TWENTY THIRD ANNUAL

TestConX™

May 1 - 4, 2022

DoubleTree by Hilton
Mesa, Arizona

Archive

A Handler-based Solution for 60 GHz AiP DUT Testing

(and an Early Look at Test Results)

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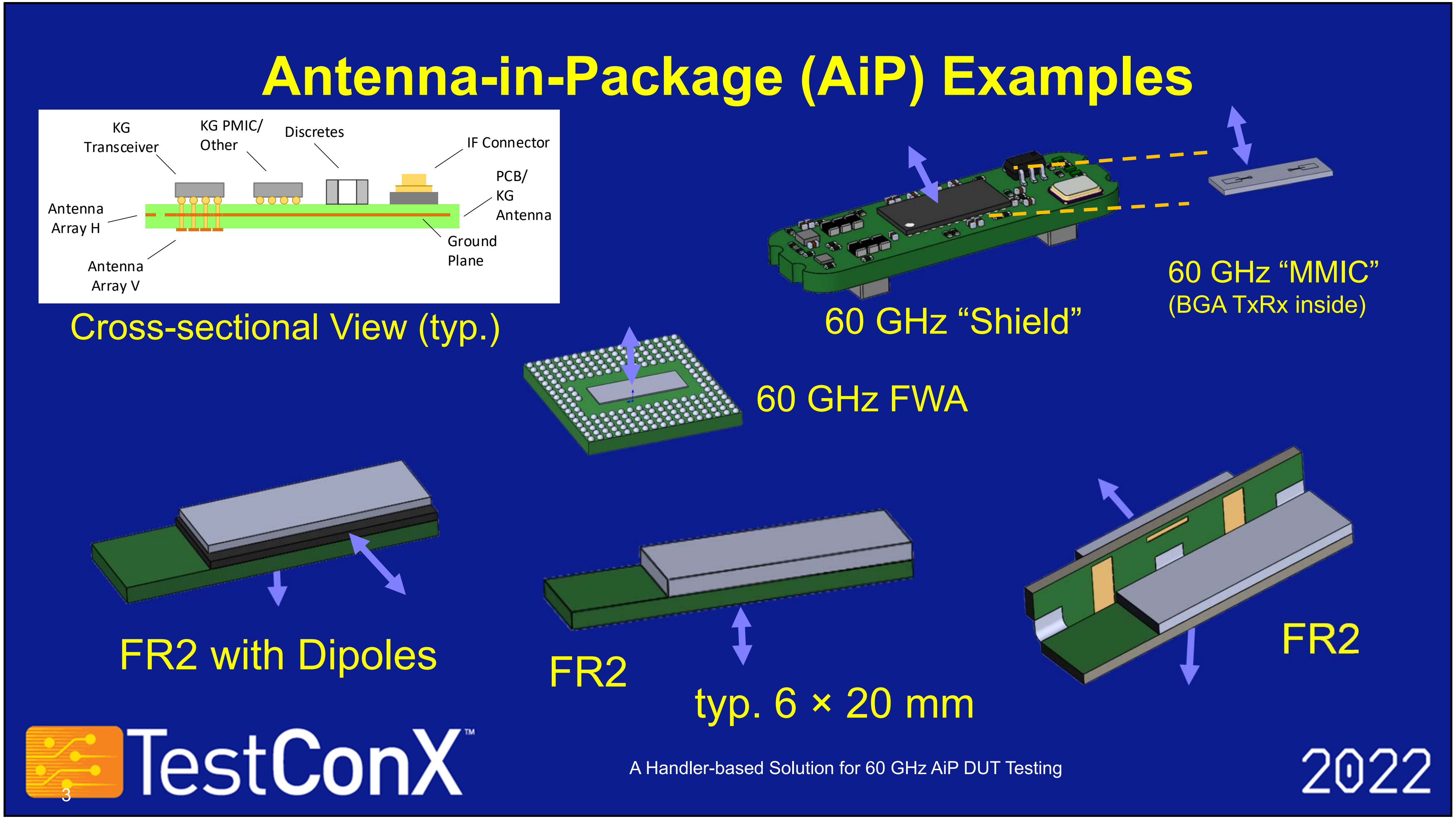
TestConX™
Mesa, Arizona • May 1-4, 2022

TERADYNE

AiP Mysteries, FUD*, or Challenges

- There some “mysteries” out there:
  - “We don’t know how to test DUTs with antennas”
  - Is OTA feasible? Is it even necessary?
  - What defects can AiP testing uncover?
  - Is 4-site testing possible?
  - Does radiated loopback (“radiate back”) provide enough coverage?
  - Near field vs. reactive vs. far field
  - Chambers will need to be huge rooms
  - Does AiP replace package or wafer testing?
  - Does wafer test replace AiP (module) tests?

* “FUD” fear, uncertainty, doubt



Antenna-in-Package (AiP) Examples

Cross-sectional View (typ.)

60 GHz "Shield"

60 GHz "MMIC" (BGA TxRx inside)

60 GHz FWA

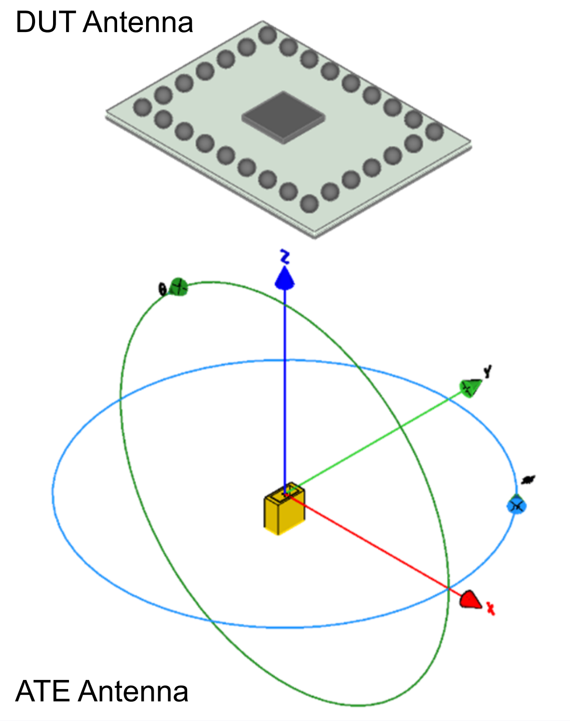
FR2 with Dipoles

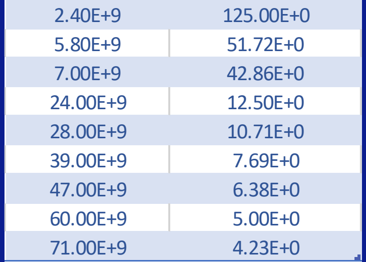
FR2

typ. 6 × 20 mm

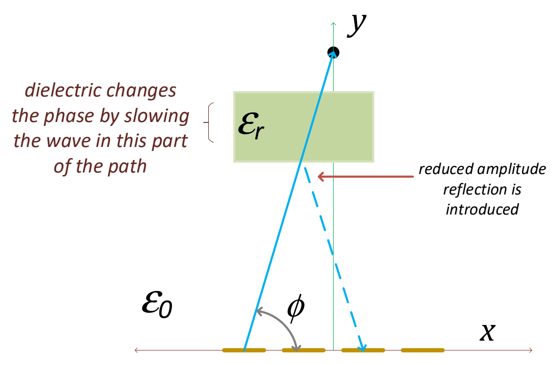
FR2

Mechanical and EM Challenges



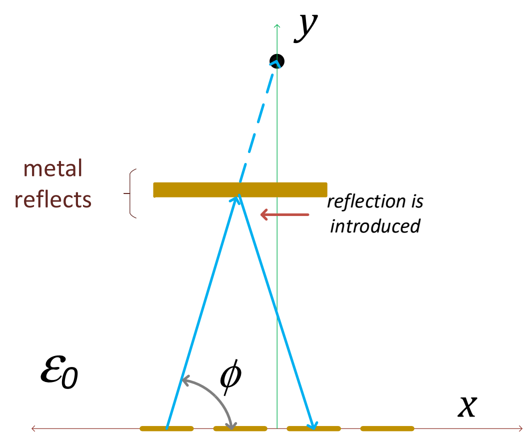


frequency (Hz	wavelength (mm
2.40E+9	125.00E+0
5.80E+9	51.72E+0
7.00E+9	42.86E+0
24.00E+9	12.50E+0
28.00E+9	10.71E+0
39.00E+9	7.69E+0
47.00E+9	6.38E+0
60.00E+9	5.00E+0
71.00E+9	4.23E+0



dielectric changes the phase by slowing the wave in this part of the path

reduced amplitude reflection is introduced



metal reflects

reflection is introduced

Example: Customer Discussion at Kickoff

Device interface requires a process to create solutions, not a point solution product

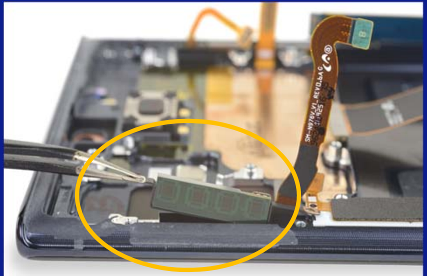
- Full 24.25-52.6 GHz (FR2) solution, up to 71 GHz in standard
- DUT volume
  - 10-100M's/launch – product iterations every 9-12 months.
- Site Count Drives Cost of Test (CoT)
  - (2) sites min., (4) sites preferred
  - Is it possible to test (8) sites, or beyond?
- Expect multiple form factors need a solution
  - "Edge Mount" – very narrow
  - "Back Mount" – can be almost square and radiates in two orthogonal axes
- AiP IF port and miscellaneous signals will be accessed via a small connector

(passive only)

"Edge AiP Module"

(2) bands

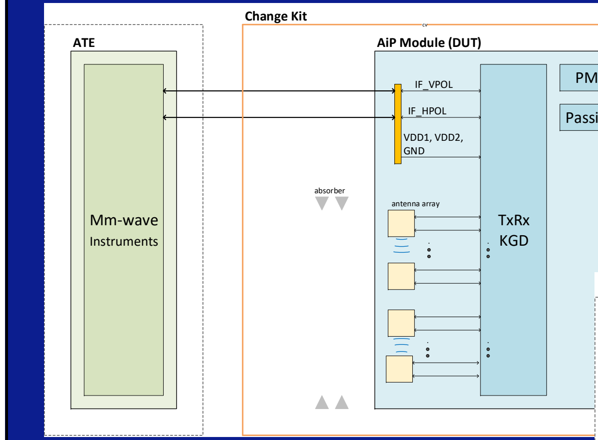
"Back AiP Module"



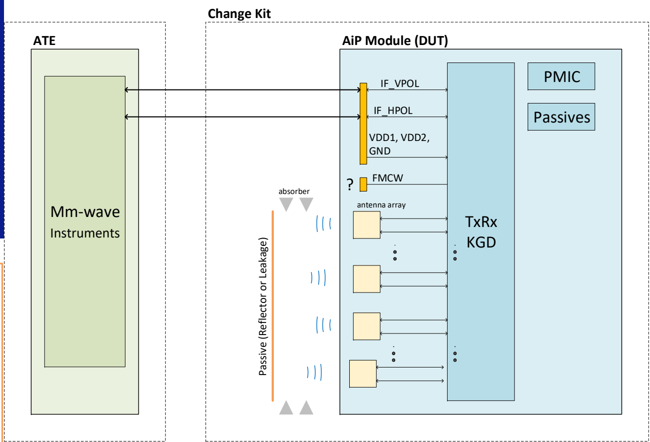
5G Mobile Phone
(ifixit.com)

NOTE: example based on public information

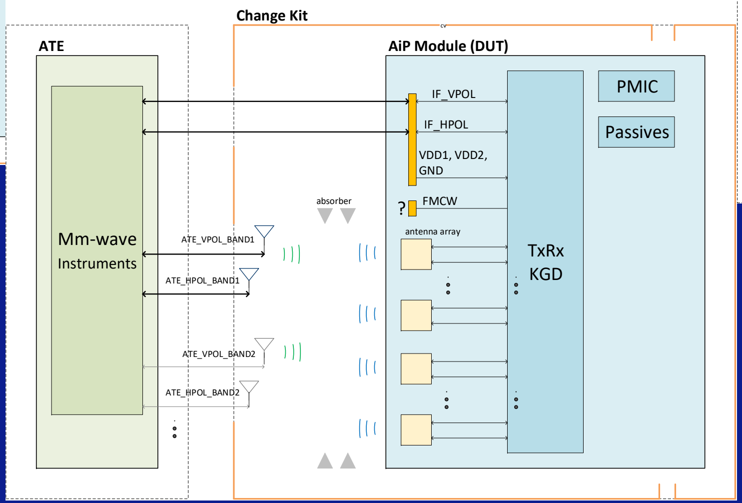
Notes on Test Philosophies



"Leakback"



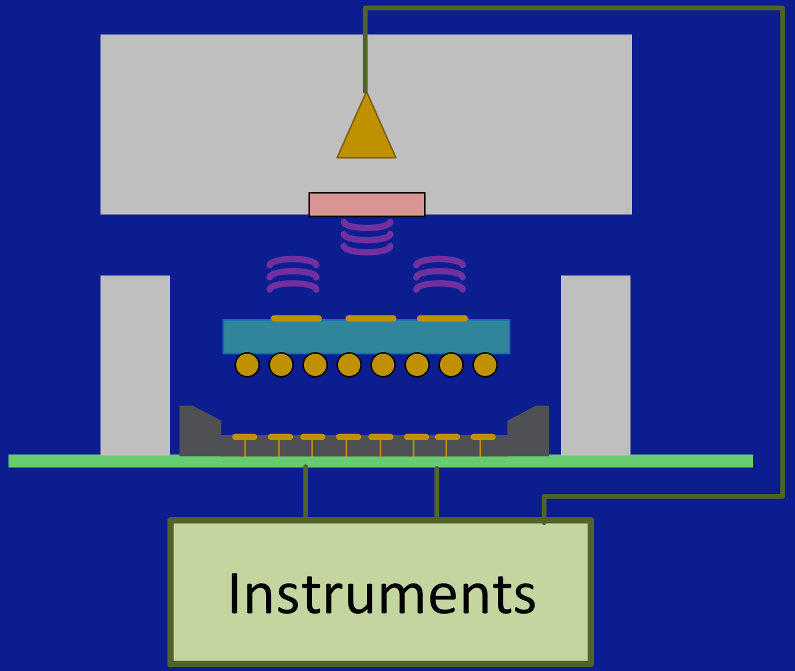
"Radiateback"



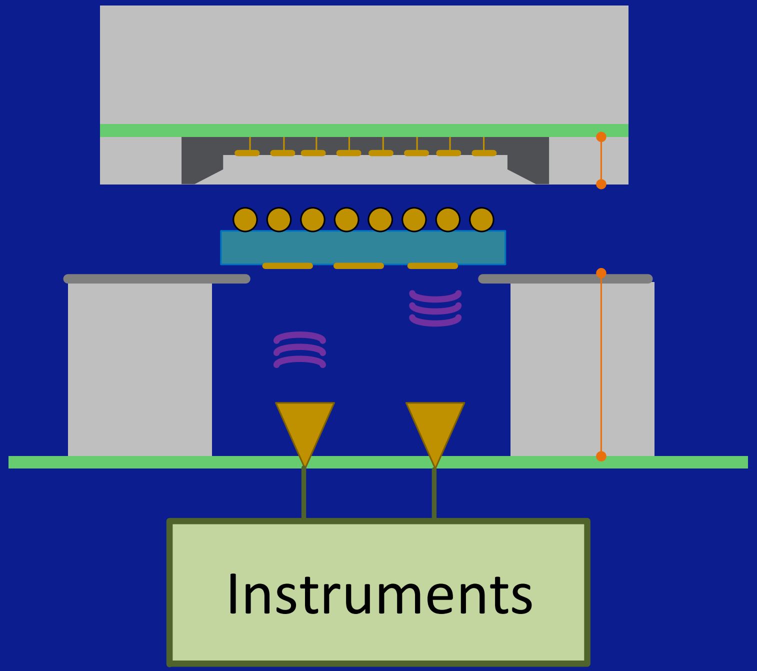
Radiated Test Configuration

DUT Orientation Terminology

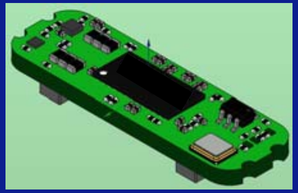
Option 1, aka "Live Bug"



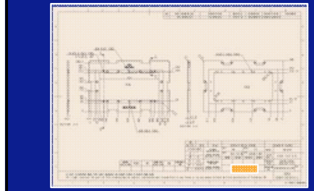
Option 2, aka "Dead Bug"



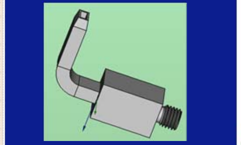
Process for DUT Package Variety and TTM*



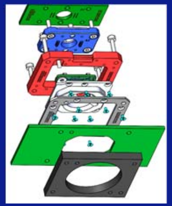
AiP DUT



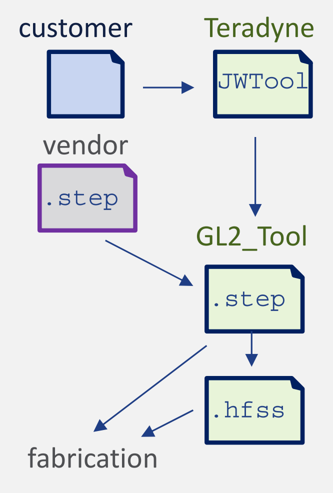
Handler CAD



ATE antenna

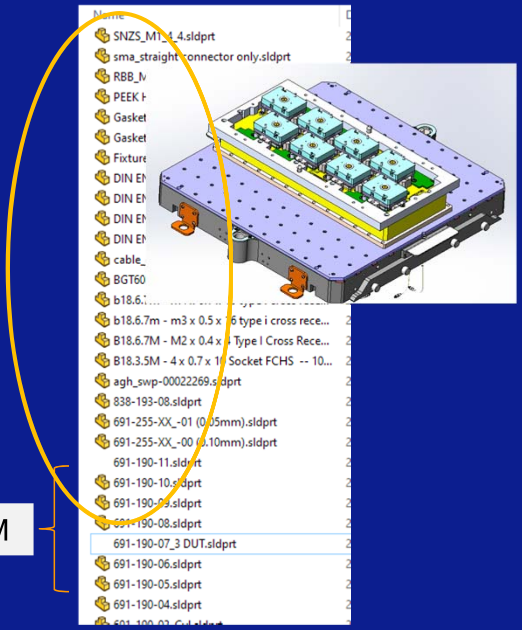


socket



customer
Teradyne
`JWTool`
vendor
`.step`
GL2_Tool
`.step`
`.hfss`
fabrication

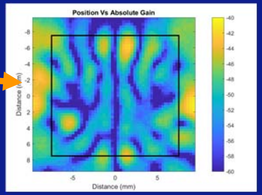
Change Kit CAD, BoM



Name
SNZS_M1_4_4.sldprt
sma_straight connector only.sldprt
RBB_M
PEEK H
Gasket
Gasket
Fixture
DIN EN
DIN EN
DIN EN
DIN EN
cable_
BGT60
b18.6.7...
b18.6.7m - m3 x 0.5 x 6 type i cross rece...
B18.6.7M - M2 x 0.4 x 4 Type I Cross Rece...
B18.3.5M - 4 x 0.7 x 10 Socket FCHS -- 10...
agh_swp-00022269.sldprt
838-193-08.sldprt
691-255-XX_-01 (0.05mm).sldprt
691-255-XX_-00 (0.10mm).sldprt
691-190-11.sldprt
691-190-10.sldprt
691-190-09.sldprt
691-190-08.sldprt
691-190-07_3 DUT.sldprt
691-190-06.sldprt
691-190-05.sldprt
691-190-04.sldprt

SLDASM

Validation of Design with EM Sims

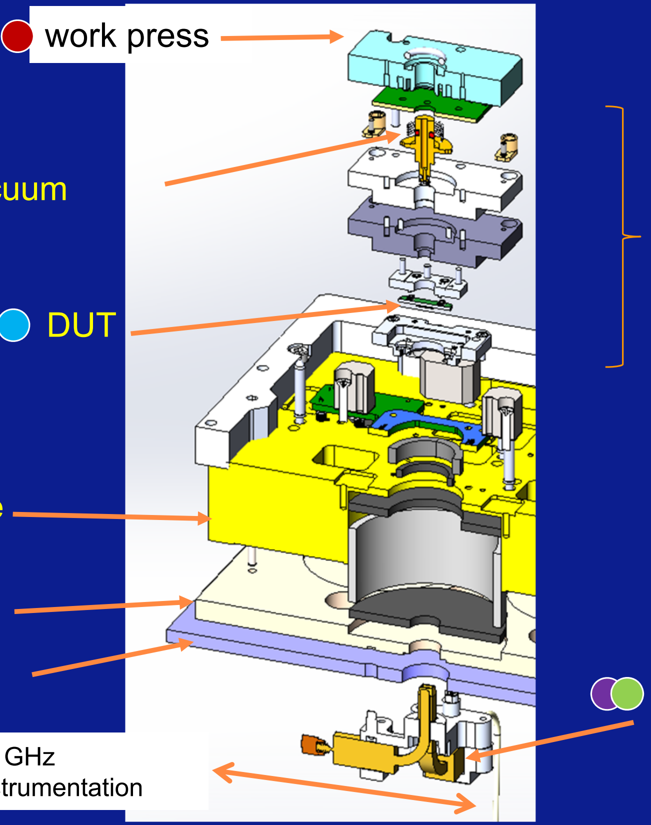


* TTM time-to-market

EM-dependent Parts are Generated Parametrically

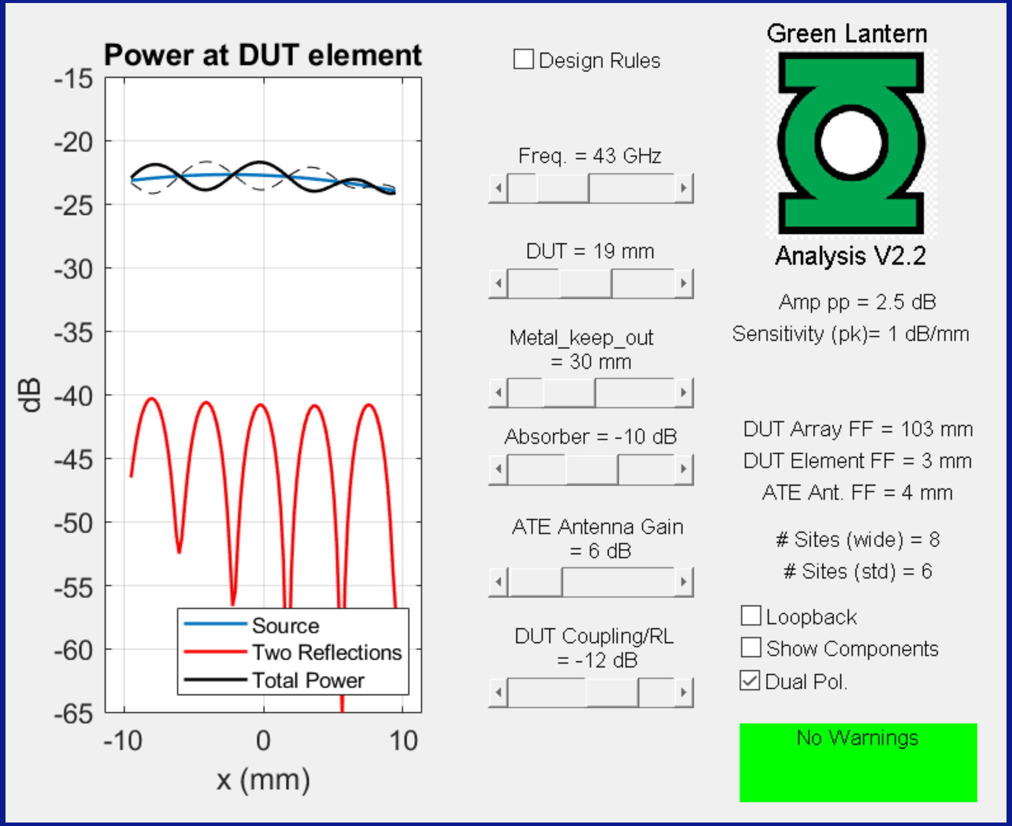
Eco System of Experts

- ● handler
- ● socket
- ● Teradyne
- ● customer
- ● antenna



DUT Radiation Direction

Interactive JWTool



☐ Design Rules

Freq. = 43 GHz

DUT = 19 mm

Metal_keep_out = 30 mm

Absorber = -10 dB

ATE Antenna Gain = 6 dB

DUT Coupling/RL = -12 dB

Analysis V2.2

Amp pp = 2.5 dB

Sensitivity (pk)= 1 dB/mm

DUT Array FF = 103 mm

DUT Element FF = 3 mm

ATE Ant. FF = 4 mm

Sites (wide) = 8

Sites (std) = 6

☐ Loopback

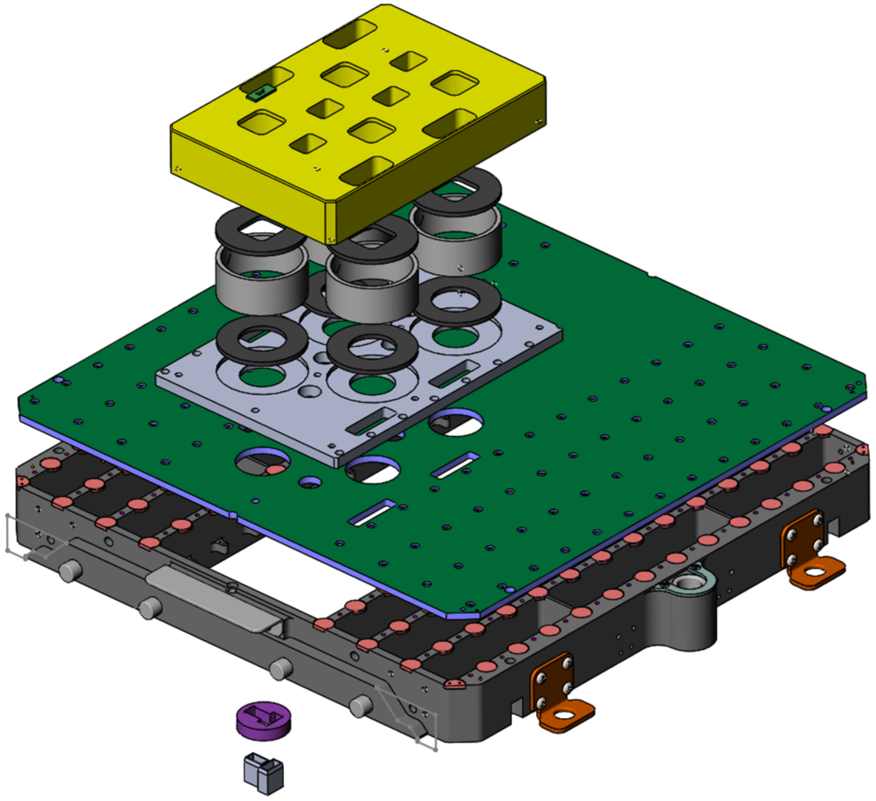
☐ Show Components

☑ Dual Pol.

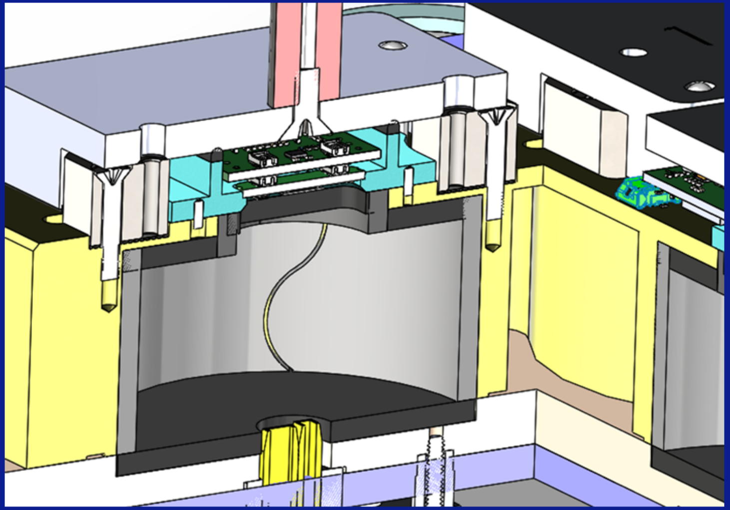
No Warnings

Fast and interactive to try ideas before cutting metal

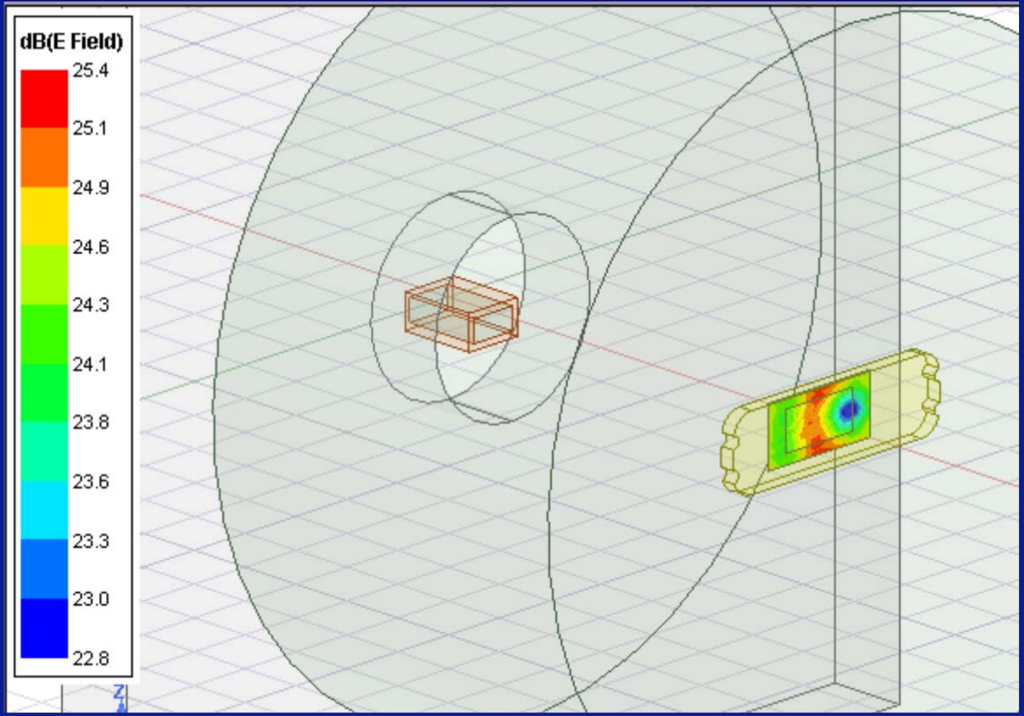
Example of Mechanical CAD



CAD is Used for Mechanical and EM



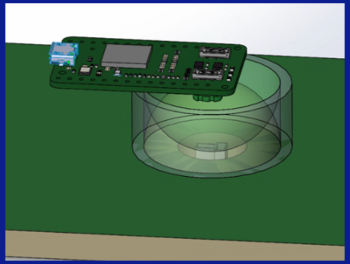
Full CAD for Fabrication

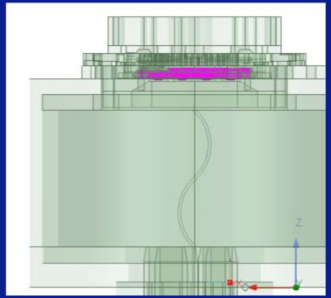


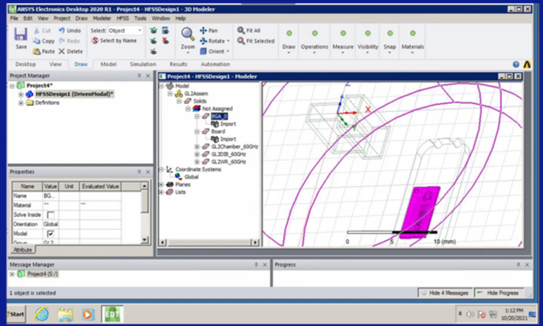
Defeatured CAD for EM Sims

Visualizations and HFSS De-featured Model

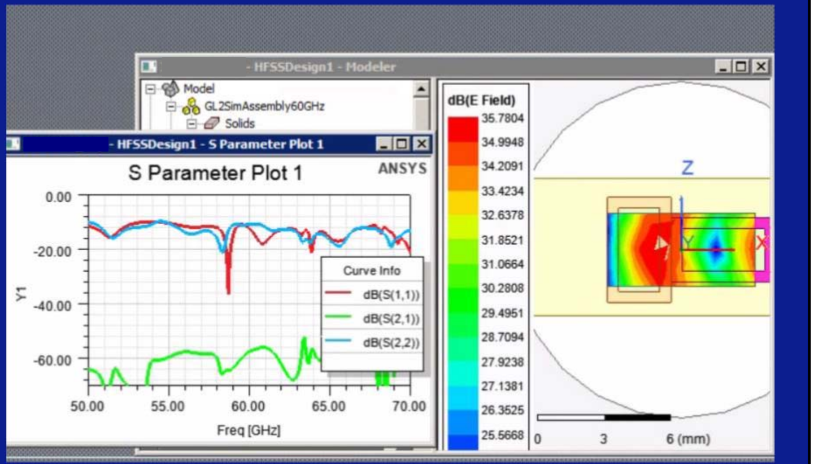
- Simulation memory and duration is set by ratio of total volume to smallest feature
- Automatically generated CAD with all mechanical features and complete BoM is too much detail for HFSS (EM) simulations
- SolidWorks can exclude features from export – “Configuration Manager”. One click changeover from complex to accurate but simplified model.
- Open SolidWorks native file directly in HFSS for simulations





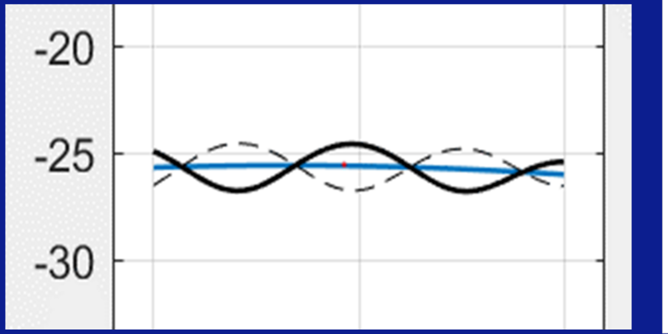


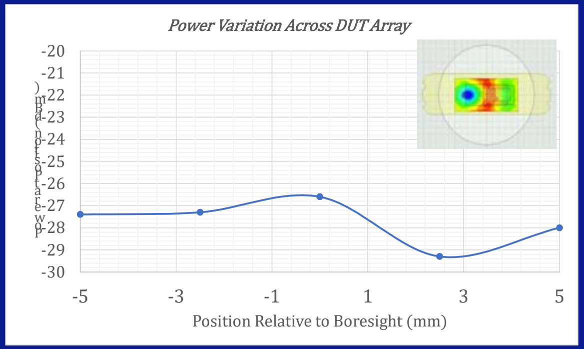
Open the **De-Featured** CAD in HFSS

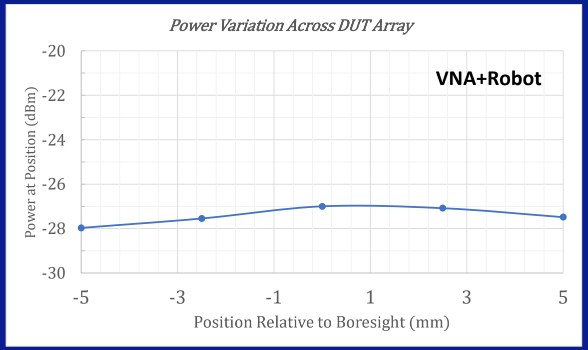


Run EM Simulations to Validate Design Meets Goals

Results Agree Well Throughout Process







Design, Predict
(JWTool)

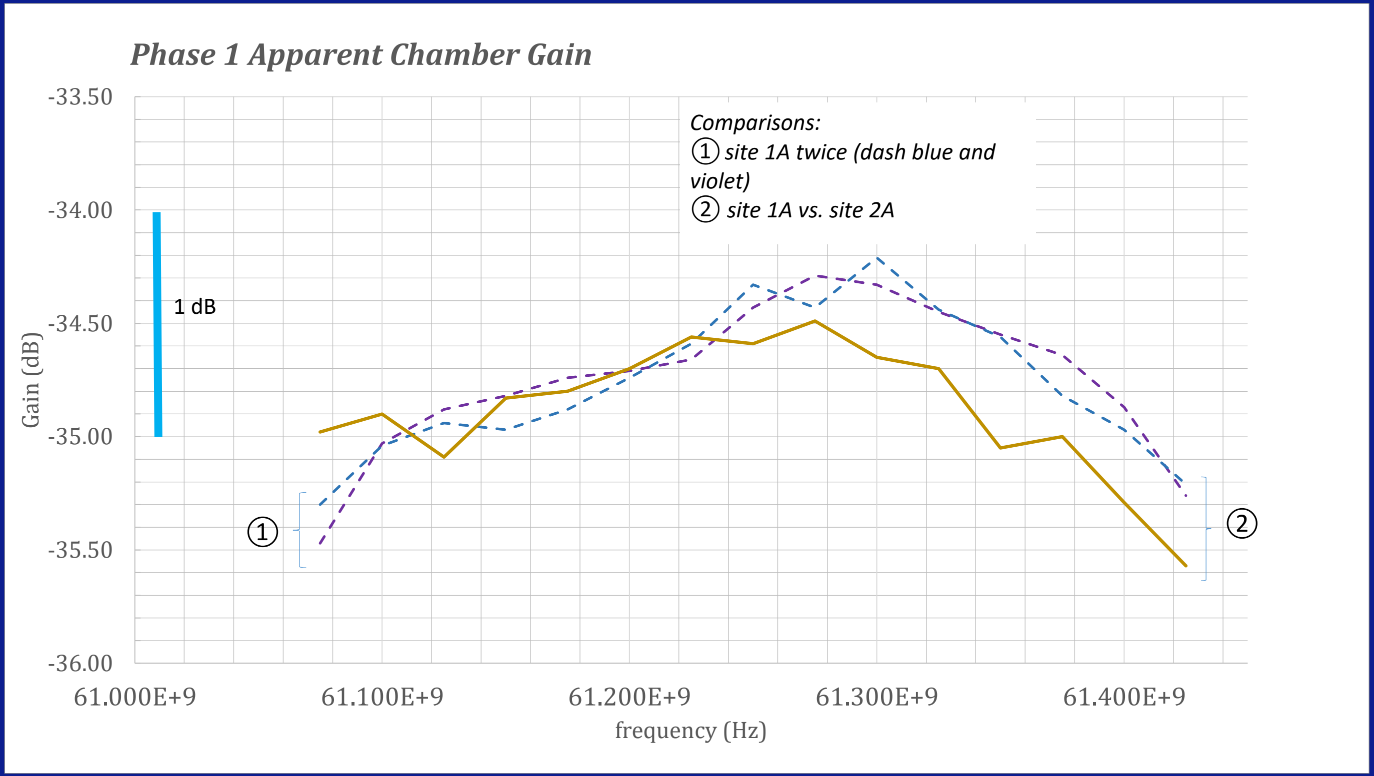
Validate CAD Design
(HFSS)

Fabricate→Measure
(robot + VNA)

Fabricated Change Kit on Tester

8-site, 60 GHz

Measurements are Repeatable:
run-run, day-day, site-to-site



Comparisons:
① site 1A twice (dash blue and violet)
② site 1A vs. site 2A

Acknowledgement

- Thanks to the whole Green Lantern 2 team
- Cross-functional, multi-national, multi-time zone, multi-company!
- It was “easy” with your help!

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