MPAR:
Defining The Technical Issues

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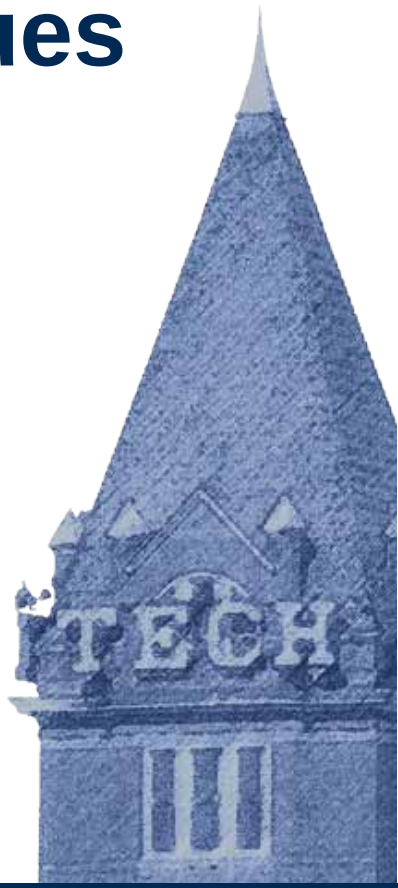
(under contract to the FAA)

November 2009



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Major MPAR Technical Issues

- Dual polarization performance for weather measurements
- In-field calibration (polarization characteristics, sensitivity) and subsequent impact on system cost
- Cost (developmental, production, and sustainment costs including software updates)
- Radome implementation and effects on performance, especially polarization
- Cooling (air versus liquid)
- Requirements creep (some requirements can take us out of the realm of low-cost commercially-available solutions)

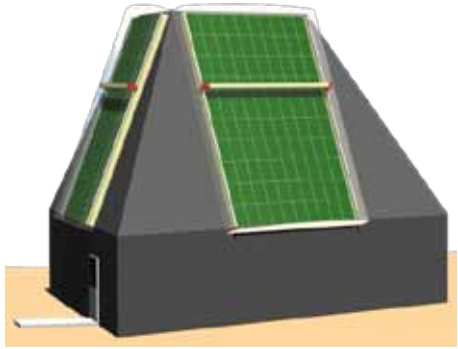
Dual Polarization Performance

- High quality dual polarization measurements are desired to enable better quantification of meteorological phenomena
- 30 dB cross pol isolation over entire scan region, not just boresite, will require :
  - Element level polarization adjustments that change with beam position
  - Complicated T/R module and radiator design
  - Utilization of circulator at each module? (Impedance differences between transmit and receive)
  - Multi-layer RF PCBs can suffer from coupling and EMI issues
- Polarization Align/Cal may be required for all beam positions
- This degree of polarization control will be a cost driver

In-Field Calibration

- Must have a plan as to how these radars will be maintained and calibrated over time
- In-field monitoring of performance, including polarization purity as a function of scan will be difficult and expensive
  - Calibration over temperature
  - After hardware failures/prior to maintenance actions
  - Post maintenance actions
- Could add substantial cost at the system level

Factory A&C



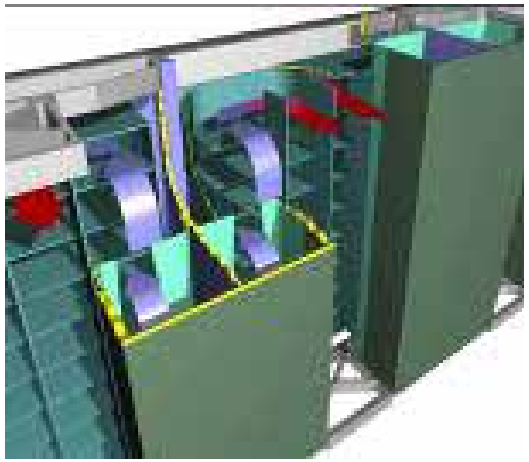
In-Field A&C (Integrated NF Probe Option)

Cost

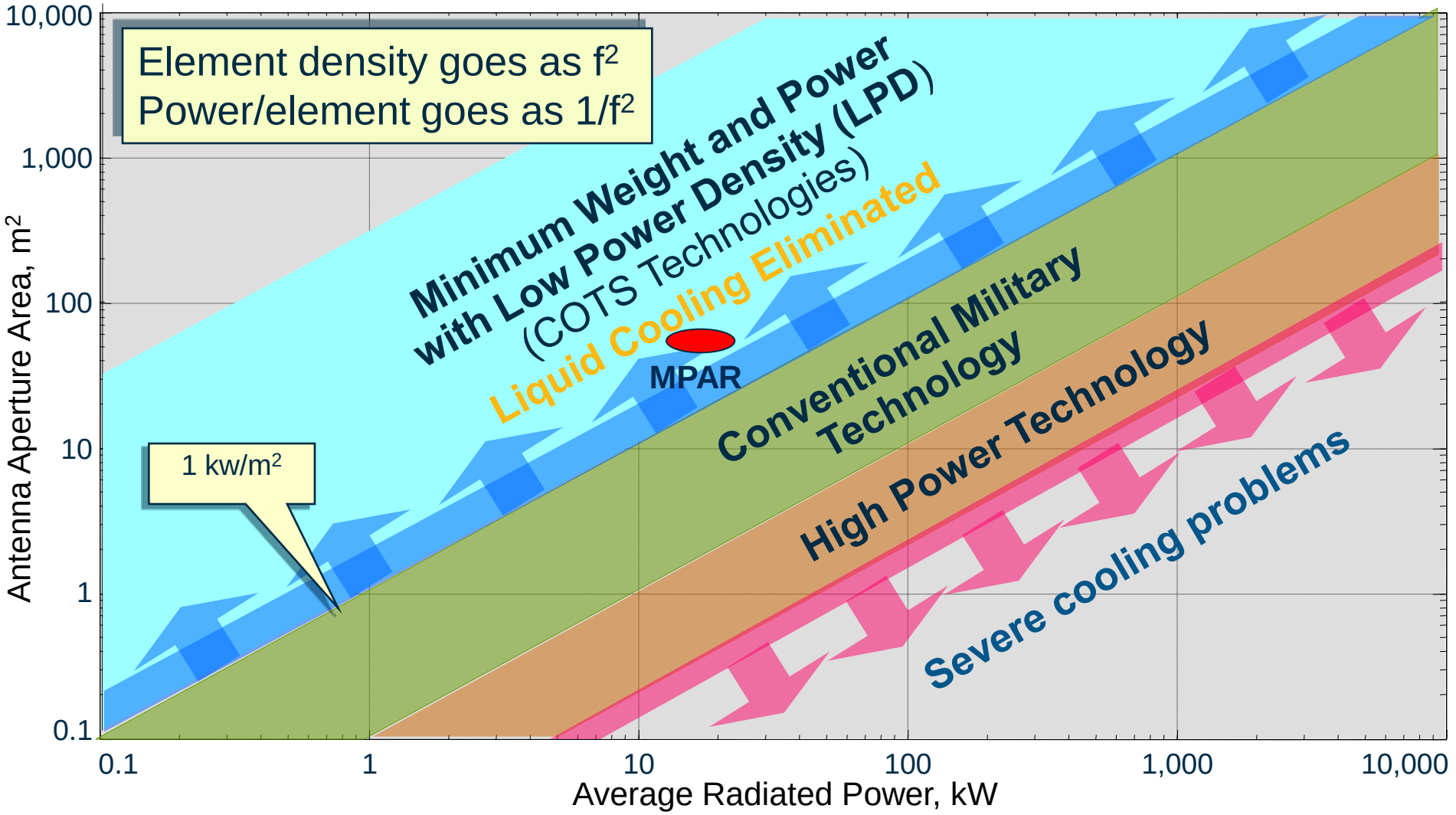
- Historically, the largest recurring cost is the array electronics
- As the array electronics get cheaper, the proportion of cost apportioned to other subsystems will increase
- If the cost goal for MPAR is $10M ($2.5M per face);
  - Assume 40% of the cost in the array, equates to $200 per element for 5000 elements ($125 if array is 25% of total)
  - Equates to $50 per element for an array of 20,000 elements ($31 if array is 25% of total)
- Implementation of low-cost digital beamforming architecture to support multiple beams on receive appears challenging
- Initial development and system engineering costs may be high, will have to be amortized over a number of systems
- Recurring costs also include software updates and maintenance – open systems architecture SW is critical

Cooling

- Air versus liquid cooling
  - Consensus is to avoid liquid if possible, but remember liquid is a better coolant than air
  - Panel architectures can be cumbersome to air cool due to ducting issues and maintaining constant temperature across the array to avoid gradients
  - Slat architecture easier to cool, can blow air through the array (if allowed by radome configuration) but is more difficult to accommodate dual polarization
  - Strong motivation for developing higher efficiency power amplifiers



Power Density Comparison for Active Phased Arrays



Should be feasible to air-cool an MPAR array

Radome

- What type of radome makes the most sense?
  - Flat, array mounted (integrated onto the panels?)
  - Rigid, stand-off type
  - Inflatable or bubble-type
- Choice can affect electrical properties of the front-end electronics
- Choice can affect how cooling is performed

What Technical Issues Should the TAP Program Address? (1 of 2)

- **Polarization performance**
  - **Prototype subarray hardware build, including radiating elements, characterize in near field range**
- **Calibration**
  - **Require contractors to describe a calibration regimen for monitoring and maintaining performance**
  - **Must be included in system-level cost models**
- **Cost**
  - **Initial cost models for array hardware, scaled up to include entire objective radar architecture**

What Technical Issues Should the TAP Program Address? (2 of 2)

- **Radome**
  - **Does the contractor advocate a flat cover type radome (integrated onto panel?) or inflatable bubble type, or other, and provide analysis/justification in Phase 2**
- **Cooling**
  - **Initial hardware build; extrapolate to full array design**
- **Requirements Creep**
  - **Require contractors to address open-architecture issues for both hardware and software (key to implementing new functionality, especially in software)**