

Ballistic Missile Defense Technology Overview For The 7th Annual AIAA Technology Readiness Conference

Cleared For Open Publication, Directorate
For Freedom Of Information And Security
Review, Department Of Defense



3 AUG 98

Dr. Bruce Pierce
Deputy For Technology
Ballistic Missile Defense Organization

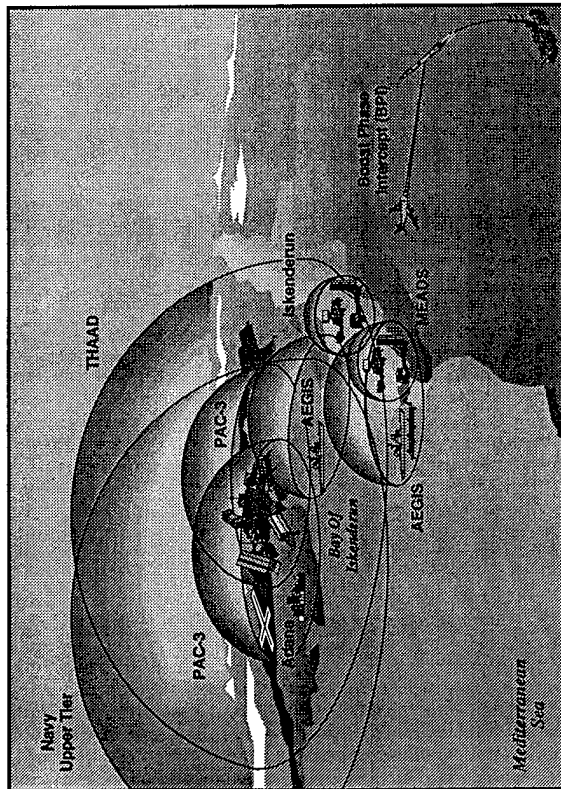
DTIC QUALITY INSPECTED 4

19981110 082

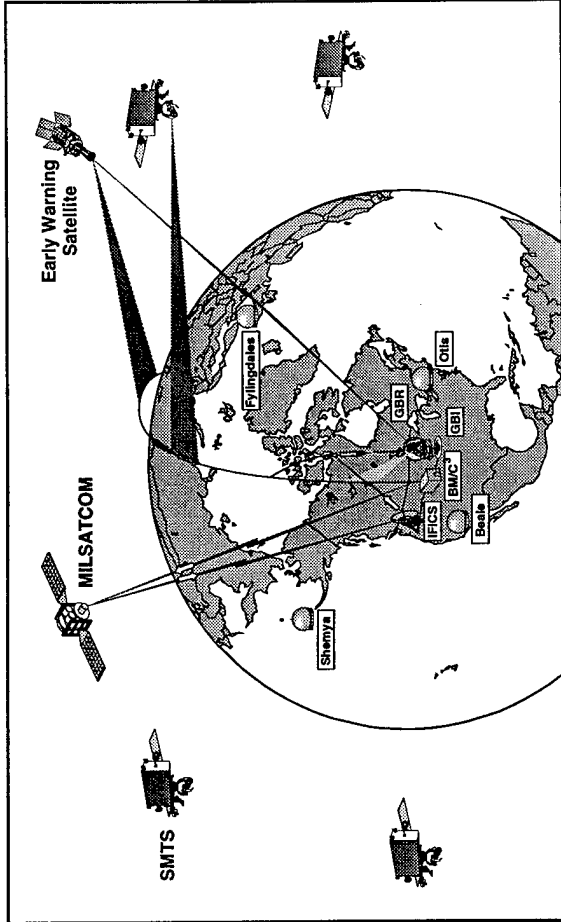


BMDO MISSIONS

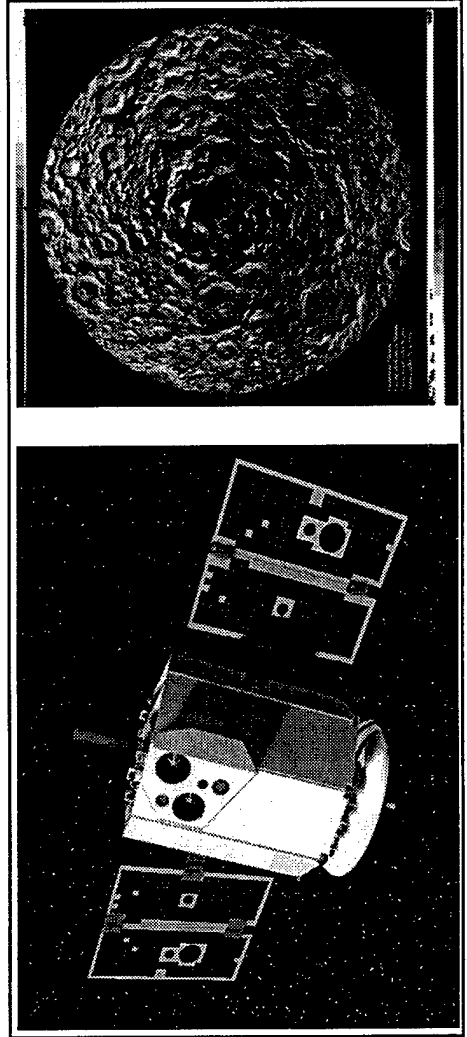
TMD • Acquisition



NMD • Deployment Readiness Program



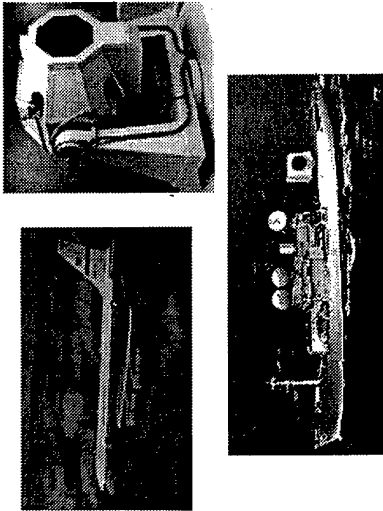
Technology • Component And Advanced Concepts R&D



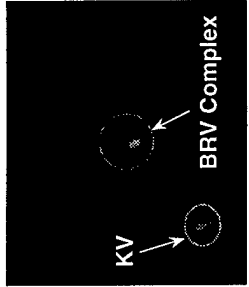


TECHNOLOGY SUPPORT OF TMD AND NMD ACQUISITION PROGRAMS

Data Collection And Analysis



Test Assets



Target Signatures

Lethality

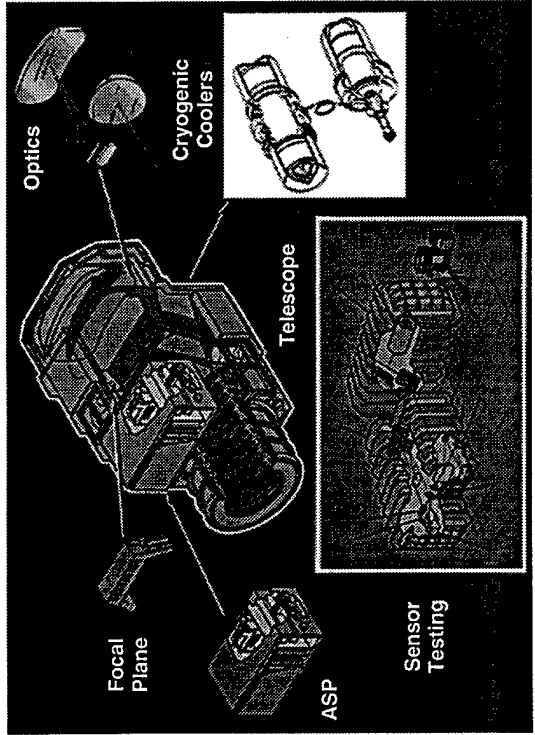


Warhead Fallout



Target Destruction

Sensors



SMTS, GBI Components

Advanced Interceptor Technology

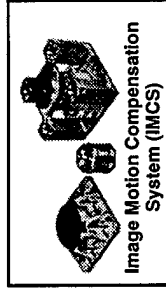


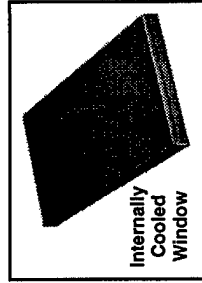
Image Motion Compensation System (IMCS)



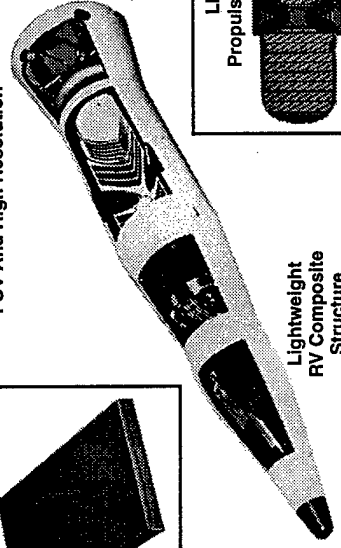
Dual FPAs For Wide FOV And High Resolution



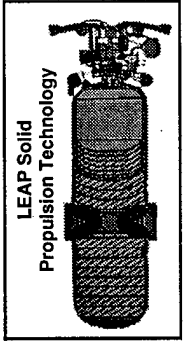
Rapid Cooldown Cryogenics



Internally Cooled Window



Lightweight RV Composite Structure

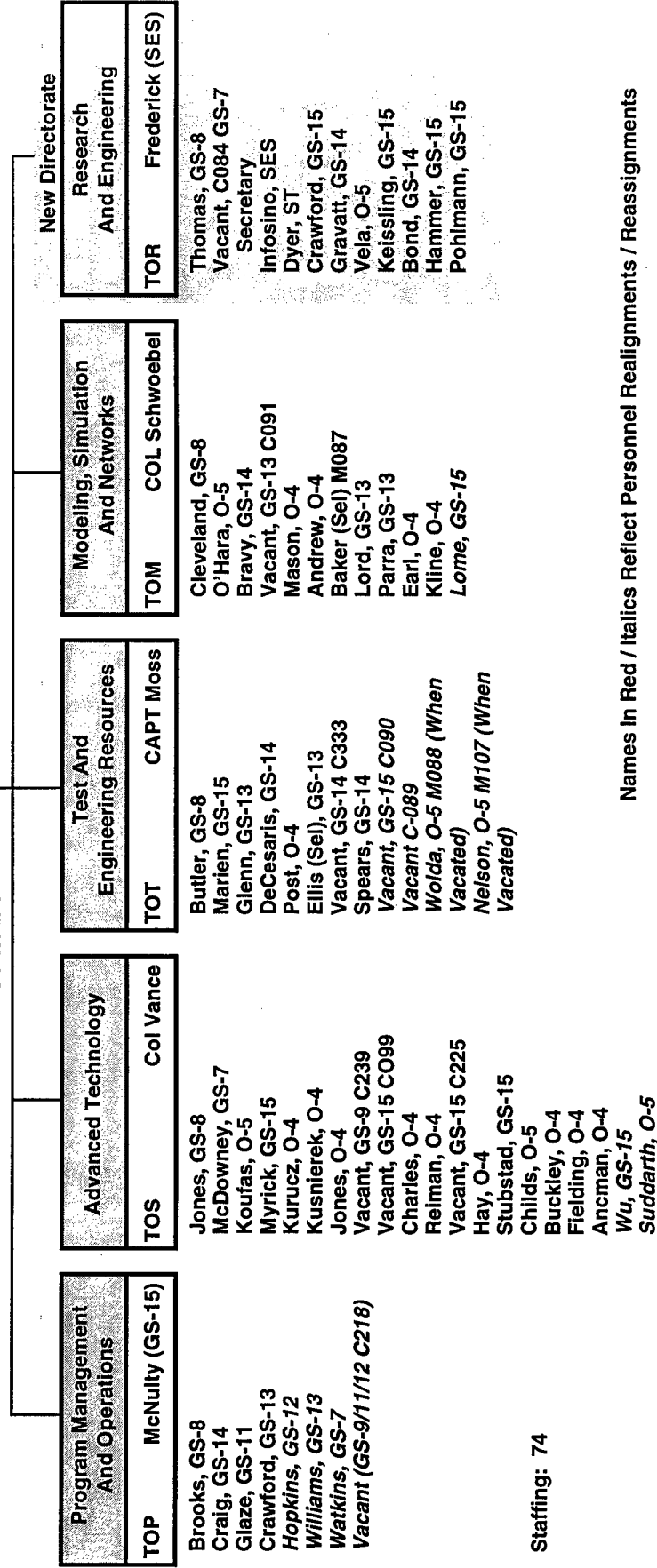


LEAP Solid Propulsion Technology



DEPUTY FOR TECHNOLOGY

TO Deputy For Technology	
Deputy Assistant Deputy	Pierce (SES) Duston (SES)
Executive Officer	Program Analyst Ruemmele, GS-15
MAJ Earl (Matrix) Secretary	
Ford, GS-9	
Secretary	
Green, GS-8	
Administrative NCO	
Baker E-5	



Program Management And Operations	
TOP	McNulty (GS-15)

- Brooks, GS-8
- Craig, GS-14
- Glaze, GS-11
- Crawford, GS-13
- Hopkins, GS-12
- Williams, GS-13
- Watkins, GS-7
- Vacant (GS-9/11/12 C218)

Advanced Technology	
TOS	Col Vance

- Jones, GS-8
- McDowney, GS-7
- Koufas, O-5
- Myrick, GS-15
- Kurucz, O-4
- Kusnierek, O-4
- Jones, O-4
- Vacant, GS-9 C239
- Vacant, GS-15 CO99
- Charles, O-4
- Reiman, O-4
- Vacant, GS-15 C225
- Hay, O-4
- Stubstad, GS-15
- Childs, O-5
- Buckley, O-4
- Fielding, O-4
- Ancman, O-4
- Wu, GS-15
- Suddarth, O-5

Test And Engineering Resources	
TOT	CAPT Moss

- Butler, GS-8
- Marlen, GS-15
- Glenn, GS-13
- DeCesaris, GS-14
- Post, O-4
- Ellis (Sel), GS-13
- Vacant, GS-14 C333
- Spears, GS-14
- Vacant, GS-15 C090
- Vacant C-089
- Wolda, O-5 M088 (When Vacated)
- Nelson, O-5 M107 (When Vacated)

Modeling, Simulation And Networks	
TOM	COL Schwoebel

- Cleveland, GS-8
- O'Hara, O-5
- Bravy, GS-14
- Vacant, GS-13 C091
- Mason, O-4
- Andrew, O-4
- Baker (Sel) M087
- Lord, GS-13
- Parra, GS-13
- Earl, O-4
- Kline, O-4
- Lome, GS-15

New Directorate Research And Engineering	
TOR	Frederick (SES)

- Thomas, GS-8
- Vacant, C084 GS-7
- Secretary
- Infosino, SES
- Dyer, ST
- Crawford, GS-15
- Gravatt, GS-14
- Vela, O-5
- Keissling, GS-15
- Bond, GS-14
- Hammer, GS-15
- Pohlmann, GS-15

Staffing: 74

Names In Red / Italics Reflect Personnel Realignments / Reassignments



BMDO CORE GROUND TEST FACILITIES

Core Ground Test Facilities
<ul style="list-style-type: none"> • Approved By T&EWG(R) • Endorsed By SEAB
ACSC-CSEDS ARC / SED-GBRTB-TRTB AEDC APTU AEDC 7V / 10V Space Chambers AOEC AEDC Range G AEDC Hypervelocity Wind Tunnel 9 AEDC VKF AMCOM IIRSS AMCOM MSS-2 CISF-EUWR HHSTT ARC / ISTD JHU / APL GSEL JHU / APL Wind Tunnel JNTF / CERES-BESC-TMDSE JTDL KHILS NHTF NIST LBIR Calibration Facility POST SED / TMTD-FMS

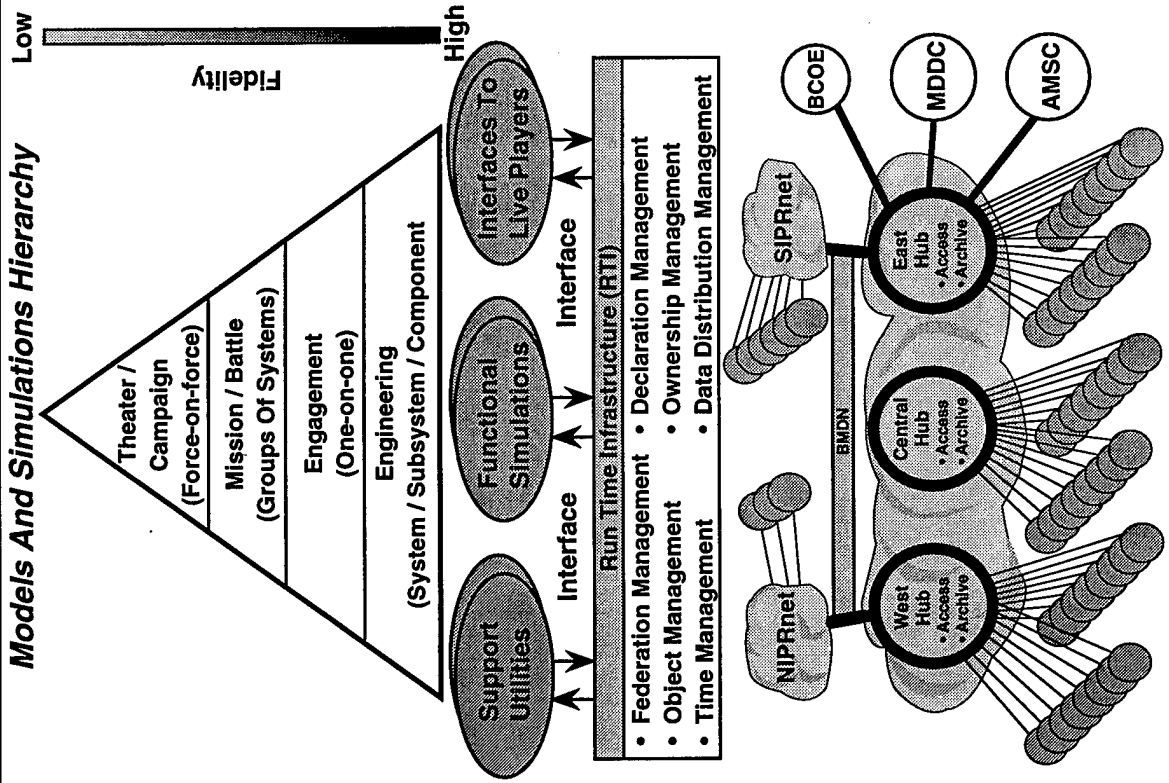
Facilities Considered But Not Designated As Core
ACSIS AMOR CCC GTSF LMMC SIL LVHWIL MFSIM NRaD PAC-3 SIM PATSIM SMCo HWIL UAH / HBRF

Note: Facilities Presented To The SAEB As The Minimum Necessary To Preserve Core Infrastructure In Support Of Multiple Programs – Not Prioritized

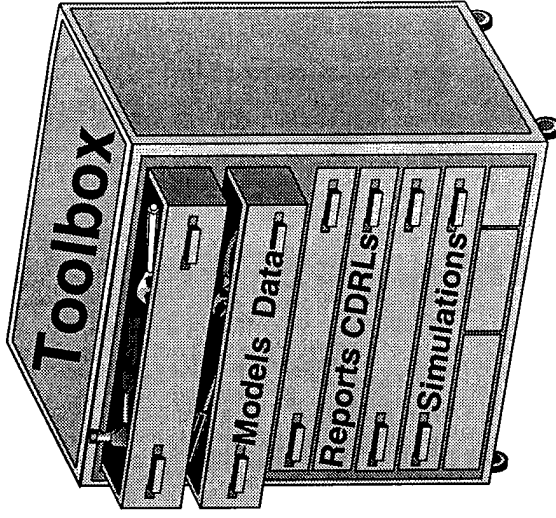


CONCEPT DEFINITION SUPPORTS OVERALL M&S VISION

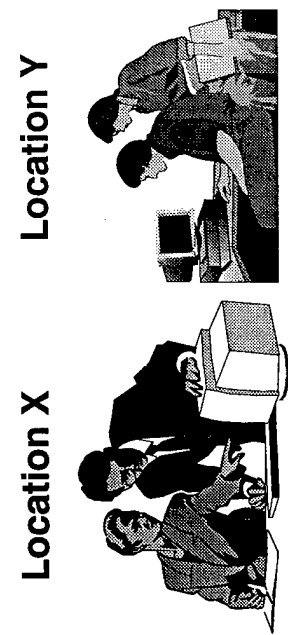
Models And Simulations Hierarchy



The Question ?



Customers
(e.g., Analysts,
Program Managers,
Contractors, etc.)

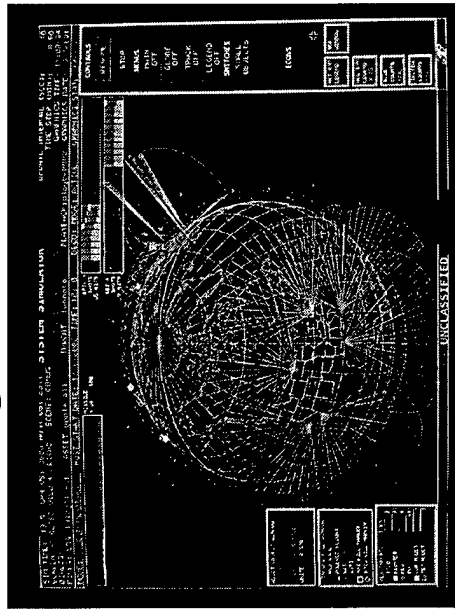


The Answer !

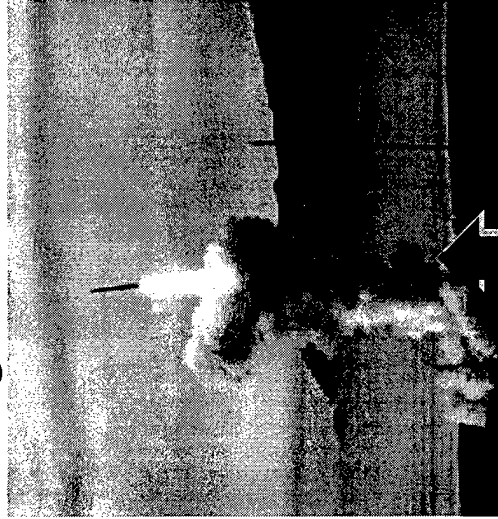


JNTF SUPPORT TO ACQUISITION AND WARFIGHTERS

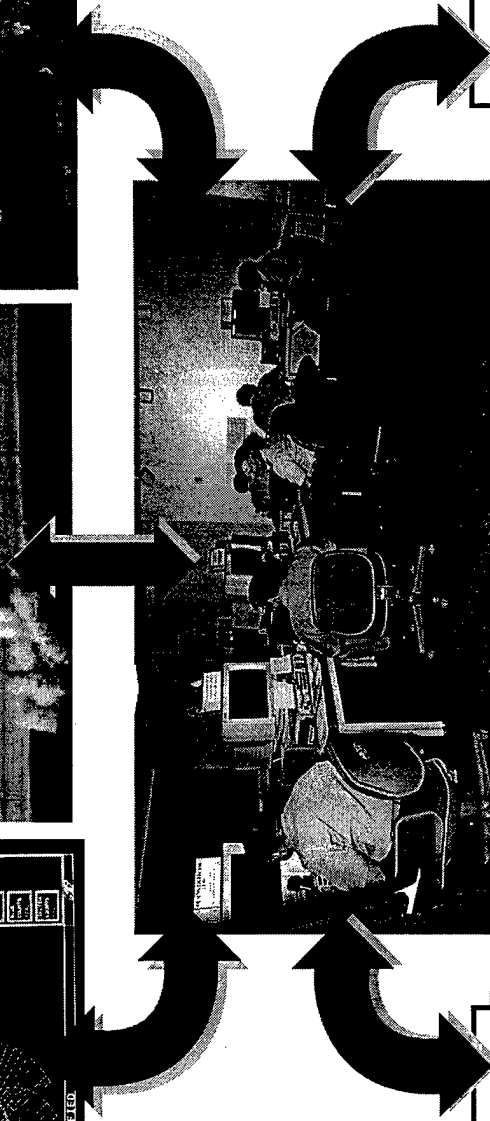
Modeling And Simulation



Testing And Evaluation



War Games And Exercises



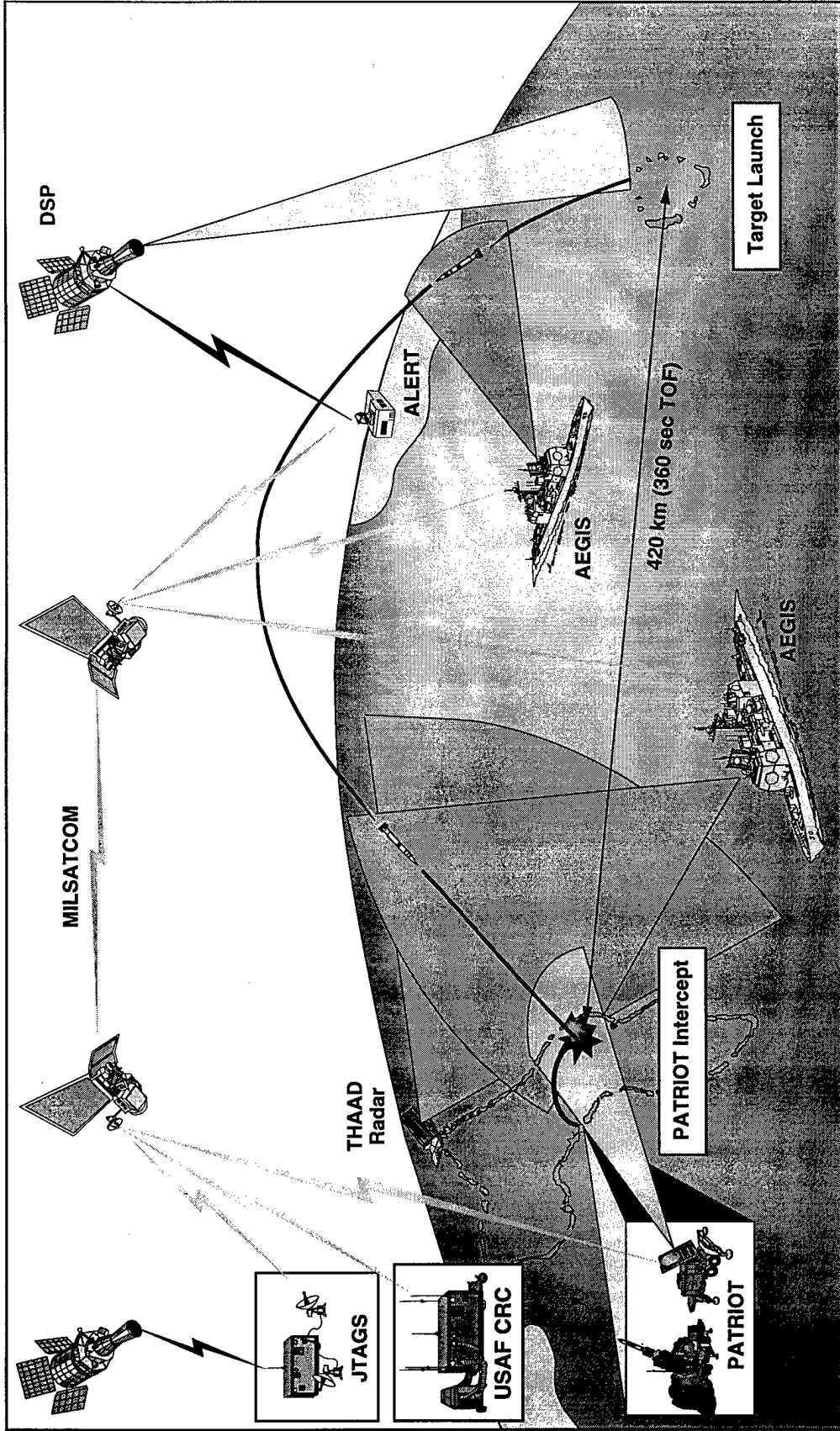
Acquisition Decisions

Analysis
Basis For Operational Capability

Warfighter Decisions



FAMILY OF SYSTEMS INTEROPERABILITY TESTING



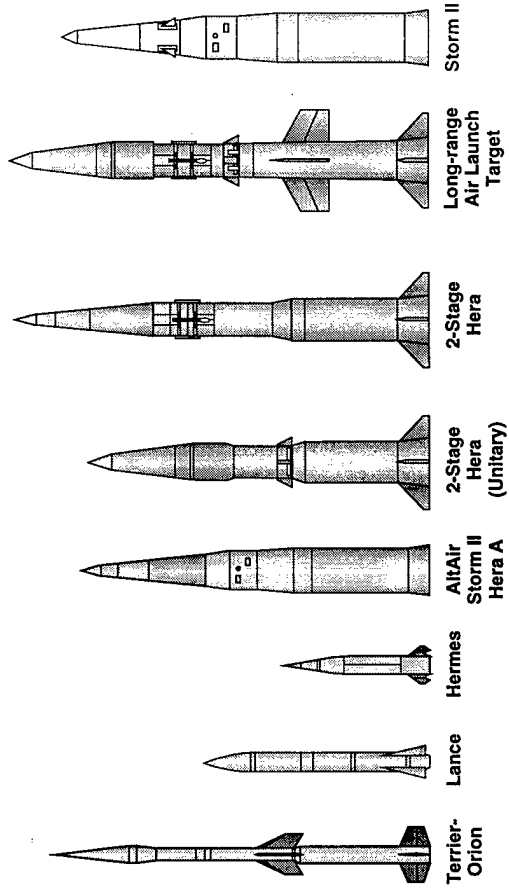
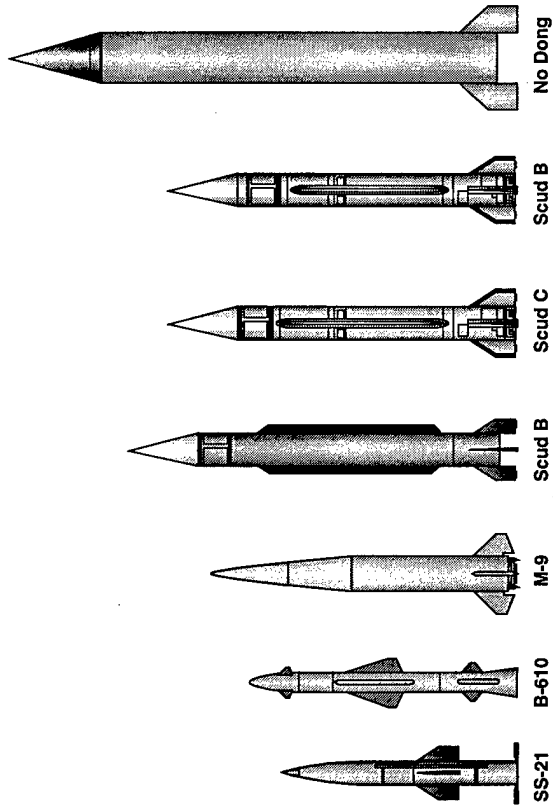
Tests Were Conducted In February And March, 1997



THREAT EMULATION

Defined Threat Choices

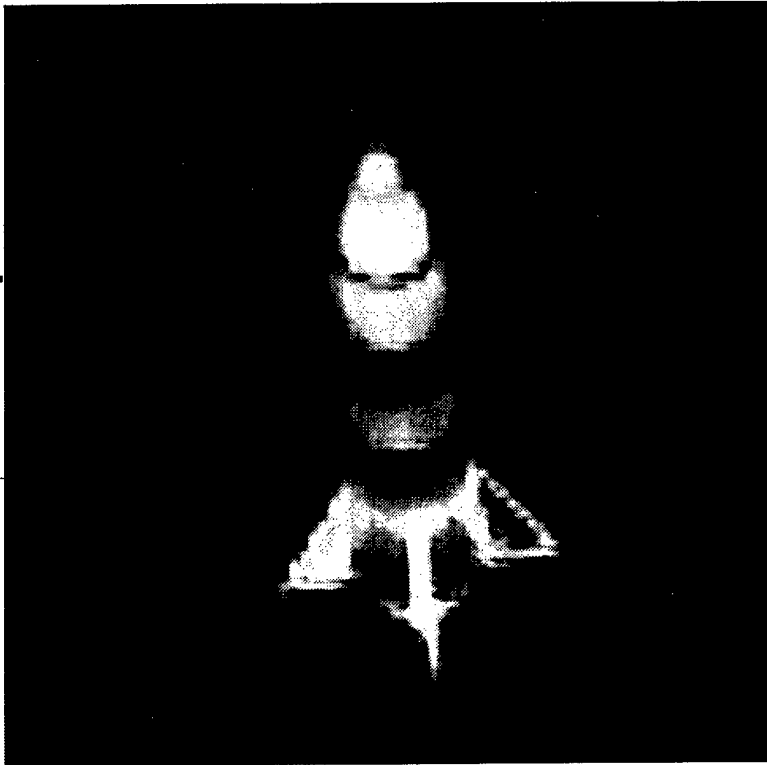
Realistic Targets Competitive Sources



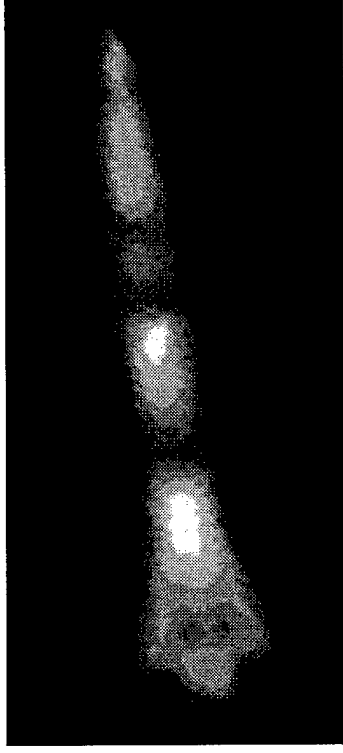


TMD TARGET SIGNATURES LANCE MISSILE

SM-2 Block IVA IR Seeker
24 JAN 97 Intercept Event



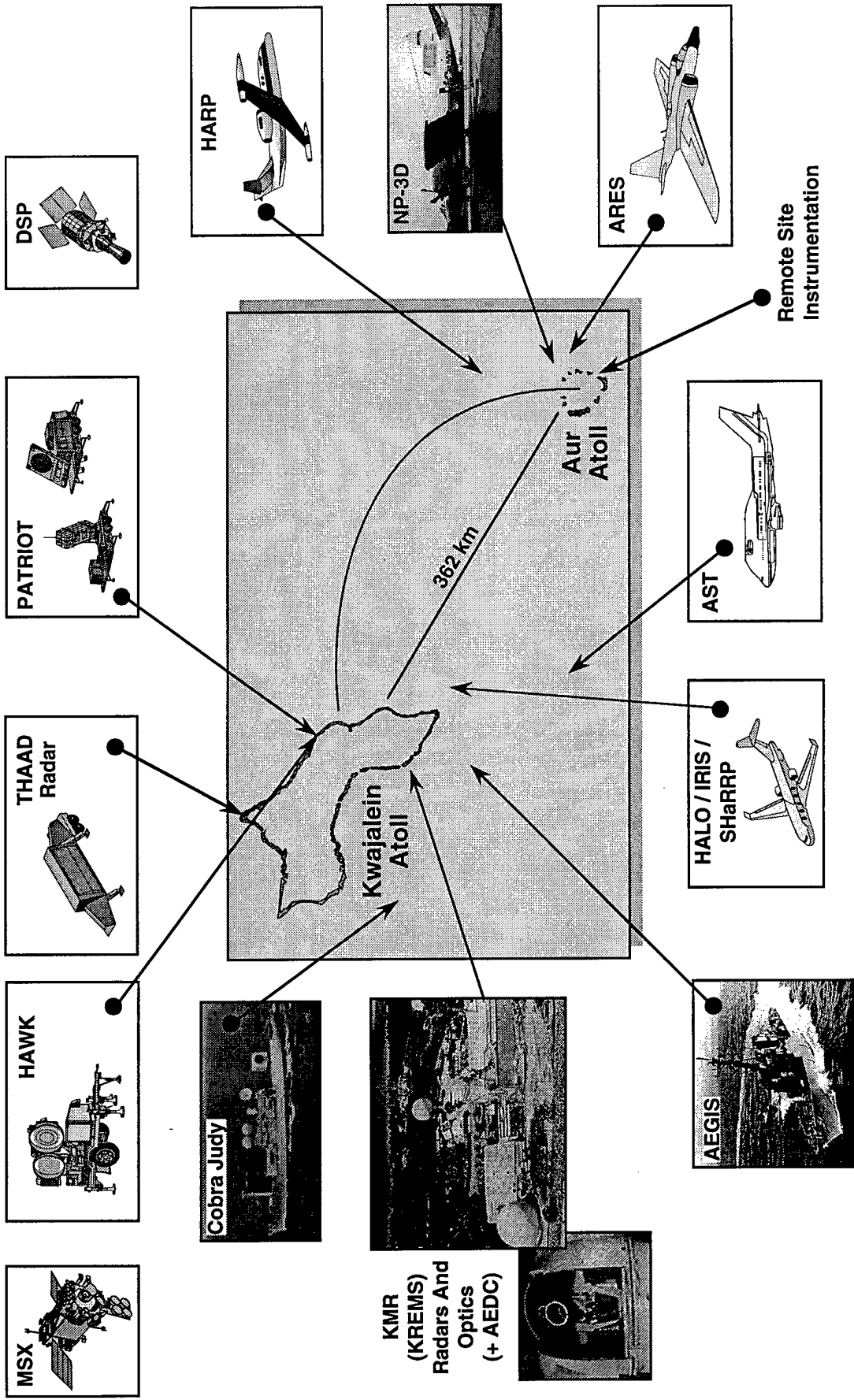
Calculated IR Image



Sea Light Beam Director
IR Image (1993)



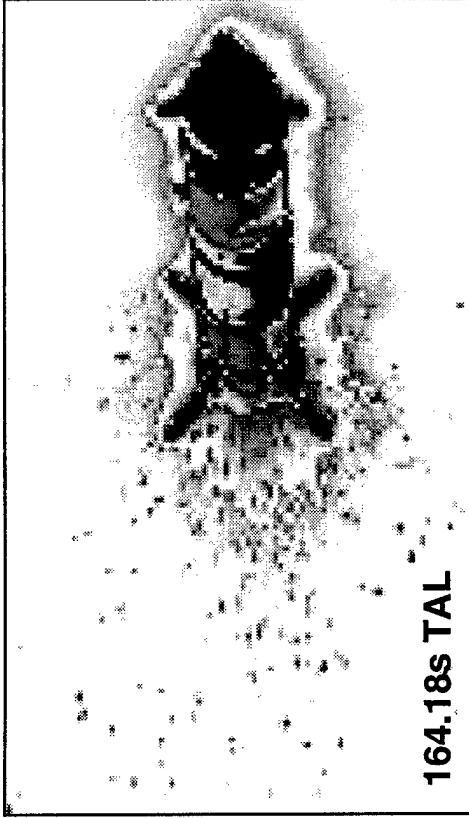
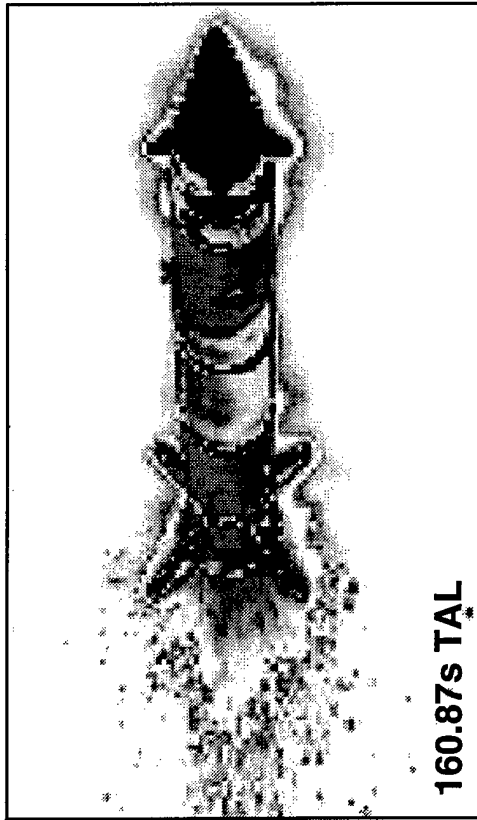
WILLOW DUNE FEBRUARY 1997





SOLID FUEL DEBRIS

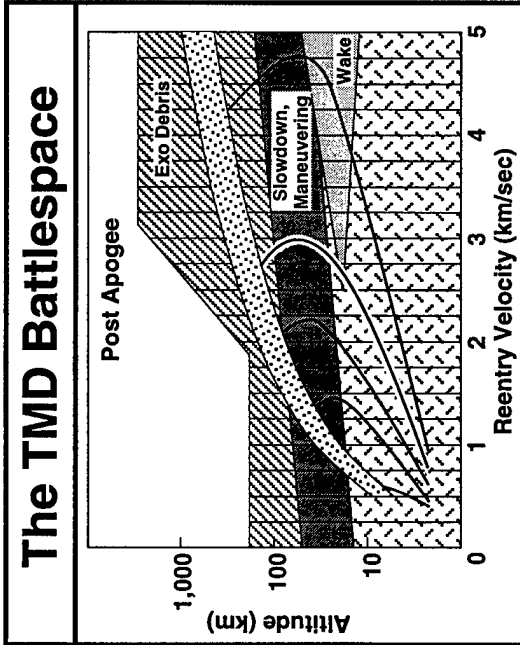
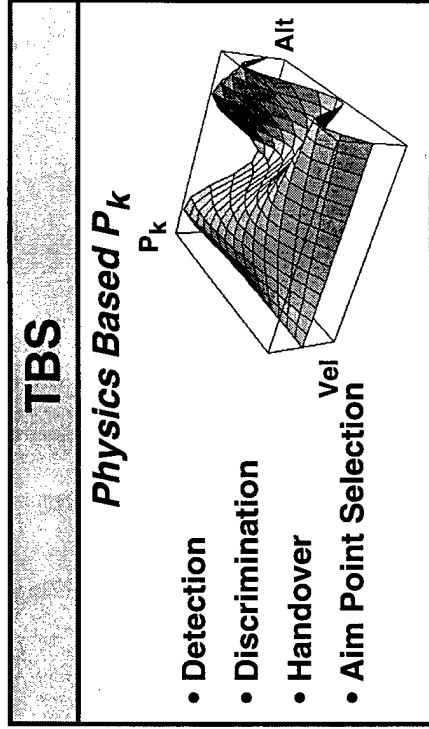
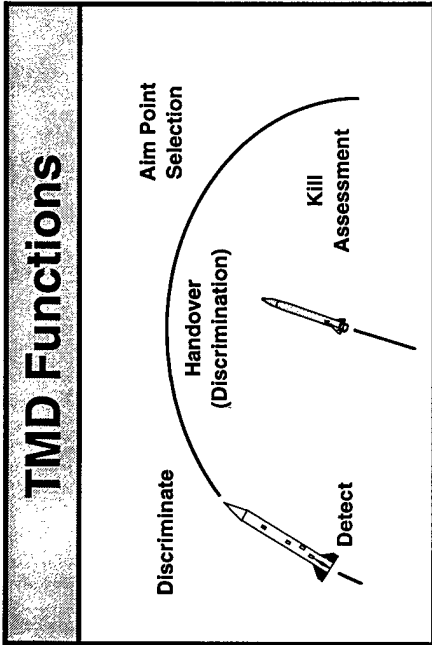
FASP IR IMAGES



Bright Solid Rocket Fuel Debris Appeared During Entire TCMP-2B Flight (Images \approx 100 Seconds After Burnout)



THE TMD BATTLESPACE STUDY (TBS)



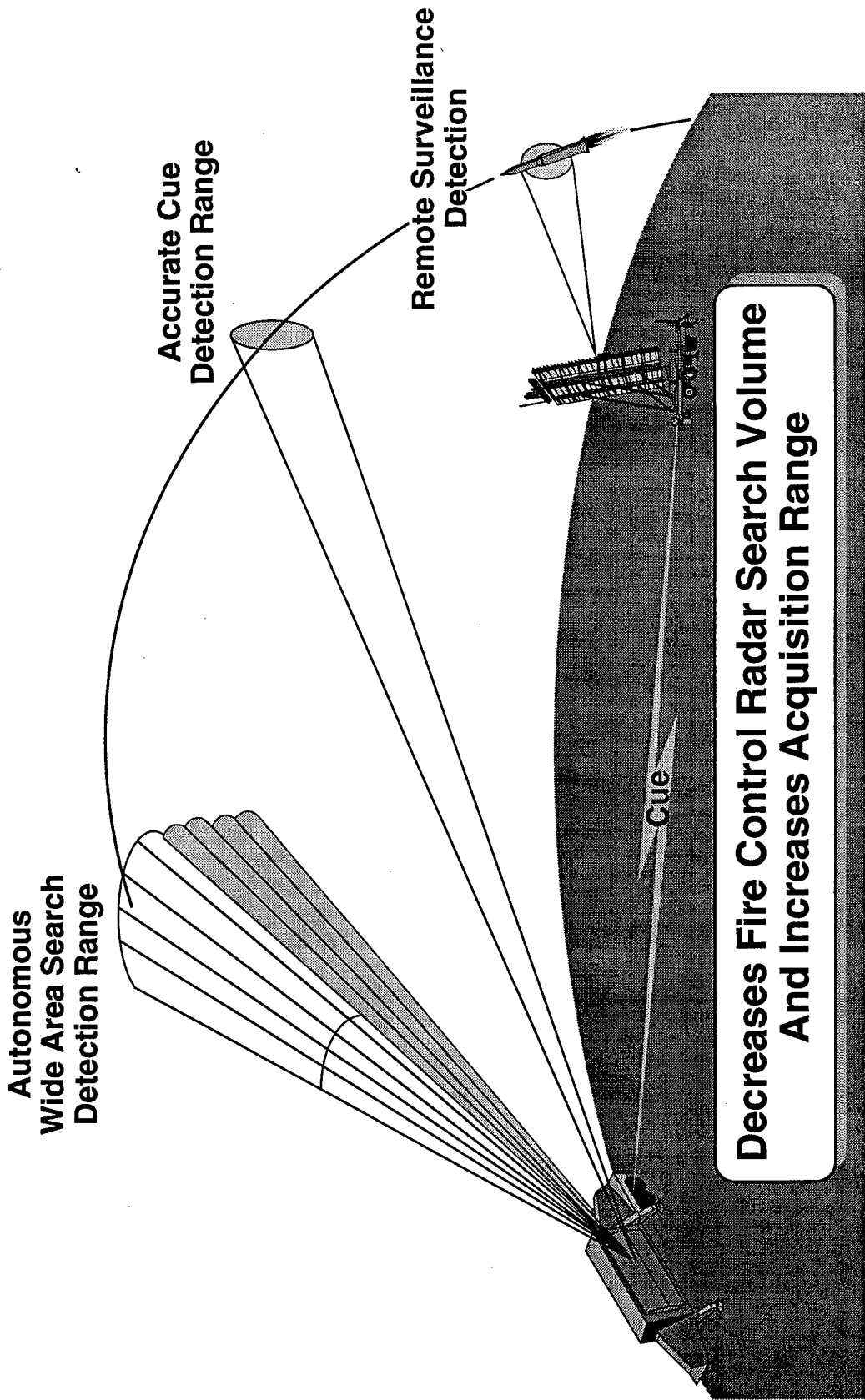
Ascent Phase (NTW)

TBS Goals

- Preserve System Performance By Establishing The Factors Which Determine P_k
- Support Engagement Strategies Based On Best P_k Available In The Battlespace - Family Of Systems Perspective
- Support Funding Decisions

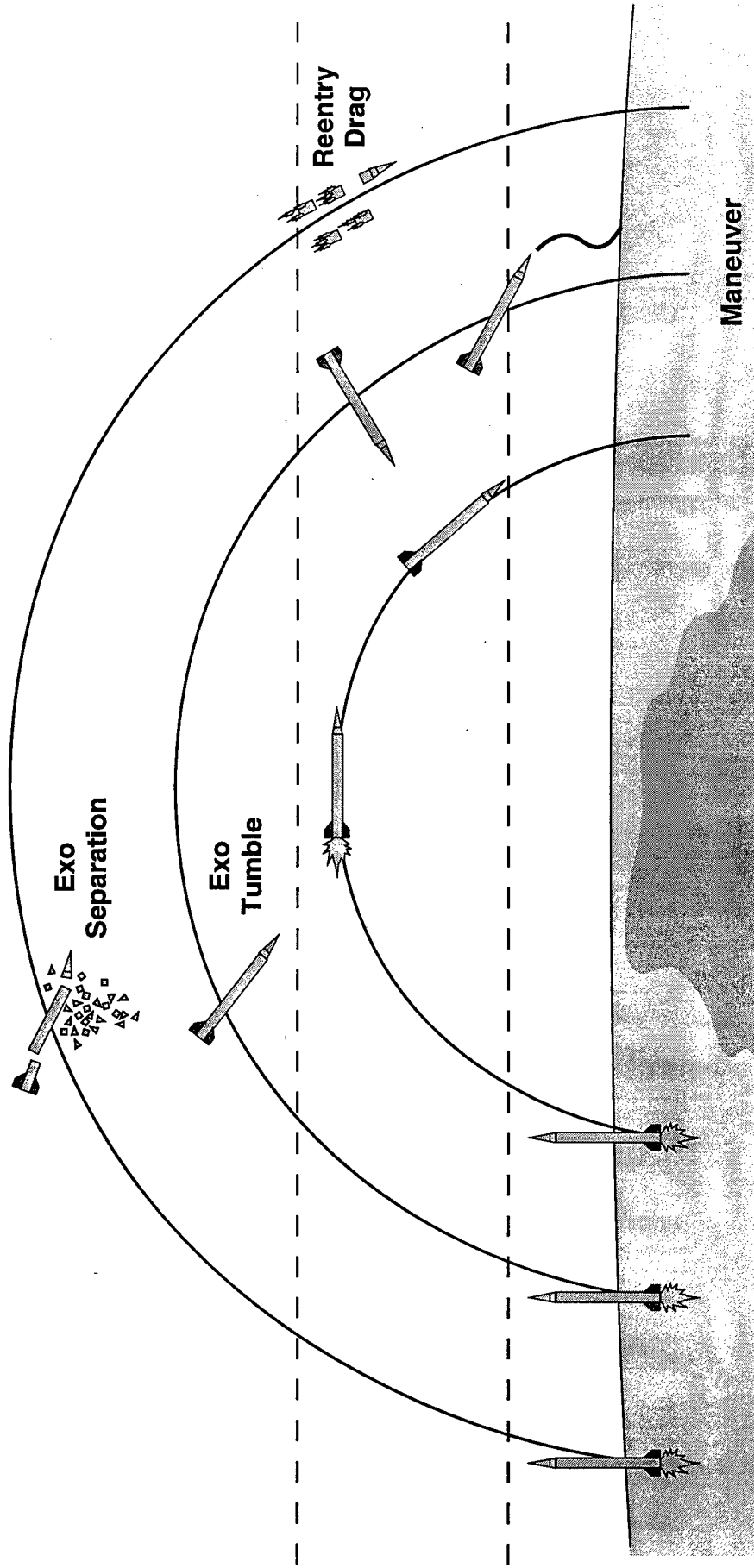


VALUE-ADDED BY REMOTE SENSOR TRACK DATA



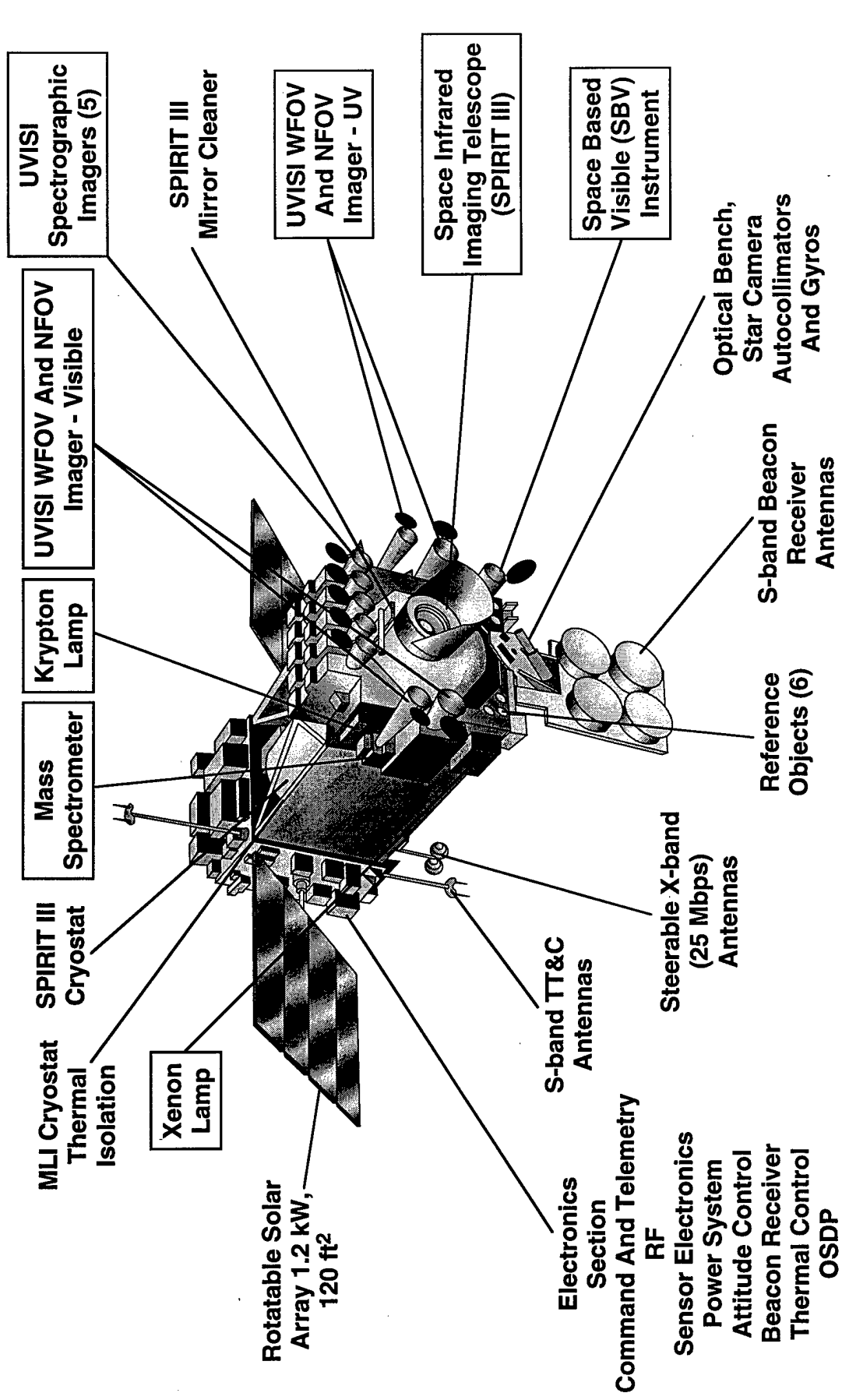


LIMITED INTERCEPTOR INVENTORIES WILL DRIVE USER TO SOPHISTICATED ENGAGEMENT STRATEGIES





MSX SPACECRAFT CONFIGURATION



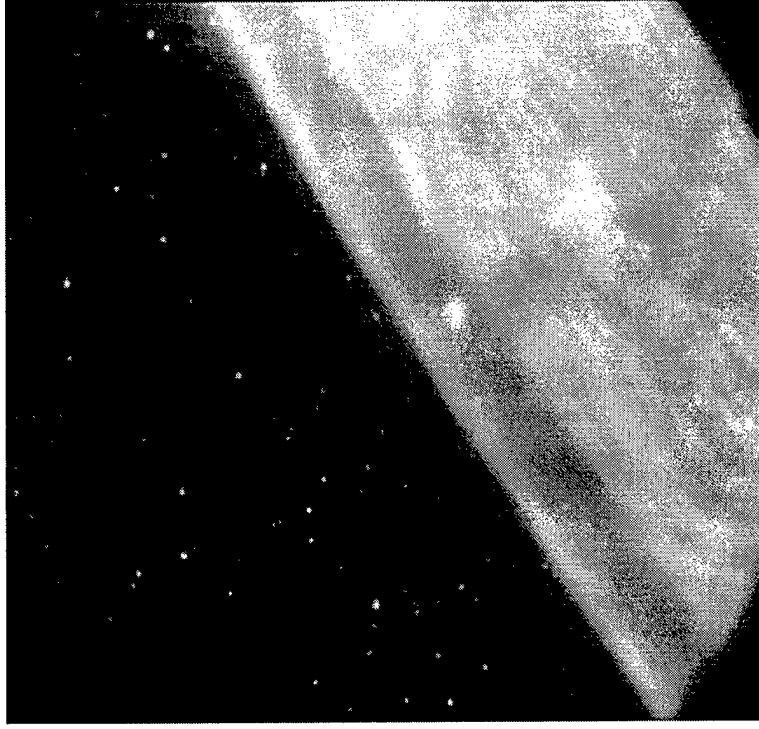


MIDCOURSE SPACE EXPERIMENT (MSX)

**MSX Dedicated Target
(MDT-2)**



**Earthlimb Backgrounds
And Reentry**



**Demonstrate Midcourse Functions And
Technologies And Measure Key Backgrounds**



SYSTEM EFFECTIVENESS

We Must Not
Engage Objects That Don't Need Killing

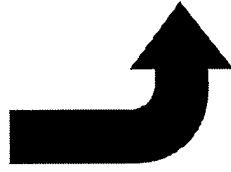
And

We Must
Kill Each Engaged Object



SUMMARY

“Fight Smart”



Sophisticated Engagement Strategies

- **Threat Characterization**
- **Robust Discrimination**
- **Firing Policy Based On Family Of Systems Capabilities**



TECHNOLOGY PROGRAM GOALS

Threats And Technology Do Not Stand Still, Therefore

- Support TMD And NMD With Component Technology Improvement

Increase And Decrease

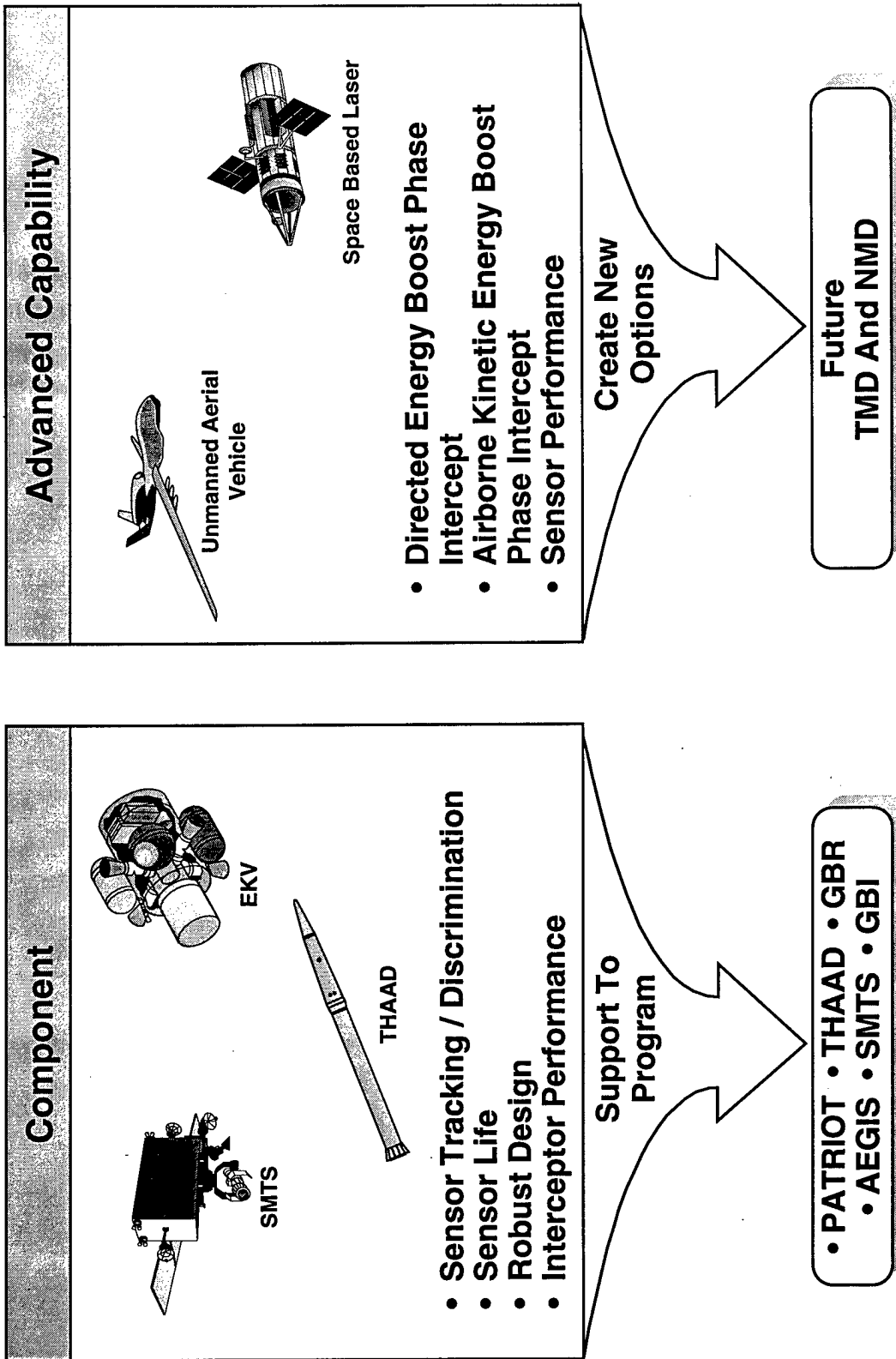
- Range
 - Lethality
 - Accuracy
 - Effectiveness
 - Producibility
- Size
 - Cost

- Pursue Advanced Concepts For Future Responses To An Evolving Threat
 - New Kill Mechanisms
 - High Payoff (Boost Phase Intercept)



TECHNOLOGY PROGRAM

*Commonality / Interoperable
Open Systems*

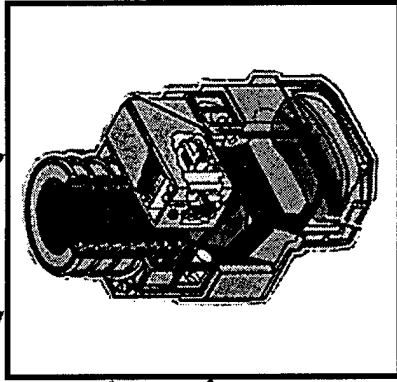
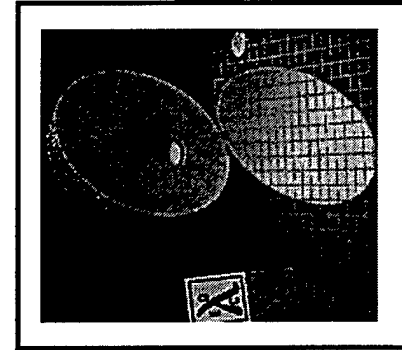
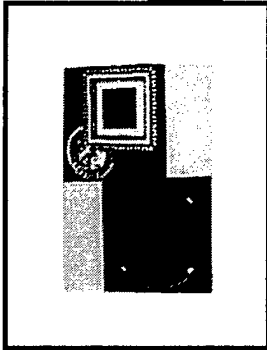
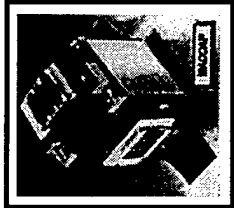




COMPONENT TECHNOLOGY UNDERPINS BMD

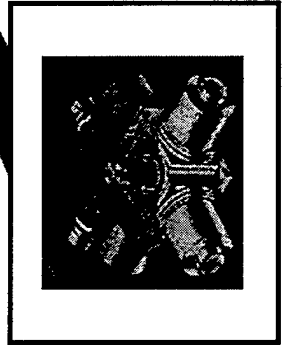
Signal Processors Optical Telescopes

Focal Planes



Mirrors

Sensor Assembly

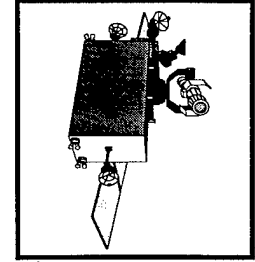
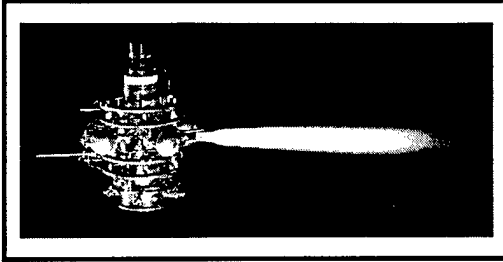


Cryocoolers



Optical Signatures

Kill Vehicle



Surveillance
Platform

mj-48968A / 052595



CLEMENTINE CONTRIBUTIONS TO SURVEILLANCE SATELLITES

Reaction Control

- Monopropellant $N_2 H_4$
- Aluminum Honeycomb (Gr / TP, Metal Matrix)

Structure

- Aluminum Honeycomb (Gr / TP, Metal Matrix)

Communications

- 60 GHz Solid-state Cross-links (Laser)
- 44 / 20 GHz Up / Downlinks
- Gimbalbed Antennas (Phased Array)

Electrical Power

- GaAs / Ge-Solar Arrays
- NiH_2 CPV Batteries

Staring Sensors

- HgCdTe MWIR
- HgCdTe LWIR
- Si CCD Visible
- Be Optics (SiC)
- 1-Stage And 2-Stage Stirling Cryocoolers (Turbo Brayton, Pulse Tube)

Signal / Data Processing

- RH-32 (RH 3000) (RH 6000)
- 1Mbit SRAMs (256K SRAMs)
- 12 bit ADC
- 256K NVRAM
- 60K - 90K Gate Arrays

GN&C

- CMG (Reaction Wheels)
- GPS
- Ring Laser Gyro
- Star Tracker

Earth Horizon Sensors

- Magnetometers
- Torquer Rods

Thermal Control

- Radiators
- Phase Change Materials
- Variable Conductance Heatpipes
- Multilayer Insulation

Scanning Sensors

- HgCdTe SWIR
- HgCdTe MWIR
- Stirling Cryocooler

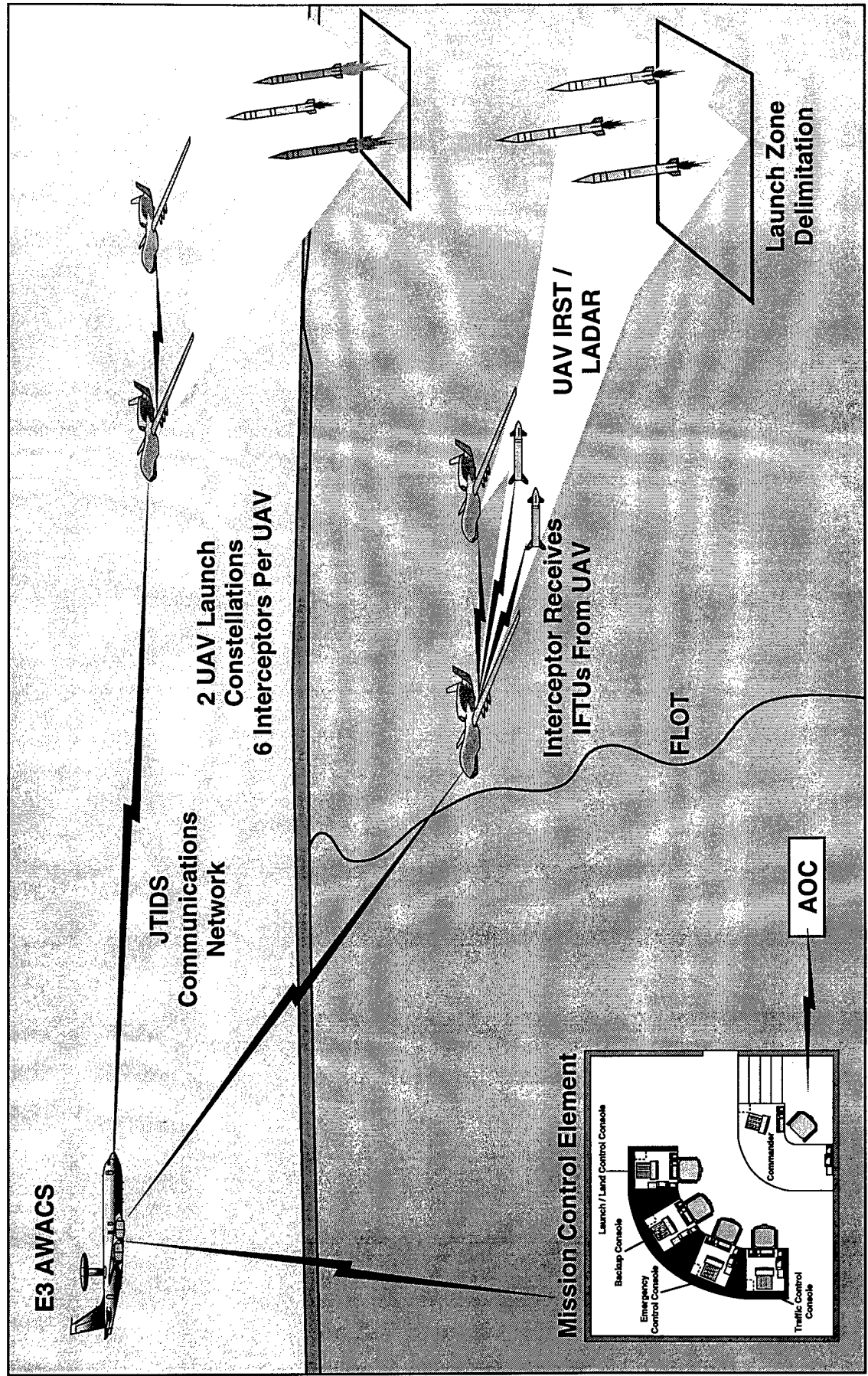
Other Technology

- SiC/Al, VISCO Elastic Material
- Lightweight Stirling Cryocooler
- SSDR
- Radiation Monitoring
- Advanced Microelectronics Radiation Testing

Legend: Technologies Applicable To Surveillance Satellites



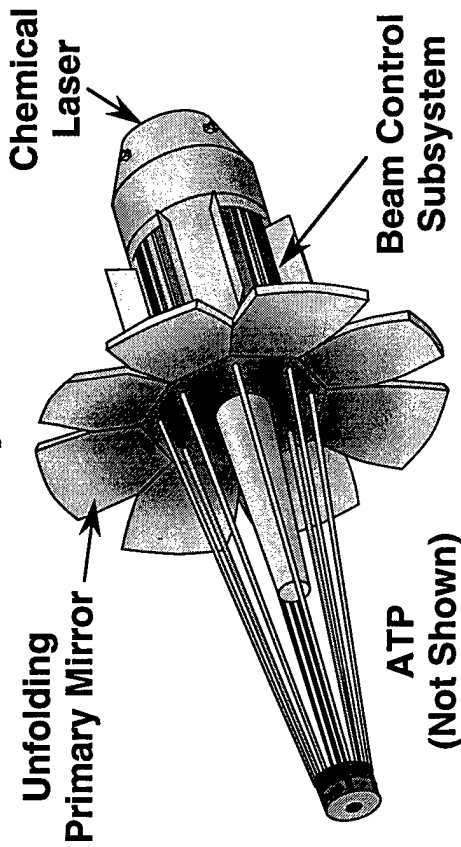
UAV BPI CONCEPT OVERVIEW





SPACE BASED LASER (SBL) SYSTEM

Notional Space Vehicle



Mission

- Continuous, Global Coverage, Boost Phase Intercept For NMD And TMD
- Space Control
- Other Futuristic Applications

Development Issues

Operational System

- Policy / Treaty
- Cost
- Launch Vehicle (Size / Weight)
- Integration Into NMD / TMD
- Alternative System Concepts
- Advanced Technology

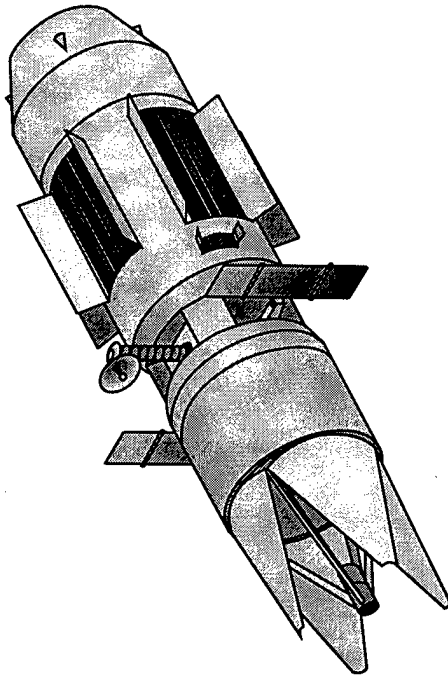
Readiness Demonstrator (RD)

- POM Funding / Schedule
- Traceability To Operational System
- Spacecraft Integration
- Maturity Of Technology (Risk)
- Test Site



SBL READINESS DEMONSTRATOR (SBLRD) TEST OBJECTIVES

- Perform A Realistic Demonstration Of An Integrated Laser Weapon Configuration In Space
 - Subscale But Representative Performance Levels
- Gain Experience Operating A High Energy Laser In Space
 - Collect Data Critical To Future EMD Design / Prototype
- Validate End-to-end Modeling
 - Laser Beam Generation, Control And Focusing At Long Range
- Perform Long-range ATP / FC Experiments
 - Low Power With Targets Of Opportunity

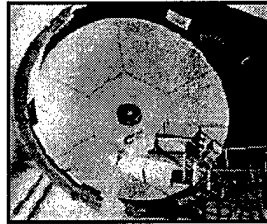


**Demonstrate The Technical Performance Of
An Integrated SBL Configuration In Space**

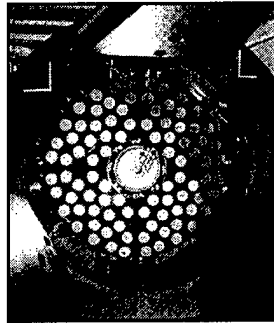


SPACE BASED LASER DEVELOPMENT CONCEPT

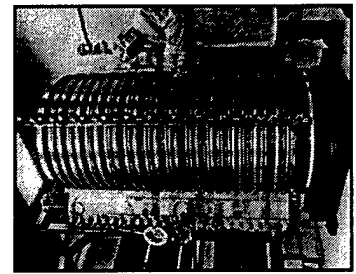
Demonstrated Technologies



Large Optics
(LAMP, 1989)



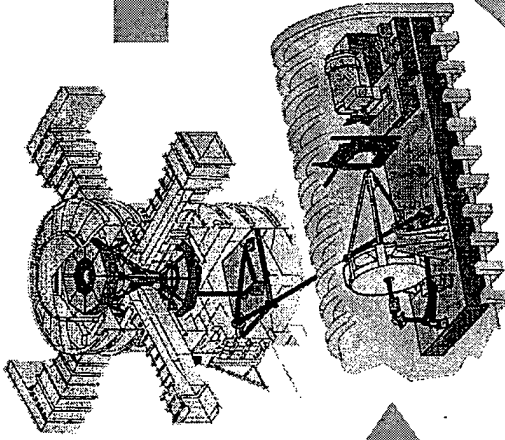
Beam Control
(LODE, 1987)



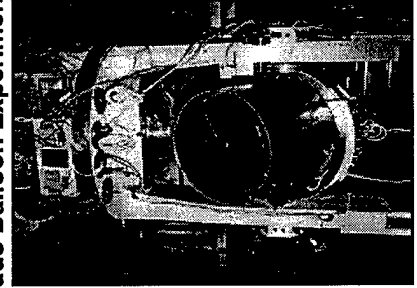
Laser
(Alpha, 1991)

Integration

Alpha LAMP Integration (ALI)
End-To-End Weapon Element Testing

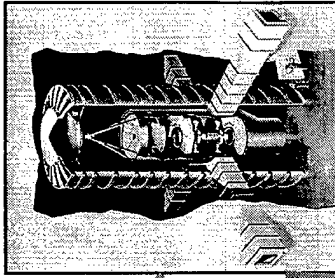


Acquisition Tracking, Pointing
And Fire Control
(High Altitude Balloon Experiment (HABE))

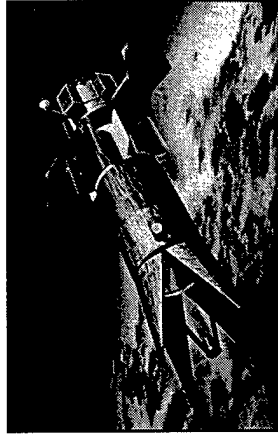


System-level Development

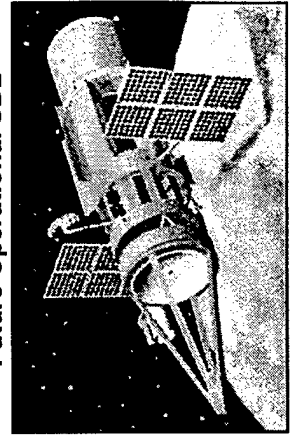
Integrated Ground Test



Readiness Demonstrator



Future Operational SBL

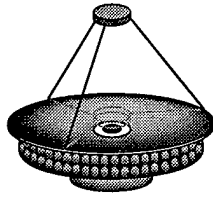


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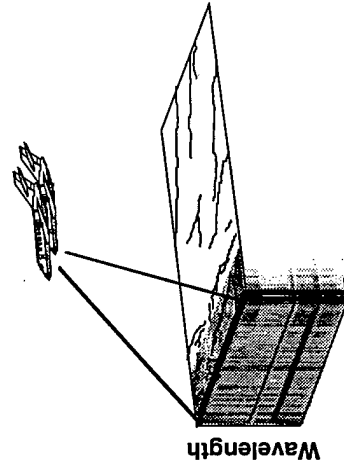
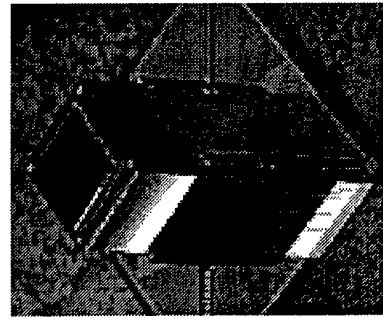
INNOVATIVE RESEARCH - HIGH RISK TECHNOLOGY FOR BMDO'S FUTURE

*Miniature Interceptors Counter
Dispersed Munitions*



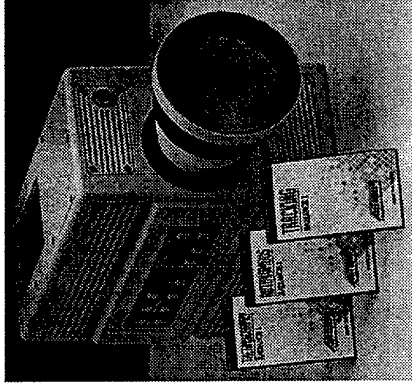
Supports Advanced Architecture Concepts

3-D Neural Network Processors



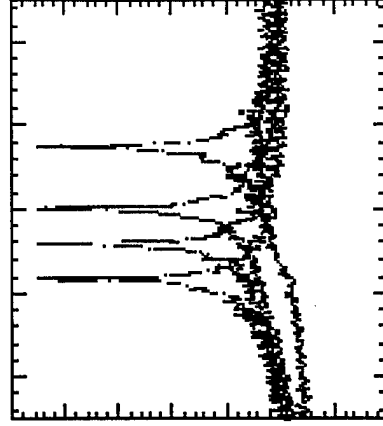
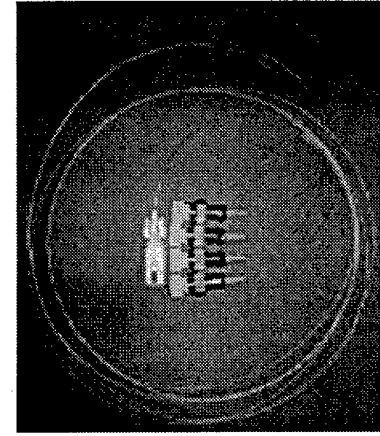
**Image Processing, Real-time Multisensor
And Hyperspectral Discrimination**

Quantum Well IR Sensor Camera



High Uniformity, Low Cost

High-speed Networks

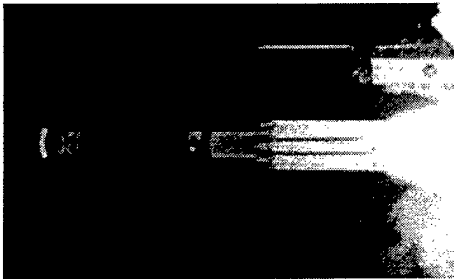


Multiwavelength Lasers Increase Bandwidth



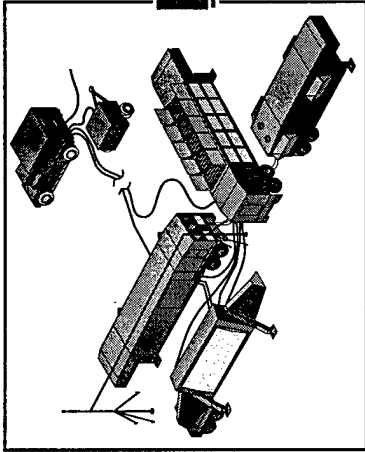
INNOVATIVE RESEARCH - HIGH RISK TECHNOLOGY FOR BMDO'S FUTURE (Cont'd)

Sensor And Data Fusion Test Bed



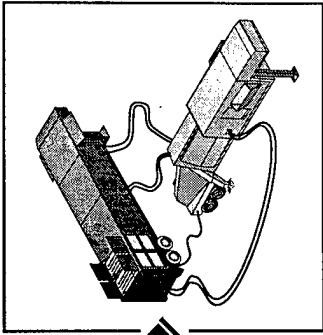
Mobile Test Facility, UV, IR, And LADAR

All Cryogenic Ground Based Radar

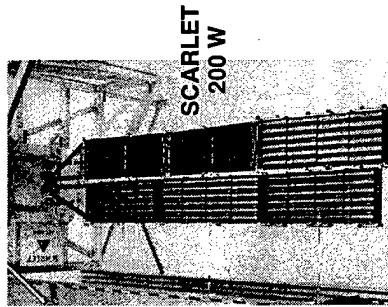
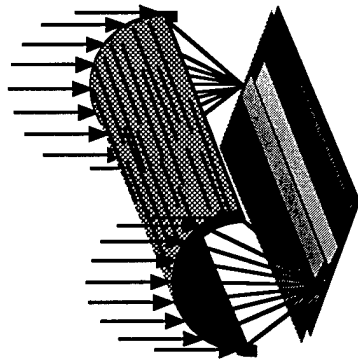


THAAD GBR (Typical)

All Cryo-GBR Concept
Cryogenic Generator, Antenna Modules,
Power Conditioning



Solar Concentrators



10 JUN 95 Goleta, CA
SCARLET Deployment Test

Cheaper, Lighter, More Efficient Space Power

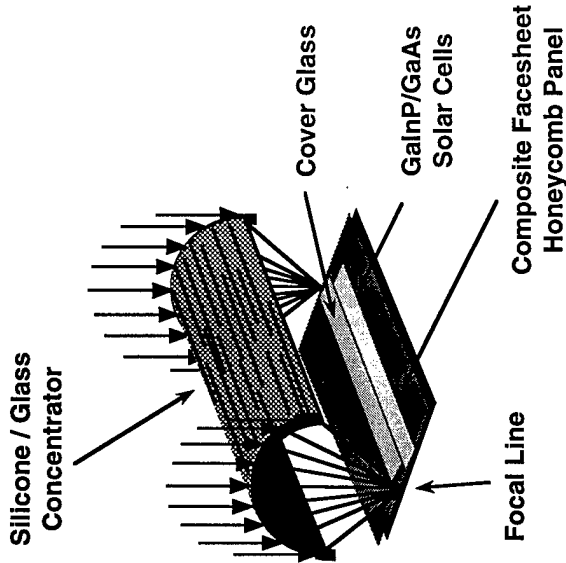
Other Topics

- High Energy Density Solid Propellants / Oxidizers
- Wide Band Gap (GaN) Microwave Power Amplifiers
- Laser Line-Of-Sight Communications
- Hyperspectral Imaging Techniques
- SBIR - Developing BMDO Required Commercial Products



SCARLET - HIGH PERFORMANCE SOLAR ARRAYS

- Solar Concentrator Arrays With Refractive Linear Element Technology
- Single Axis Inverted Through Fresnel Concentrator
- Performance Of Arrays Provides Many Operational Benefits
 - Efficiency = 23% (Versus 18% GaAs)
 - Recurring Cost < \$500 / W (Versus \$1,000 / W Si)
 - Van Allen Belt Radiation Tolerant (SBIRS, SBR, EOTV, etc.)
 - Array Specific Power > 50 W / kg (Versus 25 W / kg GaAs)

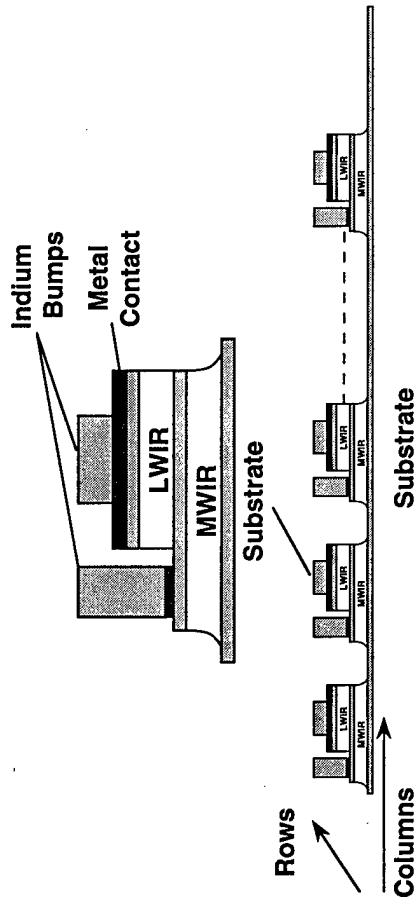


- SCARLET Will Be The Prime Power Source On NASA's / JPL's First New Millennium Deep Space Mission (DS-1)

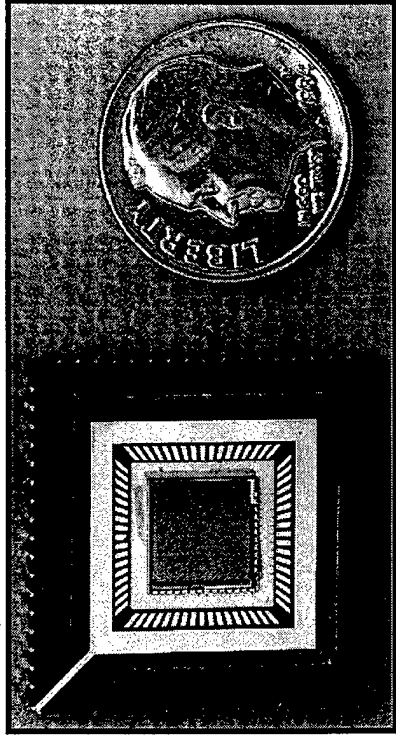


DUAL BAND QWIP FPAS

Dual Bump Two Color QWIP FPA



Multiple Quantum Well Staring Focal Plane Array Technology



Goals

- Perfectly Registered Dual Band Imagery
- Simultaneous Integration In Two LWIR Bands
- Reduced Real-time Signal Processing
- Reduced Cryogenic Size / Weight Power

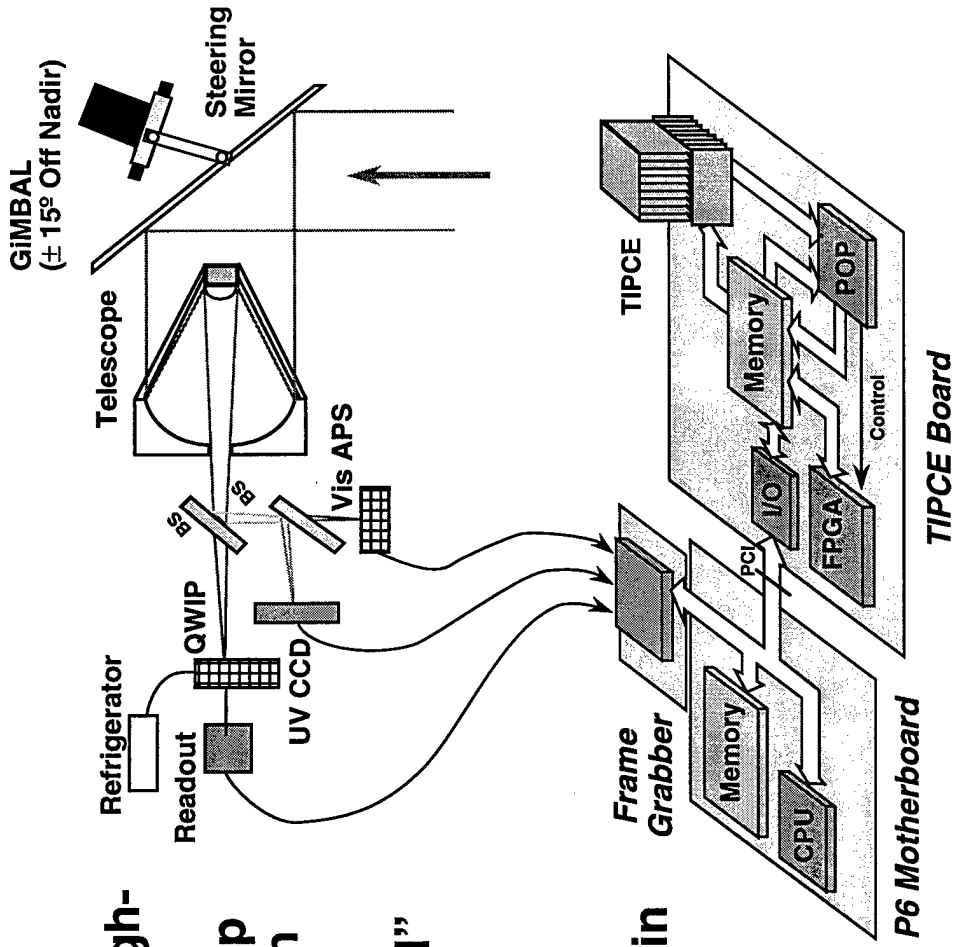
Accomplishments

- Demonstrated Feasibility Of 256 x 256 Dual Band MWIR / LWIR FPA
- Sensitivity
 - MWIR $NE\Delta T < 0.05$ K
 - LWIR $NE\Delta T < 0.05$ K
- Corrected Responsivity Nonuniformity $< 1\%$



VIGILANTE PROVIDES PORTABLE, LOW-COST SENSOR/PROCESSING TEST BED

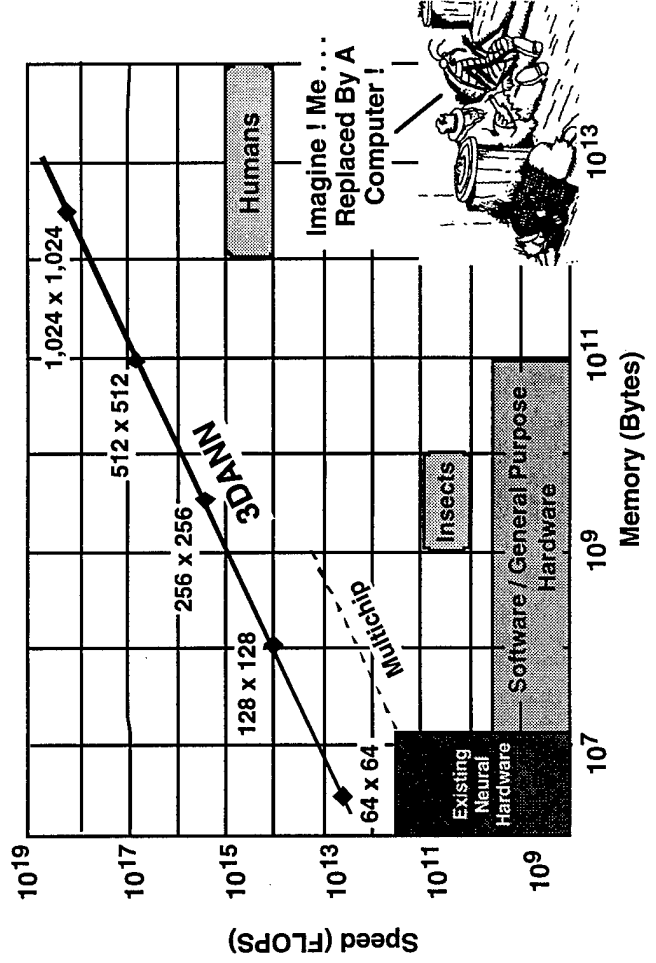
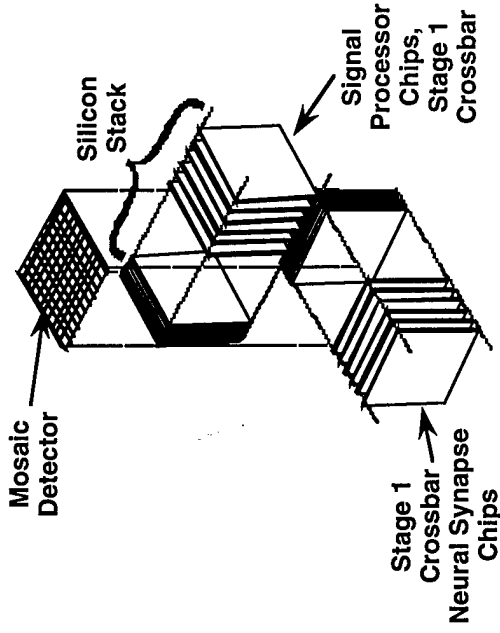
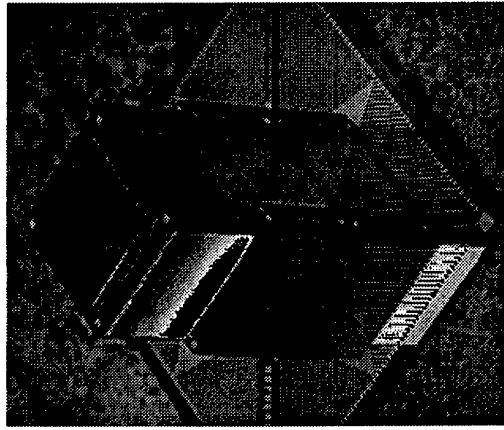
- **TIPCE Processor**
 - Board With Local Bus, High-speed Digital Signal Processor And 3D Teraflop Inner Product/Convolution Engine (TIPCE)
 - Mounted In "Conventional" Microprocessor System
- **Camera**
 - Simple Modular Cassegrain With Gimballed Mirror
 - LWIR: QWIP 9 μ m
 - UV: δ -Doped CCD - UV
 - Visible: APS





MODIFIED 3DANN CAN BE APPLIED TO SPEED UP VIGILANTE

Smaller Than 2 Stacked Sugar Cubes

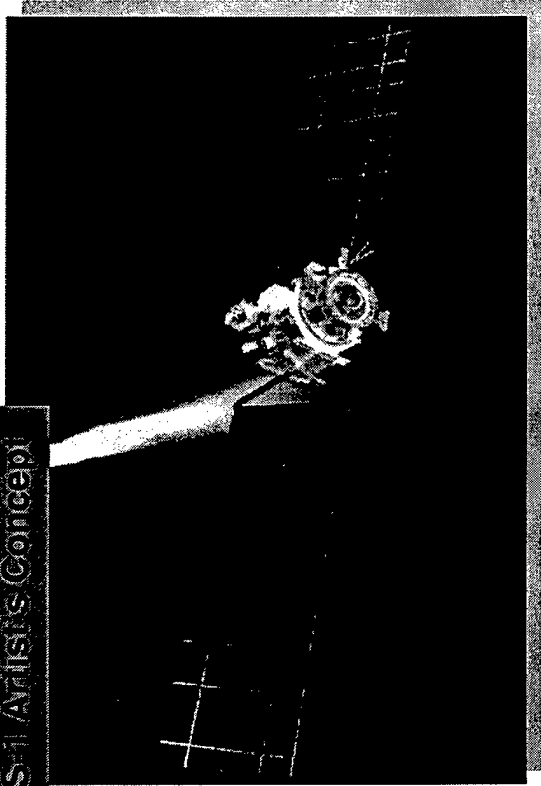


- 3DANN: Three Dimensional Artificial Neural Network
 - Compute Power Greater Than Fast Supercomputer
- Technical Leaders
 - Carson - ISC, Thakoor, Daud - JPL

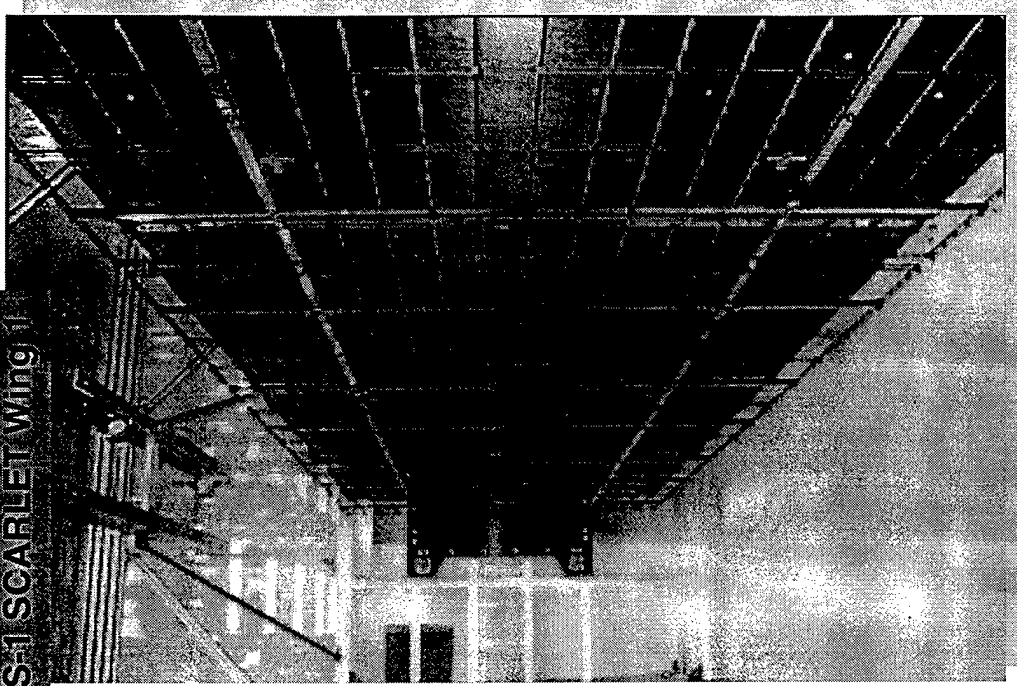


SCARLET WING 1 ASSEMBLY (LATE APRIL 1997)

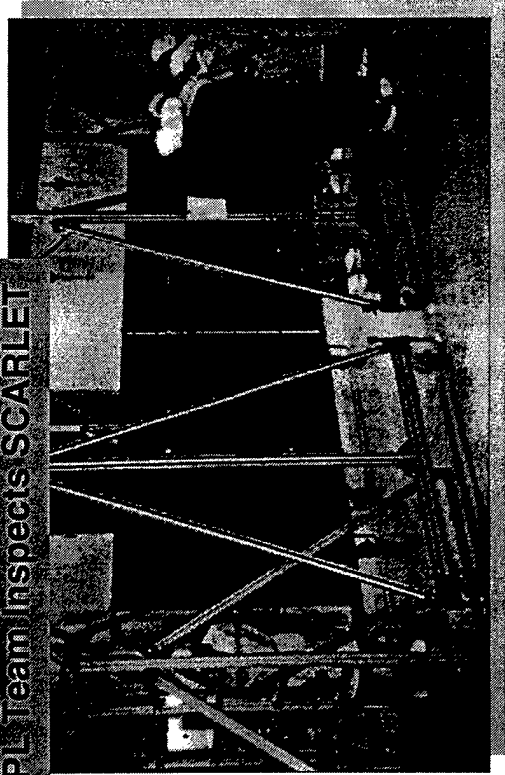
DS-1 Artist's Concept



DS-1 SCARLET Wing 1



JPL Team Inspects SCARLET





TECHNOLOGY PROGRAM PLANNING

