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Current Directions in Sensor Technologies at NVESD

Keynote Presentation: SPIE DSS IR Technology & Applications XLI Conference

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NVESD Mission

★ **CERDEC**
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Research and Development in Advanced Sensors - Military Specific Technology -

EO/IR and Electronic
Sensors/Lasers for:

Surveillance (ISR)

Targeting (RSTA)

Countermine/IED/Humanitarian Demining

Night Pilotage/Driving

Force Protection/Perimeter Defense

Laser Countermeasures and CCD

DoD Sensor Target
Acquisition
Model Development

Sensor
Fusion

**DOD CENTER FOR
IR AND COUNTERMINE**

**OWN
THE NIGHT**

**6.2 + 6.3 + 6.4 + ManTech = Transition Technology to
PMs for Future Force & war support during wartime**



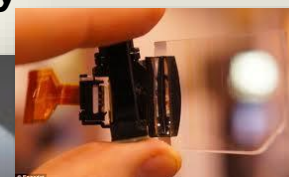


- **Key Technology Thrusts**
 - **Digital Low Light Sensors**
 - **Micro Displays**
 - **Uncooled IR**
 - **Digital ROICs**
 - **III-V and II-VI IR detectors**
- **MANTECH**
- **Trends**
 - **DVE**
 - **RSTA**

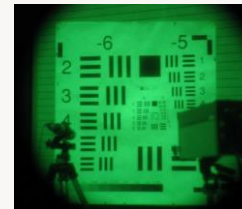
Current State of the Art Hybrid – Digital + Analog



Future Concepts Fully Digital Systems Heads Up Display



Conventional **Direct View** I2 Tube
(No Display)



Digital **Indirect View**
(Camera/Video Display)

Challenges of Digital Low Light imaging

- Power requirements for an EI2 based vision system (includes sensor and display) currently 10X that of direct view
- Maximum resolution does *not yet* meet the current capability of direct view at high light level
- Usable light level range within the same scene (dynamic range) does *not yet* meet direct view
- Image smearing degrades moving images (longer integration times than direct view) – head motion
- Image processing and digital image enhancement add to the power demand of EI2 sensor

Benefits of Digital Low Light imaging

- The only solution for remote imaging applications
- Permits 40° IR to match 40° I2
- Enables true pixel level sensor fusion with other wave band sensors (e.g., long wave infrared)
- Permits correlation with weapon sight for virtual pointer.
- Enables Soldier level networked image sharing
- Improved low light performance over direct view (control display brightness)
- Improved contrast images for mid-range spatial frequencies
- Packaging freedom for improved ergonomic design of head-borne vision system
- Digital image enhancement/processing.
(i.e., target tracking, auto-focus/no-focus, automatic target/facial recognition, edge enhancement, electronic zoom,

Digital imaging is also the only approach for high magnification stabilized sensors (turrets)



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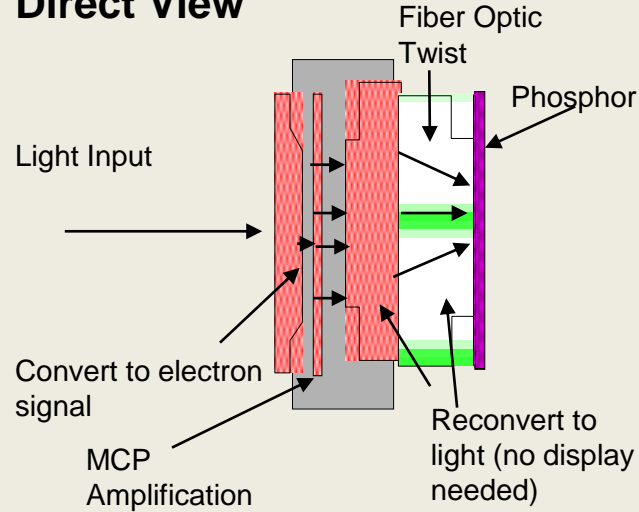
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Low Light Sensor Comparisons

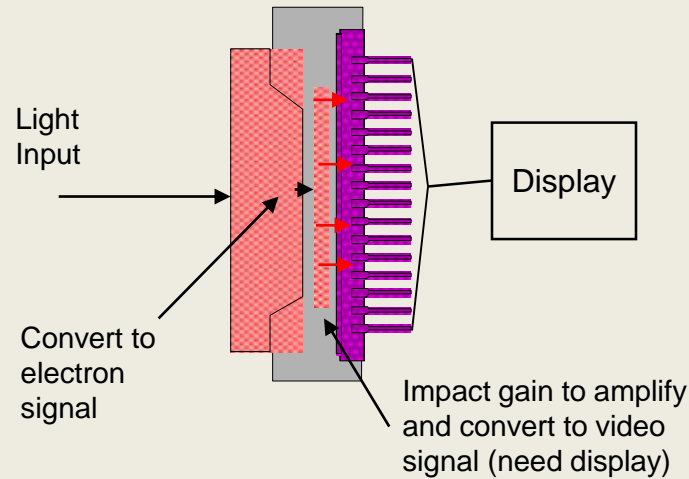


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Image Intensified Tube – Direct View



Electron Bombarded Active Pixel Sensor (EBAPS) – Indirect View



Solid State Low Noise CMOS – Indirect View

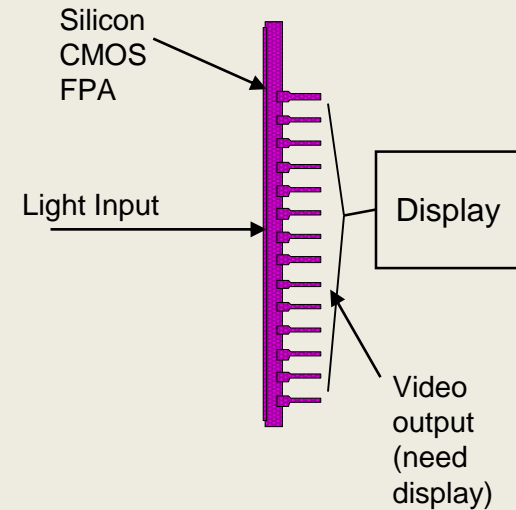
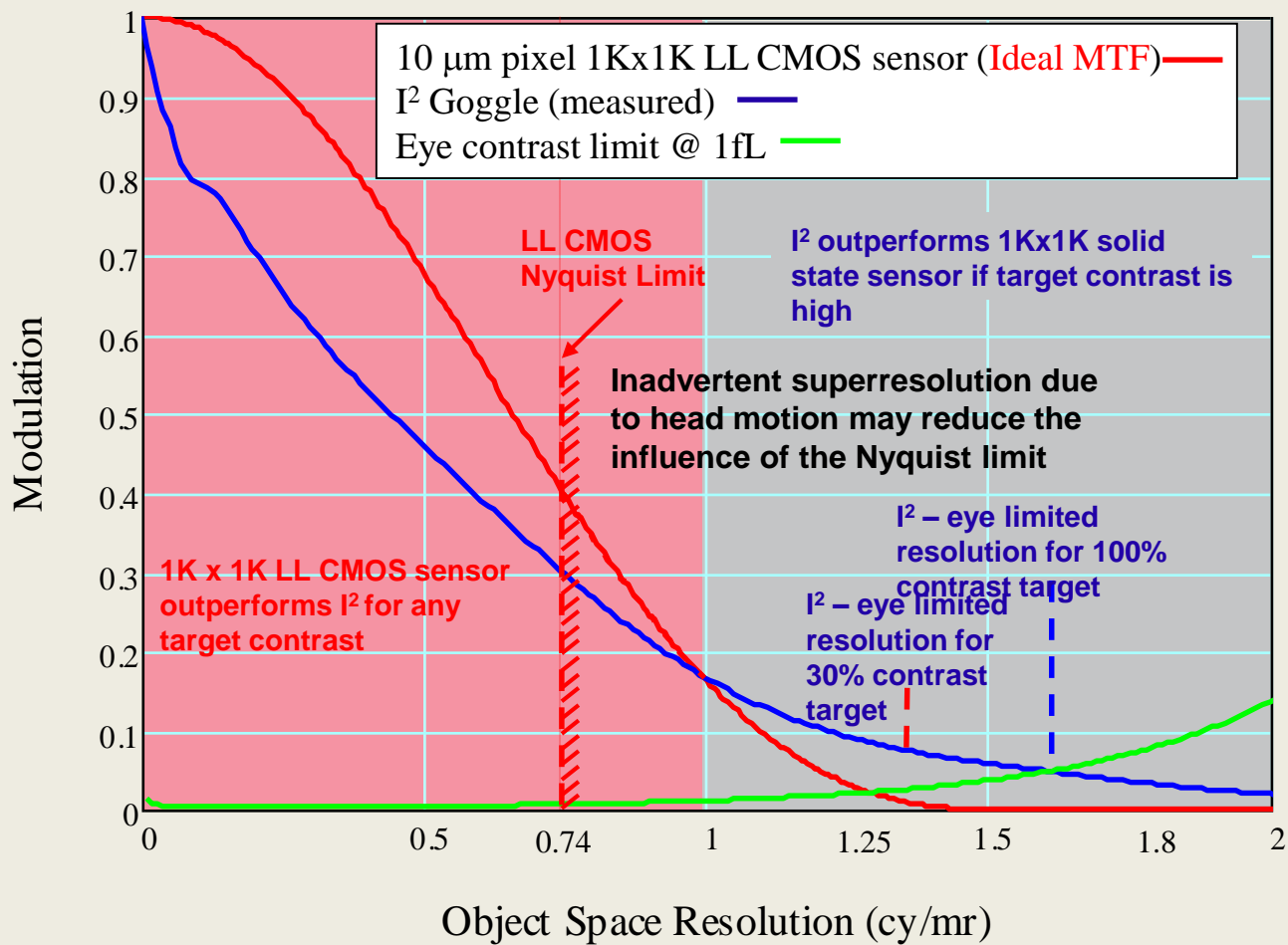


Image Intensified	EBAPS	Solid State Low Noise CMOS
Direct View / No remote use	Indirect view / Remote use	Indirect view / Remote use
No Video Output	Video Output	Video Output
Low Power	Moderate Power	Moderate Power
Low Weight	Low weight	Low Weight
Low Cost	Moderate Cost	Potentially Low Cost
High Resolution / Lower Contrast	High Resolution / Moderate Contrast	High Resolution / moderate contrast
Overcast starlight sensitivity	Overcast starlight sensitivity	Starlight sensitivity
Halo	Halo	No Halo
High Maturity	Moderate Maturity	Low Maturity

Combined Sensor & Display MTF





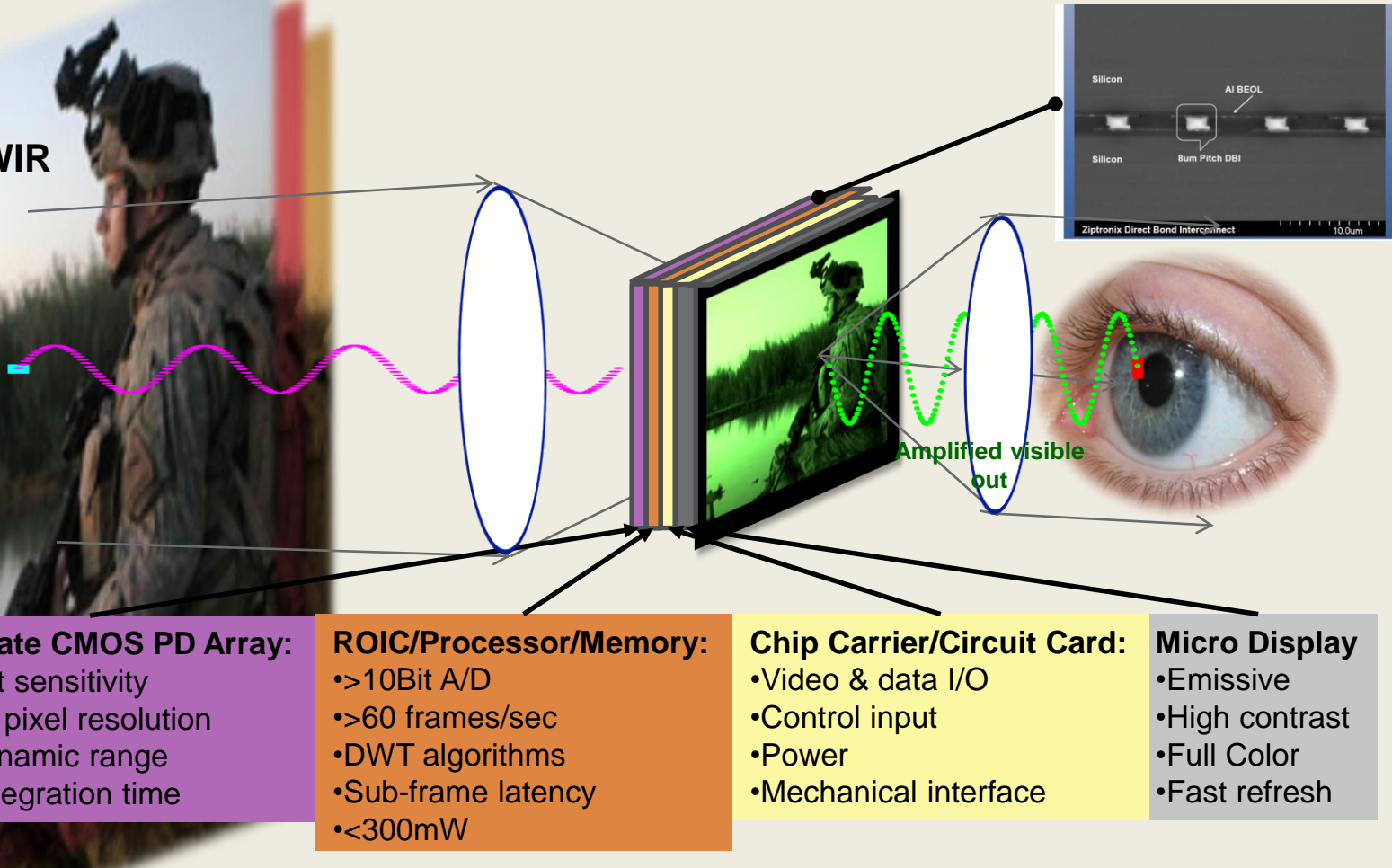
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All Digital Passive Low Light Vision System on a Chip (VSOC)

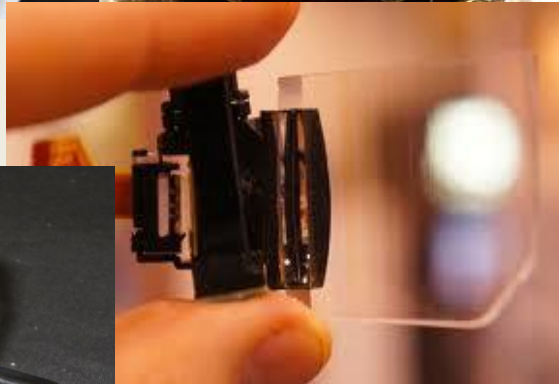
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V/N/SW/MW/LWIR
Scene data



Demonstrated Stand-alone Component Technologies integrated at wafer scale for low cost complete digital night vision system



Waveguide with mirror
based extractor



Free form molded prism with
corrector

Envisioned Characteristics:

- High efficiency (display light throughput), light weight, low obscuration see through optics suitable for ruggedized head-worn applications.
- Wide field of view, see through molded plastic prism optic for air/ground applications.
- Ultra-thin waveguide eyepiece with larger pupil.

Potential Payoffs:

- Rapid Target Acquisition
- Improved Pilotage
- Symbology
- Situational Awareness





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Uncooled History and Path Forward

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Low performance

Medium performance

High performance

1990

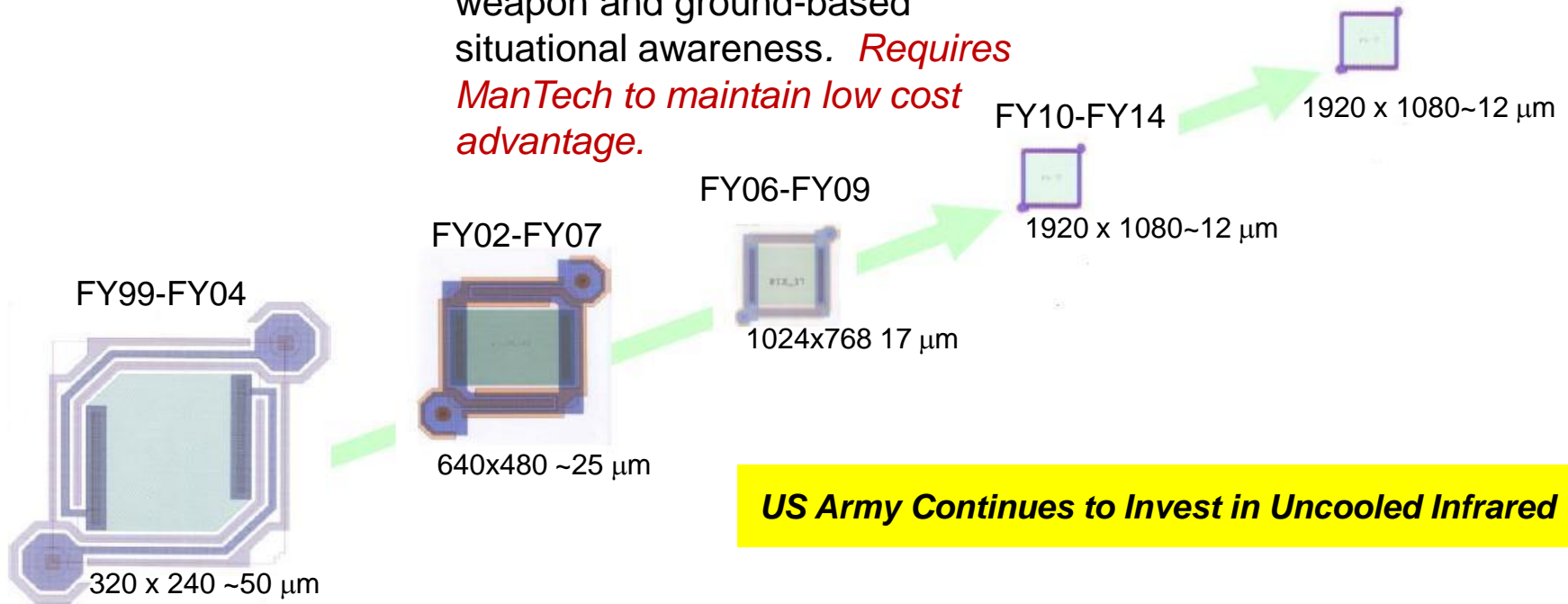
2010

2020

High performance meant large size, weight and power and high cost; low cost/SWaP meant low performance

Advances in sensor processing moved low cost sensors into medium performance sensors and opened up capabilities where none existed before: Soldier-borne capabilities—on the head, in the hands, on the weapon and ground-based situational awareness. *Requires ManTech to maintain low cost advantage.*

Advances in materials will enable high sensitivity, low latency sensors, maintaining low cost





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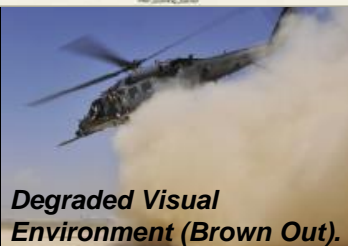
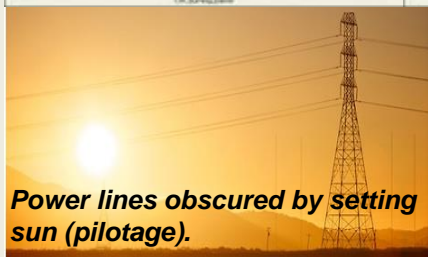
Digital Read-out Integrated Circuits

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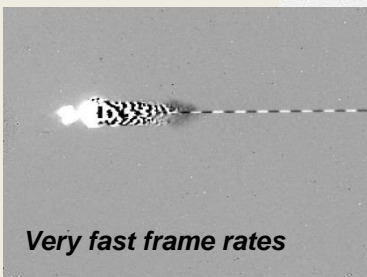
LWIR

MWIR

Burning Barrels (Large Dynamic Range, Blooming)



*Small hemispherical field
of regard sensor & optics*



Concept:

A 3D Digital Read Out Integrated Circuit (D-ROIC) technology which enables Infrared Focal Plane Arrays to achieve enhanced sensitivity and dynamic range. The D-ROICs will be low noise, low power, fast frame rate with on-chip signal processing for multifunction capabilities. Multifunction sensor capabilities to include detection of small contrast targets, see through degraded visual environments and auto detection of threats.

The Challenge:

Implement sufficient well capacity in small pixel pitch to meet sensitivity and intra-scene dynamic range requirements.

Payoff:

- Substantial performance improvement of Army's Ground and Airborne Forward Looking Infrared (FLIR) imagers
- Leap-ahead technology for EO/IR sensing with high frame rates, wider dynamic range, and on-chip processing.
- Improved performance or enabling technology for: Degraded Visual Environment (DVE), Hostile Fire Indication (HFI), Persistence Surveillance, Passive Low Light Shortwave Imaging, High Definition (HD) Uncooled and Cooled IR imaging.

SWIR Imagers



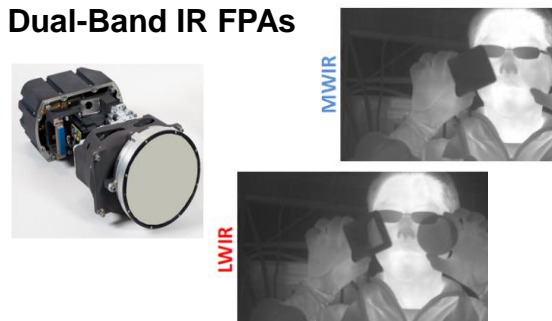
High Definition Uncooled



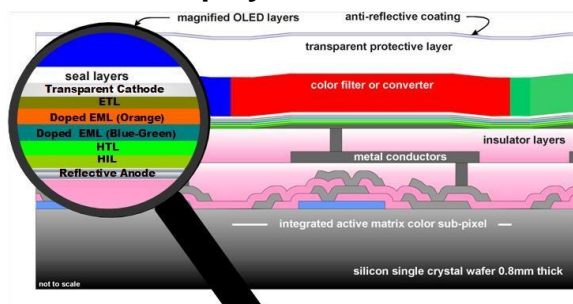
HOT Multi-Band FPAs



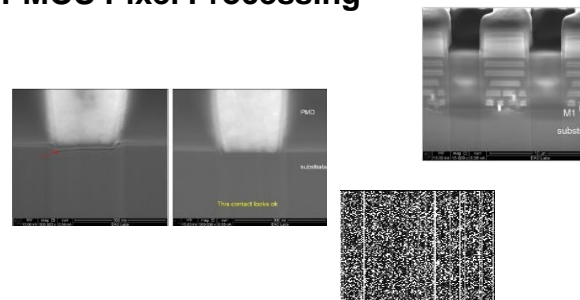
Dual-Band IR FPAs



OLED Microdisplays



PMOS Pixel Processing





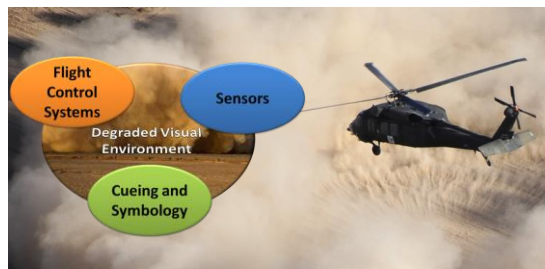
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Degraded Visual Environment Sensor System Trends

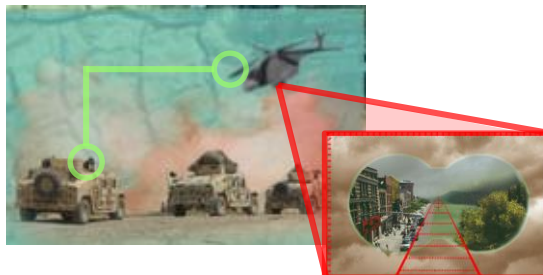
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CURRENT



- Mostly goggles which don't work in DVE
- Those equipped with thermal not optimized for DVE
- Monochrome display
- No fusion

MID



- Multipurpose passive sensing using high performance LWIR & advanced uncooled
- Operations in many DVEs
- Synthetic imagery augmented by live data on bi-ocular color display
- Fusion of on-board sensors

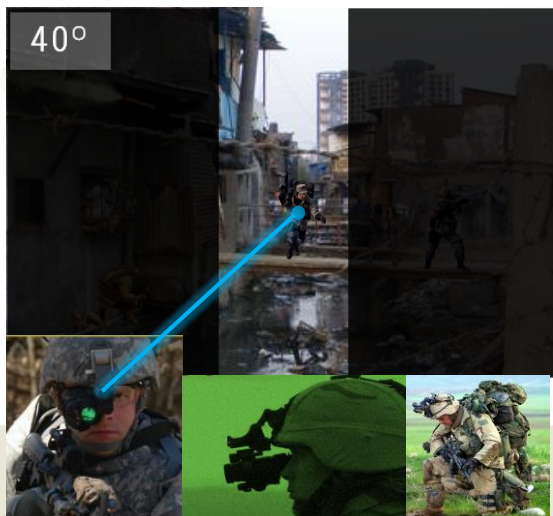
FAR



- Active/passive multipurpose sensing (DVE, threat warning/jamming and comms)
- Air and Ground ops in all conditions
- Synthetic reality on immersive heads-up displays
- Fusion of on & off-board info

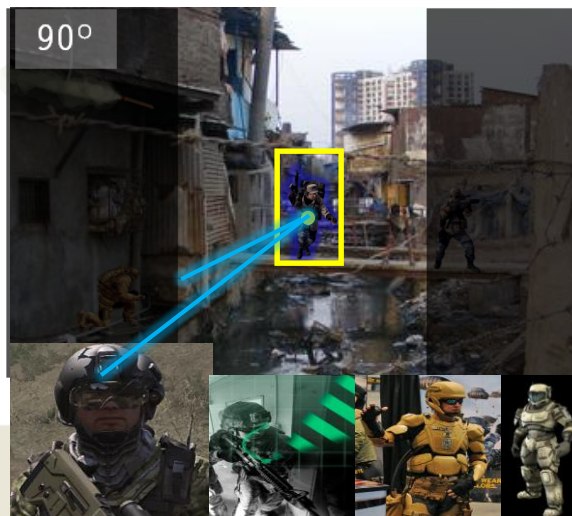
NOT JUST SURVIVE, BUT THRIVE IN DVE – “OWN THE ENVIRONMENT”

CURRENT



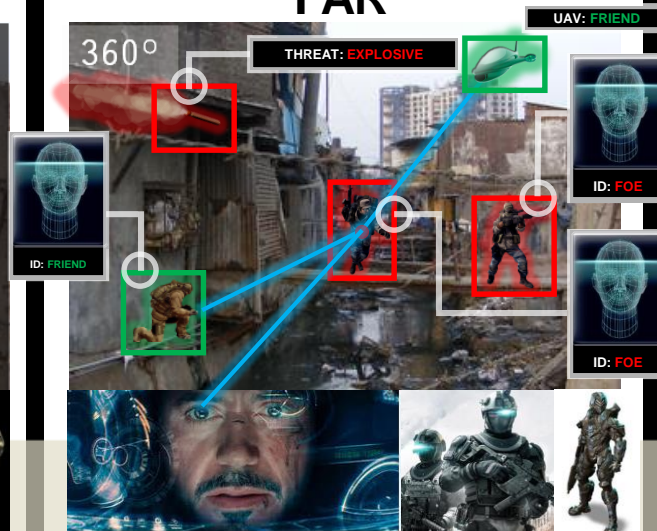
- Single mode sensors that provide limited threat detection, warning, cueing and countermeasures
- Primary vision sensor: analog goggles, 40° FOV
- Uncooled IR weapon sights with light weight optics
- Three function laser – Range-finding, illumination and pointing
- Display of secondary info limited to optical overlay

MID



- Multi-mode sensors. Transitioning to digital, fused (thermal, near IR)
- Advanced targeting (improved range and detection capability)
- Four function laser: 1. Range-finding, 2. Active imaging, 3. Wind sensing, 4. Pointing
- Wide FOV see-through, day/night displays with wireless links to other devices

FAR



- Geolocation, correlation and tracking of incoming threats; broad-band detection, real time ID
- Day/night helmet mounted 360° imagers with integrated wireless displays
- Multi-/hyperspectral. Small, lightweight optics
- Full 3-D target acquisition for linkage to precision fires
- On chip signal processing for complete situational awareness

NO FAIR FIGHTS - DAY OR NIGHT!