

Installed Antenna Scenarios and RCS Analysis in MATLAB®

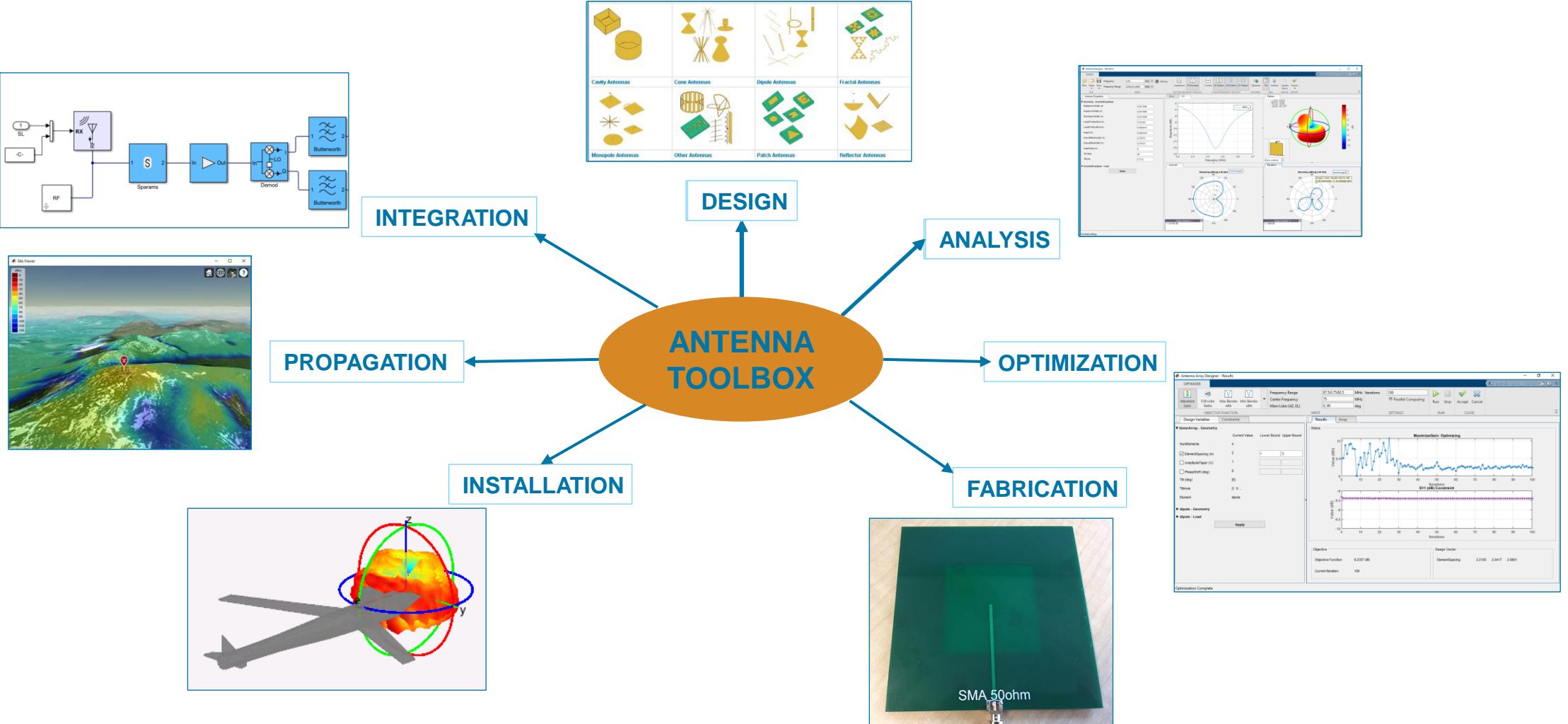
Vishwanath Iyer
06/14/2023

Agenda

- Antenna Toolbox – Introduction
- Problem Setup
- Feature Review: Installed Antenna
- Feature Review: RCS
- Solvers
- Summary

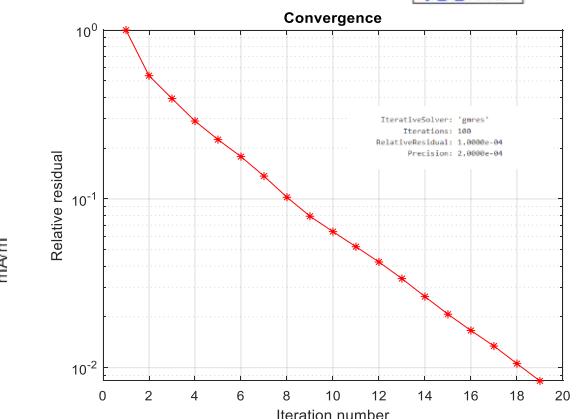
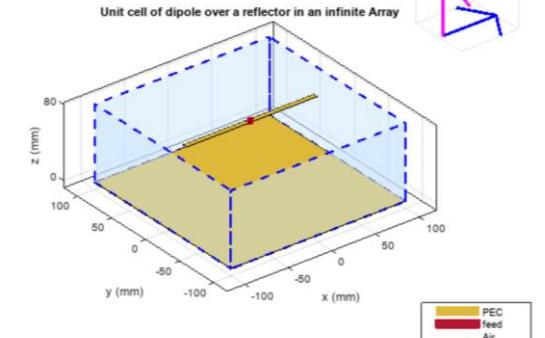
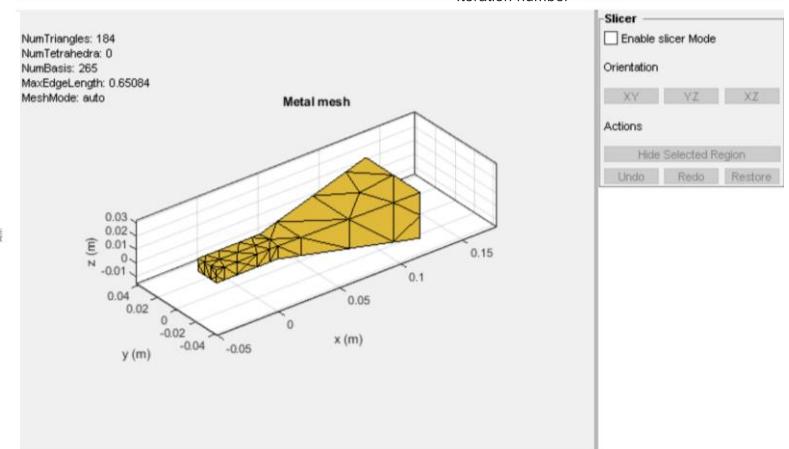
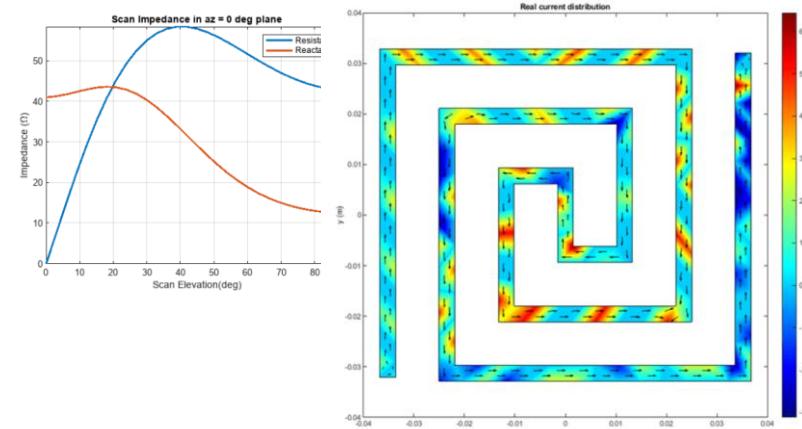
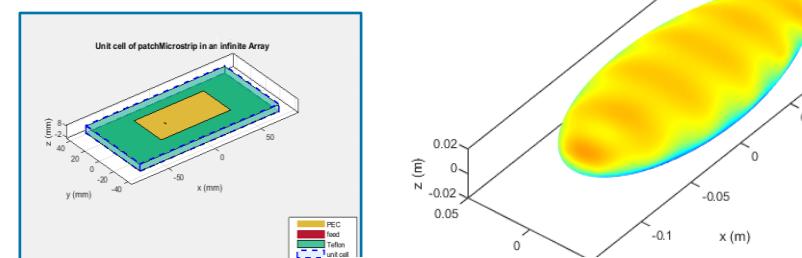
Vision

To provide one easy-to-use tool for all things antenna



Recent Feature Review

- STL-file checker
- Design for plane-wave analysis
- Plane-wave analysis using FMM
- Access to solver and convergence
- Infinite array updates
- Min. edge length and growth rate on all catalog
- Slicer capability to visualize mesh
- Overlay direction of current flow



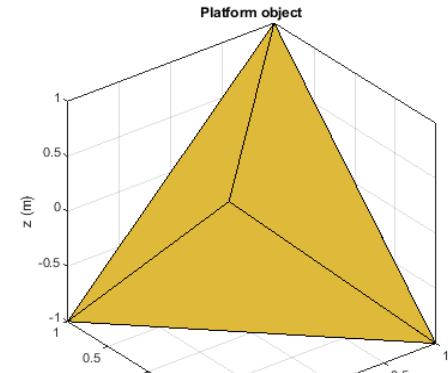
File import

Import the platform as an STL file

```
p = platform;
p.FileName = 'tetrahedra.stl';
p.Units = 'm';
```

`p =`
`platform` with properties:

FileName: 'tetrahedra.stl'
 Units: 'm'
 UseFileAsMesh: 0
 Tilt: 0
 TiltAxis: [1 0 0]

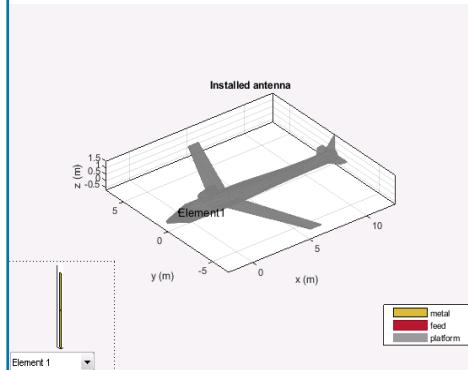


Installed antenna analysis

```
%% Set-up the installed antenna
ant = installedAntenna;
ant.Platform      = plat;
ant.Element       = design(dipole, 1e9);
ant.ElementPosition = [-1.2 0 0.5];
figure; show(ant)
```

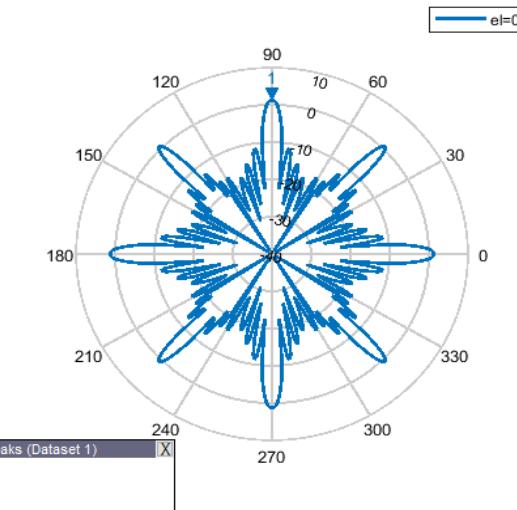
`installedAntenna` with properties:

Platform: [1x1 platform]
 Element: [1x1 dipole]
 ElementPosition: [-1.2000 0 0.5000]
 Reference: 'feed'
 FeedVoltage: 1
 FeedPhase: 0
 Tilt: 0
 TiltAxis: [1 0 0]
 SolverType: 'MoM-PO'



Radar Cross Section (RCS)

```
rcs(plat,f,az,el);
```



Detect Bad STL Files

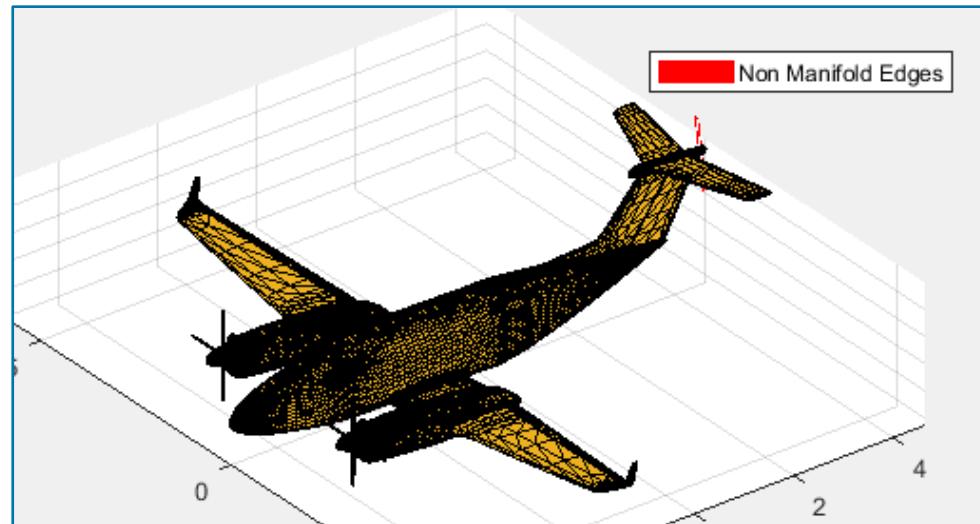
```
>> obj = stlFileChecker('beechcraft_kingair_350_blend.stl','ShowLog',0)
```

obj =

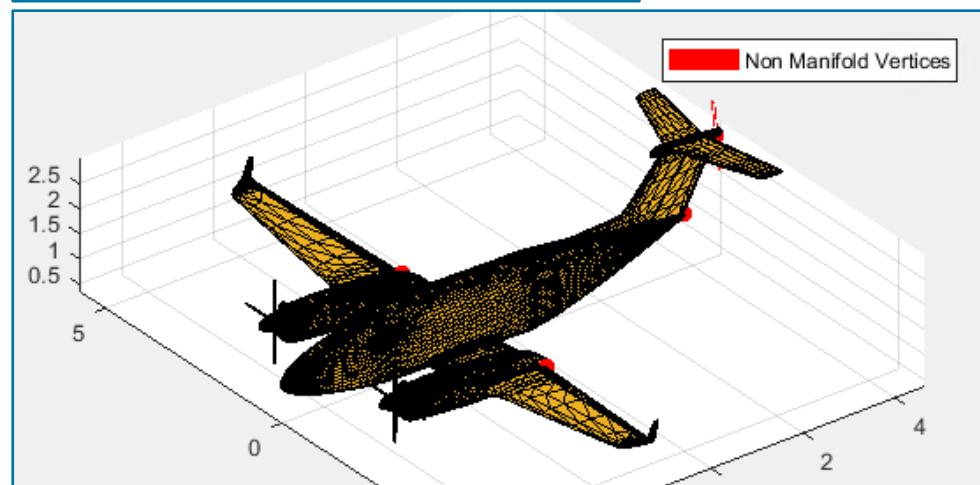
stlFileChecker with properties:

 FileName: 'beechcraft_kingair_350_blend.stl'
 Triangulation: [41884×3 triangulation]
 NonManifoldEdges: [4×2 double]
 NonManifoldVertices: [4×1 double]
 Slivers: [0×1 double]
 DuplicateVertices: {}
 NormalTransitionEdges: [0×2 double]
 FreeTriangles: [0×1 double]
 TVertices: [0×1 double]
 ShowLog: 0
 MinimumSeparation: 1.0000e-06
 MinimumArea: 1.0000e-11

obj.showNonManifoldEdges



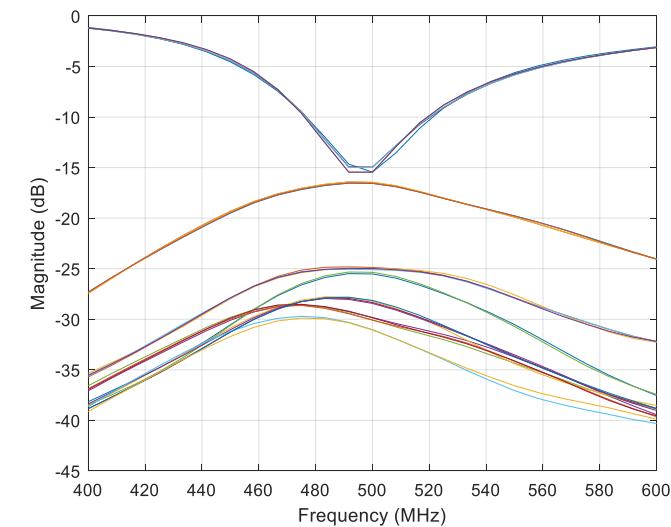
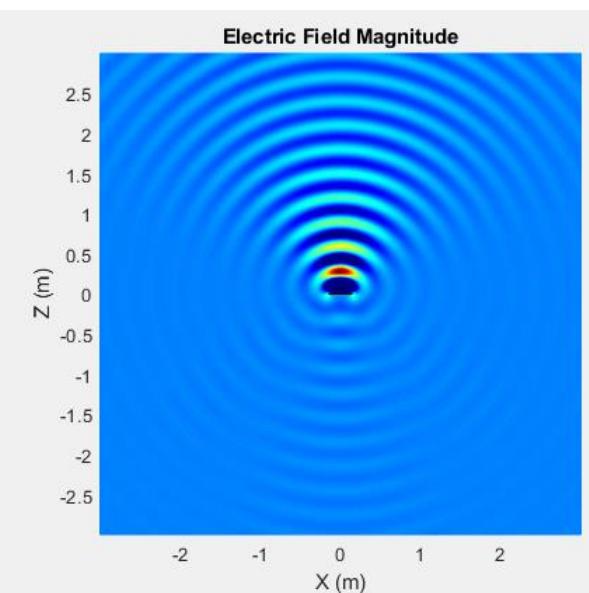
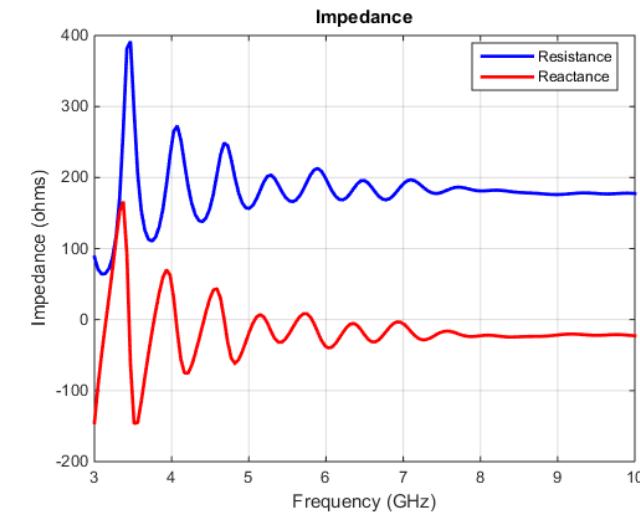
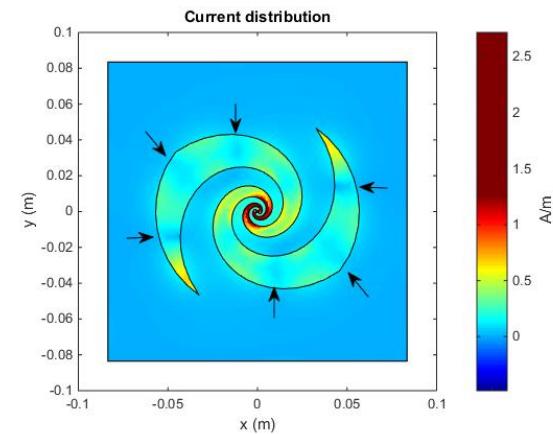
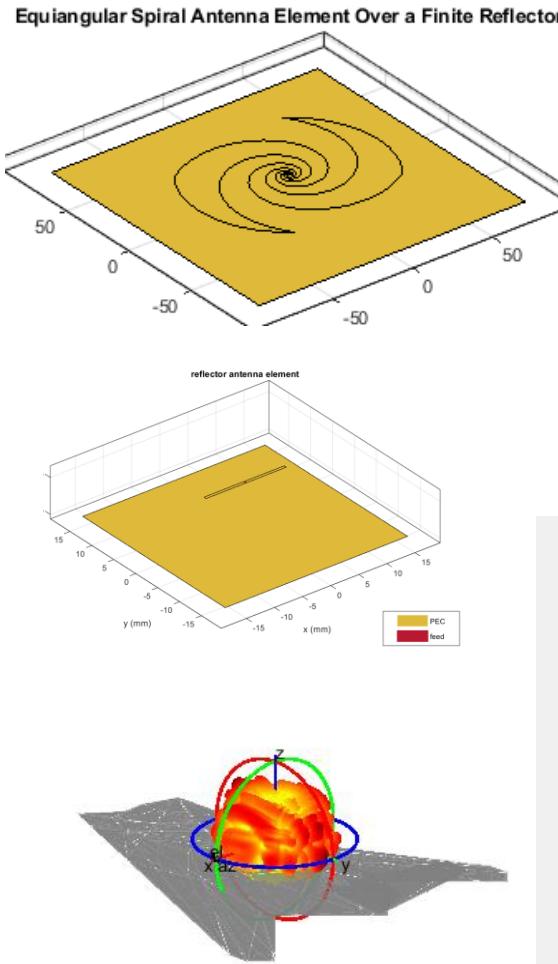
obj.showNonManifoldVertices



Installed Antenna Review

- Import a platform (e.g. STL file)
- Define 1 or more antennas around platform
- Use 3 solvers: MoM-PO (default), FMM or MoM
- Compute and visualize Far-field Pattern, Port parameters, surface currents

Installed Antenna Review



Installed Antenna Example

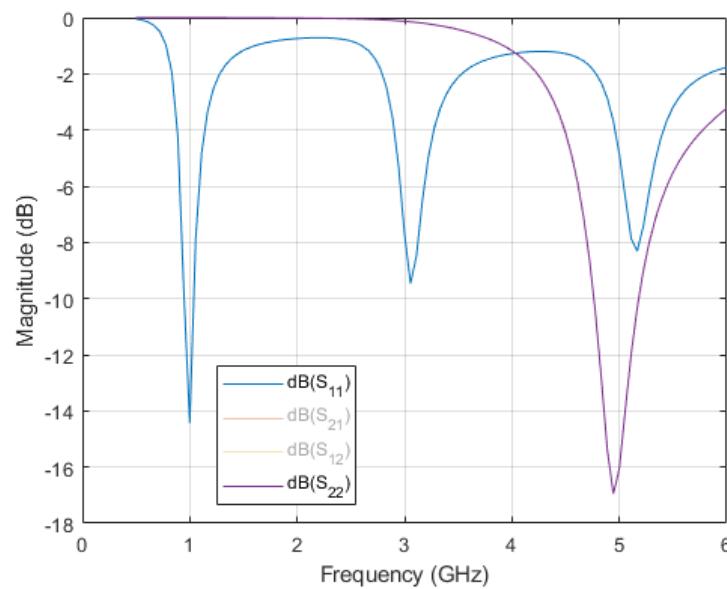
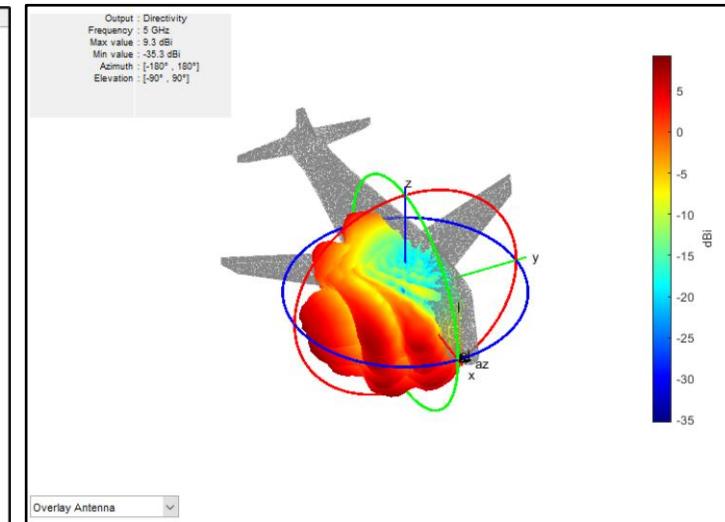
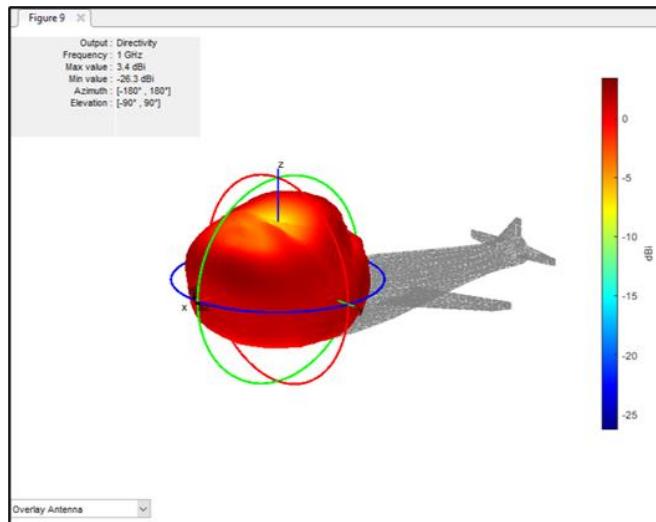
```
plat = platform('FileName', 'glider.stl', 'Units', 'm');
figure;
show(plat);
```

```
nose_ant = design(dipole,1e9);
wing_ant = design(dipole,5e9);
ant = installedAntenna;
ant.Platform = plat;
ant.ElementPosition(1,:) = [-1.2 0 0.5]
ant.ElementPosition(2,:) = [-3 -0.5 -0.15];
ant.Element = {nose_ant,wing_ant}
figure;
show(ant);
```

```
ant.FeedVoltage = [1 0];
figure;
pattern(ant,1e9)
```

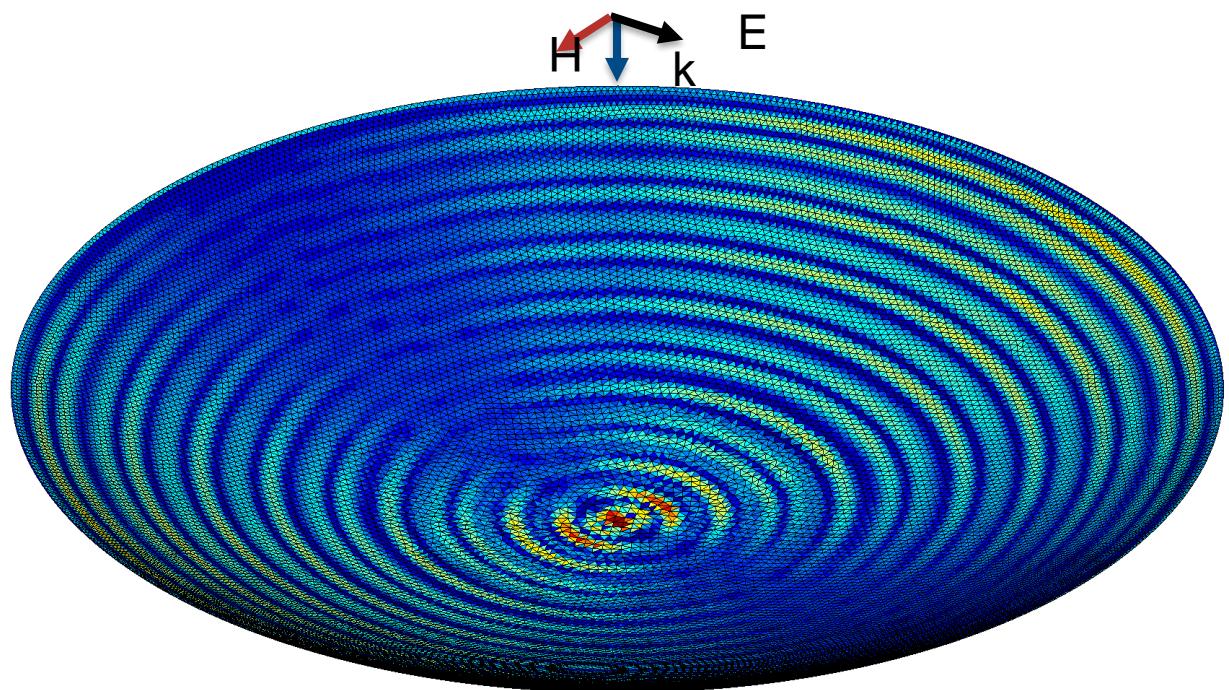
```
ant.FeedVoltage = [0 1];
figure
pattern(ant,5e9)
```

```
s = sparameters(ant,linspace(500e6,6e9,100));
```

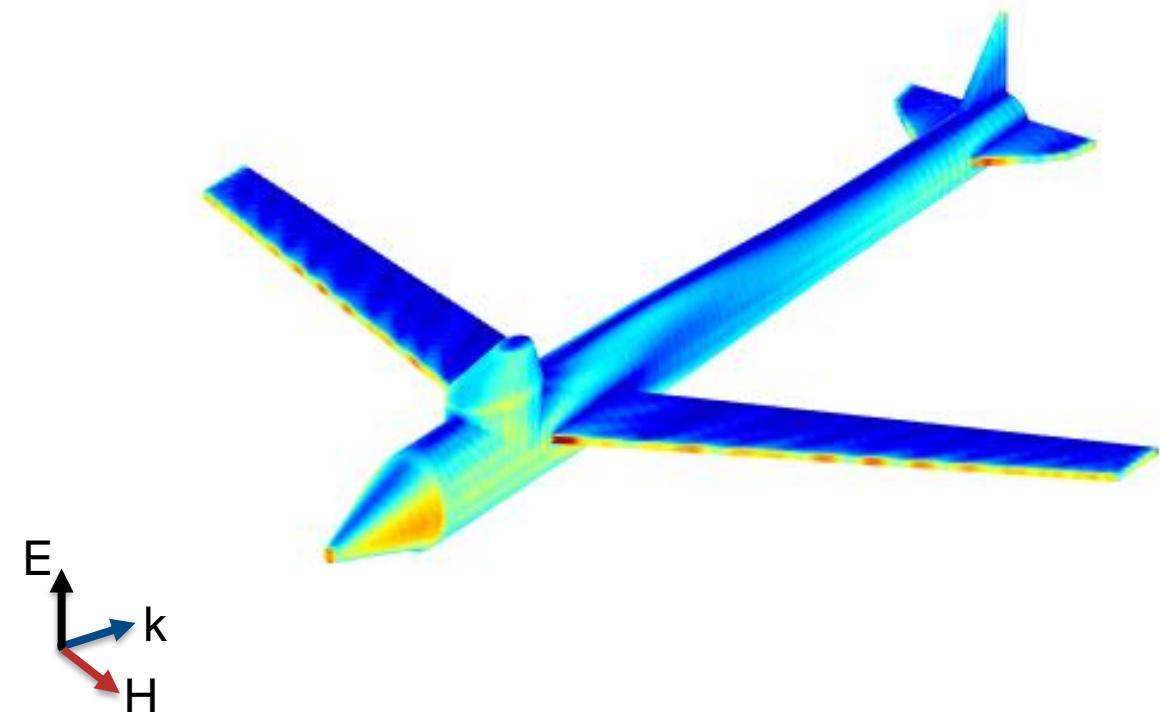


Scattering Solutions

Parabolic reflector

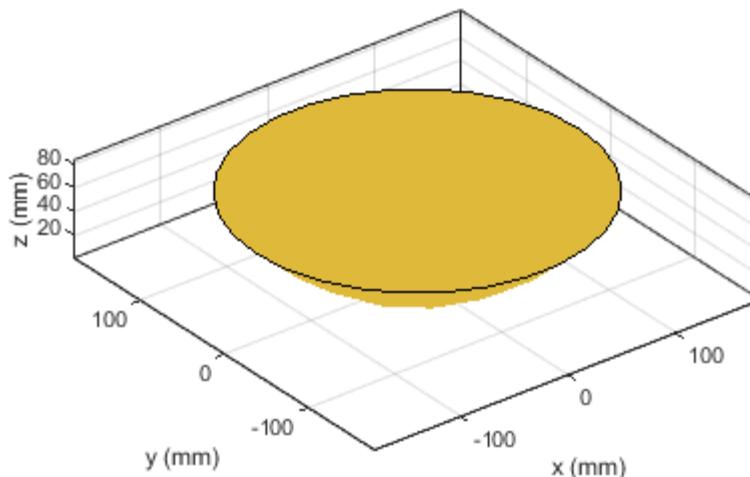


Glider



Reflector Analysis from Pattern Files

- Pick/Import reflector definition
- Import pattern data from file
- Calculate overall pattern using physical optics

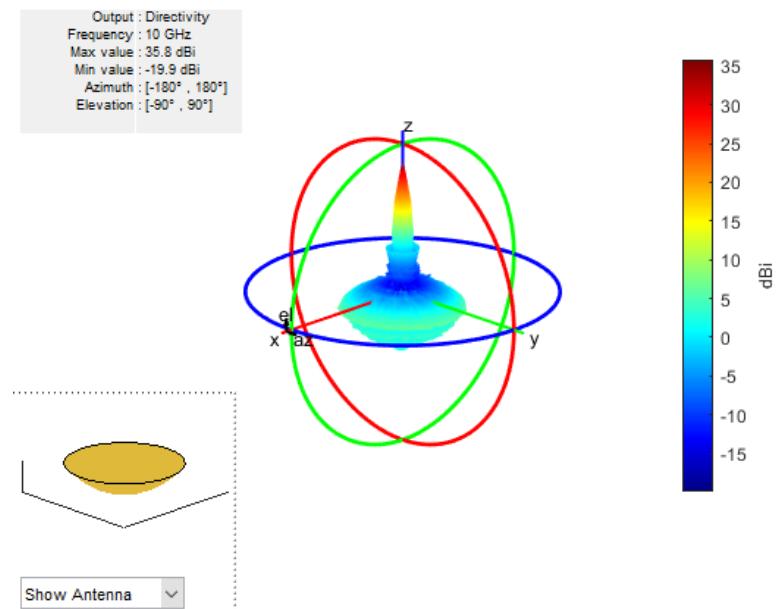


```
%Define the measuredAntenna object  
ms=measuredAntenna;  
ms.E=Einc.';

>> ms

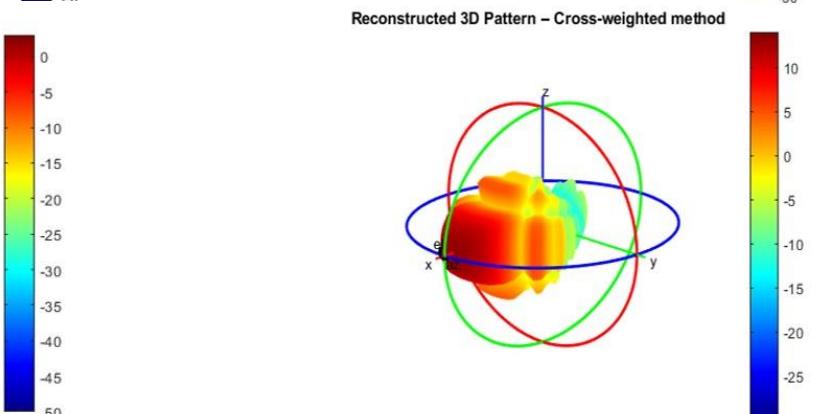
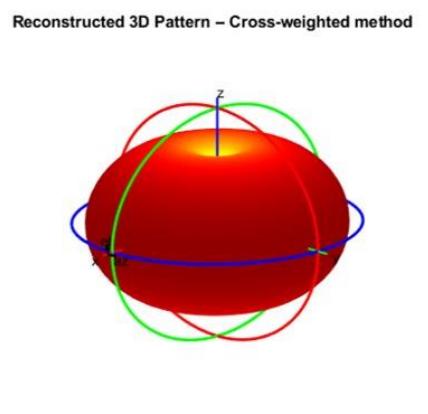
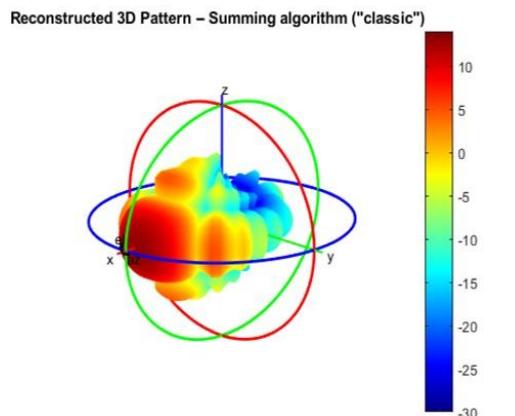
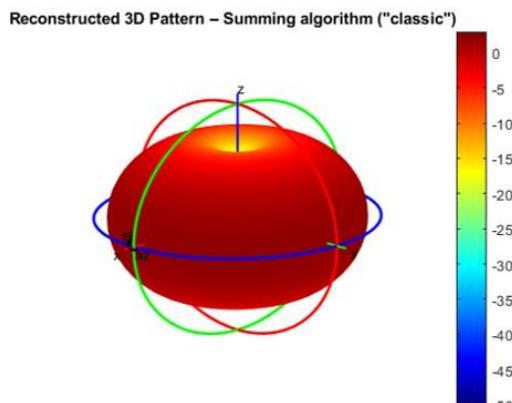
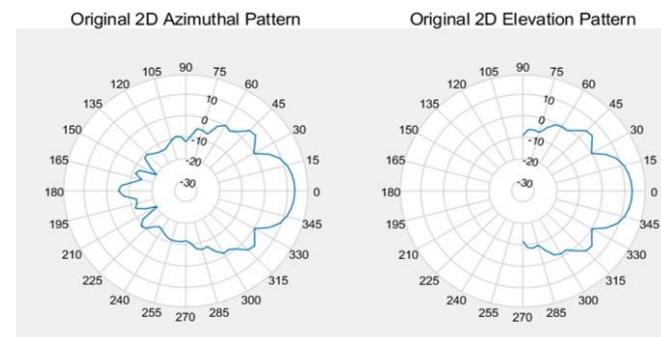
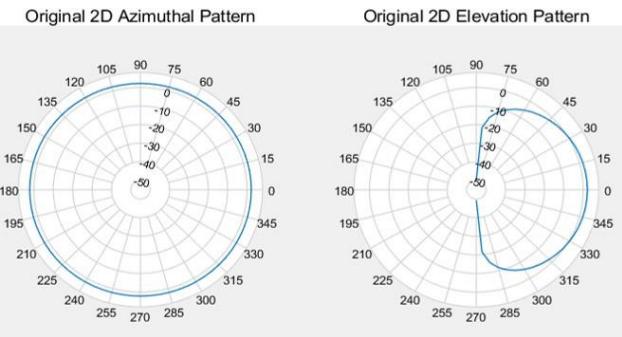
ms =  
  
measuredAntenna with properties:  
  
E: [3536×3 double]  
Direction: [3536×3 double]  
PhaseCenter: [0 0 0.1500]
```

Output : Directivity
Frequency : 10 GHz
Max value : 35.8 dBi
Min value : -19.9 dBi
Azimuth : [-180° , 180°]
Elevation : [-90° , 90°]



3D Pattern Reconstruction

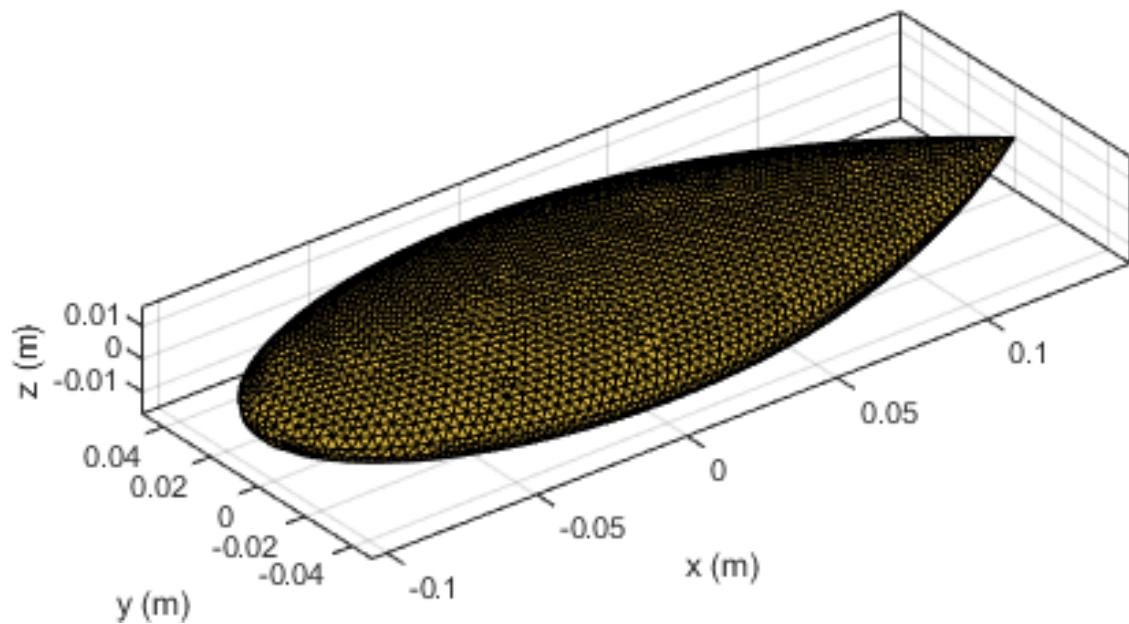
- Work with slices of pattern in 2D
- Reconstructs a 3D pattern
- Two choices for reconstruction algorithm



RCS Review

- Monostatic, Bistatic RCS functionality for antenna, arrays and custom shapes(STL file)
- PO, MoM, and FMM solver choices for calculating RCS
- Shadow region detection
- Supports VV, HH, VH, HV, Vtotal, HTotal polarizations
- Results available in complex and dBsm

RCS Benchmarking – NASA Almond @ 7GHz



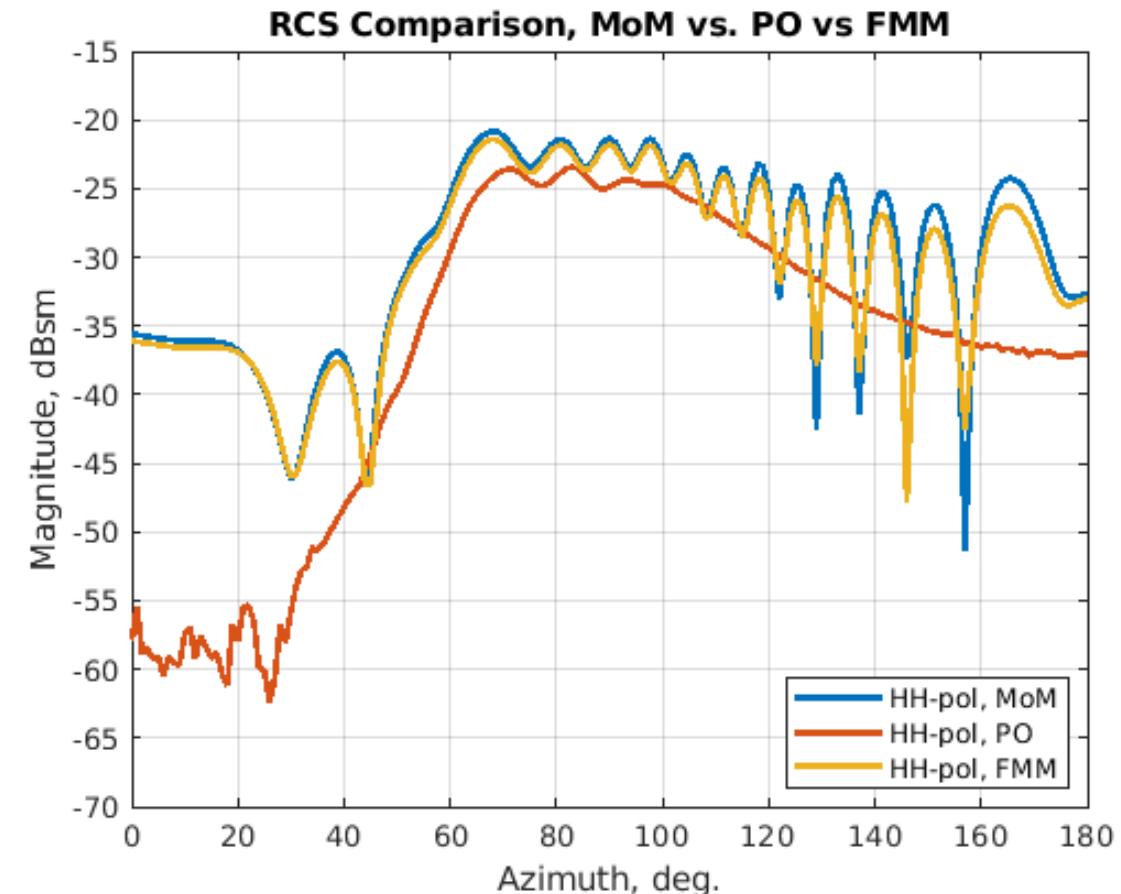
```

rcs(p,f,az,el,'Solver','PO', ...
    'Polarization','HH', ...
    'CoordinateSystem','rectangular');

rcs(p,f,az,el,'Solver','MoM', ...
    'Polarization','HH', ...
    'CoordinateSystem','rectangular');

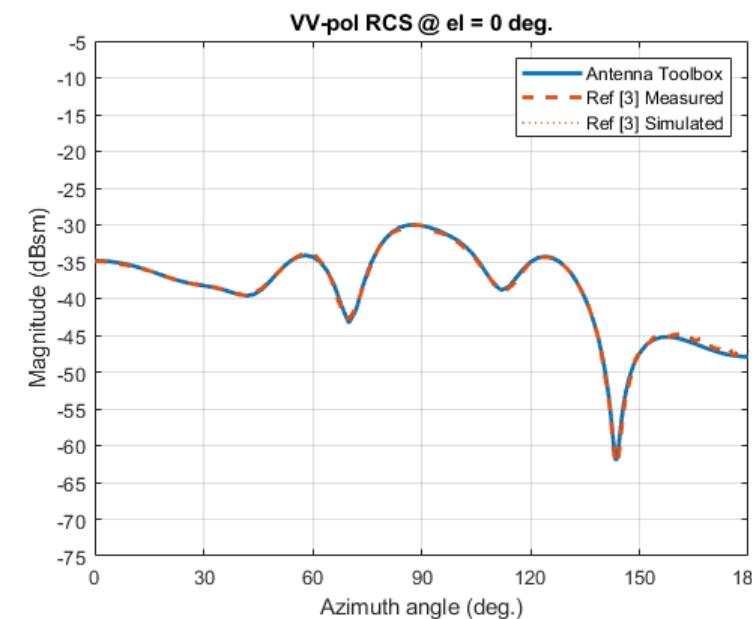
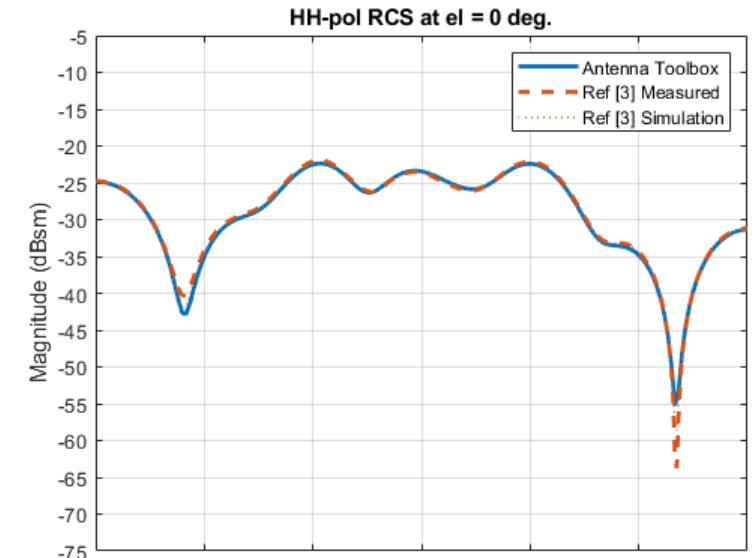
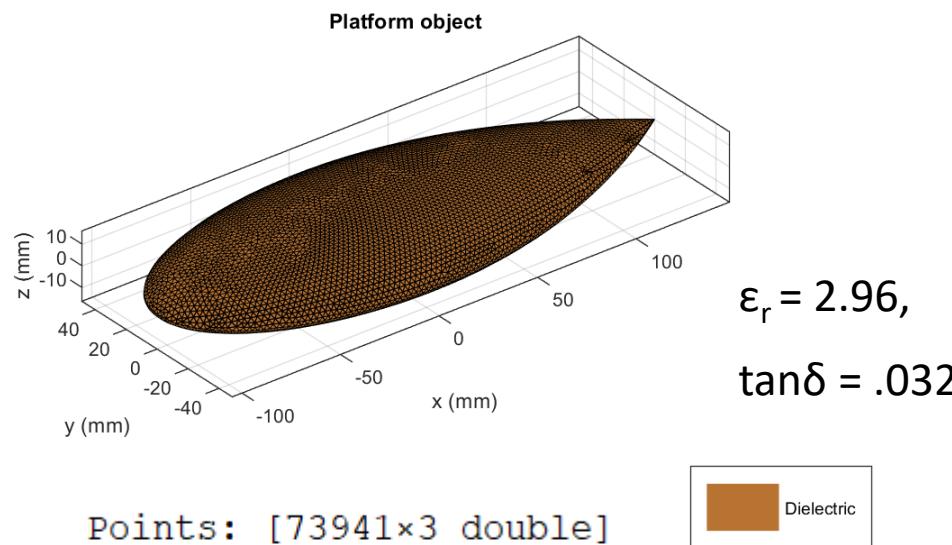
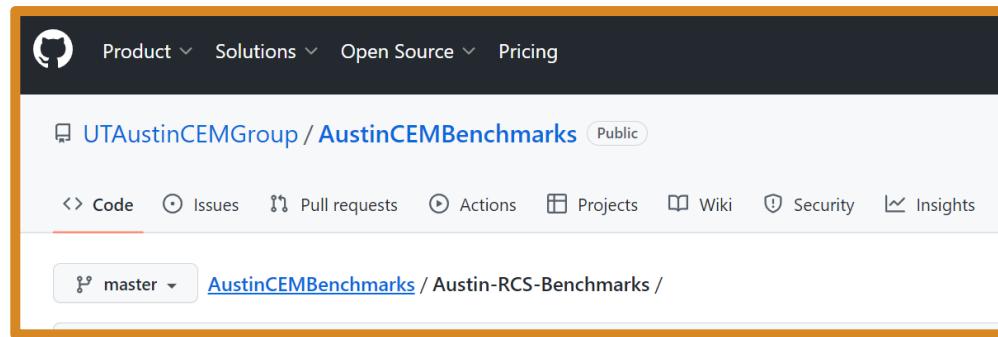
rcs(p,f,az,el,'Solver','FMM', ...
    'Polarization','HH', ...
    'CoordinateSystem','rectangular');

```

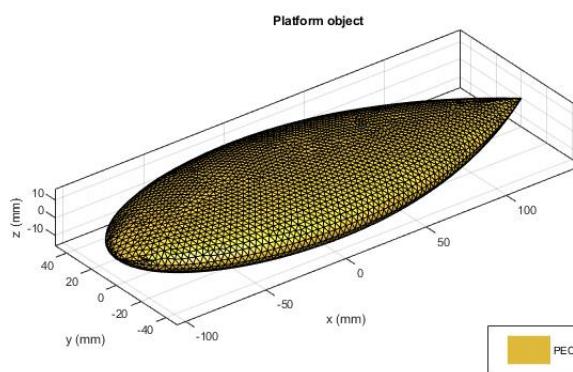


Azimuth sweep – 0:180 deg.
Elevation – 0 deg.

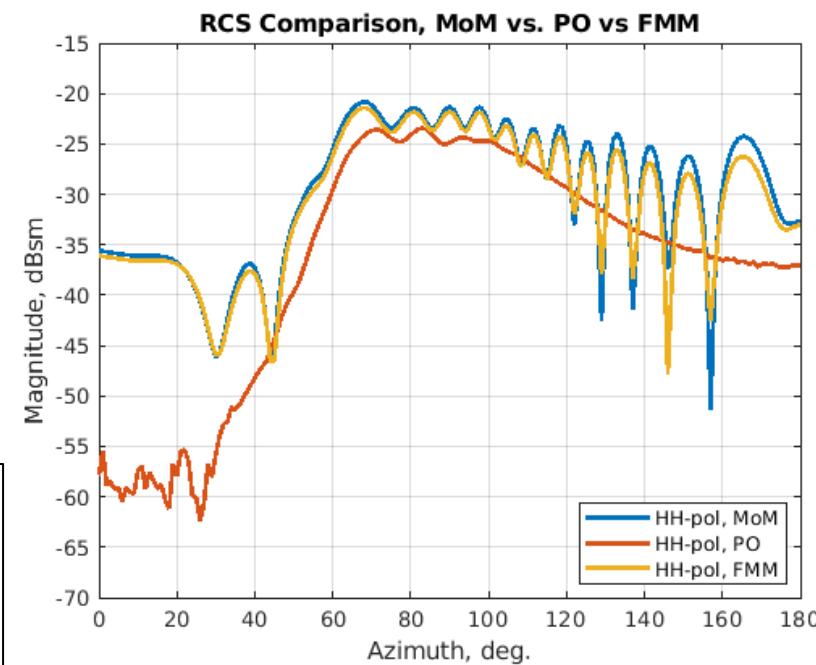
Dielectric NASA Almond – Monostatic RCS@ 2.98 GHz



Solvers



NASA Almond, 7 GHz, PEC target
 RCS Setup: Monostatic, HH pol
 32k unknowns



Solver	Time /angle
PO	Low
FMM	Medium
MoM	High

Summary

- Antenna Toolbox supports installed antenna and RCS workflows
- STL and MAT file import with more on the way
- 100+ antenna types in catalog
- Pattern analysis of reflectors with custom excitation pattern
- Pattern reconstruction from 2D slices
- 4 solvers – MoM, MoM-PO, FMM and PO

THANK YOU

Examples

Documentation

Getting Started with Antenna Toolbox

The screenshot shows the MathWorks Help Center interface. At the top, there's a navigation bar with links for Products, Solutions, Academia, Support, Community, and Events. Below that is a search bar labeled "Search Help Center". On the right side of the header, there are links for "Get MATLAB", "Help Center", and a magnifying glass icon for search.

The main content area has a blue header "Help Center" and a sub-header "Antenna Toolbox – Examples". Below this, there's a section titled "Get Started with Antenna Toolbox" which includes several thumbnail images and descriptions of various examples. The examples include:

- More options
- Current distribution
- Electric Field Plot
- Electric field magnitude plot
- Get Started with Antenna Toolbox
- Port Analysis of Antenna
- Current Visualization on Antenna Surface
- Antenna Far-Field Visualization
- Antenna Near-Field Visualization
- Field Analysis of Monopole Antenna
- Infinite Array Analysis
- Plane Wave Excitation - Scattering Solution
- Loading Using Lumped Elements
- Design Variations On Microstrip Patch Antenna Using PCB Stack
- Create Antenna Model from Gerber Files

On the left side of the main content area, there's a sidebar with a "CONTENTS" section and a "Category" section for the "Antenna Toolbox". The "Category" section lists various topics with their page numbers:

Category	Page Number
Antenna Toolbox	21
Get Started with Antenna Toolbox	21
Antenna Catalog	31
Array Catalog	11
Material Catalog	10
Custom Geometry and PCB Fabrication	22
Analysis, Benchmarking, and Verification	22
Antenna and Array Optimization	4
Import, Export, and Visualization	5
Installed Antenna and Large Structures	12

Below the "Category" section, there's a "Type" section with three radio buttons:

- All (selected)
- MATLAB
- Simulink

The page also features a "Documentation Home" link and a "R2023a" badge in the top right corner.

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