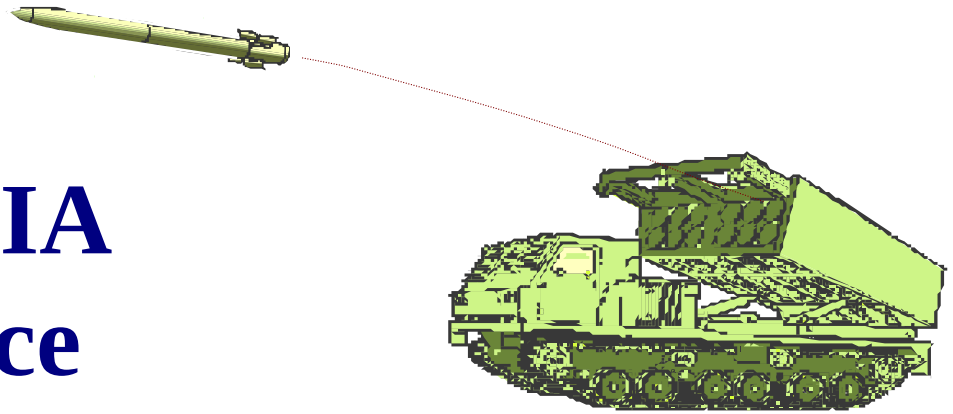
L3 communications
KDI Precision Products, Inc.

LOCKHEED MARTIN

Proximity Sensor
for
Guided Unitary Multiple Launch Rocket System



50th Annual NDIA Fuze Conference
May 9-11, 2006

EDC
Electronics Development Corporation

Overview

- System Background
- System Requirements
- Design Challenges
- Design
  - Antenna/Radome
  - Electronics
    - Signal Processor
    - Transceiver

System Background

- Multiple-Launch Rocket System (MLRS)
  - Legacy system
    - LRIP 1980
    - Ballistic trajectory
    - DPICM payload
  - GPS/IMU Guidance added 2000
  - DPICM payload with unitary 2002
    - Needed proximity sensor for maximum lethality
    - KDI/EDC turned on in December 2003

System Requirements

- Selectable Height of Burst (HOB) : 3m/10m
- 15º to 110º approach angle
  - Roll-stabilized
- 250m/s to 850m/s approach velocity
- Built-in-Test (BIT)

Design Challenges

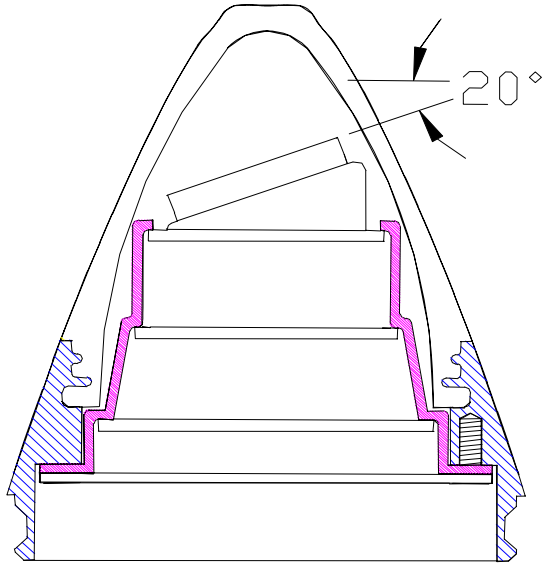
- Radome/Antenna
  - Thermal environment
    - Nose gets EXTREMELY hot
  - Cover push-through
    - Tube exit presents significant mechanical load
  - Broad angle of attack

Design Challenges

- Electronics
  - Velocity
    - Exceeds capabilities of existing transceiver/processor chip sets
  - BIT
    - Not available with legacy ASIC-based signal processors
- Aggressive Schedule
  - Approximately 13 months to CDR

Radome/Antenna

- Proposed concept was simple patch antenna and plastic radome (PEEK)
  - Antenna would be tilted to provide shallow angle coverage
  - PEEK has been used in rocket applications



Radome/Antenna

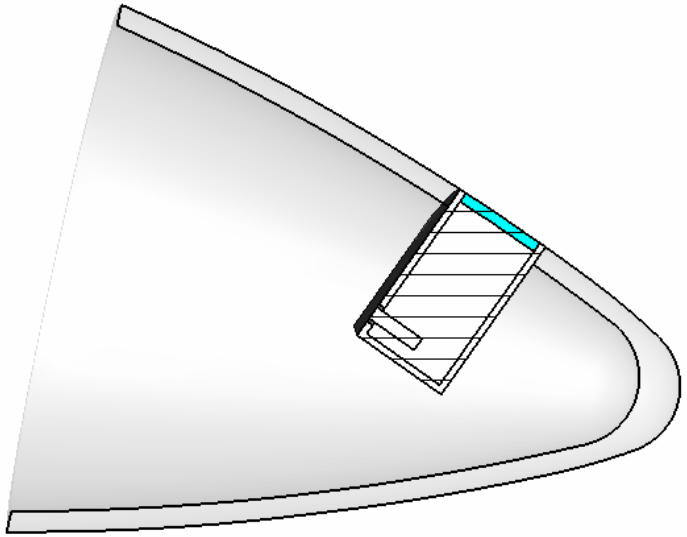
- LM concerned about thermal and mechanical radome environments
  - High temperature due to velocity
  - Severe tube-exit mechanical stress
- After contract award, LM analysis shows that PEEK won't with stand environments
  - Suggest that nose must be metal…..!

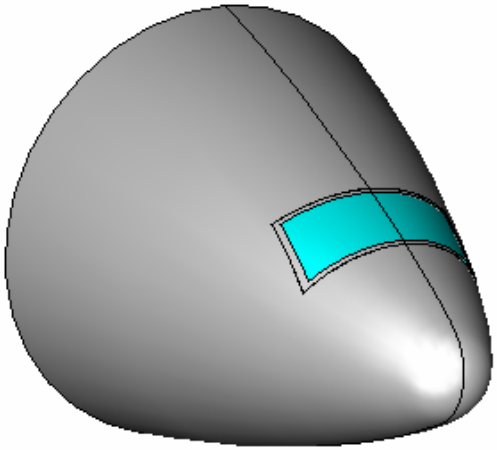
Radome/Antenna Concepts

- A window on the side of a metal nose would be provided for the antenna
- Various concepts were considered
  - Waveguide aperture
  - Patch antenna mounted in/under window
- Analysis tool was needed
  - KDI acquired a 3D EM analysis tool to quickly evaluate various options

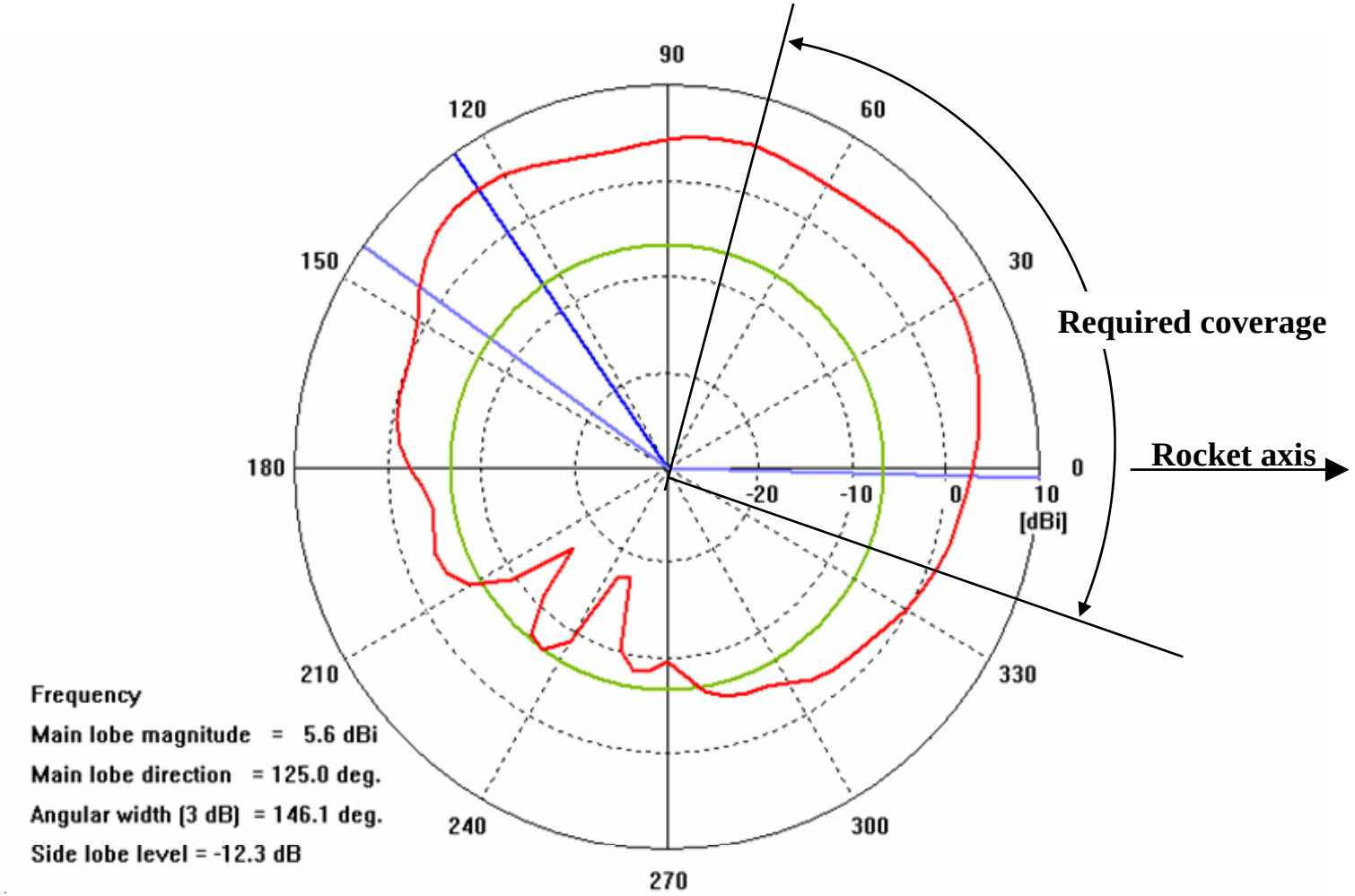
Waveguide Aperture

- Window would form waveguide aperture
  - Provided good coverage
  - Not practical to build/assemble





Waveguide Aperture



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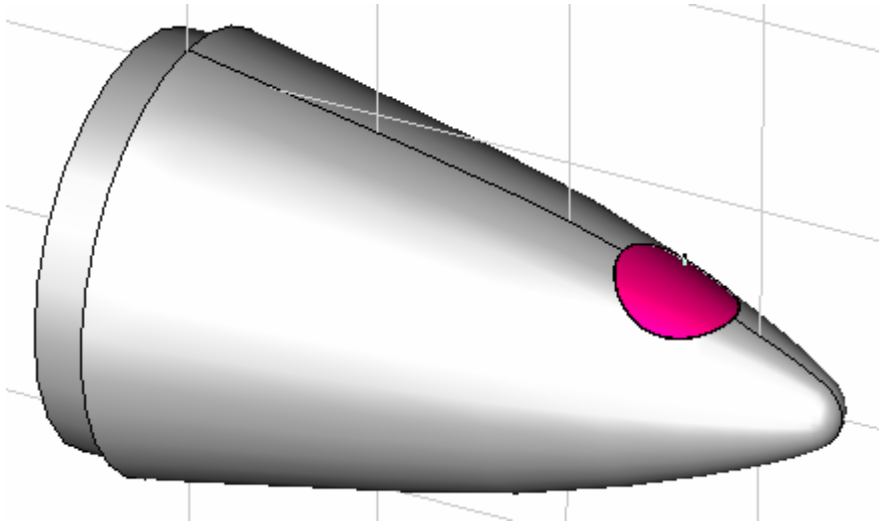
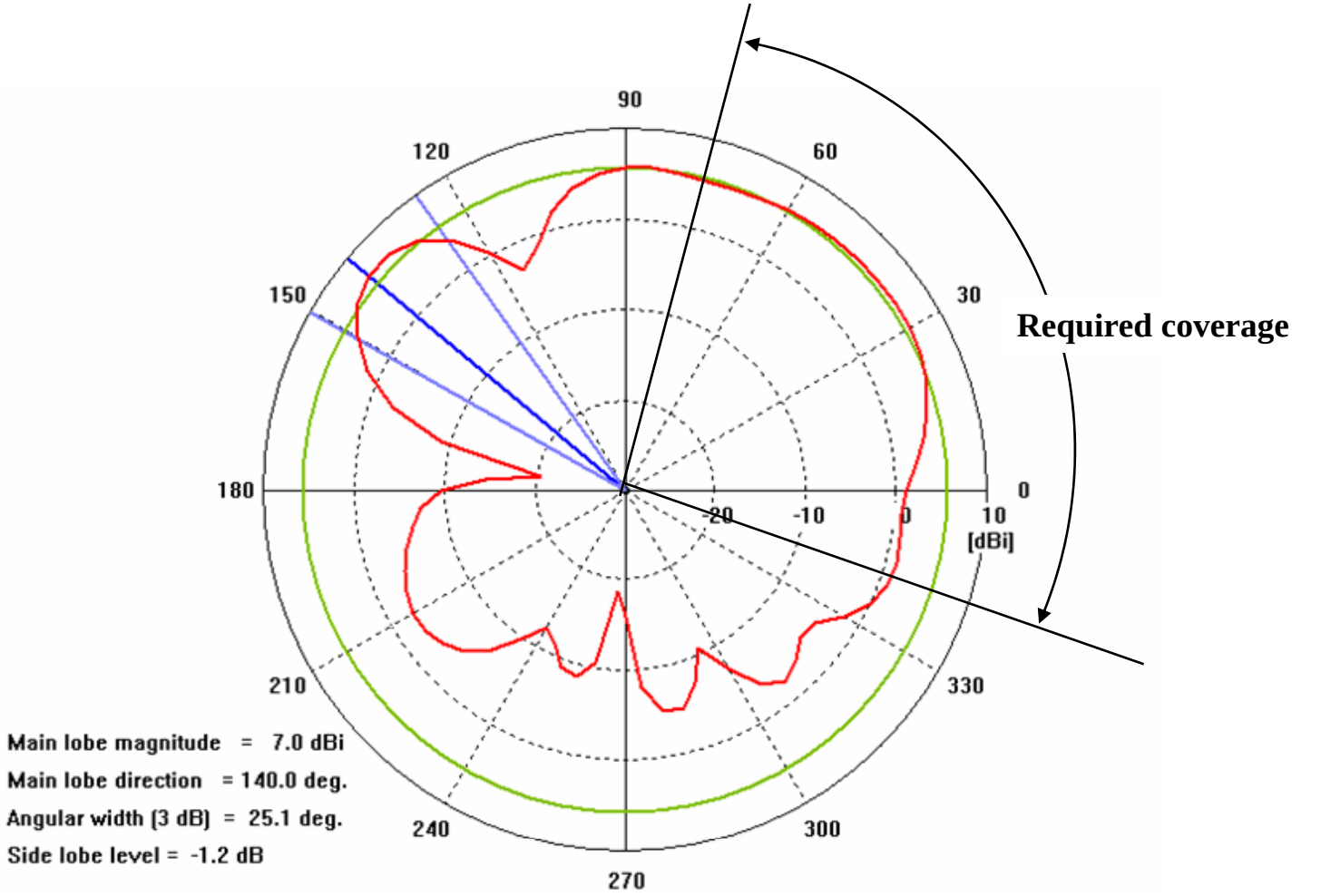
Patch Under Window

- Simple patch antenna mounted under window
  - Difficult to mount
  - Less-than-optimal pattern



Patch Under Window



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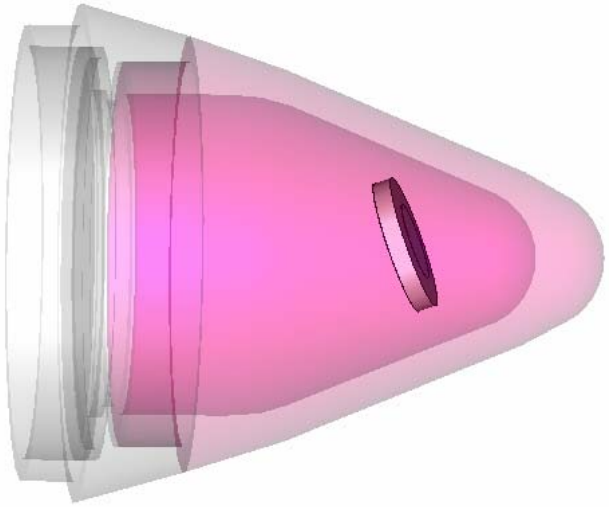
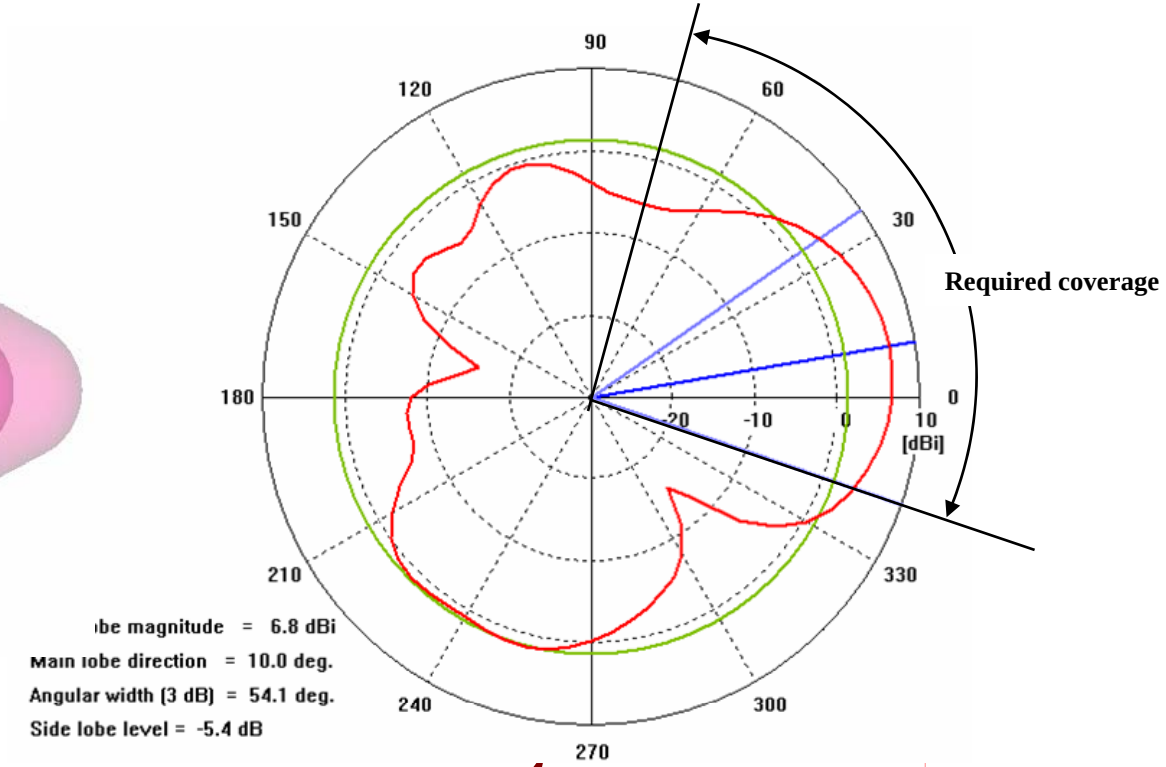
Ceramic Radome To The Rescue!

- Concurrently with KDI/EDC, LM did extensive thermal and mechanical analysis of nose tip
  - Identified proprietary ceramic material that could serve as entire radome/nose tip
    - Will withstand thermal and push-through environments
  - Greatly simplified mounting concerns
    - Back to original concept

Not So Fast...

- High dielectric constant had significant influence on pattern (and impedance)
  - Original 20 degree tilt concept didn't work too well





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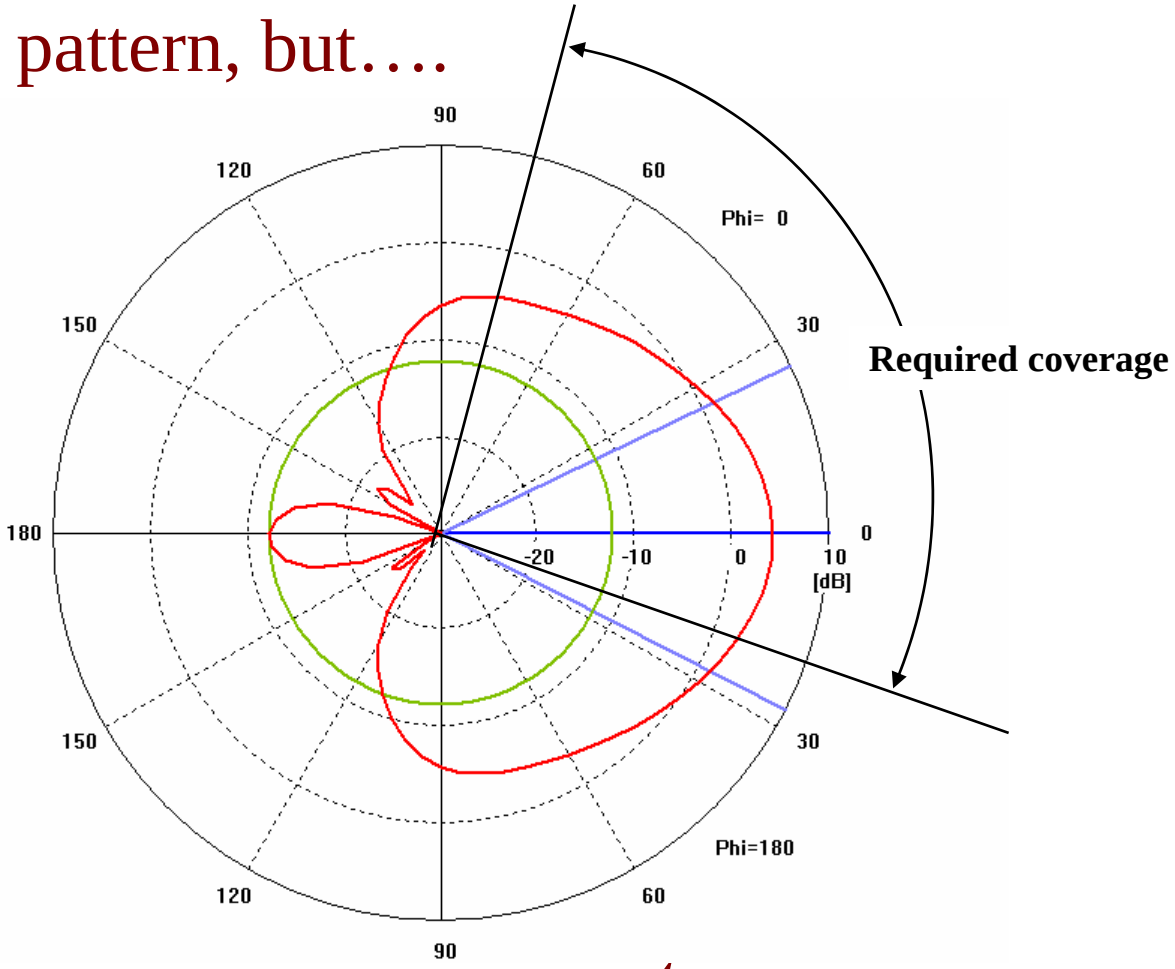
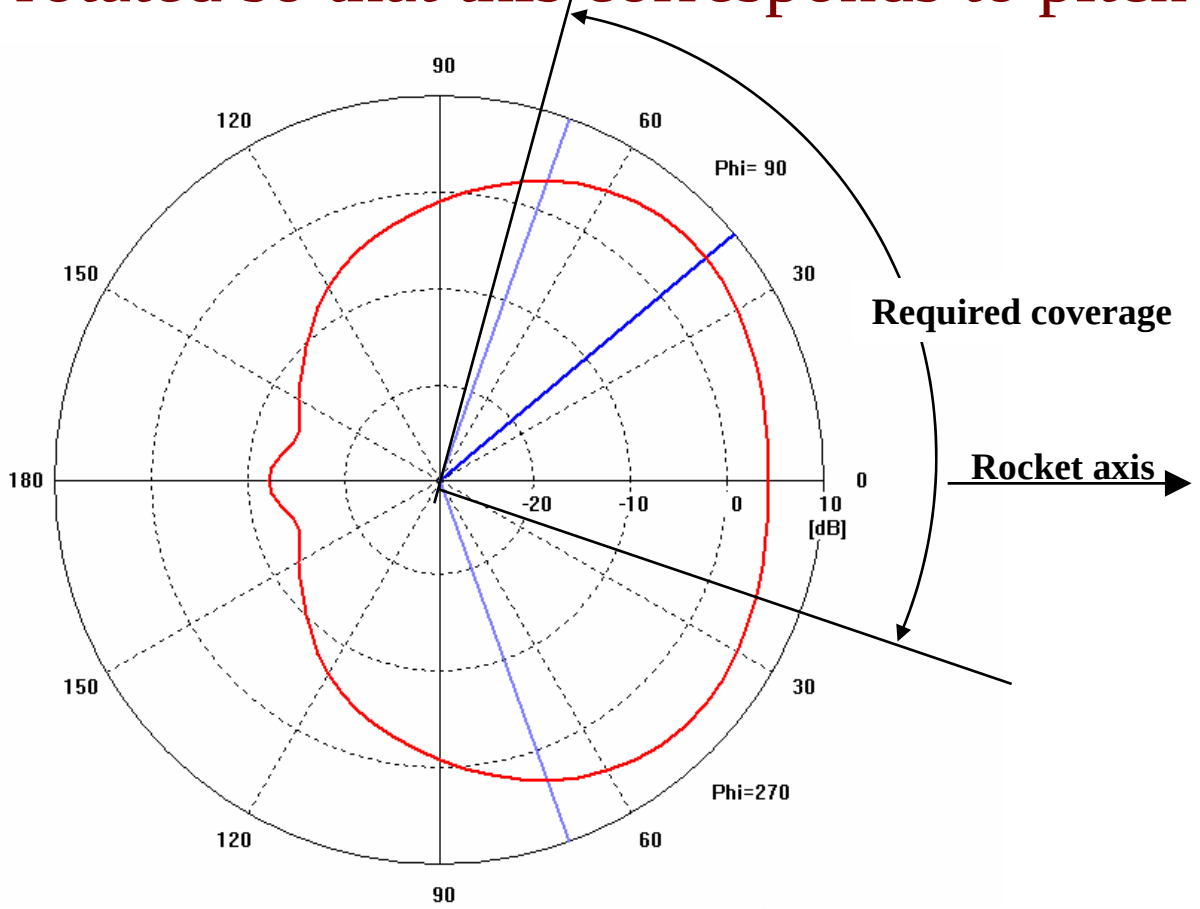
Un-tilted Antenna

- Analyzed un-tilted antenna
  - Very narrow pattern, but….



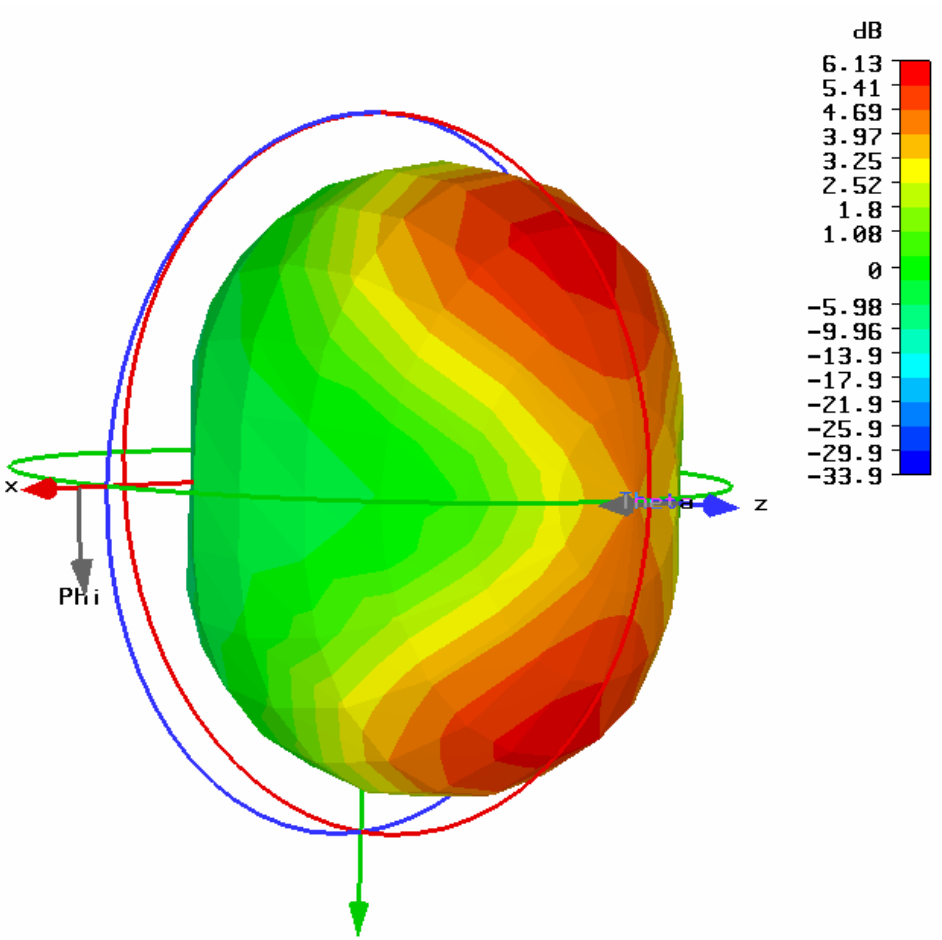
Un-tilted Antenna

- Horizontal cut
  - Antenna rotated so that this corresponds to pitch plane

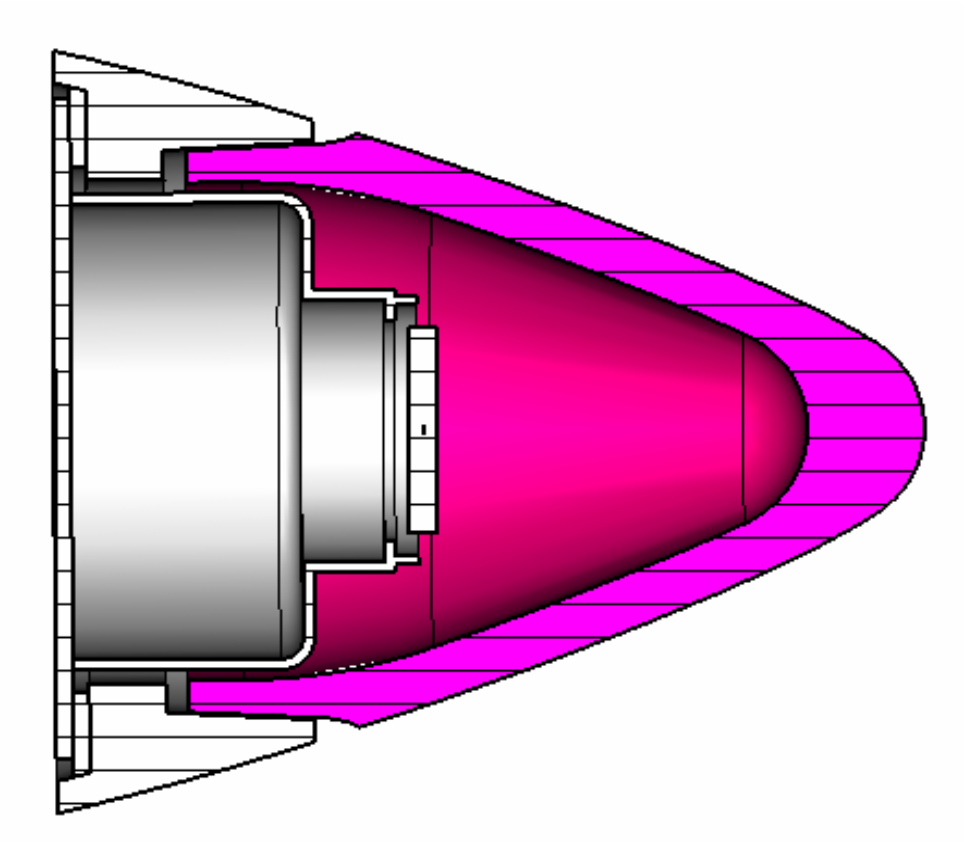


Final Antenna Configuration

- Show figure of 3D pattern

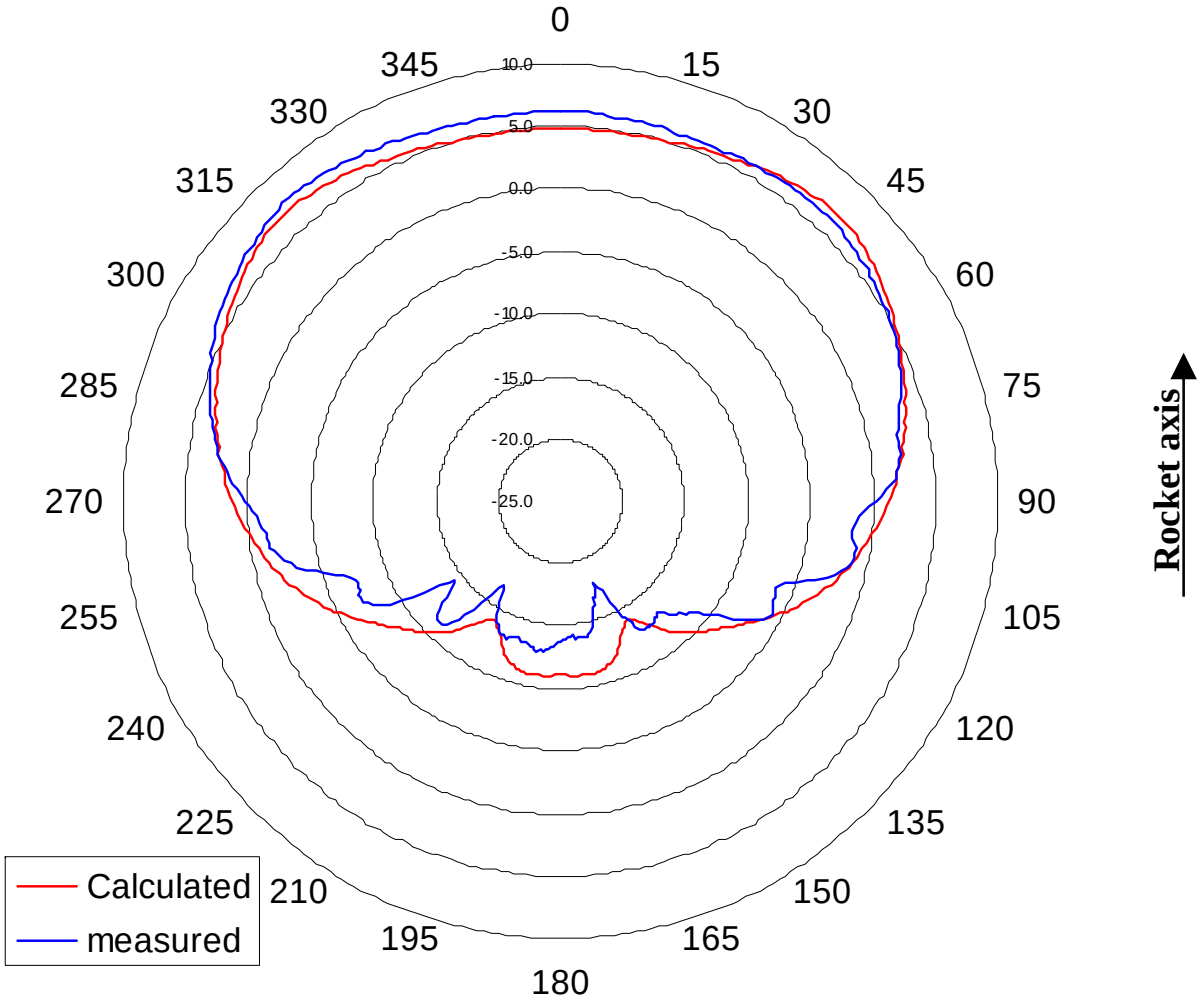


Final Antenna Configuration



Antenna Performance

Pitch Plane, Measured vs Calculated



Electronics Design
Signal Processor

- Requirements precluded use of existing signal processor
  - High velocities result in Doppler frequencies outside the passband of existing mortar and artillery processing systems
  - Built-in-Test (BIT) not possible with existing processors
  - Aggressive schedule made new ASIC impossible

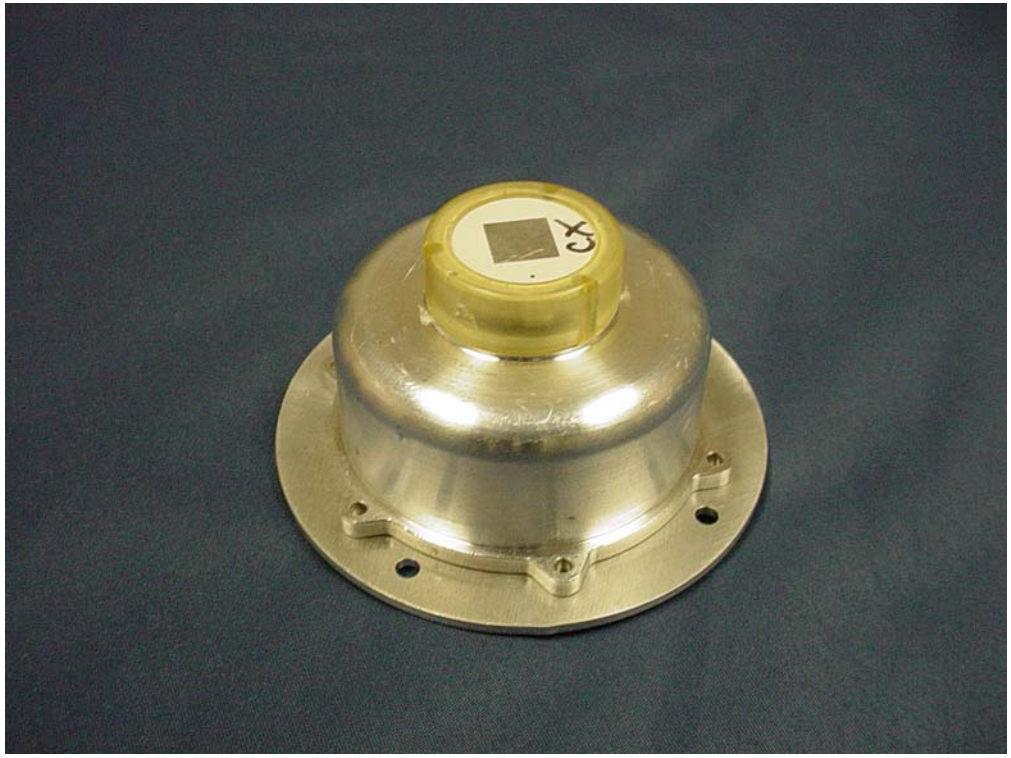
Electronics Design
Signal Processor

- KDI/EDC leveraged previous IRAD work to design completely new signal processing system
  - All parameters are re-configurable
  - Reports BIT status to ESAF, which reports to Mission Computer
  - All components are commercially available
    - ☞ **No custom IC's!**

Electronics Design
Transceiver

- Antenna/Radome design yielded good results, but only at a frequency significantly different than those used on legacy mortar and artillery systems
  - Could not use existing transceivers
  - Aggressive schedule made new MMIC impossible
  - New transceiver designed with commercially available components
    - **No custom IC's!**

Electronics Assembly



Summary

- Difficult radome/antenna problem solved through TEAMWORK
  - Concurrent electromagnetic, thermal, and mechanical analysis
- Electronics contains NO custom components
  - Rapid development
  - Versatile design
- First shot success (see next slide)!

UDT-7 Flight
January 31, 2005