



Sensors for Micro Aerial Vehicles

MAV Workshop, Elmau/Germany

22 Sept 2003

Presented By:

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**US Army RDECOM CERDEC
NVESD**

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Briefing Outline



- **Small Unmanned Testbed Aircraft**
- **Sensors and Technologies for Micro Aerial Vehicles**
 - **Uncooled Infrared**
 - **Image Mosaic and Stabilization**
 - **Mine Detection**
 - **Mission Equipment Package for Small UAVs**
 - **Mission Equipment Package for Micro UAVs**
 - **Acoustic**
 - **Chemical**
 - **Communications**



Small Unmanned Testbed Aircraft



Night Fox



Pointer

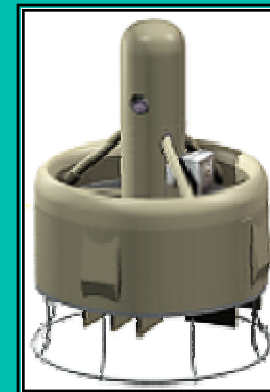


Raven

*NVESD's In House Assets
Other Platforms for Sensor Testing*



Dragon Eye



iStar



Sensor Limitations of Micro Aerial Vehicles



- **Weight**
- **Size/Volume**
- **Data link**
- **Image/Line-of-Sight Stability**
- **Cost**



Sensors & Technologies for Micro Aerial Vehicles

- **Electro-Optic (TV)**
- **Uncooled Infrared**
- **Passive Countermine**
- **Mission Equipment Packages (MEP) for Small and Micro UAVs**
- **Acoustic**
- **Chemical**



Uncooled IR Technologies for Small and Micro UAVs



160x120 (19.2K Pixels)



0.5 lb



0.25 lb

320x240 (76.8K Pixels)

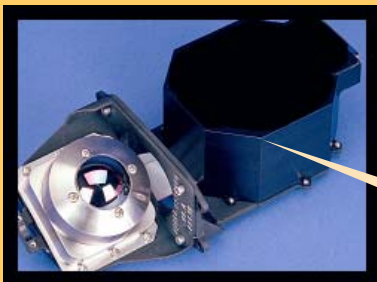


1.5 lbs



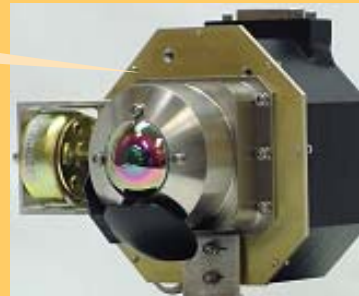
0.75 lb

640x480 (307.2K Pixels)

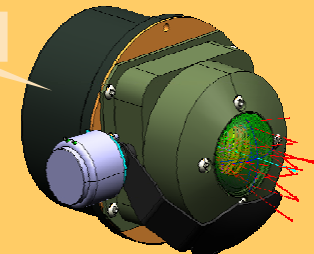


0.7 lb

0.6 lb



0.4 lb





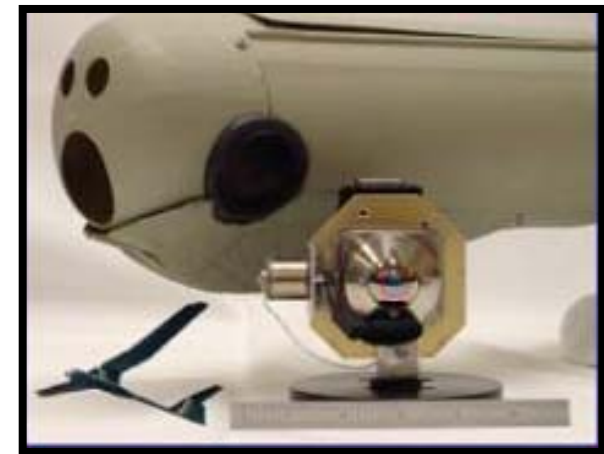
Small UAV Video 640 x 480 UCIR FPA



Pointer



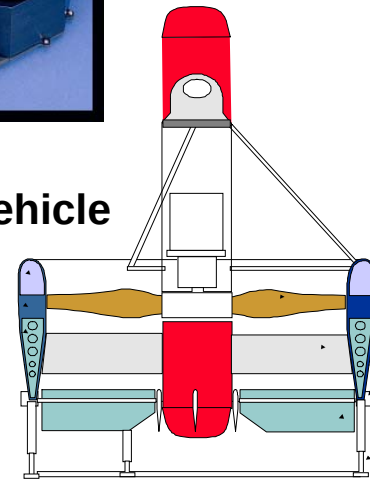
640 x 480 FPA with
Electronics < .75
Pounds



640 x 480 UCIR Imager
Flight on Pointer UAV



Organic Air Vehicle



Red areas Represent
Payload Cavities



High Resolution Sensor Capability for Small UAVs



Airborne Video Surveillance (AVS) Image Mosaic and Stabilization



**Non- Stabilized
Raw UAV
Sensor Video**



**Real-time Mosaic
of UAV Sensor
Video**

**Electronically
Stabilized
Video**



**Full Resolution
Mosaic Image**

**Provides Wide
Area
View w/ Full
Resolution Chip
Capability**



Real-Time Mosaicing Provides Electronic Stabilization for UAVs



Mine Detection (Reststrahlen Multi-Spectral Camera)



Objective:

- Find Buried Mines/Minefields on Roads

Approach:

- Exploit spectral phenomena of disturbed earth in Longwave-Infrared (LWIR) and Vegetation in Near-Infrared (NIR)

Tasks

Analysis/Modeling

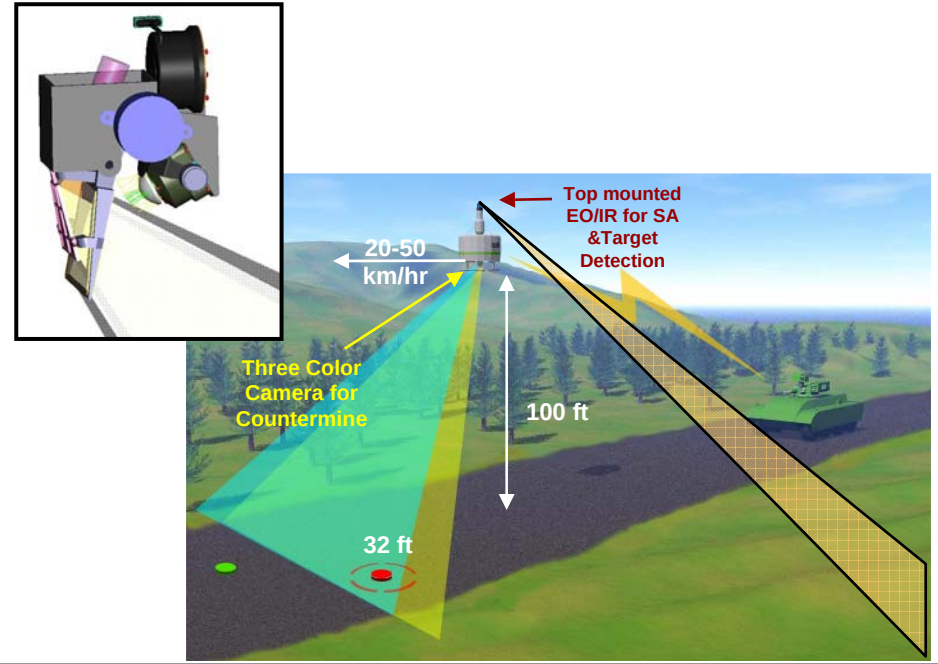
Sensor Design & Devel.

Ground Processor Design & Devel.

Systems Integration

Flight Tests & Demos

Multi-Spectral Sensor for OAV



Performance Specifications:

- Uncooled Infrared Technology
- Three Spectral Bands
 - 0.9 – 1.0 microns (NIR)
 - 8.4 – 9.4 microns (LWIR in-band)
 - 10.5 – 12.2 microns (LWIR out-of-band)
- 19" OAV Compatible



Mine Detection Physical Mechanism

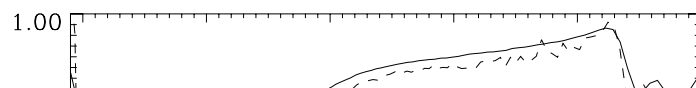
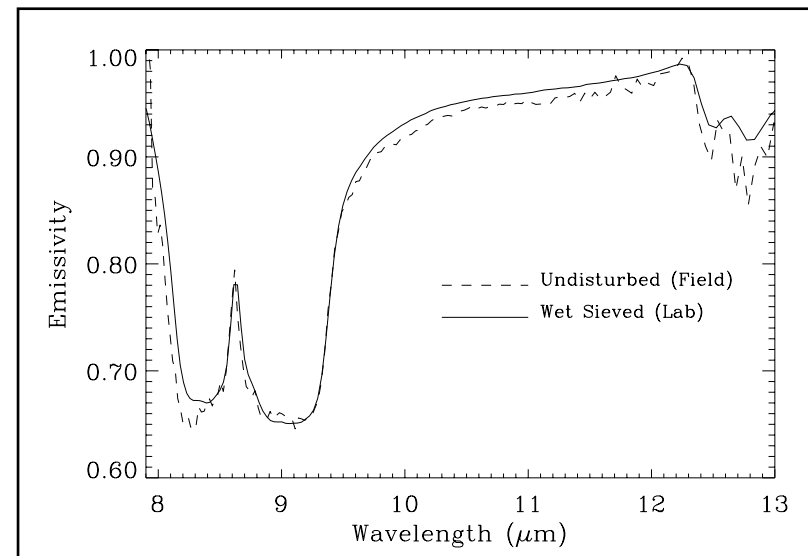
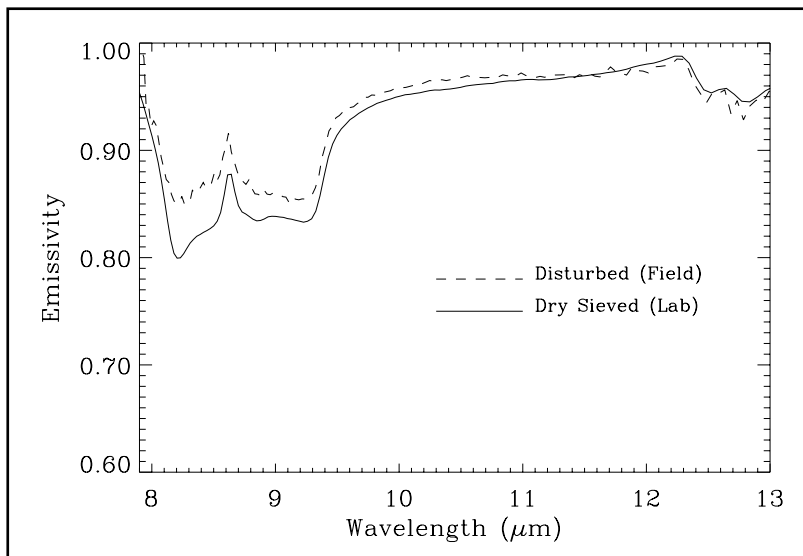
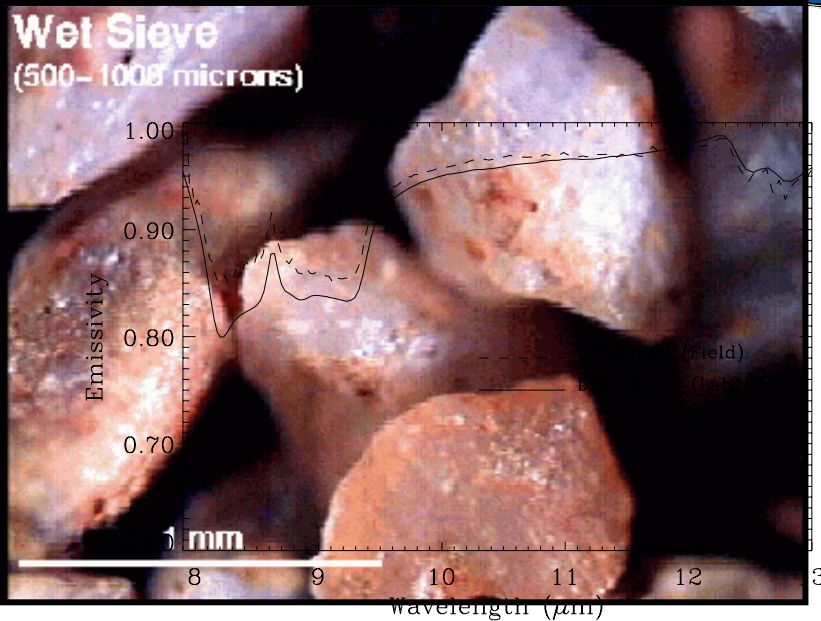
University of Hawaii



Dry Sieve
(500–1000 microns)

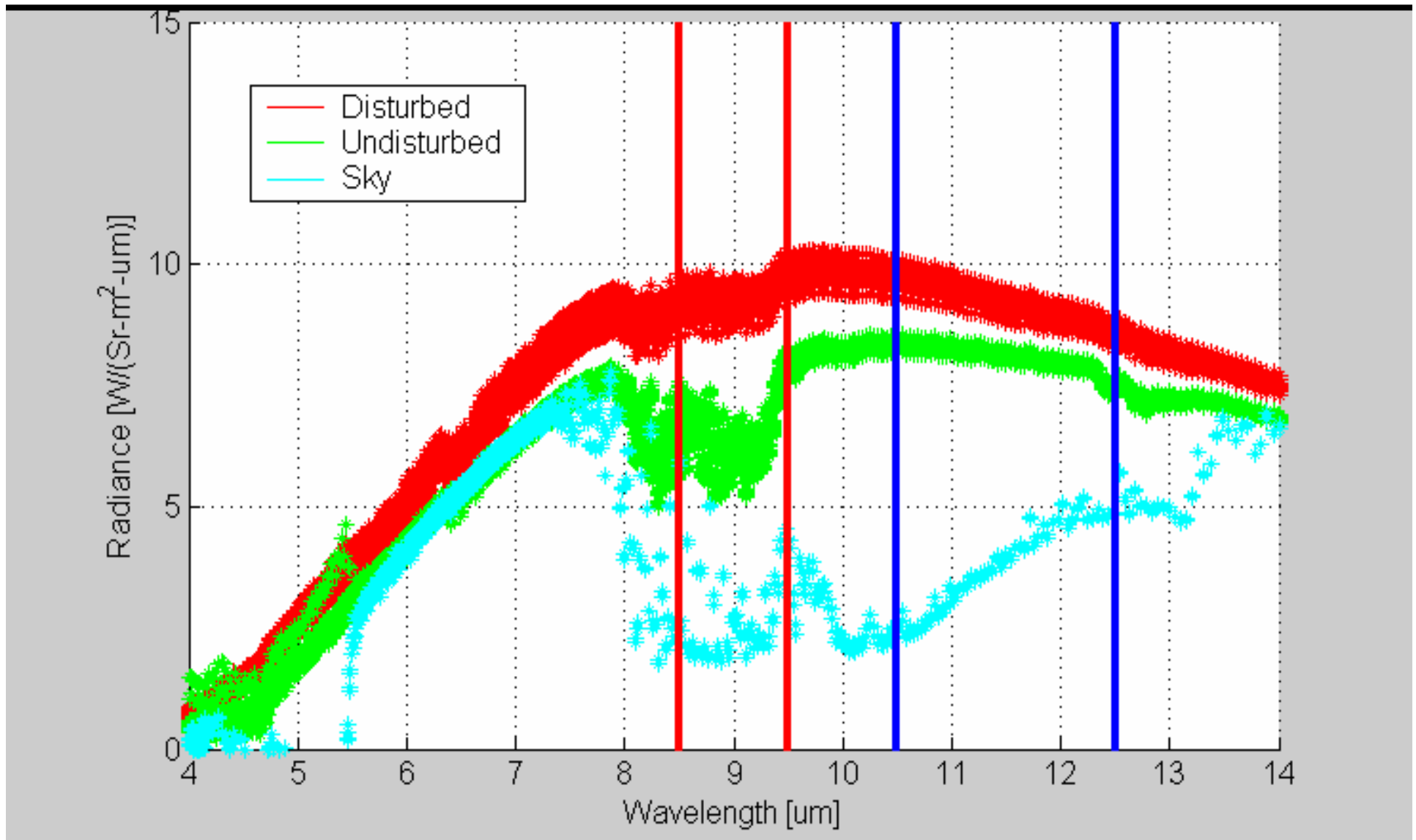


Wet Sieve
(500–1000 microns)





Reststrahlen, Open Field NVESD/ University of Hawaii





Mission Equipment Package for Small UAV



~10-12 lbs Payload

- **LADAR**
- **Laser Vibrometry**
- **Picture in Picture (PnP)**
- **Laser Rangefinder/Designator (LRF/D) – Lightweight**
- **Collision Avoidance**
 - **Micro-LADAR**
 - **Optical Flow**
 - **Acoustic**
 - **Stereo Vision**
 - **Micro-RADAR**



Mission Equipment Package (MEP) for Small UAV



Objective:

- Develop, integrate and demonstrate a Mission equipment package consisting of sensor technologies performing a significant portion of the RSTA mission requirements for the Small UAV.

(Exploring “Picture-in-Picture” concept, “see-through-foliage” sensor, and laser designator)

Tasks

Picture-in-Picture

- Rooftop Concept
- Sensor Development
- Test & Demo

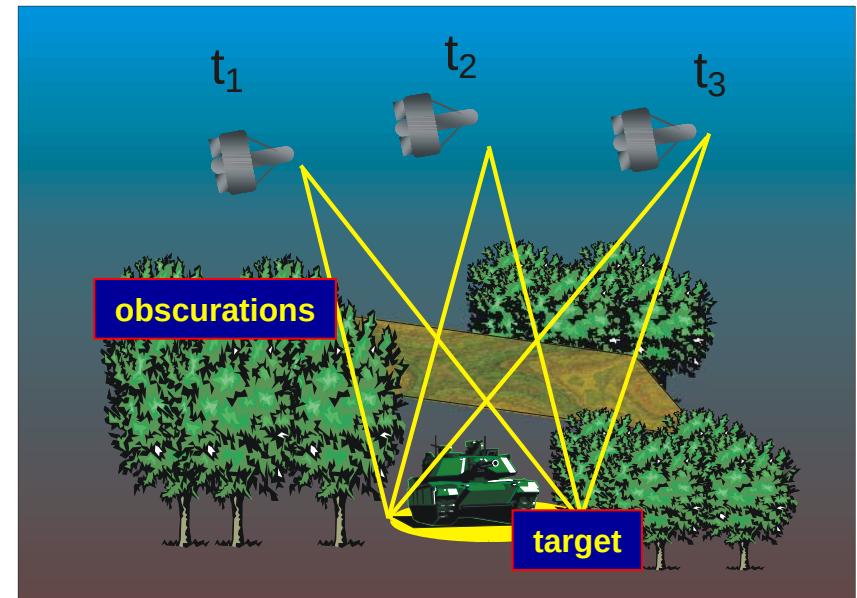
Laser Designator

- Design & Development
- Test & Demo

See-Through-Foliage

- BAA
- Sensor Development
- Test & Demo

RSTA Sensors for Small UAV



Performance:

- Sized for Small UAV (10-12 lbs).
- Accurate ID and Targeting
- Laser Designation



MEP for Small UAV Passive Recce System with “Picture in Picture” (PnP)



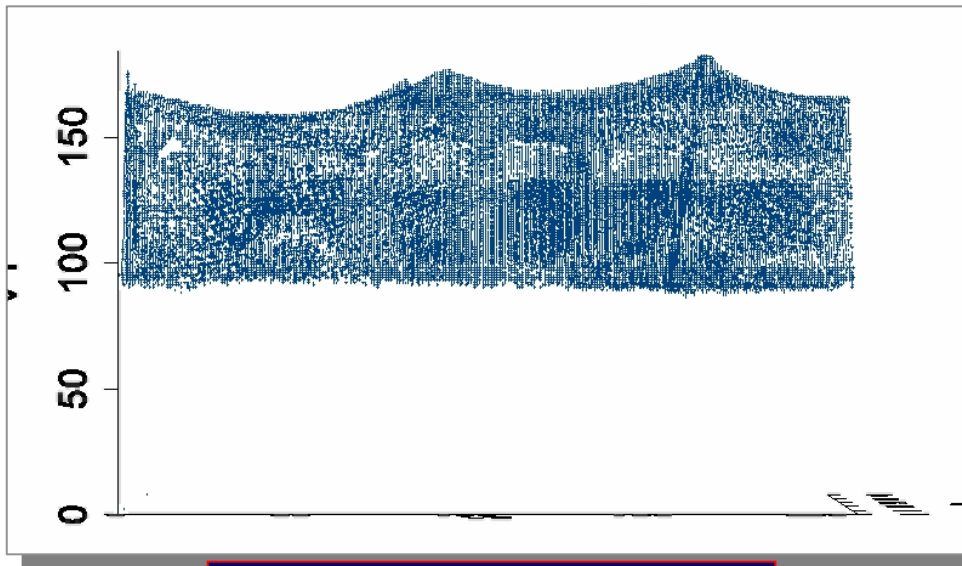
**Search-Detect with Wide Angle UCIR
Identify with High Resolution MWIR**



MEP for Small UAV LADAR Foliage Penetration



Photograph of Vehicle
Behind Camo



Point Cloud Graph



Sliding Range Gate

Target ID in Dense Cover (95% Obscuration)



MEP for Micro UAV

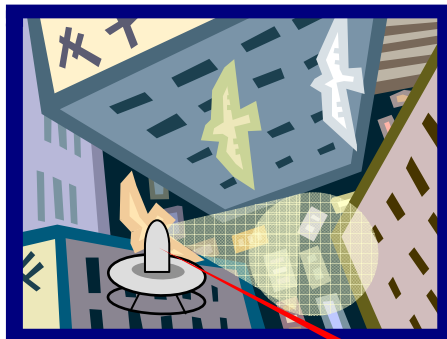


Operational Utility

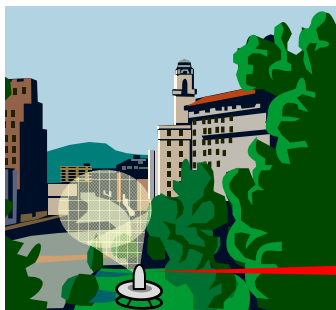
- Terrain Independence – Operations in MOUT and Complex Terrain
- NLOS Observation from Key Terrain – Perch-Stare/Hover (Line of Sight from Location)
- Unmanned Observation of Key Avenues of Approach - Bounding Overwatch
- Rear-Area, Flank, & Perimeter Security with Minimum Manning
- Assured Mobility
- Mine Detection

Sensor Technology Options

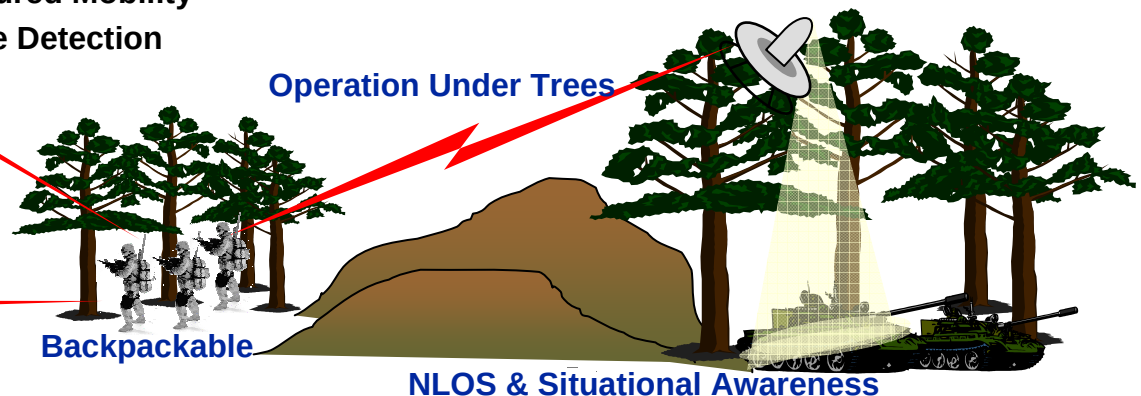
- Uncooled IR
- E-O Visible CCD
- SWIR w/Illuminator
- Acoustic Detection
- Chemical Detection
- Obstacle/Collision Avoidance
- Real Time Video Mosaics & Registration



Reconnaissance and Surveillance



Re-locatable Unattended Sensors



MEP for MAV Provides Small Units with Organic RSTA Capabilities for Situational Awareness and Force Protection



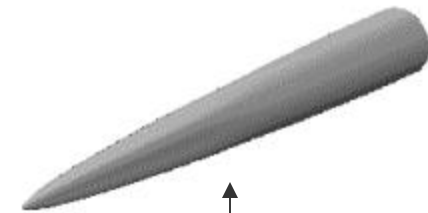
Acoustic Sensor Technology

BAT Sensor

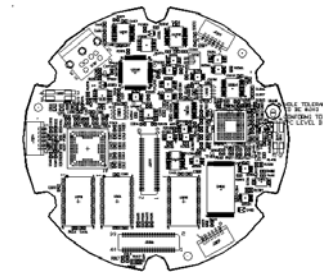


Specifications

- 0.375" diameter, 5" length acoustic probes
- 3.9" diameter by 1" thick electronics processing board
- Power requirements - 7.5-16 V DC, 700 milliwatts
- Total system weight - 3.2 ounces w/o dedicated battery
6.4 ounces w/ dedicated battery
- Texas Instruments TMS320C5410 processor
- EIA standard RS-232 interface
- 1Hz steer-to message update rate
- Outputs include:
 - detection frequency & signal-to-noise ratio
 - target bearing & elevation angles
 - target RPM & classification
 - raw acoustic signals (on extra serial ports)
- Supports triangular sensor array



BAT Acoustic Probe



LAYER 1 OF 12
VIEWED FROM COMPONENT SIDE

Electronic Processing Board

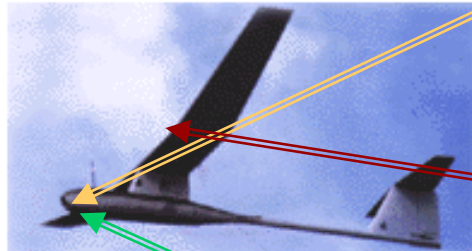
Finds targets under canopy and in tree lines.



Chemical Detection Technologies for Small UAVs

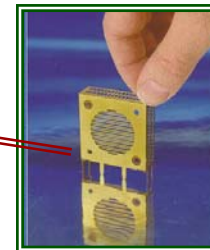


Small UAV



Long wave IR sensor locates potential cloud

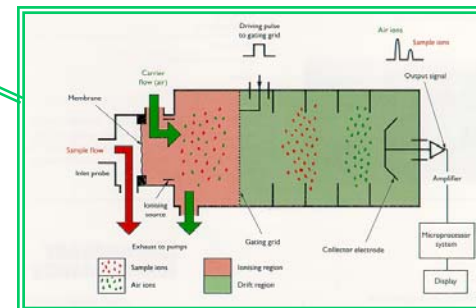
8 → 3 oz.



Switch can be passed through cloud and returned to a specific location for detailed analysis

1 oz.

Low Cost, Autonomous and Attritable



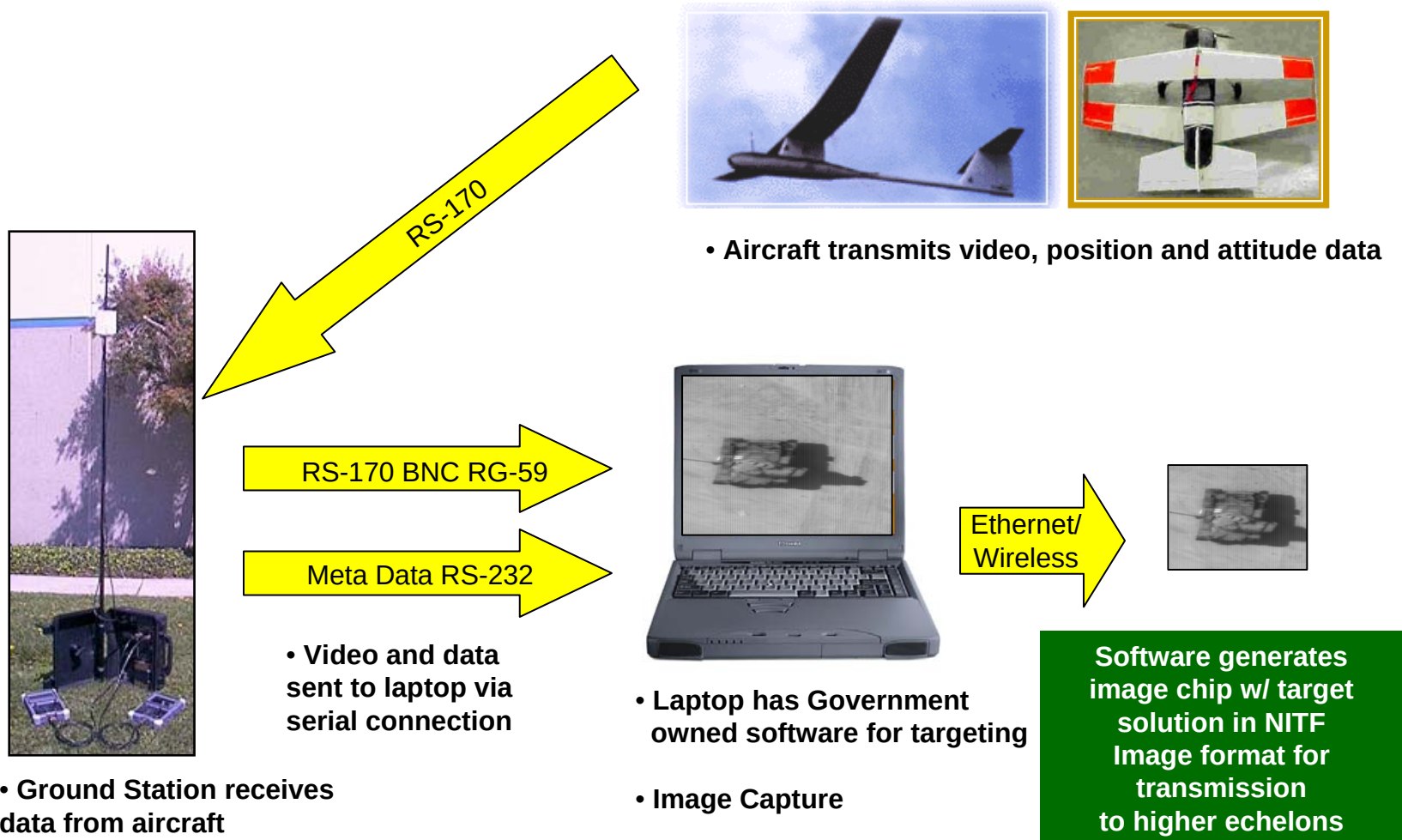
Adapt handheld analyzer for non return analysis

<2 lbs.

**Small UAV is compact and autonomous
It takes the risk instead of personnel**



Communications





Summary



- **MAV Sensor Limitations**
 - **Weight**
 - **Size/Volume**
 - **Data link**
 - **Image/Line-of-Sight Stability**
 - **Cost (Must be Attritable)**
- **Sensors & Technologies**
 - **Electro-Optic (TV)**
 - **Uncooled Infrared**
 - **Passive Countermeasure**
 - **Mission Equipment Packages (MEP) for Small and Micro UAVs**
 - **Acoustic**
 - **Chemical**



Questions?



Back-ups



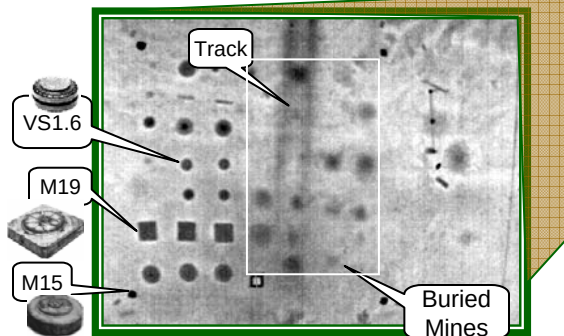
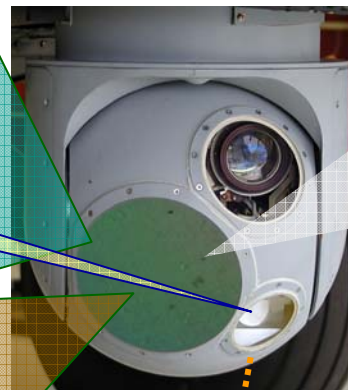
Advanced EO/IR Payload



**Long Range,
High Quality,
All Digital Imagery**

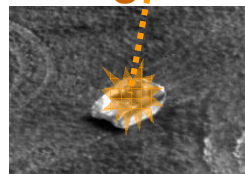


**One
Payload
(55 lbs)**

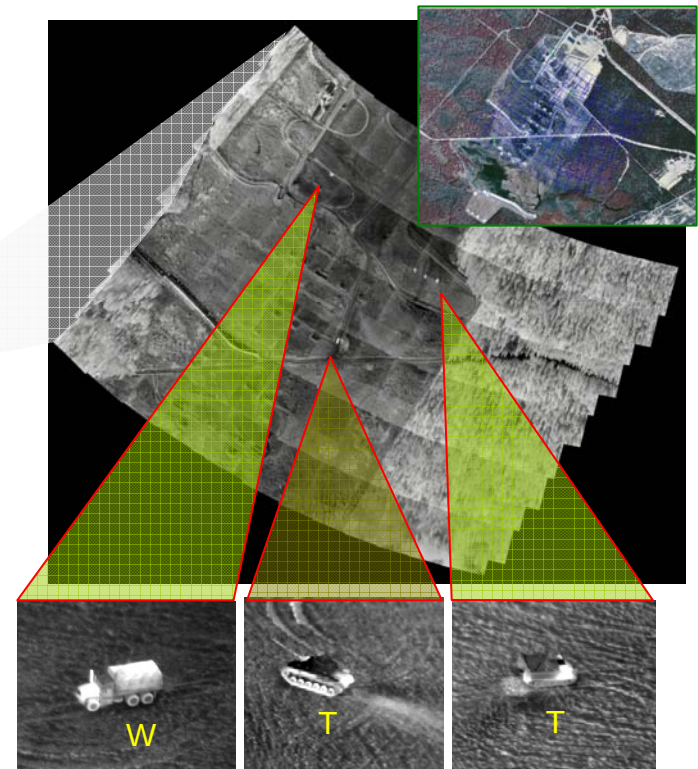


Day/Night Mine Detection

**Laser
Designator**



**Fast Wide Area Search/Step-Stare
Near Real-Time Mosaics
Near Real-Time Precision Registration**



Aided Target Recognition

An Affordable, Lightweight, High Performance Multi-Mission Payload



Aided Target Recognition with Step Stare Search



The screenshot shows a software interface for Aided Target Recognition. It is divided into two main windows: "Ground Station" on the left and "Send Receive ATR Data" on the right. The "Ground Station" window displays a grayscale aerial image of a landscape with a road and a building. A yellow crosshair is overlaid on the image, with the number "45" in a yellow circle at the intersection and the number "32" in a yellow circle at the end of the horizontal line. The "Send Receive ATR Data" window is mostly empty, with a large white area for data display. On the right side of the interface, there are several control panels. The "Imagery" panel includes buttons for "Connect", "Disconnect", "Receive", "Clone", "Stop", "Save", and "Display" (which is checked). The "Manual Sends" panel includes buttons for "Send Init", "Next Image", and "Shutdown". The "Reports" panel includes buttons for "Connect", "Disconnect", and "Send". The "Processing Mode" panel includes radio buttons for "Detector", "Tracker", "Recognition" (which is selected), "MTI", "Convoy", and "Off". Below these panels, there are input fields for "Frames/Sec:", "Frame Count:", "Memory:", and "Execution:", each followed by a "ms" label. At the bottom right, there are buttons for "Tracker", "Parameters", and "Meta Data". The Northrop Grumman logo is visible in the bottom right corner.



Manned Testbed Aircraft



AVS / UAV Payloads



ALERT / M-SUITE



HSI Program



Pilotage