R&D In Navy Phased Array Radar Research and Development

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Outline

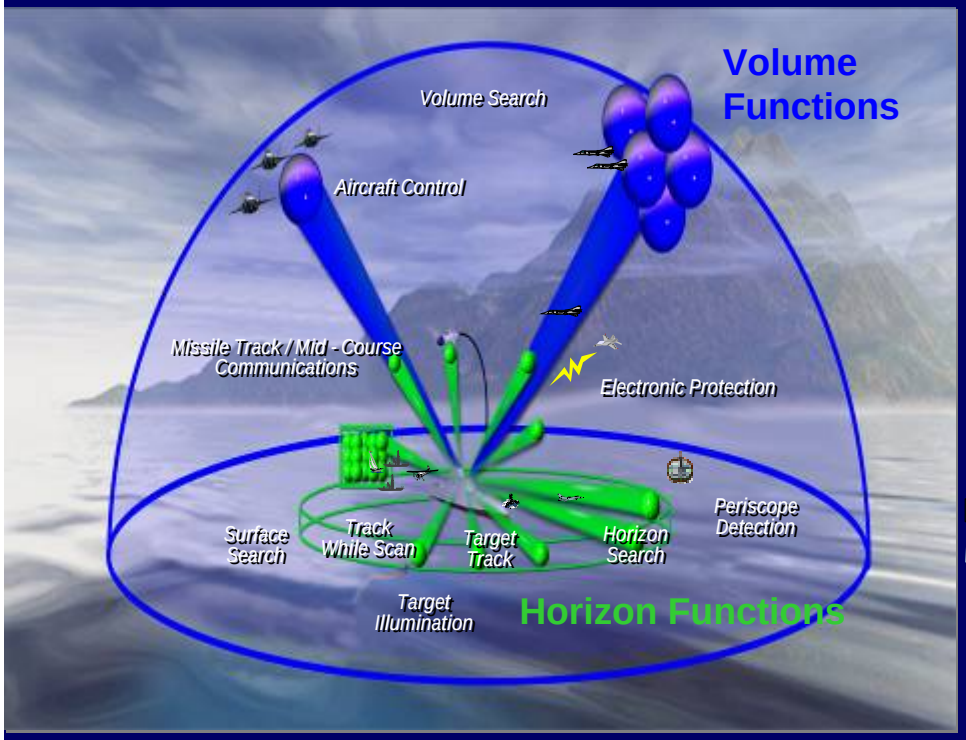
- Surface Navy Phased Array Evolution
- Digital Array Radar (DAR) Program
- Affordable Common Radar Architecture (ACRA) Program
- Navy Phased Array Radar / Multifunction Phased Array Radar Synergies / Differences

Navy Phased Array Radar Highlights

- Primary Navy research and development activities centered on S-band phased arrays for volume surveillance applications from surface combatants.
- Near term S&T need driven by risk reduction for Air and Missile Defense Radar (AMDR) area and ballistic missile defense multi-mission requirements
  - High sensitivity, wide dynamic range and flexible time energy management
- Longer term S&T need driven by risk reduction for affordable volume surveillance radar concepts to replace aging fleet of legacy long range surveillance systems
- The S&T strategy includes pushing hardware and software Open Architecture into the radar, not just at the radar / combat system interface

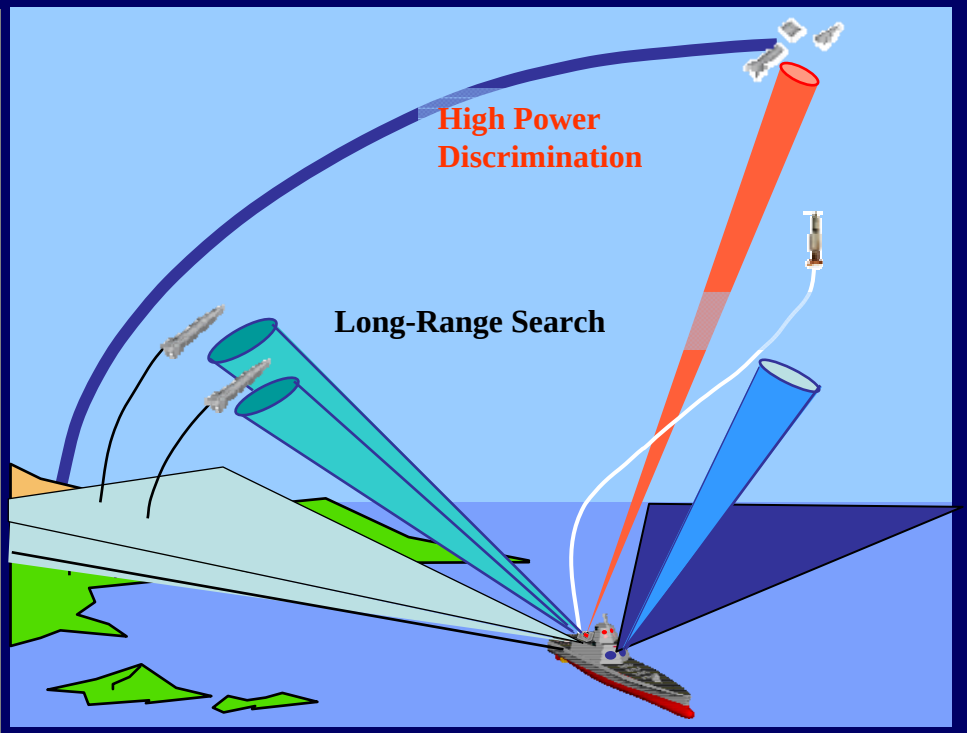
Surface Combatant Missions

Ship Self-defense



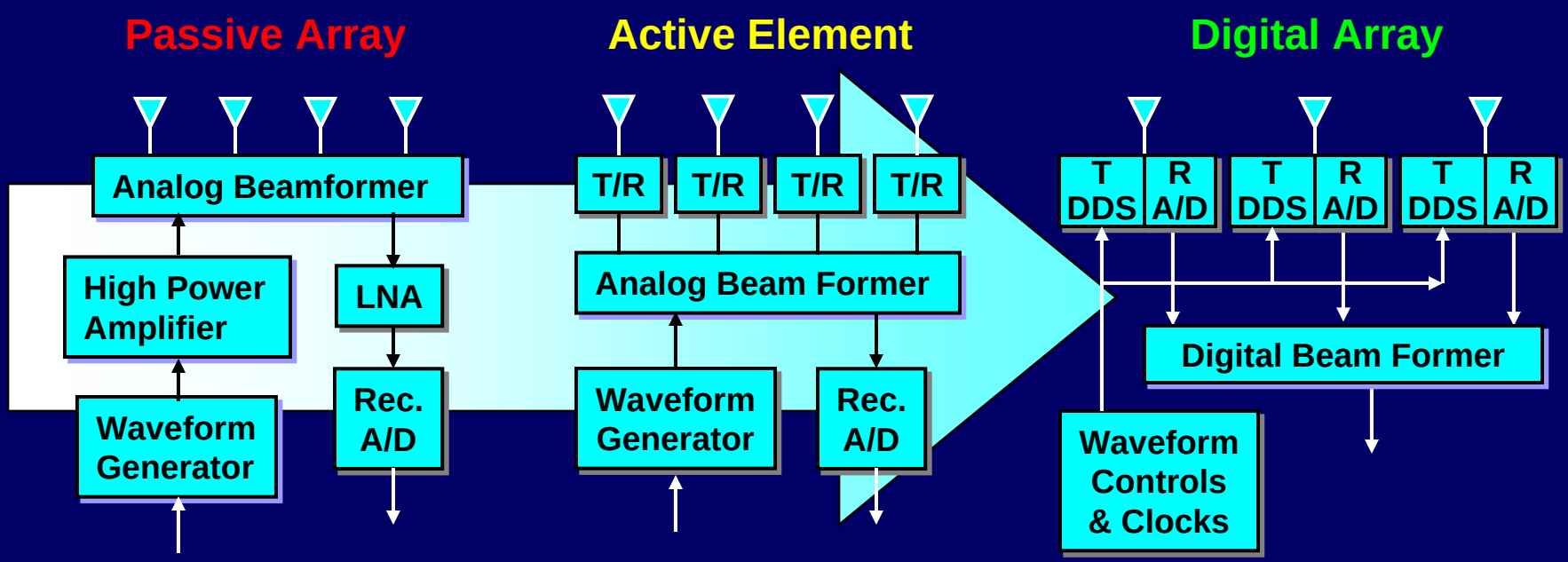
High power, multi-function radar (X-band)

Volume Surveillance



High power, S-Band Advanced Radar (SBAR)

Navy Phased Array Evolution



AEGIS AN/SPY-1

(Currently Deployed)

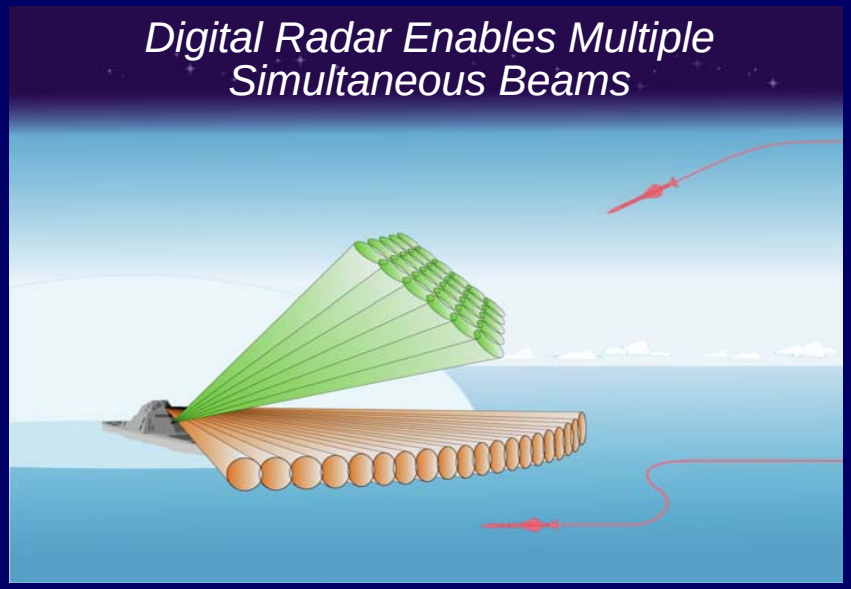
VSR

(Current Acquisition)

Future Radar

- Beam Forming
  - Multi-beam operation
- Flexible time energy management
- Power Aperture Gain Improvement
  - Large high power aperture

ONR Digital Array Radar (DAR) Program



Warfighting Improvements

- **Enabling technology for large S-band power aperture radars**
- **Improved time / energy management with multi-beam search**
- **Effective operations in the littoral**
- **Enables software upgrades as new effective techniques are discovered**
- **Increased dynamic range & stability**

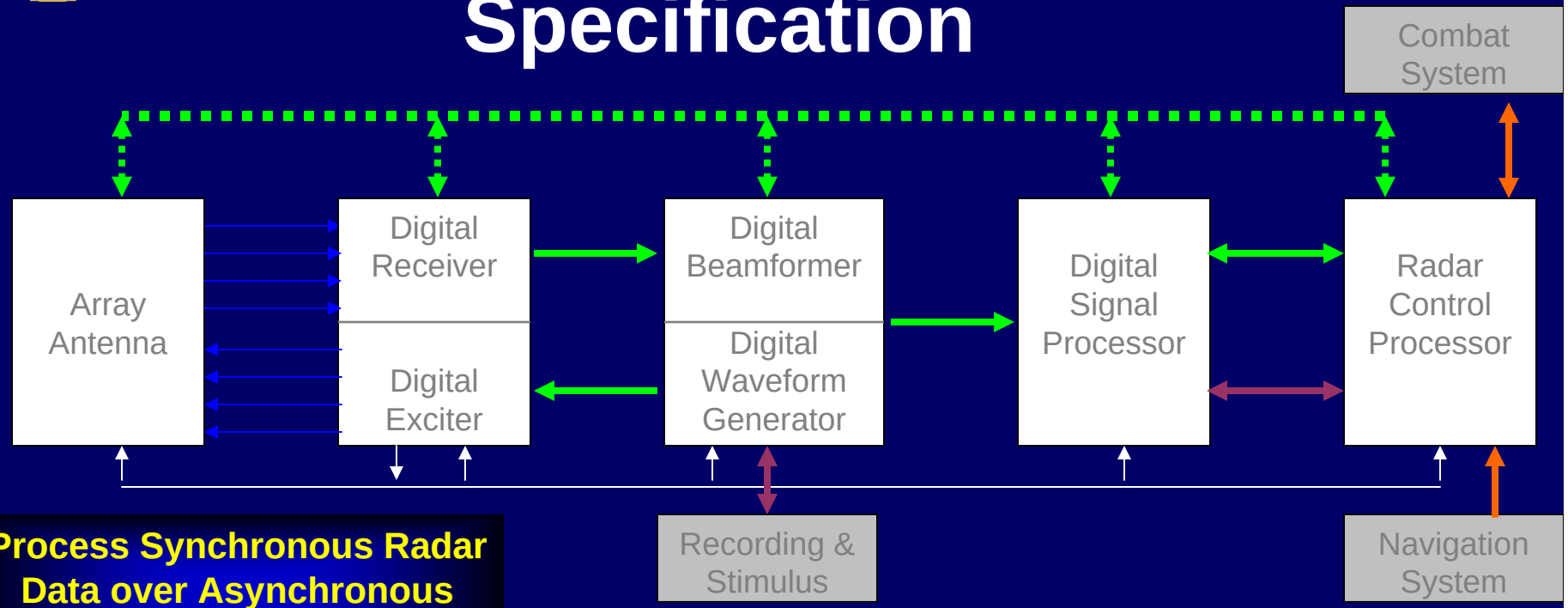
Products

- Subsystems Developed & Tested in Lab Environment
  - Digital Receiver / Exciter
  - Digital Beamform Processor
  - Digital Signal Processor

Products

- DAR Test Bed
- Test/Demo

Open Architecture Radar Specification



Process Synchronous Radar Data over Asynchronous COTS Networks

Analog Signal Lines

Digital Messages (defined in DAR Interface Control Document)

Digital Messages (defined elsewhere, but referenced by DAR ICD)

Digital Messages to be defined in future

Time of Day Clock lines

DAR Subsystems

External Subsystems

Open architecture design of radar allows subsystem development by multiple vendors

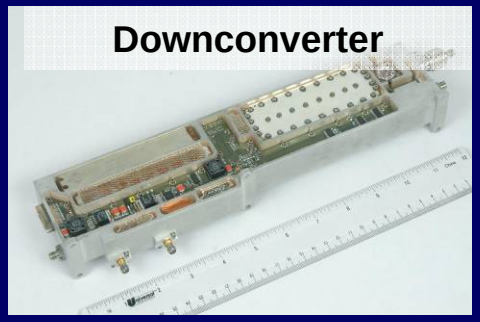
Digital Array Radar Architecture Highlights

- Decomposition of radar into loosely coupled subsystems with well documented interfaces allows
  - Potential for acquisition of radar subsystems in a more competitive environment
    - “Best of Breed” subsystems
    - Radar primes + smaller companies having niche technical capabilities compete for subsystem designs
  - Upgrade capability over time
  - Reuse of subsystems in other radar systems
- Time of Day control of subsystems facilitates coordination across a ship & in the future across a battle group
  - Sensor systems can understand what other sensors are doing in real time and adapt accordingly
  - Example: Electronic Support Measures (ESM) sensor can receive time of day based control messages for radar and determine what frequencies to avoid and when
- No contractor owned Intellectual Property in basic architecture and interfaces

DAR Digital Receiver Exciter

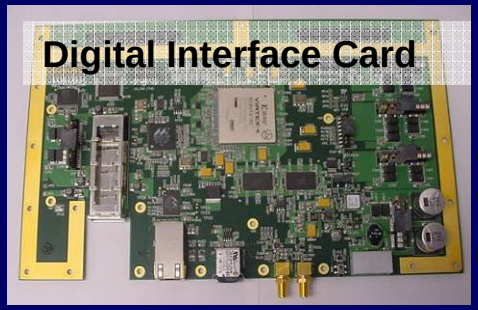
Upconverter

Downconverter



DAC Card

Digital Interface Card

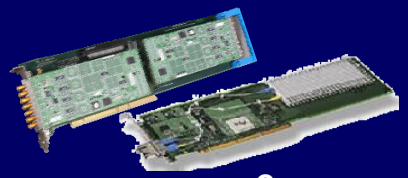


Gigabit Ethernet Control Card

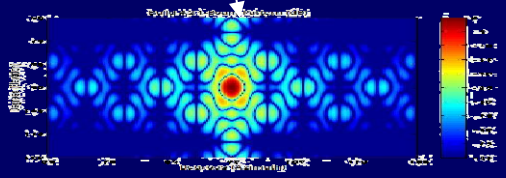
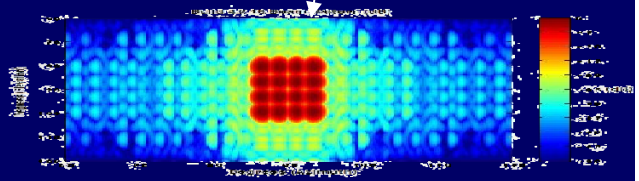
ADC Card

OA Digital Beam Forming

Fiscal Year 03 04 05 06 07


Build :	1	2	3	4	5	Chg
Channels/Board:	4	4	4	4	12	3x
Boards:	1	2	6	18	9	
Channels:	2	4	22	56	108	50x
Beams:	1	2	4	16	16	16x
Cost/Channel:	$10K	$10K	$5K	$5K	$2.3K	25%
Size/Channel:	1U	1U	0.25U	0.25U	0.1U	10%

All interfaces are Ethernet

Ongoing Improvements to Size, Cost, and Capability

Digital Processing Equipment

Commercial Network Switch

Used for Data Distribution and Control

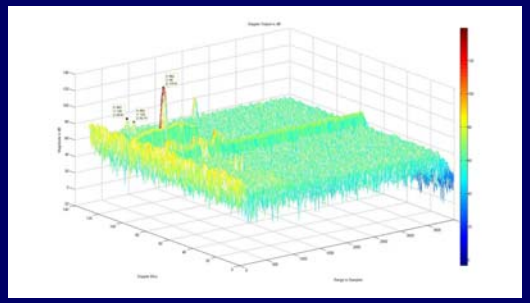
Commercial Blade Processor Example

for

Pulse compression, Doppler filtering, CFAR detection, tracking, control, etc

Digital Array Radar Test Bed

Tx/Rx array



- Test Bed construction progressing from 4 - 32 - 64 channels

ONR Affordable Common Radar Architecture (ACRA) Program

Shipboard
Fixed Phased Array

ACRA
Common Components

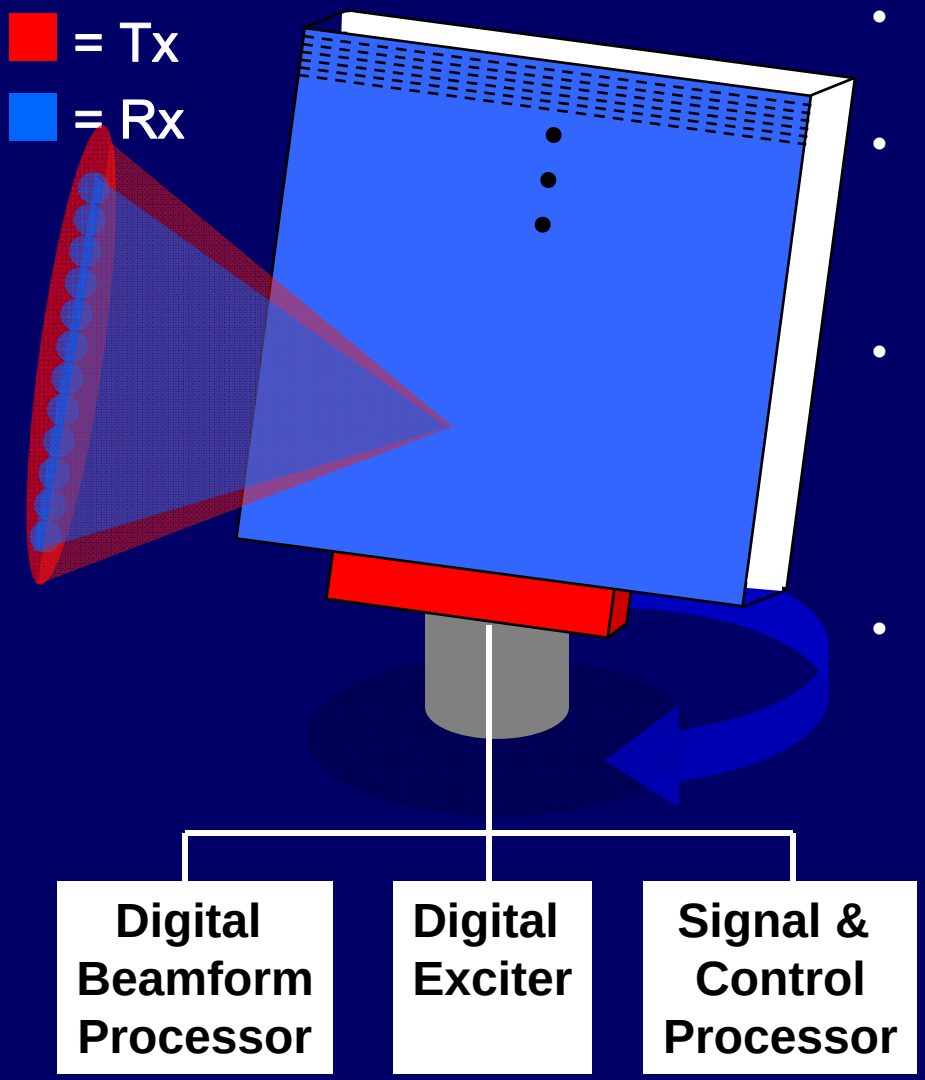
Scalable Arrays
Receiver/Exciter
Signal / Data Processor

Rotating
Phased Array

5 year (FY-09 - FY-13) Program to Build Risk Reduction Prototype

Using a Common Set of Subsystems, Build Designs That Can Meet Needs of Both Rotating Phased Array & Fixed Face Array Installations

ACRA Architecture



Federated Tx & Rx Apertures

- Transmit-elevation fan beam flooded with many high gain receive beams
- Large Rx array
  - Low cost printed circuit board design
  - Scalable 48x48 to 96x96 elements
- Smaller Tx array
  - Active array design for prototype
  - Upgrade Tx independent of Rx – over time & as new technology emerges
- Reuse of several critical technologies developed by Digital Array Radar program
  - Digital exciter
  - Digital beamformer

New technology developments

- Rx array
- Tx array
- High density, low cost downconverters

Navy PAR and MPAR Synergy/Differences

Parameter	Navy High Performance	Navy Legacy Replacement	MPAR[1]
Sensitivity	highest	high	high
Pulse width / duty cycle	highest / highest	higher / higher	lowest / lowest
Tunable Bandwidth	widest	wider	narrowest
Instantaneous Bandwidth	widest	wider	narrowest
# Simultaneous Beams	larger	lowest - largest (design dependent)	lowest - largest (design dependent)
Stability	highest	high	high
Dynamic Range	highest	high	moderate
Electromagnetic Compatibility	highest	highest	lowest
Polarization	linear	linear	linear (switchable) / circular

[1]From "MPAR Trade Studies" presentation by Mark Weber, National Symposium on Multifunction Phased Array Radar, 12 October 2007

Comments on Navy PAR / MPAR Synergy/Differences

- MPAR past notional designs appear to be focused on large arrays of low power elements with volume production and design for manufacturability applied to control costs
  - T/R module / array technologies synergy with Navy applications unclear
- Possible potential for common elements of:
  - Digital Receiver Exciter
  - Digital Beam Forming
  - Signal Processing and Controls
- A well defined Open Architecture would allow greater opportunity for re-use across programs
  - Would require design to superset of requirements
  - Cost savings potential depends on requirement specifics and volume of purchase
    - Possible to realize cost savings for all participating parties OR only for one party (low volume DoD application with more demanding requirement could benefit, while high volume application with less demanding requirement might suffer)

Summary

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