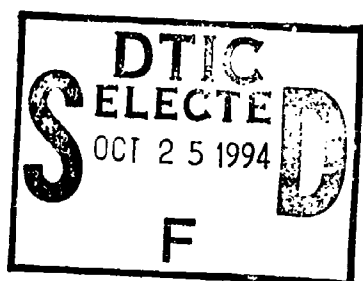


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Aerospace Materials and Processes Technology Reinvestment Workshop



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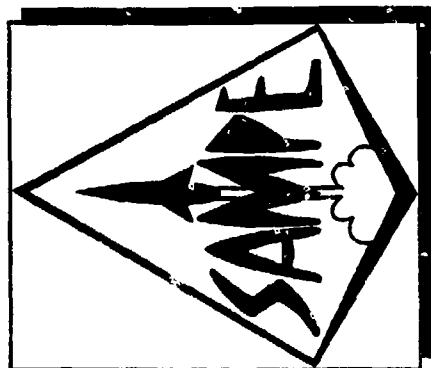


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18 & 19 May 1993
Ervin J. Nutter Center
Dayton, Ohio

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Aerospace Materials and Processes Technology Reinvestment Workshop

DTIC QUALITY INSPECTED 2

**Wright Laboratory Materials Directorate's
Aerospace Materials and Processes Technology
Reinvestment Workshop**

Tuesday 18 May 1993

| | | |
|-----------|--|-----------------------------------|
| 0730-0830 | Registration | |
| 0830-1030 | | |
| 0830-0840 | Welcome | Mr Scott Theibert |
| 0840-0910 | Purpose | Dr Vincent Russo |
| | Overviews | |
| 0910-0930 | Air Force | Air Force Materiel Command |
| 0930-0950 | DOD | Mr Jerome Persh |
| 0950-1010 | ARPA | Dr Ben Wilcox |
| 1010-1030 | NIST | Dr Lyle Schwartz |
| 1030-1100 | Break | |
| 1100-1130 | Status of Current Activities | Mr Jerry Covert |
| 1130-1230 | Examples of Current M&P Partnerships | |
| 1130-1150 | IHPTET Fiber Consortium | Mr Stephen Strunck - GE |
| 1150-1210 | Modeling of Casting Flow and Solidification | Dr Thomas Tom - Howmet |
| 1210-1230 | Intelligent Design of Aluminum Extrusion Processes | Mr Butch Dyer - Tech Dev Corp/YSU |
| 1230-1400 | Lunch | Nutter Center |
| 1400-1540 | Industrial Perspectives | Aerospace Industry |
| 1400-1420 | Northrop | Mr Allan Freedman |
| 1420-1440 | Lockheed | Mr Bill Hargrove |
| 1440-1500 | MCAIR | Mr James Dorr |
| 1500-1520 | Pratt and Whitney | Dr Bill Yee |
| 1520-1540 | Westinghouse Science & Technology Center | Dr Dick Hopkins |
| 1540-1600 | Break | |
| 1600-1700 | Industrial Perspectives (Cont) | Suppliers & Industry Associations |
| 1600-1620 | NCAT/AIA | Mr Richard Hartke |
| 1620-1640 | QuesTech Research Division | Mr Ned Maurer |
| 1640-1700 | National Automotive Center - US ARMY | Capt Richard Brynsvold |
| 1700-1830 | No Host COD Bar | Nutter Center |

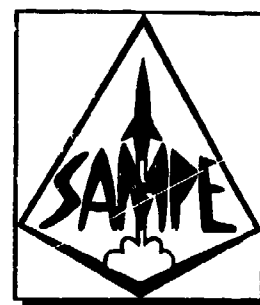
Wednesday 19 May 1993

| | | |
|-----------|---------------------------------------|-----------------------|
| 0830-1000 | Potential Topics for M&P Partnerships | Air Force |
| 0830-0850 | Introduction and Objectives | Mr Larry Hjelm |
| 0850-0930 | Metals and Ceramics Division | Dr Norm Tallan |
| | Metals, Intermetallics and MMC | Ms Katherine Williams |
| | Ceramics | Dr Allan Katz |
| | Metal and Ceramic Material Processing | Mr Jim Morgan |

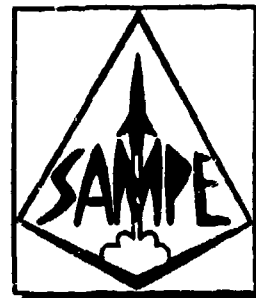
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|--------------|--|--|
| 0930-1010 | Nondestructive Evaluation System Support Division Pollution Prevention & Repair Mat'ls & Processes Aging Aircraft & Failure Analysis/Prevention | Mr Charles Buynak Mr Tom Cooper Mr Ted Reinhart Mr Ron Williams |
| 1010-1030 | Break | |
| 1030-1210 | Potential Topics for M&P Partnerships (Cont) | Air Force & Others |
| 1030-1110 | Nonmetallic Materials Division | Dr Charles Browning |
| 1110-1140 | Electromagnetic Materials & Survivability Division | Mr William Woody |
| 1140-1210 | Integrations and Operations Division | Mr Robert Rapson |
| 1210-1300 | Lunch | Nutter Center |
| 1300-1630 | Adjourn for Specialist Sessions/Discussions | All |
| Berry Room 1 | Metals and Ceramics Division | |
| Berry Room 2 | Nonmetallic Materials Division | |
| Berry Room 3 | Electromagnetic Materials & Survivability Division | |
| Room 240 | System Support Division | |
| Room 226 | Integrations and Operations Division | |

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DR. VINCENT J. RUSSO, DIRECTOR
AIR FORCE OVERVIEW



**Aerospace Materials and Processes
Technology Reinvestment Workshop**



Dr. Vincent J. Russo, Director Materials Directorate

MATERIALS DIRECTORATE MISSION

Plan and execute the USAF programs for materials and processes in the areas of basic research, exploratory development, advanced development, and manufacturing research.

Provide systems support to Air Force product divisions and operating commands to solve system related problems and to transfer expertise in the areas of materials, processes and manufacturing.

MATERIALS DIRECTORATE PHYSICAL PLANT

| | | |
|--|---------------|---|
| • ESTIMATED BUILDINGS REPLACEMENT VALUE | \$84,400,000 | |
| • ESTIMATED SCIENTIFIC EQUIPMENT REPLACEMENT VALUE | \$122,200,000 | |
| • LABORATORY MODULES | 209 | |
| • TOTAL AREA | 379,000 FT | 2 |

MATERIALS DIRECTORATE MATERIALS & PROCESSES EXPERTISE IN ML FACILITY

GOVERNMENT

| | TOTAL | MS | PhD |
|------------------------|------------|------------|-----------|
| SCIENTISTS & ENGINEERS | 229 | 123 | 70 |
| TECHNICIAN | 9 | - | - |
| OTHER | 43 | - | - |
| SUBTOTAL | <u>281</u> | <u>123</u> | <u>70</u> |

OTHER

| | | | |
|--------------------------------------|------------|-----------|-----------|
| NRC POST DOCTORATE FELLOWS | 11 | - | 11 |
| ML VISITING SCIENTISTS PROGRAM | 36 | 6 | 26 |
| INTERGOVERNMENTAL PERSONNEL ACT | 2 | - | 2 |
| ONSITE CONTRACTOR PROFESSIONAL S&E | 118 | 35 | 49 |
| ONSITE CONTRACTOR SUPPORT/TECHNICIAN | 95 | 6 | - |
| COLLEGE STUDENT SUPPORT | 43 | 1 | - |
| SUBTOTAL | <u>305</u> | <u>48</u> | <u>88</u> |
| TOTAL | 586 | 171 | 158 |

PERCENT OF S&E WORKFORCE (396)

41% 40%



MATERIALS TECHNOLOGY AREA PLAN

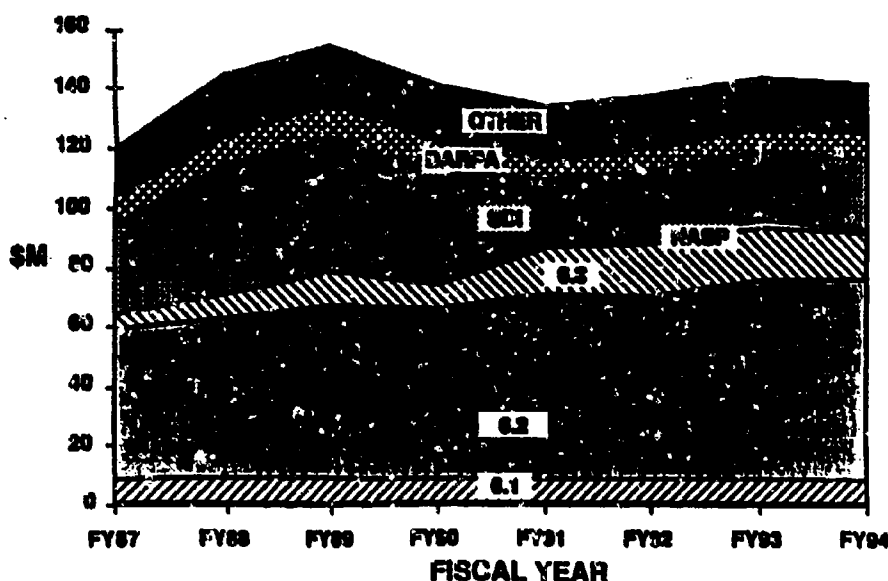
MAJOR THRUSTS

| THRUST TITLES | METALS & CERAMICS | NONMETALLIC MATERIALS | ELECTRO-MAGNETIC MATERIALS | SYSTEMS SUPPORT | INTEGRATION AND OPERATIONS |
|--|-------------------|-----------------------|----------------------------|-----------------|----------------------------|
| 1 CARBON - CARBON & THERMAL PROTECTION MATERIALS | ★ | ★ | ★ | ★ | ★ |
| 2 METALLIC MATERIALS | ★ | | | | |
| 3 NONMETALLIC STRUCTURAL MATERIALS | | ★ | | | |
| 4 NONDESTRUCTIVE EVALUATION | ★ | | | | |
| 5 CERAMICS & VERY HIGH TEMPERATURE METALLS | ★ | | | | |
| 6 NONSTRUCTURAL MATERIALS | | ★ | | | |
| 7 ELECTRONIC & ELECTRO-MAGNETIC MATERIALS | | | ★ | | |
| 8 LASER HARDENED MATERIALS | | | ★ | | |
| 9 MANUFACTURING RESEARCH | | | | | ★ |
| 10 SYSTEMS SUPPORT | | | | ★ | |



MATERIALS TECHNOLOGY AREA PLAN

FINANCIAL TREND



DEFENSE CONVERSION AND THE AFMC ROLE



DEFENSE CONVERSION HISTORY

1980, 1986

Congress requires Federal Laboratories to transfer technology to State/Local Governments and the private sector

1992

Congress establishes Defense Conversion Commission, appropriates \$1.5B for defense conversion programs

-- \$575M for Defense Conversion Initiatives

1993

President announces reorientation of Defense R&D

-- Civilian R&D to increase from 41% in 1993 to 50% by 1998 (+ \$8.7B)

TECHNOLOGY TRANSFER ACT OF 1986

- Made technology transfer a responsibility of all federal lab S&Es
- Created financial incentives through royalty sharing
 - At least 15 percent to federal inventor
 - Remainder to inventor's organization
- Created the Federal Laboratory Consortium (FLC)
- Empowered lab directors to enter into Cooperative Research and Development Agreements (CRDAs)

DEFENSE CONVERSION REINVESTMENT AND TRANSITION ASSISTANCE ACT OF 1992

- Major Congressional Initiative to promote Dual-Use Technologies
- Appropriates \$1.5B in FY 93
 - \$575M directly applicable to defense technology and industry programs
- DoD is OPR for most activities
- Implementation policy not yet formulated

BUSINESS PRACTICES REQUIRED

- Simple non-adversarial agreement/partnership mechanism
- Clarity and flexibility for intellectual property rights
- Conflict of Interest guidelines for non-adversarial partnerships
- 2371 U.S.C. 10, Cooperative Agreements
 - Delegated authority, maximum flexibility

TRANSITION AGREEMENTS AUTHORITY

New Law - 10 U.S.C. 2371

- What does it do?
 - Authorized "cooperative agreements and other transactions"
 - For "advanced research"
- Why?
 - Procurement contracts are best suited for buyer/seller relationships
 - R&D often involves support, stimulation, cooperation
 - Flexibility and innovation required
 - Impact of government funding is often more like investment than the purchase of goods and services



A TOP-LEVEL METRIC

**"ALL LABORATORIES MANAGED BY DOD
WILL BE REVIEWED WITH THE AIM OF DEVOTING
AT LEAST 10-20% OF THEIR BUDGETS TO R&D
PARTNERSHIPS WITH INDUSTRY"**

**President William J. Clinton
22 Feb 93**

MR JEROME PERSH
DEPARTMENT OF DEFENSE

THE DEPARTMENT OF DEFENSE
MATERIALS AND STRUCTURES
SCIENCE AND TECHNOLOGY PROGRAMS



**AEROSPACE MATERIALS AND
PROCESS REINVESTMENT WORKSHOP
AIR FORCE WRIGHT LABORATORY MATERIALS DIRECTORATE**

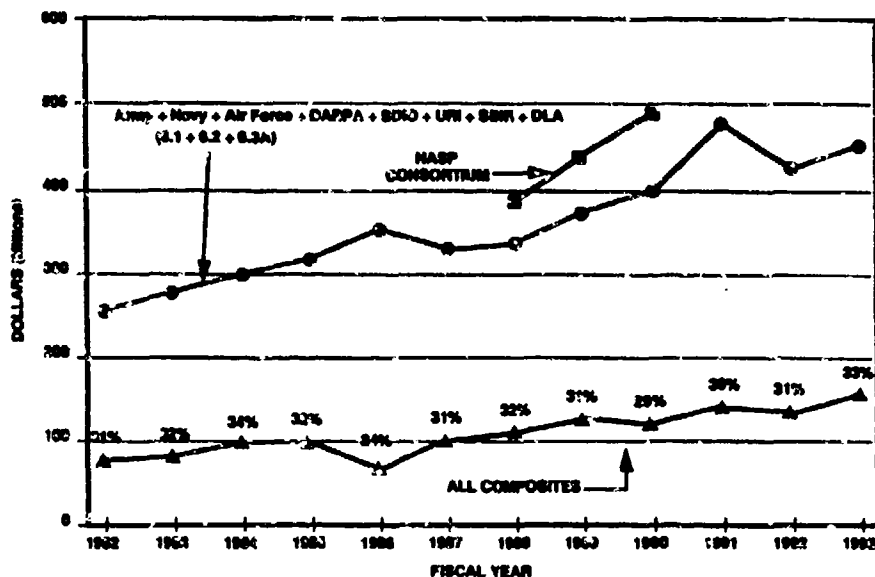
MAY 1993

JEROME PERSH
STAFF SPECIALIST FOR
MATERIALS AND STRUCTURES
OFFICE OF THE DIRECTOR/ADVANCED TECHNOLOGY
ODDR&E/ADVANCED TECHNOLOGY (AT)

DOD MATERIALS AND STRUCTURES SCIENCE AND TECHNOLOGY SUMMARY

- THE DoD IS SPENDING ALMOST 1/2 B/YR FOR MATERIALS AND STRUCTURES RESEARCH AND DEVELOPMENT (6.1 + 6.2 + 6.3A)
 - OF THIS TOTAL, 1/4 TO UNIVERSITIES, 1/2 TO INDUSTRY, 1/4 IN-HOUSE
- RESEARCH AND DEVELOPMENT INDUSTRY BASE HEALTHY
 - CHALLENGED
- PARTICIPATION BY SMALL COMPANIES (SBIR), UNIVERSITIES (6.1, URI), LARGE AND SMALL COMPANIES (6.2, 6.3A)
- THE AVERAGE ANNUAL GROWTH RATE HAS BEEN ABOUT 10% OVER THE PAST 10 YEARS
 - PROGRAM HAS ALMOST DOUBLED FY 1980 - 1993
- ROUGHLY 1/3 OF THE TOTAL EXPENDITURES ARE ON "COMPOSITES"

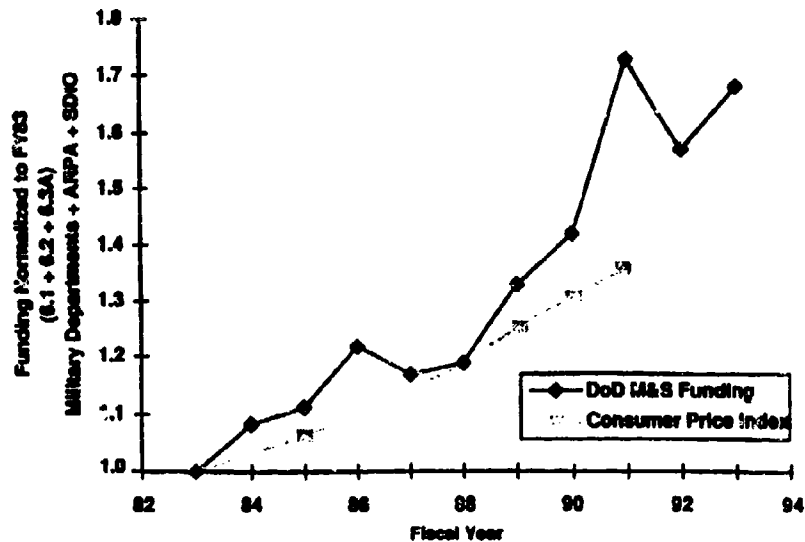
DOD MATERIALS AND STRUCTURES SCIENCE AND TECHNOLOGY PROGRAM FUNDING ALLOCATION BY MISSION AREA



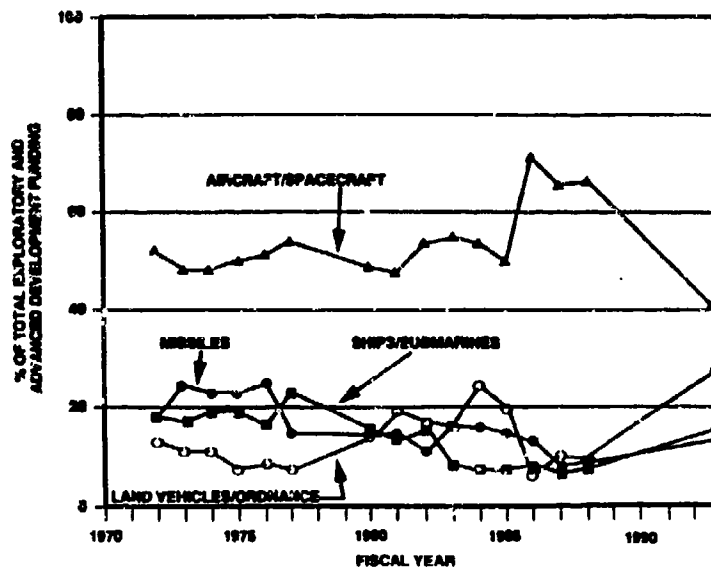


THE DEPARTMENT OF DEFENSE MATERIALS AND STRUCTURES SCIENCE AND TECHNOLOGY PROGRAMS

FUNDING HISTORY



DOD MATERIALS AND STRUCTURES SCIENCE AND TECHNOLOGY PROGRAM FUNDING ALLOCATION BY MISSION AREA



OBSERVATIONS, DIRECTIONS, AND MORE BOTTOM LINES

- **THINGS ARE CHANGING RAPIDLY**

- "BUSINESS AS USUAL" OBE
- CONSORTIA / PARTNERSHIPS / ALLEGIANCES ARE BECOMING A "WAY OF LIFE"
- DUAL USE AND ENVIRONMENTAL CONSIDERATIONS BECOMING VERY IMPORTANT
- CONTRACTING MECHANISMS EXPANDING

- **HUGE OPPORTUNITIES FOR LARGE AND SMALL COMPANIES**

- BUT CHANGES NECESSARY
 - VERTICALIZATION
 - COMPANY-TO-COMPANY ARRANGEMENTS
 - INNOVATION SHARING
 - SPECIALTIES CONCEPTS



THE DEPARTMENT OF DEFENSE MATERIALS AND STRUCTURES SCIENCE AND TECHNOLOGY PROGRAMS

- **Defense Conversion/Dual Use is Very Important for the DoD Materials and Structures S&T Community**
 - Now and in the Foreseeable Future
 - Appreciable Funding
- **Challenge is to Propose Programs that Satisfy Both Military and Civilian Needs**
 - Management Concepts (Partnerships, Consortia, Integrations/Government Labs, States, Universities, Local Jurisdictions, etc.)
 - Technical Excellence
 - Build on Existing Technology
 - Short-Term Focus

BOTTOM LINES

- **THE ADMINISTRATION AND THE CONGRESS RECOGNIZE THE IMPORTANCE OF ADVANCED MATERIALS TO WORLDWIDE COMPETITIVENESS**
 - **OFFICE OF SCIENCE AND TECHNOLOGY POLICY (OSTP)/
FEDERAL COORDINATING COUNSEL FOR SCIENCE,
ENGINEERING AND TECHNOLOGY (FCCSET)/TECHNOLOGY
AND INDUSTRY/COMAT/AMPP**
 - **SENATE AND HOUSE ARMED SERVICES AND APPROPRIATIONS
COMMITTEES**
 - **SENATE AND HOUSE COMMITTEES ON COMMERCE, SCIENCE,
TRANSPORTATION, AVIATION, SPACE, AND MATERIALS**
- **OVERALL U.S. ADVANCED MATERIALS COMMUNITY (GOV'T,
INDUSTRY, ACADEMIA) SOLIDLY SUPPORTED BY U.S.
GOVERNMENT (AND MANY STATES)**
- **U.S. INDUSTRY AND ACADEMIA ARE VERY, VERY STRONG
PLAYERS IN WORLDWIDE COMPETITION**



THE DEPARTMENT OF DEFENSE MATERIALS AND STRUCTURES SCIENCE AND TECHNOLOGY PROGRAMS

ADVANCED RESEARCH PROJECTS AGENCY (ARPA) ADVANCED MATERIALS SYNTHESIS AND PROCESSING PARTNERSHIPS PROGRAM

CHARACTERIZATION

- **State/federal government/industry/academia participation**
- **Management by partner group/government does not lead**
- **50% cost sharing/IRAD + in-kind**
- **Legal agreements/MOUs by partners**
- **Partners assume responsibility/accountability**
- **Intellectual property agreements**
- **Funding direct/milestone-schedule driven**



**THE DEPARTMENT OF DEFENSE
MATERIALS AND STRUCTURES
SCIENCE AND TECHNOLOGY PROGRAMS**

**ADVANCED RESEARCH PROJECTS AGENCY (ARPA)
ADVANCED MATERIALS SYNTHESIS
AND PROCESSING PARTNERSHIPS PROGRAM**

● **Concerns**

- Unfamiliar administrative/contracting procedures/
commercial accounting practices
- FAR / DFAR / DCAS can be waived
- Relationship to SBIR / S & T - Reliance unclear
- Small company participation
- Competition losers



**THE DEPARTMENT OF DEFENSE
MATERIALS AND STRUCTURES
SCIENCE AND TECHNOLOGY PROGRAMS**

SUMMARY

- **Future health of materials & structures funding and
Industrial base becoming dependent on ability of
Industry to:**
 - Identify high pay-off "dual-use" opportunities
 - Assemble working partnerships
 - Capture fair share of partnership funding

DR. LYLE SCHWARTZ

NIST

**THE NEW ENVIRONMENT -
NIST IN THE BRAVE NEW WORLD**

- Vision and the Technology Plan
- Congressional Lead/Response
- NIST and Other Agencies

VISION AND THE TECHNOLOGY PLAN - 1

- Extramural
 - ATP
 - MEP
 - Quality

VISION AND THE TECHNOLOGY PLAN - 2

- Intramural
 - Laboratory
 - FCCSET
 - Industry (Outreach?)

VISION AND THE TECHNOLOGY PLAN - 3

- Budgets
 - 4 year OMB Pacsback
 - FY93 Supplement
 - FY94 Request
 - FY95-97

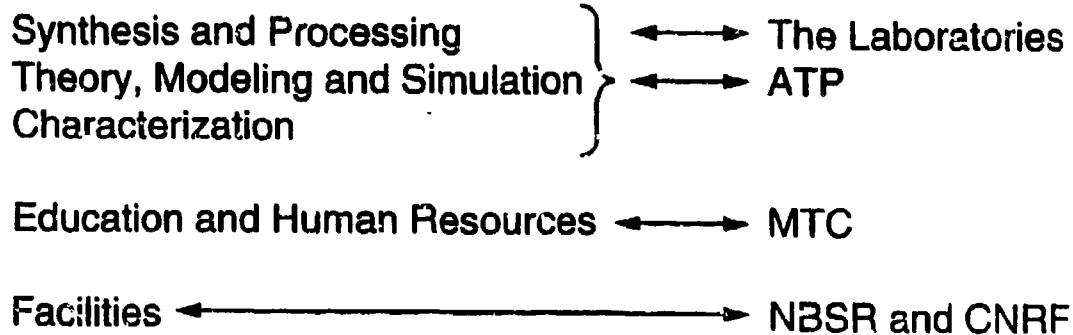
NIST AND OTHER AGENCIES

- Defense Conversion
- FCCSET
- AMPP

AMPP: THE NIST ROLE

AMPP Technical Components

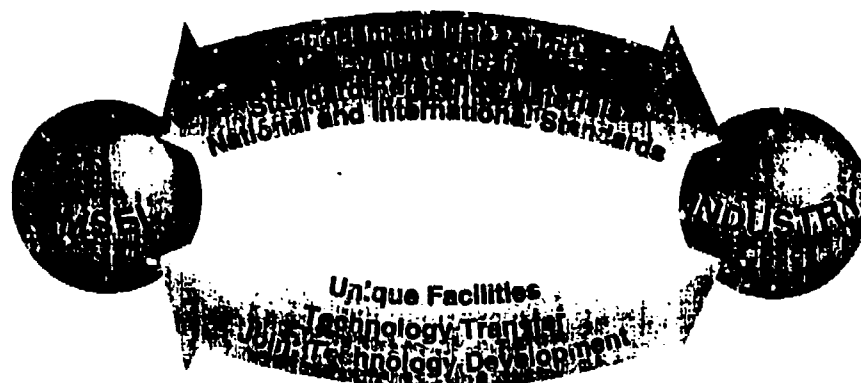
NIST Programs



MISSION

MSEL is the Federal Government's central resource for measurement-related materials research in support of industrial needs and U.S. standards.

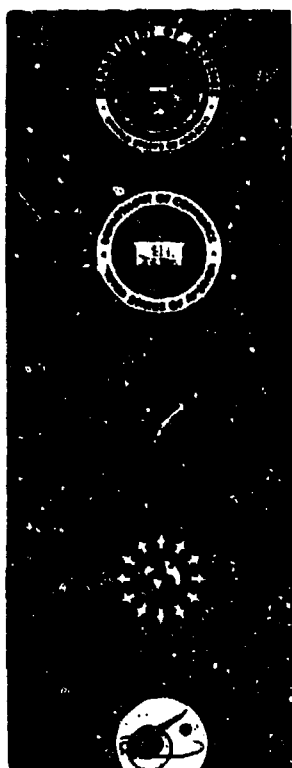
MSEL - INDUSTRY INTERACTIONS



PLANNED INITIATIVE EXPANSION (under consideration)

| Name | Cooperating Lab. |
|---------------------------------|------------------|
| Functional Gradient Materials | CSTL |
| Interconnects | EEEL |
| Distributed Theory Center | CAML |
| Nanostructured Materials | CSTL |
| Machining of Advanced Materials | MEL |
| Infrastructure Materials | BFRL |
| Metal Matrix Composites | - |
| Photonic Materials | EEEL, PL |

MR. JERRY COVERT
STATUS OF CURRENT ACTIVITIES



**Program Information Package
for
Defense Technology Conversion,
Reinvestment, and Transition Assistance**



March 30, 1993

Technology Reinvestment—What it is

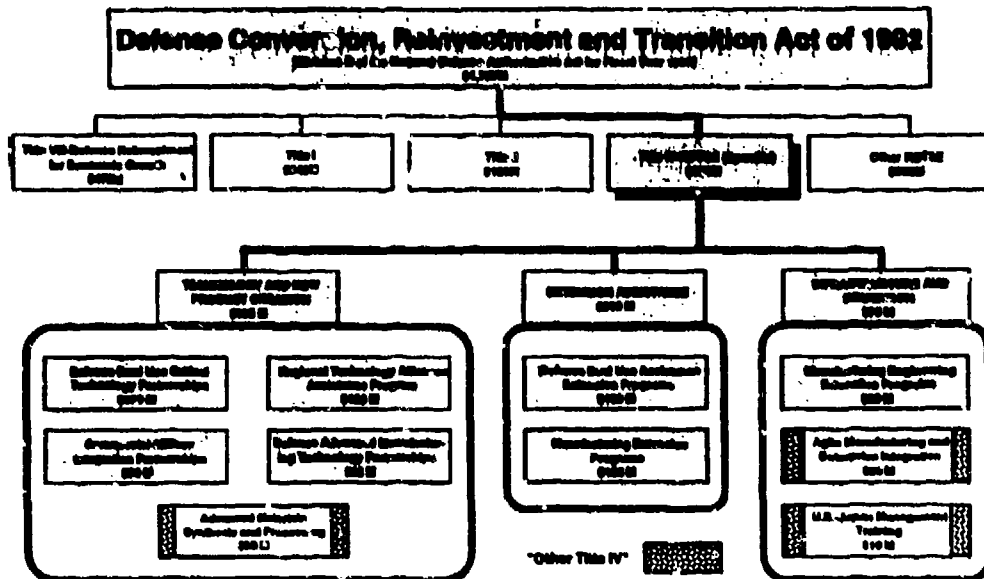
Technology Reinvestment is:

- (1) Focus on turning technologies into products/processes**
- (2) Create jobs in the long term**
 - **Diversification from defense to commercial products**
 - **Integration of defense and commercial production facilities**
 - **Deployment of technology to and from commercial industries**
 - **Development of Dual-Use technologies**

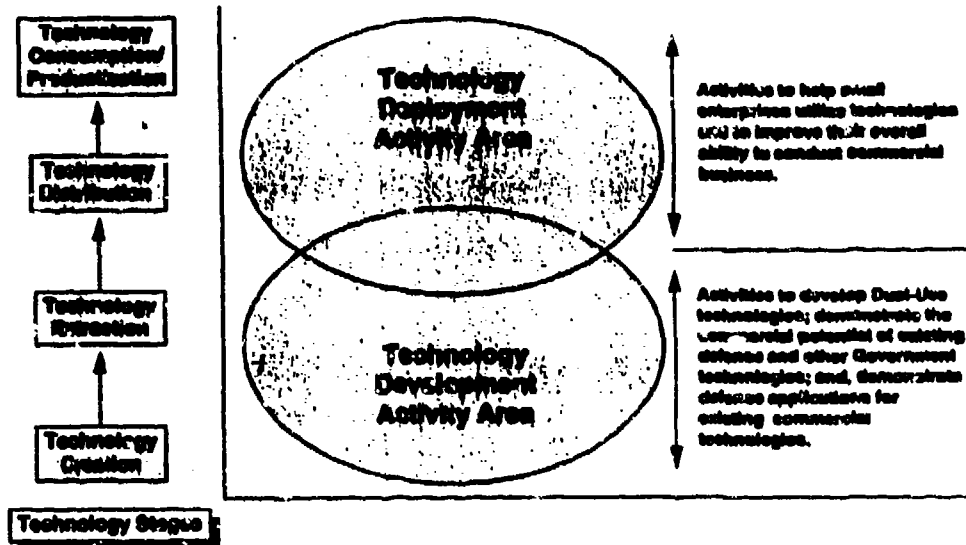
Technology Reinvestment—What It Is Not

- **NOT** near term compensation for base closings
- **NOT** extension of unemployment benefits
- **NOT** more support for basic research
- **NOT** Government venture capital
- **NOT** for transition of national laboratories to for-profit
- **NOT** a way to continue defense business as usual

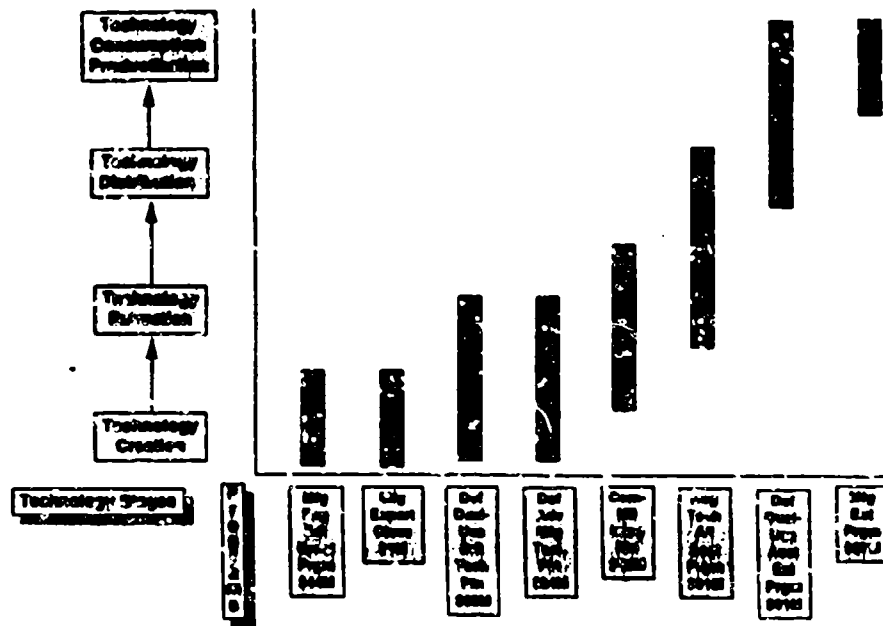
Defense Conversion, Re-Investment and Transition



Technology Stages and Activity Areas



Technology Reinvestment Project Emphases



Common Requirements

Statutory requirements common to all programs

- (1) All require competitive award
- (2) All contain participation and organizational requirements
- (3) All require industry cost sharing of at least fifty percent (50%)
- (4) Defense emphasis - 10 U.S.C. § 2501

Technology Reinvestment Project

Mission

To stimulate the transition to a growing, integrated, national industrial capability which provides the most advanced, affordable, military systems and the most competitive commercial products.

Strategy

Invest Defense Conversion, Title IV funds in activities which stimulate the:

- 1) Development of technologies which enable new products and processes
- 2) Deployment of existing technology into commercial and military products and processes
- 3) Integration of military and commercial research and production activities

Technology Reinvestment Activities

- Defense Technology Conversion Council (DTCC) established December 16, 1992
 - Department of Defense (Advanced Research Projects Agency and Military Departments)
 - Department of Energy (Defense Programs)
 - National Science Foundation
 - Department of Commerce (National Institute of Standards & Technology)
 - National Aeronautics and Space Administration
- A single competition is planned for the issuance of a formal solicitation
- Evaluation, ranking, and selection of proposals will be conducted jointly
- Distributed execution

Technology Development

Technology Development activities deal with the creation of new product and process technologies and exploration of their potential for commercial and/or defense applications. Proposals that involve either basic research OR final product development beyond the stage of product prototype/feasibility demonstration will be regarded as out of scope.

- Proposals will fall into one of three activities:

- (1) Spin-Off Transitioning activities are those that demonstrate non-defense commercial viability of technologies already developed for defense purposes.
- (2) Dual-Use Development activities are those that develop commercially viable technologies that have both defense and non-defense uses.
- (3) Spin-On Promotion activities are those that demonstrate the defense utility of existing non-defense commercially viable technologies.

Technology Development Focus Areas

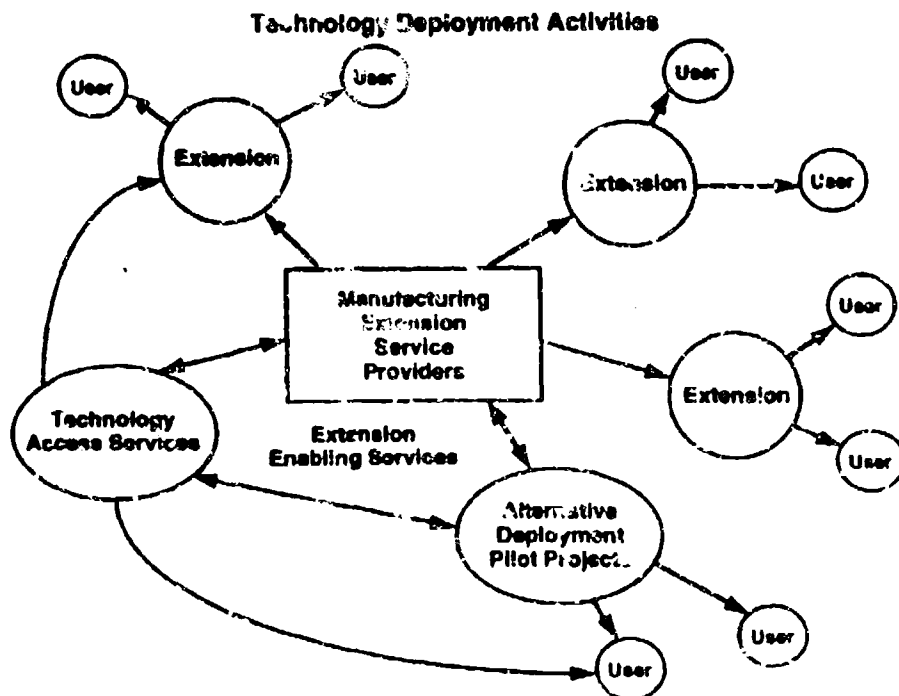
- Information Infrastructure
- Electronics Design and Manufacturing
- Mechanical Design and Manufacturing
- Materials/Structures Manufacturing
- Health Care Technology
- Training/Instruction Technology
- Environment Technology
- Aeronautical Technologies
- Vehicle Technology
- Shipbuilding Industrial Infrastructure
- Advanced Battery Technology

These topics are not to be considered exclusive; the Government will entertain ideas in other areas.

Technology Deployment

Proposals will fall into one of four activities:

- (1) Manufacturing Extension Service Providers target small businesses (fewer than 500 employees) to increase competitiveness through technical and management advancement (restructure business practices, assist with accessing consulting services and technologies).
- (2) Extension Enabling Services are activities that link together providers of Manufacturing Extension Service Providers with each other and developers of technology.
- (3) Alternative Deployment Pilot Projects are innovative modes of technology deployment that are alternatives to Manufacturing Extension Service Providers.
- (4) Technology Access Services are activities to assist the private sector with acquiring existing and emerging Dual Use technologies.



Manufacturing Education and Training

Proposals will fall into one of seven activities:

- (1) Engineering Education in Manufacturing Across the Curriculum**
- (2) Practice-Oriented Master's Degree Programs**
- (3) Retraining the Manufacturing Work Force**
- (4) Educational Traineeships for Defense Industry Engineers**
- (5) Manufacturing Engineering Education Coalitions**
- (6) Supplementary Education Awards to Ongoing Centers and Coalitions Devoted to Manufacturing**
- (7) Individual/Group Innovations in Engineering Education in Manufacturing**

- (1) **Engineering Education in Manufacturing Across the Curriculum**
- (2) **Practice-Oriented Master's Degree Programs**
- (3) **Retraining the Manufacturing Work Force**
- (4) **Educational Traineeships for Defense Industry Engineers**
- (5) **Manufacturing Engineering Education Coalitions**
- (6) **Supplementary Education Awards to Ongoing Centers and Coalitions Devoted to Manufacturing**
- (7) **Individual/Group Innovations in Engineering Education in Manufacturing**

[illegible]

Mfg. Ext. Serv. Program
Electronic Mailbox
Alt. Delivery
Terminating

Spin-On Trans
Dual-Line Operation
Spin-On Filter

Mfg. Ed. & Trng. Activity Area
Mfg. Education & Training
(7 Activities)

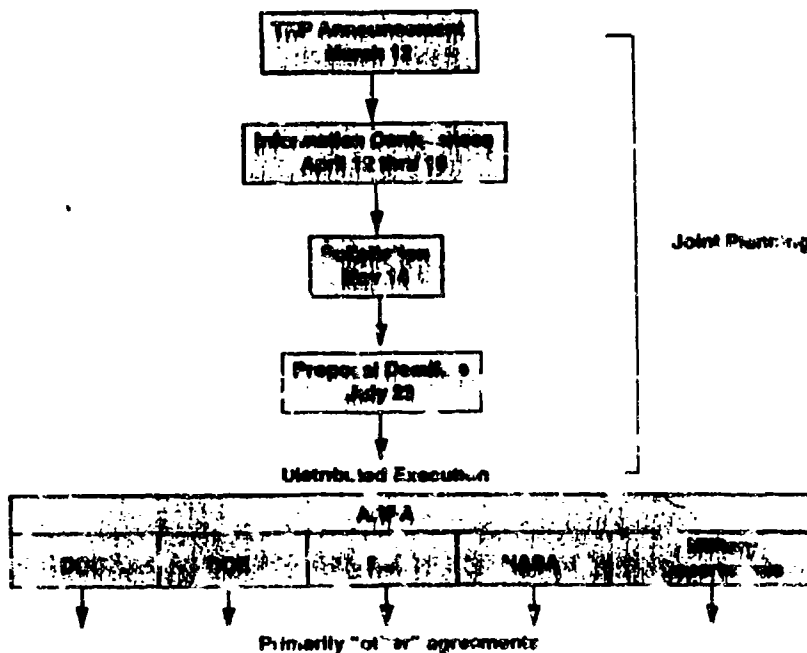
Program Emphasis

Delivery Programs

Small Business Innovative Research (SBIR)

- Technology Reinvestment Project (TRP) plans to solicit proposals from small businesses
 - Proposals will address technology development focus areas
 - Procurement will be based on Federal SBIR guidelines
- Cost sharing will be permitted for TRP SBIR proposals, but is not required and will not be an evaluation factor
- Out-year TRP activities are a natural SBIR Phase III follow-on

Joint Agency Program



AIR FORCE PAY-OFF

- AFFORDABLE AIR FORCE SYSTEMS
LEVERAGE UNIFIED INDUSTRIAL BASE VOLUME PRODUCTION PRICES
- DEVELOP AIR FORCE PROTOTYPE EQUIPMENT AT NEAR 0 COST
- MAINTAIN AIR FORCE INFRASTRUCTURE
WITHOUT CHANGE, MUCH WILL BE LOST WITH AF/DOD ONLY INVESTMENT
IMPROVED TECHNOLOGY DEPLOYMENT
- ALLOW FOCUSED INVESTMENT ON AIR FORCE UNIQUE TECHNOLOGY

NEW WAY OF DOING BUSINESS

- GOVERNMENT-INDUSTRY-ACADEMIA PARTNERSHIP VL ALLIANCES
PARTICIPATIVE GOVERNMENT INVOLVEMENT (~ AGENCIES)
NO LONGER CUSTOMER-VENDOR RELATIONSHIP
EFFECTIVE IN PRE-COMPETITIVE PHASE
- FOCUSED ON DUAL USE TECHNOLOGY
BUILDING UNIFIED DEFENSE-COMMERCIAL INDUSTRIAL BASE
DEVELOPING DUAL USE PROTOTYPE PRODUCTS
DEVELOPMENT- UNIFIED DEFENSE-COMMERCIAL INFRASTRUCTURE
EDUCATION- UNIFIED MANUFACTURING EDUCATION & TRAINING

DR. BEN WILCOX

ARPA

PRESENTATION NOT AVAILABLE

MR. STEPHEN STRUNCK
GENERAL ELECTRIC
PRESENTATION NOT AVAILABLE

DR. THOMAS TOM
HOWMET CORPORATION

**COOPERATIVE ARRANGEMENTS FOR GENERIC
TECHNOLOGIES**

BACKGROUND

- DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA) AUTHORIZED BY CONGRESS (\$50 MILLION) IN 1991 TO FORM SIX PRECOMPETITIVE CONSORTIA
- 1992 CONGRESS HAS AUTHORIZED (\$70 MILLION) FOR DUAL-USE PARTNERSHIPS SIMILAR TO 1991 PRECOMPETITIVE CONSORTIA
- 7 TECHNOLOGIES SELECTED OUT OF 121 WHITE PAPERS FOR DUAL-USE PARTNERSHIPS

BENEFITS

- Reduced Weapons System Turbine Engine Acquisition Costs - \$50 to 100 Million Per Year Achievable
- Improved Airfoil and Structural Casting Quality (Increased Yields), Reliability, and Consistency.
- Greatly Reduced "Time to Market" for Airfoil and Structural Castings (Goal is 50% Minimum).
- U.S. Technological and Competitive Advantages for Both Military and Commercial Applications.
 - Aircraft Turbine Engine Producers
 - Investment Casting Foundries
- Preservation of Product/Process Design Experience and Expertise (Organizational Learning).
- Technology Transferrable to Other US Casting Industries.

BENEFITS OF INTEGRATED PRODUCT-PROCESS DEVELOPMENT

- Today's Process



- Anticipated DARPA Result

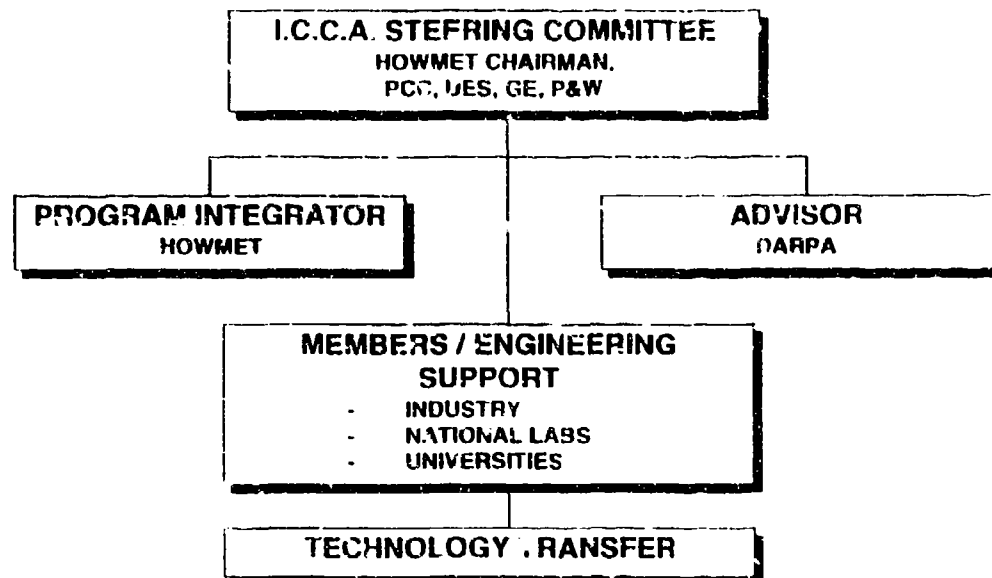


- IPD/Work Flow Approach



TIME →

INVESTMENT CASTING COOPERATIVE ARRANGEMENT (ICCA)



ICCA DARPA PROGRAM FOR PROCESS MODELING

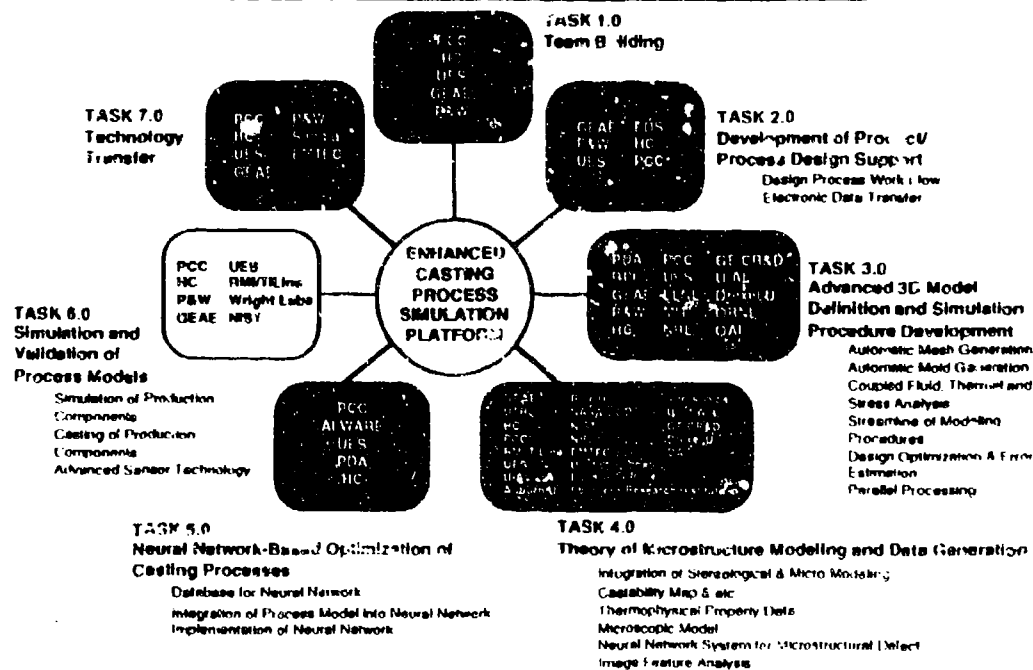


FIGURE 1-6 PROGRAM SCHEMATIC OVERVIEW SHOWING TASKS, PARTICIPANTS, AND RELATIONSHIPS.

INVESTMENT CASTING COOPERATIVE ARRANGEMENT

TECHNICAL PLAN

• EXPECTED ACCOMPLISHMENTS

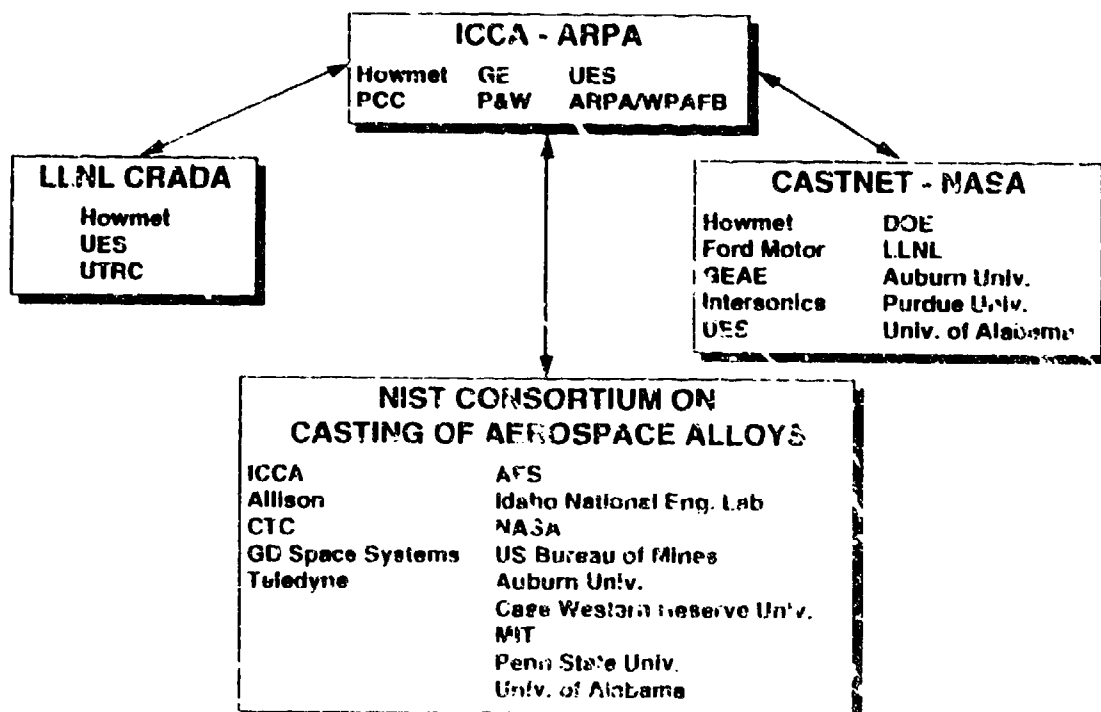
SUPPORTED PLATFORM FOR SOLIDIFICATION PROCESS MODELING WHICH PROVIDES IMPROVED USER FRIENDLINESS AND EFFICIENCY IN MODEL AND SIMULATION

VALIDATION OF SOLIDIFICATION MODELING ON PRODUCTION AIRFOIL AND STRUCTURAL CASTINGS

DEMONSTRATION THAT INDUSTRY PARTICIPANTS CAN COOPERATIVELY WORK TOGETHER TO PROVIDE AN IMPLEMENTATION STRATEGY FOR COMPREHENSIVE ANALYSIS OF COMPLEX CASTINGS, THEREBY MAINTAINING U.S. COMPETITIVENESS

CREATION OF A CASTING INDUSTRY INFRASTRUCTURE FOR CONCURRENT ENGINEERING OF PRODUCT, PROCESS, AND TOOLING WHILE PROVIDING FOR THE FUTURE INCORPORATION OF TECHNOLOGY

PROCESS MODELING



PROCESS MODELING

ALIGNMENT OF PROCESS MODELING INITIATIVES

- ICCA ARPA: \$ 12M/2 Yrs (50% Cost Share), May 1993 Integrated Modeling Procedure to Reduce Modeling Turnaround Time and Improve Model Accuracy
- NIST: 1.8M / 3 Yrs of NIST Budget Allocated April 1993
Alpha Case Prediction, Metal Mold Contact Conductance, Mold Fill and Solidification Pathway

PROCESS MODELING

ALIGNMENT OF PROCESS MODELING INITIATIVES (Continued)

CASTNET: 1.2M / 3 Yrs of NASA Budget Allocated, January 1993

- Thermophysical Properties, Defect Maps, Contact Conductance, Low Gravity Experiments, and Microstructure Modeling

LLNL CHADA: 1.8M / 3 Yrs of LLNL Budget Allocated, April 1993

- Iterative Solver, Thermal-Mechanical Code, Solidification Kinetics, and Parallel Processing

IPD PHILOSOPHY

- There is only **ONE TEAM**
- **TRUST** is the glue that holds the team together
- Team management is based on **FACT** and **DATA**
- **PROCESS DISCIPLINE** leads to real communication

"requires discipline and process uniformity"

IPD TEAM PROCESS

- Focus on customer's needs and expectations
- Build a Multi-cultural and Multi-functional teams in a complex environment
- Lead a Process-oriented/Mission focused Program
- Identify and avoid non-value-adding work
- Translate tools and techniques into daily activities
- Empower the teams to accomplish specific missions

ICCA (INVESTMENT CASTING COOPERATIVE ARRANGEMENT)

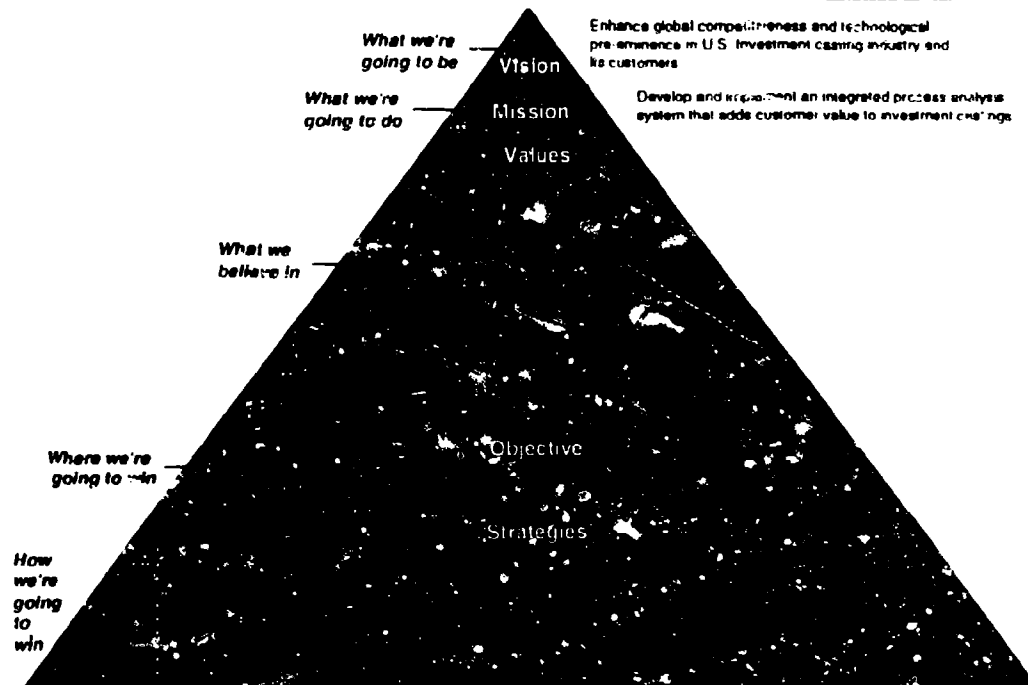


FIGURE 1-7 IPD (INTEGRATED PRODUCT DEVELOPMENT) TEAM PHILOSOPHY FOR ENHANCING INVESTMENT CASTING MODELING TECHNOLOGY AND GLOBAL COMPETITIVENESS

VISION

**ENHANCE GLOBAL COMPETITIVENESS AND
TECHNOLOGICAL PRE-EMINENCE IN U.S. INVESTMENT
CASTING INDUSTRY AND ITS CUSTOMERS**

MISSION

DEVELOP AND IMPLEMENT AN INTEGRATED PROCESS ANALYSIS SYSTEM THAT ADDS CUSTOMER VALUE TO INVESTMENT CASTINGS

VALUES

- **TRUSTING TEAM THAT WILL OPENLY SHARE CONTRACTUAL DATA TO SATISFY CUSTOMER NEEDS**
- **INTEGRATED PRODUCT/PROCESS DEVELOPMENT / CONCURRENT ENGINEERING (IPD/CE) IS OUR BELIEF**
- **STRIVE FOR WIN-WIN; COMPROMISE FOR COMMON GOOD (VISION/MISSION) AND DATA BASED DECISIONS**
- **DIALOGUE RESTRICTED TO PRE-COMPETITIVE TECHNOLOGIES (PROPRIETARY INFO - NEED TO KNOW)**
- **FOCUS ON IMPLEMENTATION WHICH IS AFFORDABLE, RUGGED, USER FRIENDLY AND COMMERCIALY SUPPORTED TECHNOLOGY**
- **EARLY USE RESTRICTED TO U.S. INDUSTRIES**
- **TECHNOLOGY RISKS & REWARDS SHAPED (MOST FAVORED CUSTOMER STATUS FOR ICCA MEMBERS)**
- **AVOID NIH SYNDROME**
- **DEVELOP ADVANCED TECHNOLOGY AS-NEEDED**

STRATEGIES

- INCORPORATE TEAM TRAINING TO ENABLE EFFECTIVE TEAMWORK - USE EMPOWERED SUBTEAMS TO MAXIMUM EXTENT POSSIBLE
- USE COMMERCIAL SOFTWARE TOOLS AND INTERFACES TO BUILD AN INTEGRATED PLATFORM FOR FUTURE PROGRAMS WITH ARPA AND/OR MANTECH
- COORDINATE PROGRAM STRATEGIES WITH DOD, DOE, DCC, INCLUDING NATIONAL AND FEDERAL LABORATORIES (SANDIA, NIST, LIVERMORE, WPAFB, NRL, ETC) AND UNIVERSITIES
- DEFINE ACHIEVABLE, MEASURABLE, AND MEANINGFUL GOALS AND MILESTONES
- ACHIEVE CONTINUOUS TECHNOLOGY TRANSFER
- ENHANCE AND VALIDATE EFFECTIVENESS AND EFFICIENCY OF MODELING CODES AND PROCEDURES
- INTEGRATE ARPA FOLLOW-ON PROGRAM(S) INITIATIVES WITH OEM SUPPLIER INITIATIVES
- MAINTAIN PROPER BALANCE BETWEEN DEVELOPMENT AND IMPLEMENTATION TECHNOLOGIES AND AVAILABLE FUNDS
- MAINTAIN PROGRAM FLEXIBILITY TO DIRECT AND REALLOCATE AS NECESSARY AND INDICATED BY FACTS/DATA

OBJECTIVE

TO ACHIEVE DEMONSTRABLE PROGRESS IN REDUCING CYCLE TIME, COST, SCRAP/REWORK THROUGH ENHANCEMENT, VALIDATION AND APPLICATION OF THE SOLIDIFICATION MODELING PROCESS FOR PRODUCTION AIRFOIL AND STRUCTURAL CASTINGS WITHIN AVAILABLE TIME/RESOURCES

COST SHARE

WHAT QUALIFIES AS COST SHARE?

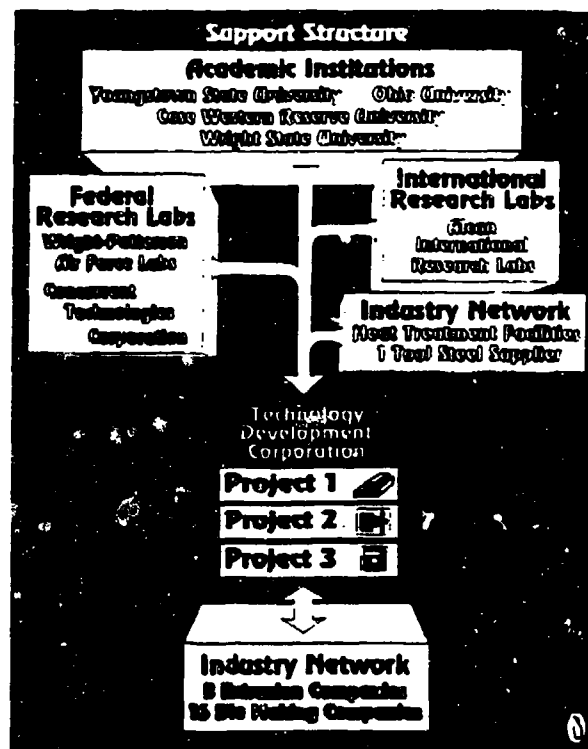
- Relevant In-Kind - Company funded programs completed prior to kickoff
- Concurrent In-Kind - Company funded parallel contributory programs
- Cash

SUMMARY

CRITERIA FOR SUCCESS FOR COOPERATIVE ARRANGEMENTS

- Individual who represents a company must be flexible, team player and results oriented
- Leader / chairperson of steering committee must be a good listener, fair and consistent
- Establish trust between all team members
- Establish & obtain buy-in to overall missions & values of the program
- Establish frequent lines of communications between all team members

MR. BUTCH DYER
YSU-TECHNOLOGY DEVELOPMENT CORP.



ALUMINUM EXTRUSION NETWORK OF THE GREATER MAHONING VALLEY, INC.

HISTORY

**MID-1990: PROPOSAL SUBMITTED TO THE OHIO DEPT.
OF DEVELOPMENT FOR NETWORK SUPPORT.**

- 11 EXTRUSION COMPANIES
- 50+ SUPPORT BUSINESSES

**MAR 1991: YSU-TDC ASSIGNED AS TECHNICAL SERVICE.
PROVIDER AND HELD FIRST NETWORK MEETING.**

- 5 EXTRUSION COMPANIES

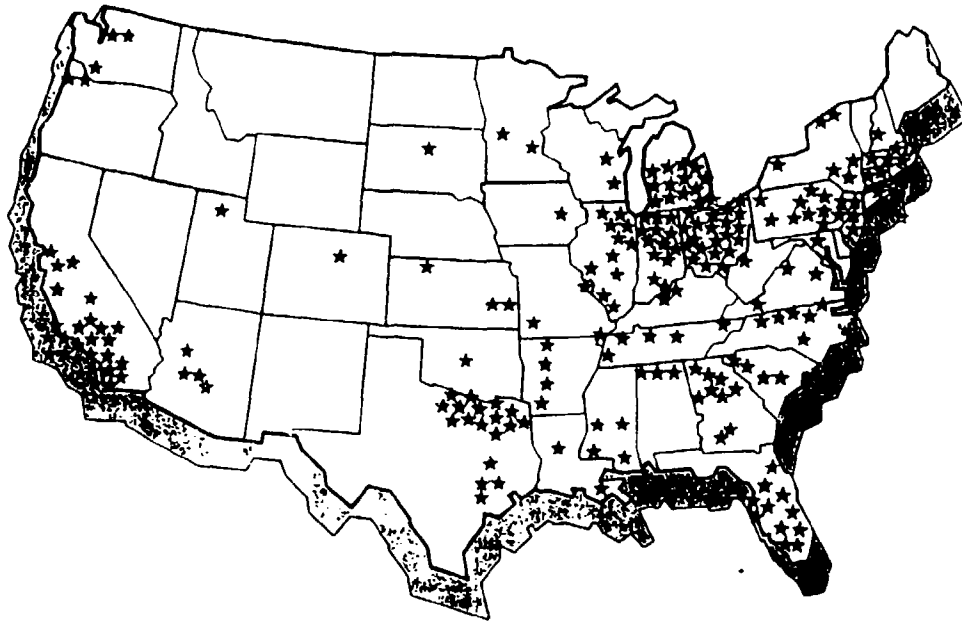
FEB 1992: TOOL & DIE MAKERS HELD FIRST MEETING.

- 16 TOOL & DIE MANUFACTURERS

NETWORK ACTIVITIES

- RESULTS ORIENTED
- 95% CONTROLLED BY NETWORK
- CAD/CAM TECHNOLOGIES
- TQM/ISO 9000
- SURFACE CORROSION
- WASTE MINIMIZATION
- INCREASED DIE LIFE
- IMPROVED HEAT TREAT TECHNOLOGIES
- SKILLS ENHANCEMENT
- TECHNICAL DATABASE
- PROCESS CONTROLS
- GROUP BENEFITS

DISTRIBUTION OF U.S. EXTRUDERS



Material
Characterization

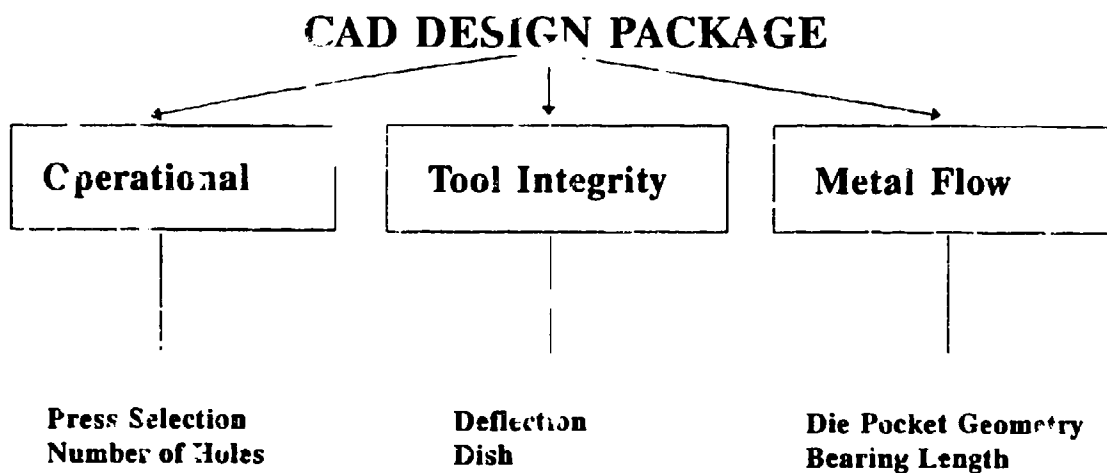
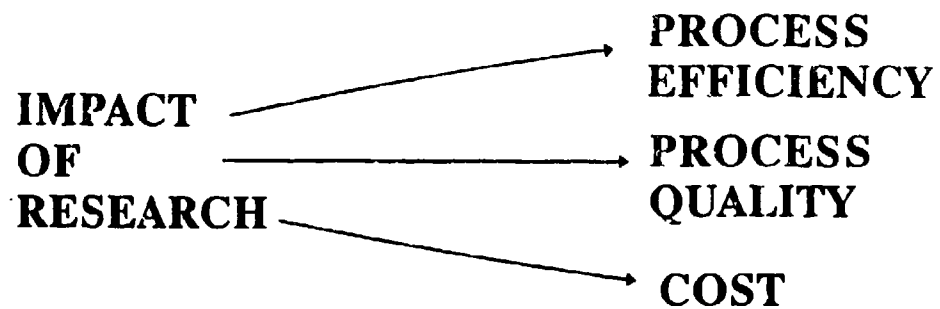
Die Design
Geometry/Configuration

**EXTRUSION
PROCESS**

**High Productivity,
Defect Free, Cost
Competitive
Extrusions**

Temperature
Measurement
& Control

Deformation
Control



Project Introduction.

Project 1

Optimal Extrusion Process Design

- i) Determine the optimum extrusion process parameters using Dynamic Material Modeling
- ii) Develop an automatic feedback control system to regulate the extrusion process

Project 2

Finite Element Modeling

Model the extrusion process to achieve further understanding and improvement of the process

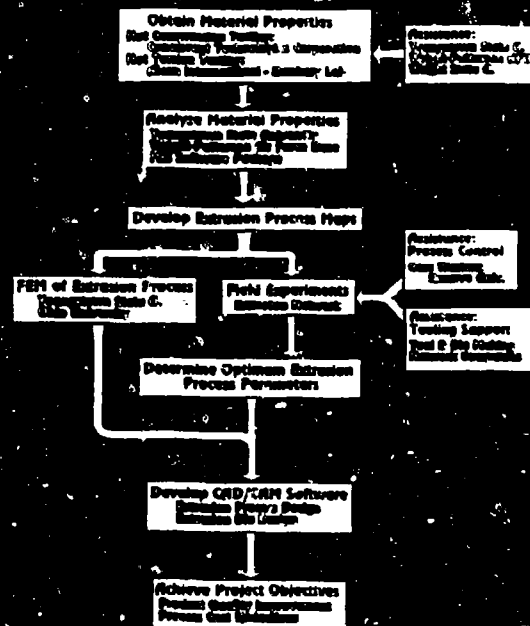
- Material Flow - product uniformity and quality
- Die Deflection - dimensional stability and precision

Project 3

CAD/CAM Computer Software

- i) Develop an extrusion process simulation package to improve quality and reduce production costs
- ii) Develop an extrusion die design software package to replace the "Trial and Error" approach

Project Strategy



Conclusion

Significant Contributions and Results:

Academic

- 1) Multi-University involvement
Youngstown State University
Ohio University
Wright State University
Case Western Reserve University
- 2) Students gain practical experience
- 3) Faculty gain and contribute knowledge to industry

Industrial

- 1) Network participants realize gains from a cooperative research effort
- 2) Benefit from the newest technologies through exposure to Universities and Federal Research Labs
- 3) Enrichment of the Network's personnel
- 4) Upgrade the aluminum extrusion and tool & die making process and practice

Economic (local)

- 1) Enable local companies to become more competitive
- 2) Improve the participating companies' profits
- 3) Encourage a cooperative atmosphere between industry and academics
- 4) Provide a model for similar efforts by other industries

MR. ALLAN FREEDMAN
NORTHROP CORPORATION
PRESENTATION NOT AVAILABLE

MR. BILL HARGROVE
LOCKHEED AERONAUTICAL SYSTEMS CO.

**Aerospace
Materials and Processes
Technology Reinvestment
Workshop**

May 1993

Dayton Ohio



Lockheed Aeronautical Systems Company



Overview

- **Potential Commercialization**
- **Supplier/Vender Issues**
- **Lockheed Experience**
- **Procurement Issues**
- **Future Programs**

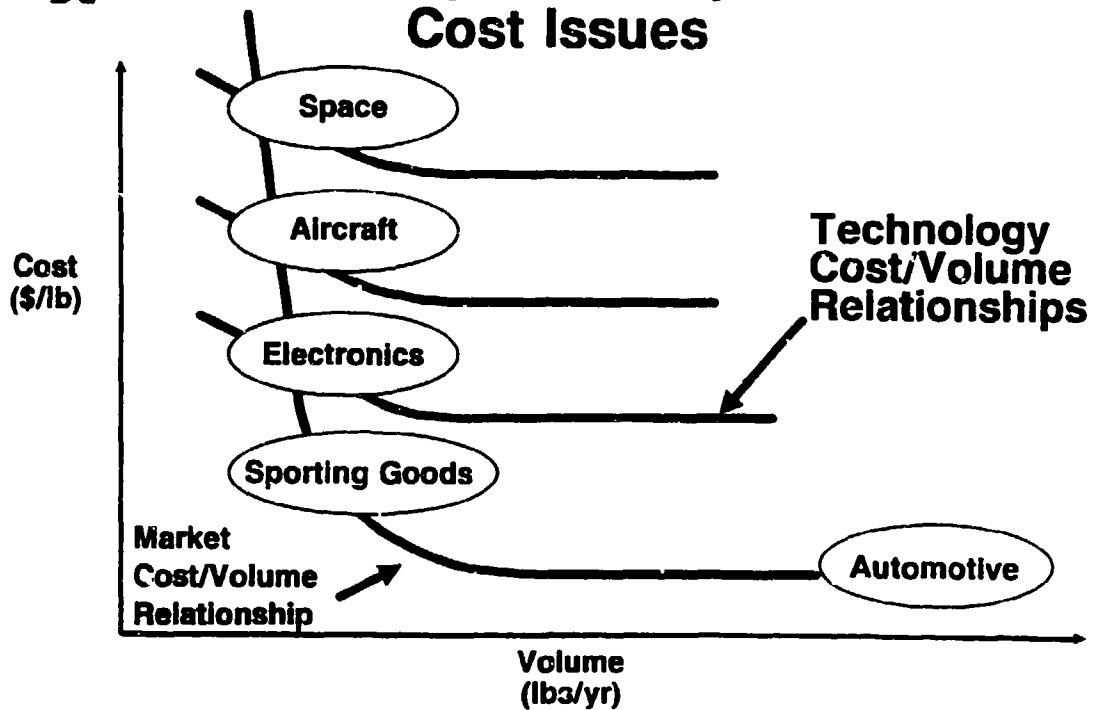


Commercialization of Aerospace Materials

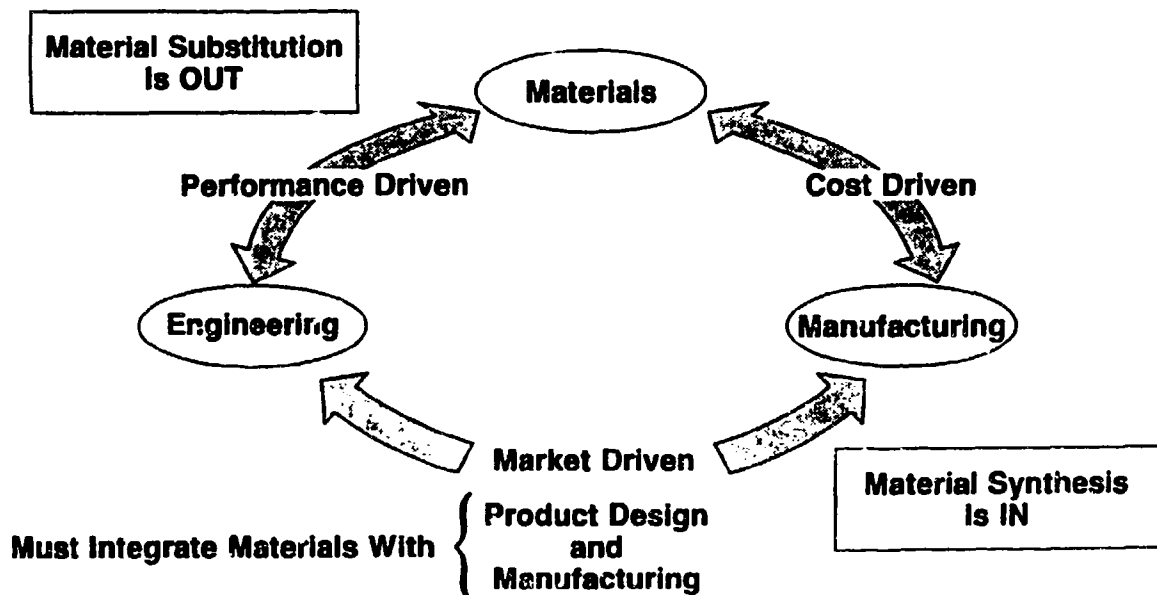
- **Commercial Aircraft**
 - **Metallic Materials Widely Used**
 - **Composite Materials Widely Used on Secondary Structure**
 - **Composite Materials Not Widely Used on Primary Structure**
- **Non Aerospace Products**
 - **Sporting Goods (Tennis Rackets, Golf Clubs)**
 - **Industrial Products (Oil Field "Down Hole" Applications)**
 - **Performance Driven Applications (Automotive)**
- **Commercialization Issues**
 - **Cost of Raw Materials and Fabrication**
 - **Standardization**



The Polymer Composite Cost Issues

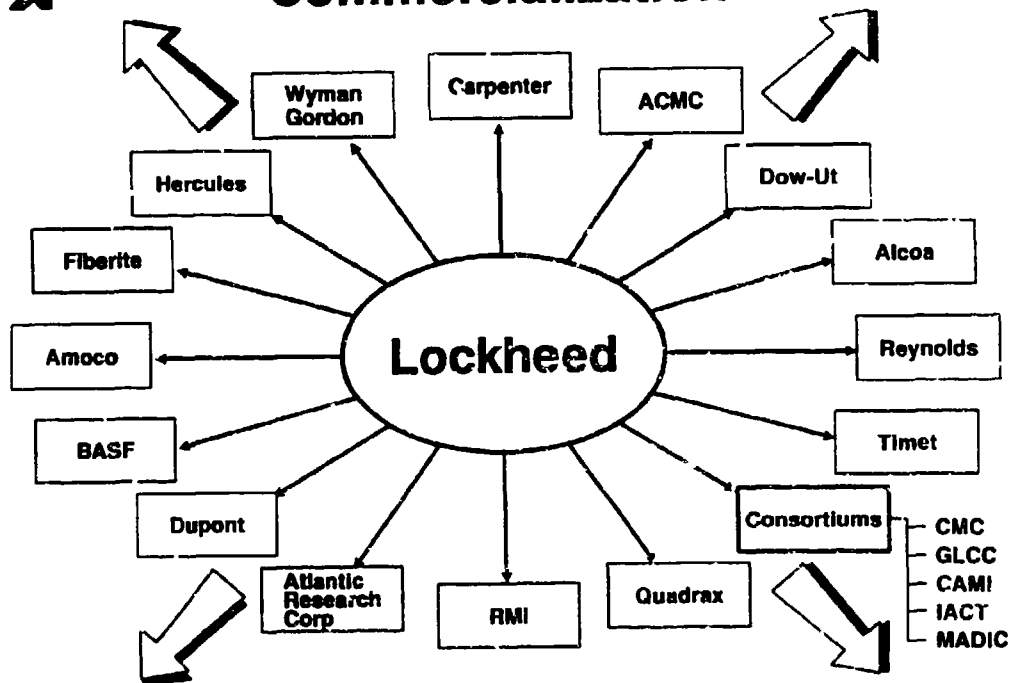


The Standardization Issue





Commercialization



Environmental Health and Safety

- Hazardous Materials (Toluene, Xylene, Isocyanates, Methyl Ethyl Ketone, etc.)
 - DoD Desires Alternative Materials
 - MIL-Spec QPLs DO Not Allow Alternative Materials
- Materials and Process Solutions Required
- Product/Field Implementation
- Recycling and Disposal



Lockheed Experience

**Composite Materials
Characterization
Inc**

- 8 Industry Members
- 5 Year Track Record
- 47 Materials in Data Base
- Standardized Test Methods



Consortium Objectives:

- Reduce Testing Cost
- Advance State-of-the-Art
- Establish Standards

**Aircraft, Helicopter,
Missile, and
Engine Programs**

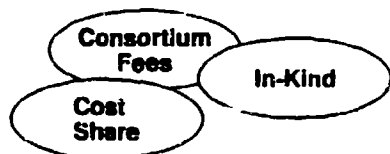


Procurement Issues

- Defense Acquisition Procurement (FARs and DARs)
- Defense Production Act - Title III
- ManTech and IMIP
- Small Business Innovation Research (SBIR)
- Cooperative Research and Development Agreements (CRADAs)
- Strategic Partnership Initiative (SPI)
- Defense Conversion and Reinvestment



Cost Share Issues



- Product Base Is Declining
- Downsizing of Facilities
- Pressure to Reduce Overhead Costs
- Reducing Research and Development Efforts



Technology Push

- High Speed Civil Transport
- Subsonic Commercial Airlift
- Next Generation Fighter
- VSTOL Fighter
- National Aerospace Plane



Summary

- **There are More Co-Operative Ventures**
- **The Aerospace Materials Industry Is Changing**
- **Industry Is Moving Toward Lean, Flexible Enterprise**
- **Cost Sharing Must Make Business Sense**
- **Good Planning Is Essential**

MR. JAMES DORR

MCAIR

PRESENTATION NOT AVAILABLE

MR. BILL YEE
PRATT & WHITNEY

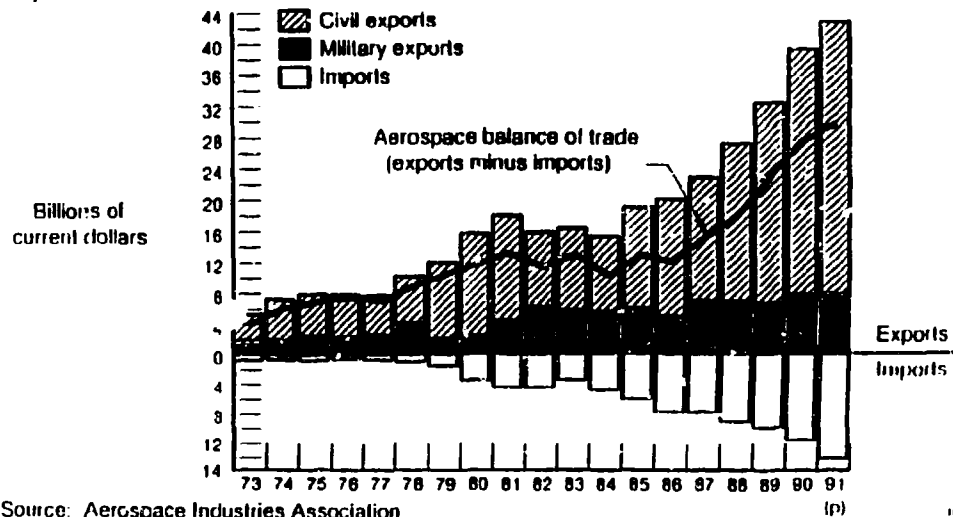
**TECHNOLOGY
REINVESTMENT**



DR. B.G.W. YEE, DIRECTOR
MATERIALS & PROCESS ENGINEERING
18 MAY 1993

AEROSPACE EXPORTS, IMPORTS, AND TRADE BALANCE

A positive trend



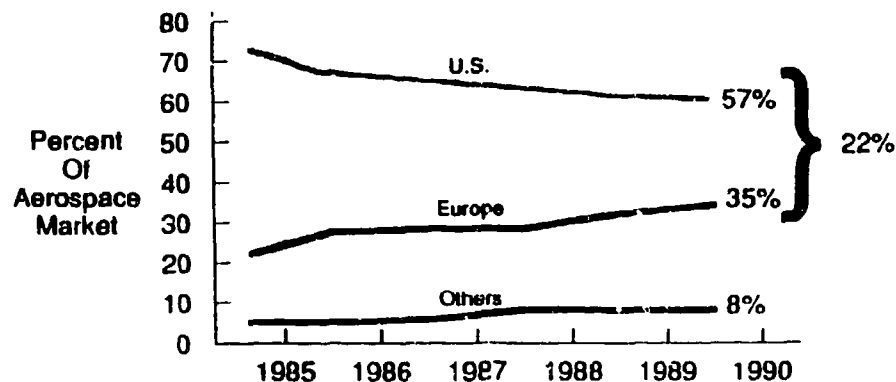
Source: Aerospace Industries Association

USE OF DISCLOSURE OF INFORMATION IS LIMITED TO THE EXTENT OF THE INFORMATION PROVIDED TO THE PUBLIC

18/70

THE WORLD-WIDE TRENDS ARE NOT ENCOURAGING

Percent of World Aerospace Market



Source: AEDC Office for International Affairs

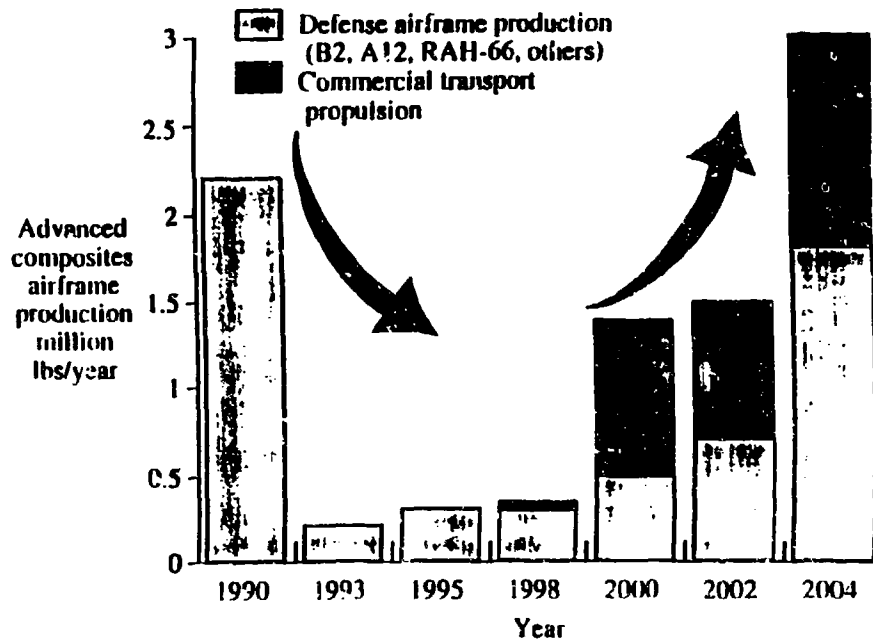
TECHNOLOGY REINVESTMENT

A National Priority

Project Candidate Characteristics

- Maintain U.S. competitiveness in aerospace
- Create U.S. jobs
- Critical defense technologies
- Maintain U.S. industrial base
- Dual-use technologies
- Integrated vertical and horizontal teaming approach

TECHNOLOGY REINVESTMENT BOLSTERS ADVANCED COMPOSITES PRODUCTION BASE



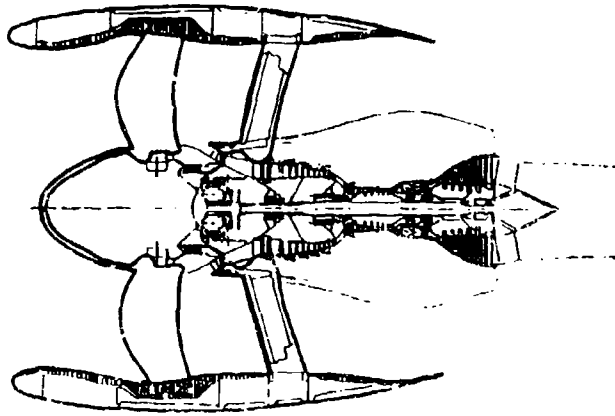
SIZE COMPARISON (Fan Diameter)



F22/F119 (37 in. dia)



C17/F117 (78 in. dia)



100K ADP (160 in. dia)

TECHNOLOGY REINVESTMENT

Summary

- Technology projects should focus primarily on risk reduction of materials/processes technologies (level 6.3 or beyond)
- Composites technology is critical to next generation propulsion systems
- Increase material usage assures U.S. industrial base capability for the future
- Dual usage strategy key for achieving commercially affordable costs
- Technologies at 6.1 and 6.2 level considered too high risk for technology reinvestment (cost sharing)
- Affordability is the key issue

DR. DICK HOPKINS
WESTINGHOUSE SCIENCE & TECHNOLOGY CTR.

**Silicon Carbide (SiC) - The Semiconductor
With the Right Stuff**

Rectification In a
Hot, Chemically
Active
Environment



Silicon Carbide Beats Nearest Competitor

High Power

- 10X Power Density
 - Reduced Parts, Size, Cost
 - New Capabilities: Stealth Detection

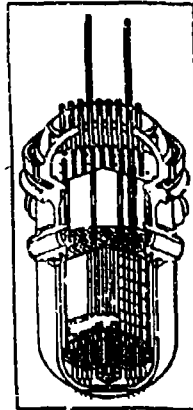
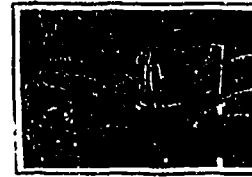
High Temperature

- 650° Operation vs. 150°
 - Less Cooling, Weight, System Cost
 - 1,000X Reliability

Radiation Hard

- 100X Gamma, 50X Neutron Resistance
 - First In-Core Electronics for Protection and Control
 - Reduced Cabling, Penetrations and Cost
 - New Services

Transistors for
Long-Range
Surveillance



Electronics in
Severe Environments:
All-Electric Vehicles

In-Core Flux and
Temperature Measurements
at 100 MRad 350°

SILICON CARBIDE ELECTRONICS HAS BEEN RECOGNIZED AS DUAL USE SINCE THE INCEPTION OF THE WESTINGHOUSE SIC INITIATIVE

SIC is a Superior Semiconductor for:

- High Temperature
- High Power
- RAD Hardness

and Westinghouse Has Internal Uses for Most of the Potential Applications

• DEFENSE SYSTEMS

Radar
Communications
E-O
ECM
Signal Processing
Aircraft Electrical Systems
Nuclear Power
Space Sensors

• COMMERCIAL SYSTEMS

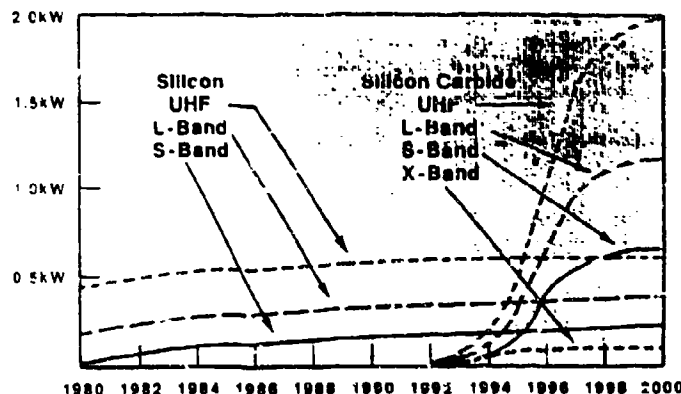
Power Generation & Controls
Automotive Electronics
Waste Management
Non-Volatile Memory
Nuclear Instrumentation
Electric Vehicle Drives
Broadcast Transmitters
Microwave Satellite Links

Silicon Carbide : A Breakthrough Technology to Leapfrog the Performance Impasse of Current Semiconductors.

We Need:

- | | |
|---------------------------|------------------------------|
| 1.) Over 700 Watts UHF | (e.g. AEW,CLO,SPS-40) |
| 2.) Over 250 Watts L-Band | (e.g. AEW,CLO,TPS-63,ARSR-4) |
| 3.) Over 150 Watts S-Band | (e.g. TPS-78,E-3,SBR,SPY-1) |
| 4.) Over 15 Watts X-Band | (e.g. ATF,MODAR,GBR) |

Device Peak Output Power



33482 / VS3236

SIC Excels at:

- High Temperatures
- High Power
- High Voltage
- High Radiation

System Benefits:

- Higher Device Power
 - Less Hardware
 - Less Cost
- Higher Temperatures
 - Improved Cooling
- New System Possibilities
 - Smaller
 - Lighter
 - Higher Power

THE BENEFITS OF SIC VMOS TO COMMERCIAL ELECTRIC VEHICLES

Higher Temperature Operation

- Air Cooling
- Higher Safety Margin
- Integrated Motor/Electronics

Higher Efficiency

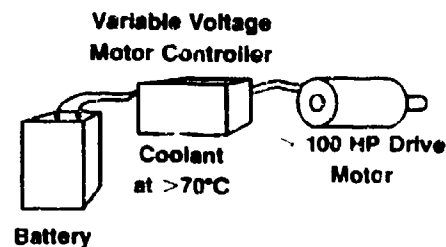
- Lower Ron
- Lower Switching Losses
- Passive Cooling

Lower Cost

- Simpler Cooling
- Higher Power Per Device
- More Rugged Devices

ALSO APPLY TO COMMERCIAL & MILITARY AIRCRAFT

- Current Electronic Thermal Management Adds Significantly to Aircraft Weight
- Emerging Needs: Engine and Skin Mounted Sensors & Control Devices
- Savings: \$10,000/lb. for 300 Aircraft Over 15 Year Life



Silicon Carbide (SiC) - The Semiconductor With the Right Stuff

Recalcification in a
Hot, Chemically
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© 1997 ST

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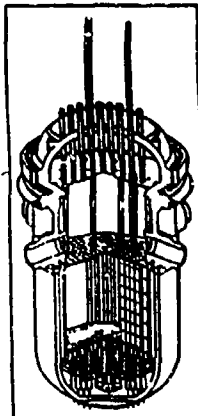
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© 1997 ST

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and Westinghouse Has Internal Uses for Most of the Potential Applications

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Radar
Communications
E-O
ECM
Signal Processing
Aircraft Electrical Systems
Nuclear Power
Space Sensors

• COMMERCIAL SYSTEMS

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Automotive Electronics
Waste Management
Non-Volatile Memory
Nuclear Instrumentation
Electric Vehicle Drives
Broadcast Transmitters
Microwave Satellite Links

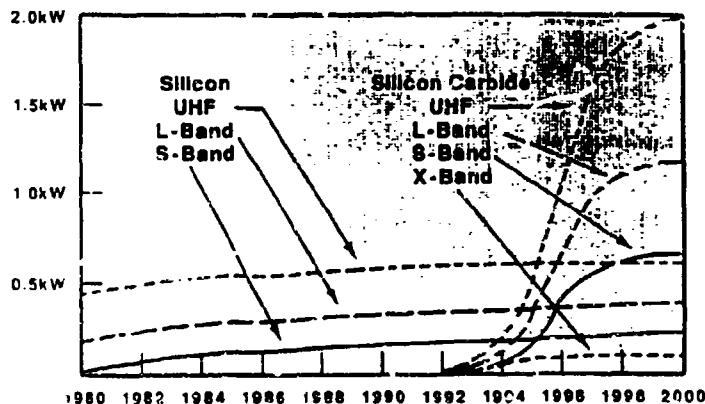
(W) STC

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|--|---|

Device Peak Output Power



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- Lighter
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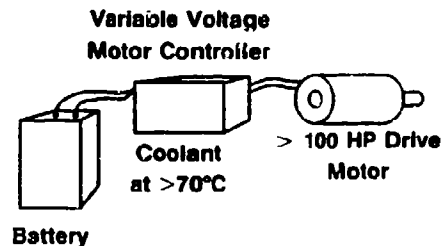
(W) STC

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- Lower R_{ON}
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STC

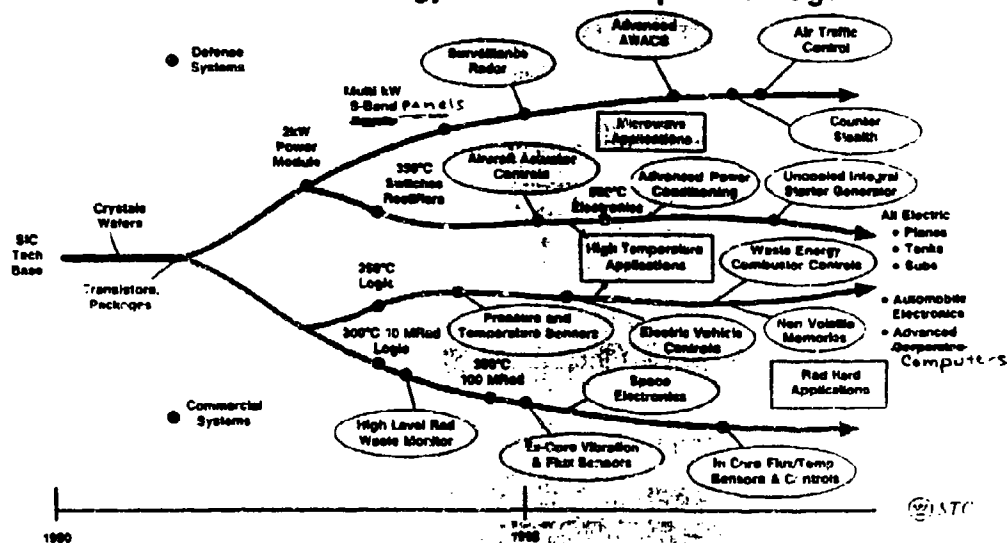
4S000

HOPKINS/SL

1-13-93

Silicon Carbide Payoff

Versatile Dual Use Technology for a U.S. Competitive Edge



STC

SILICON CARBIDE INITIATIVE

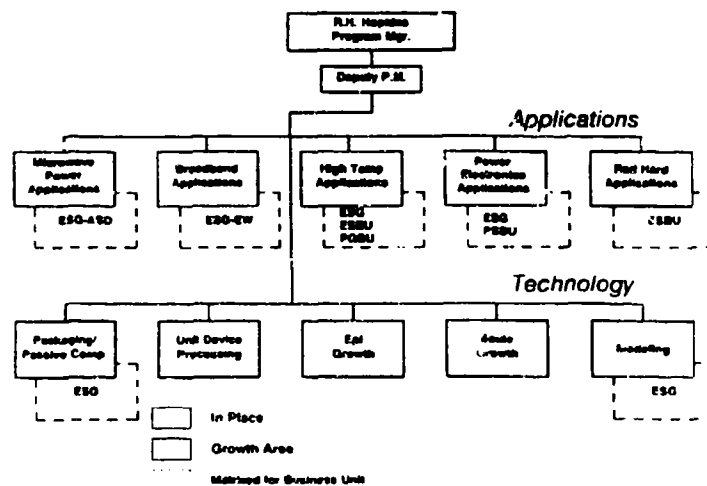
Westinghouse Is Committed to SIC Development and Commercialization

- **Product Opportunities Are Broad-Based and Fit Corporate Businesses**
- **\$7M Already Invested in Development**
- **Program Growing Rapidly**
 - Three Engineers in 1989; Over 30 in 1993
- **Major New Investments in 1993**
 - Capital and Facilities Acquisitions (Furnaces, Epl, Water Prep, Testing)
 - System Engineering/Product Development
 - Expansion of Technology Development Activity
 - Technology and Business Alliances
 - Cost Sharing

We Have Organized to Accelerate Technology Development and Product Transition

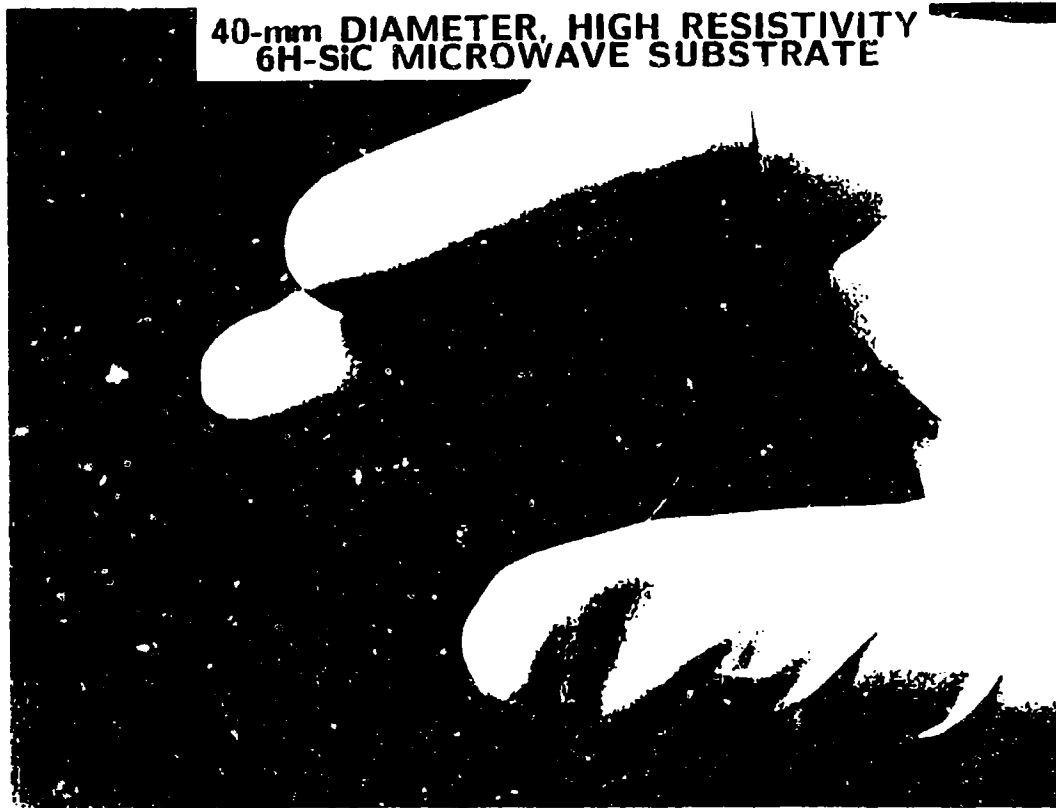
(W) SIC

THE WESTINGHOUSE SILICON CARBIDE INITIATIVE IS VERTICALLY INTEGRATED FOR RAPID PRODUCT DEVELOPMENT



(W) SIC

**40-mm DIAMETER, HIGH RESISTIVITY
6H-SiC MICROWAVE SUBSTRATE**



SILICON CARBIDE ELECTRONICS

Discrete Devices and Basic Circuits are under Development at Westinghouse Now

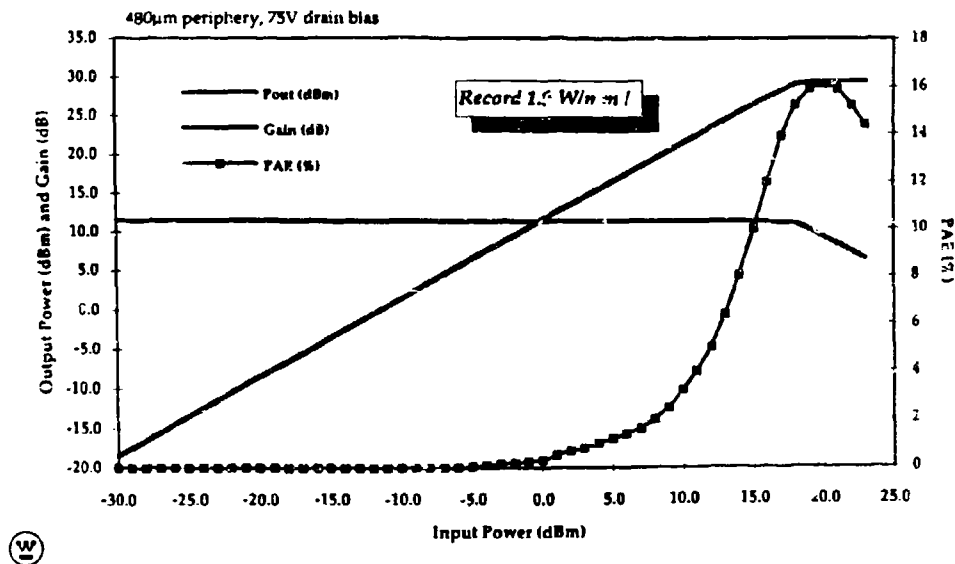
- **Static Induction Transistor (SIT)**
 - UHF to S-Band Power Applications
- **Metal Semiconductor Field Effect Transistors (MESFET)**
 - X-Band Power and High Temperature Logic
- **Vertical Metal Oxide Semiconductor Field Effect Transistor (VMOS)**
 - High Power, High Temperature Switching and Power Conditioning
- **IMPATT Diode**
 - High Power Microwave/mm-wave Sources to 35 GHz
- **Operational Amplifier**
 - Signal Conditioning and Logic for Hostile Environment Sensors/Controls
- **Non Volatile Memory**
 - Ultralong Retention Memory at Room and High Temperature.

Technology with Total Quality



Westinghouse
Science & Technology Center

Class A Power Performance of a SIC MESFET



TEAMING IS AN INTEGRAL PART OF THE WESTINGHOUSE SIC DEVELOPMENT PLAN

Strategic Approach

Use:

- Corporate Initiatives to Develop Key Technologies (Materials, Device Processes, etc.)
- Business Unit Resources to Carry Out Specific Applications Developments
- Technology Partnerships to Fill Knowledge Gaps, Strengthen Tech. Base
- Business Alliances to Broaden Product Applications
- Customer Contracts to Open New Applications and to Accelerate Technology Development

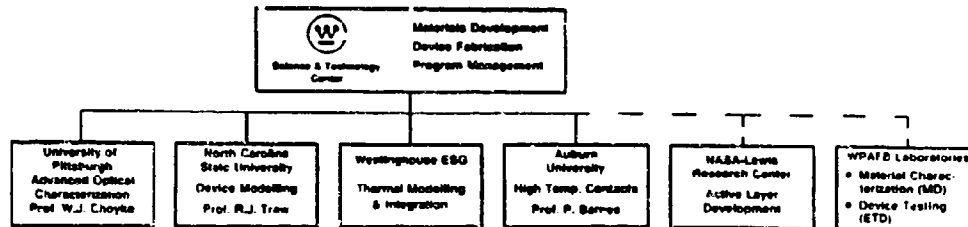
Then:

- Business Units Introduce Products in Commercial and DOD Markets

WESTINGHOUSE-AF-NASA-UNIVERSITY TEAMING FOR ADVANCED MATERIALS AND MICROWAVE DEVICE DEVELOPMENT

- Goals**
- Large Diameter, Low Defect Semi-Insulating Wafers
 - 20 W (4X Power Density Increase) X-Band FETs
 - 500°C Device Function
 - Key to Advanced Radar and Communications Transmitters

- Team Advantage:**
- Bring Together More SIC Expertise Than Exists in Any Single Group
 - Capitalize on Resources Already Invested in SIC at Organizations Elsewhere
 - Promote Technology Synergism and Fresh Ideas
 - Foster Broad-Based Industry-University Government SIC Infrastructure



Led To:

- AF - Sponsored Program

- 40% Cost Shared by Westinghouse
- Standard FAR Provisions on Intellectual Property
- Aggressive Jointly Developed Goals

WJL

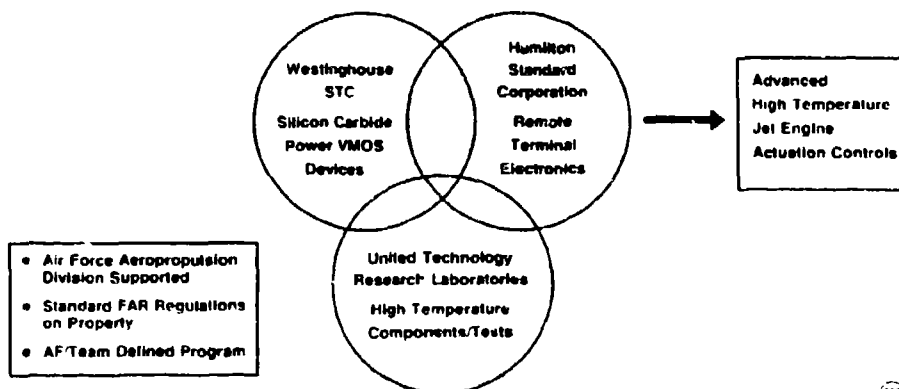
WESTINGHOUSE-AF-NASA-UNIVERSITY TEAMING

Significant Results Have Already Been Achieved

- Record Power Density (1.9 W/mm) FET at 1 GHz Demonstrated
- 2 inch Diameter SIC Wafers First Step to Scale-Up
- New Low Resistivity Contact Metal Process Will Improve Device Performance
- Model Simulation of MESFETs Leads to Improved Designs
- Identification of Wafer Contaminants by Special Optical Methods Leads to Improved Growth

HAMILTON STANDARD-UTRC-WESTINGHOUSE HIGH TEMPERATURE ENGINE ELECTRONICS TEAMING

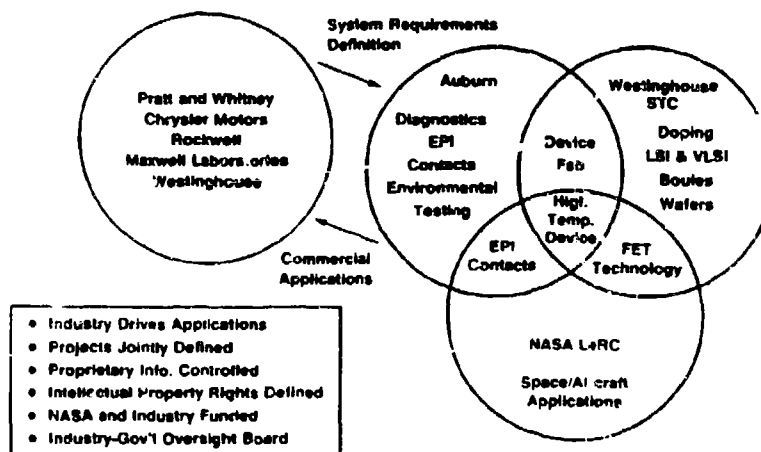
- Grew Out of Joint Interests
 - New Customers for Westinghouse Products
 - Need for High Temperature Engine Electronics
- Led to Air Force Funded Actuator Development



WV STC

NASA / AUBURN CENTER FOR COMMERCIAL DEVELOPMENT OF SPACE POWER AND ADVANCED ELECTRONICS

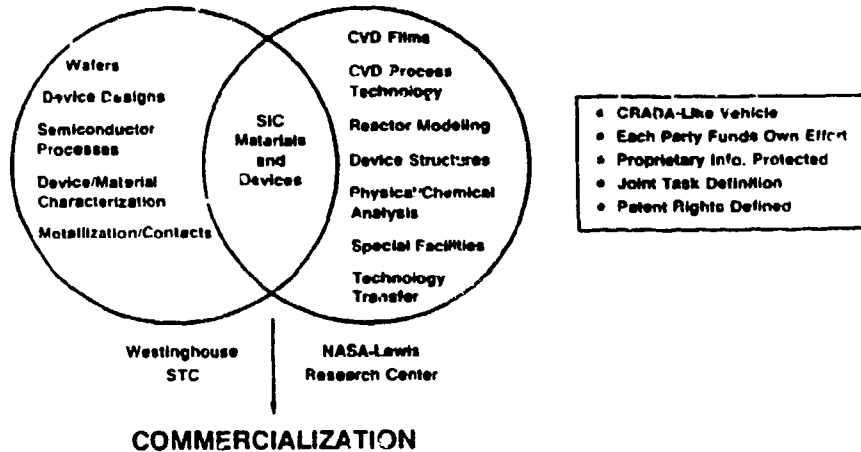
Complementary Skills Linked to Accelerate
Silicon Carbide Electronics to Commercialization



WV STC

NASA-WESTINGHOUSE SILICON CARBIDE "SPACE ACT" PARTNERSHIP

The Goal is to Accelerate the Commercial Development
of Silicon Carbide Semiconductor Technology



STC

SILICON CARBIDE ELECTRONICS

Off-Shore Silicon Carbide Programs Have Expanded and
Our Competitors Are Forming Their Own Teams

| Europe | Japan | Russia |
|--|--|--|
| <ul style="list-style-type: none"> • Siemens - epitaxy, power devices, blue LED's • Daimler Benz - epitaxy, high temperature/high power devices • Thompson CSF - microwave devices Merlin Gerin - power devices LETI (Grenoble) - epitaxy, device processing, implants Asea Brown Boveri - power/high temperature IBM (Zurich) - epitaxy, blue LED's • Erlangen U. - boules, epitaxy, physics U. Stuttgart - FTIR, ion beam mod. • U. Paderborn - defects Fraunhofer Inst. - Raman Studies, defects CERN - radioactive nuclei U. Amsterdam - defects, spectra | <ul style="list-style-type: none"> Sanyo - boules, blue LED's Sharp - blue LED's NKK Steel - boules (?) NEC - boules, devices (?) Yamanashi - high temp. devices Sumitomo - materials Toyota - MOSFET's Electrotechnical Lab - rad. effects Kyoto U. - boules, epi, devices | <ul style="list-style-type: none"> Electrotechnical U. - boules, thermochemistry Iofo Inst. - modeling, devices, epi Kiev Inst. - characterization, epi |

*Germany initiated three-year \$2EM DM SiC Program in 1993

**Thomson has teamed with Daimler

STC

SILICON CARBIDE ELECTRONICS

Government Support for Silicon Carbide has Grown. But

- Programs Tend to Be Small, Distributed Across Several Agencies
- Lack Critical Mass to Rapidly Advance Technology to Application (\$4-5 M/yr)

Navy

Westinghouse/ATM - IMPATT diodes
NRL - epitaxy, device fab.
N.C. State - advanced epitaxy
Cree - MESFET development
N.C. State/Cree - device process technology
U. Pittsburgh - characterization
Rockwell - Schottky barrier contacts
ATM - TIC substrates
INRAD (SBIR) 3C boules

DARPA/ONR

Cree - blue LED's and lasers

SDIO/ONR

Cree - NVRAM

NIST

Cree - boule and epitaxy technology

Air Force

Westinghouse - boules and X-Band
MESFETs
GE/Cree - high temperature electronics
GE/Cree - engine "light-off" sensor
Prest & Whitney/Westinghouse - high
temperature VMOS for actuators
ATM (SBIR) - improved materials
Cree (SBIR) MESFETs
Carnegie-Mellon - defects, DLTS
Oregon Grad. Ctr. - contracts

NASA

Lewis (in house) - epi, devices
Kulite (SBIR) - sensors
Auburn CCDS - implants, epi, contracts,
modeling
Case Western - defects, TEM
Howard YU. - epitaxy, FET's
U. Pittsburgh - sensors

(W) V/C

SILICON CARBIDE ELECTRONICS

The U.S. Now Leads Silicon Carbide Technology and Product Development ...

— But the Effort is Limited, and Subcritical for Rapid Commercial/DOD Insertions

Industrial

Westinghouse
Cree
General Electric
Advanced Technology Materials
Texas Instruments ?
Motorola ?
Rockwell ?
InRad

University

Auburn
Cincinnati
Lehigh
Pittsburgh
North Carolina State
R.P.I.

Government

NASA Lewis
Naval Research Labs
Air Force Wright Labs
Sandia Labs
Army Research Labs
(Adelphi)

And Foreign Competition is Growing

Technology Reinvestment Programs Can Help

(W) V/C

SILICON CARBIDE ELECTRONICS

"Reinvestment Funds" Offer Significant Potential to Accelerate Technology Development/Deployment

- **Commercialization, Competitiveness, Defense Industrial Base.**

But There's No Free Lunch:

- **Shotgun Weddings may lead to Bad Marriages**
 - **Partnerships need clear goals and good chemistry**
 - **Most complimentary partners may be competitors.**
- **Intellectual Property Rights can be a Sticking Point**
 - **Who owns the future business evolved from "precompetitive" activity?**
- **There is an Inherent Conflict in Defense Conversion Approach**
 - **Cost sharing necessary but many firms have large restructuring costs**
 - **Focus tends to near-term problem solving.**

Materials Technologies Possibly at Risk during Change in Defense Funding Strategy

- **"Upstream" Technology: The Earlier in the Product Development Cycle, the More Difficult to Acquire Development/Cost Share Funds.**

Technology with Total Quality



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SILICON CARBIDE ELECTRONICS

Summary:

- **Silicon Carbide-Based Electronics have Significant, Diverse Commercial and Military Markets.**
- **Recent Breakthroughs in Materials and Device Process Make Product Exploitation Realizable.**
- **The U. S. is Now the SiC Leader; (Subsidized) Foreign Competition is Growing.**
- **The Technology is Immature and the Activity Fragmented Among a Few Companies.**
- **Agency Support has Grown, But Remains Diversified and Below Critical Mass.**
- **The Pace of Silicon Carbide Development and Application is Resource Limited.**
- **The Timing is Right to Invest:**
 - **Major commercial payoffs are identified**
 - **Key Technology Issues are known**
 - **The groundwork has been laid for rapid progress toward products.**



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NCAT UPDATE

MAY 1993

NATIONAL CENTER FOR ADVANCED TECHNOLOGIES



PLANS → DEMOS → PRODUCTS

WHAT'S NCAT

- A NON-PROFIT EDUCATION AND RESEARCH FOUNDATION
- ESTABLISHED IN 1989 TO PROVIDE A NATIONAL FOCAL POINT FOR COORDINATION OF ADVANCED TECHNOLOGIES BETWEEN INDUSTRY, GOVERNMENT AND ACADEME
- CURRENTLY FUNDED BY AIA, DOD, AND NASA
- ACTIVELY SUPPORTED BY EIA, NSIA, AIAA, ADPA, NAM, SME AND AMT

THE NCATS STRATEGY OF COOPERATIVE CONSENSUS

- INVOLVE INDUSTRY, GOVERNMENT, AND ACADEMIA IN ALL ACTIVITIES
- DEVELOP STRATEGIC PLANS FOR KEY TECHNOLOGIES
- IDENTIFY POLICY AND TECHNOLOGY IMPLEMENTATION ISSUES
- WORK WITH TRADE ASSOCIATIONS AND PROFESSIONAL SOCIETIES (AN ASSOCIATION OF ASSOCIATIONS)
- FOSTER IMPLEMENTATION THROUGH DEMOS
- ADVOCATE RAPID COMMERCIALIZATION

INTEGRATED DEVELOPMENT

CONCURRENT
ENGINEERING

INTEGRATED
PRODUCT/PROCESS
DEVELOPMENT

APPLY
COMMERCIAL INDUSTRY
EXPERTISE
TO
TECHNOLOGY
DEVELOPMENT STRATEGY

ADVANCED
TECHNOLOGY
DEMONSTRATIONS

DEMONSTRATIONS OF
ENGINEERING &
MANUFACTURING
OPERATIONS

2 X PRODUCTIVITY

1/2 X TIME TO APPLICATION

CHANGE IN PRIORITIES AND ACTIVITIES

NCAT GOAL ➡ IMPROVING U.S. COMPETITIVENESS ➡

PAST
(89-92)

SHORT TERM
(93)

LONG TERM
(93-95)

KEY TECHNOLOGIES

- GENERATE PLANS
- HOLD SYMPOSIA
- GIVE BRIEFINGS
- SELECT DEMOS

DEMO FORMATION

- COMPLETE PLANS
- WORK DEMOS
(INCLUDING IPPD)
- PROVIDE INTERFACE
FOR INCREASED GOVT/
INDUSTRY/ACADEMIA
COOPERATION
- EMPHASIZE
AFFORDABILITY

TECHNOLOGY TRANSITION CATALYST

- CONTINUE STRONG TIES WITH
TECHNICAL COMMUNITY
- STRENGTHEN POLICY FORUM
- EXPAND TRADE ASSOCIATION
PARTNERSHIPS
- FORM PARTNERSHIPS, JOINT
VENTURES, CONSORTIA
- PROACTIVELY INFLUENCE
TECHNOLOGY TRANSITION TO
PRODUCTS
- STRESS COMMERCIALIZATION

AFFORDABILITY IS KEY TO COMPETITIVENESS

ORGANIZATION

TECHNOLOGY TRANSITION PROCESS

COMMERCIAL
INDUSTRY

AVAILABLE
TECHNOLOGY

CORPORATE
R&D

COMPETITIVE
PRODUCTS

NCAT/
ASSOCIATIONS

PLANS

DEMOS

PRODUCTS

DOD
(ALSO NASA, DOE,
DOC & DOT)

RESEARCH &
TECHNOLOGY

ATDS

SYSTEMS

COOPERATIVE EFFORTS

WHAT IS NASA DOING?

WORKING DEMOS (DEMONSTRATIONS OF ENGINEERING AND MANUFACTURING OPERATIONS)

ACTIVE

- FBL-PBW
- SMART ENGINES
- ADVANCED COMPUTATIONAL
METHODS
- INTERACTIVE EI NET

IDEAS

- ENGINEERED MATERIALS
- IN-SITU REMEDIATION
- ADVANCED SIMULATION
- IMPROVED MAN-MACHINE
INTERFACE

TECHNOLOGY FOR AFFORDABILITY

- IPPD - ELECTRONICS
- IPPD - MECHANICAL SYSTEMS
- MULTI-USE MANUFACTURING
- SIMPLIFIED CONTRACTING FOR DEMOS
- EDUCATION AND TRAINING FOR IPPD

WHAT IS NASA DOING? (CONTINUED)

INDUSTRY VIEW OF SPACE TECHNOLOGIES

- SPACE FACILITY SURVEY
- TECHNOLOGY FUNDING SURVEY
- REVIEWED INTEGRATED TECHNOLOGY PLAN

COMMERCIALIZATION OF REMOTE SENSING

NASA, DoE, DoD, DoC, SCiO

EDUCATIONAL VIDEO SERIES ON IPPD

WITH NTU (NATIONAL TECHNOLOGICAL UNIVERSITY)
AND GIT (GEORGIA INSTITUTE OF TECHNOLOGY)

EXPANDING SCOPE OF COOPERATIVE ACTIVITIES

ONGOING

- | | | |
|----------|---|--|
| INDUSTRY | - | WORKING DEMOS |
| DOD | - | TECHNOLOGY FOR AFFORDABILITY (INCLUDES AIA, EIA, NSIA, NAM, AND ADPA) |
| NASA | - | INDUSTRY VIEW OF SPACE TECHNOLOGIES |

NEAR TERM

- DOE, NASA, DOC, AF, SDIO - REMOTE SENSING
- NTU AND GIT - EDUCATIONAL VIDEO SERIES (JULY-DECEMBER '93)

FAR TERM

- DOD, DOE, DOC, DOT, NASA - AFFORDABLE TECHNOLOGY TRANSITION
- OSTP - COLLECTIVE INDUSTRY VIEW OF INITIATIVES

IMPROVING U.S. COMPETITIVENESS

President's Technology Initiative

NCAT Activities

- | | |
|---|---|
| <ul style="list-style-type: none"> ■ Investing in Technology for Economic Growth <ul style="list-style-type: none"> -- Applied R&D <ul style="list-style-type: none"> • Manufacturing • Aerospace • Biotechnology • Advanced Materials -- Increased Government/Industry Partnerships -- Information Infrastructure -- Technology to cut costs and improve efficiency -- Educational Technology ■ Provide Policy Leadership | <ul style="list-style-type: none"> Improving Efficiency of Technology Development (2x productivity, 1/2x time to application) <ul style="list-style-type: none"> -- Key/Critical Technologies -- DEMOs <ul style="list-style-type: none"> • Smart Engines • FBL-PBW • Adv. Comp. Methods • Interactive EI Net -- Technology for Affordability <ul style="list-style-type: none"> • IPPD • Dual-Use Manufacturing • Simplified R&D Contracting -- Educational Video Series ■ Aerospace Technology Policy Forum |
|---|---|

AIA/NCAT MATERIALS ACTIVITY

- 1987 CMC FORMATION
- 1989 ADVANCED COMPOSITES ROADMAP
- 1990 ADVANCED COMPOSITES CONFERENCE
- 1991 NATIONAL ADVANCED COMPOSITES STRATEGIC PLAN
- 1992 DEMO WORKSHOP
- PRECISION CASTING MEETINGS
- SACMA/USACA/AIA WHITE PAPER
- COMPOSITES ISSUES MEETING
- 1993 COMPOSITE STANDARDIZATION
- ADVANCED METALLIC STRUCTURES PLAN

SUMMARY COMMENTS

- COMPANIES CAN COOPERATE EFFECTIVELY ON TECHNOLOGIES
- GOVERNMENT AND INDUSTRY NEED TO DO MORE COOPERATIVE PLANNING
- WE NEED TO APPLY COMMERCIAL EXPERTISE TO TECHNOLOGY DEVELOPMENT STRATEGY
- EFFECTIVE USE OF TECHNOLOGY IS KEY TO COMPETITIVENESS

**COOPERATION!
TRY IT! YOU'LL LIKE IT!**

MR. NED MAURER
QUESTECH RESEARCH DIVISION

WRIGHT LABORATORY MATERIALS DIRECTORATE
AEROSPACE MATERIALS AND PROCESSES TECHNOLOGY
REINVESTMENT WORKSHOP

ELECTRONIC INDUSTRY PERSPECTIVE

NED A. MAURER
QuesTech, Inc.
(513) 258-2311

OUTLINE

- **Electronic Industry Statistics**
- **Government Responsibilities**
- **Industry Responsibilities**
- **Suggested Government Actions**
- **Suggested Industry Actions**
- **Proposal: Enhance the SEMATECH Success Story**
- **Summary**

ELECTRONIC INDUSTRY STATISTICS

- **Leading Edge Technologies Often Occur in the Civilian Sector and Only Much Later Will Move into Defense.**
- **Product Life Cycle for Many Electronic Components is Less than One Year.**
- **U.S. Electronic Components Industry Markets are:**

Weak: Actuators, Optoelectronics, & Hardcopy Technology

Losing: Memory Chips, Packaging, & Displays

OTHER FACTORS:

- **Over 50% of Doctoral Degrees in Engineering and 40% in Math and Physics are Awarded to Foreign Students.**
- **Almost 1/2 the US patents Went to Foreign Companies in 1990.**
The top 4: Hitachi, Toshiba, Canon, and Mitsubishi.
- **US Investments (1991) in Plant & Equipment Reached a 14 Year Low.**
US 10.7%GDP, Germany 14.5%, Japan 22%

GOVERNMENT RESPONSIBILITIES

ENCOURAGE AND SUPPORT:

- **Industry Led Consortia**
- **Precompetitive Technology Development**
- **Dual-Use Technologies**
- **Rapid Implementation of Technological Advances**



INDUSTRY RESPONSIBILITIES

ALL US FIRMS SHOULD:

- **Create Better Relationships with Suppliers and Customers.**
- **Increase Employee involvement and Participation.**
- **Increase Investments in :**
 1. **Process Development on a Continual Basis.**
 2. **Plant & Equipment to Support Agile Mfg. Concepts.**
 3. **Worker Training on a Continual Basis.**
- **Goal is to Shorten Cycle Time Required to Bring Products and Processes to Market.**



SUGGESTED GOVERNMENT ACTIONS

- Revise DOD Procurement Regulations to Emulate Private Sector Practices Wherever Possible.

GOVERNMENT MUST DO THEIR LIMITED PART:

- "Benchmark" What Foreign Government Actions and Align US Programs Against these Benchmarks.
- Establish an Advanced National Technical/Business Communications Network.
- Set the Correct Policy/Procedures to Create Many More Market Driven Extension Centers.
- Redirect the Federal R&D Budget from 80/40 to 50/50 Defense/Nondefense.

MILITARY LAB'S SHOULD BE A FACILITATOR.

- Provide Technical Expertise, Equipment, & Facilities in a Proper Consortia Mix
 - Keep Control in Private Sector



SUGGESTED INDUSTRY ACTIONS

- Encourage Real Employee Involvement and Good Labor Management Relationships
- Shift from Mass Production to "Agile" Manufacturing
- Push for Cooperative R&D Agreements with Government Labs and Other Companies.
 1. Share Risks
 2. Pool Resources
 3. Eliminate Duplication of Effort
 4. Make Synergistic Investments
 5. Invest in Private Sector led Consortia like SEMATECH, MCC, NCMS, and Advanced Battery
- Learn All You Can About Your Present and Developing Markets
- Think Global
- Set Your Process Goals to the Highest Practical Standards
- Find Trusting Consortia Partners to Share Your Future



PROPOSAL: ENHANCE THE SEMATECH SUCCESS STORY

- **Military Field Activities: Labs, Centers of Excellence, Logistic Centers**
 - Understand that Cooperative Coexistence will Support Your Survival
 - Be Prepared to Absorb Downizing and Market Adjustments. Survival Will Probably be of the Fittest Consortium.
- **Private Industry:**
 - Keeping "Key" Processes Locked Up Will Do No Good if There is No Business
- **Government and Industry Should Develop Team Consortia**
 - Prepackage Teams to Meet Certain Goals
 - Focus Goals on National Needs -- Both Economic and Military
 - Work With the Public, Congress, and Others to Secure Long Term Cash Flow that Supports the Goals
- **Focus on Process Technologies**

SUMMARY

NEW GOVERNMENT AND INDUSTRY RELATIONSHIPS

- **A New Government/Industry Relationship is Required to Meet the Challenge of the Future.**
 - Revolutionary Changes in Process Technology Must be Jointly Developed
 - New Training Techniques Must be Discovered and Implemented.
 - These are Dynamic and Continuous Processes and Provisions Must be Made in Policy and Procedure to Continually Improve.
- **Key Issue:**
 - Government Must First Become a Partner; Then a Customer. The Government Purchasing Power will Help Ensure Domestic Sales for what is Jointly Developed and Provide an Easier Entry into World Markets.
- **Focus Must be on Process Technology.**
- **Ultimate Goal:**
 - To Develop New Process Technologies Ahead of World Competition and BEAT the World with Rapid Implementation.
 - All Must learn Cooperatively to "Use It" or Individually "Lose It"



CAPT. RICHARD BYNSVOLD
NATIONAL AUTOMOTIVE CENTER
US ARMY
PRESENTATION NOT AVAILABLE

ILIP ENVIRONMENTAL THRUSTS

o FOUR MAJOR USAF ACTIVITIES

- RISK ANALYSIS
- CLEANUP, SITE RESTORATION
- COMPLIANCE, EXISTING TECHNOLOGY
- PREVENTION, FUTURE TECHNOLOGY

6 Aug 92

POLLUTION PREVENTION R&D

APPROACH

- o ELIMINATE THE SOURCES (i.e., EMPTY THE PIPELINE)
- o QUANTUM IMPROVEMENTS (LEAP FROG TECHNOLOGY)
- o WORK THE DIFFICULT, LONGER TERM, HIGH PAYOFF OPPORTUNITIES

POLLUTION PREVENTION R&D

WRIGHT LABORATORY AREAS OF FOCUS

- o WATER WASTE STREAM ELIMINATION
- o VOLATILE ORGANIC COMPOUNDS (VOCs) ELIMINATION
- o SOLID WASTE STREAM ELIMINATION
- o OZONE LAYER DEPLETING SUBSTANCES (OLDS) ELIMINATION

13

WL POLLUTION PREVENTION R&D ^{6Aug92}

o WATER WASTE STREAM ELIMINATION

- NON CHEMICAL BASE SURFACE TREATMENTS FOR AL, TI & CU ALLOYS FOR BONDING & COATING

FORMATION OF THERMODYNAMICALLY STABLE SURFACE MORPHOLOGIES

THIN FILM DEPOSITION, SOL GEL TECHNIQUES
HIGH VELOCITY OXYGEN FUEL, FLAME/PLASMA
SPRAY LASER BASE PROCESSES

- ADVANCED PAINT STRIPPING TECHNOLOGY

ROBOTICALLY CONTROLLED PROCESSES
PLASTIC MEDIA, WATER, CO₂

WRIGHT LABORATORY
POLLUTION PREVENTION PROGRAMS

MATERIALS DIRECTORATE (ML)

ADVANCED METAL SURFACE TREATMENT PROCESSES

**OBJECTIVE: TO REPLACE EXISTING WET CHEMISTRY PROCESSES
FOR PREPAINT / PREBOND SURFACE PREPARATION OF
ALUMINUM & COPPER ALLOYS**

APPROACH: R&D INVESTIGATIONS INTO:

- THIN FILM DEPOSITION TECHNOLOGY
- THERMAL SPRAY TECHNOLOGY
- SOL-GEL OXIDE FILM DEPOSITION
- ION-BEAM ENHANCED FILM DEPOSITION

**PAYOFF: - ELIMINATES LARGE WATER CONTAMINATING/USING
PROCESSES**
- ELIMINATES USAGE OF STRONG ACIDS AND BASES
- ELIMINATES USAGE OF SOLUBLE CHROME

WL POLLUTION PREVENTION R&D

ADDITIONAL STUDY AREAS

- o **ADVANCED PRINTED CIRCUIT BOARD PROCESSES**
- o **ELIMINATION OF WATER BASE METAL DEPOSITION
& REMOVAL PROCESSES**
- o **TURBINE ENGINE OIL RECYCLING**
- o **SOLID STATE METAL CLEANING PROCESSES**
- o **ENVIRONMENTALLY ACCEPTABLE "CHAFF"
MATERIALS**
- o **ENVIRONMENTALLY ACCEPTABLE BATTERIES
(NiMH)**

**TWO MECHANISMS FOR COOPERATIVE R&D
BETWEEN INDUSTRY & DOD (AIR FORCE)**

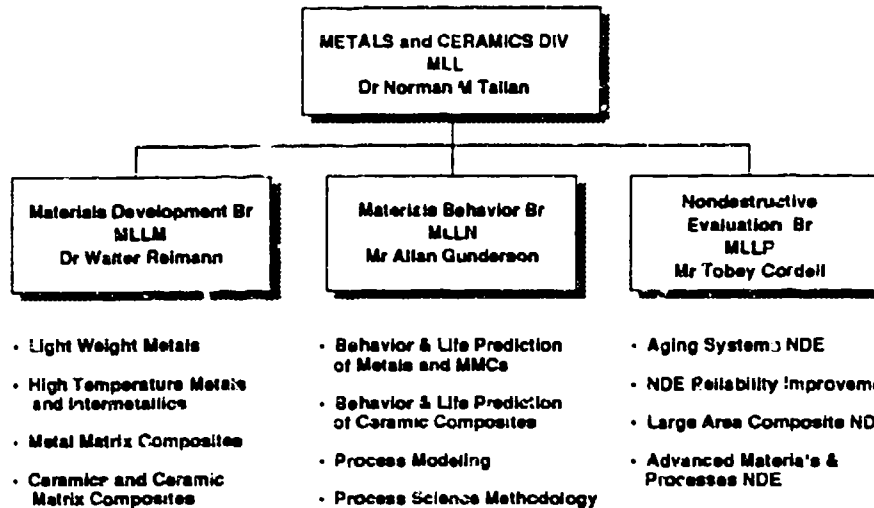
- o DUAL USE TECHNOLOGY DEVELOPMENT PROJECTS
(DARPA)**
- c COOPERATIVE RESEARCH & DEVELOPMENT
AGREEMENT (CRDA)**

- POTENTIAL AREAS OF INTEREST

**ADVANCED COATING & REMOVAL TECHNOLOGY
REMOVAL HIGH PERFORMANCE COATINGS
NON CHROME CORROSION INHIBITING SYSTEMS
(NON-LEAD, CADMIUM TOO)
ADVANCED CONVERSION COATINGS
ADVANCED FIRE EXTINGUISHING/EXPLOSION
SUPPRESSION**

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**MLL Division
Overview**



**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**Topics For Technology
Transfer**

1. Metals, Intermetallics and MMCs

- Aluminum Metal Matrix Composites
- Titanium Metal Matrix Composites
- Gamma Titanium Aluminides

2. Structural Ceramics

3. Metal and Ceramic Material Processing

- Controlled Dwell Extrusion
- Controlled Dwell Forging
- Consolidation Modeling - MMC and CMC
- Material Behavior Modeling
 - Processing Maps
 - Constitutive Equations
- Analytical Modeling
 - Deformation
 - Solidification
 - Densification
 - Fluid Flow

4. Nondestructive Evaluation

- Computed Tomography
- Large Area Composite Inspection
- High Resolution Radioscopy

5. Behavior / Life Prediction

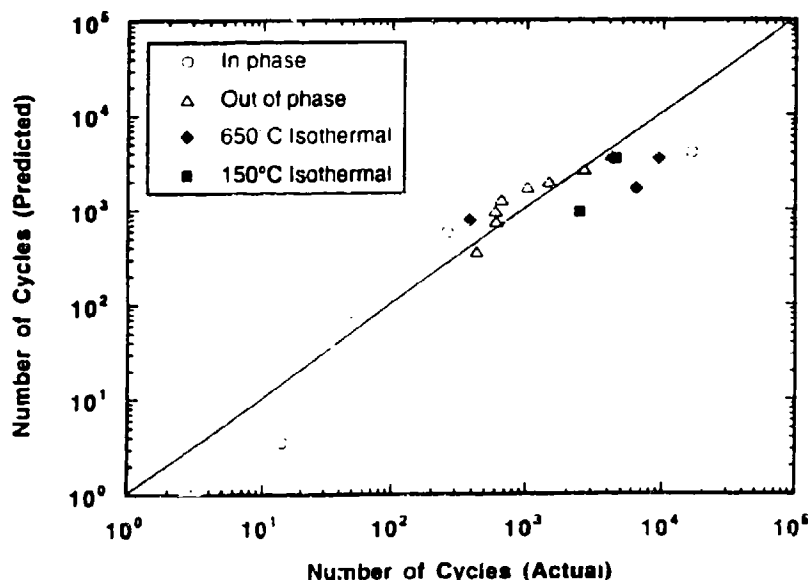
- Titanium, Aluminum and Ceramic Matrix Composites
- Gamma Titanium Aluminum
- NASP Specific Materials
- IHPTET Specific Materials

Life-Prediction Methodologies

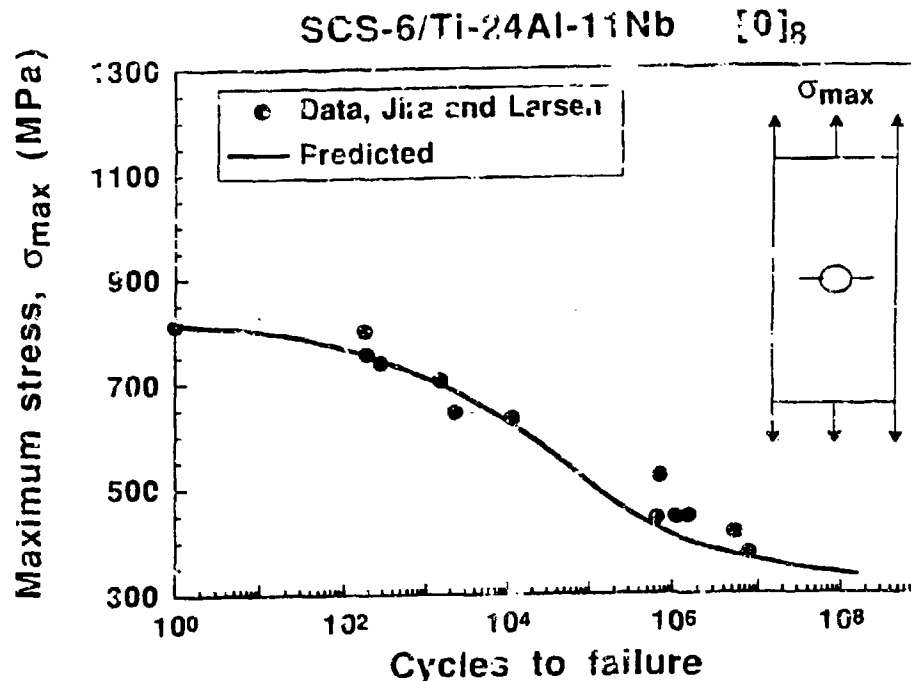
- **Metal Matrix Composites (SCS-6/Ti-24Al-11Nb, SCS-6/Timetal®21S)**
 - Developed models for thermomechanical fatigue damage
 - Developed models for crack propagation from holes and notches
- **Monolithic Metals**
 - Developed methodology to predict crack growth in nickel, titanium, and titanium-aluminide alloys under isothermal and thermomechanical fatigue
 - Developed understanding of crack growth behavior of small cracks
- **Ceramic Matrix Composites (C/SiC, SiC/SiC, SiC/1723, SiC/BMAS, SiC/CAS)**
 - Developed microscope system to study crack formation under fatigue
 - Identified fatigue limits for various systems

Comparison of Predicted and Actual Results for Thermomechanical Fatigue

SCS-6/Timetal®21S [0/90]2S



Prediction of S-N Curve for Specimen With Center Hole



Experimental Mechanics Test Methodologies

- Approach to Experimental Mechanics Testing: Two Basic Activities
 - Imposing conditions on specimen
 - Measuring specimen response
- Imposed Test Conditions
 - Mechanical: force, strain, or displacement
 - Temperature
 - Environment: lab air, vacuum, or inert gas
 - Simultaneous application of all three conditions
- Material Response
 - Mechanical: force, strain, or displacement
 - Electrical properties
 - Geometric changes: self-similar crack growth or multiple cracking

Inert Environment Thermomechanical Fatigue System

- **Developed to Enforce Conditions:**
 - Uniaxial force or strain as a function of time
 - Uniform temperature distribution as a function of time
 - Inert gas or vacuum environment as a function of time
 - Possible cryogenic testing
- **The Specimen Responses That Can Be Measured:**
 - Uniaxial force or strain
 - Crosshead displacement
 - Electrical resistance
 - Internal generation of acoustic waves
 - Response to externally imposed acoustic waves

Source: G.A. Hartman, "Integrating Experimental Mechanics Methodologies", ASTM E08.03 Subcommittee Kick-off Lecture 1993

Small-Scale Displacement Laser Interferometer System

- **Developed to Meet the Need for Precise Measurement of Specimen Displacements During Mechanical Tests**
 - Operates at gage lengths from less than 25 μ m to over 500 μ m
 - far shorter than practical with mechanical systems or other optical systems
 - Displacement resolutions of 2nm (20 \AA) or less can be achieved
 - System is fully integrated with automated test control microcomputers and sophisticated test control software
- **Has Been Used to Study Various Small-Scale Phenomena**
 - Near-crack-tip displacement fields
 - Strains within a metal grain
 - Strains or displacements inside notches and holes

Source: G. A. Hartman, "Displacement Measurements Using a Short Gage Length Laser Interferometer"
ASTM E09 task group presentation, Miami, Florida, November, 1992.

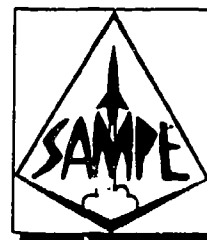
**Aerospace Materials and Processes
Technology Reinvestment Workshop**

Key Personnel

Dr James Larsen - Life Prediction Research
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Phone#: 513-255-1357

Dr Theodore Nicholas - Fatigue Mechanics, High Strain Rate Phenomena
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Capt John Pernot - NASP Structural Materials
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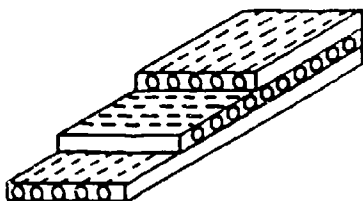


Metals, Intermetallics and MMCs

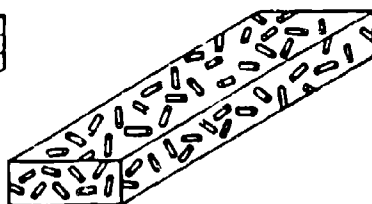
Ms. Katherine Williams
Metals and Ceramics Division

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Wright-Patterson AFB, OH
45433-1348

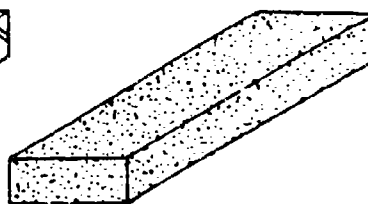
TYPES OF METALLIC MATRIX COMPOSITE MATERIALS



FIBERS



WHISKERS



PARTICULATES

5000 PSI 1000 PSI/700

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**Aluminum
Metal-Matrix
Composites**

- Why are aluminum-metal matrix composites ready for transition?
 - Standardized Products Available for SiC Particulate Reinforced Aluminum Composites
 - Title III Program
 - Manufacturers
 - DWA, Chateworth, California
 - APMC, Greer, South Carolina
 - Products
 - Extrusions, Sheet, Plate
 - Production Experience for Fiber Mat Preforms
 - Small and Large Diesel Engine Pistons
 - Squeeze Cast to Infiltrate Preform
- What are their unique features?
 - Particulate:
 - High modulus (stiffness)
 - Low coefficient of thermal expansion
 - High specific strength
 - Wear resistant
 - Preform:
 - Increased use temperature
- Current/Future Uses
 - Department of Defense
 - Non-Department of Defense

> Varies as a function of reinforcement type

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

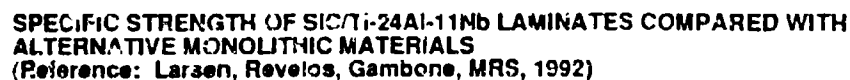
**Aluminum
Metal-Matrix
Composites**

| | Continuous Fibers | Fiber Preforms | Whiskers | Particulate |
|-------------------------------|---|--------------------------------|----------|-----------------------------|
| Manufacturing Technologies | Pultrusion Diffusion Bonding Cast | Squeeze Cast | Cast | Cast |
| Reinforcement | Gr SiC, Al ₂ O ₃ | Al ₂ O ₃ | SiC | SiC |
| Production Components | | Diesel | | Electronic Rack |
| Standard Products | | | | Plate Sheet Extrusion |

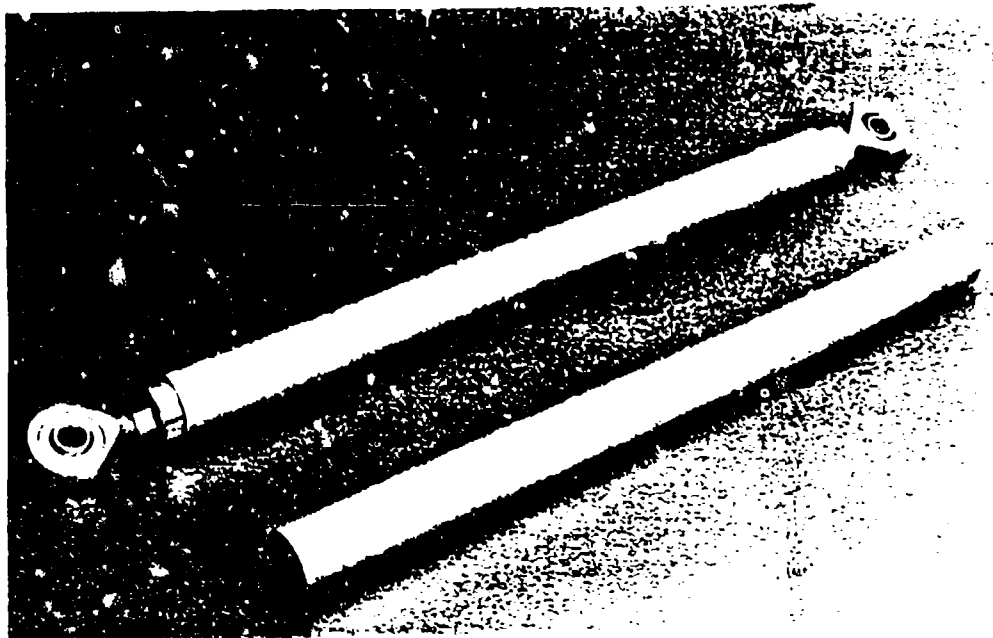
Titanium Metal Matrix Composites

- Aerospace Materials and Processes
Technology Reinvestment Workshop**

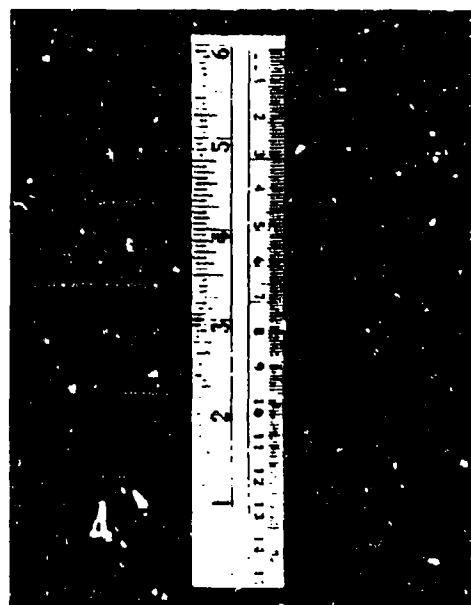
Titanium Metal Matrix Composites



(Reference: Larsen, Revelos, Gambone, MRS, 1992)



Gamma Compressor Blade



Gamma Exhaust Valve

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**Gamma Titanium
Aluminides**

- **Why is gamma ready for transition?**
 - Need lighter weight / high temperature materials to replace steel and superalloys
 - Knowledge of reproducible microstructure and properties, but technology has reached critical juncture
 - Cast technology is transitioned to vendor base
- **What are its unique features?**
 - Lighter weight than superalloys and titanium
 - Better high temperature properties (strength, modulus) than superalloys
 - Better oxidation and burn resistance than titanium
- **Current/Future Uses**
 - **Department of Defense**
 - Gas Turbine Engines
 - Near Term: Combustion swirler, high-pressure compressor stators, blade outer air seals, nozzle liner tiles
 - Mid Term: Compressor and turbine cases, compressor blades
 - **Non-Department of Defense**
 - Near Term: Cast automotive exhaust valves
 - Mid Term: Wrought gamma valves, impellers, turbochargers, commercial land-based turbine components, commercial aircraft turbine engine components, and others.

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

Key Personnel

Key Metals, Intermetallics and MMC Personnel:

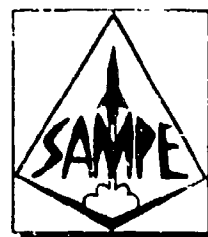
Mr Steven Baisone - Intermetallics
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Dr Daniel Miracle - Metal Matrix Composites
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Mr Gerald Petrak - Light Weight Metals
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**Mr Paul Smith - Orthorhombic
Titanium Aluminides**
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Matrix Composites**
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Structural Ceramics

Dr. Allan Katz
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Aerospace Materials and Processes Technology Reinvestment Workshop

Structural Ceramics

Why Read, ?

- State-of-the-art Structural Ceramics Have Matured to the Point of Real Application Insertion

Unique Features:

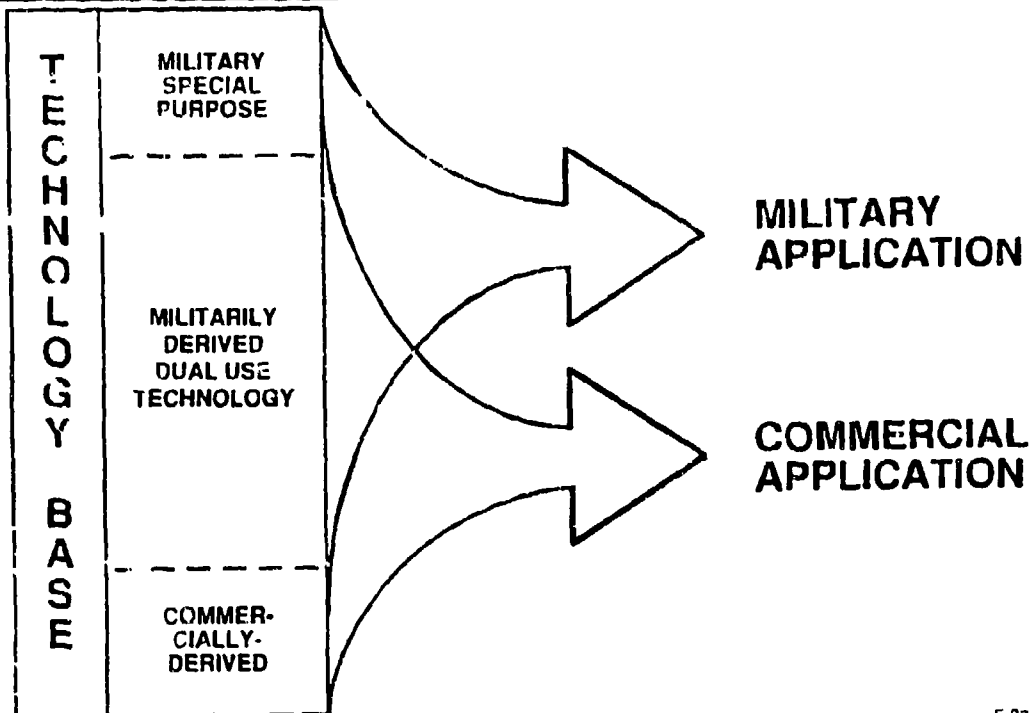
- High Strength, Stiffness
- Low Density
- Operating Capability to >2000°F
- Low Thermal Expansion Coefficient
- Thermal Shock Resistance
- Corrosion, Oxidation Resistance
- Erosion, Wear Resistance
- Tailorable Electrical Properties
- Non-strategic Constituent Materials
- Amenable to Fabrication by a Variety of Manufacturing Methods
- Resistance to Catastrophic Failure (Toughened Ceramics)

DOD Uses:

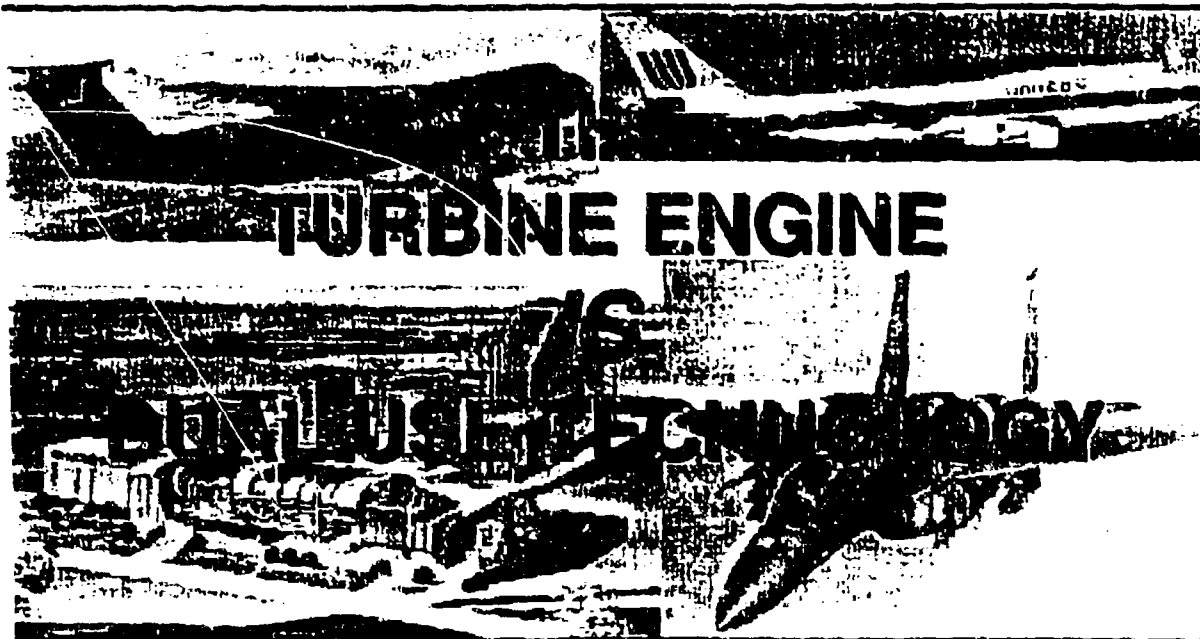
- Gas Turbine Engines
 - Aero-propulsion
 - Auxiliary Power Units
- Reciprocating Engines
 - Automotive (Diesel)



IHPTET FEEDS BOTH MILITARY AND COMMERCIAL ENGINES



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E-0325 1

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**Structural Ceramics
(Cont)**

DOD Uses (Cont):

- Hot Aerostructure (Hypersonics, Exhaust Impinged Structure)
- Armor
- Space Structures
- Rocket Propulsion
- Wear Parts

Non-DOD Uses:

- Gas Turbine Engines
 - Aeropropulsion
 - Auxiliary Power Units
 - Automotive
 - Land Based Power Generation
- Reciprocating Engines
 - Automotive
- Hot Aerostructure
- Heat Recovery Systems
- Burners, Combustors
- Chemical Process Equipment
- Dies, Tooling
- Wear Parts
- Cutting Tools, Shears



**Metal and Ceramic Material
Processing**

**Mr. James Morgan
Metal and Ceramics Division**

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2230 Tenth St. Ste 1
Wright-Patterson AFB, OH
45433-7817

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**Process Modeling
Technology**

Process Modeling Technology for the Design of Processes to Produce Metallic and Ceramic Components

• **Why Ready?**

– **Widely Used Proven Technology**

- Forging
- Extrusion
- Rolling
- Casting

• **Unique Features**

- Finite Element Based Computer Models
- Applicable to Complex Geometries and Advanced Materials
- Material Behavior Models
- Fluid Flow

• **Current/Future Uses:**

- **DOD Use:** Advanced Propulsion Systems
Advanced Airframe Systems
Space Systems
- **Non-DOD Use:** Commercial Aerospace
Automotive
Machine Tool
Space

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**Processing Science
Methodology**

• **Analytical Modeling**

- Deformation
- Densification
- Solidification
- Fluid Flow

• **Material Behavior Modeling**

- Processing Maps
- Constitutive Equations

• **Physical Modeling**

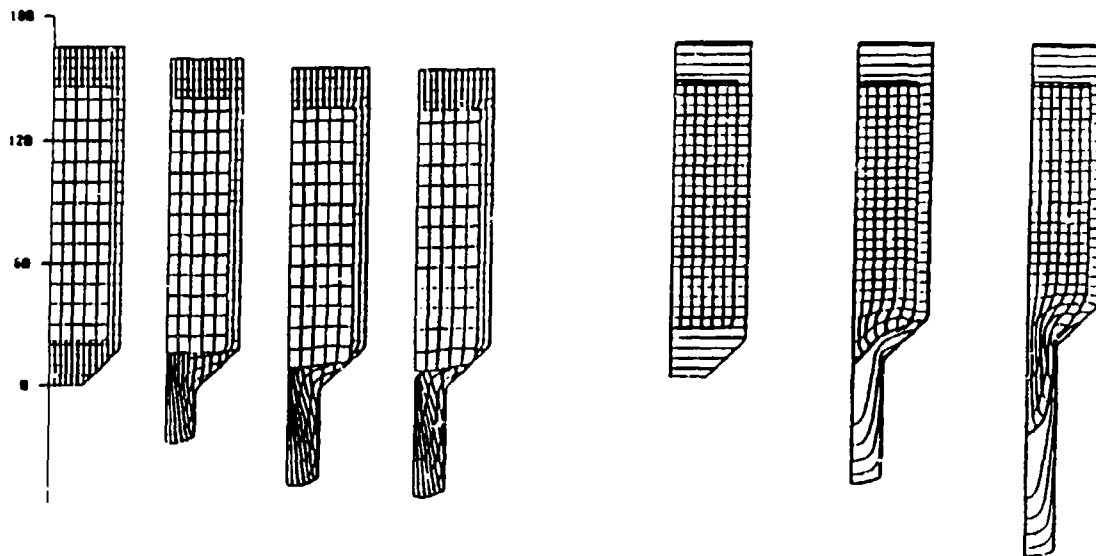
- Viscoplasticity
- Pilot-Scale Production



FEM SIMULATION OF CANNED EXTRUSION OF GAMMA TITANIUM ALUMINIDES

Wright Laboratory

Materials Directorate



Initial Billet and Can Temperatures
Assumed to be Equal

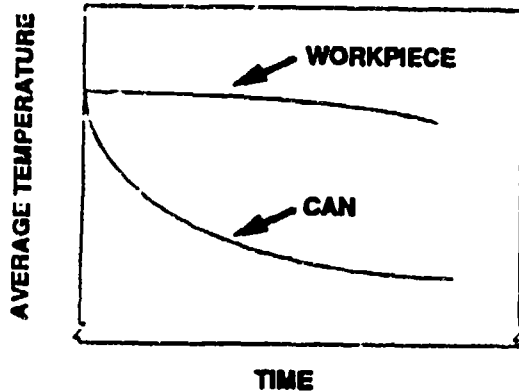
Initial Can Temperature Assumed
to be 200°C Lower Than Billet
Temperature



THE CONTROLLED DWELL EXTRUSION PROCESS

Wright Laboratory

Materials Directorate



Temperature Transients Within
Can and Workpiece Prior
to Extrusion



"Conventionally" Extruded
Gamma Billet



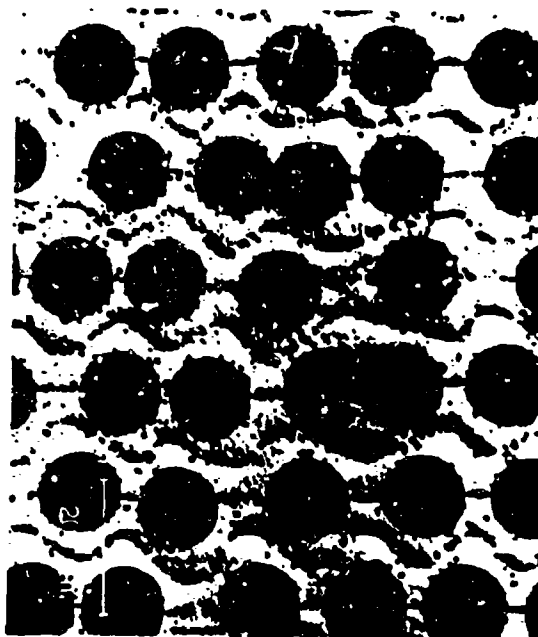
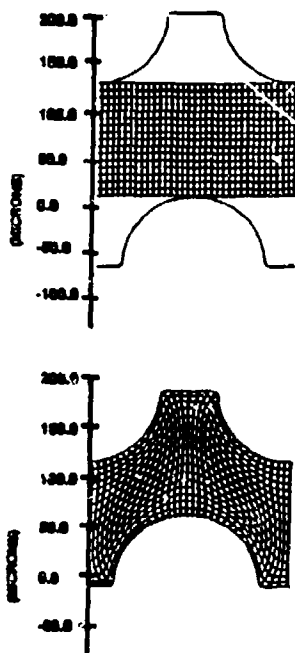
"Controlled Dwell" Extruded
Gamma Billet



FINITE ELEMENT MODEL OF FOIL-FIBER-FOIL COMPOSITE CONSOLIDATION

Wright Laboratory

Materials Directorate



WRIGHT LABORATORY MATERIALS DIRECTORATE EXPERIMENTAL MATERIALS PROCESSING LABORATORY (EMPL)



700-Ton Extrusion Press

MISSION: Provides materials processing expertise and leadership for the large scale introduction of new aerospace materials.

FACILITIES: 8,000 Sq. Ft.
8 On-site Personnel
Arc and TIG Welding
Heat Treating
Data Acquisition Support
Process Modeling
Casting

EQUIPMENT: Arc and Induction Melters
1000 Ton Forging Press
700-Ton Extrusion Press
Rolling Mill

AVAILABILITY: Available, at nominal cost, to government, industrial and academic organizations.



PAYOFFS

WRIGHT LABORATORY

MATERIALS DIRECTORATE

- **ELIMINATE COSTLY EMPIRICAL TRIAL-AND-ERROR PROCESS DEVELOPMENT**
- **PRODUCE COMPLEX SHAPE COMPONENTS WITH REQUIRED MICROSTRUCTURE AND PROPERTIES**
- **PROVIDE A RATIONAL STRATEGY FOR PROCESS CONTROL AND REPRODUCIBLE QUALITY**
- **PROVIDE U.S. INDUSTRIES WITH TECHNOLOGY TO PRODUCE HIGH QUALITY COMPONENTS AT THE LOWEST POSSIBLE COST AND TO COMPETE IN THE GLOBAL MARKET**

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

Key Personnel

Metals and Ceramics Material Processing Key Personnel:

Mr. James Morgan - Experimental Materials Processing, Modeling
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Dr. Lee Semiatin - Processing Science Methodology
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Phone: 513-255-1345



**Nondestructive
Evaluation**

Mr. Charles Buynak
Metals and Ceramics Division

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NDE IS INHERENTLY DUAL-USE

- **INDUSTRIAL**
- **CIVIL AIRCRAFT / FAA**
- **MEDICAL**

STRONG CUSTOMER PULL

DIRECTIONS

4-1 Aging Systems NDE

- Hidden Corrosion Characterization
- Detection of Innerlayer Cracks Under Fasteners

4-2 NDE Reliability Improvement

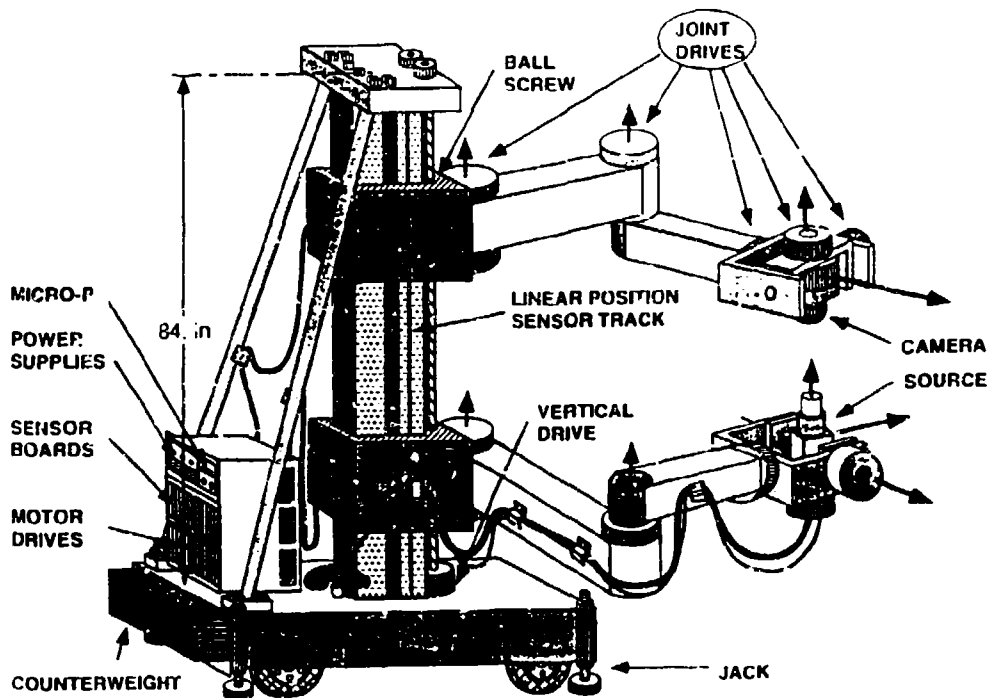
- Advanced Filmless, Real Time Radioscopy
- Advanced Computed Tomography

4-3 Composite Materials and Processes NDE

- Large Area Composites NDE System Development
- In-Process NDE for Composite Processing

4-4 Advanced Materials and Processes NDE

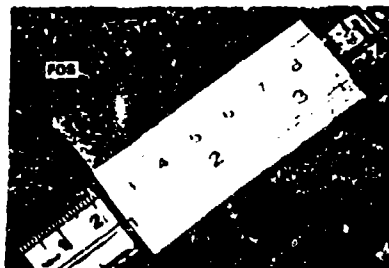
- Complex, Cast Blade NDE
- Image Enhancement / Analysis



INDUSTRIAL
QUALITY
INC

1991 R&D 100 AWARD FOR HIGH-RESOLUTION GLASS X-RAY DETECTORS

Lockheed



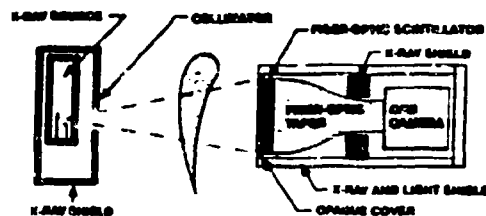
NEW GLASS FABRICATED INTO
FIBERS AND MADE INTO FIBER-OPTIC
SCINTILLATING (FOS) FACEPLATE

GLASS FEATURES

- HIGH-DENSITY, HIGH Z YIELDS IMPROVED X-RAY ABSORPTION
- HIGH SPATIAL RESOLUTION
- LOW AFTERGLOW

APPLICATIONS

- IMPROVED INDUSTRIAL AND MEDICAL X-RAY IMAGING
- MEASUREMENT OF DIMENSIONS OF INTERNAL STRUCTURE
- VERIFICATION OF NEW FABRICATION TECHNOLOGY



FOS FIBER COUPLED TO CCD CAMERA



FATIGUE CRACK AT FASTENER IN C-130 HERCULES.
CRACK WIDTH, <0.001 in., CRACK LENGTH, 0.090 in.
IMAGE OBTAINED WITH NEW GLASS USING FOS/CCD SYSTEM.
THIS CRACK WOULD NOT BE DETECTED USING NDT X-RAY FILM.

X-ray Computed Tomography Research Facility

- **OPERATIONAL AIRCRAFT NEEDS**
 - Rapid NDI for Advanced Composites with Complex Shapes and Variable Densities
- **INCREASED USE OF COMPOSITES (C-17, 777)**
 - Unique Inspection Requirements
 - Large Areas
 - Primary Structure - Mission Critical
- **COMPOSITE REPAIRS**
 - POST REPAIR INSPECTION REQUIRED

High Resolution Real-Time X-Ray Radioscopy

- **Ready for Transition**

Advanced Development hardware being developed

FY94 Demo planned of developmental system

- **Current / Future Uses**

Department of Defense

- Replace film radiography
- Field / Depot Use

Non-DOD

- Civil Aircraft Inspection
- Medical
 - Mammography
 - Dental

X-ray Computed Tomography

- **Ready for Transition**

Advanced development applications program finishing FY93
Cost advantages demonstrated - reported

- **Current / Future uses**

Department of Defense

- Inspect castings, closed systems
- Depot use, airframe, solid rocket motors

Non-DOD

- Castings
- Medical
 - Advanced Mammography
- Automotive

AIR FORCE INTEREST IN COMPUTED TOMOGRAPHY (CT)



Rockets

AF is currently using CT

- nozzles
- propellants
- bondlines



Aircraft

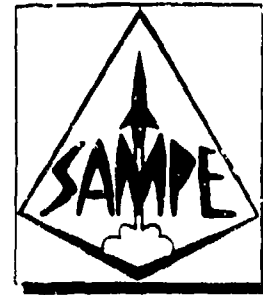
Structures, Materials, Equipment

- product development
- process monitoring
- manufacturing inspection
- inservice inspection



Payoff?

- higher performance designs
- improved manufacturing
- Reduced maintenance and repair costs
- Extended equipment life



MLB

**Dr Charles E. Browning
Nonmetallic Materials Division**

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**Aerospace Materials and Processes
Technology Reinvestment Workshop**

Agenda

-
- **Division Overview**
 - **Key Personnel for Technology Transfer**
 - **Topics for Technology Transfer**
 - **Structural Materials Branch - MLBC**
 - **Nonstructural Materials Branch - MLBT**
 - **Mechanics & Surface Interactions Branch - MLBM**
 - **Polymer Branch - MLBP**

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**Corrosion Prevention
Methods**

Corrosion Prevention Methods

The need for materials/processes to manage corrosion of aircraft systems continues to be top priority. Introduction of substitutes has been driven by environmental, health, and safety issues.

Why ready? 1) Current regulations reduce/eliminate the use of past, proven materials including inhibitors, platings, solvents, etc., 2) Qualification of acceptable substitutes needed immediately, 3) drop-in substitutes rare.

What are the unique features? 1) Applicable to numerous uses, 2) supplier/user vested interest.

What are current/future uses?

Dual Use - Qualified acceptable substitutes applicable to commercial aircraft, automotive industry, medical devices, etc.

**POC: MR. GARY STEVENSON
WJ/MLSA (513) 255-5108**

CORROSION CONTROL (CON'T)

ON-GOING EFFORT TO "QUALIFY" ACCEPTABLE SUBSTITUTES

- AEROSPACE INDUSTRY/SUPPLIERS/TRI-SERVICE/CO-OPERATION**
- QUALIFICATION VIA ACCELERATED LABORATORY EVALUATION**
- FIELD/SERVICE EVALUATION TO OBTAIN "TEST-OF-TIME" IS A LUXURY**
- RARELY SEE EQUIVALENT PERFORMANCE IN ACCELERATED TESTING**
- DROP-IN SUBSTITUTES ARE RARE**
- UNKNOWN LONG-TERM AEROSPACE PERFORMANCE**

CORROSION

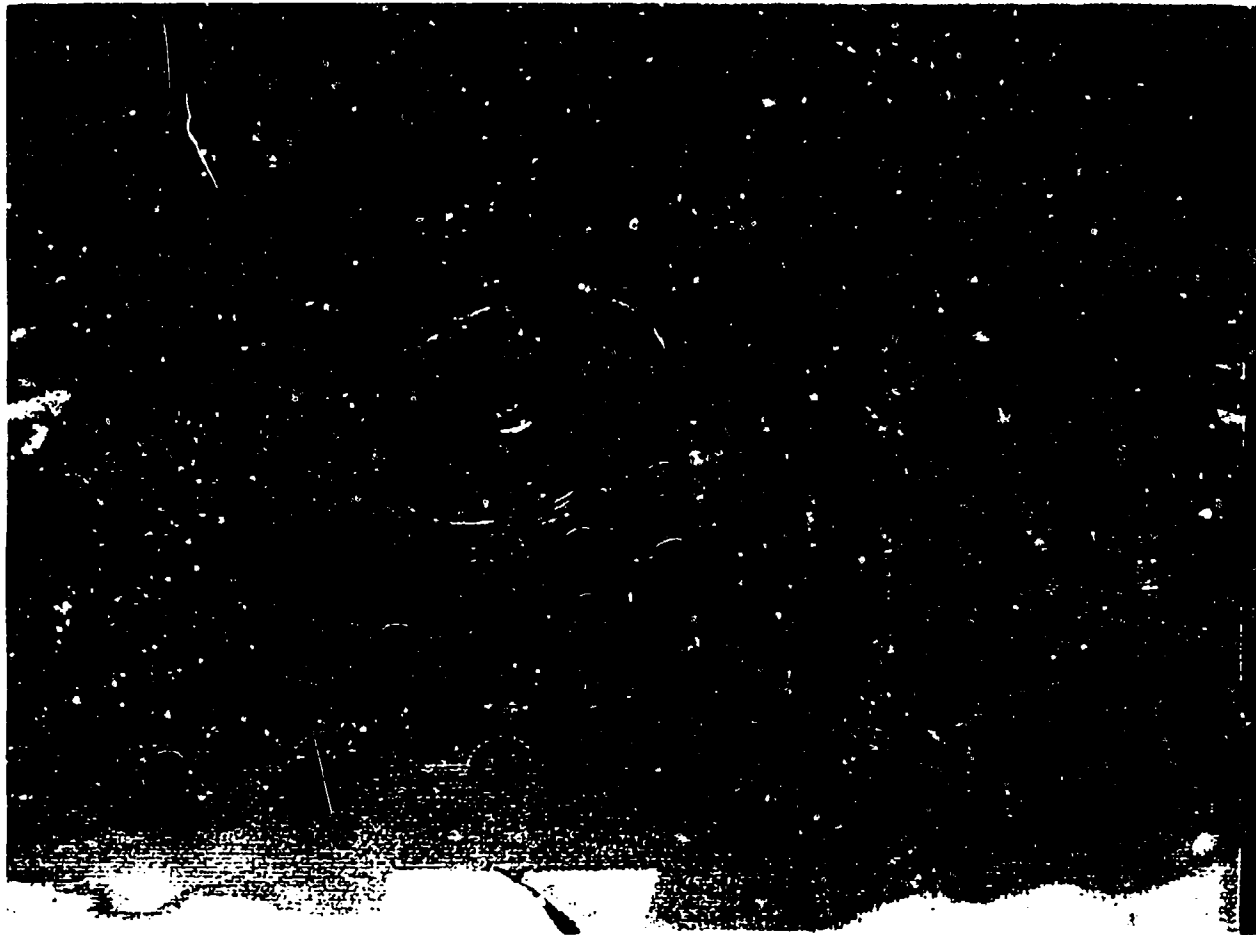
CORROSION CONTROL

•ENVIRONMENTAL, HEALTH, SAFETY ISSUES

- REPLACE PROVEN CORROSION CONTROL MATERIALS/PROCESSES**
- PROVEN MATERIALS REFORMULATED TO LOWER PERFORMANCE LEVELS**

•EVER-CHANGING REGULATIONS IMPACT

- HEXAVALENT CHROMIUM INHIBITORS**
- HEAVY METAL PLATINGS**
- OZONE DEPLETING & GLOBAL WARMING CHEMICALS**
- COATING AND SEALANT REMOVAL/REPLACEMENT**
- SOLVENT - BORNE COATINGS**



PROGRAM ACTIVITIES

- **COMPOSITE REPAIR OF CRACKED ALUMINUM STRUCTURES**
 - **MATERIAL AND PROCESS ISSUES RELATED TO COMPOSITE PATCH APPLICATION IN A FIELD ENVIRONMENT**
 - **SEVEN TASKS**
 - **INITIATED WHEN STATE OF THE ART PATCHING WAS DEFICIENT**

F-16 PATCH REPAIR

- **CRACK AROUND FUEL VENT HOLE ON LEFT WING LOWER SKIN**
- **SYSTEM SUPPORT TECHNICAL CONTRIBUTIONS**
 - **SELECTED SURFACE PREPARATION, ADHESIVE, AND PATCH MATERIALS**
 - **DEVELOPED APPLICATION PROCEDURES**
 - **APPLIED PATCHES TO F-16 AIRCRAFT AT HILL AFB UT**
- **OUTYEAR PLAN TO APPLY ADDITIONAL COMPOSITE PATCHES ON OTHER CRACK PRONE F-16 AIRCRAFT AREAS**
- **TWENTY MILLION DOLLAR COST SAVINGS ACROSS F-16 FLEET USING COMPOSITE PATCHES VERSUS DESKINNING**

Composite Materials Patch/Repair Activities

COMPOSITE MATERIAL PATCH REPAIR ACTIVITIES FOR AGING AIRCRAFT

- **F-16 WING**
- **B-1 LONGERON**
- **KC-135 KEEL BEAM**
- **B-52 WING**

Electronic Failure Analysis



TECHNOLOGY TRANSITION

Fuel Probe Failure Analysis Prevents Possible Grounding of T-37 Aircraft Fleet



NEED: Eliminate potential safety hazard caused by improperly functioning fuel probes on T-37 aircraft.

APPROACH: ML analysis of failed fuel probes revealed a materials degradation process between the fuel probes' silver plated wiring and residual sulfur in jet fuel.

Recommended improved fuel probe design and new maintenance procedures.

APPLICATION: Using ML recommendations, San Antonio ALC engineers effectively managed the fuel probe problem without having to ground the aircraft.

Structural Failure Analysis

WRIGHT LABORATORY MATERIALS DIRECTORATE

BLEED AIR DUCT FAILURE ANALYSIS IDENTIFIED ROOT CAUSE FOR C-130 SAFETY OF FLIGHT ISSUE



M L S A

**NEED: ELIMINATE BLEED AIR DUCT
FAILURES WHICH WERE A SOURCE
FOR FLIGHT CONTROL SYSTEM
FAILURE.**

**APPROACH: ML ANALYSIS DETERMINED THAT
321SS DUCT MATERIAL WAS BEING
DEGRADED AS A RESULT OF
IMPROPER WELDING DURING
MANUFACTURE.**



**APPLICATION: ML TRANSITIONED INSPECTION
PROCEDURES TO KEEP THE FLEET
OPERATIONAL. ML
RECOMMENDATIONS FOR MATERIAL
SUBSTITUTE AND PROCESS
IMPROVEMENTS AS A LONG TERM
FIX ADOPTED.**

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

AGENDA

- **Current activities within the Systems Support Division supporting aging aircraft**
 - **Structural failure analysis of C-130 bleed air ducts**
 - **Electronic failure analysis of T-37 fuel probes**
 - **Composite patch repair activities**
- **Corrosion prevention methods**

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

Aging Aircraft

Aging Aircraft

A large segment of the Air Force operational fleet is aged and deteriorated to the point where major refurbishments and retrofits are required to continue use.

Why ready? 1) Life extensions a requirement, 2) the development of new systems in the near term will be minimal, 3) mission requirements likely to be increased.

What are the unique features? 1) Environment/mission/material driven, 2) applicable to numerous systems including trainers, bombers, and fighters, 3) needed are improved inspection methods for corrosion and flaw detection, improved repair methods, etc.

What are current/future uses?

Dual Use - system enhancements applicable to commercial fleet.

**POC: MR. RON WILLIAMS
WL/MLSA (513) 255-3623**

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**Pollution Prevention
R&D**

POLLUTION PREVENTION R&D

The ML pollution prevention R&D program is focused on the elimination of water, VOC and ODC waste streams. Through the development and transfer of advanced materials and processes the Air Force will eliminate these waste streams from the manufacture and maintenance of its weapon systems

Major thrusts: - Non chemical metal surface preparation
- VOC compliant coating systems
- Super critical CO2 cleaning
- Non-TOX/HAZ anti-ice/de-ice for aircraft
- Advanced fire extinguishing materials

Potential Payoff: - Eliminate the use of bad acting materials
- Improve health/safety of workers
- Processes used universally by industry

THESE ARE NEW FY93 PROJECTS

POC: TED J. REINHART
WL/MLSE (513) 255-3691



**Aging Aircraft
and
Corrosion Prevention Methods**

**Mr. Ronald H. Williams, Chief
Materials Integrity Branch
Systems Support Division**

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2179 Twelfth St. Ste 1
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45433-7718

TWO MECHANISMS FOR COOPERATIVE R&D BETWEEN INDUSTRY & DOD (AIR FORCE)

- o **DUAL USE TECHNOLOGY DEVELOPMENT PROJECTS
(DARPA)**
- o **COOPERATIVE RESEARCH & DEVELOPMENT
AGREEMENT (CRDA)**

- POTENTIAL AREAS OF INTEREST

**ADVANCED COATING & REMOVAL TECHNOLOGY
REMOVAL HIGH PERFORMANCE COATINGS
NON CHROME CORROSION INHIBITING SYSTEMS
(NON-LEAD, CADMIUM TOO)
ADVANCED CONVERSION COATINGS
ADVANCED FIRE EXTINGUISHING/EXPLOSION
SUPPRESSION**

WRIGHT LABORATORY
POLLUTION PREVENTION PROGRAMS

MATERIALS DIRECTORATE (ML)

ADVANCED METAL SURFACE TREATMENT PROCESSES

**OBJECTIVE: TO REPLACE EXISTING WET CHEMISTRY PROCESSES
FOR PREPAINT / PREBOND SURFACE PREPARATION OF
ALUMINUM & COPPER ALLOYS**

APPROACH: R&D INVESTIGATIONS INTO:

- THIN FILM DEPOSITION TECHNOLOGY
- THERMAL SPRAY TECHNOLOGY
- SOL-GEL OXIDE FILM DEPOSITION
- ION-BEAM ENHANCED FILM DEPOSITION

**PAYOFF: - ELIMINATES LARGE WATER CONTAMINATING/USING
PROCESSES**
- ELIMINATES USAGE OF STRONG ACIDS AND BASES
- ELIMINATES USAGE OF SOLUBLE CHROME

WL POLLUTION PREVENTION R&D

ADDITIONAL STUDY AREAS

- o **ADVANCED PRINTED CIRCUIT BOARD PROCESSES**
- o **ELIMINATION OF WATER BASE METAL DEPOSITION
& REMOVAL PROCESSES**
- o **TURBINE ENGINE OIL RECYCLING**
- o **SOLID STATE METAL CLEANING PROCESSES**
- o **ENVIRONMENTALLY ACCEPTABLE "CHAFF"
MATERIALS**
- o **ENVIRONMENTALLY ACCEPTABLE BATTERIES
(NIMH)**

POLLUTION PREVENTION R&D

WRIGHT LABORATORY AREAS OF FOCUS

- o **WATER WASTE STREAM ELIMINATION**
- o **VOLATILE ORGANIC COMPOUNDS (VOCs) ELIMINATION**
- o **SOLID WASTE STREAM ELIMINATION**
- o **OZONE LAYER DEPLETING SUBSTANCES (OLDS) ELIMINATION**

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WL POLLUTION PREVENTION R&D ^{6Aug92}

o WATER WASTE STREAM ELIMINATION

- **NON CHEMICAL BASE SURFACE TREATMENTS FOR Al, Ti & Cu ALLOYS FOR BONDING & COATING**

FORMATION OF THERMODYNAMICALLY STABLE SURFACE MORPHOLOGIES

**THIN FILM DEPOSITION, SOL GEL TECHNIQUES
HIGH VELOCITY OXYGEN FUEL, FLAME/PLASMA
SPRAY LASER BASE PROCESSES**

- **ADVANCED PAINT STRIPPING TECHNOLOGY**

**ROBOTICALLY CONTROLLED PROCESSES
PLASTIC MEDIA, WATER, CO2**

14
17

ILIP ENVIRONMENTAL THRUSTS

o FOUR MAJOR USAF ACTIVITIES

- RISK ANALYSIS**
- CLEANUP, SITE RESTORATION**
- COMPLIANCE, EXISTING TECHNOLOGY**
- PREVENTION, FUTURE TECHNOLOGY**

6 Aug 92

POLLUTION PREVENTION R&D

APPROACH

- o ELIMINATE THE SOURCES (i.e., EMPTY THE PIPELINE)**
- o QUANTUM IMPROVEMENTS (LEAP FROG TECHNOLOGY)**
- o WORK THE DIFFICULT, LONGER TERM, HIGH PAYOFF OPPORTUNITIES**

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**Topics for Technology
Transfer**

**1. Pollution Prevention
FOC: Mr. Ted Reinhart (513) 255-3691**

**2. Aging Aircraft
POC: Mr. Ron Williams (513) 255-2623**

**3. Corrosion Prevention Methods
POC: Mr. Gary Stevenson (513) 255-2620**



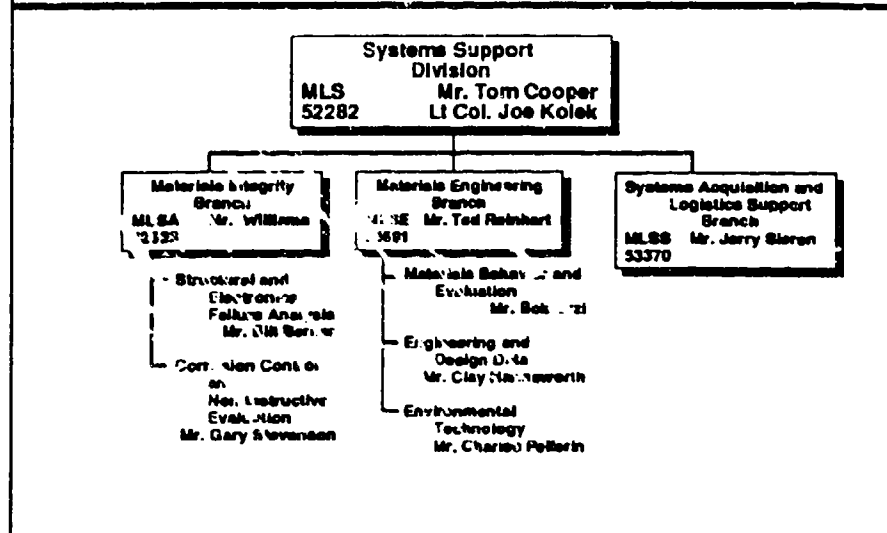
**Pollution Prevention
Research & Development**

**Mr. Ted J. Reinhart
Materials Engineering Branch
Systems Support Division**

**(513) 255-3691
WL/MLSE Bldg 652
2179 Twelfth St. Ste 1
Wright-Patterson AFB, OH
45433-7718**

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**MLS Division
Overview**



**Aerospace Materials and Processes
Technology Reinvestment Workshop**

Key Personnel

Mr. Tom Cooper, Chief
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Mr. Ron Williams, Chief
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Mr. Ted Reinhart
Materials Engineering Branch
(513) 255-3691 fax 478-4419

Mr. Jerry Storen
Systems Acquisition & Logistics Support Branch
(513) 255-3370 fax 478-4419

Mr. Bill Berner
Structural and Electronic Failure Analysis
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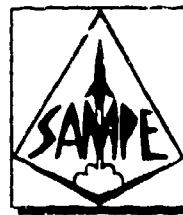
Mr. Bob Urzi
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Mr. Gary Stevenson
(513) 255-5117 fax 478-4419

Mr. Clay Harnsworth
Engineering & Design Data
(513) 255-8128 fax 478-4419

Mr. Charles Pellerin
Environmental Technology
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Mr. Thomas D. Cooper
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**Aerospace Materials and Processes
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Agenda

- **Systems Support Division Overview**
- **Key Personnel for Technology Transfer**
- **Topics for Technology Transfer**

**Aerospace Materials and Processes
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**Mobile Automated
Scanner**

Large Area Composite Inspection - Mobile Automated Scanner

- **Ready for Transition**

Advanced Development hardware being developed
Already being used on real aircraft components

- **Current / Future Uses**

Department of Defense

- Large radome inspection
- C-17 composites inspection

Non-DOD

- Civil Aircraft Inspection - Boeing 777
- Infrastructure
 - Pipes
 - Large Composite Tanks

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

Key Personnel


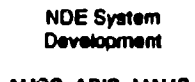


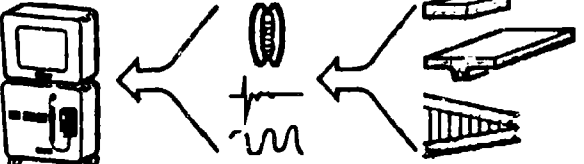
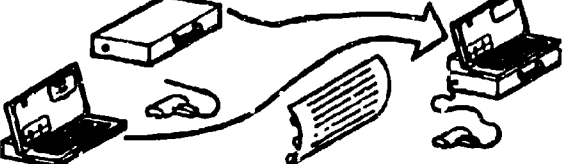

Nondestructive Evaluation Key Personnel:

Mr Charles Buyrak - Digital Radioscopy, Ultrasonics
WL/MLLP Bldg 655
2230 Tenth St Ste 1
Wright Patterson AFB OH 45433-7817
Phone: 513-255-9807

Mr Tobey Cordell - NDE Technology
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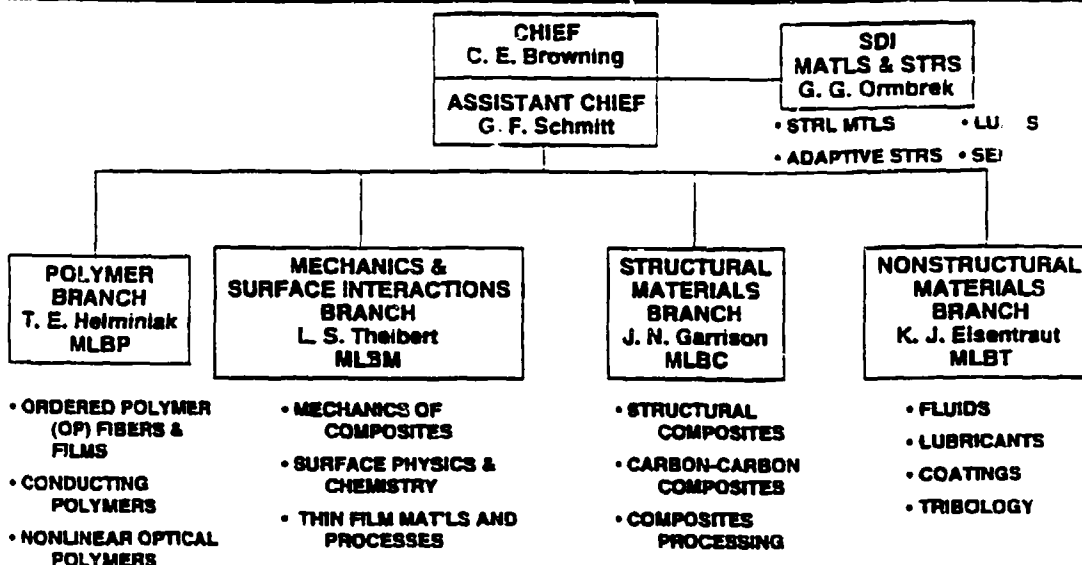
Dr Thomas Moran - NDE Research
WL/MLLP Bldg 655
2230 Tenth St Ste 1
Wright Patterson AFB OH 45433-7817
Phone: 513-255-9806

Program Overview

| | | | | |
|---|---|--|--|---|
| Previous Work Foundation |  <p>Composites Field Support/NDI</p> |  <p>NDE System Development AUSS, ADIS, MAUS, QUIC, AIMX</p> |  <p>CRAD MCAIR IRAD WL</p> |  <p>Composites Fabrication Technology</p> |
| Task I Breadboard |  | | | <p>Features</p> <ul style="list-style-type: none"> • Existing Equipment/Materials • Proven Concepts • Evaluation • Optimization • Prototype Concept Refinement • Customer Review |
| Task II Prototype Development/Evaluation |  | | | <ul style="list-style-type: none"> • Component Design • Component Development/Procurement • System Integration • Large Area Evaluation • Continual Improvement • Customer Review |
| Task III Full-Scale Inspection System Model Design/Validation |  | | | <ul style="list-style-type: none"> • Prototype Refinement • Field Hardening • Validation • Demonstration |

Aerospace Materials and Processes Technology Reinvestment Workshop

MLB DIVISION OVERVIEW



Aerospace Materials and Processes Technology Reinvestment Workshop

Key Personnel

Nonmetallic Materials Division

Dr. Charles E. Browning, Chief, 513-255-9018, FAX 513-255-9019

Mr. George F. Schmitt, Assist Chief, 513-255-9018, FAX 513-255-9019

Space Materials and Processes

Mr. Glenn G. Ormbrek, 513-255-2199, FAX 513-255-2176

Polymer Branch - MLBP

Dr. Ted E. Helminiak, 513-255-9158, FAX 513-255-9019

Structural Materials Branch - MLBC

Mr. Jan N. Garrison, 513-255-9070, FAX 513-476-4706

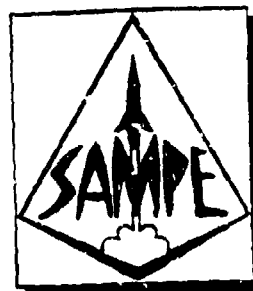
Nonstructural Materials Branch - MLBT

Dr. Kent J. Eisentraut, 513-255-5731, FAX 513-255-9019

Mechanics and Surface Interactions Branch - MLBM

Mr. L. Scott Theibert, 513-255-3068, FAX 513-476-4706

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Structural Materials Branch

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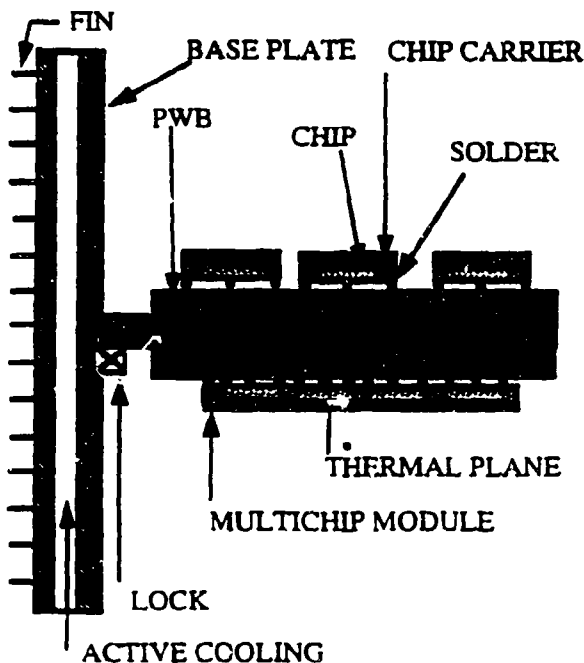
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**Technology Transfer
Topics**

Structural Materials Branch

- Carbon-carbon composites for electronic packaging
- Carbon-carbon composites for brakes/clutches
- Carbon-carbon composites as graphite replacement
- Carbon-carbon composites for space structures or thermal management
- Advanced Composites for Infrastructure
- Light Weight, Low Cost Composites for Automotive Appins
- High Temperature Organic Composites for Industrial, Automotive Appins
- Smart Materials & Structures for Infrastructure, Transportation
- Composites for Offshore Petroleum Operations

- Why is this ready for transition?
 - Concept has been demonstrated
 - Low cost options available
- What are the unique features?
 - Very high thermal conductivity
 - Low, tailorable coefficient-of-thermal-expansion (CTE)
 - Metallic & ceramic coatings/plating developed/demonstrated
- What are current/future uses:
 - Department of Defense
 - Thermal planes, heat sinks, heat sink fins
 - Multichip module (MCM) & PWB substrates
 - Matched chip/substrate CTE
 - Thermally conductive tie-down for components
 - NON-DOD
 - Same as Department of Defense
- Point of Contact: Ken Davidson, WL/MLBC, 513-255-9067



ELECTRONIC PACKAGING

- C-C potential to reduce with increased heat dissipation
- 1500 SEM E boards on advanced aircraft, C-C thermal planes save 540#
- NAWC estimates 100# weight savings = \$25 million savings over the lifetime of the F-14 fleet
- Tailorable expansion with hybrid C-C/A/C-C
- Enhanced operational reliability, MIL handbook 217D indicates MTBF lifetimes increases from 3000 hrs at 167 °F to 7000 hrs at 130 °F

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**ADV COMPOSITES
FOR
INFRASTRUCTURE**

- **WHY READY FOR TRANSITION:**
 - STRUCTURAL APPLICATIONS SINCE MID 1960'S
 - MATERIAL/MFG DATA BASE, INDUSTRIAL BASE
- **UNIQUE FEATURES**
 - WEIGHT SAVINGS
 - TAILORABLE PROPERTIES
 - CORROSION/FATIGUE RESISTANCE
- **CURRENT/FUTURE APPLICATIONS:**
 - DOD: - AEROSPACE STRUCTURES
 - MARINE STRUCTURES
 - NON DOD: - SPORTING GOODS
 - MEDICAL EQUIPMENT
 - INFRASTRUCTURE
- **POINT OF CONTACT:** JAN GARRISON, WL/MLBC, 513-255-9070

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**LIGHTWEIGHT, LOW COST
COMPOSITES FOR
AUTOMOTIVE**

- **WHY READY FOR TRANSITION:**
 - STRUCTURAL APPLICATIONS SINCE MID 1960'S
 - MATERIAL/MFG DATA BASE, INDUSTRIAL BASE
 - MAJOR DOD, NASA COST REDUCTION ACTIVITY
- **UNIQUE FEATURES**
 - WEIGHT SAVINGS
 - EASE OF ASSEMBLY/REPAIR
 - LOW MAINTENANCE COST
 - CORROSION/FATIGUE RESISTANCE
 - ENERGY ABSORBING
- **CURRENT/FUTURE APPLICATIONS:**
 - DOD: - AEROSPACE STRUCTURES
 - MARINE STRUCTURES
 - NON DOD: - SPORTING GOODS
 - MEDICAL EQUIPMENT
 - INFRASTRUCTURE
 - AUTOMOTIVE
- **POINT OF CONTACT:** JAN GARRISON, WL/MLBC, 513-255-9070

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**HIGH TEMP OMC'S FOR
INDUSTRIAL & AUTOMOTIVE APPLNS**

- **WHY READY FOR TRANSITION:**
 - USAF DEVELOPMENT PROGRAM SINCE 1988
 - ENGINE, AIRFRAME STRUCTURES
 - CURRENT FLIGHT TESTING
- **UNIQUE FEATURES**
 - WEIGHT SAVINGS
 - HIGH TEMPERATURE CAPABILITY (700°F)
 - CORROSION/FATIGUE RESISTANCE
- **CURRENT/FUTURE APPLICATIONS:**
 - DOD: • AIRCRAFT & ENGINE STRUCTURES
 - NON DOD: • ELECTRONICS
 - AUTOMOTIVE (UNDER THE HOOD, EXHAUST)
 - INDUSTRIAL (POWER GENERATORS, ENGINES)
 - COMMERCIAL AIRCRAFT ENGINES
- **POINT OF CONTACT:** JAN GARRISON, WL/MLBC, 513-255-9070

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**SMART MAT'LS & STRUCTURES FOR
INFRASTRUCTURE, TRANSPORTATION**

- **WHY READY FOR TRANSITION:**
 - AEROSPACE INDUSTRY AND GOVERNMENT ACTIVITY SINCE '80'S
 - CURRENT SPACECRAFT/ AIRCRAFT TESTING AND DEMOS
 - CIVIL ENGINEERING APPLICATIONS (JAPAN, EUROPE)
- **UNIQUE FEATURES:**
 - ABILITY TO SENSE VIBRATIONS, STRAINS
 - STRUCTURAL LIFE MONITORING
 - ABILITY TO ACTIVELY CONTROL, DAMP VIBRATION S
- **CURRENT DOD RESEARCH AND DEVELOPMENT**
 - AIRCRAFT/SPACECRAFT/SUBMARINE STRUCTURES
 - INTELLIGENT PROCESSING
- **NON-DOD APPLICATIONS**
 - AUTOMOTIVE
 - ACOUSTIC NOISE CONTROL FOR CABIN INTERIORS
 - EARTHQUAKE-PROOF BUILDINGS
 - BRIDGES
 - OIL TANKERS, PRESSURE VESSELS
- **POINT OF CONTACT:** JAN GARRISON, WL/MLBC, 513-255-9070

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Technology Reinvestment Workshop**

**COMPOSITES FOR OFFSHORE
PETROLEUM OPERATIONS**

- **WHY READY FOR TRANSITION:**
 - STRUCTURAL APPLICATIONS SINCE MID 1960'S
 - MATERIAL/MFG DATA BASE, INDUSTRIAL BASE
 - MAJOR DOD, NASA COST REDUCTION ACTIVITY
- **UNIQUE FEATURES**
 - HIGH STRENGTH/STIFFNESS-TO-WEIGHT
 - FATIGUE/CORROSION RESISTANCE
 - ACOUSTIC, VIBRATION & ENERGY ABSORPTION
 - PROCESSABLE IN VERY LONG, CONTINUOUS LENGTHS
- **CURRENT/FUTURE APPLICATIONS:**
 - DOD: - AEROSPACE STRUCTURES
 - MARINE STRUCTURES
 - NON DOD: - SPORTING GOODS
 - MEDICAL EQUIPMENT
 - INFRASTRUCTURE
 - AUTOMOTIVE
- **POINT OF CONTACT:** JAN GARRISON, WL/MLBC, 513-255-9070

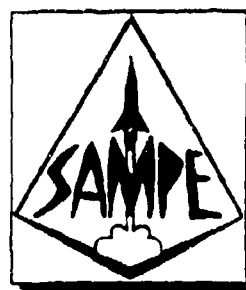
**Aerospace Materials and Processes
Technology Reinvestment Workshop**

Key Personnel

Fluids, Lubricants, Tribology, Seal and Coating Materials

Mr Carl E. Snyder, Jr.
WL/MLBT Building 654
2941 P Street Ste 1
Wright-Patterson AFB, OH 45433-7750

Phone #: 513-255-9036



Nonstructural Materials Branch

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45433-7750

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**Topics for Technology
Transfer**

Nonstructural Materials Branch

- **Nonflammable Hydraulic Fluid**
- **Fire Resistant Hydraulic Fluid**
- **Electronic Coolant**
- **Cooperative Specialty Fluid & Lubricant Development**
- **Self-Lubricating Aluminum Metal Matrix Composites**
- **Ceramic Bearing Technology**
- **Diamond Coated Ball Bearings**
- **Pulsed Laser Deposition Technology**

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**Nonflammable Hydraulic
Fluid MIL-H-53119**

Why is it ready for transition?

- A fully formulated hydraulic fluid, including the base fluid, antiwear additive and a rust inhibitor, has been developed. Validation in flight-worthy components with compatible elastomeric seals has been successfully completed

What are unique features?

- The only truly nonflammable hydraulic fluid operating from -65°F to 350°F

Future uses include

- **DOD** (currently in R&D programs)
 - US Army ground vehicles
 - Air Force brake systems
 - Electric hydraulic actuators (EHA's)
- **Non-DOD**
 - Mining
 - Rapid transit, etc.

Point of Contact: C. E. Snyder, Jr., WL/MLBT/WPAFB/ 513-255-9036

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**Fire Resistant Hydraulic
Fluid MIL-H-87257**

Why is it ready for transition?

- Developed as a replacement for flammable MIL-H-5606, this fluid has been successfully validated in the B-1 simulator

What are its unique features?

- This fluid is the only drain-and-fill replacement for the very flammable hydraulic fluid that will operate down to -65°F for cold start applications

Uses : DOD : This fluid will replace MIL-H-5606 in former SAC aircraft

Non DOD : Small commercial aircraft; industrial equipment

Point of Contact: C. E. Snyder, Jr., WL/MLBT, WPAFB 513-255-9036

**Aerospace Materials and Processes
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**Electronic Coolant
PAO Coolant**

Why is it ready for transition?

- This coolant has been successfully used since 1987 in the B-1 aircraft and since then has been converted to use in many DOD systems including Patriot missile, LANTIRN radar system and the F-18

What are its unique features?

- This non-reactive PAO coolant replaces a troublesome silicate ester coolant that reacted with water causing a gel and a flammable alcohol.
- One-fourth the cost of the old coolant

Uses:

- **DOD**
 - Currently in many applications, future uses are in all systems using silicate ester coolants and some using silicone oils
- **Non-DOD**
 - Solar heat transfer fluid for energy savings

Point of Contact: Lois Gschwender, WL/MLBT/WPAFB 513-255-7530

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**Cooperative Specialty
Fluid & Lube Development**

Why is it ready for transition?

- Specialty Fluid and Lubricant Development has successfully led to the development and transition of a wide variety of materials, - Fire resistant and nonflammable hydraulic fluids, PAO coolants, specialty greases, gas turbine lubricants

What are its unique features?

- This technology can be directly applied to non-DOD requirements, e.g., lubricants for new refrigeration systems, specialty fire resistant fluids and lubricants, replacements for mineral oil based products that are no longer available, etc.

Point of Contact: C. E. Snyder, Jr. WL/MLBT, WPAFB 513-255-9036

**Aerospace Materials and Processes
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**SELF-LUBRICATING
ALUMINUM METAL
MATRIX COMPOSITES**

Why is this ready for transition?

- Long term friction tests (1M cycles) demonstrated self-lubricating nature
- Steady state friction coefficient $<.05$ (dry) and $<.1$ ($>50\%$ humidity)

What are its unique features?

- Extremely low wear rates; Smearing of Al eliminated
- Lightweight (<3 g/cc) with tailorable mechanical properties

USES: DOD : Self-lubricating bearing material for use in vacuum,
dry and moist environments

Non DOD : Self-lubricating lightweight metal-based bearing material

Point of Contact: K. R. Mecklenburg, WL/MLBT WPAFB 513-255-2465

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**CERAMIC HYBRID BEARING
TECHNOLOGY**

Why is it ready for transition ?

- Ceramic materials provide advanced performance in demanding ball and roller bearing applications

What are its unique features?

- Ceramic balls in steel races can provide long life and reduced wear

Uses:

- **DOD :** Ball bearings for precision gimbals, turbine engines and for high and low temperature operation in air and vacuum
- **Non DOD :** Spindles for machine tools; corrosion resistant operation using ceramic balls and races; high vacuum; high speed and high and low temperature operation

Point of Contact: Karl R. Mecklenburg, WL/MLBT, WPAFB 513-255-2465

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**PLD of Thin-Film
Tribological Materials**

Why is it ready for transition?

- R&D for Deposition Technology Complete; Ready for Scale-up and Commercialization

What are its unique features?

- Low Temperature Deposition; Extraordinary Film Properties, Environmentally Friendly Process

Uses:

- DOD : High Temperature Turbine Engine Components; Ball Bearings, Races, Gimbals, etc.; Space-borne components.
- Non DOD : Ball Bearings, Races, Components requiring solid lubrication/ hard coatings, etc

Point of Contact: Dr. M. S. Donley, WL/MLBT, WPAFB 513-255-6485

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**DIAMOND
COATINGS
CERAMIC BEARINGS**

Why is it ready for transition?

- Developmental Research Completed; Ready for Commercialization

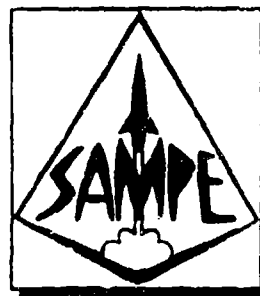
What are its unique features?

- Diamond is the Hardest Material Known; Excellent Microstructure and Surface Finish; Excellent Heat Conductor

Uses:

- DOD : Ball Bearings for Precision Applications (Gimbals, Sensors); High Temperature Corrosive Atmosphere Operations; Limited Lubricant Operations
- Non DOD : Precision Bearings for Long Life, e.g., Dental Drills; Corrosive Environments; High Speed Operations; Limited Lubricant Availability

Point of Contact: Dr. M. S. Donley, WL/MLBT, WPAFB 513-255-6485



Polymer Branch

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**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**Topics for
Technology Transfer**

MLBP Topics for Technology Transfer:

- **High Temperature Organic Electro-Optic Materials**
- **High Temperature Thermoplastic Polymers**

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

Key Personnel

Dr. Robert Spry - Conducting Polymers
WL/MLBP Bulding 654
2941 P. ST. STE 1
Wright-Patterson AFB, OH 45433-7750
513 255-9139

Dr. Seng Tan - Structural Polymers
WL/MLBP Bulding 654
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513 255-9141

Mr. Bruce Reinhardt - Organic Electro-Optic Materials
WL/MLBP Bulding 654
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513 255-9162

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**High Temperature
Thermoplastic Polymers**

Why is it ready for transition?

- Reproducible Synthesis Process

What are the unique features?

- High Use Temperature (Up to 450°F max.)
- Low Dielectric Properties (Good Insulator)
- Environmental/Moisture Resistant (Less Swelling, Good Arc Resistance)
- Tailorable Mechanical/Thermal Properties
- Some Polymers Amenable To Spin Coating-Type Technologies

Current/Future Uses:

DOD

- New High Temperature Canopy/Sensor Material
- Kapton Wire-Wrap Replacement
- Dielectric Insulator For Electronic Packages
- Thermal Barrier
- Matrix Phase for Electro-optic Polymers

NON DOD

- Sensors
- Wire insulation
- Electronic Packaging

POC: Marilyn Unroe (513) 255-9145

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**High Temperature Organic
Electro-Optic Materials**

Why is it ready for transition?

- These materials offer a substantial improvement in properties over state-of-the-art, second-order, organic electro-optic materials

What are the unique features?

- Large 2nd-Order Activity
- High transparency at visible light wavelengths
- Increased Thermal Stability
- Low dielectric constant

Current/future Uses:

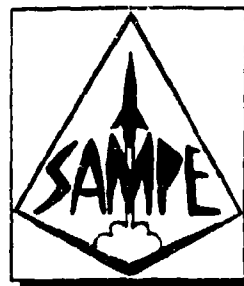
DOD

- Increased recording capacity for CD's via laser light manipulation
- Higher density of interconnects using E-O materials
- Improved thermal management of electronic devices

NON-DOD

Same as above

POC: Bruce Reinhardt WL/MLBP (513) 255-9162



Mechanics & Surface Interactions Branch

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**Aerospace Materials and Processes
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**Technology Transfer
Topics**

Mechanics & Surface Interactions Branch

- **GaAs Materials and Processing Technology**
- **Hard Coating Materials and Processing Technology**
- **Molecular Beam Epitaxy Processing Science and Control**
- **Characterization of Materials Surfaces and Thin Films**
- **Real Time Damage Monitoring**
- **Efficient, 3-D, Numerical Methods for Composite Response**
 - **Micromechanics Including Fracture**
 - **Laminate Mechanics**
- **Exact Solutions and Analytical Methods for Composite Materials**
 - **Baseline Solutions for Complex Problems**
- **Unique Experimental Capabilities**
 - **Micro/Macro/Interfacial Failure Modes**

**Aerospace Materials and Processes
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**MBE Process Control
of Low Temp GaAs**

Ellipsometer equipped MBE providing real time process control

Why ready?

- Ellipsometer has been developed providing process control of Low Temperature GaAs deposition at 250°C by controlling the temperature of the As source, stoichiometry and growth rate in real time.

What are Current/Future Uses?

- **DOD**
 - Phased Array Radar
 - Infra Red Detectors for Surveillance
 - High Temperature Electronics
- **Potential Future Commercial**
 - High Definition TV Components
 - Direct Broadcasting Satellites
 - Ultra High Speed Computers
 - Low Power Consumption Electronic Circuits

Point of Contact: L. Scott Theibert, WL/MLBM, 513-255-3068

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**Numerical Methods
for Composite Response**

Why Ready?

- Highlights of 20 years of research by Dr Pagano and associates at WL/ML have been incorporated in the software package "Automated System for Composite Analysis (ASCA)."
- Basis for user friendly numerical methods to describe composite laminates and predict their response

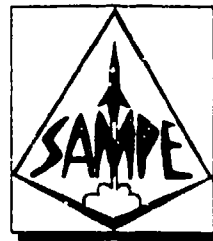
What are the Unique Features?

- Fiber, matrix, coatings and interface conditions are property inputs
- Micromechanical analysis used to compute moduli of layers with n-directional fibers
- Calculates laminate properties and stresses including interlaminar stresses
- Define stress fields due to free edges, curing, moisture, transverse cracks & debonding

What are Current/Future Uses?

- **DOD Uses**
 - Design/analysis of solid propellant rocket nozzles
 - Characterization of materials applications for air and space vehicles
- **Commercial Uses**
 - Composite materials design/selection for infrastructure, sporting goods, etc.
 - Validation of finite element programs/solution

Point of contact: L. Scott Theibert, WL/MLBM, 513-255-3068



**Mr. William R. Woody
Electromagnetic Materials
and Survivability Division**

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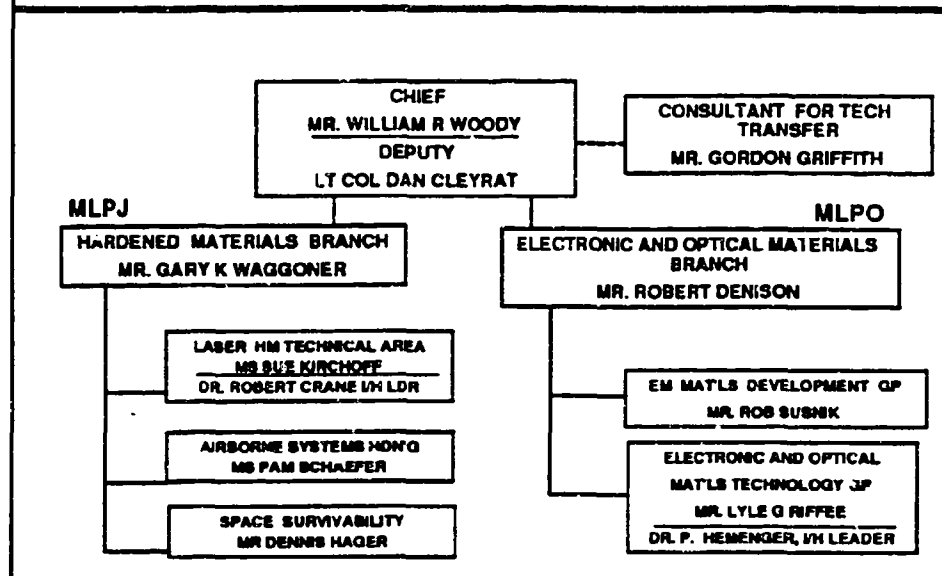
**Aerospace Materials and Processes
Technology Reinvestment Workshop**

Agenda

- **Division Overview**
- **Key Personnel for Technology Transfer**
- **Topics for Technology Transfer**

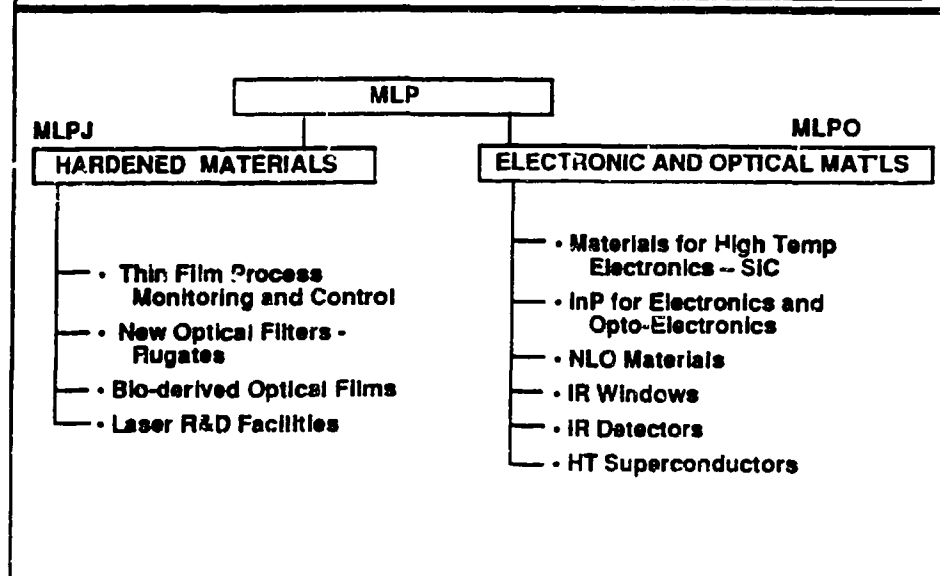
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**MLP
Management Team**



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**Major Thrusts With
Potential for Transfer**



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**Topics for
Technology Transfer**

- Materials for High Temperature Electronics – SiC
- InP for Electronics and Opto-Electronics
- NLO Materials
- HT-SC Materials & Processes
- Thin Film Process Monitoring and Control
- New Optical Filters - Rugates
- Biotechnology for Optical Materials
- Laser R&D Facilities

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**Points of
Contact**

- Materials for High Temperature Electronics – SiC
 - Mr Tom Kensky
- InP for Electronics and Opto-Electronics
 - Ms Laura Rea
- NLO Materials
 - Dr Ken Hopkins
- HT-SC Materials & Processes
 - Mr Tim Peterson
- New Optical Filters - Rugates
 - Mr Walt Johnson
- Biotechnology for Optical Materials
 - Dr Wade Adams / Dr Robert Crane
- Laser R&D Facilities
 - Mr Rob Hull / Dr Pat Hood / Mr Charles Lovett

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**Materials for High
Temperature Electronics**

Materials for High Temperature Electronics – SiC

- A NEW MATERIALS SYSTEM - FOR APPLICATION
- SPECIALTY APPLICATIONS
 - MILITARY - ADVERSE REQUIREMENTS
 - TURBINE ENGINE CONTROLS
 - T/R MODULES FOR 10 GHz
 - COMMERCIAL
 - AUTOMOBILE ENGINE CONTROLS AND SENSORS
 - ADVERSE ENVIRONMENT ELECTRONICS - YOUR CHOICE

**POC: Mr. Tom Kensky
WL/MLPO (513)255-4588 Ext. 3218**

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**SiC
Key Personnel**

Materials for High Temperature Electronics – SiC

Materials for High Temperature Electronics - SiC Program Manager

**Mr Tom Kensky
WL/MLPO Building 651
3005 P Street STE 6
Wright-Patterson AFB, OH 45433-7707
Phone #: 513-255-4474 ext 3249 or 3218**

Materials for High Temperature Electronics - Sr Tech Advisor

**Dr William Mitchell
WL/MLPO Building 651
3005 P Street STE 6
Wright-Patterson AFB, OH 45433-7707
Phone #: 513-255-4474 ext 3252**

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**InP for Electronics
and Opto-Electronics**

InP for Electronics and Opto-Electronics

- InP-based devices can operate at higher power and higher frequency than current SOA GaAs-based devices
- Technology (Bulk and epitaxial) has been demonstrated
 - devices produced, being inserted into systems
- What are current/future uses:
 - Department of Defense
 - Opto-electronics for Computing, Terahertz Communication
 - High-Speed signal processing
 - T/R Radar modules
 - NON-DOD (if any or new applications if you have examples)
 - Cellular Communications/Satellite Applications
 - Collision Avoidance Radar (Automotive)
 - GPS Radar

**POC: Ms. Laura Rea
WL/MLPO (513)255-4588 Ext. 3213**

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**InP
Key Personnel**

InP for Electronics and Opto-Electronics

InP for Electronics - Program Manager

**Ms Laura Rea
WL/MLPO Building 651
3005 P Street STE 6
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Phone #: 513- 255-4474 ext 3213**

InP for Electronics - Sr Tech Advisor

**Dr William Mitchell
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**Nonlinear
Optical Materials**

Nonlinear Optical Materials

- **Materials for New Laser Sources** (optical wavelength conversion) and for **Electro-Optic Devices** (optical wave guides and spatial light modulators)

- **APPLICATIONS**

- Department of Defense**

- Electro-Optic Countermeasures
 - LIDAR
 - Laser Radar
 - Optical Signal Processing (eg, target recognition)
 - Optical Interconnects for Electronic Pkgs

- NON-DOD (if any or new applications if you have examples)**

- LIDAR
 - Medical Lasers
 - Switching Networks for Communications
 - Optical Interconnects for Electronic Pkgs
 - Scientific Instruments

**POC: Dr. Ken Hopkins
WL/MLPO (513)255-4588 Ext. 3219**

**Aerospace Materials and Processes
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Key Personnel

Nonlinear Optical Materials

Overall Program

**Dr Ken Hopkins
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Inhouse Characterization and Materials Growth

**Dr David Zelmon
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Phone #: 513- 255-4474 (x3231)**

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**Superconducting
Materials & Processes**

High Temperature Superconducting Materials & Processes

- **A NEW MATERIAL - THIN FILMS HAVE DEMONSTRATED
POTENTIAL FOR SIGNIFICANT PERFORMANCE ENHANCEMENT**
- **APPLICATIONS**
 - **Military**
 - Rf circuits for electronic warfare
 - Signal processing
 - IR detectors
 - **Commercial**
 - Biomagnetic imaging
 - Nondestructive evaluation
 - Passive components for communication satellites
 - Signal processing
 - Multiplex modules

**POC: Mr. Tim Peterson
WL/MLPO (513)255-4588 Ext. 3235**

**Aerospace Materials and Processes
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Key Personnel

High Temperature Superconducting Materials & Processes

Characterization and Applications

**Mr. Tim Peterson
WL/MLPO Building 651
3005 P Street STE 6
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Phone #: 513-255-4474 (x3235)**

Thin Film Growth

**Dr. Rand Biggers
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**Innovative Optical
Materials**

Innovative Optical Materials

Development of Novel Materials for Optical Applications

Biomolecular materials for NLO films
Liquid crystal siloxane polymers
Fullerene-based optical limiting solutions
Photochromic films for laser dosimetry

Develop molecular materials that are easily tailorable for specific optical applications - low optical thresholds, high speed response, transparent

Current/Future Uses:

DoD
Laser Protective Visors
Electro-optic Sensor Protection

NON-DoD
Electro-Optical Devices
Optical Computing
Laser Dosimeter Badge

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Key Personnel

Biotechnology for Optical Materials

Dr W. Wade Adams
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3005 P Street STE 1
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Phone #: (513) 255-2110 extension 3171

Dr Robert Crane
WL/MLPJ Building 651
3005 P Street STE 1
Wright-Patterson AFB, OH 45433-7702
Phone #: (513) 255-2110 extension 3174

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**New Optical
Filters**

New Optical Filters - Rugates

- **TECHNOLOGICAL READINESS FOR TRANSITION:**
 - TEN YEARS OF DOD SPONSORED R&D PROGRESS
 - EXAMPLE FILTERS SURPASSING CURRENT SOA TECHNOLOGY
- **UNIQUE FEATURE: UNLIMITED FREEDOM IN THE DESIGN AND MANUFACTURING OF OPTICAL FILTERS**
- **EXAMPLE CURRENT/FUTURE USES:**

DOD

- HIGH POWER LASER MIRRORS
- ELECTRO-OPTIC SENSOR PROTECTION
- TAILORED HIGH PERFORMANCE OPTICAL FILTERS

NON-DOD

- LIGHTWAVE TELECOMMUNICATION TECHNOLOGY

**POC: Mr. Walt Johnson
WL/MLPJ (513)255-2110 Ext. 3170**

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

Key Personnel

New Optical Filters - Rugates

**Mr Walter Johnson
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Phone #: 513- 255-2110 extension 3170**

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

Laser Facilities

Laser R&D and T&E Facilities

Use of lasers for materials processing is becoming more prevalent in both DoD and commercial industries. Two state-of-the-art laser test facilities provide opportunities for proof-of-concept testing.

Laser Hardened Materials Evaluation Laboratory (LHMEI)

- Nationally unique carbon dioxide laser test facility producing repeatable high quality beam profiles at powers up to 150 kW on target. Produces beams in both continuous wave and repetitively pulsed mode.

• **Current / Future Uses:**

DoD

- Laser effect on materials
- Thermal response of materials or components
- Surface treatment and coating application

Non-DoD

- Materials processing (drilling, cutting, welding)
- Heat treatment or surface treatment - strength enhancement
- Materials performance testing - simulation of application heat loads

POC: Mr. Rob Hull
WL/MLPJ (513)255-2334 Ext. 3165

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**Laser Facilities
(Cont)**

Laser R&D and T&E Facilities (con't)

One Kilowatt Laser Lab

- 1 kW carbon dioxide laser operating in either continuous wave or repetitively pulsed mode. Extremely small spot sizes and CNC table provide precision beam positioning.

• **Current / Future Uses:**

DoD

- Materials response testing
- Manufacturing technology proof-of-concept testing
- Susceptibility (damage level) testing

Non-DoD

- Materials processing (cutting, drilling, welding)
- Precision laser machining or engraving
- Surface treatment for strength enhancement

POC: Dr. Patrick Hood
WL/MLPJ (513)255-2334 Ext. 3168

POC: Mr. Charles Lovett
WL/MLPJ (513)255-2334 Ext. 3161

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Key Personnel

Laser R&D and T&E Facilities

Mid-power materials response testing

Mr Rob Hull
Phone No. (513)255-2334, extension 3165

Laser device technology and materials response

Dr Patrick Hood
Phone No. (513)255-2334, extension 3168

Laser performance and experimental set-up

Mr Charles Lovett
Phone No. (513)255-2334, extension 3161

Mailing Address:

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**Aerospace Materials and Processes
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MLP Summary

SUMMARY

Where Are We:

- Defense Reinvestment - We're Still Learning
- Dual Use - We're already there - Can add Emphasis

Where to Go Next:

- Awaiting More Definitive Guidance
- Will be Seeking Guidance
 - From Industry - Our Development Partner
 - From the Scientific Community

The Coming Period Promises to be Interesting & Exciting

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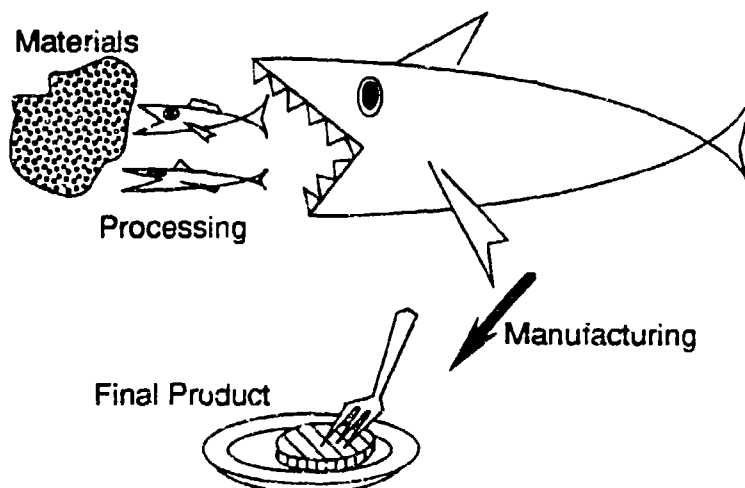
Dual Use?

Dual Use
Defense Reinvestment
Tech Transfer

What Means? - Still Learning
But - For Sure
- A Paradigm Shift Is Occurring

- Dual use is Inherent in the MLP Program
 - Materials and Processes Technologies are at the bottom of the food chain
 - Most Materials in MLP have/find Alternative Applications in US Tech Base
- Past Drivers have been Military Applications only:
 - Future investments Will Consider - Commercial Pull
 - Many Options for Inclusion of Dual Use in MLP Program

MATERIALS ARE AT THE BOTTOM OF
TECHNOLOGY FOOD CHAIN



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**Past MLP
Developments**

**Past MLP Developments
Have Found Commercial Applications**

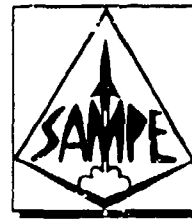
- Rare Earth Permanent Magnet Materials
- Ultra-High Purity Silicon
 - Developed for Laser Seekers and IR Detectors
 - Have found use in:
 - High Power Devices
 - VHSIC
- HgCdTe
 - Developed for Forward Looking IR Systems
 - Commonly Used in
 - Radiometers - lab & Pollution Monitoring
- GaAs Materials for Radar T/R Modules
 - Mandatory for Satellite Communication
 - Direct Broadcast TV
 - Satellite Cellular Phones

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**Future Drivers
for Dual Use**

MLP Future Drivers for Dual Use

- Will Not Abandon Our Classic AF Customers
 - AF Requirements ARE Stressing
 - Needed Capability is #1
- However
 - We Will Seek to Add the Commercial Sector to the "Customer" List
 - For Development Activities
 - Will Seek to Add Commercial Requirements / Needs
- As We Do This - We Will "Expect" Development Teams to Share the Commitment & Risk



Mr Robert L. Rapson
Integration and Operations Division

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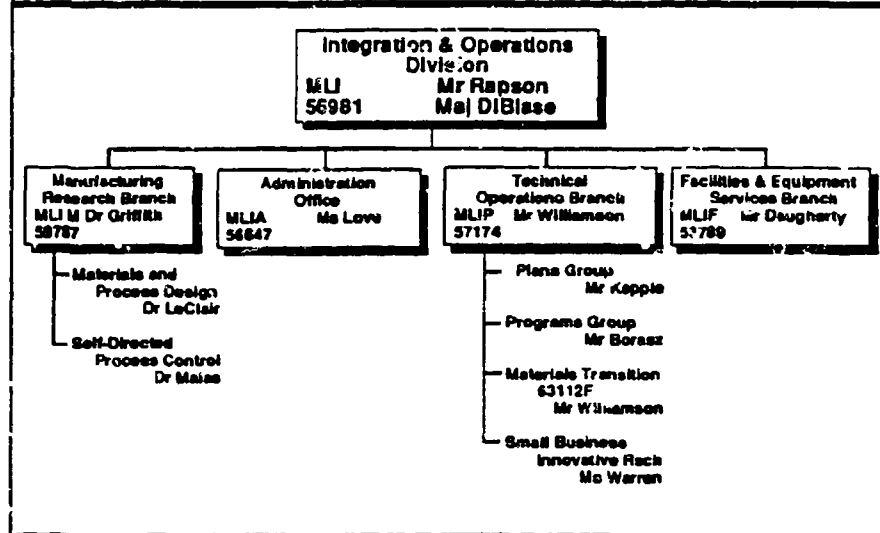
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Agenda

- **Integration and Operations Division Overview**
- **Key Personnel for Technology Transfer**
- **Topics for Technology Transfer**

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**MLI Division
Overview**



**Aerospace Materials and Processes
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Key Personnel

Mr. Bob Rapson, Chief
Integration and Operations Division
(513) 255-6981 fax 476-4831

Dr. Walt Griffiths, Chief
Manufacturing Research Branch
(513) 255-8787 fax 476-7995

Dr. Steve LeClair
Materials and Process Design
(513) 255-8787 fax 476-7995

Dr. Jim Malas
Self-Directed Process Control
(513) 255-8787 fax 476-7995

Mr. John Williamson, Chief
Technical Operations Branch
(513) 255-7174 fax 476-4831

Mr. Gary Kepple
Plans Group
(513) 255-7174 fax 476-4831

Mr. Frank Borasz
Programs Group
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Mr. John Williamson
Materials Transition (6.3)
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Ms. Sandy Warren
Small Business Innovative Rsch
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**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**Topics for Technology
Transfer**

- 1. Rapid Foundry Tooling System**
Integrated Product/Process Design System for Cast Parts
POC: Dr. Steve LeClair, WL/MLIM, (513) 255-8787
- 2. Rapid Design System**
Integrated Product/Process Design for Machined Parts
POC: Dr. Steve LeClair, WL/MLIM, (513) 255-8787
- 3. QPAL II**
Integrated Process Design and Control for Composite Parts
POC: Dr. Steve LeClair, WL/MLIM, (513) 255-8787
- 4. Innovative Forming Technologies:**
NonLinear, Open-Loop Control of Hot Deformation Processes
POC: Dr. Jim Malas, WL/MLIM, (513) 255-8787

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**Topics for Technology
Transfer (Cont)**

- 5. Deposition Processing Technologies:**
Advanced Control Software for Molecular Beam Epitaxy
POC: Oliver Patterson, WL/MLIM, (513) 255-8787
- 6. Deposition Processing Technologies:**
Self-Directed Control Software for Pulsed Laser Deposition
POC: Capt. Elizabeth Stark, WL/MLIM, (513) 255-8787
- 7. Deposition Processing Technologies:**
Self-Directed Control Software of Chemical Vapor Deposition (CVD)
POC: Capt. David Griffin, WL/MLIM, (513) 255-8787
- 8. Automated Materials Research:**
TEM Companion
POC: Dr. Al Jackson, WL/MLIM, (513) 255-8787

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**Rapid Foundry
Tooling System**

Rapid Foundry Tooling System

RFTS couples feature-based design and an associative memory to augment pattern making and process planning of mold and pattern (parting line, gates & risers, draft angle, number and location of cores, runners, etc.)

Why ready? Successful prototype implemented at Kelly AFB Foundry available for commercial use or spin-off of enabling technology. Developed and supported by commercial business (AIWARE, Inc., Cleveland, OH) and built on top of their software product called CADChem™.

What are the unique features? 1) Three dimensional associative mapping of part and casting geometry to processing problems to causes. 2) an algorithm (patent applied for) to automatically core a pattern.

What are current/future uses?

Dual Use - pattern making for sand casting, pattern making for investment casting, pattern making for rubber molding.
Non-DoD - pattern making for medical prosthesis.

**POC: DR. STEVE LeCLAIR
WL/MLJM (513) 255-8787**

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Rapid Design System

Rapid Design System

RDS couples feature-based design and a deductive-inductive memory to augment the machinist in process planning of fabrication and inspection of machined parts and enables the system to automate numerical control and coordinate measurement machine code generation.

Why Ready? Prototype implementation at the Developmental Manufacturing and Modification Facility (DMMF) at Wright-Patterson AFB and available for commercial use or spin-off of enabling technology. Developed and supported by commercial business (Technosoft, Inc., Cincinnati, OH) and built on top of their software product called CHISEL™.

What are the Unique Features? Self-improving process design system (patent pending) to augment designer/machinist in optimizing product and process (fabrication and inspection) design.

What are Current/Future Uses?

Dual Use - product/process design for machined parts, automatic fab plan, automatic inspection plan, set up configuration, and product/data exchange (STEP/PDES) standards.

**POC: DR. STEVE LeCLAIR
WL/MLJM (513) 255-8787**

**Aerospace Materials and Processes
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QPAL II

QPAL II

Qualitative Process Automation Language (QPAL) is a knowledge base methodology and supporting language for the control of dynamic, event-driven processes.

Why ready? Base technology implemented at Sacramento Air Logistics Center and at several commercial sites including Lockheed (formerly General Dynamics), and Honeywell. Original QPAL™ prototype product developed by Air Force and currently supported through (Lawrence Associates, Inc., Dayton, OH). QPAL II is being built on QPAL™ with significantly enhanced language and user interface.

What are the unique features? 1) Event-driven process development and control system (patent awarded), 2) applicable to any non-linear, sensor-based control environment, 3) supports process planning and optimization.

What are current/future uses?

Dual Use - product/process design for composite curing, product/process design for any non-linear, sensor-based materials or product manufacturing process, broadly applicable to overall manufacturing process scheduling and control, applicable to other event-driven scenarios, not limited to manufacturing (e.g., routing, scheduling, order/inventory tracking and control, etc.).

POC: DR. STEVE LeCLAIR

WL/MLIM (513) 255-8787

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**Self Directed Control
of Deformation Processes**

Non-Linear, Open-Loop Control of Hot Deformation Processes
(Forging, Extrusion and Rolling) - Optimal Control System Design For Producing Net-Shape Components having Controlled Microstructures and Properties.

Why Ready?

- 1) Material Behavior and Process Models involved have been experimentally verified.
- 2) With only partial implementation, some metal working industries are reporting 15 - 25% increase in productivity (e.g. Youngstown Air Extruder's Consortium).
- 3) Planned and current process control technologies could impact a wide range of metal working processes.

What are the Unique Features?

- 1) Practical process engineering tool, 2) Control system design includes robustness and performance analyses, 3) Especially applicable to complex geometric shapes and difficult-to-process materials.

What are Current/Future Uses?

Dual Use - Design of optimal control systems for deformation processes including forging, rolling, and extrusion; advanced control technology; hierarchical control strategies; sensor fusion; processing of difficult-to-process materials (intermetallics); improved processing efficiencies.

POC: DR. JIM MALAS

WL/MLIM (513) 255-8787

**Aerospace Materials and Processes
Technology Reinvestment Workshop**

**Advanced Control
Software for MBE**

Advanced Control Software for Molecular Beam Epitaxy - Improved control of thin-film composition and thickness is obtained via real-time control using advanced sensor technology and model based control of the flux.

Why Ready? Successful prototype has been tested at the Air Force Materials Directorate. Patent application has been submitted.

What are the unique features? 1) Automated process identification. 2) Shutter opening flux transient compensation. 3) Adaptive gain/bandwidth control. 4) An artificial neural network is used for quick reduction of ellipsometry data. 5) The control system is easy to understand and adjust.

What are current/future uses?

Dual Use - Control of processes for deposition of electronic materials; improved electronic devices; compositional control; thickness control; advanced sensors; sensor fusion.

**POC: OLIVER PATTERSON
WL/MLIM (513) 255-8787**

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**Self-Directed Control
Software for PLD**

Self-Directed Control Software for Pulsed Laser Deposition (PLD)
Produces high quality solid lubricants and hard coatings through real time control of system parameters.

Why Ready?

Control and monitoring of composition and microstructure during thin-film growth with PLD has been demonstrated.

What are the unique features?

- 1) High energy process gives good substrate adhesion.
- 2) Stoichiometric growth of material without thermal damage to substrate (20 - 200° C).
- 3) Environmentally safe.
- 4) Easy to operate.

What are current/future uses?

Dual Use - Control of processes for deposition of solid lubricants; high temperature precision mold adherence reduction (1040SS Teflon molds for laser surgery); machine tool industry hard coatings (mill and tool ends); gas turbine clearance control; vacuum lubricant applications (disk drives, robotics).

**POC: CAPT. ELIZABETH STARK
WL/MLIM (513) 255-8787**

**Aerospace Materials and Processes
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**Self-Directed Control
of CVD**

Self-Directed Control of Chemical Vapor Deposition - Produce high quality fiber coatings with desired interface properties for fabrication of ceramic matrix composites.

Why Ready? Planned and current process control technologies could impact a wide range of commercial coating applications.

What are the unique features? 1) Control of deposition morphology allows desired fiber properties 2) High purity, low internal stress coatings.

What are Current/Future Uses?

Dual Use - Control of deposition processes for coating ceramic fibers; ceramic matrix composites; deposition of thermal barrier coatings.

This is a New Project for FY93

**POC: CAPT. DAVID GRIFFIN
WL/MLIM (513) 255-8787**

**Aerospace Materials and Processes
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**Automated
Materials Research:
TEM Companion**

Automated Materials Research: TEM Companion

A memory-driven automated system for analyzing materials using electron microscopy and the crystal structure of the material; the system is coupled to an electron diffraction pattern simulator and uses a crystallography knowledge base.

Why Ready?

Prototype developed by Materials Directorate for use in-house and as a product via SBIR Phase II Contract with Thin/Alcng Software, Inc.

What are the unique features?

1) Integration of expert system and neural nets; 2) Extensive crystallographic capabilities; 3) Highly efficient material characterization; 4) Sophisticated analyses with fewer experts; 5) Extend life of expensive equipment; 6) Training aid for universities and industry.

What are current/future uses?

Dual Use - Characterization of new materials, extension of this technology to other sophisticated testing equipment, training and simulation.

**POC: DR. AL JACKSON
WL/MLIM (513) 255-8787**