REMCOM Electromagnetic Simulation Solutions

High-Fidelity Radar Cross Section Simulation of a Turbine Blade

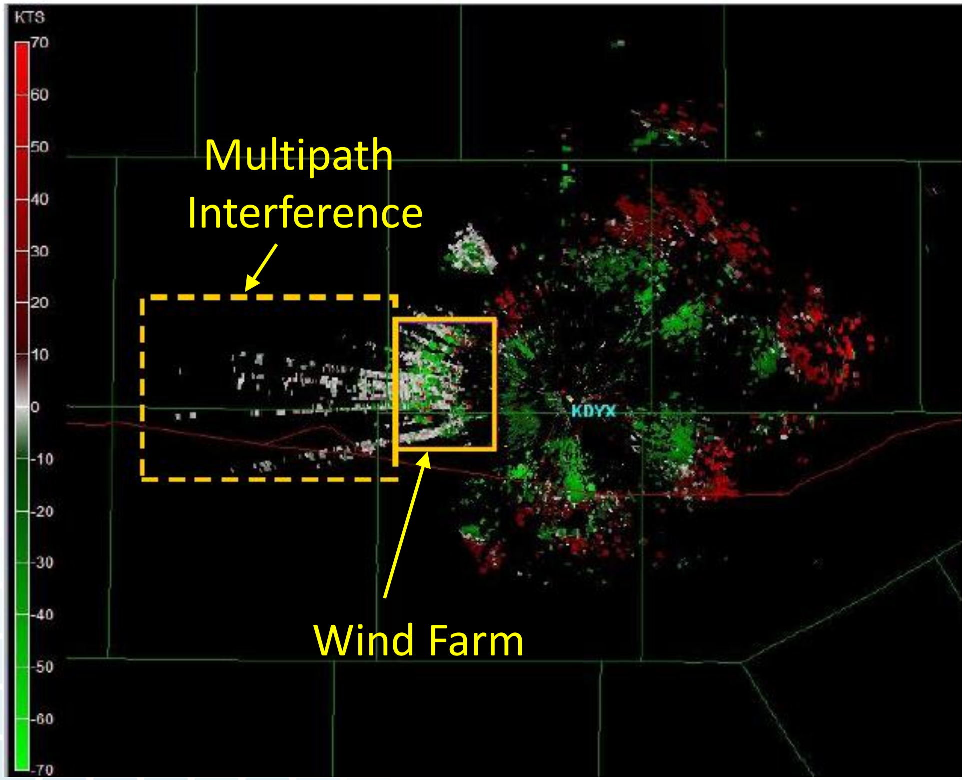
XFdtd

315 S. Allen St., Suite 416 | State College, PA 16801 USA | +1.814.861.1299 phone | +1.814.861.1308 fax | sales@remcom.com | www.remcom.com

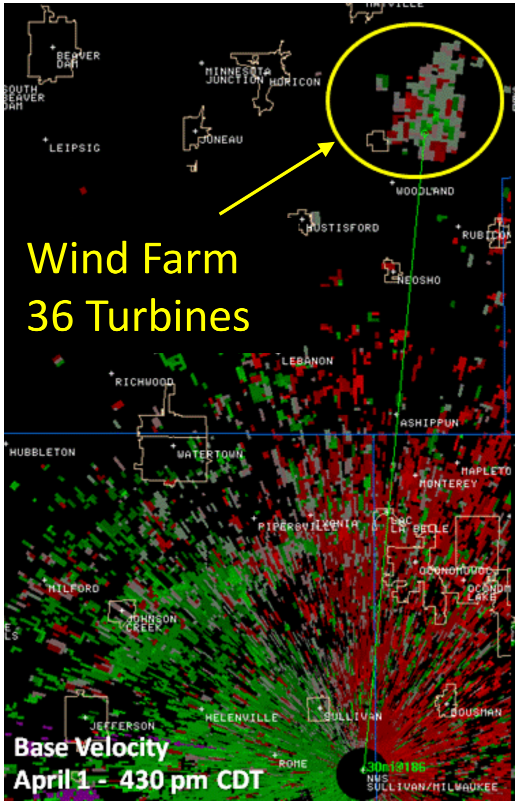
Overview

- Radar scattering from a turbine's moving blades can interfere with Doppler radar systems producing ghost images
  - Wind turbine returns can reduce the radar's probability of detecting actual aircraft and increase its probability of a false alarm
- Affected systems include
  - Air traffic control radar
  - Weather radar
  - Long range radar
- Understanding the scattering properties of a blade can provide radar manufacturers with the necessary information to mitigate any potential issues
- This study compares the radar cross section of:
  - A metal turbine blade
  - A hollow fiberglass turbine blade
  - A hollow fiberglass turbine blade with a metal spar

Examples of Interference



Multipath scattering from wind turbines
Dyess AFB, TX

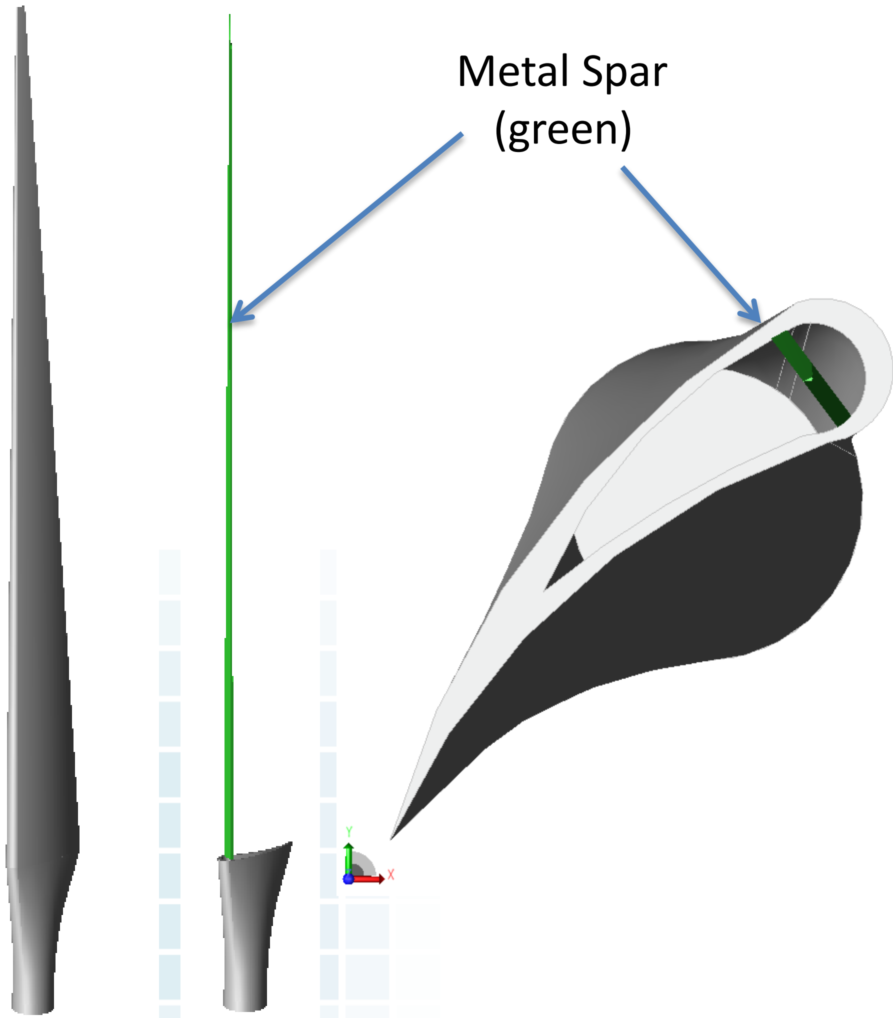


Interference with Doppler Radar in southeast WI

Method - XFdtd® (XF)

- XF is a 3D electromagnetic solver
- It utilizes the finite-difference time-domain approach to directly solve Maxwell's equations
- XF simulations include the effects of:
  - Geometry
  - Material Properties
  - Frequency
  - Polarization
- Allows extremely large simulations (> 60 GB of RAM)
- Employs CUDA-enabled Graphical Processing Units (GPU) for calculation acceleration

Turbine Blade Geometry



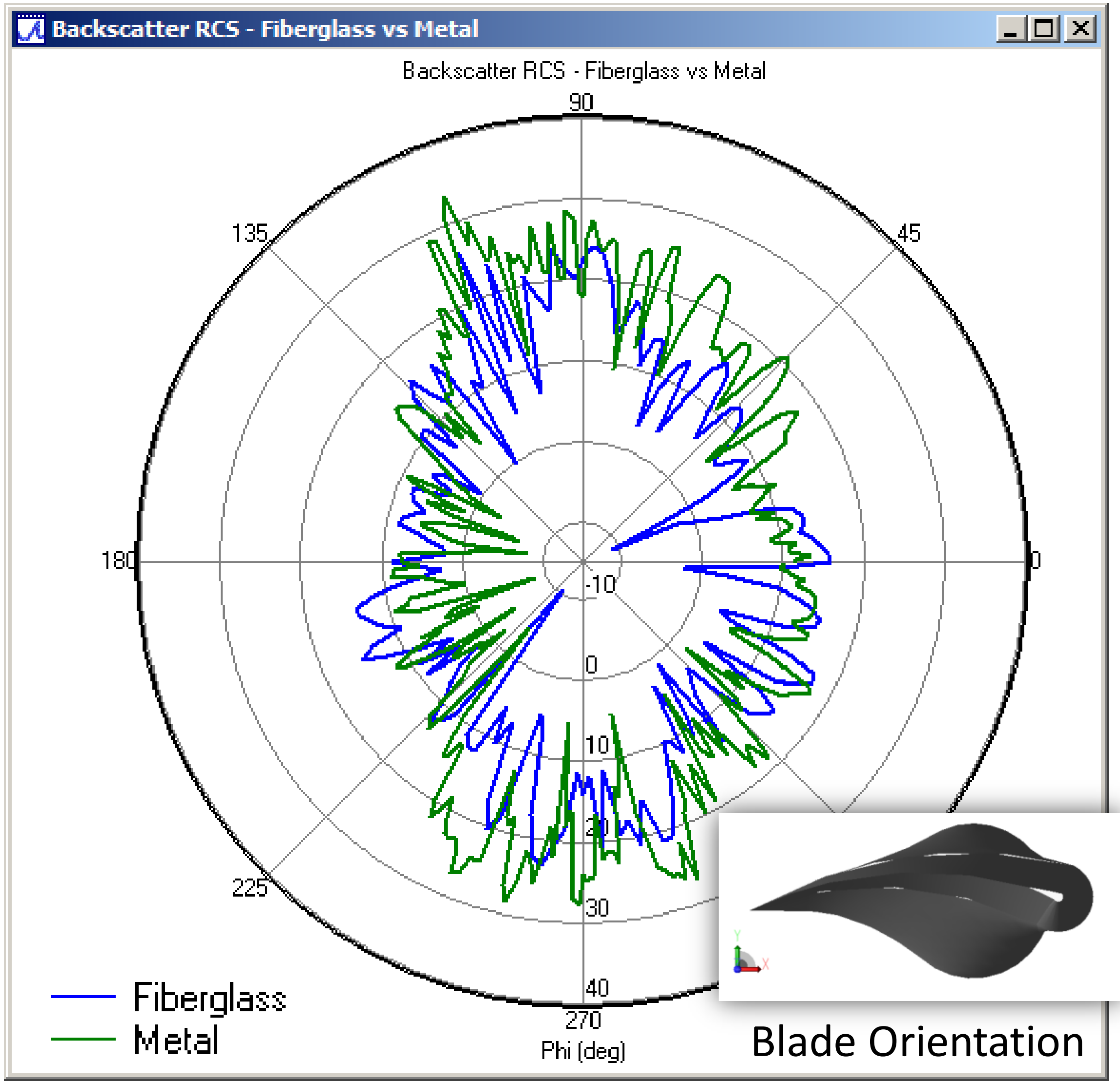
- The blade geometry was created using the solid modeling tools in XFdtd Release 7 (XF7)
- The airfoil cross section of the blade was extruded with a draft angle to create the majority of the blade.
- The attachment point to the nacelle was extruded from a circular cross section and then blended into the airfoil cross section
- The interior was hollowed out using Boolean operations
- A spar was added by extruding a define cross section down the length of the blade

XF Simulations

- The blade was illuminated with a plane wave
  - Frequency: 2.7 GHz
  - Polarization: Vertical
- 3 Material Cases
  - Hollow blade modeled as metal (perfect electrical conductor)
  - Hollow blade modeled as fiberglass
    - Fiberglass relative permittivity: 4.34
    - Fiberglass conductivity: 0.0031 S/m
  - Hollow fiberglass blade with metal spar
- Metal is included as a comparison material because it typically represents the worst case backscatter for a geometry
- Required GPU Memory: 15.8 GB
- Outputs: Backscatter RCS & Bistatic RCS
- Average calculation time per incident angle: ~13 minutes

Backscatter RCS - Fiberglass Versus Metal

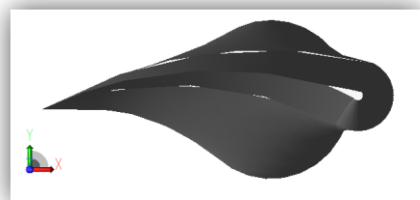
- Plot shows backscatter RCS scattering
- For backscatter calculations, RCS is measured at the same direction as the incoming plane wave
- Results show differences between metal and fiberglass blades
- The maximum backscatter RCS difference is about 15 dBsm at an angle of 242˚



Blade Orientation

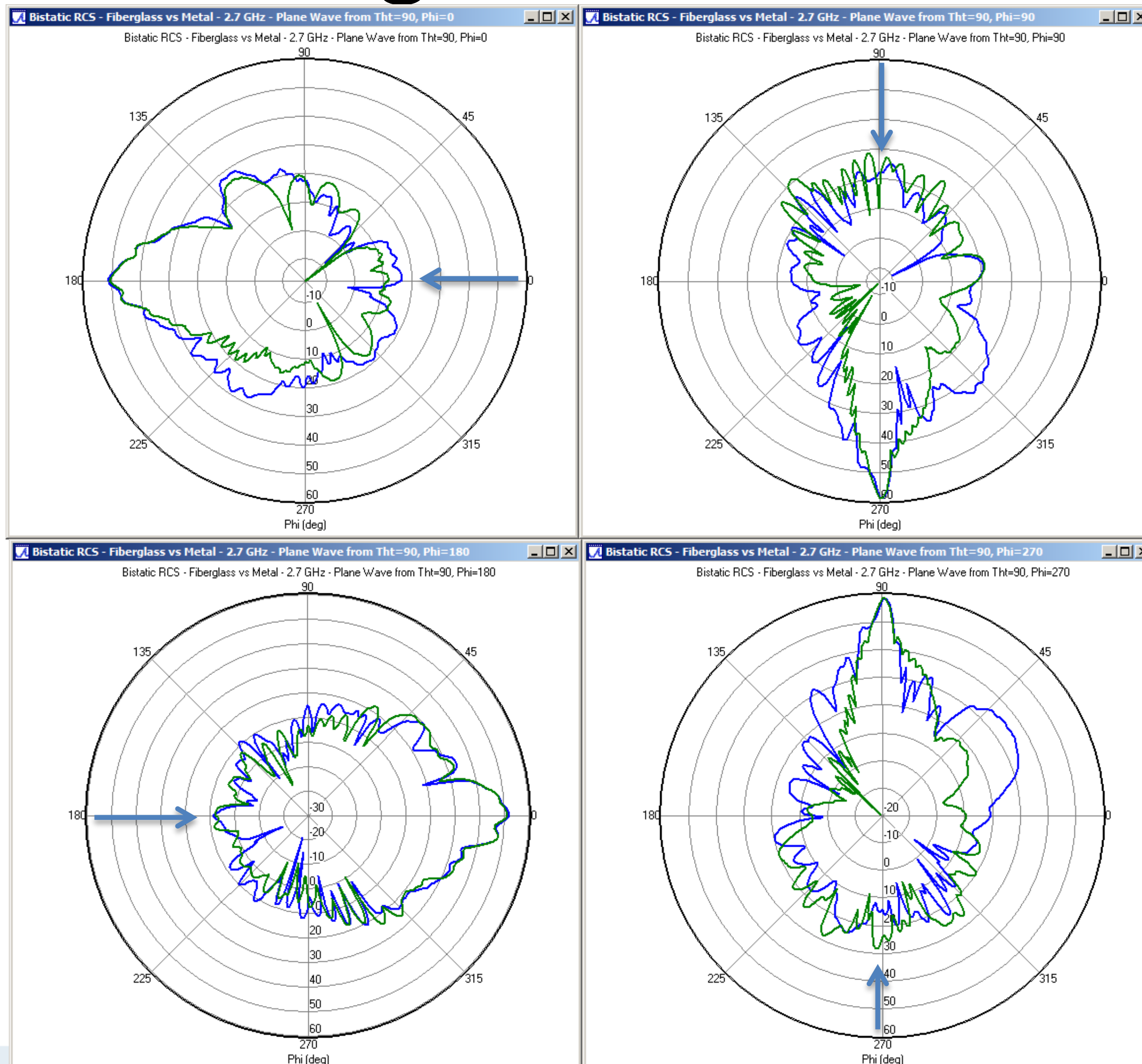
Bistatic RCS – Fiberglass vs Metal

Fiberglass
Metal



Blade Orientation

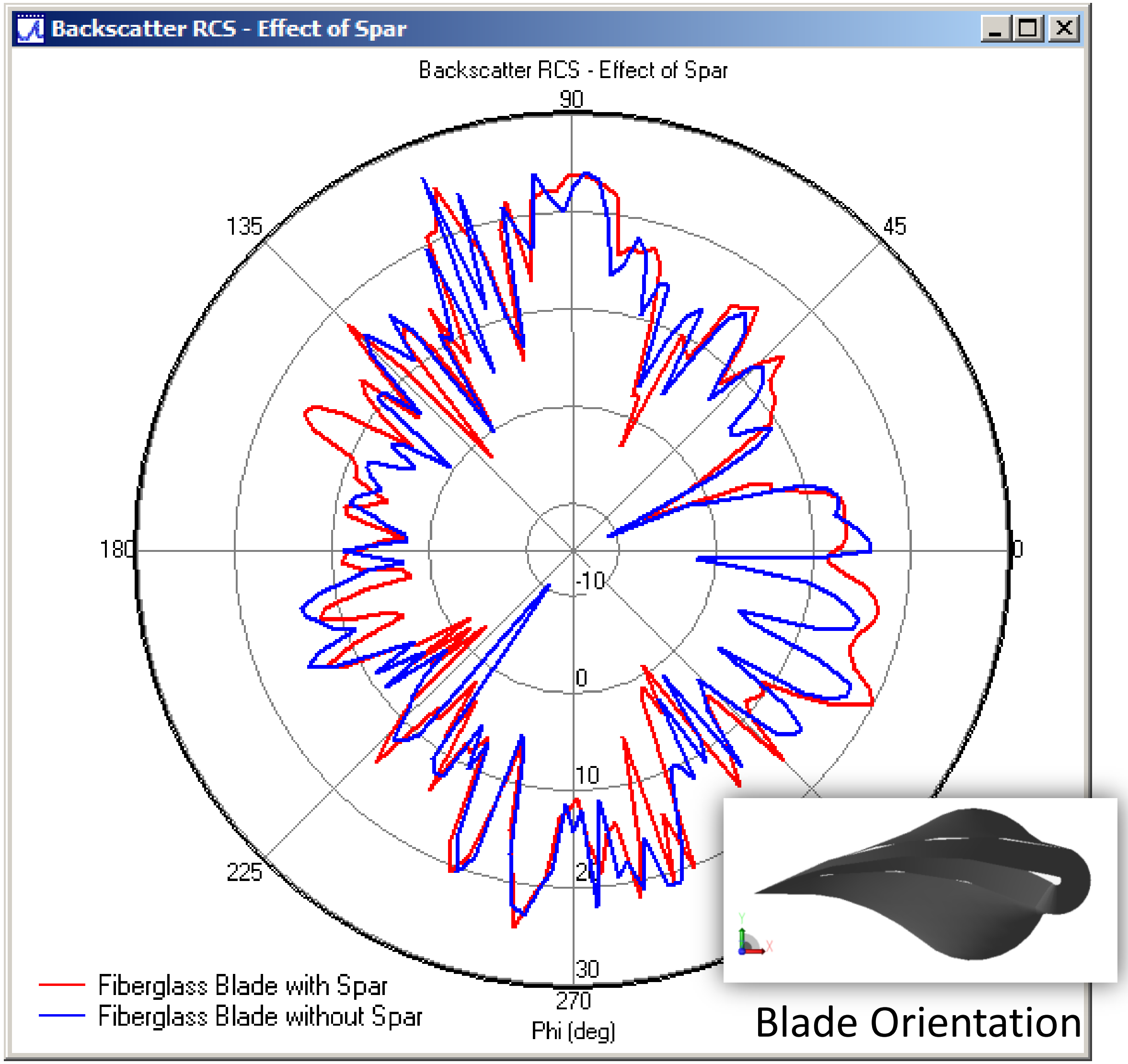
- Plots show RCS scattering from a single incoming direction
- Bistatic results show differences between metal and fiberglass blades
- The maximum difference is about 20 dBsm



Arrow indicates incoming plane wave direction

Backscatter RCS – Effect of Spar

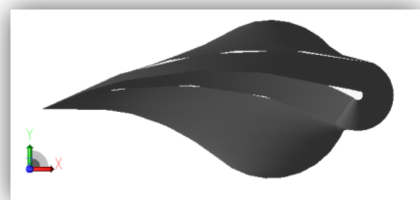
- Plot shows backscatter RCS scattering
- For backscatter calculations, RCS is measured at the same direction as the incoming plane wave
- Results show differences when the metal spar is included
- The maximum backscatter RCS difference is about 13 dBsm at an angle of 152˚



Blade Orientation

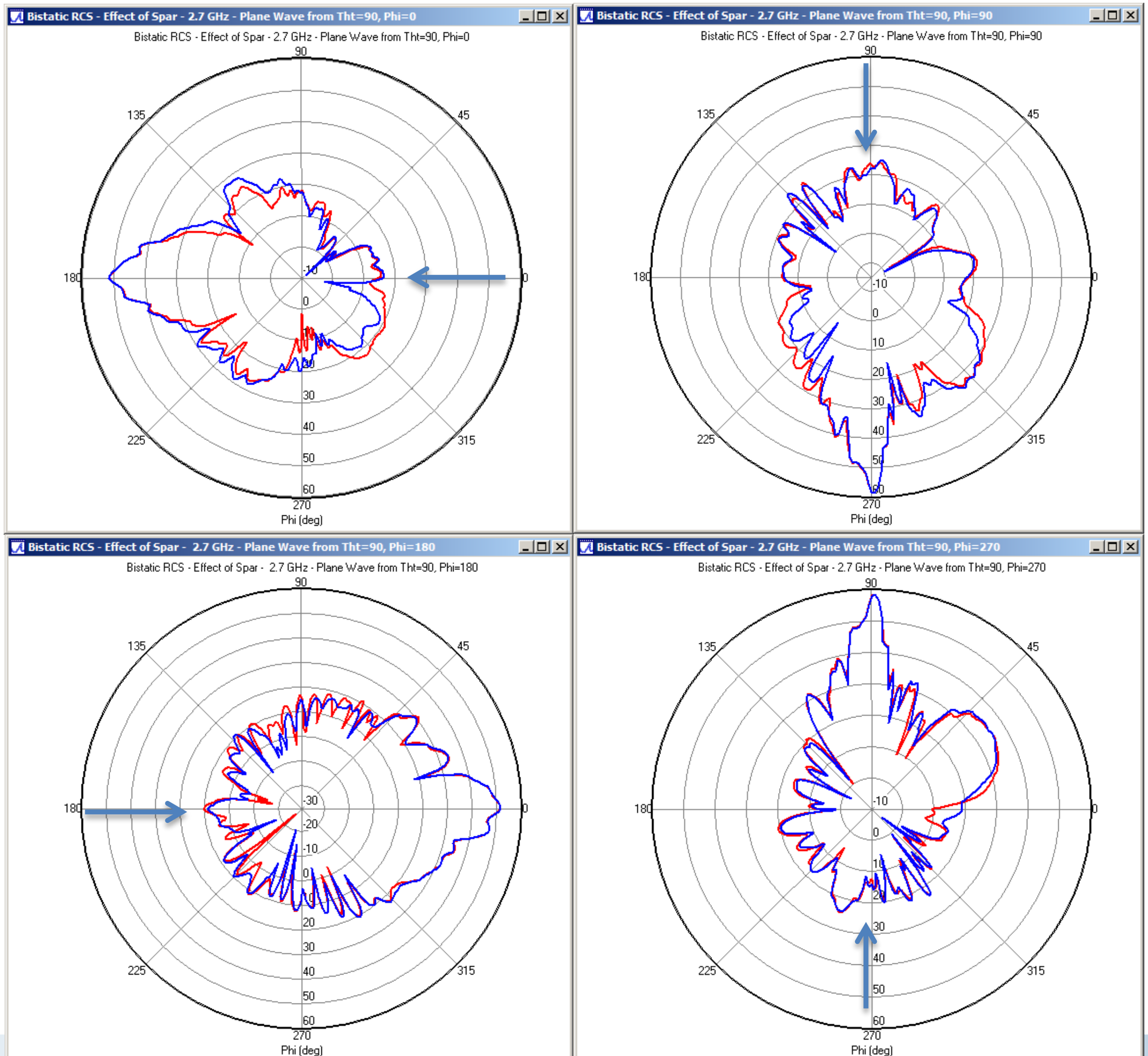
Bistatic RCS – Effect of Spar

— Fiberglass Blade with Spar
— Fiberglass Blade without Spar



Blade Orientation

- Plots show RCS scattering from a single incoming direction
- Inclusion of the metal spar does not result in a significant change in the bistatic scattering
- Different spar geometries like spar caps may have a greater effect on scattering



Arrow indicates incoming plane wave direction

REMCOM

Conclusion

- Remcom's XFdtd EM solver provides high-fidelity radar cross section results for wind turbines
- Simulations results include the effects of materials and internal blade details
- Results show scattering differences of up to 20 dBsm for the RCS backscatter for the blade materials evaluated
  - This suggests that blade materials and structure are important for high fidelity modeling of scattering from a wind turbine blade

Remcom Electromagnetic Simulation Solutions

Contact us:

Toll Free: 1-888-773-6266 (US/Canada)
Tel: 1-814-861-1299
Email: sales@remcom.com

www.remcom.com

Free Trial: www.remcom.com/free-trial-request-form
Pricing: www.remcom.com/pricing
Information Request: www.remcom.com/information-request-form

Google+: https://plus.google.com/110119589084506497581/posts
Facebook: www.facebook.com/remcomsoftware
Twitter: twitter.com/remcomsoftware
LinkedIn: www.linkedin.com/company/remcom-inc