AD-A167 088 IDENTIFICATION OF AIR FORCE EMERGING TECHNOLOGIES AND MILITARILY SIGNIFIC..(U) B-K DYNAMICS INC ROCKVILLE MD P P MCDERMOTT 31 AUG 85 BKD-TR-5-763 AFOSR-TR-86-0230 1/2

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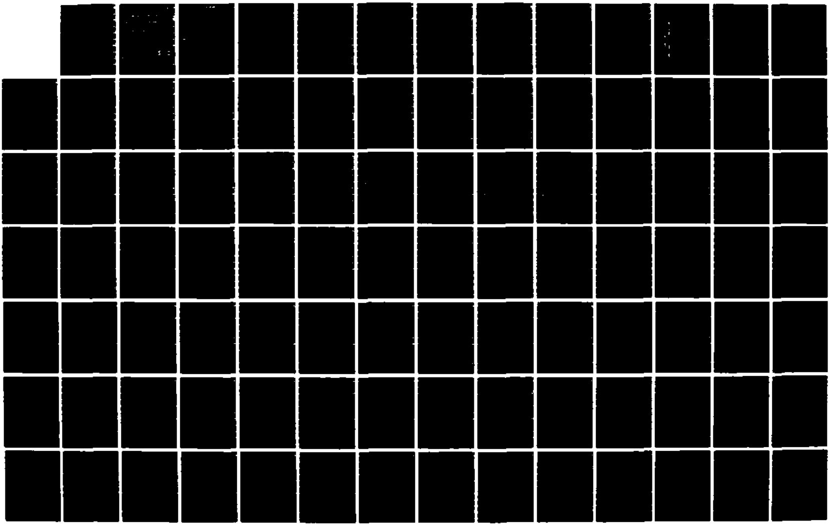

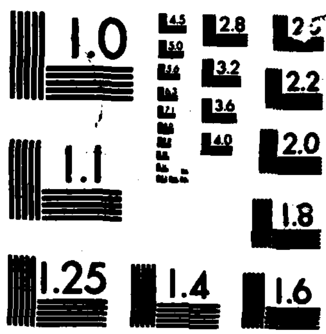

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AFOSR-TR- 86-0230

TR-5-763

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IDENTIFICATION OF AIR FORCE EMERGING TECHNOLOGIES

AND

MILITARILY SIGNIFICANT EMERGING TECHNOLOGIES

AD-A167 088

FINAL TECHNICAL REPORT

31 AUGUST 1985

PATRICK P. McDERMOTT
PRINCIPAL INVESTIGATOR
B-K DYNAMICS, INC.

WORK PERFORMED FOR
AIR FORCE OFFICE OF SCIENTIFIC RESEARCH (AFSC)
BOLLING AFB, WASHINGTON, D.C. 20332-6448

UNDER

CONTRACT NO. F49620-84-C-0099
PROGRAM MANAGER: DR. DONALD R. ULRICH

DIRECTORATE OF CHEMICAL AND ATMOSPHERIC SCIENCES
AFOSR

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies or endorsements, either expressed or implied, of the Air Force Office of Scientific Research or the U.S. Government.

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The objective of this effort was to review Air Force research and existing emerging technologies lists, to conduct interviews and analyze data in order to identify likely candidates for a Military Emerging Technologies Awareness List (METAL). A METAL was constructed, in consultation with AFOSR, based on original research and interview data. The contract effort consisted of 3 stages: 1) Preparation of a Preliminary Militarily Significant Emerging Technologies List (MSET) from 3 existing Air Force emerging technologies lists, 2) In-depth Interviews at 6 Air Force Laboratories covering 70 topical areas. Technologies were identified, based on criteria outlined in Stage 1, as Mature Technologies, Emerging Technologies, or MSETs. If technologies could be correlated to those in the Militarily Critical Technologies List (MCTL), they were designated as Militarily Critical Technologies (MCTs). Interviews provided discussion of a technology's military significance and sensitivity to public release, and 3) Assessment of Interview Results identified the preliminary METAL, and identified the importance of the interview

(cont'd on reverse)

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22a. NAME OF RESPONSIBLE INDIVIDUAL: Dr. Donald R. Ulrich/AFOSR/NC

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19. (cont'd)
process in ultimately determining the MSETs. Further efforts are to continue to identify, review, and finalize the Air Force METAL.

Key words

EXECUTIVE SUMMARY

This report represents a Summary of work performed under contract AF49620-85-C-0113 during the period 01 September 1984 through 31 August 1985. The contract effort has progressed in three stages.

Stage 1 - Preliminary Militarily Significant Emerging Technologies List (MSET)

B-K Dynamics prepared a candidate MSET list using written descriptions of Air Force Research in three source documents.

- Response to a 1984 survey of DOD wide technology base programs (Responses to the OUSDRE/R&LM Protocol)
- Maturing Emerging Technologies at AFSC Laboratories (March 1983-HQ/AFSC/DLXP/XRK)
- Recent Research Accomplishments of the AFOSR (May 1983).

Results of this preliminary list assessment were reported to the Air Force in a February 1984 Interim Report BKD#TR-5-712 reproduced in Appendix A of this report.

Stage 2 - Interviews

BKD scientists conducted indepth interviews at six Air Force laboratories:

AFWAL Avionics Lab.
AFWAL Propulsion Lab.
AFWAL Flight Dynamics Lab.
AFWAL Materials Lab.
Air Force Weapons Lab. (AFWL)
Rome Air Development Center

The interviews covered over 70 topical areas and are summarized in Appendix B of this report. The goal of these interviews was to identify Militarily Significant Emerging Technologies (MSETs) according to the criteria laid down in the previous report (BKD TR-5-712).

Elements of the technology were judged to be mature technology (MT), some sensitive technology, Emerging Technology (ET), or Militarily Significant Emerging (MSET). Certain elements were designated as Militarily Critical Technology (MCT) if they were identifiable with technologies on the Militarily Critical Technologies List (MCTL). An attempt was made also during the interview process to articulate the militarily significance of the technology under discussion and to identify any areas of sensitivity related to the public release of unclassified information.

Stage 3 - Assessment of Interview Results

Appendix C shows the preliminary Militarily Significant Emerging Technologies List (METAL) identified in the February 1984 report with an indicator of:

1. those technologies which were confirmed to be MSET.

2. those technologies assessed to be MSET but with some qualification, requiring an alternate title or description (marked MSET* on the listing).

3. those technologies titles where no MSET was identified during the interview process (marked ---).

4. technology titles previously identified as candidate MSETs but not covered in the interviews (marked o) in the lists.

Codes A, B, C, D, E, & F relate the specific Laboratory interviews (as designated in Appendix B) with the technologies listed in the Preliminary METAL.

As can be seen from an examination of Appendix C, most of the MSETs identified as such require some qualification. Rationale for the judgments made in Appendix C are contained in bulletized form in Appendix D. The text of Appendix B should be consulted for a more complete explanation of why a particular technology is characterized as such in Appendix C.

The progress of the project to this point is summarized in Table 1. Out of the original 86 responses to the R&LM Protocols, 57 were chosen in Stage 1 as Candidates for inclusion in the final MSET list. The interviews to date have covered 32 or 56% of these candidates. Out of the original 263 technologies in the AFSC MT/ET list, 91 were chosen as candidates in Stage 1 and 34 or approximately 37% were related to the Candidate MSETs. No interviews have been conducted on the AFOSR technologies. Table 1 also includes 10 new technologies which were not previously selected as Candidate MSETs but which came up during the discussion.

Table 1 shows also in the Stage 3 selection process which MSET titles were incorporated in the list "as is" and which required some qualification in order to properly identify the MSETs for the list. The far majority of those selected required qualification which indicates the importance of the interview process in ultimately determining the MSET.

Table 2 shows the set of twenty-two MSETs as defined at this stage of the project, i.e. those titles incorporated "as is", new titles resulting from the interviewing and, finally, the majority of the MSET titles to those aspects we have judged to be truly MSET. Further definition can be found in the interview summaries (Appendix B) or in the bulletized summary of the interviews (Appendix D).

CAVEAT - The interview summaries have not been submitted to the interviewees for their editing and should therefore be considered more as raw data than as validated inputs to the study. In phase two of this project, those persons interviewed will have a chance to examine, correct and/or otherwise alter the interview summaries for preparation of the final report.

TABLE 1

SUMMARY OF POST INTERVIEW - MSET ASSESSMENT PROCESS

SOURCE	ORIGINAL NUMBER OF TECH-NOLOGIES	STAGE 1 CANDIDATE MSETS	STAGE 2 INTERVIEWS RELATED TO CANDIDATE MSETS	% OF INTER-VIEWS RELATED TO CANDIDATE MSETS	STAGE 3 IDENTIFICATION OF MSETS			TOTAL MSET LIST TO DATE
					"As Is"	With Qualification	Rejected	
R&LM Responses	86	57	32	56	1	13	18	14
AFSC MT/ET	213	91	34	37.3	1	4	29	5
New Titles	---	---	10		3	---	7	3
								22

TABLE 2

MSET TITLES RESULTING FROM INTERVIEW PROCESS

MSET TITLES INCORPORATED "AS IS"	NEW MSET TITLES GENERATED BY INTERVIEWS
Modulation Doped Heterojunction Transistor	Multi-Bandgap Solar Cells
Borron Slurry Fuel Technology	Satellite Tomography
	Phased Array Beam Control and Phase-Locked Resonators

TITLES OF MSETS WITH QUALIFICATIONS (MSET)

-- Old Titles --	-- Suggested New Titles --
Focal Plane Arrays	High Density IR Focal Plane Arrays
VHSIC - Submicrometer Technology	Design Rules and Production Technology for Submicron (< 5 micron) VHSIC Chip
Monolithic Microwave Circuits	Functional Level Monolithic Microwave Circuits
Acousto-Optical Spectrum Analyzer	High Bandwidth Acousto-Optical Spectrum Analyzer
Gallium Arsenide Technology	Gallium Arsenide Technology for VLSI and MMICs
SAR Target Screening & Classification	Near Real Time SAR Target Classification
Fiber Optic Gyros	Integrated Optic Fiber Optic Gyros
Artificial Intelligence	Domain Specific Artificial Intelligence
Aeroelastic Tailoring	Active Servo Aeroelastic Tailoring
Adaptive Flutter Suppression	Adaptive Flutter Suppression Algorithms and Control Theory
Rigid-Rod Molecular Composites	Production Technology for Rigid-Rod Molecular Composites
Photo-Sensitive EO Materials	Photo-Sensitive EO Materials for Optical Switches and Modulators
Wideband Recorder Technology	Wideband Optical Recorder Technology
EHF Monolithic Antenna Arrays	EHF Monolithic Antenna Fabrication and System Integration
Very High Power Lithium Reserve Batteries for Missile Applications	Very High Power Lithium Thermal Batteries
Voice Technology/Recognition	Connected Speech Voice Recognition in Stressful Environment
High-Temperature Composites for Tactical Missiles	High-Temperature (> 600°F) Composite Resins

APPENDIX A

AIR FORCE EMERGING TECHNOLOGIES
INTERIM REPORT

(TR-5-712)

TR-5-712

AIR FORCE EMERGING TECHNOLOGIES

INTERIM REPORT

FEBRUARY 1985

B-K DYNAMICS, INC.
3204 MONROE STREET
ROCKVILLE, MD. 20850

B-K DYNAMICS, INC.

CHRONOLOGY

August 1982	SPIE Conference in San Diego
February 1983	Establishment of Steering Committee on National Security and Technology Transfer
September 1983	Final Report of the Subcommittee on Monitoring of Emerging Technologies
January 1984	DoD Directive 2040.2
July 1984	R&AT Memorandum on Militarily Significant Emerging Technologies
August 1984	Drafting of R&LM/R&AT protocol
October 1984	Collection of information DoD-wide (supported by Eagle Research Group)
September 1984 - January 1985	B-K Dynamics' analysis of Air Force protocols and other R&D descriptions and preparation of preliminary METAL
February 1985 - March 1985	Conduct interviews and finalize METAL
April - May 1985	Priorities for protection and investment

THE SUBCOMMITTEE'S DEFINITIONS

- EMERGING TECHNOLOGY (ET)

  - Translates a perceived application concept into a mature state where it can enter the product life cycle.

  - Identifiable stages in the emerging technology process are:

    1. Identification of potential functional uses

    2. First experimental device applications

    3. Identification of practical applications.

- MILITARILY SIGNIFICANT EMERGING TECHNOLOGY (MSET)

  - An emerging technology which, based on experimental evidence, is perceived to have signficant military impact, (which) is generally understood to mean that potential military uses have been identified and the subject technology meets one or more of these threat assessments factors:

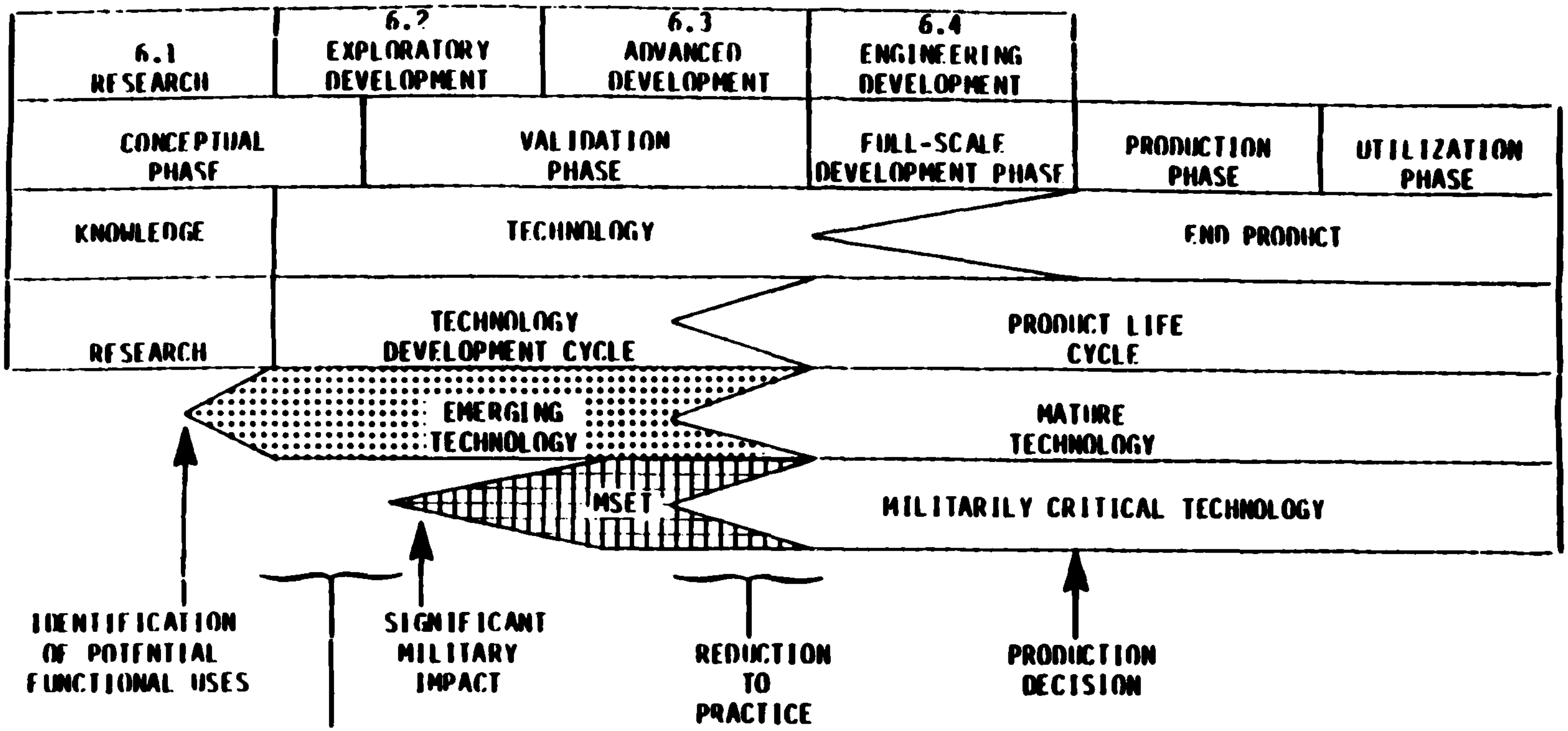
    1. Technology not processed by or available to the Soviet Bloc or, if possessed, the state-of-the-art lags the United States

    2. Technology will provide an advantage in terms of performance, reliability, maintenance, or cost

    3. Technology relates to specific known deficiences in Soviet Bloc capabilities.

  - In addition to threat assessment, it must be defined in terms of the stages of emergence and be supported by experimental evidence. Specifically, it must have at least progressed to the second stage of the emerging technology process identified above - first experimental device applications.

THE TECHNOLOGY SPECTRUM



- SCIENTIFIC FEASIBILITY
- PROOF OF SCIENTIFIC PRINCIPLE
- PROOF OF CONCEPT

- TECHNICAL FEASIBILITY

- ENGINEERING FEASIBILITY
- PROOF OF DESIGN CONCEPT

- BREADBOARD
- BRASSBOARD
- LABORATORY PRODUCTION
- LOGIC FLOW

- PROTOTYPE
- PILOT LINE PRODUCTION
- DATA FLOW

- DEMONSTRATION MODEL
- ENGINEERING MODEL
- OPTIMIZED SYSTEM

WHY THE CONFUSION ABOUT EMERGING TECHNOLOGY?

- ESTABLISHED CONCEPT/DESIGN/SYSTEM INCORPORATING ADVANCES IN OTHER TECHNOLOGIES AS THEY MATURE
  - Second and Third Generation FLIRS
  - Aerodynamic Modelling
- NEW CONCEPT/SYSTEM IMPLEMENTED WITH MATURE TECHNOLOGY
  - Integrated Closed-Loop Environmental Control System (ICECS)
- MATURE TECHNOLOGY WITH SOME ASPECTS UNDERGOING INCREMENTAL ADVANCES
  - Increased Yield In a Production Process
  - Software Improvement to Increase Utilization, Efficiency
- NEW CONCEPT/REQUIREMENT REQUIRING ADVANCES IN OTHER TECHNOLOGY AREAS
  - Space Based Radar

WORKING DEFINITIONS

	APPLICATION	AVAILABILITY	TECHNICAL RISK	COST & SCHEDULE RISK
BASIC RESEARCH	Broad potential	Far-term	High	N/A
ET	Potential identified	Far-to-mid-term	High-Moderate	N/A
MSET	*Military potential identified*	Mid-term	Moderate	High
MATURING	Military Systems use identified	Near-term ($\approx$ 1 yr)	Moderate-Low	Moderate
MATURE	Incorporated in Military Systems	Off-the-shelf	Low	Low

DATA BASE USED FOR IDENTIFICATION OF EMERGING TECHNOLOGIES

- RESPONSES TO R&LM PROTOCOL
  - Fall 1984
  - Requested information on Description, Status, Applications, and Impact of technologies
  - Based on sample completed protocol, several definitions of terms, and instructions
- MATURING/EMERGING TECHNOLOGIES AT AFSC LABORATORIES
  - March 1983
  - Compiled by HQ/AFSC/DLXP/XRX
- RECENT RESEARCH ACCOMPLISHMENTS OF THE AFOSR
  - May 1983
  - Description of research, applications

DATA BASE EXAMINED -- BUT NOT USED --

FOR ET/MSET IDENTIFICATION

- BUDGET ESTIMATE SUBMISSION (FY 86-90) RDT&E (RD-5 EXHIBIT)
  - September 1984
  - Programmatic descriptions; milestones and accomplishments but little technical description
- 1498s
  - Ongoing
  - Objective, Approach, and Progress reported
  - Not targetted for ET/MSET characterization
  - ET/MSET reporting category could be added

SUMMARY OF R&LM PROTOCOL RESPONSES

- 86 CANDIDATE TECHNOLOGIES

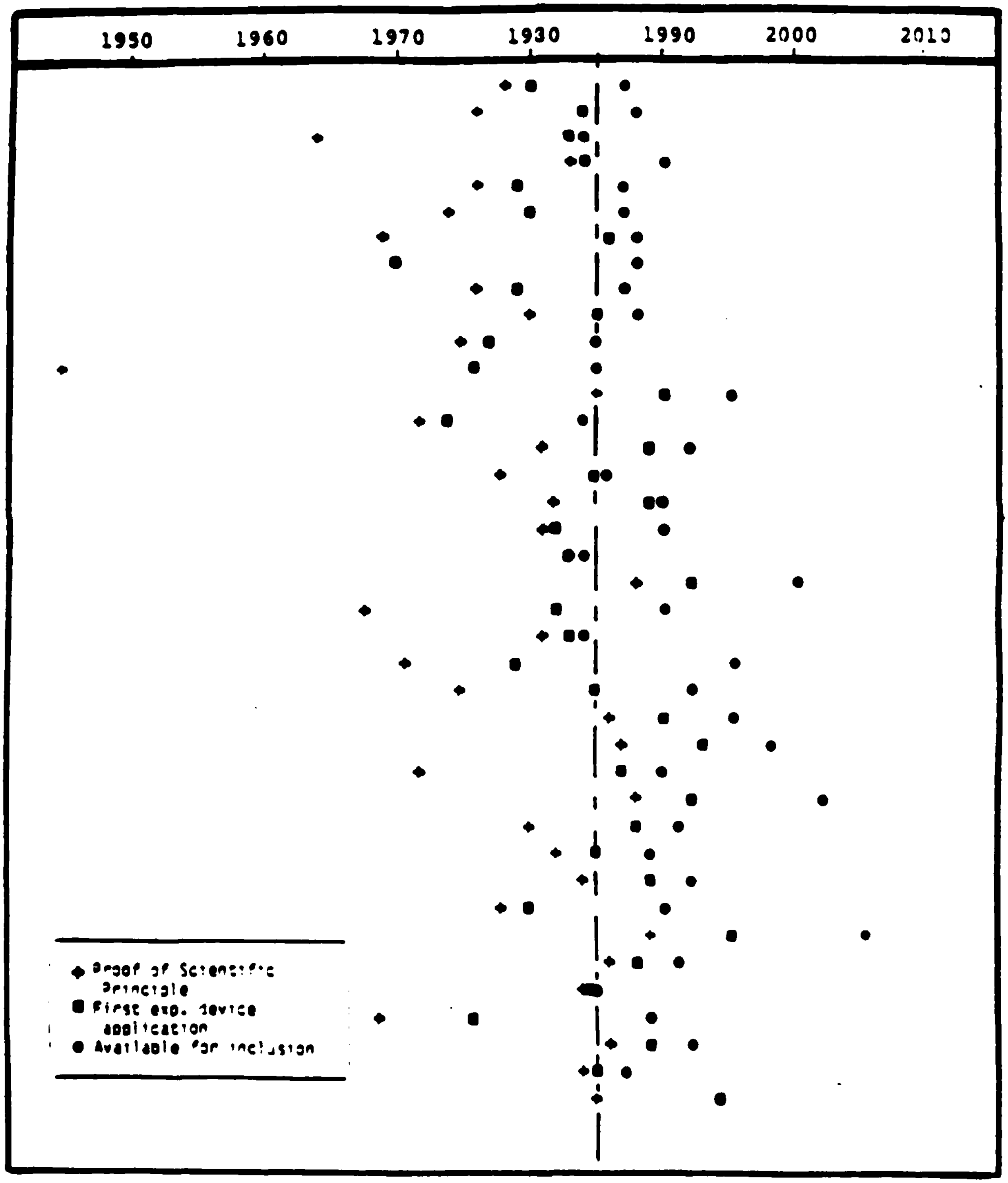
	RESPONDENTS	BKD
EMERGING TECHNOLOGIES	86	2-6
MILITARILY SIGNIFICANT EMERGING TECHNOLOGIES	0	18-56
MATURE TECHNOLOGIES	0	28-62

- MAJOR REASONS FOR DISAGREEMENT
  - Aggregated topics (e.g., VHSIC, HEMT)
  - Definition of "emergence" (e.g., Titanium Castings, Carbon Slurry Fuel)
  - Engineering/systems topics (e.g., Weapons Carriage/Separation Techniques, ICECS)
  - Mature technologies (e.g., Flat Panel Displays, UHF Power Transistors)

RESPONSES TO R&LM PROTOCOL

AF UNIT	REF NO.	TECHNOLOGY TOPIC	RSCH	ET	MSET	MT
AFWAL	1	Modulation Doped Heterojunction Transistor			●	●
	2	Focal Plane Arrays			●	●
	3	VHSIC				●
	4	VHSIC - Submicrometer Technology			●	●
	5	Monolithic Microwave Circuits			●	●
	6	Acousto-Optical Spectrum Analyzer			●	●
	7	Solid State Phaased Array			●	●
	8	Gallium Arsenide Technology			●	●
	9	High-Temperature Photoconductive HgCdTe Detectors			●	●
	10	UHF Power Transistors				●
	11	SAR Target Screening & Classification			●	
	12	Fiber Optic Gyros			●	●
	13	Adaptive Goal-Seeking Elements or Neural Networks		●		
	14	Flat Panel Display Technology				●
	15	Artificial Intelligence			●	
	16	Applied Computational Aerodynamics			●	●
	17	Weapons Carriage/Separation Techniques				●
	18	Aero-Configured Missiles			●	●
	19	Integrated Closed-Loop Environmental Control System				●
	20	Aeroelastic Tailoring			●	●
	21	Adaptive Flutter Suppression			●	●
	22	Rigid-Rod Molecular Composites			●	
	23	Titanium Castings				●
	24	ITP-90			●	●
	25	Air-Lubricated Foil Bearings			●	●
	26	Carbon Slurry Fuel				●
	27	Lubrication System Condition Monitoring		●		
	28	Advanced Technology Landing Gear				●
AFSTC	29	Polarization Diversity Meteorological Radar			●	
	30	Active Sensors from Meteorological Satellites			●	

MILESTONE DISTRIBUTION FOR R&LM PROTOCOL RESPONSES



ASSESSMENT OF R&LM PROTOCOL METHODOLOGY

- 86 CANDIDATE TECHNOLOGIES
- 58 JUDGED TO FALL WITHIN THE ET/MSET SPECTRUM
- 7 WERE JUDGED BY RESPONDENTS "READY FOR INCLUSION" BY 1985
- 10 MORE WERE JUDGED "READY FOR INCLUSION" BY 1988
- 7 WERE TO HAVE "PROOF OF SCIENTIFIC PRINCIPLE" ESTABLISHED IN FUTURE

CRITIQUE	RECOMMENDATION
• Confusion over terminology, e.g., "Proof of scientific principle" and "First experimental device application"	• Include all definitions in instructions; include timeline for technology development showing milestones
• Highly aggregated candidate technologies, e.g., VHSIC	• Emphasize that elements of technology, not projects or programs, are sought, e.g., VLSI CAD
• Many mature candidate technologies, e.g., VHSIC, FPA	• Emphasize that "emerging" is not synonymous with "ready for inclusion"; emphasize that performance optimization not synonymous with emergence

SUMMARY OF AFSC ET/MT RESULTS

- 264 CANDIDATE TECHNOLOGIES

	LABS	BKD
RESEARCH	0	0-8
EMERGING TECHNOLOGIES	71	11-20
MILITARILY SIGNIFICANT EMERGING TECHNOLOGIES	0	27-72
MATURE TECHNOLOGIES	193	173-217

- MAJOR REASONS FOR DISAGREEMENT
  - Engineering/systems topics (e.g., PAVE PILLAR)
  - Mature technologies by 1985 (e.g., Low RCS Inlet)
  - Performance improvements (e.g., Dynamically Tuned Rate Gyro System)

SUMMARY OF AFOSR RECENT RESEARCH ACCOMPLISHMENTS

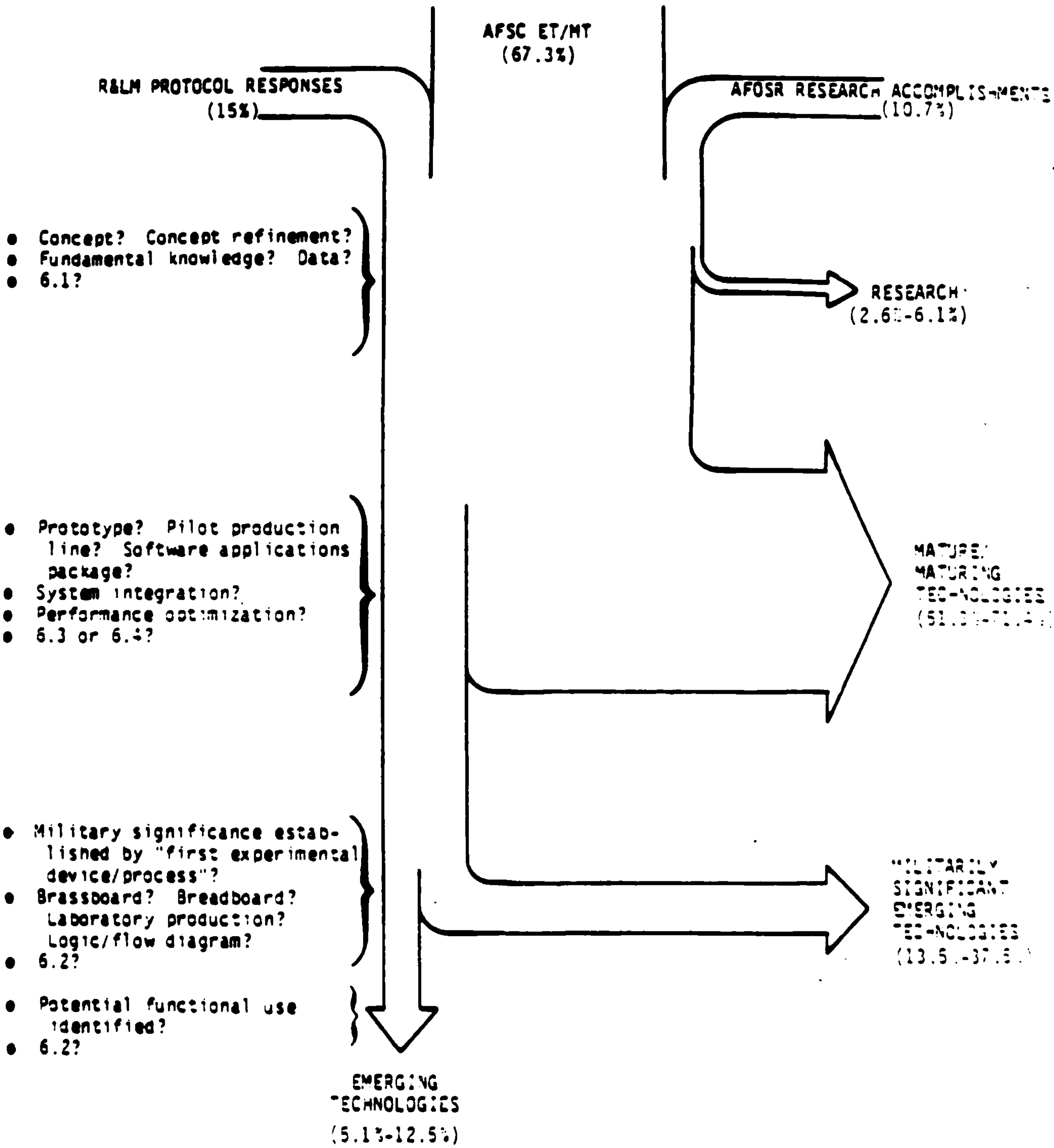
- 42 CANDIDATE TOPICS

	AFOSR	BKD
RESEARCH	42	10-16
EMERGING TECHNOLOGIES	0	7-23
MILITARILY SIGNIFICANT EMERGING TECHNOLOGIES	0	8-19
MATURE TECHNOLOGIES	0	0-1

SUMMARY OF RESULTS

	R&LM PROTOCOL RESPONSES (1984)	AFSC ET/MT (1983)	AFOSR REC. RSCH. (1983)	PRELIMINARY METAL (1985)	
CANDIDATE TECHNOLOGY TOPICS	86	264	42	Total Candidates Considered	
RSCH	0	0	10		392
RSCH/ET	0	8	6	14	
ET	2	11	7	20	
ET/MSET	4	1	10	15	181
MSET	18	27	8	53	
MSET/MT	34	44	1	79	
MT	28	173	0		

AN OVERVIEW OF
BKD METHODOLOGY AND RESULTS



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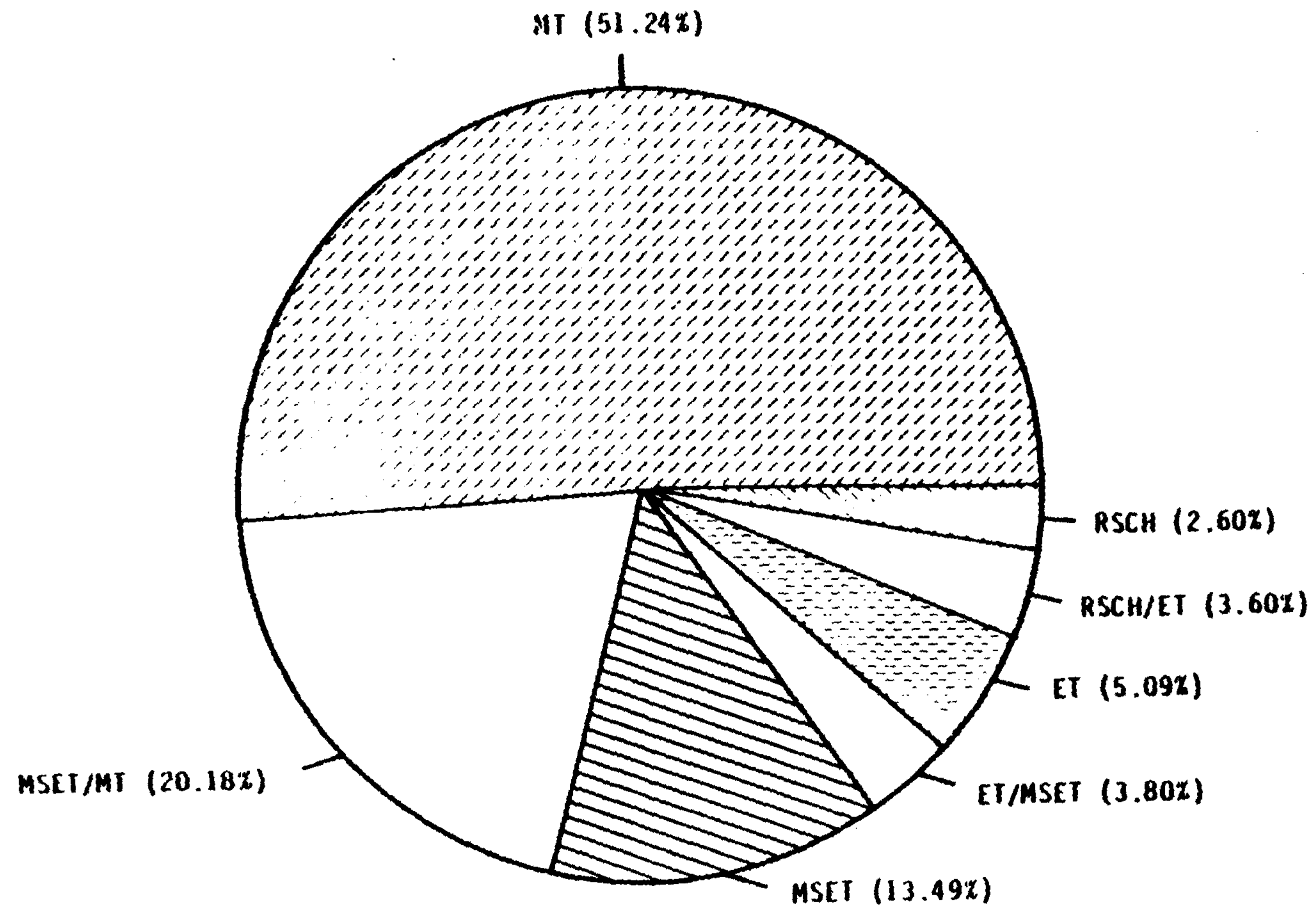


MAJOR TECHNOLOGY GROUPS
FOR 181 METAL CANDIDATES

- PROPULSION/AERONAUTICS
- ROCKETRY
- DIRECTED ENERGY
- ELECTRO OPTICS
- FIBER OPTICS
- RADAR/MICROWAVES
- AI
- SOFTWARE
- IMAGE PROCESSING
- INSPECTION/ANALYSIS
- FUELS
- CRYOGENICS
- ELECTRONICS (VHSIC-LIKE)

TYPICAL PROJECT GROUPINGS

- ELECTRONICS (VHSIC-LIKE)
  - VHSIC SUBMICROMETER TECHNOLOGY
  - SUPERCONDUCTING ELECTRONICS
  - JOSEPHSON JUNCTION COMPUTER DEVELOPMENT
  - SPACE HARDENED ELECTRONICS
  - ELECTRON BEAM LITHOGRAPHY FOR VHSIC BASED C^3I SYSTEMS
- FIBER OPTICS
  - FIBER OPTIC GYRO
  - FIBER OPTICS FOR TACTICAL/STRATEGIC INFORMATION TRANSFER
  - FIBER OPTIC COMMUNICATIONS
  - FIBER OPTICS FOR TACTICAL AND STRATEGIC PROCESSING
  - RADIATION HARD, ULTRA LOW LOSS FIBER OPTIC COMMUNICATIONS
  - DEVICE QUALITY SINGLE CRYSTAL I_NP

FIBER OPTIC GYROS

CONTRAST U.S. & U.S.S.R CAPABILITIES (CURRENT STATE-OF-THE-ART) IN:

MATERIALS, MATERIALS RESEARCH

- FIBERS, SOURCES, DETECTORS
- COLLIMATING/BEAM SPLITTING OPTICS
- MECHANICAL PARTS, ELECTRONIC PARTS

DEVELOPMENT, DESIGN, PRODUCTION

- MATERIALS
- COMPONENT PARTS
- GYRO
- CAD/CAM/CAT

PERFORMANCE, COST

- GOALS: SIZE, WEIGHT POWER
DRIFT IN DEGREES/HR
COST, RELIABILITY
- CAPABILITIES

INSERTION, RATE OF INSERTION			YEARS
● INTO EXISTING EQUIPMENT	YES	NO	____
● PRODUCTION EQUIPMENT	YES	NO	____
● EQUIPMENT UNDER DEVELOPMENT	YES	NO	____

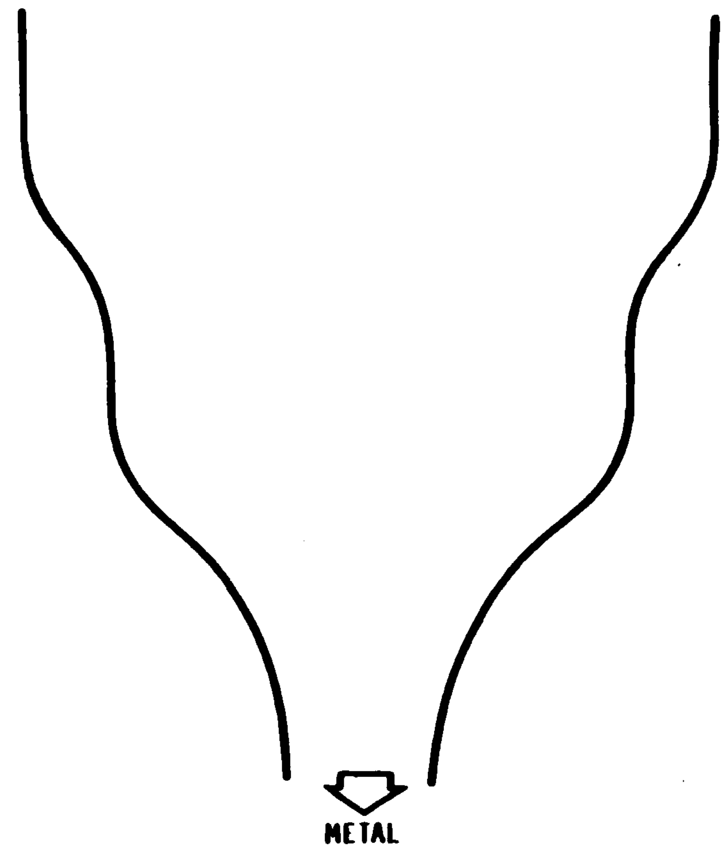
* AREAS OF SUPERIOR CAPABILITY
* CRITICAL DEFICIENCIES
* SOURCES FOR ADDITIONAL INFORMATION

INTERIM FINDINGS

- PRELIMINARY METAL COMPILATION POSSIBLE FROM SECONDARY SOURCES
  - -- R&LM PROTOCOL RESPONSES
  - -- AFSC ET/MT LIST
  - -- AFOSR RECENT RESEARCH ACCOMPLISHMENTS
- BUDGET SUBMISSIONS AND 1498s NOT ADEQUATE IN CURRENT FORMAT
  - -- 1498 FORMAT REVISION SHOULD BE INVESTIGATED FOR METAL RELEVANCE
  - -- INSTITUTIONALIZATION OF REPORTING WOULD ENABLE ANNUAL UPDATES
- INTERVIEWS IN THE FIELD NECESSARY TO:
  - -- ISOLATE/IDENTIFY ET/MSET ELEMENTS AND SUB-ELEMENTS WITHIN PROJECT/PROGRAM
- U.S./USSR LEAD/LAG ASSESSMENTS EXPECTED TO BE DIFFICULT
  - -- WILL REQUIRE SIGNIFICANT INPUTS FROM FTD
- LINKAGE WITH AF PROJECT FUNDING AND INFORMATION CONTROL PRIORITIES EXPECTED TO BE SENSITIVE
  - -- WILL REQUIRE CLOSE COORDINATION WITH AFSC AND LABORATORY EXPERTS

THE NEXT STEP

- REVIEW ALL AF TECHNOLOGY NOMINATIONS
- COMPILE PRELIMINARY METAL
- CONDUCT INTERVIEWS
- U.S. LEAD/LAG



APPENDIX A

TOPICS SELECTED FOR THE PRELIMINARY METAL

PRELIMINARY METAL

R&LM RESPONSES	RSCH	ET	MSET	MT
Modulation Doped Heterojunction Transistor			●	●
Focal Plane Arrays			●	●
VHSIC - Submicrometer Technology			●	●
Monolithic Microwave Circuits			●	●
Acousto-Optical Spectrum Analyzer			●	●
Solid State Phased Array			●	●
Gallium Arsenide Technology			●	●
High-Temperature Photoconductive HgCdTe Detectors			●	●
SAR Target Screening & Classification			●	
Fiber Optic Gyros			●	●
Adaptive Goal-Seeking Elements or Neural Networks		●		
Artificial Intelligence			●	
Applied Computational Aerodynamics			●	●
Aero-Configured Missiles			●	●
Aeroelastic Tailoring			●	●
Adaptive Flutter Suppression			●	●
Rigid-Rod Molecular Composites			●	
ITP-90			●	●
Air-Lubricated Foil Bearings			●	●
Lubrication System Condition Monitoring		●		
Polarization Diversity Meteorological Radar			●	
Active Sensors from Meteorological Satellites			●	
Laboratory Simulation of Nuclear Emission			●	
Space Environment Control			●	

PRELIMINARY METAL (Continued)

	RSCH	ET	MSET	MT
R&LM RESPONSES (Cont'd)				
Cryogenic Engine Systems			●	●
Composite Materials for Composite Motor Cases			●	●
Cryogenic Fluid Storage			●	●
Liquid Propellant Storage Tanks			●	●
Photo-Sensitive EO Material			●	●
Bistable Optical Technology			●	
HEMT Technology			●	●
Electromagnetic Launcher Technology			●	
Integrated/Fiber Optic Gyro			●	●
Artificial Intelligence Applications to Maintenance		●	●	
Sensor Correlation Technology			●	●
Reference Scene Generation Technology			●	●
Digital Cartographic Data Exploitation Technology			●	●
Automated Target Detection, Classification and I.D.			●	
Advance Terrain Data Extraction Technology			●	●
Multi-Sensor Precise Target Location Technology			●	●
C3CM Deception			●	
Automatic Speech Recognition			●	
Low Data Base Rate Communications			●	●
Wideband Recorder Technology			●	●

PRELIMINARY METAL (Continued)

	RSCH	ET	MSET	MT
R&LM RESPONSES (Cont'd)				
ELINT Identification			●	●
SIGINT Correlation			●	●
Acoustic Charge Transfer Devices and Applications			●	
Methodologies for Vulnerability Assessment of Communications Networks			●	●
Mid Range IR Materials		●	●	
Indium Phosphide Technology		●	●	
SDI Advanced On Board Signal Processing			●	
MMIC Advanced Arrays			●	
VHSIC Insertion for E-3A Signal Processors			●	
Hybrid Bistatic Radar		●	●	
Low Cost/Long Life SATCOM Thermionics			●	●
Anti Stealth RCS Models			●	
Decision Aids			●	
AFSC ET/MT LIST				
Advanced Optical Rotation Sensors			●	●
Hypervelocity Weapon Demo			●	
Aircraft/Store Integration			●	●
Guided Projectile Technology			●	●
Hypervelocity Missile			●	●

PRELIMINARY METAL (Continued)

AFSC ET/MT LIST (Cont'd)	RSCH	ET	MSET	MT
Modern Guidance and Estimation for Tactical Air-to-Air Missiles			●	
AI Applications to Training, Performance Measurement, Job Performance Aiding		●		
Combat Mission Trainer			●	●
High-Speed Thrust-Augmenting Ejector		●	●	
Productive Exploitation Unsteady Aerodynamics	●	●		
Aerodynamic Skin Friction Drag Reduction	●	●		
Energy Beaming for Space Propulsion	●	●		
HEL Thin-Film Coating Technology	●	●		
Superconducting Electronics		●		
Working Description of Cognitive Neural Processing	●	●		
Biochemical Techniques to Prevent Cell Degeneration	●	●		
Computer Processor with Adaptive (Learning) Capability	●	●		
Advanced Machine-Operator Coupling Technology	●	●		
High-Resolution Imaging of Space Objects		●		
FEL			●	
Nonlinear Adaptive Optics			●	
Space-Based Radar			●	●
MMIC T/R Modules			●	●
Limited Vocabulary Voice Systems			●	●
Fiber Optics for Tactical/Strategic Information Transfer			●	●
E-Beam Lithography for VHSIC-Based C^3I Systems			●	

PRELIMINARY METAL (Continued)

AFSC ET/MT LIST (Cont'd)	RSCH	ET	MSET	MT
Device-Quality Single-Crystal InP			●	
Josephson Junction Computer Development		●		
EHF Monolithic Antenna Arrays			●	●
Active Composite Mirrors			●	
IR Rapid Response Wavefront Sensor			●	●
Surface Measuring Device (0.05μ)		●		
Fiber Optics for Tactical/Strategic Signal Processing			●	●
Red-Hard, Ultra-Low-Loss Fiber Optics Communications			●	
Multi-Imagery Explosive System			●	
Program Visualization Systems		●		
AI			●	
Life Cycle Software Engineering Environment		●		
Space-Hardened Electronics			●	●
ADSP			●	●
Iodine Laser			●	
HF Laser			●	
Reactive Sputtering and Ion Beam Coating Techniques			●	●
Advanced Heat Exchanger Materials/Fabrication Technology			●	
Advanced Coating Fabrication Technology			●	
Advanced Glass Technology			●	
High-Performance Propellants for Air-Launched Missiles			●	
Composite Motor Cases for Air-Launched Missiles			●	●
Low Thrust Cryogenic Engine			●	●

PRELIMINARY METAL (Continued)

	RSCH	ET	MSET	MT
AFSC ET/MT LIST (Cont'd)				
Pulsed Plasma Propulsion for Satellites			●	●
Wound Insulation for Ballistic Missile Motors			●	●
Long-Term Space Storage of Cryogenic Fluids			●	●
Advanced High-Thrust Liquid Rocket Engine			●	●
Solar Thermal Rocket			●	
MPD Thruster			●	
Advanced GaAs Solar Cells			●	●
Very High Power Lithium Batteries			●	●
NaS High-Energy-Density Rechargeable Batteries			●	●
Boron Slurry Fuel Technology			●	
Lubrication System Condition Monitoring		●		
International Cruise Missile Turbine Engines			●	
Fireproof Hydraulic Systems		●		
E-Beam-Controlled High-Voltage Switch			●	●
Boron Solid-Fuel Ramjet			●	
Boron Slurry-Fueled Ramjet			●	
Supersonic Combustion Ramjet			●	
Integrated Inertial Reference Assembly Description			●	●
Imaging Sensor Autoprocessor			●	●
Integrated Communication, Navigation, Identification Avionics				
PAVE PILLAR			●	●
Advanced Imagery Transmission			●	●

PRELIMINARY METAL (Continued)

	RSCH	ET	MSET	MT
AFSC ET/MT LIST (Cont'd)				
Electronic Terrain Map System			●	●
Solid State Phased Arrays			●	●
Multifunction FLIR			●	●
Multiband Staring Sensor			●	
Combined Sensors for Target Acquisition, Recognition, and Strike			●	●
CO_2 Laser Radar			●	●
Forward-Looking Active Classification Technology			●	●
Covert Strike Radar			●	
Multiple Target Attack Algorithms			●	●
Aeroelastic Tailoring			●	●
Advanced Flutter Suppression			●	
Voice Technology			●	●
Supersonic Cruise Fighter Technology			●	●
Aero Configured Missiles			●	●
Applied Computational Aerodynamics			●	●
IR Detector Materials			●	●
High-Temperature Composites for Tactical Missiles			●	●
Ordered Polymers			●	
Iron Aluminides		●		
Ceramic Matrix Composites		●		

PRELIMINARY METAL (Continued)

AFOSR RESEARCH ACCOMPLISHMENTS	RSCH	ET	MSET	MT
Understanding Impinging Jet Structure - Improved Laser Design		●		
Computational Field Dynamics for Flow Around Turrets		●		
New Bending Theory	●	●		
Swirl Mixing Improves Combustor Efficiency			●	
Quantitative Flow Visualization		●	●	
Ordered Polymers - An Advanced Concept in Composite Materials			●	
Polymer Alloys			●	
Short Wavelength Chemical Laser	●	●		
Radar Mapping of Ionospheric Disturbance		●	●	
Phase-Synchronized Non-Rigid Airborne Radar Arrays			●	
Curved Chirped Waveguide Diffraction Lenses			●	
White Light Fourier Transform Holography		●	●	
High-Resolution Frequency-Swept Microwave Imaging		●	●	
Image Motion Estimation		●	●	
Laser Annealing to Reduce Waveguide Loss			●	
Improved Photodiodes for IR Imaging			●	
Theory of Forging		●	●	
Single-Crystal Turbine Blade Material		●	●	
Hot Pressed Silicon Nitride			●	

PRELIMINARY METAL (Continued)

	RSCH	ET	MSET	MT
AFOSR RESEARCH ACCOMPLISHMENTS (Cont'd)				
Nonlinear Optical Properties of HgCdTe		●		
Benzamides Prevent Chemically-Induced Cell Transformation		●		
Early Indications of Latent Toxicity	●	●		
Brain Response Patterns Indicate Learning Mechanisms	●	●		
Testing of the MX Intercontinental Ballistic Missile			●	●
Control of Large Space Structures	●	●		
Optimal Algorithm for Mutual Exclusion in Computer Networks	●	●		
Software Quality Improvements through Disciplined Programming		●	●	
Fast Algorithms for Electronic Circuit Analyses		●		
Precise Geodetic Meausrements		●		
Room Temperature Optical Bistability		●	●	
Stress Diagnositic for Microelectronic Devices		●		
FEL Proof of Principle		●	●	

APPENDIX B

TECHNOLOGY TOPICS (392) REVIEWED, BY SOURCE

RESPONSES TO R&LM PROTOCOL

AF UNIT	REF NO.	TECHNOLOGY TOPIC	RSCH	ET	MSET	MT
AFWAL	1	Modulation Doped Heterojunction Transistor			●	●
	2	Focal Plane Arrays			●	●
	3	VHSIC				●
	4	VHSIC - Submicrometer Technology			●	●
	5	Monolithic Microwave Circuits			●	●
	6	Acousto-Optical Spectrum Analyzer			●	●
	7	Solid State Phaased Array			●	●
	8	Gallium Arsenide Technology			●	●
	9	High-Temperature Photoconductive HgCdTe Detectors			●	●
	10	UHF Power Transistors				●
	11	SAR Target Screening & Classification			●	
	12	Fiber Optic Gyros			●	●
	13	Adaptive Goal-Seeking Elements or Neural Networks		●		
	14	Flat Panel Display Technology				●
	15	Artificial Intelligence			●	
	16	Applied Computational Aerodynamics			●	●
	17	Weapons Carriage/Separation Techniques				●
	18	Aero-Configured Missiles			●	●
	19	Integrated Closed-Loop Environmental Control System				●
	20	Aeroelastic Tailoring			●	●
	21	Adaptive Flutter Suppression			●	●
	22	Rigid-Rod Molecular Composites			●	
	23	Titanium Castings				●
	24	ITP-90			●	●
	25	Air-Lubricated Foil Bearings			●	●
	26	Carbon Slurry Fuel				●
	27	Lubrication System Condition Monitoring		●		
	28	Advanced Technology Landing Gear				●
AFSTC	29	Polarization Diversity Meteorological Radar			●	
	30	Active Sensors from Meteorological Satellites			●	

RESPONSES TO R&LM PROTOCOL (Cont'd)

AF UNIT	REF NO.	TECHNOLOGY TOPIC	RSCH	ET	MSET	MT
AFSTC	31	Laboratory Simulation of Nuclear Emission			●	
	32	Space Environment Control			●	
	33	UV Space Applications				●
	34	Cryogenic Engine Systems			●	●
	35	Low-Thrust Cryogenic Engine Technology				●
	36	Modular Storable Space Propulsion				●
	37	Composite Materials for Composite Motor Cases			●	●
	38	GAP Solid Rocket Propellant				●
	39	Thrust Vector Control of Tactical Finless Missiles				●
	40	Cryogenic Fluid Storage			●	●
	41	Liquid Propellant Storage Tanks			●	●
	42	Photo-Sensitive EO Material			●	●
	43	Radiation Shielded IC Packages				●
	44	Slurry Infiltrated iber Concrete Material				●
	45	Bistable Optical Technology			●	
	46	HEMT Technology			●	●
	47	Electromagnetic Launcher Technology			●	
	48	Integrated/Fiber Optic Gyro			●	●
AMD	49	Fiber Optic Head Mounted Display				●
	50	Anti-G Suit Valve				●
	51	ADAM II				●
AFWAL	52	Autonomous Landing Guidance				●
RADC	53	Artificial Intelligence Applications to Maintenance		●	●	
	54	Environmental Stress Screening for Equipments and Systems				●
	55	System Testability Predictions and Analysis				●
	56	Finite Element Analysis of Microcircuit Devices				●
	57	Analytical Methods for Integrated Diagnosis				●
	58	Computer Programs for Reliability and Maintainability Engineering for Use In CAD/CAM				● ●
	59	Sensor Correlation Technology			●	●
	60	Reference Scene Generation Technology			●	●

RESPONSES TO R&LM PROTOCOL (Cont'd)

AF UNIT	REF NO.	TECHNOLOGY TOPIC	RSCH	ET	MSET	MT
	61	Reference Scene Generation			●	●
	62	Digital Cartographic Data Exploitation Technology			●	●
	63	Automated Target Detection, Classification and I.D.			●	
	64	Advance Terrain Data Extraction Technology			●	●
	65	Multi-Sensor Precise Target Location Technology			●	●
	66	C3CM Deception			●	
	67	Automatic Speech Recognition			●	
	68	Low Data Rate Communications			●	●
	69	Wideband Recorder Technology			●	●
	70	ELINT Identification			●	●
	71	SIGINT Correlation			●	●
	72	COMINT Identification				●
	73	Acoustic Charge Transfer Devices and Applications			●	
	74	Methodologies for Vulnerability Assessment of Communications Networks			●	●
	75	Silicide IR Focal Plane Mosaic Technology				●
	76	Intrusion Resistant Fiber Optic Communications				●
	77	Mid Range IR Materials		●	●	
	78	Indium Phosphide Technology		●	●	
	79	Radiation Hardened VLSI Circuits				●
	80	SDI Advanced On Board Signal Processing			●	
	81	MMIC Advanced Arrays			●	
	82	VHSIC Insertion for E-3A Signal Processors			●	
	83	Hybrid Bistatic Radar		●	●	
	84	Low Cost/Long Life SATCOM Thermionics			●	●
	85	Anti Stealth RCS Models			●	
	86	Decision Aids			●	

MATURING/EMERGING TECHNOLOGIES AT AFSC LABS

AF UNIT	REF NO.	TECHNOLOGY TOPIC	RSCH	ET	MSET	MT
AMD	1	Crew Escape Technology				●
	2	Personal Thermal Control System				●
	3	Chemical Warfare Defense Vital Signs Monitor				●
	4	Advanced Chemical Defense Aircrew Respirator				●
	5	Advanced Life Support System				●
AL	6*	Advanced Optical Rotation Sensors			●	●
	7*	Dynamically Tuned Rate Gyro System				●
	8*	Hypervelocity Weapon Demo			●	
	9	Aircraft/Store Integration			●	●
	10	Anti-Material Incindiery Submunition				●
	11	Barrel Flexure Technology				●
	12	Bunkered Target Munition				●
	13	Conformal Ejector Rack				●
	14	EA Explosives				●
	15	Emitter Homing Seeker Development				●
	16	Extended Medium Range Air-to-Air Technology				●
	17	Federated Microprocessor Configuration for Guided Weapon Systems				●
	18	Guided Projectile Technology			●	●
	19	High-Altitude Aerodynamic Control Responsiveness				●
	20	Hypervelocity Missile			●	●
	21	IR High-Value Acquisition Program				●
	22	Low-Altitude Dispenser				●
	23	Modern Guidance and Estimation for Tactical Air-to-Air Missiles			●	
	24	Nitramine Aircraft Cannon Projectiles				●
	25	Selectable Linear/Area Pattern Control				●
	26	Sperry Laser Instrument Cluster				●
	27	Synthetic Aperture Seeker System				●
	28	Tactical GPS Guidance Advanced Missile Receiver				●
	29	Telescoped Ammunition Development				●
	30	30 mm Ammunition Technology				●

* Denoted/classified as ET by lab

MATURING/EMERGING TECHNOLOGIES AT AFSC LABS (Cont'd)

AF UNIT	REF NO.	TECHNOLOGY TOPIC	RSCH	ET	MSET	MT
AL	31	Kinetic Energy Penetrator Technology				●
ESC	32	Aircraft Susceptibility to Foreign Object Damage				●
	33	Computer Routine for Predicting Fighter Response on Soft Soil Surfaces				●
	34	Development and Testing of a Small-Scale Solvent Recovery System				●
	35	Prototype Packed Tower Air Stripping System				●
	36	Selective Ion Exchange for Metal Recovery from AF Plating Process				●
	37	Real-Time Toxic Vapor Analyzer				●
	38	Remote Sensing System for Airborne Pollutants				●
	39	Alternative Power for ICBM Basing				●
	40	Solar PV Applications				●
	41	Protective Antipenetration Systems Development				●
HRL	42	Simulation Assisted Maintenance Training				●
	43	Computer-Based Maintenance Aids				●
	44	Technical Order Cost Algorithms				●
	45	Unified Data Base				●
	46	Advanced Visual Technology System				●
	47	Advanced Micro Linkage				●
	48	Fiber Optic Helmet-Mounted Display				●
	49	Person-Job-Match Research				●
	50	National Labor Market Research				●
	51	Comprehensive Occupational Data Analysis Programs				●
	52	Aptitude Requirements Analysis				●
	53	Operational T&E Handbook for Aircrew Training Devices				●
	54	Computerized Adaptive Testing				●
	55*	AI Applications to Training, Performance Measurement, Job Performance Aiding		●		
	56*	Training Decisions System				●
	57*	Combat Mission Trainer			●	●
	58*	Special Function Trainer				●
	59*	Job Performance Criterion Development				●
OSR	60*	High-Speed Thrust-Augmenting Ejector		●	●	

* Denoted/classified as ET by lab

MATURING/EMERGING TECHNOLOGIES AT AFSC LABS (Cont'd)

AF UNIT	REF NO.	TECHNOLOGY TOPIC	RSCH	ET	MSET	MT
OSR	61*	Productive Exploitation Unsteady Aerodynamics	●	●		
	62*	Aerodynamic Skin Friction Drag Reduction	●	●		
	63*	Energy Beaming for Space Propulsion	●	●		
	64*	HEL Thin-Film Coating Technology	●	●		
	65*	Superconducting Electronics		●		
	66*	Working Description of Cognitive Neural Processing	●	●		
	67*	Biochemical Techniques to Prevent Cell Degeneration	●	●		
	68*	Computer Processor with Adaptive (Learning) Capability	●	●		
	69*	Advanced Machine-Operator Coupling Technology	●	●		
	70*	High-Resolution Imaging of Space Objects		●		
	71*	FEL			●	
	72*	Nonlinear Adaptive Optics			●	
RADC	73	Hybrid Scan EHF Antennas				●
	74	UHF SAW Oscillators				●
	75	BULK Acoustic Resonator Oscillators				●
	76	EHF Atmospheric Multipath Reduction				●
	77	Advanced HF Technology				●
	78	Advanced Tracking System				●
	79	Advanced Tactical Radar				●
	80	Space-Based Radar			●	●
	81	Compensated Imaging System				●
	82	Ultra-Lightweight Passive Mirrors				●
	83	Wide-Bandwidth Radar Identification Subsystems				●
	84	Coupled-Cavity TWT				●
	85	Dispenser Cathode Technology				●
	86	Extended Interaction Klystron				●
	87	MMIC T/R Modules			●	●
	88	Target Signature Data Base				●
	89	Passive Coherent Location System				●
	90	Bistatic Enhanced Altimeter Detection				●

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MATURING/EMERGING TECHNOLOGIES AT AFSC LABS (Cont'd)

AF UNIT	REF NO.	TECHNOLOGY TOPIC	RSCH	ET	MSET	MT
RADC	91	Air Surveillance Modelling				●
	92	Single-Tone HF Modems				●
	93	Adaptive HF/VHF Communications				●
	94	Limited Vocabulary Voice Systems			●	●
	95	SATCOM EHF Adapative Processor Module				●
	96	Low-Cost LMS Processor				●
	97	Flexible Digital SATCOM Terminal Modem				●
	98	Fiber Optics for Tactical/Strategic Information Transfer			●	●
	99	Fiber Optics Communications				●
	100	NMOS LSI Memory Technology				●
	101	Silicide IR Focal Plane Mosaic Technology				●
	102	E-Beam Lithography for VHSIC-Based C^3I Systems			●	
	103	Superior-Quality Quartz				●
	104	Intrusion-Resistant Optical Fiber Communication Links				●
	105	Device-Quality Single-Crystal InP			●	
	106	On-Line Digital Disc				●
	107	Electronically-Tunable Filters				●
	108	PAVE MOVER				●
	109	Specification and Measurement of Software Quality Attributes				●
	110	Mil-Std-1862A Brassboard				●
	111	Josephson Junction Computer Development		●		
	112	ADA Integrated Environment				●
	113*	EHF Monolithic Antenna Arrays			●	●
	114*	Surveillance Internetting and ID				●
	115*	Active Composite Mirrors			●	
	116*	Mirror Fabrication Technology				●
	117*	IR Rapid Response Wavefront Sensor			●	●
	118*	Surface Measuring Device (0.05μ)		●		
	119*	Fiber Optics for Tactical/Strategic Signal Processing			●	●
	120*	Red-Hard, Ultra-Low-Loss Fiber Optics Communications			●	

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MATURING/EMERGING TECHNOLOGIES AT AFSC LABS (Cont'd)

AF UNIT	REF NO.	TECHNOLOGY TOPIC	RSCH	ET	MSET	MT
RADC	121*	Multi-Imagery Explosive System			●	
	122*	Program Visualization Systems		●		
	123*	AI			●	
	124*	Life Cycle Software Engineering Environment		●		
SD	125	EHF Nulling Antennas				●
	126	High-Gain Multi-Beam Antenna				●
	127	Active Aperture Antenna				●
	128	Active Aperture Antenna				●
	129	Crosslink Antenna Subsystem				●
	130	Solid State Amplifier				●
	131	FET Amplifier				●
	132	Saturated Solid State Amplifiers				●
	133	VHSIC Processor Chip Set				●
	134	Bubble Memory Subsystem				●
	135	TWT Amplifiers				●
	136	Multimission Attitude Determination and Autonomous Navigation				●
	137	Space-Hardened Electronics			●	●
	138	Amplifier				●
	139*	AOSP			●	●
AFWL	140	Iodine Laser			●	
	141	HF Laser			●	
	142	Reactive Sputtering and Ion Beam Coating Techniques			●	●
	143	Rad-Hardened Bulk CMOS Microelectronics				●
	144	Optoelectronics Hardening Technology				●
	145*	High-Power Waveguides				●
	146*	Advanced Heat Exchanger Materials/Fabrication Technology			●	
	147*	Advanced Coating Fabrication Technology			●	
	148*	Advanced Glass Technology			●	
	149*	Integrated Optics Hardening				●
	150	C-C Nozzle Integral Throat and Entrance Section				●

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MATURING/EMERGING TECHNOLOGIES AT AFSC LABS (Cont'd)

AF UNIT	REF NO.	TECHNOLOGY TOPIC	RSCH	ET	MSET	MT
RPL	151	High-Energy Non-Hazardous Class 1.3 Propellant				●
	152	High-Efficiency Composite Rocket Motor Cases				●
	153	C-C Expandable Exit Cones				●
	154	High-Performance Propellants for Air-Launched Missiles			●	
	155	Composite Motor Cases for Air-Launched Missiles			●	●
	156	Radial Pulse Motor for Air-Launched Missiles				●
	157	Nozzleless Booster for Air-Launched Rocket Ramjets				●
	158	Low Thrust Cryogenic Engine			●	●
	159	Improved Performance Space Motor				●
	160	Modular Storable Space Propulsion				●
	161	Pulsed Plasma Propulsion for Satellites			●	●
	162	Acoustical Holography NDE				●
	163	GAP Propellant for Starter Cartridges				●
	164*	Wound Insulation for Ballistic Missile Moors			●	●
	165*	Long-Term Space Storage of Cryogenic Fluids			●	●
	166*	Advanced High-Thrust Liquid Rocket Engine			●	●
	167*	Solar Thermal Rocket			●	
	168*	MPD Thruster			●	
AFGL	169	Optical Background Suppression				●
	170	Zodiacal Background Radiation Model				●
	171	Tactical Decision Aid				●
	172	Radio Interferometric Observation of GPS Satellites				●
AFWAL	173	Air Lubricated Foil Beanings				●
	174	Carbon Slurry Fuel Technology				●
	175	Aviation Turbine Fuel Technology				●
	176	Aircraft Fire Protection Technology				●
	177	Bomber Aircraft Turbine Engines				●
	178	Fighter Aircraft Turbine Engines				●
	179	Subsonic Cruise Missile Turbine Engines				●
	180	VSCF Generators				●

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MATURING/EMERGING TECHNOLOGIES AT AFSC LABS (Cont'd)

AF INIT	REF NO.	TECHNOLOGY TOPIC	RSCH	ET	MSET	MT
AFWAL	181	Multi-Functional Integrated Power Unit				●
	182	Electrical Starters/Generators				●
	183	Electric Fuel Pump				●
	184	Advanced GaAs Solar Cells			●	●
	185	Very High Power Lithium Batteries			●	●
	186	NiH Batteries				●
	187	NaS High-Energy-Density Rechargeable Batteries			●	●
	188	Hydrocarbon Solid-Fuel Ramjet				●
	189	Liquid-Fuel Ramjet				●
	190	Ducted Rockets				●
	191*	Boron Slurry Fuel Technology			●	
	192*	Aviation Turbine Fuel Technologies				●
	193*	Lubrication System Condition Monitoring		●		
	194*	International Cruise Missile Turbine Engines			●	
	195*	Fireproof Hydraulic Systems		●		
	196*	Optical Techniques for Combustion Analysis				●
	197*	E-Beam-Controlled High-Voltage Switch			●	●
	198*	Boron Solid-Fuel Ramjet			●	
	199*	Boron Slurry-Fueled Ramjet			●	
	200*	Supersonic Combustion Ramjet			●	
	201	Integrated Inertial Reference Assembly Description			●	●
	202	Advanced High-Accuracy RLG INS				●
	203	Integrated CNI Antennas				●
	204	VHSIC				●
	205	SATCOM Terminals				●
	206	Advanced Target Acquisition Sensor				●
	207	Imaging Sensor Autoprocessor			●	●
	208	Gun-Fire Control				●
	209	Integrated Fire/Flight Control				●
	210	IR Search and Track System				●

* Denoted/classified as ET by lab

MATURING/EMERGING TECHNOLOGIES AT AFSC LABS (Cont'd)

AF UNIT	REF NO.	TECHNOLOGY TOPIC	RSCH	ET	MSET	MT
AFWAL	211	IFFN Fusion				●
	212	Missile Launch Envelope				●
	213	Expendables				●
	214	EO Countermeasures				●
	215	INEWS				●
	216*	Integrated Communication, Navigation, Identification Avionics			●	●
	217*	PAVE PILLAR			●	●
	218*	Advanced Imagery Transmission			●	●
	219*	Electronic Terrain Map System			●	●
	220*	Solid State Phased Arrays			●	●
	221*	Multifunction FLIR			●	●
	221A	Multiband Staring Sensor*			●	
	222*	Combined Sensors for Target Acquisition, Recognition, and Strike			●	●
	223*	CO_2 Laser Radar			●	●
	224*	Forward-Looking Active Classification Technology			●	●
	225*	Covert Strike Radar			●	
	226*	Multiple Target Attack Algorithms			●	●
	227	Primary Adhesive Bonded Structures Technology				●
	228	Cost Aluminum Structures Technology				●
	229	Integral Fuel Tank Sealing				●
	230	Aeroelastic Tailoring			●	●
	231	Advanced Flutter Suppression			●	
	232	Atmospheric Electricity Hazards Suppression				●
	233	Integrated Closed Loop Environmental Control System				●
	234	Long-Life Cryogenic Refrigerators				●
	235	Rough/Soft-Field Landing Gear				●
	236	Advanced Brake Control System				●
	237	Integrated Transparency System				●
	238	Flat Solid-State Pilot Displays				●
	239	Voice Technology			●	●
	240	Supersonic Cruise Fighter Technology			●	●

* Denoted/classified as ET by lab

MATURING/EMERGING TECHNOLOGIES AT AFSC LABS (Cont'd)

AF UNIT	REF NO.	TECHNOLOGY TOPIC	RSCH	ET	MSET	MT
AFWAL	241	STOL Fighter Technology				●
	242	Aero Configured Missiles			●	●
	243	Weapons Carriage/Separation Technologies				●
	244	Mission Adaptive Wing				●
	245	Automated Maneuvering Attack System				●
	246	Ground Vibration Test Technique				●
	247	FSW				●
	248*	Crew Escape Technology				●
	249*	Applied Computational Aerodynamics			●	●
	250*	Low Radar Cross Section Inlet				●
	251*	Numerical Aeromechanic Design Technology				●
	252	Nonflammablable Hydraulic Fluid				●
	253	Retirement for Cause				●
	254	X-Ray Computed Tomography				●
	255	RST Aluminum Alloys				●
	256	Semi-Insulating GaAs				●
	257	IR Detector Materials			●	●
	258	Electroluminescent Lighting Materials				●
	259	High-Temperature Composites for Tactical Missiles			●	●
	260	Reduced Vulnerability Portable Shelters				●
	261*	Ordered Polymers			●	
	262*	Iron Aluminides		●		
	263*	Ceramic Matrix Composites		●		

* Denoted/classified as ET by lab

AFOSR RECENT RESEARCH ACCOMPLISHMENTS

AF UNIT	REF NO.	TECHNOLOGY TOPIC	RSCH	ET	MSET	MT
	1	Understanding Impinging Jet Structure - Improved Laser Design		●		
	2	Computational Fluid Dynamics for Flow Around Turrets		●		
	3	New Analytical Method Model Predicts Jet Flap Thrust Recovery	●			
	4	New Mechanisms Postulated for Wake Structure Evolution	●			
	5	Understanding Drag Induced by Turbulent Bursts	●			
	6	Resonance-Related Phenomena Predicted in Dynamically Loaded Cracked Structures	●			
	7	Non-Classical Friction Model Provides More Realistic Solutions to Contact Problems	●			
	8	New Bending Theory	●	●		
	9	New Model Predicts Liquefaction from Blast Loadings	●			
	10	Seismic Behavior of Soils Found to be Independent of Transverse Loading	●			
	11	Swirl Mixing Improves Combustor Efficiency			●	
	12	Quantitative Flow Visualization		●	●	
	13	Ordered Polymers - An Advanced Concept in Composite Materials			●	
	14	Polymer Alloys			●	
	15	Short Wavelength Chemical Laser	●	●		
	16	Radar Mapping of Ionospheric Disturbance		●	●	
	17	Phase-Synchronized Non-Rigid Airborne Radar Arrays			●	
	18	Curved Chirped Waveguide Diffraction Lenses			●	
	19	White Light Fourier Transform Holography		●	●	
	20	High-Resolution Frequency-Swept Microwave Imaging		●	●	
	21	Image Motion Estimation		●	●	
	22	Laser Annealing to Reduce Waveguide Loss			●	
	23	Improved Photodiodes for IR Imaging			●	
	24	Theory of Forging		●	●	
	25	Single-Crystal Turbine Blade Material		●	●	
	26	Hot Pressed Silicon Nitride			●	
	27	Nonlinear Optical Properties of HgCdTe		●		
	28	Benzamides Prevent Chemically-Induced Cell Transformation		●		
	29	Early Indications of Latent Toxicity	●	●		
	30	Brain Response Patterns Indicate Learning Mechanism	●	●		

AFOSR RECENT RESEARCH ACCOMPLISIMENTS (Cont'd)

AF UNIT	REF NO.	TECHNOLOGY TOPIC	RSCH	ET	MSET	MT
	31	Testing of the MX Intercontinental Ballistic Missile			●	●
	32	Control of Large Space Structures	●	●		
	33	Optimal ALgorithm for Mutual Exclusion in Computer Networks	●	●		
	34	Software Quality Improvements through Disciplined Programming		●	●	
	35	Solitons in Two or More Space Dimensions	●			
	36	Fast Algorithms for Electronic Circuit Analyses		●		
	37	Precise Geodetic Measurements		●		
	38	Room Temperature Optical Bistability		●	●	
	39	Stress Diagnostic for Microelectronic Devices		●		
	40	FEL Proof of Principle		●	●	
	41	Charged Particle Access to Satellites	●			
	42	Fundamental Theory of Ion-Ion Recombination	●			

APPENDIX B

SUMMARY OF INTERVIEWS AT AIR FORCE LABORATORIES

AFWAL AVIONICS LABORATORY INTERVIEWS

A1. INTEGRATED COMMUNICATION, NAVIGATION, IDENTIFICATION AVIONICS (ICNIA)

The first major demonstration of this program will occur in the 1987/1988 timeframe. A fully operational terminal in a C-131 Test Bed will demonstrate 17 functions with about 60 modularized boards. The object here is to replace the traditional "black boxes" for each of the 17 functions with a common signal processor which may be time-shared. At the present time, the system will use existing antennas with the signals transmitted through a common data bus to the ICNIA signal processor. Although all 17 functions will be demonstrated on the test bed, particular applications may require less than the full set of functions. For example, the Army will be testing a lesser number of functions for its STAR helicopter program and the Air Force for its Pave Sprinter program (ATF).

The 17 functions to be demonstrated in the full-up version are:

- JTIDS
- Enhanced JTIDS (EJS)
- Enhanced PLRS
- HAVE QUICK
- Singgars
- GPS
- TACAN
- IFF Mark XII
- ILS
- VOR
- TCAS
- IFF Mark XV
- HF
- UHF
- VHF
- ACMI

In the ICNIA concept, all of the signal receivers reduce the signals at various frequencies to a common carrier intermediate frequency at 400 MHz. The signal processors perform functions such as spread/despread, modulate/demodulate, and signal bit and symbol processing. The data is then routed to the data processors, where communication processing (transmit/receive), navigation processing (relative nav-JTIDS/absolute nav-GPS), IFF processing, and terminal management takes place.

The ICNIA program is similar to the Integrated Electronic Warfare Systems (INEWS) program, with ICNIA probably ahead of INEWS in terms of IOC. The programs are now carried on as distinct activities with distinct program offices. In the future, however, both may be integrated into a joint program in order to exploit common signal processor technology.

The primary intention of both ICNIA and INEWS is to reduce the number of "black boxes" that have to serve the multiple functions carried out on Air Force platforms. By taking an integrated approach to avionics and EW, the various sensors and receivers on the aircraft can time-share the use of common signal processors. This approach allows for not only a reduction in weight and volume of electronic componentry, but also allows for redundancy. This has the added benefit of reliability and safety, since a faulty processor can be circumvented and replaced with one of the other signal processing modules.

As mentioned previously, the full-up system contains about 60 microprocessor boards for the 17 functions. This technology is not mission-enabling in a strict sense, but could be considered mission-enabling for certain platforms and missions given the weight and volume constraints. Traditionally, each of the functions mentioned above has required, in addition to a separate sensor or antenna, a totally independent electronics suite. Many of the advanced fighters and helicopters thus would require many "black boxes" in order to provide the full range of functions to the crew. In the constrained space of airborne platforms, however, many of these functions would not be allowed and/or would extract a significant weight penalty. Integrating these functions through a common computer contributes to mission effectiveness and survivability. In the age of spread spectrum communications, stealth, and very dense electronics countermeasures, this technology will provide a very advanced capability across many mission areas, from strategic to tactical.

ICNIA itself is a system concept, and therefore may not be considered an emerging technology. However, there are elements of this program (still a paper design) which can be identified as emerging. These include techniques for VHSIC insertion, gallium arsenide developments for the receivers, and software development and validation.

The first area of technology risk is VHSIC insertion. ICNIA relies on the inherent qualities of VHSIC and the advantages are much greater than could be achieved through current state-of-the-art VLSI. Some of these advantages include fault reconfiguration and fault tolerance. Chips should be available for the brass boards in the 1985-to-1986 timeframe. The availability of chips, however, is not guaranteed.

A second risk area is the use of gallium arsenide, particularly for the receivers. TRW is building a super heterodyne receiver, and ITT and Texas Instruments are building a gallium arsenide transversal filter receiver which digitizes the signal at a much earlier stage than traditional methods/designs. This technology is not yet proven.

The third area of risk is the software development associated with this program. The ICNIA program exists on paper only. It has yet to be implemented in a full-up system where difficulties in software development might be identified and dealt with.

In summary, ICNIA itself is not an emerging technology. As a system, risk areas involve integration and implementation.

- Military Significance - Very High.
- Possible MSET - Use of GaAs in Transversal Filter Receiver.

A2. SYNTHETIC APERTURE RADAR TARGET SCREENING AND CLASSIFICATION

One commonly thinks of a SAR imagery as a two-dimensional display of a ground image. However, there is much more information collected during a pass over ofa particular area of the ground with a SAR imaging aircraft. "Historical" data are collected, containing phase and angular information, which may then be derived from the historical record. In developing screening and classification algorithms, all of this information will ultimately be used, not necessarily to develop a two-dimensional image, but rather to derive the maximum amount of information from the data base.

Several important distinctions were made during the interview, the first being the distinction between screening and classification. Technology for screening targets in a SAR image is more advanced than those for a classification. In screening, a human interpreter tries to pick out a potential target from the SAR imagery, whether it is a truck, armored vehicle, or other object with potential military value. In the more sophisticated state-of-the-art classification process, the target is further specified as a tank or armored vehicle of a particular model or type.

Screening is now at a mature or maturing state of technology development. A demonstration for screening will occur in the 1988 timeframe from tests which were first conducted in the early 1970s. The Soviet lag in this technology is five to ten years. Classification has not matured to the point where it could be considered to have operational military utility. The first operationally valid demonstration may not occur until 1992, although there is some evidence that classification is possible via SAR imagery from experiments in 1977.

The U.S. is well ahead of the Soviet Union in terms of SAR classification. The substantial U.S. lead over the Soviet Union is partly explained by the fact that, because of deficiencies in instrumentation, the Soviets do not even possess the high resolution SAR imagery in order to do their analysis. This instrumentation seems to be a very critical element in the development of screening and classification. Without an adequate data base, the scientist or engineer cannot develop the algorithms or software for automatic screening or classification.

In terms of military impact, this technology is mission-enabling in tactical air warfare for low-altitude high-speed passes over the target field. SAR imagery is collected and displayed in near-real-time; in real-time, it is difficult for human interpreters to identify targets which are well hidden in the ground cover. When the information gained through SAR imaging is converted to displays for human interpretation, much of the information is lost. For example, the actual imagery information has a dynamic range of 90 dB, but the conversion to display drops the dynamic range to 30 dB. Human factors is a major issue in terms of the mission impact, since the human interpreter cannot absorb and process sufficient amounts of information (given the timeframe available) in order to make screening or classification decisions.

Apparently, there is little or no commercial application for these technologies. There is a well-developed security classification guideline for publication of papers. All DTIC publication requests are routed through the project office. Target classification algorithms are SECRET. Basic work involving electromagnetic scattering and modeling is in progress at Ohio State University. Everything in this arena is now unclassified, since it is not coupled directly with the military application. Low cross-section radar work at the Ohio State University, however, is tightly controlled by the Air Force contract monitor.

In summary, the topic of SAR screening and classification should be considered an emerging technology, especially the area of classification. It also should be considered a militarily significant emerging technology since the utilization is fairly pervasive and is mission-enabling in certain aspects.

- Military Significance - Very High
- MSET - SAR Classification

A3. IMAGING SENSOR AUTOPROCESSOR

The Air Force has contracted with Rockwell International and Honeywell in this work. Rockwell's work is more mature than Honeywell's because a VLSI-scale breadboard was demonstrated in 1984. This breadboard used

Motorola 68000-level integrated circuitry and was able to operate at a rate of 200 MOPS.

The Honeywell design for inclusion of VHSIC technology is to be completed in 1985. A breadboard implemented with VHSIC chips will be demonstrated in the fourth quarter of 1986 with validation in the first quarter for 1987. This breadboard is designed to operate at a rate of 3.2 BOPS. The program is also designed to be integrated with the ATAS sensor, a second generation FLIR sensor with technology insertion in systems in an 1988 to 1989 timeframe.

Certain aspects of this imaging sensor autoprocessor are mature at this point. However, many of the technologies required to exploit the full system potential should be considered emerging. When the system is fully operational, it is expected to work better than a human being in extracting FLIR information <u>in all cases</u> by the mid-90s. Actually, the system can now work <u>in specific areas</u> better than a human. In a short time-line search, for example, the system is able to pick out a tank in the field of view within 0.1 second as opposed to 5 seconds, the human reaction time. At the current state of the art the system, although faster, is not as accurate as a human interpreter.

The autoprocessor is mission-enabling in the sense that target screening and classification is very highly time-critical. In most of the scenarios concerning a low altitude pass by an aircraft over a target area, the pilot simply does not have the time to acquire, define, and target specific objects on the battlefield. The LANTIRN project officer is interested in acquiring this imaging sensor autoprocessor. The Rockwell work, which slightly lags the Honeywell work, has demonstrated the capability, but is cumbersome to use. For example, season and scene dependent algorithms need to be loaded into the memory before the autoprocessor will perform for specific environments. With scale up to higher processing powers and with the use of artificial intelligence, the Honeywell system is designed to work under all conditions and environments of season and scene characteristics. The AI techniques used by Honeywell will, in other words, make their system scene independent and able to work in many scenarios.

This technology development could continue for 15 or 20 years. At its current stage, the system would be useful if exploited, but its maximum utility will emerge in later developments. Currently, an autoprocessor can be used as a cueing device, but not as a target identifier or classifier. The current technology allows a pilot to discern some object on the battlefield, but it is not able to define the object specifically as a target of military significance.

The Soviets appear to be at least five years behind in this technology. They know it is useful and they are concentrating on algorithms and hardware integration, but their level of microelectronic manufacturing skill lags far behind the U.S. Tight security guidelines are written for this area of technology.

The autoprocessor is a system development which has high military value. Since it is a system development, it is not identified as an MSET as such, but relies on breakthroughs in other areas considered emerging (AI, software developments, algorithms).

- Military Significance: Very High.

- MSET - None Identified as Such, Depends on Other MSETs
  (e.g., Artificial Intelligence)

A4. MULTIFUNCTION FLIR

This program is aimed at combining the target acquisition function and the pilotage function of the forward-looking infrared into one package. In the LANTIRN system, for example, each of these functions remains distinct and is carried in separate electronic packages. This hardware development program establishes feasibility and a design. It is currently at the 6.2 program level. Martin-Marietta and Texas Instruments are involved in this development.

The target acquisition function is a very high resolution (2° by 2°) image and the pilotage function is a much larger field of view (26° by 20°). The FLIR performance in the current design is considered current state-of-the-art in terms of resolution and sensitivity. The innovation is the combining of the two functions in one package. In the current design, there are two telescopes, but only one focal plane with interleaving frames. Switching is an innovation using a 10-inch aperture with a 13-inch sensor. It is not necessarily advanced technology, but it is using a different packaging concept and developing a design which has not been used before. The program is slated for a full scale breadboard demonstration in FY 87; however, it will not be a "flyable" system with algorithms.

The Soviets have current developments in target recognition. Passive ranging is also described in the open literature. They do not have, however, the degree of sophistication in stabilized focal plane arrays at the VLSI level. In terms of military impact, there are aspects of this technology which are mission-enabling. In the case of target acquisition, the same arguments hold true as were described previously for SAR Imagery and for the Image Autoprocessor. That is, in a tactical warfighting situation, the pilot often does not have time to identify and target particular objects on the battlefield. The driver for using IR in the pilotage function is the requirement for stealth and reduction of the observables on an aircraft. Previous terrain-following systems rely on radar emissions which are detectable by air defense forces. In this system, the pilotage function is completely passive since it depends on the use of a forward looking infrared system.

Although developing this system has high military value, a unique technology development outside of the basic FLIR FPA does not seem to exist.

- Military Value: High.
- MSET: None Identified

A5. COMBINED SENSORS FOR TARGET ACQUISITION RECOGNITION AND STRIKE

This program has been cancelled.

A6. FIBER OPTIC GYRO

The main driver for the fiber optic gyro (FOG) is the need for lower cost navigation (to replace the ring laser gyro). The current standard for navigation is 0.01 degree per second for tactical navigation. Although the cost of fiber optic gyros is expected to be 1/3 that of ring laser gyros, the accuracies achieved by FOGs are nowhere near the standard. Current off-the-shelf FOGs possess a 10-degree-per-hour accuracy according to McDonnell Douglas with somewhat better accuracy possible in 1985. McDonnell Douglas projects accuracies of 1 to 0.1 degrees per hour in the near term.

Technology developments affecting FOG center in freqeuency shifters and integrated optics. McDonnell Douglas uses a bulk optical approach (with opto-acoustic modulators required for high power). An interesting development involves the use of frequency shifters that are based on a changing index of refraction in the fiber optic caused through the application of physical force.

A drive toward a totally monolithic FOG is emerging. In such a system, the frequency shifters, the couplers, and the detectors are all mated to a monolithic substrate. Development of integrated optical FOGs may be inhibited by the inability to produce low-loss fiber channels in a monolithic chip. FOG accuracy is highly dependent on the quality of the fiber optic. Single mode fibers, for example, are now very costly to produce, but are required in order to gain the accuracies for the standard.

Fiber optics may be pressured by the need for low-cost large-scale production of navigation systems for tactical missiles (rather than for manned aircraft). FOGs employing current technology are not able to approach the accuracies of ring laser gyro, which are becoming the standard for tactical aviation. Accuracy requirements for missile guidance, however, is very different. Missiles may only require an accuracy of 10 degrees per hour -- much less than the aircraft standard of .008 degree to .001 degree per second.

Still, there are other alternatives and competitors to fiber optic gyros for missile guidance. Currently, low-cost gyros using plastic are under development. These gyros can achieve .1 to .05 degree per hour and also operate in a severe environment.

In summary, fiber optic gyros could be competitors to ring laser gyros for navigation; but, their accuracies are nowhere near those of RLGs at the present time. Even if accuracy improvements are achieved, the cost reduction may not be significant enough to compete with ring laser gyros. In the case of missile guidance, current off-the-shelf FOGs have sufficient accuracy for a mission, but other alternatives are more accurate and can be purchased as cheaply. Finally, the most desirable technology from a military point of view might be the integrated optic FOG. Since some of the technical and engineering problems have yet to be overcome, this may be considered an emerging technology at present. FOGs at the 10 degree per hour accuracy could now be considered a mature technology. FOGs at the 1 degree per hour accuracy could be considered as maturing. FOGs at the .01 or less degree per hour accuracy should be considered as militarily significant and emerging.

Great Britain and France are equal to the U.S. in production of fibers. The Japanese lead in the development and production of solid state laser diodes and detectors. Soviet developments lag the West by several years and this is partly due to the fact that they are having trouble producing single mode fibers. Great Britain, France, and Japan could be comparable to the U.S. in FOG developments. There is a large amount of information in the open literature, including an abundance of new ideas and concepts which are not able to be implemented because the state of technology (sources, detectors, fibers) is not at a stage of development to support FSED.

- Military Significance - Very High, Pervasive Application
- MSET - Monolithic Fog

A7. ADAPTIVE GOAL SEEKING ELEMENTS OF NEURAL NETWORKS

This research is aimed at understanding learning mechanisms with an experimental design that is wholly different from current state-of-the-art. Currently, the greatest percentage of work in neurobiology focuses on brain function as analogous to a von Neumann structured computer. In this program, investigators are looking at the brain and the firing of neurons as a very highly parallel process, where the brain is actually engaged in many tasks simultaneously, with consciousness focusing on only one or a few elements of that processing. The program is based on a rather speculative theory that is being pursued by the investigators because of its implication for artificial intelligence research.

This research is very basic in nature and should not be considered either an emerging technology or an MSET at this point. It is clearly in a 6.1 stage of development.

- Military Significance - Potentially High, Speculative
- MSET - None Identified

A8. AIRBORNE IMAGERY TRANSMISSION (ABIT)

This project is aimed at developing a secure data link for over-the-horizon communication near and beyond the FEBA. Its military utility is clear in most scenarios concerning near-term future battle. With the development of highly sophisticated air defense systems by the Soviets and Bloc countries, the ability to penetrate enemy territory with manned aircraft is becoming more difficult.

To deploy over enemy territory, the aircraft must traverse the territory in a very fast profile. Systems such as FLIRs and SARs require very high processing data rates and data linkages for command and control. When a friendly aircraft is over enemy territory, high bandwidth communication is made difficult because of jamming. In order to maintain low-probability-of-intercept data links together with antijam and wideband capability, the technology is driven to line-of-sight high-frequency communication at Ku band (13-15 GHz).

This system is aimed at providing this wideband antijam communication over a 200 to 300 mile line-of-sight link based on transmission to a high-flyer aircraft, behind the FEBA. In other words, a friendly aircraft would beam its signal up to a high-flying relay aircraft over the FEBA which would then retransmit the signal down to the data station in friendly territory.

This system is adaptive because it can transmit higher data rates in a non-jamming environment and lower data rates in a jamming environment. For example, 274 megabits per second is achievable in a jam-free environment, but 150 kilobits per second is required in order to achieve 20 to 30 db of jam resistance.

Discrete data rates can be achieved with a spread spectrum of 1 kHz. The optimal achievable rates are 300 megabits per second information with 50 db of jam resistance. This system is to undergo a flight test in 1990.

The technology issues here are the very high data rates and the pointing and tracking required to engage the other aircraft. Since this system is trying to achieve low probability-of-intercept at high frequency transmission, the antennas are structured to provide a very small radiation cone. When two aircraft are trying to engage each other at relative speeds between Mach 1 and 2, remaining silent, they have difficulty in locking up to each other with very narrow beams (several degrees). This connection is easy to achieve with cones in the area of 15 to 18 degrees beamwidth. However, wider beam patterns are more vulnerable to jamming.

Along with other programs under consideration, this program is basically a system development with fairly mature technology in the near term. For future requirements, however, such system developments will require very advanced technology. High data rate antijam communications links were cited as one of the 17 top technologies by the 1981 DSB Summer Study. Therefore, from a military point of view, this development is rated as very highly significant, especially for emerging tactical applications such as in the use of multiple beams for guidance and control of several RPVs over enemy territory. From the perspective of emerging technologies, the current program is not considered an emerging technology. However, for more advanced systems, including the use of multiple agile beams, the system developments may require use of emerging technologies such as very advanced onboard signal processors, networking techniques, and system architecture.

- Military Significance: Very High.
- MSET: None Identified as Such, Relies on Development of Other Technologies.

A9. FOCAL PLANE ARRAYS

Some aspects of this technology area are mature, others are emerging, and some developments still are in basic research. All Services are currently working on two-dimensional arrays to increase sensitivity and resolution. For space applications, arrays have been demonstrated in the region of 8 microns or greater with tactical applications focusing on developments in the 3-5 micron region.

Efforts are also underway to reduce the low temperature requirements for FPAs (development of background limited IR devices at 77°K). Part of the technology for focal plane arrays is dependent upon manufacturing technology and keystone equipment which is normally used for integrated circuit manufacture. For example, in the 1977 and 1978 timeframe, technology was available for the development of 1-micron spacing in integrated circuitry (IC). The capability in IC manufacturing, however, does not usually need to translate into the same chip dimensions for focal plane arrays. Focal plane arrays require much more circuitry in order to handle the very high dynamic range per pixel required for imaging. Very high dynamic ranges are necessary for applications where the background is highly radiative, as is the case with a sensor looking at the earth. Searching for a faint target against a very high background requires a high dynamic range and thus, a very high throughput.

Technology at 5 micron or less is maturing faster than that at 5 micron or above. Due to the rationale given above, the higher-micron-region focal plane arrays require more circuitry and need to be larger in size.

There are more steps required in the manufacturing process of fabricating focal plane arrays than are required for the manufacture of integrated circuits. A nominal semiconductor requires 6 to 8 steps for production, but focal plane arrays require approximately 12 to 15 steps for detector manufacture. As focal plane arrays grow in size, there is a need to produce hybrids since the chip limit is reached in the vicinity of a 256 x 256 pixel FPA. A 128 x 128 FPA is the upper limit of the current state of the art.

There are detailed classification guidelines for focal plane arrays. The Army and the Air Force differ on some aspects, however, the Air Force guidelines are mainly concerned with classification of information with less emphasis on the classification of hardware. The Army's classification guidelines also classify hardware.

- Military Significance: Very High. Pervasive.
- MSET: FPAs with On-chip Signal Processing (Higher Risk for 8 Micron and Greater.)

A10. ACOUSTO-OPTIC SPECTRUM ANALYZER

Miniature bulk and integrated optic technologies are being pursued in this area. A miniature bulk device consists of a bulk crystal with a laser source and a line array detector. The semiconductor laser operates at .85 micron. The Air Force is funding the development of an electro-optic channelizer which divides light into different frequencies. A demonstration is scheduled for the 1987-1988 time period which will show the potential for an E-O receiver. The Air Force program is aimed at producing a 500 MHz analyzer with 2-5 MHz resolution. Multiple modules are stacked together in order to gain larger bandwidth. The Navy is currently pursuing a 250-500 MHz analyzer with a resolution of 10 MHz per channel.

Evolutionary developments in Bragg cells may result in a 2 GHz bandwidth which is a factor of 4 times the current state of the art. Technology developments will occur in two areas: Bragg cell materials and transducers. The bandwidth limitations are dependent on thickness and width of the transducer fingers which drive the bulk crystal. These devices are being developed for optical processing, signal correlation, and code generators.

The Air Force is funding work at Hughes and the Navy at Westinghouse for integrated optic technology. Production of very small waveguides which would allow parallel signal processing without crosstalk (small signal next to a large signal) has been problematic. The crosstalk caused occurs in the 35-40 db separation range. There are problems in trying to achieve a 60 db separation between signals.

The goal of this approach is to achieve very large bandwidths with a large number of channels operating, for example, between 2 GHz and 18 GHz. The miniature bulk device is being developed for availability in 1987 for INEWS. Substantial work is needed to get a 2 GHz bandwidth which is 4-8 times current state of the art. Also under development is the integrated optic channelizer.

The militarily significant emerging technology is the development of small spectrum analyzers with instantaneous spectral analysis in a very dense electromagnetic signal environment. Although many elements of this technology at this stage are mature, integration of these technologies into a system at this time does not allow for a militarily useful analyzer. Thus, the technologies required to field a militarily useful system are still in an emerging stage, especially the integrated optic technology.

- Military Significance - Very High
- MSET - Integrated Optics Signal Processor

A11. HIGH-TEMPERATURE PHOTOCONDUCTIVE HgCdTe TELLURIDE DETECTORS

This effort was aimed at developing a detector for a heterodyne receiver in a laser radar application. The technology development is aimed at increasing resolution and sensitivity and at increasing the temperature of an operation to a level where thermal coolers are operating. This development includes reduction of defects and increased quantum efficiency.

Liquid nitrogen temperature detectors and even arrays are currently a mature technology. Thus, these detectors should be considered a maturing technology and not an emerging technology.

- Military Significance - Potentially High
- MSET - None Identified

A12. SOLID-STATE PHASED ARRAY TECHNOLOGY

This program is oriented to identifying military applications which depend upon the development of monolithic microwave integrated circuits. Although one might consider solid state phased array technology as an emerging technology, it would be more appropriate to characterize the development of microwave integrated circuits, especially the gallium arsenide-based monolithic integrated circuits, as the emerging technology as it is a critical element in developing solid-state phased arrays.

- Military Significance - Very High
- MSET - MMICs, Especially GaAs

A13. MONOLITHIC MICROWAVE CIRCUITS

The goal of this program is to develop a microwave technology for the 2-20 GHz region for both communications and radar, focusing on materials development and device parameters. Yields are anticipated to be as low as 30 percent.

Therefore it would take a great number of devices to produce a small number of amplifiers. Power is in the range of .5 to 2 watts with discrete FETs at 8 watts. CAD/CAM design rules are not fixed, but efforts are aimed at trying to produce devices at the 5 micron level of integration.

AVANTEK (the leader in small commercial devices), TI, Raytheon, Hughes, Rockwell, and Westinghouse are involved in this work. Unlike the VHSIC program, there are not many uniquely different devices on the market. Most of these companies have pilot production capability, processing possibly 10 to 20 designs. Manufacturing technology in gallium arsenide is difficult. Companies are likely to openly publish performance data of their devices, but not the know-how required for manufacturing. This situation is healthy since there is a competitive international market for these devices (Plessey, GEC, Thompson CSF). Japan is considered the leader in gallium arsenide.

- Military Significance - Very High
- MSET - High Purity Materials, Device Development.

A14. MULTI-TARGET ATTACK ALGORITHMS

- Current fire-control systems handle only one target (or target cluster) per pass of aircraft. Multi-target attack algorithms (MULTAK) will handle 3-10 targets per pass.

- Now 6 months into 6.3. Working toward 1987 6.3 demo.; 1990 IOC in tactical aircraft.

- ELEMENT #1: Algorithms MT

    - New application of existing technology
    - Numerical optimization techniques
    - Algorithms have no non-military appeal
    - Algorithm publications UNCLASSIFIED RESTRICTED ACCESS

- ELEMENT #2: Data Fusion MT

  - Fusion of data from radar, CO_2 laser radar
  - May require 20,000 lines of High-Order Language (HOL) source code

- ELEMENT #3: Simulation MT

  - 6.2 simulation was non-real-time, sequential target attack for 4 targets
  - 6.3 simulation will work toward real time with man-in-the-loop
  - Simulation results CLASSIFIED

A15. CO_2 LASER SENSOR TECHNOLOGY DEVELOPMENT

- This project is concerned with the development of a breadboard multi-functional CO_2 laser radar for target detection, cueing, and 3-D target classification.

- Now 6.2. Transition to 6.3 in 6 mos. (6.3 demo within 3 years for system.) However, aspects would be pulled off earlier for other uses, e.g., to augment FLIR (weapon guidance, target acquisition, obstacle avoidance.)

- ELEMENT #1: CO_2 Laser MT

  - Waveguide lasers developed 1972-1980
  - 40 W now, 100-200 W 1989 (CW)
  - Driver for increasing power is countermeasures & weather

- ELEMENT #2: Tests MT

  - Tower and field tests now
  - Flight test in C-130 in 6.3 within 3 years

A16. FORWARD LOOKING ACTIVE CLASSIFICATION TECHNOLOGY

- This project demonstrated a forward-looking 3-D sensor/processor target classification system. CO_2 laser breadboard, rooftop and flight data, and automatic target classification algorithms were program elements.

- Publications CLASSIFIED or RESTRICTED ACCESS

- This 6.2 project (FLACT) was terminated in FY83. The 6.3 follow-on (FY84-88) is called Automated Laser Target Classification.

A17. INTEGRATED INERTIAL REFERENCE ASSEMBLY

- Two assembly clusters (gyro plus accelerometer) are used in aircraft for redundancy, and hence, survivability. The system is to provide flight control and navigation. It is not possible to place the clusters in optimum locations. Software must therefore be developed for fault detection and isolation.

- 6.3 program. Two candidate designs. Will settle on one design and produce brassboard in Oct 87. Only obstacles are programmatic.

- ELEMENT #1: Hardware MT

  - Existing hardware could be used
  - RLG and VHSIC could enhance system

- ELEMENT #2: Software MT

  - Fault detection and isolation software
  - No risk for 3-axis systems
  - Some risk for 4-axis system

A18. INTEGRATED TERRAIN ACCESS/RETRIEVAL SYSTEM (ITARS)

- ITARS is the follow-on to ETMS and AETMS. ETMS read and displayed DMA data. AETMS is a delivered, operational, militarized system to provide plan, perspective, and HUD displays in real time. ITARS will provide 3 views simultaneously and provide data to 6 users simultaneously.

- Much AETMS work is in the open literature. May '84 was cutoff for release to general public.

- Now 6.3. Transition to 6.4 in 3-18 mos. Flight test in Jan 87.

- ELEMENT #1: Data Storage/Retrieval MSET

  - Optical disc or semiconductor storage
  - 400-600 MB

- ELEMENT #2: Software MT

  - Large array addressing
  - Total integrated set of tools (debugger, editor, etc.)

A19. PILOT'S ASSOCIATE PROGRAM

- Pilot's Associate is an expert system that will manage and integrate sensor data, present combat information to the pilot for his decision, and possibly recommend tactics.

- DARPA-funded 5-year program as part of Strategic Supercomputing Initiative. 6.2 will transition to 6.3 upon successful laboratory demonstration.

- ELEMENT #1: Expert System Methodology (AI) MSET

  - Need for large-scale real-time system
  - Knowledge base and decision rules

A20. ADAPTIVE TACTICAL NAVIGATION

- This project will concentrate on aircraft navigation, and the presentation of that information to the pilot. It will include speech recognition, but not synthesis.

- 6.2 program ending in FY88 with lab demo.

- ELEMENT #1: Expert System MSET

  - Sensor management in real-time
  - Knowledge base and decision rules

A21. VHSIC PHASE II

- This project is the submicron program planned to extend for 4 years beginning Oct 84.

- Little commercial push to develop VHSIC below 0.5 micron feature size. VHSIC Phase II will meet military needs only.

- ELEMENT #1: Lithography MT/MCT

  - X-ray or Scanning Electron Beam
  - Perkin Elmer now has electron beam (EB) equipment capable of required throughput
  - Can use EB to make mask for X-ray

- ELEMENT #2: Etching MT/MCT

  - High-resolution dry etching equipment not readily available
  - Multi-level resist technique required

- ELEMENT #3: Design rules (CAD) MSET

  - 4-level metal required in Phase II
  - Requires hierarchy and integrated data base
  - VHSIC Hardware Descriptive Language will be Government-owned, but available to contractors; it may become IEEE standard.

A22. GaAs TECHNOLOGY

- This project investigates basic materials and process development problems. Objectives: low defect density, large wafers, high yield.

- 6.2. program. Publications UNCLASSIFIED RESTRICTED ACCESS. (Classified when results incorporated in system.) Air Force researchers publish results, not know-how.

- ELEMENT #1: Growth Techniques MSET

  - Basic compound synthesis
  - Magnetically-assisted growth

- ELEMENT #2: Process Development MSET

  - Dry processing (plasma processing)
  - Equipment available; not everyone has it.

A23. MODULATION DOPED HETEROJUNCTION TRANSISTOR

- This project investigates basic materials and process control problems.

- 6.2 program. Now at 4X4 multiplier (SSI) stage.

- ELEMENT #1: Growth Techniques MSET

  - Molecular beam epitaxy (MBE) equipment available from two U.S. and one French companies.

- ELEMENT #2: Process Control MSET

  - Mono- and multi-layer control required.

A24. GaAs MMICS

- This project focuses on correlating materials and device parameters to build devices. (See RADC for circuits and testing.)

- AFWAL publishes results, not know-how, as do U.S. companies. U.K. companies (Plessey, GEC) talk applications.

- Transmit/receive (T/R) modules are 4-5 years from realization.
- ELEMENT #1: Materials MSET
- ELEMENT #2: Design rules MSET
  - Few or no design rules (5 micron)
- ELEMENT #3: Process MSET
  - More difficult than digital IC
  - Must do "backside" processing while maintaining impedance of microstrip circuits

AFWAL AEROPROPULSION LABORATORY INTERVIEWS

B1. ADVANCED GALLIUM ARSENIDE SOLAR CELLS

The first flight of a gallium arsenide solar-powered system took place in February 1983. The system was developed by Hughes as a demonstration experiment. Efficiency quoted at that time was 16-18 percent with an equivalent down-sizing of the area of the solar panel of 50 percent. The gain in efficiency impacts more the size of the solar panel rather than its weight since the increased efficiency GaAs cells tend to weigh more per unit area than older silicon technology. Regarding other factors, the improvement over silicon cells is about 30 percent in terms of both volume and weight. The Japanese may fly gallium arsenide by the end of the 1980s using the same manufacturing techniques (liquid-phase epitaxy) as Hughes.

The solar array makes up roughly one third of the weight of the whole power system, with one third of the weight constituted by the battery, and the remaining third by the power control electronics. Gallium arsenide solar cells, with the efficiency cited above, should be considered mature technology.

New developments in this area concern the use of concentrators with gallium arsenide in order to produce hardened solar cell power for military spacecraft.

- Military Significance - Moderate
- MSET - None Identified

B2. MULTI-BANDGAP SOLAR CELLS

DoD, DoE, and NASA are all looking at multi-bandgaps, but have different designs based on the different and unique needs of each of these agencies. In the multi-bandgap solar cell, a number of solar cells are stacked on top of each other, each one responding to a different part of the energy spectrum.

There may be a demonstration of this technology within the next five years. In a laboratory development phase, this technology awaits a better understanding and implementation of tunnel functions which allow several solar cell layers to be interconnected electronically.

Experiments conducted to date connect the various layers electrically through contacts and conductors. The ideal situation is to electronically couple the various layers through the tunneling process, achieving an efficiency in the range of 25-30 percent. If, however, the tunnel mechanism does not work, there is still a fallback to a stacked electrically-connected array with an efficiency of approximately 22 percent. A laboratory cell will be demonstrated in two years, with pilot production possible by 1989. A full-scale model for actual flight could occur in the early 1990s. There is essentially no foreign work on multi-bandgap solar cells. Their first use will probably be in a hybrid structure.

These ongoing programs are now aimed at hardening both collectors and reflectors, and the solar cells themselves. These developments, however, are more in the line of system design architecture and do not constitute a large increment in the technology itself.

Concentrator solar cell technology is being developed for orbits in which radiation belts are a problem. These solar cells, therefore, are mission-enabling in the sense that satellites operating in the van Allen belt could have extended life without degradation of the solar panels. There is no evidence that the Soviets are working on concentrators, although they might have flown gallium arsenide on some missions.

The drive for higher-efficiency solar cells is particularly relevant in those cases where the spacecraft does not allow increased area dedicated to the solar cell but, nonetheless, requires more power.

Solar cell efficiencies of 22 percent seem to be achievable over the current 12-14 percent efficiency. A 30 percent efficiency could be obtained by pushing the state of the art and would be highly desirable. It would represent almost a twofold increase over current state-of-the-art technology and would be very desirable from a military point of view. With these cell efficiencies, the solar panels could be reduced by one half with important residual effects. There is less drag on a spacecraft with smaller solar panels, with innate advantages if a satellite is in orbit for months or years.

- Military Significante - High
- MSET - None Identified

B3. VERY HIGH POWER LITHIUM RESERVE BATTERIES FOR MISSILE APPLICATIONS

Advanced thermal batteries used for missile electrical power are listed in the MCTL. They are not an emerging technology. There are, however, new developments in lithium technology which may allow for the development of primary reserve batteries with electrical power densities ten times that of current batteries. Lithium chloride is one such candidate. Lithium chloride is a high temperature battery with a power density of 16 Amps/cm^2 at 2.5 volts, which is much higher than the standard silver zinc or other reserve batteries, 1-2 Amps/cm^2 at 1.25 volts.

The requirement for higher energy density for missile batteries is clear. In an age of stealth and reduced cross sections, future air-to-air missiles with active radar will require much higher power in order to detect targets at minimal ranges. This is due to the fact that with lower cross sections the active seeker requires a much higher power to compensate for lower-cross section power proportional to $1/R^4$. Advanced batteries may be considered an enabling technology in future missile guidance seekers. Lithium chloride batteries capable of achieving 40 watts/cm^2 is still in early 6.2 developmental research and could be considered an MSET.

Lithium thionyl or sulfuryl reserve batteries are further along in development, but are achieving higher rates than previously achieved. Also further along in the developmental stage are lithium batteries for low level drain.

These batteries are being developed as very large batteries for missile silos in the use of emergency power in case the external power supply is cut off.

In summary, most military applications up to this point, have required all thermal batteries or silver-zinc batteries for primary reserve batteries. Silver-zinc batteries are able to achieve relatively high current density from 5 minutes to 10 hours, also a requirement for specific military applications. Up to now thermal batteries have been able to achieve high current densities for only a few minutes. However, the development of thermal lithium batteries allows reserve power up to one hour and wet lithium thionyl chloride from one to two hours. Thus, lithium technology is allowing primary and reserve batteries to achieve rates and times across a full spectrum of military applications.

- Military Significance - Very High
- MSET - Lithium Thermal Batteries

B4. ADVANCED SECONDARY BATTERIES

Lithium ambient temperature rechargeable batteries are now being developed as candidates for missile silos to replace lead-acid batteries. 6.2 work in this area includes $LiTiS_2$, $LiMOS_3$, LiV_2S_5, and other electrochemical couples. These batteries are not in use now, but could be in use over the next five years. Lithium secondary technology can be considered an MSET. In the satellite application arena, thermal batteries such as sodium-sulfur may be used as the next generation of power system. Sodium-sulfur promises to achieve power densities well above those currently available in the range of over 100 watt hours per pound. Current systems are able to achieve current densities in the 15 to 20 watt hours per pound. Experimental devices have shown excellent results at Wright-Patterson with cells running for 18 months. Those devices on test now for 18 months have achieved 500-600 cycles which represent six years life in geosynchronous orbit.

High temperature battery technology is currently being developed not only in the United States, but also in Great Britain, with developments possibly ahead of those in the United States. NASA is not currently active in this area, although the Navy has shown some interest. IOC for thermal batteries may be in the mid to late 1990s for geosynchronous orbit. Sodium-sulfur may still have some problems for satellite usage since they need to be launched cold (vibration could damage sensitivity elements if the sulfur were in a molten state during launch).

- Military Significance - Moderate to High
- MSET - Lithium Secondary Batteries

B5. BORON SLURRY TECHNOLOGY

Boron is used as a highly energetic material in fuels to extend the range of turbojets/turbofan-powered missiles. The boron slurry cycle is well understood. However, there are still problems in the design of a device for combustion of fuels containing boron. There is a requirement to properly expose the boron to combustion in order to extract maximum energy from the fuel. Various coatings and combustion catalysts have been developed in order to burn the boron at high pressures. Current programs include 6.1 particle research involving investigations of oxide coatings and methods or techniques for burning off coating during combustion. There are also 6.2 program studies of ram-jets.

The technology of boron slurries is primarily military, with little or no civilian application. The processing techniques for making the powders, slurry formulations, and other processing techniques are proprietary, with some aspects classified. Slurry research is being conducted at Atlantic Research, with engine research and development concentrated at United Technologies. In the international area, boron powders are being developed by Stark in Germany. The Soviets have a large effort in boron fuel technology.

In terms of military significance, boron fuels have a potential for increasing capability 25 percent to 100 percent over hydrocarbon fuels. This increase in capability, when translated into range, makes this technology mission enabling for certain missions. With longer range cruise missiles, the cruise missile carrier is able to stand-off further from the target and thus increase its own survivability.

- Military Significance - Very High
- MSET - Fuel Development, Engine Development

B6. BORON SOLID FUEL PROPULSION

Whereas boron slurries may be used more for strategic applications, solid fuels containing boron may be useful in the tactical arena. In these applications, the boron would be contained with binders in a solid ram-jet configuration, with the boron additive increasing the overall energy density of the fuel. The propellant with the boron solid component could be designed with different fuel densities in order to alter thrust with different phases of flight if this were required by the operations of the mission. With liquid fuels, such as the boron slurry, various intensities of thrust can be achieved by moderating the flow of the liquid fuel. In solid fuel, a predetermined thrust profile would have to be designed into the solid propellant.

Boron has not been a major competitor relative to other fuels, principally because it has a less well-established technology base. With the emergence, however, of longer stand-off ranges in missiles, emphasis may shift toward boron simply because the mission cannot be accomplished with the energy densities provided by hydrocarbon-based fuels.

- Military Significance - High
- MSET - Boron Particle Design, Curing

B7. INTERCONTINENTAL CRUISE MISSILES TURBINE

This program exploits advanced technology in order to achieve an intercontinental range in cruise missiles. Since much of this work is classified, minimally at the Confidential or Secret level, it will not be treated in this discussion. Some of the technologies to support this program are discussed elsewhere, but will not be identified here.

B8. LUBRICATION SYSTEM CONDITION MONITORING

In this concept, fluids on board an aircraft are continuously monitored by an electronic device, similar to a laboratory spectrometer. It is primarily an early warning device for engines which are under high stress. It is also predominantly a military development since commercial aircraft fluid monitoring does not now require this level of sophistication. Most engines at cruise speeds do not encounter the degree of wear or stress as that encountered, for example, by a fighter aircraft. Excessive wear is caused by high cycle life and the type of engine trottling encountered in an operational mission profile. This high stress life, coupled with military engine design which is highly optimized for performance, leads to accelerated deterioration, even within one sortie. This high stress environment means that an engine could degrade even to catastrophic failure without significant tell-tale signs prior to the sortie.

This technology would be particularly advantageous for Soviet designers for the following reasons. U.S. engines are designed for very long cycle life. Soviet engines have a much shorter mean time between failure, owing in part to emphasis on low-cost engines and a less-developed technology base for turbojet engine design and production. Soviet aircraft, on a per sortie basis, would experience catastrophic failures at higher frequency than would comparable U.S. aircraft. If the Soviets were able to develop, therefore, small portable devices to monitor engine degradation, their catastrophic failure rate could be decreased substantially.

A flight-weight liquid lubrication monitor will be ready for demonstration at the end of FY 87 or early FY 88. Although the program is still funded under 6.2, the nature of the project is more like those programs monitored under 6.3 category. The current device is being implemented with x-ray fluorescence. Soviets do oil analysis on virtually every sortie at the present time. There would be a strong incentive for capturing a U.S. unit for purposes of reverse engineering. This development is primarily a design concept and does not embody unique technology. Therefore, it is not considered an emerging techology in the strict sense, but rather an emerging design concept.

- Military Significance - High
- MSET - None Identified

B9. E-BEAM HIGH-VOLTAGE SWITCH

- This project is developing an opening switch for inductive energy storage schemes. In the switch, electrons are removed from the plasma to shutoff the discharge.

- Program (6.2) now CONFIDENTIAL. Want to declassify. Similar work has been published in USSR; now less is being seen.

- ELEMENT #1: Plasma Dynamics — R

    - Theory

- ELEMENT #2: Switch Design — MSET/MT

    - Now 5 kA; want 50 kA

B10. NON-FLAMMABLE HYDRAULIC SYSTEMS

- This project is developing mechanical components for fireproof hydraulic systems. Fluids are being developed in Materials Lab. Heavier, two-component fluid requires high-pressure motors, valves, etc. A possible variable pressure system would be enabled by microprocessor.

- 6.2 program transioning to 6.3 in FY86.

- ELEMENT #1: Electro-hydraulic Motors MT

  - High-pressure systems are lighter weight, smaller.
  - May enable thin-wing design
  - Commercial interests

- ELEMENT #2: Variable Pressure System MT

  - Pumps, sensors
  - Microprocessor-enabled

B11. HIGH-PERFORMANCE TURBINE ENGINE INITIATIVE

- The purpose of this project is to develop a high-performance turbine for the 1990's.

- Goals/objectives are CLASSIFIED. Design concepts UNCLASSIFIED RESTRICTED ACCESS.

- ELEMENTS:

Compressor	MSET/MCT
Combustor	MSET/MCT
Turbine	MSET/MCT
Fuel	MSET/MCT
Lubrication	MSET/MCT
Bearings	MSET/MCT
Cycle Modelling	MSET/MCT
Testing	MSET/MCT

B12. AIR-LUBRICATED FOIL BEARINGS

- This project is investigating foil bearings for small engines to enable high-altitude high-speed cruise missiles.

- 6.2 program.

- ELEMENT #1: Modeling R

  - Integration of elasticity and hydrodynamic models

- ELEMENT #2: Design and Test MT

  - For radial and thrust loads, small engines

AFWAL FLIGHT DYNAMICS LABORATORY INTERVIEWS

C1. AERO-CONFIGURED MISSILES

Traditionally, missiles and platforms have been developed as separate entities from an aerodynamic point of view. That is, each system is optimized for its own mission with the missile generally fixed to the exterior of the aircraft on pylons or launch rails. Furthermore, missile developments have concentrated on guidance and control technology, warhead development, energetic propulsion, and device development. A relatively small amount of research has been dedicated to the shape or aerodynamic design of the missile.

This program looks at aerodynamic design as one major component contributing to missile capability. Emphasis on aerodesign could increase the capability of the missile dramatically in several different areas such as maneuverability, range, and signature. This capability can be achieved by a radical reshape of the missile itself using unconventional missile shapes, employing delta configurations for example or other design features (blending of surfaces), or the missile designer can achieve high lift/drag (L/D) and lower signature. Not only is the design of the missile being optimized for independent flight, there is also an emphasis on the mating of the missile to the platform. That is, the missile design will allow conformal carriage of the missile in order that the missile may blend in to the overall shape of the platform, thus allowing greater aerodynamic performance of the platform with a lower signature.

This project is a 6.2 program aimed at a flying testbed demonstration in 1989. It is not itself a new technology development as much as an exploitation of other technology developments (air breathing propulsion with low signature, thrust glide missile, other previous work on aero configuration) to achieve a new capability.

This project may not be MSET, but rather an emerging technology. Much of the information on configuration is already in the open literature, although in this particular project care is taken in not publishing parametric data related to shape. For example, in an AIAA paper presented on the topic, a graph of L/D for a series of shapes and configurations was presented without specific numbers on the ordinate or abcissa. The notion was given that different shapes and designs do contribute to a variable L/D, but the reader was not able to assess quantitatively how much the specific shape contributed to overall performance.

In this demonstration flying testbed, the emphasis is on low cost. It is difficult to produce prototypes of different missile shapes, fly them in a wind tunnel, and perform extensive analysis without escalating cost. This particular program therefore, tries to achieve new design at the lowest possible test cost.

- Military Significance - Potentially Very High
- MSET - None Identified

C2. AEROELASTIC TAILORING

Since aircraft are made with light-weight materials and structures often placed under load or stress, there is a certain amount of bending or twisting in these components during flight, with structures experiencing both elastic and rigid-body modes of deformation. In aeroelastic tailoring, these changes in shape or deformations are used by the designer to increase the performance of the airframe. Aeroelastic tailoring can be considered active if the design employs control surfaces. It is considered passive if the design embodies change of shape owing to the natural loading of the component during flight. A major contributor to the emergence of this technology is the introduction of composite materials in aircraft design.

The DARPA-sponsored forward swept wing demonstrator, the X-29, built by Grumman, is a good example of aeroelastic tailoring. In this concept, the layout of fibers in the composite materials is used to prevent a potentially catastrophic change in the shape of the forward swept wing under load. In the traditional back swept wing design, for example, a twisting motion called divergence is encountered when the wing is under load. Divergence is not however, a serious issue since there are other aero dynamic effects that reduce its impact. In the forward swept design, however, divergence is accentuated by the air flowing over the lifting surface causing catastrophic failure if the wing is made with traditional material and design. In the X-29 wing, the composite material fibers are laid out in a design specifically tailored to reduce divergence. This technology, when coupled with active control, enables this unique design to be flown in a high performance aircraft.

Aspects of aeroelastic tailoring may be considered mature technology since the X-29 has undergone extensive wind tunnel tests and has actually flown. Although there are already significant number of papers in the open literature on aeroelastic tailoring, there is not much public information on design techniques and tools for implementation. For example, technological know-how related to the lay down of composite fibers to compensate for twist and moments, is not contained in the open literature.

There is some work in aeroelastic tailoring in other industrialized nations. The Germans (MBB) have developed a computer program for aircraft design utilizing aeroelastic tailoring. As more and more aircraft design teams use composite materials, it is anticipated that there will be a parallel growth of the use of aeroelastic tailoring.

Although some of this technology is considered mature, there is a subset of aeroelastic tailoring which may be considered a MSET candidate. This is the active mode of aeroelastic tailoring which takes into account the movement of control surfaces coupled with the design of the component. The candidate MSET could be titled Servo Elastic Tailoring.

Some innovative concepts being studied are the use of sensors and servo mechanisms in the various components of the aircraft which allows the designer more freedom in the shape of surface and the performance of these components in flight.

- *Military Significance - High*
- MSET - Servo Elastic Tailoring

C3. VOICE RECOGNITION

This project is aimed at development of a pilot aid where the pilot communicates directly with the onboard computer/avionics by voice command. In a traditional cockpit, many of the functions are controlled manually by flipping switches or turning dials. This pilot aid allows routine functions to be initiated by command of the pilot's voice.

First-generation voice recognition systems have been built, but these are somewhat limited in capability. That is, the system will recognize a rather limited vocabulary, but must "train" on the individual pilot's voice. The system, in other words, must learn the voice print of a specific individual in order to recognize the same command during operation.

The cockpit environment places special demand on voice recognition systems. Cockpits are noisy. This raises the level of discrimination required by the voice recognition system. Often pilots are under stress, distorting the voice patterns. First-generation systems cannot handle continuous speech. That is, the speaker must pause between each word in order for the system to recognize word images. Also, the systems may require a rather rigid syntax which does not allow for variations in phrasing. First-generation systems have experienced high error rates (10%) in benign environments and very high (up to 90%) in the fighter environment.

Voice recognition is the subject of intensive research in the commercial world. Texas Instruments and a number of small companies in the U.S. are pursuing developments (Verbex, Votan, SCI, etc.). TI, for example, is developing speech command of their Personal Computers, and Votan has developed a board to fit PC size computers. The Japanese (NEC) are working intensively on speech recognition, although their system does not operate in a noisy environment.

First-generation voice recognition systems in the cockpit will have limited vocabulary and concentrate on those functions which require digital entry and are routine manual operations for the pilot (reading in the frequency for the aircraft communication system, changing headings on the autopilot, querrying the system for numerical data such as altitude, speed, etc.).

Programs in this country are aimed at a pilot aid for the Air Force's AFTI-16. The French are working on a pilot's aid for the Mirage aircraft, but work seems to be 3-5 years behind comparable work in the U.S. Marconi in Britain, is developing a pilot aid for the BAC 111.

In summary, voice recognition is a rapidly emerging technology. There is a very large commercial market for this technology which may allow the government to capitalize on private industry development. The military demands are much higher than civilian applications requiring connected speech in a very noisy environment with a voice under stress. Many aspects of this technology may be considered ET rather than MSET.

- Military Significance - High
- MSET - Connected Speech In Noisy Environment, Voice Under Stress

C4. APPLIED COMPUTATIONAL AERODYNAMICS

- This support activity uses scientific inputs for algorithm development, followed by programming, followed by code validation using test data.

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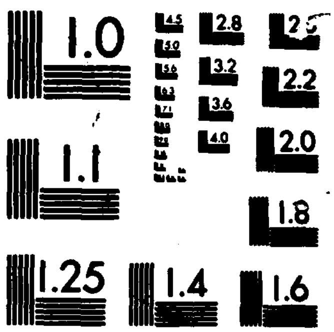

MICROCOP CHART

- 6.2 program.
- Codes not released.
- Comparison of 4 codes versus 3 generic shapes have been published recently in open literature (AIAA), but the codes were not disclosed.
- ELEMENT #1: Algorithm R/ET
- ELEMENT #2: Programming MT
- ELEMENT #3: Validation MCT

C5. ADAPTIVE FLUTTER SUPPRESSION

- If successful, this project will develop the capability to suppress flutter caused by many different stores configurations, in many different flight conditions.
- 6.2 program. Transitioning to 6.3 FY 85/86 after wind tunnel tests
- Now UNCLASSIFIED. Technical reports have RESTRICTED ACCESS. General papers with little detail are released to public.
- ELEMENT #1: Adaptive Control Theory MSET
  - Algorithms have advanced rapidly in 10 years
  - Much work done overseas
  - Soviets interested
- ELEMENT #2: System Design MT
  - Enabled by microprocessors & digital flight control

AFWAL MATERIALS LABORATORY INTERVIEWS

D1. RIGID ROD MOLECULAR COMPOSITES

This technology is a materials development which has wide applications for fibers, sheets, and solid materials. This polymer developed at the AFWAL Materials Lab has ladder structure which allows for high molecular weight polymeric materials to be built or to be created with unique properties.

In development of traditional materials like nylon or polyethylene, very long hyrdocarbon chains are developed in a flexible molecular form. In rigid rod polymers, monomers are generated and linked together with non-rotational bonds. The polymeric structure built-up with these monomers is "stiff." Since the monomers are not allowed to rotate around the linkage bonds, the base material can be used in a variety of forms. These rigid molecules can be joined together in fibers, bundles, or sheets, the resulting material having superior strength. These fibers can also be used to produce structural composites, reinforcing thermal plastics or other matrix materials. The chopped rigid rod polymer itself can be used as the matrix material. Three major topics in the discussion of this technology should be considered -- the manufacture of fibers, the processing of films, and finally the production of molecular composites.

Fiber Production. When the substance, PolyBenzImadizole (PBI) is extruded into material fibers, a material is formed which has a low compressive strength, but a modulus 2 to 4 times that of Kevlar. DuPont could produce this material within the year if there were a customer. An important aspect of this technology is the fact that Kevlar and graphite fibers for composites are already solidly entrenched in the market place. The rigid rod polymers therefore will have to break into a well-established market. However, as the need and the market develops for this material, it will be commercialized.

Production of Films. These rigid rod molecules can be made into sheets through an extrusion process in either a uniaxial or a biaxial form. Whether or not the film can be processed outside of a laboratory environment within a couple of years without further development has not been well established. The industry is very cautious at this point in producing films for the 1 mil to millimeter thickness. A prime candidate for films may be the development of structures such as space mirrors for SDI with radiation and temperature resistance superior to other materials. In summary, if there were a dedicated customer, this substance could be made within a couple of years.

Molecular Composite. Thermal plastic composites made from this material are not out of the laboratory yet, but offer great promise. This substance has a control stiffness and does not exhibit characteristics like the glass transition of nyl n. It is projected that if a market were available, molecular composites could be generated by the year 1990.

An interesting industry/academic relationship has built up around the technology of rigid rod polymers. Initially, the Air Force began the development and research projects were sponsored at the University level (Carnegie Mellon, University of Massachusetts). This research, however, has not been process oriented nor have potential manufacturers invested in development efforts. There is, however, some flexibility in the relationship when an academic institution like University of Dayton Research Institute (UDRI) can be co-located with or near the processing site.

In terms of military significance, the payoff for the Air Force could be considerable with a 30-50 percent reduction in weight and cost savings for critical components.

- Military Significance - Extremely High, Pervasive Application.

- MSET - Production Technology for the Materials, Films, and Solid Composites.

D2. HIGH TEMPERATURE COMPOSITES FOR TACTICAL MISSILES

The High Temple (Temperature Plastic Laminate Evaluation) program is a tri-Service approach to the development of high temperature resins operable in excess of 400° F. Principle materials currently being examined are: PBI (PolyBenzImadizole), PBQ (PolyPhenylBenzineQuinaxilene), and PI (Poly-Imadizole).

Most graphite epoxy composite materials cannot sustain long periods of temperatures above 270° F. The wing skin of the F-16 fighter aircraft at Mach 2.5, for example, must sustain temperatures in excess of 550° F. The ATF may be designed for velocities approaching Mach 3 with air-to-air and air-to-ground missiles at the level of Mach 3 to Mach 5.

The Bis-Maleimide system is approximately six months behind the PolyImides in development. Some of this technology is maturing, but also could be considered as emerging. In hypersonic flight above Mach 4, temperatures above 600° would be experienced and materials to support this temperature regime definitely would be considered MSET.

Preliminary work in this technology has been done at DuPont, 3M, and Monsanto with some developmental work being performed by NASA's Langley and Lewis Centers. NASA has published quite a bit on this subject and the Air Force is now taking the lead in High Temple efforts. Meetings with controlled access, U.S. contractors only, are sponsored periodically by DoD (approximately every 9 months). Some of this work may be considered classified if it concerns sensitive areas like laser hardening or low observables.

- Military Significance - Very High
- MSET - High Temperature Resins (>600° F Operating Temperature)

D3. LIGHTWEIGHT ARMOR FOR 30 CALIBER ARMOR PIERCING ROUND

This is an interesting technology development using appliques to increase the resistance of battlefield armor to anti-armor munitions. Various forms of alumina, made by Coors, are fabricated into small tiles and fixed to a backing plate. The concept is relatively simple: an armor piercing round striking the plate would fracture only one small tile and not a larger segment. Although the small tile is destroyed, the whole plate remains intact and can therefore guard against a second round being fired at the target.

This technology is not considered a MSET since the alumina technology is well in hand, but it is an interesting design concept which will be tested in the field.

- Military Significance - High
- MSET - None Identified

D4. CERAMIC MATRIX COMPOSITES

This technology is barely beyond the laboratory experimentation stage. Components are made by heating glass ceramics to refractory temperatures. The French use a chemical vapor infusion or infiltration process inside the reactor.

There are interesting properties that can be exploited with ceramic matrix composites, especially matrices that are lower density (40 percent porosity). High porosity hard ceramic structures have interesting thermal qualities (high temperature insulation) which could be exploited for many military applications.

The Japanese have been experimenting with ceramic materials for engines in an attempt to commercialize ceramics on a large scale. AFOSR is looking into ceramics at the basic research level, but considerably more basic research is needed in order to characterize fracture toughness, materials properties, etc.

- Military Significance - Moderate to High
- MSET - None Identified, Probably ET at this Stage

D5. IR DETECTOR MATERIALS

- This project investigates material processing and growth, and fabricates simple devices of Si and HgCdTe.

- No Classification Guide for materials. (U.S. Army has draft Classification Guide).

- Liquid-phase epitaxy (LPE) about to transition to Manufacturing Technology where it will be classified.

- 6.2 program.

- ELEMENT #1: Material Growth

- Bulk growth (followed by doping)	MT
- Liquid phase epitaxy	MSET/MT
- Vapor phase epitaxy	ET/MSET
- Superlattice	ET

D6. ALUMINIDES

- This project is aimed at developing aluminides to get high strength at high temperature for turbine mid-sections, which now use Ni-based alloys.

- No Classification Guide. To protect, must put in Manufacturing Technology program.

- ELEMENT #1: FeAl MSET/MCT

- ELEMENT #2: TiAl MSET/MCT

  - Engine tested
  - Several patents pending, one is CLASSIFIED.

- ELEMENT #3: TiAlLi ET/MSET

AIR FORCE WEAPONS LABORATORY (AFWL) INTERVIEWS

E1. SATELLITE TOMOGRAPHY

The object of this research is to develop a tool for examining the internal components and subsystems of a satellite in three dimensions. Some of the equipment is built in-house, but AFWL uses commercial hardware as subcomponents. The algorithms for the signal processing are not new, but the computer codes developed for this project may be unique and, in some respects, could be considered emerging. The computer codes perform theoretical calculations and construction of a 3-D model of the components inside a satellite. The goal is to examine and model the radiation transfers inside the satellite in order to determine the best layout for radiation hardening. There is still some developmental work (basic research) on cross-sections of materials and the use of tomography for examining non-biological objects. Work in this technology field is on-going at TRW, but AFWL is the major center for subsystems work.

There are no specific guidelines for public release of information. The computer codes themselves and possibly some of the hardware details are sensitive. It is the opinion of the interviewee that guidelines should be developed concerning hardware survivability.

- Military Significance - High
- MSET - Possibly Algorithms and Software Developments

E2. RADIATION HARDENED BULK CMOS MICROELECTRONICS

This program is aimed at producing higher levels of radiation hardening for silicon technology. GaAs has potential for greater hardness than silicon, but the manufacturing costs are much higher. Also, silicon devices can be made with higher chip density and at a lower cost. This program dealt with materials improvement, fabrication processes, and architecture/design at the LSI and VLSI levels. New fabrication processes or circuit designs may be required, however, in order to gain significant radiation hardness.

A problem still exists with commercialization in the sense that the military market is now only a small percentage of the total microelectronic market (5-7 percent). Within the military market, only 20 percent of the applications require high-level hardening. The outcome of this is that only one percent of all electronics produced in the U.S. are required to have severe military hardening requirements. Silicon (CMOS) technology may be a useful alternative to GaAs in those applications where speed and high degree of hardness are not as demanding.

Much of this technology is available in the open literature across the board. In the past, specific system parametrics were given in unclassified papers. However, there is now more sensitivity concerning the technology itself. According to the interviewee, it would be useful to have guidelines in this area. In fact, the negative aspect of strict controls would be more desirable than no control at all.

Although radiation hardening was not a central issue in VHSIC, Phase 1, there is now an adjunct program in DNA for VHSIC hardening. Hardening work is being performed at the SANDIA, NRL, AFSTC (sponsoring work in industry), NSA, and SDIO centers.

Radiation hardness should be considered in all aspects including: total dose for permanent damage (Rad/Si), total dose for upset (Rad/Si/Sec), and neutron effects (neutrons/cm^2).

- Military Significance - Very High
- MSET - Process Technology for Devices above VLSI Level

E3. REACTIVE SPUTTERING AND ION BEAM COATING TECHNOLOGY

This project is aimed at improving the material properties of coatings for small objects. The reactive sputtering is near maturity with 6.2 and 6.3 funding and ion beam coating technology near maturity for fiber optic gyro mirrors. For high density work, however, this technology is in more of a research stage. The amount of energy a mirror can absorb before degrading is an issue for high power lasers. Laser coating technology is more of an enhancing technology for most systems, and thus, is not essential for operation. As for optics, it is not a enabling technology. The availability date is estimated to be in the 1990s or later. General work is in process at NRL, NWC, DoE, Los Alamos, and Livermore laboratories.

- Military Significance - Moderate
- MSET - None Identified

E4. ADVANCED COATING FABRICATION

This work is presently not being funded and, in the opinion of the interviewee, is not an emerging technology. The concept of this program is to use a laser beam as the thermal source in a standard coating technique. It is not an essential component of the laser and not a critical technology.

- Military Significance - Moderate
- MSET - None identified

E5. ADVANCED HEAT EXCHANGE MATERIALS/FABRICATION TECHNOLOGY

This project is aimed at finding appropriate materials as structural support for laser mirrors. A problem exists in making large mirrors for high power lasers with the thermal expansion of the materials supporting the mirror. This research is aimed at defining the best design and composition of the materials supporting the laser mirror.

The Air Force has made high performance silicon carbide mirrors but in very small lots. Molybdenum has been used for a 1-m^2 cooled mirror. The use of carbon-carbon has been studied, but has yet to be successfully used as a backing material.

Silicon has a high thermal productivity, a good rate of expansion, and is easy to machine with passages etched or ground into the bulk material in intricate patterns. Silicon carbide is a good candidate with moderate thermal expansion and can easily be handled. The Air Force is looking for ways to scale up this process and to grow a face plate with chemical vapor deposition.

Carbon-carbon, although it exhibits zero thermal expansion with high conductivity, is difficult to use because it is difficult to achieve a solid bond between the surface and the substrate. It has been found that other products have to be coated onto the substrate in order to achieve bonding. Carbon-carbon is potentially an ideal material, but it has not yet developed to the point of application.

Silicon-carbon mirrors are now being used in a variety of applications. There is nothing new about the materials and, therefore, the technology need not be protected from transfer. The specific designs may warrant protection with performance characteristic of some mirror designs requiring to be classified (or protected through proprietary data restrictions).

There seems to be adequate protection now with companies maintaining proprietary rights. Heat exchange technology is mature or maturing.

- Military Significance - Moderate to High
- MSET - None Identified

E6. ADVANCED GLASS TECHNOLOGY

This technology concerns materials development for laser windows. According to the interviewee, the technology could be characterized at a research stage and not a emerging technology. This glass is being developed by the Navy for fiber optics and there is an interest for its use in high power lasers for bulk windows. There seems to be no outstanding commercial applications and the component technology is absolutely essential for military developments (lasers windows are already available with fairly low absorption). These advanced glasses may perform better, but it is difficult to quantify the potential enhancement in military applications since the improvements are evolutionary or incremental in nature. The requirements are relatively less stringent for the infrared region than for visible or UV where the short wavelength increases the need for high tolerances.

Information concerning the materials development is not classified, but data oriented toward system applications (the absorption coefficients, thermal distribution under load, etc.), would be sensitive and may be subject to classification. If, for example, a window is built for a real system, the characteristics of the window might be classified, whereas the basic materials performance is not considered sensitive.

- Military Significance - Moderate
- MSET - None Identified

E7. SHORT WAVELENGTH CHEMICAL LASERS

The interviewee pointed out that this topic is rather broad and covers many different types of lasers, including the oxygen iodine laser which is discussed under a separate title. It was further specified that much of the technology is covered on the Militarily Critical Technologies List (MCTL) and is therefore not emerging in a strict sense. Although the system design or actual application may be emerging, the basic physics is well understood. For example, many of these lasers have been tested in the laboatory, but never transitioned into an application due to lack of a project office or specified program. Some projects were begun and simply terminated because there was no near-term application upon which to continue funding. This does not mean that more work will not have to be done to allow technology insertion into weapon systems but there seems to be no easily defineable militarily emerging technology.

- Military Significance - High
- MSET - None Identified, Some Elements Emerging, Some Mature, But Not Applied

E8. HIGH POWER WAVE GUIDES

This program is no longer being funded and should be removed from the list.

E9. PHASED ARRAY BEAM CONTROL AND PHASE-LOCKED RESONATORS

Phased array beam control and phase-locked resonators are both subjects which are well covered in the MCTL. Although the technology has not been prototyped or applied, the principles are well understood. (It was difficult to assess the emerging technology aspects of this and other topics related to high energy lasers, because the interviewee postulated that anything covered by the MCTL was, or should be, considered mature technology). Although the principles are well understood, the technologies associated with laser phased arrays and phase conjugation have not been reduced to practice and technologies are in development. They could have high payoff value particularly in space applications. Very detailed classification guidelines have been worked out for high energy lasers.

- Military Significance - High to Very High
- MSET - Devices and Technology for Phase Conjugation

E10. PHOTO-SENSITIVE EO MATERIAL

The substance PLZT (Lead Lanthenum Zirconate Titanate) demonstrates rare characteristics which are now being studied for optical applications. The material is transparent between 3 and 8 microns relative to scattering. Under certain circumstances, it will scatter when sandwiched between contacts driving it to the point of saturation. This scattering thus reduces the transmissivity and allows a possibility of applications as an optical switch. A switch at 2 GHz can be made with a 5 x 5 x 1 micron device. It is theoretically possible to achieve 10^{12} cycles per second and at that frequency level, the device could be very critical for optical communications.

In addition to scattering, the material also exhibits a change in the index of refraction under a controlled environment which may allow color multiplexing. The multiplexed signal can be transmitted down a single fiber and then decoded with the PLZT device.

Queens University in Canada has recently been involved in PLTZ thin film research. An RF sputtering technique is being examined by the Japanese for use in producing PLZT. Amorphic crystals (BCC or FCC depending on the composition) are the subject of research for up to five or six phases of materials composition. Sandia, under contract to AFWL, is doing basic research for increasing the photo sensitivity of PLTZ aimed at applying the technology to spatial modulators and adaptive optics.

The most mature application for this material to-date has been for switching multi-color light sources on a flat panel display. This application is analagous to a liquid crystal modulator for a TV screen, but with characteristics that make ferroelectics more desirable for specific applications. In high-flying aircraft for example, there are significant temperature variations which militate against the use of liquid crystal displays having a very narrow band of temperature response.

The Soviets have three top experts in ferroelectricity. They may be investing more into basic research programs than the U.S., although their papers tend to lag several years behind those published in the U.S and Canada. Although Japanese publications seem to lag by approximately 18 months, it is suspected that the lag is due to the desire to patent the devices before allowing publications. The following is in order of priority of the applications for ferroelectrics: 1) optical communication, 2) digital switching, and 3) displays in hazardous or stressful environments.

- Military Significance - High to Potentially Very High
- MSET - Modulators for Optical Communications, Digital Switches

E11. RADIATION HARDENING USING BI-STABLE OPTICS

This project is aimed at achieving Josephson-Junction-level speeds at room temperature, thus achieving very large computing throughput at low power. The devices are capable of pico-second and femto-second rates. AFOSR is funding work at Trinity College in Dublin for the development of bi-stable devices using a cleaved coupled-cavity approach with laser diodes. These crystals are optically coupled, but electrically isolated, allowing the device to operate with optical bi-stability.

There is nothing emerging about the theoretical aspects of this work in the sense that the state-of-the-art is published widely by large companies (Xerox, IBM, Bell Labs) and researchers at various universities (UCLA, Stanford, University of Arizona). Work in Beta reversal switches and fiber optics is experiencing tremendous growth. Research in U.S. government labs tends to be slightly behind the state of the art.

The Soviets may not have an abundance of information on this research area and do not seem to be as interested in this technology as they are in other areas of research. (Perhaps they are less concerned than the U.S. about EMP). The Japanese are probably the world leaders in the field of distributed feedback (DFB) lasers.

- Military Significance - Very High
- MSET - None Identified, Probably at an ET Stage of Development

E12. INTEGRATED OPTIC HARDWARE

This program is aimed at providing optical materials for radiation testing in demonstration experiments. Some of these devices for transmitting and receiving signals are actually more radiation resistant than the fiber optic transmitting the signal.

- Military Significance - High
- MSET - None Identified, May be at ET Stage

E13. DISCUS

This program is aimed at simulating a surface or near-surface nuclear burst over a missile silo by locating a portable device (EMP generator) in the field near the actual structures to be evaluated. A proof of concept, which has been discussed openly for many years, is the major objective of this program. In fact, the concept was presented in the early 1970's in an IEEE conference on EMP/radiation effects. Since that time, there has been some concern that too much information was released at that time. More specific EMP classification guidelines could have helped. Maxwell and PI (Physics International) are the primary contractors on this project.

- Military Significance - Moderate
- MSET - None Identified

E14. HARDNESS ASSURANCE MONITORING SYSTEM (HAMS)

HAMS is a mature to maturing technology in the 6.3 - 6.4 arena. There is no aspect of this program which is considered classified and no classification guidelines as yet. In this system, a signal is generated in order to test signal coupling to aircraft and to determine which ports are subject to electromagnetic leakage. The system cannot necessarily pin point the point of entry of the radiation, but it can predict with high probability that there is some leakage. An attempt will be made in 1985 to demonstrate the concept with the device being operational by 1990.

- Military Significance - Moderate
- MSET - None Identified

RADC INTERVIEWS FROM RHA

F1. WIDEBAND RECORDER TECHNOLOGY

- This project is concerned with developing wideband digital and analog recorders of all types.

- ELEMENT #1: Magnetic Analog — MT
  - Longitudinal 2-4 MHz
  - Rotary 6-15 MHz

- ELEMENT #2: Optical Analog — MCT
  - 200 MHz transitioning into 6.3 — MSET/MCT
  - 1000 MHz now beginning — MSET/MCT
  - Critical components UNCLASSIFIED, but the system configuration using them can be "tweaked" for optimization.

- ELEMENT #3: Optical Digital — MSET
  - 50 - 1000 Mbps

- ELEMENT #4: Electron Beam — ET
  - Discontinued project

- ELEMENT #5: Solid State — R/ET
  - Infancy
  - Architecture to be determined

F2. MMICs

- This activity is developing circuiting and testing for GaAs MMICs.
- 6.2 program. Reports classified by STRAM (Strategic and Tactical Radar Array Module) Guide.
- ELEMENT #1: Circuiting — MSET
    - Compilation of MMIC circuit library
- ELEMENT #2: Test — MSET
    - Software and hardware development
    - Pulse measurements

F3. HYBRID BISTATIC RADAR

- This project is based on a concept study of a space-based illuminator and an airborne receiver with on-board signal processing to detect and track low-altitude low-radar-observable vehicles.
- Completed concept study in 6.2. Beginning 6.3 clutter measurement program.
- ELEMENT #1: Simulations — MT
    - Systems plus phenomenology
- ELEMENT #2: Signal Processing — MSET/MT
    - Advanced tracking algorithms
    - Synchronization
    - S/N

F4. EHF MONOLITHIC AIRBORNE TERMINALS

- The purpose of this activity is to develop (nearly) monolithic conformal antennas (transmit at 44 GHz and receive at 20 GHz) for high-performance aircraft.

- Classification Guide is Advanced Space Communication Classification Guide

- ELEMENT #1: Fabrication — MSET

  - New techniques using MBE, MOCVD to construct 10-in sq aperture with 2,000-4,000 elements with 4X4 array on 1 chip.

  - 44 GHz more suitable for monolithic techniques than 20 GHz

- ELEMENT #2: Signal Processing — MSET/MCT

  - Beam Steering

- ELEMENT #3: System Integration — MSET

  - Bring together microprocessors, synthesizers, low-noise amplifiers (LNAs), phase shifters, etc.

- ELEMENT #4 Devices — MSET

  - HEMT LNA 2.1 db NF uncooled

F5. ARTIFICIAL INTELLIGENCE

- Work is being conducted in the areas of Survivability, R&M, Communications, Intelligence/Reconnaissance, C^2. Three major programs are underway. RADC is a DARPA contracting agent under Supercomputing Initiative and is involved with AI consortium.

- ELEMENT #1: Knowledge-based Mission Planning System MSET
  - Expert system
  - Demo on tactical air strikes

- ELEMENT #2: Intelligent Man/Machine Interface for C^2 MSET

- ELEMENT #3: Knowledge-based Software Assistant MSET
  - 4 efforts in software development
  - Large domain implies military application

- ELEMENT #4: Knowledge Acquisition Techniques ET

F6. SOFTWARE ENGINEERING TECHNOLOGY

- This project is developing software engineering tools to effect order of magnitude improvement in software productivity.

- Research/Methodology/Results reports/UNCLASSIFIED. The "tool" is not disclosed. Controlled access to tool (e.g., ADA compiler at 8 test sites). ($200k for theory versus $2 million to implement.)

- Transition from 6.2 upon a feasibility demo, from 6.3 upon a larger-scale demo, not human engineered.

- ELEMENT #1: Rapid Prototyping MT
  - Related to requirements phase
  - Based on HOL
- ELEMENT #2: Visible Language MT

F7. BATTLE MANAGEMENT SYSTEMS

- This activity is developing decision aids and processing aids, and automating many processes now done manually. Deals with military information processing of data, data correlation, dissemination, and feedback.
- ELEMENT #1: C^3CM (6.2) MT
  - Automating decision making, planning
  - Deterministic approach
  - Output is software specification
  - Program Element 62702 Classification Guideline
  - A lot of work is UNCLASSIFIED
- ELEMENT #2: Critical Node Recognition (6.3) MSET/MCT
  - Software & display capability to use data from advanced sensors for recognition of tactical nodes.
  - Have 2 flight tests
  - Now working on identification of nodes using simulation
- ELEMENT #3: PAVE MOVER (6.2/6.3/6.4) MCT
  - Flight test Sept 83

F8. REFERENCE SCENE GENERATION

- Reference scenes are generated (using multi-spectral imagery) to be stored on digital tape to assist terminal homing for conventional weapons.

- 6.3 program.

- ELEMENT #1: Processing/Correlation Algorithms MT

  - 3-D geometric shell construction
  - Material identification

- ELEMENT #2: Automation of processing MT

  - Trying to move from simple to complex scenes

F9. SCENEVIEW

- The technique being developed converts oblique imagery into other perspectives. Merges information from source image with DMA data to produce static snapshots.

- 6.3 program.

- ELEMENT #1: Algorithms MT

  - Standard transformation algorithms

- ELEMENT #2: Automation MSET

  - Aiming to improve scene generation rate.

F10. ADVANCED TERRAIN DATA EXTRACTION TECHNOLOGY

- The techniques being developed will produce high-resolution high-accuracy scenes from photographic sources.

- Early 6.2. RESTRICTED ACCESS reports

- ELEMENT #1: Image Correlation ET/MSET

    - New approach using AI
    - Algorithms originated at Stanford
    - Digital stereo reconstruction using DMA data

F11. MULTI-SENSOR PRECISE TARGET LOCATION TECHNOLOGY

- Near-real-time high-accuracy geoposition information can be developed from imaging reconnaissance sensors using techniques being investigated in this project.

- Latter stage of 6.2. About to transfer to 6.3.

- ELEMENT #1: Image Correlation/Processing MSET

    - Uses photogrammetry, AI
    - Convert to digital format, store on optical disc
    - Uses image compression

F12. COMMUNICATION VULNERABILITY ASSESSMENT

- This project is examining the susceptibility, interceptability, a ccessibility, and feasibility of networks.

- 6.3 program.

- ELEMENT #1: Protocol Verification & Validation MT

  - Identify suspicious behavior
  - Use network modelling
  - Use discrete - event simulators (GPSS, Simscript 2.5)

APPENDIX C

PRELIMINARY MILITARY EMERGING TECHNOLOGY AWARENESS LIST

SUMMARY OF JUDGMENTS

PRELIMINARY METAL

TECHNOLOGIES DESCRIBED IN R&LM RESPONSES	INTERVIEWS CONDUCTED	MSET TECHNOLOGIES
Modulation Doped Heterojunction Transistor	A23	MSET
Focal Plane Arrays	A9	MSET*
VHSIC - Submicrometer Technology	A21	MSET*
Monolithic Microwave Circuits	A13, F2	MSET*
Acousto-Optical Spectrum Analyzer	A10	MSET*
Solid State Phased Array	A12	---
Gallium Arsenide Technology	A22	MSET*
High-Temperature Photoconductive HgCdTe Detectors	A11	---
SAR Target Screening & Classification	A2	MSET*
Fiber Optic Gyros	A6	MSET*
Adaptive Goal-Seeking Elements of Neural Networks	A7	---
Artificial Intelligence	A19, A20, F5	MSET*
Applied Computational Aerodynamics	C4	---
Aero-Configured Missiles	C1	---
Aeroelastic Tailoring	C2	MSET*
Adaptive Flutter Suppression	C5	MSET*
Rigid-Rod Molecular Composites	D1	MSET*
ITP-90	B11	---
Air-Lubricated Foil Bearings	B12	---
Lubrication System Condition Monitoring	B8	---
Polarization Diversity Meteorological Radar	●	●
Active Sensors from Meteorological Satellites	●	●
Laboratory Simulation of Nuclear Emission	●	●
Space Environment Control	●	●

* Needs qualification (may require alternate title/description)
--- Interview conducted -- No MSET identified
● No interview conducted

Laboratory Code - A = AFWAL Avionics Lab
B = AFWAL Propulsion Lab
C = AFWAL Flight Dynamics Lab
D = AFWAL Materials Lab
E = Air Force Weapons Laboratory (AFWL)
F = Rome Air Development Center (RADC)

PRELIMINARY METAL (Continued)

TECHNOLOGIES DESCRIBED IN R&LM RESPONSES	INTERVIEWS CONDUCTED	MSET TECHNOLOGIES
Cryogenic Engine Systems	●	●
Composite Materials for Composite Motor Cases	●	●
Cryogenic Fluid Storage	●	●
Liquid Propellant Storage Tanks	●	●
Photo-Sensitive EO Material	E10	MSET*
Bistable Optical Technology	E11	---
HEMT Technology	●	●
Electromagnetic Launcher Technology	●	●
Integrated/Fiber Optic Gyro	●	●
Artificial Intelligence Applications to Maintenance	●	●
Sensor Correlation Technology	●	●
Reference Scene Generation Technology	F8	---
Digital Cartographic Data Exploitation Technology	●	●
Automated Target Detection, Classification and I.D.	●	●
Advance Terrain Data Extraction Technology	F10	---
Multi-Sensor Precise Target Location Technology	F11	---
C3CM Deception	F7	---
Automatic Speech Recognition	●	●
Low Data Base Rate Communications	●	●
Wideband Recorder Technology	F1	MSET*

* Needs qualification (may require alternate title/description)
--- Interview conducted -- No MSET identified
● No interview conducted

Laboratory Code - A = AFWAL Avionics Lab; B = AFWAL Propulsion Lab; C = AFWAL Flight Dynamics Lab; D = AFWAL Materials Lab; E = Air Force Weapons Laboratory (AFWL); F = Rome Air Development Center (RADC)

PRELIMINARY METAL (Continued)

TECHNOLOGIES DESCRIBED IN R&LM RESPONSES	INTERVIEWS CONDUCTED	MSET TECHNOLOGIES
ELINT Identification	●	●
SIGINT Correlation	●	●
Acoustic Charge Transfer Devices and Applications	●	●
Methodologies for Vulnerability Assessment of Communications Networks	F12	---
Mid Range IR Materials	●	●
Indium Phosphide Technology	●	●
SDI Advanced On Board Signal Processing	●	●
MMIC Advanced Arrays	●	●
VHSIC Insertion for E-3A Signal Processors	●	●
Hybrid Bistatic Radar	F3	---
Low Cost/Long Life SATCOM Thermionics	●	●
Anti Stealth RCS Models	●	●
Decision Aids	●	●

* Needs qualification (may require alternate title/description)
--- Interview conducted -- No MSET identified
● No interview conducted

Laboratory Code - A = AFWAL Avionics Lab
B = AFWAL Propulsion Lab
C = AFWAL Flight Dynamics Lab
D = AFWAL Materials Lab
E = Air Force Weapons Laboratory (AFWL)
F = Rome Air Development Center (RADC)

PRELIMINARY METAL (Continued)

TECHNOLOGIES DESCRIBED IN AFSC ET/MT LIST (1983)	INTERVIEWS CONDUCTED	MSET TECHNOLOGIES
Advanced Optical Rotation Sensors	●	●
Hypervelocity Weapon Demo	●	●
Aircraft/Store Integration	●	●
Guided Projectile Technology	●	●
Hypervelocity Missile	●	●
Modern Guidance and Estimation for Tactical Air-to-Air Missiles	●	●
AI Applications to Training, Performance Measurement, Job Performance Aiding	●	●
Combat Mission Trainer	●	●
High-Speed Thrust-Augmenting Ejector	●	●
Productive Exploitation Unsteady Aerodynamics	●	●
Aerodynamic Skin Friction Drag Reduction	●	●
Energy Beaming for Space Propulsion	●	●
HEL Thin-Film Coating Technology	●	●
Superconducting Electronics	●	●
Working Description of Cognitive Neural Processing	●	●
Biochemical Techniques to Prevent Cell Degeneration	●	●
Computer Processor with Adaptive (Learning) Capability	●	●
Advanced Machine-Operator Coupling Technology	●	●
High-Resolution Imaging of Space Objects	●	●
FEL	●	●
Nonlinear Adaptive Optics	●	●

* Needs qualification (may require alternate title/description)
--- Interview conducted -- No MSET identified
o No interview conducted

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PRELIMINARY METAL (Continued)

TECHNOLOGIES DESCRIBED IN AFSC ET/MT LIST (1983)	INTERVIEWS CONDUCTED	MSET TECHNOLOGIES
Space-Based Radar	●	●
MMIC T/R Modules	●	●
Limited Vocabulary Voice Systems	●	●
Fiber Optics for Tactical/Strategic Information Transfer	●	●
E-Beam Lithography for VHSIC-Based C^3I Systems	●	●
Device-Quality Single-Crystal InP	●	●
Josephson Junction Computer Development	●	●
EHF Monolithic Antenna Arrays	F4	MSET*
Active Composite Mirrors	●	●
IR Rapid Response Wavefront Sensor	●	●
Surface Measuring Device (0.05)	●	●
Fiber Optics for Tactical/Strategic Signal Processing	●	●
Rad-Hard, Ultra-Low-Loss Fiber Optics Communications	●	●
Multi-Imagery Explosive System	●	●
Program Visualization Systems	●	●
AI	●	●
Life Cycle Software Engineering Environment	F6	---
Space-Hardened Electronics	E2	---
AOSP	●	●
Iodine Laser	●	●
HF Laser	●	●
Reactive Sputtering and Ion Beam Coating Techniques	E3	---
Advanced Heat Exchanger Materials/Fabrication Technology	E5	---
Advanced Coating Fabrication Technology	E4	---

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PRELIMINARY METAL (Continued)

TECHNOLOGIES DESCRIBED IN AFSC ET/MT LIST (1983)	INTERVIEWS CONDUCTED	MSET TECHNOLOGIES
Advanced Glass Technology	E6	---
High-Performance Propellants for Air-Launched Missiles	●	●
Composite Motor Cases for Air-Launched Missiles	●	●
Low Thrust Cryogenic Engine	●	●
Pulsed Plasma Propulsion for Satellites	●	●
Wound Insulation for Ballistic Missile Motors	●	●
Long-Term Space Storage of Cryogenic Fluids	●	●
Advanced High-Thrust Liquid Rocket Engine	●	●
Solar Thermal Rocket	●	●
MHD Thruster	●	●
Advanced GaAs Solar Cells	B1	---
Very High Power Lithium Reserve Batteries for Missile Applications	B3	MSET*
NaS High-Energy-Density Rechargeable Batteries	●	●
Boron Slurry Fuel Technology	B5	MSET
Lubrication System Condition Monitoring	B8	---
Intercontinental Cruise Missile Turbine Engines	B7	---
Fireproof Hydraulic Systems	B10	---
E-Beam-Controlled High-Voltage Switch	B9	---
Boron Solid-Fuel Ramjet	●	●
Boron Slurry-Fueled Ramjet	●	●
Supersonic Combustion Ramjet	●	●
Integrated Inertial Reference Assembly Description	A17	---
Imaging Sensor Autoprocessor	A3	---

* Needs qualification (may require alternate title/description)
--- Interview conducted -- No MSET identified
● No interview conducted

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PRELIMINARY METAL (Continued)

TECHNOLOGIES DESCRIBED IN AFSC ET/MT LIST (1983)	INTERVIEWS CONDUCTED	MSET TECHNOLOGIES
Integrated Communication, Navigation, Identification Avionics	A1	---
PAVE PILLAR	●	●
Advanced Imagery Transmission	A8	---
Electronic Terrain Map System	A18	---
Solid State Phased Arrays	●	●
Multifunction FLIR	A4	---
Multiband Staring Sensor	●	●
Combined Sensors for Target Acquisition, Recognition, and Strike	A5	---
CO_2 Laser Radar	A15	---
Forward-Looking Active Classification Technology	A16	---
Covert Strike Radar	●	●
Multiple Target Attack Algorithms	A14	---
Aeroelastic Tailoring	C2	---
Advanced Flutter Suppression	C5	---
Voice Technology/Recognition	C3	MSET*
Supersonic Cruise Fighter Technology	●	●
Aero Configured Missiles	C1	---
Applied Computational Aerodynamics	C4	---
IR Detector Materials	D5	---
High-Temperature Composites for Tactical Missiles	D2	MSET*
Ordered Polymers	D1	---
Iron Aluminides	D6	---
Ceramic Matrix Composites	D4	---

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● No interview conducted

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APPENDIX D

RATIONALE FOR INCLUSION OF TECHNOLOGIES ON META - SUMMARY TABLES -

AIR FORCE EXPERT INTERVIEWS

- Technologies Described in R&LM Responses -

A23. MODULATION DOPED HETEROJUNCTION TRANSISTOR

All aspects

A9. FOCAL PLANE ARRAYS

- IR FPAs (especially for wavelengths greater than 5 microns)
- On-chip signal processing
- Large (>256 x 256 pixels) single ship arrays

A21. VHSIC - SUBMICROMETER TECHNOLOGY

- Design rules (for 0.5 to 1.0 micron featuresize)
- Lithography, etching, design rules, etc. (less than 0.5 micron)

F2., A13. MONOLITHIC MICROWAVE CIRCUITS

- GaAs
- Higher levels of functional integration (e.g., T/R module)
- Yield (materials, manufacturing technology)

A10. ACOUSTO-OPTICAL SPECTRUM ANALYZER

- Integrated optics approach (minimum number of discrete elements)
- Wide device bandwidth (greater than 2 GHz)
- Multi-channel analyzers (2 to 18 GHz)

A12. SOLID STATE PHASED ARRAY

- MSET aspect is solid state array element (See A10)

A22. GALLIUM ARSENIDE TECHNOLOGY

- All aspects of materials, design, manufacturing for levels of integration greater than VLSI and for monolithic analog circuits (e.g., MMICs).

A11. HIGH TEMPERATURE PHOTOCONDUCTIVE HgCdTe DETECTORS

- Subject technology limited to 195°K operating temperature laser radar IR (10.6 micron) detector.
- High temperature HgCdTe materials development for FPAs is MSET (See A9).

A2. SAR TARGET SCREENING AND CLASSIFICATION

- Only near-real-time SAR target classification

A6. FIBER OPTIC GYROS

- Low-cost FOGs with RLG accuracies
- Integrated Optic FOG (minimum number of discrete elements)

A7. ADAPTIVE GOAL SEEKING ELEMENTS OF NEURAL NETWORKS

- Pure research

F5., A19., A20. ARTIFICIAL INTELLIGENCE

- Domain-specific military applications (near-real-time, large-scale problems)

C4. APPLIED COMPUTATIONAL AERODYNAMICS

- Mature technology

C1. AERO-CONFIGURED MISSILES

- System design issue dependent on emergence of other technologies (advanced ramjets, conformal arrays, stealth)

C2. AEROELASTIC TAILORING

- Active mode of aeroelastic tailoring takes into account the movement of control surfaces in the design of the component (sensors, servomechanisms, microprocessor control).

C5. ADAPTIVE FLUTTER SUPPRESSION

- Adaptive control theory and algorithm development

D1. RIGID ROD MOLECULAR COMPOSITES

- Production technology for the materials, films, and solid composites.

B11. ITP-90

- System design issue dependent on emergence of other technologies (materials, fuels, coatings, etc.)

B12. AIR-LUBRICATED FOIL BEARINGS

- Mainly a design issue with no technology breakthroughs required
- Promises incremental performance improvements

B8. LUBRICATION SYSTEM CONDITION MONITORING

- Unique design concept which embodies mature technology

E10. PHOTO-SENSITIVE EO MATERIAL

- Modulators or optical communications
- Digital switches

E11. BISTABLE OPTICAL TECHNOLOGY

- Early stage of emergence

F8. REFERENCE SCENE GENERATION TECHNOLOGY

- Mature technology

F10. ADVANCE TERRAIN DATA EXTRACTION TECHNOLOGY

- Application of AI to image correlation algorithms is MSET (See F5, A19, A20)

F11. MULTI SENSOR PRECISE TARGET LOCATION TECHNOLOGY

- Application of AI to image correlation algorithms is MSET (See F5, A19, A20)

F7. C^{3}CM Deception

- Applications of AI to data fusion (See F7, A19, A20) in C^{3}CM and Critical Node Recognition

F1. WIDEBAND RECORDER TECHNOLOGY

- High bandwidth optical disc technology (analog and digital)
- Read/write technology

F12. METHODOLOGIES FOR VULNERABILITY ASSESSMENT

- New approach to vulnerability assessment using well-developed tools (e.g., network modeling)

F3. HYBRID BISTATIC RADAR

- System concept development requiring technology advances in other areas (e.g., signal processing)

AIR FORCE EXPERT INTERVIEWS

- Technologies Described in AFSC ET/MT List Interviews -

F4. EHF MONOLITHIC ANTENNA ARRAY

- Fabrication and system integration

F6. LIFE CYCLE SOFTWARE ENGINEERING ENVIRONMENT

- Application of well-developed techniques to large-scale programs

E2. SPACE-HARDENED ELECTRONICS

- Incremental advances in hardness based on a variety of techniques in materials, design, and fabrication

E3. REACTIVE SPUTTERING AND ION BEAM COATING TECHNIQUES

- Some aspects in research stage
- Laser coating is enhancing technology but not essential for operation

E5. ADVANCED HEAT EXCHANGER MATERIALS/FABRICATION TECHNOLOGY

- Most aspects are mature technology with exception of carbon-carbon

E4. ADVANCED COATING FABRICATION TECHNOLOGY

- Mature technology

E6. ADVANCED GLASS TECHNOLOGY

- Research

B1. ADVANCED GaAs SOLAR CELLS

- Mature technology

B3. VERY HIGH POWER LITHIUM RESERVE BATTERIES FOR MISSILE APPLICATIONS

- Lithium thermal battery technology

B5. BORON SLURRY FUEL TECHNOLOGY

- All aspects

B8. LUBRICATION SYSTEM CONDITION MONITORING

- New concept implemented with mature technology

B7. INTERCONTINENTAL CRUISE MISSILE TURBINE ENGINES

- New system concept relying on advances in other technology areas

B10. FIREPROOF HYDRAULIC SYSTEMS

- Mature technology

B9. E-BEAM CONTROLLED HIGH VOLTAGE SWITCH

- Incremental advances in established technology areas

A17. INTEGRATED INERTIAL REFERENCE ASSEMBLY

- Mature technology

A3. IMAGING SENSOR AUTOPROCESSOR

- System concept depends on advances in other areas (AI)

A1. INTEGRATED COMMUNICATION, NAVIGATION, IDENTIFICATION AVIONICS

- System development depends on advances in other areas (GaAs in transversal filter receiver, software)

A8. ADVANCED IMAGERY TRANSMISSION

- Relies on development of other technologies

A18. ELECTRONIC TERRAIN MAP SYSTEM (AETMS)

- ITARS, the Advanced Electronic Terrain Map System (AETMS) follow-on, relies on development of other technologies (optical data storage/retrieval)

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