Current Directions in Sensor Technologies at NVESD

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EO/IR and Electronic Sensors/Lasers for:

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
Outline

- 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
**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 headborne vision system
- Digital image enhancement/processing. (i.e., target tracking, auto-focus/no-focus, automatic target/facial recognition, edge enhancement, electronic zoom, etc.)

**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

Digital imaging is also the only approach for high magnification stabilized sensors (turrets)
### Low Light Sensor Comparisons

**Image Intensified Tube – Direct View**
- Light Input
- Convert to electron signal
- MCP Amplification
- Fiber Optic Twist
- Phosphor
- Reconvert to light (no display needed)

**Electron Bombarded Active Pixel Sensor (EBAPS) – Indirect View**
- Light Input
- Convert to electron signal
- Impact gain to amplify and convert to video signal (need display)

**Solid State Low Noise CMOS – Indirect View**
- Light Input
- Display
- Video output (need display)
- Silicon CMOS FPA

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<td>Indirect view / Remote use</td>
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<td>High Maturity</td>
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Combined Sensor & Display MTF

10 μm pixel 1Kx1K LL CMOS sensor (Ideal MTF)
I² Goggle (measured)
Eye contrast limit @ 1fL

1K x 1K LL CMOS sensor outperforms I² for any target contrast

LL CMOS Nyquist Limit

I² outperforms 1Kx1K solid state sensor if target contrast is high

Inadvertent superresolution due to head motion may reduce the influence of the Nyquist limit

EBAPS Starlight Image

Intensifier Image

10K x 1K LL CMOS sensor

I² – eye limited resolution for 100% contrast target

I² – eye limited resolution for 30% contrast target

EBAPS Starlight Image
Micro Display
- Emissive
- High contrast
- Full Color
- Fast refresh

Chip Carrier/Circuit Card:
- Video & data I/O
- Control input
- Power
- Mechanical interface

ROIC/Processor/Memory:
- >10Bit A/D
- >60 frames/sec
- DWT algorithms
- Sub-frame latency
- <300mW

Solid State CMOS PD Array:
- Starlight sensitivity
- 2 Mega pixel resolution
- High dynamic range
- 8 ms integration time

V/N/SW/MW/LWIR Scene data

All Digital Passive Low Light Vision System on a Chip (VSOC) demonstrated stand-alone Component Technologies integrated at wafer scale for low cost complete digital night vision system
**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
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.

US Army Continues to Invest in Uncooled Infrared
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.
Manufacturing Technology (MANTECH) Efforts

SWIR Imagers

High Definition Uncooled

HOT Multi-Band FPAs

Dual-Band IR FPAs

OLED Microdisplays

PMOS Pixel Processing
Degraded Visual Environment Sensor System Trends

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)
- 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!