Military Update

Carole Winterhalter
Chief Technology Officer
Textile Technologist

US Army Natick Soldier Research, Development and Engineering Center

Military Update

Outline:

- Manufacturing Innovation Institute – ***Revolutionary Fibers and Textiles***
- Overview of US NSRDEC
- Other Business Opportunities - BAA
- Army, Navy and Air Force Needs

The Administration's Early Focus on the U.S. Manufacturing Sector…

"I want us all to think about new and creative ways to engage young people in science and engineering …

encourage young people to create, build, and invent

*to be **makers** of things, not just **consumers** of things"*

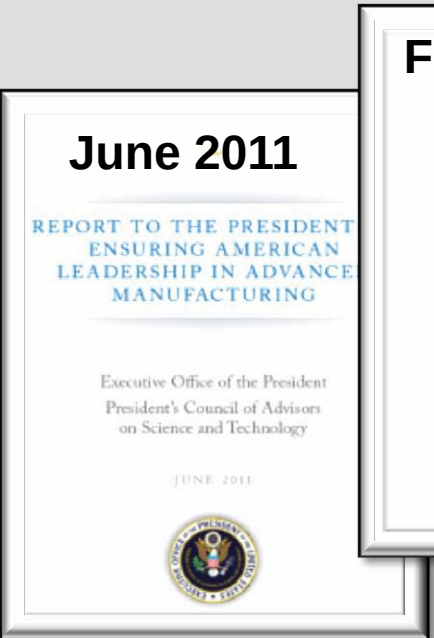
President Obama - 2009 National Academy of Sciences Annual Meeting

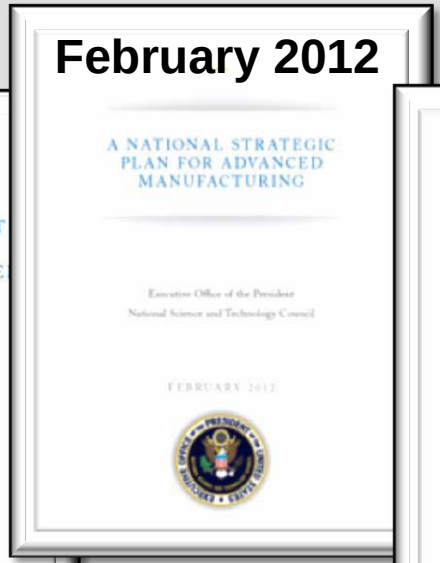
…is now a Growing National Advanced Manufacturing Initiative

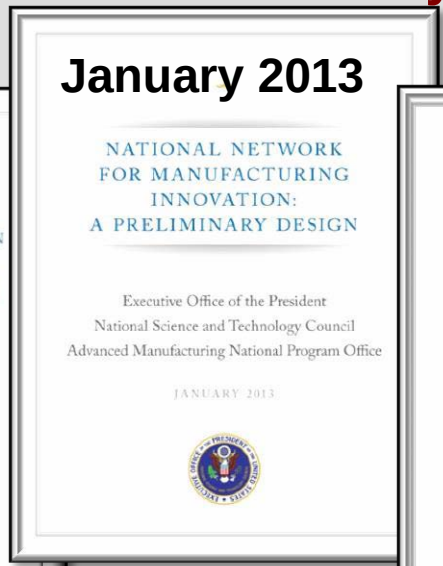
January 2013

January 2014

February 2014







President's Council of Advisors on Science and Technology

Advanced Manufacturing Partnership

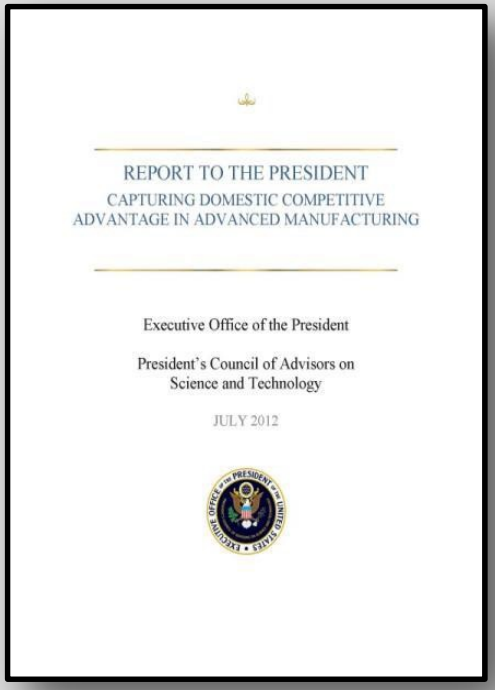
AMP Co-chairs

Andrew Liveris
CEO, Dow Chemical

Susan Hockfield
President, MIT

PCAST / AMP report released July 2012 on whitehouse.gov

- 16 Recommendations in three areas: innovation, talent, and policy


REPORT TO THE PRESIDENT
CAPTURING DOMESTIC COMPETITIVE ADVANTAGE IN ADVANCED MANUFACTURING

Executive Office of the President

President's Council of Advisors on Science and Technology

JULY 2012

Two of these recommendations:

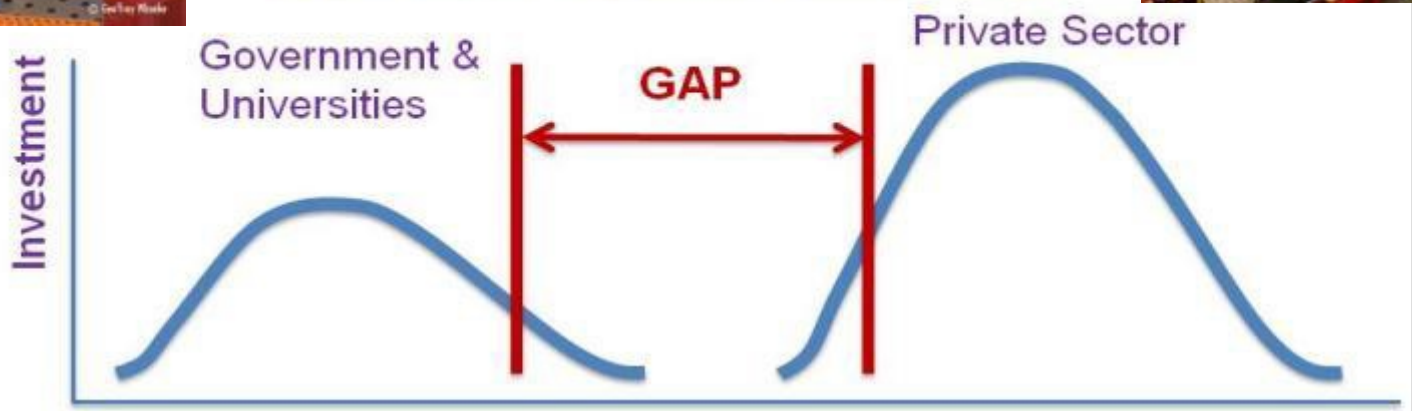
1) Coordinated "whole of government" effort via Advanced Manufacturing National Program Office

2) Pursue the "missing middle" via manufacturing innovation hubs ➔ NNMI

The Scale-up Gap or Missing Middle

Common terms
The "valley of death"
The "missing Bell Labs"
The "industrial commons"

Gap in Manufacturing Innovation

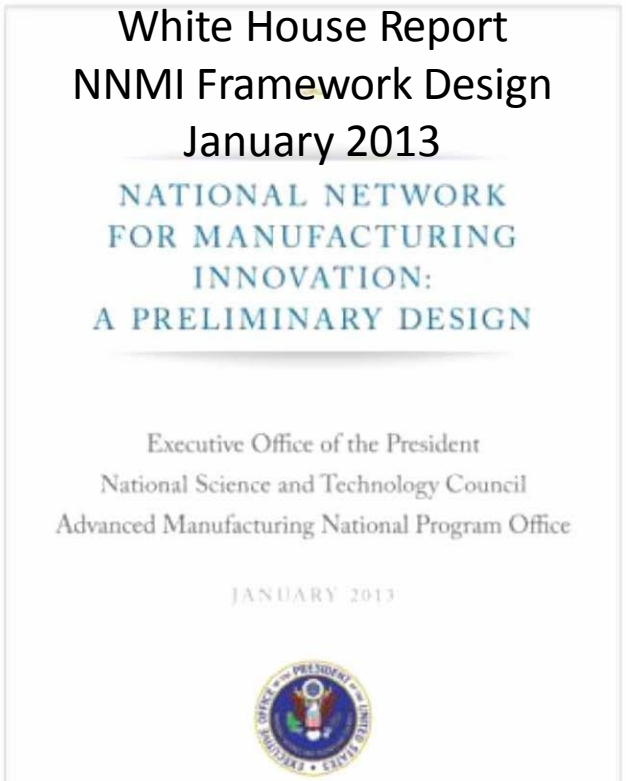


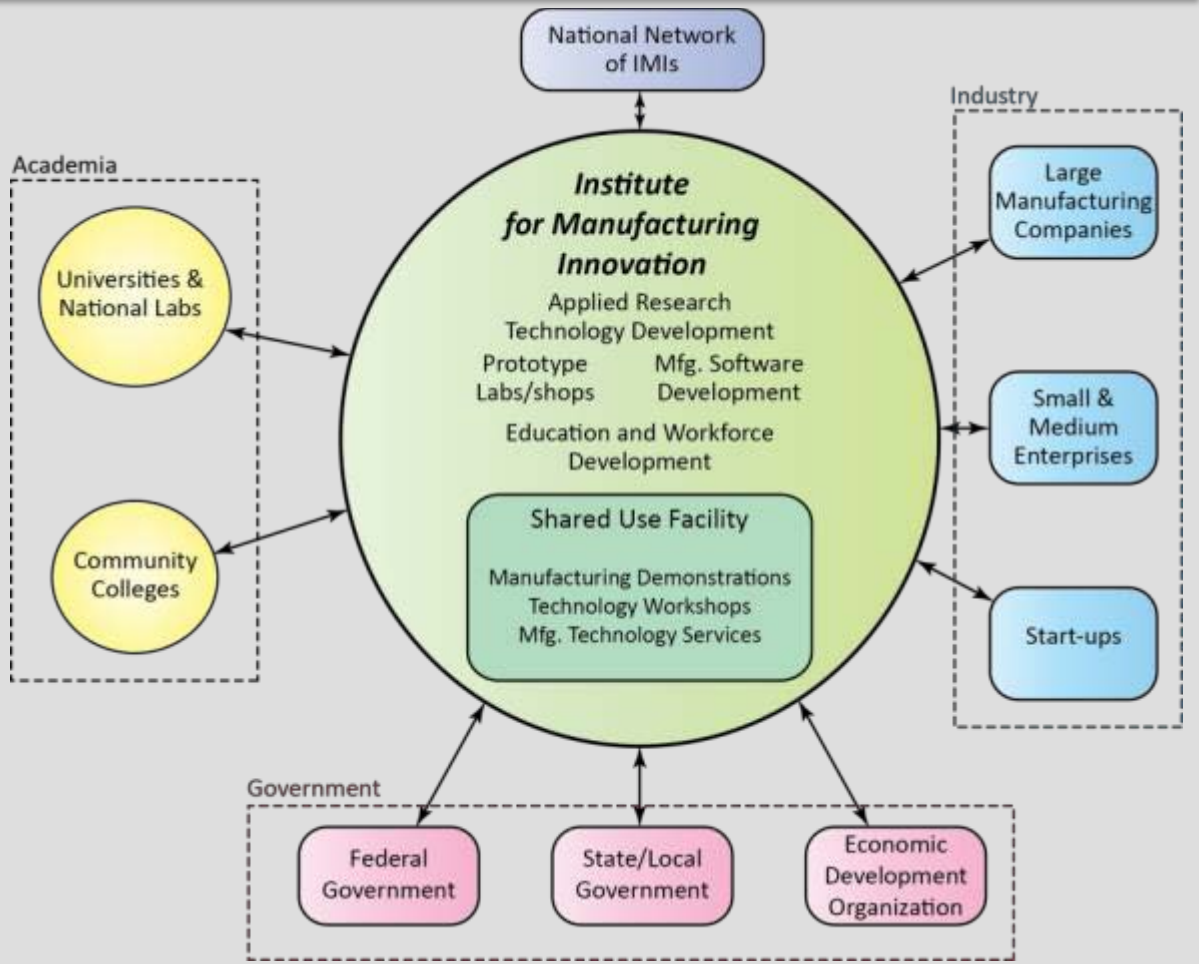
Manufacturing Readiness Level

The Institute Design

Creating the space for Industry & Academia to collaborate

White House Report
NNMI Framework Design
January 2013





Partnership: *Industry – Academia – Government*

Working better, together to create transformational technologies and build new products and industries

Institute Major Activities

Applied Research & Demo projects for

- reducing cost/risk on commercializing new tech.
- Solving pre-competitive industrial problems

Tech Integration - Development of innovative methodologies and practices for supply chain integration

Small/Medium Enterprises

- Engagement with small and medium-sized manufacturing enterprises (SMEs).

Institute

Education, technical skills and Workforce development

Education and training at all levels for workforce development

Summary:
A U.S. Game Changing Opportunity

- Establish a presence, at scale, in the "missing middle" of advanced manufacturing research
- Create an Industrial Commons, supporting future manufacturing hubs, with active partnering between all stakeholders
- Emphasize/support longer-term investments by industry
- Combine R&D with workforce development and training
- ***Overarching Objective: Unleash new U.S. advanced manufacturing capabilities and industries – for stronger global competitiveness and U.S. economic & national security***

DoD and DOE Established Institutes

- *America Makes* (The National Additive Manufacturing Innovation Institute)—DoD-Led; Established August 2012
- *Power America* (Next Generation Power Electronics Manufacturing Innovation Institute)—DOE-Led; Announced January 2014
- *Digital Manufacturing & Design Innovation Institute* (DMDII)—DoD-Led; Established February 2014
- *LIFT -- Lightweight Innovations for Tomorrow* (Lightweight & Modern Metals Manufacturing Institute)—DoD-Led; Established February 2014
- *Institute for Advanced Composites Manufacturing Innovation* (IACMI)—DOE-Led; Established January 2015

Fiscal Year 2015
Institutes in Acquisition

- DoD-Led Institutes
  - Integrated Photonics Institute for Manufacturing Innovation
    - FOA released November 2014
    - Institute award anticipated June 2015
  - Flexible Hybrid Electronics Manufacturing Innovation Institute
    - FOA released February 2015
    - Institute award anticipated September 2015
- DOE-Led Institutes
  - Smart Manufacturing Institute for Energy Efficiency
    - FOA to be released early 2015
    - Institute award date TBD

Manufacturing Innovation Institute Revolutionary Fibers and Textiles

FY15 Institute Readiness Review for Modern Fibers and Textiles – a study

- Market Investigation and Analysis
- Request For Information - Closed July 2014
- Request For Information – Closed October 2014
- Industry Workshop – October 2014
- Identified technical textile needs for both defense and commercial applications
- Broad and enthusiastic industry participation
- www.manufacturing.gov

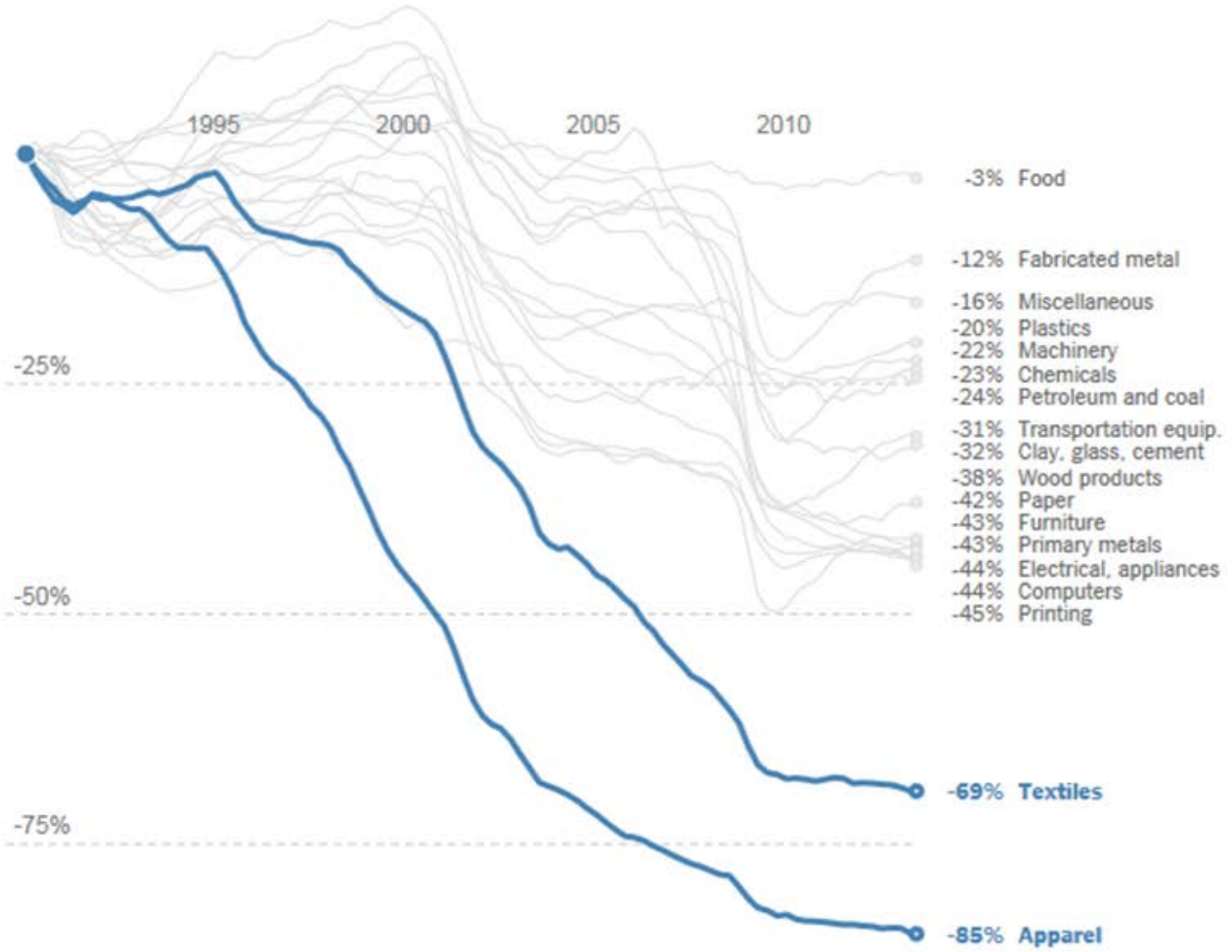
Manufacturing Innovation Institute
Revolutionary Fibers and Textiles

How American Manufacturing Has Changed

Jobs | Capacity

Since 1990, job losses in apparel and textile manufacturing have been greater than those in any other type of manufacturing.

Sources: Bureau of Labor Statistics; Federal Reserve



Manufacturing Innovation Institute
Revolutionary Fibers and Textiles

$75M in federal investment over five years

Transportation – Covers and Airbags

Geosynthetics – Construction

Revolutionary Fibers and Textiles

Advances in fiber science have created fibers with extraordinary properties of strength, flame resistance, electrical conductivity.

Revolutionary fibers are composed of specialty fabrics, industrial fabrics, e-textiles, and advanced textiles; they are built upon a foundation of synthetic fibers and/or multi-material fibers that have a wide-range of applications in both the defense and commercial sector that go beyond traditional wearable fabrics

Objective:

- *Serve as a public-private partnership between government, academia and industry to address manufacturing challenges from design to end products*
- *Support an end-to-end innovation 'ecosystem' in the U.S. for revolutionary fibers and textiles manufacturing and leverage domestic manufacturing facilities to develop and scale-up manufacturing processes*
- *Provide rapid product realization opportunities, based on robust design and simulation tools, pilot production facilities, a collaborative infrastructure with suppliers, and workforce development opportunities through targeted training and curriculum programs*

Military & Commercial Shelters

Military & Commercial Smart Clothing

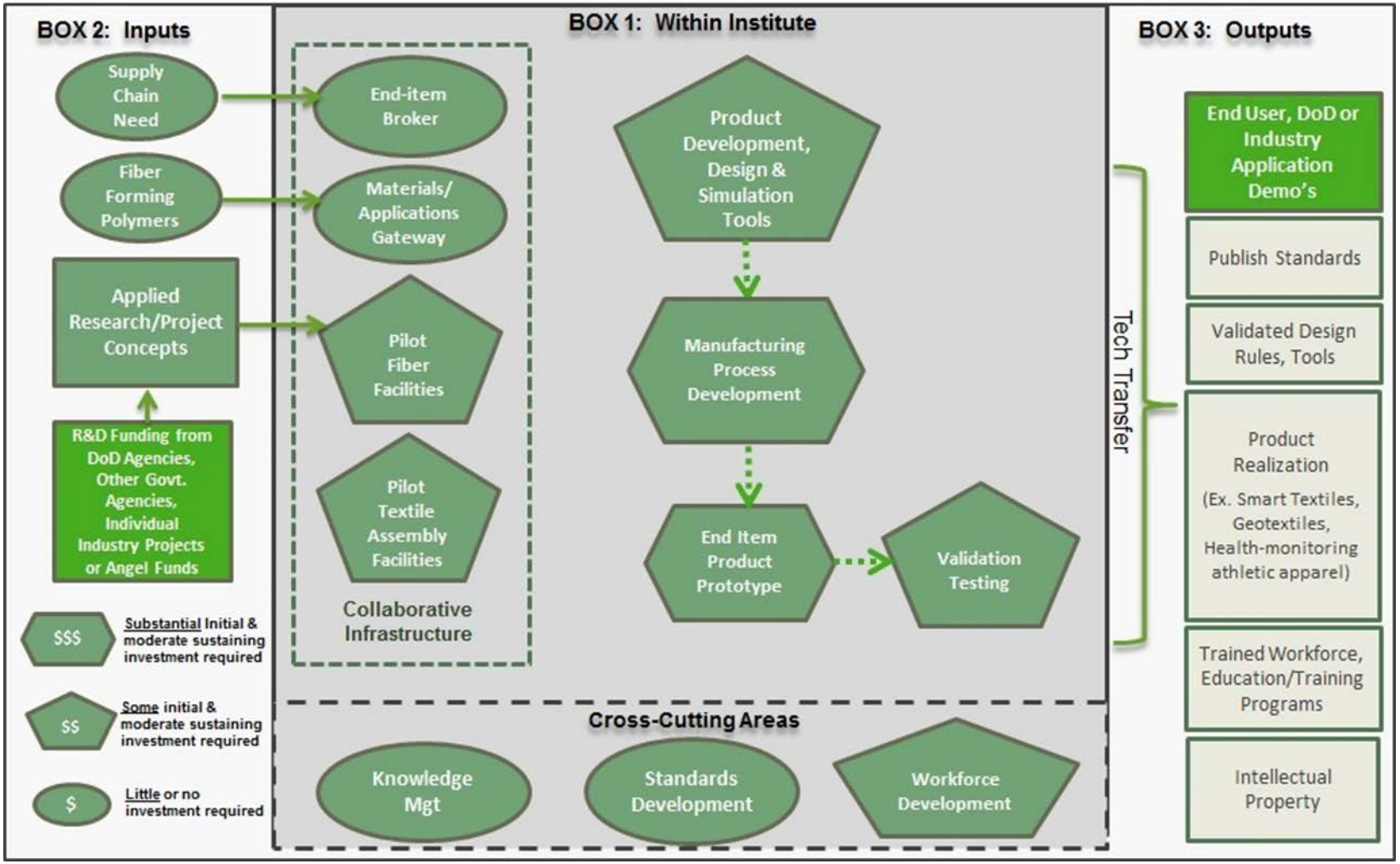
POTUS Announcement – March 18th 2015

Roles, Responsibilities, and Schedule

- **OSD Leadership and Support**: Adele Ratcliff, Director OSD ManTech
- **Institute Leadership**: Army-led government Team collaboration between ARDEC/NSRDEC
  - Program Manager: Steve Luckowski, US Army ARDEC
  - Chief Technical Officer: Carole Winterhalter, NSRDEC
  - Contracting , ACC-NJ: US Army ARDEC (Travis Clemons, Lauren McDermott)
- **SME team:** comprised of subject matter experts from cross-government and involved in institute technology area (Army, Navy, Air Force, DOE, NIST, DLA, NSF)

Institute Timeline	2015
Notice of Intent (NOI) released	18 March 2015
FOA Released	12 May 2015
Industry/Proposers' Day - *(Atlanta, GA)*	20 May 2015
FOA Concept Papers Due (open 45 days)	26 June 2015
FOA Full Proposals Due (60 days)	14 Sep 2015
Technical Evaluation Complete (5 weeks)	9 Oct 2015
Negotiation and Selection (4 weeks)	6 Nov 2015
Congressional Notification and 15 day waiting period	20 Nov 2015
Award and announcement	10 Dec 2015

Conceptual Operational Ecosystem

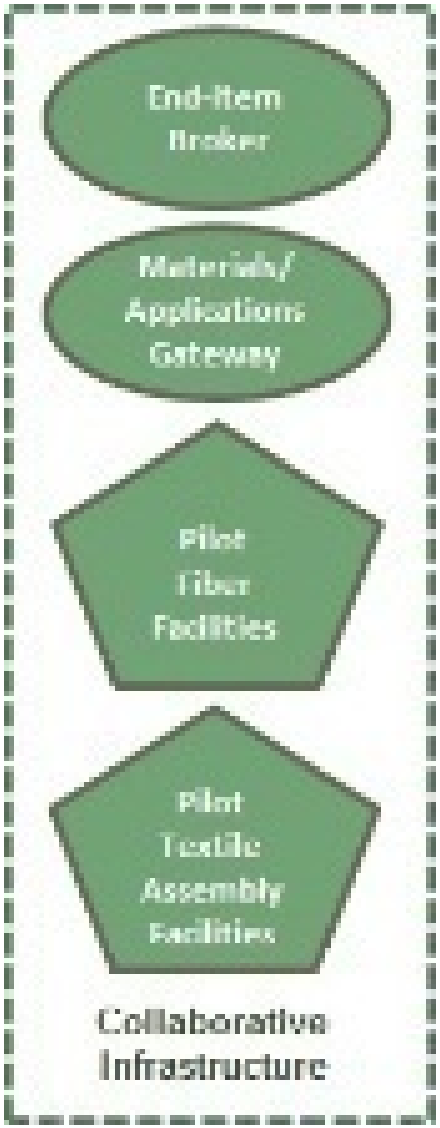


Technology/Manufacturing Readiness Levels

	TRL 1:	Basic principles observed and reported	MRL 1:	Manufacturing feasibility assessed
	TRL 2:	Technology concept and/or application formulated	MRL 2:	Manufacturing concepts defined
	TRL 3:	Analytical and experimental critical function and/or characteristic proof of concept	MRL 3:	Manufacturing concepts developed
NNMI Target	TRL 4:	Component and/or breadboard validation in a laboratory environment	MRL 4:	Capability to produce the technology in a laboratory environment
NNMI Target	TRL 5:	Component or breadboard validation in a relevant environment	MRL 5:	Capability to produce prototype components in a production relevant environment
NNMI Target	TRL 6:	System/subsystem model or prototype demonstration in a relevant environment	MRL 6:	Capability to produce prototype system or subsystem in a production relevant environment
NNMI Target	TRL 7:	System prototype demonstration in an operational environment	MRL 7:	Capability to produce systems, subsystems or components in a production relevant environment
	TRL 8:	Actual system completed and qualified through test and demonstrated	MRL 8:	Pilot line capability demonstrated; Ready to begin Low Rate Initial Production
	TRL 9:	Actual system proven through successful mission operations	MRL 9:	Low rate production demonstrated; Capability in place to begin Full Rate Production

Project Objectives:
Collaborative Infrastructure (CI)

- The Collaborative Infrastructure is a collection of facilities and capabilities enabling innovative fiber and textiles prototype manufacturing, process development, and supply chain coordination
  - May consist of technical expertise, physical infrastructure and equipment assets both within the Institute and those that are shared with industry partners as part of a network
    - What's required for simulation, design, rapid prototyping/manufacturing and scale-up activities of fiber materials and textile assemblies
  - Can provide a more integrated supply chain for new product development by configuring the manufacturing processing at a scale that is currently unavailable or too costly for product developers
- Includes four components:
  - End Item Product Broker
  - Materials / Applications Gateway
  - Pilot Fiber Facilities
  - Pilot Textile Assembly Facilities



Project Objectives:
CI – End Item Broker

Little or no investment required

- **As an End Item Broker, the Institute will:**
  - Use its detailed knowledge of the manufacturing ecosystem to help provide partnership opportunities for OEMs to develop and mature supply chains, based upon product needs
  - Assist in matching customers' needs to the most appropriate materials and/or applications
  - Facilitate the rapid design, manufacture, and testing of new combinations of fiber materials and textiles
  - Explore manufacturing technology improvements in fibers, textiles, and functional finishes
  - Develop end-item prototypes through use of the collaborative infrastructure
- **Leverage industry cost share through its membership to provide rapid access to fiber, textile and finishing equipment necessary to realize an end-item prototype**
- **Develop and refine a competency in value stream analysis, identify gaps and anticipate failure nodes in the supply chain, and develop solutions on how gaps or vulnerabilities can be overcome**

Project Objectives:
CI – Materials/Applications Gateway

Little or no investment required

- **The role of the Materials and Applications Gateway will be to:**
  - Become aware of and catalog new materials (TRL/MRL 4 and above) and applications
  - Characterize and document materials, fibers, and fiber forming polymer processing conditions in a shared knowledge management system
  - Apply design and simulation tools to more accurately predict performance
  - Enable the virtual application of new/existing materials to new textile combinations in the modeling and prototyping phases
  - Provide opportunities for knowledge-based hybridization of fiber materials
  - Broaden the applications for these materials
- **Function as an 'honest broker' in documenting materials performance**
- **Support the Broker function by facilitating the development of applications where the supply chain is currently unavailable**

Project Objectives:
CI – Pilot Fiber Facilities

Some initial & moderate sustaining investment required

- **The Pilot Fiber Facilities will be a capability to support:**
  - Fiber performance improvement through modification of fiber materials provided by the Materials/Applications Gateway function
  - Low volume fiber manufacture within the physical infrastructure and post-pilot scale-up within the collaborative infrastructure
  - Wide-range of conventional manufacturing processes (melt-spinning, wet solution-spinning, mono bi-component extrusion)
  - Small-scale and intermediate-scale processes currently missing in both academia and industry
  - Full characterization of enhanced performance fibers, using design and simulation tools, to extend fiber performance into textile products
- **Within the Institute's physical infrastructure, there needs to be the capacity to have throughput to sufficiently scale and demonstrate the reproducibility of fiber properties and performance and support rapid prototyping, testing and evaluation of related end items**

Project Objectives:
CI – Pilot Textile Assembly Facilities

Some initial & moderate sustaining investment required

- **Pilot Textile Assembly Facilities should:**
  - Have a flexible assembly capability with advanced support for 2-D and 3-D fabric formation
  - Be supported by robust design and simulation tools which enable the functionalization and hybridization of fibers into novel product applications
  - Support the fabrication of novel structures from polymer, fiber or yarn to finished fabric, focusing on the textile as opposed to a garment, or end-item product
- **Through both a physical and collaborative infrastructure, this functional area should encompass the ability to:**
  - Produce small quantities of fabrics
  - Dye, print and finish small batches of fabric
  - Rapidly produce small quantities of test items from that same fabric
  - Quickly perform evaluations of these prototypes in simulated use
  - Include processes such as yarn spinning, 2D/3D weaving, knitting, braiding, including nonwoven technology
  - Produce e-textiles that incorporate sensors and/or support the` 'Internet of Things' (IoT)
  - Ability to conduct fabric dyeing, printing, finishing, and laminating, with associated chemicals and processes
  - Produce various patterns and sizes
  - Include fabric forming, sewing, and bonding methods/equipment
  - Conduct 3D printing

Project Objectives:
Product Development, Design and Simulation Tools

Some initial & moderate sustaining investment required

- **Product Development, Design and Simulation Tools can facilitate predictive design and will be supported by a robust knowledge management system that provides validated performance data for fibers and textile assemblies**
- **The development of Textile Design Automation (TDA) tools that seamlessly incorporate all aspects of design from end-to-end, from multi-physics simulation to delivery of a finished product**
  - Includes validation testing
  - Based on robust knowledge management capability
- **There is an expectation to leverage tools developed by allied industries (Ex. Composites) in order to support a full range of design and modeling tools that facilitate product design, product development, cost analysis, and trade-off studies**

Project Objectives:
Manufacturing Process Development

Substantial Initial & moderate sustaining investment required

- **Conduct innovative Manufacturing Process Development and technology improvements using the collaborative infrastructure of the Institute in both fibers and textiles**
- **The Manufacturing Process Development function will focus on a variety of factors, including:**
  - Processing conditions
  - Control technology
  - In-process QC/QA
  - Incorporation of modeling and simulation
  - Energy efficiency
  - Sustainability
  - Environmental stewardship
- **Support for innovation in manufacturing process development such as ink-jet printing for fabrics, methods of improved fiber processing, incorporation of sensors into textiles, and end-item product manufacture**

Project Objectives:
End-Item Product Prototype

- **The End-Item Product Prototype is the capability to provide rapid product realization on a small-scale, within the Institute's physical infrastructure, by integrating fibers, textiles, assembly and validation in the pilot manufacturing capabilities**
  - Includes capabilities provided by the Institute, industry and academia for novel end-item assembly and rapid prototyping across many applications
  - Provides for opportunities for student practical training and internships
- **Includes organic capability to prototype at many stages of manufacturing as well as some discrete processes, outside the Institute, to support the realization of end-item products**
  - Since most Institute activities will result in an end-item prototype, the Institute's physical infrastructure will be configured to be a resource for this activity
- **"Smart Luggage" Example**
  - Integrating GPS tracking capability into a smart fabric for luggage
  - Broker function: helps select appropriate fibers, develops manufacturing method
  - Physical infrastructure: makes prototype quantities, assembles full-scale, end-item prototype (e.g. a luggage sample)
    - Broker function obtains capability to do this from CI when Institute can't
  - Validation Testing: validates the design
  - CI function: facilitates pilot-scale manufacturing to enable commercialization of the product

Substantial Initial & moderate sustaining investment required

Project Objectives:
Validation Testing

Some initial & moderate sustaining investment required

- **The Validation Testing function will develop the needed testing techniques, and procure the associated equipment required to support cost-effective, high-volume end-to-end manufacture of hybrid and functionalized textile components**
- **Includes capability:**
  - For testing at the component and product levels
  - Within physical infrastructure to provide this service to members
  - To support product testing, such as human factors for garment sizing and customization
- **Data gathered in component and product testing will populate the knowledge management repository and inform industry standards**
  - Important for exports to countries which require certification for properties

Project Objectives:
Knowledge Management

Little or no investment required

- **Knowledge Management involves the creation and maintenance of a data repository of fiber and textile materials performance, as well as lessons learned, that:**
  - Is accessible to Institute members and the wider community
  - Serves as validated/pedigreed data for input to design and simulation tools
  - Stores data on fibers, fiber combinations as well as human sizing information
  - Combines performance data with knowledge of processes
  - Contains both open source and member-restricted data, depending upon IP considerations
- **The Institute should act as "third-party" arbiter of fiber and textile performance, with capability to validate material properties that are provided as part of the Materials Gateway**
- **The data stored in this system could provide design information and trade-off analysis that can be individually customized and thus support mass customization of wearable technology for both commercial and military applications**

Project Objectives:
Standards Development

Little or no investment required

- **Standards Development includes creation of common industry standards and practices essential to minimize barriers in product development and supplier/customer relationships**
  - Using the collaborative infrastructure, validate material performance and work to develop and publish standards
  - Partnering with professional societies, standards organizations, and other Institutes and consortia
  - Development of test method and component standards for the emerging electronic textiles and smart fabrics areas
    - Could include electronic yarns, fabric-based networks associated wearable connectors and antennas
- **New fibers, manufacturing processes and applications present a number of challenges ranging from fiber manufacturing to scale-up**

Project Objectives:
Workforce Development

Some initial & moderate sustaining investment required

- **Workforce Development includes:**
  - Shaping and influencing positive workforce outcomes at the strategic level
  - Leveraging other activities both inside and outside (e.g. state, local, industry associations) the Institute
  - Performing and supporting the integration of education, internships, and professional training/retraining
  - Creating an educated and skilled workforce at each technical and supply-chain level
  - Development of curriculum for educational institutions including K-12, community colleges, and universities
  - Partnering with existing Science, Technology, Engineering, and Mathematics (STEM) related activities related to novel fiber and textile technologies and applications
- **The Institute should work with government-enabling agencies and organizations, such as state agencies, Departments of Education and Labor, and relevant industry associations/consortiums**
- **Integral aspect to Education and Training is free or low-cost access to design tools and software that can enable academic institutions and publicly funded research laboratories to participate in Institute resources that would otherwise be inaccessible due to high costs**

Example Manufacturing R&D Project Categories

1. Establishment of a fiber and textile knowledge management data repository and development of design automation tools

2. Innovative product realization in next-generation apparel technology

   – Examples: concepts such as micro-climate conditioning, energy harvesting and transport and real-time health-monitoring for soldier and athletic performance wear

3. Innovative product realization in Next Generation non-apparel technology

   – Examples: concepts such as electronic-enabled geosynthetic textiles, smart shelters, and smart structures.

UNCLASSIFIED

US Army Natick Soldier RD&E Center

Overview

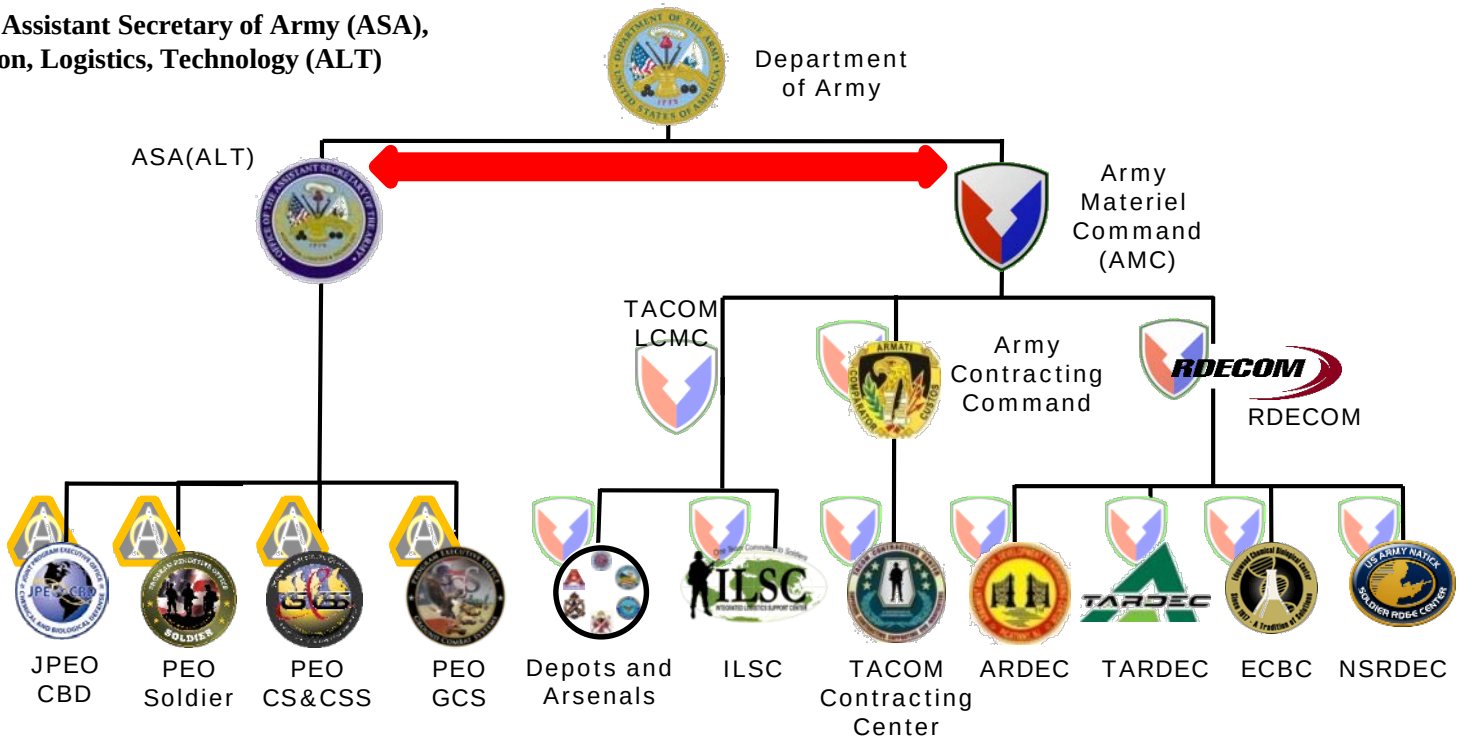
Carole Winterhalter

The Leader in Empowering the World's Most Capable Soldiers

UNCLASSIFIED

Military Overview

ASA(ALT) - Office of Assistant Secretary of Army (ASA), Acquisition, Logistics, Technology (ALT)



Chain of Communication
-DA
-ASA(ALT)
-PEO Soldier

Chain of Communication
- DA
- AMC
- RDECOM
- NSRDEC

Army Materiel Command

GEN David G. Perkins
CG TRADOC

GEN Dennis L. Via
CG AMC

Ms. Heidi Shyu
ASA(ALT) & AAE

U.S. ARMY RDECOM®

MG John F. Wharton
CG RDECOM

CSM James P. Snyder
CSM RDECOM

Mr. Jyuji D. Hewitt
Deputy Director RDECOM

BG William E. Cole
DCG RDECOM

- RFEC Atlantic
- RFEC Pacific
- RFEC Americas

AMRDEC	ARDEC	CERDEC	ECBC	NSRDEC	TARDEC
Aviation & Missile Research, Development & Engineering Center	Armaments Research, Development & Engineering Center	Communications-Electronics Research, Development & Engineering Center	Edgewood Chemical Biological Center	Natick Soldier Research, Development & Engineering Center	Tank Automotive Research, Development & Engineering Center

ARL
Army Research Laboratory

UNCLASSIFIED

NSRDEC Organization

Acting Director
Ms. Suzanne Milchling

Senior Scientists
- ST, Behavior and Performance VACANT
- ST, Biological Anthropology VACANT
- ST, Nanomaterials Dr. Ramanathan Nagarajan

Office of Director

Chief Scientist
Dr. Charlene Mello

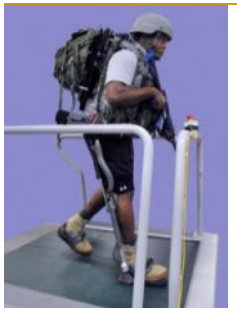
Associate Director for Operations & Outreach
Ms. Donna Bulger
- Workforce Development
- Resource Management
- Business Management
- Army Audit Readiness
- Foreign Intelligence and Security
- Information Management Office
- Operations Support
- Strategic Outreach

Associate Director for Technical Plans & Portfolios
Mr. David Carney
- Human Systems Integration & Performance Portfolio
- Individual Multi-Threat Protection Portfolio
- Force Projection & Sustainment Portfolio
- Portfolio Management Support
- Soldier Capabilities Integration Cell

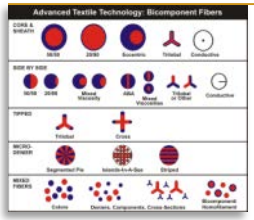
Associate Director for Science & Engineering
Mr. Craig Rettie
- Warfighter Directorate
- Aerial Delivery Directorate
- DoD Combat Feeding Directorate
- Expeditionary Basing/Collective Protection
- Soldier Systems Engineering

Military Deputy
COL Charles H. May
- Detachment Operations / Soldier Research Support
- Human Research Volunteer (HRV) Program
- Unit Ministry Team

Unique Capabilities that Foster External Industrial/Academic Partnerships



Center for Military Biomechanics Research
Allows for 3D analysis of movement, measurement of external forces on the body, monitoring of muscle activity, assessment of O_2 consumption, and real-time mapping of pressure patterns



High Performance Fiber Facility
One of a kind bi/tri-component fiber extrusion capability that enables the exploration of lightweight and reactive/ responsive multi-functional fibers

Doriot Climatic Chambers
Tests the limits of human performance under extreme conditions. Primarily used for human research, where a dedicated group of Soldiers perform as human research volunteers.

Ouellette Thermal Test Facility
Includes a propane fire cell, flame & thermal lab, laser lab, and CO_2 laser

3D Laser Scanning Lab
Whole body & head/face laser scanning system that enables measurements for current and next generation armor and helmet systems

Cognitive Performance Lab
Virtual Reality & Mobile Cognitive Assessment Platform Capabilities

Polymer Film CoE
Enables R&D of new plastics and nanocomposites formulations at lab scale production level

Base Camp Integration Lab – PM Force Sustainment Systems
Based at Fort Devens - Team Effort (Active and Reserve)
Two 150 man Force Provider Expeditionary Base Camps
Test and Improve Current Component Systems Develop New Technologies for Future Use – Power & Water
Great Potential to Expand

Partnerships: S&T Force Multipliers

Technology Transfer – Leveraging of Resources and Expertise

- 35 Active Cooperative R&D Agreements (CRADAs) in FY14
- CRADA Revenue FY14 - $640K

Academic Outreach

- 19 Partnerships with Academic Institutions
  - 8 CRADAs, 5 Master CRADAs, 6 Education Partnership Agreements

Public/Private Transfer of Technology FY14

- 12 Active Patent License Agreements, 85% with Small Businesses
- Total Active Licensable Inventions - 115
- FY14 Invention Disclosures - 11

Enabling the Future Force

Enhancing the Current Force

Military Overview

DoD R&D Definitions

NSRDEC "S&T"

Basic Research (6.1) – Systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and/or observable facts without specific applications toward process or products.

Fiber & Fabric R&D

Applied Research (6.2) – Systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met.

Advanced Technology Demonstration (6.3) – Includes all efforts that have moved into the development and integration of hardware for field experiments and tests.

-- Requirements Document --

PEO/PM

Demonstration and Validation (6.4) – Includes all efforts necessary to evaluate integrated technologies in as realistic an operating environment as possible to assess the performance or cost reduction potential of advanced technology.

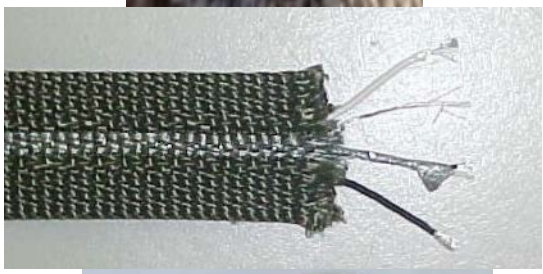
Engineering and Manufacturing Development (6.5) – Includes those projects in engineering and manufacturing development for Service use but which have not received approval for full rate production.

Military Overview

Business Opportunities:

Broad Agency Announcement (BAA) – 6.2 S&T

Small Business Innovative Research Program (SBIR) Program – 6.2 S&T



- NSRDEC topics
- Two Phases - I&II, Phase II Enhancement
- Third Phase – Commercialization

Defense Manufacturing Science & Technology – Improve or establish a new manufacturing process, exploit new business practice, or expedite transition of emerging technology.

Others…

Aerial Delivery

- Personnel Parachuting Systems
- Cargo Airdrop Systems

S&T Thrust Areas:

- Precision Airdrop
  (sensors, guidance & control systems)
- Integrated Logistics Aerial Resupply
- Modeling and Simulation
- Parachutist Safety
- Test Instrumentation
- Materials Research

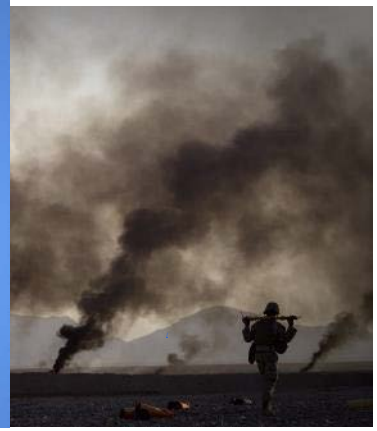
Aerial Delivery

Improved Steerability for Ram Air GPS Guided Canopies

- Current: Steer canopy by use of large motors to pull on control lines to change shape of canopy.
- Need: Materials that can actively change permeability (within the fabric or by use of vents) to reduce size/cost/weight of motors needed to steer canopy.

LCADS One-Time-Use Materials

- Current: COTS geo-textile polypropylene woven slit film, typically used as road liners.
- Need: Materials similar in all physical properties to current, except shelf stable to 12+ years, and upon application of a trigger, degrades very quickly.



Wear Monitoring of HSL Ropes

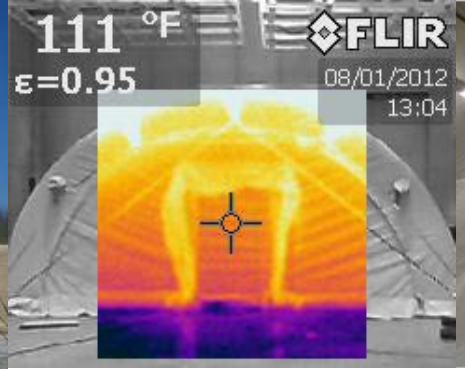
- Current: Visual inspection of the outside of 2”+ diameter double braided fiber ropes determines serviceability.
- Need: “Go/No-Go” inspection technology using smart textiles embedded in the rope to detect damage and accurately determine serviceability.

Expeditionary Basing/ Collective Protection

- Soft Wall Shelters
- Rigid Wall Shelters
- Integrated Expeditionary Base Camp Systems

S&T Thrust Areas

- Barrier Materials
- Structures
- Thermal Management
- Energy Management
- Finite Element Analysis
- Ballistics



Paper Thin, Super Tough Next Generation Tent Textiles

S&T Information: New tent skin textiles are needed for expeditionary basecamps. Basecamp must be easily set-up with minimal personnel.

Challenge: Deliver reduced weight and high performance in an affordable easy to manufacture textile.

Approach: Integrate multi-functionality and advanced materials into a lightweight, flexible composite.

Where we need assistance: Seeking high performance tent fabrics that are lightweight, highly flexible, durable and flame resistant

Keeping your Cool: The Importance of Tent Insulation

S&T Information: Tent insulation solutions are needed to reduce air conditioning which is the Army's single largest fuel user. Lives are lost in convoys delivering this fuel.

Challenge: Technology solutions that are lightweight, low cube, durable and flame resistant.

Approach: Combine flexible materials that reduce heat transfer due to radiation, conduction and convection.

Where we need assistance: Seeking highly insulating textiles that could be integrated within tent walls during manufacture, or easy to install as a liner

Soft Walled Shelters

Textiles as Structures

- Textiles can provide the highest strength to weight ratio for structures
- Rapidly deployable tents that create a robust protective enclosure are needed
- Leap-ahead technology advancements have been made in the area of inflatable textiles
- Flexible textiles that can become rigidized during/after deployment and even evolve over time are of interest.
- New manufacturing technology is needed to optimize performance and end-item cost

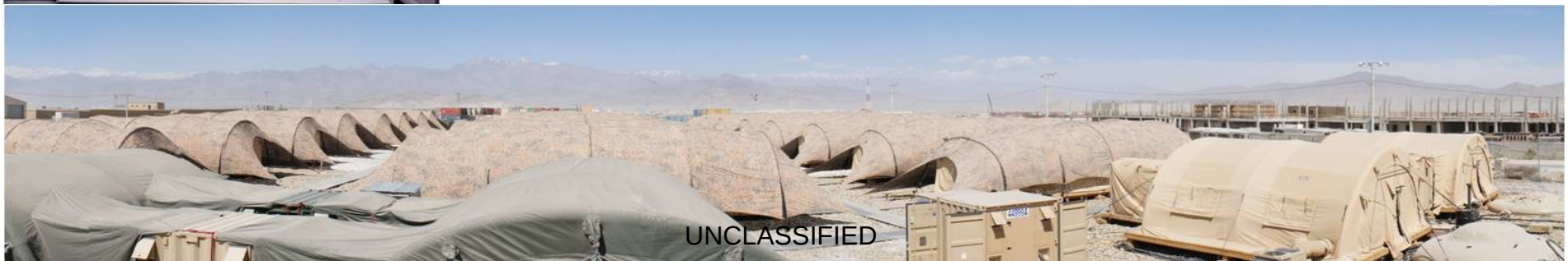
Shelter Needs

Overall Needs:

- Lightweight, durable materials (high strength to weight)
- Flame resistant
- Reduced life cycle costs
- Insulation with improved R-value
  - Reduced packing volume
  - Resistant to mold and mildew from condensation

CBRN Needs:

- Multifunctional shelter fabrics with inherent protection, reducing number of fabrics and components; 11 osy max.; $35/yd max.
- Self-decontaminating surfaces (biostatic/biocidal) to reduce spread of infectious pathogens in medical shelters



Warfighter Directorate

Development & Engineering Competencies

- Combat Clothing & Individual Equipment
- Chemical/Biological Protective Ensembles
- Load Carriage Systems
- Camouflage & Concealment
- Soldier & Small Unit Power/Data Systems
- Mission Information & Planning Systems
- Situational Awareness Tools (micro-UAVs)
- Human Factors
- Prototyping & Testing

S&T Thrust Areas

- Multifunctional Materials
- Biological Sciences
- Protective Materials & Systems
- Human Sciences (Physical and Cognitive)
- Human Anthropometry

Foundation Areas

Foundational Areas

HUMAN SCIENCES

- Anthropometry
- Biomechanics
- Cognitive Science
- Consumer Research
- Human Factors/MANPRINT

MATERIALS SCIENCES

- Advanced/Interactive Textiles
- Bioscience & Technology
- Modeling & Analysis (Physics–based)
- Multifunctional Material Systems
- Nanomaterials Science & Technology
- Polymer Science & Engineering

PROTECTION

- Ballistic Protection
- Chemical/Biological Protection
- Camouflage
- Environmental Protection
- Eye Protection
- Flame/Thermal Protection

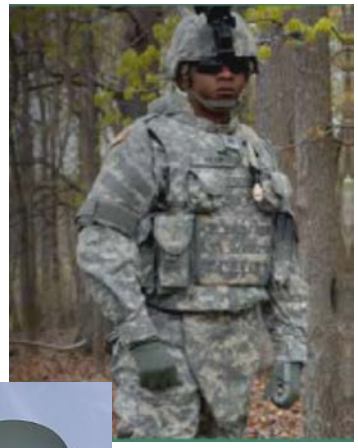
Technology Analysis and Advancement

- Force-on-force constructive simulation for operational effectiveness analyses
- Textile Testing and Evaluation
- Design, Patterns and Prototyping

Body Armor – No Single Solution

Countermine, BASIC

Advanced Bomb Suit



Interceptor

Advanced Combat Helmet

Inconspicuous Body Armor

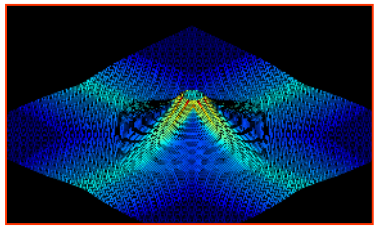
AIRSAVE

Combat Vehicle Crewmen Vest

Combat Vehicle Crewmen Helmet

Emerging Ballistic Protection Materials Technologies

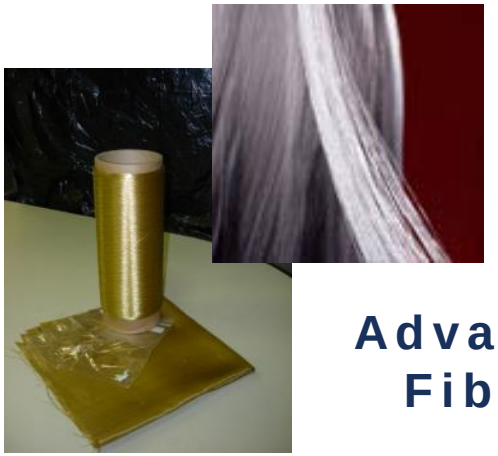
Transparent Armor Materials



Materials Behavior Models and Test Methods

Ballistic Composites and Processing Methods

Lightweight Textile and Ceramic Armor Materials

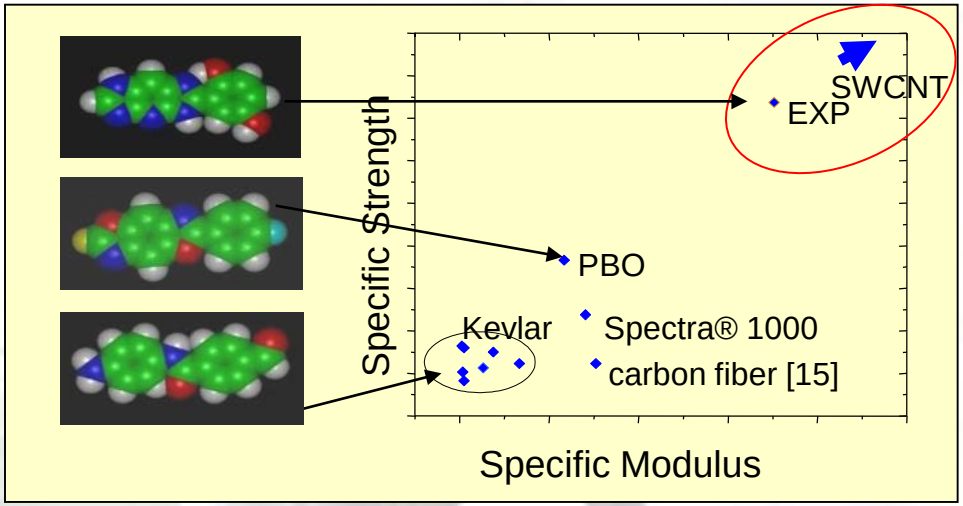


Advanced Fibers

Continuous improvement in materials technologies for ballistic protection

Technology for Individual Ballistic Protection - Fiber Compositions

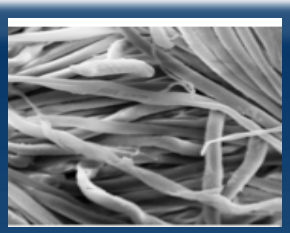
- Critical to next generation armor weight goals
- Fiber component for all except transparent



Fiber	Tensile Strength (GPa)	Tensile Modulus (GPa)
Para-aramid	2.8	66.7
UHMWPE	3.0	115
PBO	5.8	180
Carbon IM7	5.15	276
Experimental	6.0-8.5 (goal)	
C/CNT	10.0-12.0 (goal)	

Ballistics Summary

- **Future Desired Capabilities**
  - Reduced load
  - Improved tactical mobility
  - Increased survivability
- **Technology Barriers**
  - Development and integration of high performance materials to protect against multiple ballistic threats
  - Understanding the coupled response of the body & armor at high strain rates
  - Reduction of weight and bulk associated with increased protection
- **Pacing Technologies**
  - New high performance fibers & composites
  - Advanced ceramics & metals
  - Enhanced predictive modeling
  - Material systems integration

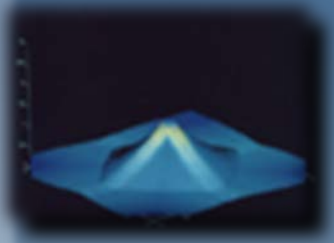


Fibers & Textiles

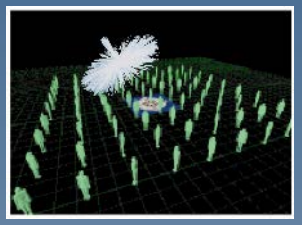
Biomechanics

Composites Engineering

Transparent Polymers



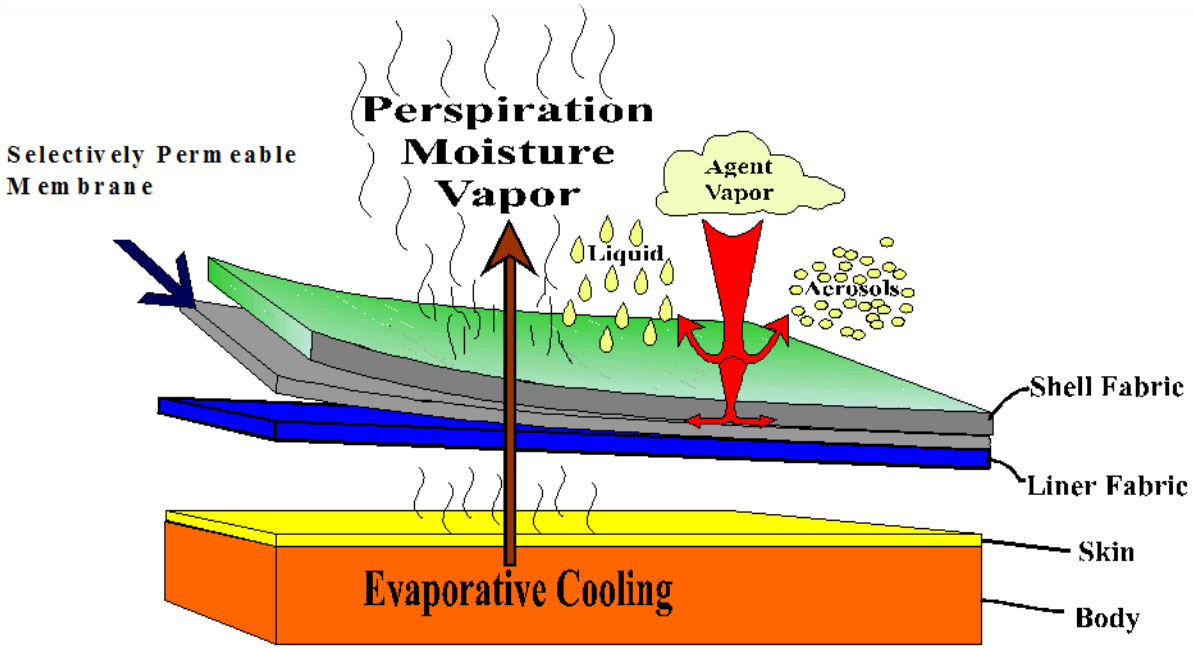
Materials Behavior Modeling



Casualty Reduction Modeling

Chemical/Biological Protection

Protection versus Thermal Burden



Chemical-Biological Protection

Future Desired Capabilities

- Increased tactical ability (reduced weight/bulk)
- Increased mission duration
- Increased percutaneous protection (aerosol, liquid, vapor)

Technology Barriers

- Lightweight, carbon-free materials
- Deactivate chemical hazards via reactive mechanisms
- Neutralize biologicals on contact
- Improved Closure systems

Pacing Technologies

- Super omniphobic surface treatments
- Advanced C6 formulations for water and oil resistance
- Selectively permeable membranes with high MVTR
- Improved fiber functionality (metal organic frameworks, polyoxometallics)
- Intelligent textiles

Camouflage – Signature Reduction

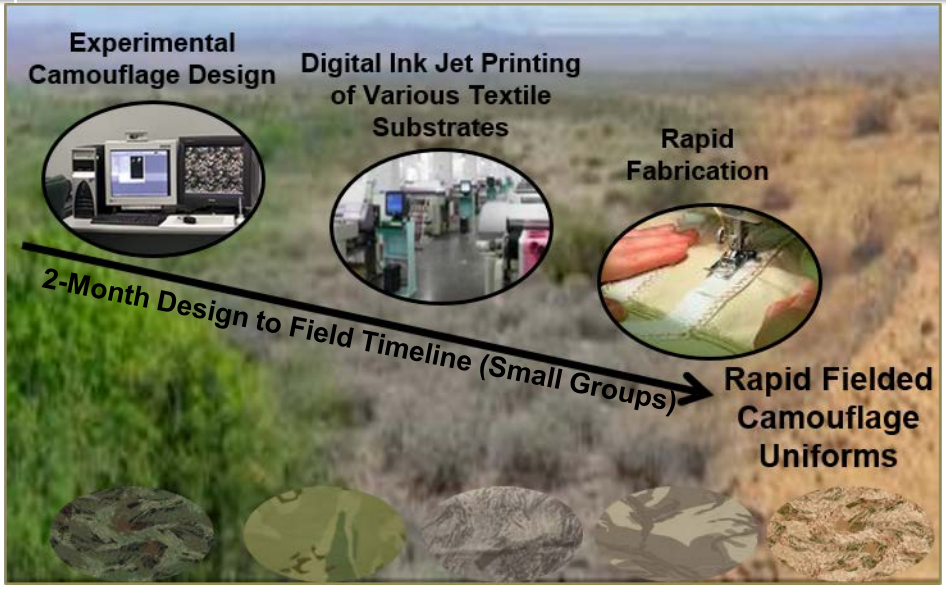
Digital Ink Jet Printed Camouflage and Rapid Fabrication of Soldier Uniforms and Equipment

Challenge: The focus of this effort is to extend camouflage protection on all military fabrics, and rapidly construct uniforms and equipment for small groups of Soldiers. A challenge exists with balancing performance goals and requirements in visual, near infrared, and short wave infrared spectral regions while maintaining a durable print. Also a challenge exists of streamlining processes to develop unique designs, ink jet print, and rapidly fabricate end items within a specific time frame.

Army Benefit: This project will show the ability to rapidly produce theater-specific camouflage uniforms, in limited quantities, while reducing costs associated with minimum orders of traditional printing processes. It will extend camouflage protection in the visual, near infrared, and short wave infrared spectral regions on all fielded textile substrates. It also provides the ability to print unique designs that are incompatible with rotary wet print process.

Accomplishments: Initial studies have been conducted in developing site-specific camouflage patterns with ink jet printing technology that meet spectral requirements in a durable print. Print durability needs improvement. Field tests of the site-specific camouflage patterns will be conducted in Jul/Aug 2015 to help validate the camouflage design process. Traditional fabrication of small quantities of uniforms and Soldier equipment have proven to be costly, without appropriate colors on-hand for trim and webbing components resulting in delays in fabrication of both uniforms and equipment. Dedicated fabrication lines for large quantities of end items could not be interrupted for small quantities of goods.

Results: More focus on rapid fabrication techniques and durability of ink jet camouflage prints is needed. Dedicated fabrication lines for small quantities with assortment of appropriate materials in stock may increase production output in a more timely manner.



Payoff:

- Environmental Impact: More cost effective printed textiles in a greener manner (reduced waste water & energy use).
- Increase quality assurance, i.e. meet color tolerance set for a product, Reduce waste product (seconds) that does not meet color tolerance. Matched colors more closely and replicate colors time after time.
- Provide “On-Demand” capability: Provide the capability to produce on-demand region-specific camouflage covering multiple areas of interest to enable the rapid deployment of effective camouflage for small contingency groups.

Multifunctional Combat Uniform Fabrics

Operations in Iraq and Afghanistan have demonstrated the need for FR protection but durability and colorfastness need to be significantly improved. Insect resistance, camouflage, and liquid chemical agent protection also need to be **integrated into one combat uniform fabric, with Berry Amendment compliant textiles**.

Flame Resistance

Camouflage

Liquid Chemical Resistance

(CB Option)

Insect Resistance

Durability

Integrate

Comfort

Nonwoven Flame Resistant Coverall

Thermal Manikin Testing

- Nonwoven fabric
- Nomex IIIA blend
- Over BDU, t-shirt, and briefs
- Simple construction

- Quick don
- Low cost ($60)
- Disposable
- Limited wear life

- DuPont tested
- 4 sec exposure
- Provides protective char
- Underlayers intact

- Reduces body burn from 88 to 8%
- Field evaluated
- Approved patent
- May be GSA listed

Antimicrobial Interests

Operational Challenges

- Body odor and hygiene issues related to field training and deployments
- Bacterial infection of skin and soft tissue:
    - Affect 23,000 soldiers per year, $470 million in medical costs
    - Staphylococcus aureus:
        - Female health issues (UTI) affect 20,000 active duty female soldiers per year, $440M for treatments
    - Escherichia Coli:
        - Secondary infections from blast injuries/other war wounds, persistent challenge often colonized with multidrug-resistant bacterial strains (Staphylococcus, Acinetobacter Calcoaceticus-Baumannii complex, Pseudomonas or Klebsiella)
- As of 2010 - > 15,000 Warfighters wounded in action and not returned to duty within 72 hours
- Costly operational impact in lost duty/training time

NSRDEC Objectives

- Investigate broad versus narrow spectrum solutions
- Develop targeted antimicrobials to preserve commensals and limit resistance caused by broad-spectrum antibiotics
- Determine best approaches to incorporate antimicrobials into clothing and individual equipment

Advanced/Interactive Textiles

Temperature Adaptive "Smart" Insulation

Concept

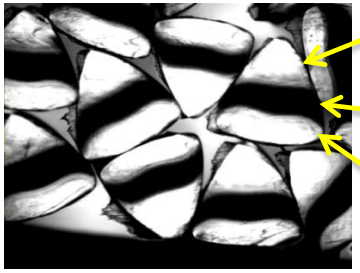
- Fibers act like a bi-metal spring coiling when cooled.
- Coiled fibers create loft, which provides insulation.

3 different polymers - Fibers curl, batting gets thicker.

3 components using the same polymer - No curling or change in thickness.

Fiber Cross Section

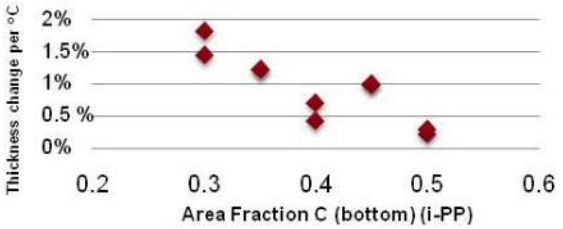
- Tricomponent capabilities allow polymer compatibilization



Micrograph of undrawn fibers

CTE = Coefficient of Thermal Expansion

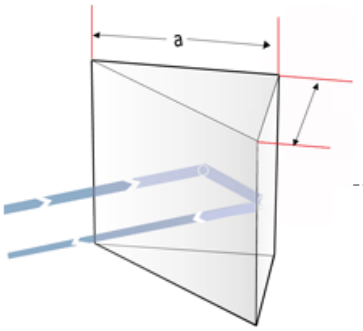
Temperature Response of Battings



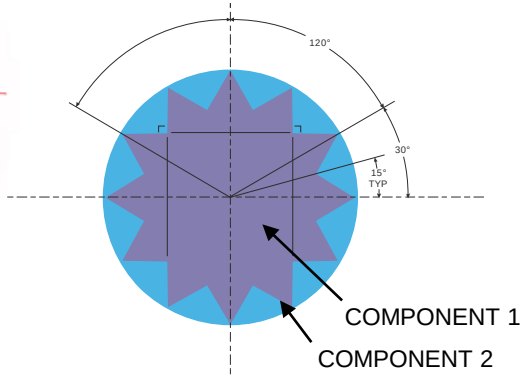
Enhanced Reflection Fiber

Fiber with Enhanced Optical Response

- **Right angle feature:**
  - *Redirects light back to source*
  - *Enables multiple reflections at fiber surface*
  - *Increased sensing surface area*
  - *Single, bi- or tri-component*



Retro-reflection from a right angle feature



Bi-Component Fiber

Cross Section

Electronic Textiles

- **Electronic Equipment -**The Warfighter is increasingly being equipped with a variety of electronic devices designed augment their abilities. These include: wearable displays, computers, radios, phones, GPS &dead-reckoning units, sensors

- **Etextile Networks** - Wearable networks transporting power and data through out the soldier system from energy harvesters to energy consuming devices reducing the need for batteries.

- Demonstrated power loads up to 64W at 4A; e-yarn voltage ratings of ~ 1 kV
- Demonstrated support of network protocols: analog audio/video, Serial (RS-232, etc.) 1000BaseT (Gigabit) Ethernet, high-speed USB 2.0

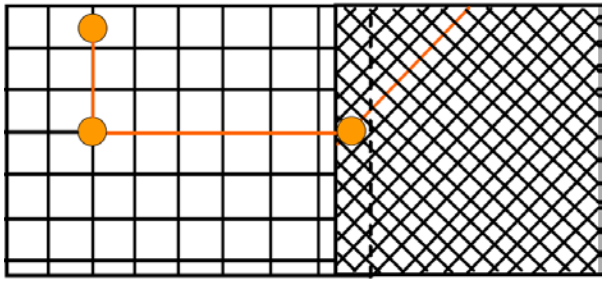
- Etextile Connectors

- Etextile Antennas

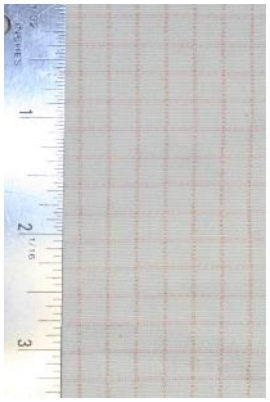
Electronic Textiles

- Electro-textile jacket contains integrated personal area network composed of insulated copper wire
- Electronic subsystems can be attached to the conductive grid

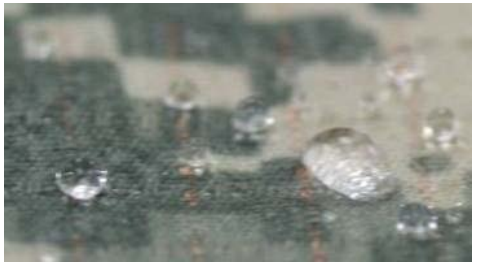
Insulated copper wires wrapped around a nylon/cotton yarn



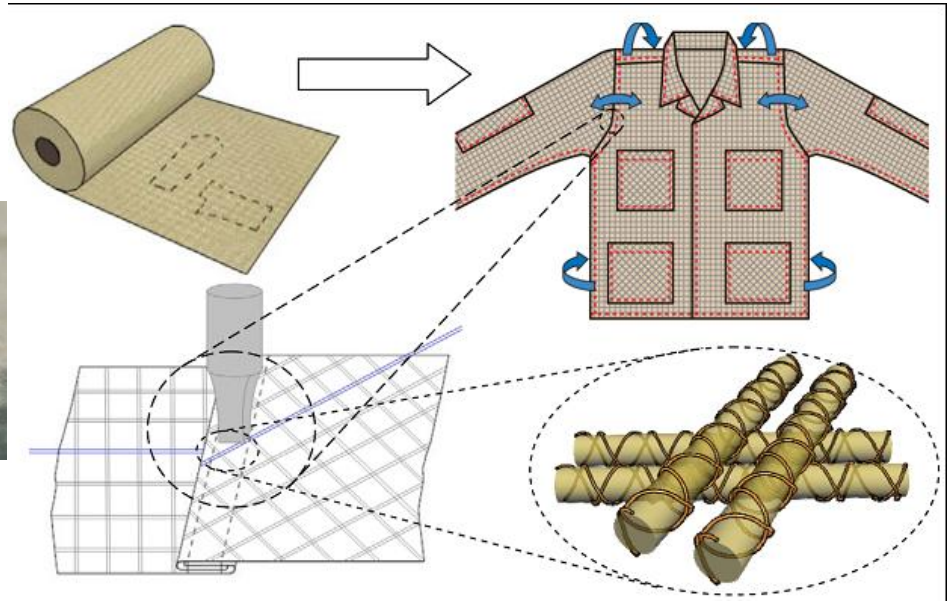
Untrasonic welding junctions at seams and within fabric



Copper wire grid woven into combat uniform fabric prior to camouflage printing



Copper wire grid woven into combat uniform fabric, camouflage printed and water repellent treated



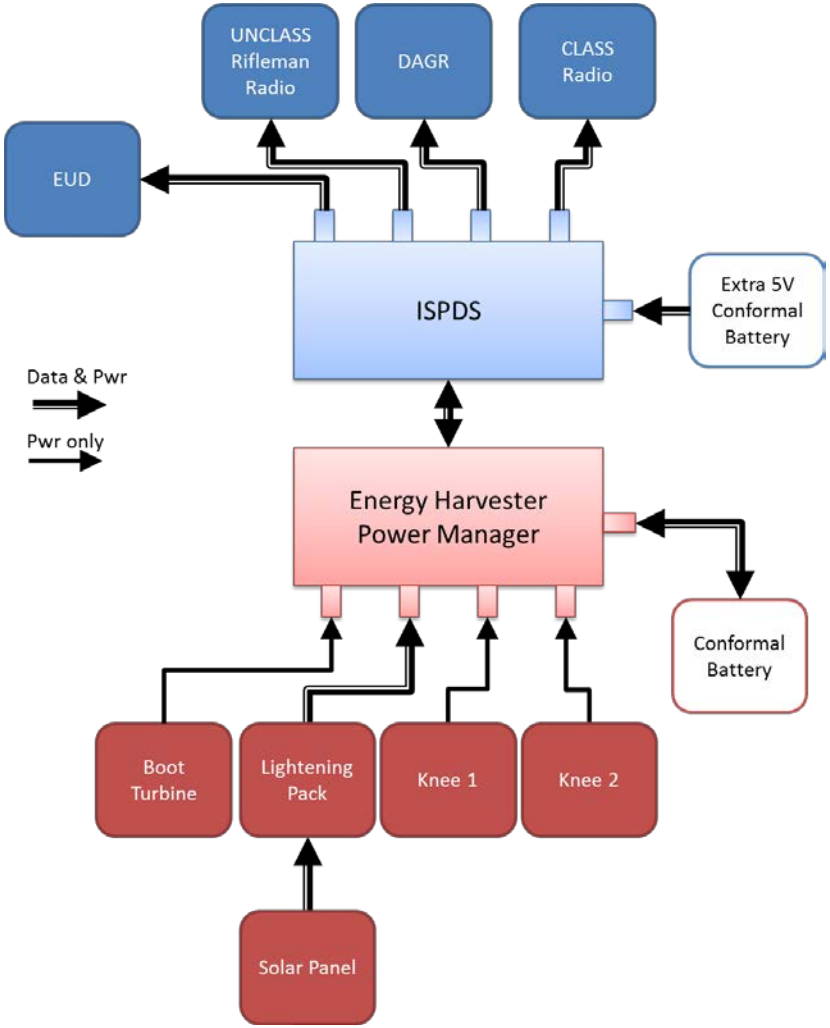
Ultrasonic seaming technology forms electrical pathways across seams

Control module and battery in pocket, Illuminated patch for demonstration of seaming technology only

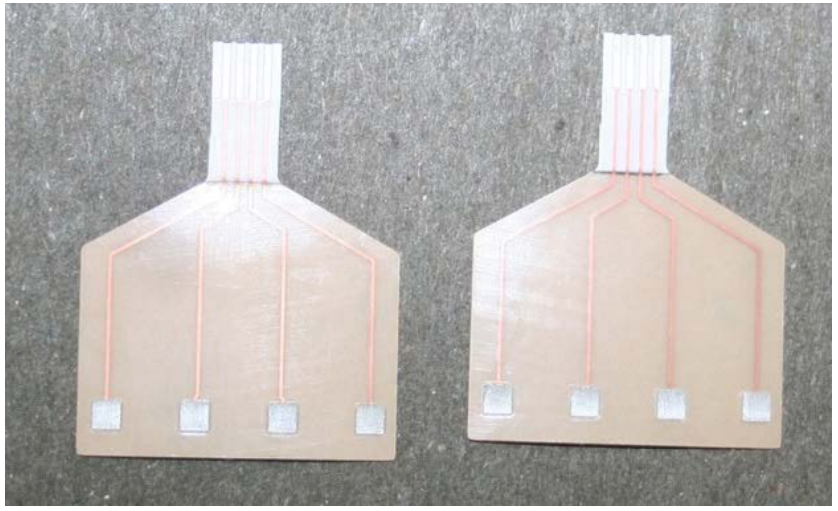
Etextile System Level Development

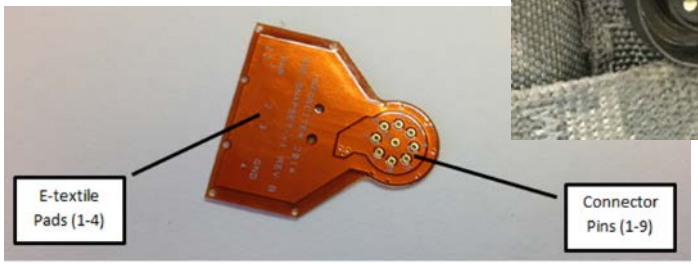
E-textile network integration into the soldier ensemble:

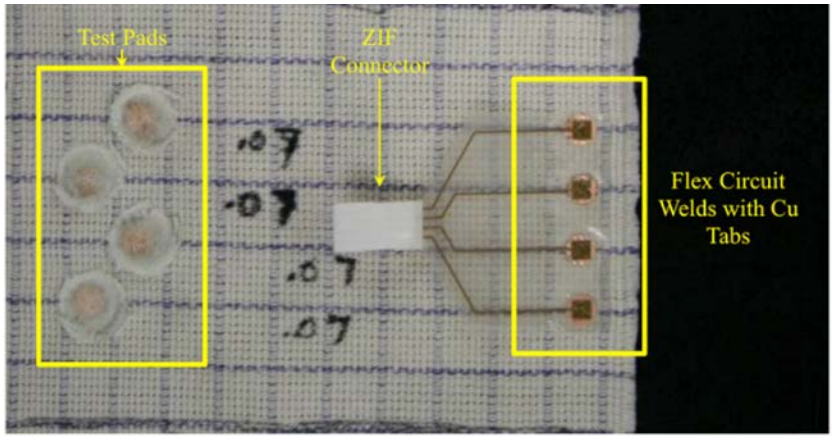
- Integrated Soldier Power and Data System (ISPDS)
- Energy Harvester Power Management System



Etextile Connectors



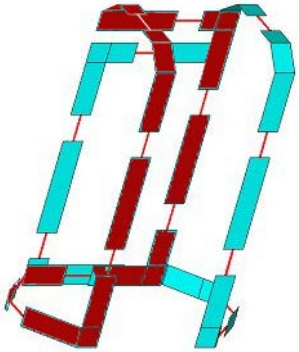




Electronic Textiles

Radiating Conductor:

- Double plain weave narrow fabric technology
- Parallel conductive strips made from tinsel wire
- Nylon filament warp, filling and binder yarns
- Optical fiber stuffer components



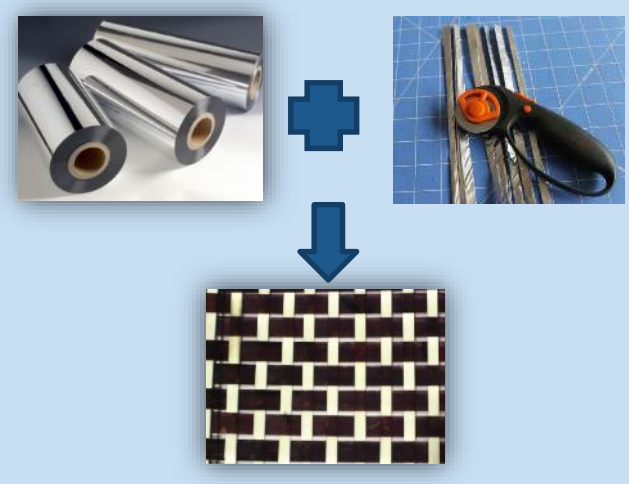
M02 019-2

Single Channel Ground and Airborne Radio System (SINCGARS)

- Double Loop Merenda Antenna
- Electronic switching modules (CERDEC)
- Body conformal, visually covert

M02 019-4

Photovoltaics



S&T Information: NSRDEC is developing next generation alternative energy photovoltaic "pseudo textiles" to allow for low cost recharging of batteries in situ, and reduce the need for logistical resupply in the field

Where we need assistance: NSRDEC is seeking to a private industry supplier to metalize three (3) mil polyethylene napthlate (PEN) rolled film with one (1) mil of silver via a low cost, high speed, high quality method. This metalized PEN will subsequently be slit to 4.5mm wide and used in the development of a quasi-textile material.

Challenge: NSRDEC has been unable to source a supplier of low cost silver metalized PEN film where the thickness of the metalized layer is adequate for use in this effort.

Approach: The PEN material sourced for metallization will need to be of electronics grade, with associated low surface irregularity / smoothness. Metallization will most likely need to be done via active cooling of the polymer during a single pass deposition, via a roll to roll multi-pass deposition process, or via lamination of the silver film to the PEN.

S&T Information: NSRDEC developing flexible colorized photovoltaic modules that allow for dual use military applications. It is expected that Soldier use of these items will reduce the need for logistical battery resupply in the field – especially for low power electrical loads.

Where we need assistance: Concepts and "outside the box" ideas for creating flexible colorized photovoltaic modules that have the ability to accurately be produced in any color, and do not utilize a mask or outer film that would reduce the conversion efficiency of the PV module itself. PV that has the ability to change color on demand via use of an external control is especially desirable.

Challenge: Traditional flexible PV modules are able to bend / roll in one axis only, and are typically less than 10% efficient. NSRDEC seeks solutions with "textile like" flexibility, and high conversion efficiency for consideration and development.

Approach: All approaches considered, with high Technology Readiness Level (TRL) concepts that require minimal modification to existing high volume production lines preferred. Simultaneous flexibility in all three dimensions is highly preferred.

High Performance Fiber Facility

The **High Performance Fiber Facility (HPFF)** will combine DoD, academic and industrial expertise in novel fiber/textile technology to invent and rapidly transition new optical, electronic, high strength, flame retardant and reactive materials to Warfighters and First Responders.

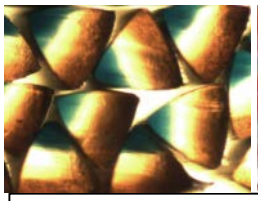
Mono/Bi/Tri-Component Fiber Extruder: Capacity is 1-6 pounds/hour and uses three separate melt pumps to optimize extrusion of polymers with different melt profiles.

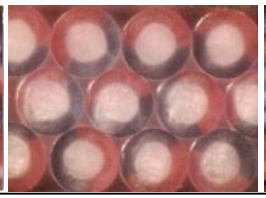
Knitting Machine

Dobby Loom
24 in. Cloth Width

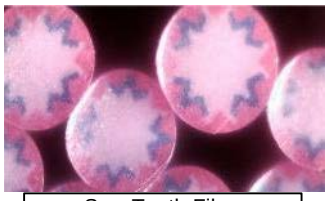
Yarn Twister

Braiding Machine

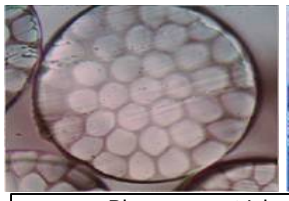


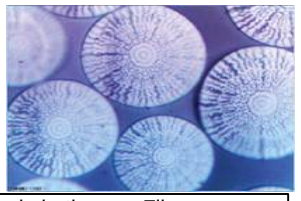


Tri-component Fibers



Saw Tooth Fiber

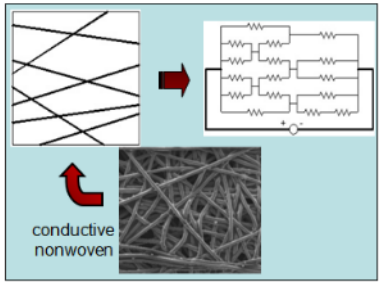




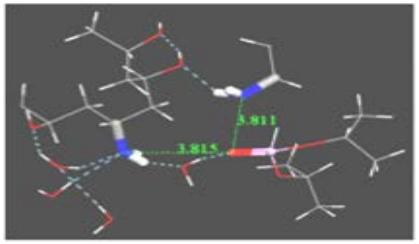
Bi-component Islands-in-the-sea Fiber

Modeling & Analysis (Physics based)

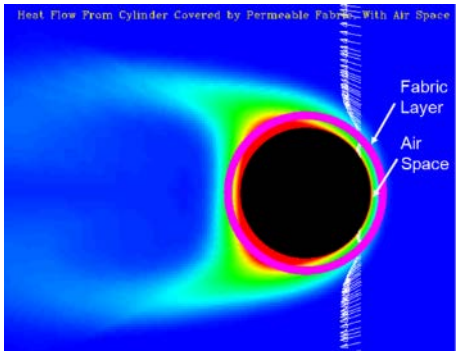
Nonwoven Network Resistivity Modeling



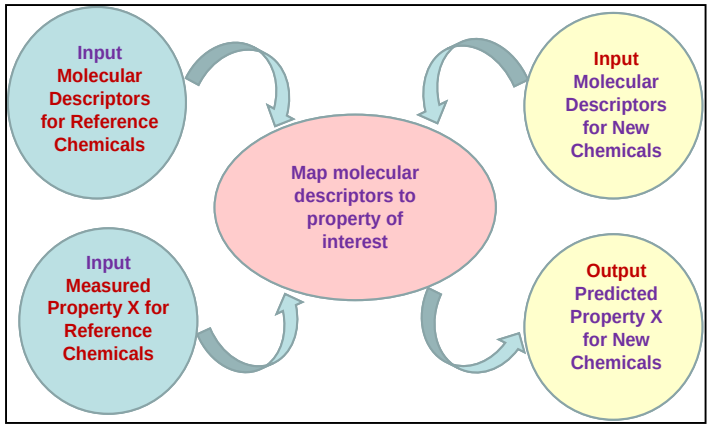
Molecular Modeling



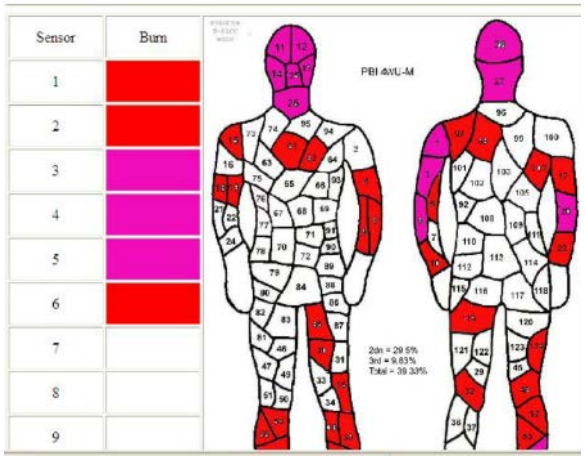
Transport Modeling



Computational Chemistry Modeling

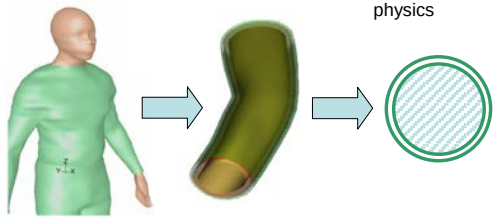


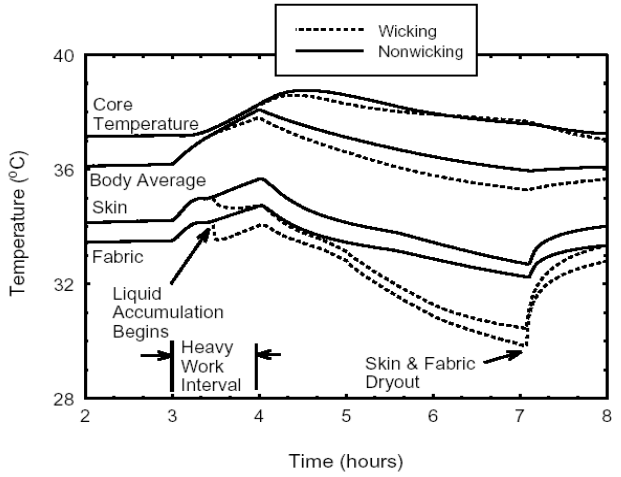
Burn Injury Prediction Modeling



Modeling of Human Thermal Physiology and Clothing Systems

Full Body (3D)	Body Section (3D)	Cylinder (2D)
•High memory and run-time; very large number of grid points •Incompatible length scales between human body and fabric thickness	•Captures 3-D flow effects •Good compromise between geometric accuracy and memory requirements	•Least memory and grid requirements •Best for time-dependent modeling and complicated physics





Textile Materials Evaluation

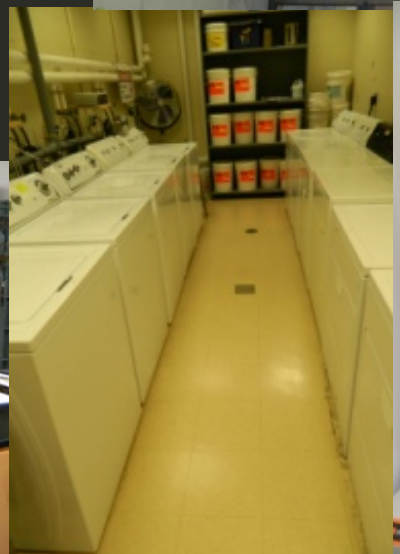
Primary Focus Areas

- Textile testing (> 100 test methods)
- Shade standard and tolerance development; shade assessment
- Expertise in findings, closures, fabrication techniq
- Permethrin testing, S&T efforts to develop insect repellent technologies
- Dyeing, printing and functional finishes technical and test support

Textile Performance Testing Facility

ISO 9001 certified for over 12 years

Robust quality management system



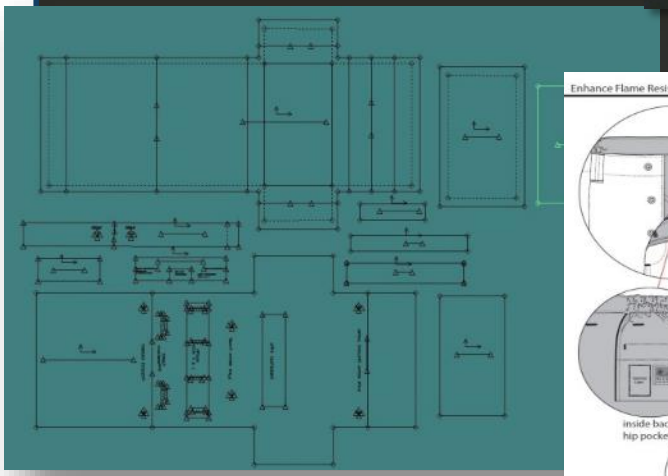
Design, Pattern, & Prototype

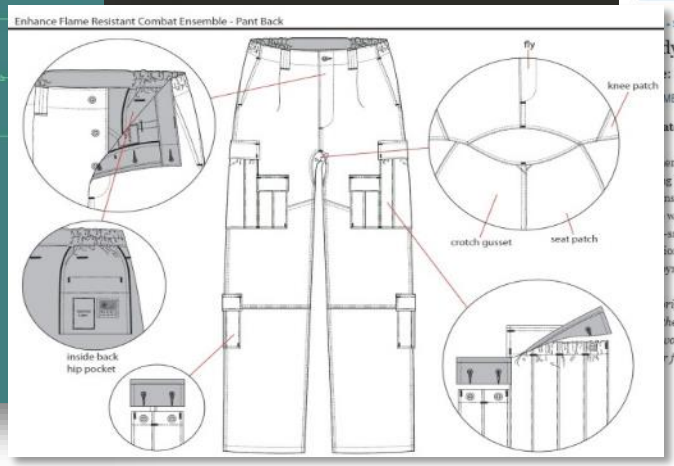
Capabilities Include:

- Original Concept Design
- Design Improvement
- Concept Illustrations/Art
- First Patterns
- Pattern Modification
- Grading/sizing patterns
- Prototyping
- Proof of Concept
- Computer Aided Design
- Technical Illustrations for specifications

Technical Support for:

- Fit tests & user evaluations
- First article tests & source selections
- Technical information for product descriptions
- Transferring pattern data to DLA Troop support.






BEST INVENTIONS

Best Inventions of the Year 2012

Robots, rovers and the rest of 2012's most important innovations, from the affordable to the extreme

Share Like 481 Tweet 28 +1 11 Share 6 Read Later

\$500

ly Armor for Women

: \$555

ME Staff | Oct. 31, 2012 | 0

ate Appended: Nov. 2, 2012

12 of 26 VIEW ALL

en are not small men. Finally realizing this, the U.S. military is g body armor designed expressly for a woman's body. Current ns are too loose and too long, leaving gaps that might make women more vulnerable to bullets and shrapnel. Even a men's small is too big for 85% of female troops. The 101st Airborne ion's 1st Brigade will test the new armor during an upcoming yment to Afghanistan.

riginal version of the article has been updated to reflect the fact he current designs of the armor provide protection for men omen against gunfire fragments; the new version provides a r fit.

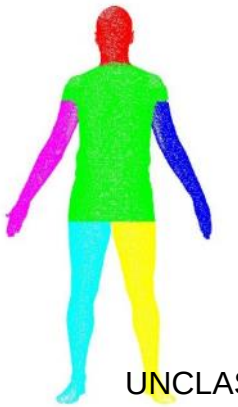
Anthropometry

Joint Service Anthropometric Study (JSAS)

Support to Directorates, PMs and other customers for:

- Clothing & Individual Equipment
- Load Carriage & Airdrop Harnesses
- Workspaces & Workstations
- Aircraft & Ground Vehicle Cockpits
- Computerized Man-models
- International Standardization

Scan



Segment

Measure

Center for Military Biomechanics Research

Facility

- Joint Natick/USARIEM Research Laboratory (Bldg 45)
- Unique facility within the Department of Defense
- 7,500 square foot facility
- State-of-the-art equipment
-

Capabilities

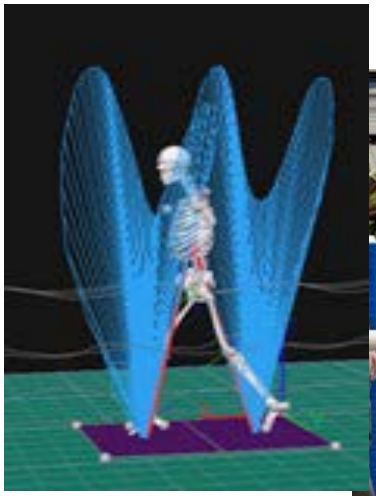
- Kinematic and kinetic analysis of movement
- Postural sway testing and balance testing
- Physiological measurements; muscle activity, oxygen consumption
- Performance tests; box lift, indoor and outdoor obstacle course
- Center of Mass and Moment of Inertia test instruments

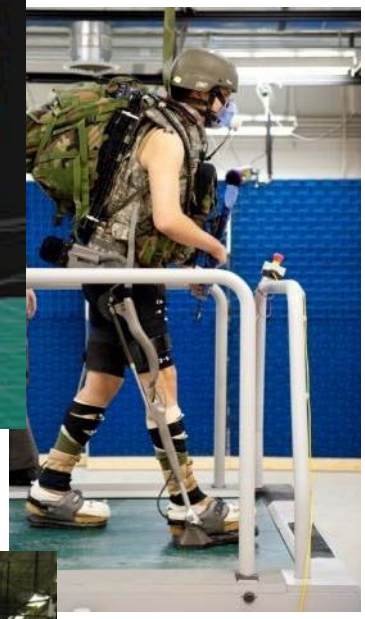
Basic Science

- Mass properties of load carriage
- Fundamental modeling mass properties of body segments
- Nonlinear analysis to track and predict physiologic fatigue using motion data
- Load and movement: perception/action coupling
- Fundamental exoskeleton investigations

Applied Science

- Footwear
- Physics based human modeling validation
- Biomechanical indices associated with the onset of fatigue
- Mass properties testing of Soldier equipment: helmet attachments, vests, etc
- Perception/action coupling and operational performance parameters
- Exoskeleton prototype evaluations





Service Needs

Navy Clothing and Textile Research Facility

- **White Dress Fabrics** – durable, comfortable, and wrinkle resistant
- **Flame Resistant Fibers and Fabrics** – low cost
- **Environmental Protective Fabrics** – improved water resistance, and improved thermal insulation
- **Electronic Textiles and Power Sources**
- **Green Textiles**

Air Force Clothing Office

- **Flame Resistant Materials** – improved comfort, non-pilling
- **Smart FR Materials** – responsive and adaptive to hot and cold weather (passive or active)
- **Boot Insulation Materials** – low bulk; aviation safe battery heated
- **Boot Socks** – low cost, comfortable, durable, non-melting
- **Aviator Gloves** – improved tactile, water-proof breathable, insulated
- **Seaming and Closure Systems** – non-snag can withstand windblast
- **Indicators** – for garment or materials signaling end of wear life, loss of protection, holes in CB clothing

Naval Air Warfare Center

- **Flame Resistant Fabrics** – low cost, 3.5 – 6.5 osy
- **Coated Fabrics**- improved self-healing for pneumatic bladders (life rafts, anti-gravity suits, etc.)
- **Dry Suit Fabrics** – puncture resistant, improved flame resistance
- **Filament Aramid Twill Fabrics** – alternatives to this discontinued flight jacket fabric (Mil-C- 81814)

Questions?