Presented to:

MUNITIONS EXECUTIVE SUMMIT 2010

TECHNOLOGY DEMANDS ON THE FUTURE INDUSTRIAL BASE

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

9 FEBRUARY 2010

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Outline

- BLUF
- Advanced IR Sensors
- Affordable Phased Array Sensor Systems
- Guidance Electronics Miniaturization
- Energetics
- Nanotechnology
- Conclusions

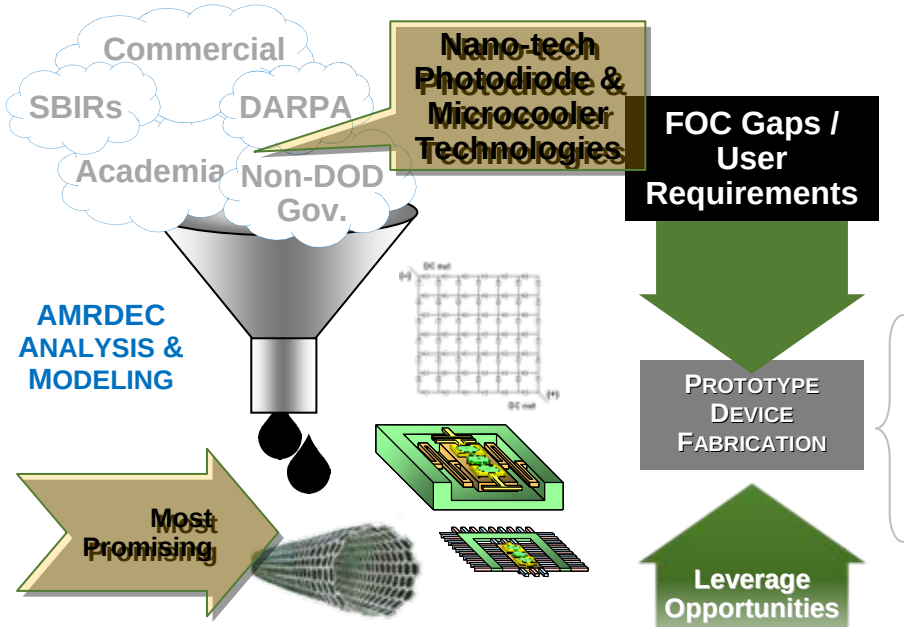
BLUF

- **Advanced IR Sensors**
  - Industrial base for imaging infrared focal plane array technology is limited
  - Investments in new and innovative technologies are required
- **Affordable Phased Array Sensor Systems**
  - The APASS program focuses on affordability, achieving the goal by leveraging the commercial fabrication industry established by the telecommunications industry, and utilizing commercial parts where available.
  - Potential industrial base issues are Import problems, Availability of rare earth metals, and Challenges to a diminishing SME pool to develop required technologies such as thermal management techniques
- **Guidance Electronics Miniaturization**
  - MMC, Die availability, Die harvesting potential, Die redistribution to avoid stud-bumped die assembly, Minimum purchase quantities, Post assembly testing, ODP, Integrated imager/die package for pick-and-place, Low-cost imager (lens), and VCSEL die mass production
- **Energetics**
  - Solid Propulsion issues are driven by small production quantities, new performance parameters and environmental/safety issues
  - Gaps in Propulsion technology still exist
- **Nanotechnolgies**
  - Safety in handling these items (Skin porosity)
  - Advanced production capabilities to maintain quality
  - Maintaining quantities

Advanced Technologies for Next Generation IR Cooled/Uncooled Sensors and Seekers

- **Next Great Idea for Advanced IR Seekers**
  - Supports Lower Cost Seekers and Increased Fidelity That Could Enable ATR (Quantum Det.)
- **Use of Nano/Micro Technology Allows Tailored Response**
  - Flexibility: Technology Core Solves Multitude of Problems (Benefits of Both Cooled & Uncooled)
  - Benefits of either MWIR and LWIR Using Common Design Framework
  - MicroCoolers Offer Fast Cooldown and Long Operation Period (Loiter Functions)
  - Multi-Mode Seekers: Passive Imaging, SAL, Taggant-Based Methods

- **Nano-IR Photodiodes are Immature**
  - Quantum Dot FPAs maturing
  - Devices have been demonstrated under less than optimal conditions
  - Measured results equate to less than 0.1% photon to electron conversion ratios
  - Improved photon absorption is required
  - Capacitance matching required
- **Micro-Cooler Technology Development**
  - DARPA effort holds promise
  - Sort out far-term potential and new concepts



FOC Gaps / User Requirements

PROTOTYPE DEVICE FABRICATION

Leverage Opportunities

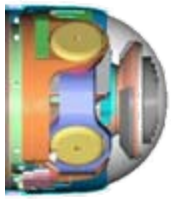
COMPONENT INTEGRATION

LABORATORY EVALUATION

RADIOMETRIC CHAR.

AMRDEC HANDS-ON R&D

SYSTEM DESIGN, TRADES



SUB-SYSTEM DEMONSTRATION

Nano-IR Photodiodes have the potential to provide the best sensitivity and best resolution at the lowest cost and without the need for cryogenic cooling

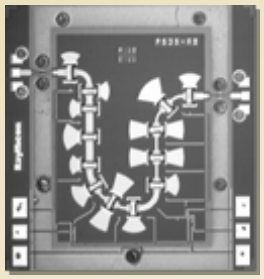
Micro Cryogenic Coolers (MCC) save power and reduce size by selectively cooling

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

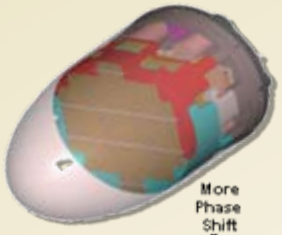
Potential Industrial Base Issues – Advanced IR Sensors –

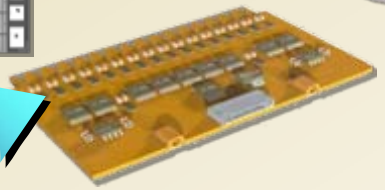
- **Industrial base for imaging infrared focal plane array technology is limited**
  - **Quantities of military and commercial sensors are small**
    - Cooled and uncooled technologies are utilized by U.S Army missile and aviation applications
  - **Thermal detectors (uncooled infrared) are affordable but lack performance and design flexibility**
  - **Quantum detectors (cooled infrared) require closed or open cycle cooling to achieve desired performance**
  - **Export limitations have resulted in worldwide efforts to reduce or eliminate U.S. infrared dependence**
    - The U.S has lost it's technical advantage
- **Investments in new and innovative technologies are required**
  - **Alternative uncooled technologies for more improved performance and increased design flexibility**
    - Nano-scaled infrared photodiodes potentially allow quantum detection without cryogenic cooling
  - **Alternative cooling technologies for improved management of size, weight, power and array cooling**
    - Micro-cryogenic cooling potentially provides commercial and military users of imaging infrared with high performance cooled, quantum detectors in a solid state device package eliminating reliability issues of closed cycles coolers and shelf life of gas bottles

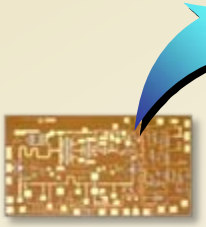
Affordable Phased Array Sensor Systems (APASS)



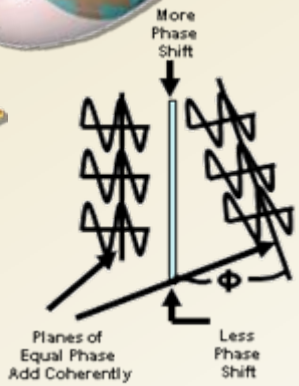
Ka-band Micro Electro-Mechanical Systems (MEMS) Phase Shifter, 4-bit, 1.7dB – 2.5dB loss







Ka-band Monolithic Microwave Integrated Circuit (MMIC) based T/R Module to Slat to Array



APASS Focuses on Affordability Resulting in:

- **Use of commercial products and commercial manufacturing techniques**
- **Ease of manufacturing / producibility through the use of commercial products and commercial fabrication base.**
- **Leverages the communications industrial base for fabrication and many sub-components:**
  - Printed wiring boards
  - Semiconductor components
  - Power and digital control

Purpose:

Develop advanced technologies for affordable phased array sensors for air and ground based systems including tactical seekers, fire control sensors and data links

Key Attributes:

- **Reduced array size and weight**
- **Gimbal elimination**
- **Reliability increased as much as 95%**
- **Eliminates the single point failure of conventional arrays**
- **Graceful degradation – can lose 14% of elements before experiencing performance slip**
- **Cost reduction of 50%**
- **Per system specific target sets**
- **Instantaneous beam reposition**
- **Ability to track multiple targets**
- **Increased performance**
- **Increased lethality**

Challenges:

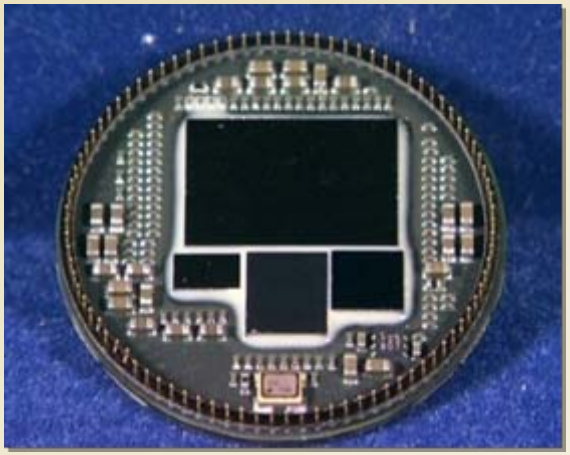
- **Power**
- **Sufficient for given target set, all solutions may not address most stressing target set**
- **MMIC design, fab and test at required power level**
- **Thermal**
- **Thermal management to address higher MMIC power levels**
- **Address unit cell junction temperature, integrated AESA, and final environmental temperature**
- **Strap-down Guidance Techniques**
- **Calibration**
- **Is in-flight necessary, or BIT adequate**

Potential Industrial Base Issues – APASS –

- **The APASS program focuses on affordability, achieving the goal by:**
  - **leveraging the commercial fabrication industry established by the telecommunications industry.**
  - **utilizing commercial parts where available.**

- **Potential industrial base issues:**
  - **Semiconductor Issues**
    - Availability of rare earth metals for semiconductor fabrication (such as Gallium)
    - Import issues associated with both rare earth metals and semiconductor components
  - **Challenges to a diminishing SME pool to develop required technologies such as thermal management techniques**

Guidance Electronics Miniaturization



Miniature Mission Computer (MMC)
DSP, FPGA, Memory
31.75 mm - diameter
3.0 mm - thickness

Optical Data Pipe (ODP)
High-bandwidth digital link
6.0 mm - square
5.0 mm - height

GEM Focuses on Affordability Resulting in:

- Use of commercially available components and commercial manufacturing techniques and processes
- Ease of manufacturing / producibility through the use of commercial products and commercial fabrication base
- Leverages existing industrial base for fabrication and component processing:
  - Substrate design
  - Semiconductor components
  - PWB assembly and testing

Purpose:

Develop, test, and transition miniaturized electronics technology to AMRDEC missile programs to decrease flight electronics weight, space, and power footprint

Key Attributes:

- Reduced size (up to 80%) and weight (up to 90%) for embedded computers, depending on design
- Reliability equivalent to standard PWB technology (MMC)
- Production Cost equivalent to standard PWB technology (MMC)
- Volume dependent
- Lower system weight and size (ODP)
- Reduce/eliminate connectors
- Reduce/eliminate wires
- Performance improvement (ODP)
- Wide misalignment tolerance
- High channel count allows redundant data paths
- 100+ channels @ 100Mbps/channel

Impact to the Industrial Base:

- MMC
- Die availability
- Die harvesting potential
- Die redistribution to avoid stud-bumped die assembly
- Minimum purchase quantities
- Post assembly testing
- ODP
- Integrated imager/die package for pick-and-place
- Low-cost imager (lens)
- VCSEL die mass production

Advanced Propellant S&T Joint Strategic Vision

LETHAL & SURVIVABLE

- **Advanced Propellant Attributes:**
  - **Increased lethality and precision targeting at all ranges with smaller, lighter munitions**
  - **Insensitive formulations enabling survivable weapons platforms in tactical & logistical use**
  - **Environmental & lifecycle compliance**
  - **Cost effective for long-term planned use**
- **Advanced Propellant Critical Needs to Accelerate the Pace of Transformation:**
  - **New chemistries**
  - **S&T to dynamically manage and tailor propulsive energy release**
  - **Underpinning S&T to break the paradigm between increased energy translating to increased sensitivity**

Missile Structure Technologies

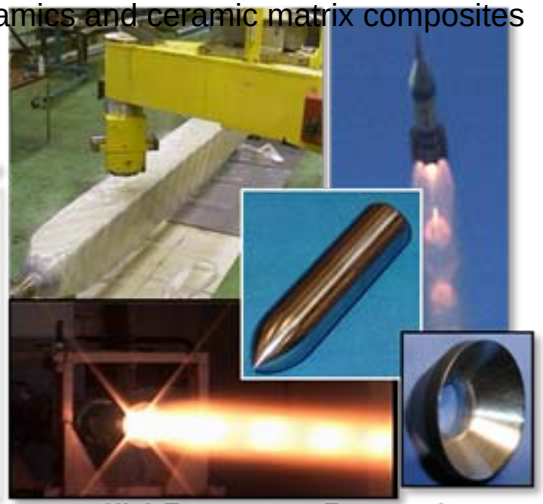
Material Development & Fabrication Technology

CONSTITUTIVE MATERIALS

- **Processable High Temperature Resins**
  - high temp. performance without excessive cure temp.
  - good flow at room temperature
- **Next Generation of Structural Fibers**
  - high strength, stiffness, and impact resistance
- **Oxidation Resistant Materials for Nozzles and Hypervelocity Missile Control Surfaces**
  - toughened ceramics and ceramic matrix composites

Wound-in-place Nozzle

Fiber/Resin Characterization



High Temperature, Zero-erosion Nozzle Components

STREAMLINED PROCESSING TECHNIQUES

- **Metallic and Ceramic Coatings for Hot Structures**
  - rapid, high-quality deposition techniques
- **Affordable Thermoplastic Fiber Placement for on-the-fly cure of fiber reinforced composites**
- **Integral Attachment Methods for Composite Structures**
  - bonded/wound-in adapters (reduction of post-processing/assembly burden)

Thermoplastic fiber placement

Electrodeposited Rhenium-coated Pintle

Integrally-wound Motorcase Joint

ENABLING TECHNOLOGIES: net-shape fabrication techniques, high throughput fabrication methods for tactical, novel design approaches for high performance with improved producibility

Potential Industrial Base Issues

- **Solid Propulsion issues – driven by small production quantities, new performance parameters and environmental/safety issues**
  - **Availability of raw materials (obsolescence even before production)**
  - **Challenges to a diminishing SME pool to develop required technologies**
  - **Challenges to a diminishing production pool to make cases, nozzles, rocket propellant – all components of the propulsion units**
- **Gaps in Propulsion technology still exist**
  - **New EM ingredients for lower shock sensitivity, environmental-acceptability, improved aging, improved mechanical/physical properties, lower cost**
  - **New cases/ nozzles will face cost and performance and availability issues as well**

Current Industrial Base Issues – Propulsion –

- **Solid Propellants**
  - **Obsolescence may become the most critical aspect for Ems; Examples:**
    - BT – precursor to BTTN
    - AP – program requirements and environmental
    - Lead compounds – environmental
- **Inert components (nozzles, cases, throats); Critical materials:**
  - **Rayon**
  - **Carbon/Carbon**

AMRDEC Nanotechnology Research Initiative

	SWFTICE (ATO)	Nanopower Storage	Nanosensors & Nanoelectronics	Nanocomposites	Nanoenergetics
Capability Gap	Capability to identify targets on impact and autonomously configure warhead detonation with single missile does not exist	Longer munition mission timelines requires increased capacity and higher density storage batteries; Quick reaction muntions need higher power delivery.	Non-availability of miniature health-monitoring sensors to detect rocket motor propellant outgassing	Metal motor casings are heavy; replacing metal reduces electrical and thermal conductivity	Monomethyl hydrazine is not environmentally friendly
Solution	Develop MMME warhead with inertial sensor capable of target identification	Grow high surface area nanomaterials for super capacitors and thermal batteries; Develop hybrid systems	Develop mini devices capable of detecting nano-particle chemicals for weaponry health	Reduce weight and improve thermal management with nano-enhanced resins and fibers	Utilize tertiary amines and manipulate particle and pore size
Applications	• TOW • Javelin • HELLFIRE • JAGM • NLOS-LS PAM	• PAC-3 (longer lifetime sources) • KEAPS (energy storage capacitors) • NLOS (power systems)	• RRAPDS (weaponry health) • THAAD (hydrazine detector) • MMMPSMP	• Javelin (launch tube) • Lightweight Launcher Motor Cases	• Gellants for Fuels of Bipropulsion Systems
Endorsements	• TRADOC • USAISC • PEO Missiles & Space – CCWS – JAMS – NLOS-LS – PFRMS • USAFAC	• PEO Missiles & Space	• NAWC • AMRDEC – RRAPDS (Technology Base Program) – SWFTICE (ATO) – ASLCMC (ATO)	• PEO Missiles & Space – CCWS – JAMS	• PEO Missiles & Space • AMRDEC – MMMPSMP (ATO)

Key DoD Partners

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Conclusion

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