



**DEFENSE MATERIALS  
SCIENCE & TECHNOLOGY:  
OVERVIEW & OPPORTUNITIES**

**ELECTRON BEAM CURING OF COMPOSITES WORKSHOP  
OAK RIDGE, TENNESSEE  
SEPTEMBER 10, 1997**

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**DEFENSE INVESTMENT IN S&T**



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**IN SUPPORT OF NATIONAL GOALS THE DoD  
INVESTS IN S&T TO**

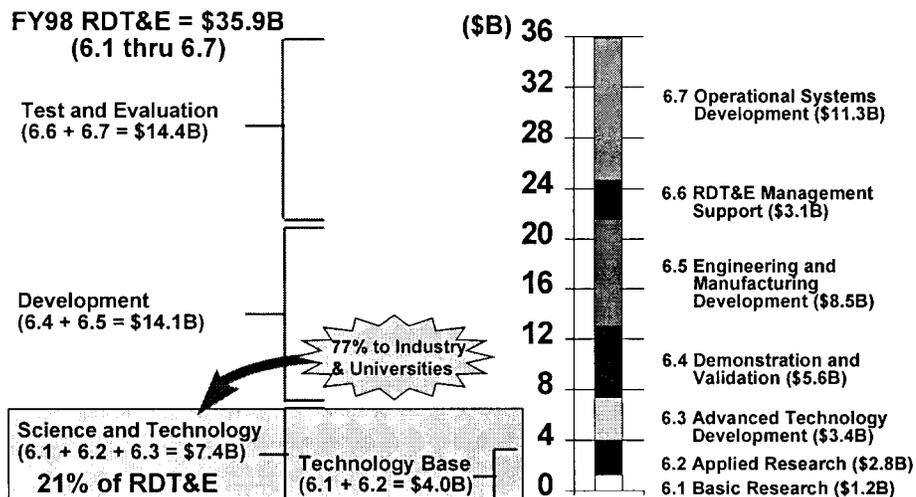
- MAINTAIN OVERWHELMING QUALITATIVE MILITARY ADVANTAGE ON THE BATTLEFIELD BASED ON THREATS AND PRIORITIES
- PROVIDE A BASIS FOR READINESS, ACQUISITION, & MODERNIZATION
- INTEGRATE REVOLUTIONARY AND EVOLUTIONARY COMPONENTS AND TECHNOLOGIES INTO LEADING EDGE SYSTEMS
- PROVIDE OPTIONS TO FUTURE WARFIGHTERS AND PLANNERS
- ENSURE AGAINST TECHNOLOGICAL SURPRISE
- INVEST IN MILITARILY CRITICAL COMPETENCIES/ CAPABILITIES

# CHANGING S&T PRIORITIES



- **NEW THREAT TECHNOLOGIES**
  - DEMINING AND EXPLOSIVES COUNTERMEASURES
  - COUNTER TERROR AND LAW ENFORCEMENT
  - PROTECTION OF FORCE AND CRITICAL INFRASTRUCTURE
  - BIOLOGICAL AGENT DETECTION AND COUNTERMEASURES
  - COUNTER PROLIFERATION
  - NON-LETHAL WEAPONS
  - OPERATIONS IN URBAN AREAS
  - SENSORS, SURVEILLANCE AND COMMUNICATIONS
- **EMPHASIS ON INFORMATION TECHNOLOGIES**
- **AFFORDABILITY, COMMERCIAL TECHNOLOGIES, AND DUAL-USE**
- **LEVERAGE MORE RESOURCES FOR LONG TERM RESEARCH**
  - E.G., GOVERNMENT-INDUSTRY CO-SPONSORSHIP OF UNIVERSITY RESEARCH

## Research, Development, Test and Evaluation (RDT&E)



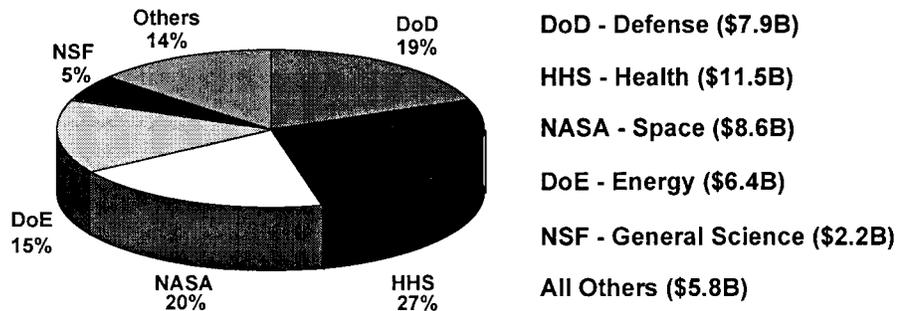
## RESOURCE BACKDROP



### IN REAL BUYING POWER SINCE END OF COLD WAR (FY89)

- DOD TOTAL OBLIGATIONAL AUTHORITY DOWN OVER 30%
- FORCE STRUCTURE CUT BY 1/3
- PROCUREMENT CUT OVER 1/2
- DEFENSE INDUSTRY IR&D DOWN 50% (KEYED TO DEFENSE PROCUREMENTS)
- OVERALL DEFENSE S&T LOWEST SINCE FY86

### 1995 Total Federal Science and Technology by Activity (6.1 + 6.2 + 6.3 Funding)



**1995 Total Federal S&T: \$42.6B**

Source: Federal Funds for R&D NSF Report #95-334 (except: DoD)

## DoD S&T IS MORE CRITICAL THAN EVER



- DEFENSE MODERNIZATION ACCOUNTS DOWN 65% SINCE FY86
- DEFENSE INDUSTRY INDEPENDENT R&D DOWN 52% SINCE FY89
- INDUSTRY R&D TYPICALLY HAS LESS THAN 3-YEAR HORIZON
- DEFENSE TECHNOLOGY BASE LOWEST SINCE FY80 (18 YEARS)
- DEFENSE S&T LOWEST SINCE FY86 (12 YEARS)
- DOD S&T PROGRAM IS BETTER PLANNED, MORE FOCUSED

## S&T CRITICAL TO 21ST CENTURY READINESS



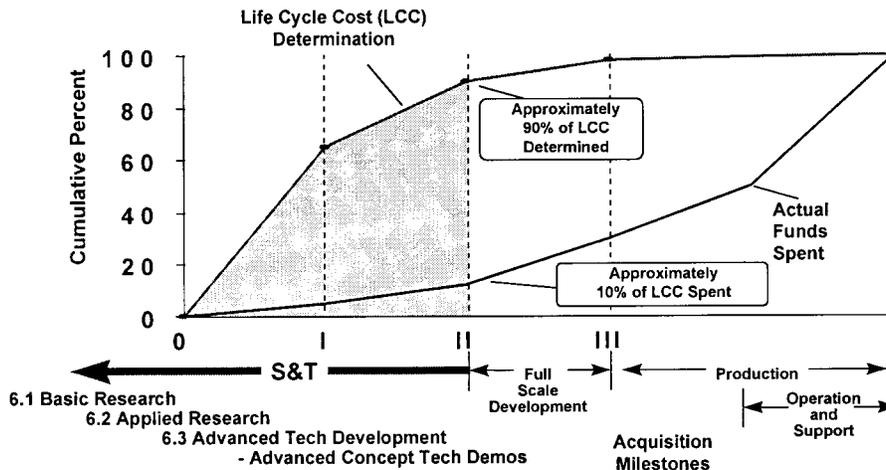
- **JOINT VISION 2010 (JV2010) FORCE DOMINANCE** DEPENDS ON ADVANCED TECHNOLOGY
- SWIFT, DECISIVE VICTORY WITH **MINIMAL** CASUALTIES BY A **SMALLER FORCE** REQUIRES **MORE** TECHNOLOGY ADVANTAGE...NOT LESS
- 21ST CENTURY **UNCERTAINTY** REQUIRES **MORE** OPTIONS, AGILITY AND **RAPID** INSERTION
- HEDGE AGAINST **TECHNOLOGY SURPRISE** AND FOES' RAPID APPLICATION OF ADVANCED TECHNOLOGY
- FEWER NEW SYSTEMS DEVELOPED/PRODUCED, **INCREASED UPGRADES** REQUIRES PROLIFIC S&T AND RAPID TECHNOLOGY INSERTION

*S&T Shapes the Future & Hedges Uncertainty*

# LIFE CYCLE COST LEVERAGE DEFENSE SYSTEMS



## DEFENSE COMMUNITY IS FOCUSED ON COST REDUCTION EFFORTS IN ACQUISITION CYCLE

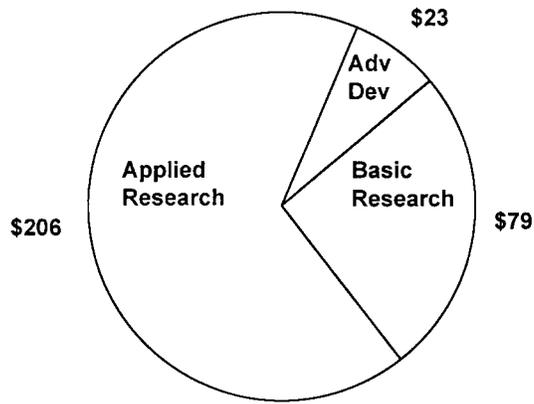


## MATERIALS SCIENCE & TECHNOLOGY



- **BASIC RESEARCH: \$71M in FY97**
  - INCREASE KNOWLEDGE & UNDERSTANDING
- **APPLIED RESEARCH: \$260M in FY97**
  - TRANSLATE KNOWLEDGE INTO SOLUTIONS
  - NONSYSTEM SPECIFIC DEVELOPMENT
- **ADVANCED TECHNOLOGY DEVELOPMENT: \$28M IN FY97**
  - DEVELOPMENT & INTEGRATION OF HARDWARE FOR FIELD EXPERIMENTS
  - PROVE TECHNOLOGICAL FEASIBILITY

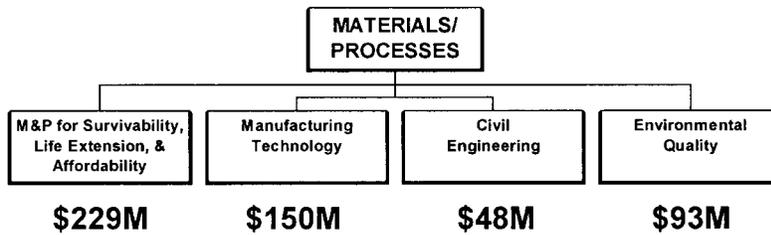
# FY 1998 MATERIALS S&T BUDGET



Dollars in Millions

GRAND TOTAL = \$308 Million

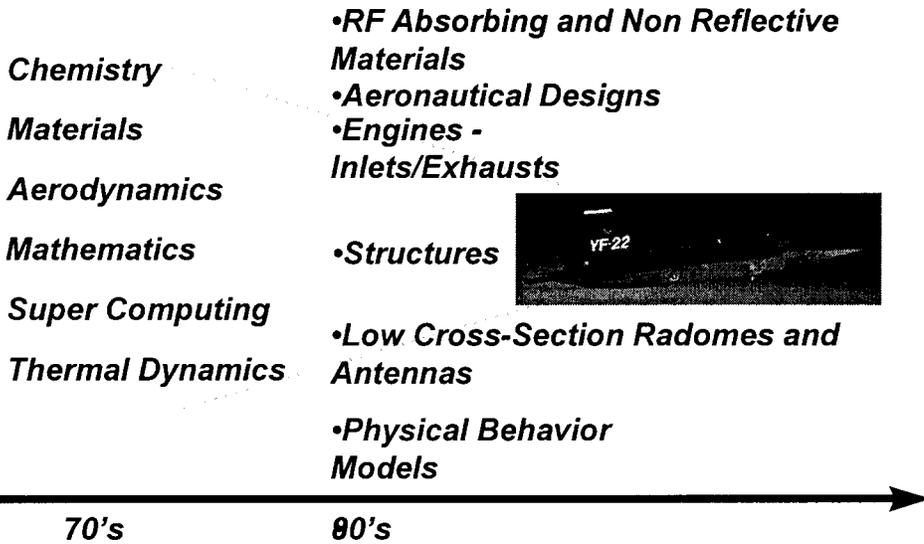
# MATERIALS/PROCESSES



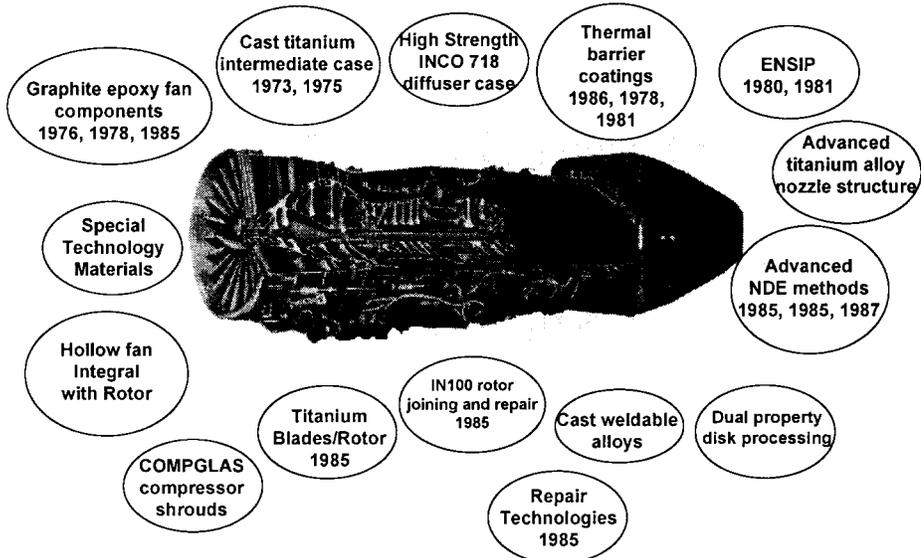
TOTAL M/P: \$520M

FY98 FUNDING

## Technologies Enable... (e.g., Stealth)



## The F119 Engine for the F-22 is the Product of Many Technology Efforts



# COMPOSITE ARMORED VEHICLE



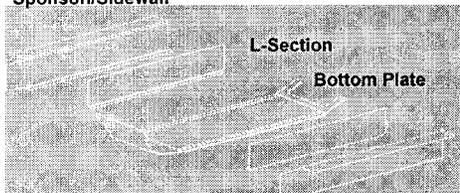
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## COMPOSITES ARMORED VEHICLE (CAV)



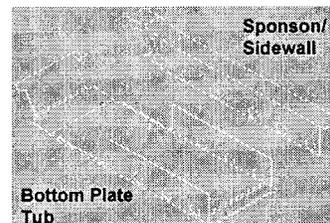
### SDR

Sponson/Sidewall



**Weight:** 4692 lbs Goal 4035  
**Cost:** \$109K  
**No. of Pieces:** 5  
**Sigma:** 3.2

### PDR



**Weight:** 3848 lbs. Goal 4035  
**Cost:** \$60K  
**No. of Pieces:** 3  
**Sigma:** 4.2

- Drawing Changes
  - Prior to CAV, UDLP averaged 2.3 changes per drawing
  - CAV IPTs using 3-D solid modeling had 0.56 changes per drawing



# Composite Armored Vehicle

## Advanced Technology Demonstration

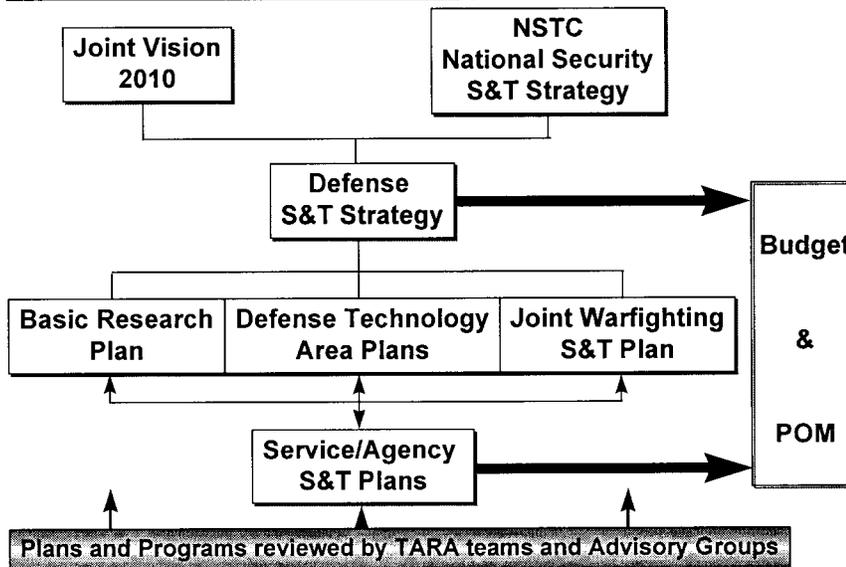


- **Combat vehicle demonstrator featuring weight saving composite materials and ceramics for hull and armor**
  - 35% structure/armor weight savings
  - Embedded radar/thermal signature management
  - Damage tolerant, field repairable
- **Transition Opportunities:**
  - Crusader\*            - C2V
  - MLRS                - AAV
  - FSCS

\* Will save one ton in turret alone

# S&T Strategic Planning - How Parts Relate

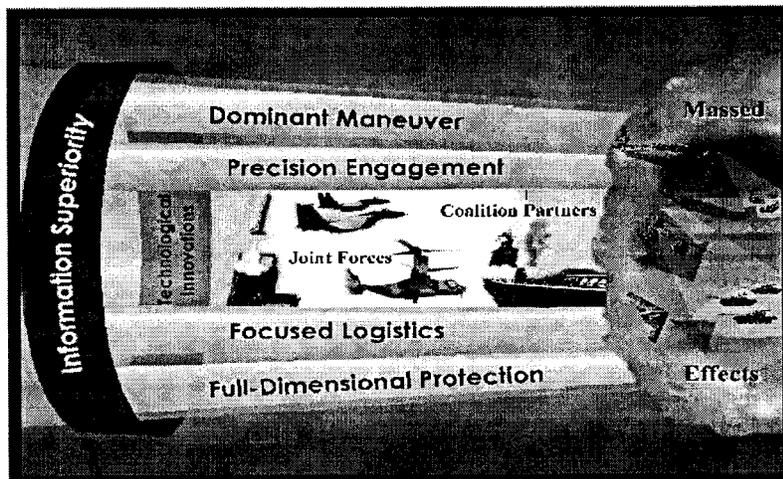
(plans available on Internet at [www.dtic.mil/dstp](http://www.dtic.mil/dstp))



# Joint Vision 2010 - The Future *Emerging Operational Concepts*



The Lens of Information Superiority Integrates and Amplifies Four Operational Concepts



## JOINT WARFIGHTING CAPABILITY OBJECTIVES

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- INFORMATION SUPERIORITY
- PRECISION FORCE
- COMBAT IDENTIFICATION
- JOINT THEATER MISSILE DEFENSE
- MILITARY OPERATIONS IN URBAN TERRAIN
- JOINT READINESS AND LOGISTICS
- JOINT COUNTERMINE
- ELECTRONIC COMBAT
- CHEMICAL BIOLOGICAL WARFARE DEFENSE & PROTECTION
- COUNTER WEAPONS OF MASS DESTRUCTION
- PROPOSED FOR FISCAL YEAR 1998
  - DOMINANT RAPID FORCE PROTECTION
  - COMBATING TERRORISM
  - STRATEGIC SYSTEMS SUSTAINMENT

## MATERIALS TECHNOLOGY PRIORITIES

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- PROTECTION OF THE INDIVIDUAL COMBATANT
  - LASER EYE PROTECTION
  - PERSONNEL ARMOR
- SURVIVABILITY OF MILITARY EQUIPMENT
  - VEHICULAR ARMOR
  - LOW OBSERVABILITY
- IMPROVED MILITARY EQUIPMENT
  - ADVANCED GAS TURBINE ENGINES
  - HIGH TEMPERATURE SEMICONDUCTORS
- IMPROVED MILITARY COMBAT CAPABILITY
  - HIGH TEMPERATURE PAVEMENTS
  - SENSOR MATERIALS

## MATERIALS TECHNOLOGY PRIORITIES (Cont'd)



- **PRESERVATION OF AGING ASSETS**
  - SUSTAINMENT PROGRAMS
  - NONDESTRUCTIVE INSPECTION/EVALUATION
  - CORROSION CONTROL
  - FATIGUE MANAGEMENT
- **ACQUISITION AFFORDABILITY OF NEW EQUIPMENT**
  - ADVANCED COMPOSITE-FABRICATION PROCESSES
  - ADVANCED METAL-FABRICATION PROCESSES
- **ENVIRONMENTAL QUALITY AND IMPACT**
  - METAL CLEANING PROCESSES
  - PAINTS AND COATINGS
  - NON-TOXIC, ENVIRONMENTALLY BEGIGN ELECTRONIC MATERIALS & PROCESSES

## CHALLENGES FOR MATERIALS S&T



- **BUDGETS WILL BE STABLE AT BEST**
  - SCIENCE & TECHNOLOGY AT RISK FOR BILL PAYING
  - RESEARCH & DEVELOPMENT MORE RISK AVERSE
- **FEW MAJOR NEW SYSTEMS FOR A DECADE (GENERATION)**
  - F/A-18E/F
  - F-22
  - RAH-66 COMANCHE
  - CRUSADER
  - LPD-17
- **INFORMATION TECHNOLOGIES FAVORED OVER MATERIEL TECHNOLOGIES**
  - INFORMATION EXPLOITATION HAS GREAT GROWTH POTENTIAL
  - MATERIEL VIEWED AS MATURE AND EVOLUTIONARY
- **NUMBER OF SYSTEMS AREAS REQUIRING SUPPORT INCREASING**
  - TOUGH CHOICES IN PRIORITIES MUST BE MADE
  - NEAR, MID, & FAR TERM NEEDS MUST BE BALANCED

## OPPORTUNITIES FOR MATERIALS S&T



- **SUSTAINMENT PROGRAMS**
  - LAUNCH AND REENTRY SYSTEMS
  - SHIP/AIRCRAFT STRUCTURAL LIFE EXTENSION PROGRAMS
- **PLANNED SYSTEM UPGRADES**
  - F-15 AND F-18 EMPENNAGE
  - M1, M2/M3
- **ADVANCED CONCEPT TECHNOLOGY DEMONSTRATORS**
  - COMPOSITE ARMORED VEHICLE
  - UNINHABITED AIR VEHICLES
- **ADVANCED TECHNOLOGY DEMONSTRATORS**
  - WATERFRONT TEST BED
  - GEN II SOLDIER
- **UNINHABITED VEHICLES**
  - AIR AND UNDERWATER
  - COMBAT VEHICLES

## OPPORTUNITIES (Cont'd)



- **NEW SYSTEMS AND NEW BLOCKS OR FLIGHTS**
  - JOINT STRIKE FIGHTER
  - SURFACE COMBATANT - 21
  - NEXT GENERATION ATTACK SUBMARINE
  - DDG-51
  - V-22
  - F-22, F119 ENGINE
  - STANDARD MISSILE
  - CVN-77, CVX-78
  - SATELLITES
  - COMMON SUPPORT AIRCRAFT
  - UNINHABITED COMBAT AIR VEHICLES
- **MAJOR INITIATIVES**
  - INTEGRATED HIGH PERFORMANCE TURBINE ENGINE TECHNOLOGY
  - INTEGRATED HIGH POWER ROCKET PROPULSION TECHNOLOGY
  - ARSENAL SHIP

## OPPORTUNITIES (Cont'd)



- 
- NEW ELECTRONIC SYSTEMS AND SENSORS
    - ACOUSTIC TRANSDUCER MATERIALS
    - MAGNETIC SENSOR & STORAGE MATERIALS
    - FUEL CELLS AND POWER CELLS
    - ELECTRIC DRIVE AND POWER CONDITIONING
    - THERMAL MANAGEMENT
    - PACKAGING AND ENCLOSURES
  
  - LIFE EXTENSION, MAINTAINABILITY, OPERATIONAL COST REDUCTION
    - ADVANCED COATINGS
      - WEAR
      - CORROSION & OXIDATION RESISTANT
      - ANTI-FOULING
    - MEMBRANES
      - FUEL CELL
      - WATER PURIFICATION
      - WASTE CONTAINMENT/CONSOLIDATION

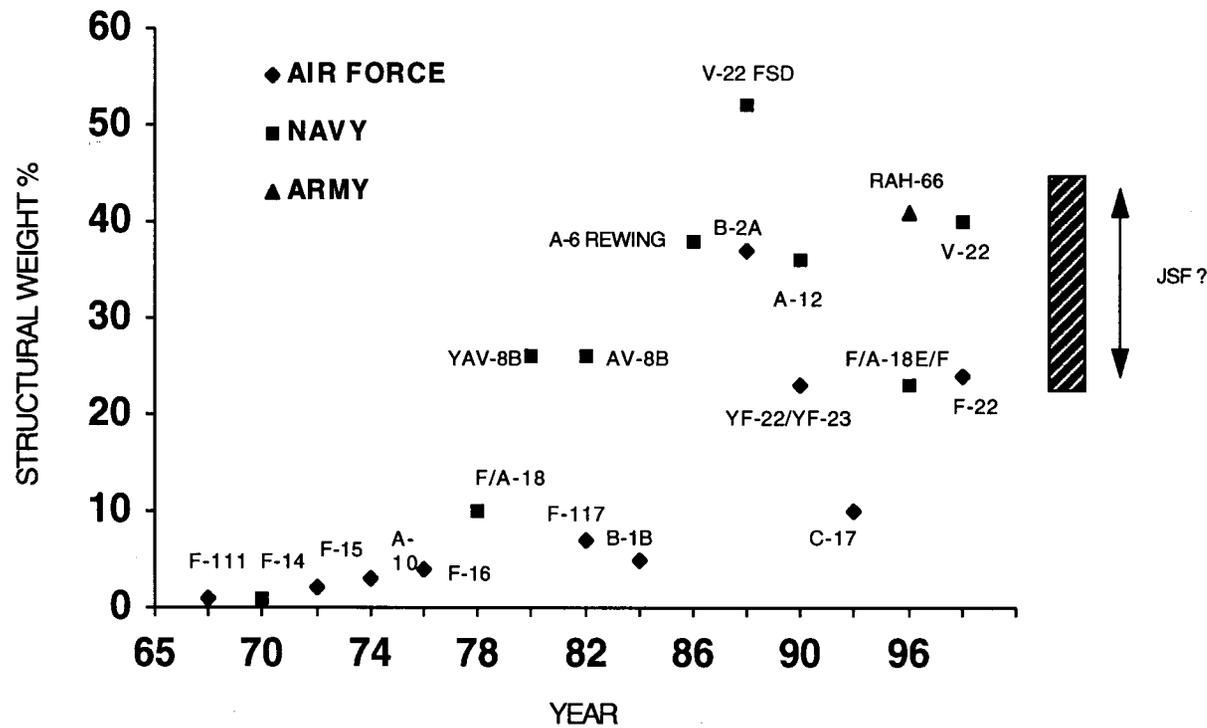
## COMPOSITE CONTENT ON MILITARY AIRCRAFT



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- SEE FOLLOWING CHART



# SUMMARY OF COMPOSITE CONTENT ON MILITARY AIRCRAFT



## CURRENT STATUS OF POLYMER- MATRIX COMPOSITES

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- SEE FOLLOWING CHART

## OPPORTUNITIES FOR EB PROCESSING

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### TECHNOLOGICAL

- TOOLING
- LIMITED LIFE PROTOTYPES
- RESIN TRANSFER MOLDED COMPONENTS
- COMPLEX BONDED STRUCTURES
  - PROOF OF CONCEPT DEMONSTRATORS
  - METAL-RESIN-FIBER HYBRIDS
- AUTOMOTIVE & MARINE STRUCTURES
- UNINHABITED VEHICLES
- TACTICAL MISSILES AND MUNITIONS
- AVIONICS & ELECTRONICS ENCLOSURES

### PROGRAMMATIC

- DUAL-USE APPLICATIONS PROGRAM
- MANUFACTURING TECHNOLOGY
- EMPHASIS ON INTEGRATED APPROACHES

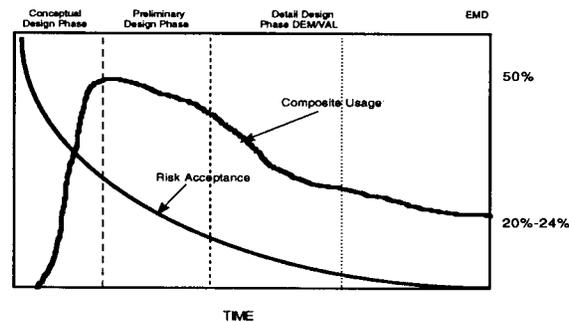


## CURRENT STATUS OF POLYMER MATRIX COMPOSITES



- PMC'S ARE AN ACCEPTED ENGINEERING MATERIAL THAT OFFER SIGNIFICANT PERFORMANCE BENEFITS
- PREVIOUS PMC TECHNOLOGY DEVELOPMENT PROGRAMS DID NOT ADEQUATELY ADDRESS AFFORDABILITY
  - PERFORMANCE DRIVEN
- COMPOSITES CAN REPRESENT AN UNACCEPTABLE LEVEL OF COST AND SCHEDULE RISK TO ACQUISITION PROGRAMS
  - ONLY UTILIZED WHERE AN ALTERNATIVE TO ACHIEVE DESIRED PERFORMANCE DOES NOT EXIST

TYPICAL PROGRAM : COMPOSITE CONTENT VS PROGRAM MATURITY



## SOME USEFUL SOURCES OF INFORMATION



- DEFENSE LINK
  - <http://www.dtic.dla.mil/defenselink/index.html>
- SERVICE/AGENCY PAGES
  - ARMY: <http://www.arl.army.mil/>
  - NAVY: <http://www.onr.navy.mil/> and <http://www.onr.navy.mil/links.htm>
  - AIR FORCE: <http://picard.ml.wpafb.af.mil/>
  - DARPA: <http://info.arpa.mil/index.html>
  - BMDO: <http://www.acq.osd.mil/bmdo/bmdolink/html/bmdolink.html>
  - DSWA: <http://www.dswa.mil/>
- LINK TO MOST DoD LABORATORIES "LABLINK"
  - <http://www.dtic.dla.mil/lablink/>
- DEFENSE RESEARCH & ENGINEERING
  - <http://www.dtic.mil/ddre/>

## ADDITIONAL SOURCES OF INFORMATION



- DEFENSE SCIENCE AND TECHNOLOGY PLAN
  - <http://www.dtic.mil/dstp/> (REGISTRATION)
  - <http://www.dtic.mil/dstp/DSTP/index.html> (DIRECT)
- VISION 21: PLAN FOR DoD LABORATORIES & TEST CENTERS
  - <http://www.dtic.mil:80/labman/vision21/index.html>
- DUAL-USE APPLICATIONS PROGRAM
  - <http://www.acq.osd.mil/es/du/>
- ADVANCED COMPOSITES INSERTION REPORT (TO CONGRESS)
  - <http://www.dtic.mil/ddre/index.html> (under "S&T Programs")
  - <http://www.dtic.mil/ddre/docs/adcom.pdf> (the report itself)
- THE FEDERAL RESEARCH AND DEVELOPMENT PROGRAM IN MATERIALS SCIENCE AND TECHNOLOGY
  - <http://www.msel.nist.gov/fmrd95/>