

# Risk Management Lessons Learned from the APG -79 Radar Test Planning and Execution



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# Outline

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- Overview
- Background
  - APG-79 Basics
  - Performance
  - Schedule
- Risk Management- Others
- Risk Management- Goods
- Summary
- Questions



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This Briefing is Classified  
**UNCLASSIFIED**



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# Overview



# Overview



## More Lethal...

- Engages targets at very long ranges
- Tracks twice as many targets as the APG-73 radar
- High resolution SAR maps at long stand-off ranges
- Interleaved multi-mode operation

## More Survivable...

- Controlled radar cross section
- Improved Situational Awareness



Funded by  
the U.S. Navy

## More Affordable...

- Procurement cost comparable to APG-73
- Low maintenance cost
  - The average array will not need to be replaced during its lifetime

***The F/A-18E/F AESA radar is a quantum leap in sensor technology for unequaled air combat capability***



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# APG-79 Basics



# Main Elements of the AESA Upgrade



**High Speed  
Data Network**

**Advanced Mission Computers / HOL Software**

**Engine  
Integration**

**Integrated Forebody/  
NT Technology**

**Liquid Cooling  
System Upgrade**



**AN/APG-79  
Radar**

**Wideband Radome  
with Guard Antenna**

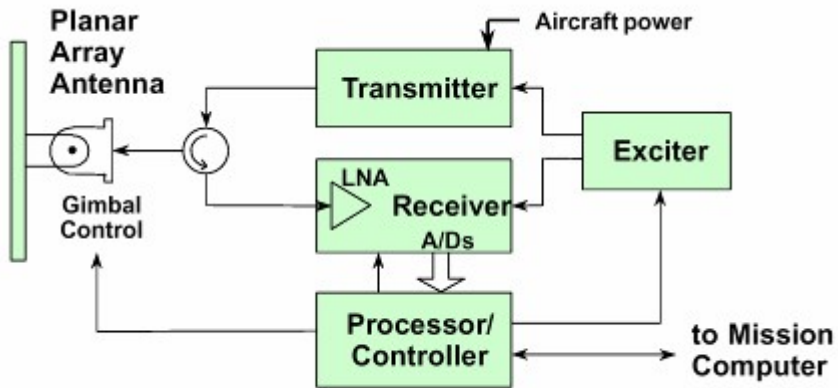
**EW Upgrades  
Electrical Partitioning**

**ECP 6038R1 Forward Fuselage**

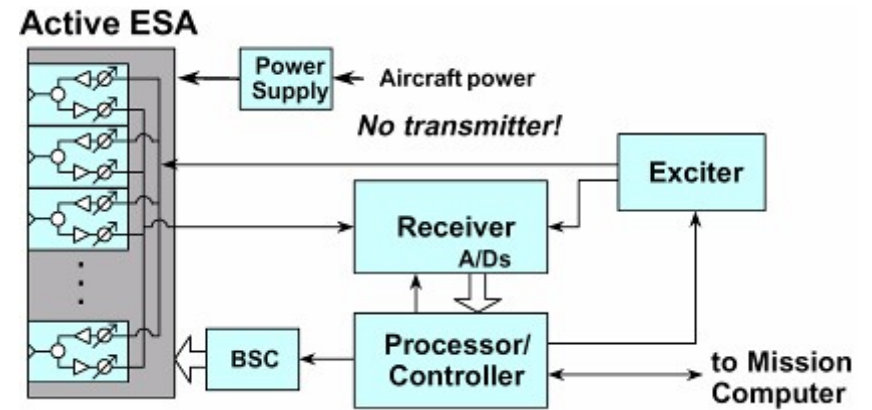
- ✓ Milestone II Approval / EMD Contract Awarded on Schedule
- ✓ EMD Program Ramp-up Successfully Accomplished
- ✓ All Radar Subsystem Hardware Internal CDRs Completed
- ✓ All Aircraft Subsystem CDRs Completed
- ✓ Rapid Prototyping used Extensively to Reduce Program Risk
- ✓ Commenced EMD Test Hardware Deliveries
- ✓ Production Equivalent Radar STE / Subsystem Laboratories are in Place
- ✓ Weapon System Software SDRs Completed
- ✓ Radar CDR Successfully Completed
- ✓ Weapon System CDR Successfully Completed
- ✓ Commenced Radar Hardware/Software Integration on Schedule



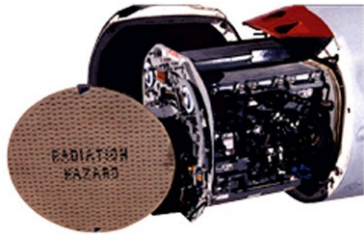
## MSA



## AESA







**APG-73 Radar**

**Mechanical Scan Antenna**



**Transmitter**



**Power Supply Unit**



**Receiver/Exciter**

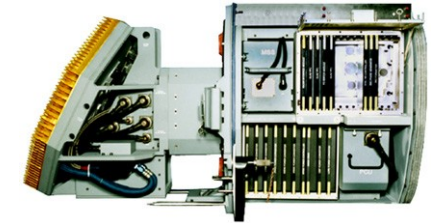


**Radar Data Processor**

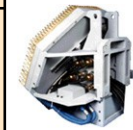


(1) Observed Field Data  
(2) Estimated Field Reliability

Mean Time Between Critical Failure			
APG-65 <sup>(1)</sup>	APG-73 <sup>(1)</sup>	Difference	AESA <sup>(2)</sup>
70 <sup>(1)</sup>	115 <sup>(1)</sup>	1,100%	1,280 <sup>(2)</sup>
315	615	14,100%	29,876
224	322		
638	3,294	140%	4,885
255	347	1,000%	3,511
737	1,578	350%	5,566



**AESA Multi Function Radar**



**Multi Function Aperture**



**Radar Power Supply Unit**



**Receiver/Exciter (REX)**

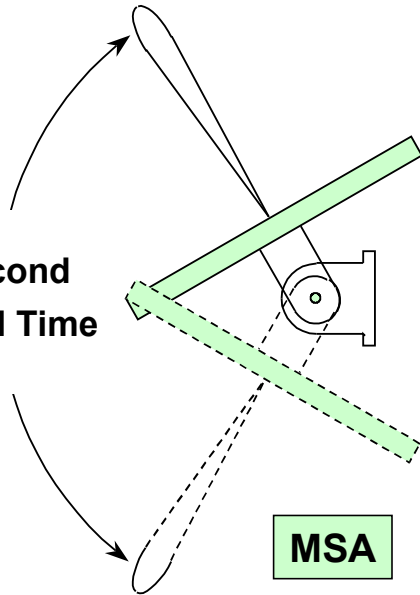


**Common Integrated**

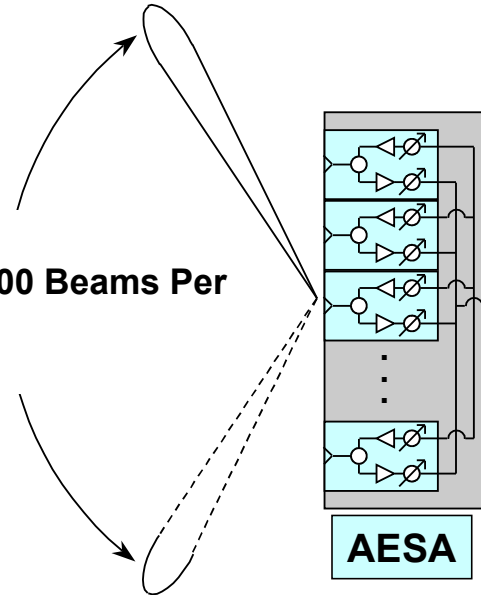
**Sensor Processor/  
Beam Steering  
Controller**

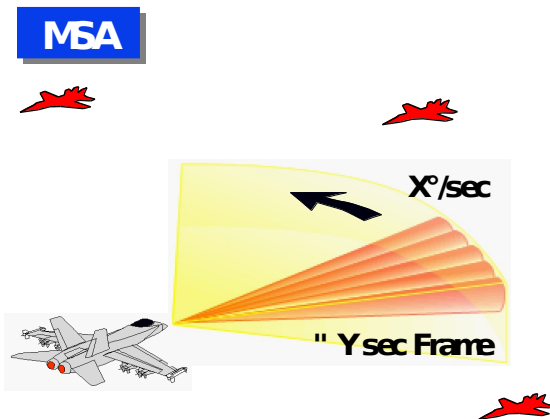


- ~65° Per Second
- Turn Around Time



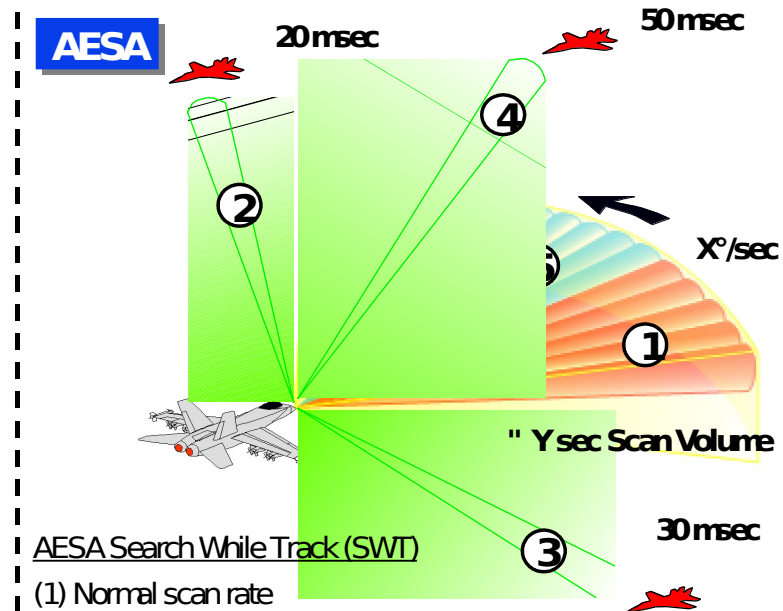
Up to 2800 Beams Per Second





### MSA Track While Scan (TWS)

- Fixed scan rate
- Track updates occur when beam returns to target during scan
- No track of targets outside scan volume



### AESA Search While Track (SWT)

- (1) Normal scan rate
- (2) (3) (4) Interrupted with out of scan volume track updates. Adaptive dwell time determined by track requirements.
- (5) Return to scan

Note: Scan rate can be optimized for scan volume



# Air to Air Capabilities

## Selectable Search Volumes

- Target Acquisition
- Target Track/Situational Awareness
- Electronic Protection
- Air Combat

## Exovolume Tracking

Steady State Track  
Short Range Track

Weapon Support

Weapon  
Quality

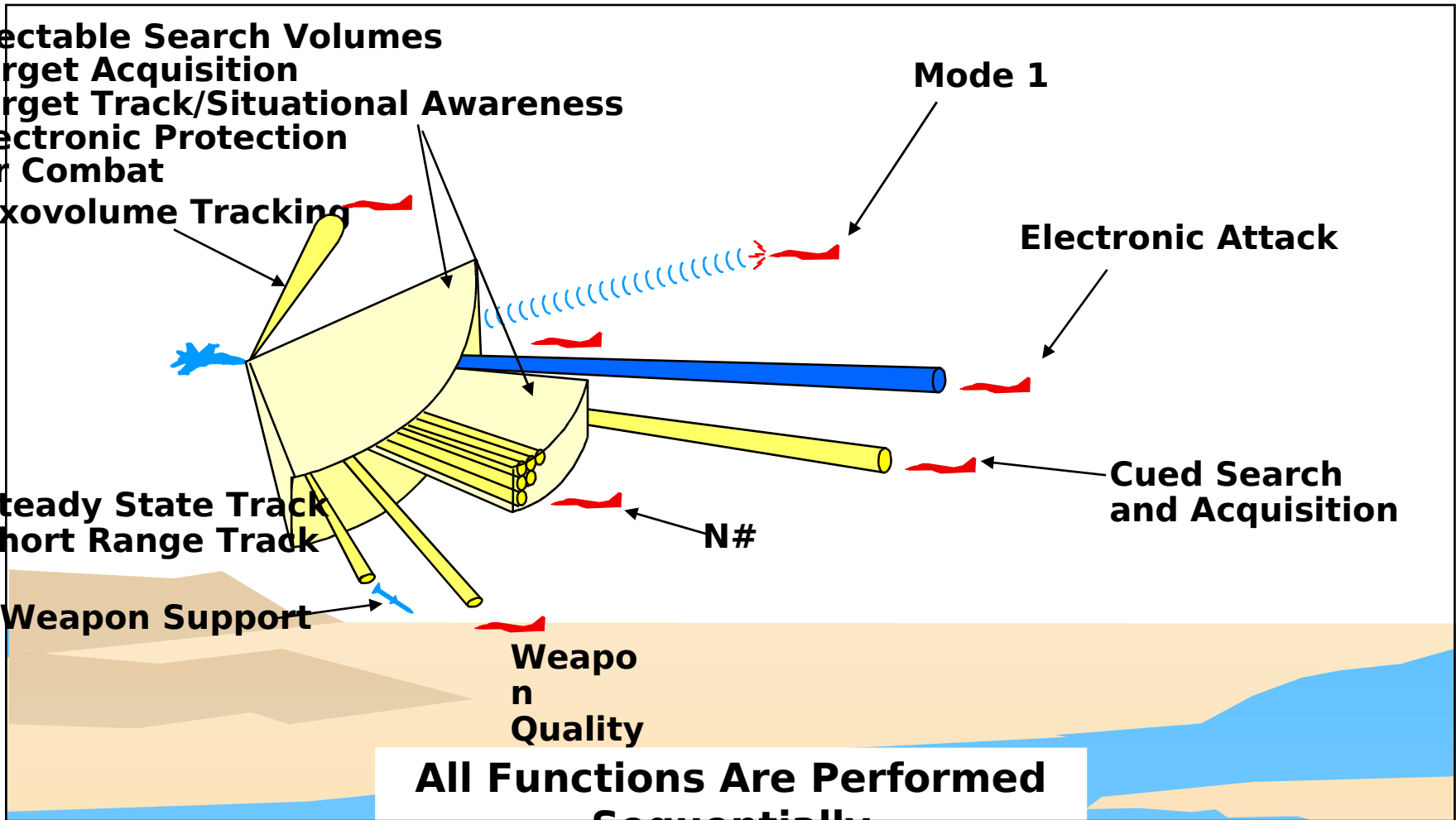
All Functions Are Performed  
Sequentially

Mode 1

Electronic Attack

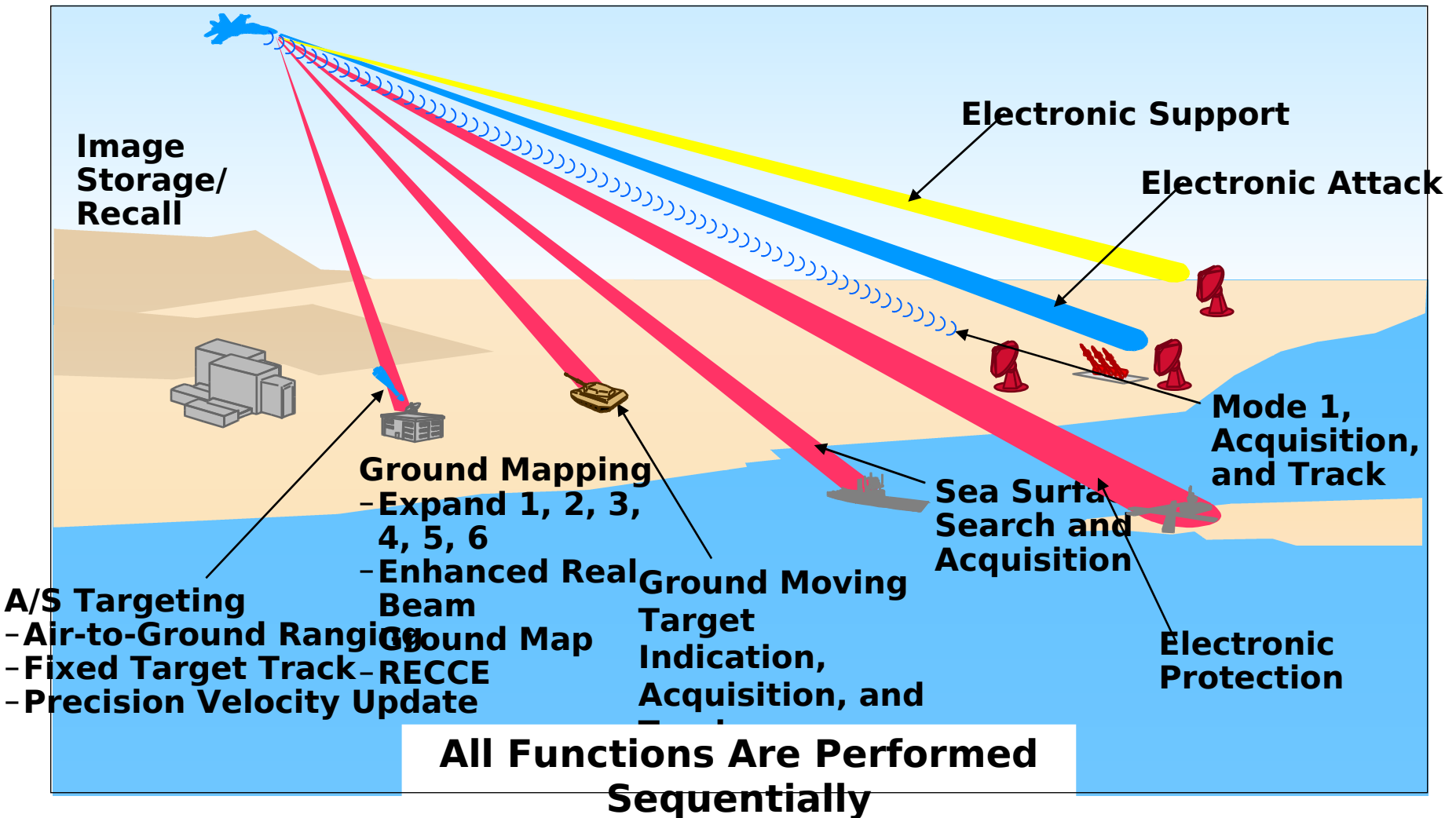
Cued Search  
and Acquisition

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# Air to Surface Capabilities





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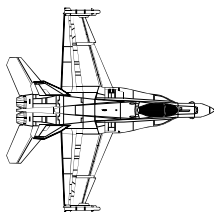
# Performance



# Reduced RCS and Increased Detection Range Provide Significant Operational Advantage



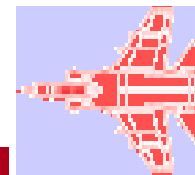
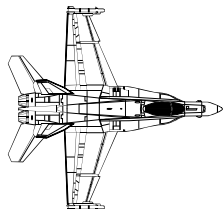
**AESA**



**0.5X**

**2005  
Threat  
(1 sqm)**

**MSA  
Scanning**

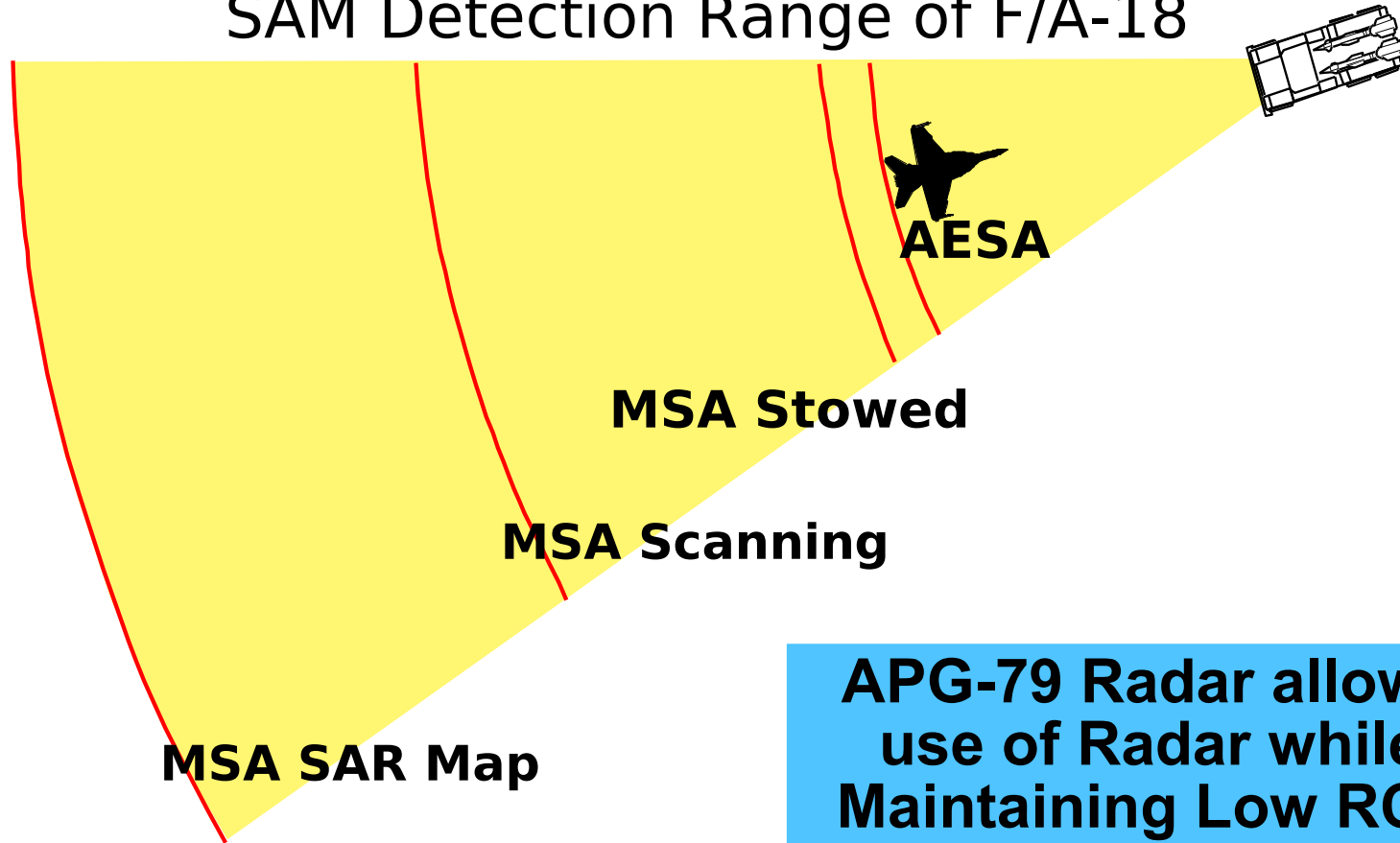


**1.0X**



# Reduced Detection by SAM Radars

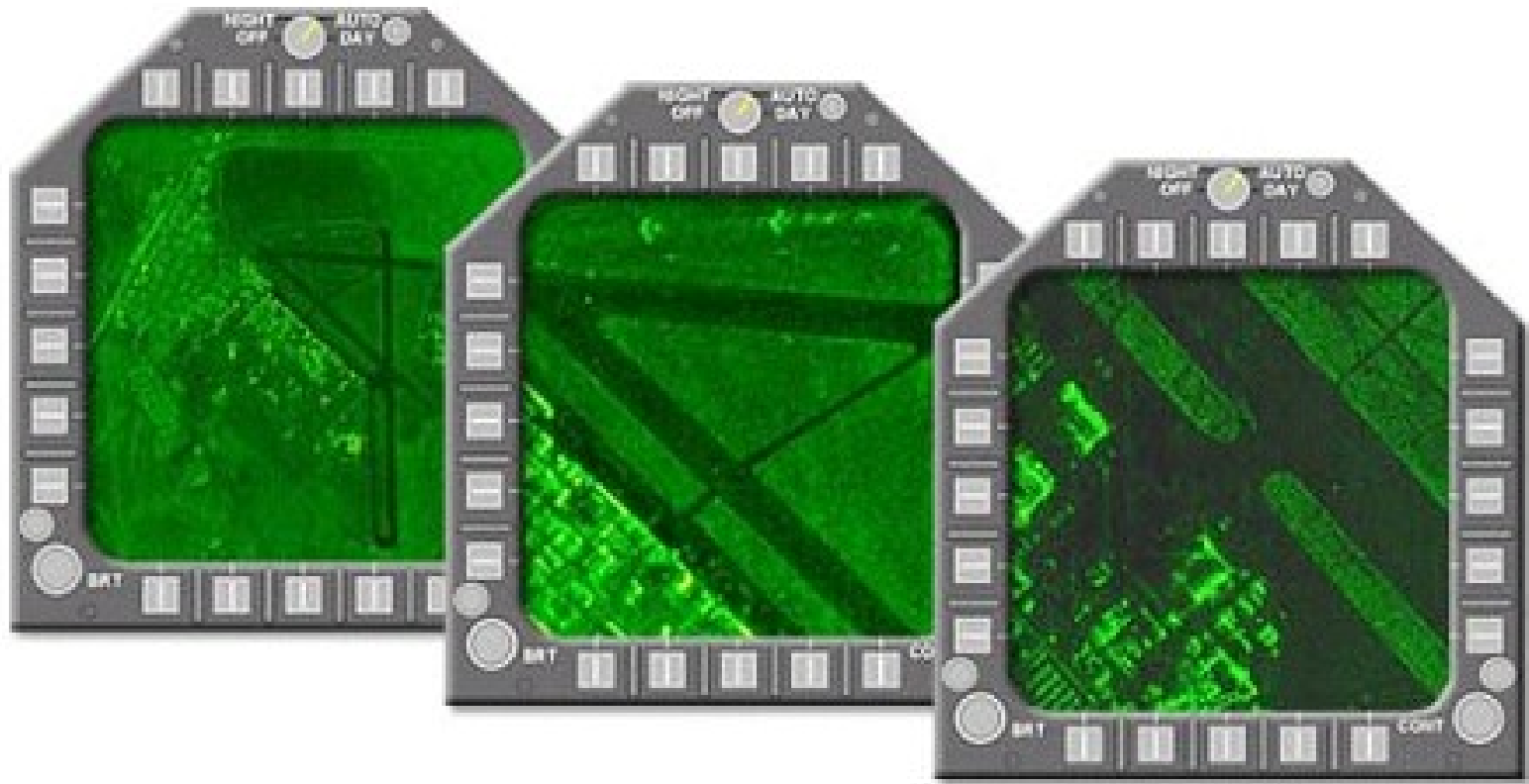
SAM Detection Range of F/A-18







# Better Map's at Longer Ranges

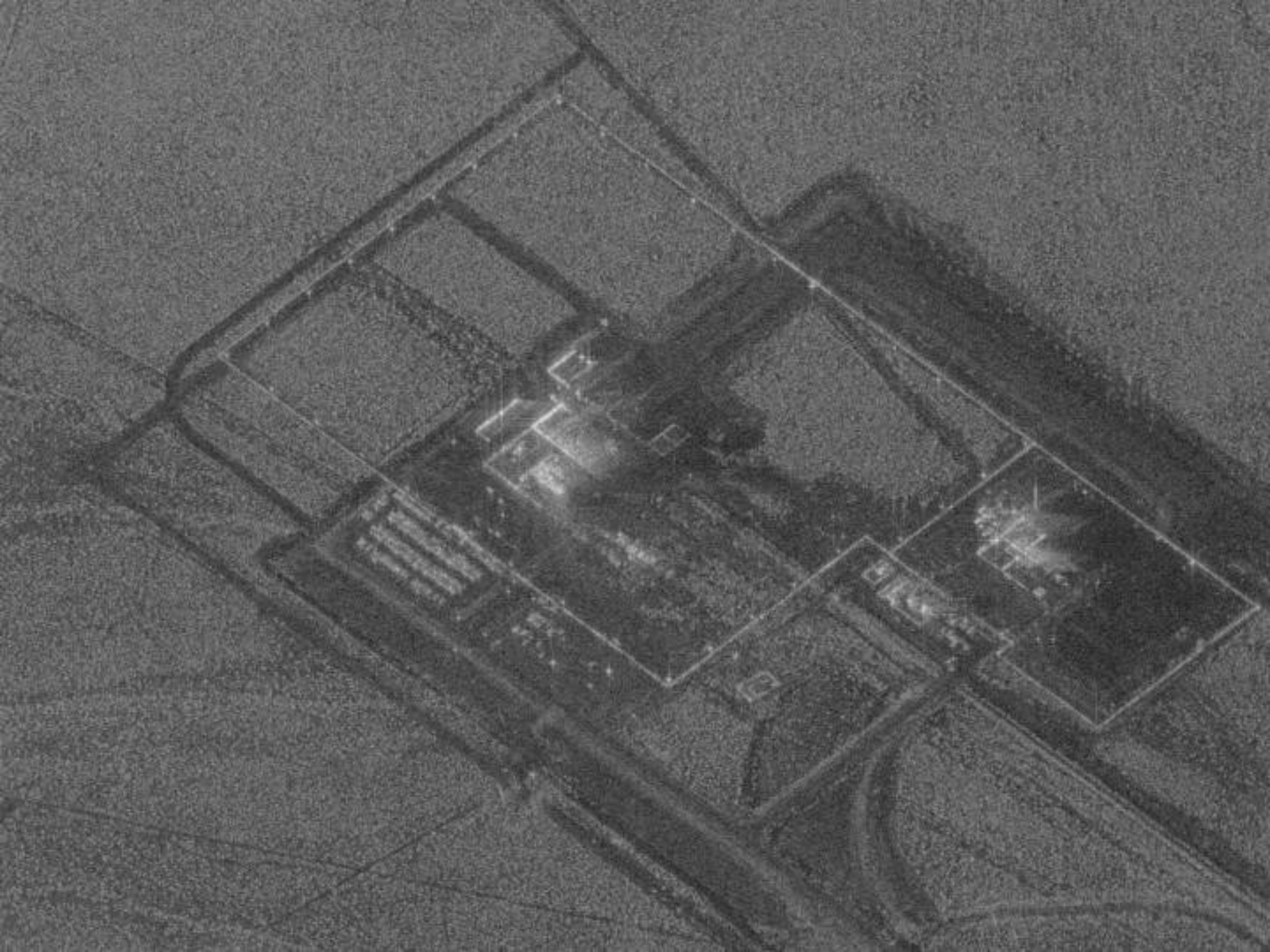














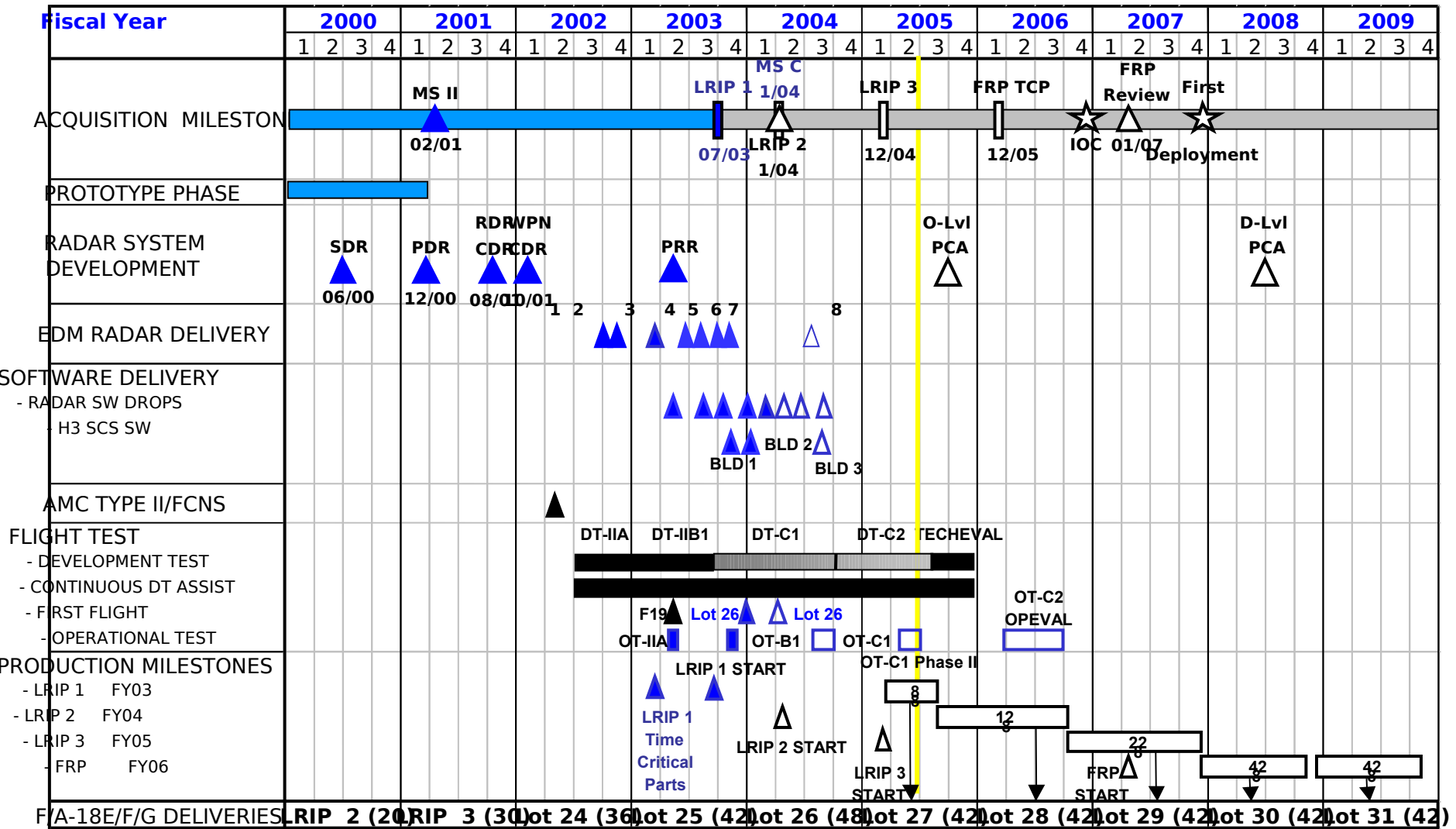
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# Schedule



# AESA Integrated Schedule







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# Risk Management- Others



# Risk Management- Others



## Background

- FA-18E/F Super Hornet Block II (Lot 27) includes APG-79 radar upgrade
- Validation of Block II design used an extensively modified Lot 23
- Modification included major changes to the ECS, fuel system, electrical power distribution system, mission computers, and cockpit displays
- Ground test procedures were established as part of the Block II AESA Flight Test Plan
- Test Hazard Analysis addressed perceived risks associated with ground and flight test
  - FOD “walkdown”
  - Exterior Inspection





# Risk Management- Others



## Events

- During first high power turn, substantial damage occurred to one engine
- Further investigation revealed a metal fastener was inadvertently left in the ECS ducting during the aircraft modification





# Risk Management- Others



## Lessons Learned

- Review of FA-18E/F aircraft EMD ground testing revealed that “internal FOD” damaged several engines early in the effort
- FA-18E/F aircraft EMD ground testing subsequently adopted a thorough Safety Checklist that included internal FOD checks and reduced FOD damage to zero
- Block II AESA test plan did not include a thorough review of the Safety Checklist of the FA-18E/F aircraft ground test plan
- Failure to properly absorb lessons learned from previous test plans/tests





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# Risk Management- Goods



# Risk Management- Goods



## Background

- High risk flight test points were identified prior to first flight
- Simulator rehearsal within 14 days was required to perform the flight
- Simulator facility was more than 200 miles from the test airfield
- Consequently the aircraft experienced a series of aircraft discrepancies that delayed the first flight
- Simulator currency was overdue
- Significant pressure was placed upon the test team to conduct first flight





# Risk Management- Goods



## Events

- A waiver of simulator rehearsal was proposed to the test team
- Despite significant pressures, the test team elected to delay first flight to facilitate the simulator requirement
- During first flight, a mechanical failure within the ECS allowed bleed air to leak into the engine bay
- Test aircrew had rehearsed this specific emergency the day prior and recovered the jet safely without any further problems





# Risk Management- Goods



## Lessons Learned

- Value of sound decision making in the test planning process and the importance of honoring the process despite perceived pressure to execute







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# Summary



# Summary



- Methodical test planning to include lessons learned from previous like tests is essential for the safe execution of any test
- Perceived or unperceived pressures “to get the test point” or “get the x” has no place in the flight test environment
- A detailed “safety first” approach from the test team will enable the AESA radar to be integrated into the FA-18E/ F Super Hornet and deliver tremendous capability to the warfighter





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# Questions



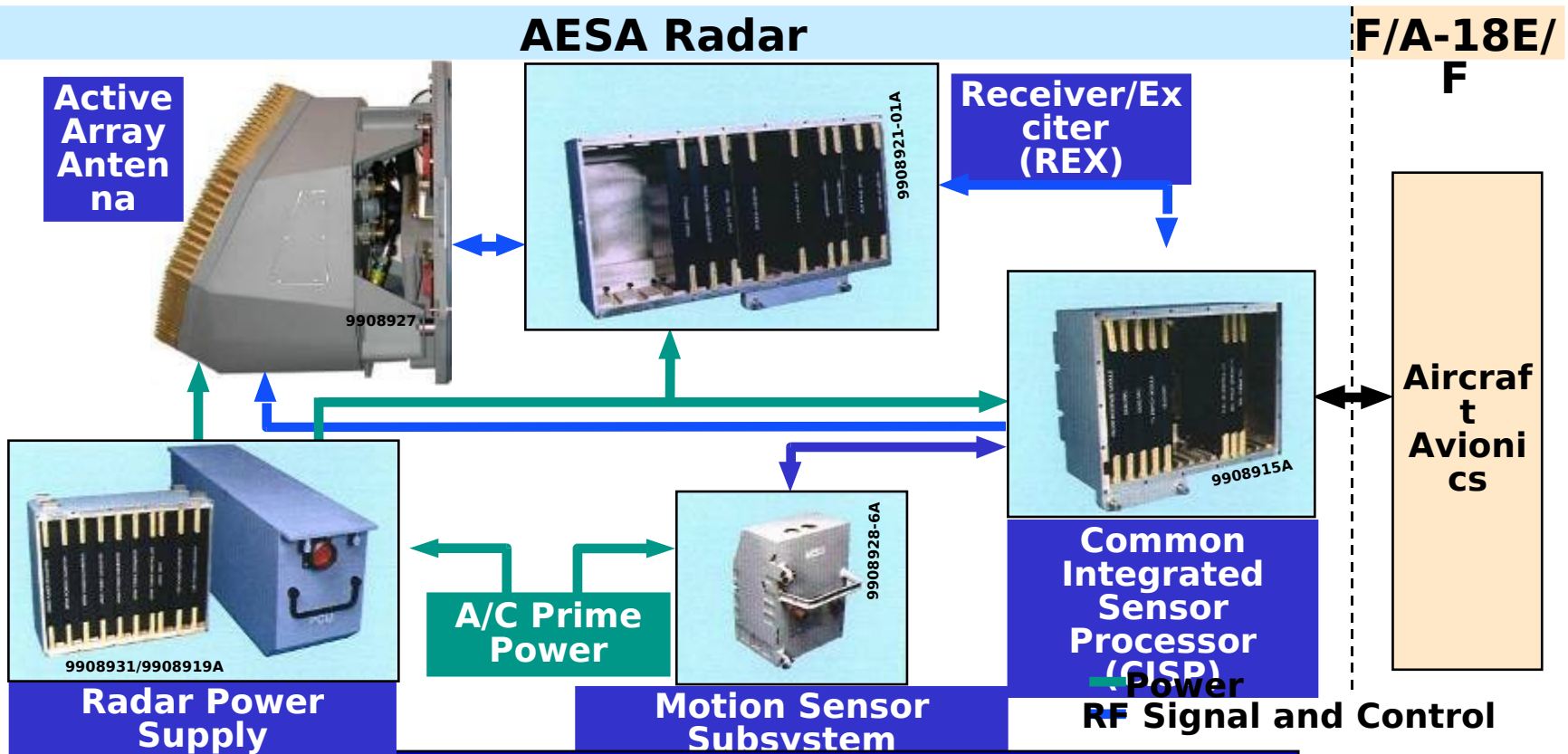
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# Backups



# The AESA Sub-system

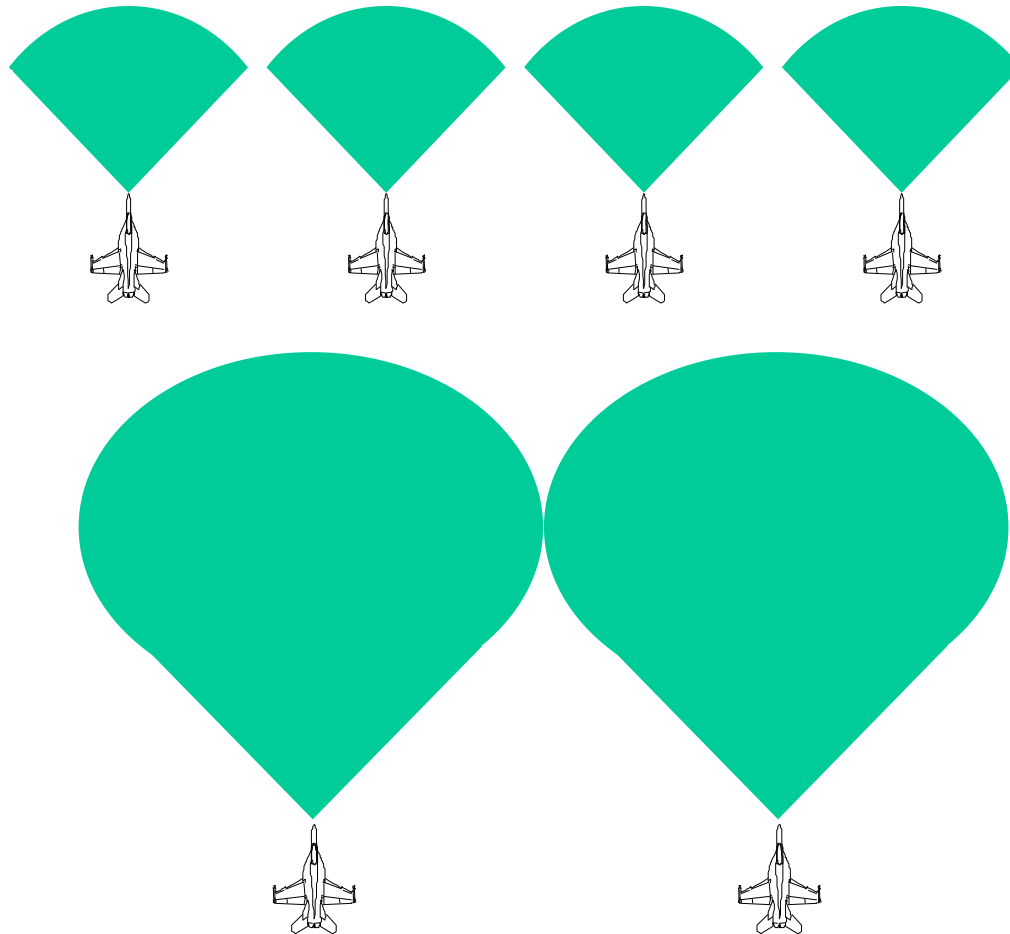


## Open System Architecture

Standard Interfaces      Affordable and Supportable  
COTS Components      Easily Upgradable and Scalable  
H/W + S/W Isolation Layers      Obsolescence Resistant Architecture

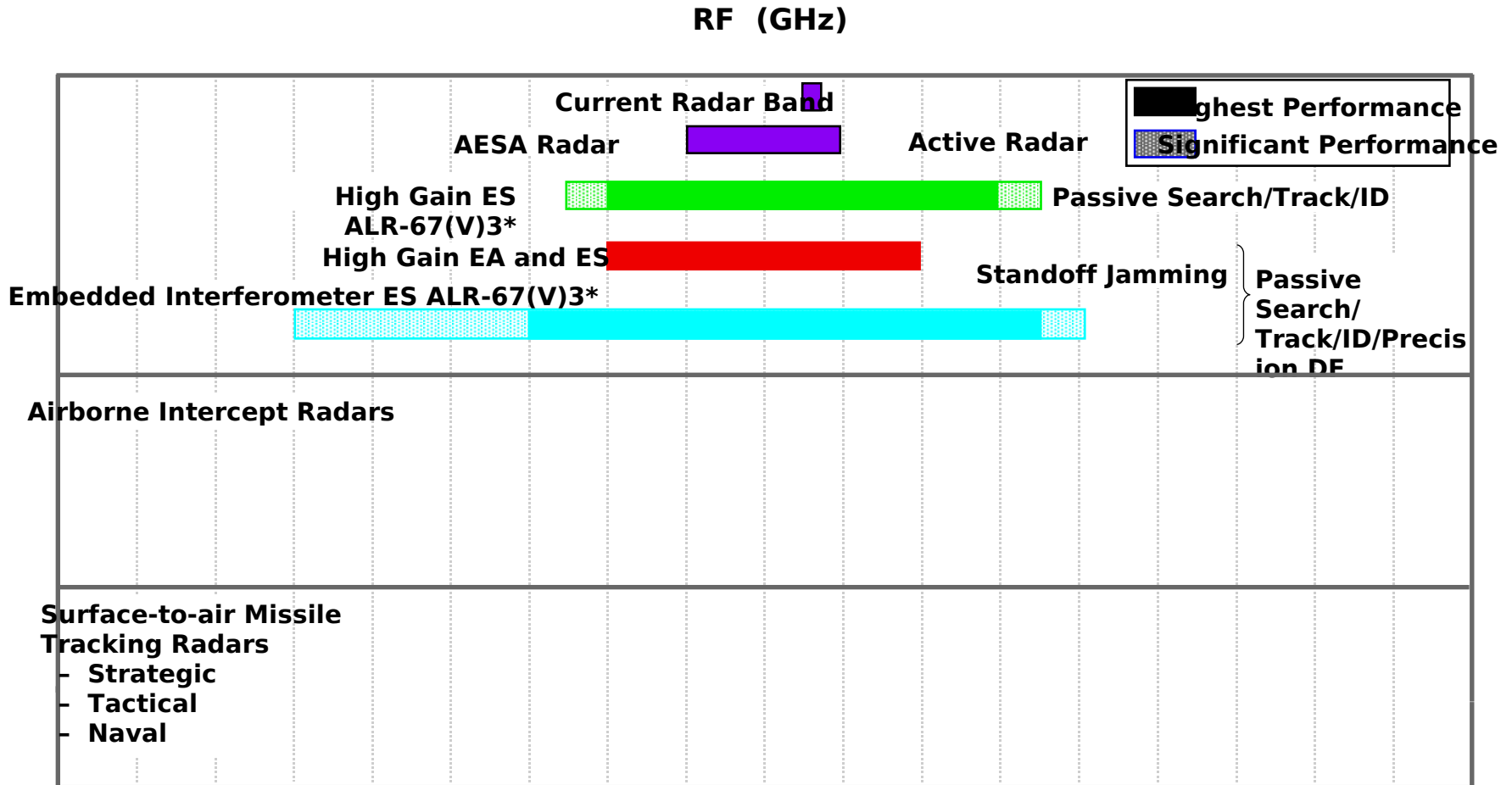


# Better Coverage and Reduced Assets with Improved Multi-Target Tracking





# AESA's RF Coverage for Active and Passive Operations

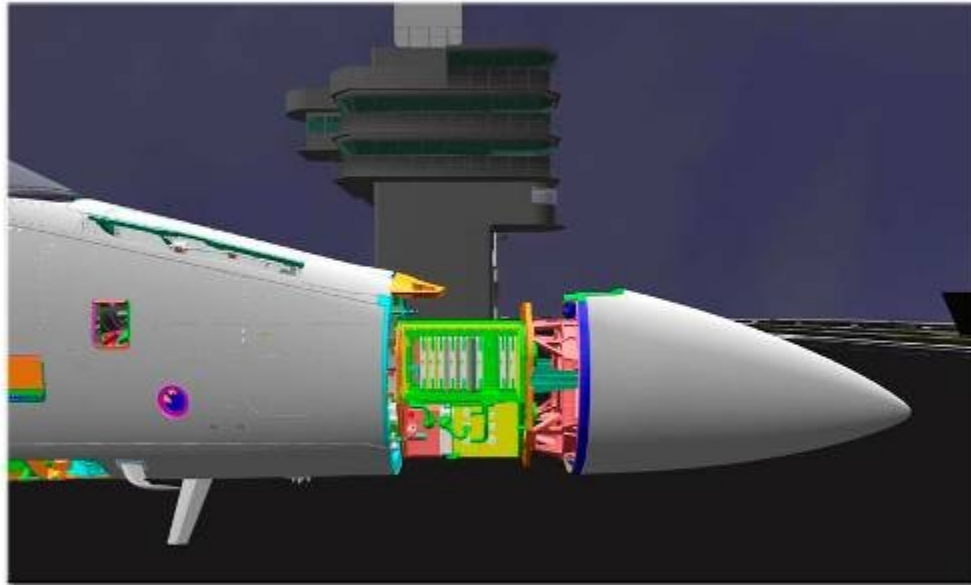


\* Note: All Functions are not Ba

**AESA Bandwidth Covers High Interest Threats**



# New Maintenance Concept



**Maintenance Position, Rack Extended**





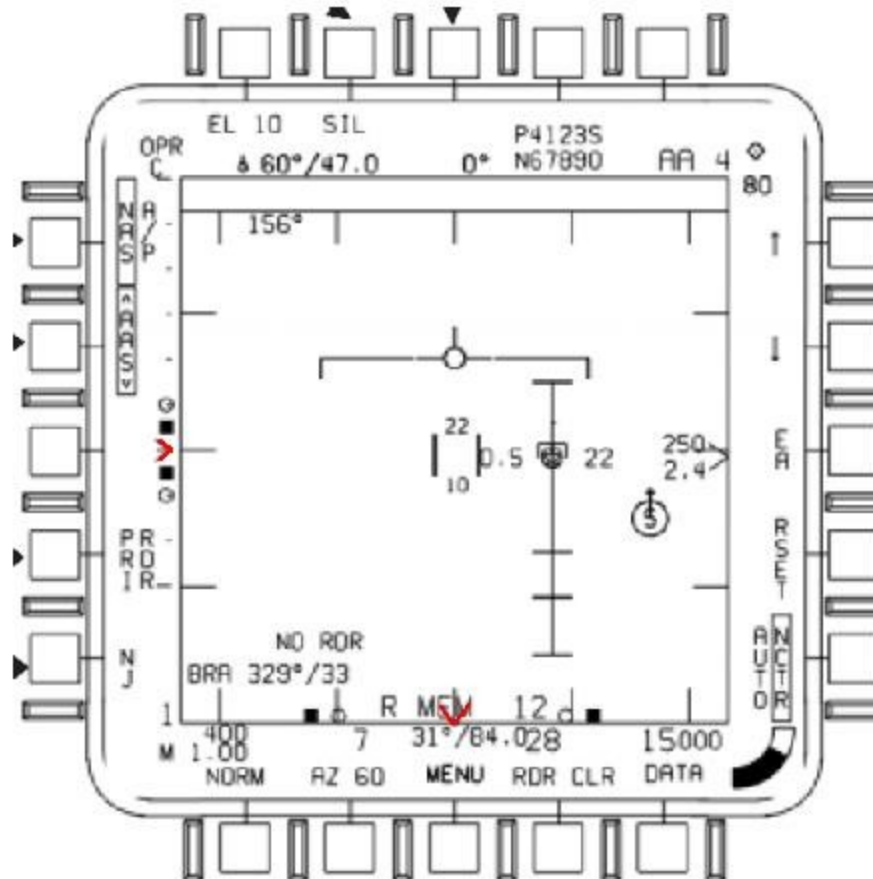
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# New Controls and Displays

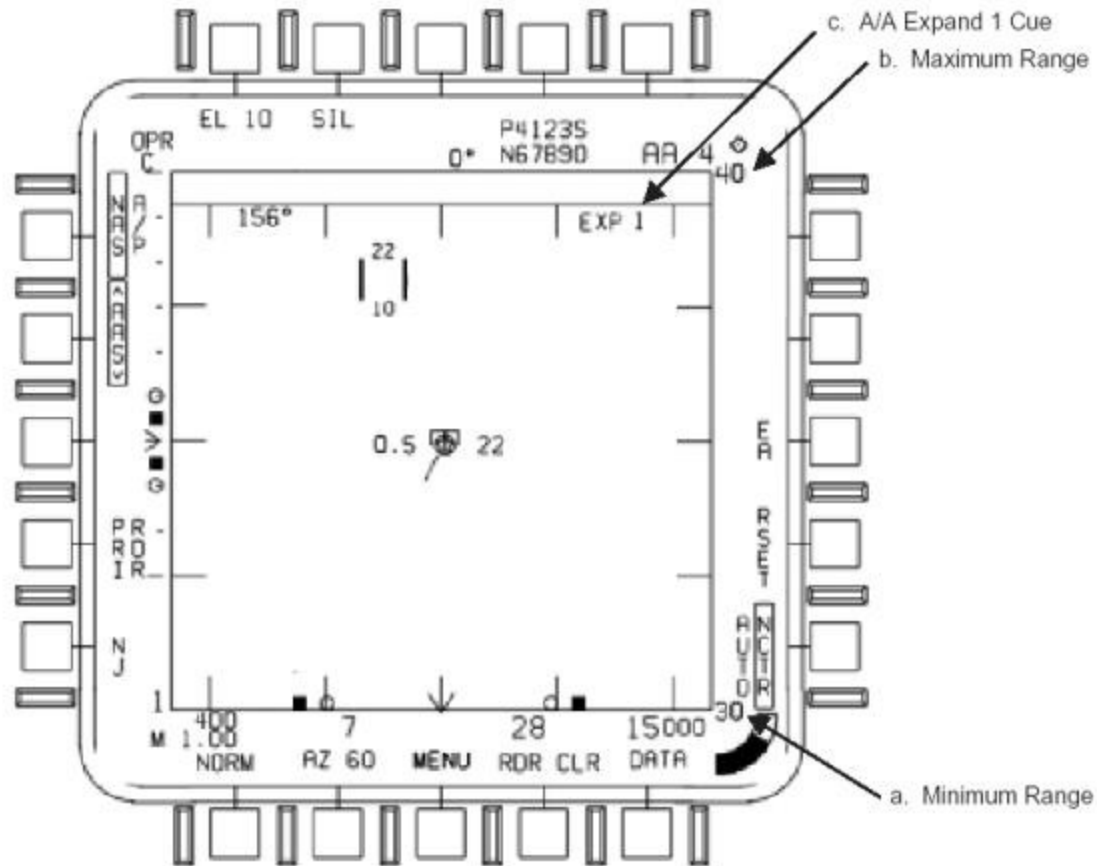


# A/A Attack Format



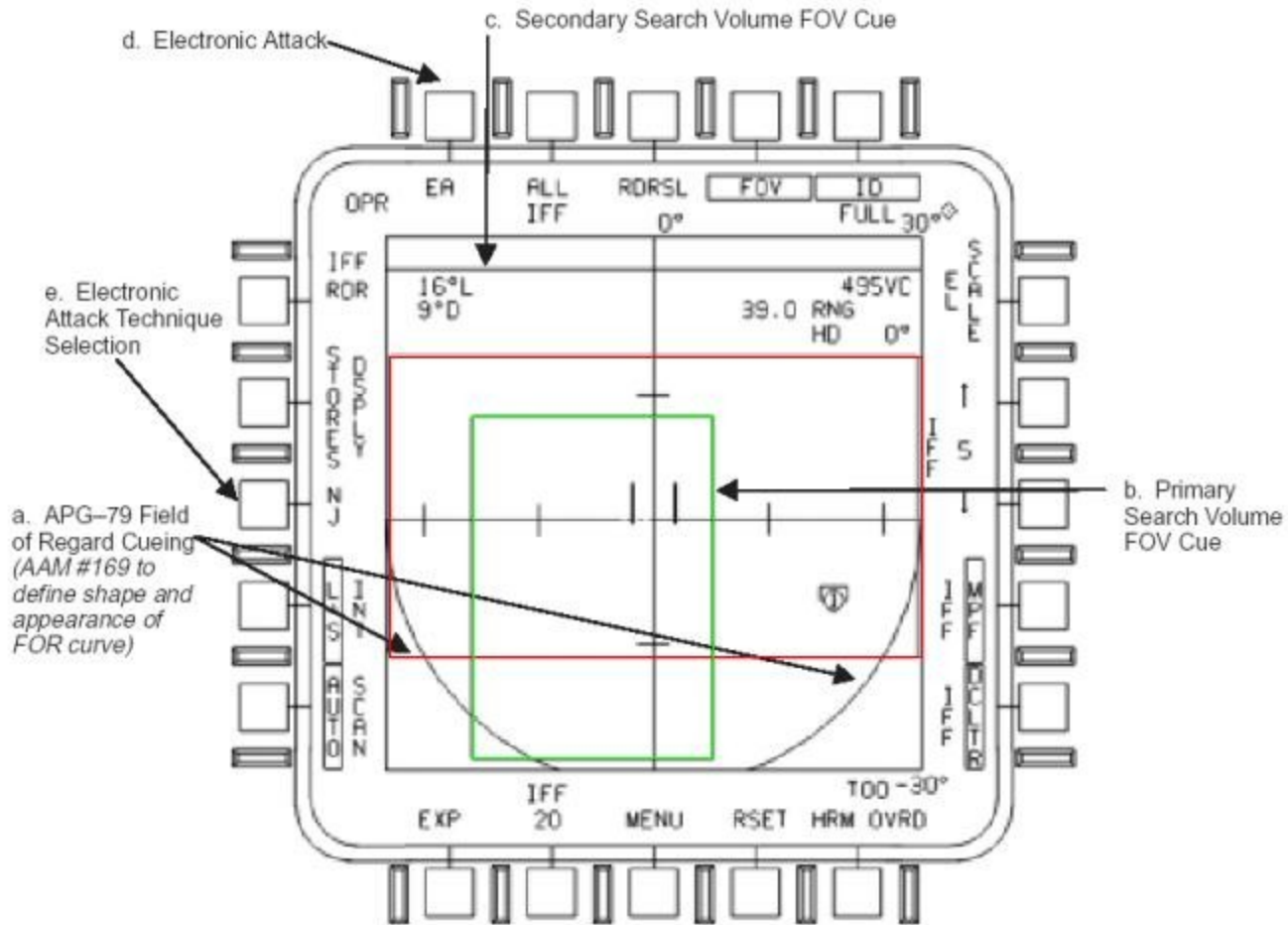


# A/A Expand 1



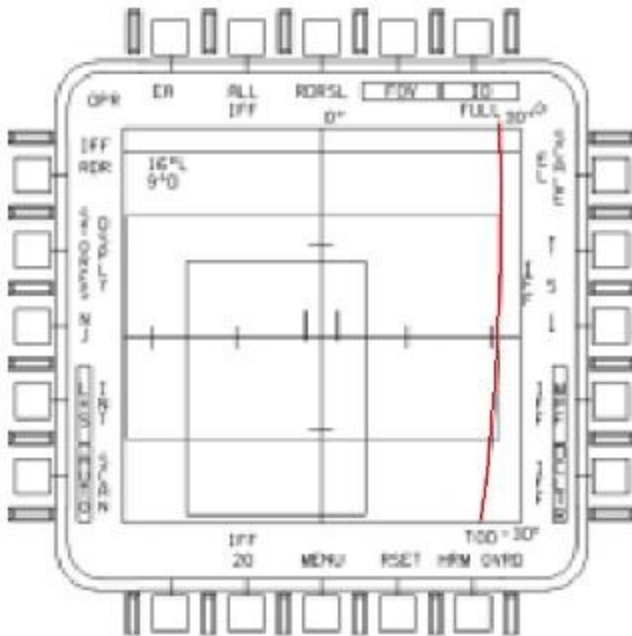


# Az/EI Format

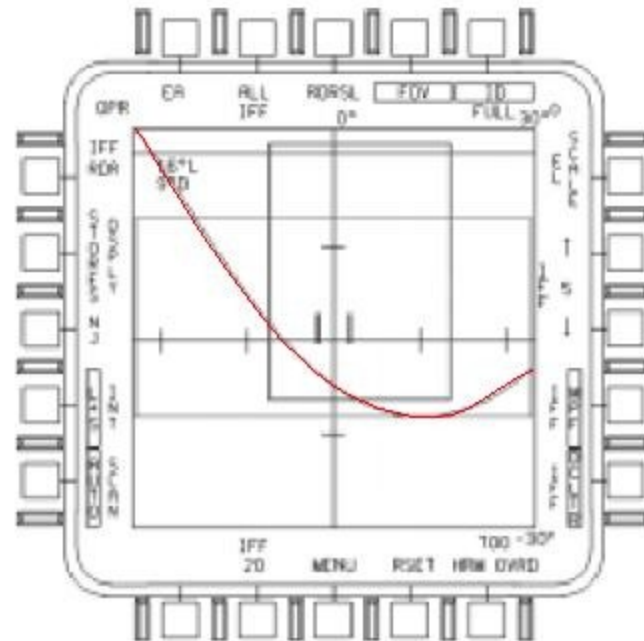




# Az/El Field of Regard Limitations



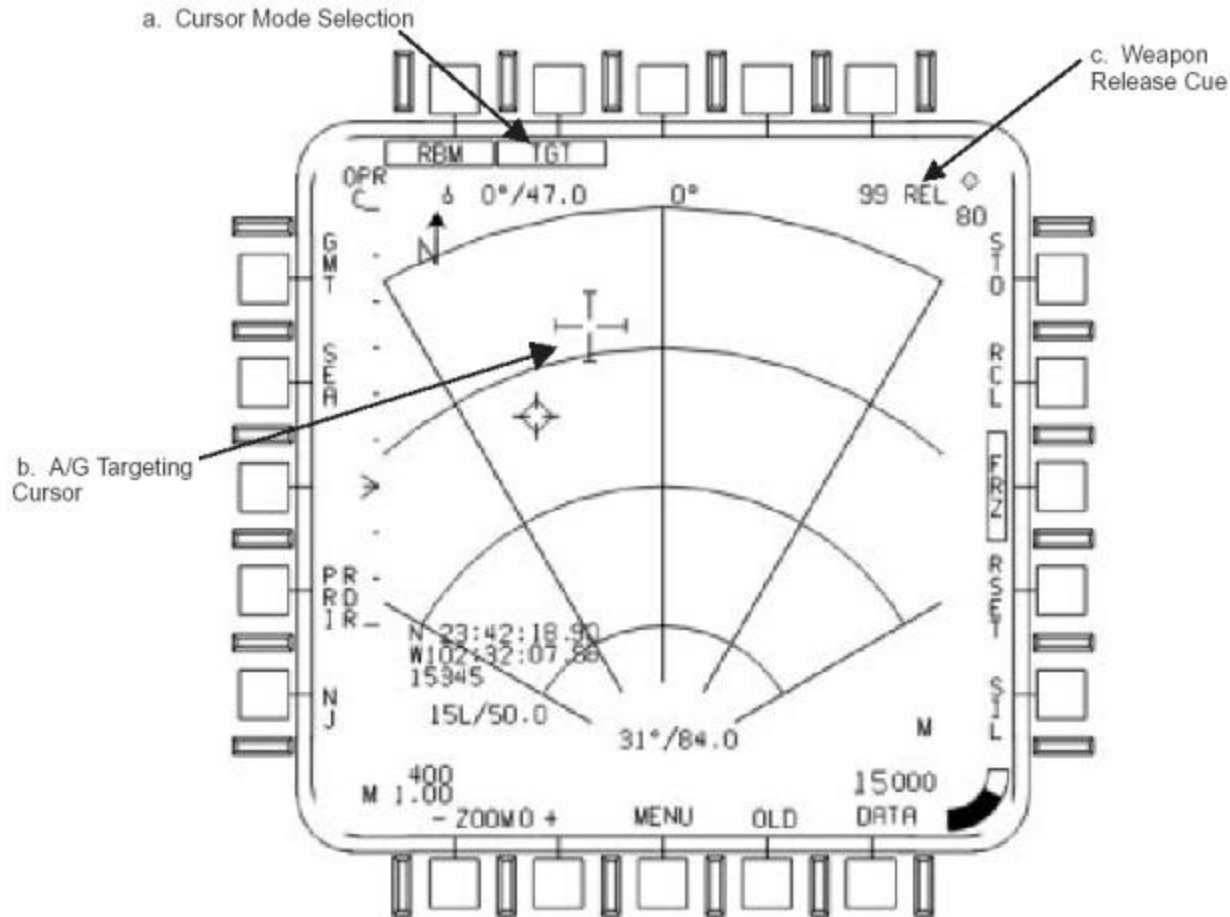
Aircraft Attitude of  $-20^\circ$  Pitch,  $-20^\circ$  Roll



Aircraft Attitude of  $+40^\circ$  Pitch,  $+40^\circ$  Roll

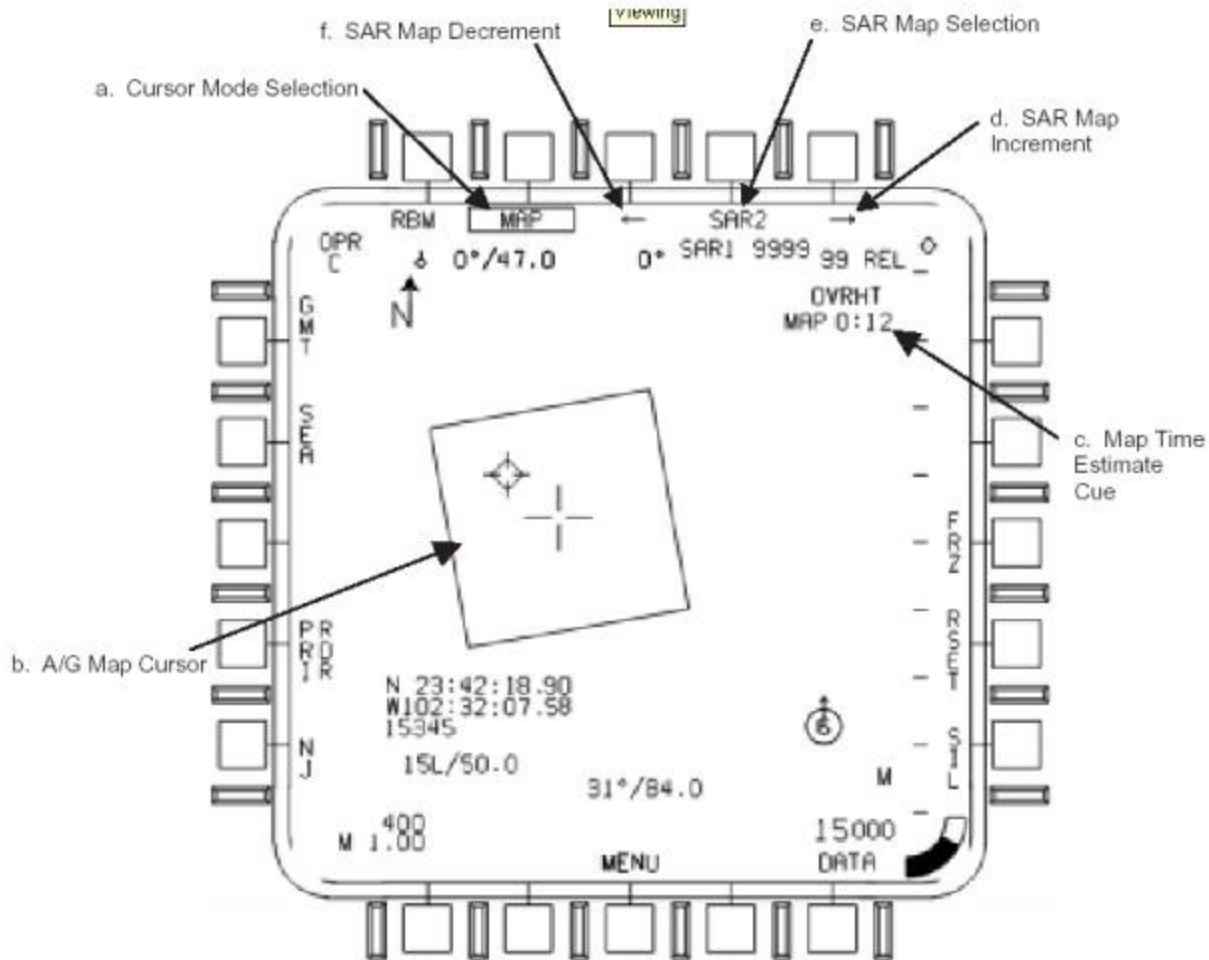


# A/G Targeting Cursor



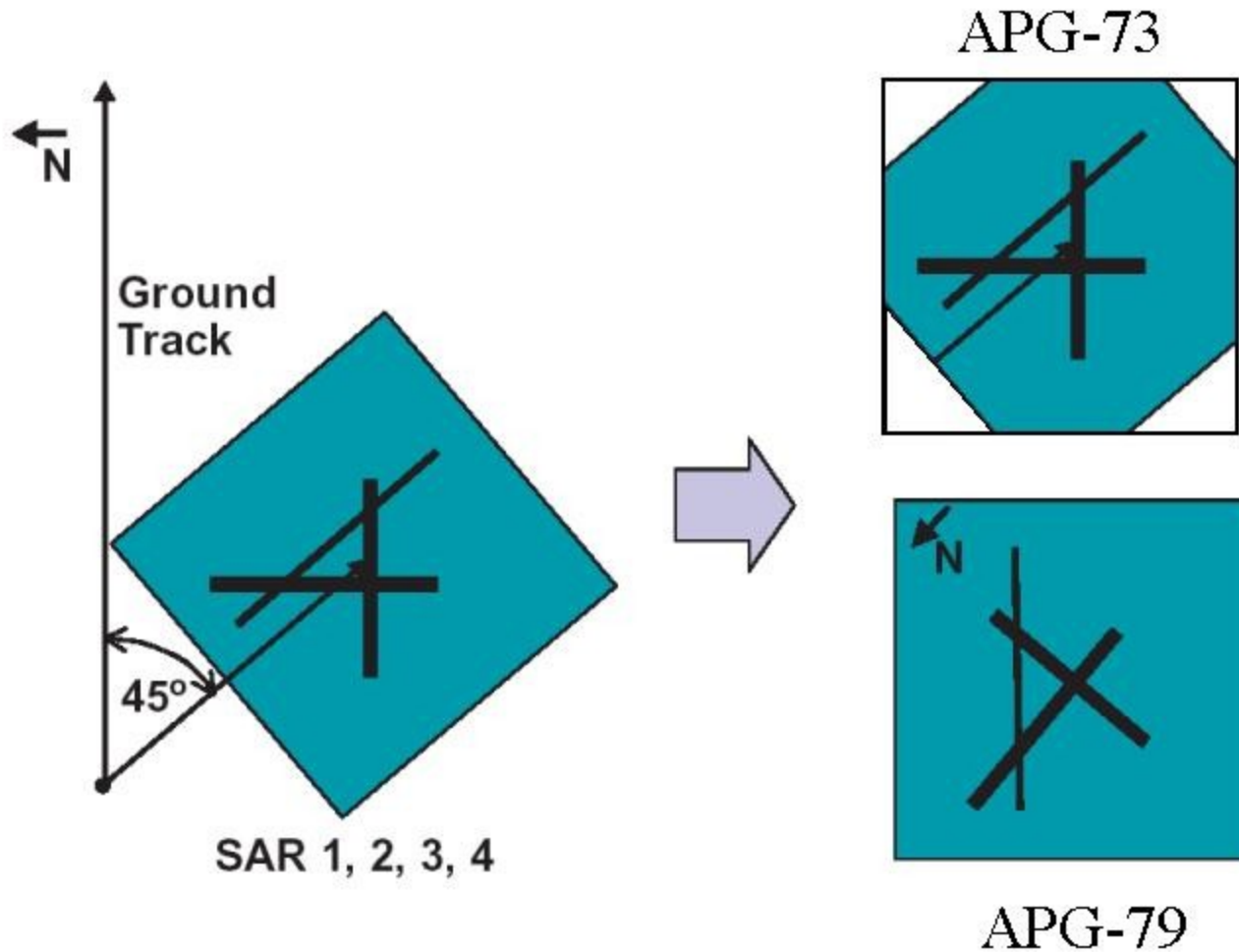


# A/G Mapping Cursor





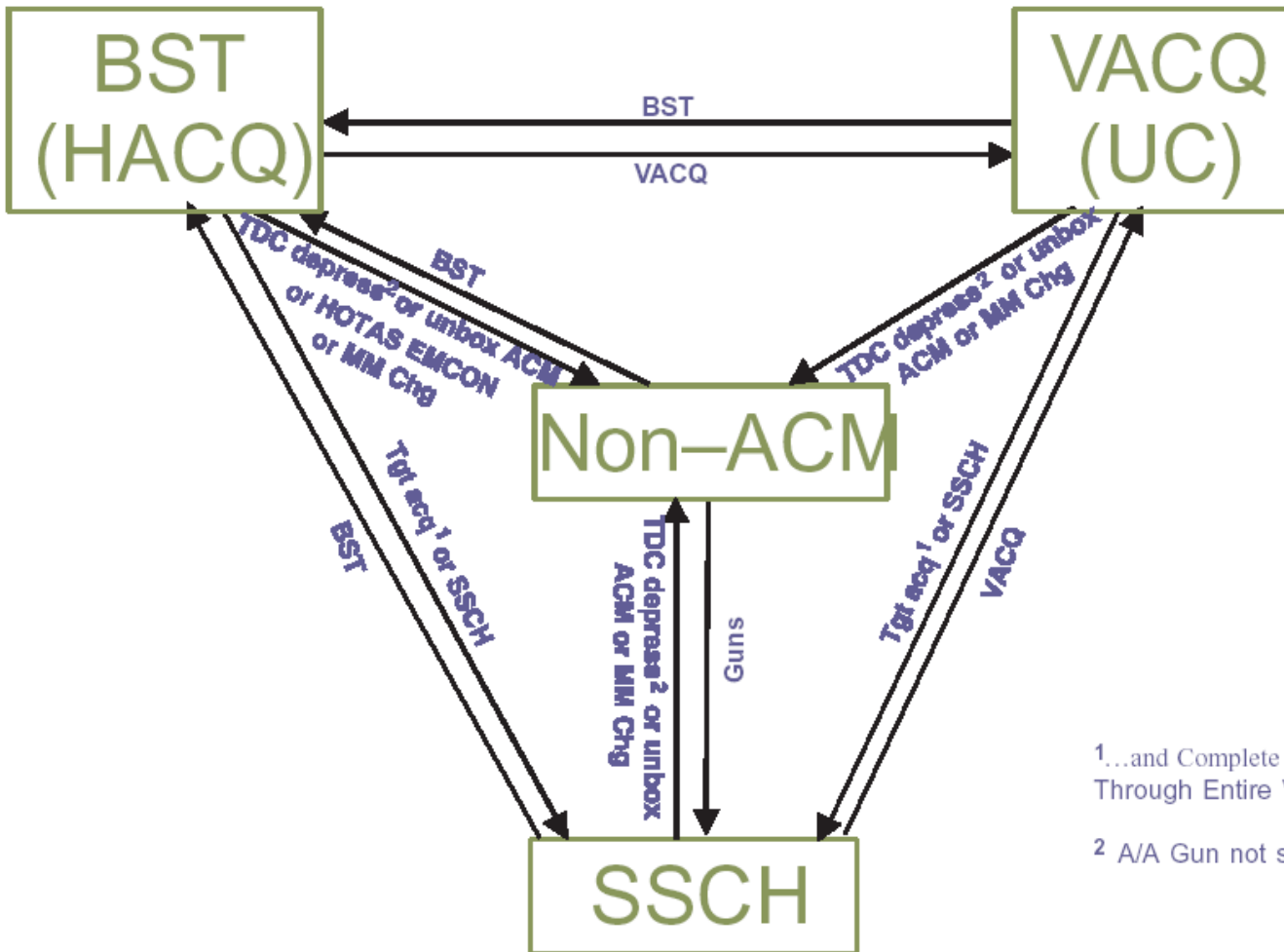
# A/G Patch Map Presentation







# A/A Mode Selection



1...and Complete at Least 3 Searches Through Entire Volume

2 A/A Gun not selected



# Key Performance Parameters

Characteristic (ORD)	ORD	Status		Margin	
		Prod.	EDM	Prod.	EDM
<b>Air to air</b> Multiple target track •Detection/track range for 11th target	100%	118%	116%	18%	16%
<b>Air to surface</b> SAR Imagery - Expand 6 •Range for $\leq X$ ft resolution @ 30° squint angle SAR TLE with Existing CAINS II/MAGR System (KPP A) SAR TLE with Accurate Navigation System (KPP B)	100% <100% <100%	109% 89% 89%	9% 11% 11%		
<b>Mode interleaving</b> Make SAR map @ X NM while maintaining track of four targets	<100%	62%	38%		
<b>Interoperability (AMRAAM)</b>	Critical IERs	All IERs	Yes		
<b>Operational Availability</b>	95%	98.1%	3.1%		



# Technical Performance Measures

Characteristic	Threshold	Status	Margin
Maintainability (MMH/FH)	0.0075	0.00345	54%
Reliability MTBF - radar only	917	818	30%
AESA weight increment (includes ECP 6038)	420 lbs	303 lb (Prod) 308 lb (EDM)	28% 27%
Power	21 KVA	18 KVA (Prod) 17.9 KVA (EDM)	14% 14.7%
Liquid cooling	15.6 kW	14.76 kW (Prod) 15.02 kW (EDM)	5.4% 3.7%