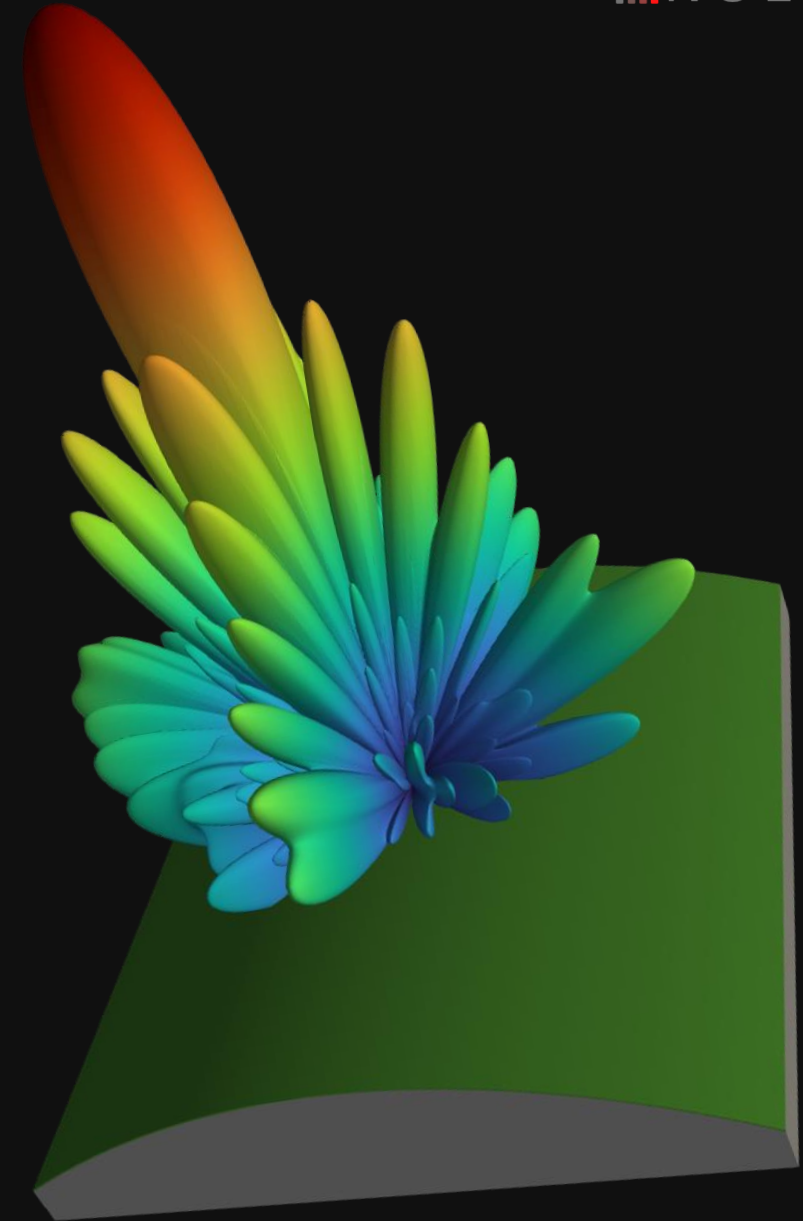


Reducing Cost & Schedule Risk Through Advanced EM Simulation: A Phased Array Radome Case Study

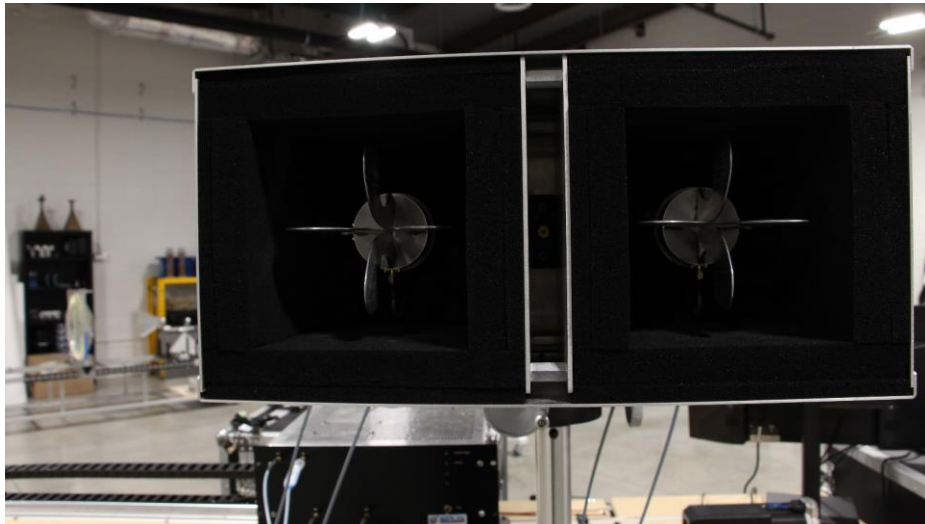
Dr. Daniel Faircloth
CTO
Nullspace, Inc.

IMS 2023 MicroApp Presentation
June 15, 2023



About Nullspace, Inc.

Spun out of IERUS Technologies,
an established Huntsville-based
defense contractor



Nullspace software validated
with real-world applications and
products for 10+ years



Our Products

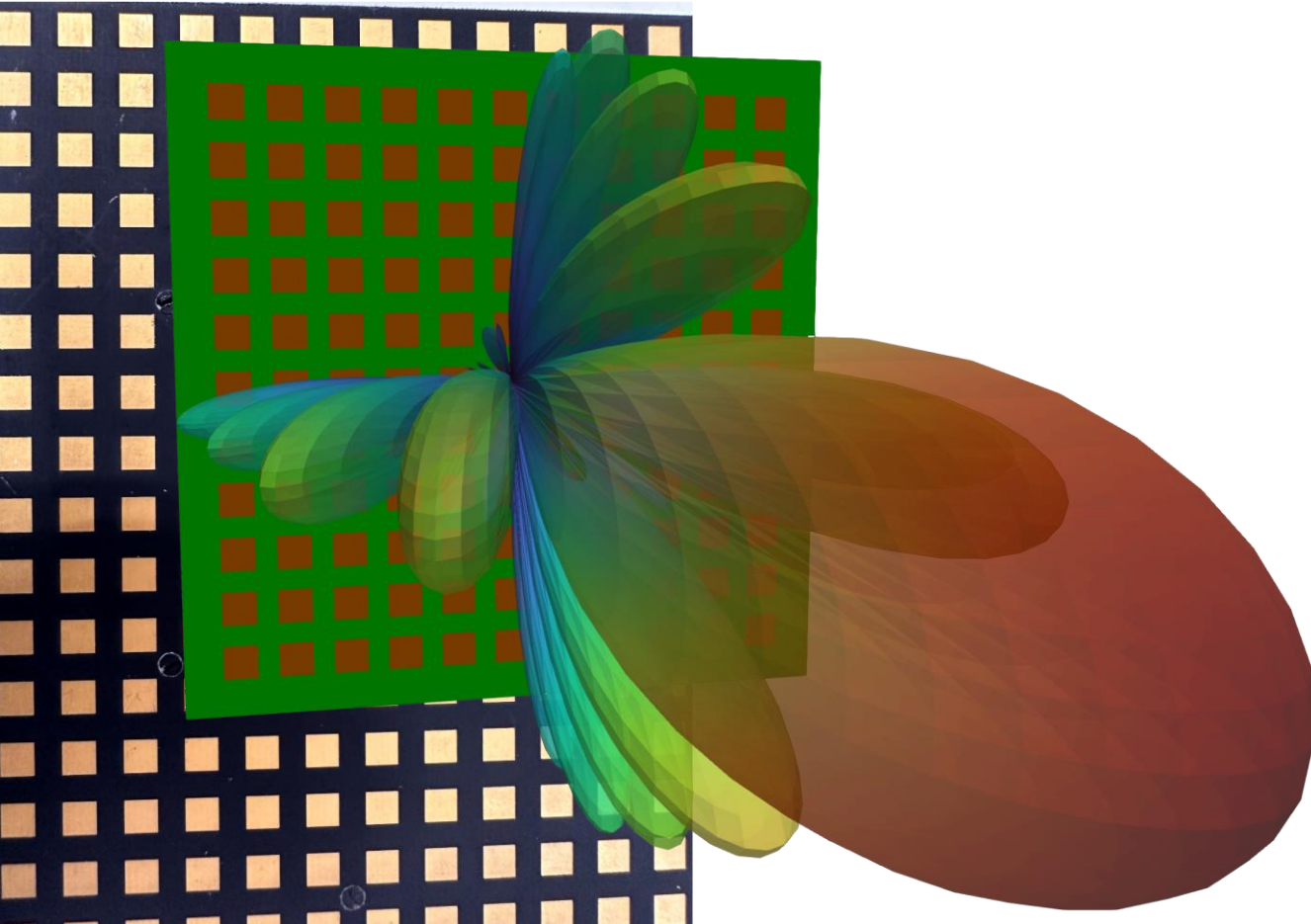
Nullspace **Prep**

- **CAD** and **meshing** pre-processor
- User-friendly **GUI**
- Import/Export many formats
- Powerful Python **API**

Nullspace **EM**

- Fast, accurate, 3D electromagnetic simulation software
- Designed for **speed** and **accuracy** of large **optimization** problems
- Robust, validated solver technology

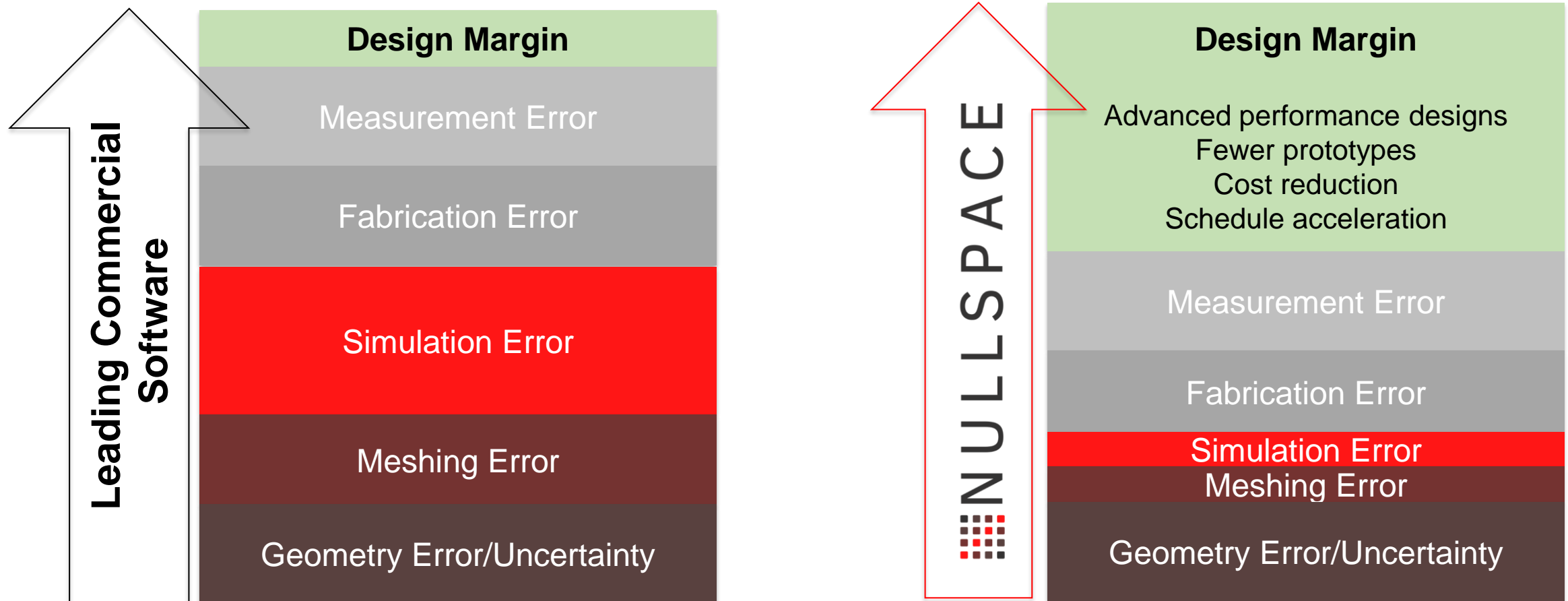
Solving Large Problems ... Accurately



- **Electrically large simulations** with many excitations – Phased arrays, scattering, co-site, etc.
- Available solutions are expensive and inaccurate for large problems
- With **Nullspace EM**, run much larger simulations **accurately and efficiently**

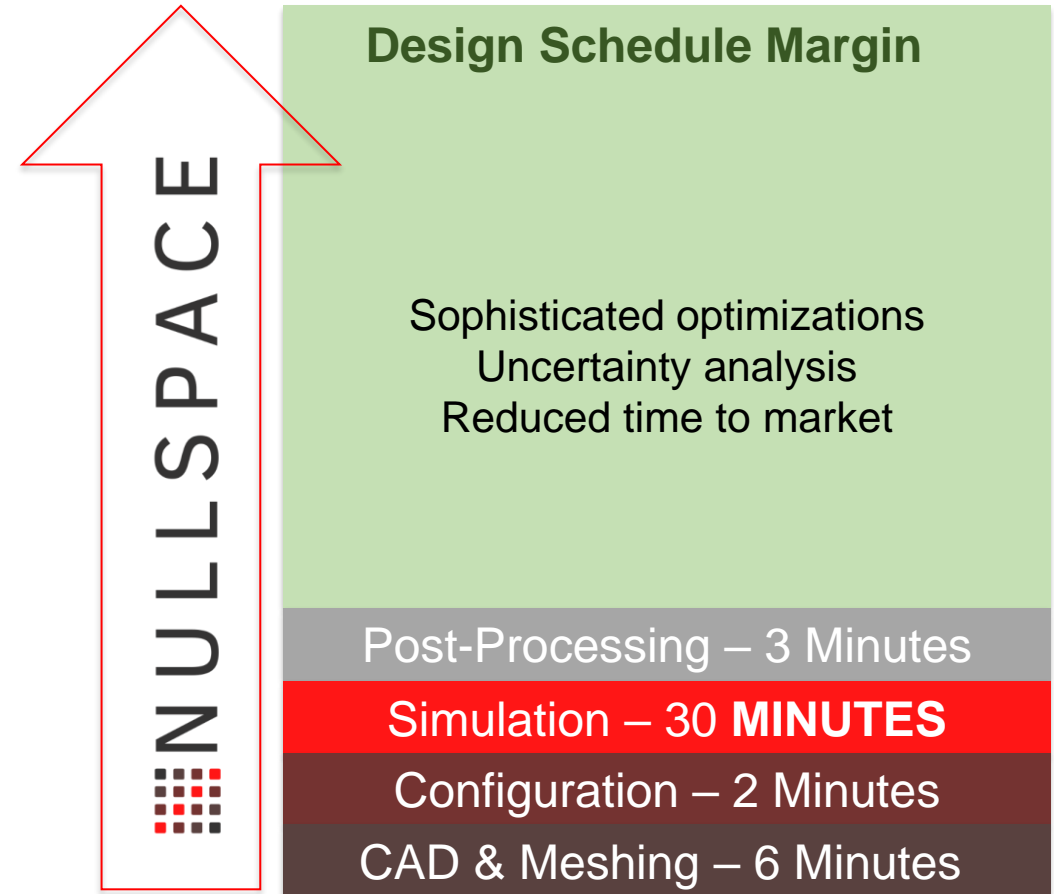
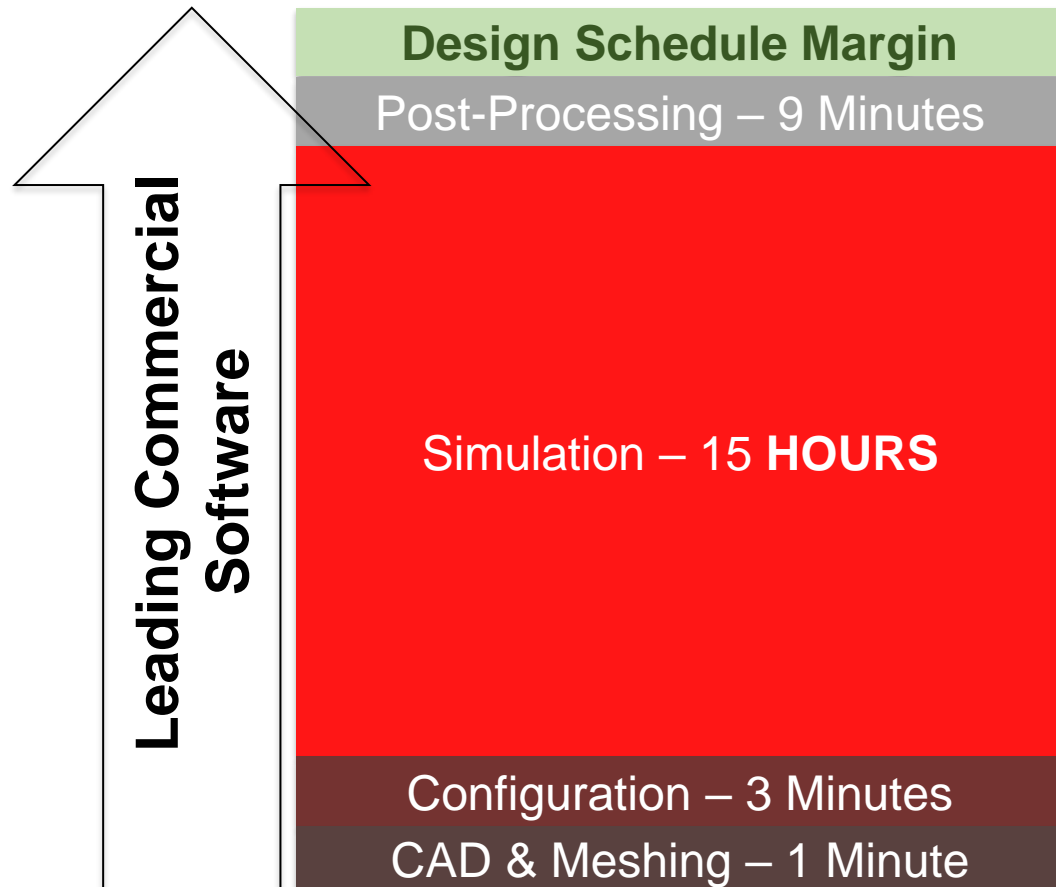
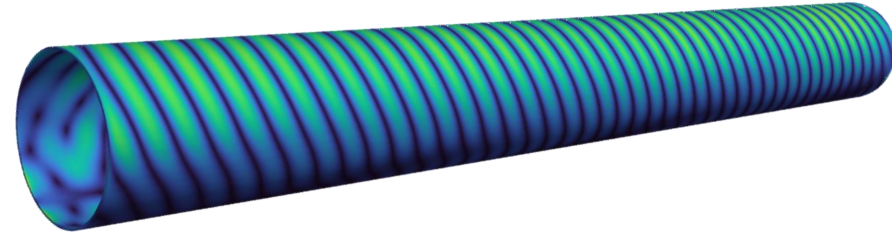
Why Accuracy Matters

Error build-up for a typical design process – 2-5X Error Reduction



Why Speed Matters

Actual time comparison for a challenging, large-scale EM simulation



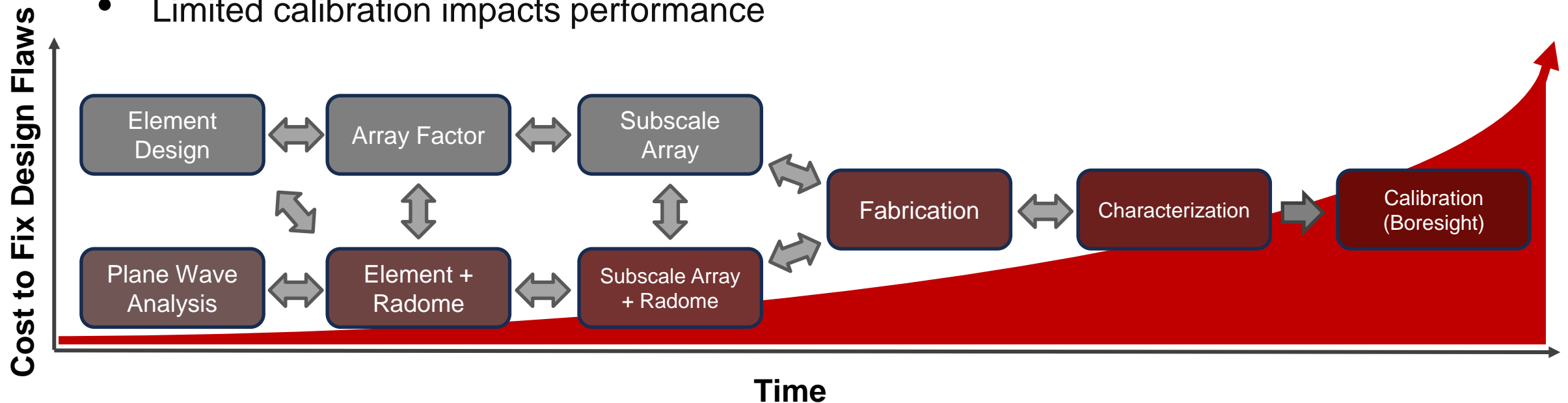
Radome Impacts on Antenna Performance

- Radomes offer environmental protection for antennas and arrays
 - Wind, precipitation, lightning, static discharge, etc.
- Tug-of-war between protection and performance
- Impact to performance must be considered but ...
 - No/Limited ability to perform detailed analysis before fabrication
 - Limitations on antenna calibration



The Radome Design Dilemma

- Disaggregated design tools introduce cost and schedule risk
- No/Limited ability to assess antenna+radome performance in simulation
- Delayed identification of design issues -> Higher cost to fix
- Limited calibration impacts performance

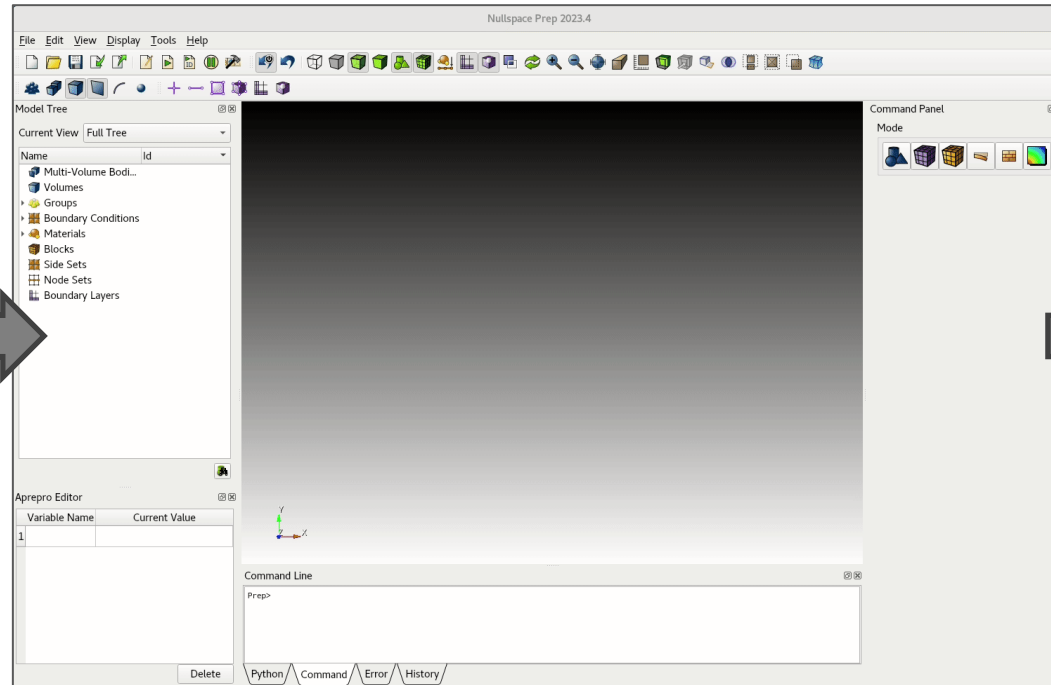


Phased Array Example

Nullspace Prep
Python API

```
dipoles_full_triangular_lattice.py
#python
2 import math
3 cubit.cmd('reset')
4 cubit.cmd('view iso')
5 cubit.cmd('rotate 90 about world y')
6 cubit.cmd('rotate 90 about world x')
7 cubit.cmd('zoom reset')
8
9 numY = 30
10 numZ = 15
11 lam = 3e8/6e9*1000
12 L = lam* 45
13 dv = 0.25*lam
14 dZ = lam/2
15 w = 0.81*lam
16 xOffset = lam/4
17 zExtent = ((numZ+1)*dZ/2)
18 yExtent = ((numY-1)*dv/2)
19 radomeR = yExtent + dv/2
20 radomeH = lam*1.75
21 radomeHEdge = radomeH - lam
22 radomeL = lam*.025/.0254/lam #2x QCE thickness at 6 GHz
23 radomeSep = lam/4
24 numPoints = 51
25 gOffset = 0
26
27 # Draw the antenna lattice
28 cubit.cmd('create surface rectangle width (w) height (L) yplane')
29 dipole_v = cubit.get_last_id('volume')
30 cubit.cmd('split surface in volume (dipole_v) across location(-w) @ 0 location')
31 dipole_s1 = cubit.get_last_id('surface')
32 cubit.cmd('move volume (dipole_v) x (xOffset) y (-dv*(numY-1)/2)')
33 cubit.cmd('move volume (dipole_v) z (-dZ*(numZ-1)/2)')
34
35 cubit.cmd('group "dipole" add volume (dipole_v)')
36
37 for iZ in range(0, numZ):
38     for iY in range(0, numY):
39         if iY > 0 or iZ > 0:
40             yPos = dv*iY
41             if iY > 2 == 1:
42                 zPos = dZ*iZ + dZ/2
43             else:
44                 zPos = dZ*iZ
45             cubit.cmd('volume (dipole_v) copy move x 0 y (yPos) z (zPos)')
46             v_tnp = cubit.get_last_id('volume')
47             cubit.cmd('group "dipole" add volume (v_tnp)')
48
49 # Draw radome curve
50 yStart = -radomeR
51 dYRadome = -yStart/(numPoints-1)*2
52 for iP in range(0, numPoints):
53     y = yStart + iP*dYRadome
54     b = radomeH
55     xMin = radomeHEdge
56     a = (xMin - b)/radomeR/radomeR
```

Parameterized model creation

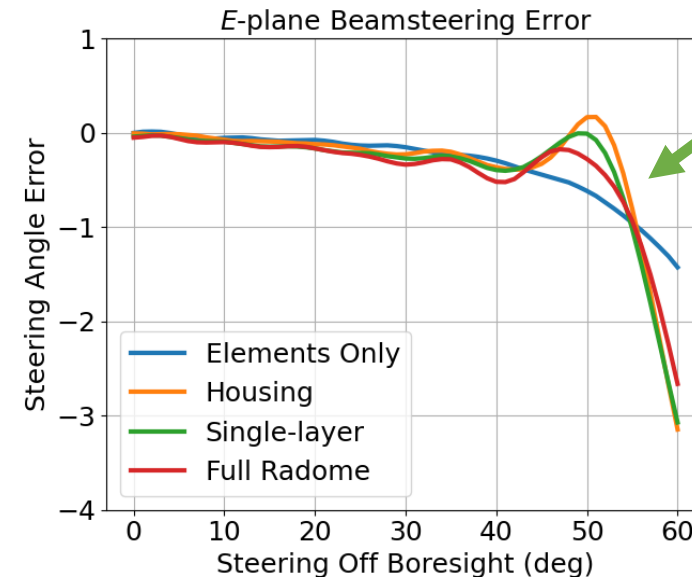
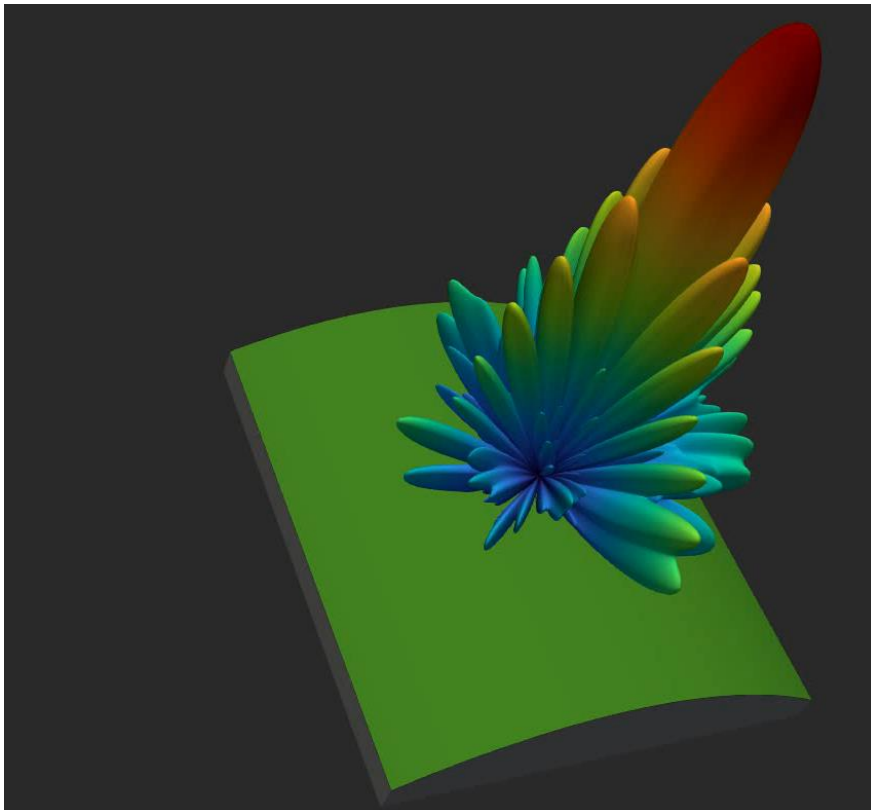


30x15 Dipole
Triangular Lattice

QCE - Foam - QCE

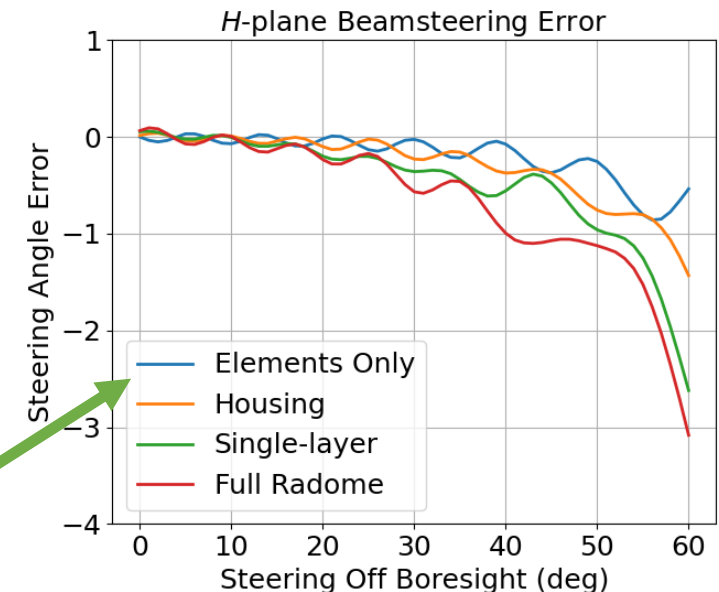
Beamsteering Error

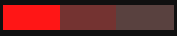
- Before fabrication, opportunity for ...
 - Weights optimization
 - Uncertainty analysis
 - Simulation-based calibration



Degradation at steep angles

Parametrically identify contributors





Contact Us

**Come see us
at Booth 2141!**

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