



# Plenary Session: MTO and the Outside World

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*Customer Success Is Our Mission*

## DARPA MTO Symposium

Air  
Land  
Sea  
Space  
Cyberspace

Innovation. In all domains.

# Microsystems for a Changing Battlespace

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March 3, 2009

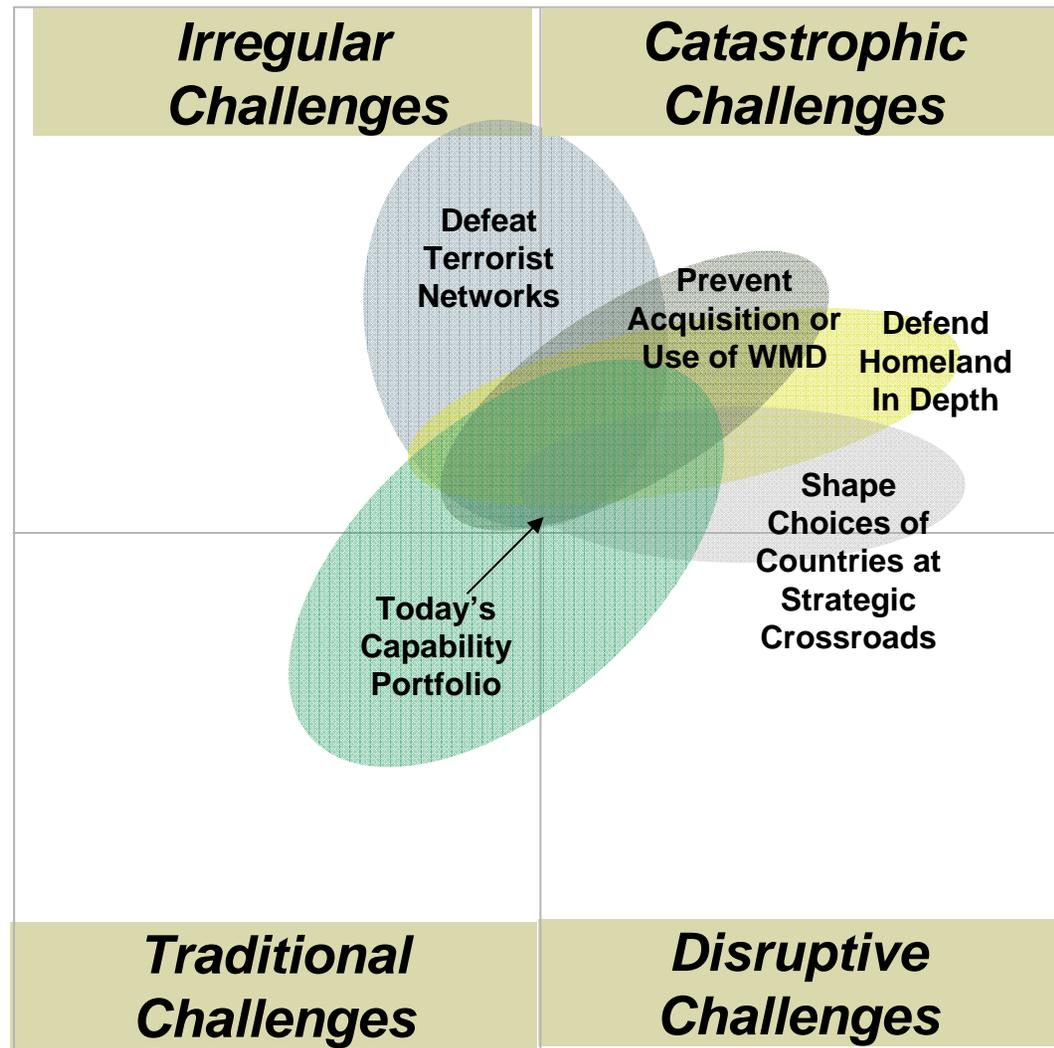
# Challenges From Multiple Fronts: Rapidly Evolving and Diverse Threats

## **Asymmetric**

- Unpredictable
- Rapidly evolving and highly adaptable
- Decentralized C2
- Highly effective low-tech threats
- Indiscriminant targeting – civilians, military, infrastructure

## **Near-peer**

- Focused defense strategy
- Rapidly growing military capabilities
- Centralized C2
- Rapid evolution in advanced technologies
- Focused targets – military, infrastructure



**U.S. strategy must encompass terrorist networks to near-peer competitors**

# Challenge: Low Cost Asymmetric Disruptors

- Denial of service, disruption, deception, destruction
  - Information Operations (only takes a laptop and an internet connection)
- Degradation of GPS, communications, radar systems
  - Low cost rf jammers (digital and rf COTS electronics widely available)
- Increased instability, highly unpredictable, rapid evolution
  - SAMs, RPGs, IEDs (wide availability of low cost electronics and munitions)
- Disruption, deception, destruction of satellite operation
  - Nano-satellites
  - Laser dazzler
- Surreptitious surveillance, unpredictable destruction
  - Small & Mini-UAVs (growing UAV proliferation)

**Asymmetric disruptors enabled by low cost COTS**

# Challenge: Near-Peer Disruptors Advancing Rapidly

- Harder to detect & counter: shortens our kill chain
  - Highly Mobile Theater Ballistic Missiles
  - Increasing sophistication of Camouflage, Concealment, and Deception
  - Lower Observable Cruise Missiles
  - Weaponized UAVs
  
- Deny US surveillance & access to their territory
  - Hard Deeply Buried Facilities
  - High Energy Lasers
  
- Achieve precision nav, global comm, 24/7 surveillance
  - Nav, Comm, Imaging Satellites
  - Expanding community for space access

**Adversaries have national strategy with focused R&D**

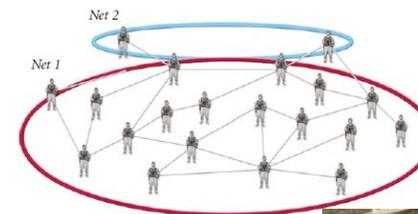
# Challenge: Asymmetric Threat Undermining U.S. R&D Prowess

- System reverse engineering
  - Enables compressed development cycle for our adversaries
  - Dramatically reduces cost of weapon system development
  
- Technology transfer
  - “Through any and all means necessary” activity to counter US economic and engineering advantage
  
- Multiple conflicts lead to increased opportunity for adversary
  - Battlefield loss of critical technology & information
  - Export

**Adversaries clone our weapon systems to reduce R&D cost**

# Challenge: Information Assurance in a Highly Information Dependent and Networked World

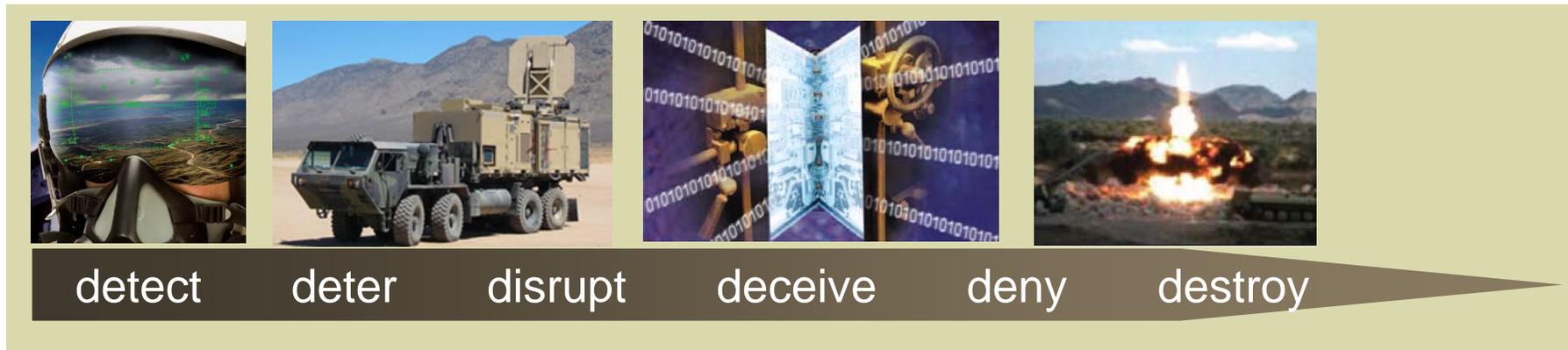
- Asymmetric strategies exploit our weaknesses:
  - Highly information dependent
  - Technology dependent
  - Large investment in space & air-power
  - GPS-dependent
- Trends:
  - Increased net-centricity & info sharing
    - Net-enabled weapon systems
    - Service-Oriented Architectures (SOA)
  - Tech adoption before vulnerabilities are understood
    - Virtual machines, SOA, VOIP
  - Untrustworthy supply chain
    - Off-sourcing of COTS hardware, software, firmware



**How do we protect our information in an info-sharing world?**

# Challenge: Cross Domain Dominance

- Cross domain dominance: Ability to span entire spectrum of effects to *detect, deter, disrupt, deceive, deny, destroy*



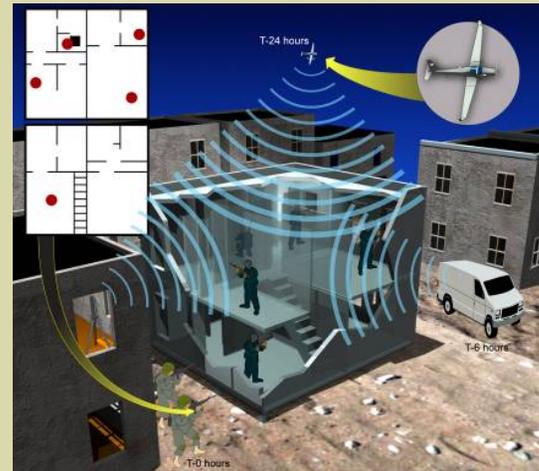
- Maximize knowledge of information on “object”
  - Leverage multi-functionality, multi-frequency, multi-spectral, multi-INT
- Rapidly link discoveries
  - Extracting Knowledge from information from data
- Ensure information assurance and anti-tamper

***“Problems cannot be solved by thinking within the framework in which the problems were created” – Albert Einstein***

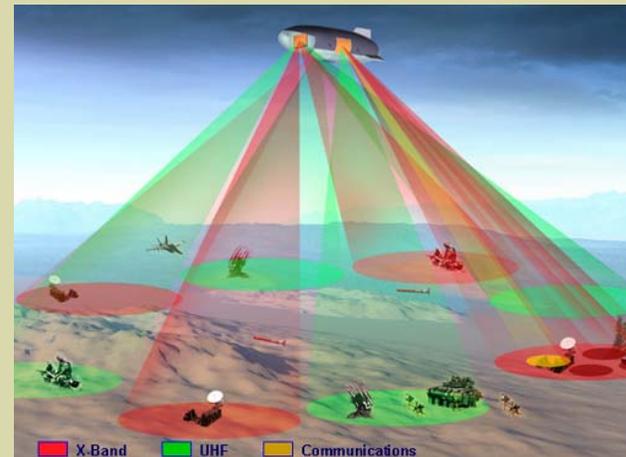
# Challenge: Respond to Threat Evolution with Multifunction RF Systems

## ■ Evolution towards

- Multi-functional systems
- Multi-frequency
- Multi-mode
- Multi-static
- Low cost, light weight
- Integrated structure
- Soft programmable



DARPA VisiBuilding



DARPA Integrated Structure is Sensor (ISIS) Program

Sensing

# Challenge: Tactical High Power Lasers and Beam Controllers

- **Current laser systems:**
  - Utilize gimbals
  - Mounted in turrets
- **Problem:** Turret creates drag & turbulence
  - Reduces mission duration
  - Limits platform speed
  - Degrades beam



## Paradigm Shift:

Effects

- APPLE fiber laser beam steering
  - Electronically steered
  - Conformal mount
  - Modular & scalable architecture



*Significant reduction in size, weight, and power*



*Airborne tactical laser*

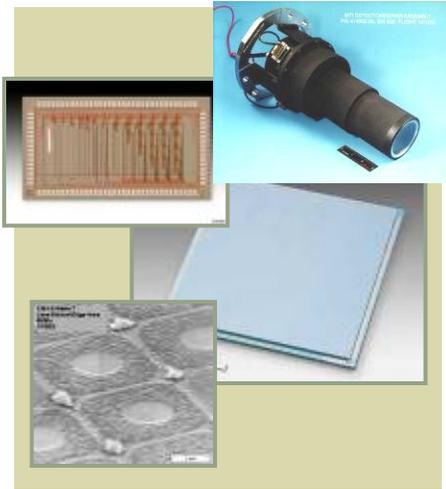


Applications:

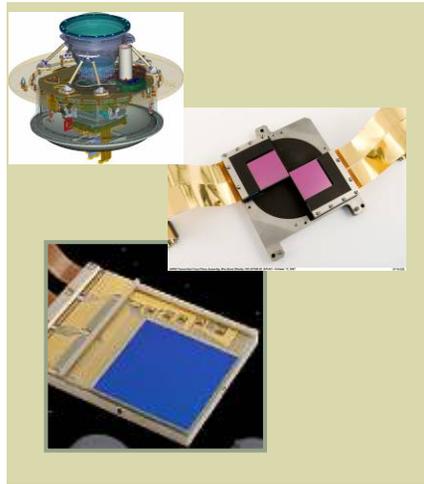
- High energy laser
- Laser communications
- Search & track

# Challenge: Maintaining the Edge in EO Sensing through 3<sup>rd</sup> Gen Technology

**Si PIN**



**Large Format IR**



**Advanced Uncooled**



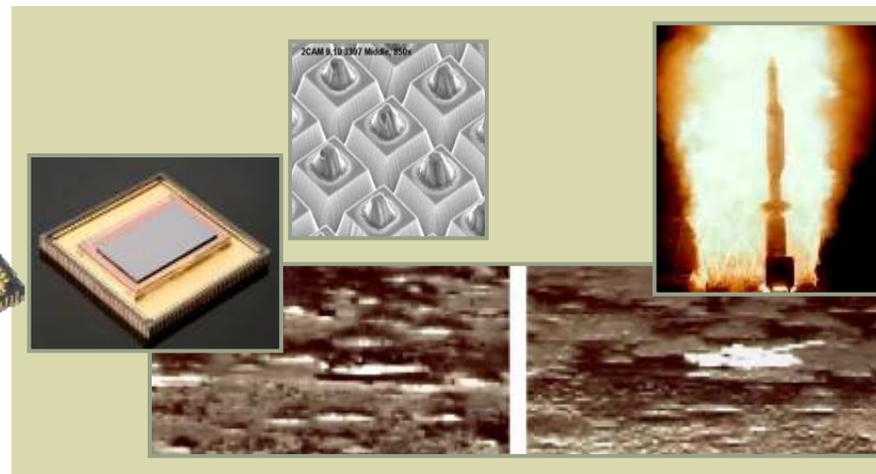
**LADAR**



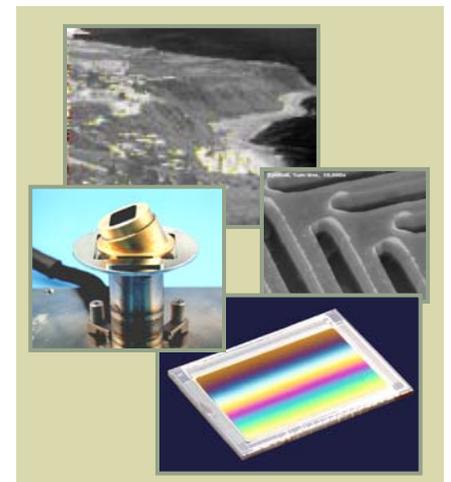
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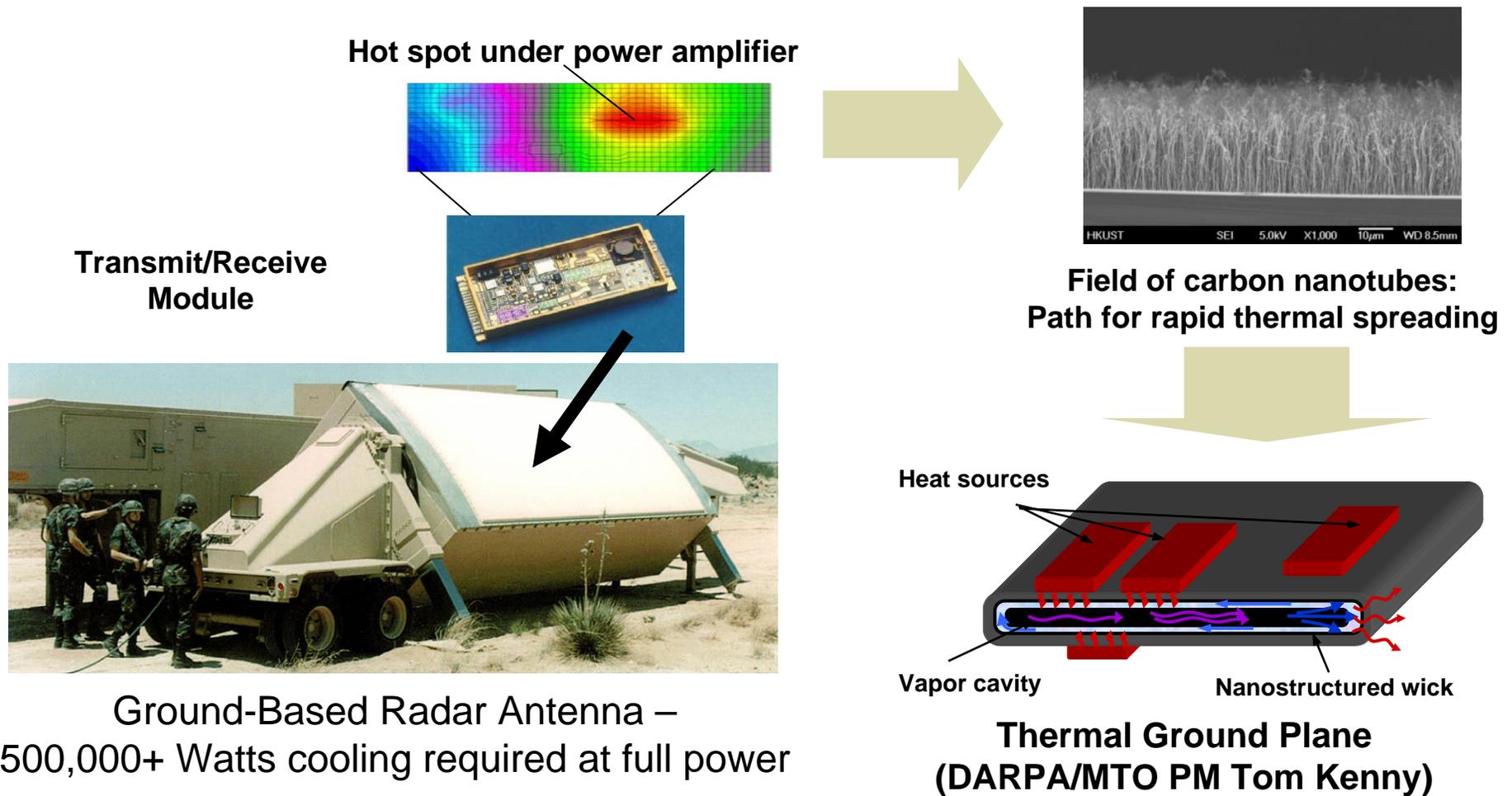
**Dual Band**



**Polarimetry/  
Hyperspectral**



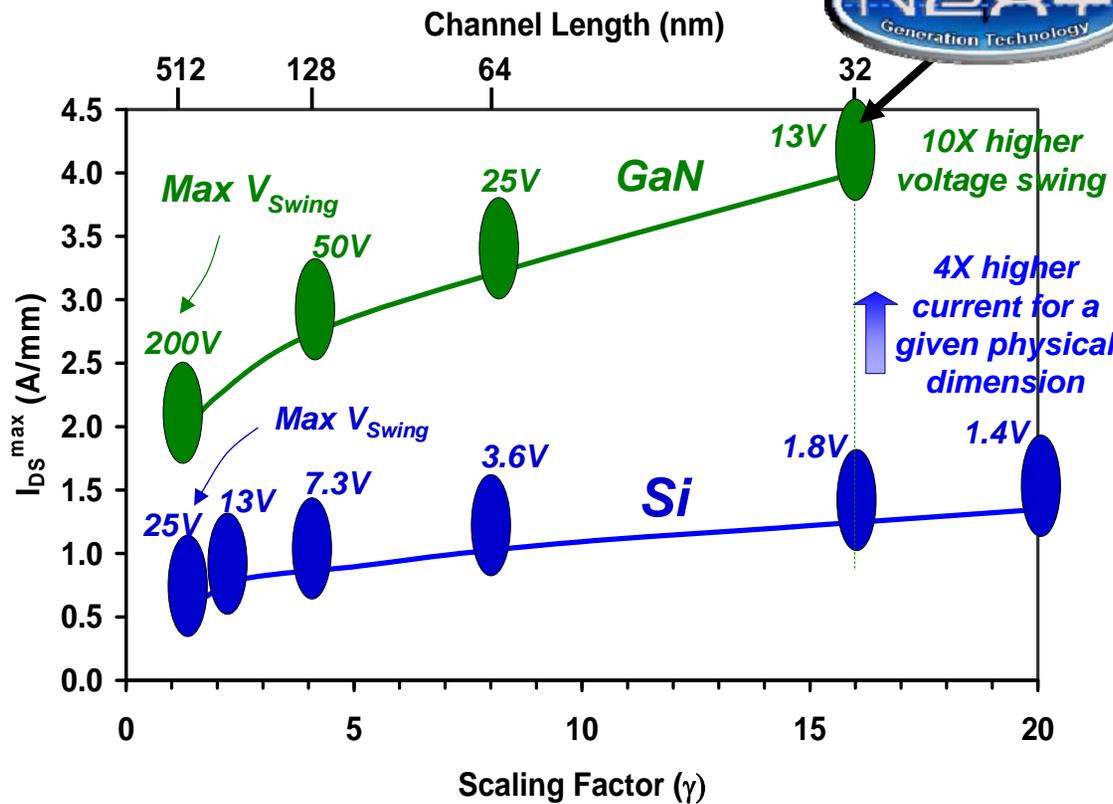
# Challenge: Thermal Management of High Power Electronic Systems



**Engineered nanomaterials enable cooler electronics =  
higher reliability and higher performance**

# Challenge: Maintaining Dominance of the Electromagnetic Spectrum

NEXT: DARPA/MTO  
PM Mark Rosker



## Program Objectives

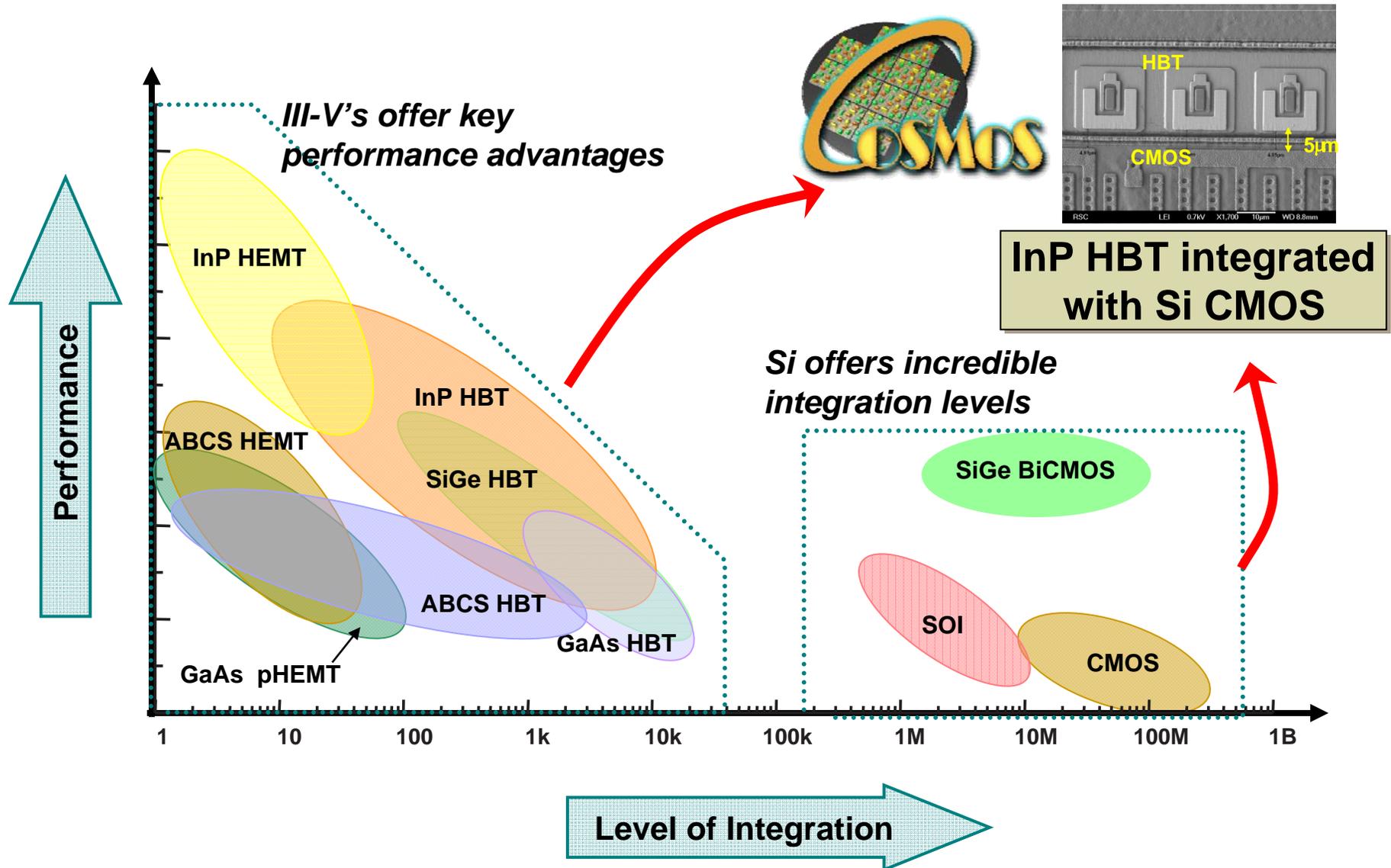
- Develop a high performance nitride transistor for high speed RF, analog, and mixed signal electronics
  - $I_{DS}$  levels 4X better than SOA Si
  - Voltage swings 10X more than Si
  - Enhancement mode operation
- Enable high integration level
  - High yield transistor process
  - Uniform
  - Reliable

## Impact

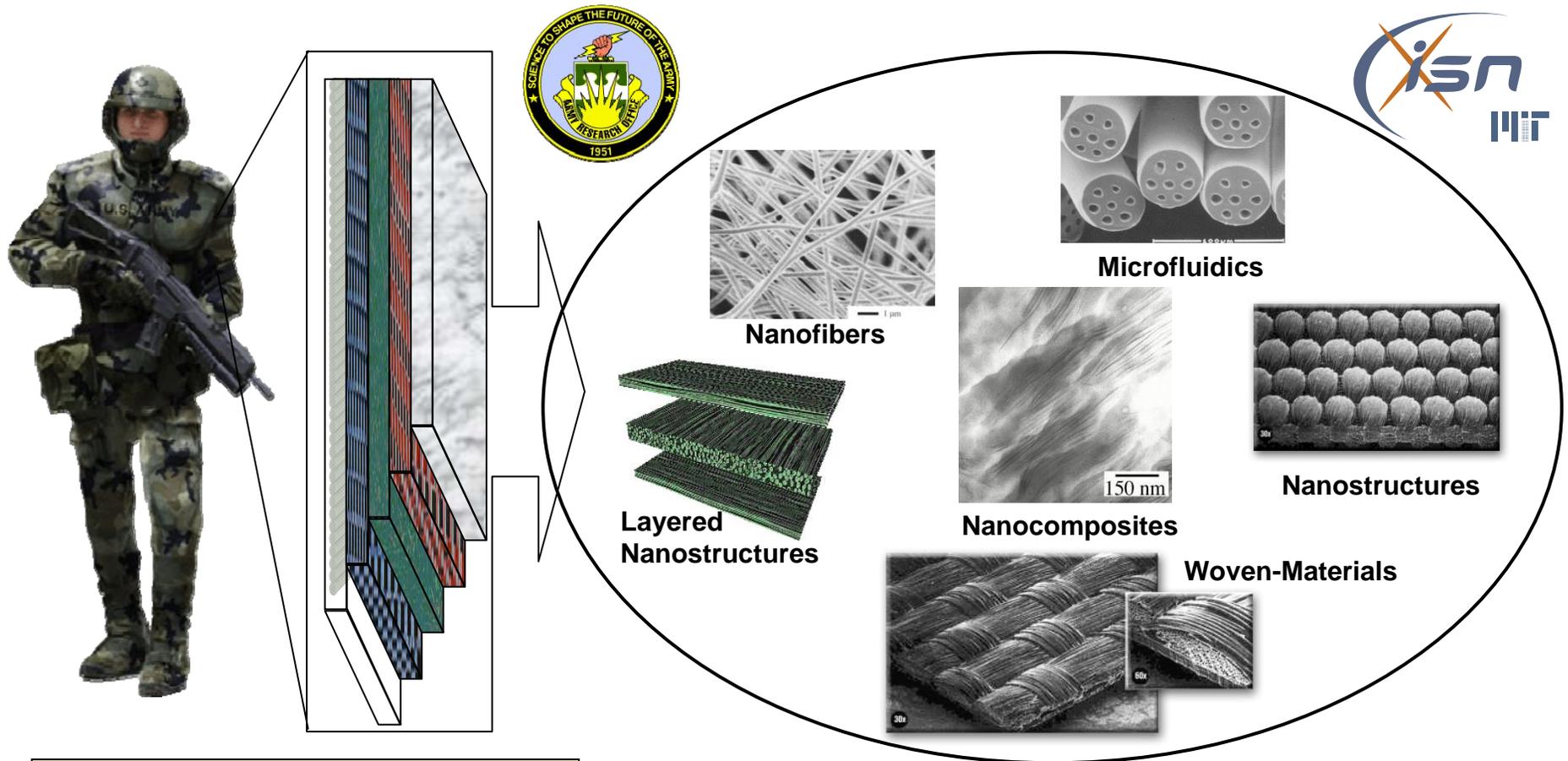
- High dynamic range mixed-signal electronics
  - Would enable wideband power DACs with >100X increase in output power
  - Also enables 25 dB improvement in mixer IP3
- Enables complex E/D logic circuits
  - Ultra-low gate delay

High frequency, high dynamic range, solid state technology opens new EM opportunities

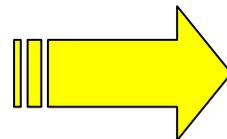
# Challenge: Discriminating Circuit Performance at an Acceptable Cost Point



# Challenge: Soldier Battlesuit for CBNRE Protection and Networked Connectivity



**The Battlesuit:**  
Layers of Multifunctional Nanomaterials  
Systems of Nanosystems



**Massive Functionality**  
with **Decreased Weight & Volume**

Nanotechnology advances ripe for integrated solution.

# Additional Microsystems Challenges

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## Sensing

- Room temperature broadband EO sensing
- Chip-scale hyper-spectral sensing
- Multi-domain imaging
- Linear, efficient, broadband RF
- Sensors for stand-off biometrics
- Efficiency

## Processing

- Heat dissipation and management
- Latency and communication
- Complexity and parallelism in circuit design
- Analog to digital conversion
- Trusted ICs
- Exploiting entangled systems

## Communication

- Spectral efficiency
- Reduced latency
- mm-wave communications

## Actuation

- Universal MEMS packaging
- Ultra-stable, lower power timing devices
- Robust, efficient actuation

## Energize

- Efficient, high power lasers
- Smart power management
- High energy density storage
- Efficiency, efficiency, efficiency

# Summary

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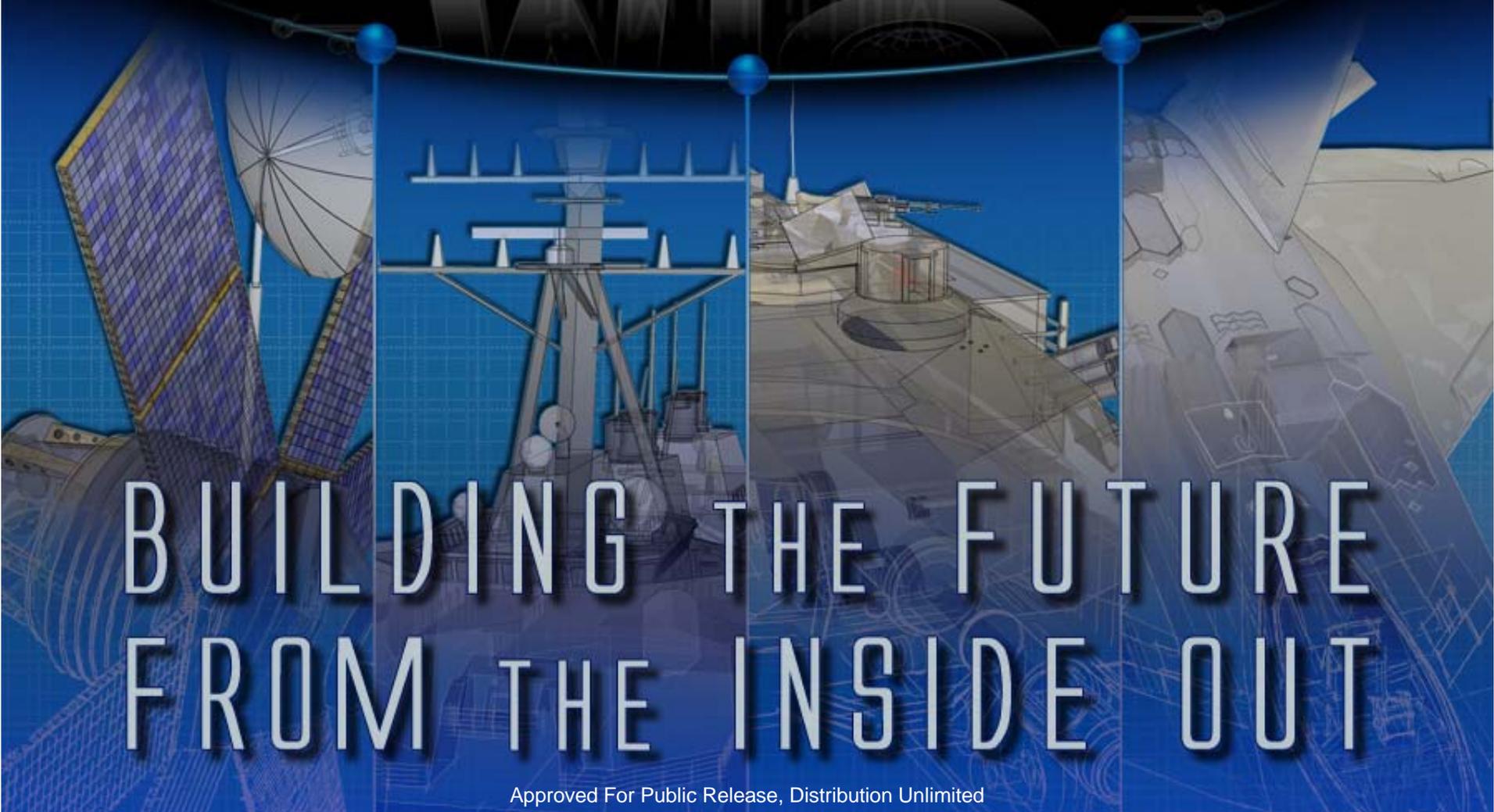
- The rapidly changing world and battlespace makes the delivery of rapid, innovative solutions more critical than ever for the DoD.
- Microsystems remain at the core of new system concepts and new capabilities for the warfighter.
- A strong DARPA, industry, university, and government partnership is critical to continue to deliver timely solutions to the warfighter.

MICROSYSTEMS TECHNOLOGY OFFICE

# MTO SYMPOSIUM



BUILDING THE FUTURE  
FROM THE INSIDE OUT



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