Emerging Sensors and Electron Devices for Army Applications

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National Defense Industrial Association
Disruptive Technologies Conference

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RDECOM

ARL


POWER
ELECTRONICS
SENSORS

Persistent ISR

"The ability of the future force to establish an "unblinking eye" over the battlespace through persistent surveillance will be key to conducting effective joint operations"

- Quadrennial Defense Review Report
(February 6, 2006)


POWER
ELECTRONICS
SENSORS

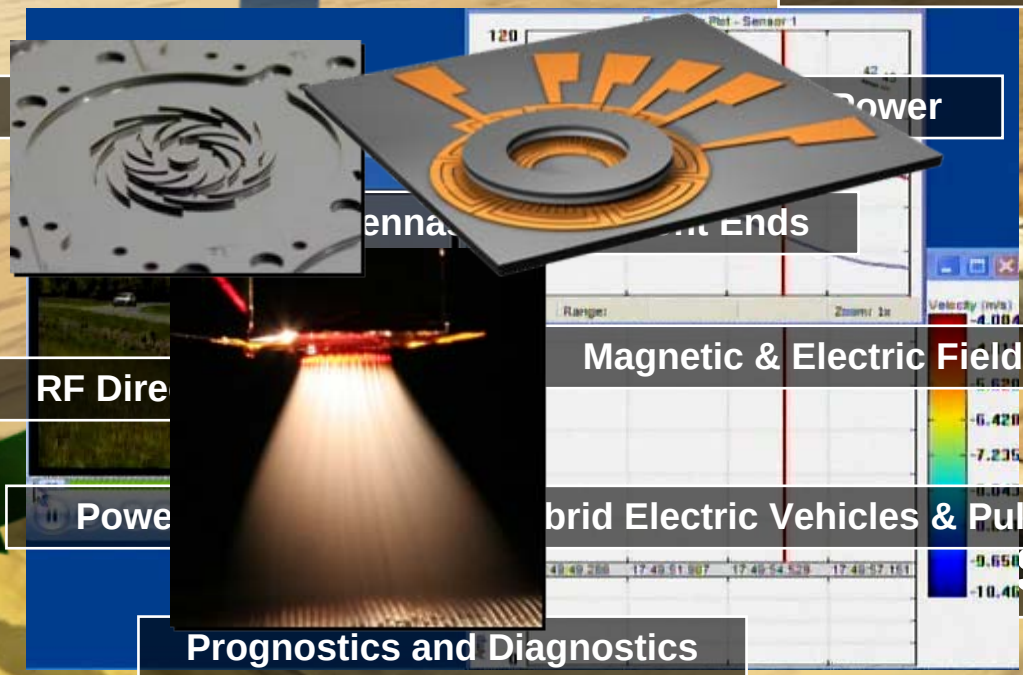
Enabling Electronics

Photonic Devices

Nanoelectronics and MEMS

Flexible Displays

Advanced Concepts



Magnetic & Electric Field Sensing

Prognostics and Diagnostics

Lasers / Sources

Magnetic & Electric Field Sensing

Challenges: The Stage

Urban

Riverine

Borders/Perimeters

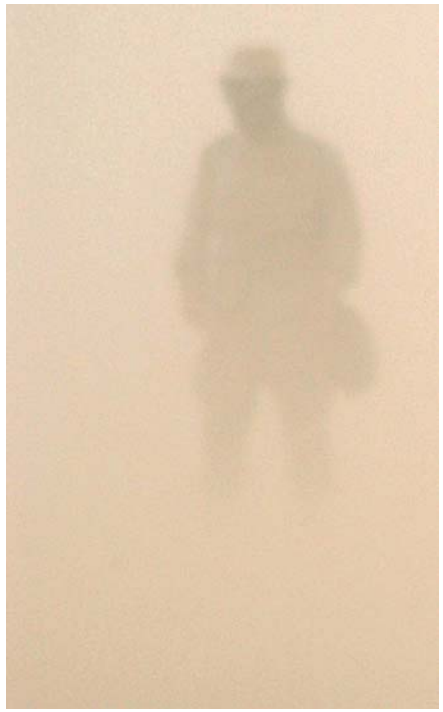
Caves

Jungles/Canopy

Challenges: The Environment

Urban / Cave Warfare Requires Sensors for Detecting the Enemy

Riverine – Limited Access Environment



Excessive Heat, Humidity, and Dust in the Environment

Non Line of Sight in Urban Environments

Jungle Canopy – degraded mobility, aerial surveillance, and communications

Emerging Solutions

Family of UGS

Persistent ISR to OIF

Microsystems

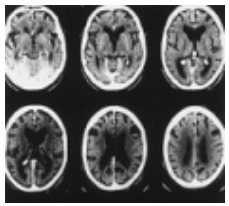
Persistent Threat Detection System to OIF

Wearable Sensors

Unmanned Equipment for Scouting and Detection

Decade of the 1970's

Structural Imaging



1971 – First Practical X-ray Computed Tomography Image

Artificial Intelligence

1970-Shakey the robot

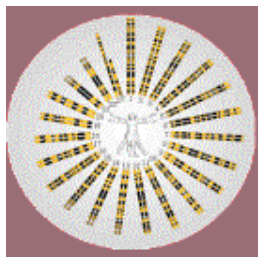
Microprocessors

1971 – First 4 Bit Microprocessor in Production

Supercomputing

1975 – Cray I Supercomputer

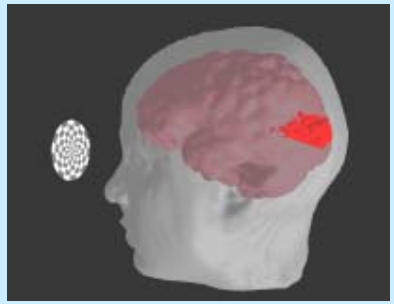
Genetic Engineering



Arcade Games

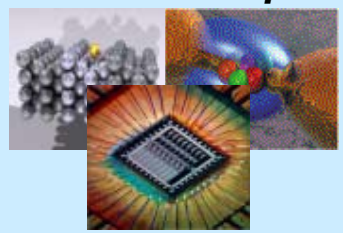
Today for 2020 and beyond…

Functional Brain Imaging

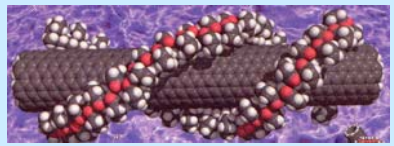


Robotics

Quantum Computing

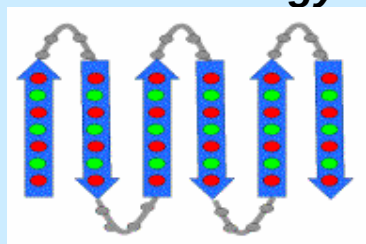


Nanotechnology



Immersive Environments

Biotechnology

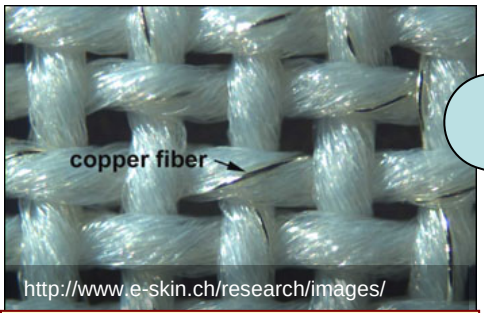


From March, 2006 presentation by Dr. John Parmentola, Army Director for Research and Laboratory Management

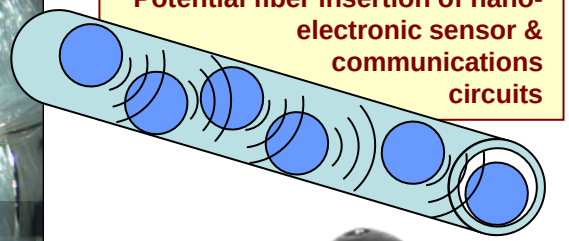
Nanoelectronics: Devices & Sensors

GOAL: **Multifunctional 3-D nanodevice architectures for electronic textiles and networked microsystems for remote sensing applications**

OBJECTIVE: **Fundamental research on integrated nanoelectronic devices**



Current Technology for E-textiles



Potential fiber insertion of nano-electronic sensor & communications circuits

Nanoelectronic sensor & communications devices for networked microsystems

Fundamental nanoelectronic device research for future soldier requirements.

ARL's *in-house* nanoelectronics basic research capability:

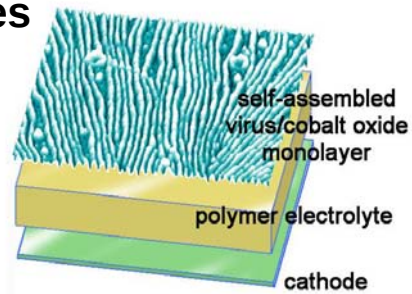
- Discrete nanodevice fabrication:
  - Thermal CVD SW-CNT growth
  - Directed nanoscale assembly
  - Nanoscale manipulation
  - 3-D nanoscale architectures
  - Microfluidic channels
- Nanoelectronic device testing:
  - Micro- to nanoscale probing
  - DC to 110 GHz
  - 4.5-475 K
  - fA sensitivity
  - Controlled ambient environments

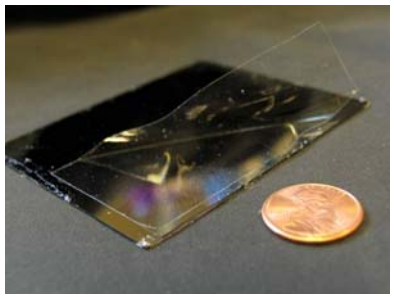
Research focus:

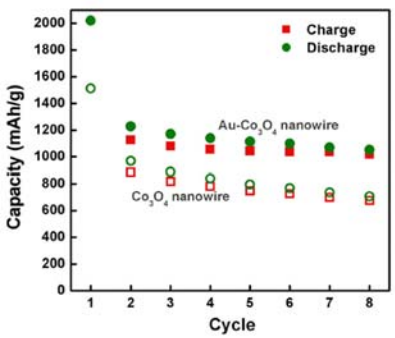
- Amperometric sensors
- Ultra-high frequency (GHz-THz) communications & sensor devices
- Nanoscale thermal management
- Ensemble effects in nanoelectronic devices

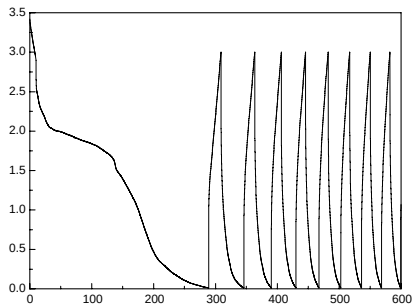
Biologically directed assembly of flexible batteries:

- Use genetically modified viruses to control assembly of cobalt oxide anode
- Polymer electrolyte
- Standard cathodes (metal rod or sheet shown)







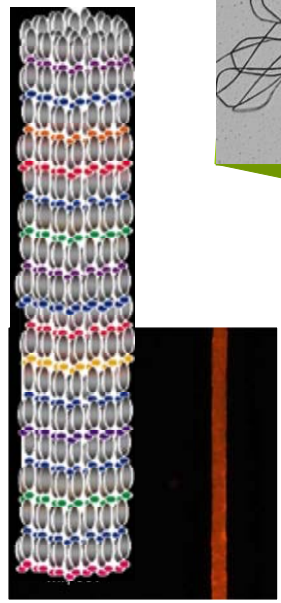


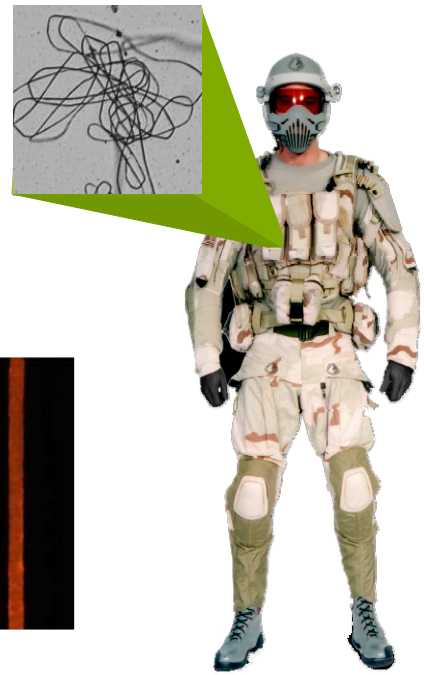
Higher Capacity, Faster Reaction Rates

Prof. Angie Belcher, MIT

Virus fibers for use in multi-functional textiles:

- Virus-assembled barcodes
- Electro-spun virus fibers for sensor & electronics applications





Prof. Angie Belcher, MIT
Dr. Charlene Mello, NSRDEC

MEMS for Power & Energy

Fuel Supply

Centrifugal Pump

Fuel pump: Radial

Micro Ball Bearing

Starter Generator

Micro Pump

Cooler Heat Exchanger

Ceramic plate

Contact pads

p-type

n-type

Thermo Electric/Others

Cooler Heat Exchanger

Energy Reclamation Heat Exchangers

MEMS Actuators / Valves

Atomizer

Nozzles

Reclaimed Electrical

Exhaust

Exhaust

12.9 mm

UC Berkely Wankel Engine

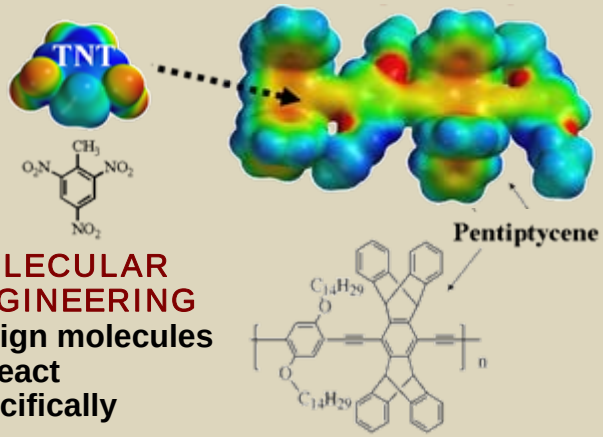
Heat Engine

Fuel

Heat

Electrical

Chem-Bio Detection and Defense

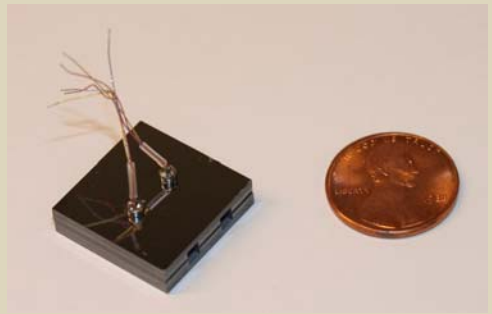


MOLECULAR ENGINEERING
design molecules to react specifically

TNT Detected

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

MEMS Photo Acoustic Sensor



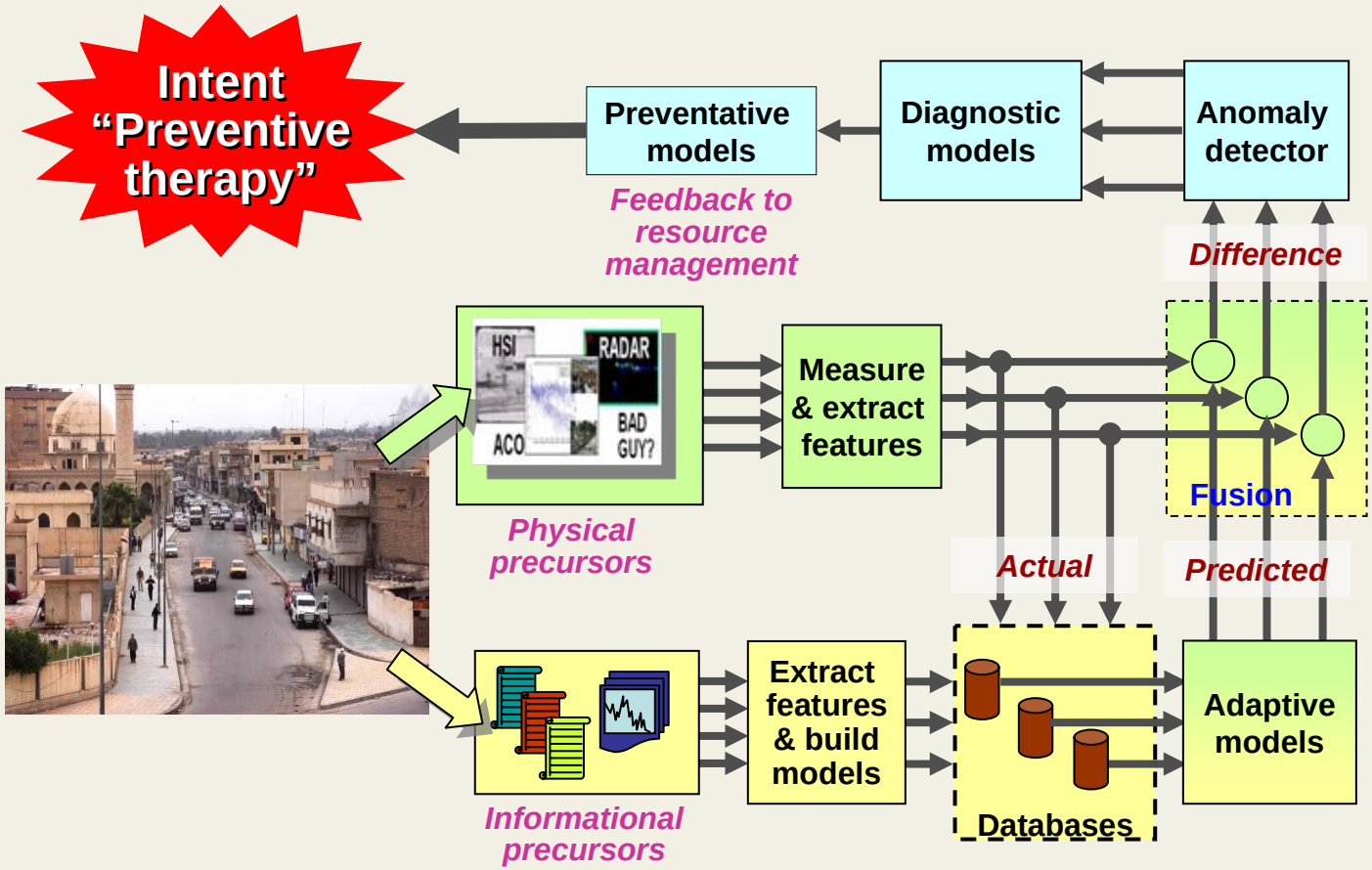
Science Making a Difference for Soldiers: FIDO Explosives Detector

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

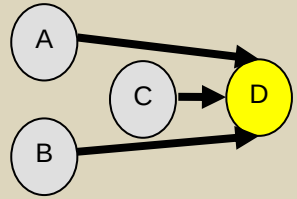
FIDO Units in Iraq for Evaluation (2005) – Integrated on robot and handheld

Integration of Chemical / Biological Sensing with Electronics.

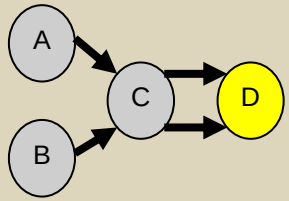
Networked Fusion & Understanding



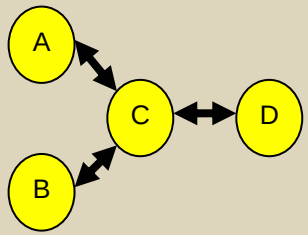
Data Flow Architecture



Centralized



Distributed



Decentralized

Characteristics:

- Scalable
- Adaptive
- Expandable
- Modular

Challenges:

- Network Architecture
- Robust Fusion Engines
- Autonomous Management
- Up-to-date

Shaping the Vision: Operational Scenarios

Autonomous networked ensembles of multifunctional microsystems for enhanced battlefield situational awareness for the Soldier

Scenario #1: small unit building search

Autonomous navigation in benign indoor environment with human mission control

Scenario #2: small unit cave search or demolished building

Autonomous navigation in complex environment with human mission control

Scenario #3: small unit perimeter defense

Autonomous navigation in complex environment with autonomous mission control

Electronics, Power, and Microsystems

Critical Components for Emerging Army Applications

We can make a **difference** to them