The ATLAS Powered Rope Ascender

Student Technology Transition

-Fall 2004: Team ATLAS Enters *MIT-ISN Soldier Design Competition*
-Spring 2005: Working Prototype wins 3rd Place
Atlas Devices, LLC Incorporates, files patent
-Summer 2005: Demo at Infantry Center at Ft. Benning
-Since then: 3 more patents, Partnerships, further iterations, and contract with US Army Rapid Equipping Force

nate.ball@atlasdevices.com

The Device

Original Challenge: 50 ft in 5 seconds with 250 lbs
- -Device Weight: <25 lbs!
- -5 kW Mechanical Output in 25 lb package

Team ATLAS Original Design:
- -Similar to Cordless Power Tool
- -High Output DC Powertrain
- -Innovative Capstan Mechanism
- -Achieved 50 ft in 7 seconds with 250 lbs

Current Model: SRA03-1
- -17 lbs total weight
- -350 lbs at 5 ft/sec
- -600 ft vertical per charge

$$T_1 = T_2 e^{(\mu\theta)}$$

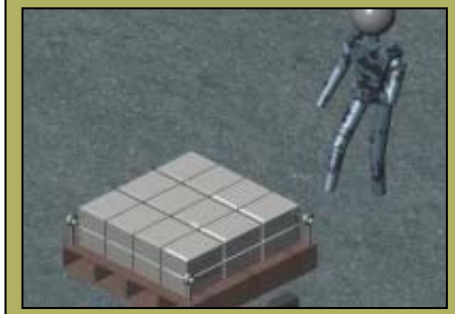
Multiple Iterations, Multiple Uses

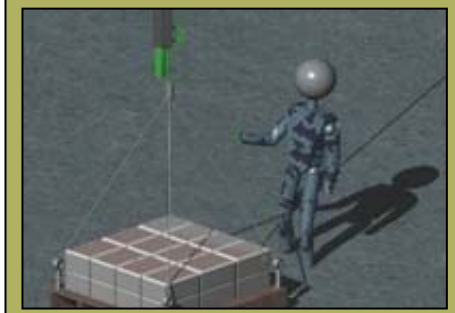
ATLAS DEVICES

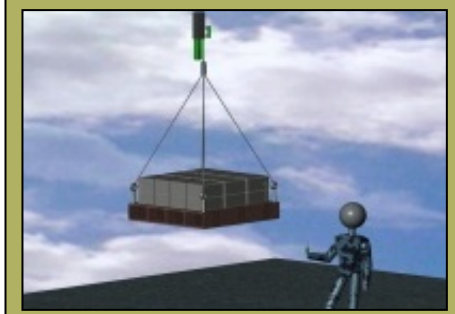
Powered Ascent

Rescue, Towing

Equipment Hauling







…and More

…

- Ship Boarding
- Maritime Rescue
- Obstacle creation & removal
- Gate/door breaching
- Cave exploration
- Maintenance access
- Industrial load positioning
- Helicopter rescue
- Portable winching
- Minefield Raking
- IED Removal

…

Current Focus

- US Army Rapid Equipping Force Delivery
- Development of further iterations for Specialized Applications
- Upgrading capabilities: Lighter-Weight, Smaller, Faster
- Graduation
- *Further sales:* Small-batch orders of the SRA03-1 for testing, evaluation & refinement

ATLAS DEVICES is:

Tim Fofonoff
- Ph.D. Candidate, S.M. Mech. Eng. MIT
- Member of MIT ISN and BioInstrumentation Lab
- Winner of 2006 $50K MIT Hatsopoulos prize

Bryan Schmid
- S.M., S.B. Mech. Eng. MIT
- Serial Entrepreneur
- Padmakar P. Lele undergraduate teaching award

Nathan Ball
- S.M. Student, S.B. Mech. Eng. MIT
- All American pole-vaulter
- Winner of 2007 $30K Lemelson-MIT Student Prize

Daniel Walker
- S.M. Student, S.B. Mech. Eng. MIT
- Experienced climber and rescue instructor
- Former MIT outing club president

Emerging Technologies from the Army-Funded Institute for Soldier Nanotechnologies (ISN)

by MAJ Rex Blair
Harvard Applied Physics Graduate Student and Uniformed Army Scientist at ISN

Harvard
School of Engineering and Applied Sciences

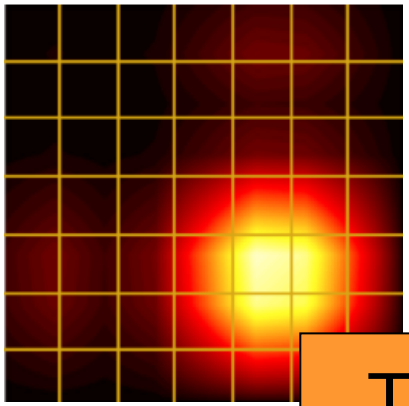
Massachusetts Institute of Technology

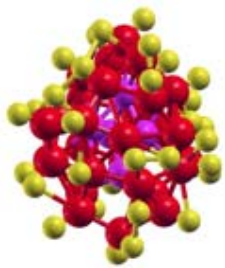
INSTITUTE FOR SOLDIER NANOTECHNOLOGIES
Enhancing Soldier Survivability

Boots to Benchtop… and Back…

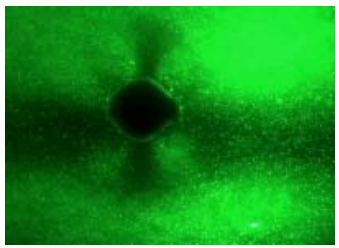
Rex.Blair@us.army.mil

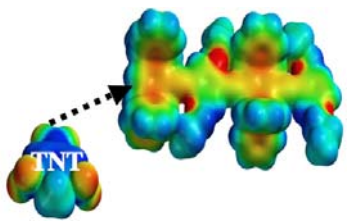
Institute for Soldier Nanotechnologies
MISSION





To dramatically improve the survivability of the Soldier by working at & extending the frontiers of Nanotechnology *through fundamental research*





ISN Research to Enable Key Soldier Capabilities

ISN Dedicated Facility

State of the art instrumentation

Multidisciplinary

40 Faculty (8 Departments)

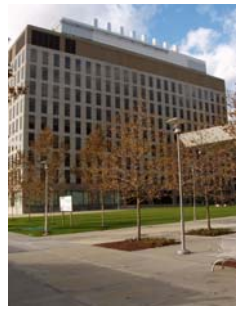
80 Grad students

30 Post-docs

2 Uniformed Army Scientists

4 Civilian Army Scientists

8 Industry Visiting Scientists



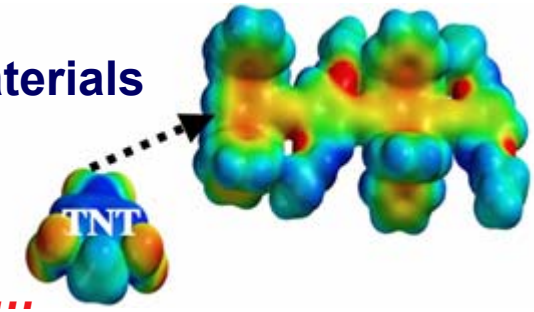
Industry Consortium

Army S&T Labs

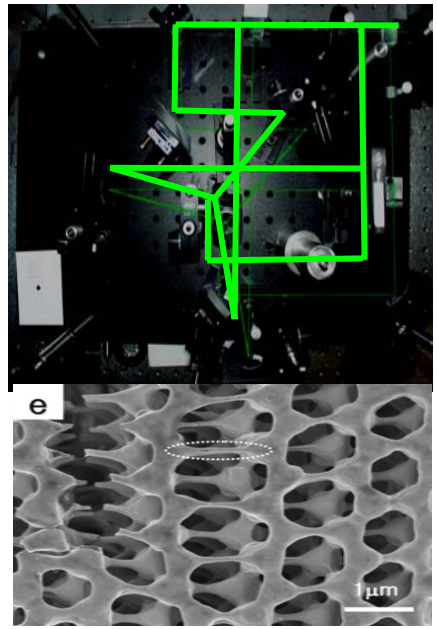
Rex.Blair@us.army.mil

ISN Research to Enable Key Soldier Capabilities

- ***Protect:***
  - *Lightweight,* **strong structural materials**
  - ***Ballistic + blast protection***
- ***Detect unseen threats:***
  - ***Explosives, chemicals, biotoxins…***



- ***Enhance:***
  - **Adaptive,** ***multifunctional materials***
  - **Soldier** ***performance monitoring*** **(medical status)**
  - **Injury triage and** ***treatment for survivability***
- ***Improve Performance:***
  - **Mechanical actuators:** ***"exo-muscle"***
  - **Situational** ***awareness***
  - **Give individual Soldiers** ***small-unit*** **capabilities: chem-bio, awareness, far forward medical care**

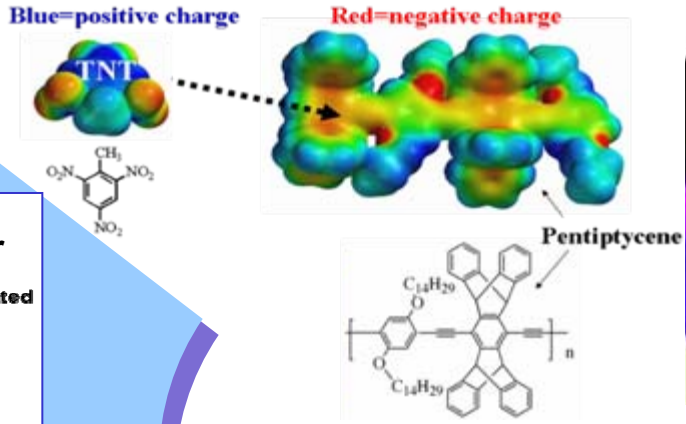


Microtrusses via 3D photolithography

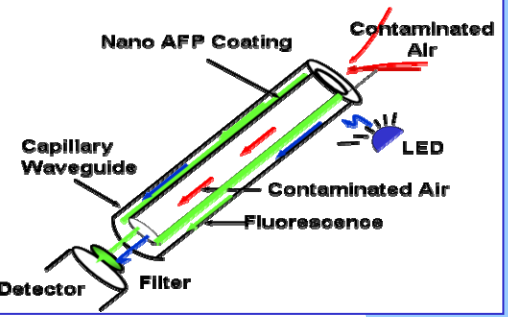
Soldiers are FIRST customers for improved protection

Science Making a Difference for Soldiers: FIDO Explosives Detector

MOLECULAR ENGINEERING:
designed molecules

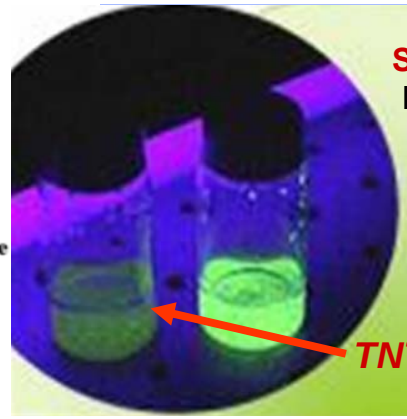


OPTICAL ENGINEERING:
integrated Detector/Sampler



REPACKAGING:
from DARPA Dog Nose concept to real Warfighter Device

DETECTION OPPORTUNITY:
Hidden explosives give off traces of chemicals, which may be detected.



SCIENCE: Amplifying Fluorescing Polymer (AFP) developed by MIT ISN Prof Swager glows green, but quenches when TNT is present.

TNT Detected

Assessments:
USMC in Iraq (2004), ATEC in Iraq (2005)
Procurements:
SOCOM (2005),
PMs (2006) for handheld + robot-integrated

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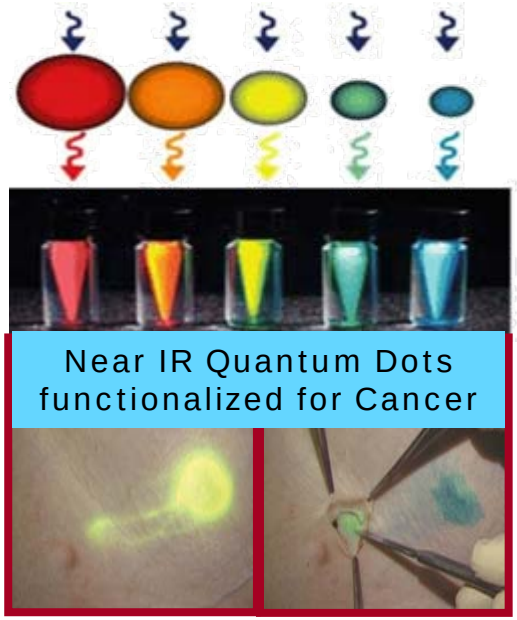
Mar 2007

Projects with Medical and Other Military Benefit Can Speed Technology *Adoption* (more than "*Availability*")

- **Near IR Quantum dots are functionalized for cancer, injected into patient; migrate to cancer cells (Bawendi)**
  - **Surgeon assesses Near IR image before a single cut**
  - **Cluster == much cancer, few dots == less surgery**
- **MEMS Microchip addresses Hemorrhagic shock (Cima)**
  - **Enables rapid drug delivery**
  - **Military is "lead user," leverages FDA approval process**



Near IR Quantum Dots functionalized for Cancer

Rapid drug delivery via MEMS device: prevent hemorrhagic shock

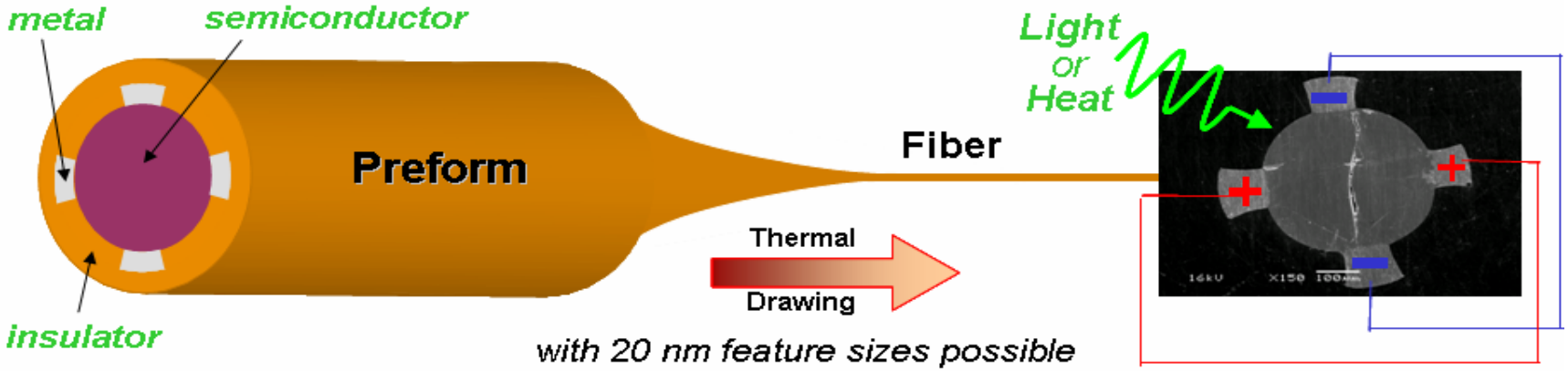
Explore implant (long term) and "Epi-Pen" (short term) types of delivery

Leveraging med research & partners:
Saves lives + grows market + accelerates tech adoption
== reduces costs + risks for Soldier applications

Fiber Web Linear Sensors

Optoelectronic fiber-devices for light, heat, & acoustic sensing:

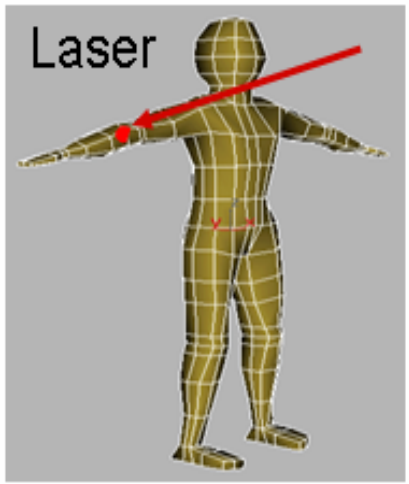
Full-body sensing (Photonic Band-gap Fibers)– new paradigm fibers & fabrics that can see, feel, hear…



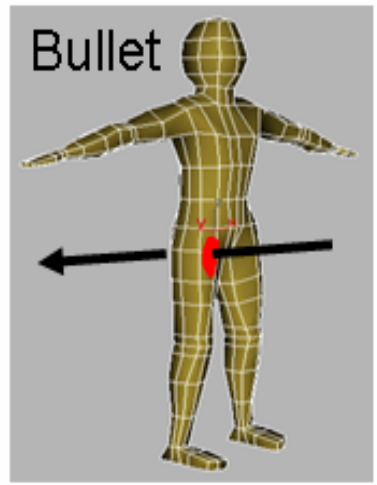
Full Body ID;

Laser-to-Uniform Non-RF Communications;

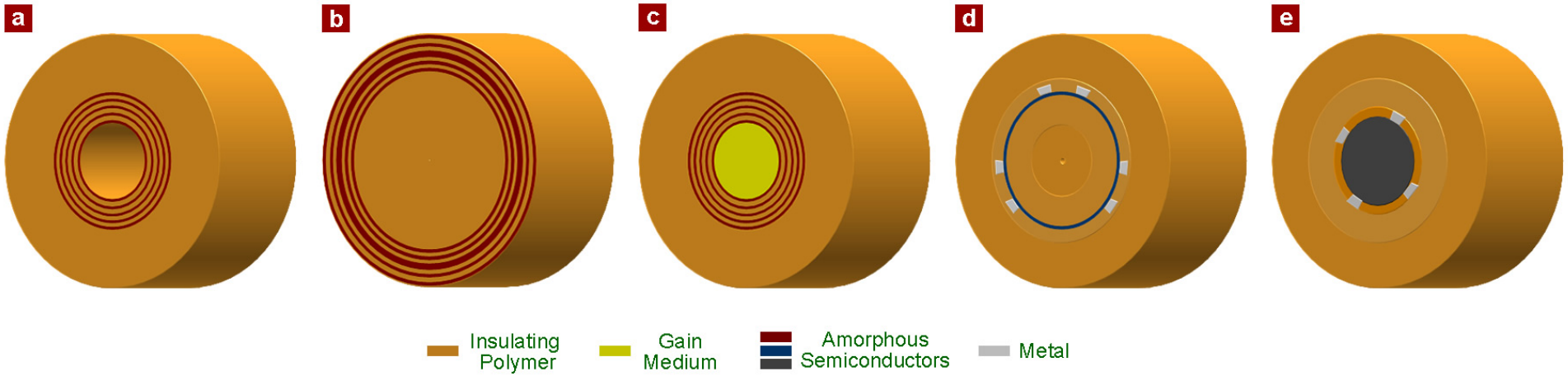
Improved MILES

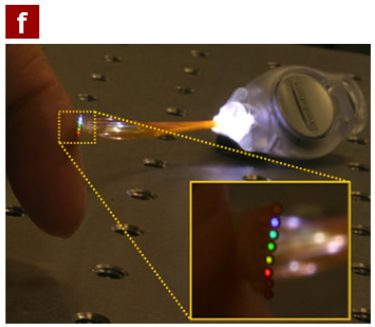


Full Body Thermal Sensing *Remote Triage*

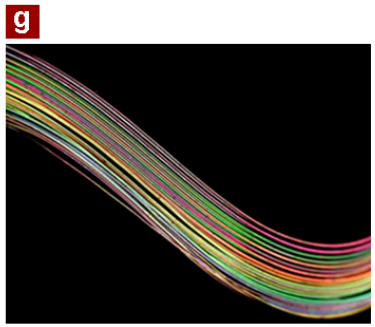


Fiber Web Linear Sensors:
Tunable Metal-Insulator-Semiconductor Fiber Devices



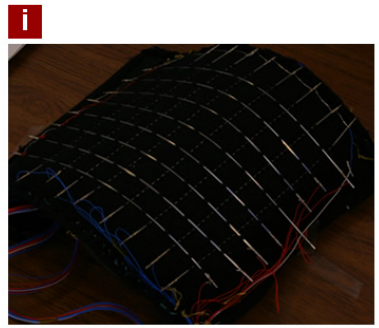


Hollow transmission fibers



Optical cavity fibers

Surface emitting fiber lasers



Thermal detector fibers

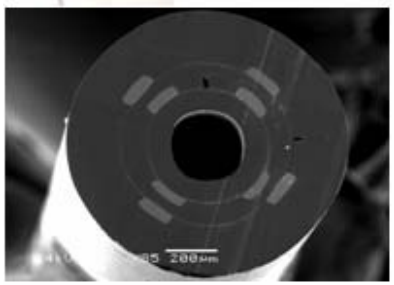
Optical detector fibers

ICOM-H Identification & Communication Helmet Prototype

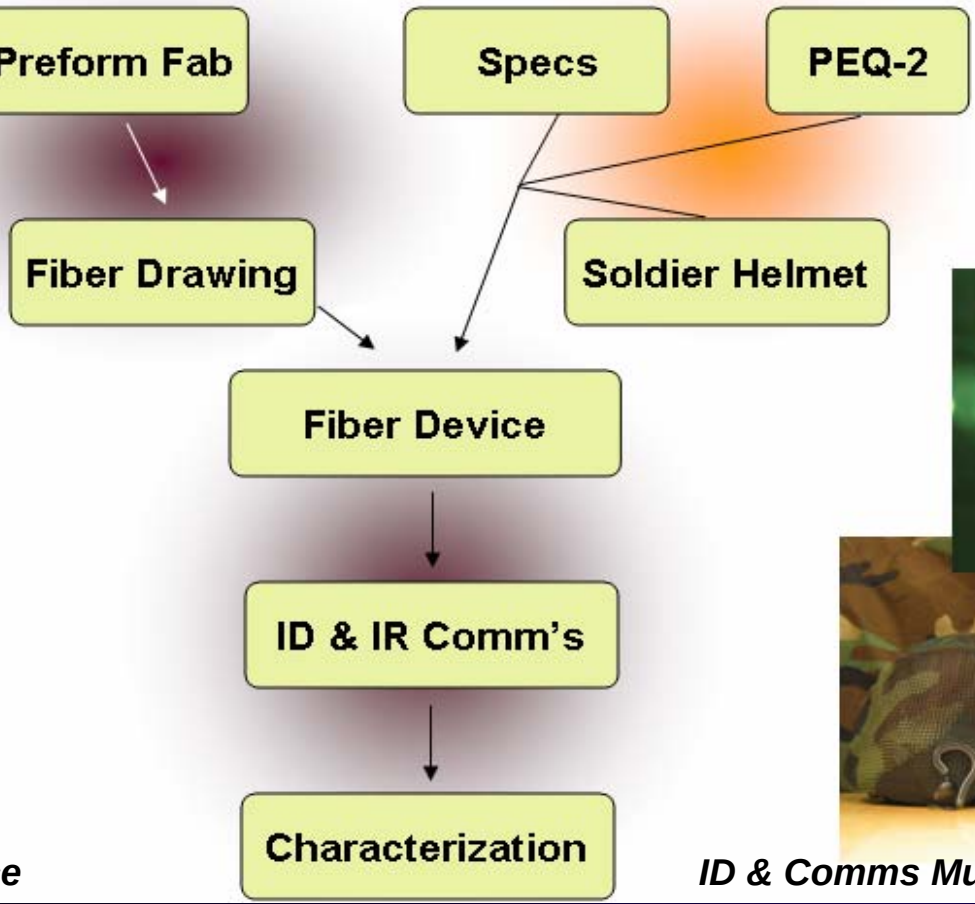
Design, fabricate, and implement an optoelectronic fiber-device covering for combat ID and line-of-sight IR communication

Prof. Y. Fink
Prof. J. Joannopoulos
MAJ R. Blair

NSC –
PM SOF Warrior
R. Elder



Optoelectronic Fiber-Device



ID & Comms Multifunctional Helmet

ICOM-H Identification & Communication Helmet Prototype

Be Alert for Opportunities:
MIT ISN Soldier Design Competition

COL Terry Clemons, QM DCD & COL Ernest Forrest, TSM-Soldier, look on as Team TXI demo their novel parachute canopy release mechanism

Judging the SDC

CSM Michael Kelso & COL Forrest examine TacShot's rocket-based photography system

Team Surreptiles, with COL Ted Johnson (center), show off their check for placing 2nd in the SDC finals

ISN Soldier Design Competition: Dealing with Success….

RALLYPOINT

Directional Gesture Communication System

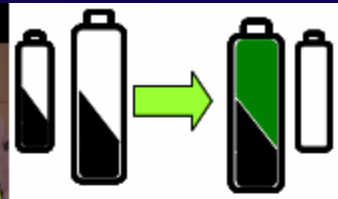
SDC-1: Digitized Hand-Arm Signals with Personal Direction Reference: Incorporated as RallyPoint, Inc., won 2 Army SBIRs ($750K) for Future Force Warrior (FFW) Handwear Computer Input Device

Army & Marine Challenges Ensure relevance

ATLAS Powered Rope Ascender

TLASmini.gif

USMA Team Supercharged



MIT Team Xitome: Kailas Narendran, CEO

SDC2: Battery Power Scavengers:

PEO Soldier – 2 designs (MIT + USMA) for Soldier field testing by Fall 2005 ($250K); FY07 contract for Iraq

Goal: Involve undergrads in ISN

- ➔**Solve real problems, to help Warfighters**
- ➔**Involve military: USMA, mentors, judges**
- ➔*Innovate to make a difference sooner:*

technology for Warfighters

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Mar 2007

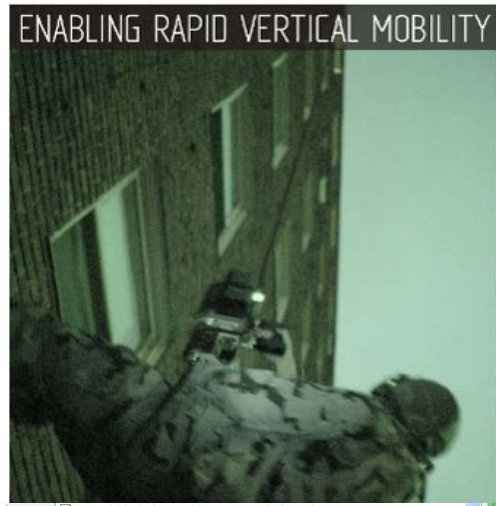
Broader Impact & Media Coverage

POPULAR science best of what's new 2004

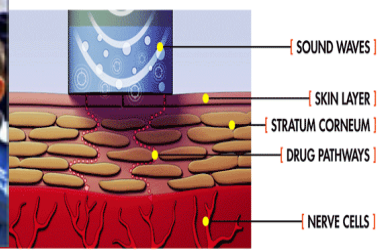
SonoPrep Skin Permeation Device
Injecting drugs with acoustics—not needles

SBIR: SonoPrep
Needle-less drug
delivery for vaccines
-- future battlesuit

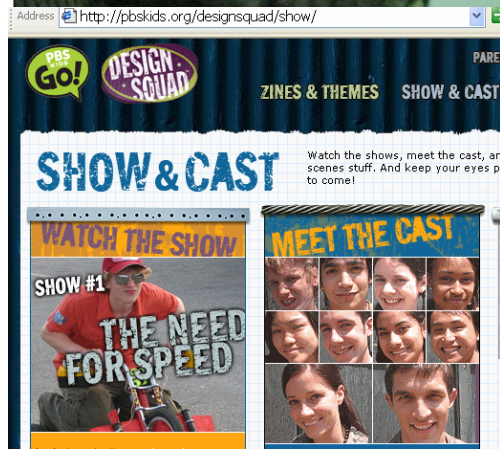
www.atlasdevices.com



ATLAS / Nate Ball:
MIT-Lemelson $30K
Inventiveness Award;
PBS Design Squad;
Army Rapid Equip Force
$120K Procurement of
ISN SDC-award winning
ATLAS Powered
Rope Ascenders
-- current needs



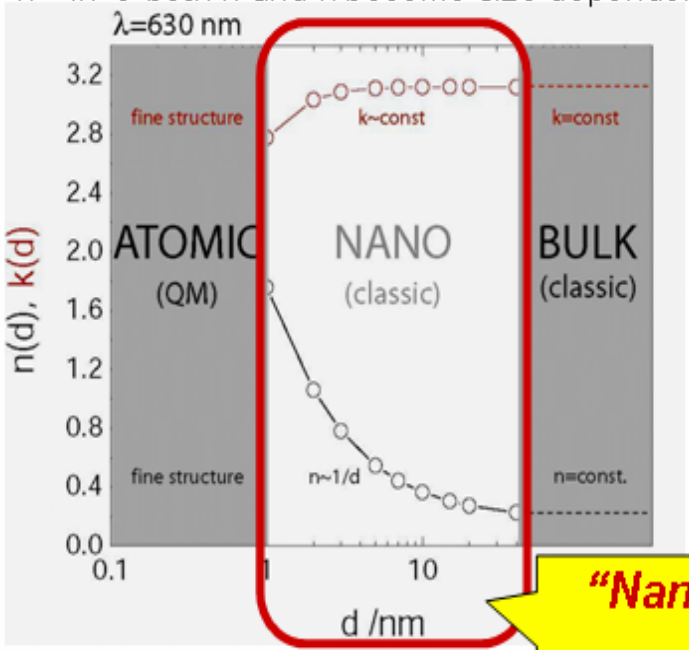
http://wbztv.com/video/?id=29313@wbz.dayport.com



ISN: Building Understanding of a New Class of Materials with a Human Customer in Mind

Size Effects on the Optical Properties of Gold:

Plotting the Index of Refraction of Gold shows
n + ik → both n and k become size dependent



The color of Gold varies by Size

"Nano" == Where things change

Opportunities:
Understand the physics better

– new design space, new tradeoffs….

Characterize properties and Explore MANY uses of these new materials

Define Parameter Space of new nanotechnologies – Don't target a single specific application

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Soldier Capabilities Enhancement: Technology from the ISN This Decade

Improved Performance:
- 'Exomuscle' actuators
- Situational Awareness (SA) from Quantum Dot thermal detectors & conformal computing displays

Improved Development Tools:
- Advanced Modeling & Simulation
- New Materials Characterization, Design and Test Tools
- Nano manufacturing

Improved Protection:
- Sense unseen threats: chem/bio
- Nano-enhanced protective Materials (Transparent Armor, flexible protective materials)
- Smart coatings
- Smart materials with dynamic, switchable surfaces

Broader Enhancements:
- Nanoscientists work for Soldiers
- Nano-systems engineering know-how
- Commercial Apps for Soldiers, First Responders (via Industry Partners, Small Businesses, Soldier Design Competition)
- Unexpected advances

Improved Soldier Capability:
- Soldier bio-med: far forward triage & treatment (Needle-less drug delivery, dynamic splints…)
- Give individual Soldiers *small-unit* capabilities: Ubiquitous sensors, SA…

Improved Military Capabilities:
- Improved Armor Materials
- Lightweight materials for Army systems (Vehicles, weapons, etc.)
- Advanced Materials + Optical Properties
- Laser Detection Sensors

*** Army Collaboration*

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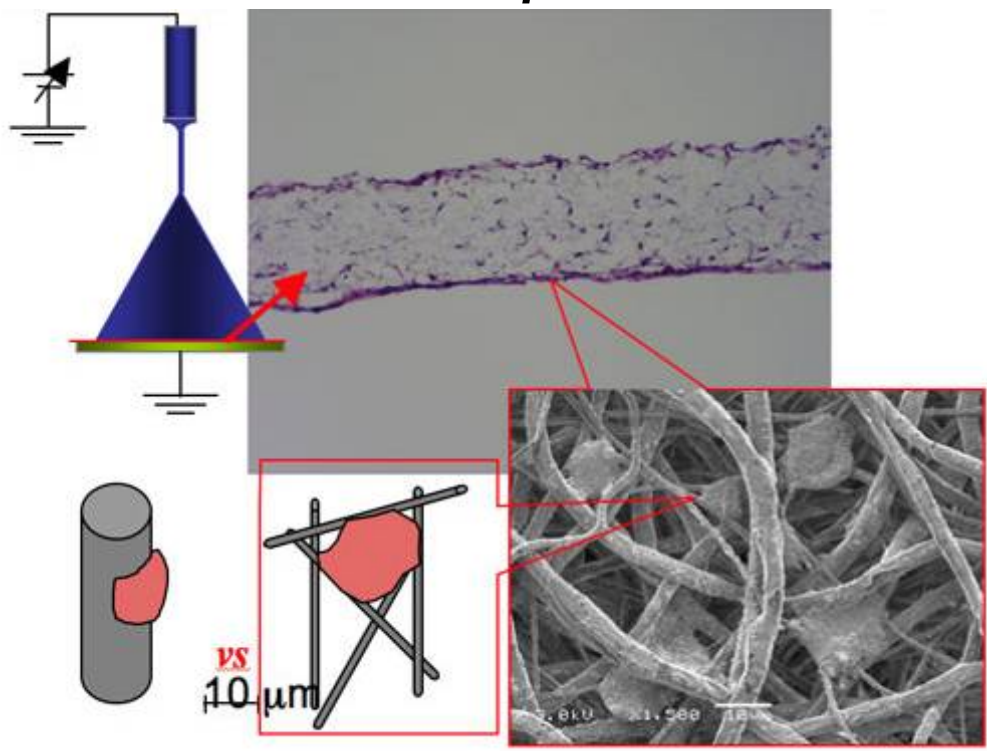
- **Project 4.4 partners Prof. Gregory Rutledge's team with Dr. Sonya Shortkroff (BWH and CIMIT)**
  - **Exploring electrospun PCL scaffolds to grow new biological tissues such as chondrocytes**

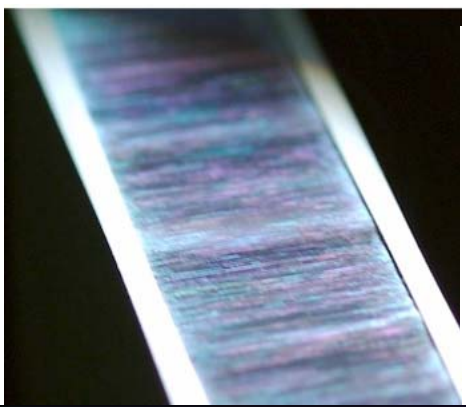
Electrospinning & Polymer Nanofibers

(L. Chen, J.L. Lowery, M. Ma, M. Wang, KK.Gleason, RM.Hill /DCC, D.Kaplan, S. Shortkroff)

Superhydrophobicity

Electrospun scaffolds exhibit unconventional cell/fiber interactions





With R. Hill, DCC Visiting Scientist @ ISN, Rutledge group co-invented monodispersed color-shifting nanofibers

Collaboration between ISN researchers and Army Scientists: On-Site Army Research Lab (ARL-WMRD) Scientist

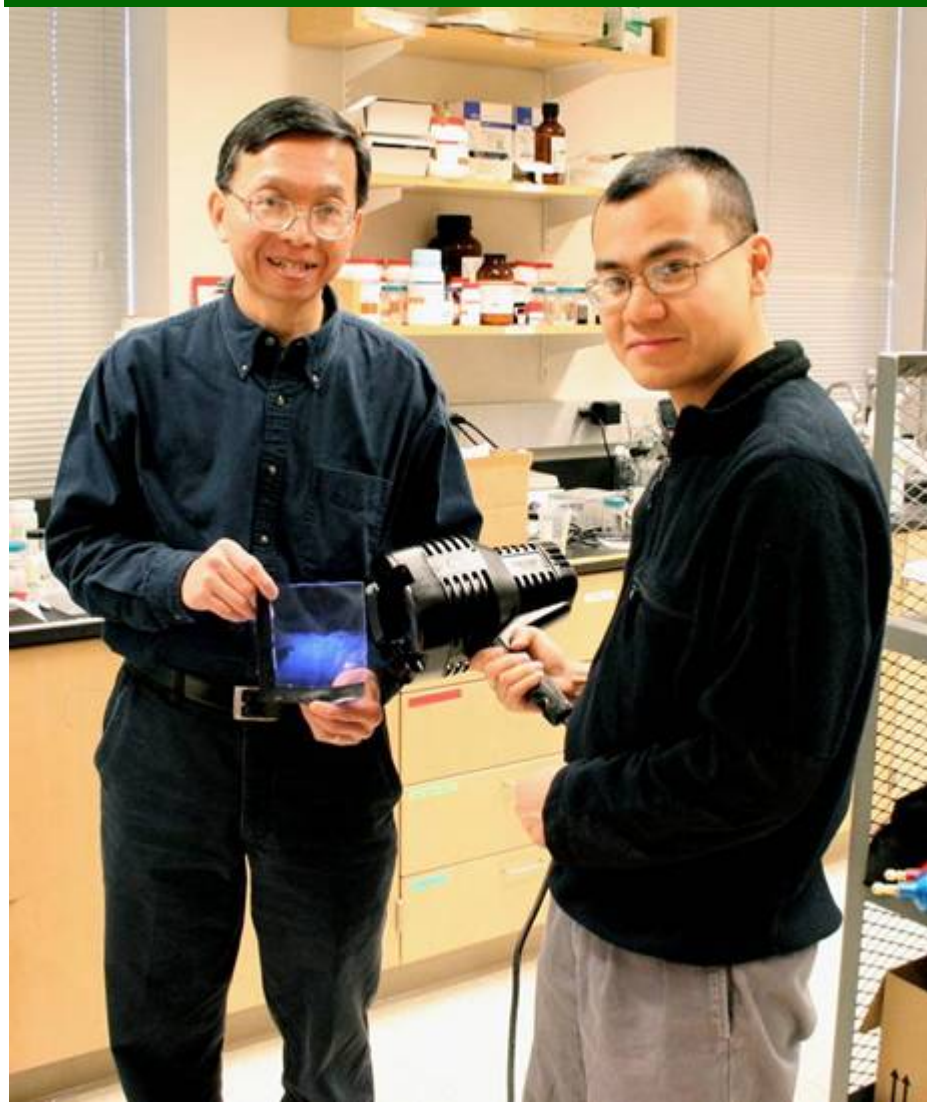
- Interesting material system developed at ISN
  - ➔ ***Army Scientist Alex Hsieh*** **creates transparent armor, understands Army context**
  - ➔ ***ISN researcher Jian Yu*** **created a polymer system with embedded nanofibers**
- Initial goal leads to transition opportunities:
  - ➔ **Initially: reinforce eyewear**
  - ➔ **Discovered *interesting optical properties in UV***
  - ➔ **Many potential applications *(optical tagging):***

lead users for feedback / testing....

Optically transparent in visible light

Pattern detectable under UV

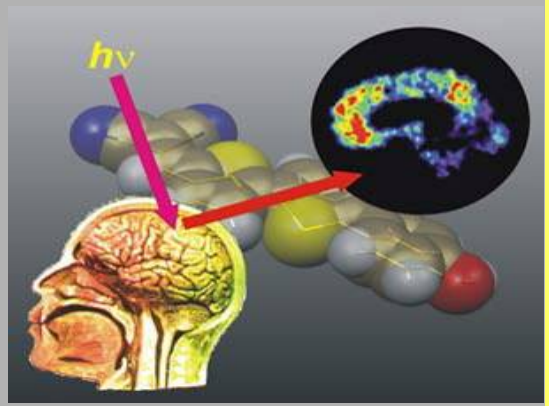
Army Scientist Alex Hsieh + ISN researcher Jian Yu



ISN Tech Insertion: Army-funded 6.1 & 6.2 Science continues to improve explosives detection, leading to other capabilities

Extending chromophore use:

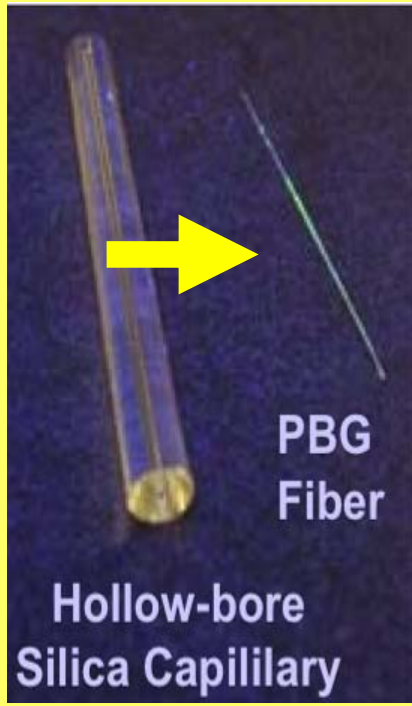
from finding explosives (FIDO) to finding Alzheimer's: Swager's group designed new dye (NIAD-4) to bind with brain plaques (TBI?)



Changing chem platform:

Swager / Bulovic / Fink

Nature Materials **5,** 532–536 (2006)



Hollow Photonic Band Gap (PBG) Fiber: Smaller Size & Better Signal

Nomadics FIDO == PLATFORM technology to insert new capabilities

Future Developments…
Information-bearing Protective Materials?

- **Possible structural materials:**
  - + **Next-gen Light-transmitting polymer (fiber optics inside polymer matrix)**
    - ➔**CNT-reinforced polymer matrix**
    - ➔**Embedded FiberWeb fiber sensors**

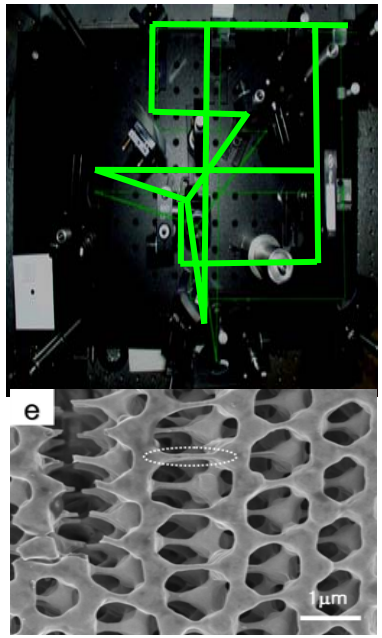
- **Possible protective materials:**
  - + **3D Microtruss system**
  - + **Holographic Data Storage**
    - **DCC subsidiary Aprilis**

- **Micropumps + FiberWeb == lightweight laser warning systems, systems (OPTICAL SOUND) etc…**

- **Lens-less Imaging with FiberWeb**

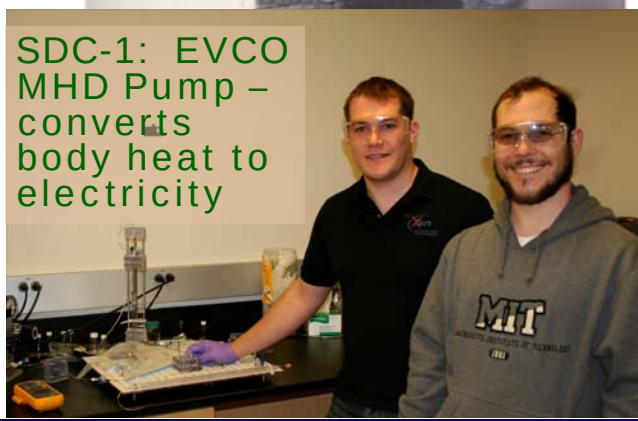
- **Flexible EMI Shielding with iCVD**

- **New computer interfaces: logistics ops**



Microtrusses via2D & 3D photolithography

LitraCon light-transmitting concrete invented by Hungarian architect Áron Losonczi – Structural material embeds optical fibers <*www.litracon.hu*>



SDC-1: EVCO MHD Pump – converts body heat to electricity

Army Expectations of Industrial Partners

Focus: Nanotechnologies to improve Soldier protection

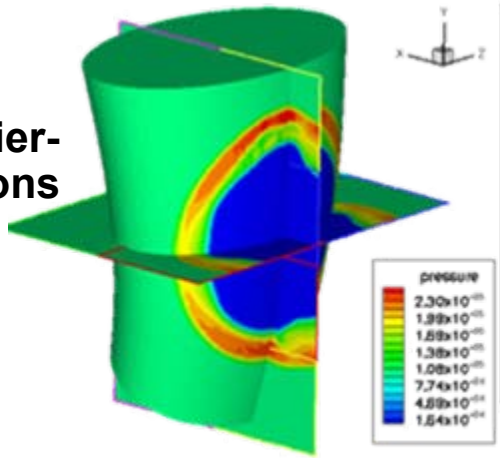
- **Industry Partners should support Soldiers as valued customer**
  - **Collaboration with Army/DoD S&T encouraged**
- **6.2 Research should be scientifically compelling, AND should lead to commercial applications for nanotechnologies, leveraging 6.1 basic research**
  - **Two major paths:**
    - ***Commercialize*** **for open market; Army / other Gov't == Customers**
    - **With Army programs,** ***customize*** **for applications for the Soldier**
  - **Seek ways to** ***expedite*** **transition into products**
    - **Early products may be incremental improvements over current tech**

➔Soldiers = *Lead Users*, giving feedback on future directions

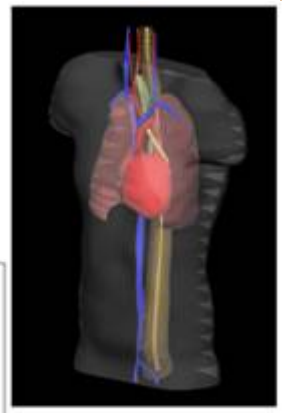
Army-funded University Affiliated Research Centers work with Army Scientists to address challenges

Energy Absorption:
Modeling Soldier-Blast Interactions

Radovitzky



Simulation of lung injury due to blast overpressure (BOP)



Target human organ models

Army ARL-WMRD @ISN: Scientist Alex Hsieh

Multi-Hit Resistant System

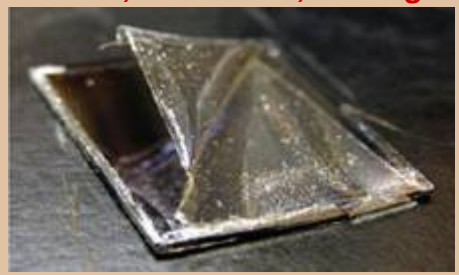
IP: 4.5 Energy Absorbing Responsive Fluids

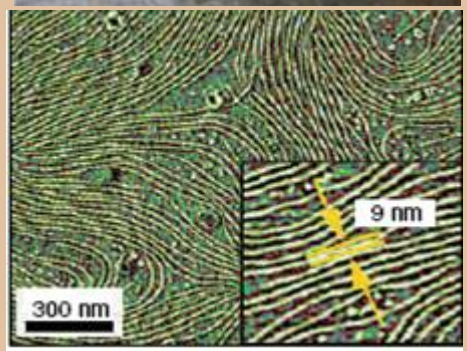
ISN Researcher Giorgia Bettin

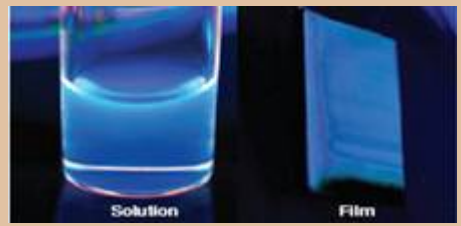
Transparent Protection:
Shear Thickening Foam system, tested at ARL-WMRD

Portable Energy:
Virus-based Self-assembly of flexible Lithium batteries

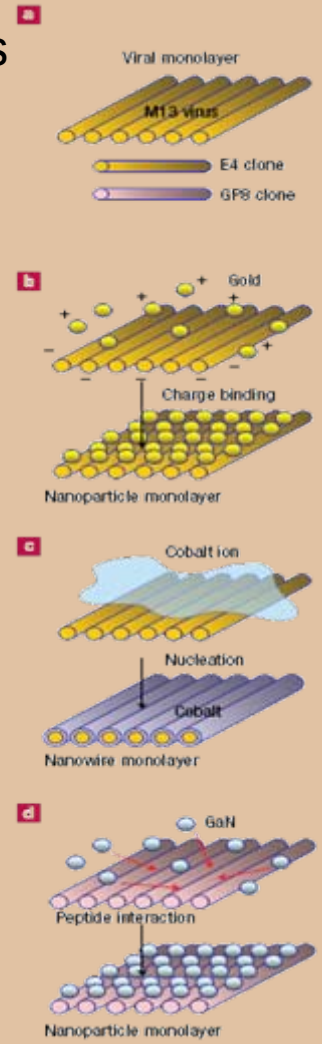
Belcher, Hammond, Chiang







Nature Materials, Vol 5, Mar 2006



SDC Transition: Ancile Warning System

Cadets 1st Class Brian Lebiednik and Greg Isham (front center and right) smile as Ancile system picks up another mortar round at the C-RAM exercise at Yuma Proving Grounds, AZ. Army officials said they hope to issue pagers to Soldiers in Iraq within the next nine months. *U.S. Army Photo*

Reward Innovation for Soldiers!

"Cadet project could save lives"

By MAJ Fernando J. Maymi, D/EE&CS

"Pointer View," May 27, 2005

http://www.usma.edu/PublicAffairs/PV/050527/project.htm

Four senior USMA cadets helping make troops safer.

EECS senior project for USMA Cadets 1st Class:
Jeffrey Hermanson, Jamie Dayton, Brian Lebiednik, Gregg Isham
Cadet team designed and built an Ancile pager to warn Soldiers of incoming artillery/mortar strikes

Army tested at Yuma PG: "significant advance notice each time"

Project sponsor Paul Manz, technical director for ground combat command and control in Fort Monmouth, NJ, developed a plan to field pagers within 9 months.

Their senior project was a great way for them to help Soldiers:

"wonderful that we were able to do something that helps keep our fellow Soldiers safe while they are working to keep us here at home safe"

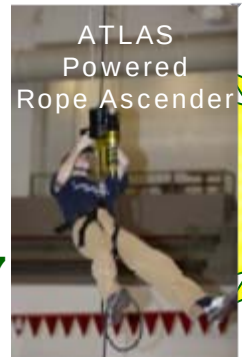
➔ **Florida-based Mahdahcom licensed + is producing Ancile**

Dealing with Success: Innovation Challenges

Secretary of the Army joined us for ARO @ ISN Workshop, 11 Apr 2006

- In innovation, tech **availability ≠ adoption**
  - *Absorptive capacity issues*
    - *Practice for major change (FCS)*
  - *Clockspeed differences*
  - *Impedance mismatch*
- Outsourcing risk == outsourcing process
  - *Other peoples' processes reward differently*
    - MIT TLO → patenting IP, $$$
    - Small business marketing needs vs. OPSEC
- Entrepreneurs need to survive
  - *First customer == favorite customer*
    - *Lead users: **joint**, varied missions*
    - *Champions crucial*
  - *Timelines are very different!!*
    - RallyPoint: Apr 2004 vs. FFW Dec 2007
- Need to help manage risk
  - Army can help! Eg, Safety Certs, operational assessments
  - Need business growth: shared costs / revenues
- Innovation can help the Army & the Army can help innovators!
  - *Need adaptive leaders who train in innovation*
    - *–Science must translate to technology*
      - *– Technology must come to market*
        - *– Customer purchases make a difference*

RALLYPOINT



Good challenges to have....

Fido™ Explosives Detector

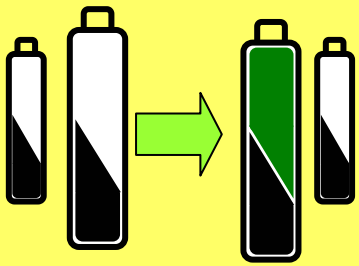
Support to Current Operations

- Nomadics FIDO explosives detector has been in Iraq since Summer 2004: limited assessments by Soldiers and Marines, and screening with EOD Tech
  - ➔*Detects TNT/TNT-based explosives, usable in several modes: handheld, on robot, underwater, down wells*
  - ➔*Air Force bought systems for cargo screening*
  - ➔*Army Rapid Equipping Force and Joint IED Task Force funding Iraq-based ATEC Warfighter Assessment of integrated FIDO on iRobot PackBot for vehicle inspection*

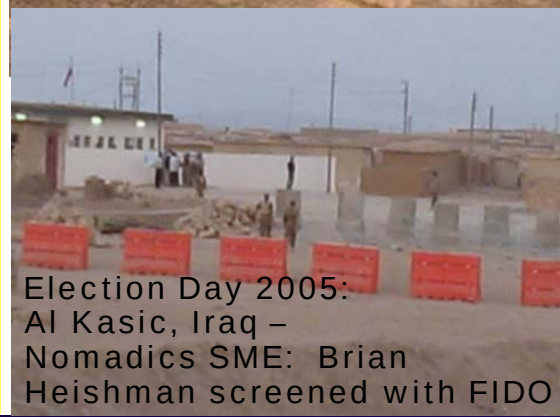
Fido™ Explosives Detector

- PEO Soldier procured ISN Soldier Design Competition award-winning Battery Power Scavenger designs from undergraduate teams for Soldier assessment
  - ➔*Designs from Supercharged (USMA) and Xitome (MIT) help Soldiers by scavenging power from used AA batteries for rechargeable batteries*

USMA Team Supercharged: Cadets Nick Barry, Jeremy Spruce, Walter Velasquez



MIT: Xitome CEO Kailas Narendran shows PowerPlus

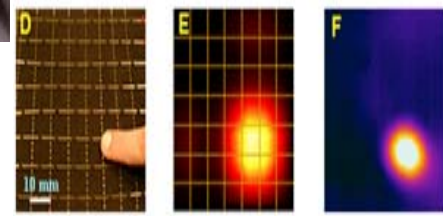


Election Day 2005: Al Kasic, Iraq – Nomadics SME: Brian Heishman screened with FIDO

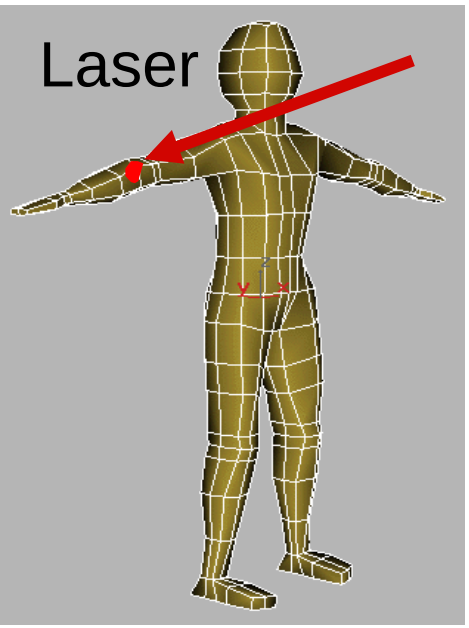
ISN "Fiber Web" linear sensors (Profs. Fink & Joannopoulos)

Same Material: FIBER WEB:
Senses light from lasing
(both ops + embedded training),
Temperature for well-being,

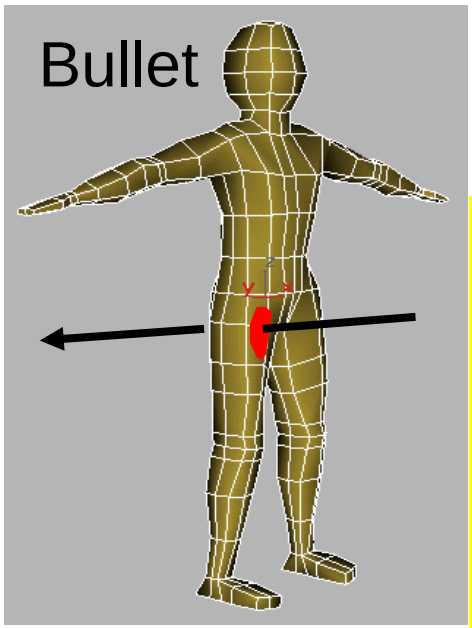
Lasers for intra-squad comms
(when RF not available or desired)



Full Body MILES++
For Realistic Training



Full Body Thermal Sensing



-- Rapid helmet prototype for
PM SOF Warrior CID user demo
27Nov2006

-- Based on 20Dec2006 VTC,
PM Live Training Systems will assess
for potential use in
Training devices e.g. MILES, E-Targets

Challenge: Tech vs. OPSEC

- Why ISN good idea: ISN acts as hub
  - Multi-dept professors brought together
    - Chem Eng (Gleason) + Chem (Klibanov)
    - Big discoveries at the crossing of academic boundaries
    - Army benefits from interaction of smart people
      - They benefit by meeting / knowing customer
- My role: Military liaison – people get immediate feedback from me as combat commander on technology uses
- Some ISN projects
  - FIDO
  - Cima Microchips vs. hemorrhagic shock --??
- My special project
  - FiberWeb ICOM-H: comms over light
- SDC rapid innovation program: How are we helping the Soldier today