F-22 wing control surfaces by 2001.

•Hybrid metal laminates for JSF skins by 2002.

•Materials to allow propulsion thrust-to-weight improvements of 100% by 2003 including compressor materials capable of 1700°F and turbine materials capable of 2800°F (titanium aluminides, ceramics, and their matrix composites).

•Qualify wider and higher temperature (-65°F to 700°F) fluid and lubricant systems for propulsion, hydraulic, and cooling subsystems by 2003.

•Demonstrate shape stable retention of guided RV materials for nosetips, heat shields, and antenna windows by 2003.

•Advanced intermetallics for space engines by 2005.

•CMCs for rocket engines and turbine retrofits by 2003 with advanced ceramics for reusable liquid rocket engines by 2007.

Thrust 2: Materials And Processes For Electronics, Optics And Survivability

The overall objectives of this thrust are to provide new electronic and optical materials and material processes for:

1) Electronic, optical, and electro-optic devices and subsystems for aircraft, missile, and space systems
2) Survivability of aircrews, sensors, aircraft and space systems.

A roadmap for Thrust 2 is presented in **Figure 6** and a correlation between Thrust 2 key technologies for Air Force missions is presented in **Table 7**.

As illustrated by Desert Storm, advancements in electronics [radar, infrared (IR) detectors, communications, and their associated computation systems] have revolutionized warfare and provided the US with an important war fighting advantage. The ***Materials and Processes for Electronic and Optics*** Technology Area "Spectrum of Applications" extends from low frequency electronics (DC) through visible light and into the ultraviolet. It addresses all four "S&T Priorities" identified by Dr. Anita Jones (information technology, sensors, materials and affordability). In general, goals include development of high payoff electronic and optical materials and processes (M&P) for Air Force systems applications, program balance to address both requirements pull and technological opportunity (a.k.a. the Materials Revolution), and focus on US industrial competitiveness (since economic and military strength serve the same national goals). The commercial electronic and electro-optic (E-O) community is working certain technologies. Thrust 2 is working niche technologies that are Air Force unique and for which there is no commercial development effort.

Electronics and optical technologies will ultimately be merged into single integrated technology for sensing, computing, processing and communication. Electronic and optical materials will revolutionize weapons concepts by making possible high sensitivity sensors across the entire electromagnetic spectrum, data transmissions links with greater than 200 gigabytes / second, three-dimensional data storage with almost instantaneous access, parallel processing of data at breathtaking speeds and holographic cockpit displays.

This technology area has helped provide many of the materials utilized in systems and continues the development of many breakthrough technologies. Specific examples include:

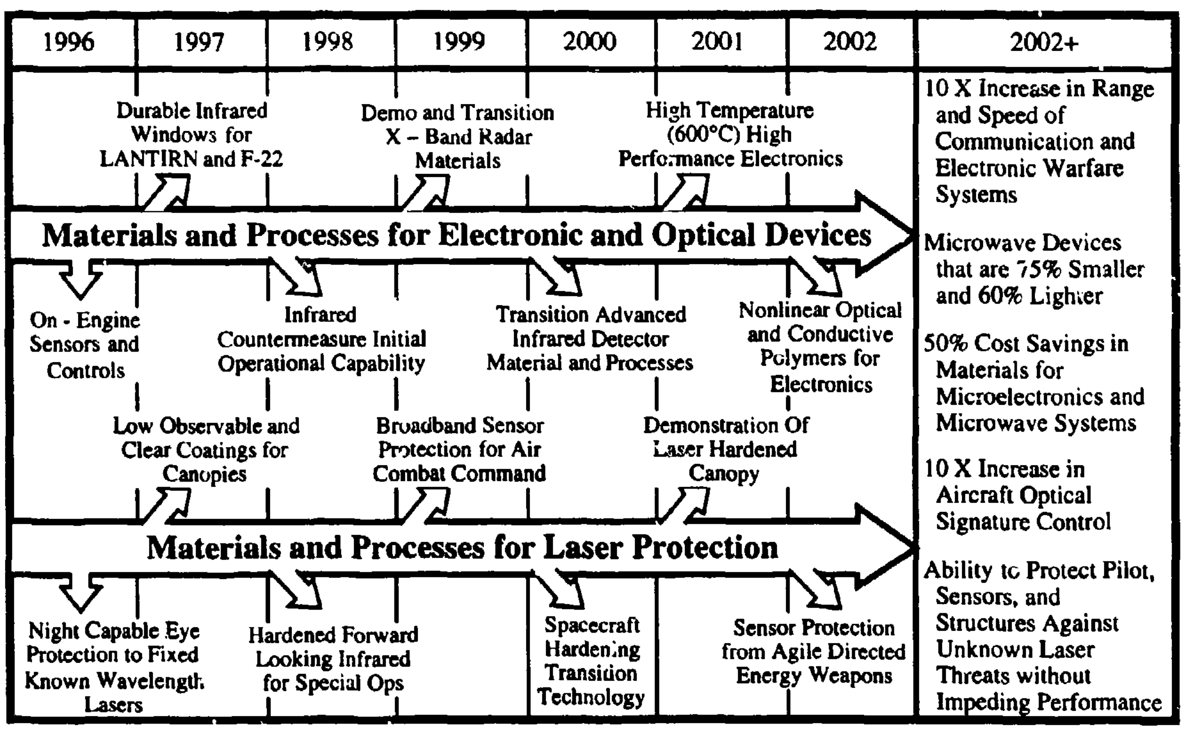


Figure 6: Thrust 2 – Materials And Processes For Electronics, Optics And Survivability

- Indium Phosphide (InP) to provide higher power / speed than Gallium Arsenide (GaAs) and are the next generation of materials for all weather radar and space based communication.
- Silicon Carbide (SiC) for very high temperature and power applications such as engines, more electric aircraft (MEA) and uncooled electronics.
- Mercury Cadmium Telluride (HgCdTe) defect reduction / small lot growth to enable affordable high performance space IR detectors.
- High temperature superconductors (HTSC) such as yttrium barium copper oxide (YBCO) and thallium barium calcium copper oxide (TBCCO) for dramatic increases in radar and communication performance.
- E-O polymers for low cost, high performance multichip modules (MCMs), interconnects, space communication, and low probability intercept (LPI) imagery reception.
- Nonlinear optical (NLO) materials such as zinc germanium phosphide ($ZnGeP_2$) to enable E-O and IR countermeasure (EOCM and IRCM), frequency agile lasers, wind shear detection, and for remote sensing of chemical and biological contaminants, etc.
- Several materials (yttria, zirconia, polycrystalline diamond [PCD], zinc sulfide [ZnS], and zinc selenide [ZnSe]) will provide improved sensor domes for enhanced performance, durability and reduced life cycle cost for LANTIRN and Maverick plus stealth and supersonic operation for other current and future systems.

While the M&P Electronic and Optics Technology Area is balanced between near and mid-term needs, the area will continue transition throughout the near, mid and far-term. Technologies for current systems will be inserted through upgrades / retrofits. There will be technology demonstrations (conducted by users) of concepts enabled by these M&P technologies (IR and EOCM by WL/AA, full scale supersonic IR windows by ASC, high temperature electronics for engines by WL/PO, and Rome Laboratory). Much of the transition will be through our industry partners back to the Air Force.

The ***M&P for Laser Hardening*** Technology Area programs provide validated laser hardening technology options to users, developers, and designers of Air Force systems. These systems include aircraft, sensors, spacecraft, and laser eye protection devices. During Desert Storm the Air Force demonstrated the accuracy and efficiency of E-O precision-guided munitions to a worldwide audience. Since then, our ability to maintain that technological edge has been compromised by the proliferation of low-cost lasers throughout the world. Using low-power lasers, the enemy can negate our ability to perform critical missions by spoofing or jamming unhardened sensor systems and aircrews. Dedicated high-power lasers even pose a significant threat to the survivability of systems and crews. Current hardening technologies are able to selectively excise specific known laser wavelengths from the electromagnetic spectrum through the use of absorptive / reflective dyes and coatings. However, the broad range of available laser wavelengths and the development of tunable / agile wavelength laser devices presents a serious technological challenge. The emerging laser threat has been recognized by Air Force Major Commands (MAJCOMs) who consistently rank laser hardening advanced technology demonstrations (ATDs) in their top 10% and highlight the need for this technology in Mission Area Plans (MAPs), Operational Requirement Documents (ORDs), and other requirements documents. Some specific Laser Hardened Materials (LHM) Technology Area objectives for personnel, sensor and structure protection from directed energy weapons (DEWs) are as follows:

- M&P for personnel protection to provide laser eye protection for day / night operations.
- M&P for sensor protection that provide full mission capability under threat exposure for airborne sensors; missile sensors; and space sensors in the visible spectrum, mid and long wave IR (LWIR) spectral bands.
- M&P for structural laser hardening to provide high power laser protection countermeasures.
- M&P for laser threat simulation to validate protection solutions via repeatable experimentation.

The LHM efforts are leveraged with coordinated tri-service teams to assess current capabilities and required research and development (R&D). Thrust 2 is also coordinated with the other services through the Joint Directors of Laboratory (JDL) electromagnetic protection; electrical, magnetic and optical; and advanced processing subpanels.

USER NEEDS

Advanced electronic and optical devices are critical to having a smaller Air Force with global reach, global power because of the need to obtain, process and disseminate time critical information. New all weather sensors are needed to gather data at longer ranges, over a broader electromagnetic spectrum and with increasing resolution. Secure (near) real-time transmission / communication devices are needed to relay the data to and from many potential users such as operational commanders, in-field commanders and pilots. Radiation hardened mass data storage with high speed data retrieval hard drives are needed to store the increasing amount of information. Distributed / autoreconfigurable systems with high speed data processors are needed to analyze the time critical information. With the information analyzed and transmitted, high resolution multifunctional, color displays are needed to easily and rapidly understand the data. Users must then be able to precisely target weapons using advanced global positioning system (GPS) technologies and then be able to re.ch the target using advanced (counter) countermeasures and terrain following / terrain avoidance devices. An overlying requirement to all of these mission needs is the drive to make electronic and optical devices smaller, operate with less (or no) cooling, and less power. The role of the M&P Technology Area is to develop the necessary materials and materials processes, not the specific devices or their integration. Specific concepts and missions identified in which this area supports are as follows.

Table 7: Thrust 2 Key Technologies By Air Force Mission

Primary TPIPTs (Mission Categories)	M&P For Offensive / Defensive Sensors	M&P For Electromagnetic Windows & Canopies	M&P For Data Transmission / Communication	M&P For Data Storage / Hard Drives	M&P For Computing / Processing Devices	M&P For Display Devices	M&P For Navigation / Positioning Systems	M&P For Countermeasures / Defensive Systems	M&P For Personnel Laser Protection	M&P For Sensor Protection	M&P For Structural Hardening
Aerospace Control	■	■	■	■	■	■	■	■			■
Air-to-Surface	■	■	■	■	■	■	■	■	■	■	■
Mobility	■	■	■				■	■	■	■	
Special Operations	■		■			■	■	■	■		
Rescue	■		■		■		■				
Electronic Combat	■		■		■			■		■	
Air Base Systems	■		■								
Force Enhancement	■	■	■	■	■	■	■			■	
Space Control	■		■		■			■		■	■
Strategic Deterrence			■				■				
Space Support			■		■						
Information Warfare	■		■	■	■		■				
Weather	■				■						

M&P for offensive / defensive sensors are critical for a broad range of Air Force missions including Aerospace Control, Air-to-Surface, Mobility, Special Operations, Electronic Combat, Rescue, Information Warfare, Air Base Systems, Weather, Force Enhancement and Space Control. Sensor requirements documented are dual-mode, multimode, multispectral (all weather, through obscurants, color, like eye vision), 4-pi coverage, real-time target identification, low-cost, enhanced light imaging detection and ranging (LIDAR), FLASER [active laser radar (LADAR) target recognition integrated with forward looking IR (FLIR)], increased sensitivity at longer ranges with wider angle (spatial) resolution, single aperture / multipurpose, miniaturization, detection methods using new phenomena, lightweight, less power, asynchronous, ability to function at higher mach and a modular synthetic aperture radar (SAR).

Past efforts by the M&P Technology Area have resulted in the development of rare earth cobalt magnets which are now used in virtually every traveling wave tube in every aircraft and satellite radar as well as in electronic warfare systems. For passive sensors, there is a strong activity in IR detector materials where new processes are being developed to enhance growth and reduced defects in HgCdTe materials which will enhance detector sensitivity while lowering input power requirements, cost and size. This defect control and reduction focus is a key enabling technology for space IR focal plane arrays

(FPAs). Key customer are the Space and Missile Center System Project Offices (SMC SPOs) and this area is closely coordinated with the Phillips Laboratory (PL/VT) to meet their needs. Another development is in multispectral passive detector materials with reduced dependency on auxiliary technologies (such as cooling). Thrust 2 efforts in SiC, InP and bulk crystal NLO materials strongly support new generations of active sensors.

M&P for electromagnetic windows and canopies are being developed. Current IR transparencies for FLIR, Infrared Search and Track (IRST) and IR missile seeker applications are maintenance intensive and incapable of supersonic operation. Air Force missions identified with these needs include Aerospace Control, Air-to-Surface, Mobility and Force Enhancement. Concepts documented were for improved radome materials, Air Force (and Army) tactical missiles, windows for reentry vehicle (RVs), hardened transparencies, and cockpit canopies with liquid crystal displays (LCDs) and electro-chromatic variable transmittivity.

Past M&P Technology Area efforts were in the development of ZnS and ZnSe IR windows which are the state-of-the-art for current aircraft and missile FLIR, IRST and seeker systems. Current efforts for more durable IR sensor windows and canopies include the development of transparent polymers for near-term retrofits with the potential for extended life at a lower cost. Advanced polycrystalline semiconductor material coating processes are also being developed for window application with particular emphasis on a near-term solution to improve rain / sand erosion protection doubling the window's life under these hostile environments. Near-term IR window retrofits will be demonstrated in concert with the Air Logistic Centers (ALCs) and reliability & maintainability technology improvement program (RAMTIP) and transitioned to the Maverick (Ogden ALC) and LANTIRN SPO. A further term solution being developed is the application of Diamond coatings for evolving systems to enable supersonic flight of IR sensors. None of today's coatings systems will meet this requirement. These mid-term materials for emerging requirements will be validated in WL/AA program demonstration efforts, or in collaborative efforts with the appropriate Aeronautical System Center (ASC) SPOs for potential application to the F-22 and Joint Strike Fighter (JSF).

For aircraft canopies and radomes, advanced high temperature transparent structural polymers are being developed. These structural polymers with enhanced thermal, electrical and optical properties offers unique multifunctionality capabilities to enable sustained Mach 2+ flight. New canopy materials will be transitioned through WL/FI.

M&P for data transmission/ communication are needed for antijamming secure (near) real-time devices to relay information to and from many users. These requirements are from Air Force Aerospace Control, Air-to-Surface, Mobility, Special Operations, Air Base Systems, Electronic Combat, Information Warfare, Force Enhancement, Strategic Deterrence and Space Support missions. This area is developing InP semiconductor materials for the next generation communication electronic devices. InP will provide higher power and speed than GaAs. Also under development are E-O polymers for optical interconnects and HTSC electronics to enable higher performance and LPI for space communication. To assist in transitioning of InP this area proposed a Title III program to develop a viable domestic supplier to assure availability of this strategic material.

M&P for data storage (libraries) that are radiation hardened and have a high speed of data retrieval from multi-gigabyte hard drives are needed to store the increasing amount of information. Air Force missions with data storage needs identified are Aerospace Control, Air-to-Surface, Force Enhancement and Information Warfare. This area is developing NLO polymers for solid state lasers that transmit low power coherent blue light to enable super fast switching speeds and increased data storage in the mid- to far-term timeframe. These materials will be transitioned through WL/AA and Rome Laboratory (RL).

M&P for computing / processing devices that are high speed, small, inexpensive auto-reconfigurable / distributed systems are needed to analyze the time critical information. Air Force missions identified with computing / processing requirements are Aerospace Control, Air-to-Surface, Electronic Combat, Rescue, Weather, Force Enhancement, Space Control, Space Support, and Information Warfare. NLO materials for high speed on board data processing and transmissions will make major contributions to weight / volume reductions in aircraft and spacecraft. The M&P Technology Area is demonstrating thin film NLO materials for beam steering and on-board interconnects for next generation computers. These materials will be transitioned through WL/AA.

With the information analyzed and transmitted, **M&P for display devices** are needed so that the data can be easily and rapidly understood. Air Force missions with this high resolution multifunctional color display needs documented are Aerospace Control, Air-to-Surface, Special Operations, Aircrew Training And Force Enhancement. This area is developing inherently conducting polymers to improve light emission for flat panel displays (FPD).

With the information, users must then be able to precisely target weapon systems using advanced global positioning system (GPS) technologies and then be able to reach the target using terrain following / terrain avoidance devices. Key to this ability is the development of extremely small GPS receivers for aircraft, ground personnel tactical missiles and reentry vehicles. **M&P for navigation / positioning systems** are needed to support Air Force mission of Air-to-Surface, Mobility, Special Operations, Rescue, Force Enhancement, Strategic Deterrence, and Information Warfare. To meet the need for extremely small electronics, this area is developing InP semiconductor materials that operate at lower power and higher frequency than current Si and GaAs based devices with higher density circuits.

The Air Force desires the ability to jam enemy's radar, IR detectors and communication systems and the ability to operate their own systems while being jammed. **M&P for countermeasure / defensive system** are being developed to miniaturize systems and enable higher energy conversion with a wider spatial area of coverage at longer ranges. Higher energy conversion relates to the desire for lower input power requirements while increasing output power which will lower the overall systems weight and complexity. Air Force missions with these needs are Aerospace Control, Air-to-Surface, Mobility, Special Operations, Electronic Combat, Rescue and Space Control. To support this need the M&P Technology Area is developing NLO ($ZnGeP_2$), semiorganics, E-O polymers, and ferroelectric M&P. The primary M&P Technology Area development in this area is in NLO M&P for laser systems to enable wavelength doubling and tuned wavelength operations for EOCMs. In particular, $ZnGeP_2$ will enable higher power, cost effective mid-IR EOCM systems against IR seekers.

Consistent across Air Force mission is the drive to make electronic and optical devices smaller, operate with less (or no) cooling and less power. This drive is inherent in all M&P Electronic and Optical programs. However, three materials under development would provide the most significant payoff in ***miniaturization and reduced power*** consumption. InP semiconductor materials will enable 50% increase in both frequency and power for microwave and millimeter wave devices relative to GaAs. SiC will enable 600°C operational capability without cooling for high temperature engines, electronics, power devices, and high frequency devices. Inherently conducting polymers will offer revolutionary capabilities in flat panel displays, batteries and wiring for aircraft, missiles and satellites. These technologies will be transitioned through WL/AA, WL/PO & PL.

In the area of ***laser protection***, near-term concern is low power, fixed wavelength lasers which are now commercially available with sufficient intensity to disrupt sensors and aircrews. Past developments by the M&P Technology Area have provided daytime protection capability for personnel and day / night protection for sensors against a limited number of these lasers. Current M&P efforts focuses on developing nighttime personnel protection and enhanced sensor protection against multiple wavelengths. However, currently there are lasers under development in which the laser frequency will be tunable, not a known fixed entity. No capability presently exists for broad band protection required to counter these agile lasers. In addition, future high power DEWs will be able to structurally damage aircraft, missiles and spacecraft, and this threat is also being addressed by this area.

The primary emphasis for the LHM effort is balanced across near, mid, and far-term applications such as agile eye protection, sensors, multispectral devices, and canopies. Other needs considered are for laser apertures, satellites, threat simulation, and structures. Throughout, LHM technologies are developed and transitioned to maintain a research strategy balanced around near, mid, and far-term solutions.

Lasers have become popular items on and off the battlefield. **M&P for personnel protection** are being developed to address laser hazards including range finders, designators, illuminators, and even entertainment lasers used in laser light shows. Requirements for day / night protection of aircrew eyes from fixed, agile and broadband threat lasers are dependent upon the development of new M&P. Concepts such as goggles, visors, heads-up displays (HUDs), night vision goggles (NVGs), and helmet mounted displays (HMDs) need hardening / protection with minimal impact on vision performance and weight. While all aircrews need protection from the laser hazards described, Special Operational Forces may be the first to encounter laser threats in the form of jammers or damaging weapons. Identified Air Force missions with these requirements are Air-to-Surface, Special Operations and Mobility.

The Air Force Special operations Command (AFSOC) as well as the US Special Operations Command (USSOCOM) have verbally and monetarily supported the LHM efforts this year. The M&P Technology Area for personnel protection is coordinated with Armstrong Lab and MAJCOMs. Also, the M&P Technology Area has been instrumental to the Federal Aviation Administration (FAA) by providing glare studies and models as the FAA contends with similar problems. Current efforts are in the development of highly transparent NLO polymers which when hit with high intensity laser light will limit the transmitted intensity to <0.1 micro joule per centimeter squared (eye protection). Near-term milestones include development of fixed-wavelength holographic aircrew visors and NVGs.

M&P for sensor protection are being developed to provide protection to advanced optical subsystems. Specific requirements are for low cost, lightweight protection of aircraft, satellite and missile sensors from fixed / agile broadband laser threats. The performance criteria are for hardening concepts that not only protect the sensor but also allow the system the ability to complete its mission while under engagement. These hardening concepts can be applied to laser warning, FLASER, EO/IR & Radio Frequency (RF) sensors, FLIR and LADAR. Air Force missions with these requirements are Air-to-Surface, Mobility, Electronic Combat, Force Enhancement and Space Control. Current efforts will develop protection technologies that provide full mission capability under threat exposure for airborne sensors; missile sensors and space sensors in the visible spectrum, mid IR and LWIR spectral bands. Near-term milestones include development of retrofit hardening options for LANTIRN, gunship FLIRs and AGM-130 seeker.

Besides protecting sensors and eyes from lasers, **M&P for structural hardening** are being developed to address other long-term needs. Structures identified as being vulnerable to high power laser threats include load bearing structures, canopies, fuel tanks, munitions, solar arrays, antennas, laser crosslinks, radiators, multilayer insulation and radar absorbing materials / radar absorbing structures (RAM/RAS) for aircraft, missiles and spacecraft. Air Force missions with structural laser protection requirements are Aerospace Control, Mobility and Space Control. In order to quantify the susceptibility levels of these structural components, this area is compiling a comprehensive database of material susceptibilities. Protective materials and coatings are being developed for critical components such as aircraft canopies and windows.

To develop protection for sensors, personnel and structures from lasers, realistic ***M&P for laser (threat) simulation*** must be developed. This effort is not directly identified by the users since it is used to validate concepts developed to protect personnel, sensors and structures. However, Air Force missions with DEW device development needs are Aerospace Control, Air-to-Surface, Special Operations, Air Base Systems, and Space Control. The M&P Technology Area conducts accurate, repeatable laser simulation similar to future threats to gather survivability / lethality data on weapon effectiveness in their Laser Hardened Materials Evaluation Laboratory (LHMEL). The goal is to determine the survivability of US systems and the lethality of our future DEWs against enemy systems. Also, the LHMEL facility has been made available for commercial development with new pollution prevention, surface treatment, environment simulation, and laser processing concepts being tested.

GOALS

Materials for radar systems, microwave and micro-electronic equipment, IR detectors, photonic devices, and optical processors are being developed to meet mission requirements in target acquisition, guidance, communication, electronic warfare, and data processing. Specific goals include:

- Transition IR window coatings that have >200% improvement over current capability in rain and dust durability. Then, develop more affordable dome that is inherently more durable for tactical missiles followed by development of aircraft IR windows that are survivable at supersonic speeds to allow passive IR sensors to operate on advanced aircraft (critical to stealth/night operations).
- 10X increase in microwave Transmit/Receive (T/R) module array power without increasing array size through insertion of SiC technology.
- 50% cost savings in materials for microwave and microelectronics systems through increased production yield.

- •IR detector materials with sufficient resolution and range to augment radar.
- •HTSC for radar and communication systems to increase dynamic range 10-100X while being 90% smaller. A projected electronic warfare receiver application would be reduced in weight from 1500 lbs to 150 lbs with dynamic range increased from 60 dB to 85 dB.
- •Increase wavelength tunable IR laser power output 10X using improved materials.
- •E-O polymers with high thermal stability and large E-O coefficient for high density photonic switching networks.

Overlying the above goals is a strategy to address cost and availability of E-O materials to fulfill system needs.

Laser hardening goals include:

- •Laser protective eye wear for aircrews flying day / night.
- •Laser hardened tactical and strategic electro-optic sensors.
- •Provide structural protection for aircraft, missile, and spacecraft critical components.

The goal is to provide protection for aircrews, strategic / tactical sensors and weapon systems without disruption of their primary mission. Eyes and E-O sensors are sensitive to glare and jamming at power levels many orders of magnitude below damage levels. This necessitates protection with very high dynamic ranges or the combination of multiple protection devices. Protection goals will be achieved by incremental steps progressing from fixed wavelength protection to tunable laser protection.

MAJOR ACCOMPLISHMENTS

- •InP substrates were grown to 2-inch single crystal diameters with defect (dislocation) densities significantly lower than defect densities in commercial InP. Will potentially improve device yield and enable optimal performance.
- •New process produces a 20X increase in crystal output for solid state IR laser systems.
- •Completed project to improve performance of laser crystals by resisting gray track fogging. Used a Neodymium Yittrium Aluminum Garnet (Nd:YAG) lasers with $KTiOPO_4$ (KTP) crystals which also are less expensive and more reliable.
- •Developed an advanced semiconductor material (ZnGeP2) to improve coverage of near IR by solid-state lasers.
- •Successful early operation of holographic laser protection spectacles. USSOCOM helicopter crews wore spectacles at night with and without NVGs and has provided verbal and monetary support for alternative configurations of these spectacles. First phase deliverables delivered to USSOCOM.
- •Conducted specific system field and flight demonstrations for Survivable High Performance Sensor (SHPS).
- •LHMEL used to demonstrate economical method to simulate rocket nozzle environment.
- •Preliminary designs of laser hardened environmentally durable aircraft transparency coatings passed initial testing.

CHANGES FROM LAST YEAR

The Space, Life Management of Aging Systems, and Pollution Prevention Special Emphasis Areas (SEAs) have all had a significant impact on Thrust 2 and some of the new efforts involve:

- •Lower cost and more reliable LWIR space-based detectors
- •Form and function replacement of aging electronic and avionic subsystems with added functionality and reliability.
- •Materials fabrication techniques for short-run production replacement of avionics.
- •Metal-organic molecular beam epitaxy (MBE) fabrication of electronics using reduced toxicity reactants.

MILESTONES

- •Transitioned E-O polymer with high thermal stability and large E-O coefficient for high speed avionics to adv. technology development program by 1997.
- •Coatings with a 3X durability improvement over current materials for IR windows transitioned in 1997 for F-15, F-16, F-22 and other advanced supersonic aircraft applications.
- •Multilayer HTS technology for interconnects and superconducting normal superconducting Josephson Junctions will be optimized by 1997 for specialized applications.
- •Develop high yielding vapor phase growth techniques using molecular beam epitaxy (MBE) processing method for cost effective, high performance semiconductors (HgCdTe) that are responsive across the IR spectrum for space sensors by 1999.
- •A series of milestones will lead to personnel and sensor protection from lasers through 2005. These milestones include:
  - ••Night capable aircrew eye protection for fixed wavelength lasers by 1996
  - ••Broadband sensor hardening for pulsed lasers by 1996
  - ••Laser and environmentally hardened aircraft canopy coating by 1997
  - ••Preliminary day-only aircrew eye protection for agile wavelength lasers by 2000.

Thrust 3: Materials And Processing Technology for Sustainment

The overall objectives of this thrust are to:

1) Establish nondestructive evaluation (NDE) methods
   - to detect and monitor service-initiated damage or deterioration
   - to assure optimum quality in the production of Air Force systems.
2) Provide materials and processing support across all Air Force missions
   - quick reaction support (i.e. failure analysis) to material problems in the operation commands and maintenance facilities
   - support to System Program Offices (SPOs) through collocated engineers
   - data on new materials and processes (M&P) for transitioning of technology.
   - develop M&P to minimize hazardous / toxic (HazTox) materials in the fabrication, repair and disposal processes.

This area is coordinated with the other services through the Joint Directors of Laboratory Technology Panel for Advanced Materials (JDL/TPAM) NDE technology, advanced processing, and materials transition / technology demonstration subpanels.

A roadmap for Thrust 3 is presented in **Figure 7** and an illustration of the correlation between Thrust 3 and user needs from Air Force Center Technology Council (CTC) and Mission Area Plans (MAPs) associated with the Technology Planning Integrated Product Teams (TPIPT) are presented in **Table 8**.

USER NEEDS

Thrust 3 develops technologies that directly support documented MAPs deficiencies and TPIPTs technology needs, but the primary source of technology needs is from the CTC within the Technology Master Planning (TMP) process. These CTC technology needs are from Air Force Air Logistic Centers (ALCs), test & engineering (T&E) centers and flight test centers (FTCs).

Ways of extending lifetime for the current aircraft, spacecraft and missiles have become an important part of the Air Force and Thrust 3. The combined effort of Systems Support and NDE makes up the majority of the activities under the Life Management of Aging Systems Special Emphasis Area (SEA). In general the Life Management of Aging Systems

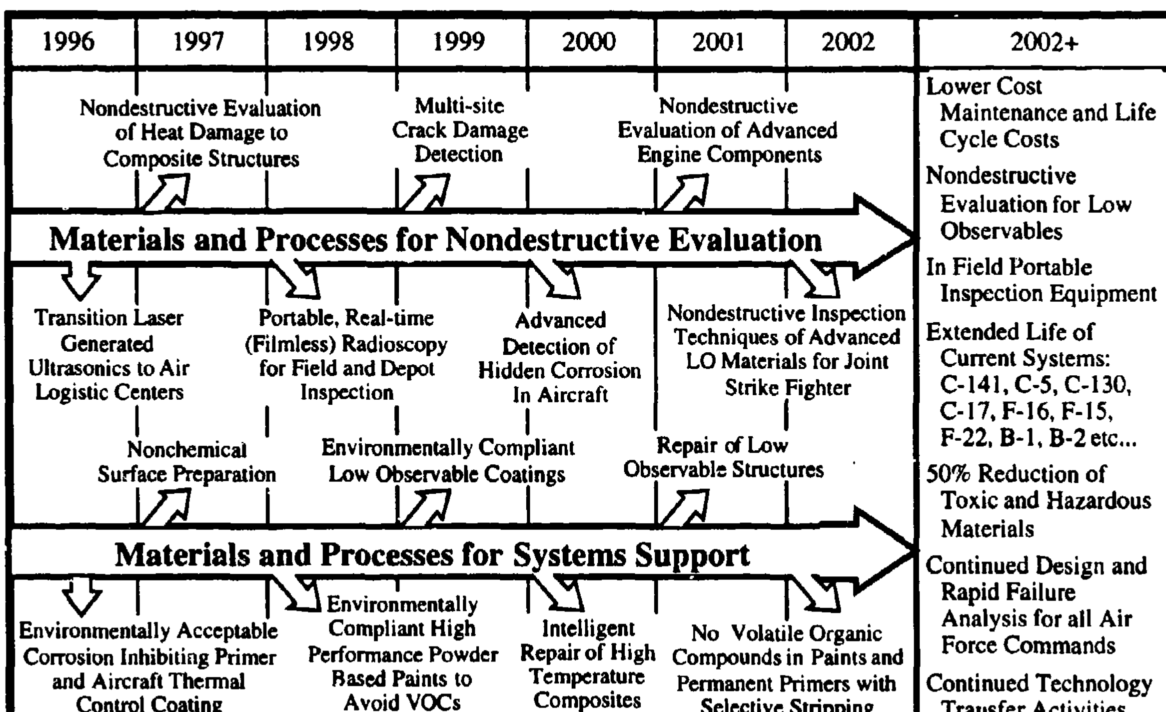


Figure 7: Thrust 3 – Materials And Process Technologies For Sustainment

Table 8: Thrust 3 Key Technologies vs. Air Force Missions

Primary TPIPTs (Mission Categories)	Nondestructive Evaluation	Systems Support	Pollution Prevention
Aerospace Control	■	■	
Air-to-Surface	■	■	■
Mobility	■	■	■
Special Operations	■	■	■
Rescue		■	
Air Base Systems		■	■
Training		■	
Force Enhancement			■
Space Control	■		
Strategic Deterrence	■		■
Space Support		■	
Information Warfare			■
Env.Safety & Occ. Health			■
Infrastructure (CTC)	■	■	■

SEA covers a broad spectrum of technologies to enable using systems beyond their original service life including corrosion, crack and fatigue detection.

M&P for Nondestructive Evaluation (NDE) are being developed to meet user needs, primarily infrastructure needs from Air Force Centers (flight, test, engineering, and logistics), for reduced production and maintenance costs of current and future Air Force weapon systems. The majority of NDE requirements from the Air Force Centers are documented as part of the CTC technology needs and coordinated via technology development plans. Of particular interest are the CTC technology needs from the ALCs which covers all aircraft, aeropropulsion and strategic missile systems maintenance and overhaul requirements. Other technology needs supported are from the Air Force Aerospace Control, Air-to-Surface, Mobility, Special Operations and Strategic Deterrence missions.

In developing advanced materials, it is critical that inspection techniques to monitor a structure's degradation and internal damage be developed to promote the usage of advanced materials and to avoid costly removal and premature replacement. The primary emphasis of the NDE effort is to support the documented near-term customer needs for aging systems and include corrosion and crack detection. Secondary emphasis is on mid-term / near-term requirements to support increasing use of composites and low observable structures on aircraft such as the F-22, rapid inspection for delamination in large area composites, and assessing the electromagnetic integrity of low observable (LO) components and repairs. The Air Force will operate an aging fleet for the foreseeable future, thus the need for enhanced detection of hidden corrosion and (multi-site) crack damage. Corrosion is a $1 billion per year Air Force problem and crack detection is critical to airframe structural integrity. With the increased use of composites and low observables in aircraft, rapid, large area inspection is needed. Specific M&P Technology Area efforts are in developing real-time active inspection of systems to increase combat readiness, inspection of large areas of aircraft by semi-automated techniques, detecting cracks through paint and multi-layer surfaces via eddy current and radiographic techniques, automated quantification and recognition technologies to enhance "accept / reject" decisions, and computer data strategy capabilities to provide historical monitoring of in-service components and to enable a change to condition based maintenance of weapon systems.

The M&P NDE Technology Area transition strategy is by working joint programs in conjunction with the Air Force Nondestructive Inspection (NDI) Program Office and ALC NDI managers, as well as support for new weapon systems technologies. Rapid technology transfer to both Air Force depot and field level applications will occur to increase the capability and reliability of currently used NDI/E methods to detect / characterize performance threatening defects (cracks, delaminations, corrosion, etc.) and the creation of new NDI/E methodologies. The result will be increased weapon system availability with reduced maintenance cost.

The primary **M&P for Systems Support** objectives are to provide quick reaction materials engineering support to user organizations [ALCs, System Project Offices (SPOs), and Major Commands (MAJCOMs)]; expedite the M&P transition of development efforts from the M&P Technology Area to use in systems; and support depots and industry with M&P for repair of metal structures with composite materials and composite repairs. In doing so the M&P Technology Area provides a direct interface to all levels of Air Force Operations from design to field and depot repair and maintenance. These customers include the ALCs, SPOs, MAJCOMs, and Air Force Accident Investigation Boards. Other customers include those fulfilling Air Force missions of Aerospace Control, Air-to-Surface, Mobility, Special Operations, Air Base Systems, Space Support and Rescue.

The two primary System Support needs dependent upon or impacted by M&P can be summarized as 1) solving problems with existing M&P methods and 2) reducing the risk of incorporating manufacturing process changes and advanced materials. In responding to these needs a full-spectrum of technical M&P support is available including structural and electronic failure analysis; corrosion control and prevention; mechanical and environmental testing; and nonmetallic materials selection with special attention paid to composites, fluids, lubricants, elastomeric materials and transparencies.

The M&P Systems Support effort often times is involved with the "here and now" of Air Force needs and requirements. For example, engineers respond within 72 hours to any serious operational problem caused by a materials reliability and maintainability issue. However, long-term engineering approaches across a wide-range of specialties are required so that this area can respond to the "here and now" requests. Current M&P System Support efforts underway are to understand materials behavior for enhanced designs and life cycle estimates; generation of industry standards for aerospace welding and joining; and developing repair procedures for failed aerospace components. To promote the increase usage of organic matrix composites the M&P System Support area is establishing guidelines for large area repair, developing fundamental understanding of heat damage to composites, transitioning / transferring composite patch technology Department of Defense (DoD) / industry, and supporting the technical cooperation program through the composite action group. Also being addressed by this area is the development of composite patch technology for cracked metal structures for life extension.

The M&P Systems Support Technology Area has established extensive databases on materials and their performance under service conditions, including life prediction. These databases are critical when predictions fail, designers underestimate load conditions, etc. Then failure analysis and recommended solutions are needed, often to prevent fleet grounding. Thus a payoff from this effort is to provide failure analysis support in a timely manner, normally within 72 hours. The Air Force does not plan for failures, but the M&P System Support Technology Area is there when needed. With the drop in new system procurements over the next 10 years, the age of systems will increase and associated maintenance problems will grow. Thus, this Thrust 3 will continue to grow in importance.

During a typical year, approximately 60 structural and 40 electrical failure analyses, as well as many other support activities such as corrosion prevention support, are provided to these customers. Typical activities over the past year included investigating the following:

- C-21 Fuel Pump
- F-16 Wing Fuel Tank Weld
- U-2 Tailpipe Cracking
- C-21 Accident
- T-3 Accident
- F-15 Tailhook
- C-130 Truss Mount

The primary means of technology application / transition is through the direct involvement with the ALCs, Product Center SPOs and the AFMC Technology Transition Office. To expedite the orderly transition of new technology to Air Force systems, this effort evaluates new M&P and develops engineering data, application criteria and specifications for their use. This information is documented in several vital engineering handbooks maintained by the M&P Technology Area: i.e. Mil-Handbook-5, Damage Tolerance Handbook, and Electronics Failure Analysis Handbook amongst others.

M&P for pollution prevention efforts are primarily near-term to reduce / eliminate hazardous waste during processing, fabrication, and maintenance of aerospace materials. It does not address waste disposal nor remediation which are the responsibility of Armstrong Laboratory with which this area is well coordinated. Environmentally compliant M&P is probably the fastest growing user need, and the M&P Technology Area has the Air Force responsibility to develop new M&P that minimizes or eliminates hazardous / toxic (HazTox) waste. The pollution prevention needs in which the M&P Pollution Prevention Technology Area is working are Ozone Depleting Chemical (ODC) free fire suppressants and refrigerants (Halon & Chloro Floro Compounds [CFC] replacements), Volatile Organic Compounds (VOCs) free cleaning & degreasing materials and techniques, processing methods to avoid metal bearing waste, low emission protective coatings, processes to avoid other air emissions, propellants, reduction / elimination of 17 chemicals targeted by the Environmental Protection Agency (EPA), and biodegradable chaff. The primary source for Pollution Prevention needs are from the Environmental Safety & Occupational Health TPIPT. Other sources are from Air-to-Surface, Mobility, Special Operations, Air Base Systems, Force Enhancement, Strategic Deterrence and Information Warfare missions.

The largest M&P Pollution Prevention Technology Area effort is the development of environmentally friendly ***aircraft paint / coating*** application and stripping materials and processes. To meet the new environmental requirements, waterborne and high solids containing primer / coatings, as well as revised, less efficient processes are now being used. Use of these new materials/processes, however, results in coatings which have degraded corrosion performance. Besides protecting an aircraft from corrosion, paints / coatings are used to enable infrared signature reduction as an integral part of low observable technology approaches. The M&P Technology Area is developing multi-spectrally tailored coatings which can substantially reduce airframe infrared signatures. The most promising environmentally compatible and tailored materials and related technologies will be transitioned through systems program offices, prime contractors, operating commands, and the Coatings Technology Integration Office. The ultimate benefit from these developments of surface treatments and related materials will be the ability to protect aircraft surfaces for their entire lifetime. Also, development of mission related coatings (and required interfaces) which last from one scheduled program depot maintenance cycle to the next (usually 5-7 years).

GOALS

Goals include:

•NDE techniques for hidden corrosion

•NDE techniques that can identify areas of multiple small cracks that together constitute structural integrity concerns

•Maintaining a quick reaction response of less than 72 hours to critical materials related problems in the field

•Ability to inspect low observable structures for electromagnetic integrity

•Continued collocated engineering support to major SPOs

•50% reduction in HazToxs used in Air Force operations.

•40X increase from 5 to 200 ft^2/hr in speed of inspecting large areas of composites.

MAJOR ACCOMPLISHMENTS

•Demonstrated prototype rapid, large area (200 ft^2/hr) aircraft composite inspection system.

•Conducted full scale NDE demonstrations at all five ALCs with a prototype Mobile Automated Scanner (MAUS).

•Prototyped X-ray computed tomography to improve accuracy of castings.

•Demonstrated high resolution filmless X-ray radioscopy for crack detection on B-1B.

•Demonstrated non-contact laser generated ultrasonics with increased evaluation speed for complex composite components.

•Conducted C-5 engine fan blade analysis & repair which saved the Air Force $300M.

•Provided technical support concerning welding procedures and NDI to F-22 SPO during their Critical Design Review (CDR).

•Provided timely analysis to help solve F-15 rudder acuator problem.

•Provided critical data to help solve fatigue problem in F-16 bulkhead.

•Evaluation of specifications for B-1B conventional weapons systems to cuts cost by removing specification duplications and conflicts.

•Provided quick solution to F-15 fuel leakage problem.

•Helped solve fuel leakage problem on aircraft ground power generation systems.

•Established mobile composite patch facility to reduce aircraft maintenance turn-around time.

CHANGES FROM LAST YEAR

Both the Life Management of Aging Systems, and Pollution Prevention SEAs have all had a significant impact on Thrust 3. Some of the new efforts involve:

- •Four new start pollution prevention projects were placed on contract to address high priority requirements. The four new starts cover 1) Solid State Metal Cleaning, 2) Atomic Oxygen Cleaning Process, 3) Laser Decomposition of Organo-Metallic Chrome and Nickel, and 4) Large Area Powder Base Priming and Coating.
- •Designs for composite patch repairs and a patch repair handbook for depot engineers.
- •Intelligent high temperature advanced composite and adhesively bonded repair system utilizing new heating blanket concepts to reduce temperature variations.
- •Initiated enhancement of the inspection methods, equipment and processes for use in the Retirement - For - Cause and Engine Structural Integrity Programs at San Antonio and Oklahoma City ALCs (SA-ALC and OC-ALC), respectively, to inspect gas turbine engine disks for the F100 and F110 engines.
- •Enhanced C-scan corrosion detection image analysis tools for OC-ALC.

MILESTONES

- •Efficient corrosion NDI detection (increased productivity and reliability of NDI corrosion detection with decreased maintenance actions due to false calls) for C/KC-135 Service Life Extension Program (SLEP) by 1997.
- •Faster nondestructive failure analysis of complex specimens using computed tomography by 1998.
- •By 1998 develop a portable, real-time (filmless) radioscopy system for aircraft inspection and battle damage assessment.
- •Demonstrate a high resolution computed tomography inspection of solid rocket motorcase and bondlines by 1998.
- •Establish environmentally compliant coating by 1998.
- •Provide nonchemical surface preparations to eliminate hazardous materials by 1998.
- •Distribute composite repair design guidelines by 1998.
- •Develop new heating blanket system by 1998 for faster composite patch curing, heats more uniformly and produces higher quality patches / bonds.
- •Identify a nonintrusive NDE technique for the detection of hidden corrosion in aircraft structures by 1999.
- •Ability to conduct rapid, reliable, laser based ultrasonic inspection of composites and bonded structures by 1999.
- •Demonstrate ability to detect hidden flaws and multisite cracks by 2000.
- •Establish inspection techniques to assure structural and electromagnetic integrity of low observable materials by 2000.
- •Demonstrate large area repair of composite structure by 2000.
- •New paint coating systems for increased lifetime by 2001.
- •Insitu NDE for operational readiness by 2004.
- •Real-time of monitoring performance and structural integrity by 2008.
- •Continued 72-hour quick-action response to field / depot material related problems.

GLOSSARY

AA – Avionics Directorate
AF – Air Force
AFB – Air Force Base
Affordability – A balance of risk, performance and cost
AFMC – Air Force Materiel Command
AFR700 – Air Force Resin 700 / An Air Force developed high temperature composite.
AFOSR – Air Force Office of Scientific Research
AFSOC – Air Force Special Operational Command
AL – Armstrong Laboratory
Air Force – U.S. Air Force
AIT – Advanced Interceptor Technology (An Army Demonstration program)
Al – Aluminum
Al-Li – Aluminum Lithium
ALC – Air Logistic Center
AGM – Air-to-Ground-Missile
AMC – Air Mobility Command
AOA – Angle of Attack
Army – United States Army
ARPA – Advanced Research Project Office
ASC – Aeronautical Systems Center
ATD – Advanced Technology Demonstrator
Bling – Bladed Ring
C-C – Carbon-Carbon
CDR – Critical Design Review
CFC – Chloro Floro Carbon
CFIPT – Customer Focus Integrated Product Teams
CM – Countermeasure
CMC – Ceramic Matrix Composite
Cost – R&D, Acquisition and / or Operational & Support cost
CRDA – Cooperative Research & Development Agreement
CTC – Center Technology Council
dB – Decibels
DEA – Data Exchange Agreement
DEW – Directed Energy Weapon
DMSP – Defense Meteorological Satellite Program
DoD – Department of Defense
E-O – Electro-Optical / Electro-Optics
EELV – Enhanced Expendable Launch Vehicle
EOCM – Electro-Optic Countermeasure
EPA – Environmental Protection Agency
FAA – Federal Aviation Administration
FAC – Forward Air Control
FI – Flight Dynamics Directorate
FLASER – Forward-Looking Infrared Laser Radar
FLIR – Forward-Looking Infrared
FOD – Foreign Object Damage
FPD – Flat Panel Display
FPA – Focal Plane Array
FSU – Former Soviet Union
ft^2 – Square Feet
FY – Fiscal Year
GaAs -- Gallium Arsenide
GE – General Electric
GEO – Geosynchronous Earth Orbit
GPS – Global Positioning Satellite
GSE – Ground Support Equipment
HazTox – Hazardous and Toxic
HCF – High Cycle Fatigue
HgCdTe – Mercury Cadmium Telluride
HMD – Helmet Mounted Display
hr – Hour
HTSC - High Temperature Superconductor
HUD – Heads Up Display
HySTP – Hypersonic System Technology Program
HyTech – Hypersonic Technology
IBR – Integral Bladed Rotor
ICBM – Intercontinental Ballistic Missile
IEA – International Exchange Agreement
IHPRPT – Integrated High Performance Rocket Propulsion Technology
IHPTET – Integrated High Performance Turbine Engine Technology
InP – Indium Phosphide
IR – Infrared
IRAD – Independent Research and Development
IRCM – Infrared Countermeasure
IRST – Infrared Search and Track
JDL – Joint Director of Laboratories
JJ – Josephson Junction
JSF – Joint Strike Fighter
KEW – Kinetic Energy Weapon
kgs – Kilograms
ksi – Thousand Pounds Per Square Inch
LADAR – Laser Radar
LANTIRN – Low Altitude Night Targeting IR Navigation
LCC – Life Cycle Cost
LCD – Liquid Crystal Display
LCF – Low Cycle Fatigue
LHM – Laser Hardened Materials
LHMEL – Laser Hardened Materials Evaluation Laboratory
LIDAR – Light Imaging Detection and Ranging
LO – Low Observable
LPI – Low Probability of Intercept
LWIR – Long Wave Infrared
M&P – Materials and Processes or Materials and Processing

GLOSSARY

MAJCOM – Major Command
MAP – Mission Area Plans
MAUS – Mobile Automated Scanner
MCT – Mercury Cadmium Telluride (HgCdTe)
MCM – Multi Chip Module
MEA – More Electric Aircraft
MILSATCOM – Military Satellite Communication
Mk21 – A RV Warhead
ML – Materials Directorate
MLI – ML's Integration and Operation Division
MMC – Metal Matrix Composite
MOU – Memorandum of Understanding
MTBF – Mean Time Between Failure
Navy – United States Navy
NaS – Sodium Sulfur
NASP – National Aerospace Plane
NDE – Nondestructive Evaluation
NDI/E – Nondestructive Inspection / Evaluation
Nd:YAG – Neodymium Yittrium Aluminum Garnet
Ni – Nickel
NLO – Nonlinear Optical or Nonlinear Optics
NVG – Night Vision Goggles
OC-ALC – Oklahoma Air Logistic Center
ODC – Ozone Depleting Chemical
OMC – Organic Matrix Composite
OO-ALC – Ogden Air Logistic Center
Ops – Operations
ORD – Operational Requirement Document
P&W – Pratt & Whitney
P3I – Preplanned Product Improvement
PAC-3 – Patriot Advanced Concept, Version 3 (Army)
PCD – Polycrystalline Diamond
PE – Project Element
PL – Phillips Laboratory
PO – Aeropropulsion and Power Directorate
RM&S – Reliability, Maintainability and Supportability
RAM – Radar Absorbing Materials
RAMTIP – Reliability and Maintainability Technology Improvement Program
RAS – Radar Absorbing Structures
RCS – Radar Cross Section
RF – Radio Frequency
RL – Rome Laboratory
RLV – Reusable Launch Vehicle
RPV – Remotely Piloted Vehicle
S&T – Science and Technology
SA-ALC – San Antonio Air Logistic Center
SAR – Synthetic Aperture Radar
SB – Silo-Based
SBIR – Small Business Innovation Research
SCARLET – Solar Concentrator with Refractive Linear Element Technology satellite
SEA – Special Emphasis Area
SHPS – Survivable High Performance Sensor
Si – Silicon
SiC – Silicon Carbide
SLEP – Service Life Extension Program
SM-ALC – Sacramento Air Logistic Center
SMC – Space and Missile Systems Center
SOTA – State-of-the-art
SPO – Systems Project Office
STTR – Small Business Technology Transfer
T&E – Test and Engineering
TAP – Technology Area Plan
TBCCO – Thallium Barium Copper Calcium Oxide
TCC – Thermal Control Coating
Ti – Titanium
TiAl – Titanium Aluminide
Title III – Title III of the Defense Production Act to create or stimulate a domestic capability of a defense critical material or technology
TMP – Technology Master Planning
TPAM – Technology Panel for Advanced Materials
TPIPT – Technology Planning Integrated Product teams
TPS – Thermal Protection System
TR – Technical Report
Trimarc – A trade name for a gamma TiAl otherwise described as Ti-6242, or Ti-6Al-2Sn-4Zr-2Mo
TTIPT – Technology Thrust Integrated Product Teams
TTW – Thrust-to-Weight Ratio
US – United States
UK – United Kingdom
UAV – Unmanned Aerial Vehicle
UHF – Ultra High Frequency
USD/DDRE – Undersecretary of Defense, Deputy Director of Research and Engineering
USSOCOM – US Special Operations Command
UV – Ultraviolet
Vis – Visible
VOC – Volatile Organic Compounds
WL – Wright Laboratory
X-link – Cross-link
YBCO – Yttrium Barium Copper Oxide
$ZnGeP_2$ – Zinc Germanium Phosphide
ZnS – Zinc Sulfide
ZnSe – Zinc Selenide

TECHNOLOGY MASTER PROCESS OVERVIEW

Part of the Air Force Materiel Command's (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, and
- Transferring dual-use technologies to improve economic competitiveness

To ensure this mission is effectively accomplished in a disciplined, structured manner, 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 8:

- Phase 1, **Technology Needs Identification** – Collects customer-provided and prioritized technology needs associated with both weapon systems, product groups and supporting infrastructure; then identify them by the need to develop new technology or apply/insert emerging or existing technology. These needs are derived in a strategies-to-task framework via the user-driven Modernization 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 laboratories, develops a set of projects for those needs requiring development of new technology, while the Technolology Transition Office (TTO) orchestrates the development of a project portfolio for 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 and obtains approval for the portfolio through the budgeting process. The output of Phase 3 is the authorizations and appropriations required, by the laboratories and application/insertion programs, to execute their technology projects
- Phase 4, **Program Execution** – Executes the approved S&T program and technology application/insertion program within the constraints of the Congressional budget and higher headquarters. The products of Phase 4 are validated technologies that satisfy customer weapon system and infrastructure deficiencies.

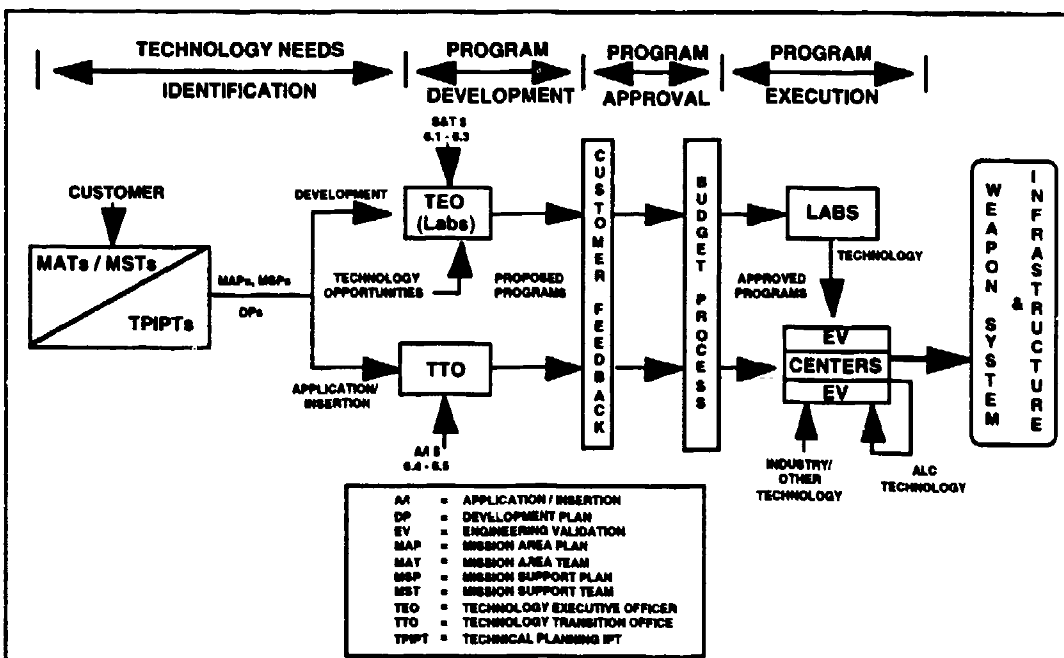


Figure 8 - Technology Master Process

Additional Information

Additional information on the Technology Master Process is available from HQ AFMC/STR, DSN 787-6777/8764, (513)257-6777/8764.

INDEX

INDEX