Powering Innovation That Drives Human Advancement

Using Software to Meet EMC Standards for Electronics

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EMA President

https://www.ansys.com/blog/ansys-ema-intel-emi-simulation-entire-server

Motivation 1: Avoid Expensive Test Failures

- EMC testing often must occur toward the end of a product development cycle when production is being ramped up
- Test failures during this stage (production) mean that design changes are costly in both price and schedule
- Predicting device performance early is essential to making design changes when it is less costly to do so

Motivation 2: Better Product Performance

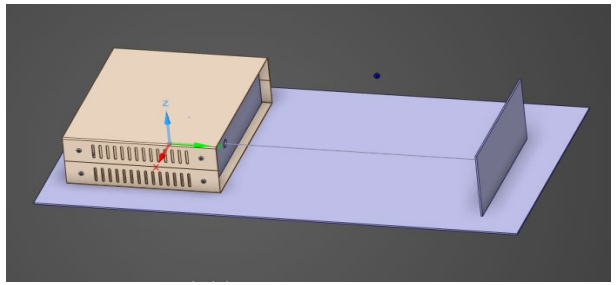
- Even if a device passes government-mandated regulatory testing, EMC and EMI issues may degrade product performance . . . And the customer experience
- Consider an RF data link. EMI self-interference may cause the link to drop packets, causing for slower data rates and increased device power consumption
- We all experience EMI/EMC impacts on product performance in our daily lives and make judgements on the quality of those products as a result

Development 1: Digital Engineering

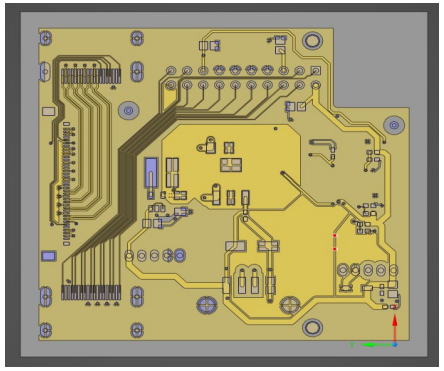
- Every aspect of the product design is moving quickly to a digital process
- Design iterations occur with fewer or no prototypes
- The cost and time of development is greatly reduced
- Simulation benefits by having necessary input data at the ready
- Engineering for product development is moving rapidly toward digital simulation for all disciplines, including EMC

Development 2: Simulation Technology Advancements

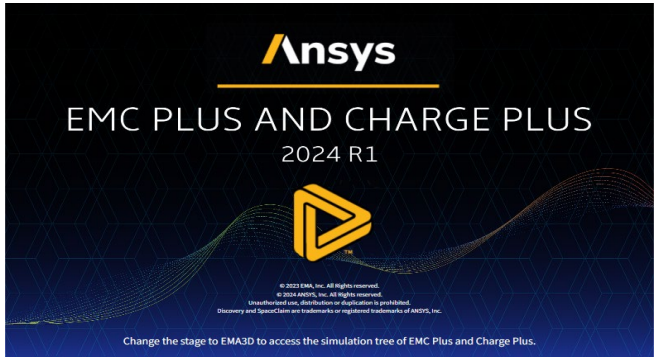
Mechanical CAD



PCB eCAD

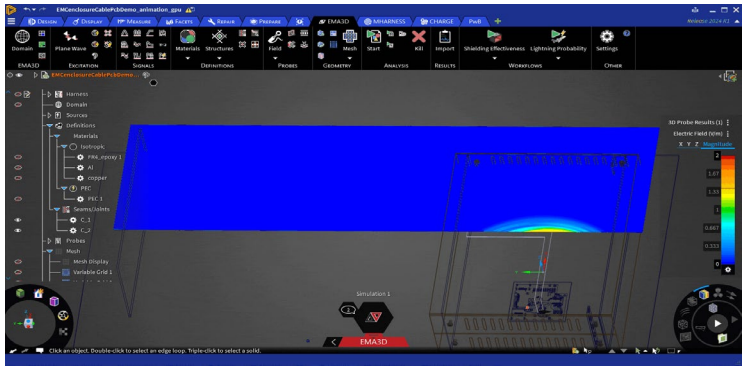


Ansys EMC Plus

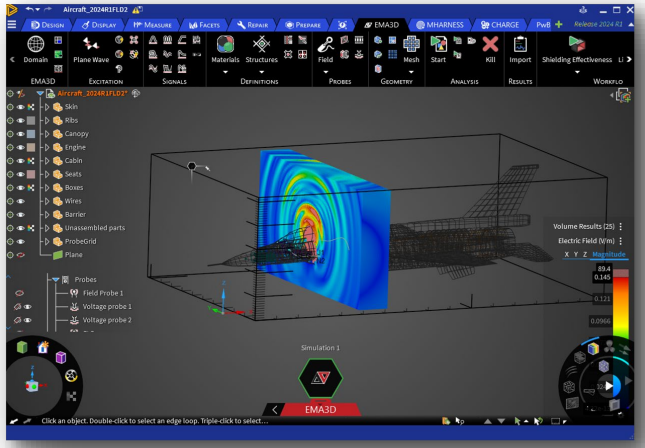


< Two Hours

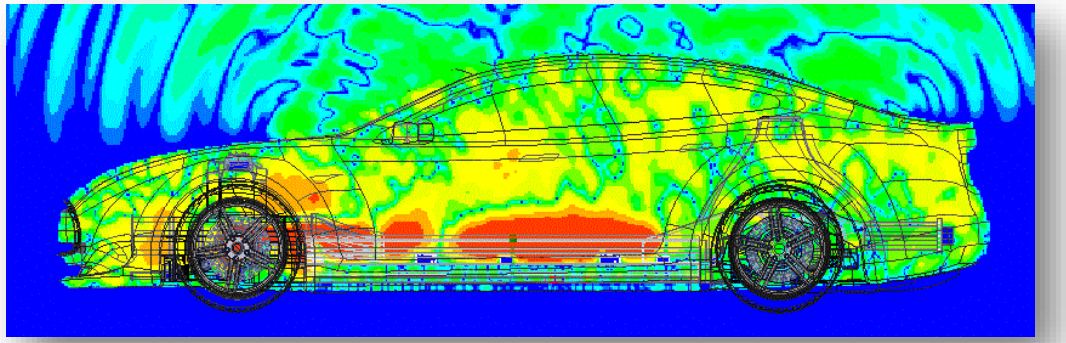
Full Device EMC!



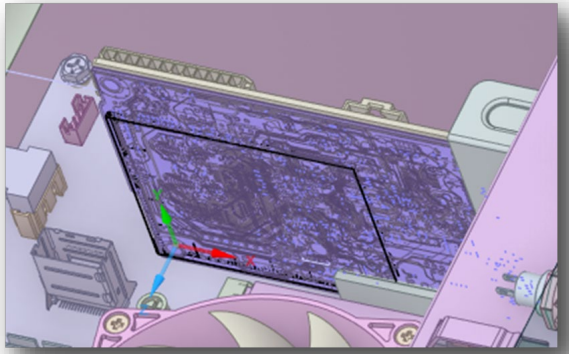
Ansys EMC Plus Application Areas



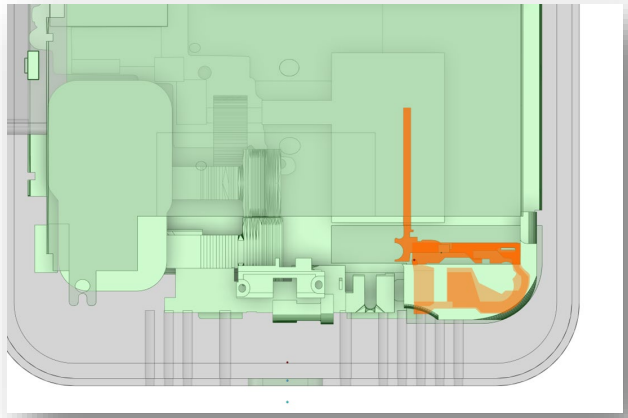
Electromagnetic Environmental Effects (E3)



Full-vehicles with Cables and Power Industry

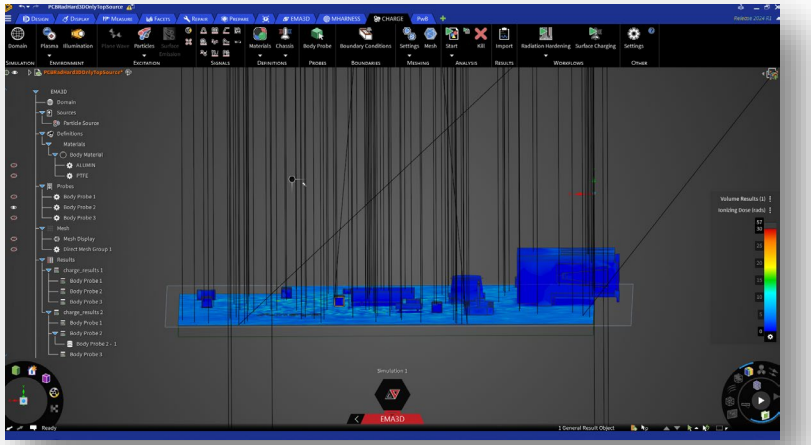


EMI/EMC in Full Devices

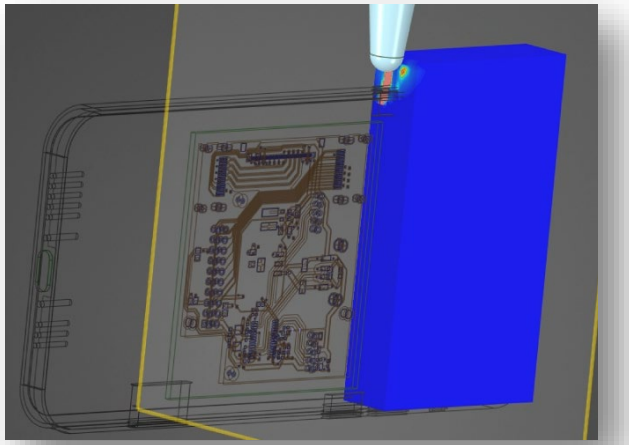


RF De-sense in Devices

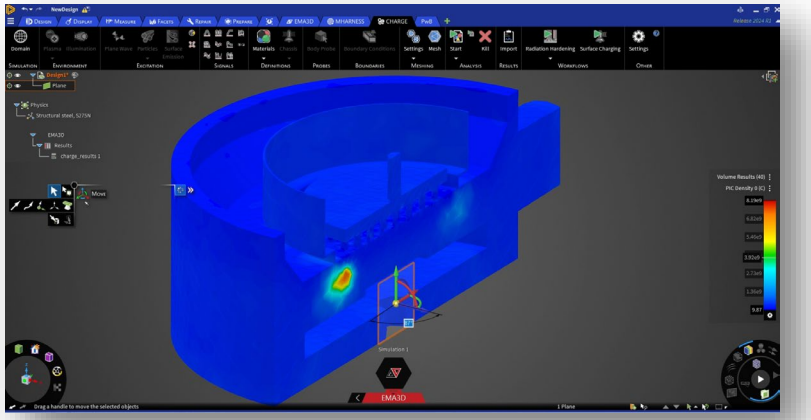
Ansys Charge Plus Application Areas



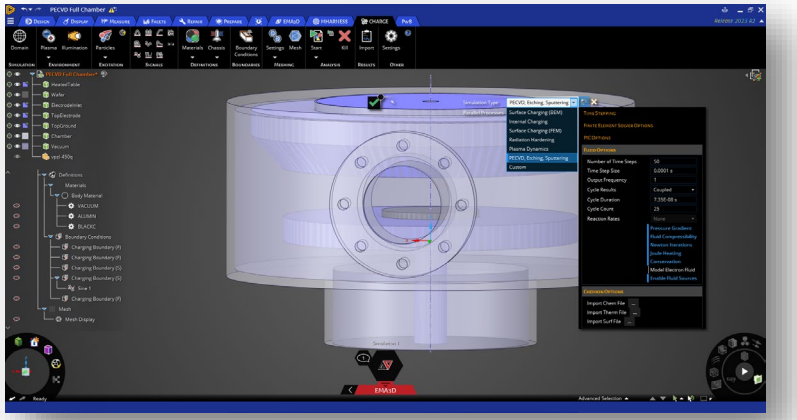
Space Plasma Environments and Radiation Effects



Electrostatic Discharge (ESD)



Arcing (Plasma in air)



Semiconductor Processing Plasmas

Ansys EMA

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Shielding Effectiveness of an Enclosure

One click starts the automated workflow


1458VG3_case:1
1458VG3_case:1
1458G3_plate:1
1458G3_plate:1
SC18394 (screw #6X 1_4" PN):1
SC18394 (screw #6X 1_4" PN):1
SC18394 (screw #6X 1_4" PN):1
SC18394 (screw #6X 1_4" PN):1
SC18394 (screw #6X 1_4" PN):1
SC18394 (screw #6X 1_4" PN):1
SC18394 (screw #6X 1_4" PN):1
SC18394 (screw #6X 1_4" PN):1
Physics
EMA®
Ansys EMC Plus
Consumer Electronics
Shielding Effectiveness
MODEL

Ansys EMA

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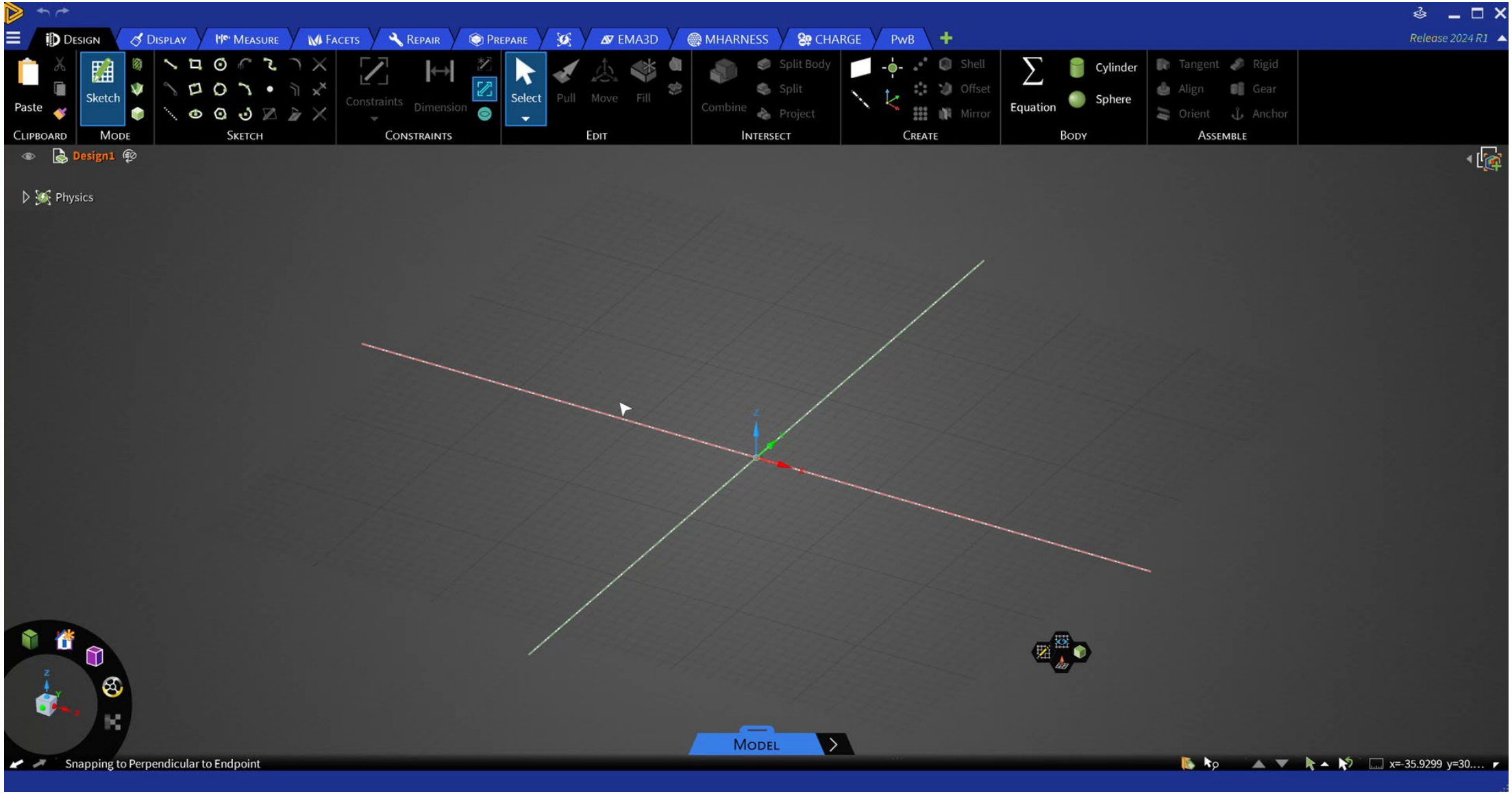
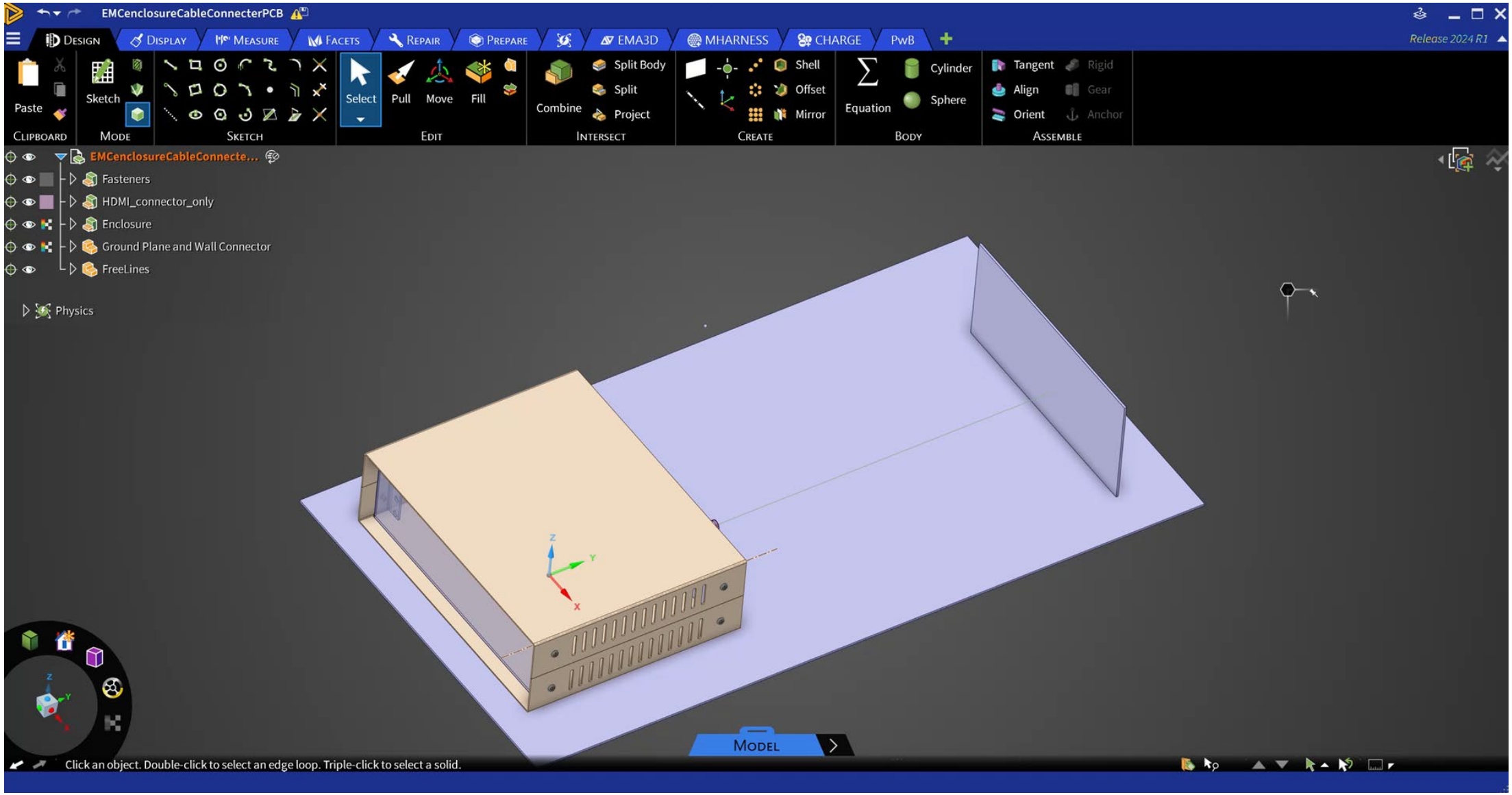
Radiated Emissions of an Enclosure, PCB, and Cable

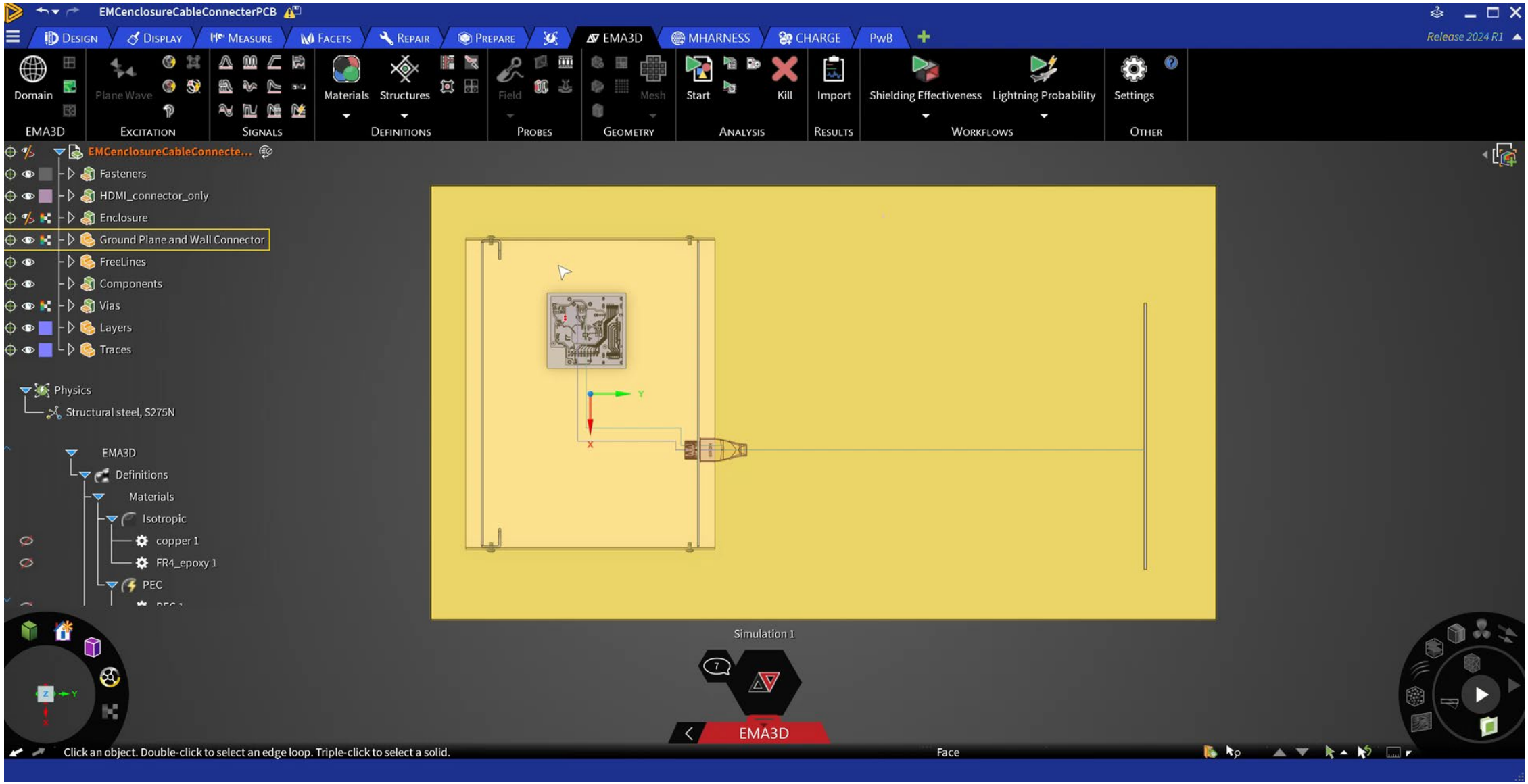
Easy enough to be applied to all electronic devices prior to finalizing the design

Enclosure & Ground Plane Geometry Import

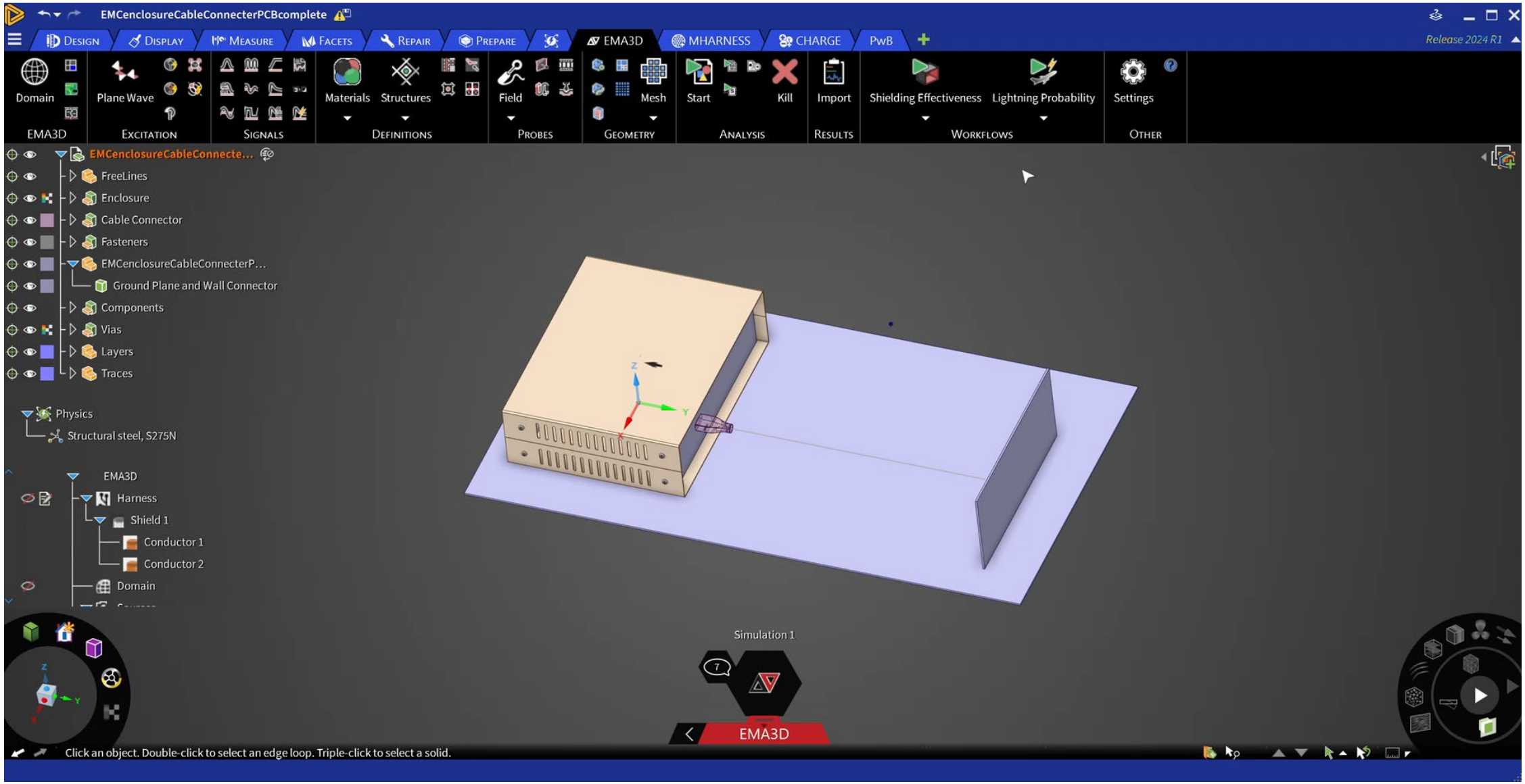


PCB (edb.def) Import

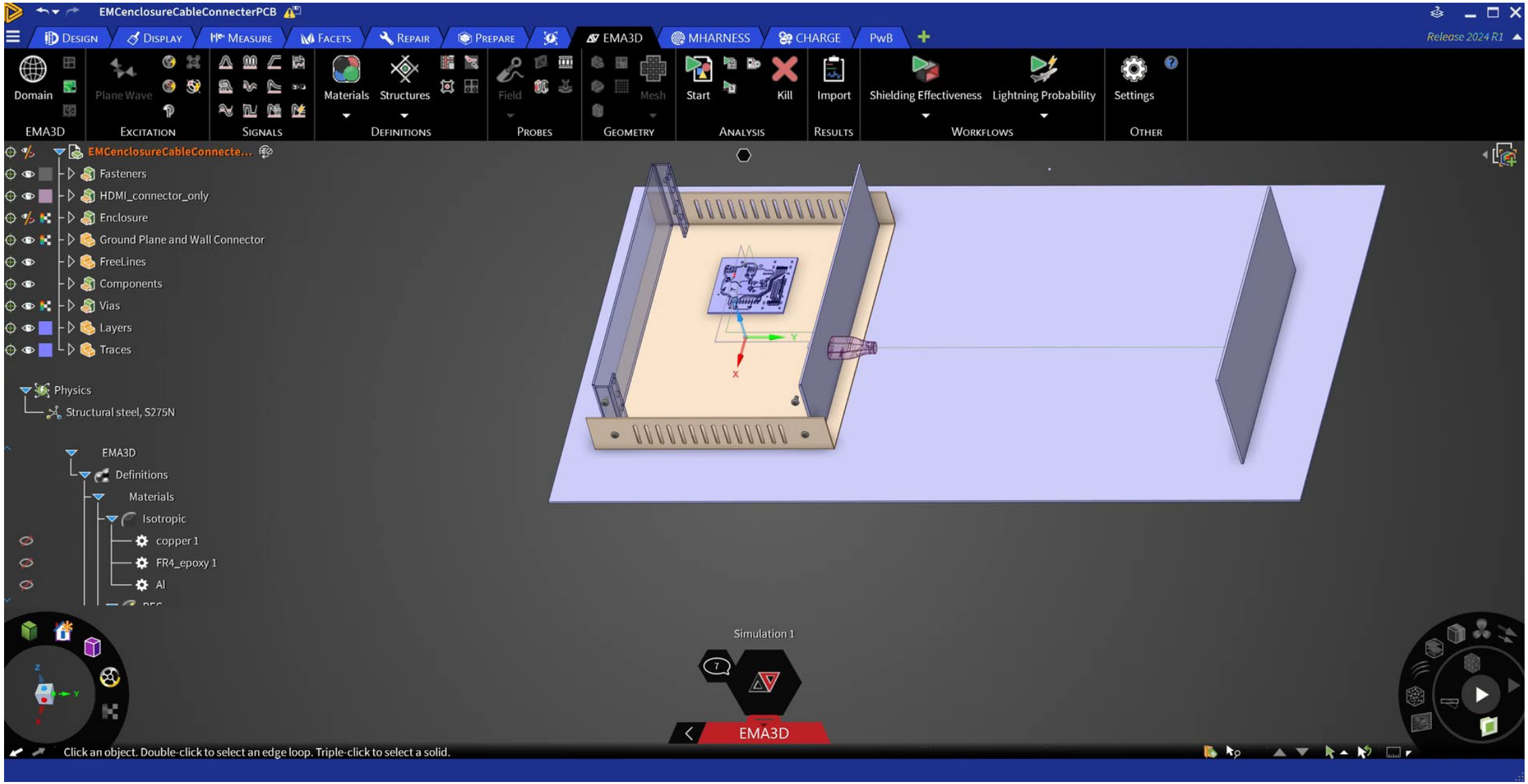



EMCenclosureCableConnecterPCB
Design
Display
Measure
Facets
Repair
Prepare
EMA3D
MHARNESS
CHARGE
PwB
Release 2024 R1
Domain
Plane Wave
Materials
Structures
Field
Mesh
Start
Kill
Import
Shielding Effectiveness
Lightning Probability
Settings
EMA3D
Excitation
Signals
Definitions
Probes
Geometry
Analysis
Results
Workflows
Other
EMCenclosureCableConnecte...
Fasteners
HDMI_connector_only
Enclosure
Ground Plane and Wall Connector
FreeLines
Components
Vias
Layers
Traces
Physics
Structural steel, S275N
EMA3D
Definitions
Materials
Isotropic
copper 1
FR4_epoxy 1
PEC
Simulation 1
EMA3D
Click an object. Double-click to select an edge loop. Triple-click to select a solid.
Face

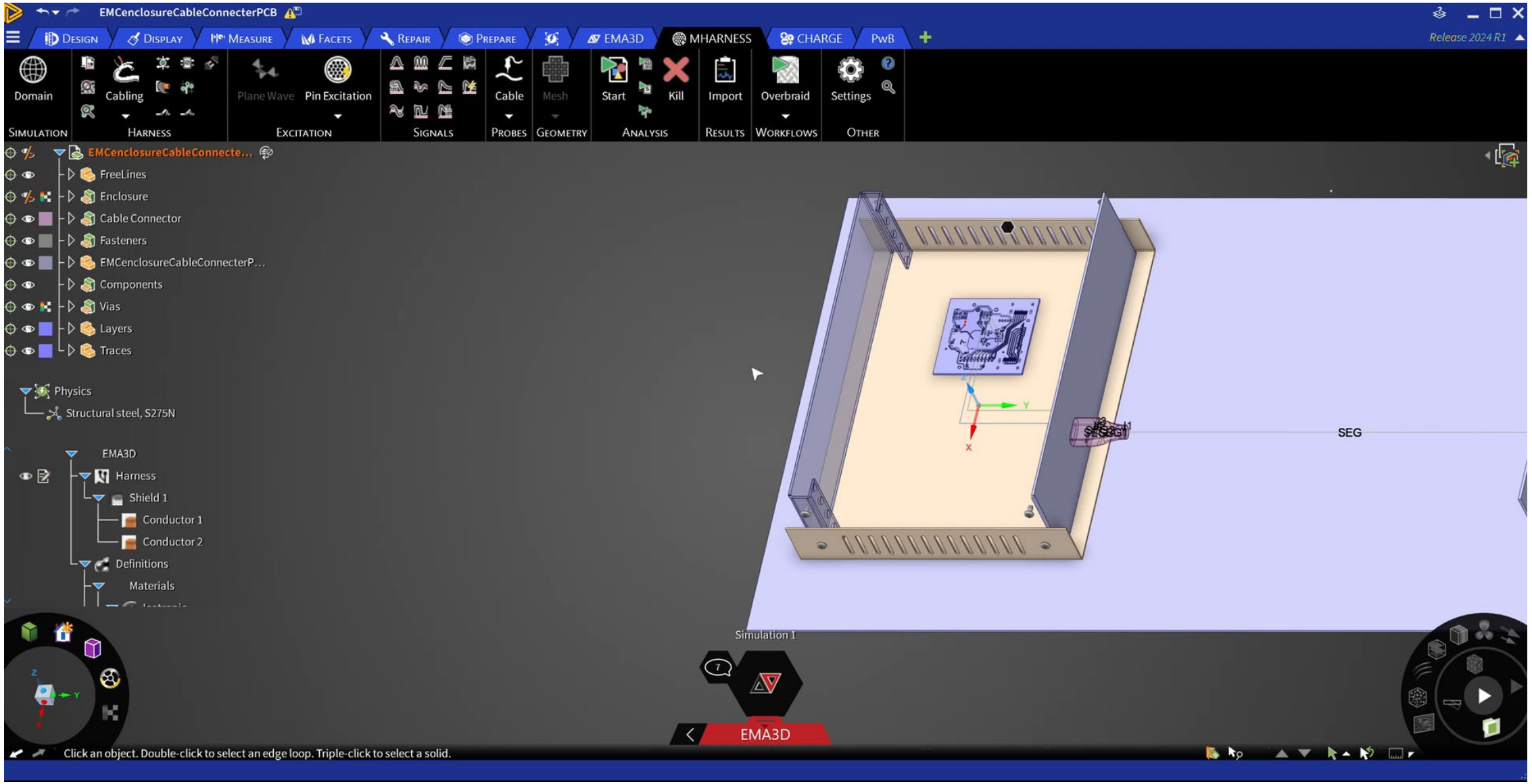
Material Assignment (PEC & Al)



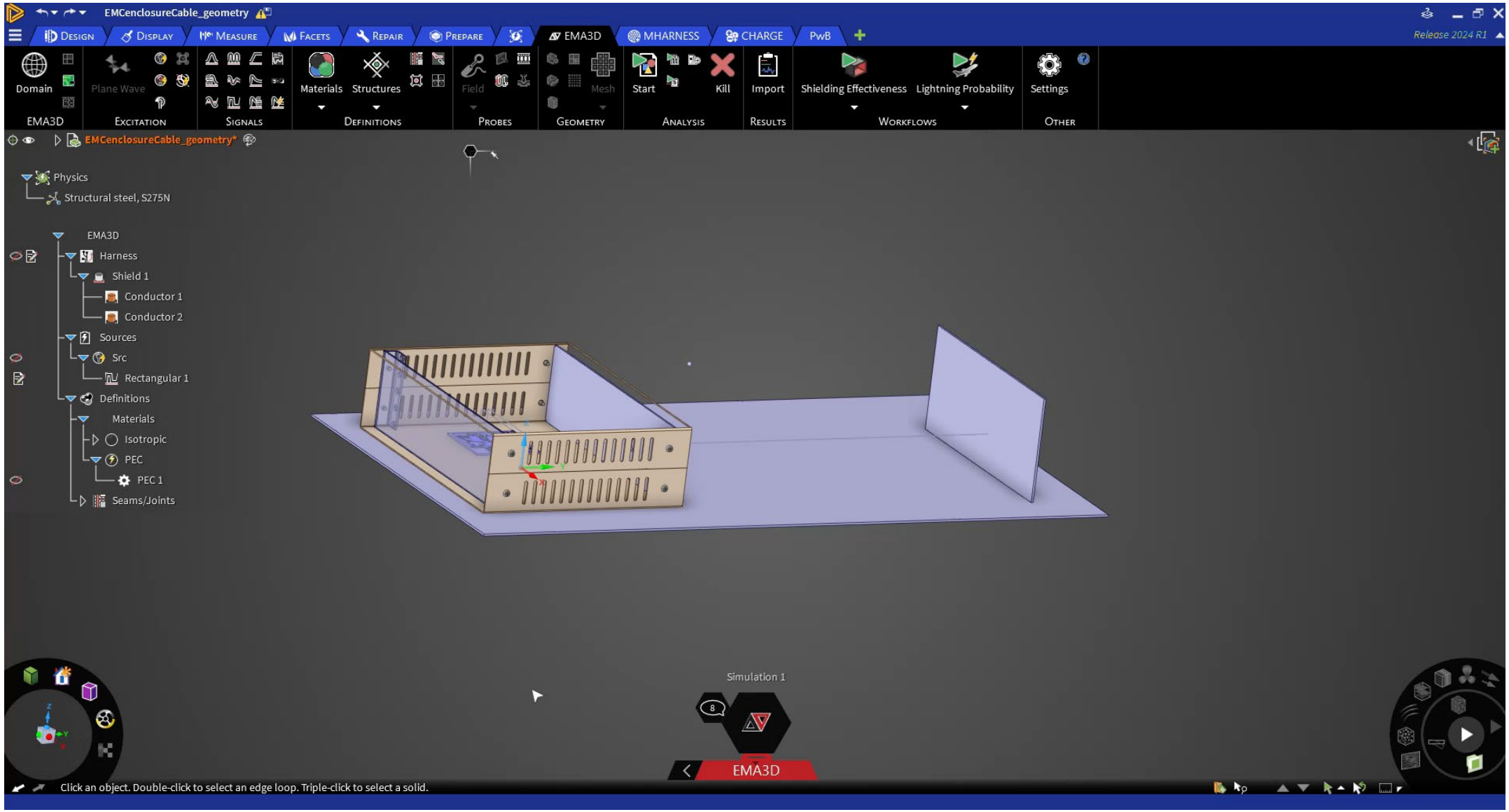
Harness Definition



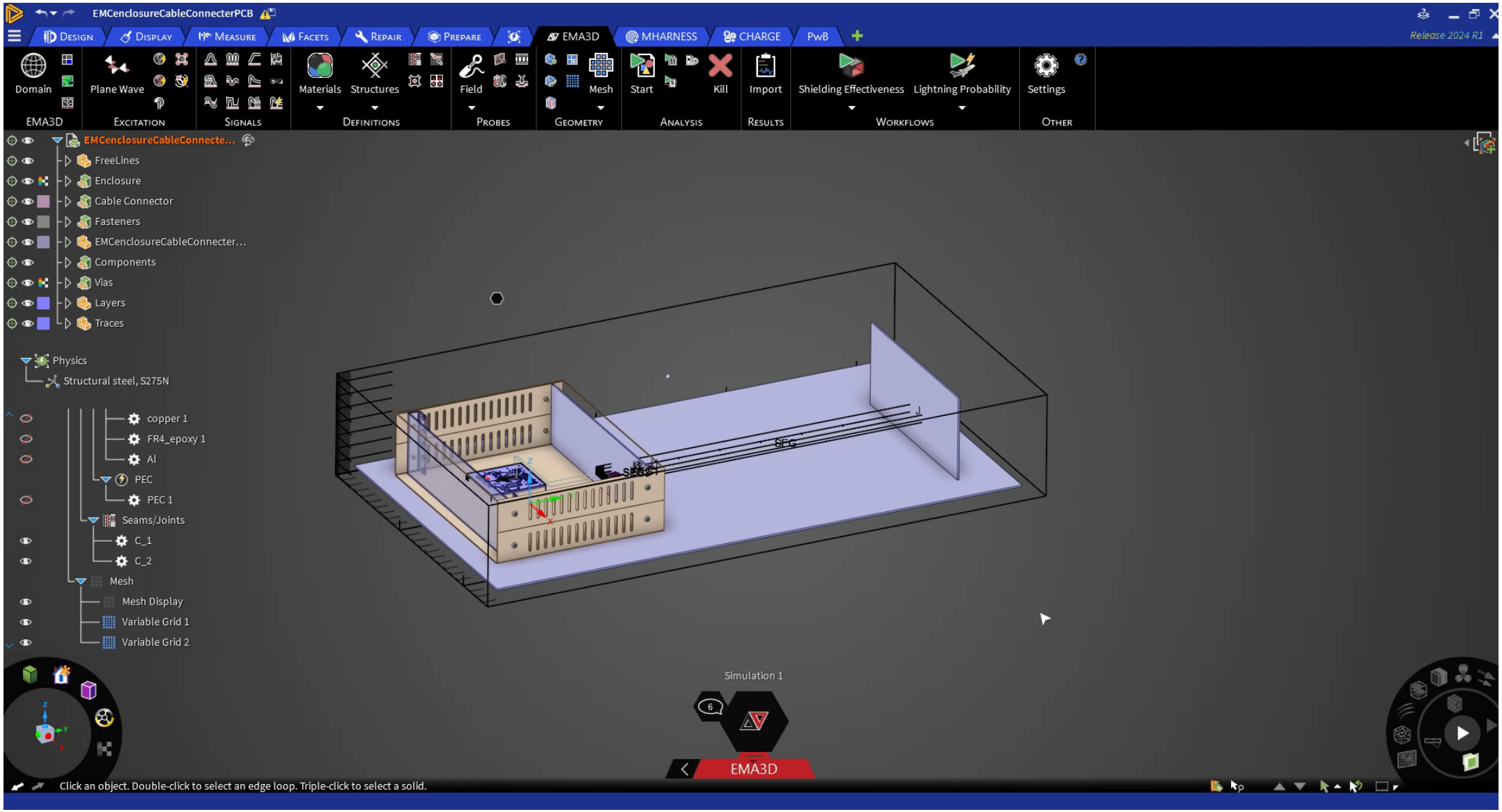
Source Definition



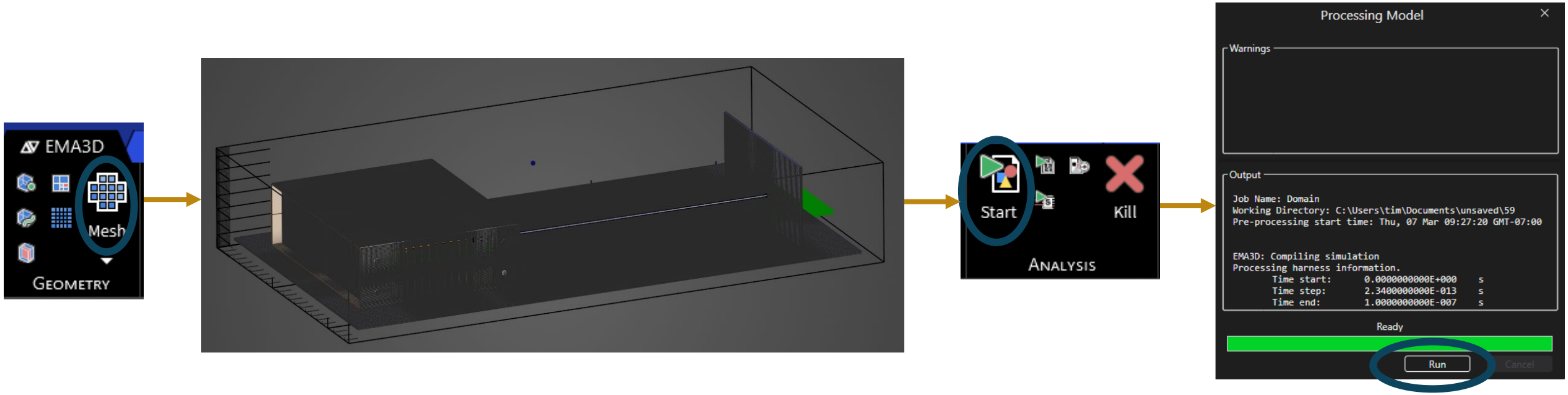
Domain Definition



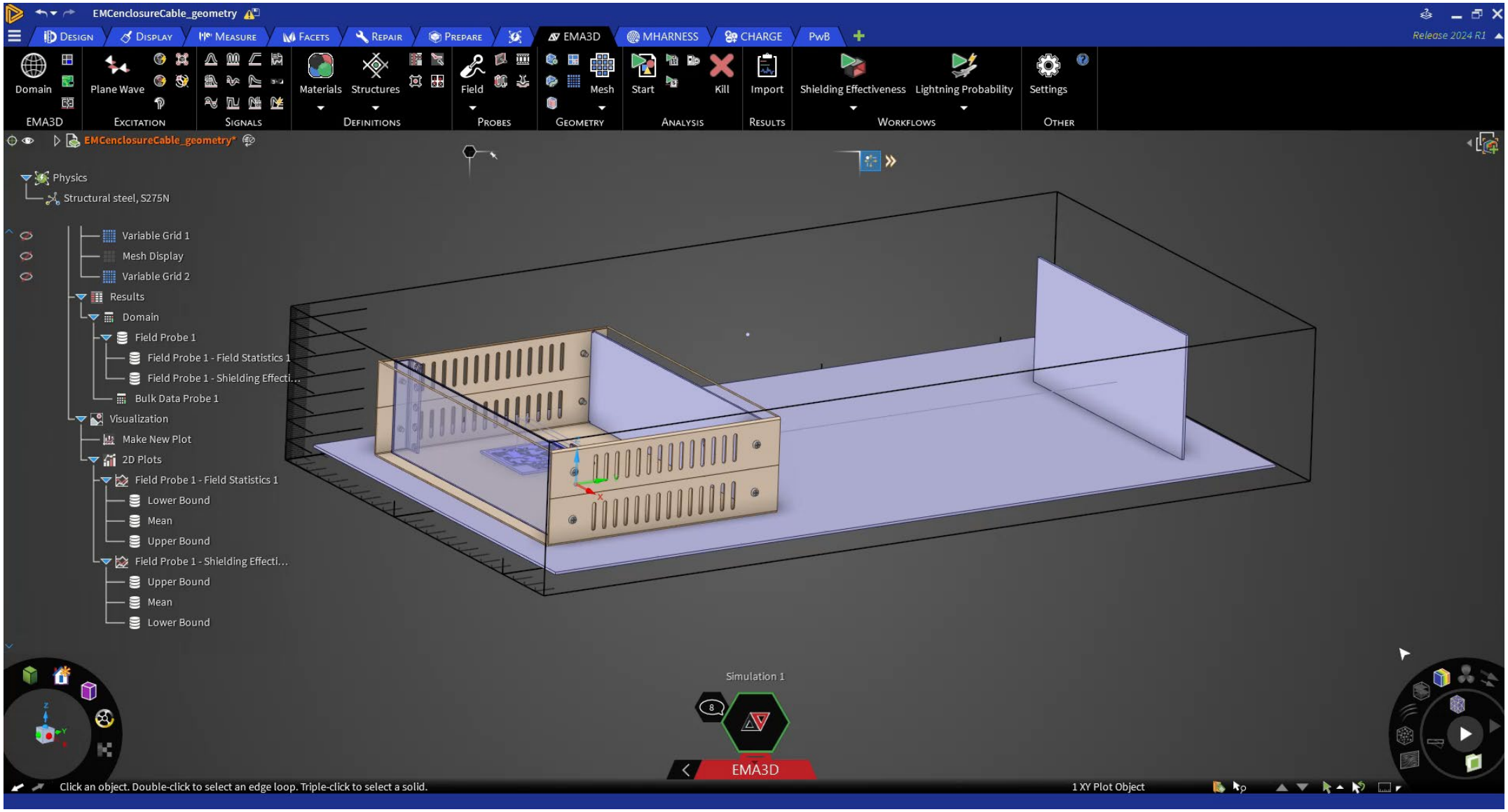
Probe Definitions

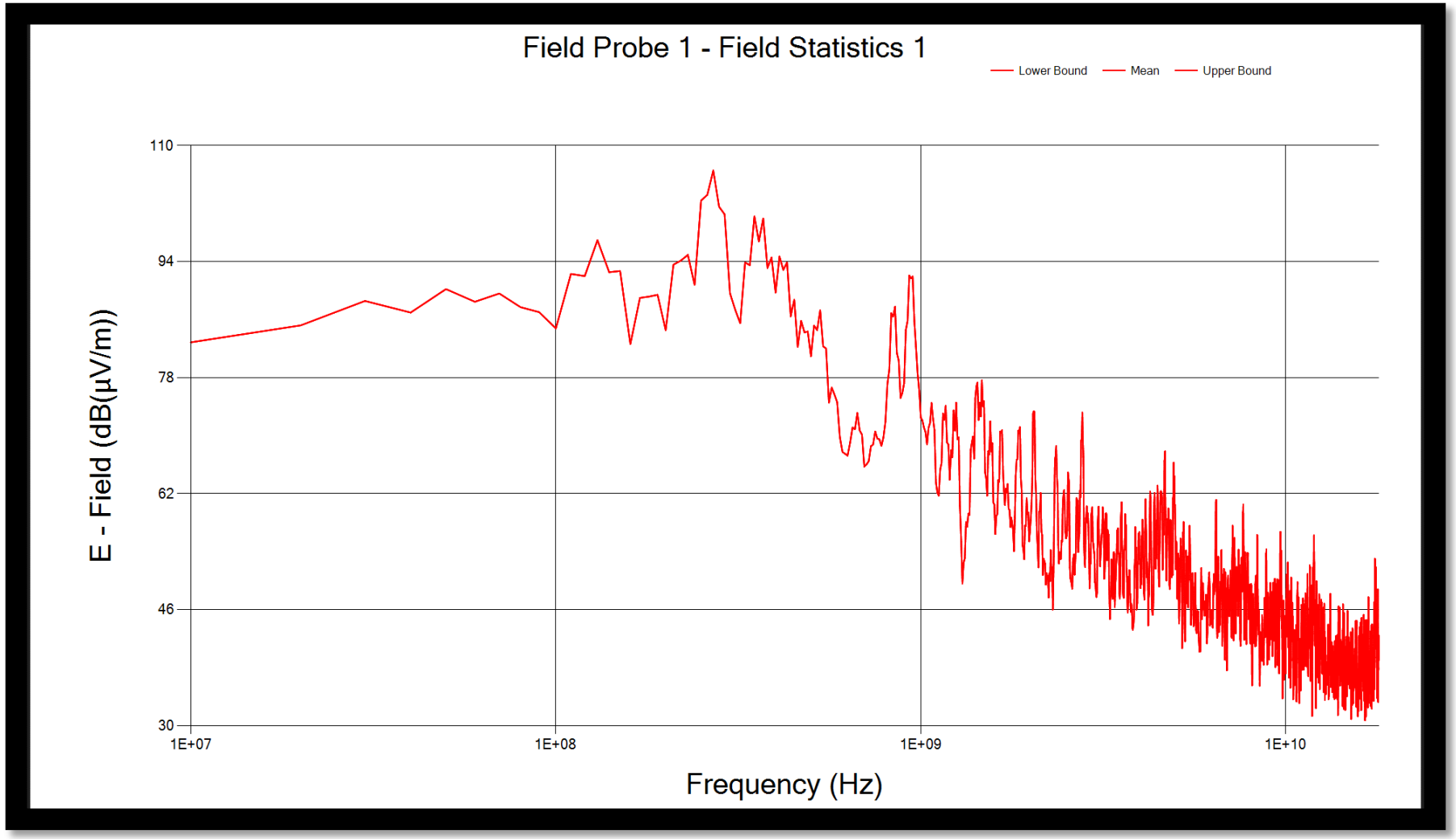


From Mesh To Run

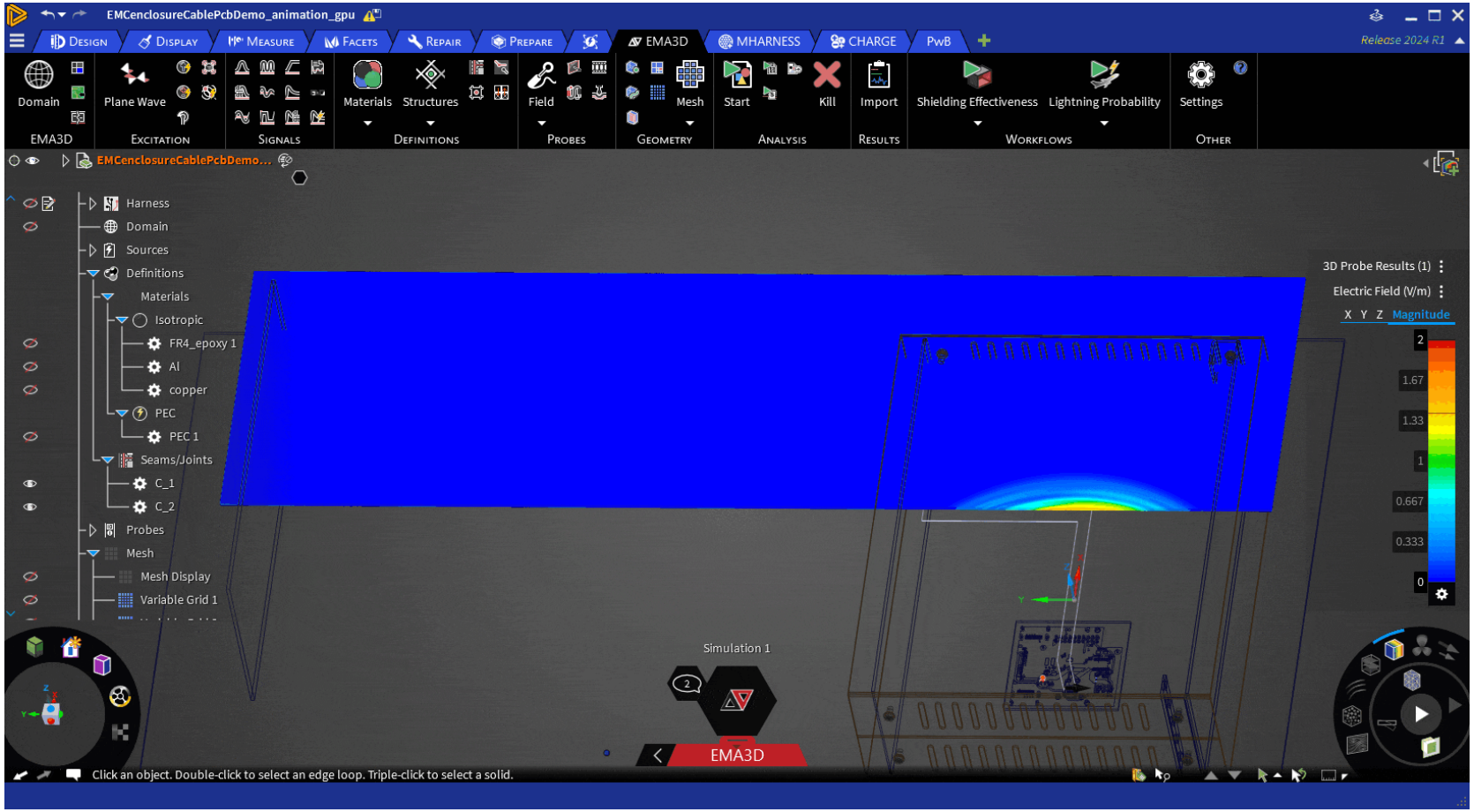


3D Probe Data Visualization




Field Probe 1 - Field Statistics 1
Lower Bound
Mean
Upper Bound
110
94
78
62
46
30
E - Field (dB(µV/m))
1E+07
1E+08
1E+09
1E+10
Frequency (Hz)

Results


EMCenclosureCablePcbDemo_animation_gpu
Release 2024 R1
Design
Display
Measure
Facets
Repair
Prepare
EMA3D
MHARNESS
CHARGE
PwB
Domain
Plane Wave
Materials
Structures
Field
Mesh
Start
Kill
Import
Shielding Effectiveness
Lightning Probability
Settings
EMA3D
Excitation
Signals
Definitions
Probes
Geometry
Analysis
Results
Workflows
Other
EMCenclosureCablePcbDemo...
Harness
Domain
Sources
Definitions
Materials
Isotropic
FR4_epoxy 1
Al
copper
PEC
PEC 1
Seams/Joints
C_1
C_2
Probes
Mesh
Mesh Display
Variable Grid 1
3D Probe Results (1)
Electric Field (V/m)
X Y Z Magnitude
2
1.67
1.33
1
0.667
0.333
0
Simulation 1
EMA3D
Click an object. Double-click to select an edge loop. Triple-click to select a solid.

Ansys EMA

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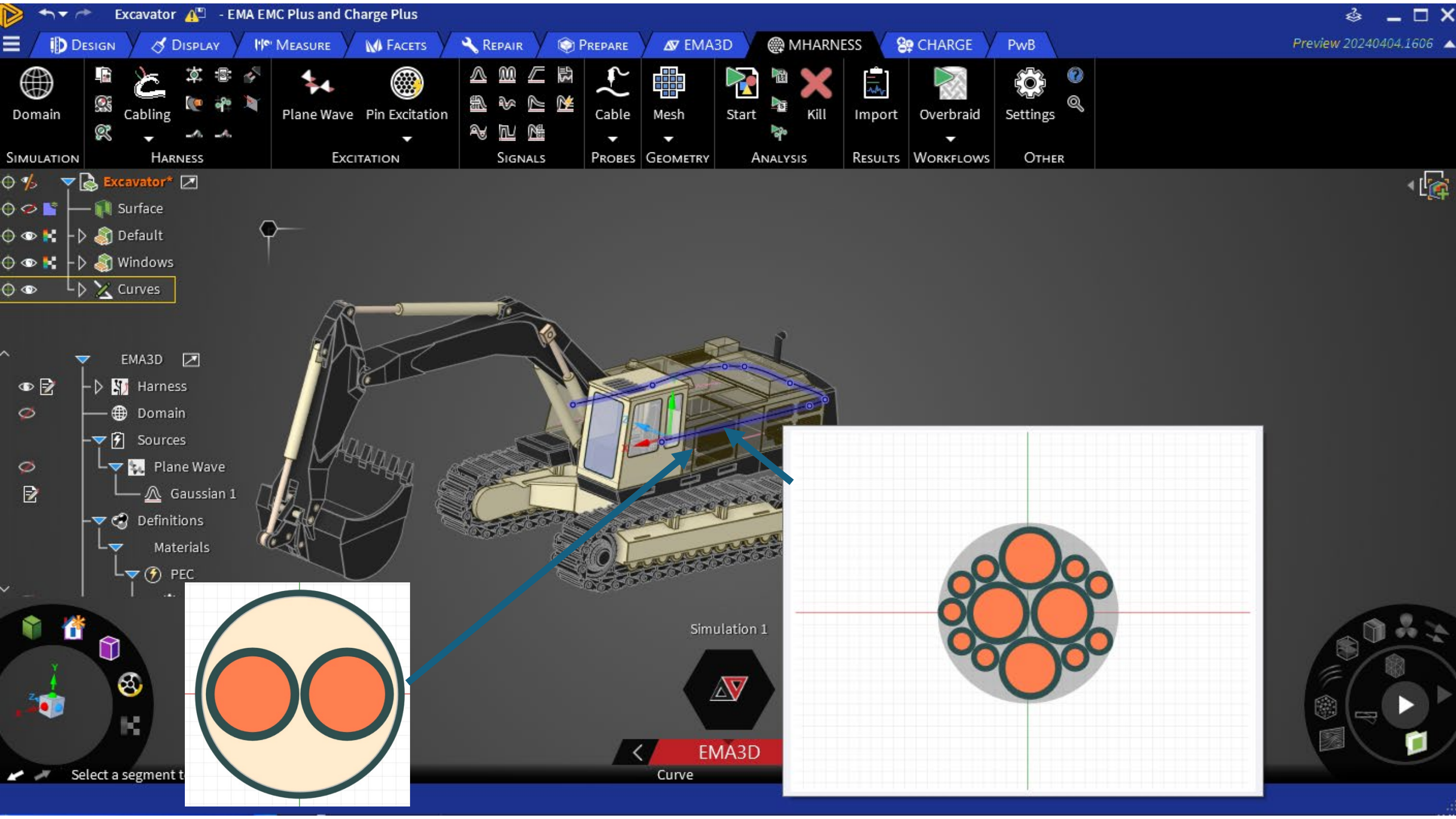
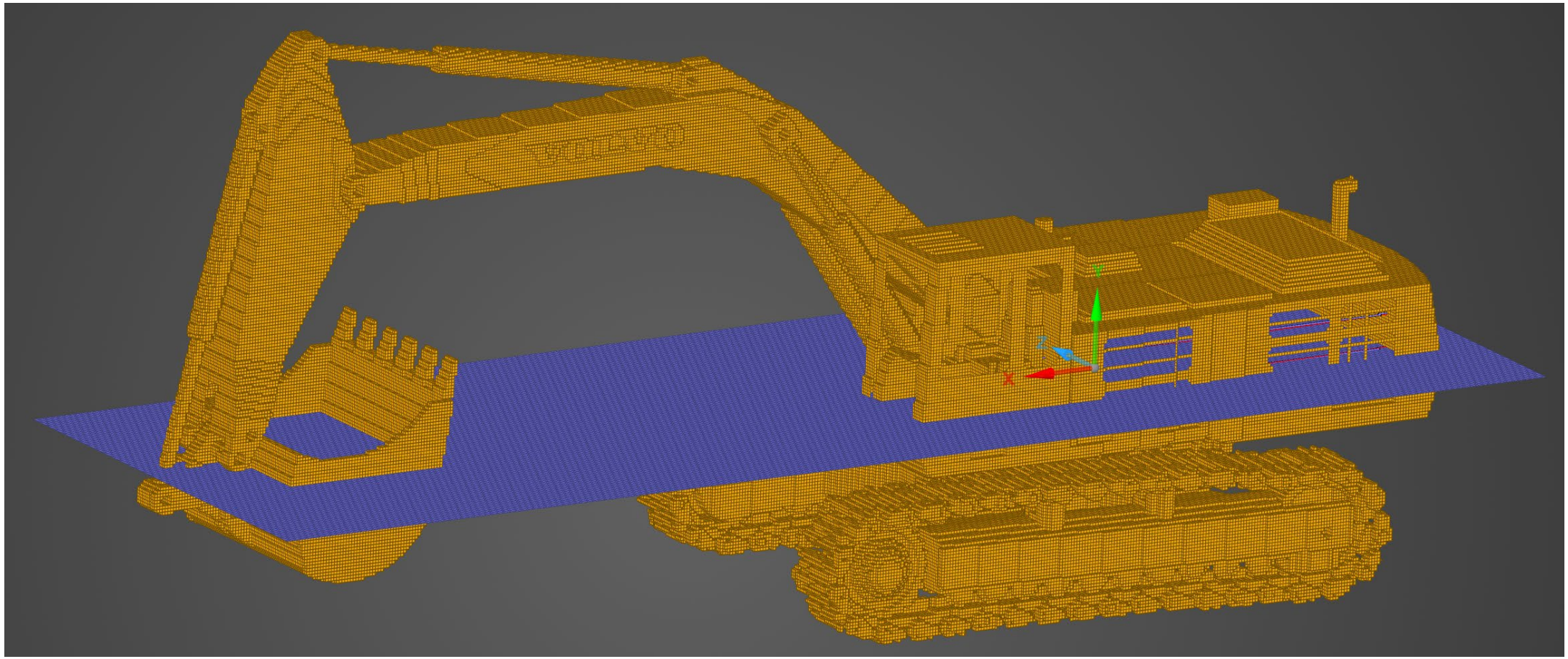
Radiated Susceptibility in a Large Platform

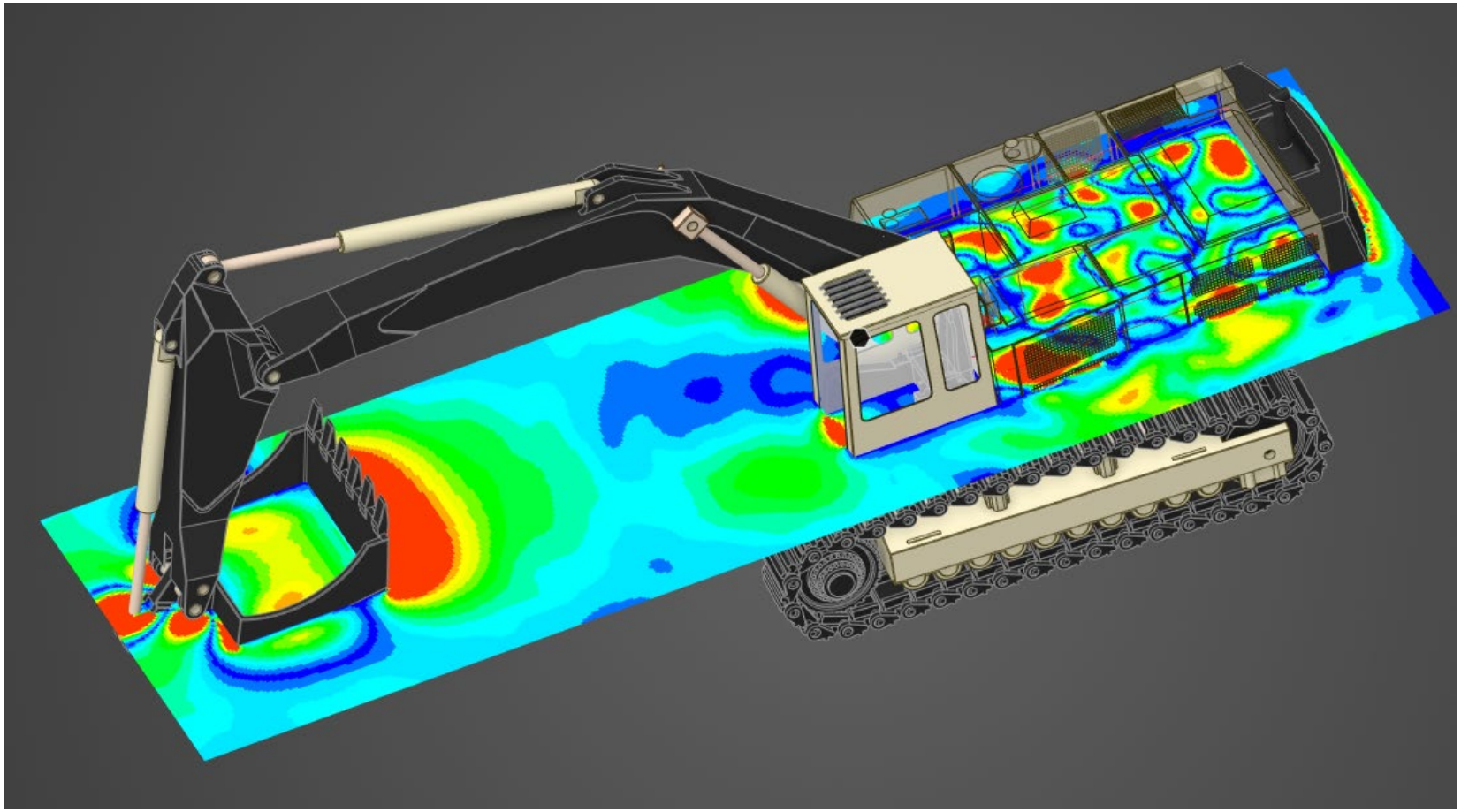
Vehicles, robotics, heavy industry, and aerospace and defense

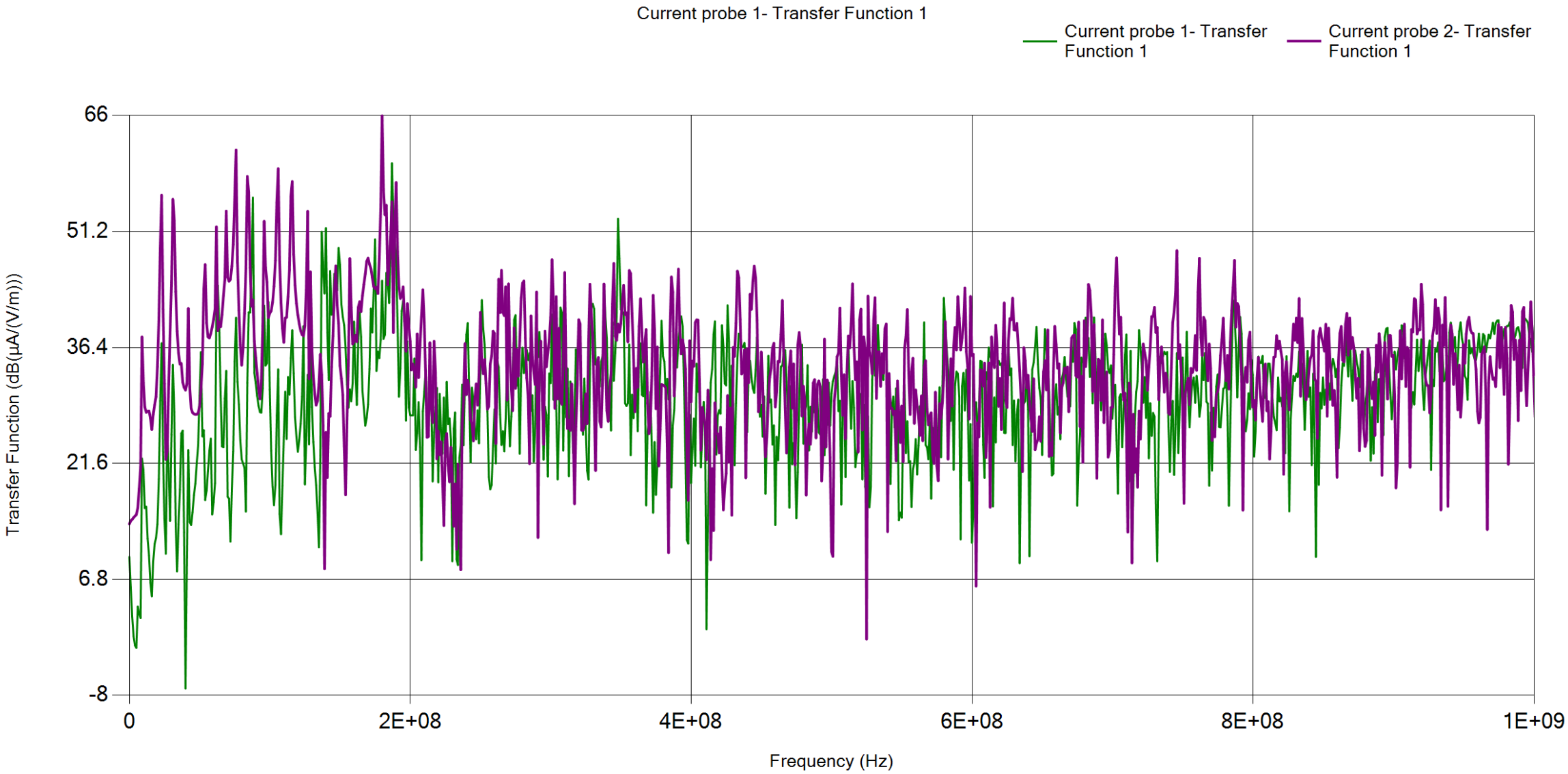

Excavator - EMA EMC Plus and Charge Plus
Design
Display
Measure
Facets
Repair
Prepare
EMA3D
MHARNESS
CHARGE
PwB
Preview 20240404.1606
Domain
Cabling
Plane Wave
Pin Excitation
Cable
Mesh
Start
Kill
Import
Overbraid
Settings
Simulation
Harness
Excitation
Signals
Probes
Geometry
Analysis
Results
Workflows
Other
Excavator*
Surface
Default
Windows
Curves
EMA3D
Harness
Domain
Sources
Plane Wave
Gaussian 1
Definitions
Materials
PEC
Simulation 1
EMA3D
Curve
Select a segment t

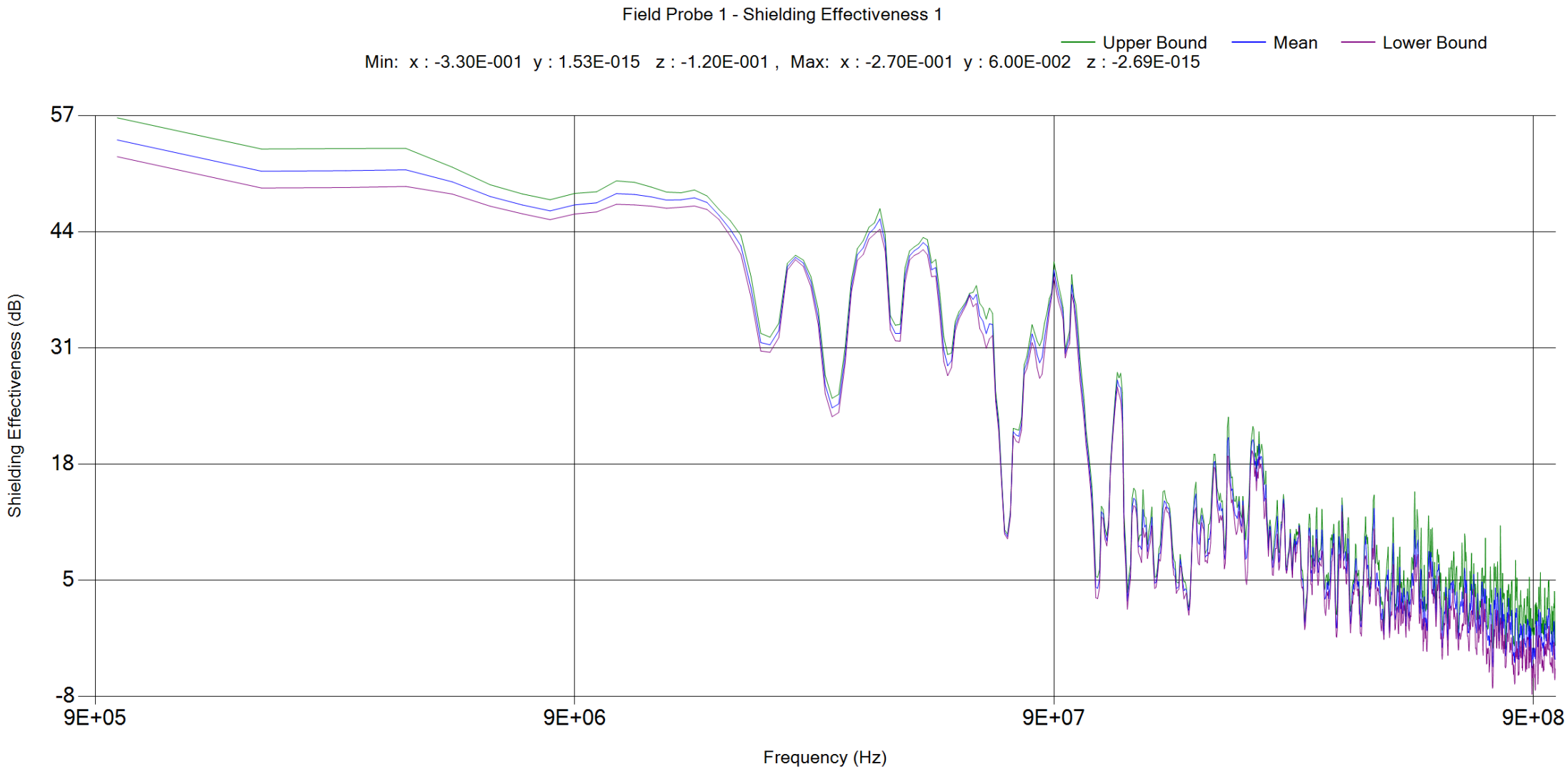
Forgiving Voxel Meshing



Immunity Field Results




Current probe 1- Transfer Function 1
Current probe 1- Transfer Function 1
Current probe 2- Transfer Function 1
Transfer Function (dB(µA/(V/m)))
66
51.2
36.4
21.6
6.8
-8
0
2E+08
4E+08
6E+08
8E+08
1E+09
Frequency (Hz)


Field Probe 1 - Shielding Effectiveness 1
Upper Bound
Mean
Lower Bound
Min: x : -3.30E-001 y : 1.53E-015 z : -1.20E-001 , Max: x : -2.70E-001 y : 6.00E-002 z : -2.69E-015
57
44
31
18
5
-8
Shielding Effectiveness (dB)
9E+05
9E+06
9E+07
9E+08
Frequency (Hz)

Ansys EMC Plus Automotive Success Stories

Problems:

1) The DC/DC converter selection was ideal in terms of cost and performance, but came with potential concerns about electromagnetic noise based on CISPR 25 testing

2) Knowledge that high voltage/high power systems of this kind have been known to cause self-compatibility issues on other EVs, with interference to CAN lines sometimes rendering a system inoperable

3) The need to avoid impact to schedules if an EMC problem was discovered on a physical site troubleshooting and potentially costly re-designs.

Set-Up:

- Using CAD provided by Lightning eMotors, a simplified model was created for EMC simulation
- Cable harness parameters were selected to capture the potential noise level of the threat (shielded HV cable carrying high frequency noise from the DC/DC converter) and immunity concerns of the victim (co-routed or nearby low voltage CAN lines). The stimulus on the threat cable was chosen to replicate the levels found in component level CISPR 25 testing
- These steps took **~48 hours of work by a single Staff Scientist, new to Ansys EMC Plus**, to develop

Solution:

Model was updated to try multiple solutions including re-routing the CAN and HV lines to increase separation distance and limit parallel routing. The final iteration was adding an aluminum conduit for the HV cable routing. This allowed the original routing placement to be maintained for both the HV and CAN lines. Solution was a cheap, effective, and kept Lightning eMotors delivery schedule intact.

Total engineering time: 120 hours

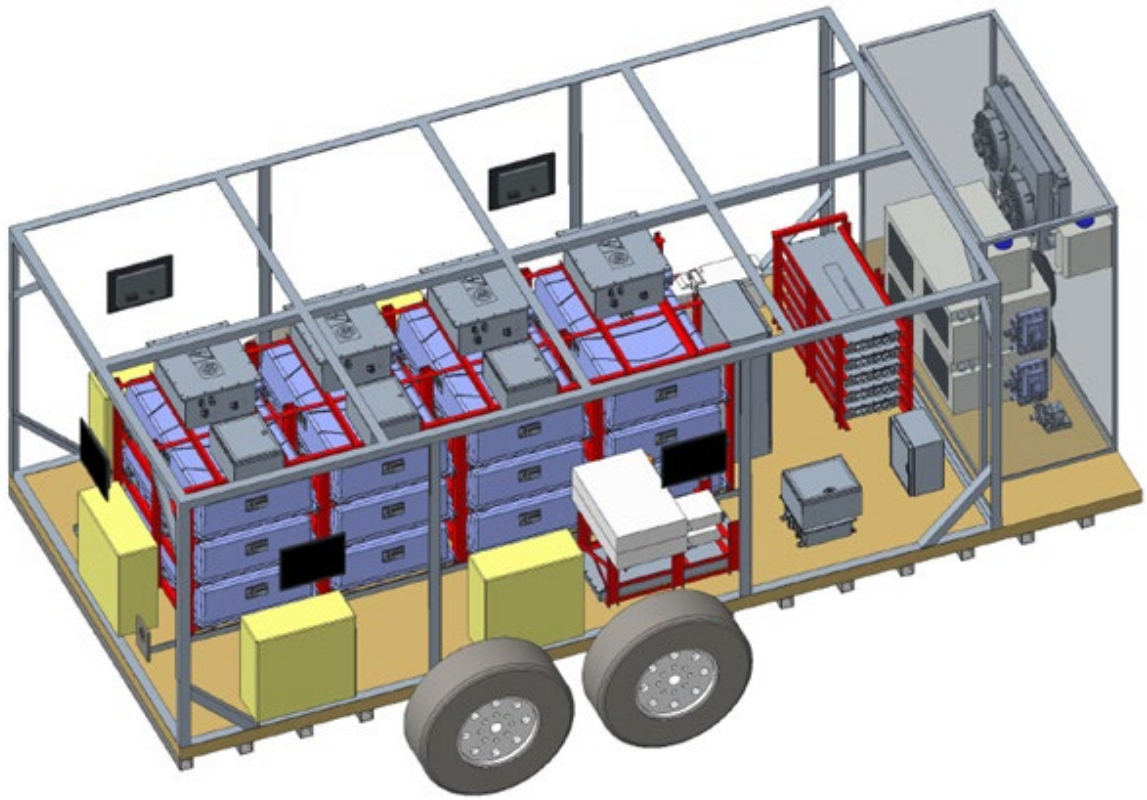


Figure 1. Trailer shown with enclosure skeleton, minus enclosure covers

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EMC for Devices

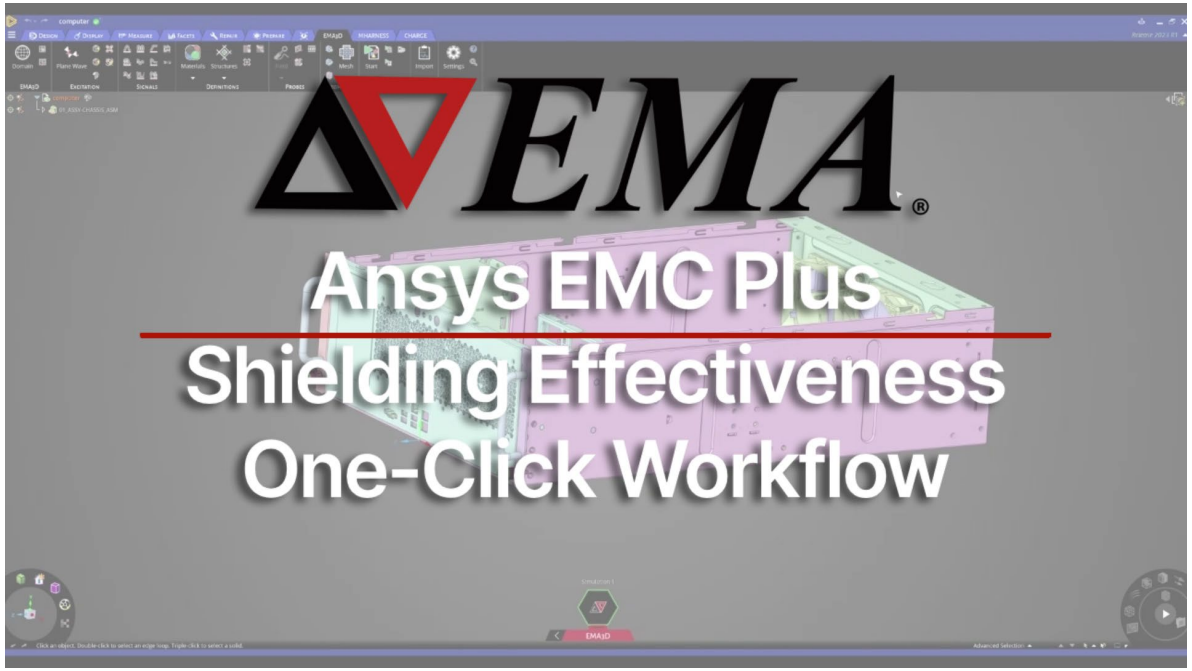
How to get started?

How to get started?

- Though an electronic device may consist of many sources of noise, not all sources are likely to create emissions near the limit curve
- Focus on the aspects of the design that:
  - Include the largest magnitudes of current/voltage
  - May have an abrupt change of state (high dI/dt) that would create broadband noise
  - Serve as a mechanism to unbalance an otherwise differential signal or power to become common mode noise
  - Locations where parasitic coupling may allow unintended energy to find its way to cables, cable shields, or structures

Start with the enclosure or vehicle chassis

- By using the mechanical CAD with reduced need to clean and prepare geometry, there is no penalty to considering the entire device or vehicle first
- Enclosures and chassis have a large impact on radiated EMI/EMC
- The initial results come in minutes to give feedback on the main frequencies of coupling

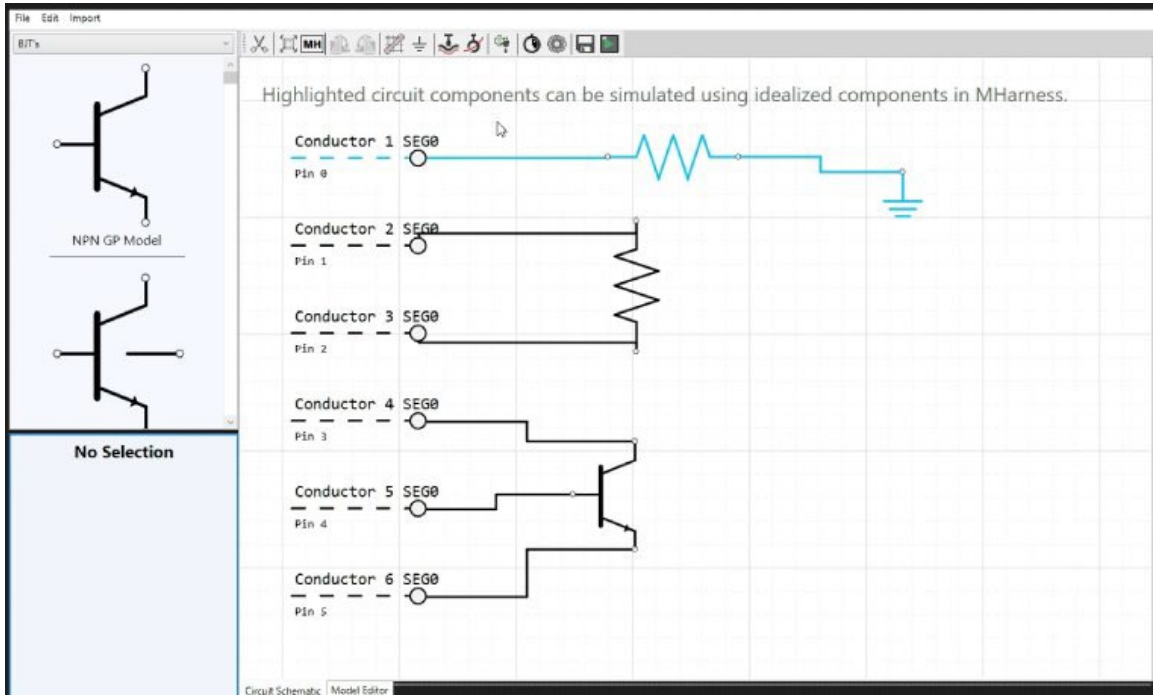


Add the cables of highest concern

- Using transmission line theory, cables may be added quickly and efficiently
- KBL import allows for automated addition of cable descriptions from cable database software (digital engineering)
- EMC Plus automatically fuses cable information and mechanical CAD

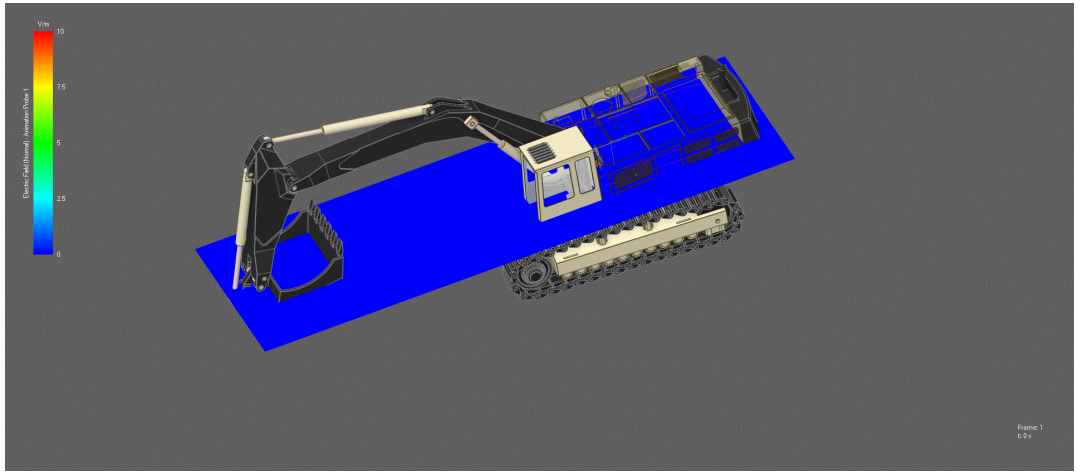
Add representation of termination impedances

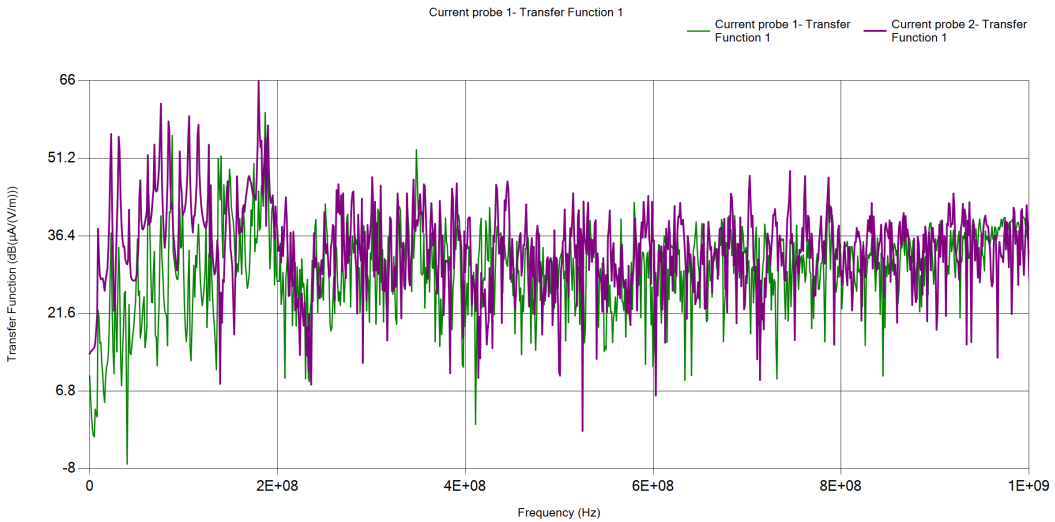
- Impedance of the termination of cables may be specified using co-simulation with the included circuit solver
- Include Touchstone files for characterization of PCB for parasitics
- Add the EMI filter circuit elements
- Add the differential mode inductance and common mode (to vehicle chassis) capacitance of electric motors



Radiated/Conducted Immunity

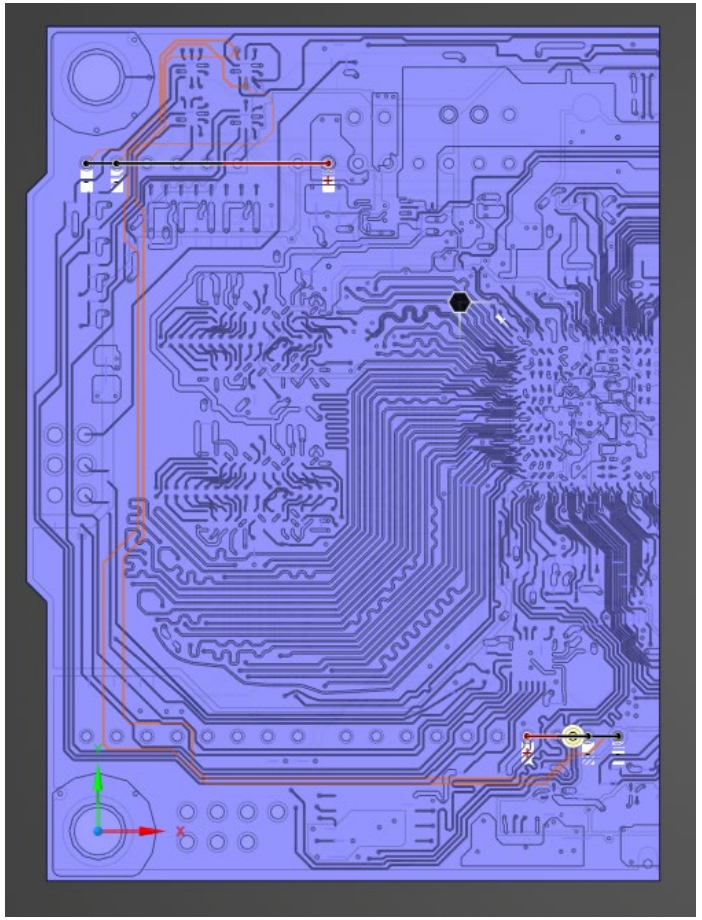
- The simulation is ready for radiated immunity of the included connections
- Threats recorded at interfaces may be compared to component specification sheets and operational voltages to estimate potential for upset or damage





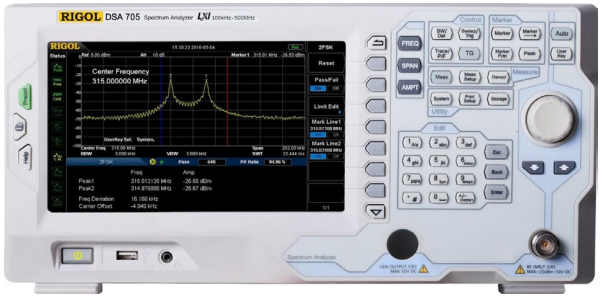
PCB Inclusion

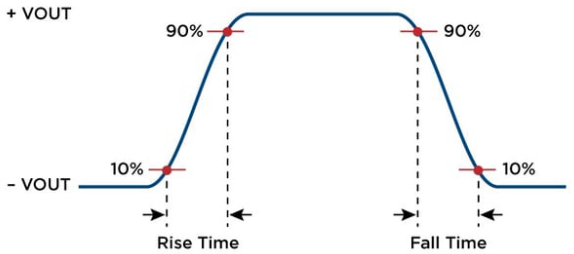
- Add PCBs to the simulation explicitly as needed and data is available
- Impedance, parasitics, and radiation directly from board is explicitly modeled
- Variable grid resolution along with automated component and material specification allows for reasonable analyst time to prepare models

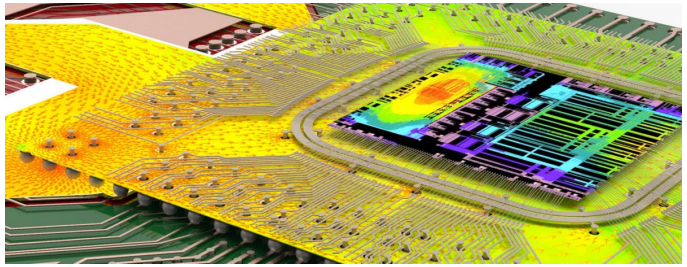


Excitations on nets and cables

- There are many methods to determine the excitations:
  - Pre-compliance lab experimental characterization
  - Device specification sheets
  - Component modeling
  - Engineering judgement

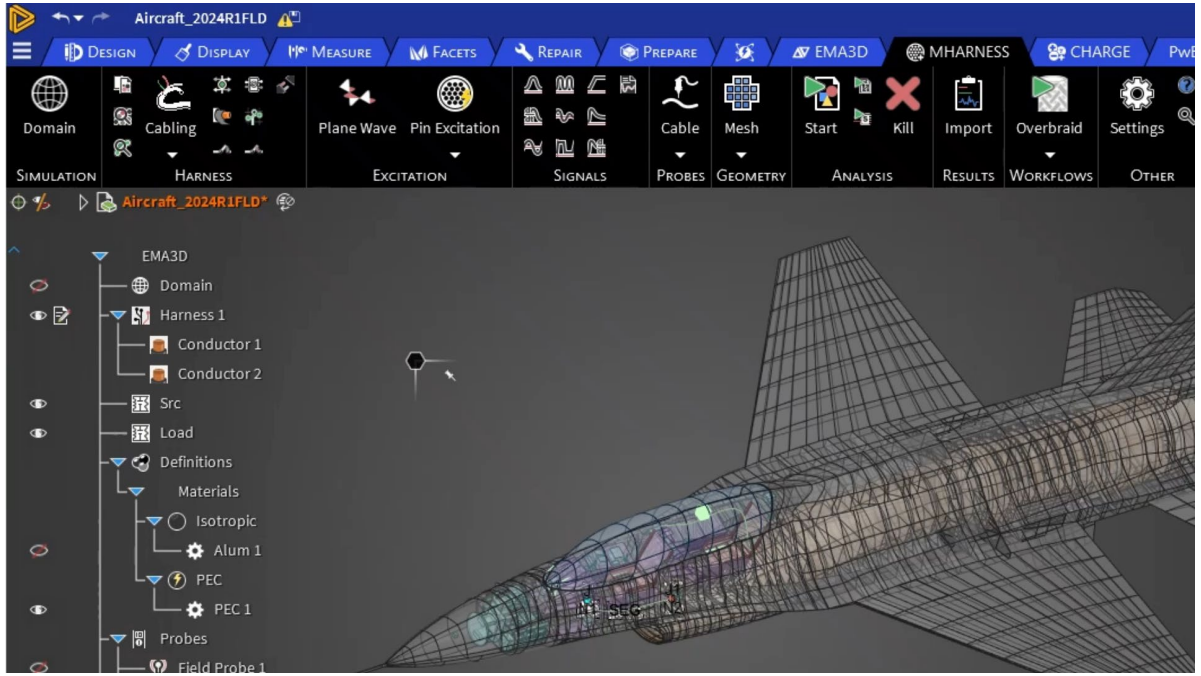






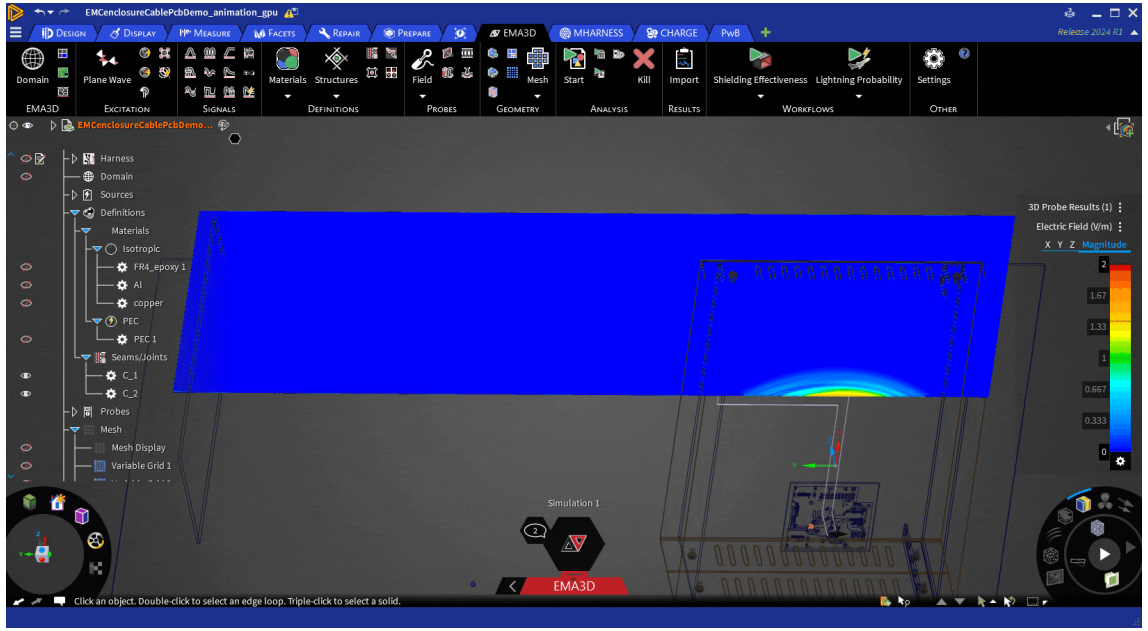
Assign Excitations

- EMC Plus combines three solvers:
  - Non-linear circuit solver (SPICE/IBIS)
  - Multi-conductor Transmission Line solver
  - 3D Finite Difference Time Domain Solver
- The solvers are linked self-consistently on the same mesh grid
- Energy flows in both directions



Radiated/Conducted Emissions

- Radiated emissions modeling in EMC Plus combines all product details in one self-consistent simulation:
  - Excitations on nets
  - PCB effects
  - Differential to common mode coupling
  - Parasitics
  - Shielding of cables
  - Shielding of enclosures and structures
- External field probes estimates the power at the receive antenna without computational expense of modeling the entire chamber



ESD Gun

- Charge Plus allows for self-consistent modeling of the ionization of air during the discharge process
- Only full-physics method of simulated ESD on real products
- Secondary arcs, image charges, and recombination are considered in the simulation

EMC Plus and Charge Plus

- EMI/EMC simulation is not impossible
- You can get started today, and we can help
- Tools have evolved to reduce the analyst time
- Start with the largest items of EMI/EMC concern in your design and proceed systematically through all nets and cable lines of interest