Automatic Target Recognition Update 2002

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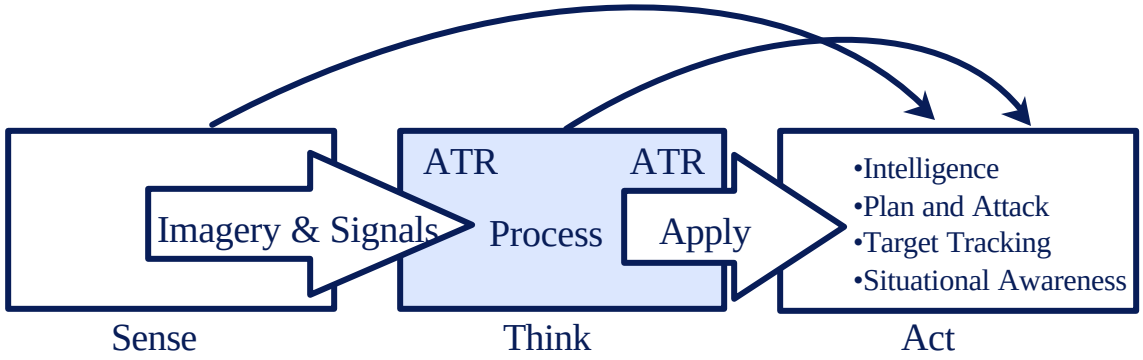
ATR Solves Many Problems

Definition: Computer processing of sensor signals to *detect*, *classify*, *recognize* and *identify* targets and other things of interest

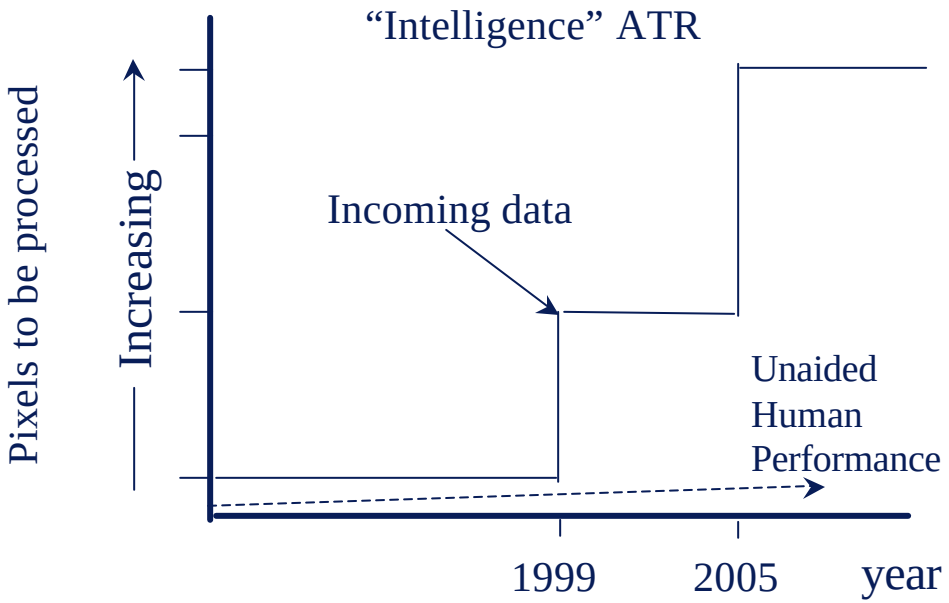


Tasks:

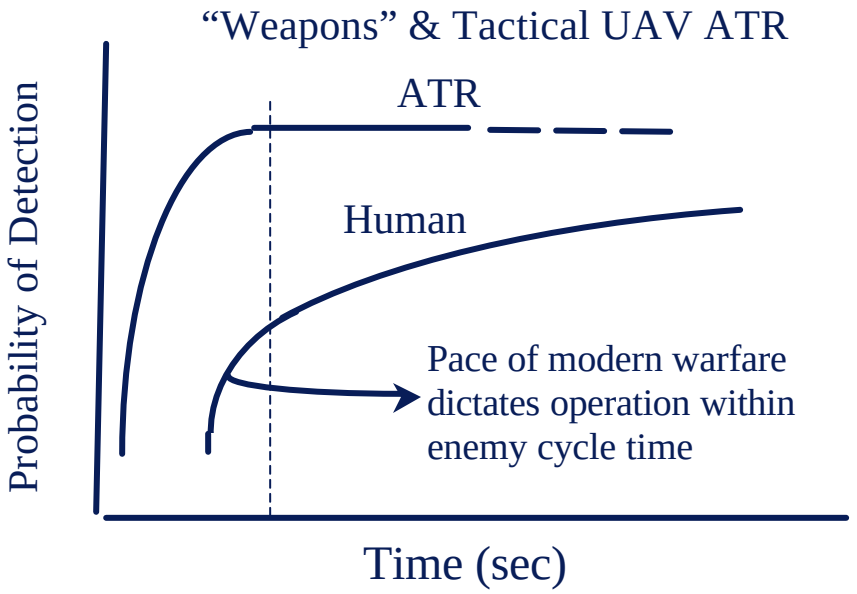
Detect	(There is a target of some kind)	***Detect Change***	(Find what's new)
Classify	(The target is a wheeled vehicle)	***Cue***	(Look here)
Recognize	(The target is a TEL)	***Delimit***	(TELS can't drive there)
Identify	(The target is a SCUD-B launcher)	***Target***	(Kill target)
		Track History	(SCUDs appear to be ready to launch)
Screen	(Scan these images for all TELs)		
		Map	(That is a pine forest**)**

ATR spans many different functions

Data Quantity & Response Time are Today's Forcing Functions



Data to be processed increases over 100 fold

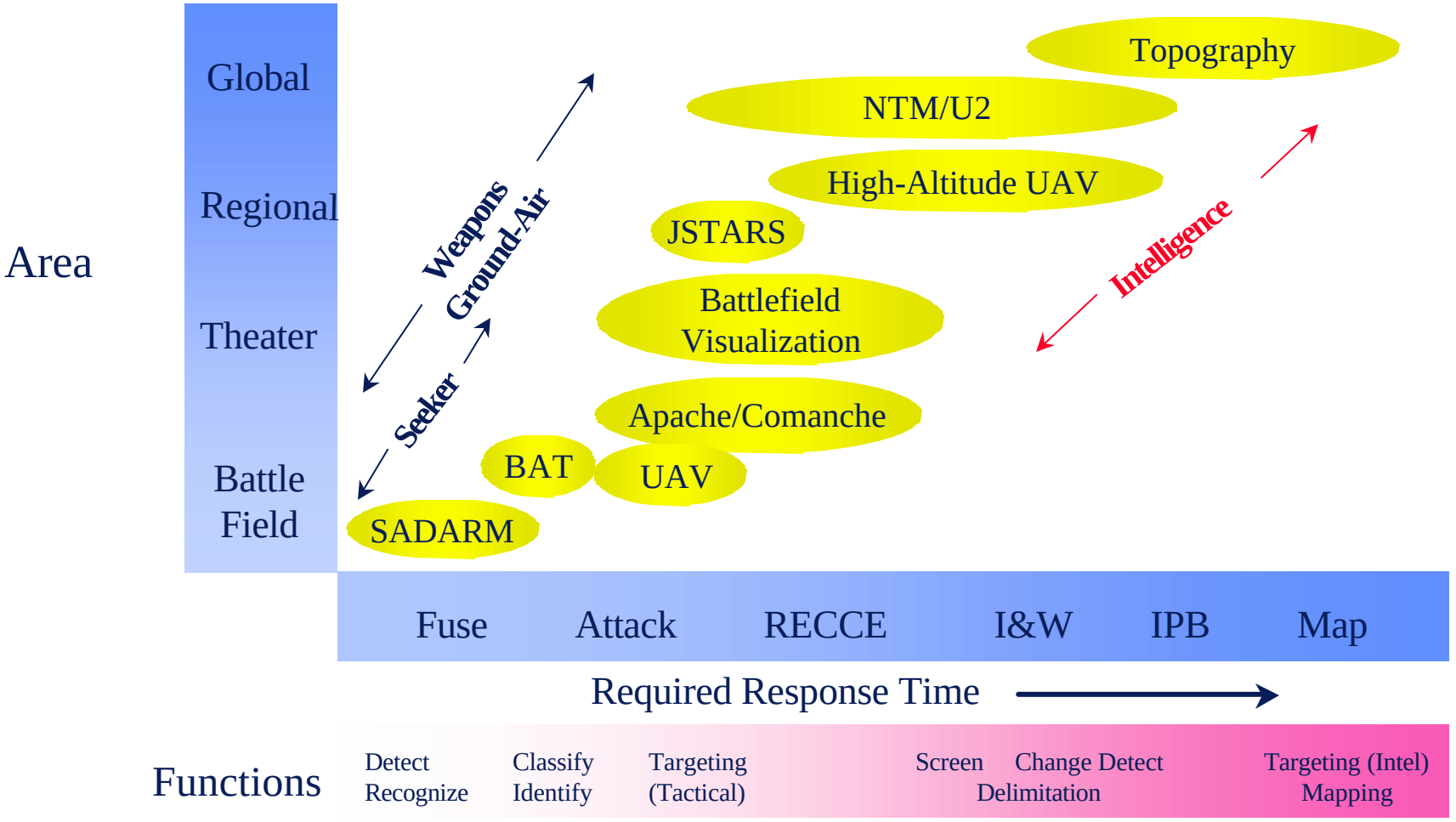


Computers are better than people at TR

- Unaided human performance is limited: – poor at repetitive tasks
  – poor at area search
  – easily fatigued
  – exceeds needed response time

We will be overwhelmed without ATR

Many ATR Requirements



ATR Technology Evolution

70-80's | 90's | 00 +

PERFORMANCE

Pershing

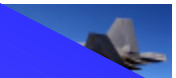
Tomahawk

DSP

JSTARS

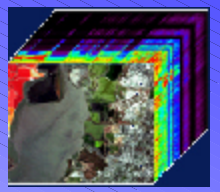
SADARM

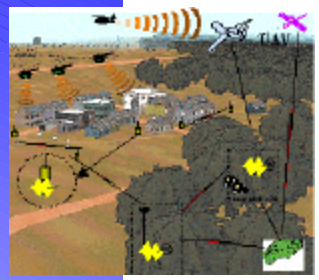
F-22



2nd GEN ATR

Hyperspectral



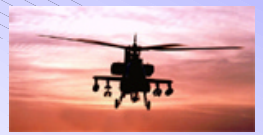


Smart Sensor Web

UAV

LRAS3

LOCAAS



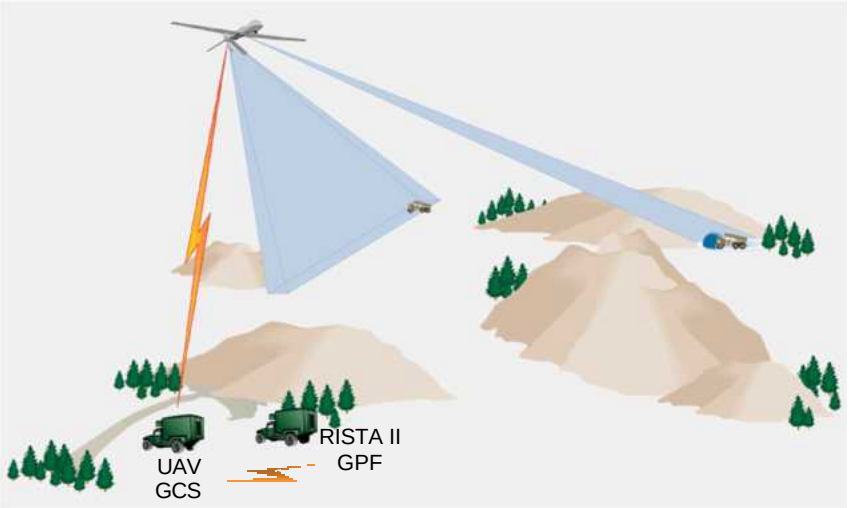
Apache

Feature Based | **Template Match** | **Model Based** | **Multi-Sensor Fusion**

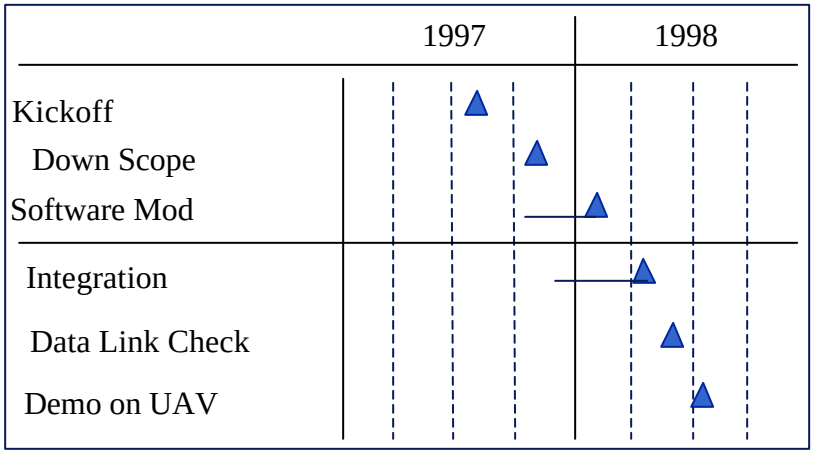
RISTA II on UAV Overview

Demonstration Objectives

- Remotely Control and Task the Sensor in Real Time
- Process and Display Imagery in Mobile Ground Processing Facility (GPF)
- Send Processed Imagery to Rosslyn, VA Near Real Time
- Show Multiple Applications



SCHEDULE



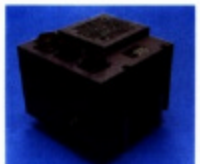
CHARACTERISTICS:

- Increase Current Coverage Rate ~20x
- Day/Night Operation w/2nd GEN IR FPA
- Multi-Mode: DLIR, FLIR, other
- Aided Target Detection in Ground Processing Facility
- User Friendly Image Manipulation and Target Reporting

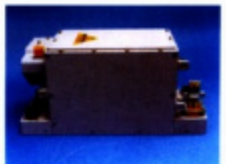
RISTA II Sensor Characteristics

Airborne Sensor Configuration

Sensorhead



Power Supply



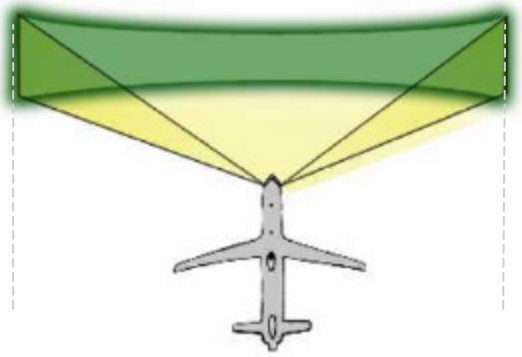
SEU

Altimeter
(Not Used in ALTUS)

FOV		
	Scanning	**120 deg x 2.0 deg**
	FLIR	**2.75 deg x 2.0 deg**
FOR		**+ 90 deg, -180 deg Az +55 deg, -30 deg El (+75, -10 in ALTUS)**
Clear Aperture		**5 Inches**
EFL		**13.75 Inches**
System F/#	**2.75**	
Video		**12 bit Digital or RS-170**
Focal Plane Array		**SADA II**
MTBF		**> 800 Hours**
Environmental		**Full Military**
Weight (Sensorhead, Power Supply, Electronics Unit)		**140 lbs**
Power		**650 Watts, 28VDC**
Volume		**1.63 Cubic Feet**
Wave Band	**8-12 mm**	
Resolution	**1’ / Pixel @**	**12,000’**
Pointing Accuracy		**1 - 2 mrad**
Gimbal Stabilization		**26 Microrads**
Gimbal Scan Rate		**134 deg per sec**

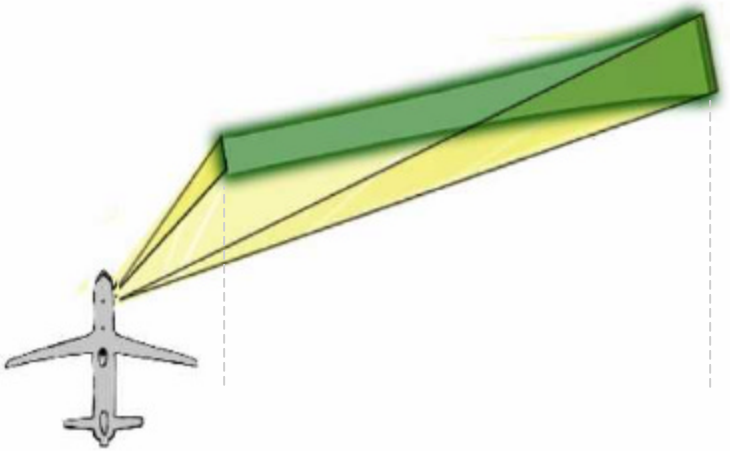
RISTA II Scanning Modes

Nadir Scan



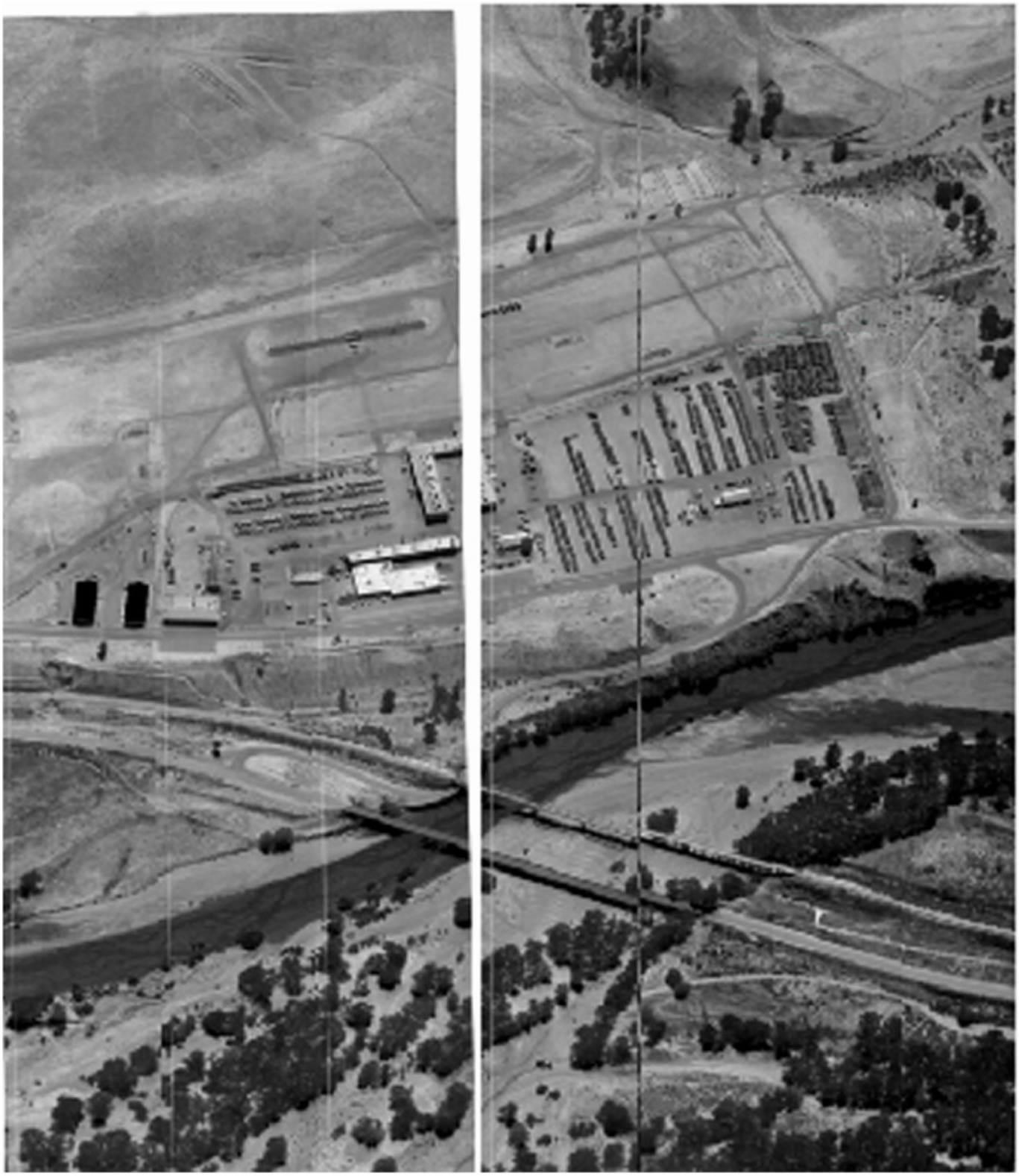
Forward Scan

Offset Scan



Oblique Scan

Sector Scanned Infrared Images of Camp Roberts MATES from RISTA II on UAV, Jul 98 (20°< f<60°)

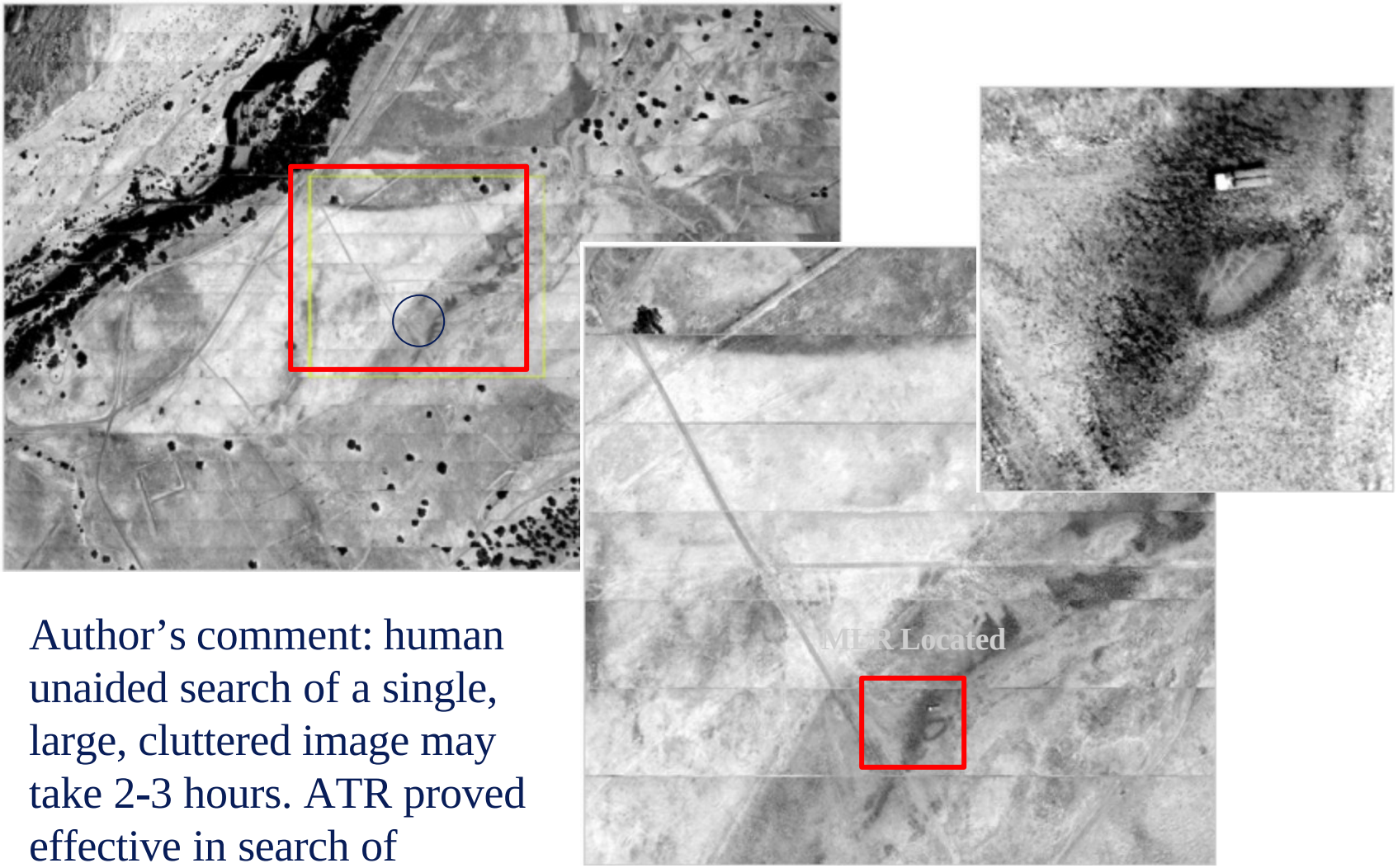


ALTUS UAV

- Endurance > 30 hrs
- Payload ~ 350 lbs
- Ceiling > 40,000 ft
- Cruise Speed ~ 90 kts @ 15,000
  ~ 145 kts @ 40,000 ft
- Turn Radius < 500m

- Length 22 ft
- Wingspan 55 ft
- Weight 1600 lbs
- Payload Power > 1000 w

RISTA II Search for MRL



Author's comment: human unaided search of a single, large, cluttered image may take 2-3 hours. ATR proved effective in search of RISTA II images.

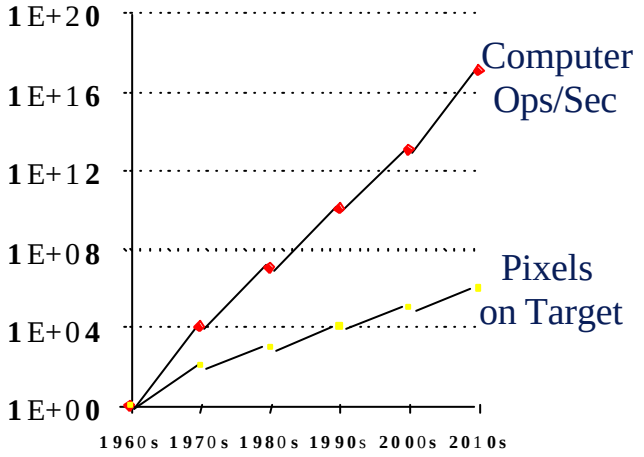
ATR Key Enabling Technologies

Computer power

Sensor resolution

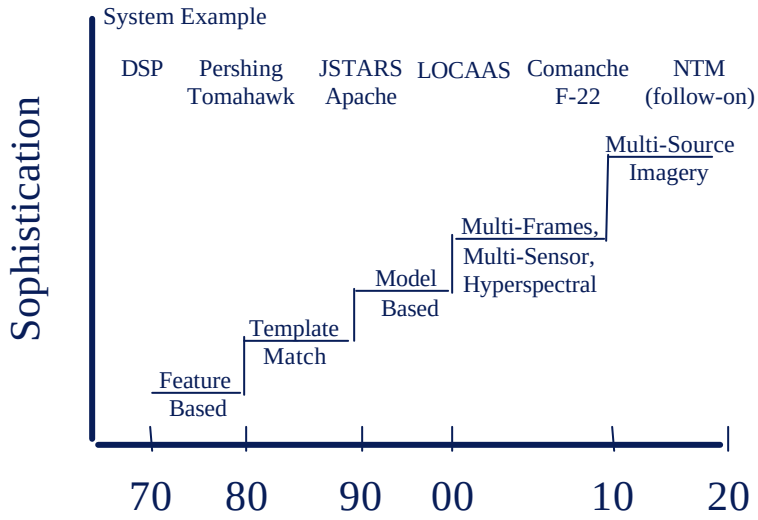
Increase allows → known techniques to be applied within enemy's operational cycle

Computer Power Growing Faster than Sensor Resolution



Enables

Advanced Techniques become Practical



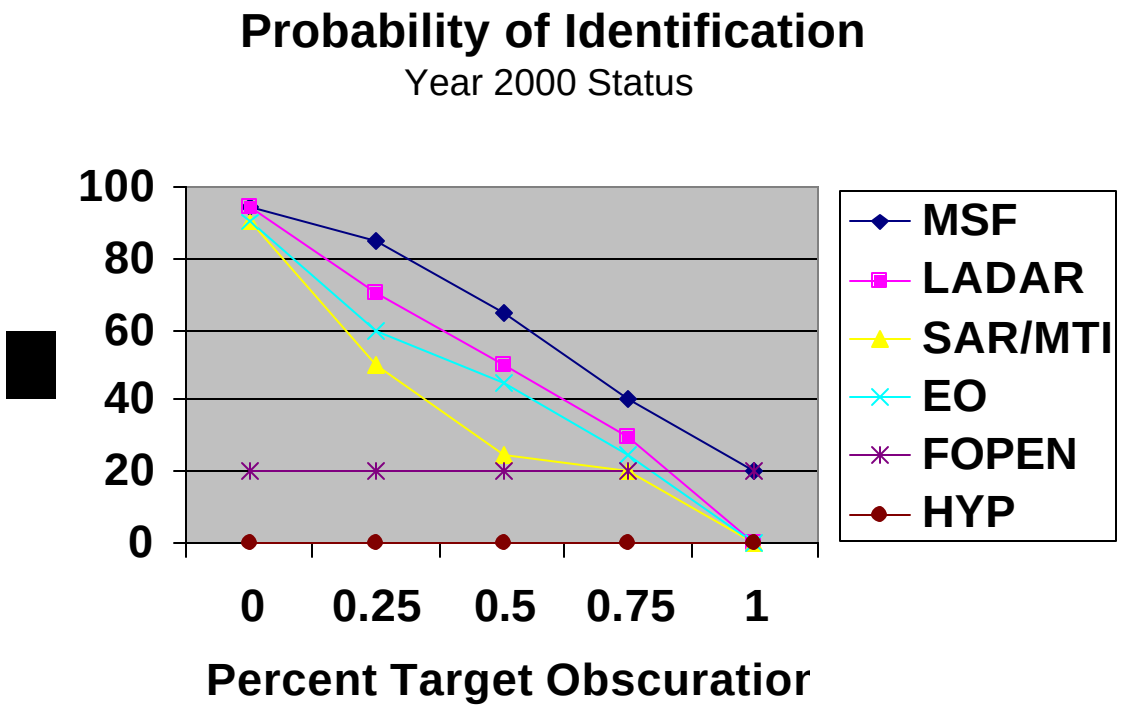
What Do We Know?

Today is 10/2/02

- Template Matching provides a useful military capability
- ATR aids in search of large images
- Resolution and dynamic range are essential
  - » Spatial
  - » Spectral
  - » Doppler
  - » Temperature
- Greater image dimensionality improves ATR performance
- False Alarm Rates could be 10X lower

ATR cannot fabricate data that isn't there

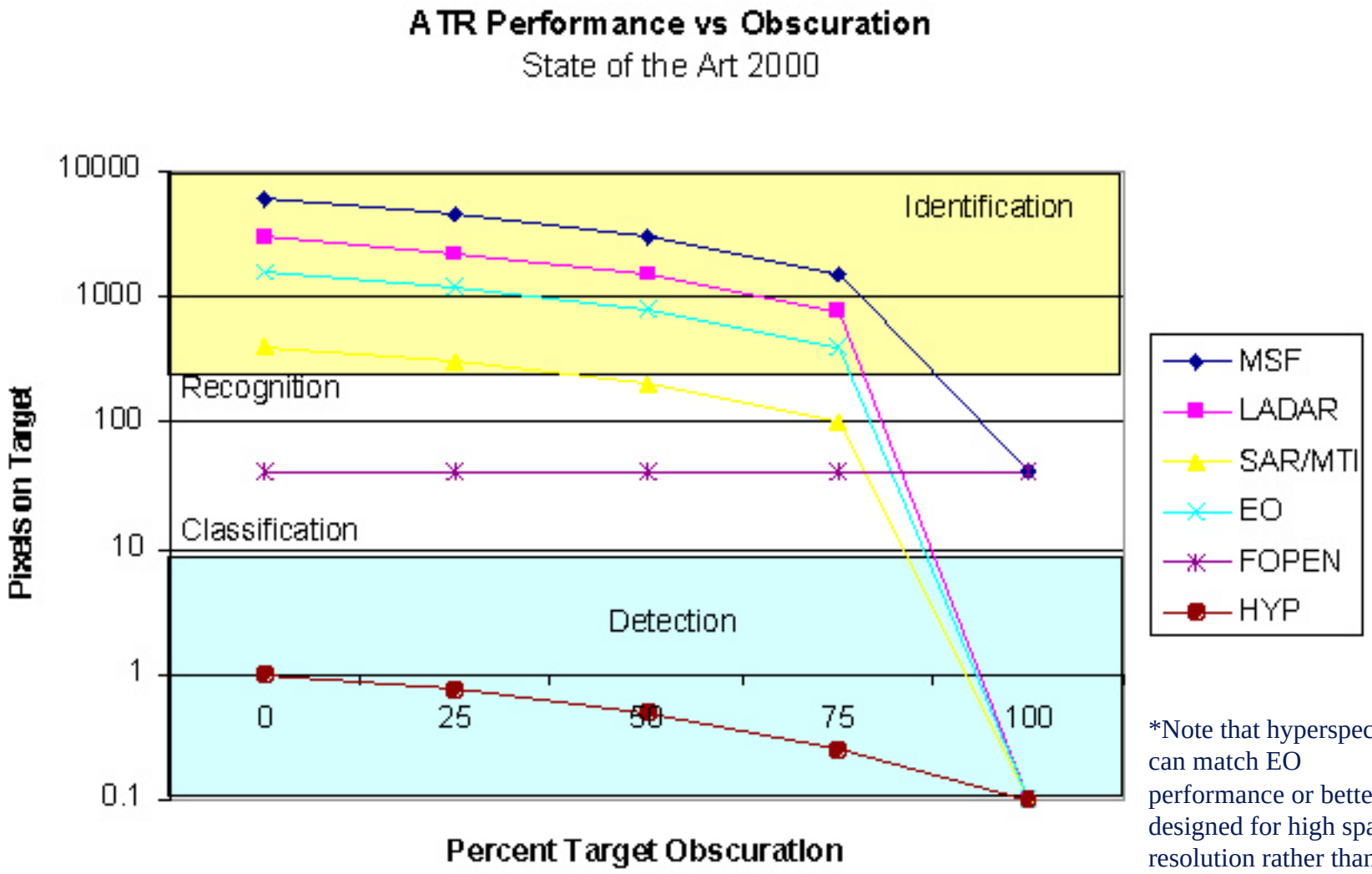
ATR Approximate Status* 2002



*Strictly the opinion of the author; not endorsed by the DoD or any component, organization.

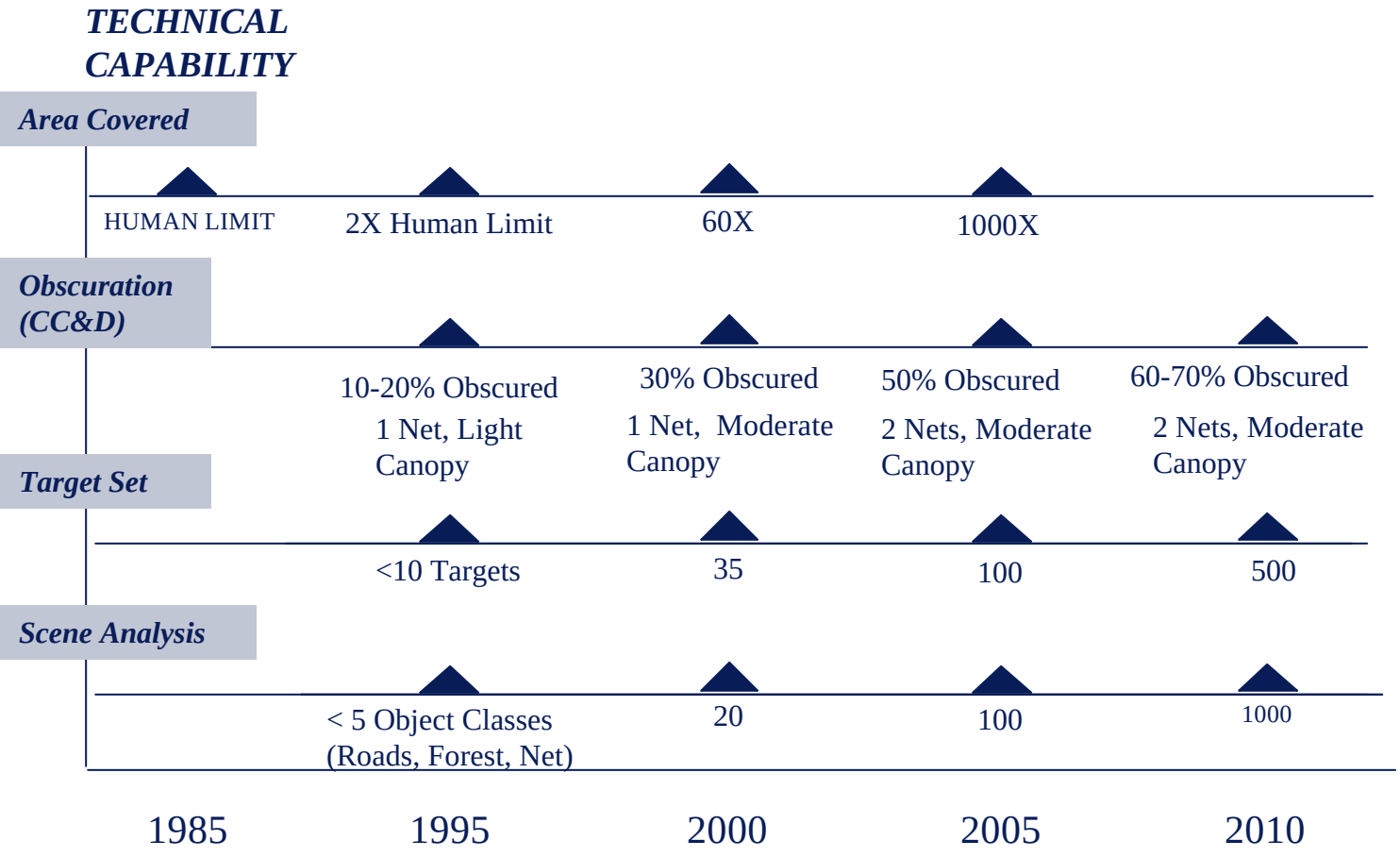
Pixels Matter

Approximate impact of spatial resolution* and dimension



*Note that hyperspectral can match EO performance or better if designed for high spatial resolution rather than wide area search.

Goals



KEY TECHNOLOGY

- Memory
- Processor Speed

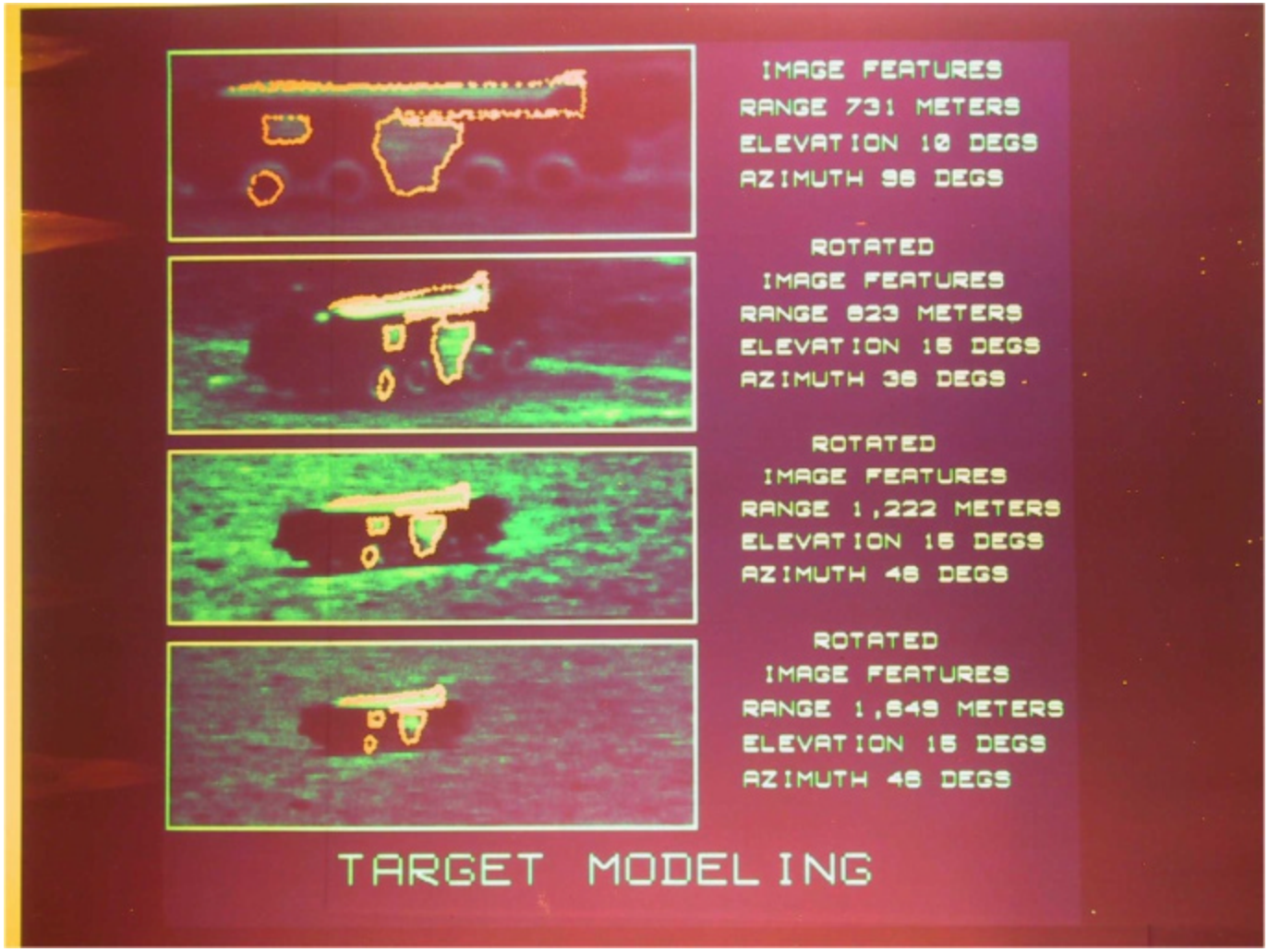
- Multi-mode ATR
- Multi-sensors
- Foliage Penetration SAR
- Laser Radar

- Model based ATR
- Memory
- Processor Speed

- 3D Imagery
- Model based ATR
- Hyperspectral sensors
- Memory
- Processor Speed

APPLIED RESEARCH ASSOCIATES, INC.

Model Based Vision & Recognition by Components May Extend ATR Performance to EOC

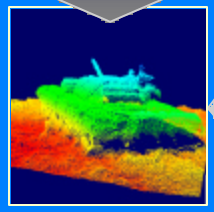


Exploitation of 3D Data (E3D) Program

To develop novel and efficient techniques for rapidly exploiting 3-D sensor data to achieve precise targeting capability.

Classification and ID via **Recognition by Components (parts)**

Direct Comparison



Target Search using **context cues**

Tracks

Approach

- System is given small (100x100x10m) block of 3d data
- Find and segment the target in the block using context models and statistical features
- Classify based on functional description before ID (allows classification of never before seen types)
- Identify using a large model set (achieve .99 Pc)
- Fingerprint using discriminating features

Military Payoff

- Achievement of rapid and precise identification in the targeting process
- Identification from 3-D data based on measurements obtained directly from the sensor data
- Ability of the military to utilize 3-D data rapidly becoming available from advanced sensors
- Creates a superior market for the use of 3-D data.

Major Milestones (Phase I)

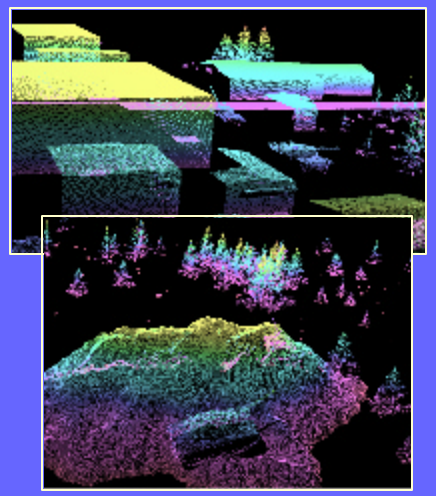
25		**Mar 02**	**BAA published**
(completed)			
15		**Aug 02**	**Contracts started**
(completed)			
	8	**Sept 02**	**ICD Design**
1*(completed)*			
	1	Nov 02	1st Model Delivery
(on schedule)			
	12	Dec 02	Component Tech
S/W Drop 1			
	8	Jan 03	1st Eval Phase
	4	Feb 03	ICD Design 2
	4	Mar 03	2nd Model Delivery
	15	Apr 03	Component Tech

E3D Component Technologies

	Technology	Capability Goal
Target Acquisition	**Local Area 3-D Data Search**	●Find and locate ●Cues from 3-D ●Change Detection
Target Acquisition	**Clutter Rejection**	●Is there anything there? ●Decoy mitigation ●Background/target discretion
Target Recognition	**ID/Classification of Targets by Components**	●ID of 3-D targets using detailed models ●Classification using generic models
Target Recognition	**Fingerprinting**	●ID objects by measurements and unique features ●Reacquisition of targets: *"Is this the same vehicle I saw yesterday?"*

Accomplishments to date

- **Performers contracted:**
  - » **Recognition:** ALPHATECH Team (Veridian, SRI); Sarnoff Team (UC Berkeley, CMU)
  - » **Acquisition:** SAIC-Tucson, Raytheon Team (CUNY, UMD)
  - » **Modeling:** SAIC-Huntsville Team (Demaco, NextEngine, Dynetics)
- **Data Supply:** Synthetic data distributed at kickoff (14 DVDs) high density
- **Data Collection Plans:**
  - » "Tower" Collection (9/16 – 20) Redstone Arsenal
  - » Targets T72, BTR70, SA13, M2, M35, M60, HMMWV, Technical
  - » Sensor: DCS ladar, scanning, 3" range and spatial resolution
  - » Point clouds will be registered
  - » Viewer customized: Matlab reader, Pioneer



- **System Design Team:** Fully operating; addressing TA and TR interface; DIRO Gate test definition in progress.
- **Modeling:** Reworked existing models to E3D specs. Plan to model backhoe and "technical" within 7 days.
- **Representation Decisions:** Faceted surface models with articulatable parts stored in hierarchy; three different resolutions—highest 1" tolerance (for varying levels of recognition: class, type, fingerprint)

OSD ATR Technology Assessment Program

Automatic Target Recognition: Descriptive Summary PE 0603232D8Z

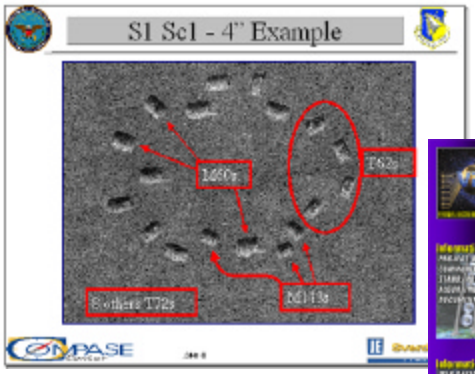
Objective:

- Provide DoD-wide “honest broker” assessment of ATR technology
  - » Standardized criteria (procedures and metrics)
  - » Realistic military scenarios
  - » Common Data Sets in realistic scenarios/environments
  - » Broad technical collaboration
- Identify/promote early transition opportunities for ISR and weapon systems

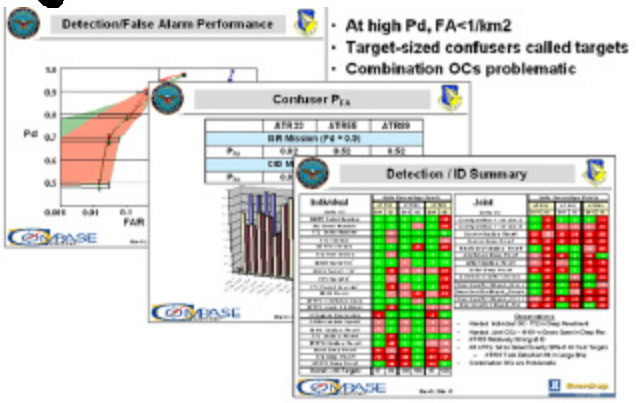
ATR Technology Assessment Program
Program Description

Problem Sets

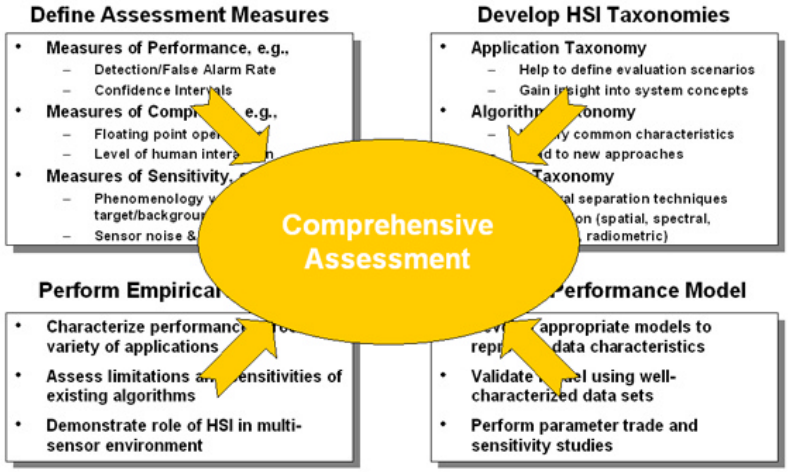
Collect/Distribute Data



Assess ATR



Assess Hyperspectral Imaging



Identify/Sponsor Transition Opportunities

ATR Technology Assessment Program Transition Opportunities

Hyperspectral Sensors in Space

LOCAAS

LRAS 3

Other Opportunities

- Comanche
- Predator
- Global Hawk
- P-3
- Joint Strike Fighter
- SAIP (Intel.)

ATR Technology Assessment Program

FY03 Priorities

- *Joint data collections to create Problem Sets for the evaluation of multispectral sensor fusion ATR technology.*
  - » *Participants: AFRL, NVESD, ARL, Sandia, MIT/LL, DARPA, ONR, IC*
  - » *Sensor Domains: SAR, EO/IR, Hyperspectral, LADAR, other sensors (grd/air/space)*
- *Creation/use of Problem Sets with standardized procedures & metrics for ATR technology assessments.*
  - » *Benchmark ATR algorithms for: SAR, IR, LADAR and Hyperspectral*
  - » *Assess Sensor Fusion for ATR Enhancement for Precision Targeting and BattleSpace characterization*
- *Continue Hyperspectral Assessment*
- *Transition of the Program to the Services/Agencies for FY04*

Summary: ATR Status 2002

Findings & Unfinished Business

- ATR key to search of UAV imagery
- Needed: ATR for Extended Operating Conditions (industrial strength ATR)
  - » Obscuration
    - – Partial
    - – Patchy (foliage)
  - » Articulated and variable targets
  - » CC&D
  - » Reduction of false alarm rates in real scenarios and MOUT
- Number of target classes needs to grow 10-100X
- Programs in place to move to new performance levels
- Standard problem sets need wide dissemination and USE
  - » Quantitative difficulty ratings for problem sets
  - » Continuation of rigorous evaluation

The Need for Objective Evaluation Will Always be With Us