Multifunction Phased Array Radar (MPAR) Risk Reduction Effort

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*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

Terminal Area Surveillance

Non-Cooperative targets

Weather Fronts

Chemical Dispersion
Outline

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

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 μs
Peak power/element: 8W
### MPAR Mode Scheduling Example

<table>
<thead>
<tr>
<th>Radar Mode</th>
<th>Scan Update Period (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft “Track While Scan”</td>
<td>4.8</td>
</tr>
<tr>
<td>Horizon Weather Scan</td>
<td>60</td>
</tr>
<tr>
<td>3D Volume Weather Scan</td>
<td>72</td>
</tr>
</tbody>
</table>

#### Digital Beam Clusters
- **Two 6 x 2 beam clusters**
- **Aircraft** (up to 24 linear pol beams)
- **Weather** (up to 12 dual pol beams)
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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

- TX IC*
- RX IC*
- HPA*
- Logic IC*
- T/R Module

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

Dual pol Radiators and Beamformers

Dual Pol Radiator

Beamformers

Panel Control Standards

Performance Testing

0.43 m
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
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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
- Heat Sink
- Top View
- Bottom View
- Polarization Flexible T/R Module
Currently supported efforts focus on panel
Considerable additional effort required to develop multi-mode radar test bed
Notional Development Approach

Current Status

Low Cost Scalable Panel Demonstration

Scaled Aperture Radar Demo

Full Scale Array

Testing and Evaluation

PDR

CDR

Testing CDR

- Multiple Panel Array
- Full Scale Array
- Data Collection

Analog and Digital Hardware:

- Bench Tests
- Array Measurements

- Reduced Range Testing
- Outdoor Demo

- Full Functionality
- Multiple Modes
- Data Collection and Evaluation

Systems Analysis & Signal Processing:

- Waveform Design
- Systems Analysis

- Algorithm Dev
- System Simulation

- System Simulation
- Test Planning
- 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