RFT Manufacturing Innovation Institute –
A New Industry/Government Partnership to Meet Future Defense and Commercial Needs

November 15, 2017

Defense-Wide Manufacturing Science & Technology (DMS&T) Program

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arroa

AFFOA Mission

AFFOA At-A-Glance

The Fabric Revolution: From Fiber Devices to Fabric Systems

MOORE'S LAW FOR FIBERS

The world's largest cache of fiber device intellectual property enabling the first technology and manufacturing roadmap for advanced fabrics.

PRODUCT

AFFOA is a product oriented manufacturing institute delivering "fabrics as a service."

INDUSTRIAL SUPPORT

AFFOA is funded by industry to accelerate introduction of revolutionary fabric products across industries from materials to apparel, fashion, electronics, transportation, defense, medical and consumer good sectors.

GOVERNMENT

AFFOA works closely with government partners, specifically the DoD to deliver revolutionary fabric products to the benefit of our men and women in uniform.

FABRIC INNOVATION NETWORK (FIN)

A collaborative infrastructure of 100 prototyping and pilot manufacturing facilities in 29 states spanning the entire connected fabric manufacturing: CAD, fiber devices, textiles, system integration.

FUNDING

AFFOA award winning proposal secured 340M in commitment from industry, universities and state governments to fuel the AFFOA manufacturing innovation engine.

FABRIC DISCOVERY CENTERS (FDCs)

A national network of centers combining advanced fabric start-up incubators with end-to-end prototype facilities with education and work force development.

affoa

AFFOA Leadership:
Industry, Academia, and Government

AFFOA Board of Directors

GEN Paul Kern (Ret.)
AFFOA Chairman of the Board
The Cohen Group

Norman Chapman
Inman Mills
President and COO

John Fry
Drexel University
President

Katie Stebbins
State of Massachusetts
Asst. Sec. of Technology,
Innovation & Entrepreneurship

Steve Rendle
President and COO
VF Corporation

Maria Zuber
MIT Vice President
for Research

Michael Spillane
Nike, Inc.
President, Product
and Merchandising

Yoel Fink
AFFOA CEO

Charlie Howland
Warwick Mills
President and Chief Engineer

Ray Stata
Analog Devices
Chairman of the Board
AFFOA Board Advisor

All Stakeholders Council (ASC)

+

Steve Luckowski
Govt PM

Tracy Frost
Director, DoD
MfgUSA Institutes

Phil Singerman
Assoc Director,
NIST

AFFOA Team: Institute HQ

CEO
Yoel Fink

COO
Tairan Wang

Director, Admin. & Membership
Tina Gilman

Senior Process Engineer
Chia-Chun Chung

Senior Admin. Asst.
Lorena Fiori

CMO
Eric Spackey

CPO
Tosha Hays

CTO
Aimee Rose

General Counsel
Tena Zara

Director, EWD.
Noah Drori

Senior Product Engineer
Mihai Ibanescu

Senior Product Engineer
Jason Cox

Defense Technology Lead
Sasha Stolyarov (LL)

AFFOA Membership

Membership Accrual

110 SIGNED AGREEMENTS

Startup/NPO (43)

AAFA
AFMA
American Boronite
APJet
ATACAMA
Ben Franklin Tech Partners
Bioteotix
Biowear
BK Accelerator
Blue Export Group
Bonbouton
Brrr!
Chameleon International
Electroninks
Elizabeth Whelan Design
Empatica
FabNewport
Factory 404
Force Fibers
FullScaleNano
Glocal Network
IFAI
Lean Enterprise Institute
Loomia
Ministry of Supply
Nanocomp Technologies
Nanowear
Nashville Fashion Alliance
NCTO
Parent Technology Group
Principled Design
Protect the Force
Rebel
Reserved Studio
SEAMS Association
Solielle Design Studio
TexDel
Textile Instruments
Uwila Warrior
Veil Intimates
Vorbeck
WETESO
WiseWear

Academic (26)

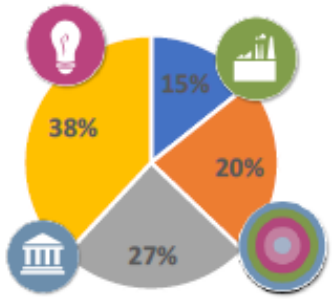
Carnegie Mellon
Clemson University
Drexel University
FIT
Indiana University Bloomington
Iowa State University
MassMEP
MIT
Manufacturing Solutions Center
NC State University
Ohio State University
Pennsylvania State University
Philadelphia University
RISD
TCC at Gaston
Thomas Jefferson University
University of Georgia
UMass Amherst
UMass Dartmouth
UMass Lowell
University of Central Florida
University of Kentucky
University of Maine
University of Minnesota
University of Texas at Austin
Virginia Tech

FIN (25)

American & Efird
Apex Mills
Auburn Manufacturing
Bluewater Defense
Boston Engineering
DSM Dyneema
E Ink
Fabreeka
Flextronics
Haartz
Hills
IDEO
Inman Mills
International Textile Group
Intradeco Apparel
Lakeland Industries
Milliken & Company
Otex Specialty Narrow Fabrics
Renfro Corporation
RTI International
Saab Barracuda
Sage Automotive
Tencate Protective Fabrics
Triton Systems
Warwick Mills

Industry (16)

ADS
Analog Devices
Cintas
Corning
DuPont
Gap
Highland Industries
Lear
Lubrizol Advanced Materials
New Balance Athletics
Nike
PVH
Saint-Gobain
Steelcase/DesignTex
VFC
Sumitomo Chemical



Institute Membership, cont.

The Model Member

AFFOA members have one thing in common, **they understand the need to innovate,** leveraging the access and connectivity of a robust ecosystem…

- Effective POC, actively engaged, forward thinking
- Management support
- Committed to manufacturing in US
- Recognizes market is changing
- Understands growth will come through collaboration

Industry

Accelerating product
Access to IP
Domestic supply chain

FIN

Business dev.
Access to new tech
Job creation
Workforce dev.

Startup

Access to market
Strategic investors
Rapid prototyping

Academia

Transitioning IP to product
Education
Job creation
Leadership

Low "barrier to entry" model

Basic membership principles:

- Simple 1-2 page agreement
- "No more tiers"

AFFOA developed a profile of a "model member" for each member category which is being used in recruitment efforts.

Technical and Product Strategy

Technical Strategy

IP Derived Roadmap

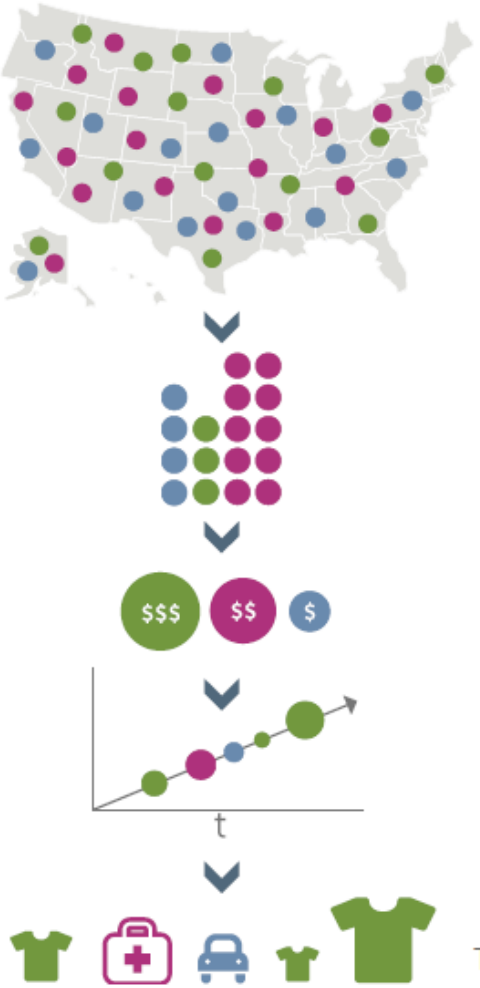
IDENTIFY
Geographically distributed IP in fibers, fabrics and textiles

CLASSIFY
Core IP Capabilities (CIC)
e.g. Antennas, Batteries, Color Change, FR, Antimicrobial, Heating/cooling

PRIORITIZE
Rank by market potential, time to market, enabling/strategic

ROADMAP
Key Technology Capabilities – Tech and manufacturing roadmap

INVEST
Roadmap projects



200,000 Patents and Applications - *July*

1,200 University RFT Patents and Applications with validation - *Sept*

40 Core IP Capabilities - *Sept*

Roadmap 1.5 - *Oct*

10 Roadmap Project Topics Released - *Nov*

Technical Strategy Development, cont.:
1-Stop Licensing Initiative

Universities
- Underserved, unencumbered IP marketed to manufacturers
- IP is bundled to make license valuable
- Follow-on roadmap funding
- Receive revenues minus fee

AFFOA
- Eliminates barrier to innovation and commercialization
- Establish platform technologies for the country
- Made in America clause
- Harnessing University R&D for the country

Industry
- One-stop shopping for IP
- Simple fee and royalty structure
- High value products
- Made in America

Technical Strategy Development, cont.:
IP Agreement Structure

Overview

- AFFOA can grant royalty bearing non-exclusive licenses to relevant RFT IP in aggregate to companies that agree to manufacture in the US
- The UNIVERSITY maintains the right to directly license on a non-exclusive basis the covered IP, subject to the requirement to manufacture in the US only
- AFFOA can bundle different pieces of IP from different universities for One Stop Licensing
- AFFOA offers simple terms to companies *($10k annual fee per patent, approximate1% royalty, split among patent suite owners*) for non exclusive license
- UNIVERSITY receives licensing revenues minus 15% admin fee
- UNIVERSITY can withdraw IP that is not currently under license or AFFOA investment

Technical Execution

3 Main Means of Execution

Technical Execution: First Project Call

Year 1 Project Attributes

"Moore's law" to "Apparel as a service"

Manufacturing Thrust	
Computer-Aided Design of Integrated Textiles (CAD-IT)	• Each project goes from CAD, fiber device (FYD), textiles systems and assemblies (TSA), SI • Relies on MRL 4+ technology • Prototype needs to demonstrate a value added service that can form the basis for a business model • Limited size working prototype • IP protected – subject to "made in US" • Market (company) targeted value • Manufacturing scalability needs to be executed in partnership with a manufacturer • Field programmability • Offer new and revolutionary capabilities • Connection to the digital world • Demonstrate a platform for additional capabilities, path towards improvement
Fiber and Yarn Devices (FYD)	
Textile Systems and Assemblies (TSA)	
System Integration (SI)	

Project Call 1.0 Topics

Climate Control
A fabric system capable of providing local climate control

Construction Fabrics and Composites
Fabric system capable of providing a new service in construction material or interior design and includes fabric-based composites

Color and Appearance
Designed color profiles to create new fabric capabilities

Monitoring and Acting
Fabric systems that can both sense and respond to external stimuli

Physiological and Medical Monitoring
Fabric systems that can monitor and report physiological and performance status

Touch/User Interfaces
Fabric systems that enable new, natural user interfaces to existing electronic devices

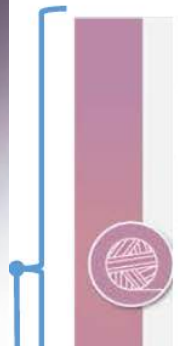
On-Demand Chemical Release
Fabric systems capable of releasing chemicals on demand

Fabric Optical Communications
Fabric systems that enable optical-based communications to provide overt or covert communications outside RF bands of energy

Energy
Generating, storing and/or supplying power to relevant, modern electronic systems

Engineered Properties
Self-clean, change shape, remember shape, control moisture, self-heal, react or respond based on surface properties, control and vary permeability or other properties

Technical Execution: First Project Call



Capability	Market	Methods	Materials	Machine	Man
Conductive	5	✓	✓	✓	◌
Capacitive	5	◌	✓	✓	◌
PBG	2	✓	◌	◌	◌
Light Emission	3	✓	✓	✓	◌
Battery	5	◌	◌	✓	◌
OD Chemical Release	4	◌	✓	◌	◌
Strain/Pressure Sensing	4	◌	◌	✓	◌
Knitting		✓	◌	✓	✓
Weaving		◌	◌	✓	◌
Interconnect		✓	✓	✓	✓
		◌	◌	✓	✓

Technical Execution: First Project Call

Color Change *Technology Roadmap*

E ink. RISD affoa

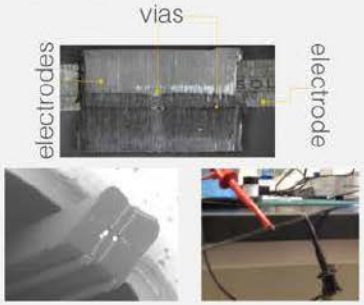
Q2 2017	Q3 2017	Q4 2017	2018
• 35% Fill Factor ✓ • 10% Contrast ✓ • 1000 V Switching ✓ • 800 x 450 µm ✓	• 67% Fill Factor ✓ • 25% Contrast ✓ • 500 V Switching ✓ • 240 x 440 µm ✓ • Lensing Integration ✓ • 100s m Fiber ✓ • Reliable Switching ✓	• 75% Fill Factor • 60% Contrast • 50 V Switching • 500 µm Round	• 80% Contrast • 15 V Switching • Ink in Draw • Arbitrary Colors • 200 µm Round
• Manual Shuttle Weaving ✓		• Automated Weaving & Knitting	
• Two sided B&W ✓ • Low-power (9V battery) ✓ • Miniaturized Control ✓ • IP Filed ✓	• Standardized Contrast Measurements ✓	• Colors • Waveform Optimization • Reliable Connections	• Miniaturized & Optimized Electronics • Product Forms

Technical Execution: First Project Call

Interconnect *Technology Roadmap*

1 affva 2 flex affva 3 principled design

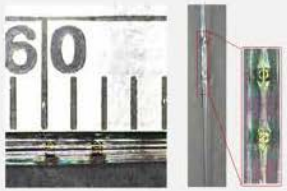
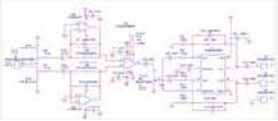
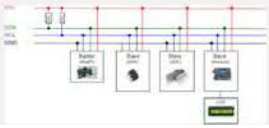
	Q3 2017	Q4 2017	Q1 2018	Q2-4 2018
FIBER	1 • Surface Terminated Electrode (STE) Preform Fibers ✔	2 • Machine Vision • Pick and Place • Laser Photoetching • Microindentation	1 • Optimized STE Fibers	
CONNECTOR		2 • Wire Bonding • Anisotropic Adhesive • Ink-jet Solder • Encapsulation	1 • STE Crimp Connectors	3 • Hybrid crimp/IDC style connectors • Stamp tool for 1 electrode fibers
SCALE			2 • Downselect of Semiconductor Tools for Manufacturing Integration	1 • Automated Crimp Connection of Textile 2 • System Integration of Semiconductor Tools



Technical Execution: First Project Call

Fabric Comm *Technology Roadmap*

MIT · Boston Engineering · Analog Devices · army · IDEO · David Bono & Assoc.

	Q2 2017	Q3 2017	Q4 2017	2018
	• Device spacing 1m ✓ • Fiber Diameter 800µm ✓ • Photosensitivity UV-near-IR (visible comm) ✓ • Yield 30% ✓	• Device spacing 2mm ✓ • Fiber Diameter 275 µm ✓ • Device photosensitivity UV through mid-IR ✓ • Device density 3x ✓ • Light Emission & Detection in Single Fiber ✓ • Yield 90% ✓	• Bussed Preform Scale and Crimp Connectors • I2C Implemented • Textile Quality Fibers 	• Custom Aspect Chips • Integrated Circuit Fibers • Automated Device Placement in Draw • High Throughput Preform Manufacturing
	• Gen 1 Hat ✓ 	• Gen 2 Hat ✓ 	• Orientational Weaving • Knitted Form Factors 	• Composites 
	• 1D Source ✓ • Common Mode Rejection ✓ • kB/s bit rates ✓ 	• 1D Indoor Tour ✓ • I2C Protocol Design ✓ • Invisible Comm testbed ✓ 	• Bidirectional Fabric Comm • Multichannel Comm • Dynamic Indoor Nav. • MB/s Bit Rates ✓ 	• Physiological Monitoring Fabric • Chemical Release • Sensing Composites • Light Emitting Composites

Product Overview

LOOKS™

Fabric as a service….Fabric as software

LOOks Product Evolution

Q4 2016 | Q1 2017 | Q2 2017 | Q3 2017

December 2016

February 2017

March 2017

June 2017

Product Overview

LiFi Cap Design

- ✓ Updated Design
- ✓ Streamlined Interconnect and Circuitry Construction

Product Strategy

MIT Freshman Orientation:
Class of 2021 with LOOKS backpacks

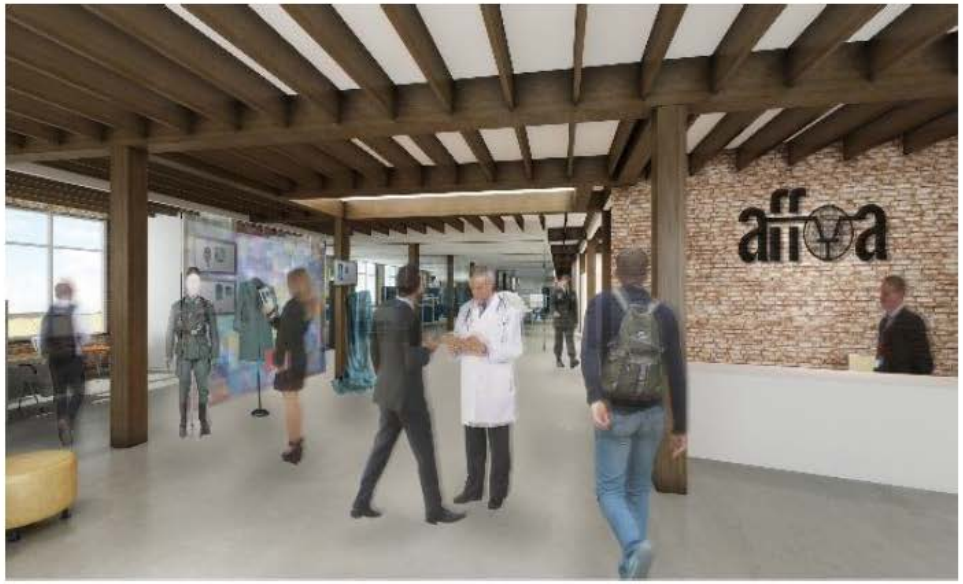

Fabric Discovery Centers
(FDCs)

End-to-End Prototyping Facilities

Fabric Discovery Center

Technology, Product, Manufacturing, and Education

- Technology
  - Rapid prototyping
  - Immediacy
  - Low cost
  - Heart of IP-creation
- Stakeholders
  - FEN
  - NNMI
  - FIN
  - Universality
  - Cost share
- EWD
  - Light weight innovation
  - Enabling play!
  - Student centered
  - Low barrier
  - Hands-on learning

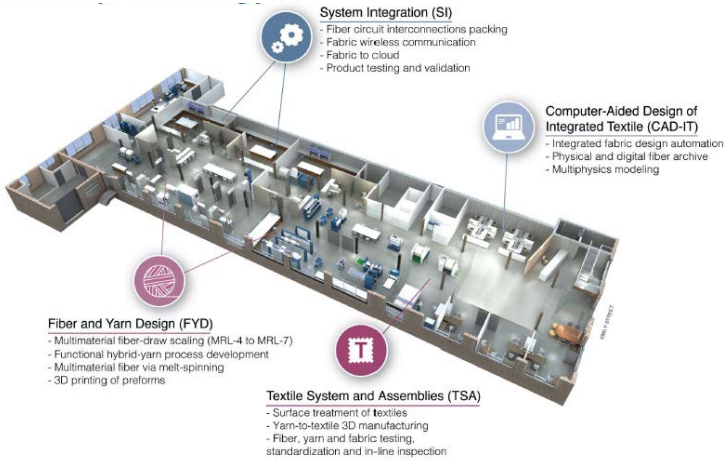


AFFOA Start-up Incubator Strategy

Fabrics Discovery Centers (FDC)
Establish near University Hub
State cost share for space & equipment
Competition for ideas
Diverse funding sources – AFFOA (federal, member), member direct, VC
Co-locating with prototyping capability, EWD assets
Jump start with regional competitions modeled after MIT $100k Entrepreneur challenges

Each FDC has its own distinct capability

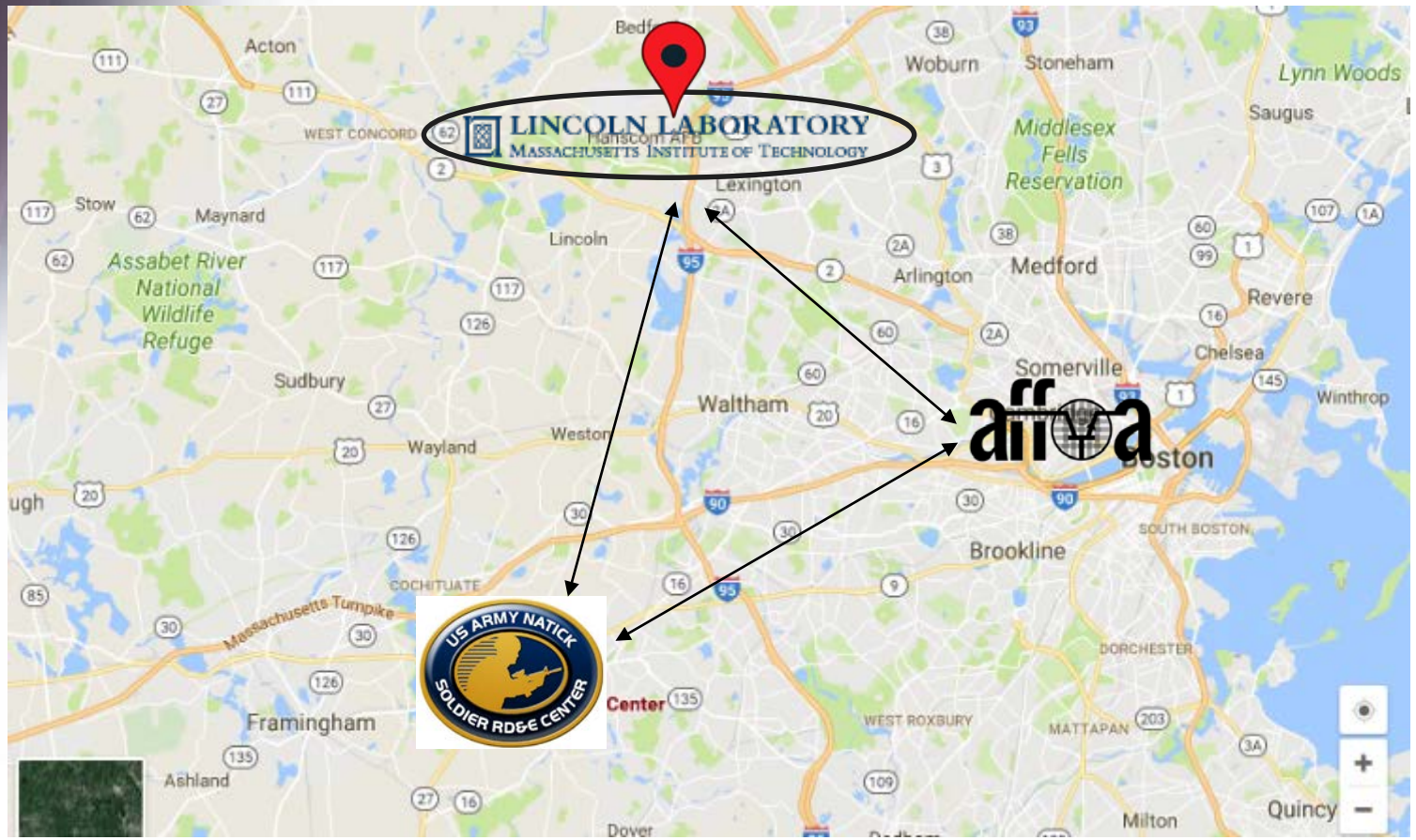
- Massachusetts: HQ, Defense, and Joint use (AFFOA, NextFlex)
- Pennsylvania – 3D knitting
- North Carolina – Non-wovens
- Georgia -- ??



- The FDCs' provide startup incubation space and other support to accelerate the formation of advanced functional fabric start-up companies
- The network of FDCs is expected to promote product innovation for the textile industry and thus, transition institute-developed technologies into commercial products

Operational Overview:
Anticipated FDC Locations

Defense Fabric Discovery Center (FDC)



Based at MIT Lincoln Laboratory (LL), the Defense FDC leverages a joint team, core competencies and existing facilities at LL, Natick Soldier Research, Development and Engineering Center (NSRDEC) and AFFOA

"Blue Teaming" Approach to Defense FDC Roadmap Projects

1 Understand Key Capability Gaps

Army Stakeholders:

- Combat Vehicle Protection
- Aviation Protection and Mobility
- Soldier survivability / protection
- Soldier load reduction
- Soldier situational awareness improvement

Navy Stakeholders:

- Low cost undersea acoustic sensor arrays
- Undersea optical comms
- Fiber antenna concept

Intelligence Community/Other Stakeholders:

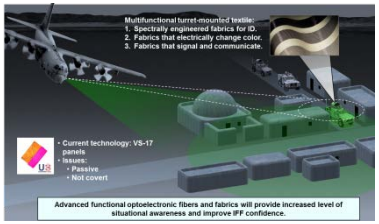
- Secure communication
- Other

DASD, Emerging Capabilities & Prototyping

- Other GAs covering broad set of DoD problem space

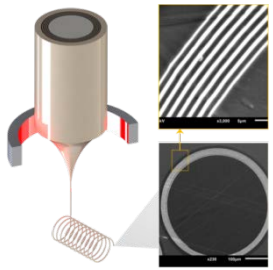
2 Develop System Concepts Leveraging Advanced Fibers

Identification and communications fabrics



3 Innovate on Enabling Fiber Technology

Photonic fibers



4 Perform System analysis

Viable?

No

Yes

5

- Develop Technology
- Prototype System Concept

Raise awareness to new capabilities

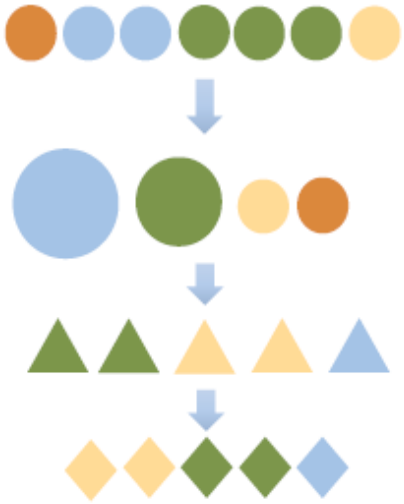
Projects driven by system concepts enabled by advanced functional fiber technology

Defense FDC Benefits to DoD

- Joint team of Lincoln Laboratory, NSRDEC and AFFOA provides near-term capability and long-term mechanism for stakeholder input
- Provide immediate capability to perform work on classified DoD products
  - Reduce time and program risk compared to obtaining facility clearance for non-Federal facilities
  - Establish more refined boundaries in classification guide to help facilitate commercial manufacturing, while protecting critical data
- Transition and share unclassified manufacturing processes to other FDC's and industry partners through a central data repository
- MA provides $6.25M of equipment capability as cost share to the Federal commitment of $3M (for projects) to the FDC (2:1 cost share)
- Provides linkage of other Lincoln Laboratory Federal customers to fiber and textile technologies

Education and Workforce Development Process

STUDY: the current and future needs of the technical textile industry utilizing quantitative data and qualitative analysis



PRIORITIZE: Rank by industry pull, time to market on product, strategic fit

ROADMAP: Address current needs, and future needs by aligning with technology capabilities

ANNOUNCE: innovation opportunities and EWD technology deliverables

FUND: product & prototype develop learning

Summary

- Participation in institute allows for project planning and leveraging Federal Investment of $75M
  - AFFOA has secured nearly 3:1 cost share from industry, universities, and state/Federal government
- Opportunity to partner with non-traditional industry members and access supply chain
- Opportunity to develop new domestic sources and capabilities
- Access to new technology, rapid prototyping network (FIN), and start-up assistance (FDCs)
  - Provide shared assets and knowledge to help companies access cutting-edge capabilities and equipment
- Affords opportunities beyond typical government contracts