Collaborative Technology Alliance (CTA)

Advanced Sensors

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"ASCTA is Developing the Critical Technologies to Enable the Future Force to See First, Shoot First, & Finish Decisively"

REALIZING THE VISION

Advanced Sensors Collaborative Technology Alliance

Consortium Partners

- BAE SYSTEMS
- Northrop Grumman
- DRS Infrared
- Quantum Magnetics
- General Dynamics Robotic Sys
- U. New Mexico
- Clark-Atlanta
- MIT
- U. Maryland
- Georgia Tech
- U. Michigan
- U. Florida
- U. Mississippi
- U. Illinois – Chicago
- JPL

Objectives

Technologies that increase sensor performance and utility, and techniques to combine many types of data to provide timely and meaningful information to the soldier.

Affordable sensors that provide:

- Continuous situation awareness
- Rapid, precise detection and ID of camouflaged targets
- Environmental sensing for navigation and self-defense

Technical Areas

- Microsensors
- Electro-Optic Smart Sensors
- Advanced RF Concepts

Advanced Sensors Collaborative Technology Alliance

ARL CAM: Dr. Dan Beekman
BAE Systems PM: Mr. Steve Scalera

Microsensors

ARL: Nino Srour
BAE Systems: Mark Falco

Provide All-Weather, Persistent Situational Awareness

EO Smart Sensors

ARL: Dr. Arnie Goldberg
BAE Systems: Dr. Parvez Uppal

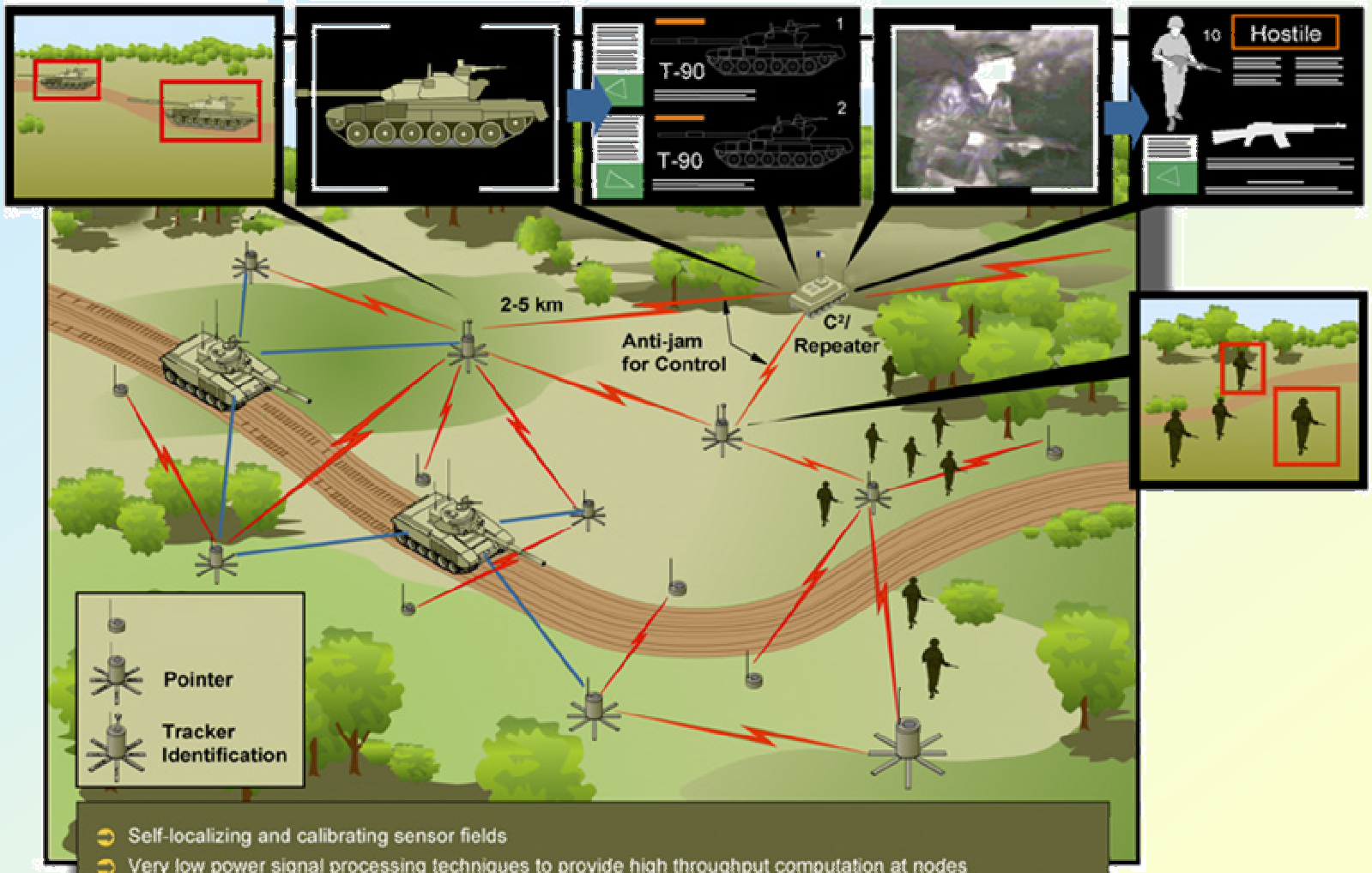
Reduce Sensor To Shooter Time

Advanced RF Concepts

ARL: Ed Viveiros
BAE Systems: Dr. Norm Byer

Enhance Warfighter Lethality & Survivability with Mobile Integrated MFRF Systems

Microsensors
The Vision



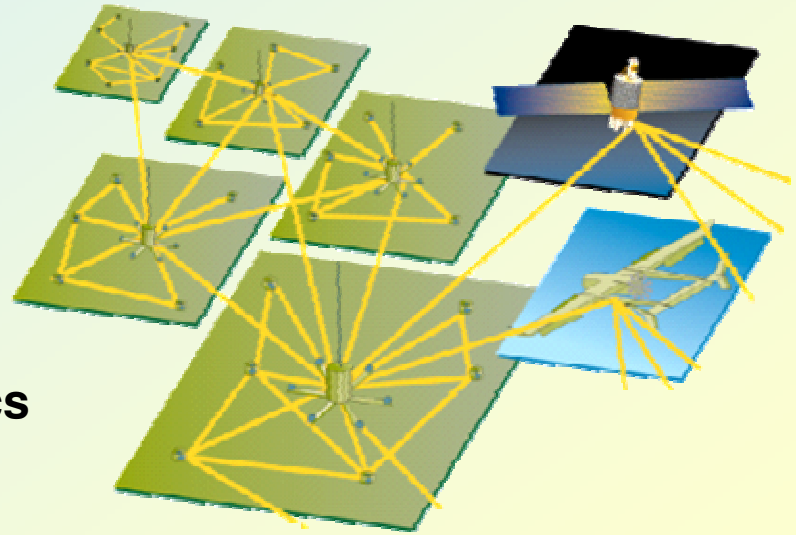
- Self-localizing and calibrating sensor fields
- Very low power signal processing techniques to provide high throughput computation at nodes
- Fusion of data, features and decisions for robust performance and greatly reduced false alarm rates
- Hierarchical network with intelligent control to preserve power, reduce communication bandwidth and remove operator overload.
- Multi-sensor, multi-modal(imaging and non-imaging) low cost sensors for all weather performance
- Advanced algorithms for multi-target discrimination, tracking and identification of people and vehicles

Microsensors
The Focus

Objective: Demonstrate a family of low cost sensors utilizing a wide range of sensor types, to enable overarching situational awareness & provide a common operational picture across all echelons of the future Army

Challenges:

- Effectively prosecuting time critical targets
- Robust & efficient multi-sensor signal processing, ID & data fusion algorithms
- Robust & computationally efficient sensor field organizational algorithms
- Small, lightweight, low power electronics



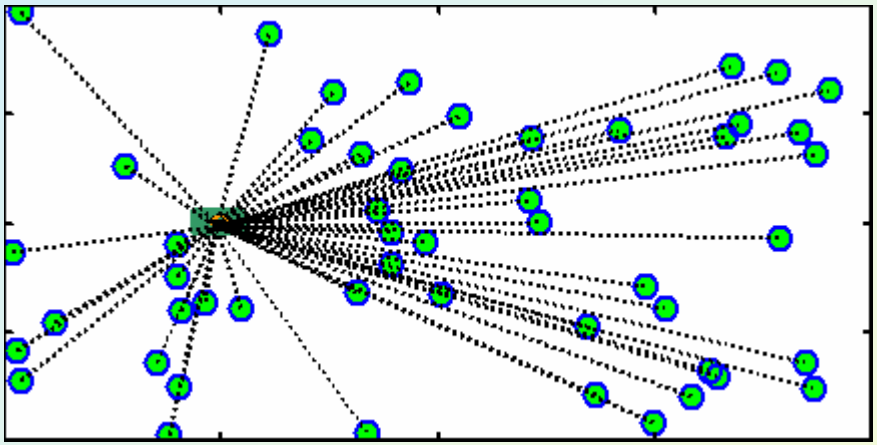
Research Tasks:

- Non-Linear Spatial Processing
- Multimodal Sensor Fusion
- Low Power Sensor Detection
- Magnetic Sensors
- RF Microsensors
- Detection & Tracking with Distributed Imagers

Microsensors
Highlights

Multi-Target Discrimination, Tracking and Classification Algorithms

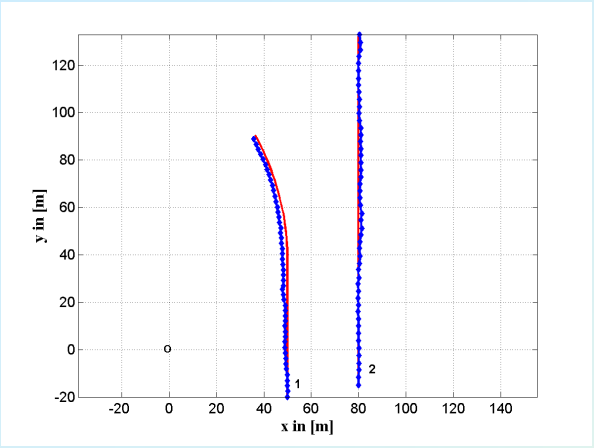
- **Significant progress towards an integrated algorithm that fuses acoustic and infra-red sensor information to detect, track and classify multiple enemy targets simultaneously.**
- **University of Maryland, BAE SYSTEMS, and Georgia Tech, collaborate on Acoustic/Infrared signal processing and target classification .**



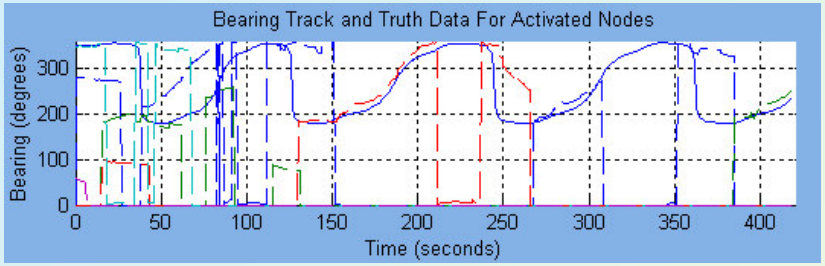
Autonomous Node Selection Algorithm.

Multi-Modal, Multi-Sensor processing and fusion enables situational awareness and threat assessment under a wide range of environmental conditions

Microsensors
Highlights



- Improved the performance of the independent partition particle filter (IPPF) by incorporating a time-varying frequency estimate of the targets into the filter.
- The new filter achieves superior tracking resolution that should enable the tracking of multiple targets in a convoy simultaneously by acoustic array..

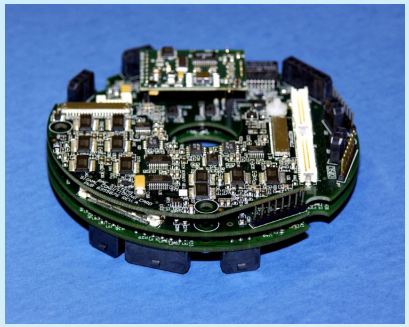


Developed a baseline acoustic classification algorithm in a multi-target environment using short duration signal estimation and feature extraction

Developed an approach that incorporates appearance based models in a particle filter to realize robust visual tracking algorithms

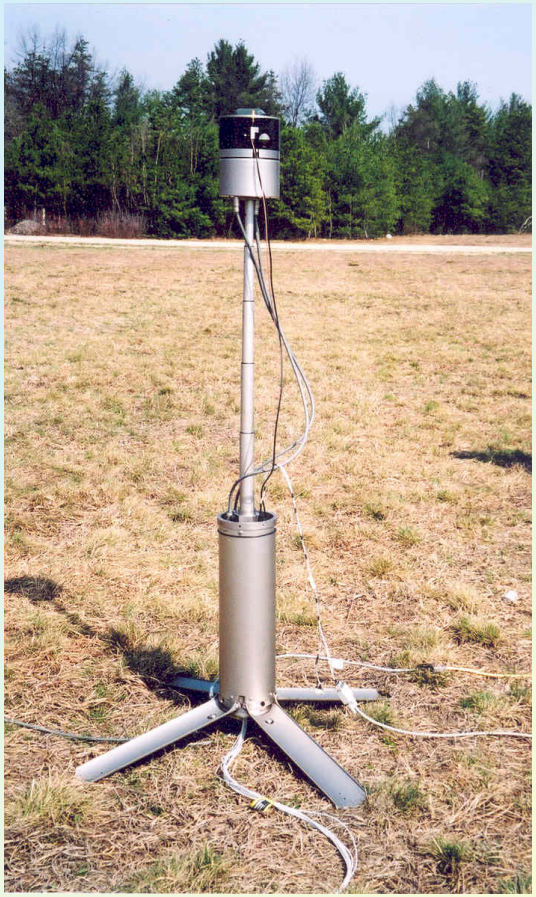
Multi-target classification processing will be integrated with particle-filter based acoustic processing, image sensor processing and data fusion techniques to correlate clusters of target position estimates/tracks by associating similar feature measurements along a track

Microsensors
Transitions



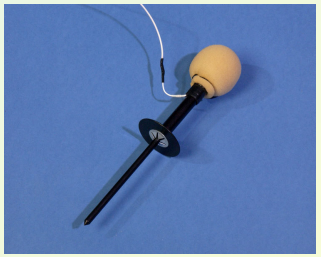
Card Set

Electronics Stack



MAIS Imaging Node

Imaging Head



Acoustic Sensor

Seismic Sensor

MAIS Imaging Node provides infrared and day images, 10 acoustic sensors, 4 seismic sensors, 4 analog spare inputs, 8 serial ports for digital magnetic sensors and a short haul radio

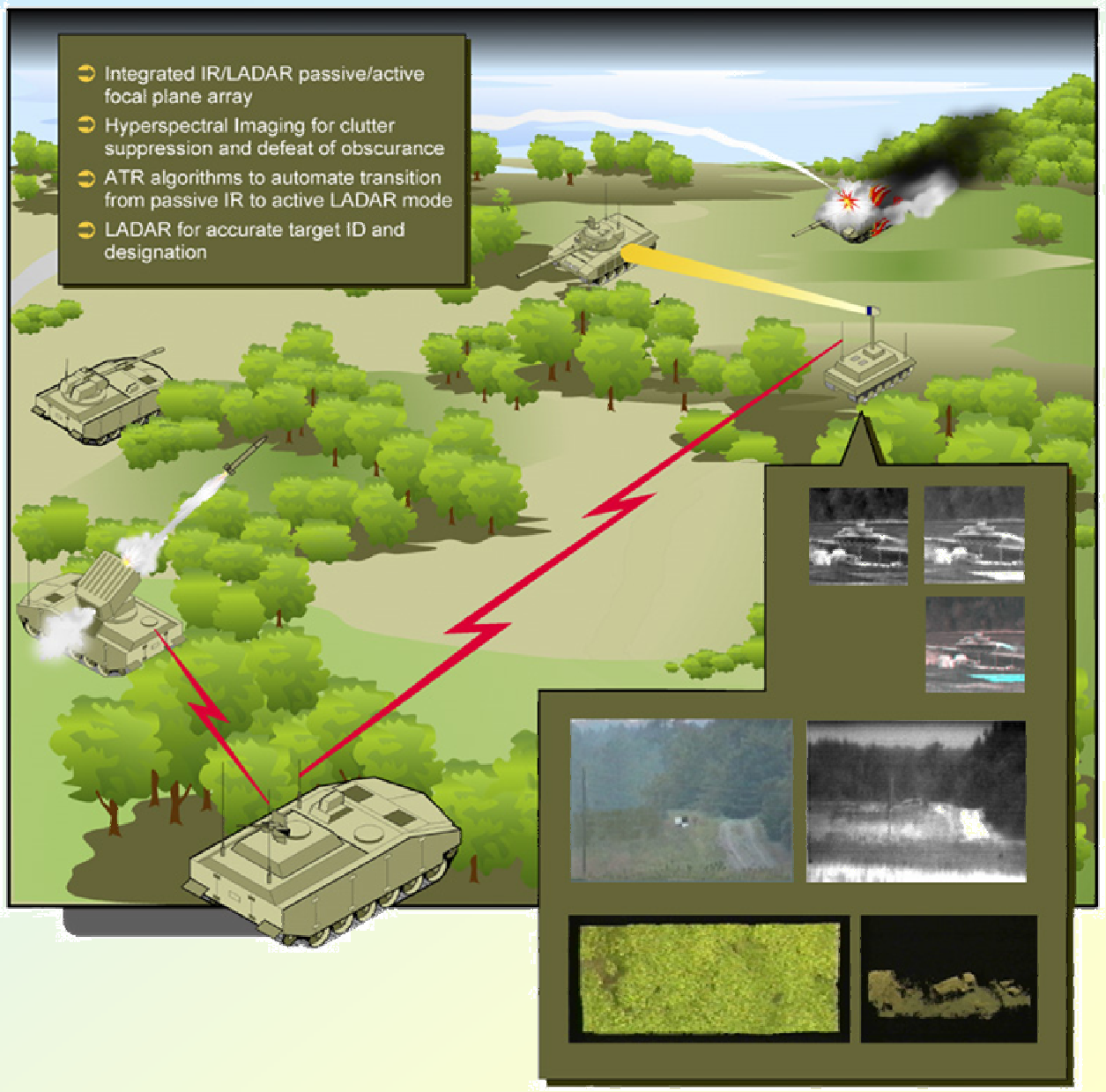
Microsensors
Transitions

- Currently technical area has two technology agreements with CERDEC and one task order contract with ARL.
  - Technology agreement with CERDEC focused in battlefield acoustic technology. This work will focus in the areas of advanced acoustic sensors and signal processing algorithms for recognition and localization.

  - Technology agreement with CERDEC to investigate non-imaging sensor technology to support the joint NVESD/ARL WEBS STO. Specific areas of interest include acoustic, seismic and magnetic sensing as well as exploration of other sensors that can detect, locate and identify battlefield targets.

  - Task order contract for the development of disposable sensor technology. This stems from the basic research findings in FY03 under disposable sensors.

EO Smart Sensors
The Vision



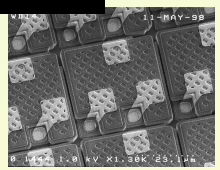
EO Smart Sensors
The Focus

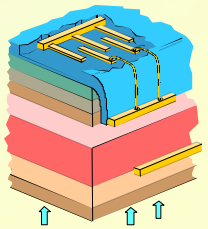
Objective: Develop multifunction EO/IR components for next generation Army Systems, which will;

- Allow exploitation of information in the full EO spectrum
- Allow rapid detection and identification of targets under all conditions

Challenges:

- Effective Operation in Diverse Battlefield Conditions
- Extended ID range allowing the soldier to react first
- Target detection under low contrast and camouflage
- More functionality in a compact form factor





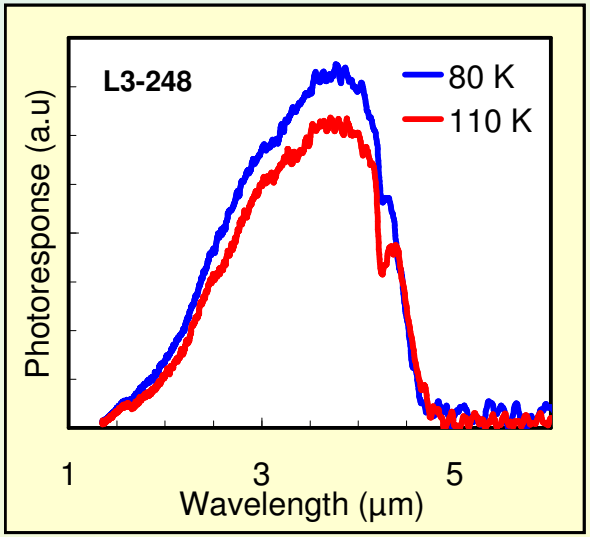
Research Tasks:

- Integrated Active/Passive Imagers
- Higher operating Temperature detector arrays: HgCdTe & GaSb/InAs Strained Layer Superlattice
- Hyperspectral sensor components
- 2-5 Micron Lasers
- Data fusion algorithms for automatic target recognition
- VSCEL Data Links & Optical FPA Read Out

EO Smart Sensors
Highlights

Higher Operating Temperature Detectors Based on InAs/GaSb Strain Layer Superlattices (SLS)

- **High quality GaSb/InAs SLS material grown at UNM/ARL**
- **Single pixel MWIR detectors operate at 110K**
- **Higher material quality will allow BAE SYSTEMS to fabricate detector arrays**

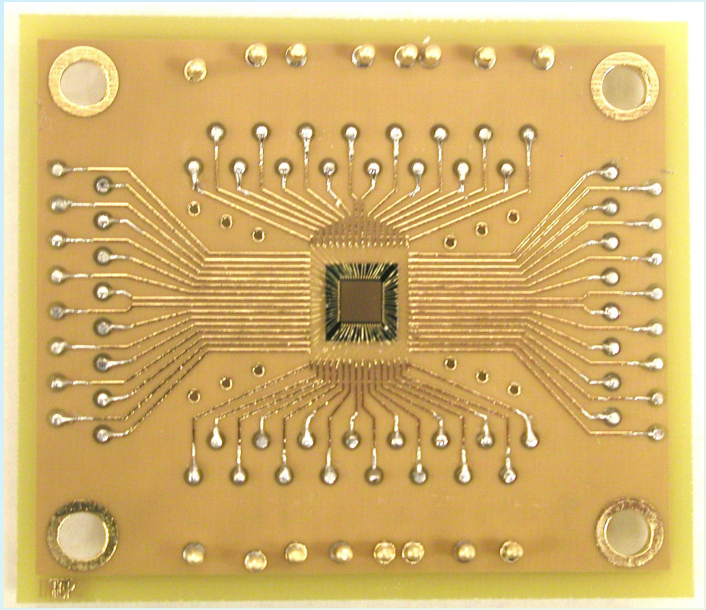


SLS Detector Shows High Temperature Response

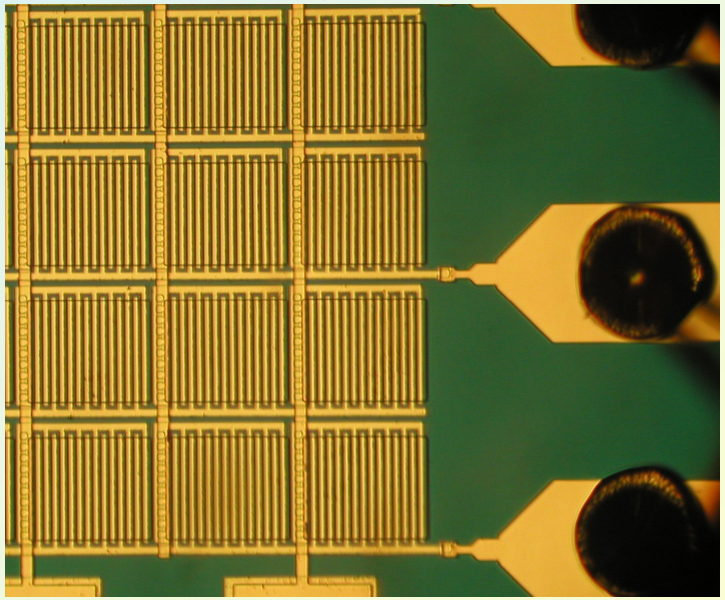
Higher operating temperature FPAs will lead to lower system weight and longer life cryo-coolers for Army infrared imagers

EO Smart Sensors
Highlights

32x32-Pixel
GaAs Laser Detector Array



32x32 pixel array (100 μm)
on microstrip fan-in board



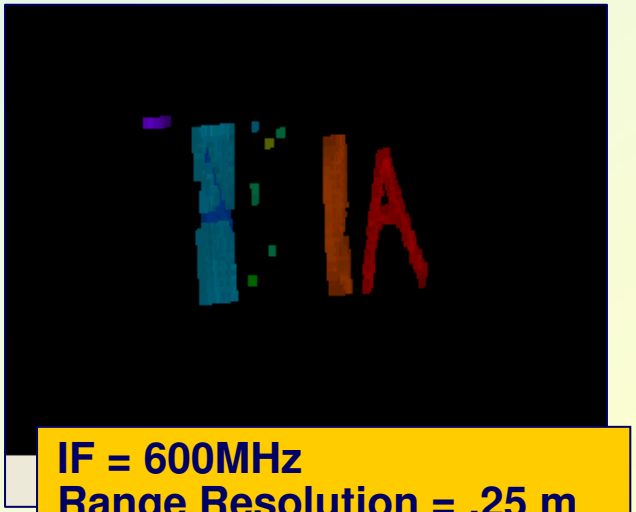
Portion of 32x32 pixel array (100 μm)

- Metal-semiconductor-metal (MSM) design
- 50x50, 100x100, 250x250 μm pixels (BAE Systems fabricated)
- 60x60 μm pixels (ARL fabricated)

BAE Systems has fabricated 32x32 pixel array with built-in bypass capacitors for active/passive imaging

EO Smart Sensors
Highlights

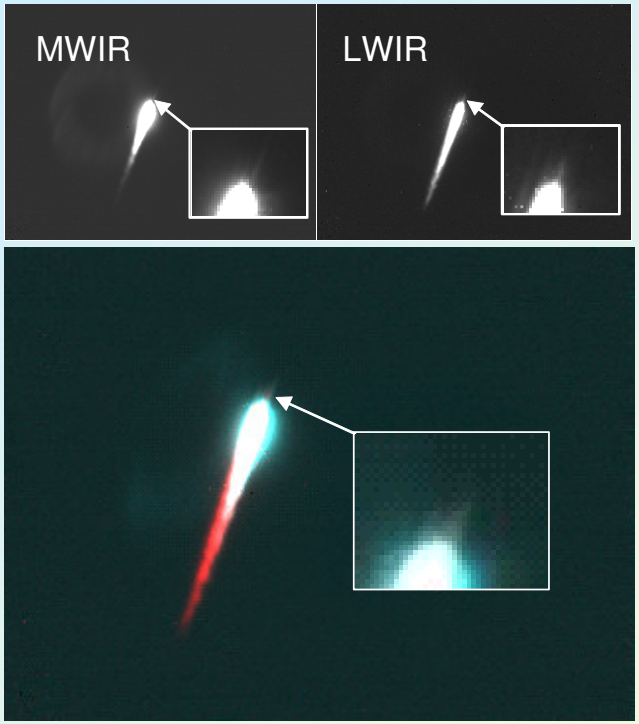
32x32 Pixel Image Captured with Ladar Breadboard



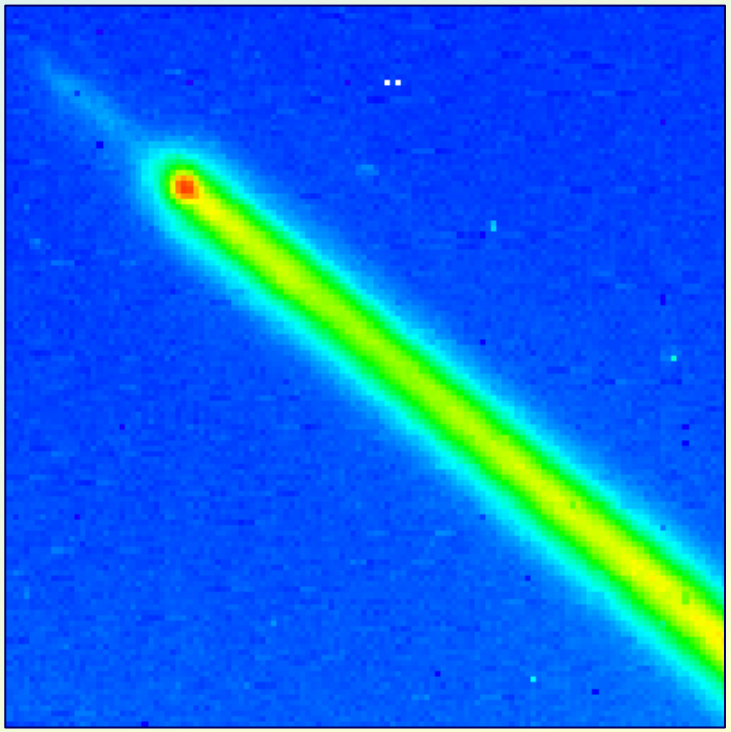
- IF = 600MHz
- Range Resolution = .25 m
- Frame rate = 3 Hz
- Power per pixel ~ .2 mW
- Range = 10 m
- Lens diameter = 5 cm

EO Smart Sensors
Transitions

Two-color IR Imagery for MDA Applications

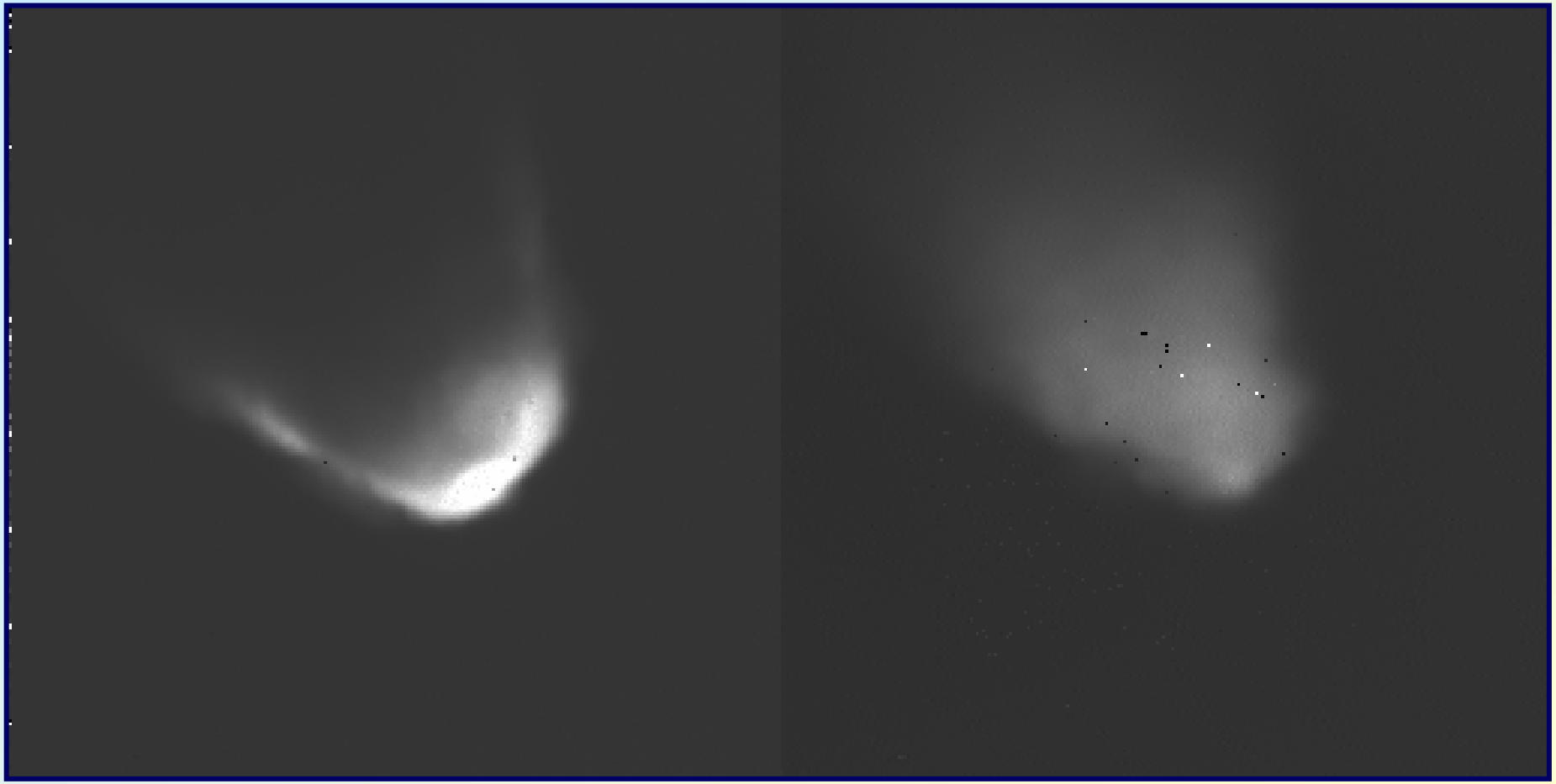


Simultaneous MWIR (top left), LWIR (top right) and red-cyan color fused images of a Minuteman III missile during boost phase. The inset box in each image shows the position of the missile hardbody.



False color LWIR image of the boost phase of an Aries target vehicle.

EO Smart Sensors
Transitions



MWIR

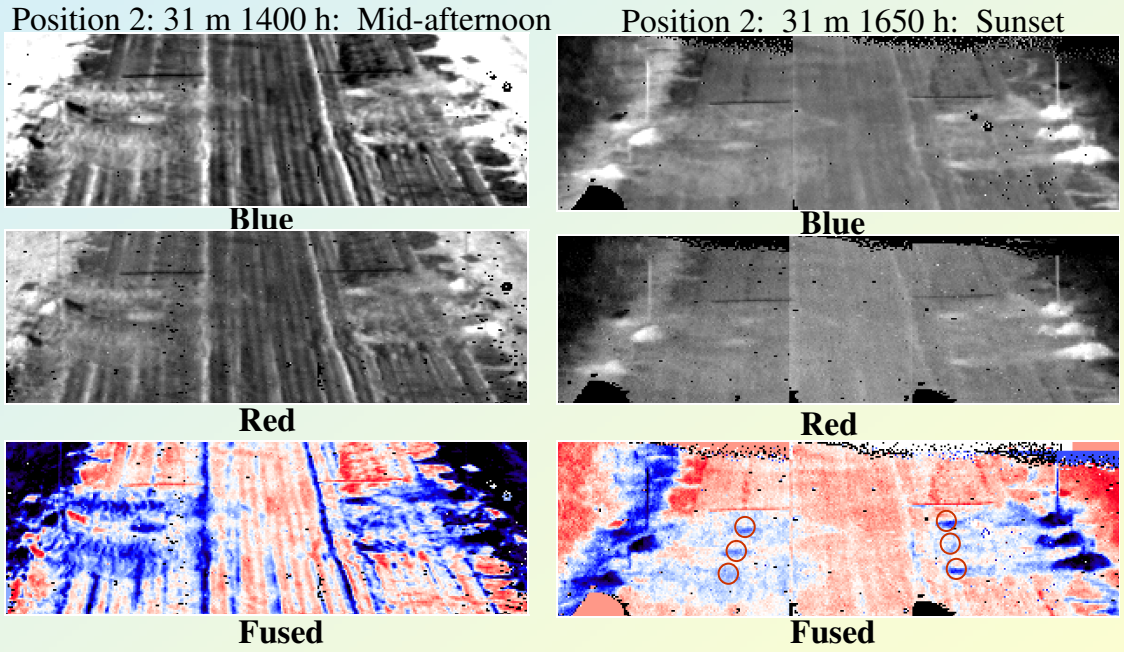
LWIR

Two-color IR Imagery for MDA
Delta Rocket Plume Signatures

EO Smart Sensors
Transitions

Long Wave Infrared (LWIR) Focal Plane Arrays for Mine Detection

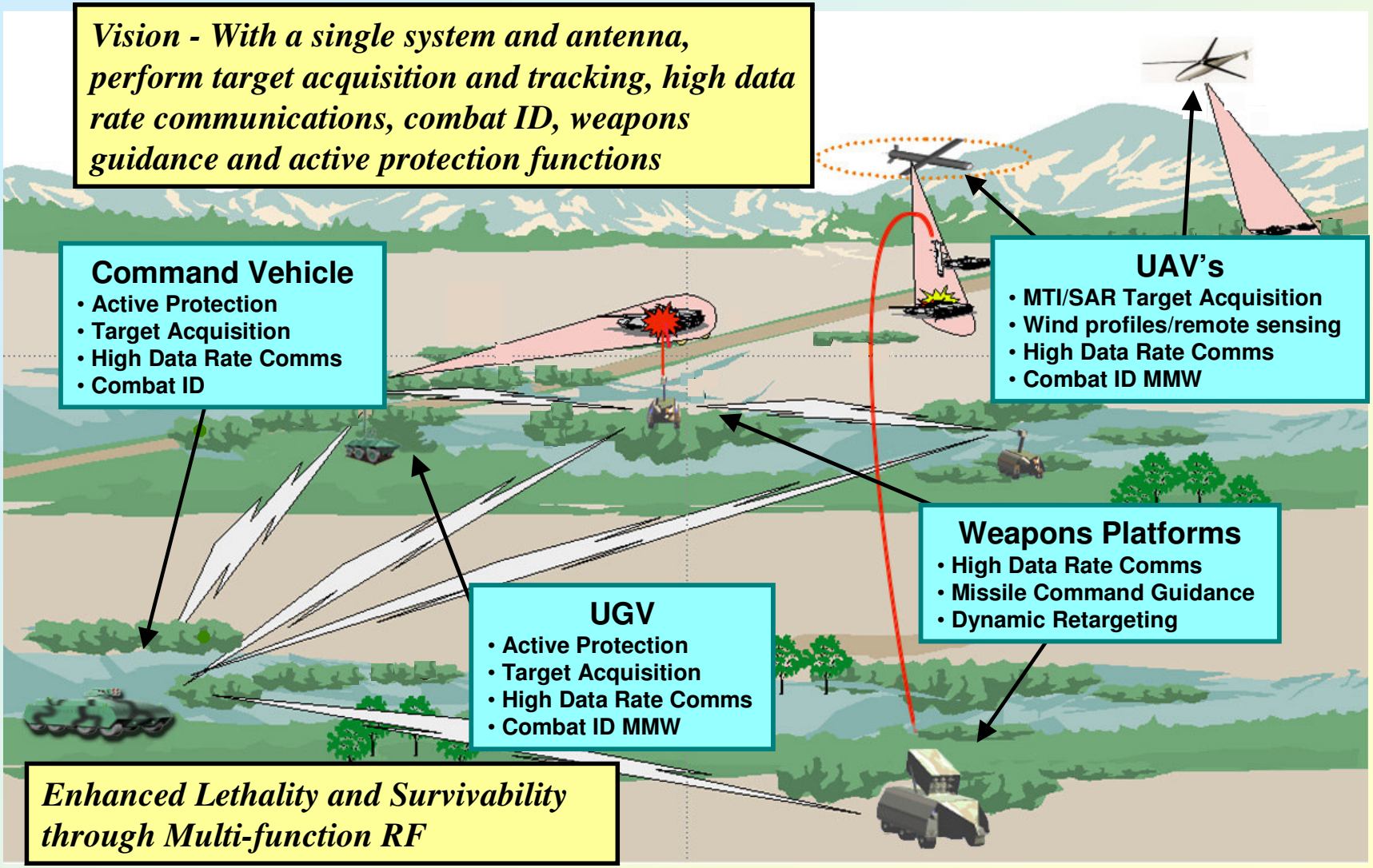
- **ARL in collaboration with BAE Systems has demonstrated the use of two-color LWIR/LWIR infrared imagery for the detection of freshly buried mines.**
- **BAE Systems fabricated two-color pixel registered LWIR/LWIR focal plane array (FPA) detector under a task order**
- **Ultimately this technology will be transitioned into the Lightweight Airborne Minefield Detection (LAMD) at NVESD.**
- **Existing system flown on helicopter platforms for demonstration**



Simultaneous composite images of mine positions 1, 2, and 3 from the blue (top), and red (center) parts of the dual-band QWIP FPA taken in mid-afternoon.

Advanced RF Concepts
Vision

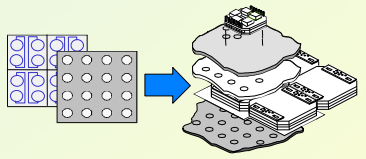
Vision - With a single system and antenna, perform target acquisition and tracking, high data rate communications, combat ID, weapons guidance and active protection functions



Enhanced Lethality and Survivability through Multi-function RF

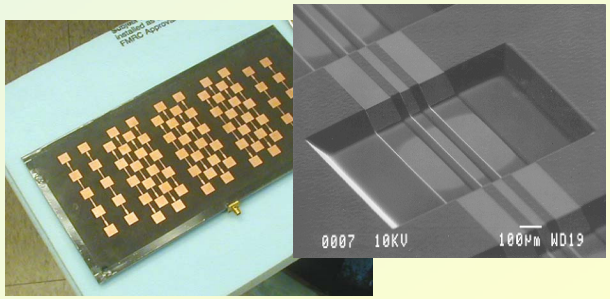
Advanced RF Concepts
The Focus

Objective: **Provide enabling subsystem, component and systems studies for low cost multifunction Ka-band RF systems that provide FCS with longer range all-weather operation for radar, communication, IFF and EW/SIGINT functions.**



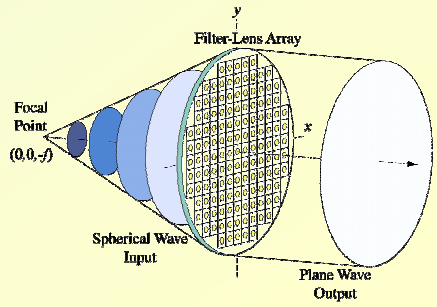
Challenges:

- **Affordable MMW Electronically Scanned Antennas (ESAs)**
- **Low Cost Hermetic Packaging for Reliable MEMS Devices**
- **Efficient, High Dynamic Range Power Devices for T/R Modules**

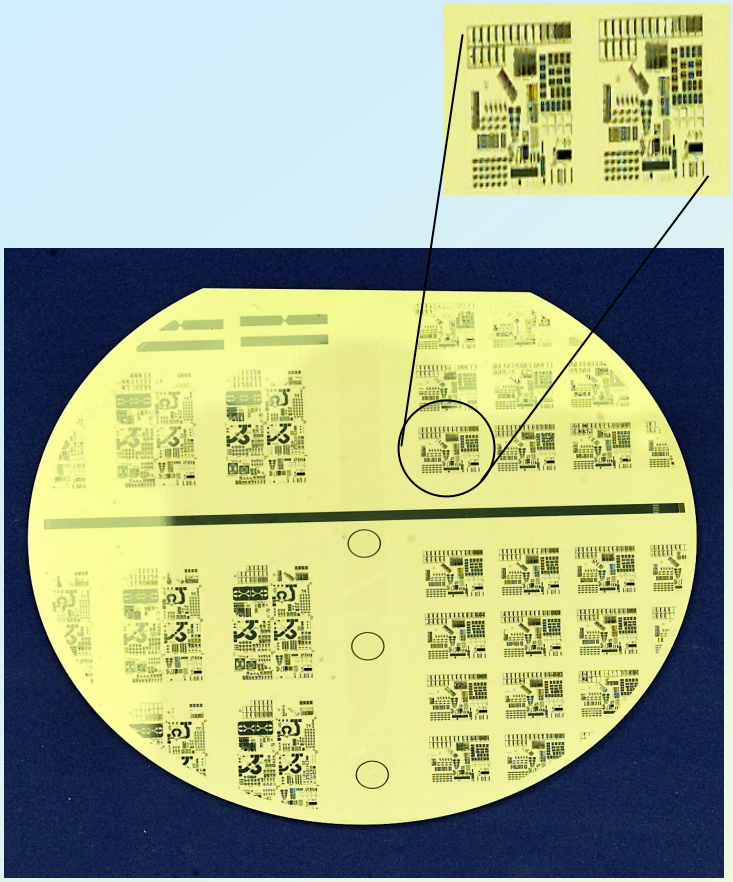


Research Tasks:

- **MEMS Ka Band Phase Control Module**
- **MEMS TTD Elements & Device Reliability**
- **MMW Bistatic Scattering Phenomenology**
- **MMW GaN Materials and Components**
- **Novel ESA Architectures (Lens Filter Array)**



Advanced RF Concepts
Highlights



First functional RF MEMS devices on an LCP Substrate

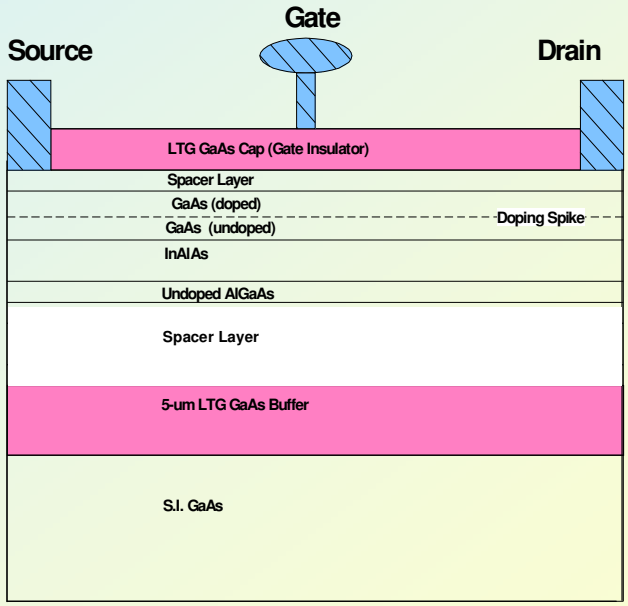
- Efficient, compact, and affordable phased array antenna technology is the most critical element for any multifunction RF system
- Batch fabrication of MEMS phase shifter array integrated into a planar, multilayer-, liquid crystal polymer (LCP) substrate assembly – offers 10x reduction in cost compared to LTCC packaging approach
- Recently we demonstrated MEMS switches on LCP – a significant milestone.

Batch Fabricated MEMS Devices will lead to affordable ESAs

Advanced RF Concepts
Highlights

Low Temperature Growth (LTG) GaAs Switch Technology - A Semiconductor Approach to Batch Fabricated Phase Shift Arrays

- **Successfully demonstrated the first generation of a novel switch device which utilizes LTG GaAs material layers**
- **Technology offers the potential for 3x reduction in phase shifter loss at MMW frequencies compared to conventional PHEMT GaAs devices.**
- **In contrast with MEMS switches, LTG GaAs devices are compatible with existing GaAs MMIC fabrication lines.**



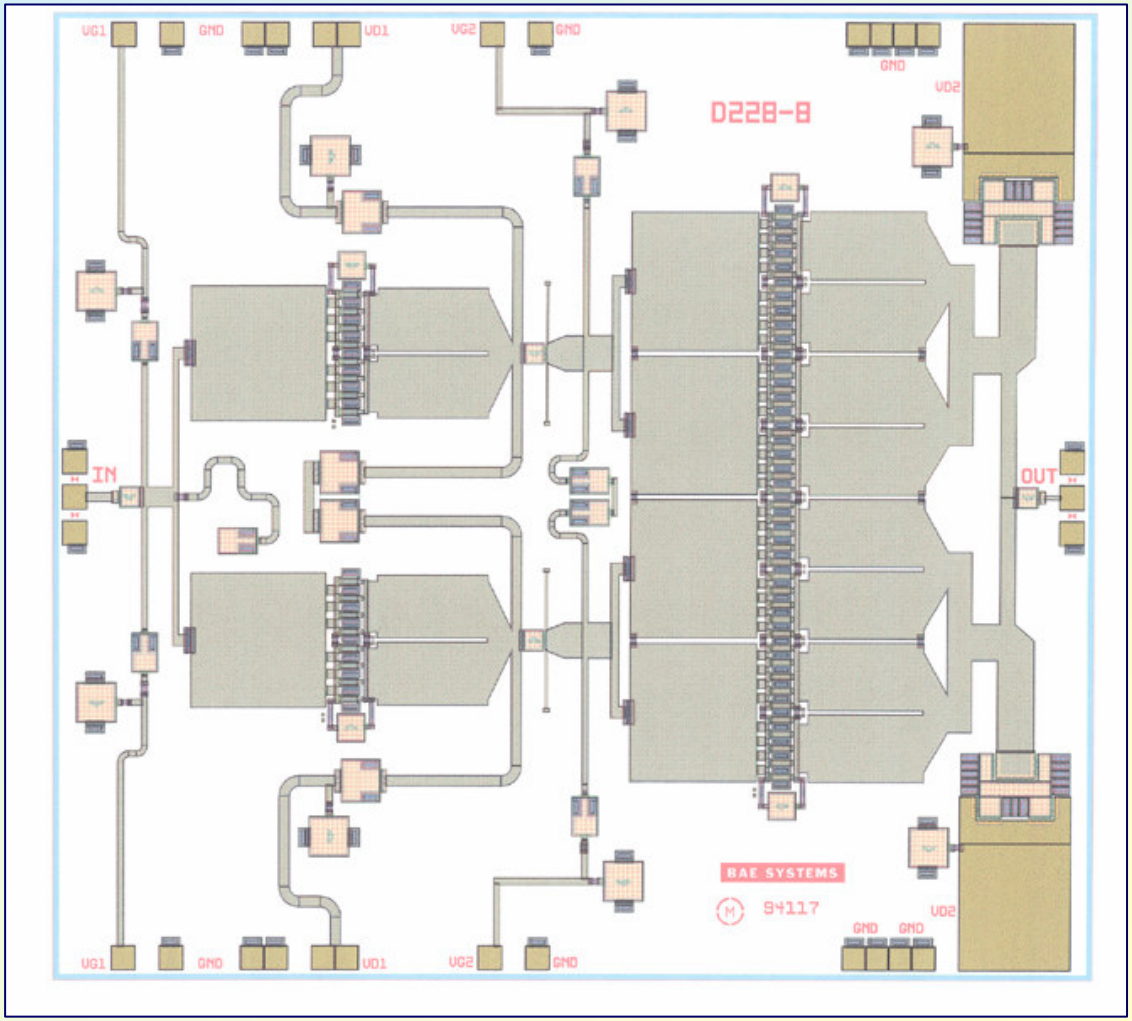
Layer structure of a LTG-GaAs insulted-gate PHEMT

LTG GaAs Technology Promises to minimize costly amplifying components in ESAs, enabling affordable multifunction radar systems for Army FCS vehicles

Advanced RF Concepts
Transitions

Ka-band (27–40 GHz) MHEMT MMIC for Future Army Multifunction Apertures

- Under a task order BAE SYSTEMS has produced a variety of MMIC types including all transmit/receive (T/R) functions
- Enables high levels of integration for affordable multifunction apertures.
- Eight different MMIC types, a total of 41 Ka-band MHEMT MMIC chips, were delivered to ARL for integration into multifunction radars



1 W High Efficiency Power Amplifier

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