

Advanced Acoustic Sensor Technologies

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Tank-automotive & Armaments COMmand

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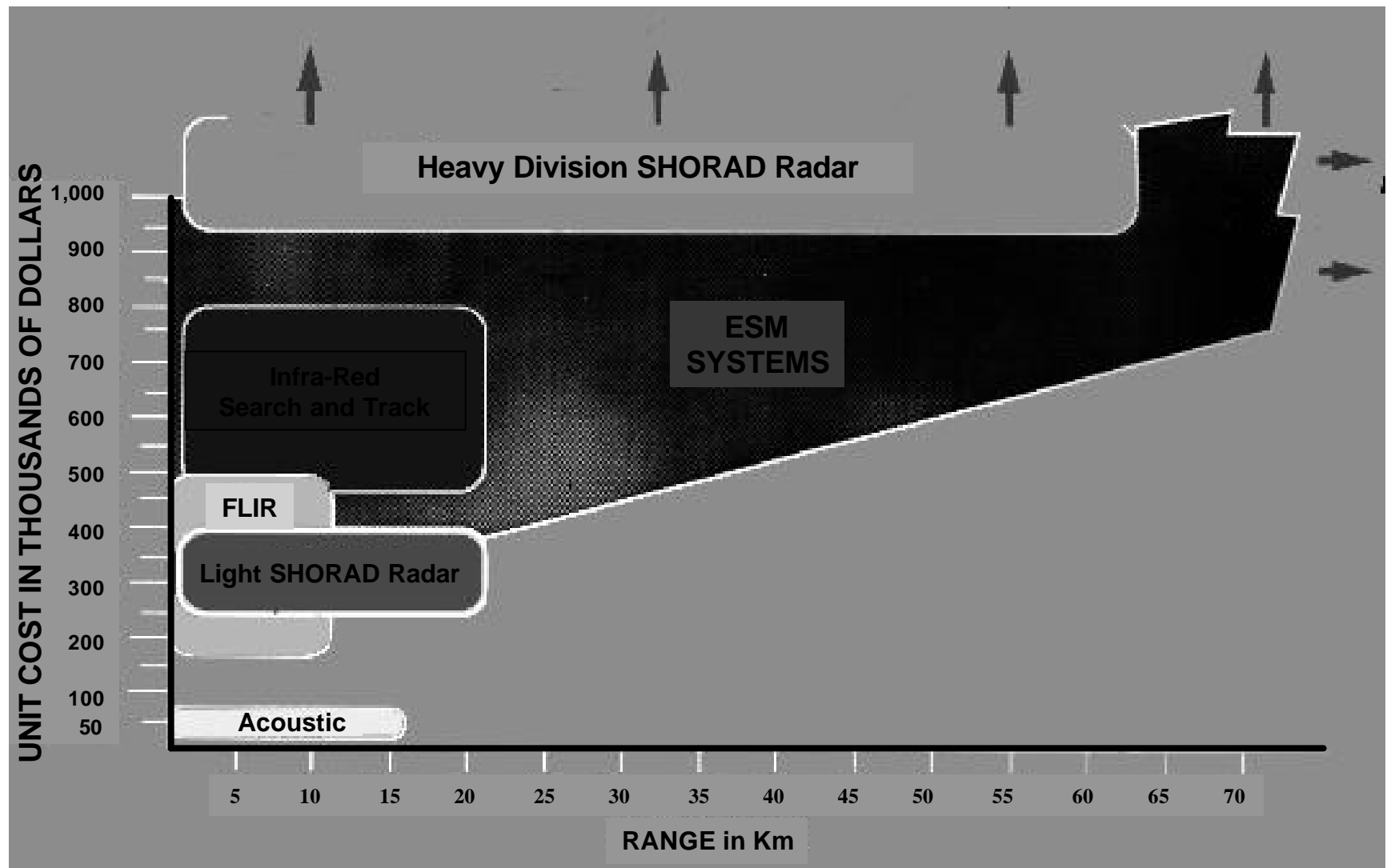
OUTLINE

- **BACKGROUND**
 - WHY ACOUSTICS
 - TECHNOLOGY EXPLOITED
 - PRIOR ARDEC PROGRAMS
- **PRIOR TECHNOLOGY/PROGRAMS**
 - FAAD
 - HELO & BAT
 - COUNTER SNIPER
 - RFPI
- **CURRENT TECHNOLOGY/PROGRAMS**
 - NINOX
 - RAPTOR
 - CLASSIFIER
 - TARGET COUNTER
 - TECH BASE (6.2)
 - ACOUSTIC COUNTER BATTERY SYSTEM (ACBS)
 - ACOUSTIC/SEISMIC MODELING
 - NETWORKED DISTRIBUTED SENSORS

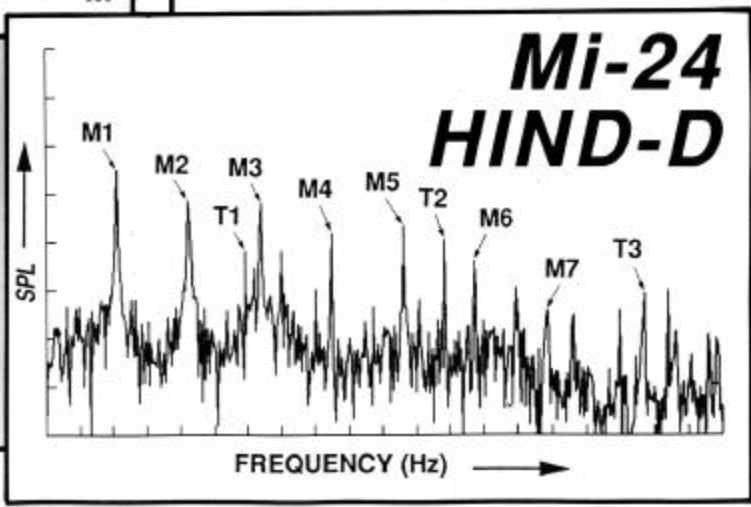
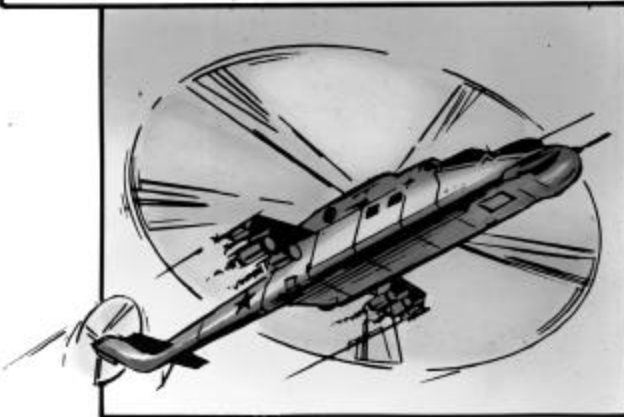
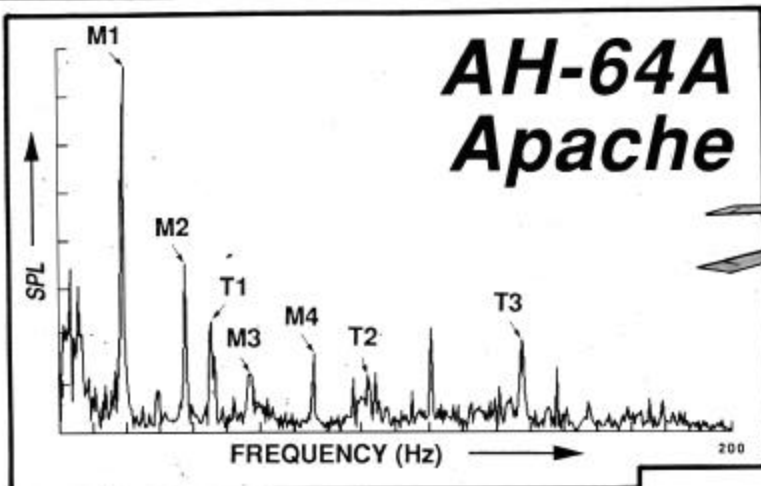
Army Benefits

- Passive
- Day/Night/Adverse Weather
- NLOS Threat Target Detection
- NC-IFF, PHID (Avoids Fratricide)
- Acquire Threats at Stand-off Ranges
- Support Shoot-on-the-Move
- Range to Target

BATTLEFIELD SENSOR COMPARISON



Helicopter Acoustic Signatures



Concept Definition

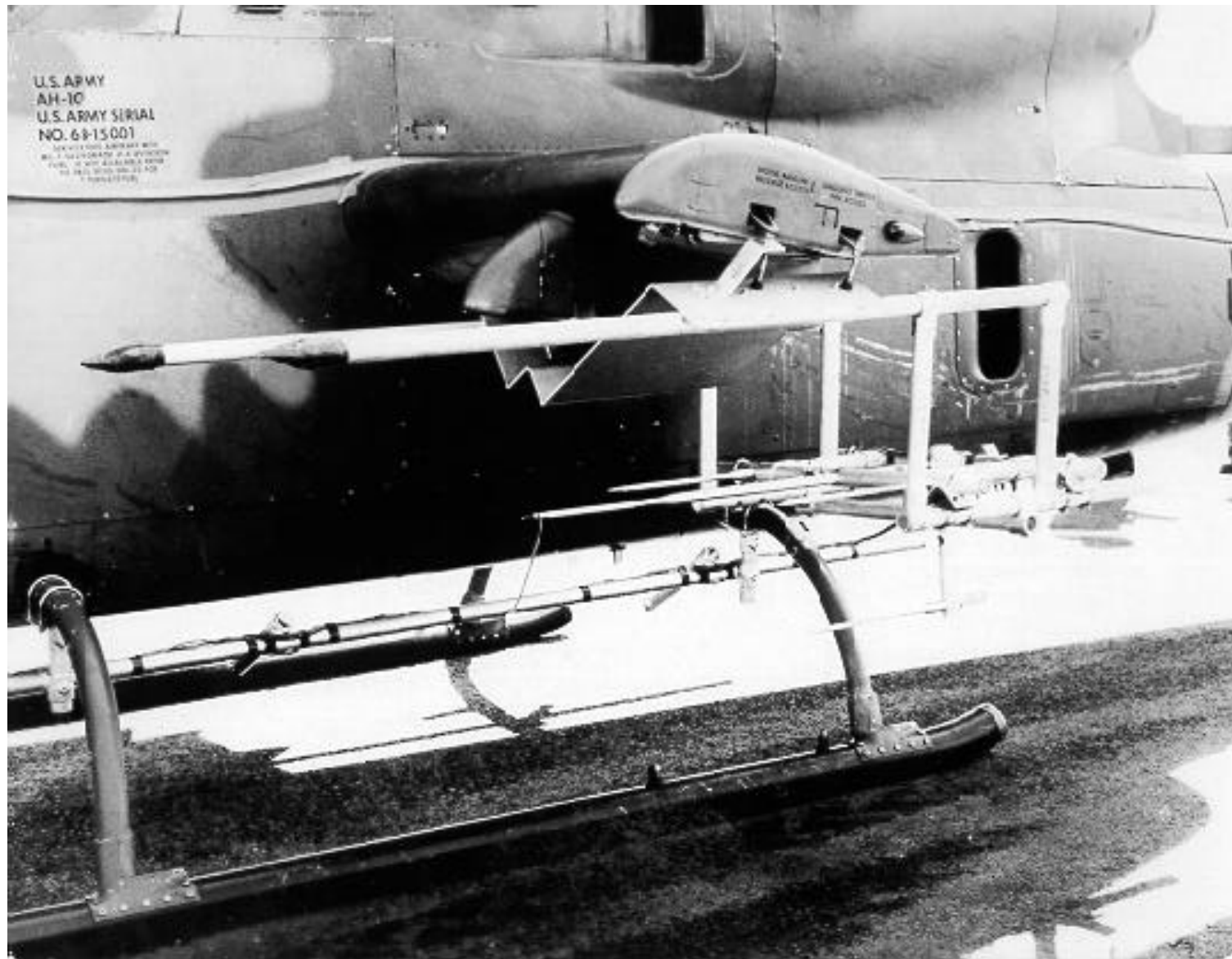
- ***System Description***
 - Acoustic Sensors for Target Detection, Tracking and Location
- ***Unique Capabilities***
 - All weather, Day/Night, All Terrain Target Tracking
 - Provide Situational Awareness
 - Low Cost
 - BCID (Battlefield ID/Classification)
 - Passive and Resists CM
 - Promotes Fratricide Avoidance
- ***Operational Capability Requirements (OCRs) Addressed***
 - BC01, BC09, DSA06, DSA12, DSA13, DBS01A, DBS03, DBS04A, DBS05A, DBS10, DBS12, MTD04, MTD14, MTD22, EEL13



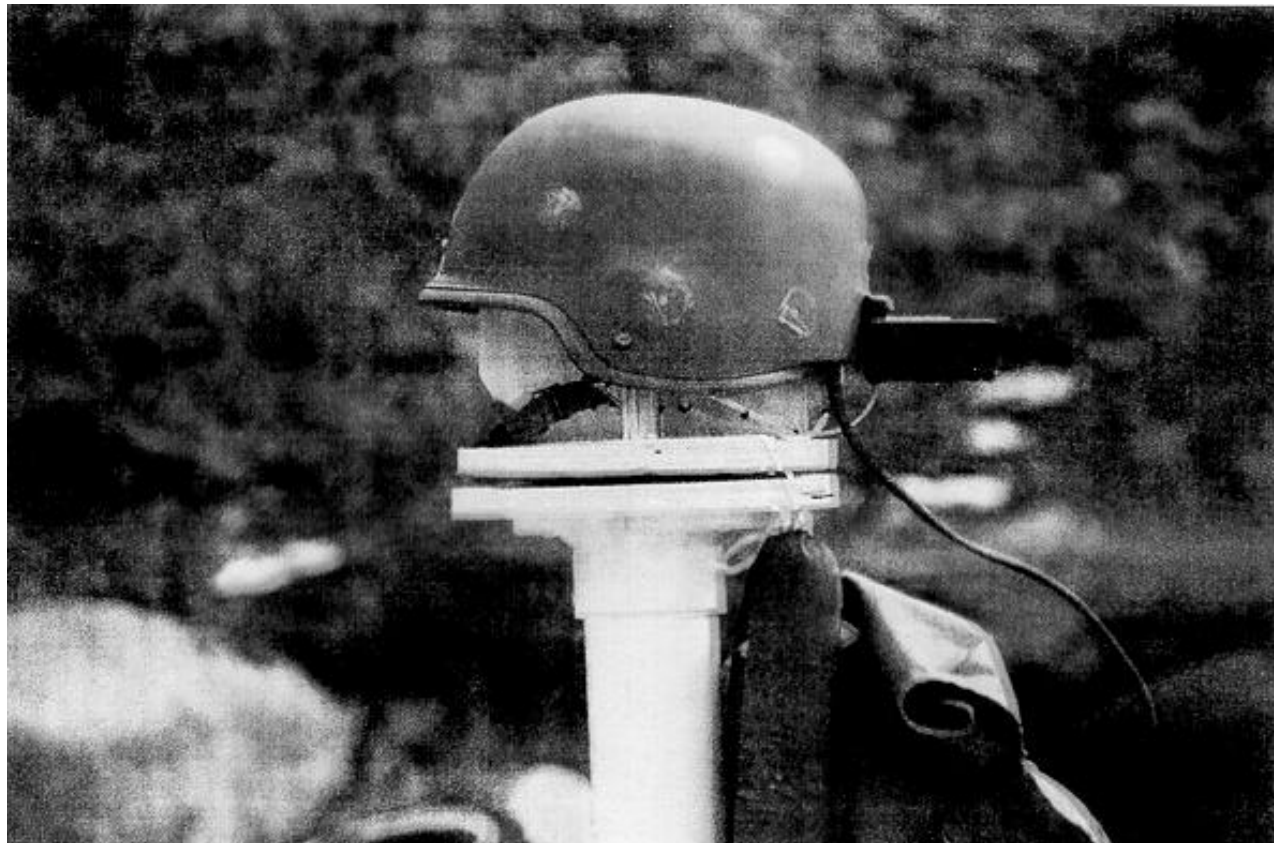
Operational Benefit

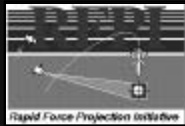
Low cost, passive acoustic sensor systems provide non-line-of-sight situational awareness and target acquisition and handoff to weapon systems fire control. New integrated warfighting capabilities are provided through sensor fusion and battlefield digitization.



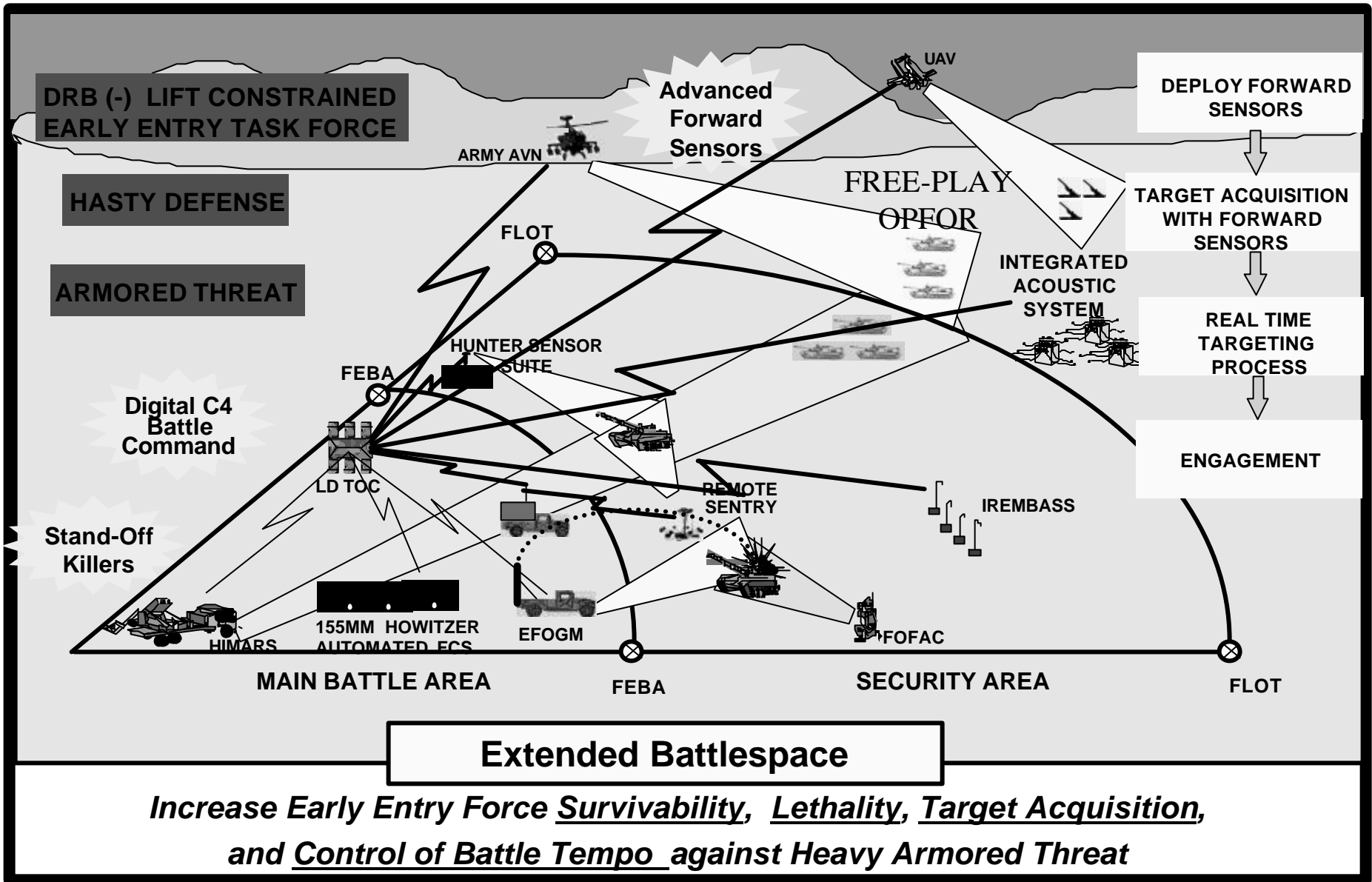


***BBN-12 Channel Acoustic Helmet
Heading Sensor***





RFPI ACTD HUNTER/ STANDOFF KILLER CONCEPT

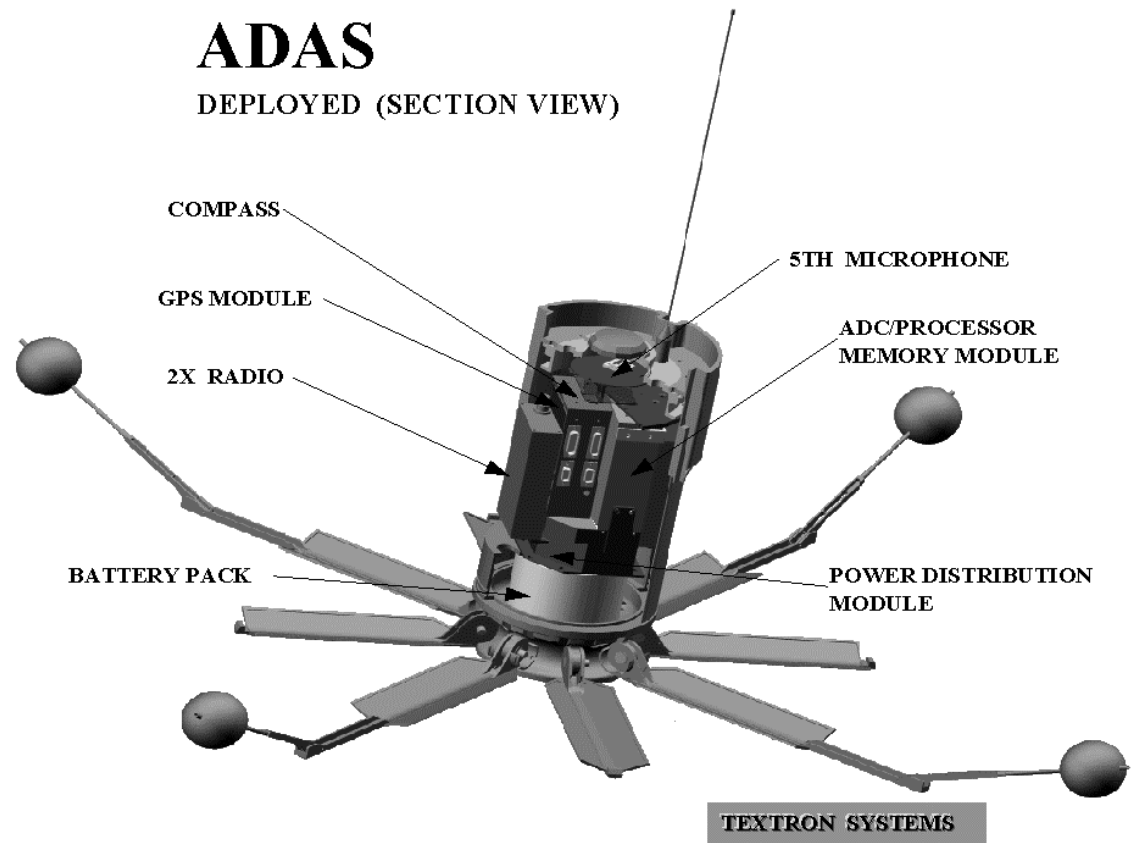




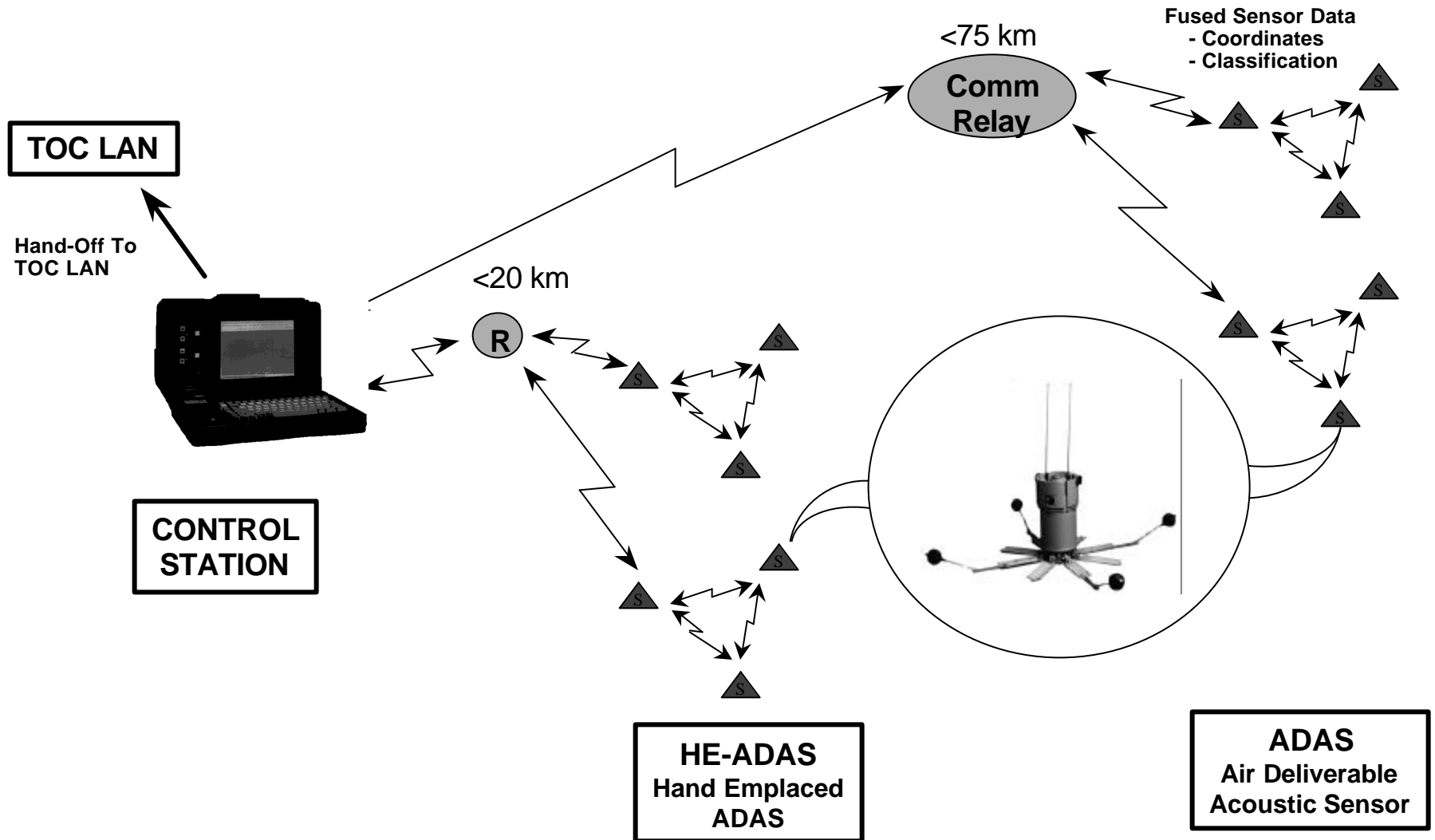
IAS Array Configuration

Air Deliverable Acoustic Sensor

- Detect, track, and classify ground/air vehicles
- 4' aperture, 5 mic array, DSP
- Hand emplace or air deploy w/ optional parachute
- Self mapping via GPS
- Separate long haul and short haul data radios



IAS System Components



Acoustic CRADA (TSD & ARDEC)

ARDEC to develop improved air-acoustic signal processing techniques for IAS/ADAS

- **Advanced detection & classification methods**
 - **Field test facility support (ADAS units, site, drivers, etc.)**
 - **GFE ADAS units for Operational Testing**
- **Textron to support & implement**
- **Tech support & consultation to above tasks**
 - **Provide GDAS to ARDEC for Development Testing**
 - **Implement ARDEC algo improvements in ADAS S/W**
 - **Field test support (personnel, met, truth, etc.)**

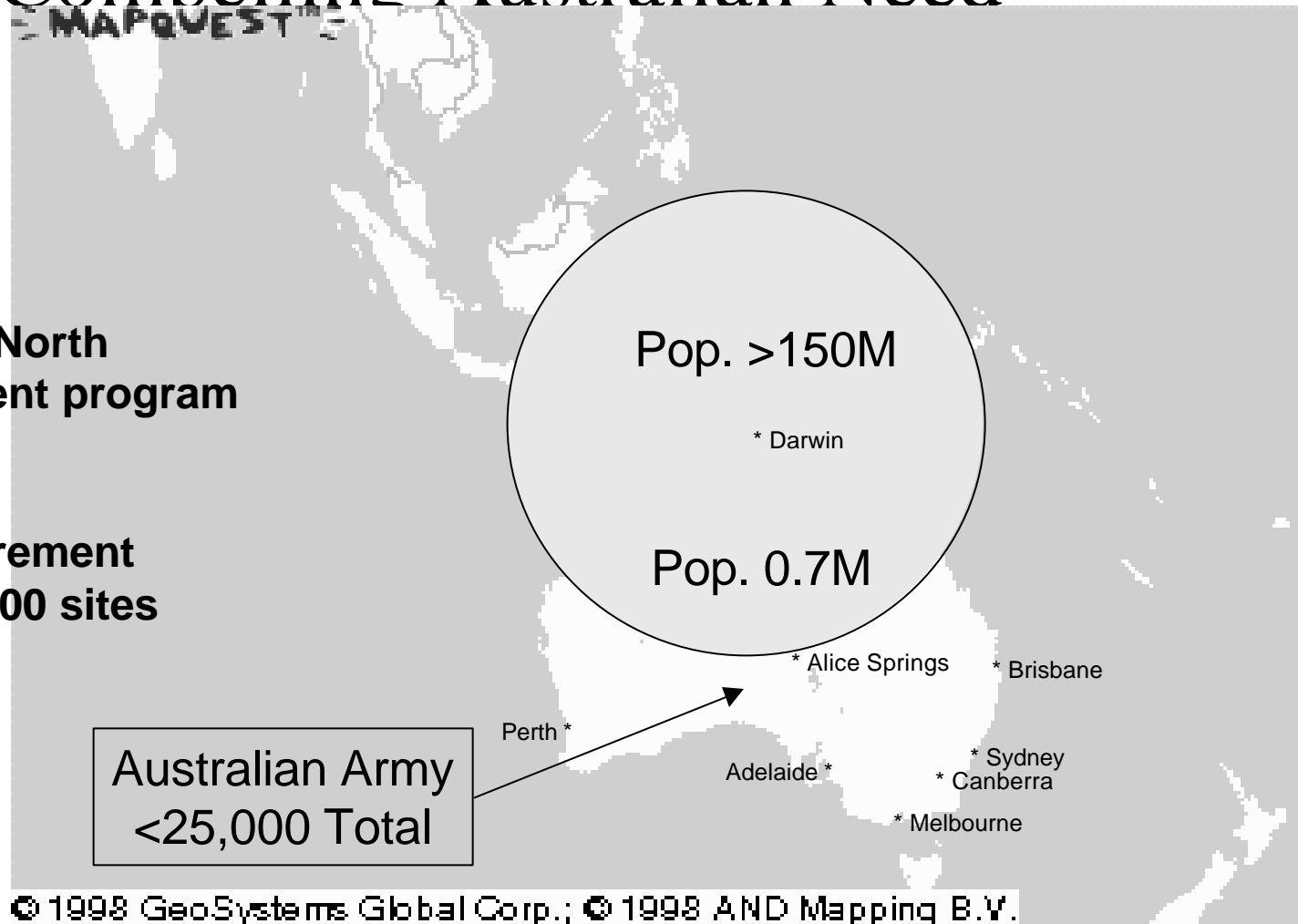
Compelling Australian Need

Ninox UGS

70 sites in the North
funded in current program
~\$20-33M US

Eventual requirement
may exceed 1000 sites
>\$200M US

Australian Army
<25,000 Total

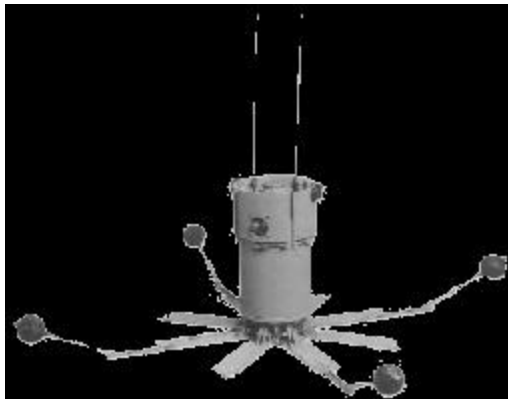


Development Plan

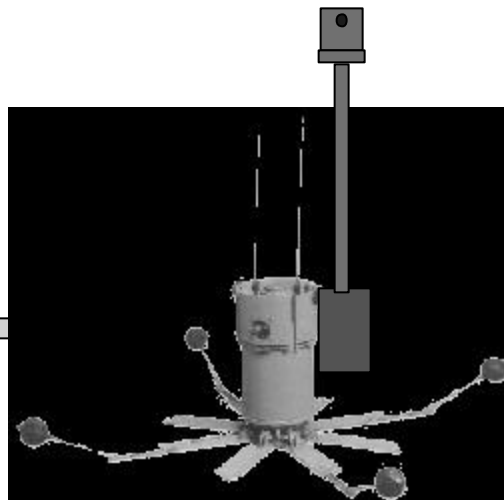
Current Hardware 1998

Confirmatory Demo Nov,1999

Deliveries 2001-2002

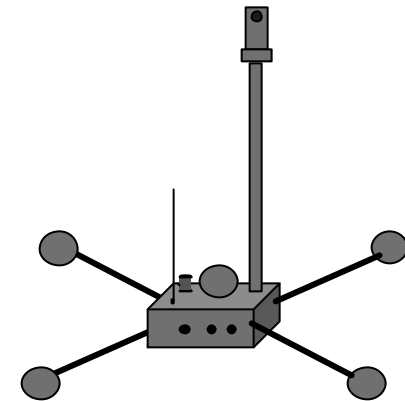


ADAS



Prototype OASIS

- ADAS H/W & S/W modifications
funded by Contractors



OASIS Deliverables

- Development completed under
NINOX UGS contract

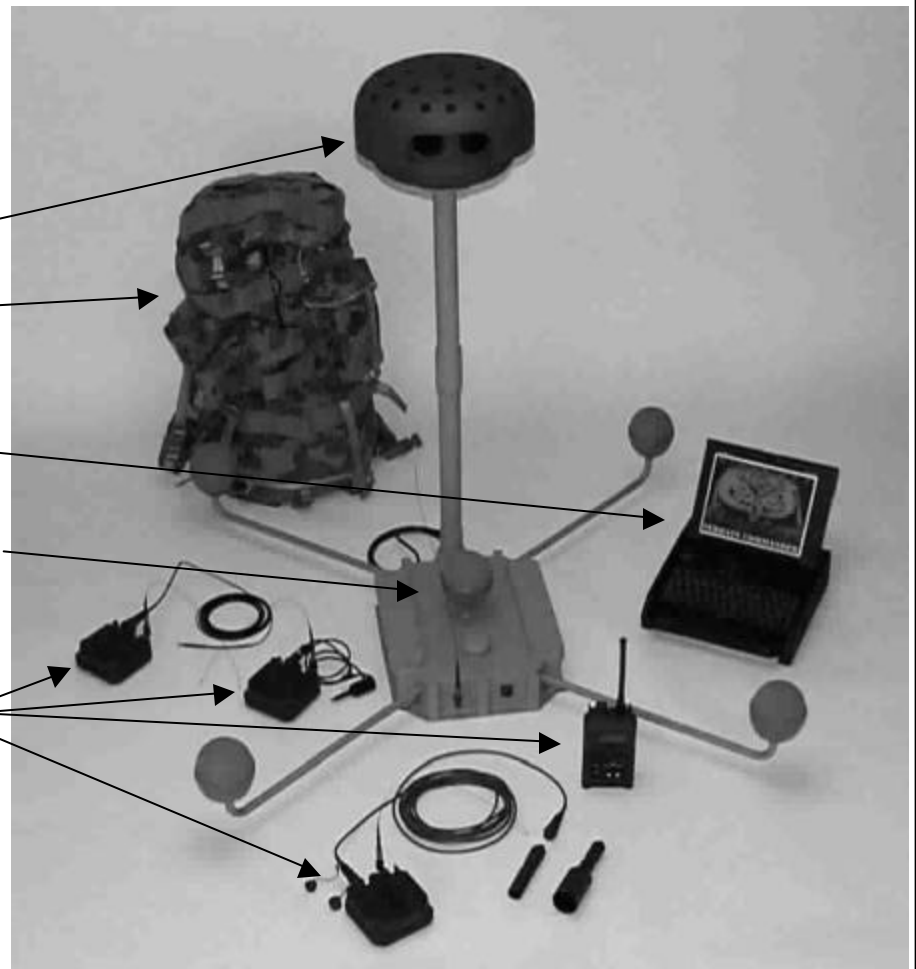
Some Key Features

- **Beamforming Acoustic Array** (*TSD*)
 - Long Range Discrimination & Tracking of Motor Vehicles
- **Distributed Mini-Sensors** (*RACAL->Thompson->THALES*)
 - Seismic, Magnetic, & Passive Infrared
 - Personnel Detection & Back-Up for Acoustics
- **Precision Cued Day/Night Electro-Optics** (*TENIX*)
 - Operator in the Loop Target Recognition
- **Satellite Based Long Haul Communications**
 - Operation in Remote Areas - Unlimited Range
- **Advanced Integrated Control Station**
 - Remote Situational Awareness

Terrain Commander

OASIS - Optical Acoustic SATCOM Integrated Sensor

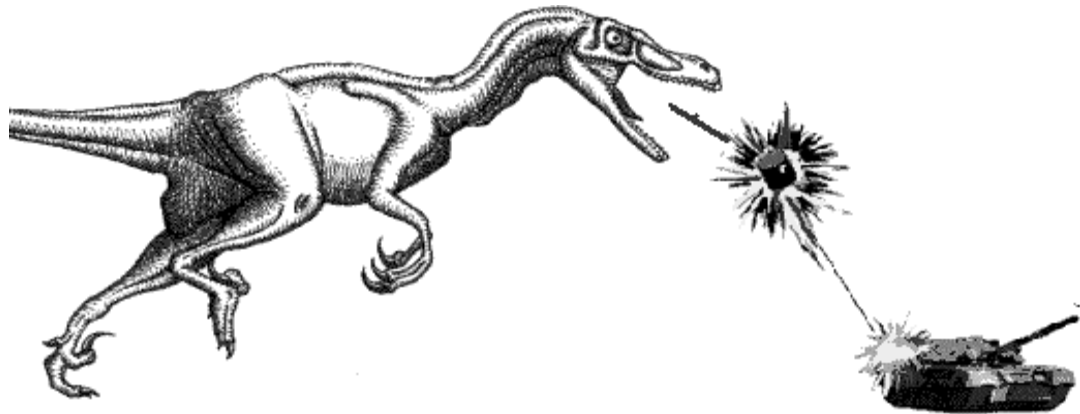
- OASIS Day/Night Electro-Optics Head
- Rucksack
- Central Monitoring Facility (CMF)
- OASIS Base Unit w/ 5 Mic Beamforming Acoustic Sensor & Satellite Comms.
- CLASSIC 2000 Seismic, Magnetic, Passive Infrared, & Monitor



WHAT IS RAPTOR?

A Network of:

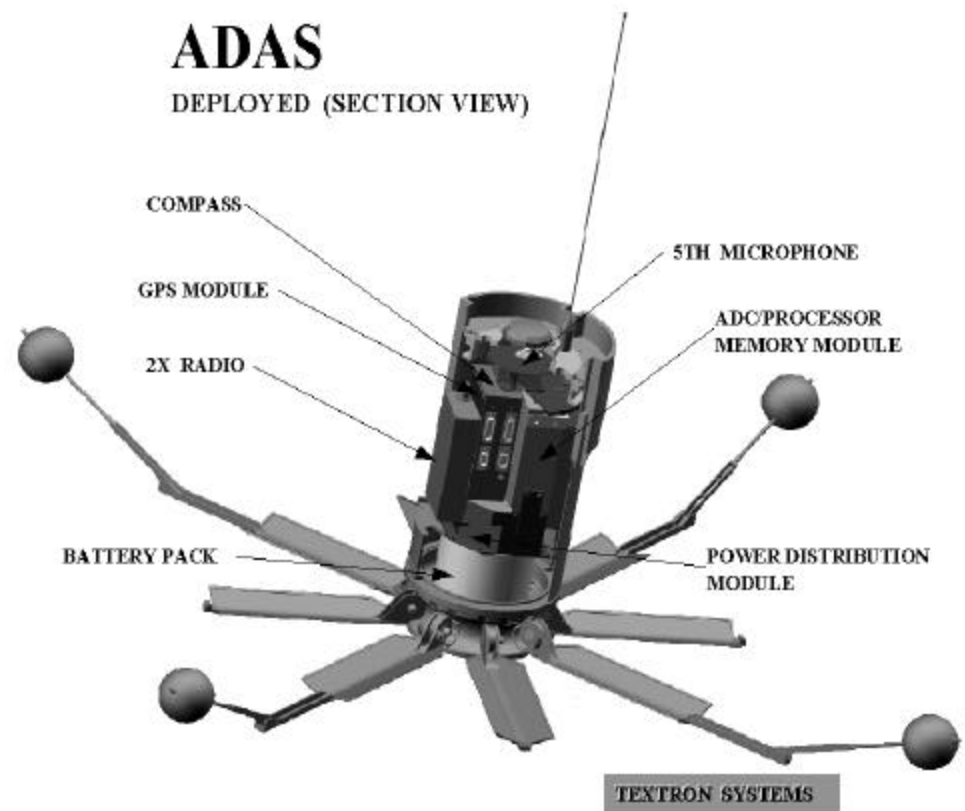
- Sensors
- Gateways
- Munitions
- Control Station



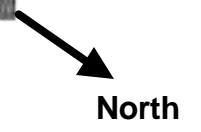
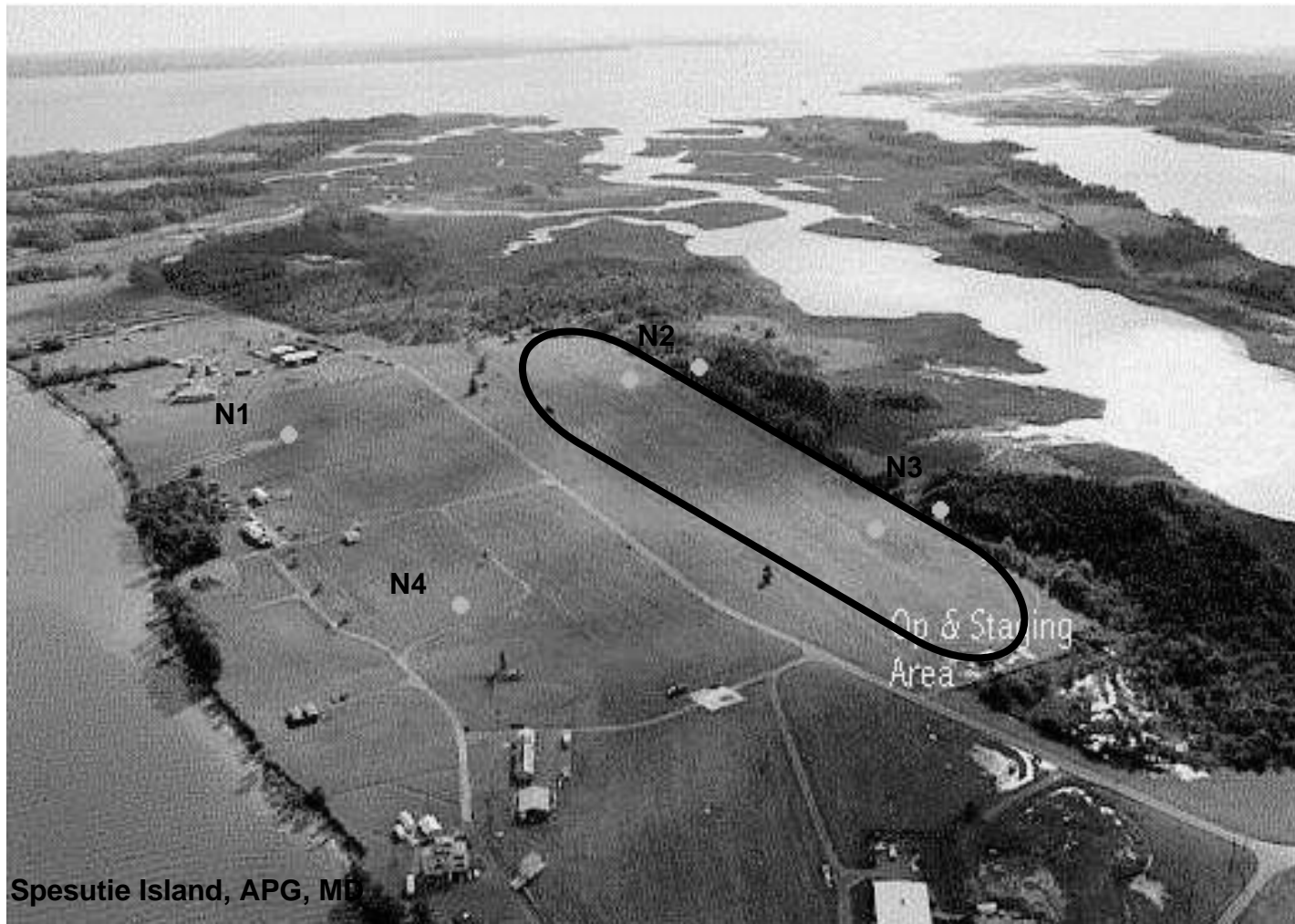
- *A smart, autonomous, anti-armor/vehicle system which increases lethality of its own Wide Area Munitions and other weapon systems through the synergistic effects of its munitions and sensors.*

Current UGS Functions/Features

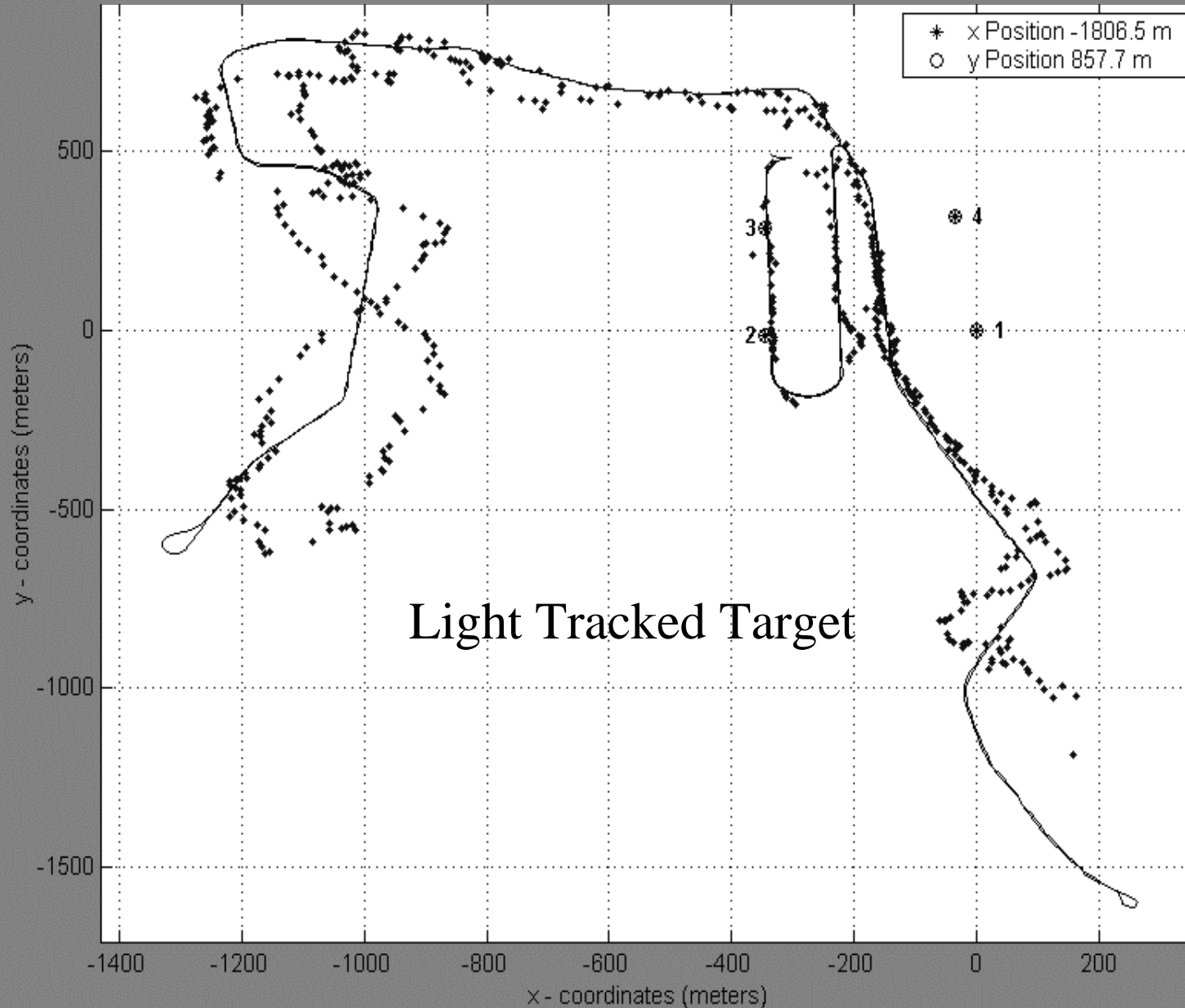
- Autonomous sensor networks deployed in clusters
- GPS, Compass, Radios
- DSP hardware/software
- Detection, Multiple Target Tracking, Classification
- Master/Slave Data Fusion
- Early Warning for Munitions & TOC
- Target Info for Long Range Shooters/Hunters



IASFT SENSOR LAYOUT



Current UGS Systems



Detection
M60 – 4km

Tracking
4 Targets
Simultaneously

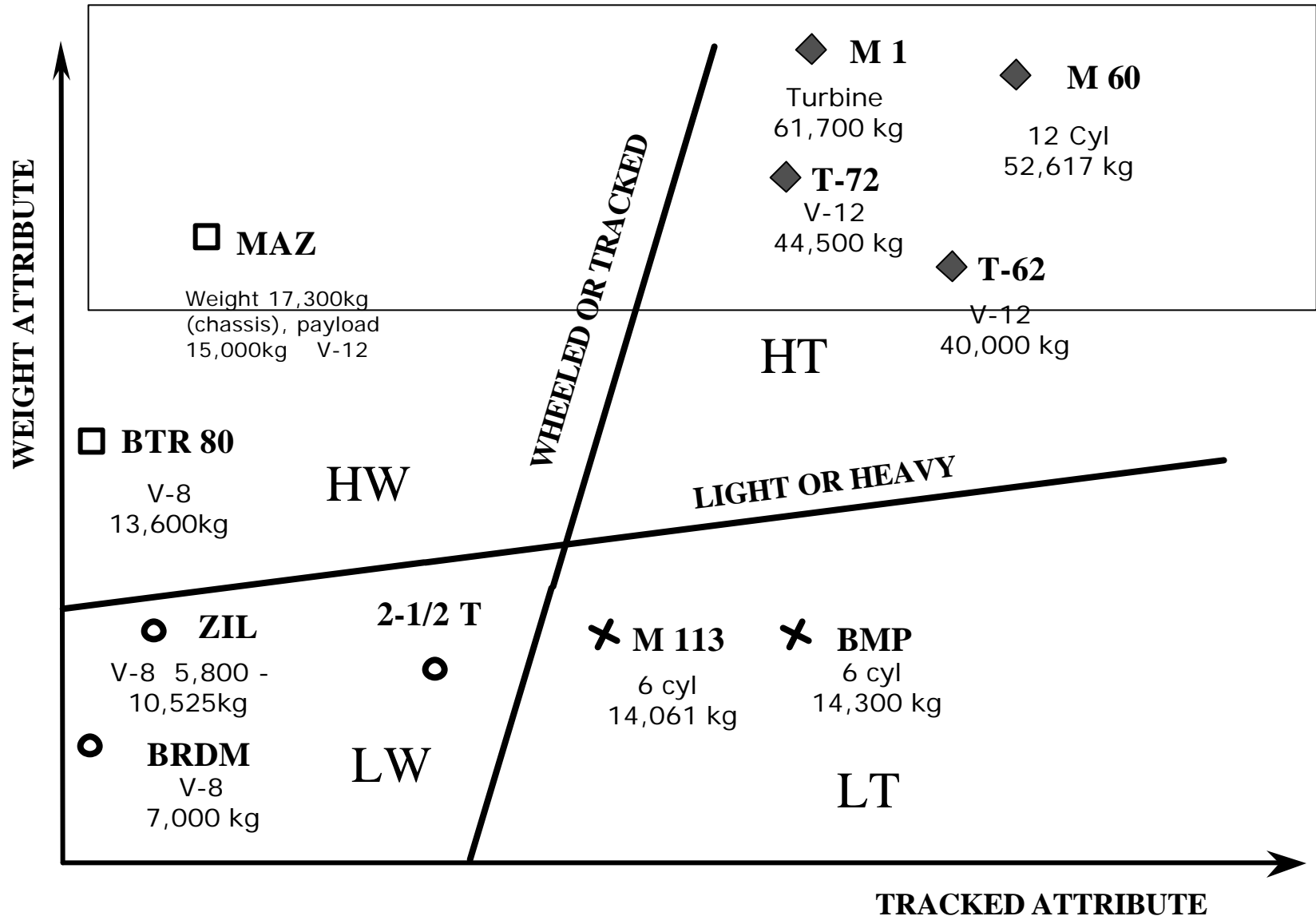
Classification
M60 – 3km

Target Class
Heavy Tracked
Heavy Wheeled
Light Tracked
Light Wheeled

Algorithm Development for RAPTOR

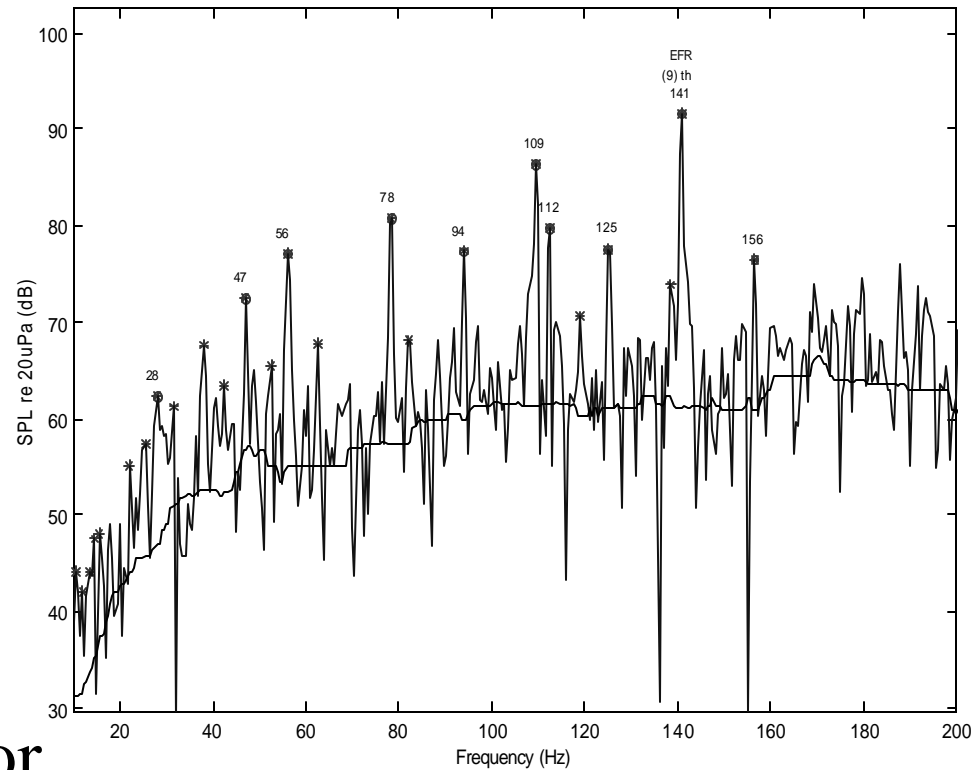
- *Two Areas of development:*
 - *Classification - Cylinder Counting Algorithm*
 - *Template Based Approach – Using HLA information*
 - *Statistically Enhanced using naïve Bayesian classifier*
 - *Tracking - Target Counting Algorithm*
 - *Requires Enhanced Directivity Using Adaptive Beamforming*
 - *Null – Steered Response useful*
 - *Minimum Variance Distortionless Response*

RAPTOR Vehicle Classifier



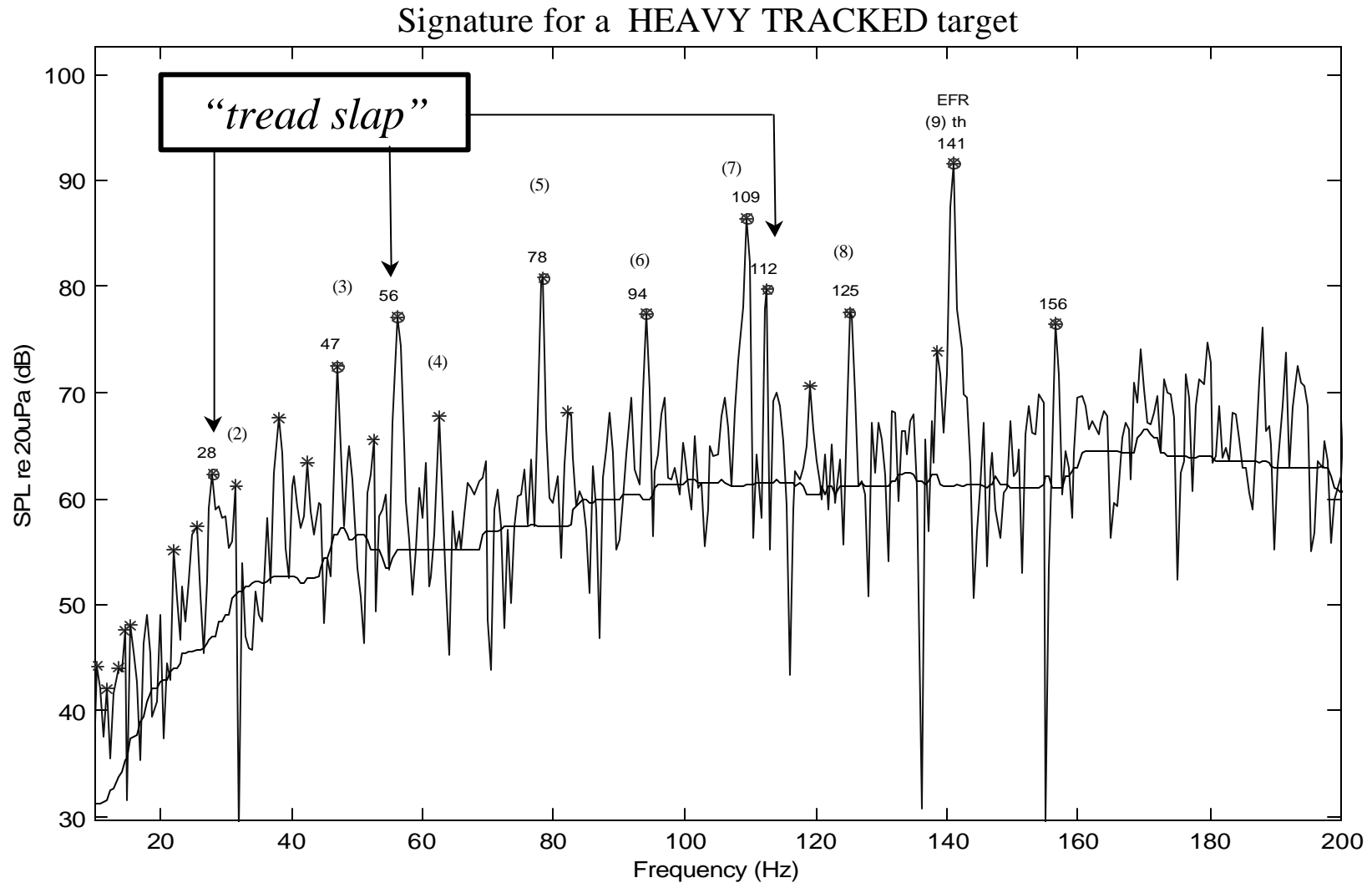
Classification Algorithm Development

- Frequency domain features
 - spectral content
- Harmonically associated spectral components
- Clustered according to number of cylinders & target type
- Statistical properties tabulated
- Bayesian statistics used for classification algorithms

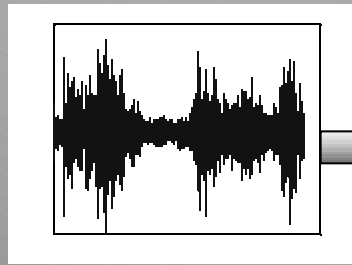


Classifier Improvements for RAPTOR

- The identification of HLA templates relies on the 3 tallest harmonics (e.g. 9 – 7 – 5 for T72) 6 %



Cylinder Counting Algorithm



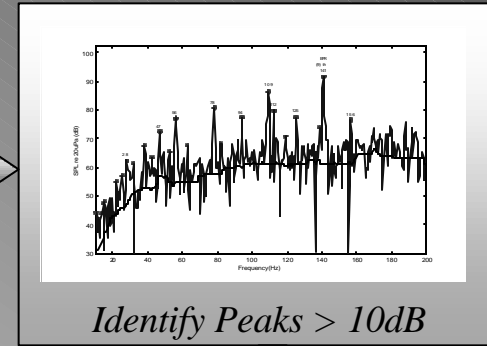
*Load signature
from file*

FFT

*Obtain
Spectrum*

Median Filter

*Calculate
Noise Floor*



Identify Peaks > 10dB

Template
Database

*Database
Compare*

Retain 3
Tallest Peaks

Extract Features

Group
Harmonically
Related Peaks

Perform HLA

Tallest Peak

Determine EFR

Perform
Template
Match

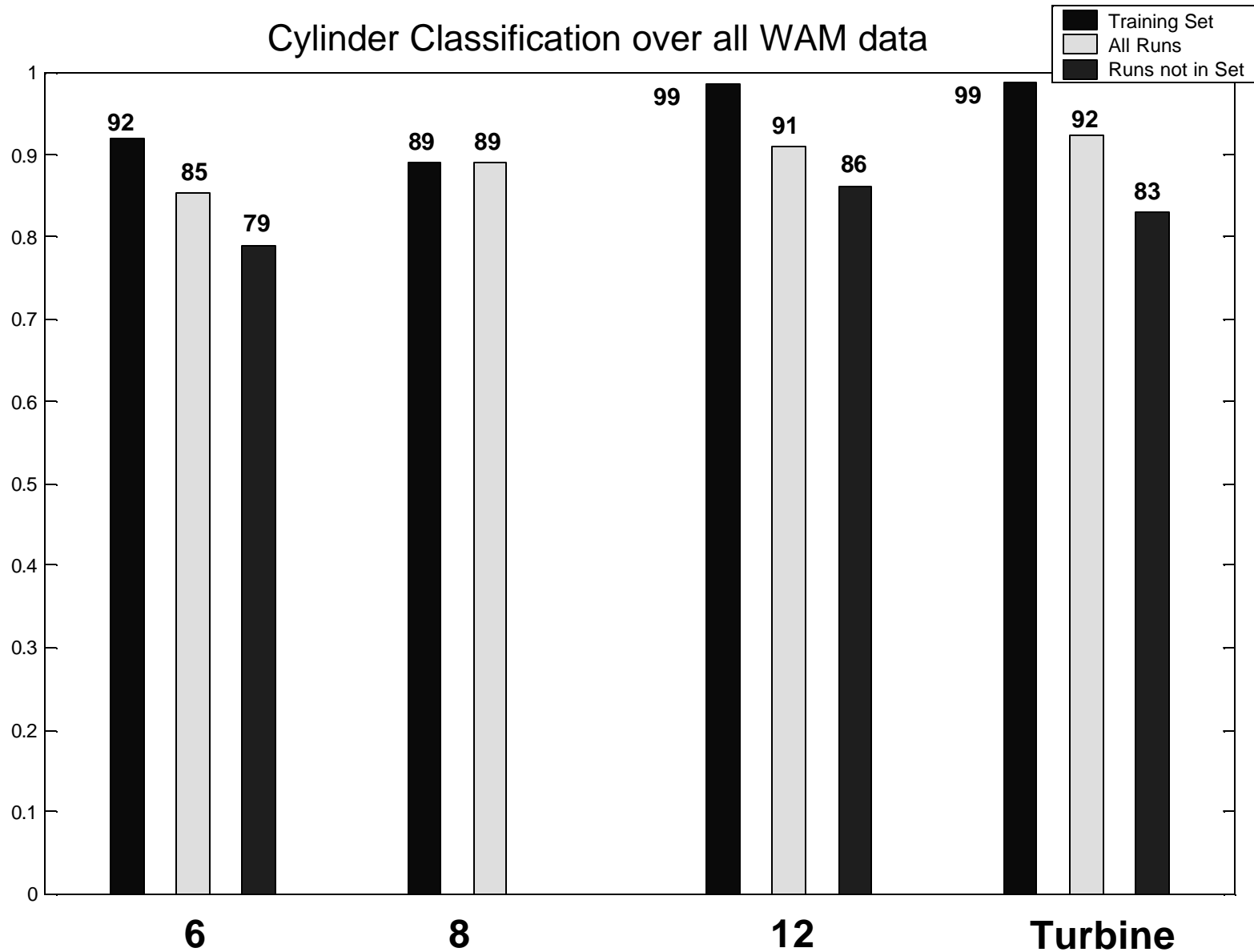
Discrimination

Estimate
Number of
Cylinders

Classification

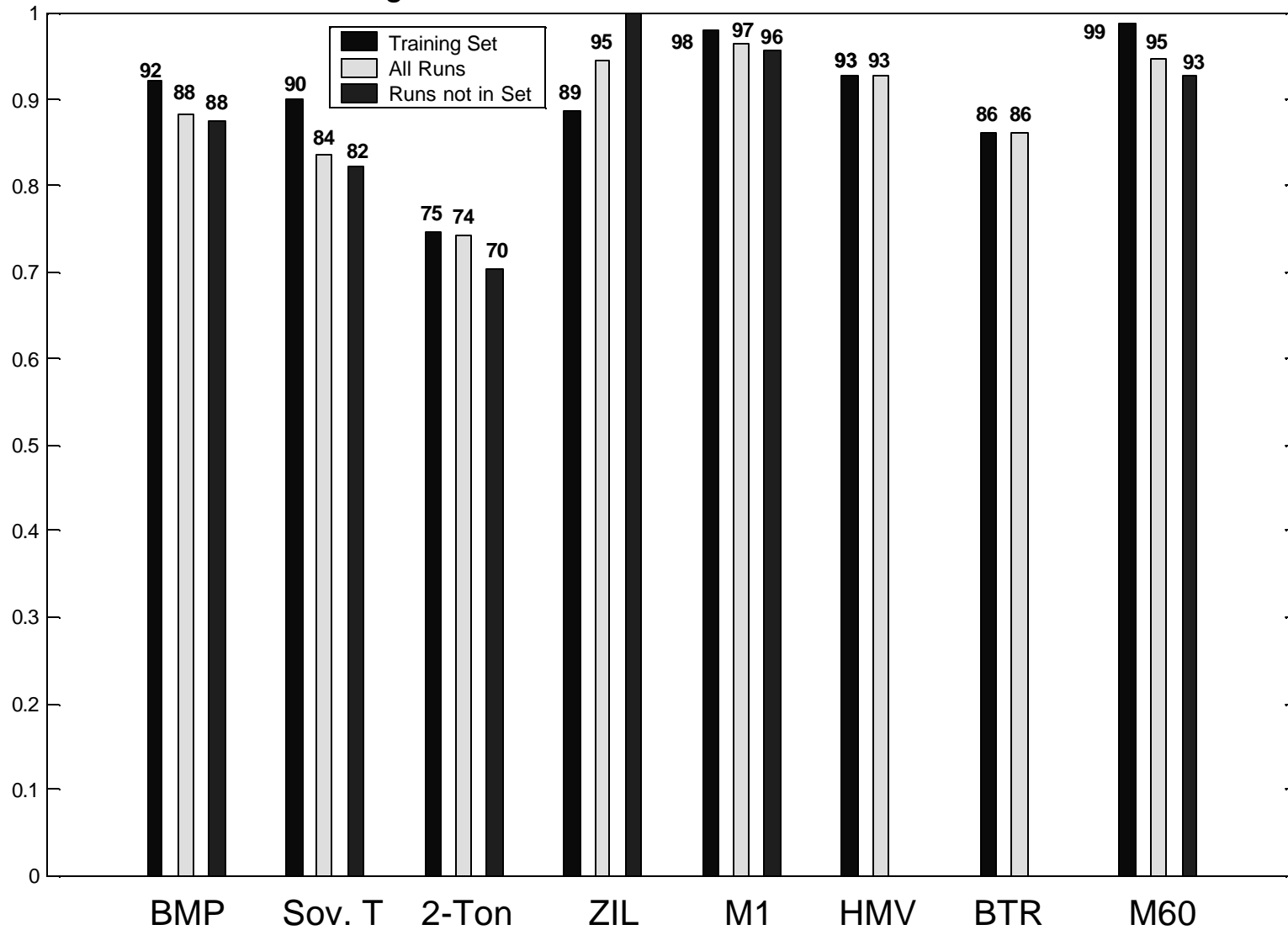
***Cylinder
Attribute***

Classification Algorithm Results

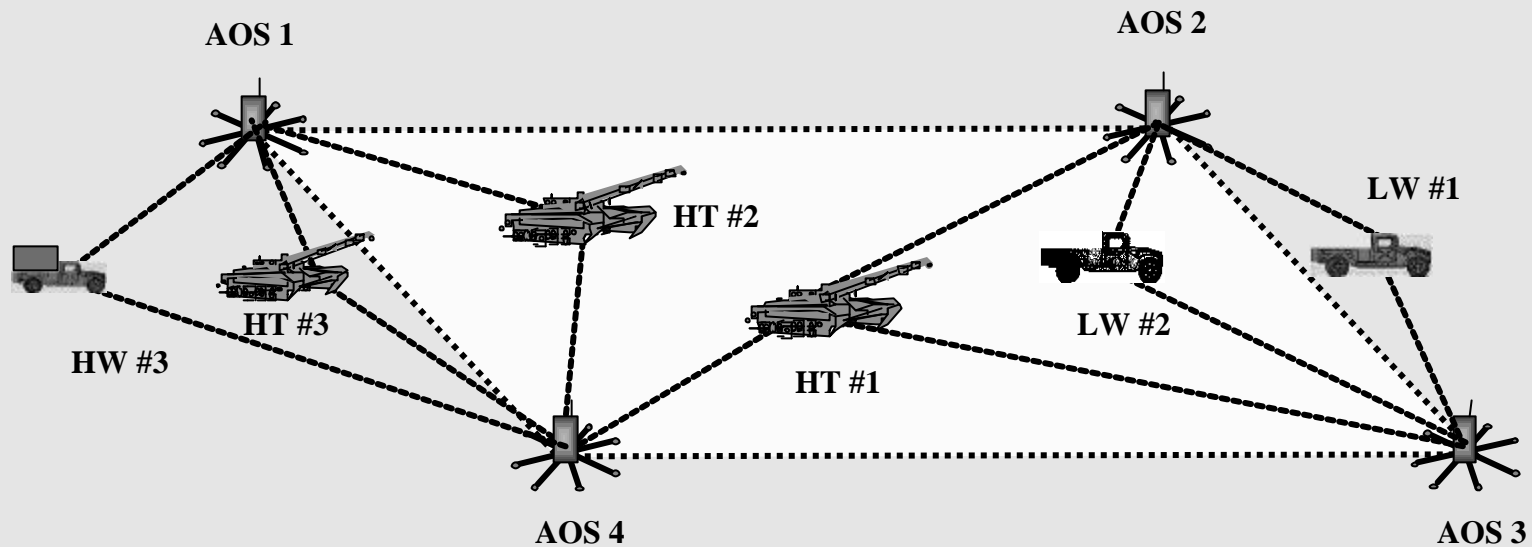


Classification Algorithm Results

Target Identification over WAM all data sets



Target Counting Algorithms



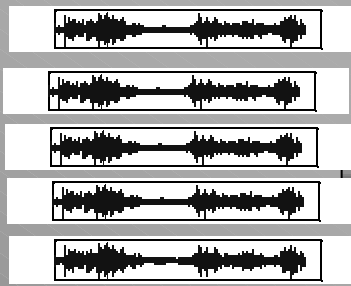
- Threat tracked as a “target mass” at long ranges
- Decomposed into list of individual targets at closer ranges
- Target tracking maintained throughout scenario

Target Counting Algorithm

- **Preliminaries**

- *Requires superior bearing resolution*
- *MATLAB program to test beams for different array geometries and apertures*
- *Try adaptive beamforming methods to check the feasibility of assumptions made*
- *Nullsteering, Optimal Beamformer response is determined as weights are obtained*
- *MVDR solution*

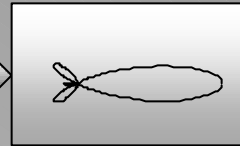
Target Counting Algorithm



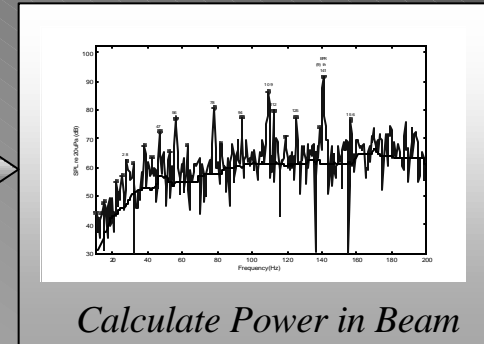
*Load
microphone
data from file*

FFT

*Obtain
Spectrum*



*MVDR
Beamformer*



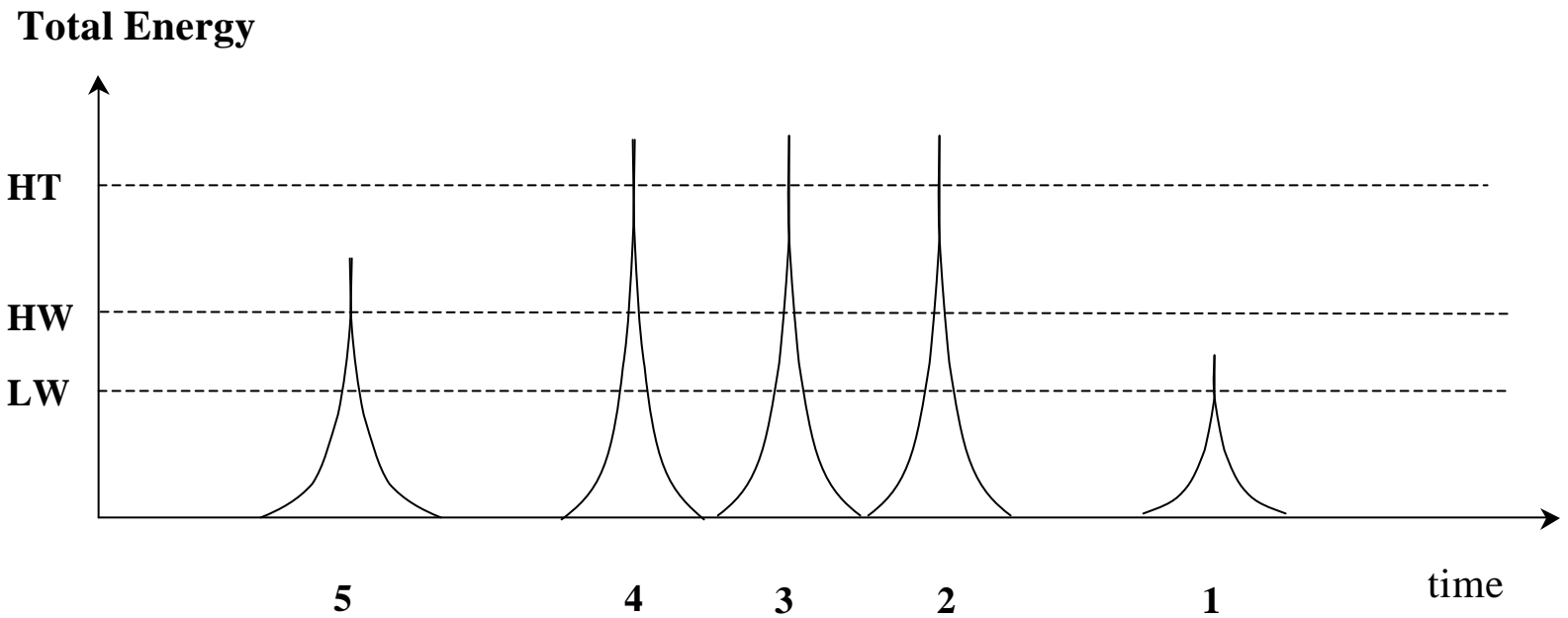
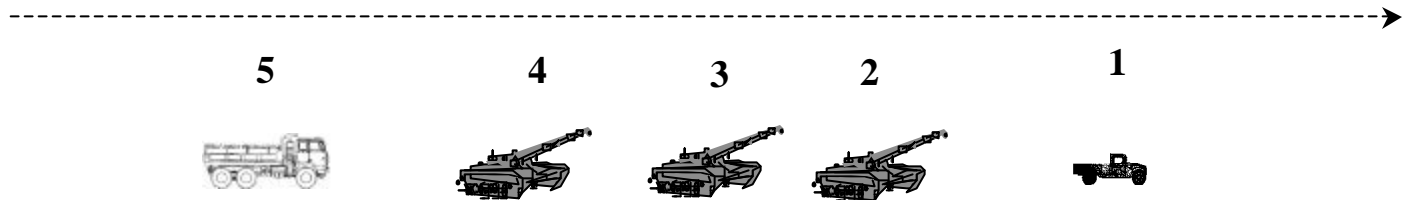
Fuse Results
from all
sensors

Compare with
PSD at $t-1$

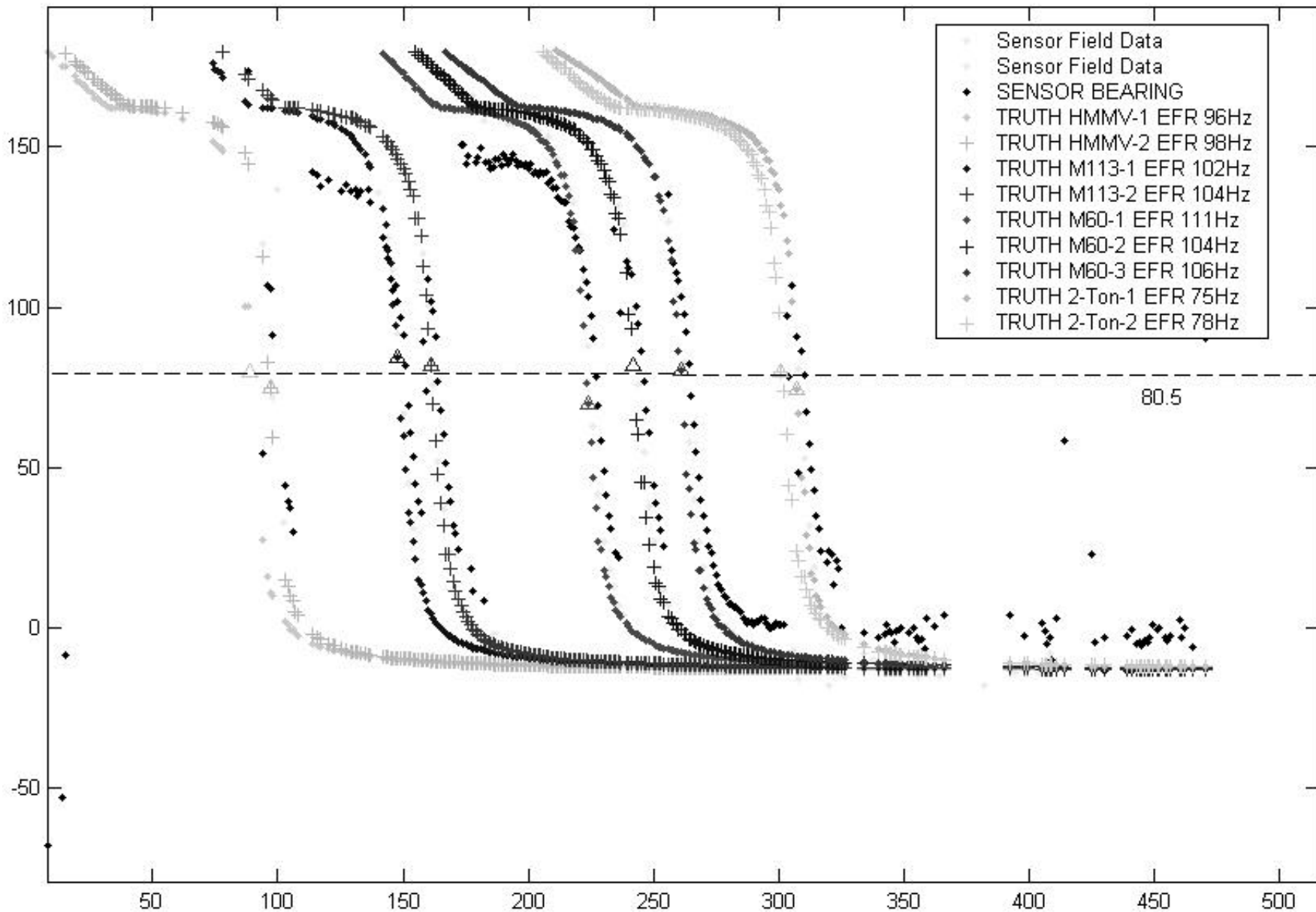
Current
Power
Spectral
Density

*Scenario
Assessment*

Target Counting Algorithm



Multiple Target Tracking & Counting



Summary

- *Algorithm Development using MATLAB/SIMULINK*
- *Extensive Signature Databases w/ Ground Truth*
- *Sensor Hardware / MATLAB models*
 - *IAS Overwatch Sensor*
 - *Wide Area Munition (WAM)Sensor*
- *Currently working on*
 - *Target Classification*
 - *Multiple Target Tracking*