



Unmanned Aircraft Systems Sensors

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OUSD(AT&L)/Defense Systems
Air Warfare

Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE 01 MAY 2005		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE Unmanned Aircraft Systems Sensors				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) OSD UAV Planning Task Force OUS(AT&L) Defense Systems Air Warfare 3090 Defense Pentagon, Room 3E139 Washington, DC 2031-3090 USA				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES See also ADM202032., The original document contains color images.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 44	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			



Outline

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 - Operational
 - Theater UA
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 - Tactical UA
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- Summary

Small UA in Operation IRAQI FREEDOM



		<u>User / Mission</u>	<u>Size</u>		<u>Payload</u>	<u>Endurance</u>
		Army, Air Force & SOCOM				
	Over the Hill Reconnaissance		Weight	4 lbs		
			Length	3 ft		
			Wing Span	4.4 ft		
Raven			Payload Weight	1 lb	EO or IR	80 min
		Marine Corps	Weight	4 lbs		
	Over the Hill Reconnaissance		Length	2.4 ft		
			Wing Span	3.75 ft		
			Payload Weight	1 lb	EO or IR	40-60 min
Dragon Eye						
		Air Force	Weight	4.5 lbs		
	Force Protection		Length	3 ft		
			Wing Span	4 ft		
			Payload Weight	1 lb	EO or IR	60-90 min
FPASS						
		SOCOM	Weight	8 lbs		
	Special Operations		Length	6 ft		
			Wing Span	9 ft		
			Payload Weight	2 lbs	EO or IR	60 min
Pointer						
		SOCOM/USMC	Weight	14 lbs		
	Special Operations		Length	4.2 ft		
			Wing Span	7.7ft		
			Payload Weight	4 lbs	EO or IR	3-5 hr
Silver Fox						
		USMC	Weight	40 lbs		
	Force Protection		Length	4 ft		
			Wing Span	10 ft		
			Payload Weight	6 lbs	EO or IR	15 hr
Scan Eagle						

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Tactical UA in Operation IRAQI FREEDOM

	Army	Weight	327 lb	EO/IR	5 hrs
		Length	11.2 ft		
	Brigade Level	Wing Span	12.8 ft		
	Recce	Payload Weight	60 lbs		
Shadow (RQ-7)					
	Marine Corps	Weight	452 lbs	EO/IR	5 hrs
		Length	14 ft		
	Suveillance/Recce	Wing Span	17 ft		
		Payload Weight	75 lbs		
Pioneer (RQ-2B)					
	Army	Weight	1600 lbs	EO/IR	11.6 hrs
		Length	23 ft		
	Division/Corps Level	Wing Span	29.2 ft		
	Recce	Payload Weight	200 lbs		
Hunter (RQ-5)					

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Operational UA in Operation IRAQI FREEDOM



		<u>User / Mission</u>	<u>Size</u>		<u>Payload</u>	<u>Endurance</u>
		Air Force	Weight	2250 lbs		24 hrs
			Length	28.7 ft		
		Armed Recce	Wing Span	49 ft		
			Payload Weight	Internal: 450 lbs	EO/IR & SAR	
				Wings: 100 lbs each	Hellfire	
Predator (MQ-1)						
		Army	Weight	2250 lbs		24+ hrs
		Division/Corps Level	Length	27 ft		
		Recce	Wing Span	49 ft		
			Payload Weight	450 lbs	EO/IR & SAR	
I-Gnat						

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Prototype Theater UA in Operation IRAQI FREEDOM

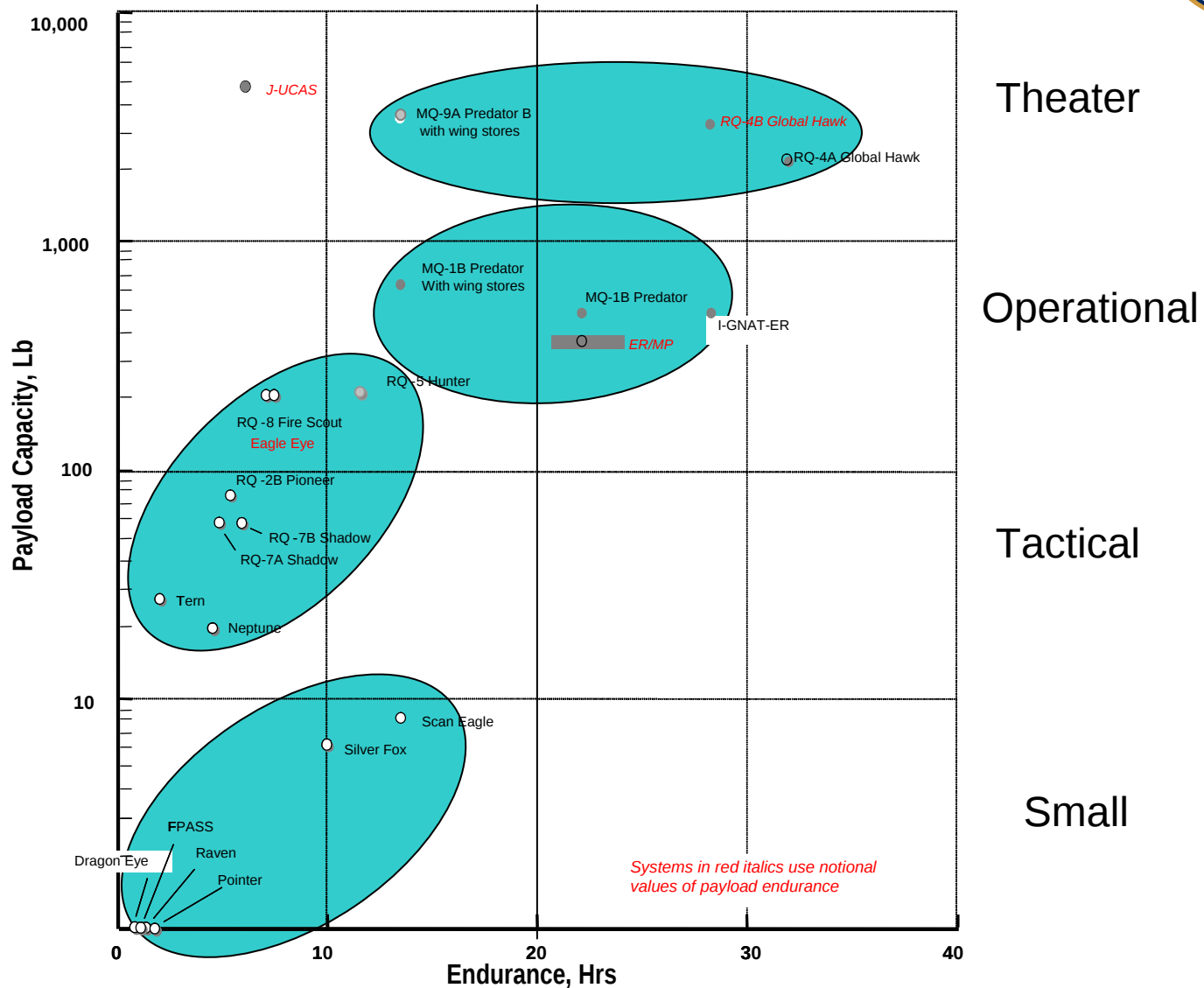


		<u>Service / Mission</u>	<u>Size</u>	<u>Payload</u>	<u>Endurance</u>
 Predator B (MQ-9) Prototype		Air Force	Weight	10,000 lbs	
			Length	36.2 ft	
		Armed Recce	Wing Span	64 ft	
			Payload Weight	Internal: 750 lbs	EO/IR & SAR
				Each Wing:	GBU-12
				Inboard: 1500 lbs	
				Middle: 350 lbs	
				Outboard: 150 lbs	
				Maximum: 3750 lbs	
 Global Hawk (RQ-4A) Prototype		Air Force	Weight	26,700 lbs	
			Length	44.4 ft	
		Persistent High	Wing Span	116.2 ft	
		Altitude Surveillance	Payload Weight	1950 lbs	EO/IR & SAR
		& Reconnaissance			24+

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UA Payload Weight vs. Endurance



Systems in red italics use notional values of payload endurance

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UA Sensor Summary

- All UA have an Electro-Optic (EO) and Infrared (IR) capability
- Small UA sensors
 - EO/IR is primary sensor
 - Fixed vs Gimbaled
- Tactical UA sensors (in order of priority)
 - EO/IR
 - SIGINT
 - Radar
 - Comm relay
- Operational & Theater UA sensors (in order of priority)
 - EO/IR
 - Radar
 - SIGINT
 - Comm relay
- Sensor specifications drive UAS costs and capabilities
 - Cost control is critical to development of UAS and UA sensor capabilities



Small UA EO/IR Sensors

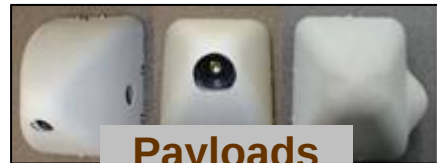
- **EO** – Requirement for a facial recognition capability while remaining undetected (NIIRS 8+)
- **IR** – Requirement for identification and tracking while remaining undetected
- **Small UA (SUA)**
 - **SUA** are *expendable* and *numerous*
 - Sensors must be
 - Reliable
 - Low Cost
 - Supportable
 - Commercially available
- **Goal for Industry**
 - Gimbaled sensor with EDTV capability (480P)



Raven



Air Vehicle (AV)



Payloads



Ground Control Unit (GCU)



Remote Video Terminal (RVT)

System Components:

- 3 Air Vehicles (AV) per system
- 3 Payloads
- One (1) Ground Control Unit
- Remote Video Terminal (RVT)
- Batteries: Mission & Rechargeable
- Carry / Protective Cases
- Battery Charger / Power Supply
- Field Maintenance Kit
- Spares and Repair Parts

Mission: Army tactical level reconnaissance, surveillance, target acquisition, and battle damage assessment

Capabilities:

- Hand Launched / AutoLand Recovery
- Military P(y)-Code GPS
- AutoNavigation
- Quick Assembly (< 3 min)
- Man Portable / Backpackable
- Quiet
- Reusable (100+ flights)
- Typical Operational Altitude 150-500 ft AGL
- Climb to Operational Altitude in 1-2 mins

Characteristics / Description:

- | | |
|---------------------|--|
| ▪ Power: | Batteries <ul style="list-style-type: none">– Mission: Lithium (LiSO2)– Rechargeable: Lithium Ion |
| ▪ Wing Span: | 4.5 feet |
| ▪ Weight: | 4 lbs (w/carrying case, 12 lbs) |
| ▪ GCU Weight: | 17 lbs |
| ▪ Range: | 8-12 km |
| ▪ Endurance (Mins): | 90 (Lithium) / 60 (Lithium Ion) |
| ▪ Speed: | 27-60 mph, Cruise 40 mph |
| ▪ Payload(s): | High Resolution, Day / Night Camera & Thermal Imager |
| ▪ Crew / Manpower: | 2 Soldiers |

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Raven Image – OEF

“Altitude Hold” Mode
(Commanded Altitude)

DTG

GPS Satellites

Aircraft MH
Battery Voltage
Reading



AGL Altitude
Range from
GCU

Raven video and image capture from food distribution convoy mission.

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ScanEagle

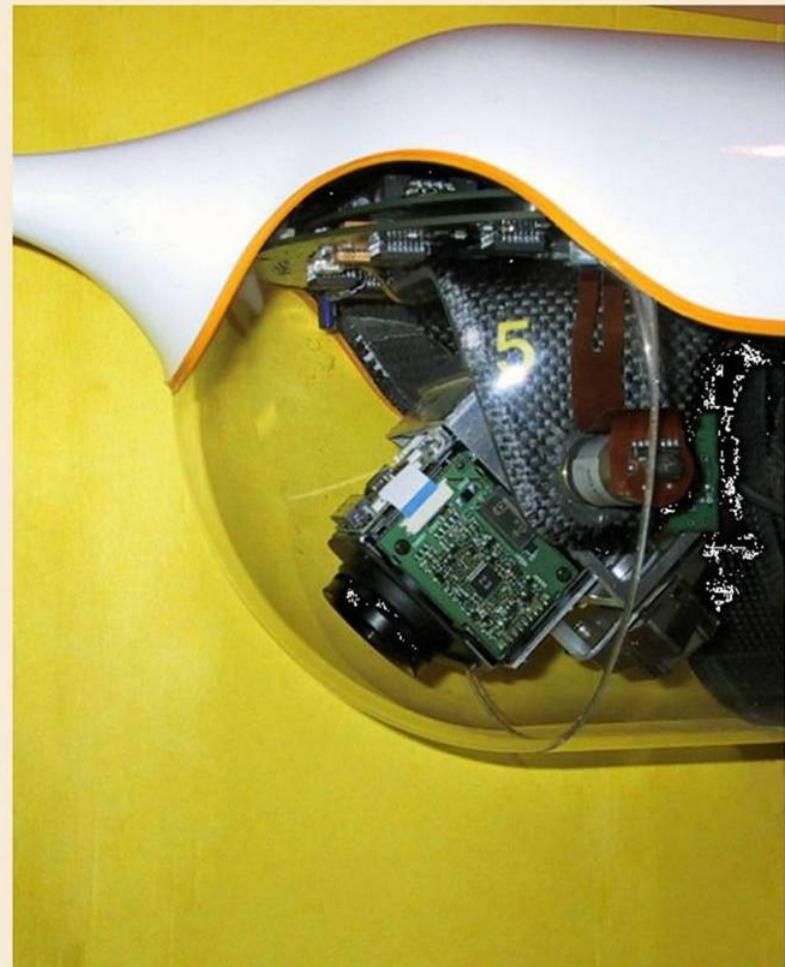
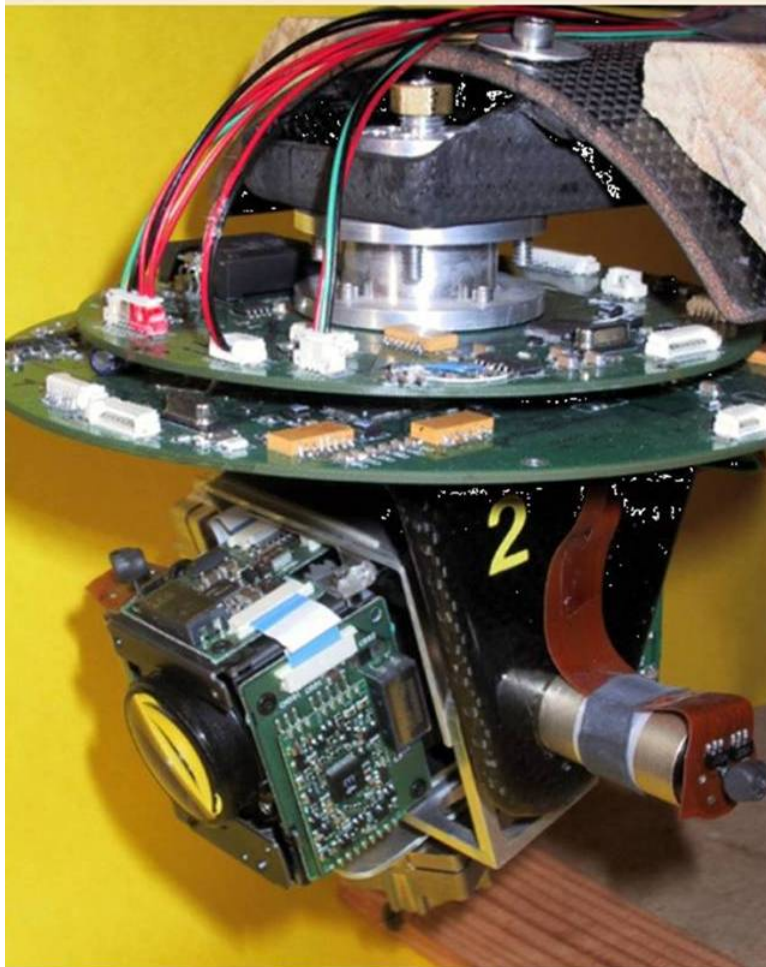


Wing span	10.0 ft
Fuselage diameter	7.0 inches
Overall length	4.0 ft
Folded length	6.5 ft
Folded width	1.5 ft
Folded height	1.3 ft
Max. Gross Wt.	40.0 lbs

- **Max level speed** 68 knots
- **Cruise spd @ max wt.** 48 knots
- **Loiter spd @ max wt.** 42 knots
- **Service ceiling @ max wt.** 16,000 ft
- **Endurance, no reserves** Current : 15+ hrs
Planned:
B: 30+ hrs
C: 40+ hrs
- **Launch** Pneumatic catapult
- **Recovery** "Skyhook" wingtip snag/
land in 600 x 100 ft field
or skid landing
- **Navigation** D-GPS
- **Surveillance** 25:1 zoom daylight color video
camera (or IR) in inertially
stabilized nose turret



Stabilized EO Turret System



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Stabilized Camera System



Note: ScanEagle UA

Video Camera System Stabilized on Mobile Flight Test Center and Zoomed to 11:1 at 2000'.

Full Motion Video Camera System Stabilized on Mobile Flight Test Center at Wide Angle FoV at 2000'.

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Tactical UA EO/IR Sensors

- EO – Requirement for a facial recognition capability while remaining undetected. (NIIRS 8+)
- IR – Requirement for identification and tracking while remaining undetected
- Laser Designator Range Finder – Requirement for integration with EO/IR sensor
- Tactical UA (TUA)
 - **TUA** are **attritable**, fewer in number than SUA
 - Sensors must be
 - Gimbaled turret providing weapons quality precise coordinates
 - Reliable
 - Supportable
 - Commercially available
- Goal for Industry
 - Gimbaled sensor with HDTV capability (720P)
 - Challenge is low cost gimbaled turret
 - Ability to upgrade easily (FPA)



Shadow RQ-7B



Characteristics / Description:

Wing Span	14 feet
Weight	380 lbs
Range	~ 125 km
Airspeed	(60 kt loiter, 105 kt dash)
Altitude	14,000 Ft
Endurance	> 5 Hours @ 50 km
Primary Payload (s)	EO / IR (up to 60 lb)
Launch / Recovery	100m x 50m Area

Capabilities :

- Automatic Landing and Takeoff
- System and Maintenance Section transportable on 3 C-130s
- Early entry capability with 1 C-130
- Compatible with ABCS
- EO / IR Sensor
- TCDL Ready

Unit Composition

- Platoon Set = a System:
 - 22 Soldiers (2 Officers, 20 Enlisted)
 - 4 - Air Vehicles
 - 6 - HMMWVs (Ground Control Station, air vehicle transport, troop transports, maintenance shelter)
 - 3 - Trailers (equipment, launcher)
 - 4 - Remote Video Terminals



POP 300 Sensor Characteristics



Detector	640 x 480 InSb
Narrow Field-of-View	2.3 x 1.7 Deg
Medium Field-of-View	9.2 x 6.9 Deg
Wide Field-of-View	28.9 x 21.6 Deg
Instantaneous Field-of-View	0.062 mrad

FLIR

CCD Type	1/6", 768 x 494 Pixels
Optical Zoom	1.00° - 22.5° Continuous optical zoom
Digital Zoom	0.5° - 0.37° Digital Zoom
Resolution	480 TV Lines

Electro-Optical

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Operational & Theater UA EO/IR Sensors

- EO – Requirement for a facial recognition capability while remaining undetected. (NIIRS 8+)
- IR – Requirement for identification and tracking while remaining undetected
- Laser Designator Range Finder – Requirement for integration with EO/IR sensor
- Operational and Theater UA
 - Global War on Terrorism requires precision and facial recognition capability
 - Stand-off range is important
- Goal for Industry
 - Multi-spectral Capability with Fusion Onboard
 - HDTV resolution (720P) in Full Color
 - Weapons quality precise coordinates



MQ-1 Predator / AGM-114 Hellfire



- Testing began in Feb 2001
- Operationally employed in Afghanistan and Iraq
- IOC declared 2005

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Predator / Hellfire Launch



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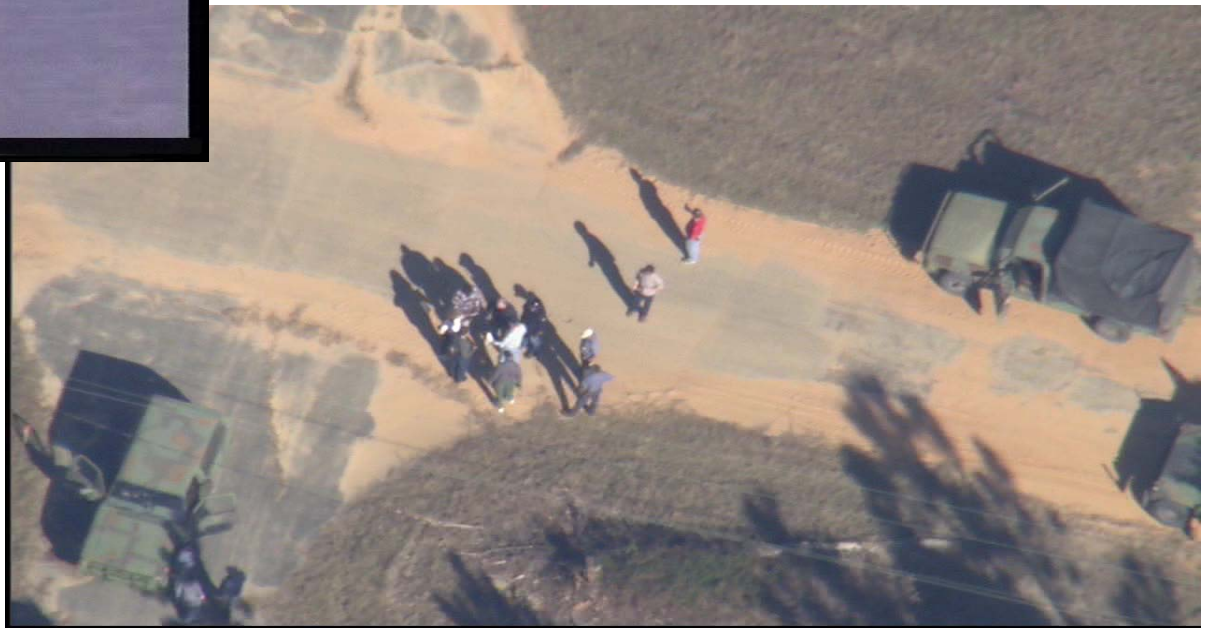
Human Activity

Predator vs HDTV – 3 mile slant range



Predator, 955 mm focal length

HDTV, 1200 mm focal length



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Global Hawk

High-altitude, long-endurance capability providing intelligence, surveillance and reconnaissance information

Unique Capabilities

- Persistence
- Responsive
- Multi-INT Collection



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PROB FAN SONG RADAR

PROB SA-2 LAUNCHERS WITH MISSILES

**Global Hawk EO Image: Ad Hoc Suspected SA-2
Battery 20NM N of Baghdad**

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IR SIGNATURE

This is a black and white infrared (IR) image of a highway in Western Iraq. The highway runs diagonally from the bottom left towards the top right. A bright, glowing spot on the road surface is identified as a suspected SCUD hide site. A white line points from a black box labeled 'IR SIGNATURE' in the top right corner to this glowing spot. The surrounding terrain is dark and textured, showing some vegetation and possibly other structures or vehicles in the distance.

**Global Hawk IR Image: Western Iraq Highway
Suspected SCUD Hide Sites SE of Aflid H-2**

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UA Radar Sensors

- Most UA will not have radar as the only system
- Goals for Industry
 - Literal radar image with same level of fidelity as low end monochromatic or high end IR image
 - Multi-band
 - Low frequencies for foliage penetration
 - High frequencies for detail
 - Sub-foot resolution
 - GMTI
 - Radar Video – Full motion video representation
 - Radar to EO/IR cueing



Army I-GNAT System



Characteristics / Description:

Wing Span	48.7 feet
Length	27 feet
Max Gross Weight	2,250 lbs
Fuel Weight	500 lbs
Speed Range	70-125 KIAS
Ceiling	25,000 feet
Endurance	40 hours
Payload (Internal)	450 lbs
Data Link	C-Band

Army I-GNAT UAV Characteristics

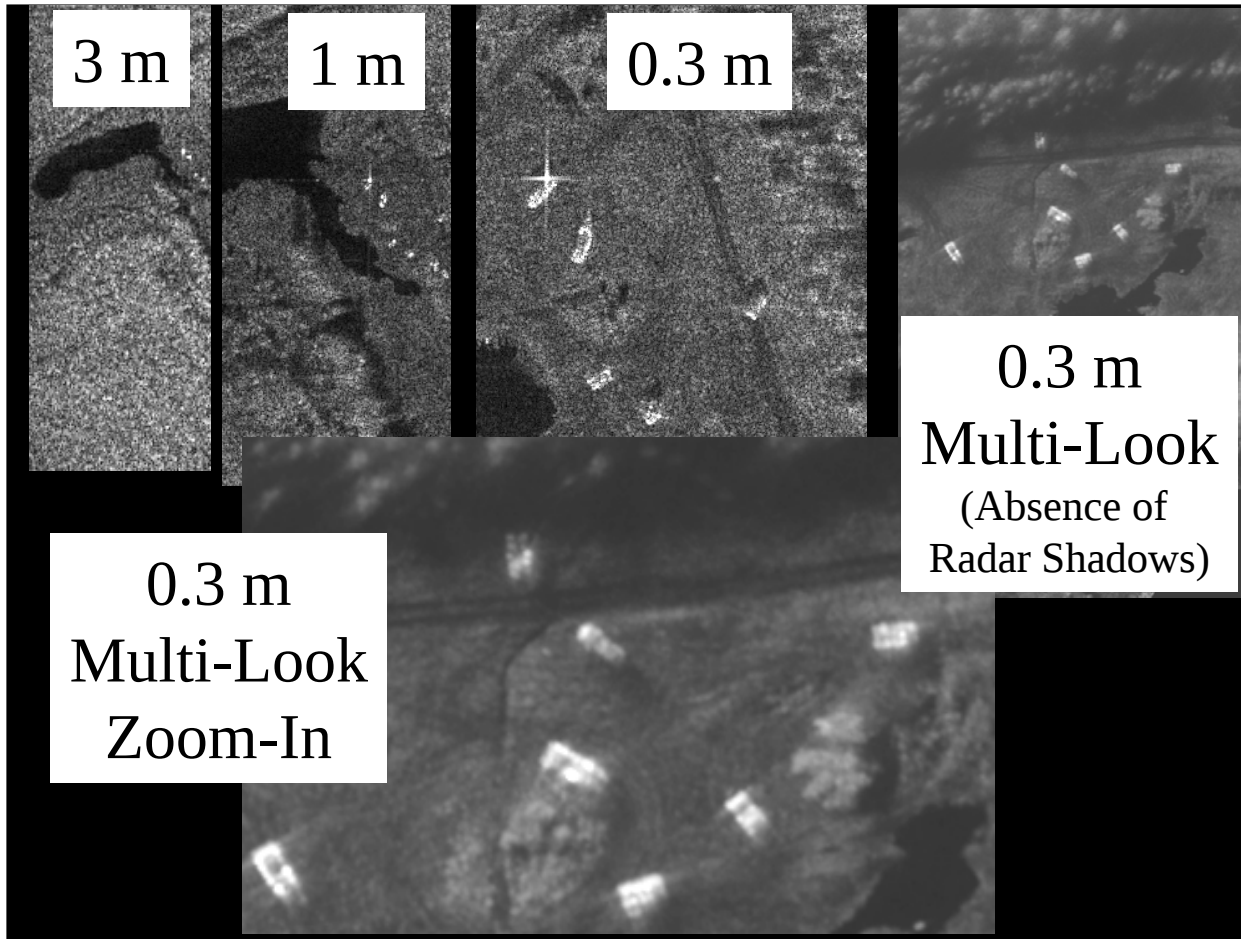
- Multi-Payload / Mission Capable / Hellfire Capable
- Numerous combat area deployments
- C-130 Transportable
 - In-Place Logistics
- Current IRAD Programs:
 - TUAV GCS
 - Differential GPS Auto Launch & Recovery
 - Point-n-Click Operation (No sticks/pedals)

One System

- Three (3) Air Vehicles
- One (1) Ground Control Station
- Two (2) Antennas
- Repair and Spare Parts
- Ground Support Equipment
- OIF since May 2004

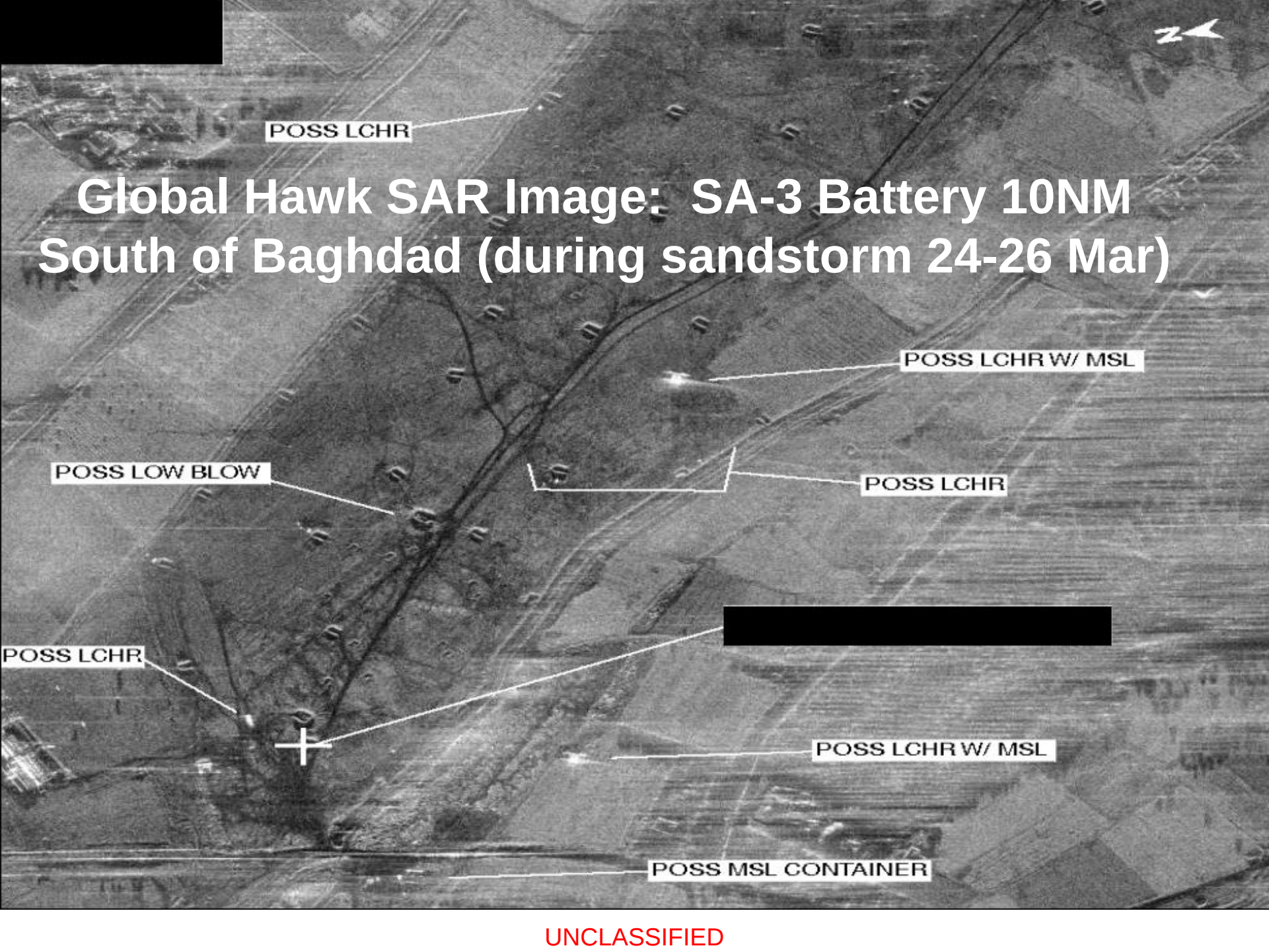


LYNX SAR



Convoy Search Ft Dix: 2 x Cargo Trucks / 6 x Hummers

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A grayscale Synthetic Aperture Radar (SAR) image showing a large, rectangular, fenced-in area, likely a military installation. The area is filled with numerous small, dark, circular structures, possibly tents or small buildings. A road or path runs along the left side of the installation. A white crosshair is visible in the lower-left quadrant of the installation. Several white lines with labels point to specific features within the installation. A north arrow is in the top right corner.

POSS LCHR

Global Hawk SAR Image: SA-3 Battery 10NM South of Baghdad (during sandstorm 24-26 Mar)

POSS LCHR W/ MSL

POSS LOW BLOW

POSS LCHR

POSS LCHR

POSS LCHR W/ MSL

POSS MSL CONTAINER

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Sensor Standards

- Time sensitive operations currently hampered by
 - Lack of sensor metadata
 - Use of multiple, non-standard formats for sensor data
- Requirement for standard metadata for time sensitive operations
 - NGA Motion Video Metadata (KLV) allows derivation of Precision Guided Munitions-quality coordinates in near real-time from video
 - GRIDLOCK Advanced Concept Technology Demonstration
 - Critical component of Global Information Grid integration
 - Makes integration and fusion of products, and use by others, easier

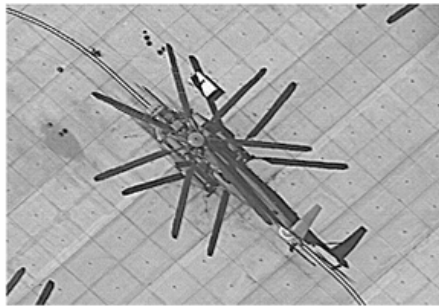


Sensor Fusion

- Fusion enhances visible image
 - Hyperspectral has potential, but not robust
 - No single frequency provides best solution
 - Hyperspectral + EO/IR = Image with highlights
 - Need to be able to select the frequency, or combination thereof, that best fits the situation/environment



High Altitude ISR System Performance



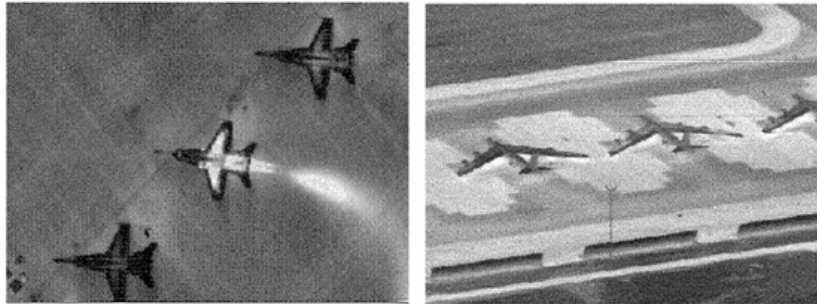
Detail Image
Chip examples
from the
Pan/NIR band at
various ranges.



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High Altitude ISR System Performance



MWIR Band
Night time
Detail Imagery
examples
collected over
various ranges.

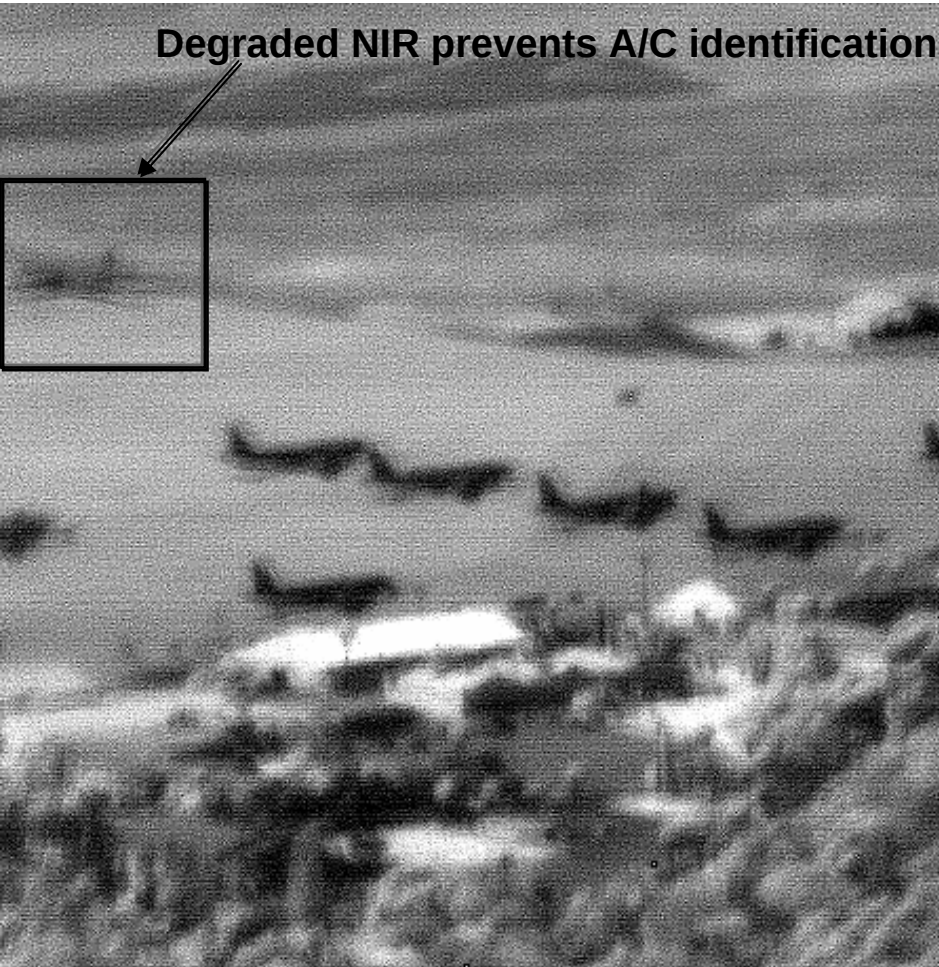
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Poor Visibility Enhancement (Pan vs. SWIR)



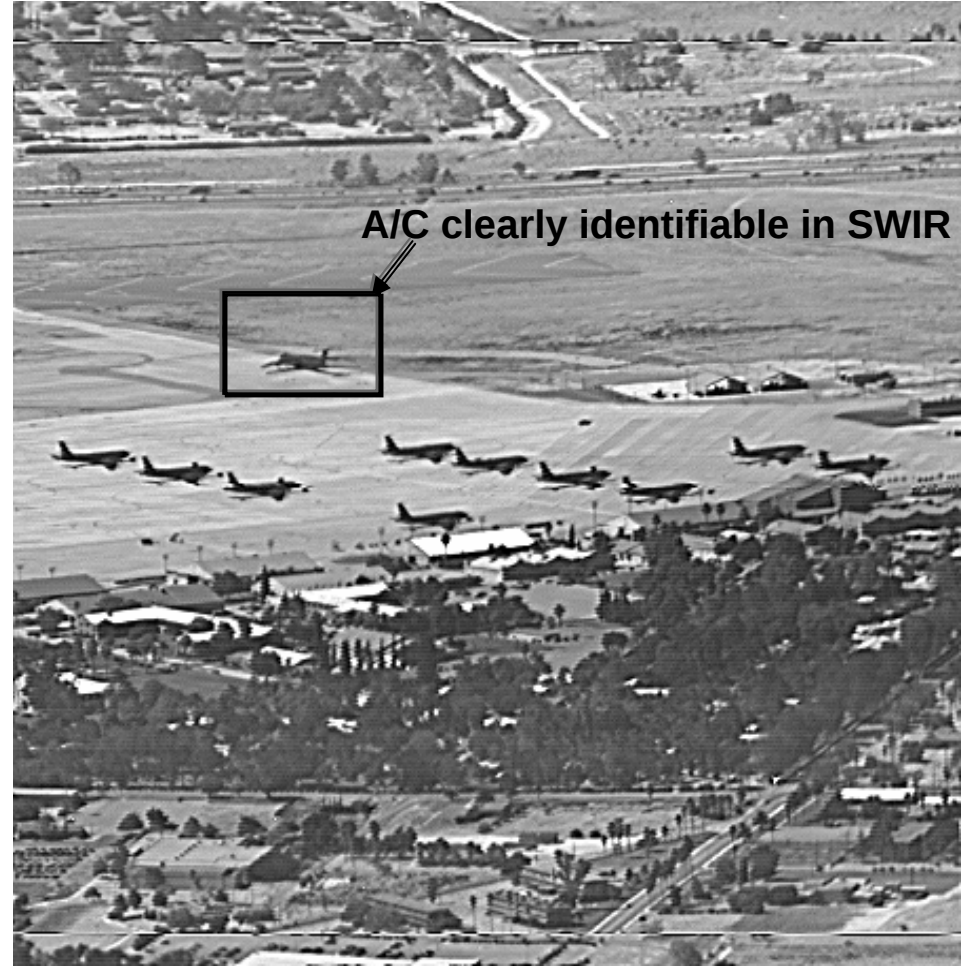
AOB: Identify/Detect Aircraft Activity

Degraded NIR prevents A/C identification



NIR

A/C clearly identifiable in SWIR

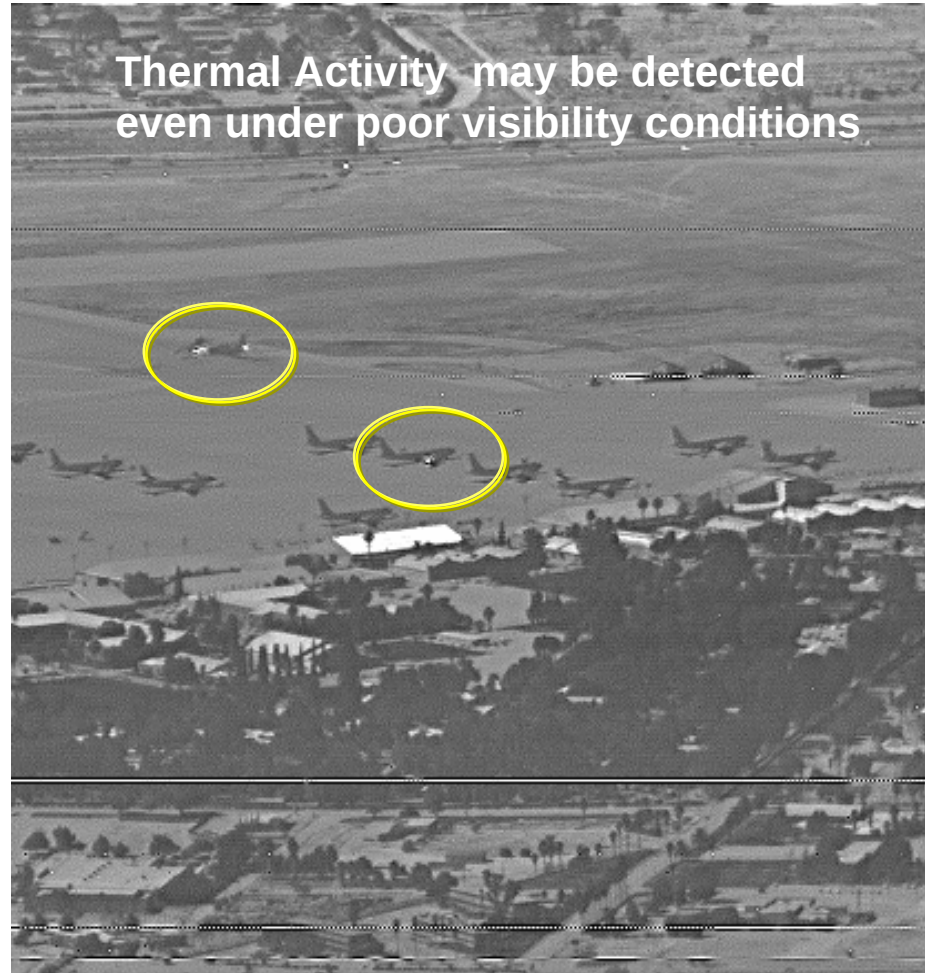


SWIR2

Poor Visibility Enhancement (SWIR & MWIR)



AOB Identify/Detect Aircraft Activity



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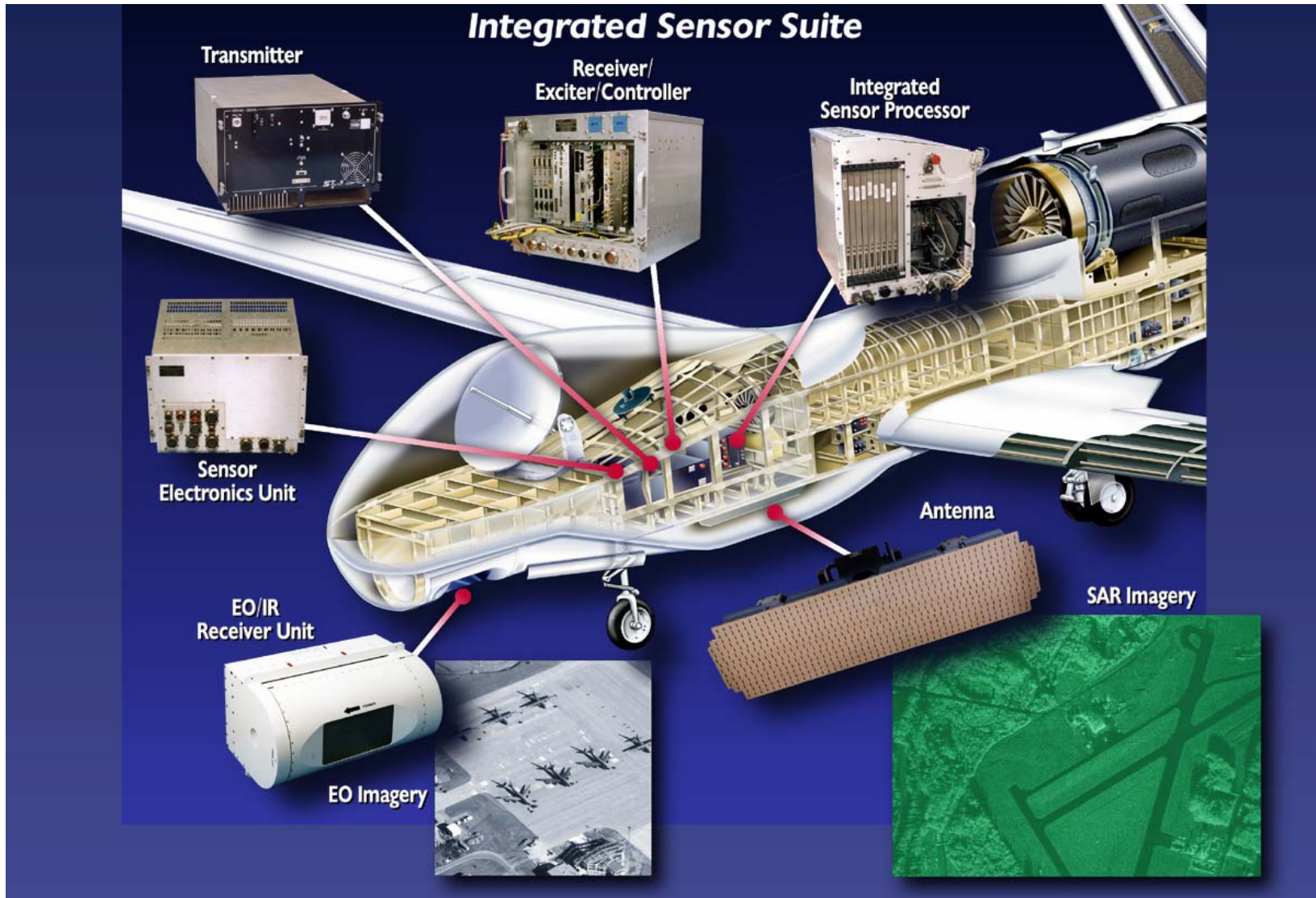


Summary

- Cost control is critical to development of UAS and UA sensors
- Standard metadata and standard data formats are:
 - Essential for time sensitive operations
 - Critical component of Global Information Grid integration
- Fusion enhances visual image
- Different sensor capabilities required to combat full range of asymmetrical threats:
 - Small
 - Tactical
 - Operational
 - Theater

Back Up Slides

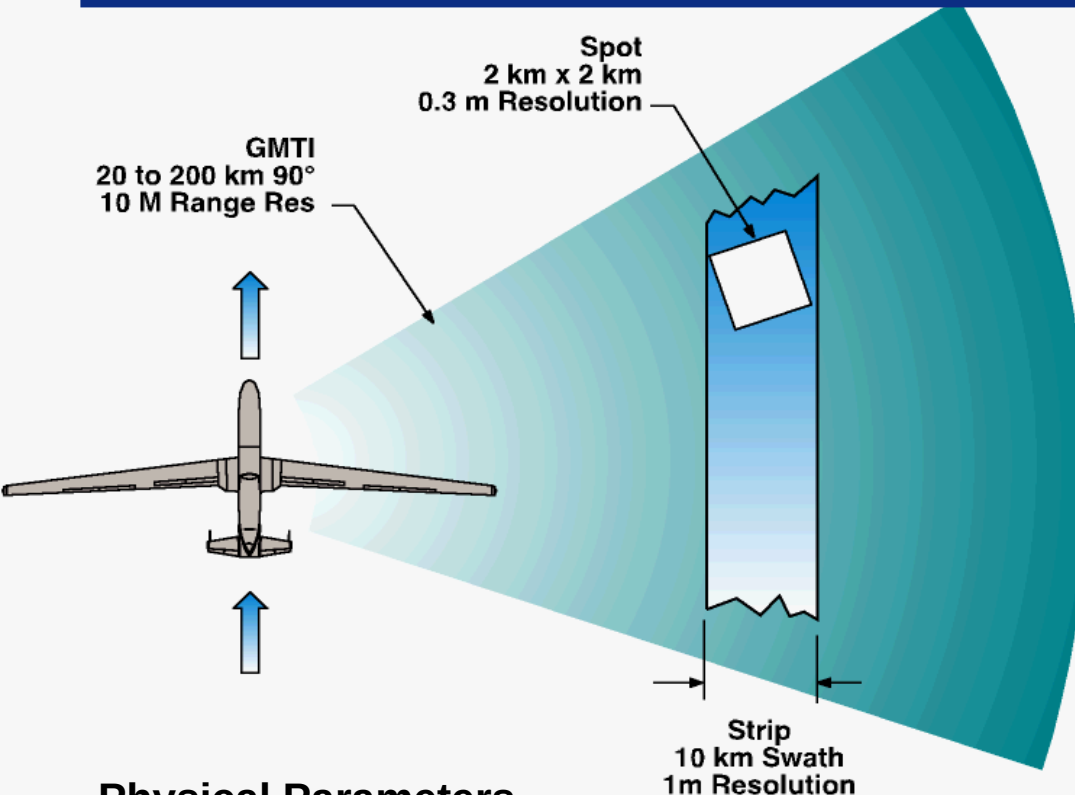
Global Hawk Integrated Sensor Suite



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SAR/MTI Sensor



Physical Parameters

7 LRUs

15 cu. ft. (excluding antenna)

640 lb

Power Required: 4700 W 400 Hz 3Ø
1300 W 28 Vdc

Radar Characteristics

X-Band Frequency

480 MHz Bandwidth

3.5 kW Peak Power

±45° Antenna Field of Regard
Either Side of Aircraft

Performance Parameters

Spot Mode: 1900 images/day
200 km Range
Squint to ±45°

Search Mode: 138,000 sq km/day
200 km Range

GMTI Mode: 15,000 sq. km/min
Search Rate
4 knots Minimum
Detectable
Velocity @ 100 km

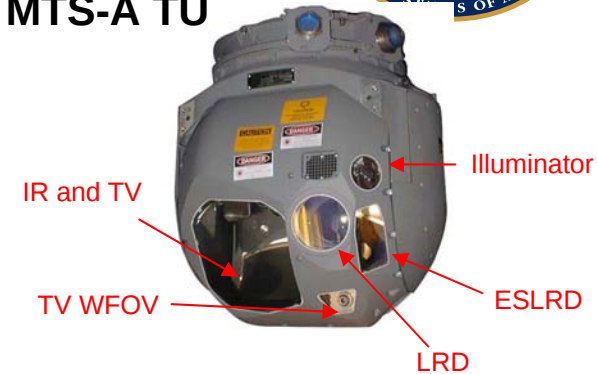
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MTS System Overview

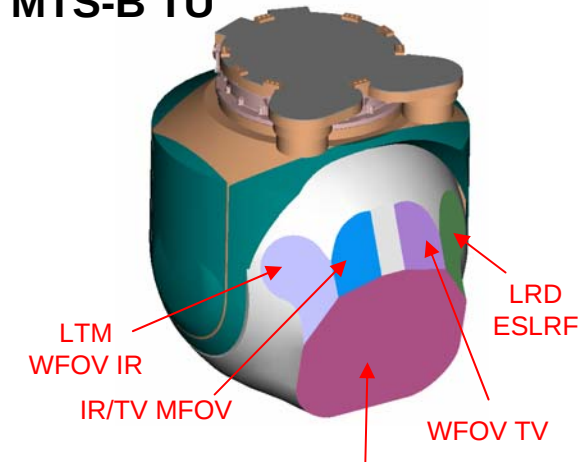


Physical Characteristics			MTS-A			MTS-B		
Diameter			17.43"			22.0"		
Height			18.70"			26.0"		
Weight								
Turret			124 lbs			230 lbs		
Electronics Box			30 lbs			30 lbs		
Power (nominal)			28Vdc, 30 Amps			28Vdc, 30 Amps		
Video Interfaces			RS-170, NTSC, Firewire, DVI			RS-170, NTSC, Firewire, DVI		
System Interface			MIL-STD-1553, RS-422, Ethernet			MIL-STD-1553, RS-422, Ethernet		
Temp			-54C to +55C			-54C to +55C		
Altitude			30,000 ASL			50,000 ASL		
Imaging Sensor								
Fields of View (FOV)			TV	IR	IITV	TV	IR	IITV
Wide	W-1 45°		33 X 44	33 X 44	--	34 X 45	34 X 45	--
Medium-Wide	W-2 22°		15X 20	15X 20	--	17 X 22	17 X 22	--
Medium	M-1 7.6°		5.7 X 7.6	5.7 X 7.6	5.7 X 7.6	5.7 X 7.6	5.7 X 7.6	5.7 X 7.6
	M-2 2.6°		--	--	--	2.2 X 2.6	--	--
Narrow	M-2 3.7°		1.2 X 1.6	1.2 X 1.6	1.2 X 1.6	--	2.8 X 3.7	2.8 X 3.7
	M-3 1.3°		--	--	--	0.96 X 1.3	--	--
Ultra-Narrow	N-1 0.63°		0.21 X 0.28	0.6 X 0.8	0.6 X 0.8	0.47 X 0.63	0.47 X 0.63	0.47 X 0.63
	N-2 0.22°		--	--	--	0.16 X 0.22	--	--
	N-2 0.31°		--	--	--	--	0.23 X 0.31	0.23 X 0.31
	N-3 0.011°		--	--	--	0.08 X 0.11	--	--
Spectral Band (microns)			0.4 to 0.7	3 to 5	0.6 to 0.89	0.4 to 0.7	3 to 5	0.6 to 0.89
Focal Plane Array Size			640 X 480 InSb			640 X 480 InSb		
Autotracker			Yes			Yes		
Laser Rangefinder Designator			Yes			Yes		
Eyesafe Laser Rangefinder			Not Installed			Yes		
Laser Illuminator			Yes			Yes		
Laser Spot Detection			Yes			Yes		
Inertial Measurement Unit			Yes			Yes		
Target Location Error			Weapons Quality			Weapons Quality		

MTS-A TU



MTS-B TU



Common EU

IR/TV/LLTV

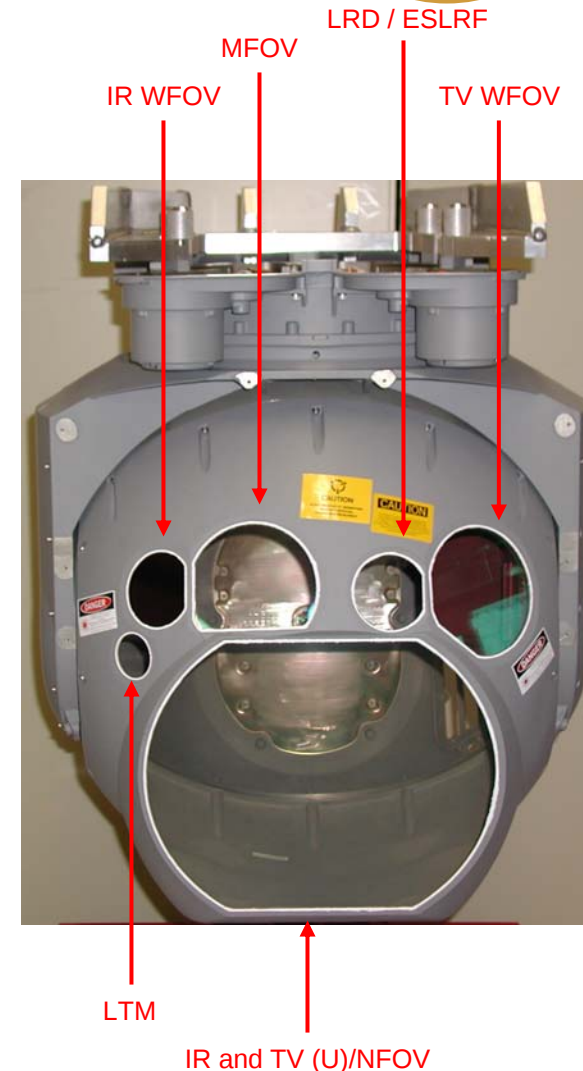


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MTS-B Prototype

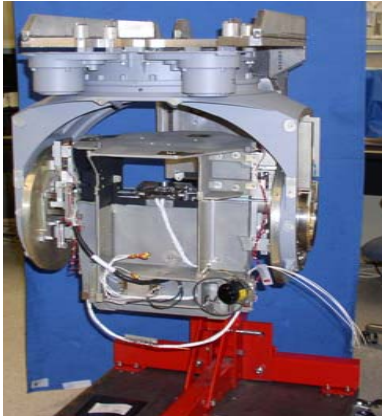
Physical Characteristics			MTS-A			MTS-B		
			17.43"			22.0"		
			18.70"			26.0"		
			124 lbs			230 lbs		
			30 lbs			30 lbs		
			28Vdc, 30 Amps			28Vdc, 30 Amps		
			RS-170, NTSC, Firewire, DVI			RS-170, NTSC, Firewire, DVI		
			MIL-STD-1553, RS-422, Ethernet			MIL-STD-1553, RS-422, Ethernet		
Temp			-54C to +55C			-54C to +55C		
Altitude			30,000 ASL			50,000 ASL		
Imaging Sensor								
Fields of View (FOV)			TV	IR	IITV	TV	IR	IITV
Wide	W-1	45°	33 X 44	33 X 44	--	34 X 45	34 X 45	--
Medium-Wide	W-2	22°	15X 20	15X 20	--	17 X 22	17 X 22	--
Medium	M-1	7.6°	5.7 X 7.6	5.7 X 7.6	5.7 X 7.6	5.7 X 7.6	5.7 X 7.6	5.7 X 7.6
	M-2	2.6°	--	--	--	2.2 X 2.6	--	--
Narrow	M-2	3.7°	1.2 X 1.6	1.2 X 1.6	1.2 X 1.6	--	2.8 X 3.7	2.8 X 3.7
	M-3	1.3°	--	--	--	0.96 X 1.3	--	--
Ultra-Narrow	N-1	0.63°	0.21 X 0.28	0.6 X 0.8	0.6 X 0.8	0.47 X 0.63	0.47 X 0.63	0.47 X 0.63
	N-2	0.22°	--	--	--	0.16 X 0.22	--	--
	N-2	0.31°	--	--	--	--	0.23 X 0.31	0.23 X 0.31
	N-3	0.011°	--	--	--	0.08 X 0.11	--	--
Spectral Band (microns)			0.4 to 0.7	3 to 5	0.6 to 0.89	0.4 to 0.7	3 to 5	0.6 to 0.89
Focal Plane Array Size			640 X 480 InSb			640 X 480 InSb		
Autotracker			Yes			Yes		
Laser Rangefinder Designator			Yes			Yes		
Eyesafe Laser Rangefinder			Not Installed			Yes		
Laser Illuminator			Yes			Yes		
Laser Spot Detection			Yes			Yes		
Inertial Measurement Unit			Yes			Yes		
Target Location Error			Weapons Quality			Weapons Quality		



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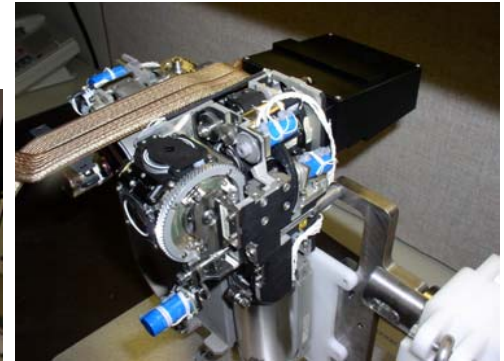
MTS-B Hardware



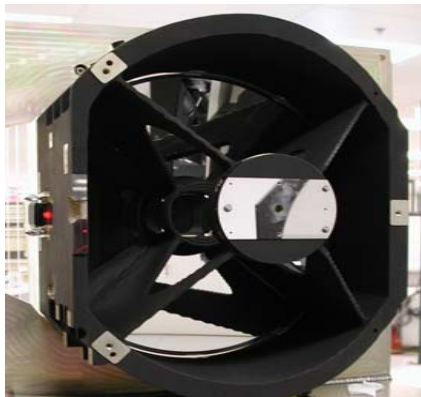
MTS-B Gimbal



MTS-B Turret Unit



Common Imager



MTS-B 12X Afocal



MTS-B Receiver Assy

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Unmanned Aircraft Systems Sensors

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presentation without supporting text.*

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