Materials & Manufacturing Processes: Technologies that Ensure Capability

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Chair, M&MP COI

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M&M COI Portfolio Description

Purpose

Materials and Manufacturing Processes: The purpose of the Materials and Manufacturing Processes COI is to provide National leadership in developing technology-based options for advanced materials and processes for the Department of Defense. The COI delivers technology products as well as the scientific and engineering expertise needed to maintain and enhance U.S. Defense capability.

*Materials and Manufacturing Processes is a Technology Focused COI and is inherently broad.*

Activities are part of every DoD laboratory and impact every system and platform, and span full technology and manufacturing readiness spectrums.

*Materials and Manufacturing Processes COI is a uniquely long-standing community of DoD scientists and engineers operating in an effective framework*

- Assess the technical health of DoD Materials & Manufacturing Processes investment areas
- Identify emerging technology opportunities, trends and associated risks
- Engage in multi-agency coordination and collaboration
- Optimize results of engagements with industry and international partners
- Strategize and measure progress
Materials S&E & Manufacturing

in the context of S&E

Applied Mathematics
Solid State Physics
Theoretical Physics
Physics
Biology
Chemistry
Electrochemistry
Mechanics
Computational Chemistry
Surface Sciences

Materials Science & Engineering

Civil Engineering
NDE, Quality Control
Manufacturing Automation
Aeronautical Engineering
Weapons Design
Systems Engineering
Naval Architecture
Mechanical Engineering

Power Systems EE

Electrical Engineering

Sensor Design

Biomedical Engineering

NDE, Maintenance Support

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M&MP COI
in the context of Reliance COIs

Materials & Manufacturing Processes

- Civil Engineering
- NDE, Quality Control
- Manufacturing Automation
- Aeronautical Engineering
- Weapons Design
- Systems Engineering
- Mechanical Engineering
- Naval Architecture
- Power Systems EE
- Electrical Engineering
- Electronic Hardware EE
- Sensor Design
- Biomedical Engineering
- NDE, Maintenance Support

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M&MP COI
in the context of Reliance COIs

Materials & Manufacturing Processes

- Energy & Power Technologies
- Sensors
- Advanced Electronics
- Engineered Resilient Systems
- C4I
- Human Systems
- Electronic Warfare
- Biomedical (ASBREM)
- Counter IED
- Counter WMD
- Ground & Sea Platforms
- Cyber Security
- Autonomy
- Air Platforms
- Weapons Technologies
- Space

Designations based on expertise of practitioners

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The Center of the Universe

**Microstructure**

*Ti α–β microstructure*

32 layer PC/PVDF-HFP film

*lithium dendrite*

... for some
Mechanical Properties

Common Engineering Concepts?

EBSD image

MIL-HBK-5H

Table 5.4.1.0(b). Design Mechanical and Physical Properties of Ti-6Al-4V Sheet, Strip, and Plate

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Adapted from D. Furrer, April 2013

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Processing to Design to Manufacturing in ICME

Efficient use of models, experiments, and experience reduces design challenges and enables performance probability distribution predictions and reliable confidence levels.

AIM Materials Development
- Optimized between computation and testing
- Utilizes focused testing
- Uncertainty is managed
- Models linked across time and length scales
- Rapid development and lower cost

iSIGHT: Integrated design tool enables virtual manufacturing and property distribution prediction.

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Full AIM Tool Demonstration at the Component Level

Allowing concurrent optimization of processing/microstructure and disk geometry enabled
~ 20% Part Weight Reduction &
~19% Burst Speed Increase.

Integrated tool & models reduced development and test cycle by greater than 50%
• demonstrated improved design capability (5% in speed)
• identified and tested process outside of experience base
• eliminated subscale experimentation
• mapped & integrated material property spatial variation into structural performance
• provided insight into material impact (failure location)
• readily integrated and responded to evolving model capability
Historical Perspective

Computational Tools for Better Implementation of Materials Research Products

1988
COTA: Advanced Materials by Design

1989
DOE: Advanced Strategic Computing Initiative

1995
NRC: Materials Science & Engineering for the 1990s

The Problem

2004
ONR-D3DDS

2001
AFOSR-MEANS

2001
DARPA-AIM

2008
NRC-ICME

2009
DOE-CMS&C

2010
NSTC-AMP

2011
NSTC-MGI

2012
NRC-Lightweighting

2013
NSTC-AMP

2013
NSTC-NNMI

Distribution A. Approved for public release: distribution unlimited. Adapted from T. Pollock, July 2011
Integrated Computational Materials Engineering


ICME: Integrated Computational Materials Engineering (ICME) is the integration of materials information, captured in computational tools, with engineering product performance analysis and manufacturing-process simulation.

- ICME is an emerging discipline, in its infancy
- ICME can provide a significant positive return on investment; 7:1 to 10:1
- Successful model integration involves distilling information at each scale
- Experiments are key to the success of ICME
- Achieving the full potential of ICME requires sustained investment
- ICME requires a cultural shift

Emphasis on “I” and “E”

Development of ICME requires cross-functional teams focused on a common goal or “foundational engineering problem”
Within the Community

• **Spring Planning Meetings**
  – Held annually and continuously since 2000
  – Forum for peer-peer networking, personnel development, resource sharing, coordination and collaboration
  – Next meeting June 28-29, 2016
  – This year’s emphasis
    – TTCP & International liaison, JDMTP & SERDP engagement, DoD Innovative Manufacturing Institutes

• **Joint Program Plan (since 2000)**
  – Living document
  – Mission goals and objectives
  – COI structure and taxonomies
  – Portfolio assessments
  – Points of contact

• **Annual Persh Workshop (1st in 2008)**, typically 80-100 participants
  – Next workshop is Winter/Spring 2017: *Interfaces of Biology and Materials*
Beyond the DoD Community

- Federal Interagency Materials Representatives Meeting (FiMAR)
- Federal Interagency Representatives Meetings for VAATE, Ceramics and Chemistry (long standing)
- Structures & Materials Intelligence Seminar

National Innovation Initiatives
- National Nanotechnology Initiative
- Materials Genome Initiative
- Critical and Strategic Mineral Supply Chain Subcommittee
- National Network of Manufacturing Institutes

The National Research Council
- Sponsored studies and workshops with the National Materials and Manufacturing Board and the standing committee on materials for defense, the DMMI

The Technical Cooperation Program (TTCP) Materials Group

International Engagements
Materials/Processes for Survivability & Life Extension is comprised of all materials and processes that enable mission operations. This contains M&MP COI technical area teams for structures and protection; propulsion and extreme environments; sensors, electronics and photonics; power and energy; the individual warfighter; corrosion; and readiness.

Civil Engineering supports all aspects of technology necessary for force protection, force projection, and sustainment, including logistics planning, amphibious assault and rapid port enhancement, base and in-theater infrastructure, and force protection on the battlefield and at installations and bases with an emphasis on expedient protection systems. Projects are reported in the M&MP technical area team, Materials and Processes for Civil Engineering.

Manufacturing Technology for Affordability contains the materials, processing and fabrication techniques to significantly change the manufacturing cost curve. This includes but is not limited to processing and fabrication of electronics, composites and metals, as well as emerging capabilities developed within the advanced manufacturing enterprise. This is coordinated via the Joint Defense Manufacturing Technology Panel (JDMTP) and efforts are integrated into M&MP technical area teams' roadmaps for Materials/Processes for Survivability & Life Extension.

Environmental Quality reflects the DoD activities conducted within the framework of the DoD-DoE-EPA Strategic Environmental Research and Development Program (SERDP). This includes research and development in five program areas: energy and water; environmental restoration; munitions response; resource conservation and climate change; and weapons systems and platforms.
Technology Area Teams (TATs) Tier 2 Taxonomy

Materials/Processes for Survivability & Life Extension

1 Structures & Protection
   Platform M&MP
   Survivable Structural M&MP
   Multifunctionality

2 Propulsion & Extreme Environments
   Turbine Engines
   Missile Propulsion Systems
   Hypersonic Capabilities
   EM-Railgun/Directed Energy
   Reactive/Energetic Materials

3 Sensors, Electronics & Photonics
   Sensors
   Next-Generation Devices
   EM Transparencies
   Photonics

4 Power & Energy
   Power Generation & Energy Conversion
   Electromechanical Conversion
   Energy Storage
   Power Control & Distribution

5 Readiness
   NDE/I Prognostics
   Wear Resistance
   Hard Coatings, Fluids, Lubes
   Repair

6 Individual Warfighter
   Warfighter Protection
   Materials for Logistics
   Warfighter Enhancement
   Bio/Bio Inspired Materials

7 Civil Engineering
   Force Protection for Facilities
   Force Projection and Maneuver
   Sustainability of Critical Infrastructure

8 Corrosion
   Corrosion Mechanisms
   Surface Protection
   Corrosion Modeling
   In-situ Corrosion Detection
   Corrosion Repair

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**TAT 1 M&MP for Structures & Protection**

**Objectives**
Confident design of materials, joining technologies and integration tools for damage tolerant, survivable, structurally efficient assets

**Program Overview**
- Platform M&MP
- Survivable Structural M&MP
- Multifunctionality

**Key Technical Challenges**
- Lack of material models to enable rapid material qualification – metal, composite, ceramic, hybrid & multifunctional materials
- Material failure/fracture modeling for blast and ballistic impact
- Difficulty joining dissimilar materials – modeling and manufacturing challenges
- Limited availability of strategic raw materials
- Agile laser protection

**Operational Opportunities**
- Increased platform survivability, lethality, and mission capability
- Ability to anticipate/forecast warfighter structures and protections needs
- Adaptive response to emerging threats & needs – 50% reduction in time from idea to implementation
- Transition leading edge technology for affordable acquisition and sustainment – 50% R&D cost savings
Development Strategy of 3D-TTR Technology for Protection Applications

**MODELING , SIMULATION, DESIGN**
- Multi-scale modeling: fiber properties to ballistic performance
- 3D composite characterization
- Progressive failure modeling
- Ballistic simulation/validation

**FABRICATION TECHNOLOGY**
- MANTECH
- Scale 3D-TTR for armor sizes
- Gap control & on-loom insertion
- CAD/CAM automation
- Weaving process modeling for higher fabrication accuracy and efficiency

**ARMOR APPLICATIONS**
- Mission & Customers
- Armor for various threats:
  - GCV
  - DARPA
  - TARDEC JLTV
  - AATD helicopter

JLTV/DARPA

AATD

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Development Strategy of 3D-TTR Technology

Technological Breakthrough - successful multi-hit demo in ceramic composite armor

• Enabled by advanced material hybridization, 3D fiber architecture & TTR weaving
• Successful implementation of multi-scale material computational modeling procedure
• Co-developed with academic partner and transitioned to industry through MANTECH

65% lower cost, 20% lighter weight than existing armor solutions

Successfully demonstrated multi-hit capability against a KE threat. Winner (3/3)
Coupling International Collaborations & ARL with Navy MURI pays dividends

- Developing the fundamental (micromechanics) understanding of air/soil impulse and projectile impact on composite cellular structures with ceramic/polymer hybrid cores.
- Incorporating this fundamental understanding into constitutive to inform armor design capabilities

Micromechanics-based impact constitutive models for ceramics and hybrid cellular structures transitioned into The National Armor Design Codes (ALEGRA via Sandia National Laboratory and EPIC via SRI)

- Deshpande (UK) – Evans (UCSB) ceramic impact model
Objective
Advanced systems for increased power projection and lethality enabled by high performance materials

Program Overview
- Turbine Engines
- Missile Propulsion Systems
- Hypersonic Capabilities
- EM-Railgun/Directed Energy
- Reactive/Energetic Materials

Key Technical Challenges
- C/C and CMC affordability and scale up – automation/rapid manufacturing and repair
- Lack of Domestic SiC (2400-2700°F) fiber sources
- Cyclic oxidation and corrosion resistance at >1800°F in marine (salt-ladden) environments
- In-process quality assurance of small lots
- Better understanding of the role of bonding in high temperature materials to allow design of structure and reduced reliance on scarce materials

Operational Opportunities
- Enable increased range, fuel efficiency, and loiter time for military flight vehicles
- Increased standoff distance for warfighter
- Mitigate/Control Corrosion and CMAS attack in turbine engine systems for increase time between maintenance cycles
- Enable CPGS and hypersonic systems into arsenal
- Enable EMRG for theater defense & fleet use
- Increase warhead lethality and reduce mass with improved energetics and reactive warhead/case
ONR 6.1/ Thermal Barrier Coatings (TBC) MURI 2000-2007

- Initialized multi-dimensional, interdisciplinary physics-based mechanistic understanding of TBC durability
- Designed models and codes that was incorporated into OEM lifing code
- Identified and developed new routes to advanced materials and coatings

DVD Benefits

- Cost reductions by reduced processing time for complex-shaped parts
- Reduced doublet vane cooling air requirements with thicker TBCs in shadowed regions of airfoils
- Extended time between engine removals

DVD Approach

- Created fluid dynamic models to predict coating flow over complex structures
- Combined high pressure and coaxial gas stream to entrain and focus vapor plume to improve deposition rate, ensure more molecule collisions, and enable non line-of-sight coating of complex geometries
- Spin-off DVD technology via forming new company (DVTI) funded with 6.2 and SBIR/STTR $
Objectives
New materials and heterostructures designs for increased speed, agility and reduced power needs of sensors for computation, communication and weapons systems.

Key Technical Challenges
- FM films to enhance E-field penetration & ME coupling
- Modeling/simulation to guide the experimental methods for VCM heterostructures
- Increasing scale and reliability of fabrication
- CMOS compatibility: low temperature (Tp≤ 500 C) integration between FM and high K dielectric films
- Minimal data/results and technical demonstrations of incremental advancements

Program Overview
- Sensors
- Next Generation Devices
- EM Transparencies
- Photonics

TODAY
~2 inch device
Large & Bulky

TOMORROW
Voltage Controlled Magnetism (VCM)
Integrated Device ~3mm x 3mm

Operational Opportunities
- 30-40% improvement in SWaP Figure-of-Merit for non-reciprocal devices
- Lowers production costs by 40%; Enables low cost and rapid device calibration
- Offers frequency agility of non-reciprocal devices; Extends the effective band width by at least 15%
Artificial Multilayer Superlattice Structures to Enable Enhanced Performance Next Generation Communications Systems

Designed, developed & demonstrated a non-linear complex oxide Artificial Multilayer Superlattice Structure, i.e., optimized $[(\text{BaTiO}_3)_{0.5}/(\text{SrTiO}_3)_{0.5}]_{16}$ with N (repeat) =16, for tunable varactor elements to enable next generation low-cost widely tunable devices which simultaneously possess a high dielectric permittivity to enable miniaturization while maintaining low losses to minimize signal attenuation.

**IMPACT:** Demonstrated, for the first time, artificial multilayer BT/ST superlattices in the frequency range of 10-13 GHz (X-band). The optimized dielectric constant of 445 with low dielectric loss of 0.01 and tunibility of 35% exceeds the impedance matching device requirements while achieving low loss and high tunability required for room temperature MW tunable elements in phase array antennas & radar within the system operational frequency.

![BT/ST superlattice TEM BF image & SAD pattern from film/substrate interface](image1)

![High-Angle Angular DF-STEM image: BT/ST superlattice](image2)

![Design Space](image3)

![Dielectric constant & loss tangent](image4)

![Tunability BT/ST superlattices](image5)

TEM BF image & SAD pattern from film/substrate interface: The interface relationship of the BT/ST ML is (001)BTO/STO//(001)MgO & [100]BT/ST//[100]MgO with respect to the MgO substrate.

(US Army Research Laboratory Innovation)
**Objective**

Material and process optimization and integrated device design protocols for affordable, safe, efficient, light-weight, long-endurance, and rugged power & energy devices

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**Program Overview**

- Power Generation and Energy Conversion
- Electromechanical Conversion
- Energy Storage
- Power Control and Distribution

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**Key Technical Challenges**

- Improved cycle-life, additional organic electrolytes, and new electrode materials for high energy density (> 500 Wh/kg) battery chemistries
- Computational tools for modeling multi-material and multi-scale devices as well as electrochemical processes
- Dielectric materials with both ms and ms response times that enable high energy density (> 4 J/cc) devices
- Organic photovoltaic donor & acceptor materials that enable devices with high efficiency (15%) and air stability
- Sulfur-resistant materials for fuel cells

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**Operational Opportunities**

- Light-weight, safer, energy dense batteries for autonomous vehicles, reduced carried weight, and longer missions
- High-temperature, high energy density capacitors for directed energy and power conditioning applications
- Energy generation and storage technologies for more agile power networks for more electric aircraft/ships and FOB or infrastructure applications
- Low-cost, high efficiency solar panels to reduce FOB refueling logistics and reduce battery carried weight
- Logistic-fuel compatible fuel cells for ultra-long endurance autonomous vehicle operation and tactical power needs
Fuel Cell Powered Small Unmanned Aircraft Systems (SUAS)

Cross-Service Demo & Development of Fuel Cell Materials & Components
- History of collaborative multi-service efforts focused on fuel cell membranes, materials, components, reformers, modeling approaches
- Developed & demonstrated in-situ characterization techniques for fuel cell materials
- Demo’d additive manufacturing for rapid prototyping and testing of fuel cell stack bipolar plate technology
- Demonstrated higher temperature membranes for PEM fuel cells
- Demonstrated higher thermal cycle tolerant interconnect materials and a ruggedized stack design

Fuel Cell SUAS can provide 6-24+ hrs. flight endurance.

AFRL

ONR & NRL

Sea Robin XFC

Ion Tiger

500 W Fuel Cell Stack with Additive Manufacturing Components

DARPA, ARO, ARL

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Dielectric Materials for Pulse Power Capacitors

Dielectric Materials Development
BOPP, PVDF, alkali-free glass, nanocomposites

Capacitor Film & Fabrication Process Development
• Manufacturing scale-up or roll-to-roll processes
• Fabrication and test of packaged capacitors for Army, Navy and Air Force applications

High Impact Applications
Air Force HPM
Army EM Armor
Navy Rail Gun

Tri-Service investments will enable pulse power applications with needed range of discharge & temperature capabilities.

ONR  AFOSR  ARO  SBIR / STTR
AFRL  ARL  ONR  Army ManTech

250 kJ, 2J/cc 10,000 shots
8 µm thick, 3000 ft roll

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TAT 5 M&MP for Readiness

Objectives
Damage diagnostics, repair and life-extension technologies for asset readiness

Program Overview
- NDE/I
- Prognostics
- Repair
- Wear Resistance, Hard Coatings, Fluids, Lubricants

Key Technical Challenges
- Damage modeling and prediction within 95% accuracy for degradation mechanisms in legacy and new materials
- Probability of detection less than ~1mm with inspection techniques and detection / assessment of damage precursors
- Reliable fabrication and integration of structural health monitoring systems

Operational Opportunities
- In-situ non destructive techniques and advanced computational tools for lifing to increase operational availability
- Advanced structural health monitoring sensors for condition based maintenance and remaining life
- Damage diagnostics for asset/platform maintenance and/or repair at the depot level
- Advanced coatings to mitigate wear in severe loading and harsh operational environments for extended platform life and extended time between maintenance cycles

Tools for improved mx/repair processes
Wear Coatings and Lubrication
Characterization Technology

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Cold spray technology enabled reclamation of parts otherwise scrapped due to wear and corrosion; i.e. the Army Research Laboratory (APG) repaired a TD-63 Actuator from a Navy submarine for the Puget Sound Naval Shipyard & Intermediate Maintenance Facility (NAVSEA).

**TD-63 Actuator repair**

Cold spray repair of a UH-60 Main Rotor Sump

1. **Maintenance Engineering Order (MEO)**
   - T7631 UH-60 Sump Repair
     - Army Aviation & Missile Research, Development & Engineering Center (AMRDEC)
     - Program Office –UH-60 Blackhawk- Rios Merritt
     - Corpus Christi Army Depot-SAFR Program Office-Mark Velazquez

2. **Overhaul Repair Instruction (ORI)**
   - SS8491 UH-60 Sump Repair
     - Sikorsky Aircraft Company-Technology Integration-Bill Harris and Eric Hansen

**Annual Savings $860K**

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LO Handheld Imaging Tool

Program
• ATD delivering technical data and a fully functional residual prototype for a handheld zonal LO NDE tool capable of imaging 100% of the aircraft
• In-situ RF imaging capability with easy to use graphical user interface

Status & Impact
• Tech Availability 1Q FY15
• Solves current F-35 JCS requirement shortfall by providing capability to image 100% of aircraft surface
• Common NDE solution for AF, Navy & Marines
• Provides quality signature assessment data at field level
• Eliminates unnecessary maintenance, potentially increasing mission capability rates
• F-35 SPO wants 6 more

Technician on the flight line and maintenance supervision

Handheld

F-35 LO Health Assessment System (LOHAS)
TAT 6 M&MP for the Individual Warfighter

Objectives
High performance lighter-weight materials including advanced textiles and soft materials to protect, sustain and enhance the performance of the individual warfighter

Key Technical Challenges
- Multi-threat protection without overburdening the warfighter
- Durable ballistic, blast and agile laser eye protection system
- Low-cost, wearable sensors and wearable energy sources to power them
- Selectively permeable reactive textiles and use them to design low thermal burden chem/bio protective garments

Program Overview
- Warfighter Protection Systems
- Materials for Logistics
- Warfighter Enhancement
- Bio/Bioinspired Materials

Operational Opportunities
- Increased mobility of individual warfighter by enhancing/optimizing protection at lower weight
- Improved situational awareness of the individual warfighter through networked individual sensors
- Operational capability with a minimal thermal burden in a CBRNE environment
- Improved capability for individual sustainment independence/"self-sufficiency" and reduction of sustainment demands at contingency bases

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Advanced Eye Protection

Goals for Vision Protection

Variable Transmission Lens
- High light-dark contrast ratio (85%-15%)
- Fast light-dark transition time (<3s)

Frequency-Agile Laser Protection
- Combination fixed-line/tunable
- Laser eye protection against
  - Laser Dazzle
  - Continuous wave lasers
  - Pulsed Laser

Ballistic Fragmentation Platform Integration

Environmental Hardening

Anti-fog coating

New Waveplate Optics

- Manipulate light in micron thin layers
- Resolve issues with clarity, substrate compatibility, manufacturability
- Automatically diffract specific wavelengths
- Provide optical correction and magnification on demand

Pixelated Lens Structure
Provides laser dazzle/flash protection via active control of localized transmission through threat-relevant portion of lens area, thus maintaining peripheral vision

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Objectives
Efficient plans, designs, construction, operations and maintenance that are mission ready, energy & water secure, highly sustainable and low lifecycle cost for installations

Program Overview
- Force Protection for Facilities
- Force Projection and Maneuver
- Sustainability of Critical Infrastructure

Key Technical Challenges
- Need for greater force protection that is lighter and easily constructed
- Need to achieve operational maneuverability through lighter weight surfacing in austere environments
- Need for sustainable bases in all operational environments using indigenous materials

Operational Opportunities
- New capabilities to protect the Warfighter and critical assets
- Proactive means to ensure Joint Forces can deploy and freely enter the theater of operations
- Improved ability to design, construct, and operate sustainable bases
Passive Protection
Deployable Force Protection S&T Program

Technologies
- Modular Protective Systems (MPS) for critical assets
- Retrofits and structural upgrades
- Expedient and low-logistics vehicle stopping
- Low-logistics guard towers and fighting positions
- Camouflage, concealment, and deception for critical assets

Developers
USAERDC, NSRDEC

Transition
- JPEO-CBD/JPMG draft TTA and in-theater evaluations
- PEO-CS&CSS/PdM FSS MoA
- Procured by REF (i.e. 82nd ABD, 1BCT)

Funding: $32M

9 products ranging from materiel to knowledge information
TAT 8 M&MP for Corrosion

Objectives

• Application of robust phenomenologically based models for holistic system-design and protection

Key Technical Gaps

• Mechanistic study of corrosion in materials/structures under environment
• High performance coatings technology that is universal and/or application specific and environmentally safe
• Science based multi-scale corrosion models
• Prediction of materials performance/service life
• Sensors and processes

Program Overview

• Corrosion Mechanisms
• Surface Protection
• Corrosion Modeling
• In-situ Corrosion Detection
• Corrosion Repair

Operational Opportunities

• Reduce O&S corrosion cost to enable asset recapitalization and modernization (35%)
• Extend service life of DoD assets (1.5X) beyond original design
• Increase readiness (2X) for present and future missions while reducing resource requirements

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Army ManTech

Enabling Hybridized Manufacturing Process for Lightweight Body Armor

Army ManTech partnered with DMS&T, Army S&T and PM SPIE (Project Manager Soldier Protection and Individual Equipment) to enable new body armor processing methods resulting in a 10% weight reduction over current body armor systems. The manufacturing technology transitioned to PM SPIE in September 2014 for use on the SPS (Soldier Protection System).

Affordable Chemical/Biological Resistant Fabric

Army ManTech enabled new fabric processing methods to successfully achieve target weight and cost goals of CBRN (chemical, biological, radiological, nuclear) shelter liners. The manufacturing technology transitioned to JPM (Joint Project Manager) Protection for production starting in FY15.

Chip Scale Atomic Clock (CSAC)

Army ManTech partnered with DMS&T to improve CSAC manufacturing processing methods resulting in 20% fewer parts, increased production capability, and cost reductions from $8,700/unit to $200/unit for production volumes. The manufacturing technology transitioned to PD PNT (Product Director Positioning, Navigation & Timing) in 2014.

Low Light Level Sensor

ManTech helped to increase low light level sensor production yield, optimize processes for better performance and automate production steps resulting in sensor cost reductions of over 60% and increased production capacity 20 times over previous production capacities. The manufacturing technology transitioned to PM Apache starting in late 2013 for initial production and continued through FY14 with FRP (Full Rate Production) and FUE (First Unit Equipped) for equipping the 1stBattalion, Apache 82nd Combat Aviation Brigade (CAB).
VIRGINIA Class Submarine Affordability Initiative

- On track to save over $500M through Block IV POR
  - Potential for $600M additional pending approval to expansion to 48 hulls
- Projected acquisition savings: $36.5M/hull
  - Cost savings to date: $32.4M/hull
  - 36 implemented projects per Electric Boat (8/2014)
- Projected class maintenance/repair cost savings: $100+M
- Won 2013 DOD Value Engineering Achievement Award (Jun 2014)
  - Presented to ONR ManTech, VCS Production Cost Reduction Team (PMS 450), and Electric Boat
- Annual Navy ManTech budget returned with yearly VCS cost savings of >$60M

Joint Strike Fighter (JSF) Affordability Initiative

- Navy impact – projected $700M savings for DoD aircraft
- Joint Navy, Air Force and OSD ManTech collaboration
- Project highlights --
  - Canopy Thermoforming Automation - $75-125M DoD
  - Automated Fiber Placement of BMI Materials - $100M+ DoD
  - Controlled Volume Molding (CVM) – $20M+ DoD savings
Air Force ManTech

- **1st High-Precision Robotics for Aerospace:** F-35 inlet duct drilling cycle time reduced 4X
- **AESA Radar Mfg Assembly Improvements for F35:** $380M Impact
- **New Materials and Mfg Processes for Turbine Engine Industry:** $1B Impact
- **Launched Digital Thread Pilot for EMD Efficiencies**
- **Engine Rotor Life Extension**
- **Life Extension to 12,000 Cycles**
- **Cost Avoidance:** $1.1B
- **Record 30% Efficiency for Production Space Solar Array**
- **Mfg Readiness Level Risk Reduction for AETD Transition to EMD**

ManTech Leads Establishment of 1st Nat'l Mfg Innovation Institute

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Innovative Manufacturing Institutes

Advanced Manufacturing Partnership-
Active and Planned Institutes

• National Additive Manufacturing Innovation Institute (NAMII)
  – a.k.a. America Makes (DoD/DOE) FY12
• Digital Manufacturing and Design Innovation Institute (DMDII)
  – (DoD) FY14
• Lightweight and Modern Metals Manufacturing Innovation Institute
  – a.k.a. LIFT(DoD) FY14
• Next Generation Power Electronics Manufacturing Innovation Institute
  – a.k.a. Power America (DOE) FY14
• Institute for Advanced Composites Manufacturing Innovation (IACMI)
  (DOE) FY15
• American Institute for Manufacturing Integrated Photonics (AIM Photonics) (DoD) FY15
• NextFlex, the Flexible Hybrid Electronics Manufacturing Innovation Institute (DoD) FY15
• Advanced Functional Fibers of America (AFFOA) Institute (DoD) FY16

http://manufacturing.gov
Impact of M&MP COI

- Durable Structural Materials (TAT 1.0)
- Communication Systems (TAT 3.0)
- Damage Detection and Assessment (TAT 5.0)
- Heads’ Up Display (TAT 6.0)
- Corrosion Control (TAT 8.0)
- Runway Assessment/Repair (TAT 7.0)
- Turbine Engine Propulsion Materials (TAT 2.0)
- Efficient Thermal Management (TAT 4.0)