



Multifunction Phased Array Radar (MPAR) Risk Reduction Effort

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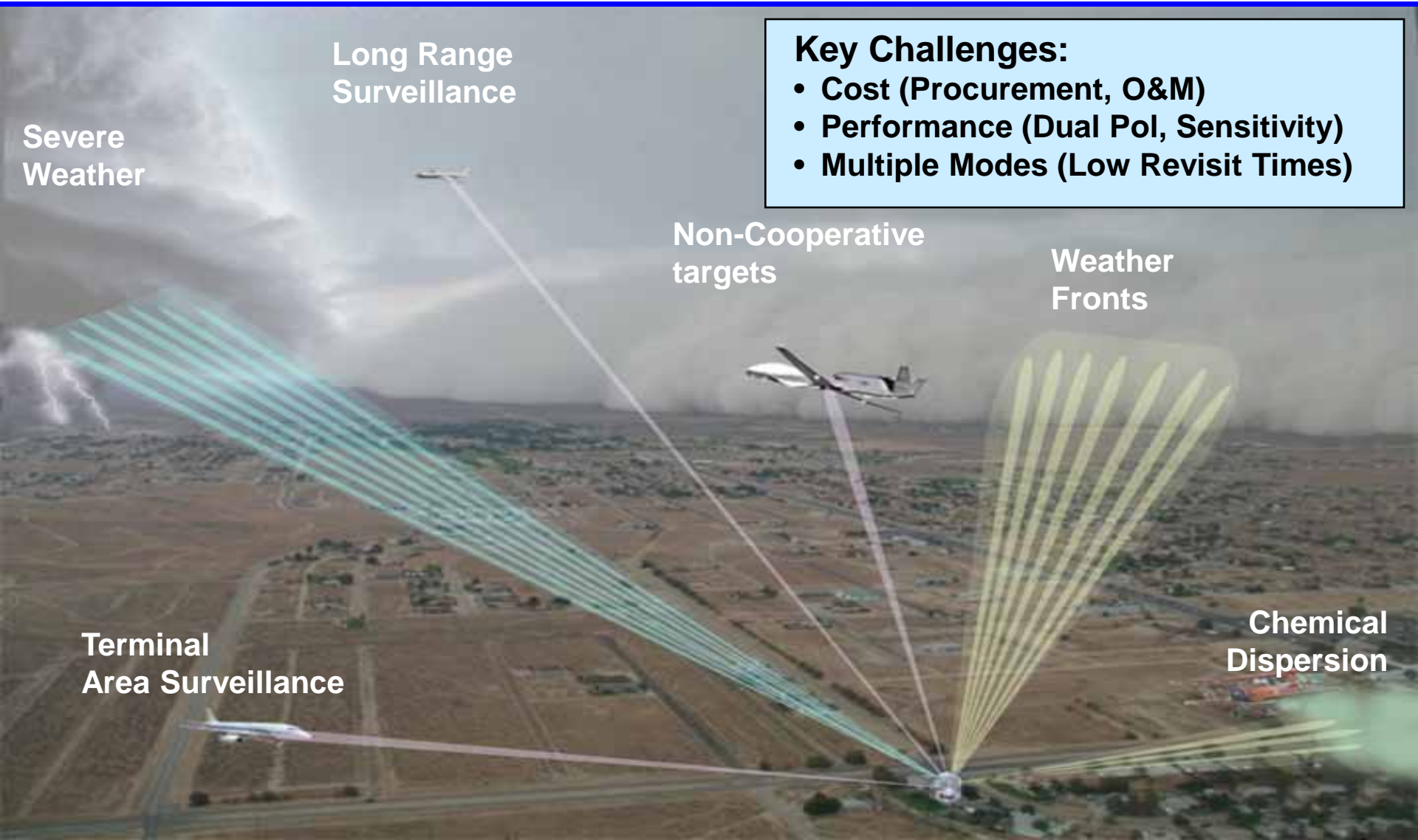
M/A-COM Technology Solutions

*This work was sponsored by the FAA under Air Force Contract FA8721-05-C-0002. Opinions, interpretations, conclusions, and recommendations are not necessarily endorsed by the United States Government

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MPAR Operational View



Key Challenges:

- Cost (Procurement, O&M)
- Performance (Dual Pol, Sensitivity)
- Multiple Modes (Low Revisit Times)

Long Range Surveillance

Severe Weather

Non-Cooperative targets

Weather Fronts

Terminal Area Surveillance

Chemical Dispersion





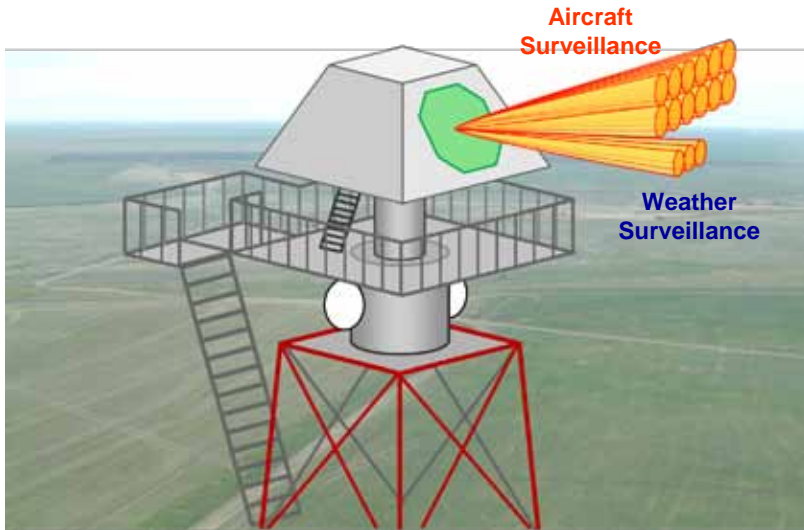
Outline



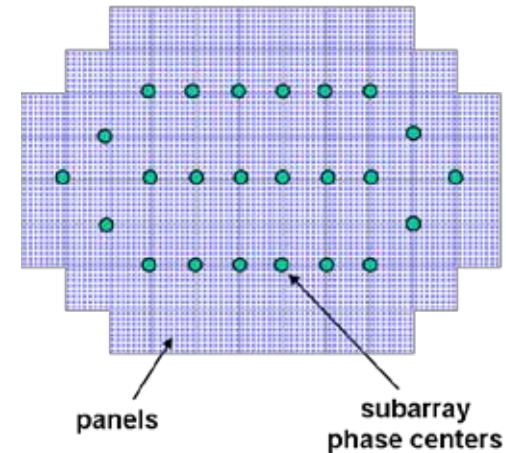
- Introduction
- ➔ • Multifunction Phased Array Radar (MPAR) Concept
- MPAR Technology Risk Reduction Effort
- Summary



FAA Multifunction Phased Array Radar (MPAR) Concept



Example Array Configuration



Challenges:

- Ultra-low cost array (~ \$50k / m²)
- Scalable aperture sizes
- Dual polarization
- Low operations and maintenance costs

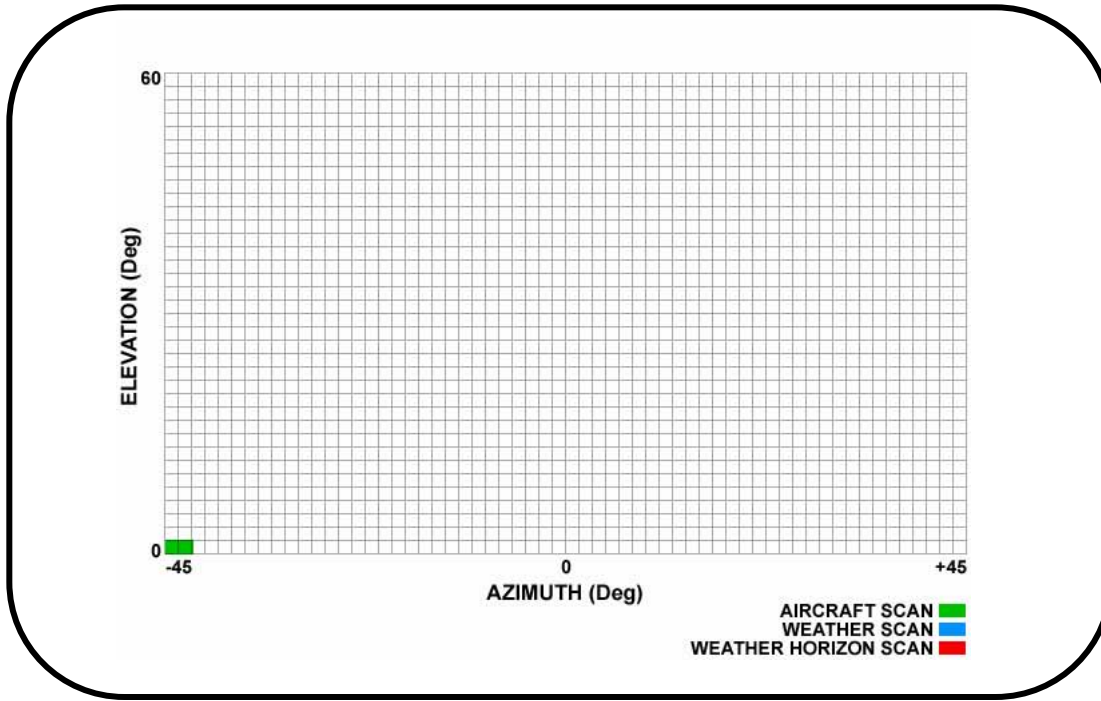
Enablers:

- Modest HPA power (8W peak)
- Highly integrated T/R chipset
- Low cost T/R module packaging
- Panel design for manufacturability

Diameter: 4m
T/R / face: ~5,000
Beamwidth: 1.2° (broadside)
Gain: > 40 dB
Dual pol
Band: 2.7–2.9 GHz
Bandwidth/channel: 1 MHz
Pulse length: 80 ms
Peak power/element: 8W



MPAR Mode Scheduling Example



Digital Beam Clusters



Two 6 x 2 beam clusters

Aircraft
(up to 24 linear pol beams)



Weather
(up to 12 dual pol beams)

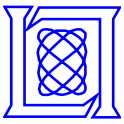
Radar Mode	Scan Update Period (sec)
Aircraft "Track While Scan"	4.8
Horizon Weather Scan	60
3D Volume Weather Scan	72



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MPAR Technology Risk Reduction Effort



- **Program Objectives:**
 - Define and retire key technical risks
 - Establish measured performance capability
 - Provide realistic cost model for MPAR panel
- **Critical Tasks:**
 - Technical Requirements Document (TRD)*
 - Interface Control Document (ICD)*
 - Antenna elements and beamformers*
 - Panel interface control software*
 - Custom T/R module**
 - Prototype panel development *,**
 - Prototype panel test and evaluation*

* *MIT LL*

** *Subcontract to M/A-COM Technology Solutions*



Low Cost Panel Demonstration

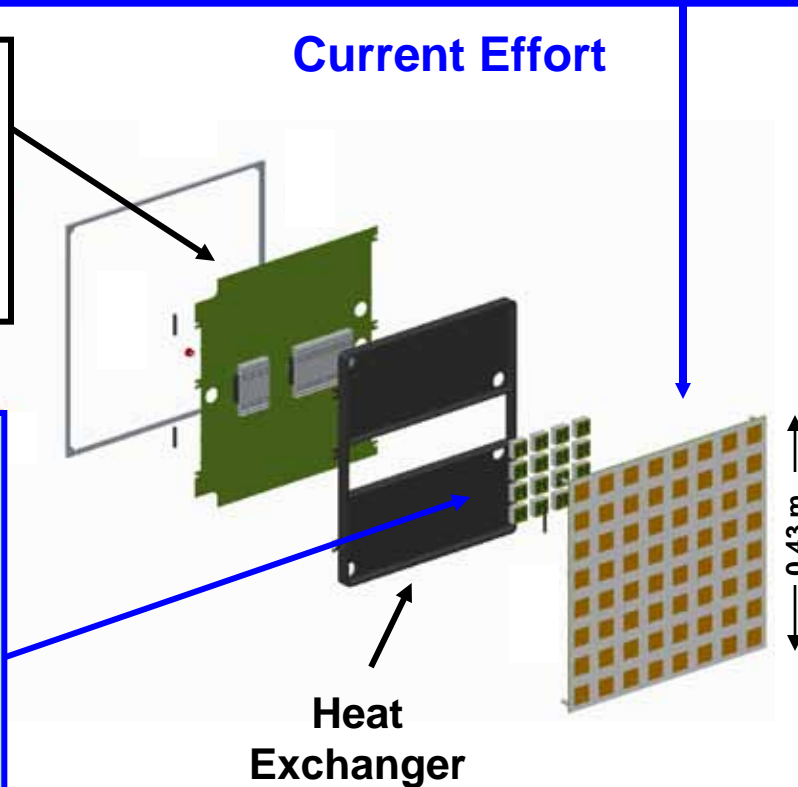
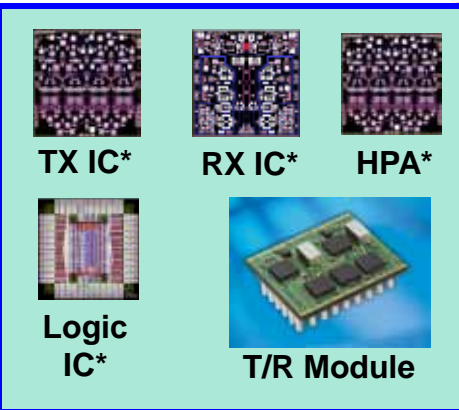


Aperture Panel: Including 64 dual pol Radiators, Beamformers, 64 T/R Elements, DC and Logic Distribution, Low Level Power Conditioning

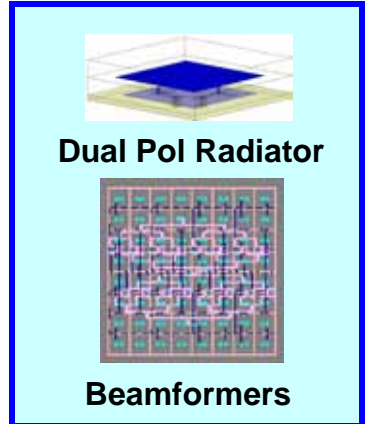
Backplane: Includes Beam Controller, Logic Fan Out, High Level Power Conditioning

Current Effort

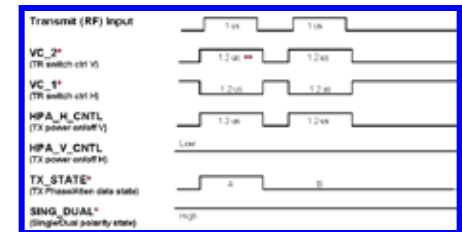
Dual Pol T/R Module



Dual pol Radiators and Beamformers



Panel Control Standards



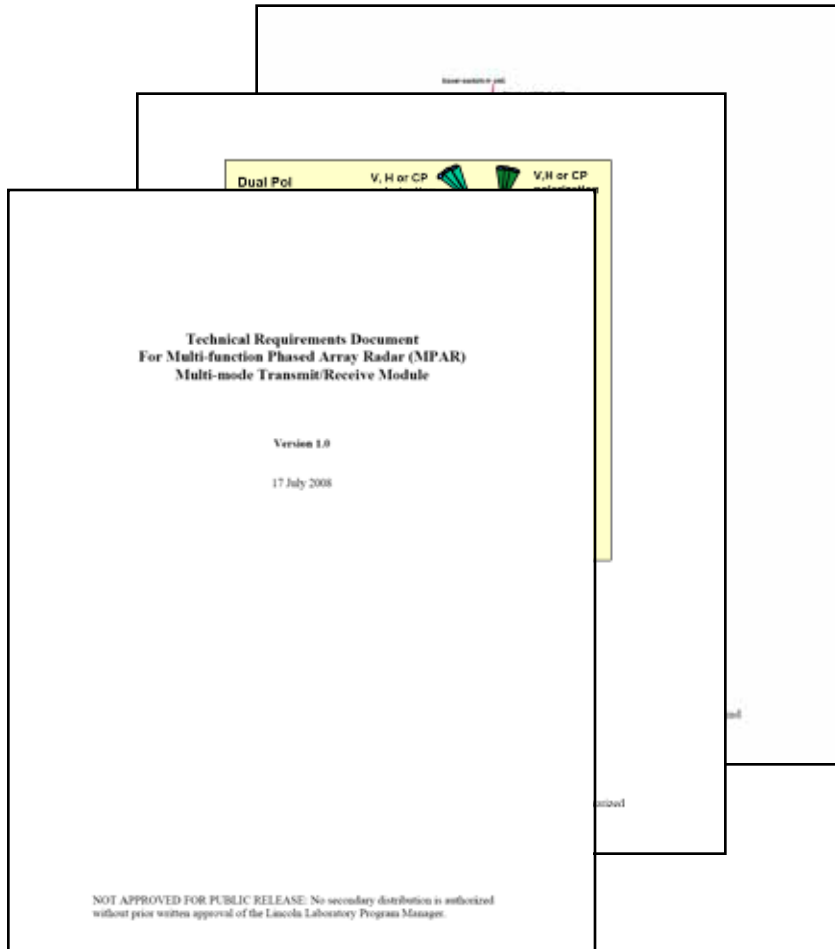
Performance Testing



* Chips developed under M/A-COM IR&D



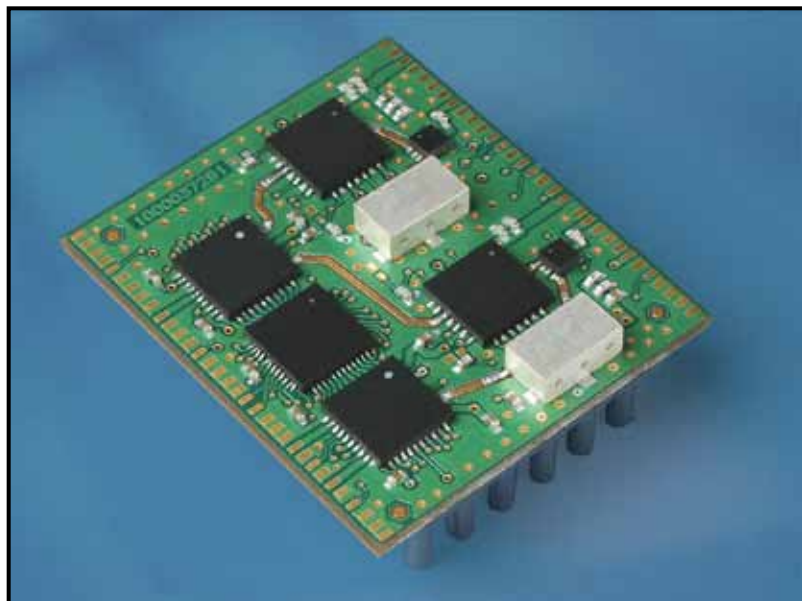
Open System Approach



- **Technical Requirements Document (TRD)**
 - Functional specifications
 - Operational description
- **Interface Control Document (ICD)**
 - Control/power/timing inputs
 - Diagnostic signals
 - Mechanical/thermal
- **Government-owned**
 - Provides direction for MPAR technology development phase and future acquisition
 - Defines interfaces for Open System Architecture

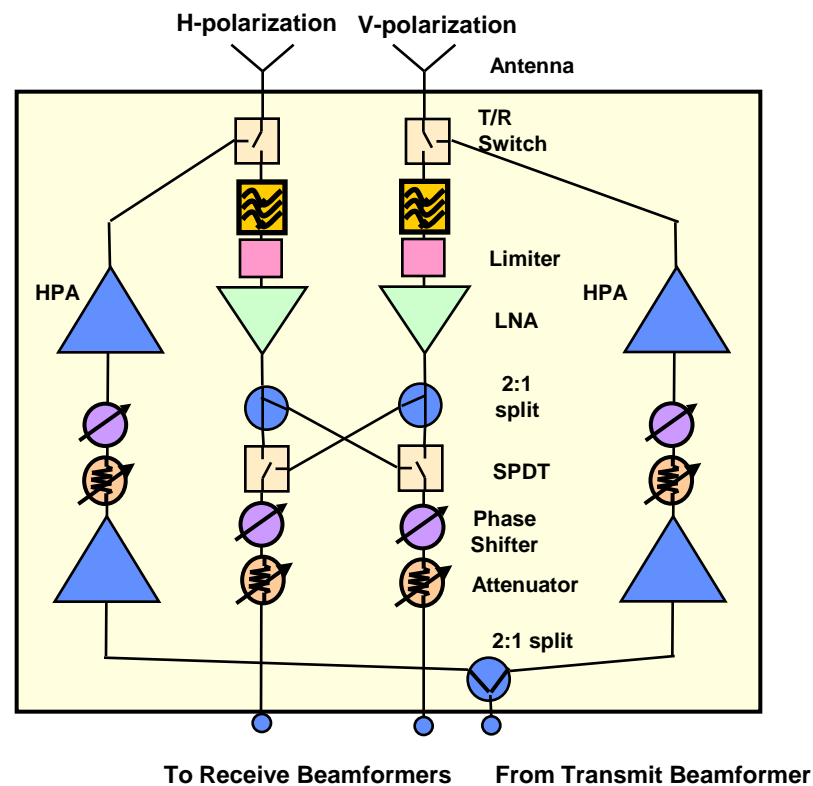


MPAR T/R Module



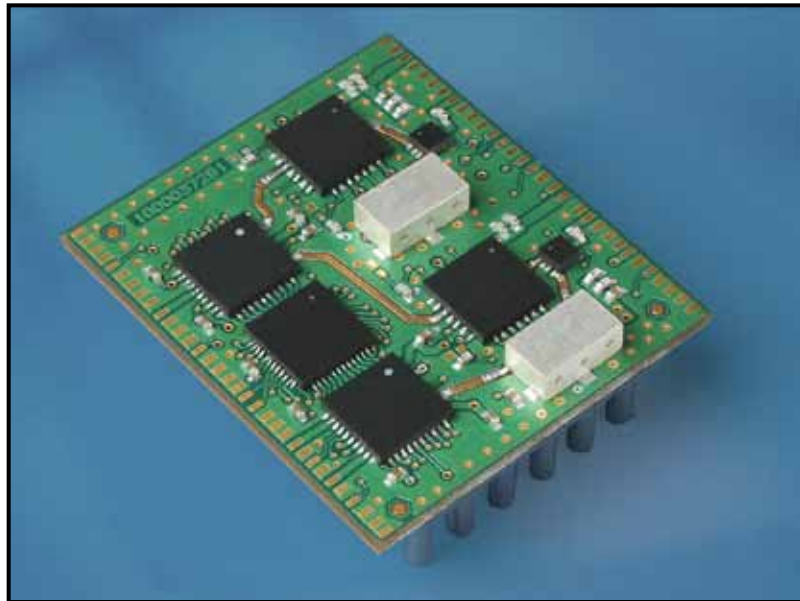
MIT LL MPAR T/R Module Concept: April 2008

- **Polarization flexible**
 - Single dual pol or two linear pol beams
- **2.7 – 2.9 GHz operating band**
- **Plastic Quad Flat No-lead (QFN) RF packages for low cost**
- **Automated pick and place / assembly / test**
- **Low cost (< \$25 ea)**
 - Based on current high volume wafer costs and automated assembly/test



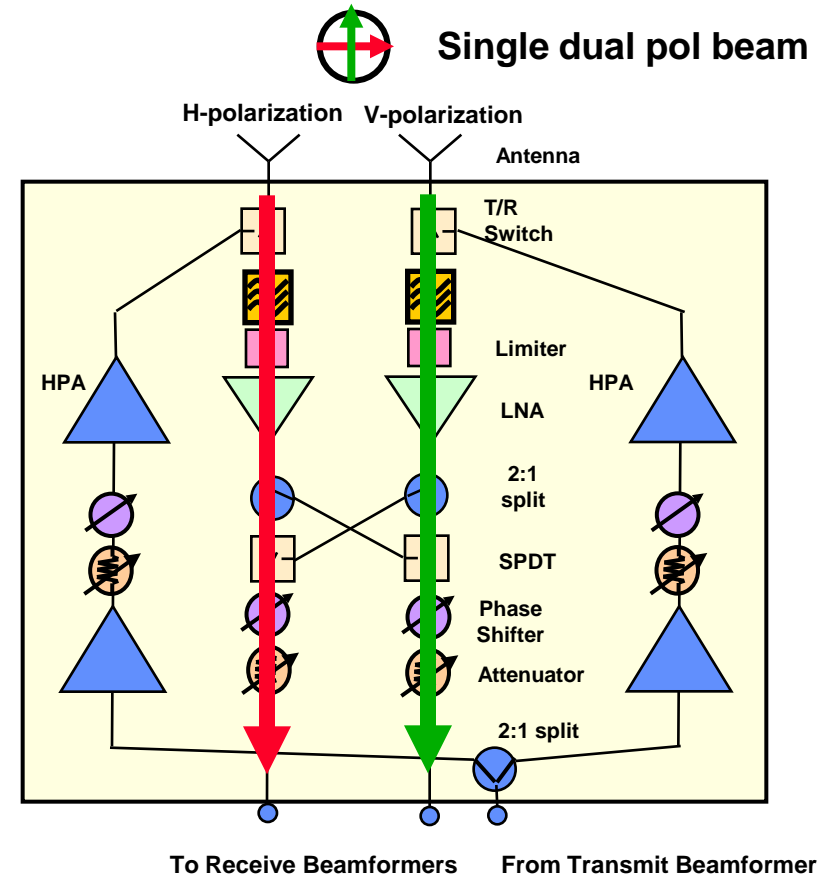


MPAR T/R Module



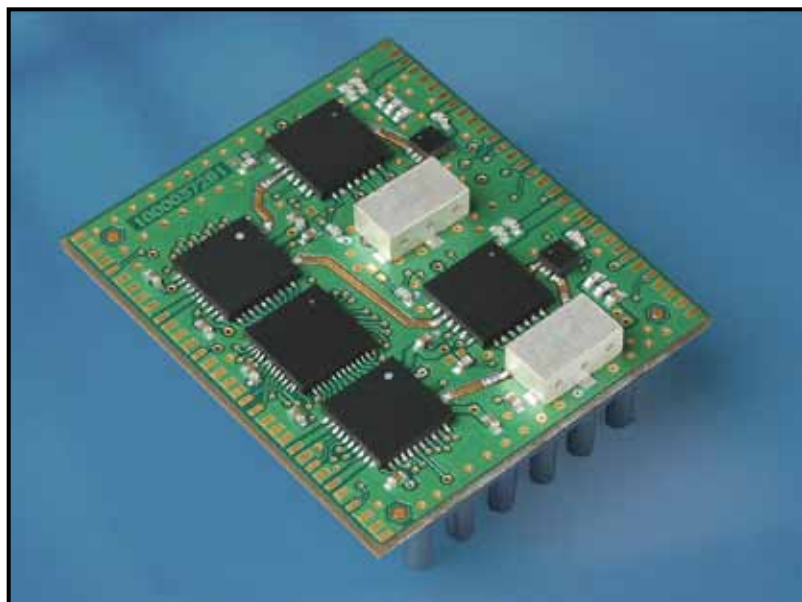
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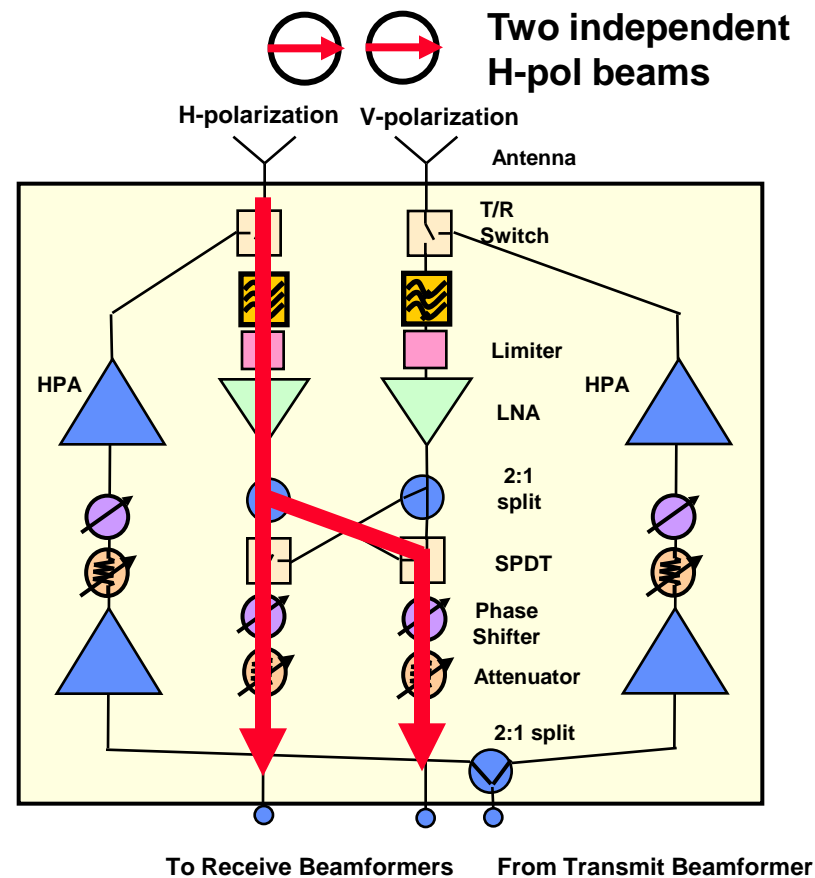


MPAR T/R Module



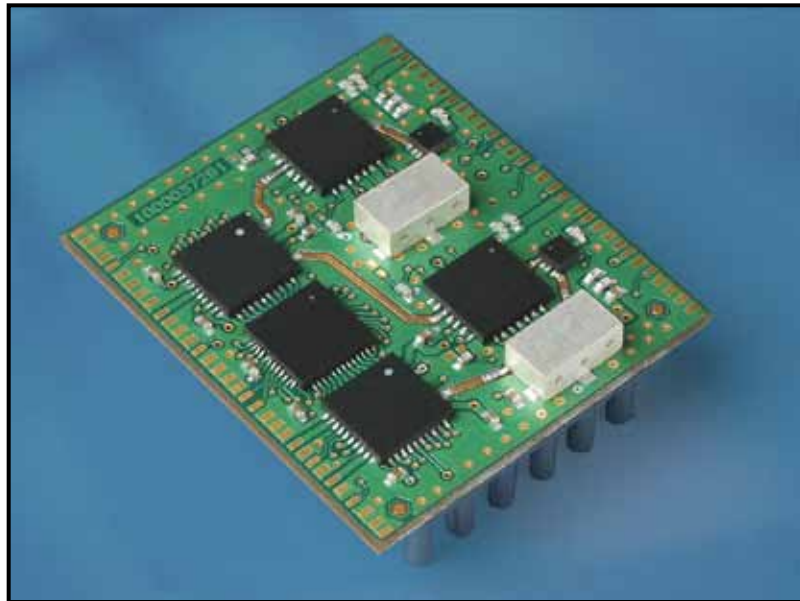
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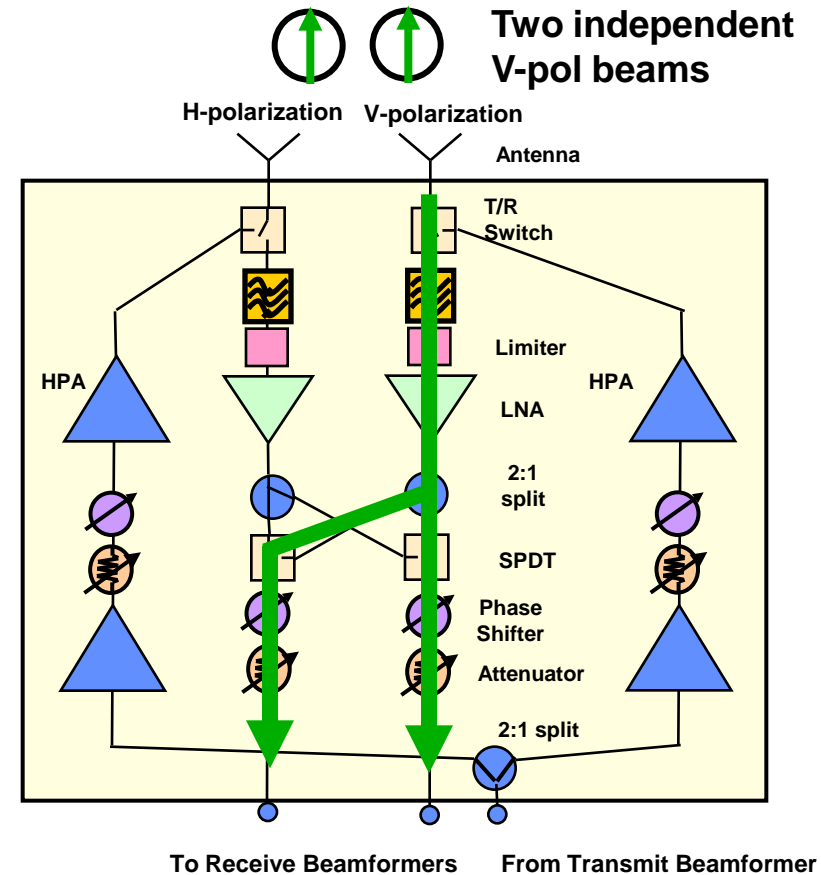


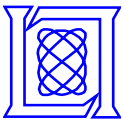
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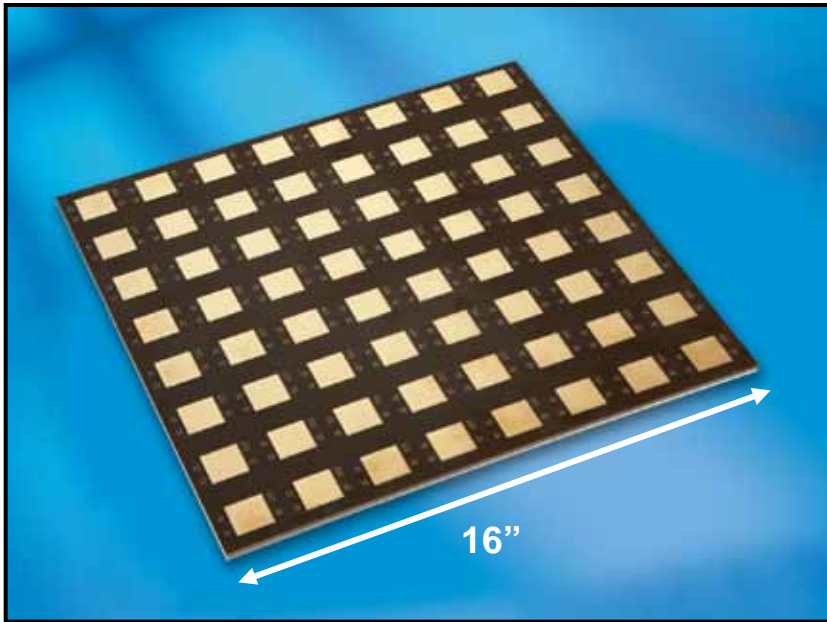
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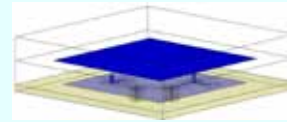


MPAR Low Cost Panel Demonstrator

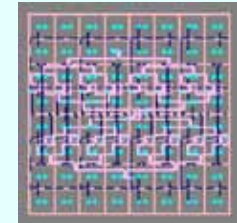


- 64 element Line Replaceable Unit (LRU)
- Polarization flexible
 - 12 dual pol or 24 linear pol beams
- 2.7 – 2.9 GHz operating band
- Automated pick and place / assembly / test
- Low cost (<\$20k ea)
 - Based on actual BOMs from multiple vendors

Critical Technologies



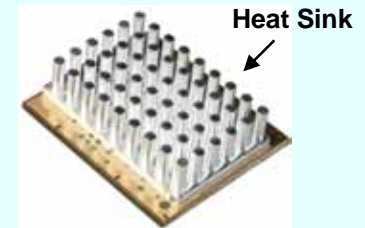
Dual Polarized
Balance-feed Stacked
Patch



Overlapped Digital
Subarray Beamformer

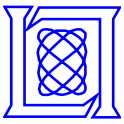


Top View



Bottom View

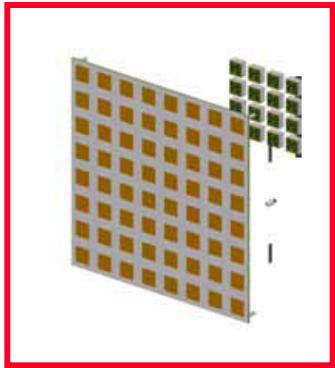
Polarization Flexible T/R Module



MPAR System Block Diagram

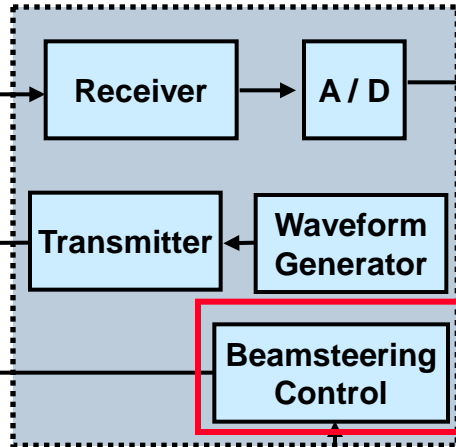


Active Array Panels



Current Development Effort

Digital Receiver/Exciters



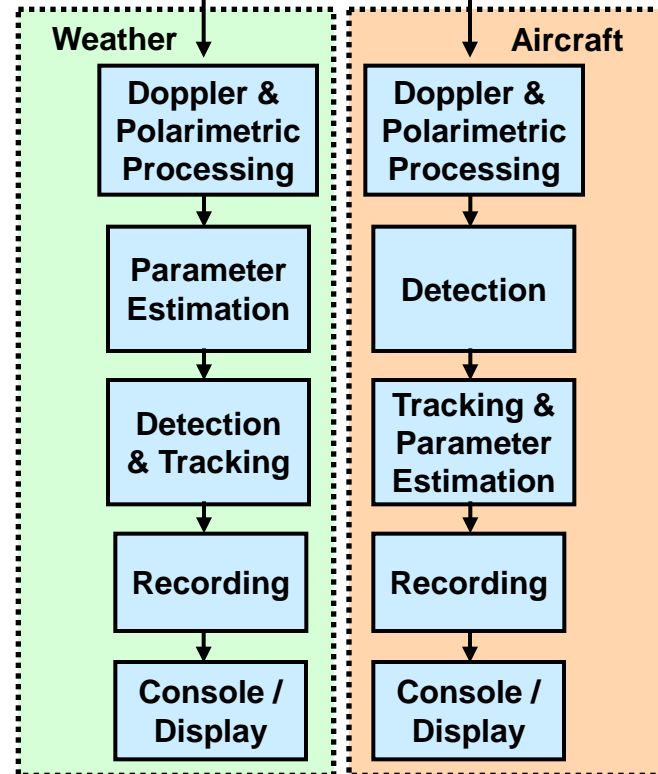
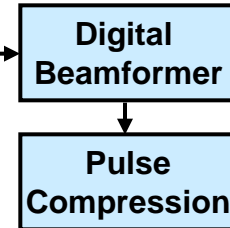
Digital Channels (2 per panel)

Master Timing

Radar Controller

Radar Scheduler

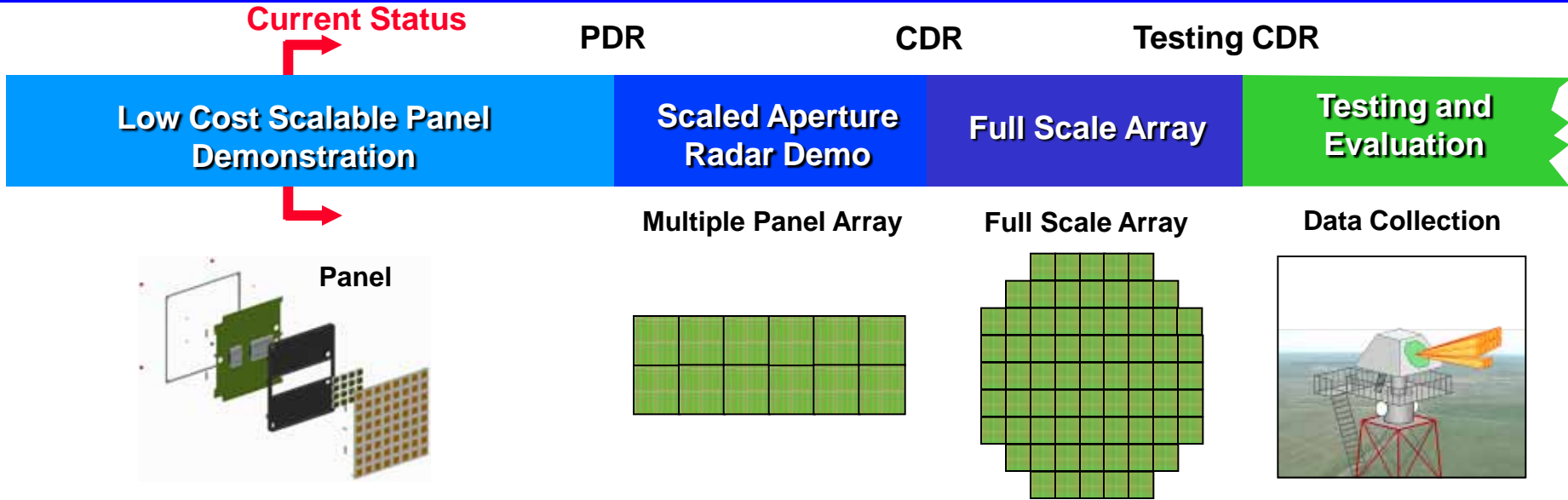
Digital Signal Processing



- Currently supported efforts focus on panel
- Considerable additional effort required to develop multi-mode radar test bed



Notional Development Approach



Analog and Digital Hardware:

- | | | | |
|---|---|--|--|
| <ul style="list-style-type: none"> • Bench Tests • Array Measurements | <ul style="list-style-type: none"> • Reduced Range Testing • Outdoor Demo | <ul style="list-style-type: none"> • Full Functionality • Multiple Modes | <ul style="list-style-type: none"> • Data Collection and Evaluation |
|---|---|--|--|

Systems Analysis & Signal Processing:

- | | | | |
|---|--|--|--|
| <ul style="list-style-type: none"> • Waveform Design • Systems Analysis | <ul style="list-style-type: none"> • Algorithm Dev • System Simulation | <ul style="list-style-type: none"> • System Simulation • Test Planning | <ul style="list-style-type: none"> • Process Data • Report Results |
|---|--|--|--|

Full scale prototype provides multi-mode concept evaluation, algorithm development and data collections



Summary



- **Phased array affordability being addressed through exploitation of commercial microwave approach**
 - Mitigate risk and advance low cost design through industry partnership
- **Prototype panel provides critical assessment data**
 - Panel fabrication, assembly and test costs
 - Dual polarization performance
 - Panel calibration techniques
 - Multiple mode functionality