SIMULIA CST Studio Suite ®

MWS overview

3DEXPERIENCE®

Agenda

SIMULIA CST Studio Suite: industry focused solutions

Satellite antennas

Communication systems in aircrafts

Land-based RF and MW communications

Conclusion

2021 A&D Industry Business Drivers

Develop Agile Technology & Services Portfolio

HOW TO: introduce new technologies & services to increase portfolio competitiveness quickly with low risk?

Achieve Sustainability through Innovations

HOW TO: deliver on economic, environmental and social promises ?

Drive Costs Down

HOW TO: accelerate program integration while driving 40-60% of cost out?

Enable Flexible Production

HOW TO: support flexible rate to adapt to market needs and demand?

Transform Supply Chain In Value Network

HOW TO: drive integration to improve visibility, on-time delivery and first-time quality?

Aerospace Communication & Detection System Performance | **Challenges**

1. Safely and profitably introduce innovative new solutions in a complex system of systems environment

2. Manage increasing production rates efficiently, from concept to production to recycling

3. Facilitate knowledge transfer and intellectual property protection within the workforce and with the partners

4. Reduce certification and testing costs while ensuring highest level of quality and security

Aerospace Communication & Detection System Performance | **Challenges**

5 Demand for more data bandwidth extends the use of frequency spectrum increasing system complexity

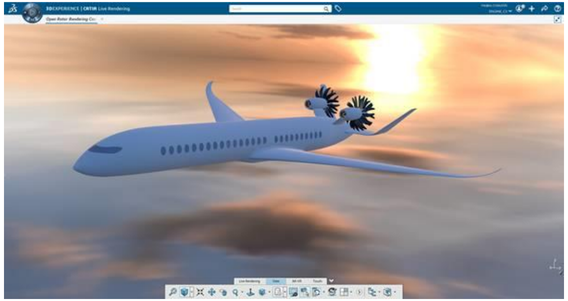
6 Increasing number of antennas on aircraft increases the probability of co-site interference events

7 Greater dependence on automated flight requires highly reliable communication and detection system performance

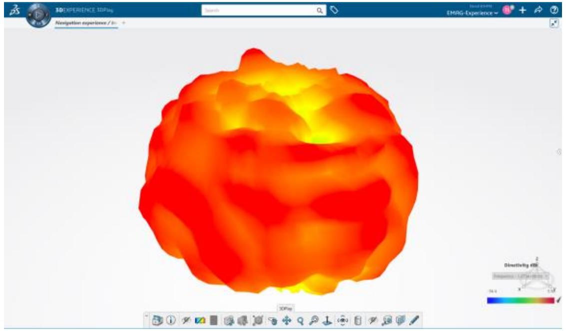
8 Increasing use of lightweight composite materials presents new challenges for antenna integration

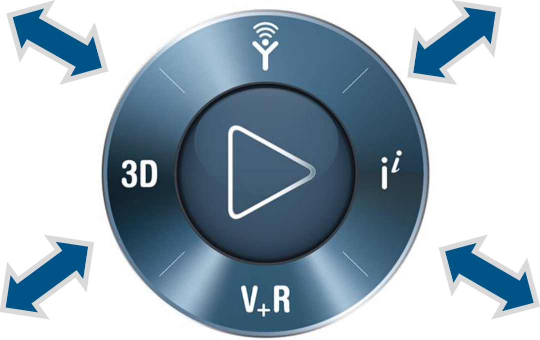
Aerospace Communication & Detection System Performance | **Solution Description**

CATIA



3DPlay

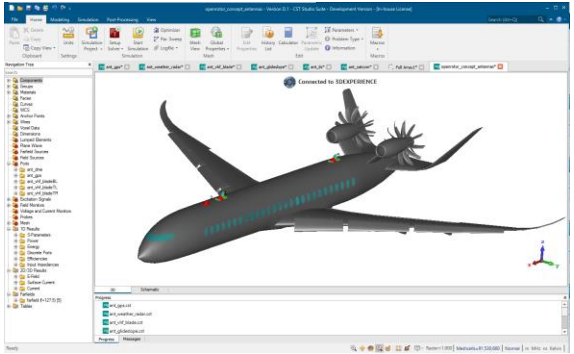


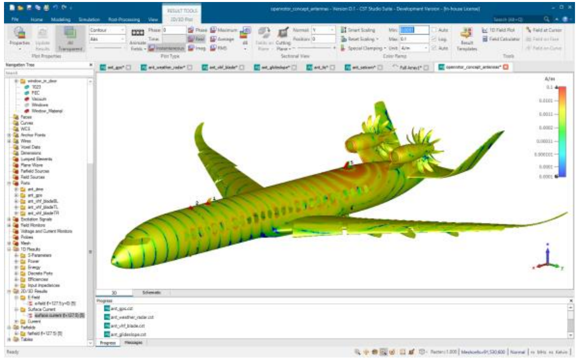


3DEXPERIENCE®

Digital continuity
Versioning
Seamless collaboration

CST Studio Suite





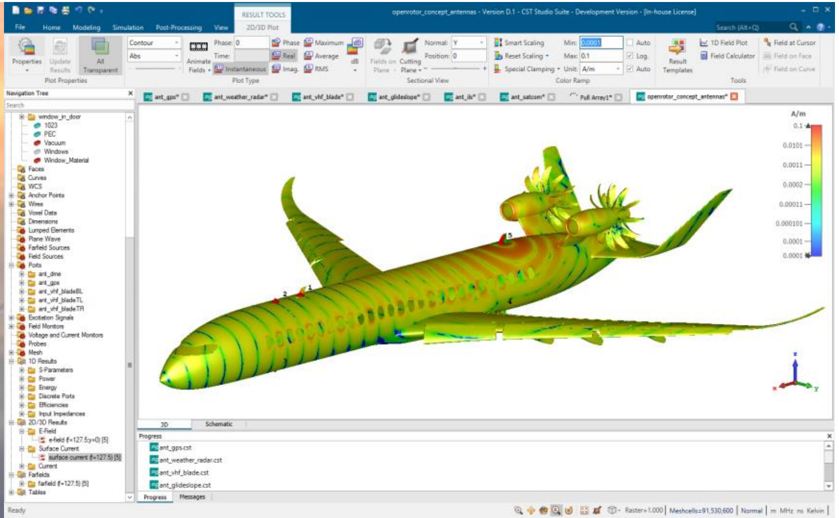
SIMULIA

DASSAULT SYSTEMES

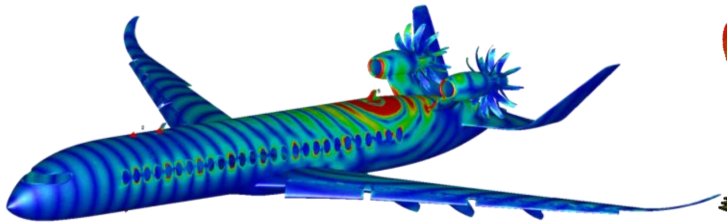
Aerospace Communication & Detection System Performance | **Context**

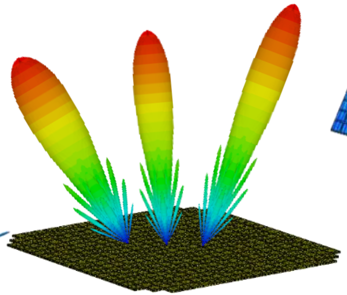
How do we reduce physical testing? Testing is costly, time-consuming and difficult.

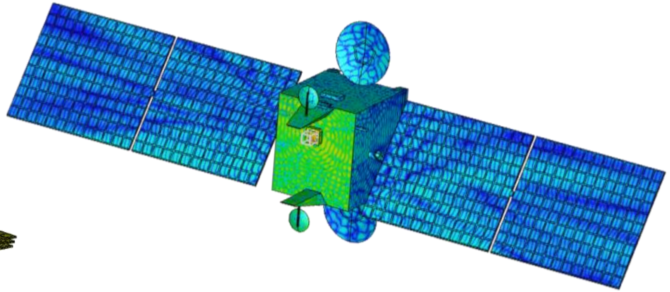
Virtual prototyping can drastically reduce the effort required and the risks of finding problems late in the design stage.

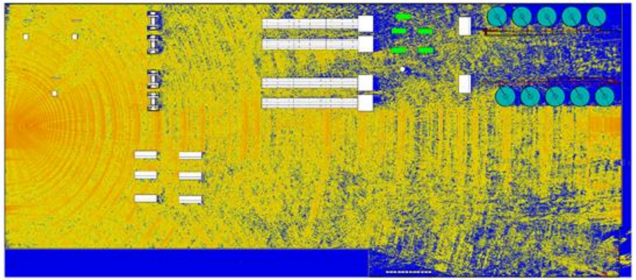


SIMULIA CST Studio Suite Solution



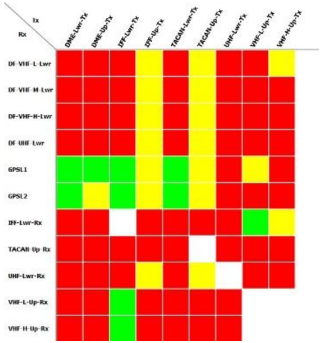


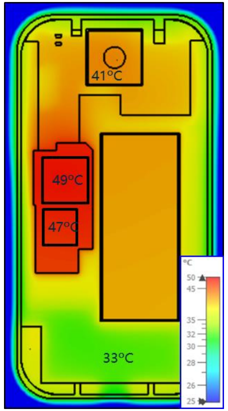




Network Coverage

Electromagnetic Dosimetry





SIMULIA

DASSAULT SYSTEMES

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SIMULIA CST Studio Suite: industry focused solutions

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Conclusion

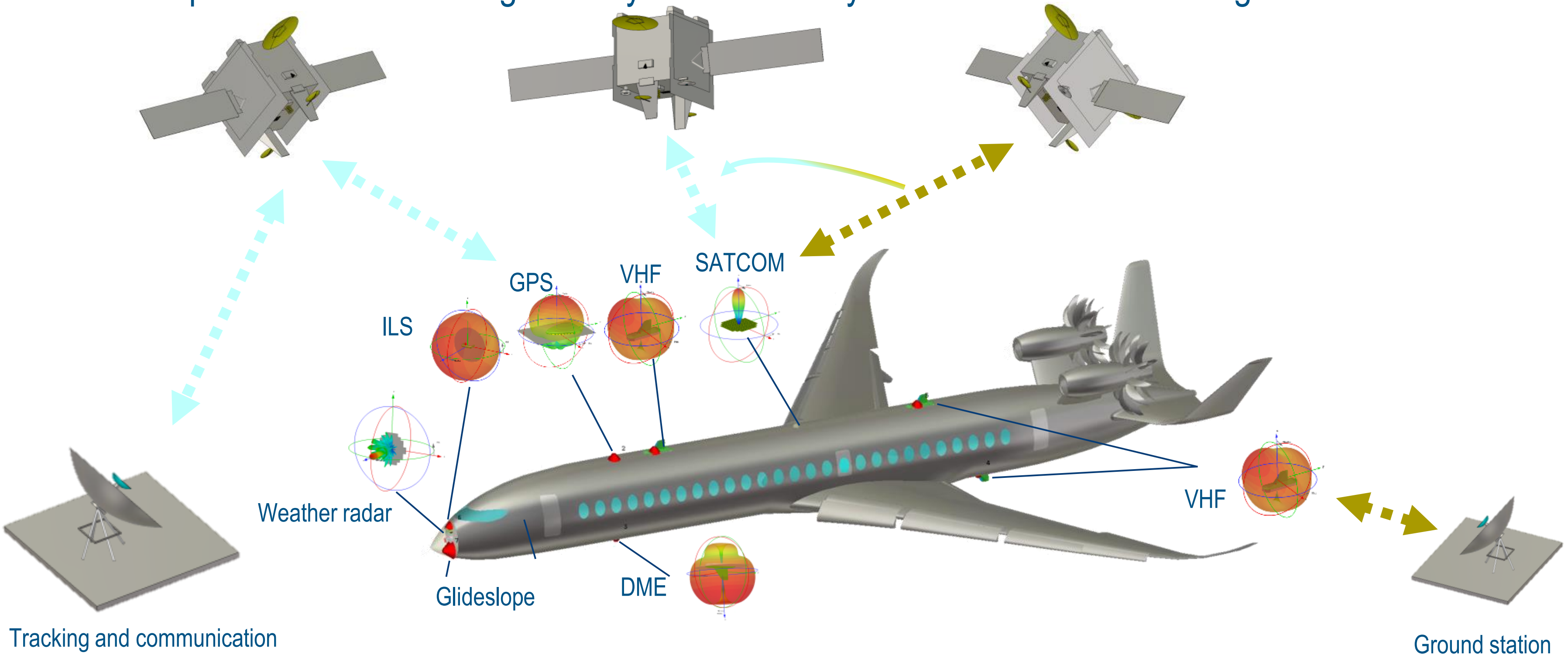
Reliable communication is crucial for safe and efficient operation of spacecraft

- Thera nearly 5000 satellites orbiting the earth and nearly 10000 aircraft in the sky at any given time.
- Trend towards highly autonomous flight means air- and spacecraft satellite communication is more important than ever.
- Passengers are also demanding faster communication speeds and more bandwidth for their own devices which puts more demand for satellite based broadband connection.
- With increased demand for communication and evolving, the number of antennas and communications systems on spacecraft is expected to increase, which also increases the probability of interference events.


Is space available to route cables to the antennas?
How do we reduce physical testing to a minimum?
Will the antennas work in their proposed locations?
Will the satellite structure affect antenna performance?
Will the communications systems interfere with each other?

Aerospace Communication & Detection System Performance | **Context**

Number of antennas on aircrafts is increasing. How do we make sure they work in the proposed locations and with all possible satellite and ground systems that they need to be communicating with?



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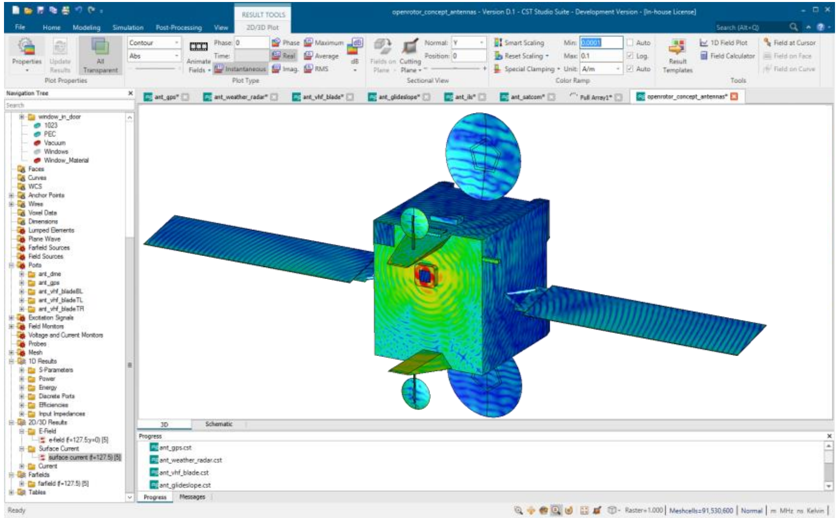

Aerospace Communication & Detection System Performance | **Challenges**

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Aerospace Communication & Detection System Performance | **Challenges**

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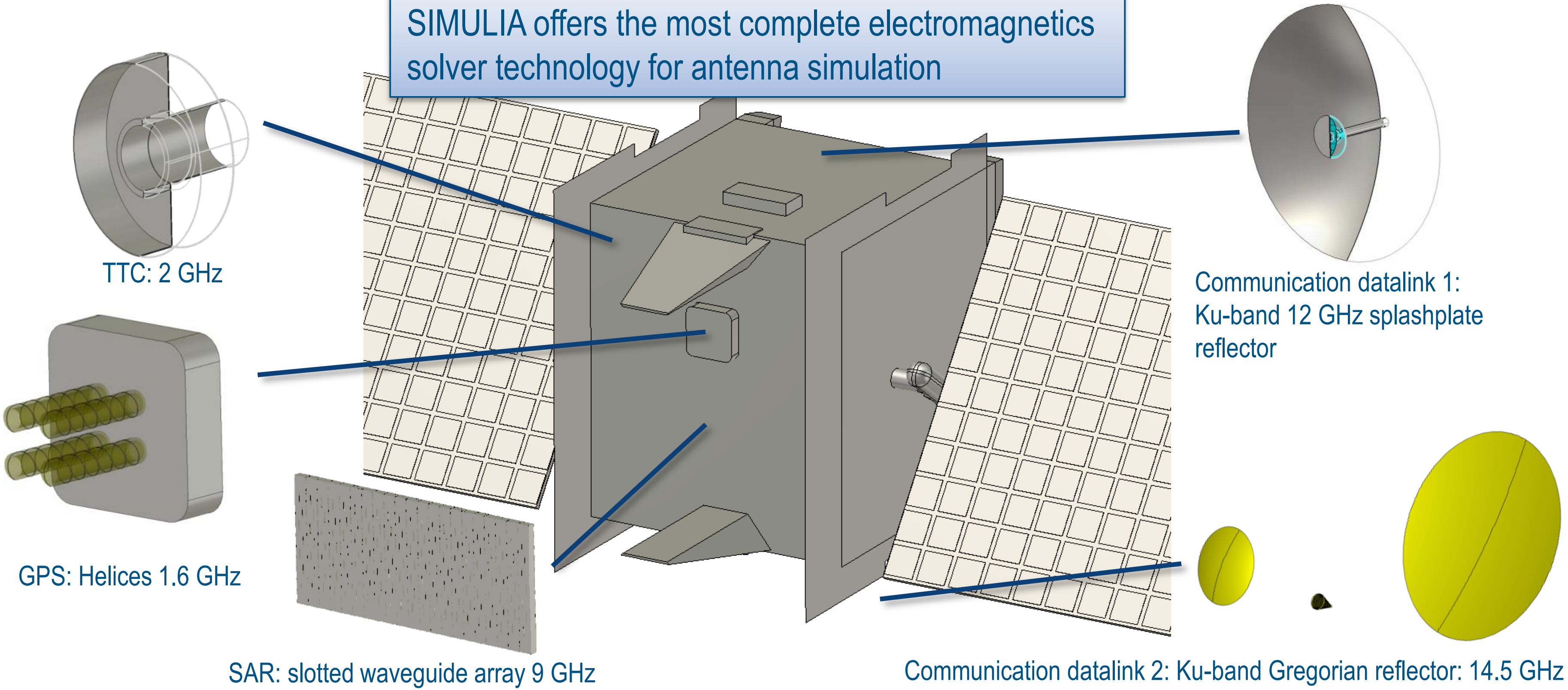
Aerospace Communication & Detection System Performance | **Solution Description**

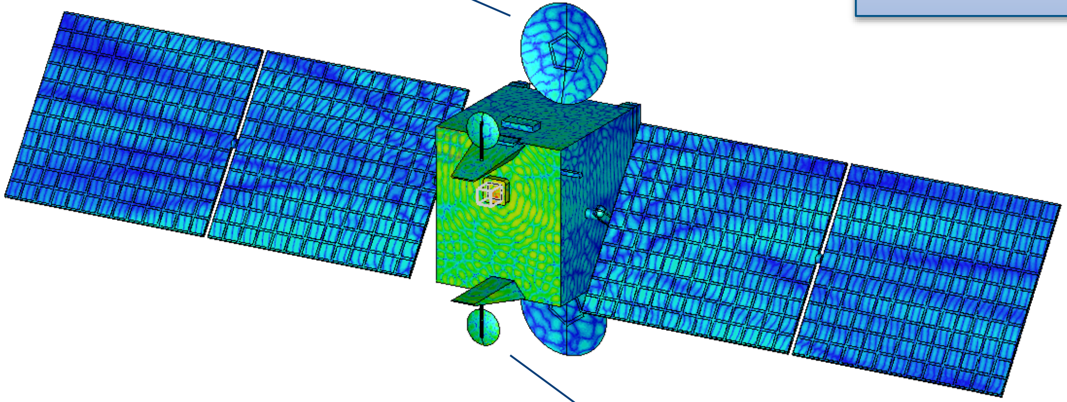
SIMULIA offers the most complete electromagnetics solver technology for antenna simulation



Aerospace Communication & Detection System Performance | **Solution Description**

Communication antenna reflectors be affected by the GPS antenna radiation field

Field and surface current visualization shows how the satellite geometry affects the antenna performance



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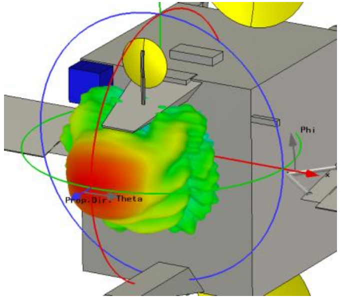

Visualization of installed radiation pattern

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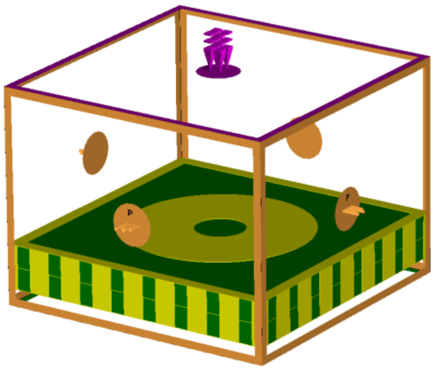
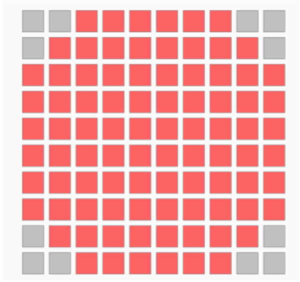
Aerospace Communication & Detection System Performance | **Solution Description**

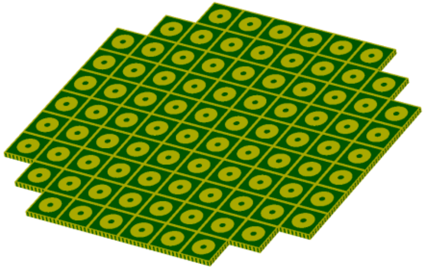
Specialized tools for antenna array design allow engineers to quickly estimate, optimize and validate array performance



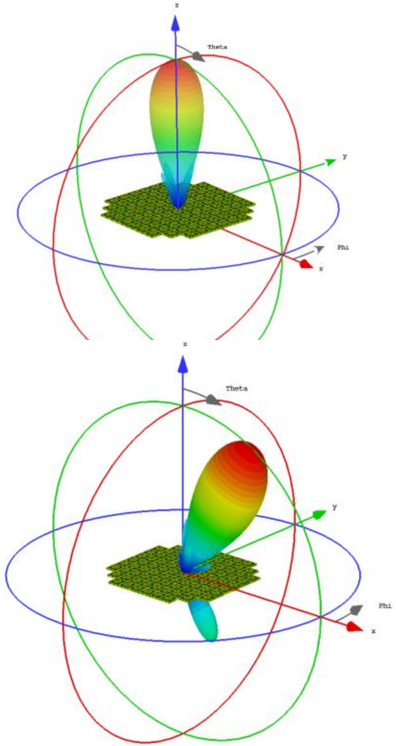
Infinite array analysis based on unit cell model, rapid design of element



Finite array design tool used to define array size, shape and active/passive elements



Automatic array geometry construction
Automatic amplitude/phasing for beam-steering



Beam-steering analysis

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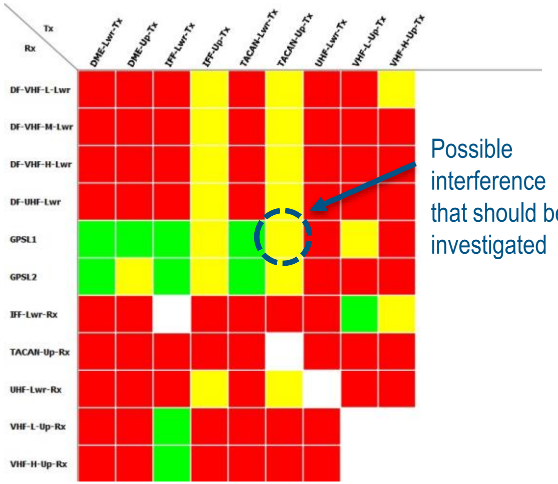
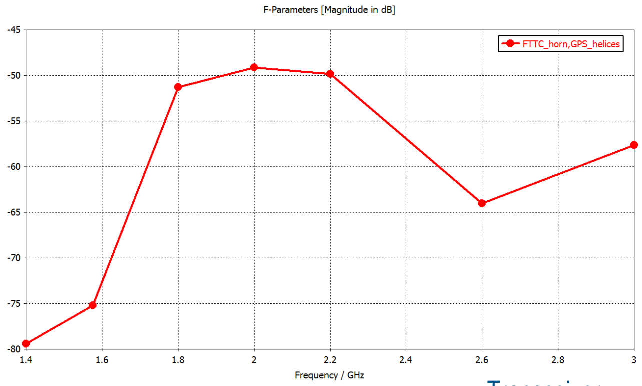
Aerospace Communication & Detection System Performance | **Solution Description**

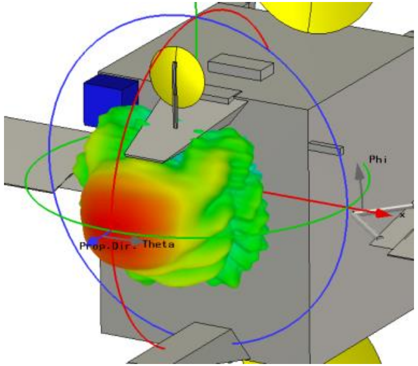
RF interference analysis made simple – define and simulate radio system coupling performance, analyze results at a glance through violation matrix.

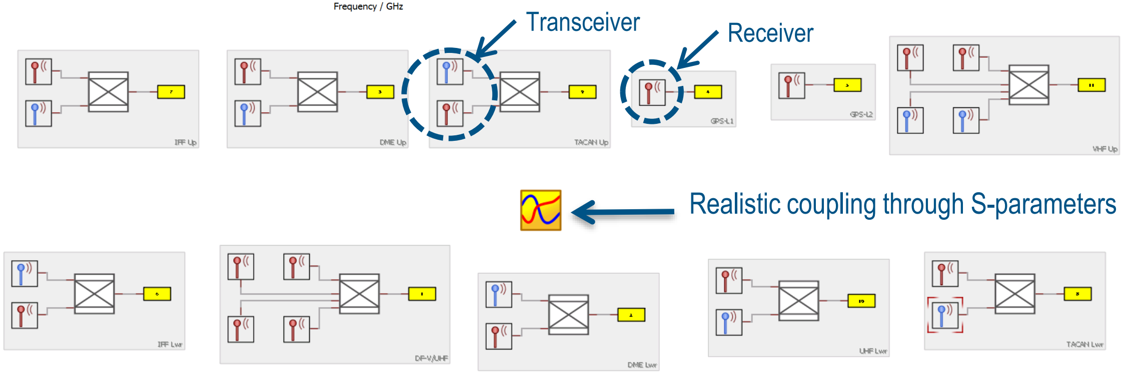


Possible interference that should be investigated

Antenna to antenna coupling

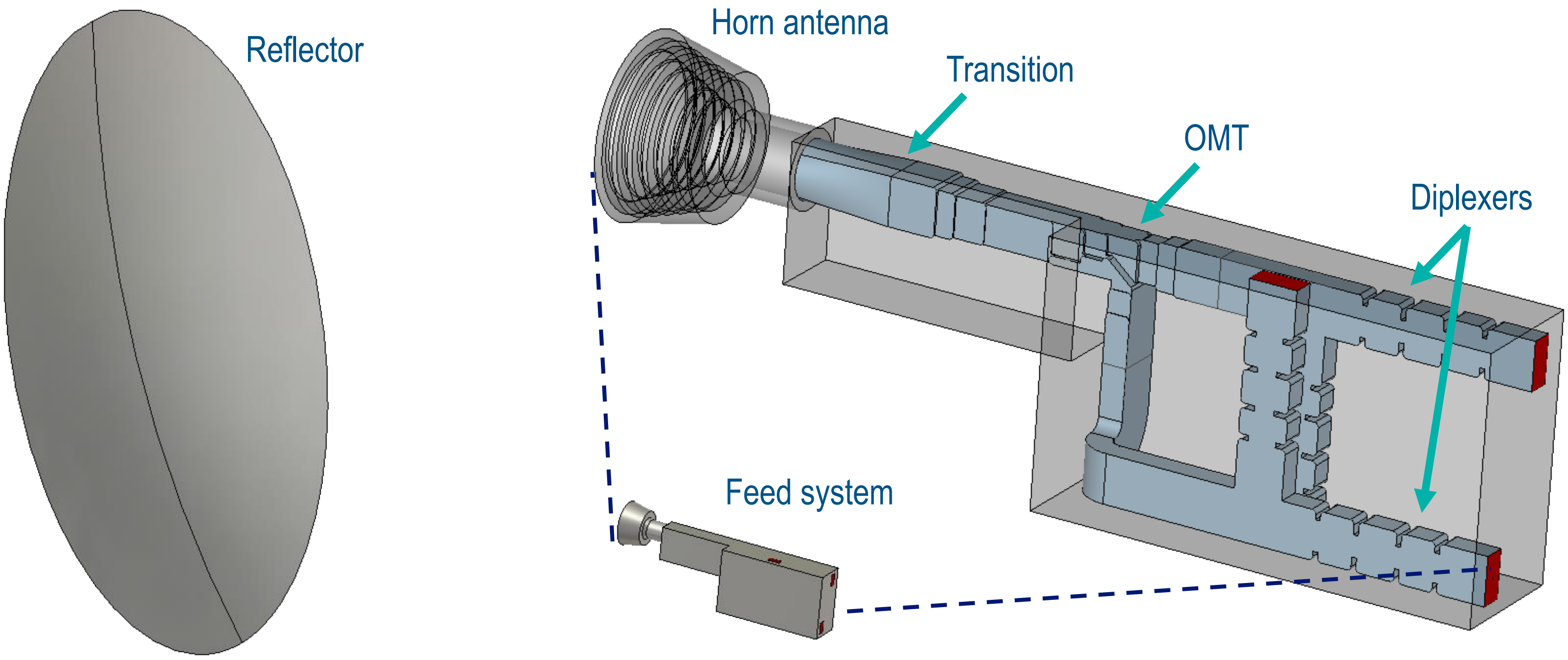






Aerospace Communication & Detection System Performance | **Solution Description**

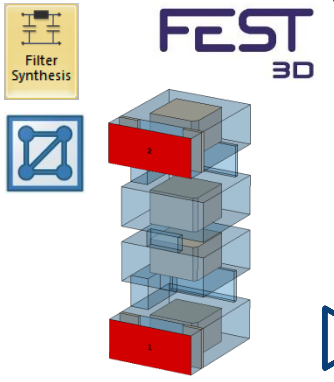
High power communication systems feed system design can be made easier by divide-and-conquer approach by splitting the problem into smaller pieces and using the best solution technology for each part



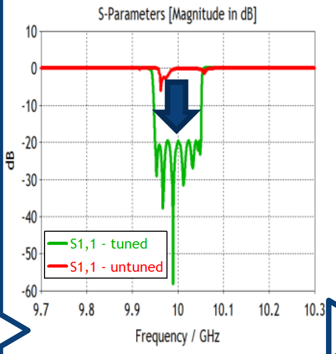
SIMULIA DASSAULT SYSTEMES

Specialized tools for filter design and tuning provide optimized solutions in shorter time than generic simulations.

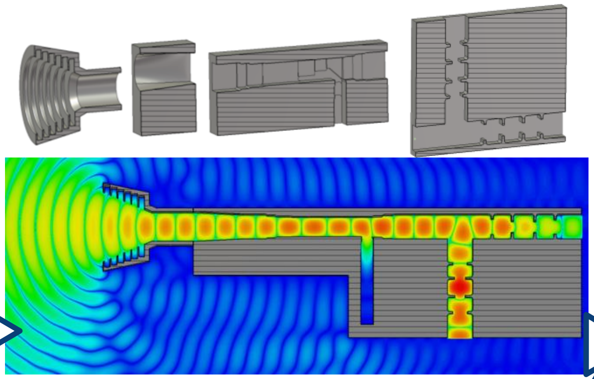
Synthesis



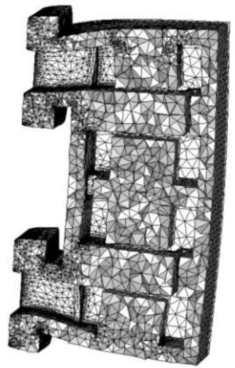
Tuning



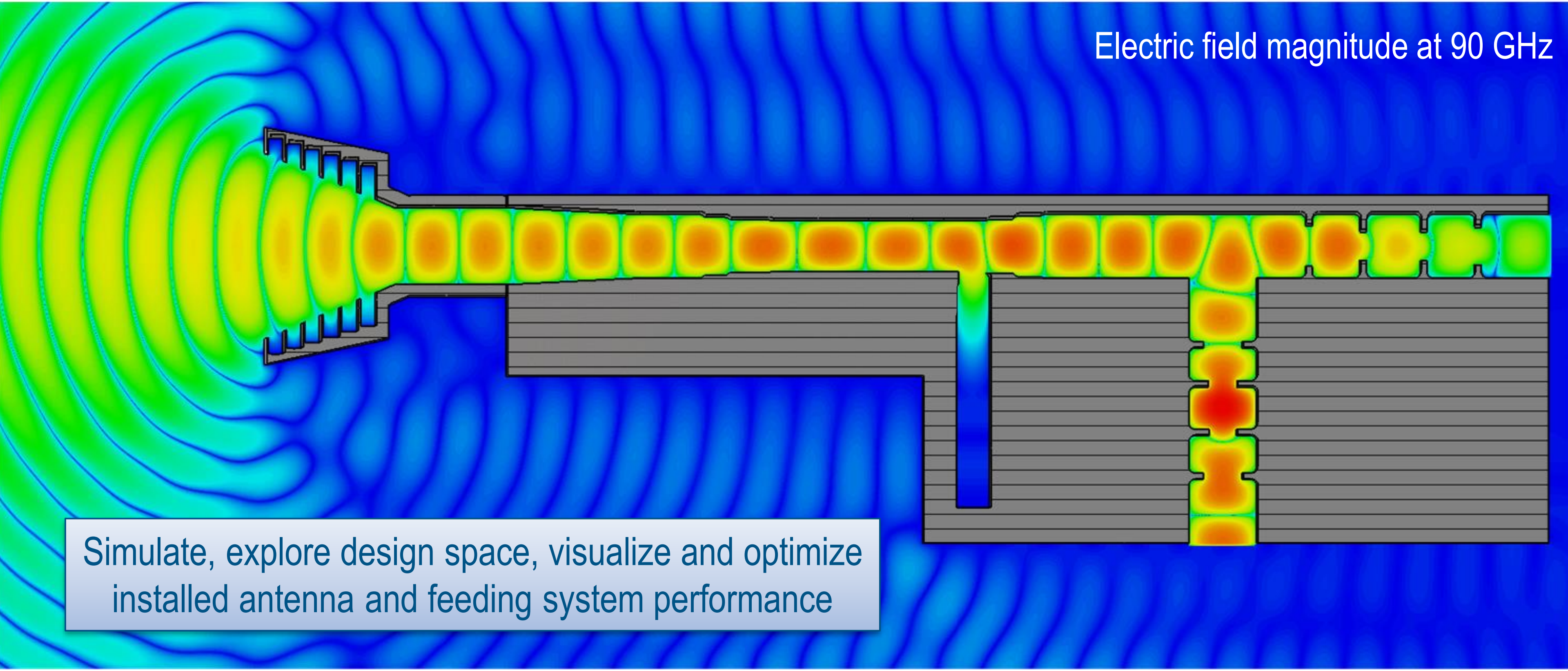
Assembly



Multiphysics



Aerospace Communication & Detection System Performance | **Solution Description**



Aerospace Communication & Detection System Performance | **Benefits**

1 Rapid development and validation of communication systems

- ✓ Automated robust meshing or import of validated mesh of source design geometry
- ✓ Accurate and fast multi-scale simulation of antennas on aircraft at physical and system level
- ✓ Efficient design, positioning and performance optimization of multiple antenna systems

2 Reduction of physical testing through realistic simulation

- ✓ Use of simulation throughout design cycle reduces risk of physical test failure and need for redesign
- ✓ Confidence in realistic multi-scale simulation reduces number of measurement iterations

3 Reduce time to market by virtual compliance testing

- ✓ Achieve certification in shorter time-frame due to confidence in validated simulation results

4 Improve product quality by effective collaboration

- ✓ Integrated solution from antenna design to placement and system interference
- ✓ Effective communication between multi-disciplinary teams facilitated by 3DEXPERIENCE platform
- ✓ Single source of truth for all data

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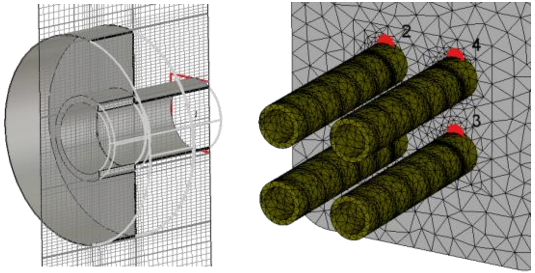

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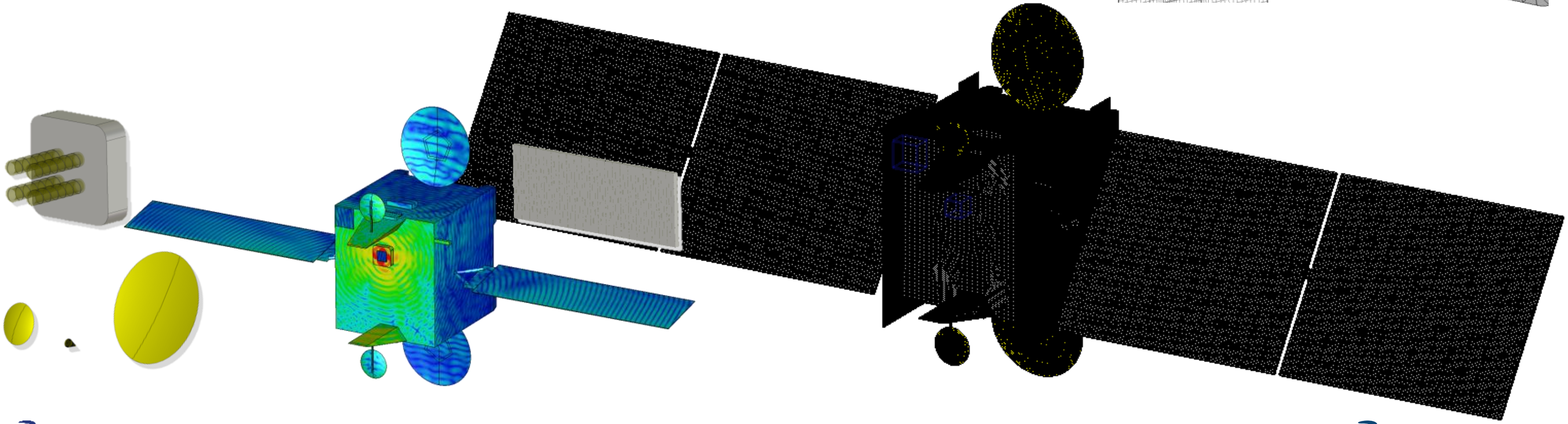
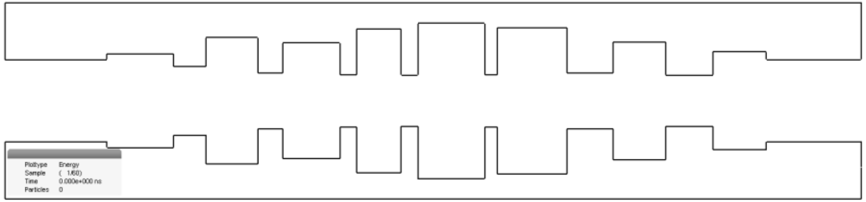


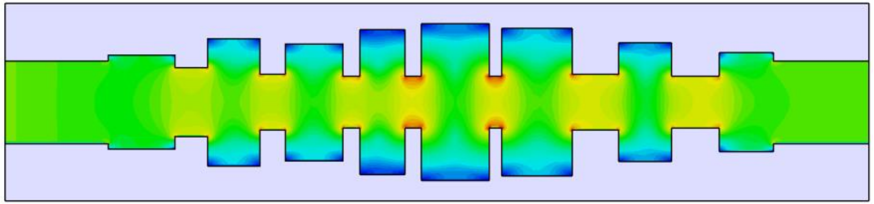
Aerospace Communication & Detection System Performance | **Benefits**

2 Reduction of physical testing through realistic simulation

- ✓ Use of simulation throughout design cycle reduces risk of physical test failure and need for redesign
- ✓ Confidence in realistic multi-scale simulation reduces number of measurement iterations
- ✓ Specialized solutions for space applications for e.g. breakdown and corona discharge analysis reduce the risk of problems and over-engineering solutions



Multipaction in a waveguide



Electric field in a waveguide

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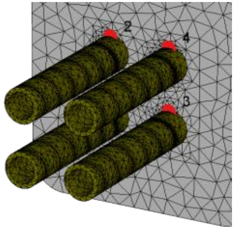

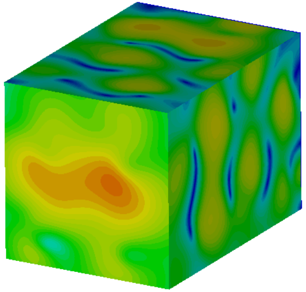

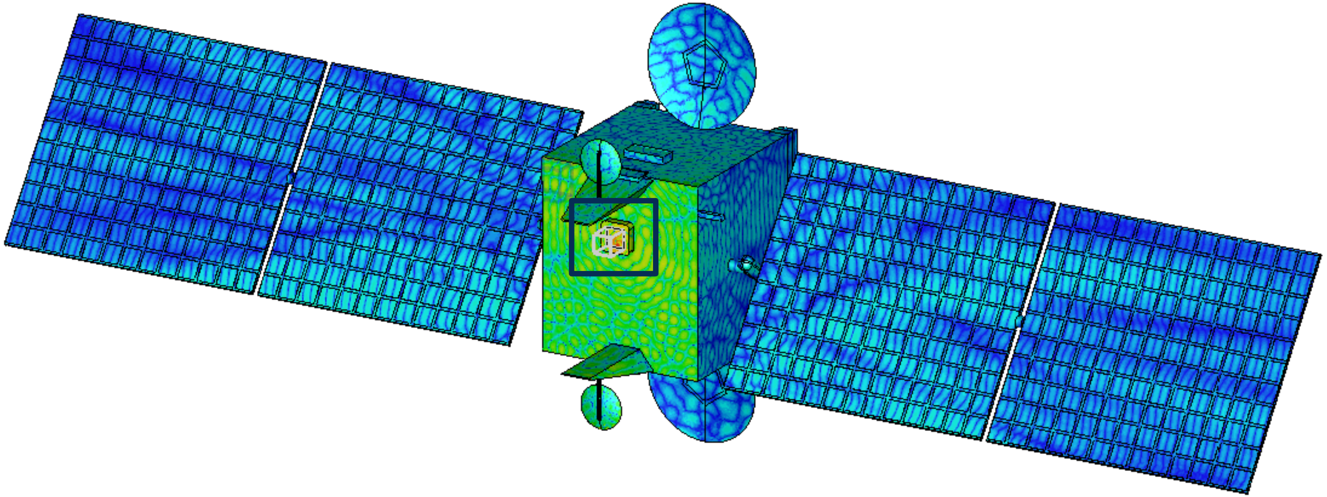

Aerospace Communication & Detection System Performance | **Benefits**

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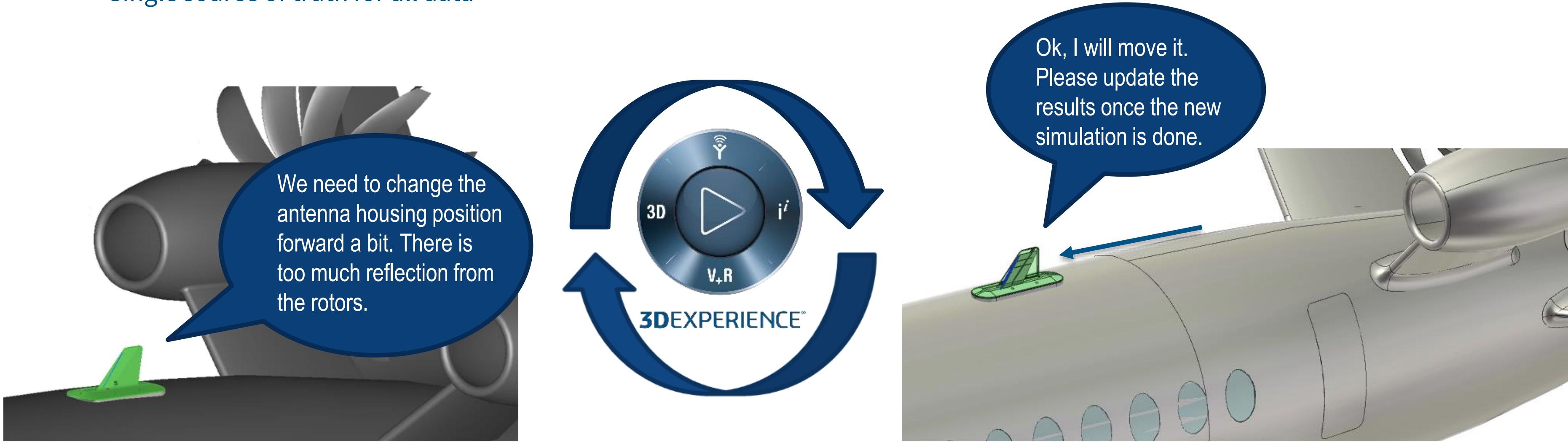
- ✓ Effective communication between multi-disciplinary teams facilitated by 3DEXPERIENCE platform
- ✓ Single source of truth for all data



Aerospace Communication & Detection System Performance | **KPIs**

Reduce development time

5 min

Rapid and virtual antenna design and validation – simulate antenna concepts and validate performance within minutes. Antenna placement study feedback potentially **reduced from weeks to hours** when compared to other simulation and build-test-build approaches.

Reduce cost of physical testing

0

Minimize in-flight and ground-based testing and unnecessary prototypes and measurements with rapid and accurate electromagnetic simulations.

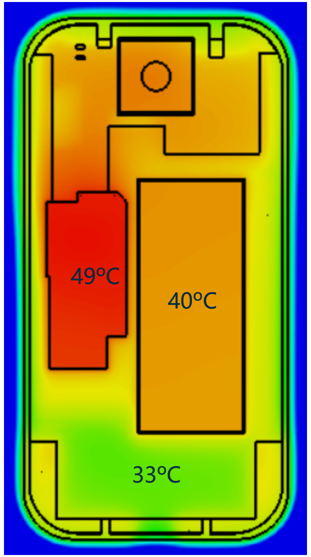
Improve safety and product performance

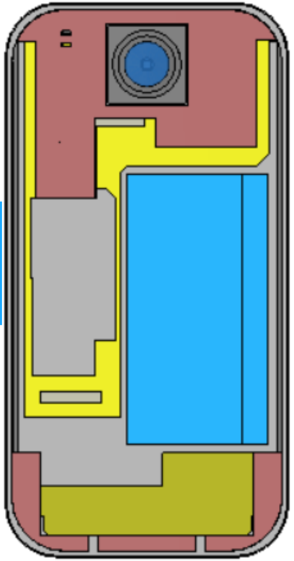
Ensure performance and reliability of co-existing communication systems

Reduce risk of failing certification tests

High accuracy simulations **ensure compliance** with **measurement results** and required **certification tests.**

Thermal Simulation

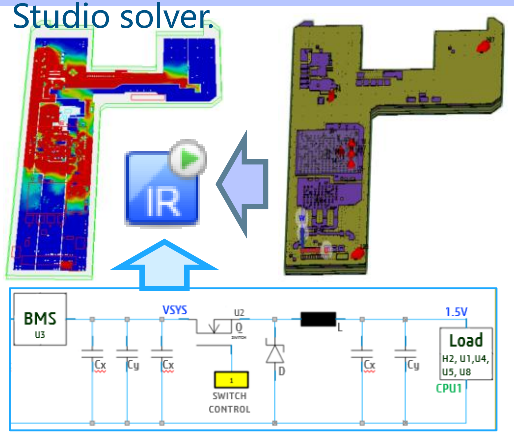




E-CAD

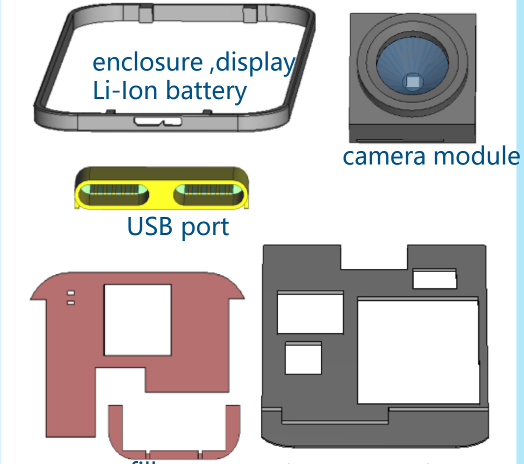
EDA Import
IR-Drop
Simulation

Calculation of system power losses,
heat sources and equivalent thermal models of PCBs with PCB Studio solver.

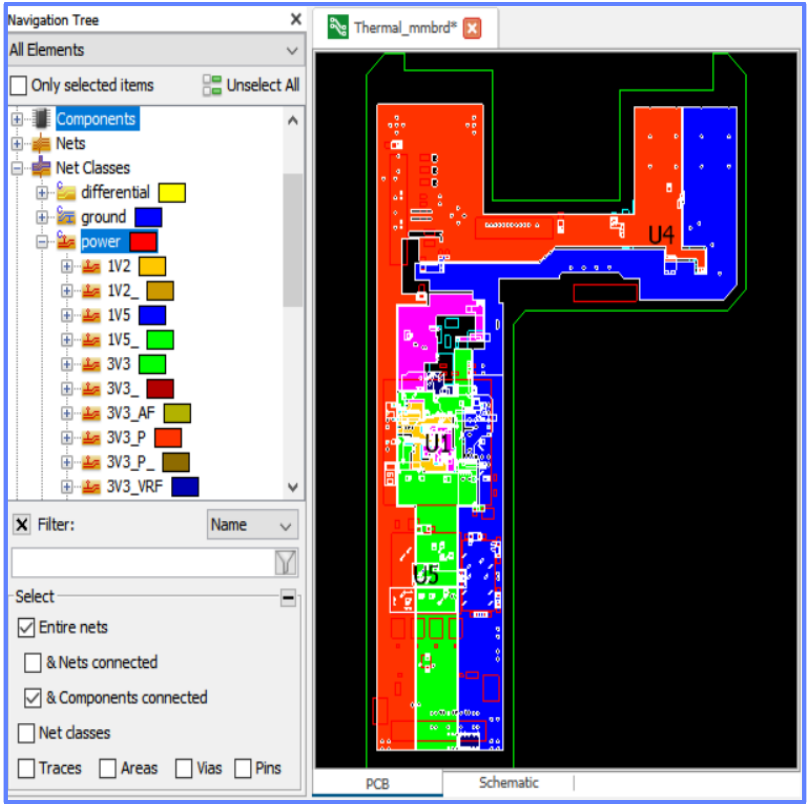


M-CAD

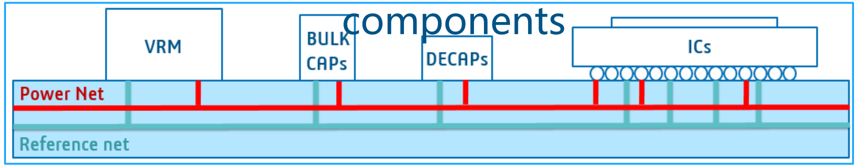
3D Import

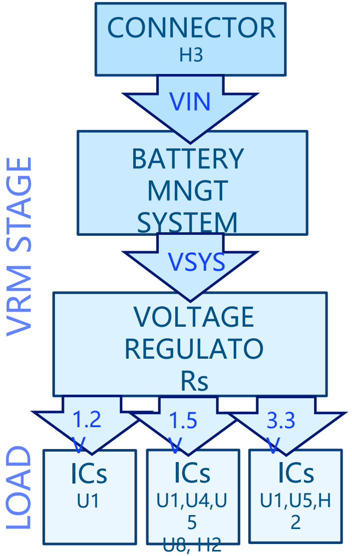


Thermal Simulation: IR-Drop



Power loss of PDN and components





Net Selection
Auto-Tagging

Components Info

DC Path Definition:
- DC source
- VRM stage
- Load: ICs

Thermal Simulation: IR-Drop

Heat Sources and Losses Calculation

VOLTAGES & CURRENTS

- Voltages & Currents
  - Power Supply and IO (8)
  - Additional Components (9)
  - Vias (3316)

POWER SUPPLY AND IO

Index	Component	Power Pin	Power Net	Ground Pin	Ground Net	Voltages[V]	Drop at ...	Drop at G...	Currents[A]
0	h3	h3_36	VIN	h3_35	GND	4.99981	0.00019	0.0	0.928709
1	h1	h1_17	NETH1_17	h1_21	GND	3.21983	0.07938	0.0007878	-0.08
2	h1	h1_18	NETH1_17	h1_21	GND	3.21981	0.0794	0.0007878	-0.08
3	h2	h2_18	NETH2_18	h2_17	GND	3.21996	0.07922	0.0008211	-0.06
4	h2	h2_19	NETH2_18	h2_17	GND	3.21998	0.0792	0.0008211	-0.06
5	h2	h2_20	NETH2_18	h2_17	GND	3.22	0.07918	0.0008211	-0.06
6	h2	h2_21	NETH2_21	h2_1	GND	1.46957	0.0297	0.0007329	-0.02
7	h2	h2_22	NETH2_21	h2_1	GND	1.46957	0.0297	0.0007329	-0.02
8	h2	h2_23	NETH2_23	h2_27	GND	3.22055	0.07867	0.0007816	-0.06
9	h2	h2_24	NETH2_23	h2_27	GND	3.22055	0.07867	0.0007816	-0.06
10	u1	u1_b5	3V3	u1_b7	GND	3.26599	0.03324	0.0007664	-0.015
11	u1	u1_b9	3V3	u1_b7	GND	3.26604	0.03319	0.0007664	-0.015
12	u1	u1_b13	3V3	u1_c14	GND	3.26614	0.03315	0.0007082	-0.015

Heat Source

POWER LOSSES

- Power Losses
  - System (2)
  - Layers (9)
  - Components (6)
  - Nets (5)
  - Vias (1010)
  - Detailed (21)

NETS

Index	Net	Power loss[W]
0	1V2	0.000255
1	1V2_	0.0003734
2	1V5	0.0001248
3	1V5_	0.0002171
4	3V3	0.0001433
5	3V3_	0.0002918
6	3V3_AF	9.6E-7
7	3V3_P	0.0022739
8	3V3_P_	0.0018856

LAYERS

Index	Layer	Power loss[W]
0	GND_1	0.0000829
1	GND_2	0.00005
2	GND_2_1	0.000036
3	GND_3	0.000124
4	PWR_PLANE1	0.0059435
5	PWR_PLANE2_...	0.0074253
6	SIGNAL_1	0.0006373
7	SIGNAL_2	0.0025727
8	SIGNAL_HS_1	0.0000319

COMPONENTS

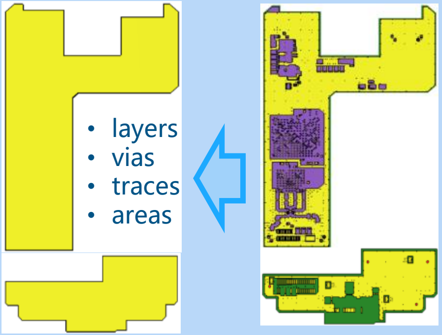
Index	Component	Power loss[W]
14	u1	1.12402
15	u2	1.23755
16	u4	0.257603
17	u5	0.184088
18	u8	0.191054

Thermal Losses

Thermal Simulation

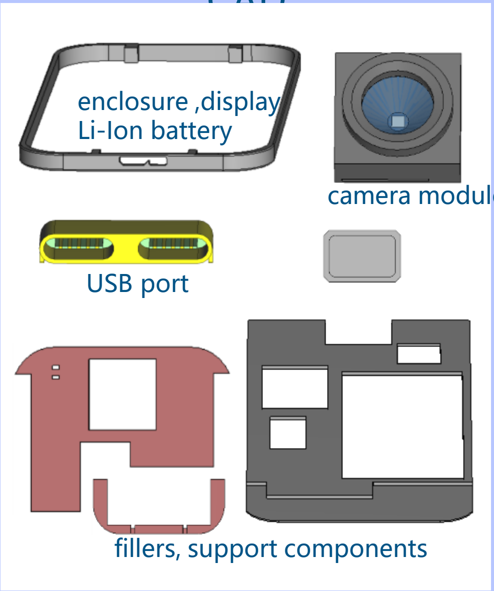
Thermal Models

Thermal Losses



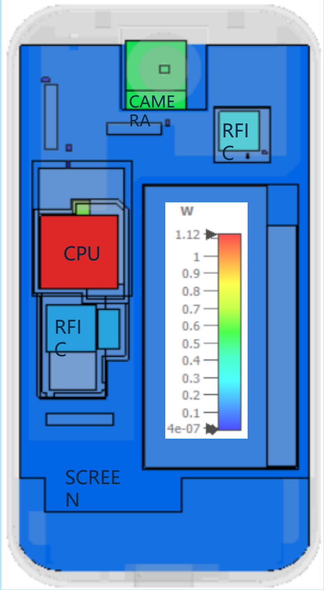
- Materials with thermal properties
  - Anisotropic thermal conductivity
  - Diffusivity
  - Specific heat
  - Material density
  - Emissivity
- Contact properties

Phone Components – 3D CAD



Components Heat Sources

Heat Source

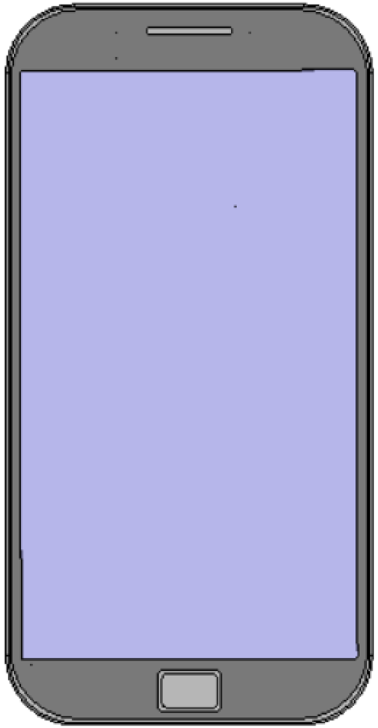


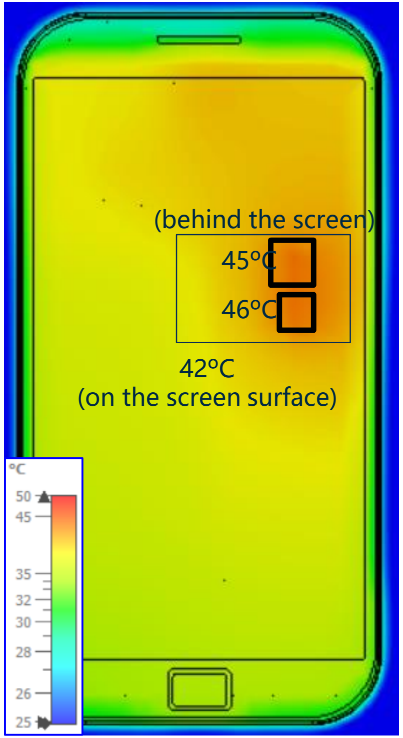
Bringing CAD data together in 3D:
- WCS
- Anchors
- Pick tools
- Align tool

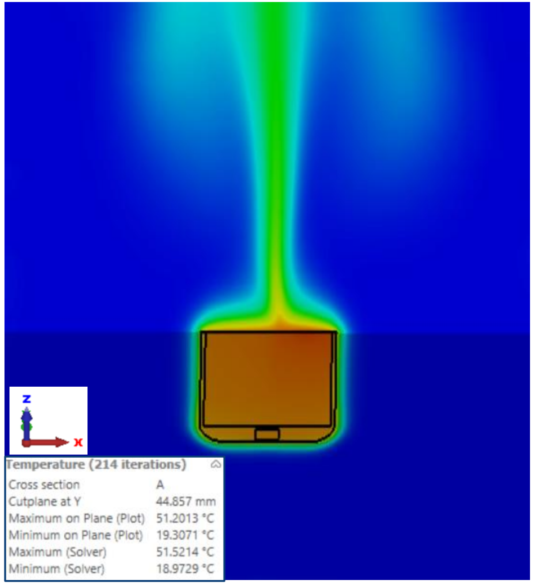
Heat Sources automatically placed on the PCBs

Thermal Simulation

Conjugate Heat Transfer

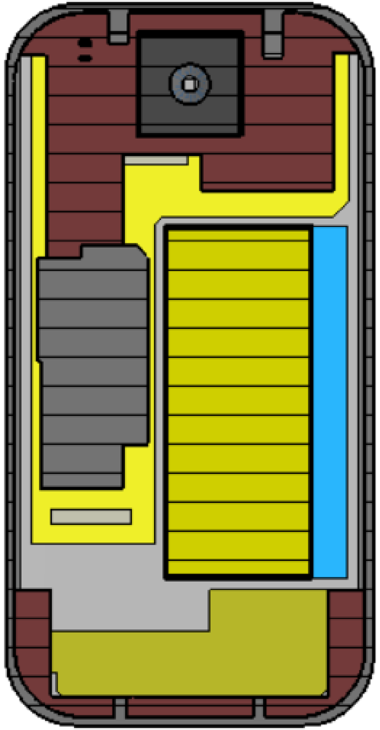


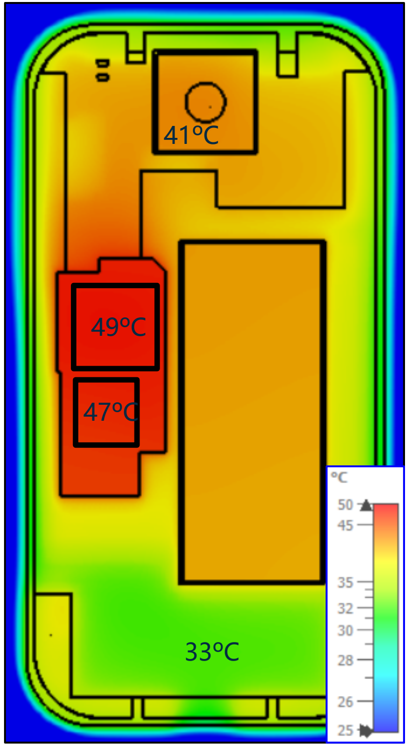


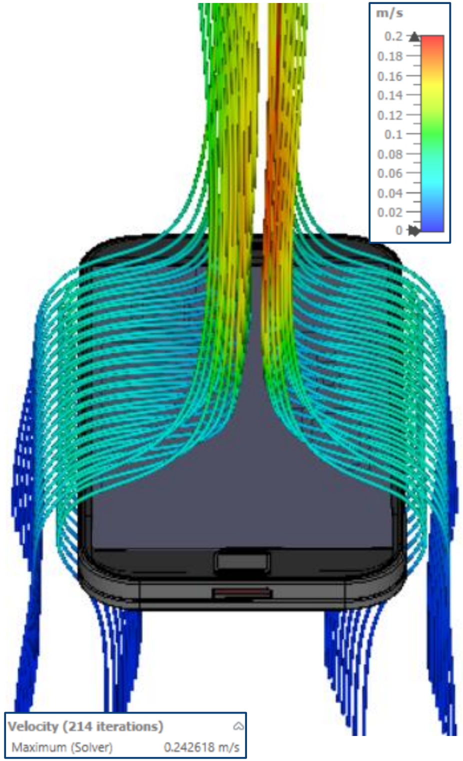


Thermal Simulation

Conjugate Heat Transfer

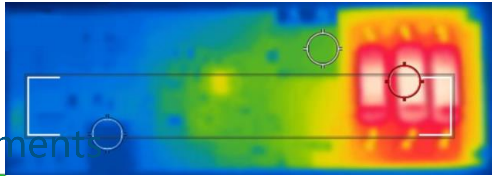


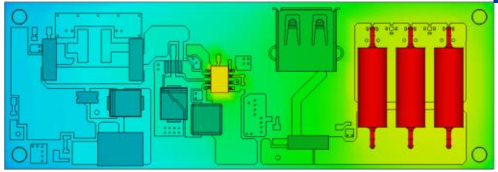


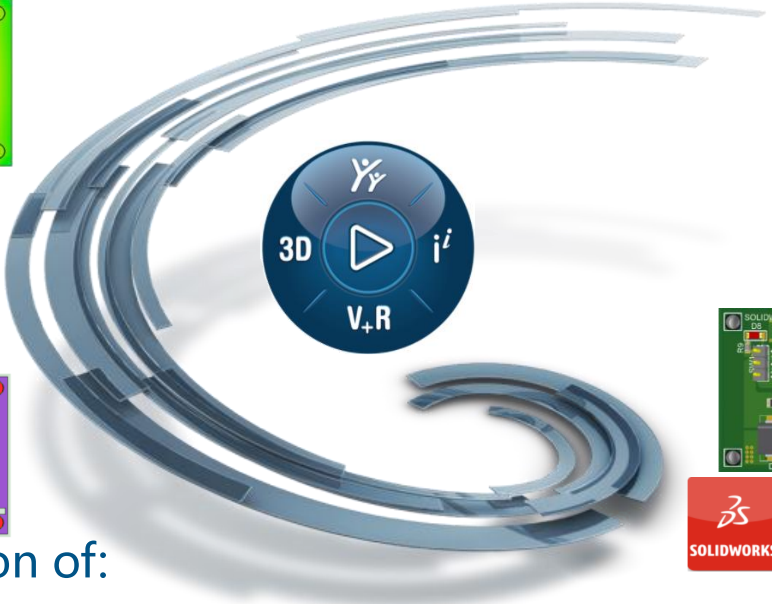


Simulation vs. Measurement
Thermal Analysis: Workflow overview

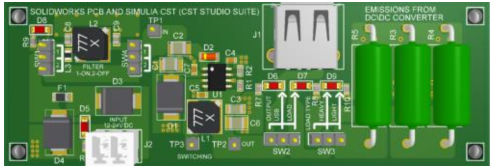
sis
Comparison with Measurements





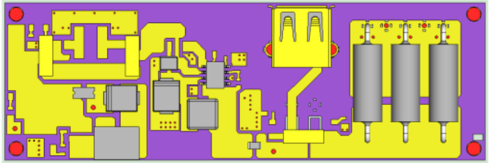


CAD Data



SOLIDWORKS CATIA

- Altium
- Cadence
- Mentor Graphics
- Zuken

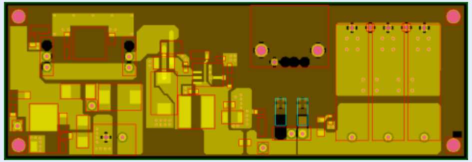


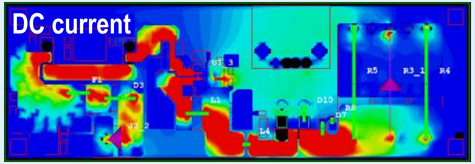
Import and preparation of:

- CAD data
- Schematics
- Heat Sources
- Thermal Losses

Thermal Analysis: Simulation workflow

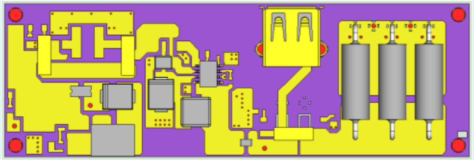
DC - Thermal Analysis with PCBS

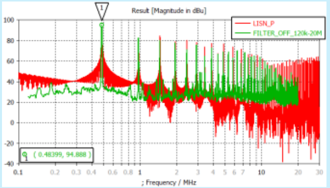


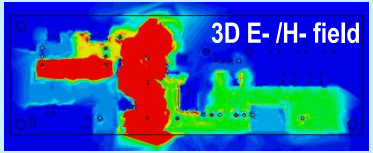


- ✓ Getting Started Analysis
- ✓ Automatic calculation of PCB's equivalent thermal model
- ✓ Automatic calculation of DC power losses
- ✓ Automatic setup of heat sources
- ✓ Quick in terms of model setup and simulation time
(does not require a lot of computing power to run)

DC+AC - Thermal Analysis with PCBS + 3D

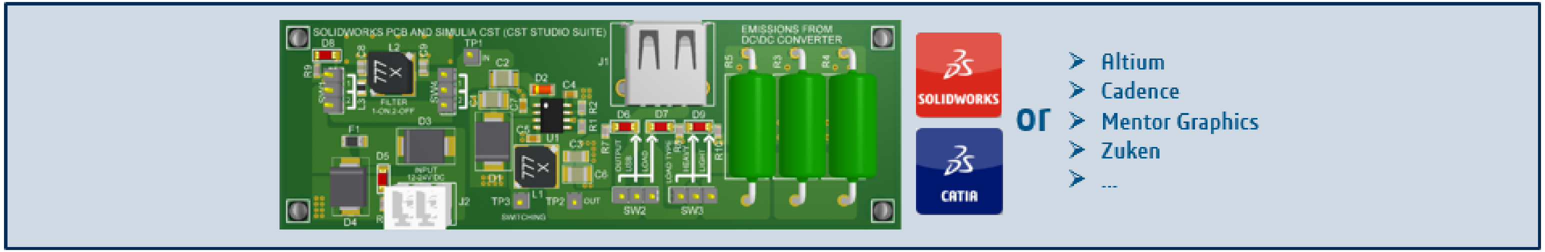


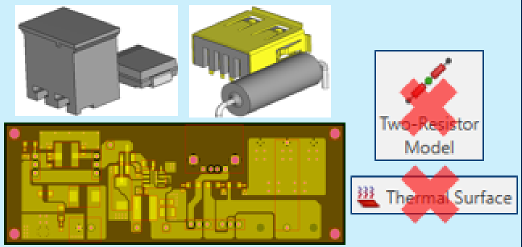




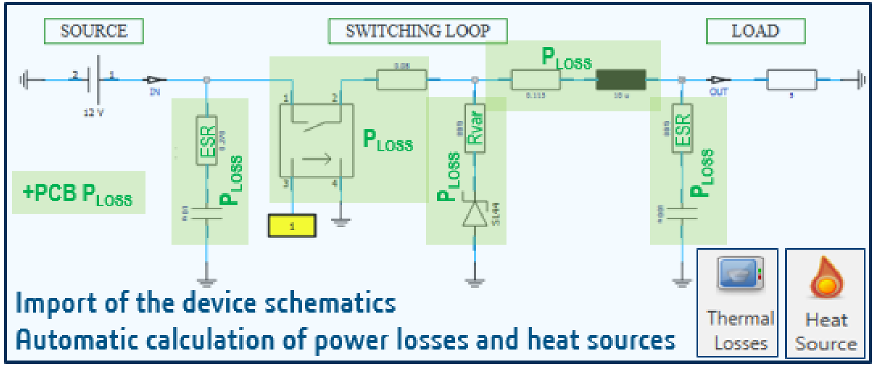
In addition to DC – Thermal Analysis:
- ✓ Calculation of AC (HF) power losses
- ✓ View of DUT's functionality
- ✓ "What if" analysis, optimization process
- ✓ EMC/EMI analysis

Thermal Analysis: Import and preparation of input data



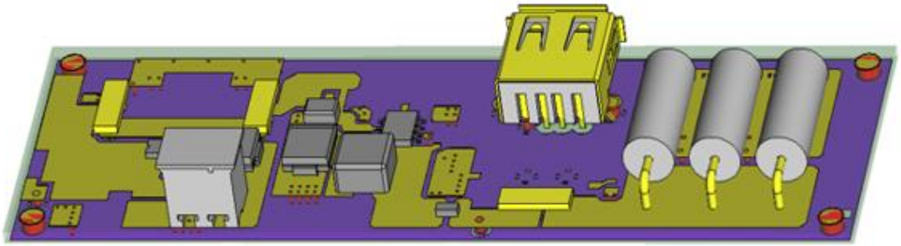


PCB and CAD components import
Automatic thermal components definition

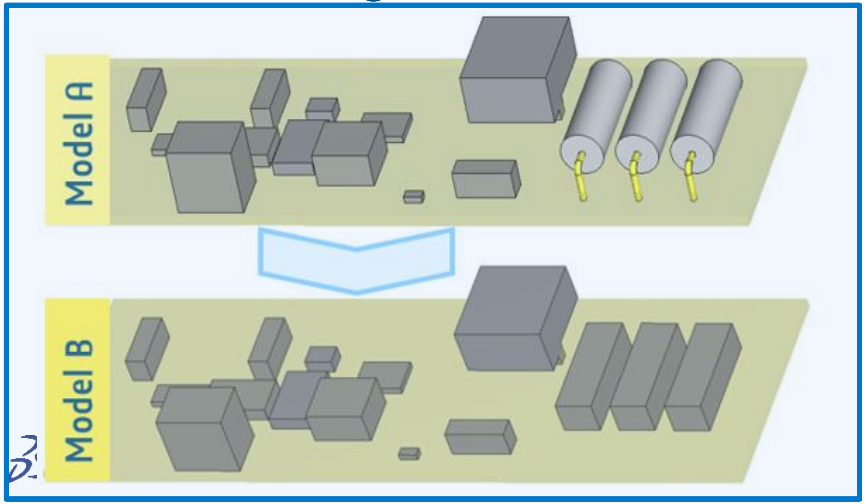


Import of the device schematics
Automatic calculation of power losses and heat sources

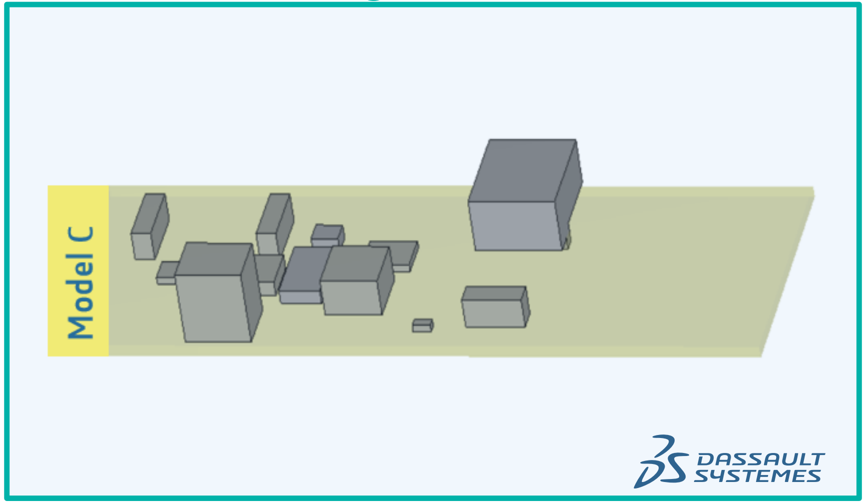
Thermal Analysis: Model simplification



Loading condition: 1.5W



Loading condition: 5W



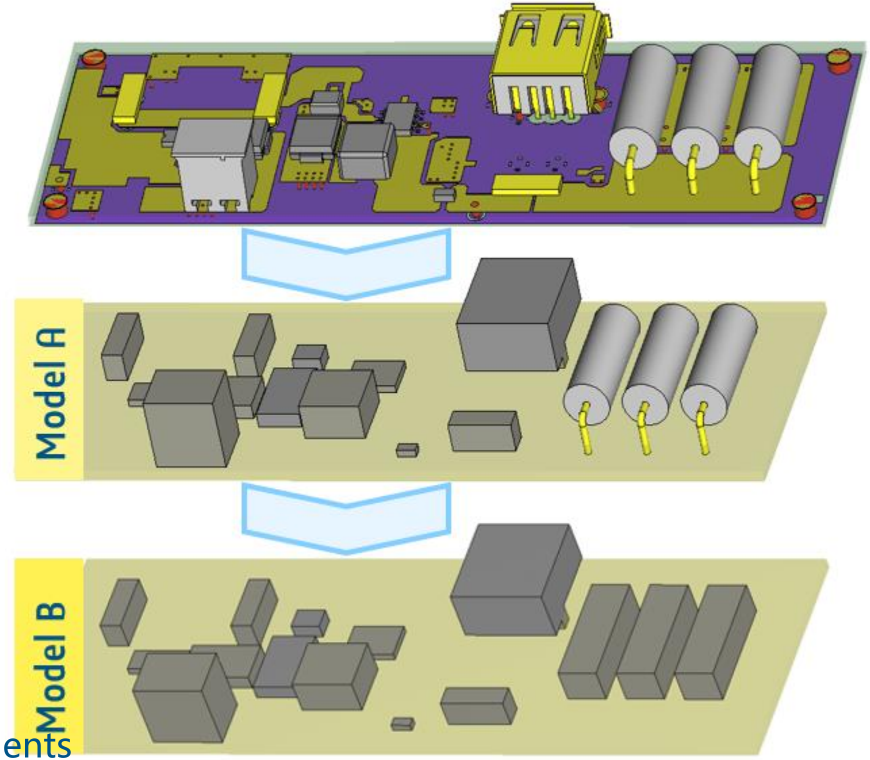
Thermal Analysis: Model simplification

Components power losses

Index	Component	Power loss[W]
0	D3	0.0384093
1	F1	0.0035122
2	L1	0.0050471
3	L4	0.0010094
4	R4	0.527101
5	R5	0.527131
6	R8	0.0
7	SW1	0.0000245
8	SW2	0.0000245
9	SW3	0.000101
10	j2	1.83622
11	r3	0.527108
12	u1	0.205454

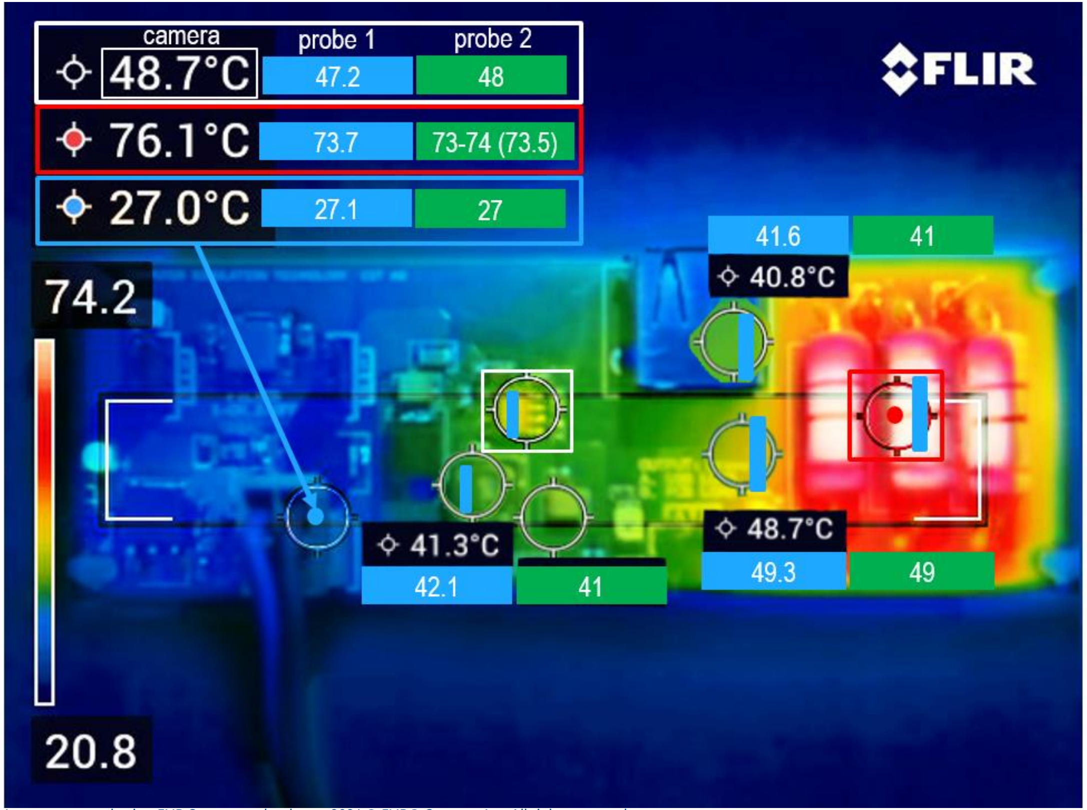
PCB power losses

Index	Net	Power loss[W]
0	GND	0.0001596
1	N04615	0.0000627
2	N047971	0.0
3	R_LOAD	0.000147
4	VIN	0.0001637
5	VINF_A	0.0000245
6	VINF_B	0.0000138
7	VINF_C	0.0000413
8	VOUT	0.0001951
9	VOUTNF	0.0001201
10	VSW	0.0003625



Contact properties: PCB <> Components
- lumped (thermal resistance/capacitance)
- material-based (air gap)

Thermal Analysis: Measurement setup



Probe placement (thermal paste used 6W/mK)

Measurement interval: 5-10min.
Additional waiting time of 50min before measuring, adds ~0.5°C
Measurement tolerance: -+3% (2°C)

Thermal image: Flir C5
ε = 0.95
temp. = 20 °C
dist. = (0-1) m

Probe 1:
Habor Thermometer (0.1°)
Probe 2:
Extech MA445 + K-type probe (1°)

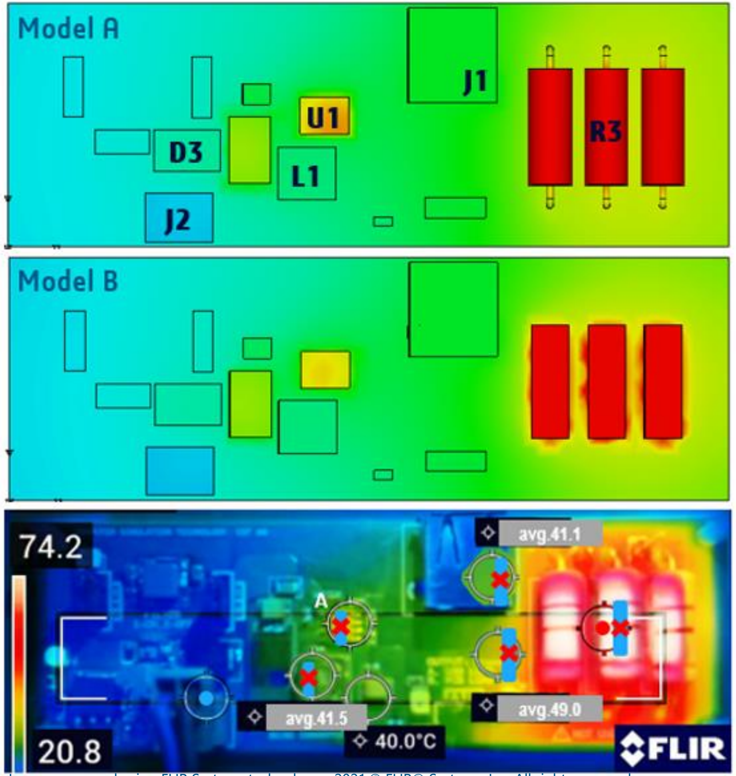
Thermal Analysis: 1.5W load, Comparison

(+/-4) / ºC	MEAS.	Model A	Model B
R3	74.4	72.2	73.2
U1	47.9	49.0	47.1
L1	41.5	33.4	33.0
J1 (usb)	41.1	37.9	37.3
J2	27.0	27.3	26.7
D3	~32.0	32.4	31.8

Monitors at Points

Simulation time:
Model A: ~2h45min, 1.36M cells, i7-6820hq (4-cores)
Model B: ~40min, 640k cells, i7-6820hq (4-cores)

MEAS. – measurement results

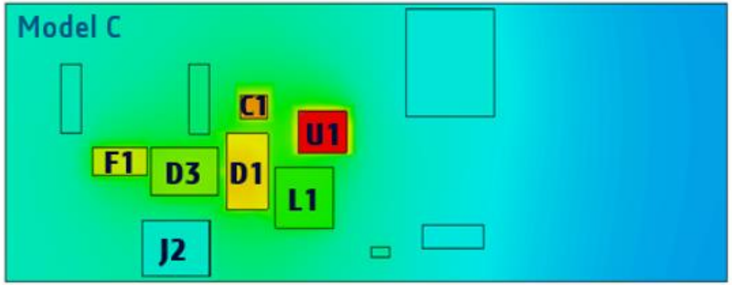


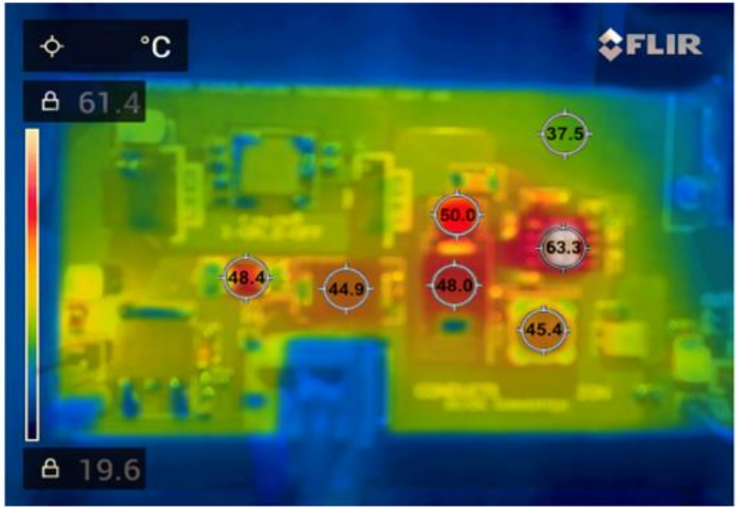
Thermal Analysis: 5W load, Comparison

(+/-4) / ºC	MEAS.	Model C
U1	63.3	61.3
C1	50.0	39.6
F1	48.4	44.3
D1	48.0	38.8
L1	45.4	34.8
D3	44.9	39.5
pcb	37.5	31.4

Monitors at Points

Simulation time:
Model C: ~40min, 570k cells, i7-6820hq (4-cores)

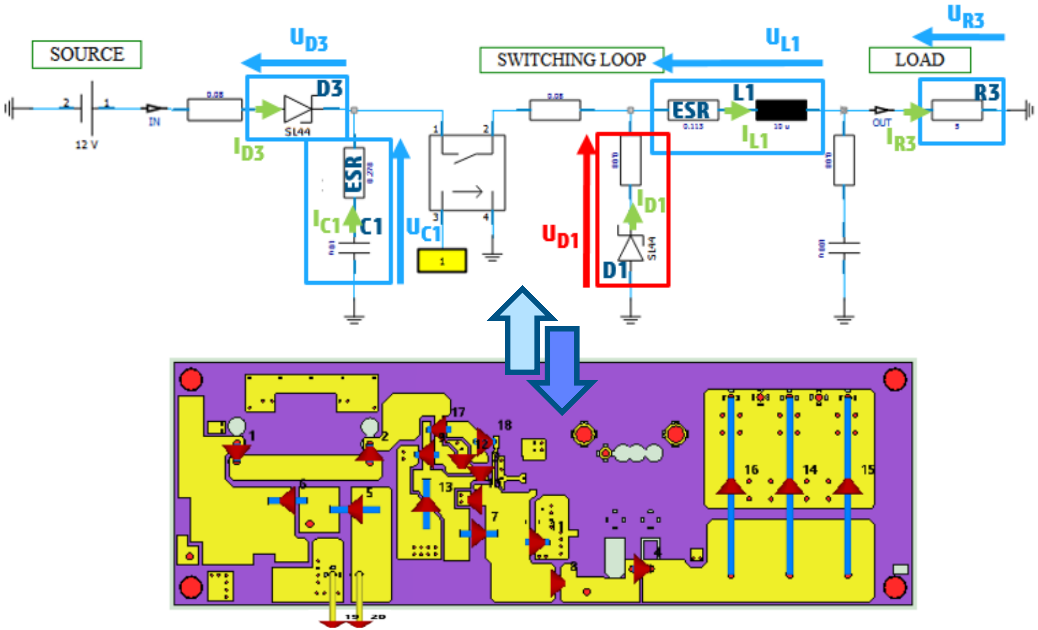




SIMULIA
DASSAULT SYSTEMES

Thermal Analysis: 3D co-simulation model

Calculation of DC and AC losses

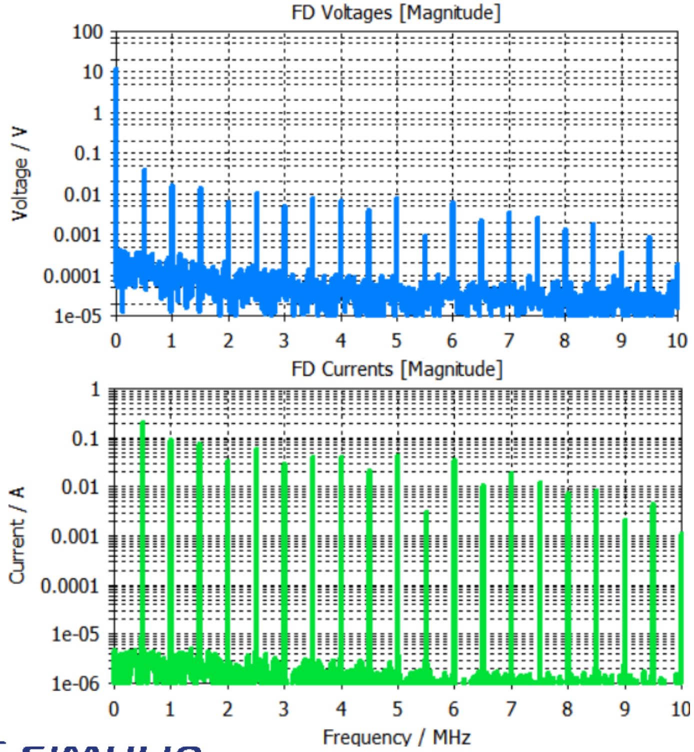


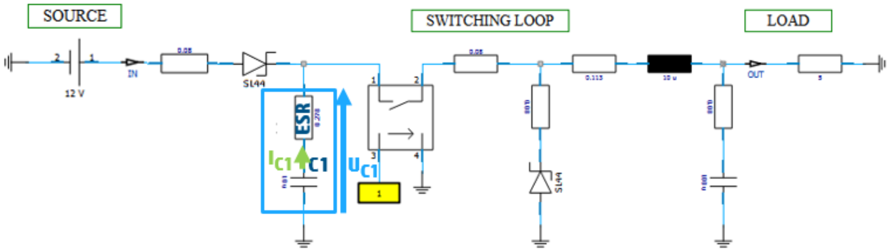
SIMULIA

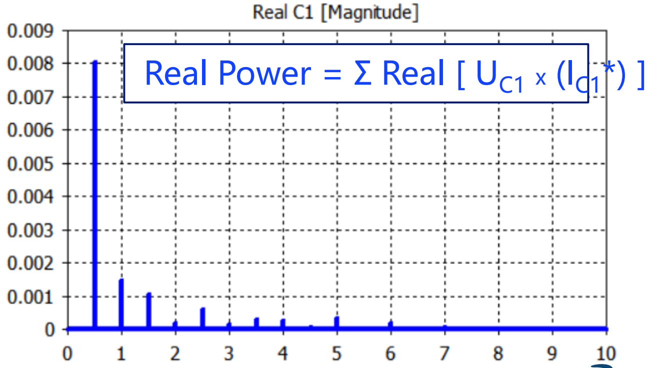
DASSAULT SYSTEMES

Thermal Analysis: 3D co-simulation model

Calculation of DC and AC losses







Thermal Analysis: DC vs. DC+AC losses

Loading condition: 1.5W

(+/-4) / °C	MEAS.	Model A	Model B	Model A (DC+AC)	Model B (DC+AC)
R3	74.4	72.2	73.2	72.0	73.3
U1	47.9	49.0	47.1	51.0	49.1
L1	41.5	33.4	33.0	37.4	37.0
J1 (usb)	41.1	37.9	37.3	39.0	38.4
J2	27.0	27.3	26.7	28.5	28.2
D3	~32.0	32.4	31.8	34.4	33.9

Loading condition: 5W

(+/-4) / °C	MEAS.	Model C	Model C (DC+AC)
U1	63.3	61.3	64.4
C1	50.0	39.6	52.4
F1	48.4	44.3	46.8
D1	48.0	38.8	50.1
L1	45.4	34.8	40.0
D3	44.9	39.5	42.9
pcb	37.5	31.4	34.1

Agenda

SIMULIA CST Studio Suite: industry focused solutions

Satellite antennas

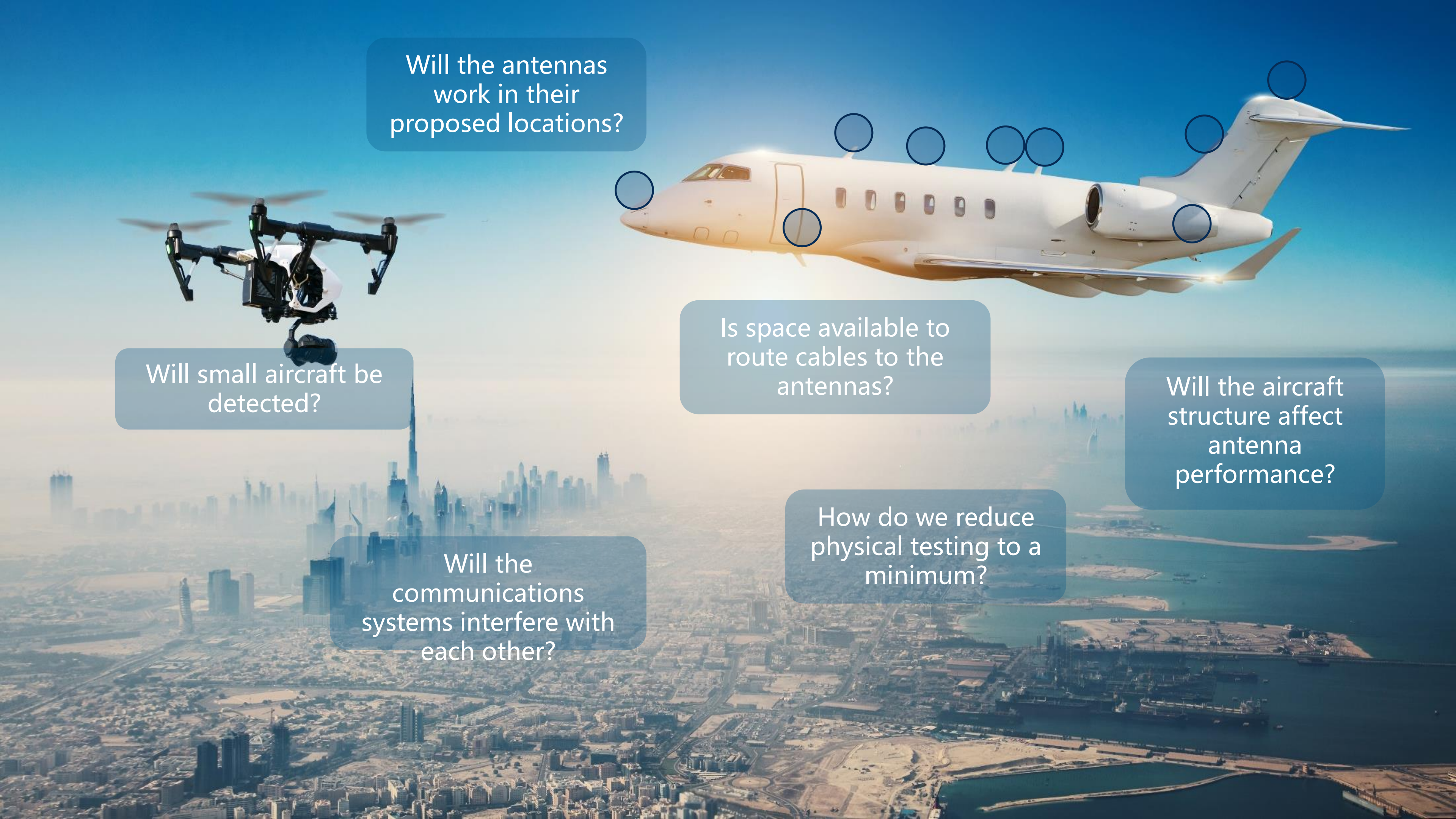
Communication systems in aircrafts

Land-based RF and MW communications

Conclusion

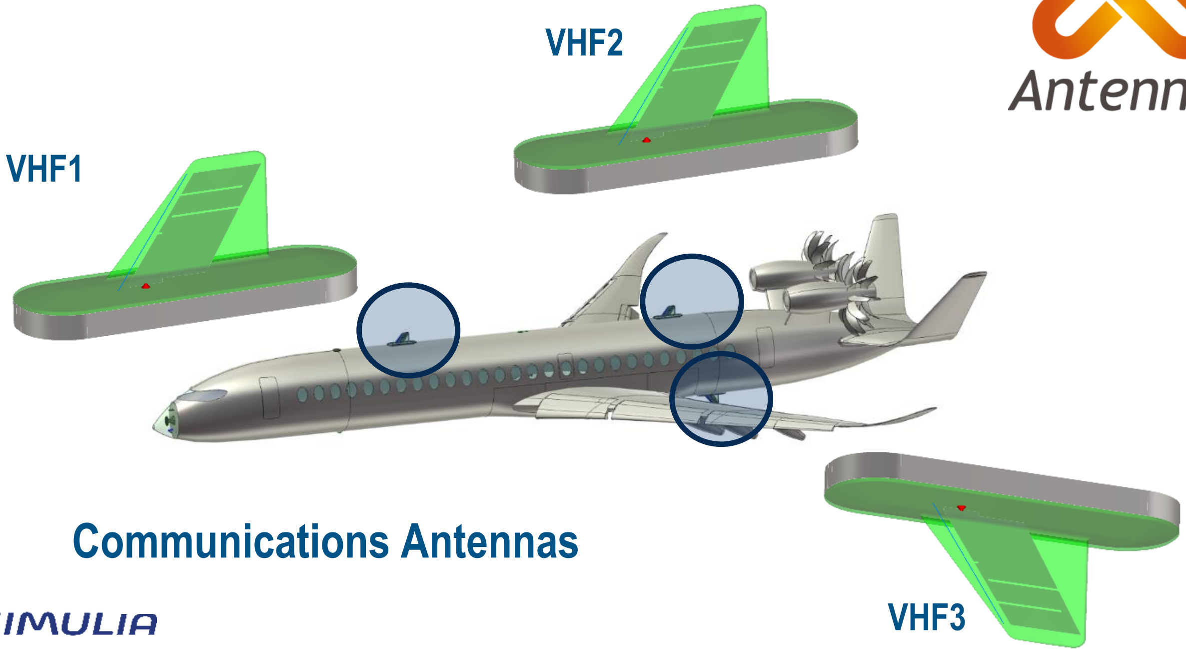
Reliable communication is crucial for safe and efficient operation of aircraft

- At any given moment there are on average 10000 aircraft in the sky and it is expected that the airspace will get even denser.
- In addition to increasing number of regular airplanes, the evolving technology is bringing new types of aircrafts to the sky, drones, air taxis etc.
- Trend towards highly autonomous flight means aircraft communication and detection system performance is more important than ever.
- Passengers are demanding faster communication speeds and more bandwidth for their own devices while in flight.
- With increased demand for communication, evolving technology and autonomous aircrafts, the number of antennas and sensors on aircraft is expected to increase, which also increases the probability of interference events.


Will the antennas work in their proposed locations?
Will small aircraft be detected?
Is space available to route cables to the antennas?
Will the aircraft structure affect antenna performance?
Will the communications systems interfere with each other?
How do we reduce physical testing to a minimum?

Antenna element design with

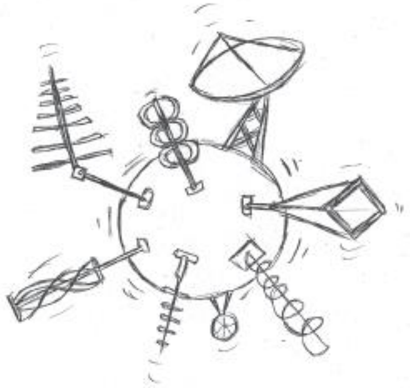
AntennaMagus &



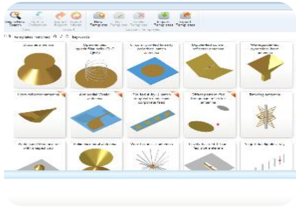
Communications Antennas

Antenna design with Antenna Magus®

- Antenna design is a specialized workflow requiring domain expertise, however…
- Antenna Magus is a software tool to help accelerate the antenna design and modelling process.
- Antenna Magus increases efficiency by helping the engineer to make a more informed choice of antenna element and obtain a good starting design.



Antenna Magus workflow



Finding antennas
- Specification chooser
- Extensive library of antennas

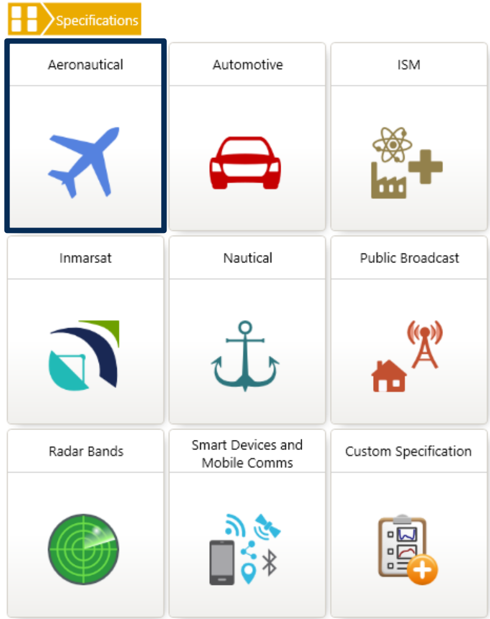
Design & tweak
- Design guidelines

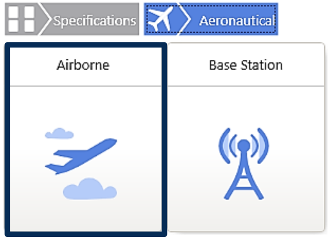
Evaluate
- Quick eval. of antenna performance KPIs

Export CST model
- Seamless exported into CST STUDIO SUITE
- Fully parametric models set-up by experts
- Ready for simulation

Finding antennas

Specification based workflow





Specifications > Aeronautical > Airborne

Name	About
Marker Beacon (Aeronautical - Airborne)	Marker beacons form part of the Instrument Landing System and provide an aircraft information about its position along an established route. This specification is set up to help find antennas for an aircraft.
Radar Altimeter (Aeronautical - Airborne)	A radar altimeter measures the distance of the aircraft above the immediate terrain beneath it.
Radar Warning Receiver (RWR) (Aeronautical - Airborne)	A radar warning receiver on an aircraft detects and warns an aircraft (pilot) about radar activity.
Tactical Air Navigation System (Aeronautical - Airborne)	A TACAN (Tactical Air Navigation) system is essentially the millitary version of the VOR/ DME system and provides an aircraft with bearing and distance to a ground or ship-borne station.
VHF Omnidirectional Range (Aeronautical - Airborne)	The VOR (VHF Omnidirectional Range) navigation system allows an aircraft to determine its posisiton via signals transmitted from fixed ground based beacons.
VHF communications (Aeronautical - Airborne)	Voice communication between an aircraft and the ground station in the VHF band is achieved over the frequency range of 118 - 137 MHz. This specification is set up to help find these antennas on an aircraft.
Weather Radar (Aeronautical - Airborne)	A weather radar on an aircraft provides the pilot with information about the upcoming weather conditions on the flightpath.

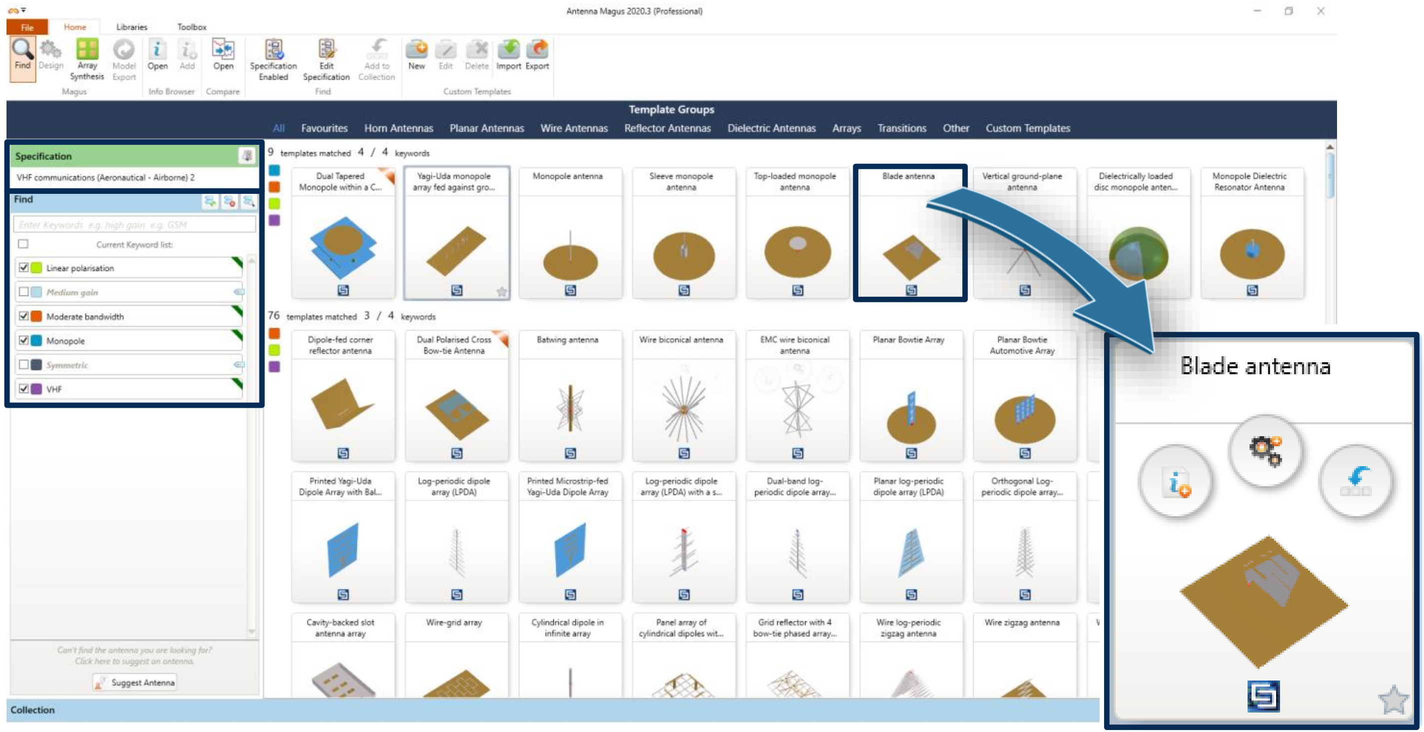
Finding antennas

Select VHF blade antenna

Preset

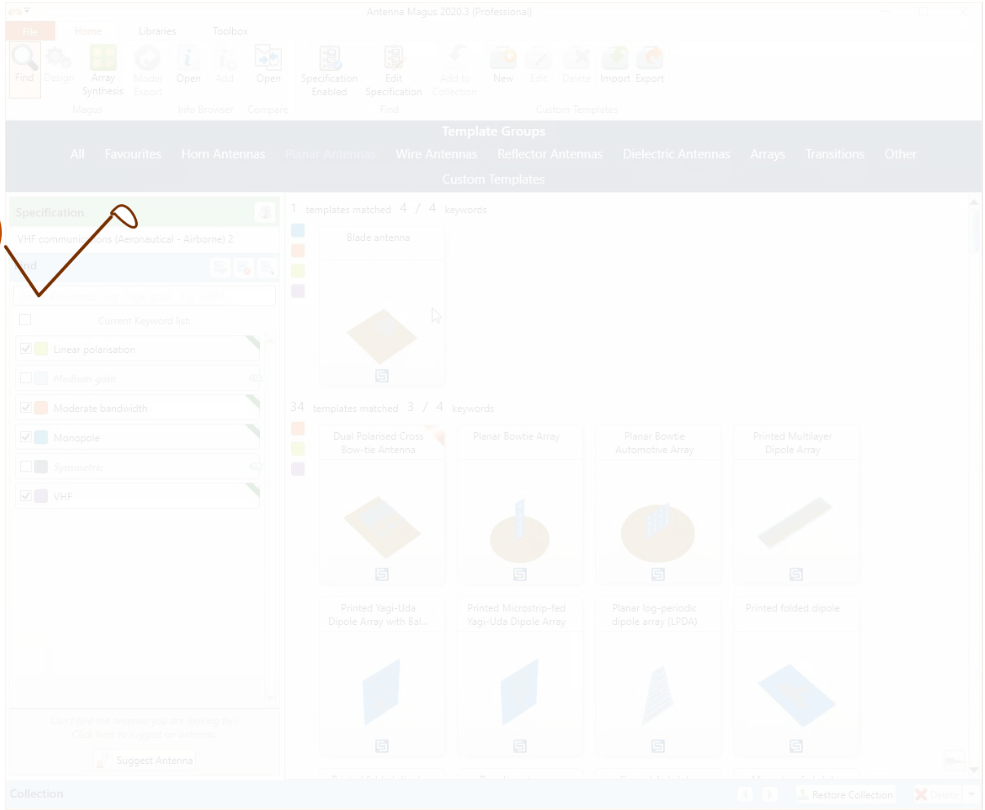
Specification

Keywords

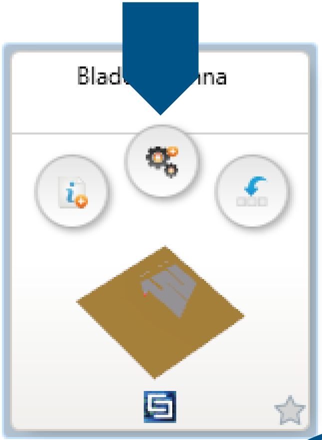


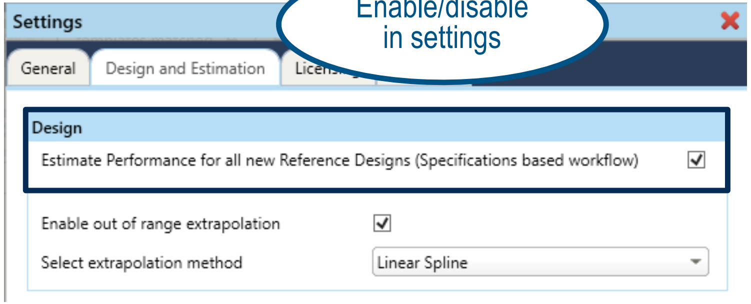
Finding antennas

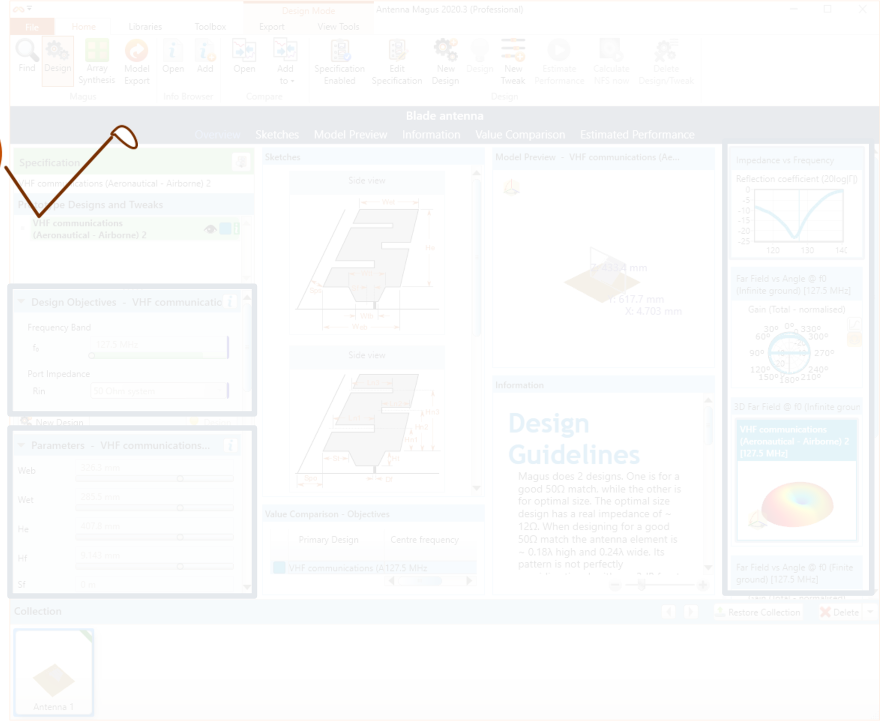
VHF antenna information



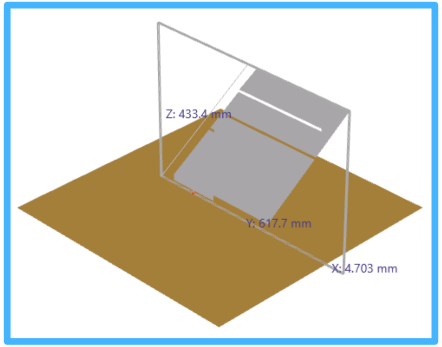
Automatically design antenna and estimate perform.

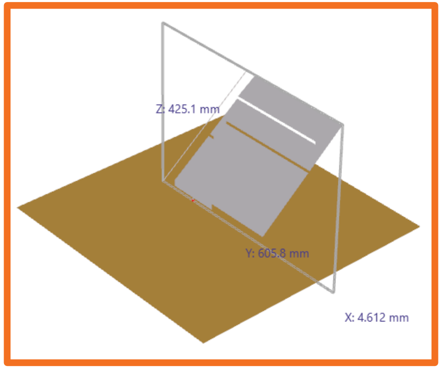


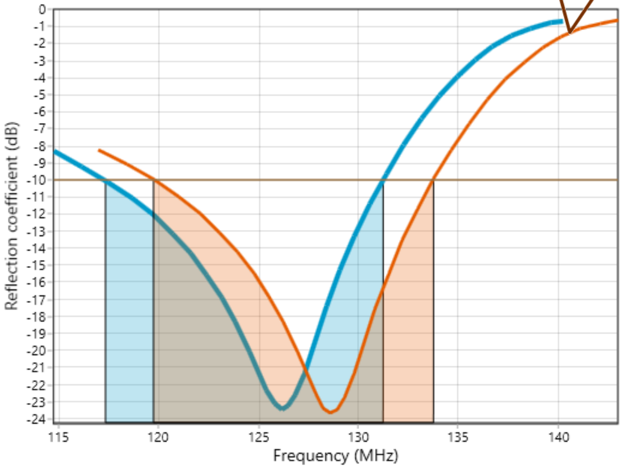


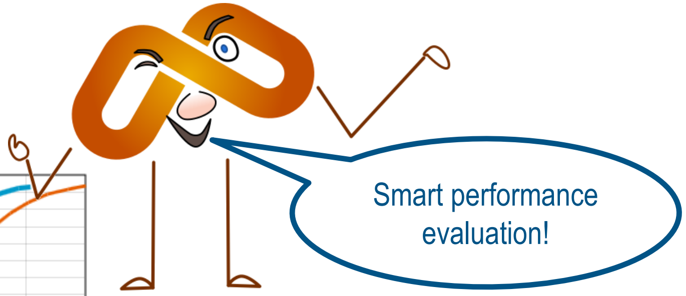


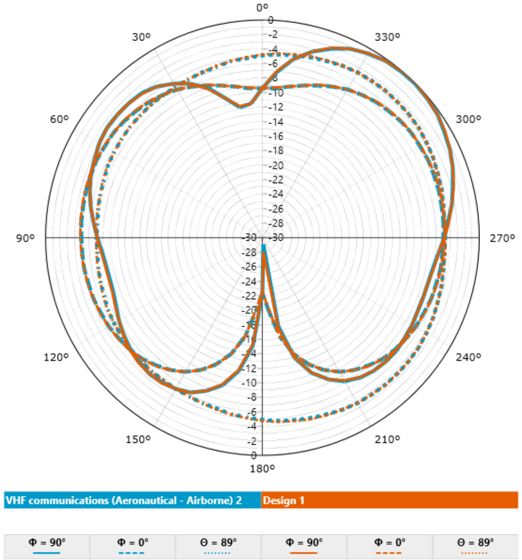
Initial performance evaluation







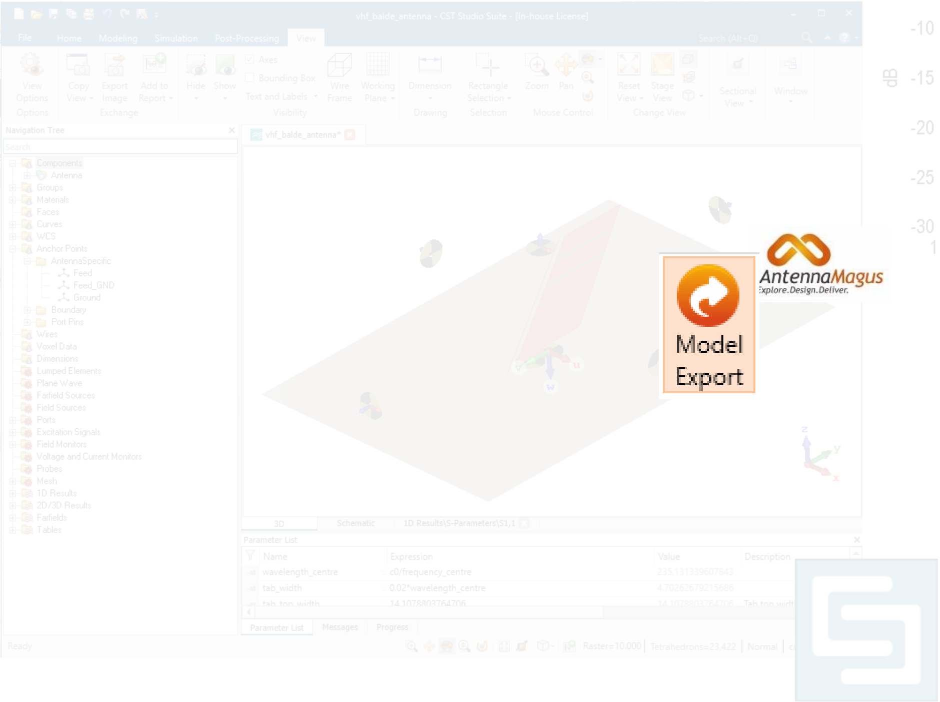


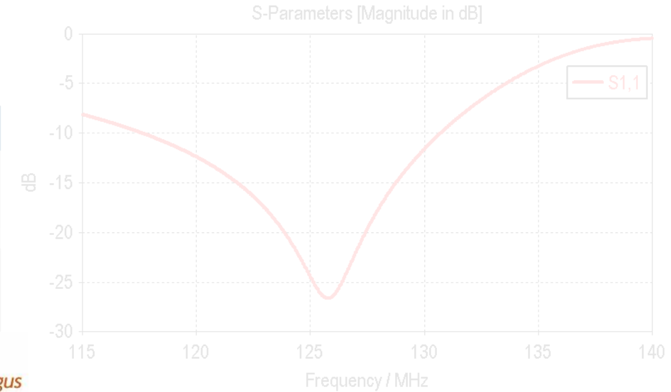


Objectives

Primary Design	Centre frequency	Design impedance
VHF communications (A	127.5 MHz	A 50 Ohm design
Design 1	130 MHz	A 50 Ohm design

Export and simulate the blade antenna

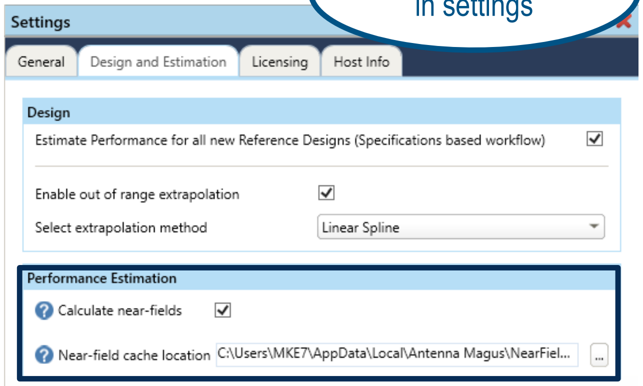


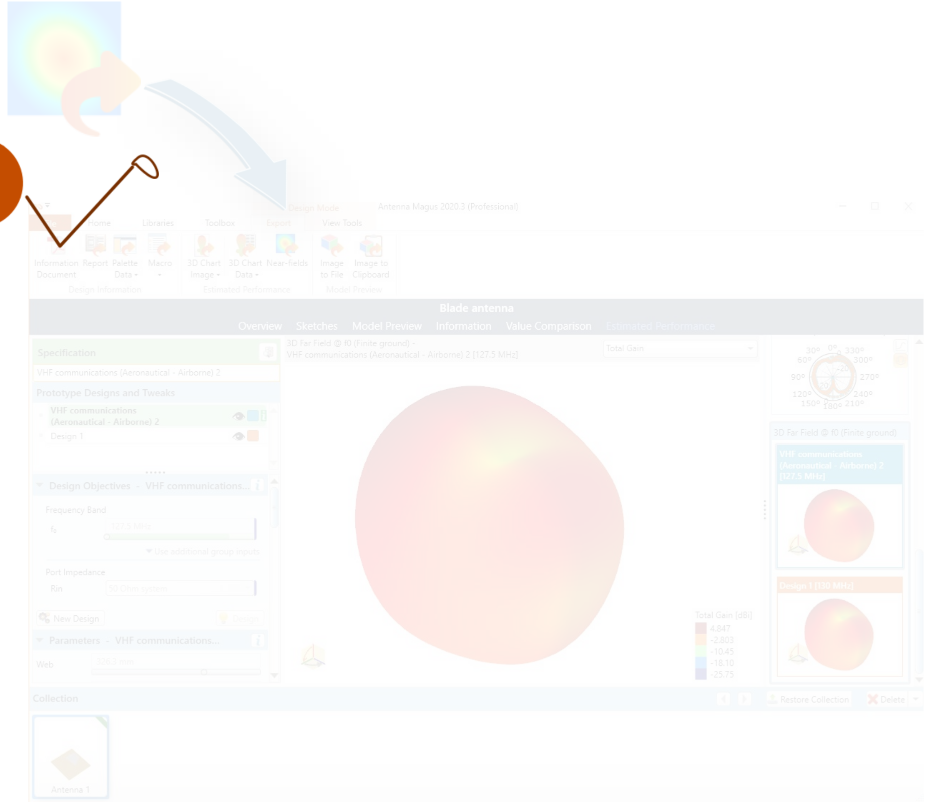


Near field source export

Improves the antenna placement workflow

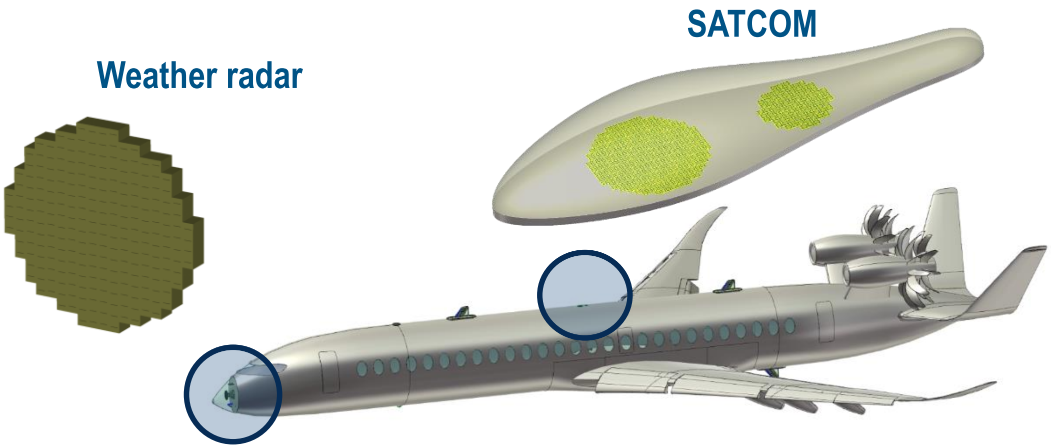
Enable/disable in settings

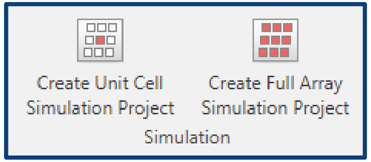




Antenna array design with

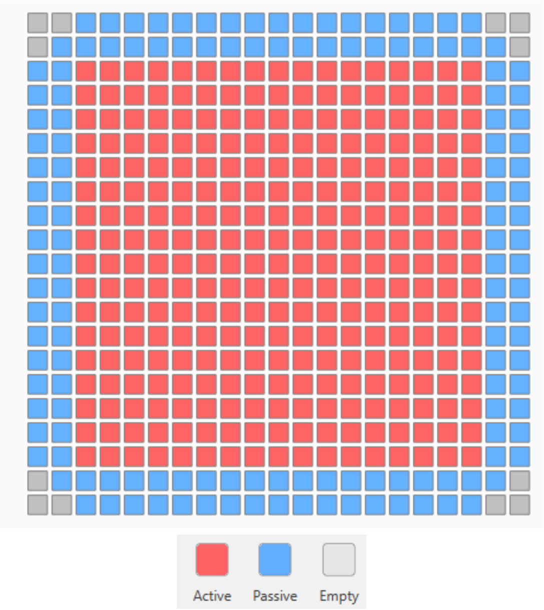
CST Studio Suite Array task



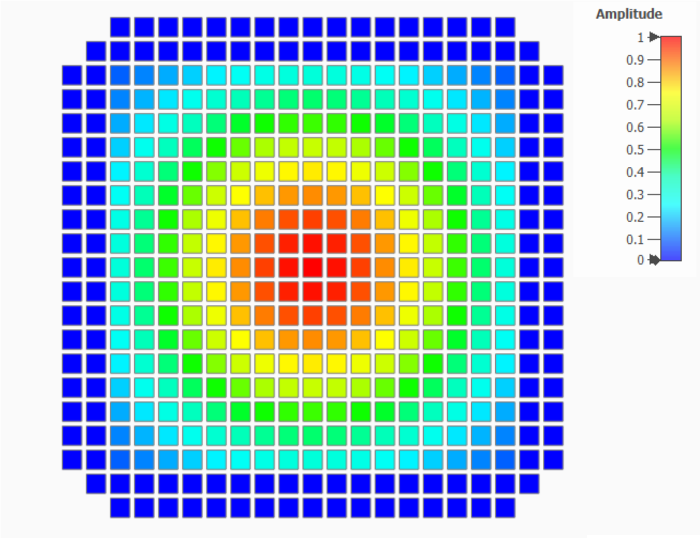


Layout creation

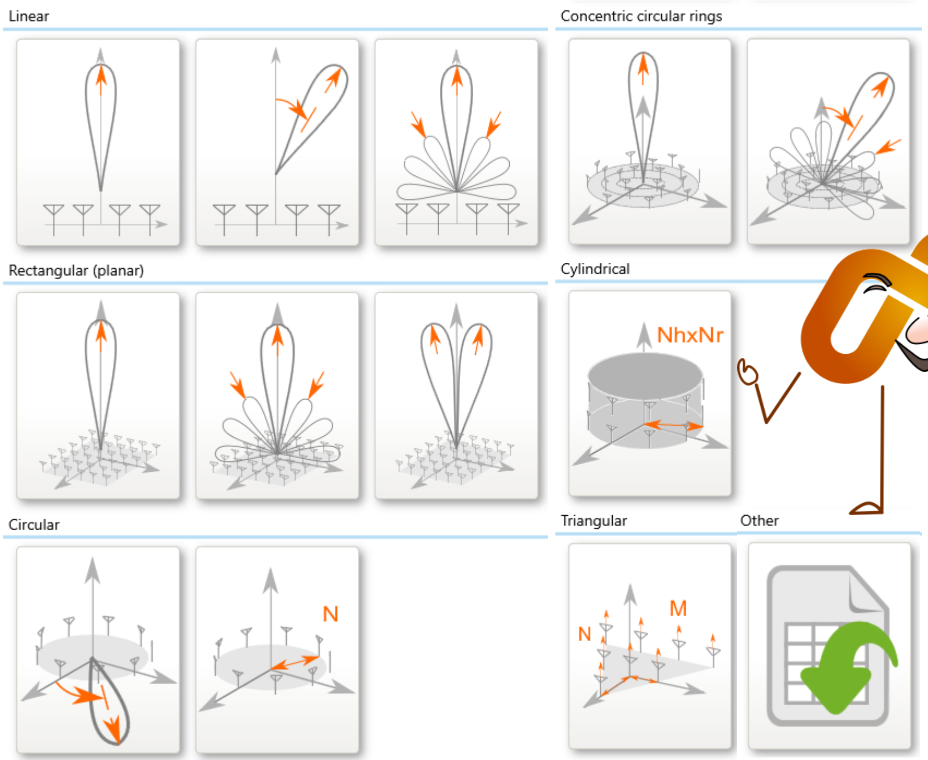
Array Layout

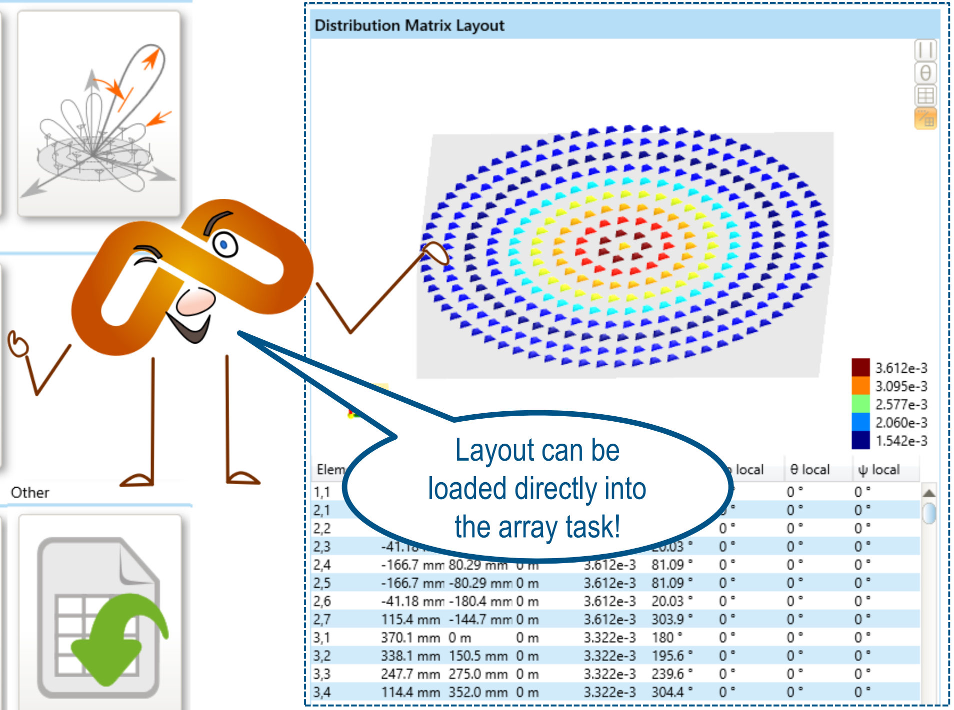


Excitations Taper

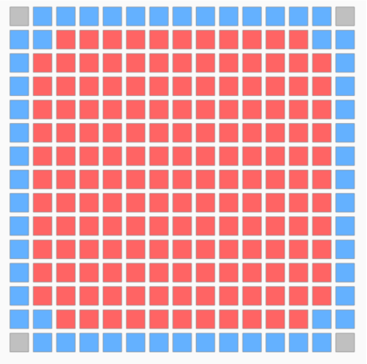


Array synthesis with Antenna Magus



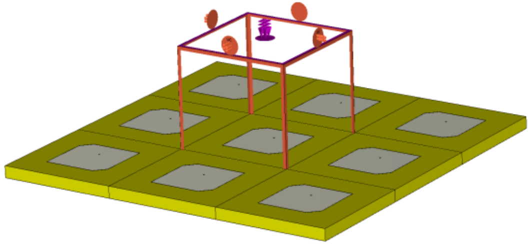


Project creation



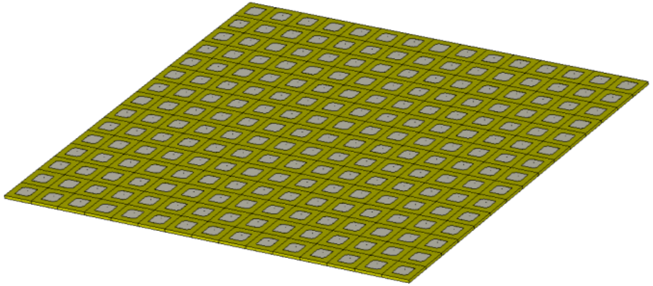
Create Unit Cell Simulation Project

Create Full Array Simulation Project



Infinite array

(Active element pattern / impedance)



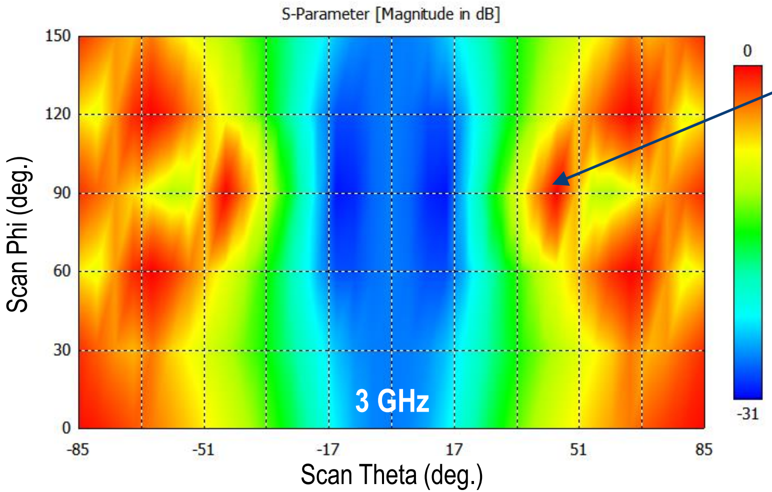
Finite array

(edge diffraction / surface waves)

Simulation of Unit Cell

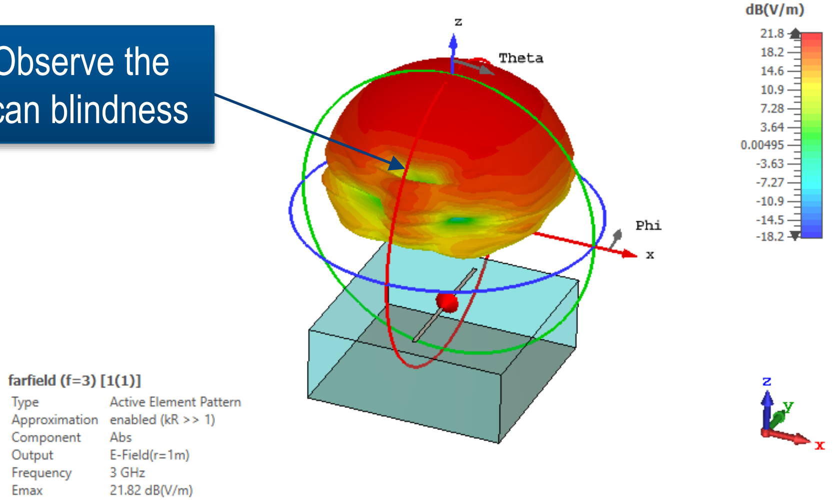
Results automatically produced after parameter sweep of scan angles:

Active Input Impedance



Observe the scan blindness

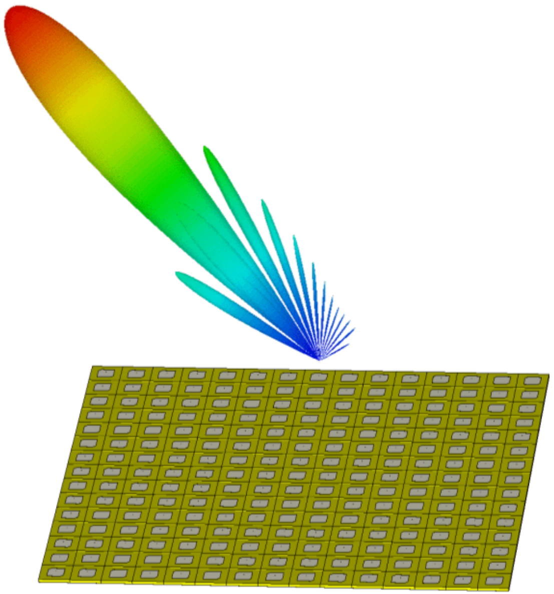
Active Element Pattern



Simulation of full array

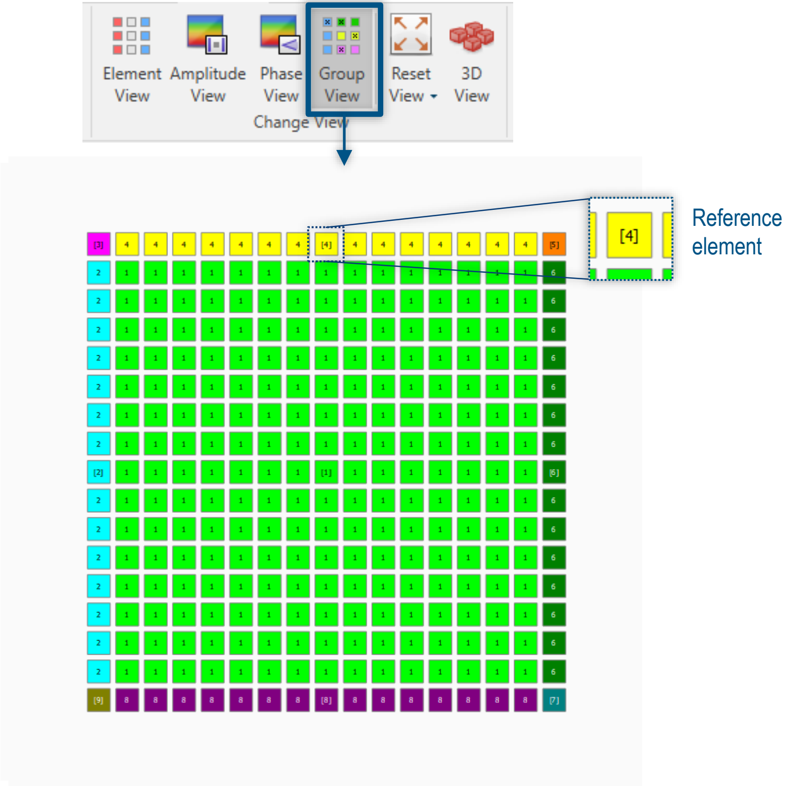
Excitation options

1. **Simultaneous excitation**
   - ▷ all the ports are excited together with the specified weighting distribution.
2. **Sequential excitation**
   - ▷ each element port is sequentially excited and farfields are combined in a result template with the specified weighting distribution.
3. **Group sequential excitation**
   - ▷ same as the previous option except that only reference elements of each group will be excited.



Simulation of large arrays

Simulation by groups



Task Parameter List (Array)

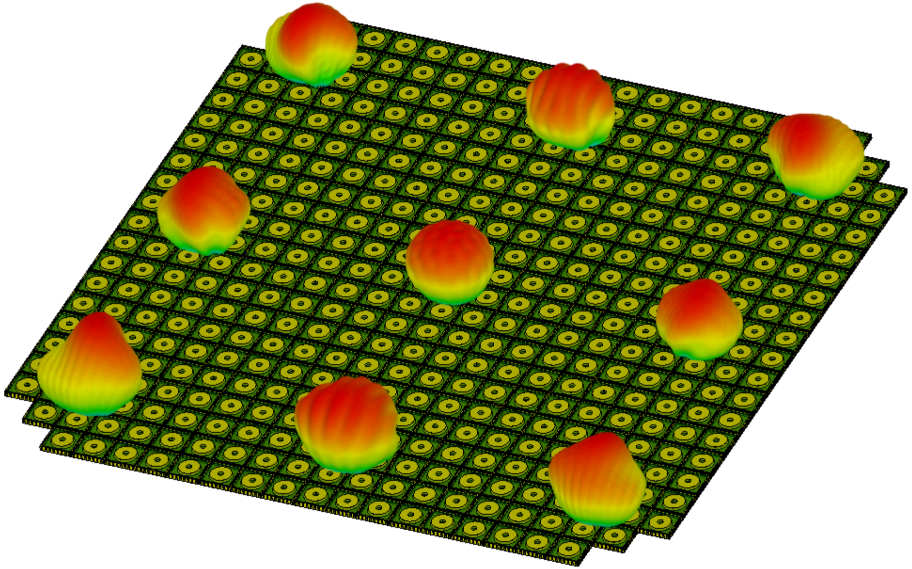
Name	Type
Group1 (225 elements)	
Group2 (15 elements)	
Group3 (1 elements)	
Group4 (15 elements)	
Group5 (1 elements)	
Group6 (15 elements)	
Group7 (1 elements)	
Group8 (15 elements)	
Group9 (1 elements)	
Not grouped (152 elements)	

Simulation of large arrays

Simulation by groups

▶ Elements excited according to the group references:

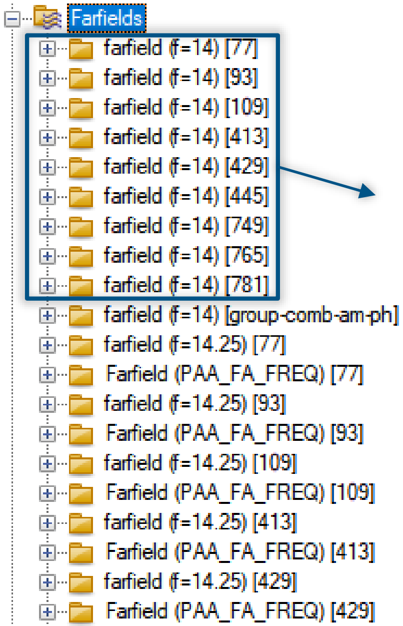
- Farfields
  - farfield (f=14) [77]
  - farfield (f=14) [93]
  - farfield (f=14) [109]
  - farfield (f=14) [413]
  - farfield (f=14) [429]
  - farfield (f=14) [445]
  - farfield (f=14) [749]
  - farfield (f=14) [765]
  - farfield (f=14) [781]
  - farfield (f=14) [group-comb-am-ph]
  - farfield (f=14.25) [77]
  - Farfield (PAA_FA_FREQ) [77]
  - farfield (f=14.25) [93]
  - Farfield (PAA_FA_FREQ) [93]
  - farfield (f=14.25) [109]
  - Farfield (PAA_FA_FREQ) [109]
  - farfield (f=14.25) [413]
  - Farfield (PAA_FA_FREQ) [413]
  - farfield (f=14.25) [429]
  - Farfield (PAA_FA_FREQ) [429]

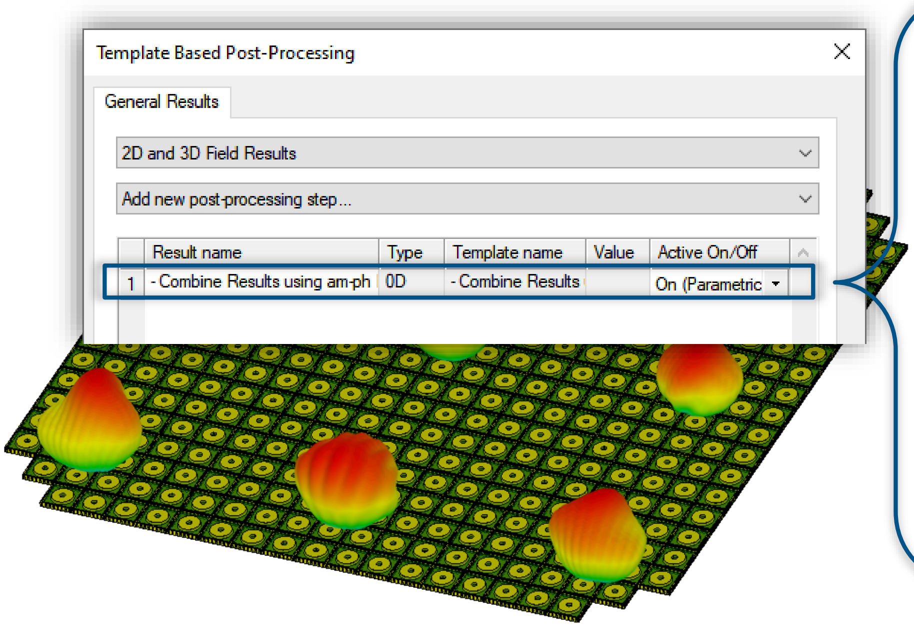


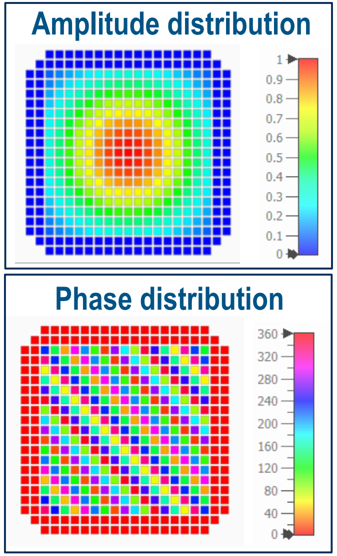
Simulation of large arrays

Simulation by groups

▶ Automated post-processing template:







SIMULIA

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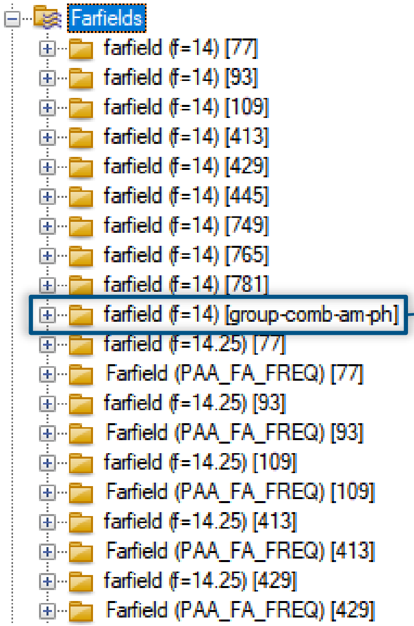
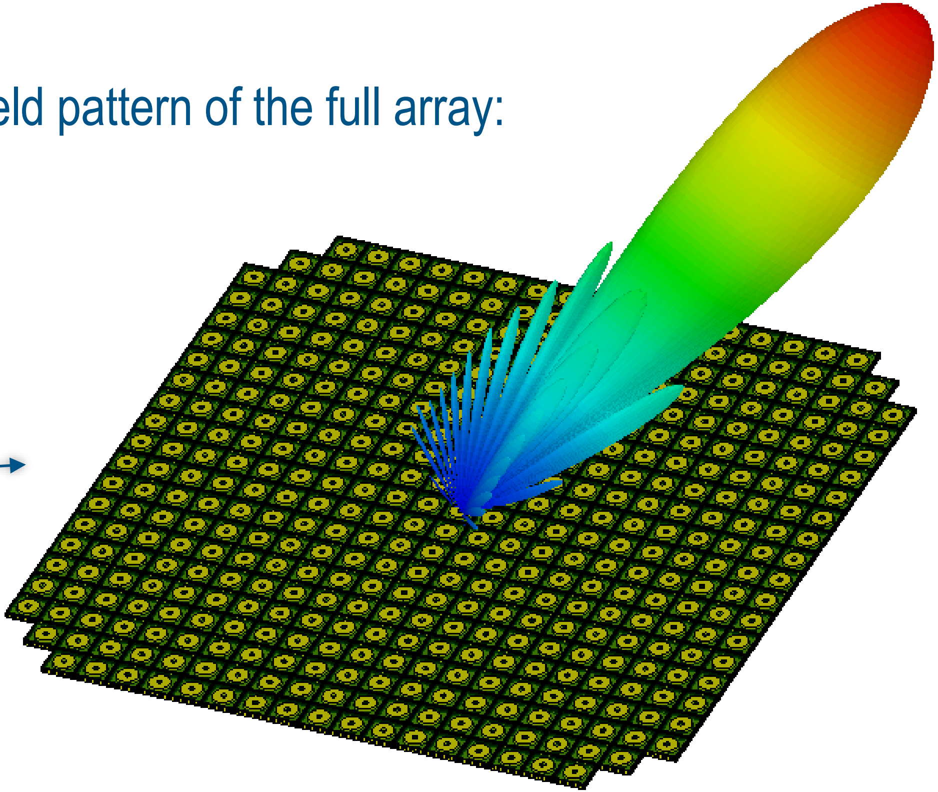
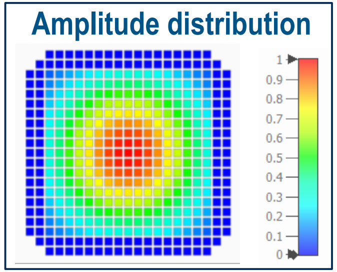
Simulation of large arrays

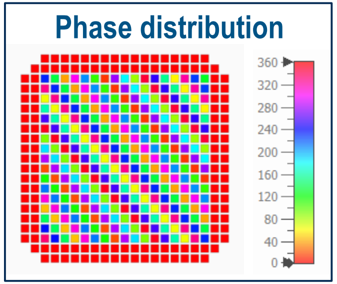
Simulation by groups

- Reconstructed farfield pattern of the full array:









3DS SIMULIA

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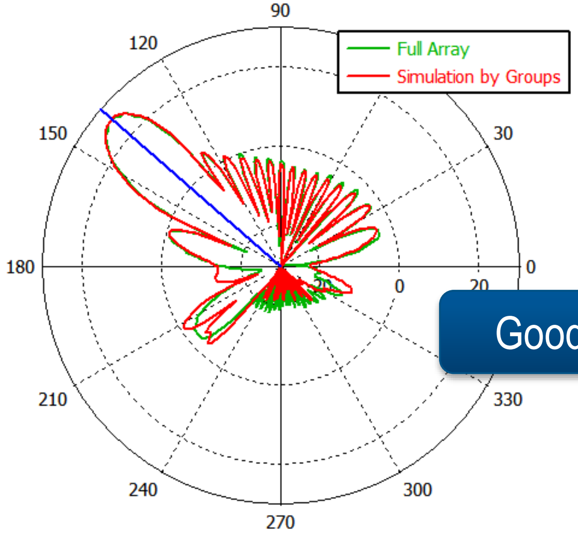
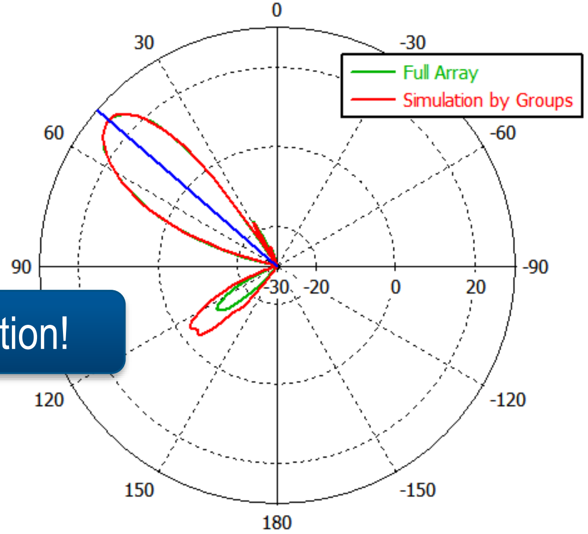
Simulation of large arrays

Comparison with all-ports simultaneously excited (for worst case scenarios)

Scanned to
θ=50˚, ϕ=0˚



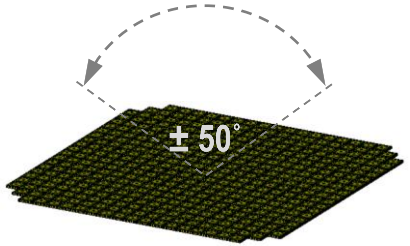
Scanned to
θ=50˚, ϕ=45˚

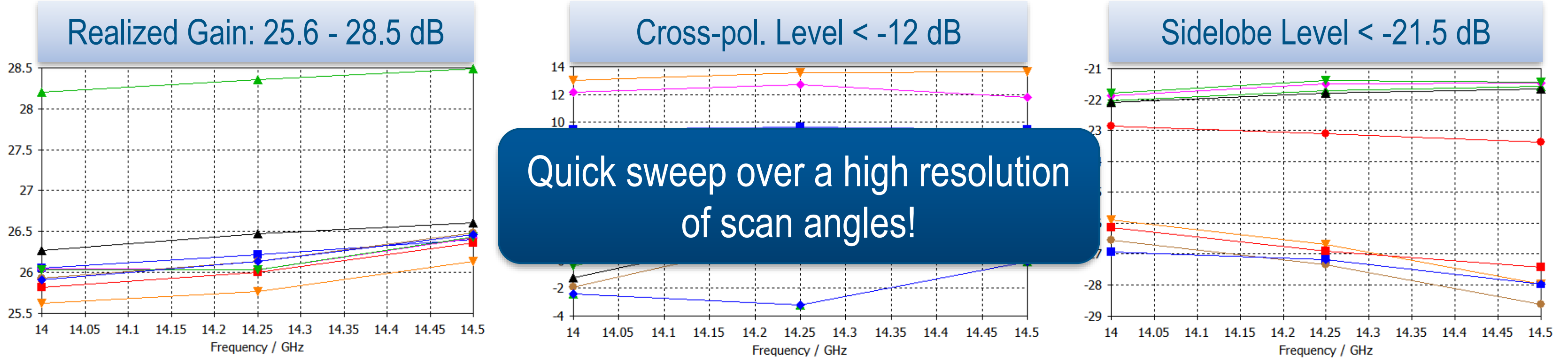


Good approximation!

Simulation of large arrays

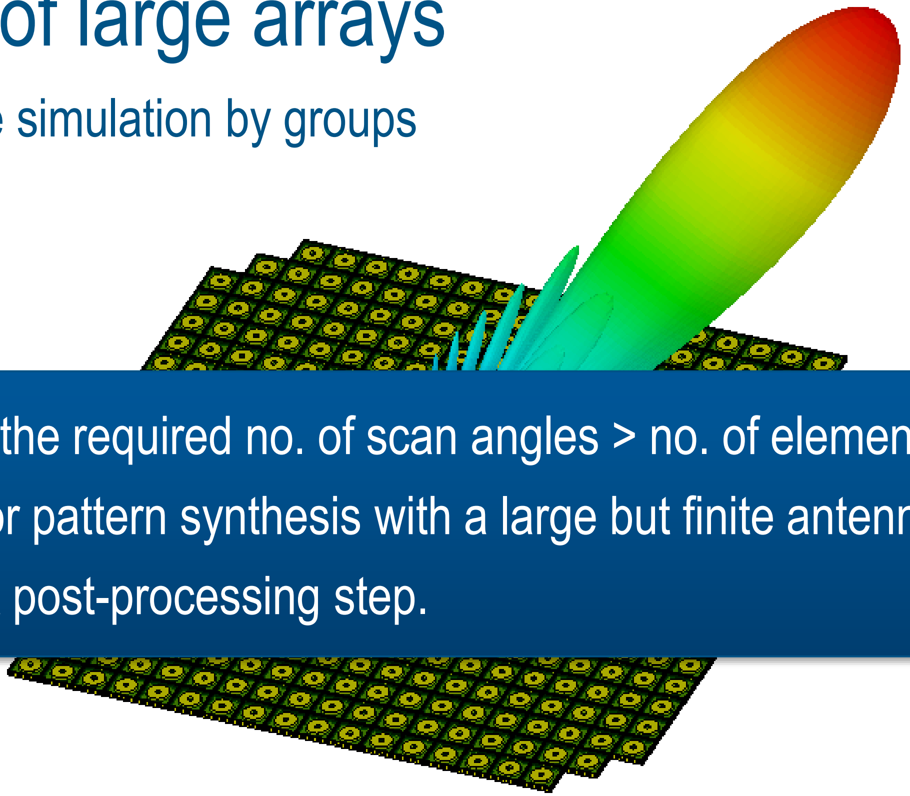
KPI's over a solid angle of ± 50˚:





Simulation of large arrays

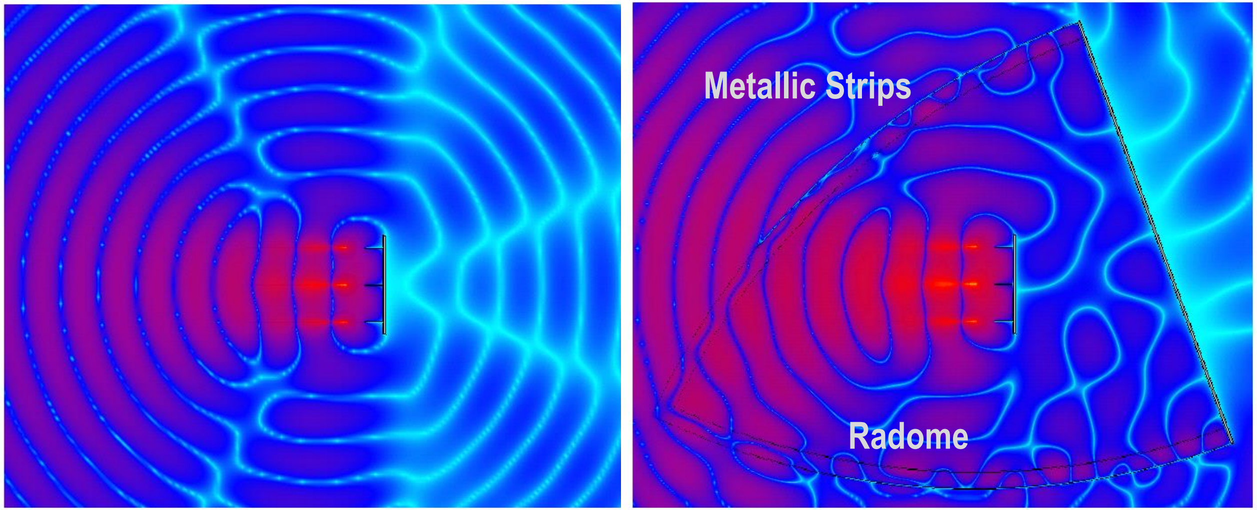
Advantages of the simulation by groups



- ✓ Useful if the required no. of scan angles > no. of element groups.
- ✓ Allows for pattern synthesis with a large but finite antenna array.
- ✓ Very fast post-processing step.

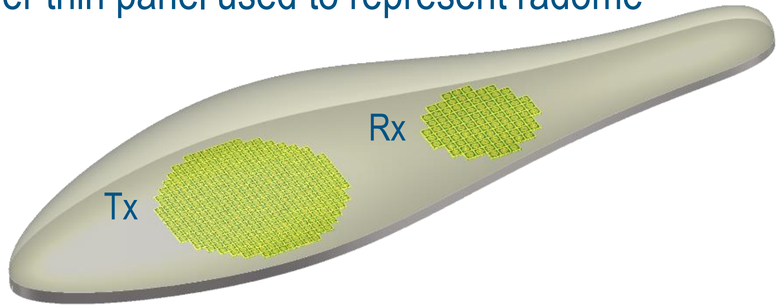
Antenna radome analysis with

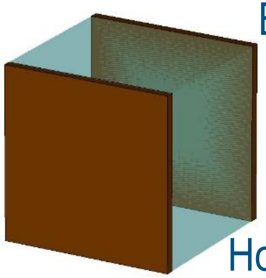
CST Studio Suite



SATCOM antenna radome analysis

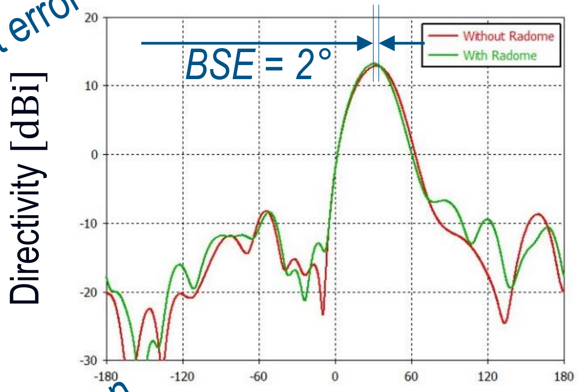
Multi-layer thin panel used to represent radome



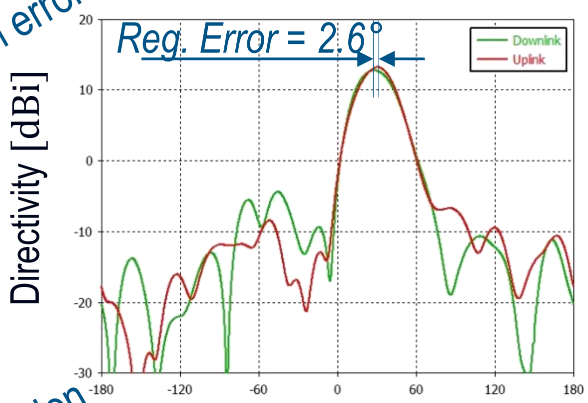


Radome KPIs

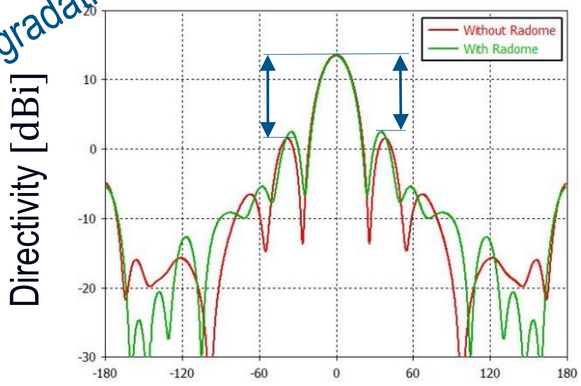
Boresight error



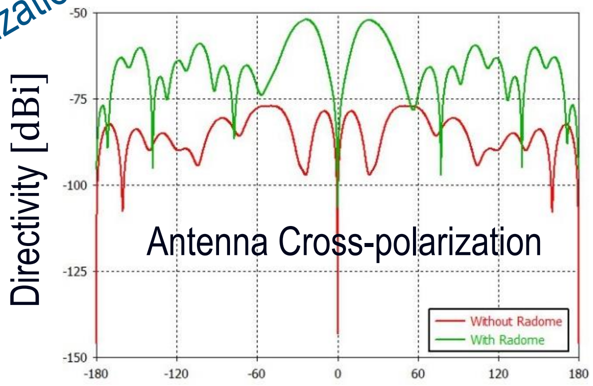
Registration error



Sidelobe degradation



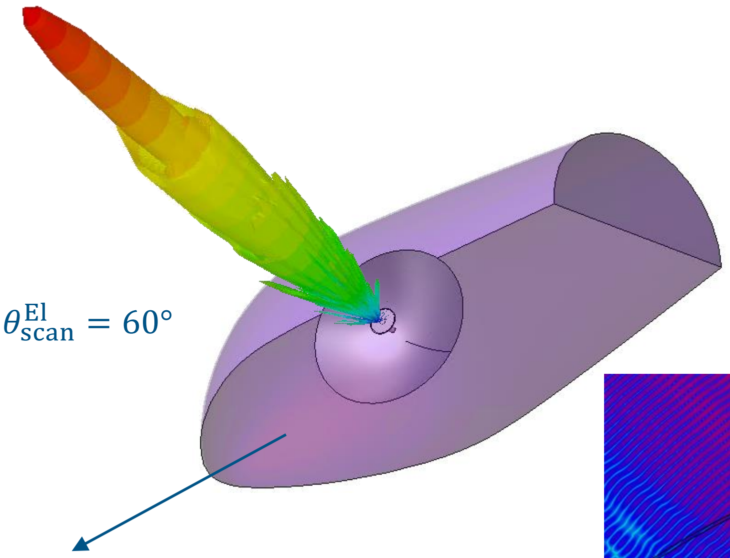
Depolarization



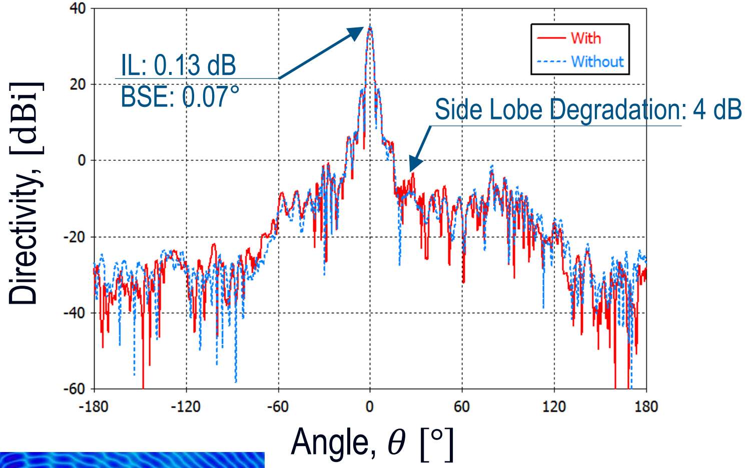
Angle in Azimuth [°]

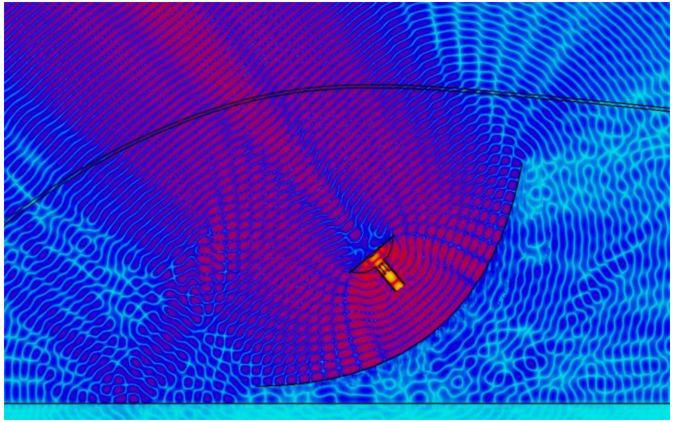
Angle in Azimuth [°]

SATCOM antenna radome analysis



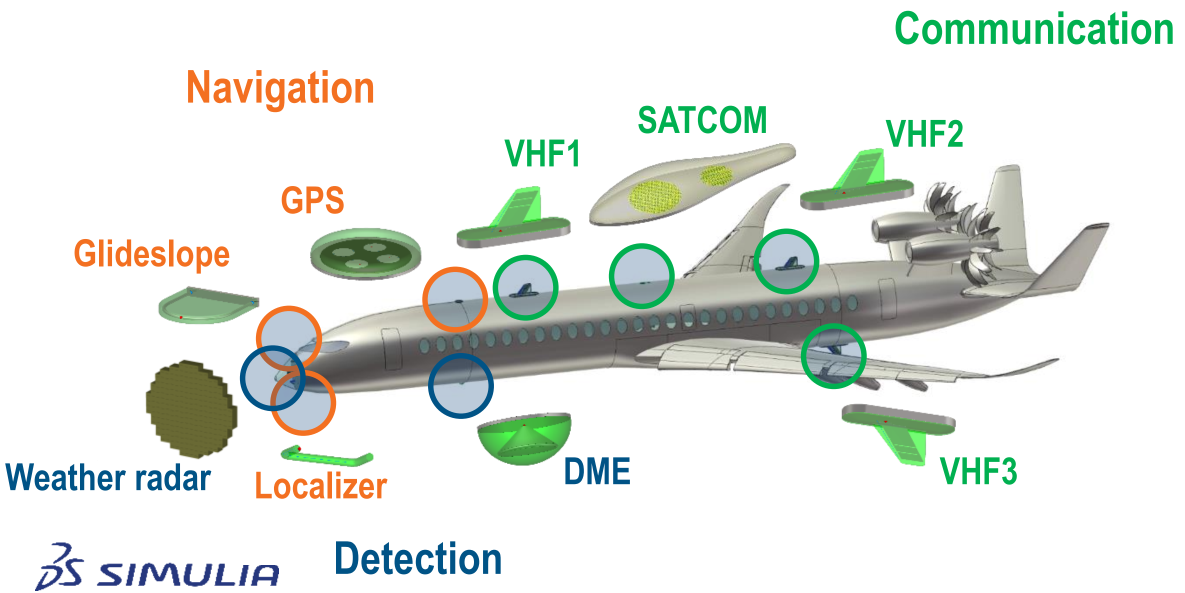
$\theta_{\text{scan}}^{\text{El}} = 60°$





Antenna placement analysis and optimization with

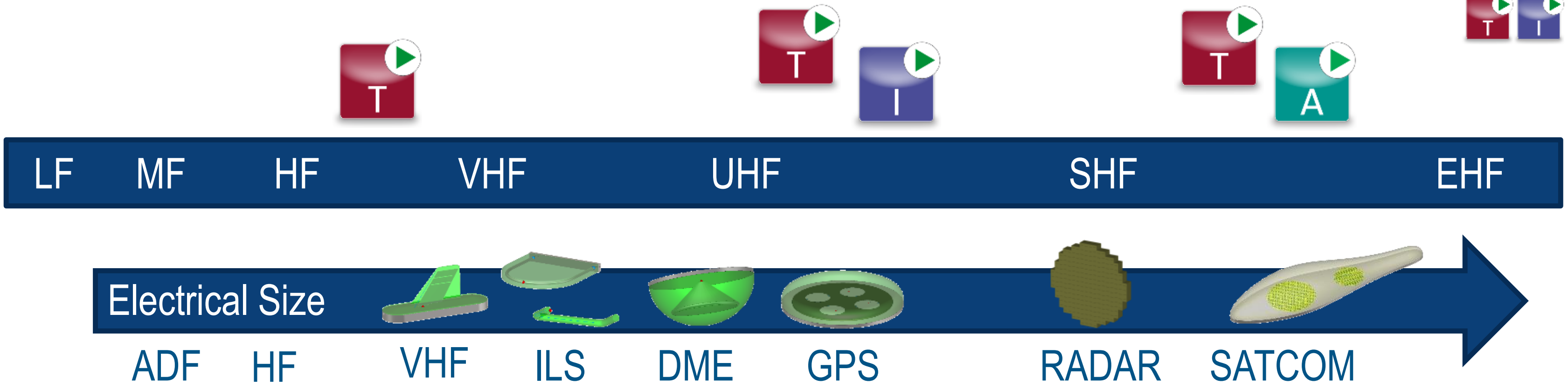
CST Studio Suite



Antenna placement analysis and optimization

- Solver choice depends on antenna type, materials and electrical size
- Hybrid solution used to efficiently handle large electrical size
- Uni-directional hybrid approach sufficient for many cases

Most Complete EMAG Simulation technology



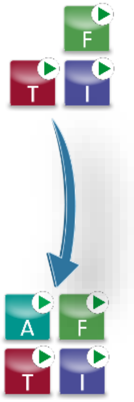
3DS SIMULIA

3DS DASSAULT SYSTEMES

Antenna placement analysis and optimization

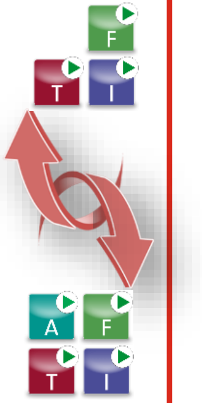
Hybrid solution used to efficiently handle large electrical size

Uni-directional



- When to use?
  - ▷ Low reflection of energy
  - ▷ Loosely coupled antennas
  - ▷ Fast design exploration
- Unique Technology
  - ▷ Time domain solver with PBA
    - Complex CAD, broadband, dielectrics

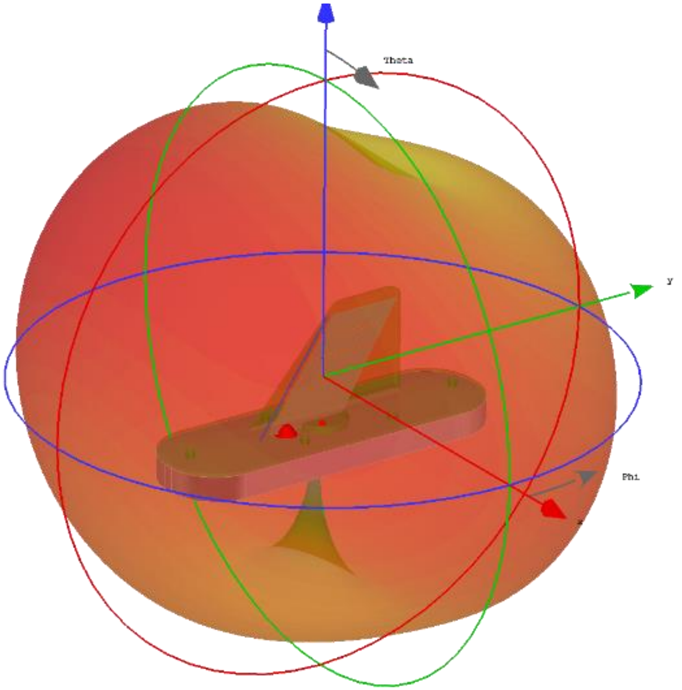
Bi-directional



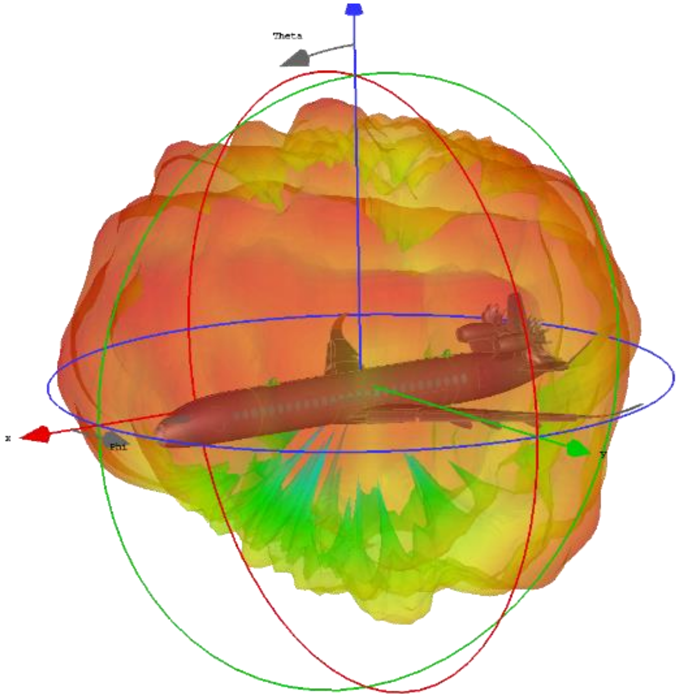
- When to use?
  - ▷ High reflection of energy
  - ▷ Tightly coupled antennas
  - ▷ Accurate impedance & farfield
- Unique Technology
  - ▷ Time domain solver with PBA
    - Complex CAD, broadband, dielectrics

Installed VHF antenna performance analysis

VHF band: Radiation pattern performance @ 127.5 MHz



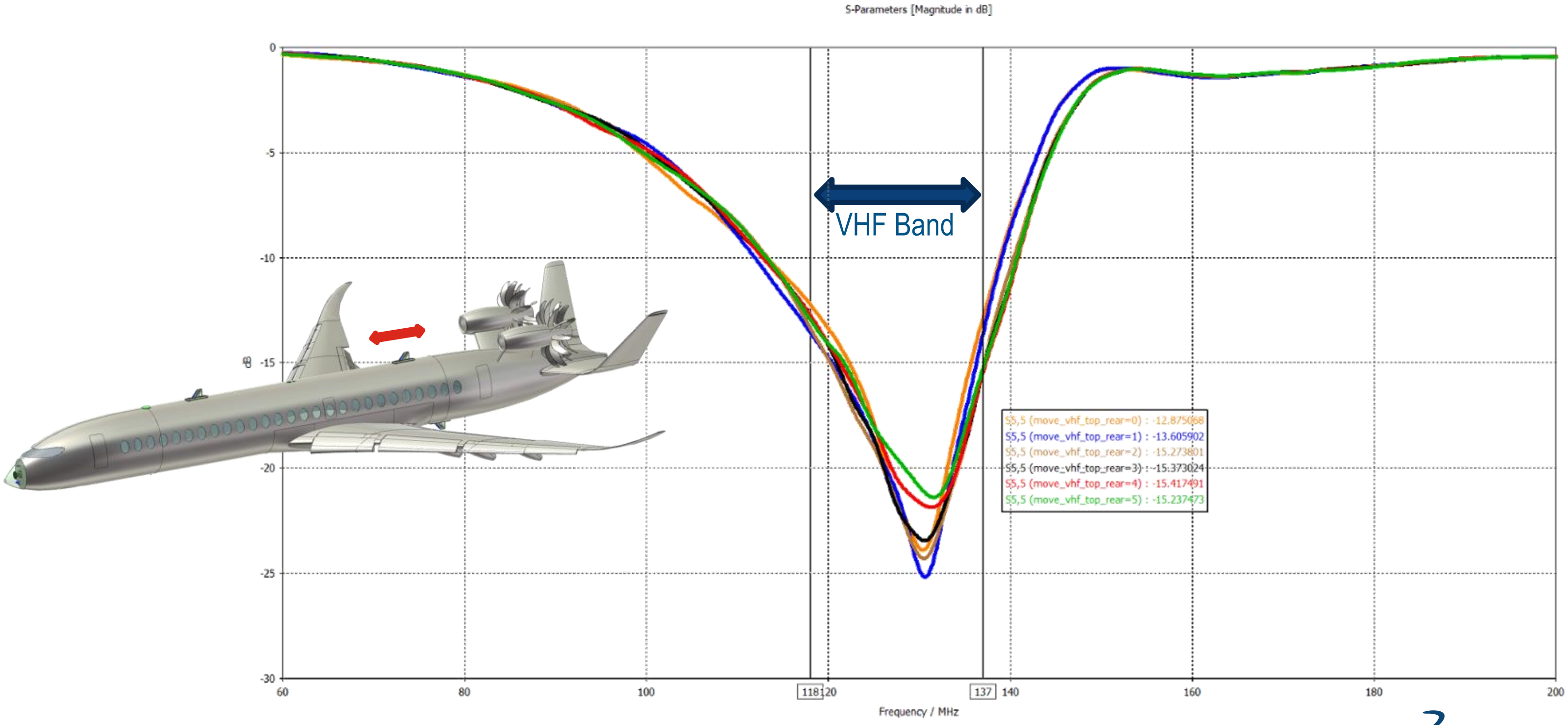
Installed on ideal ground plane



Installed on open rotor aircraft

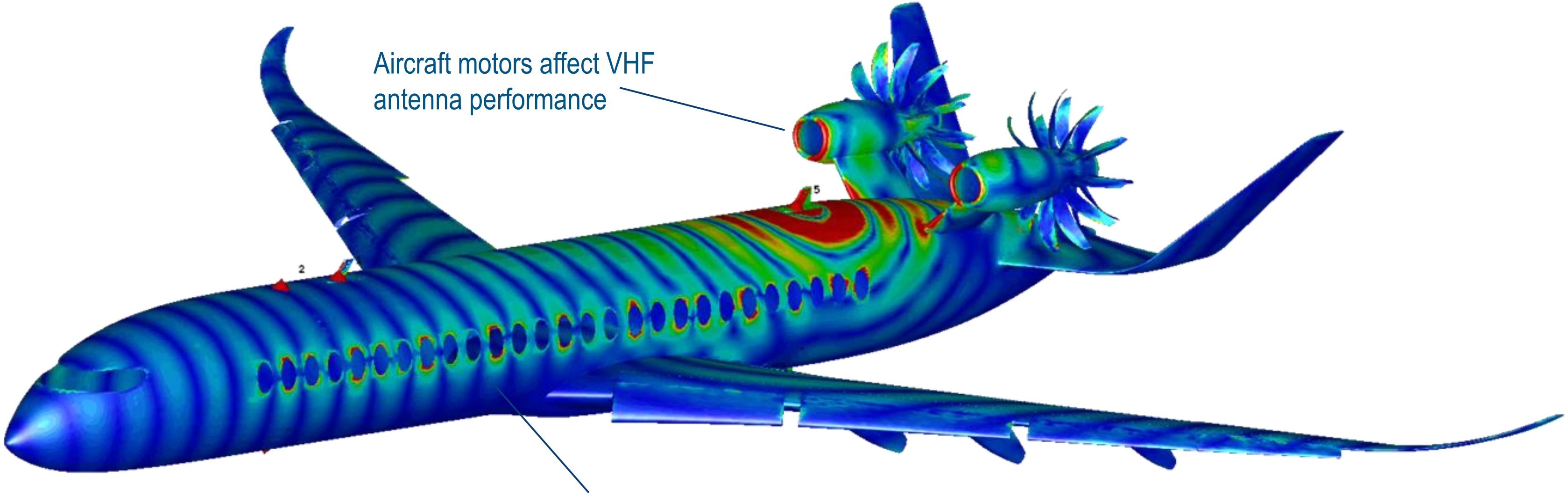
Installed VHF antenna performance analysis

VHF band: Impedance performance



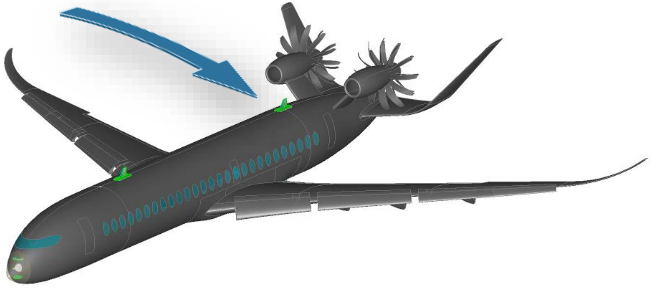
Installed VHF antenna performance optimization

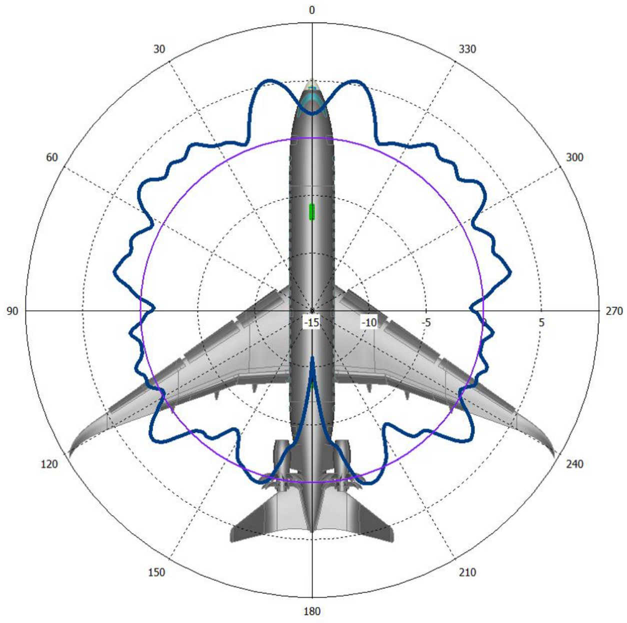
VHF band: Induced surface current



Installed VHF antenna performance optimization

VHF band: VHF3 placement study

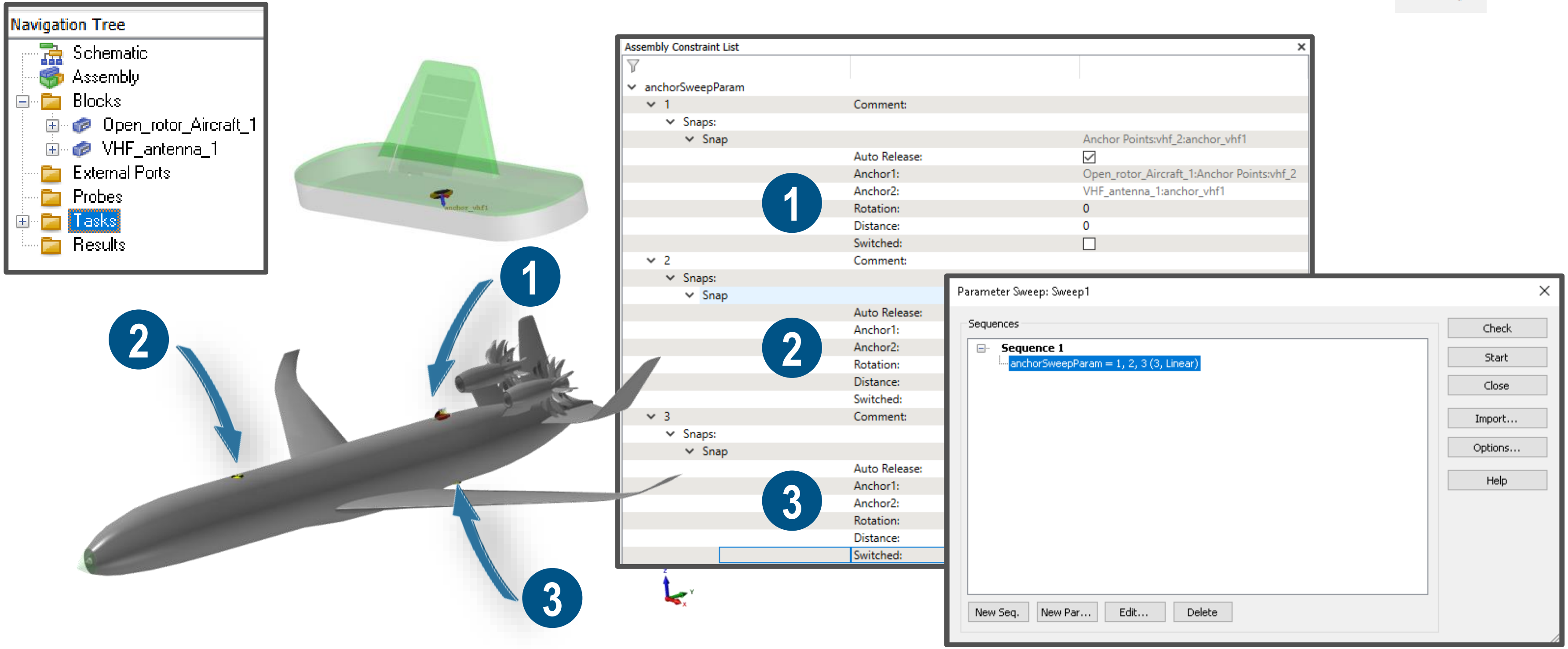




SIMULIA
DASSAULT SYSTEMES

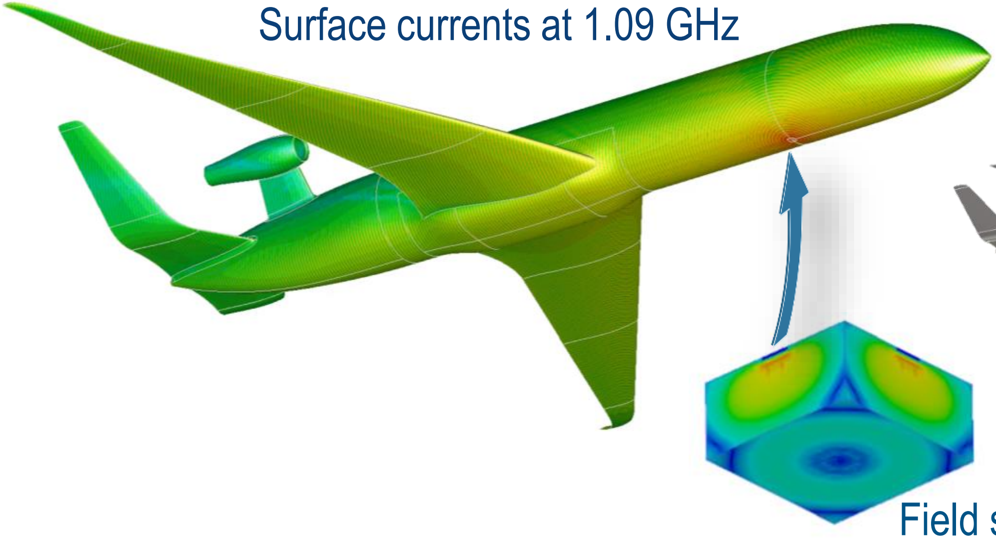
Installed VHF antenna performance

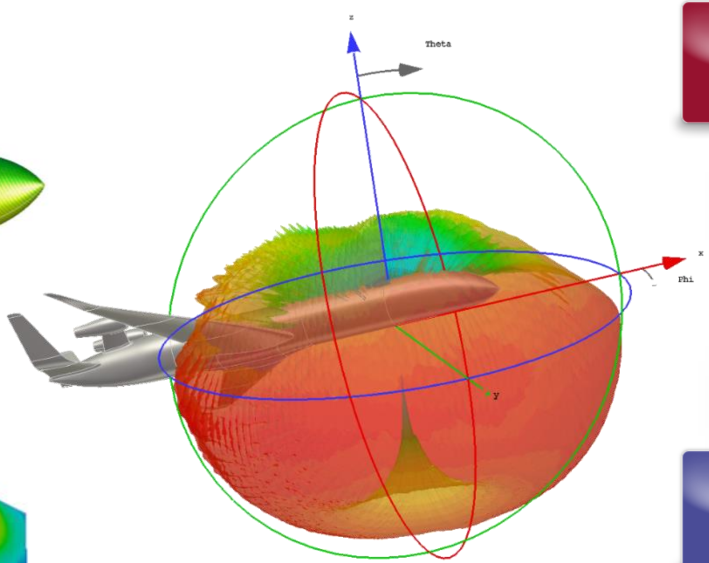
Antenna positioning with anchor sweep



Installed DME antenna performance analysis

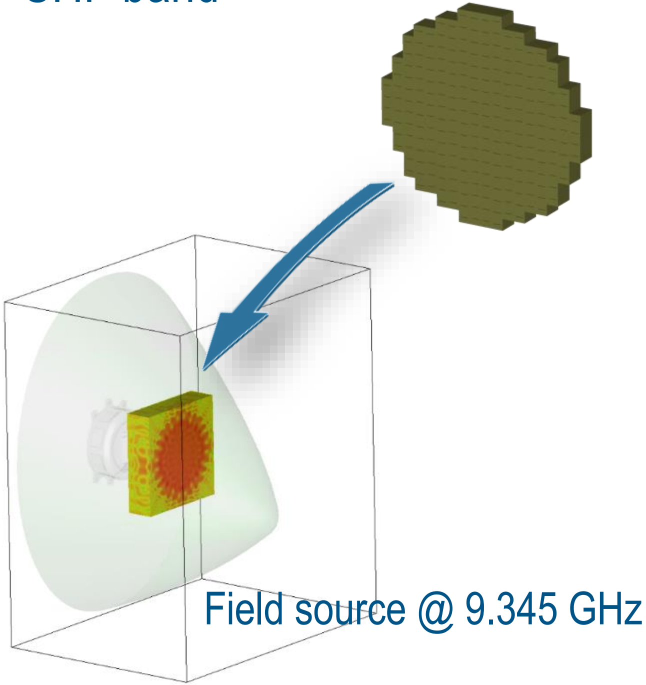
UHF band

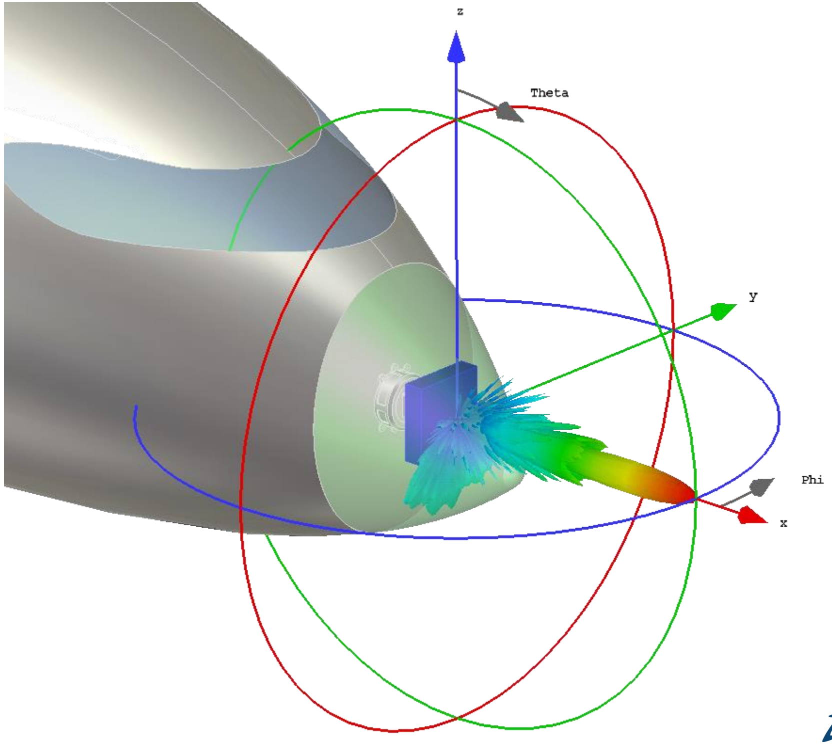




Installed radar antenna performance analysis

SHF band

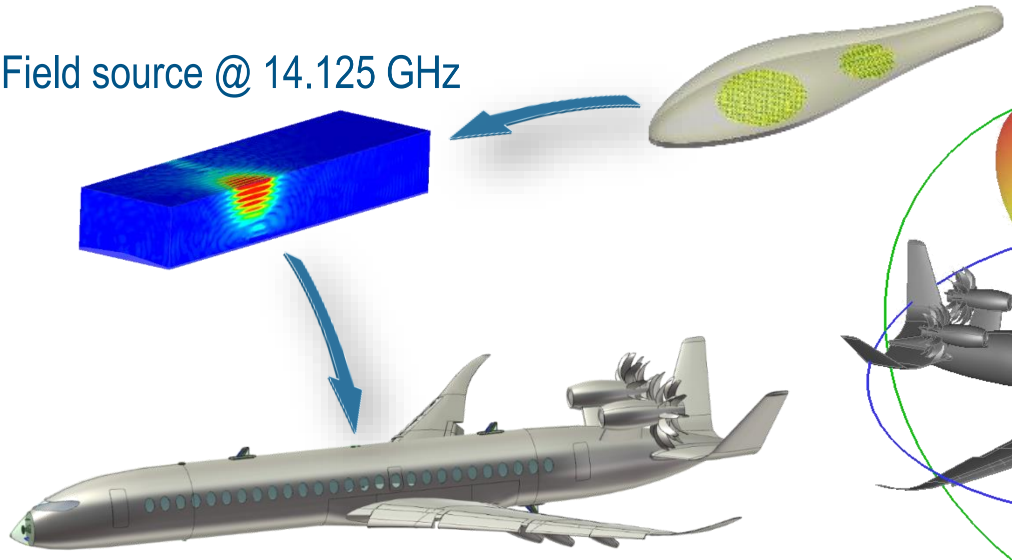


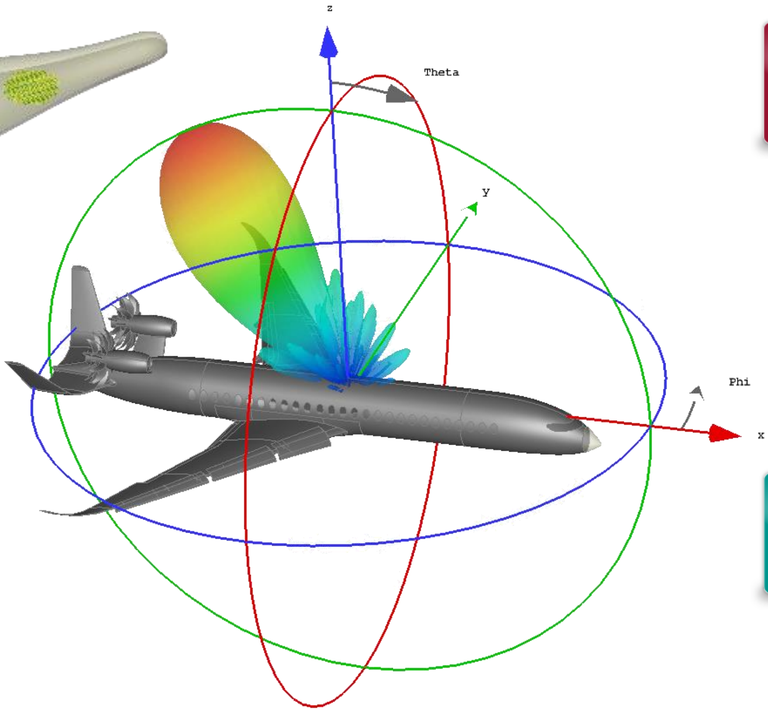


Installed SATCOM antenna performance analysis

SHF band

Field source @ 14.125 GHz





TLM

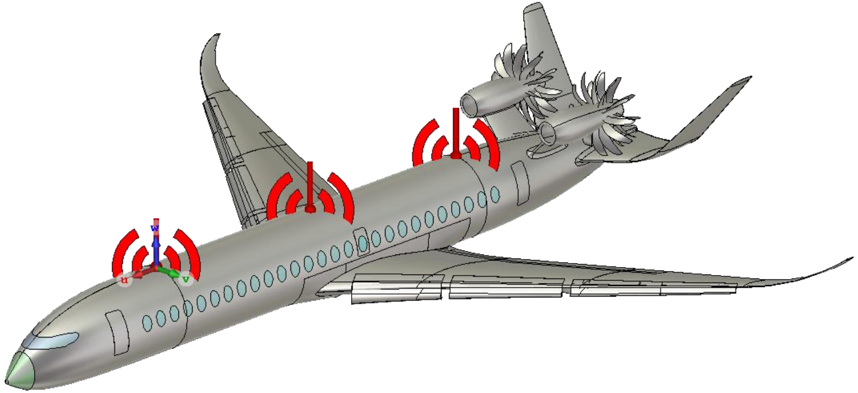
SBR

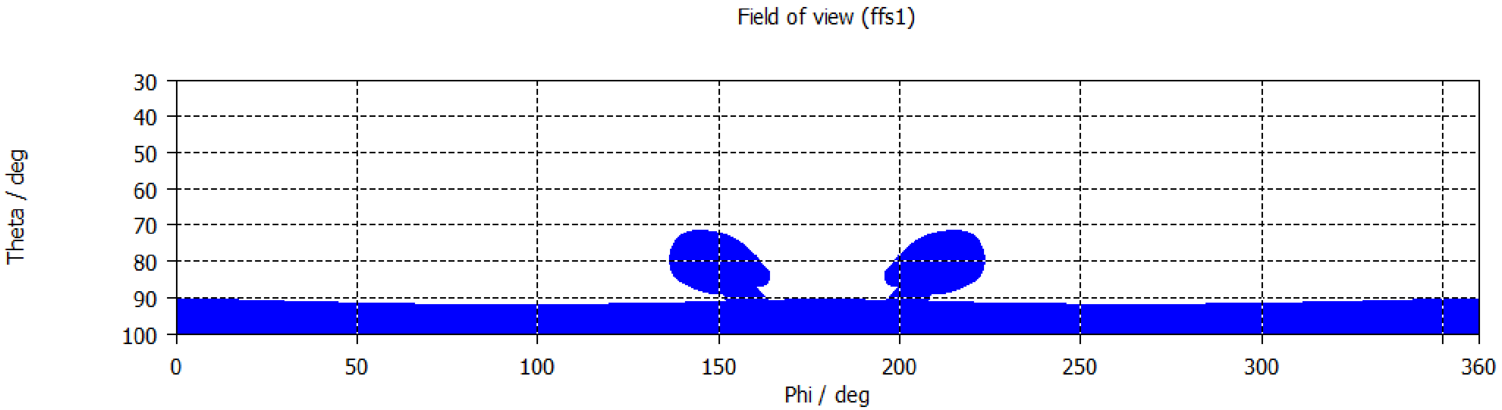
Scan at theta 45 degrees

Antenna placement analysis and optimization

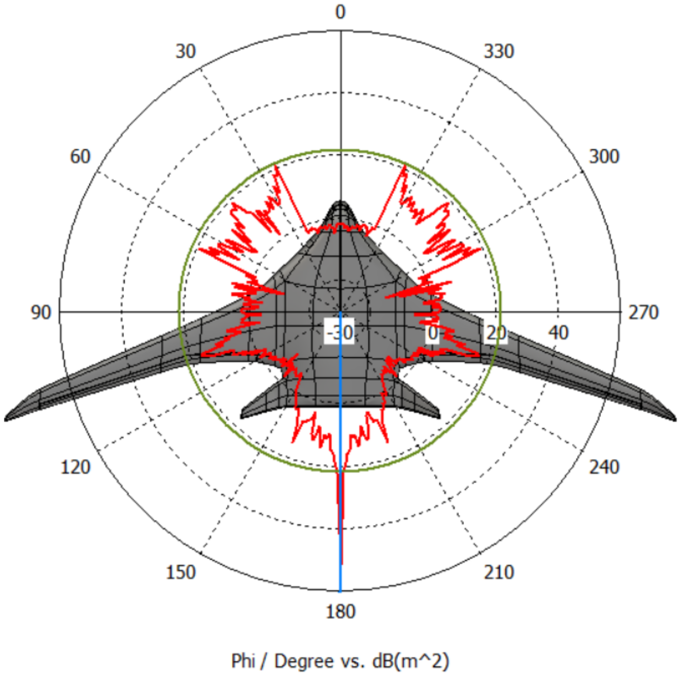
Field of View Analysis

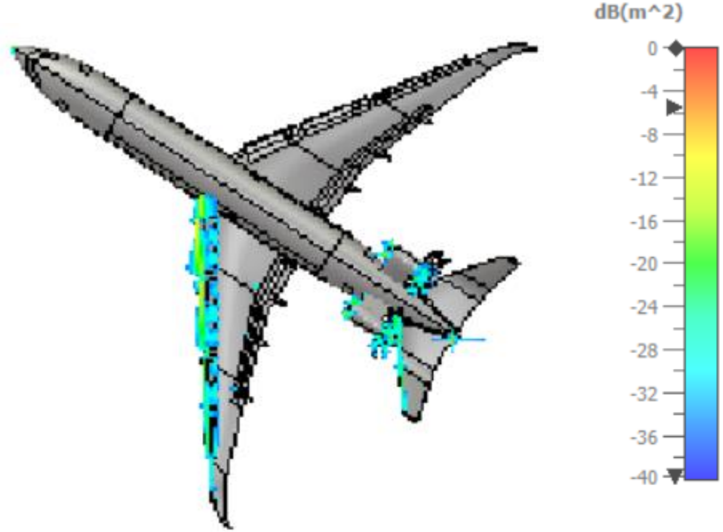
First order ray visualization of unblocked rays





Detection Analysis: Radar Cross Section





Agenda

SIMULIA CST Studio Suite: industry focused solutions

Satellite antennas

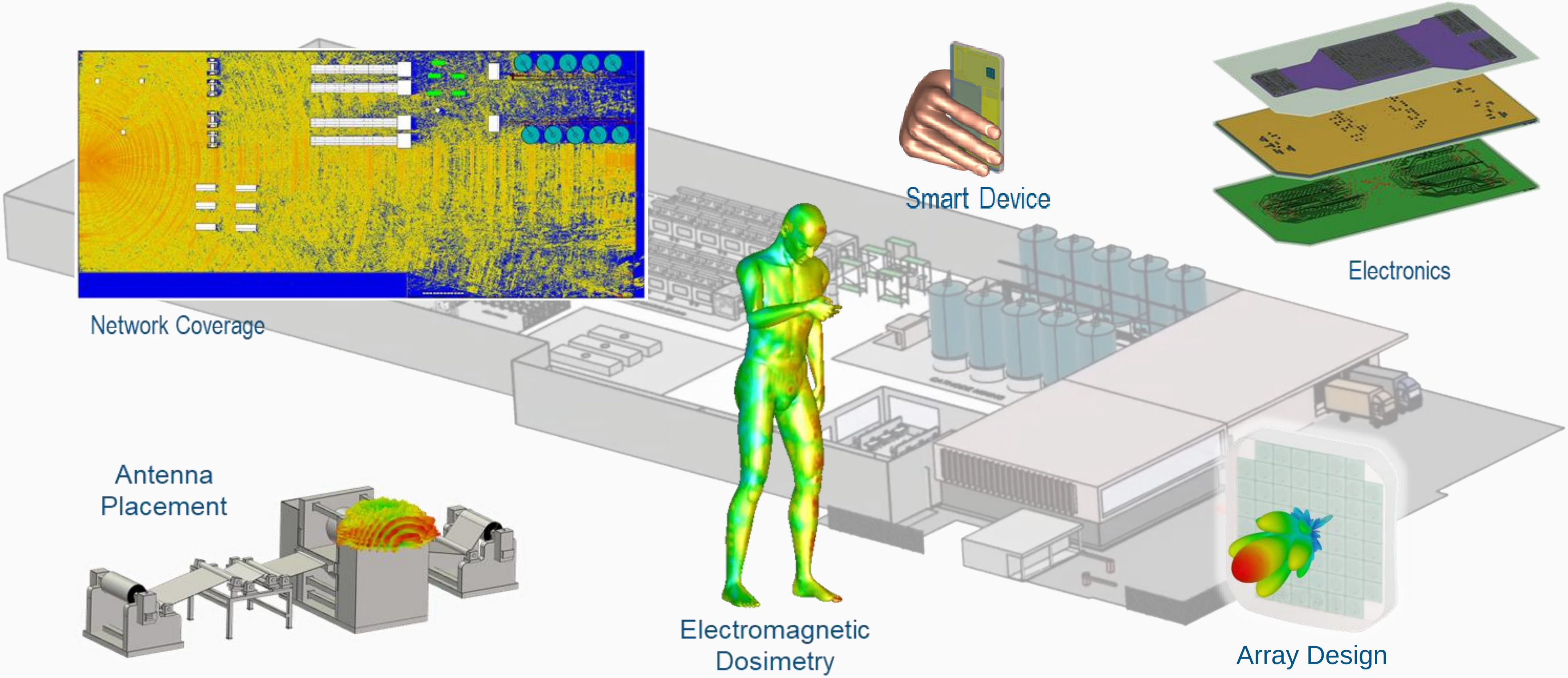
Communication systems in aircrafts

Land-based RF and MW communications

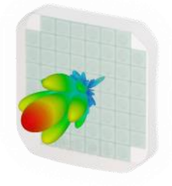
Conclusion

Antenna Engineering and Certification for 5G Network Design

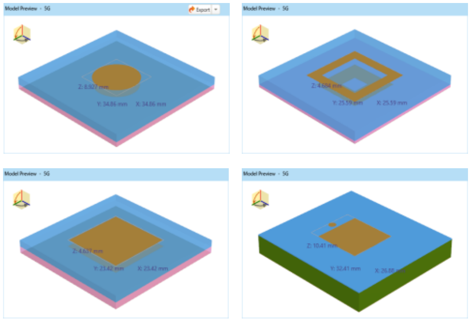
5G Wireless Indoor Network Design



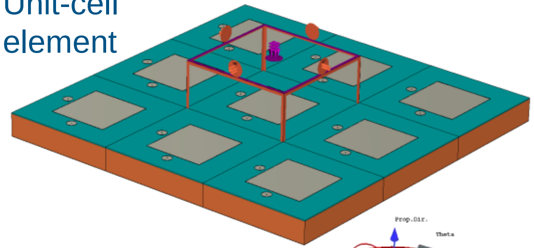
Antenna Array - Design Workflow



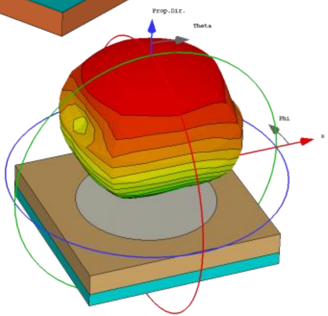
Identify Antenna Candidates → ANTENNA MAGUS (ANTENNA DESIGN SOFTWARE) → *Evaluate* Antenna Candidates → *Construct* Full Antenna Array



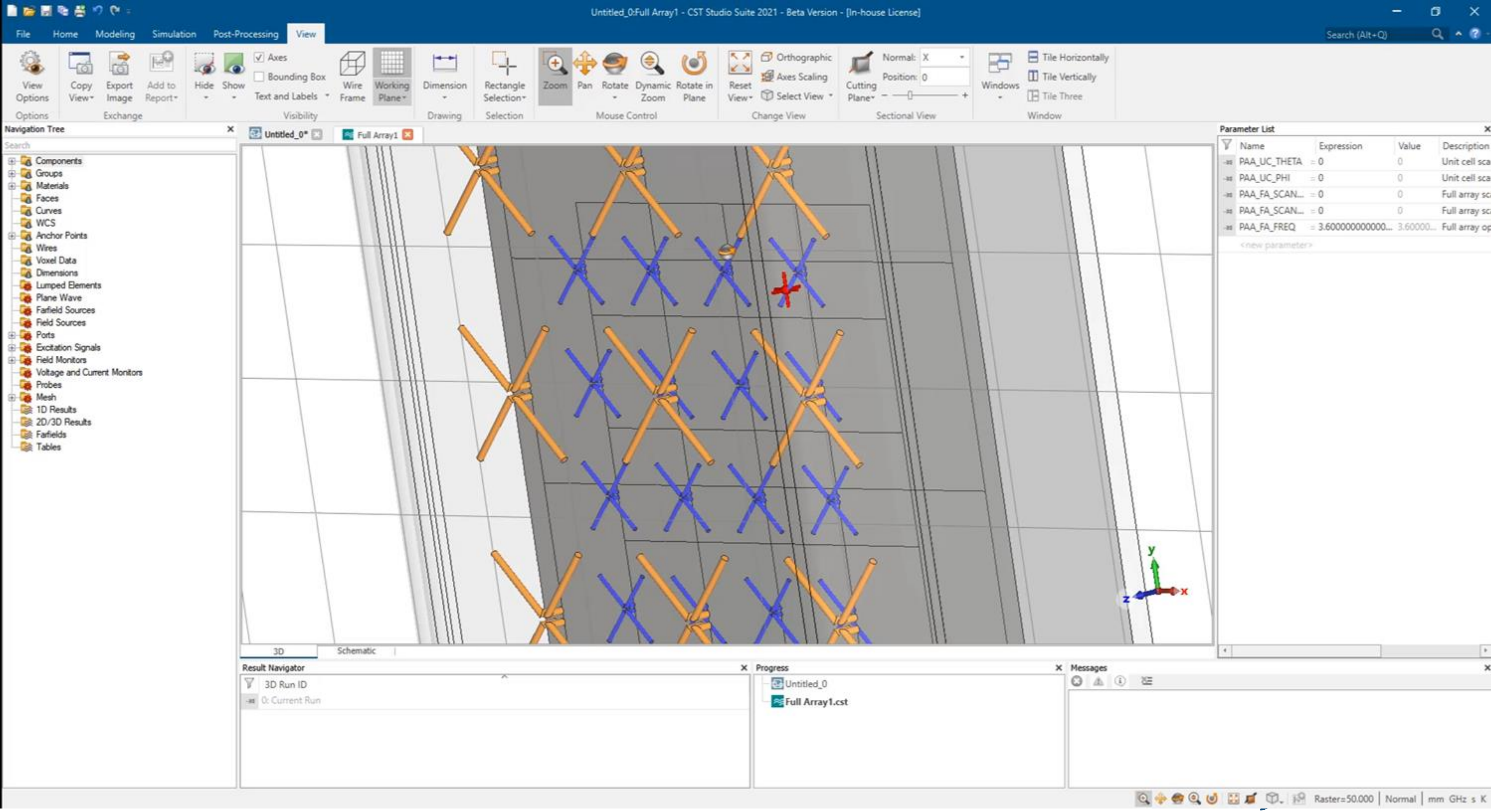
Unit-cell element



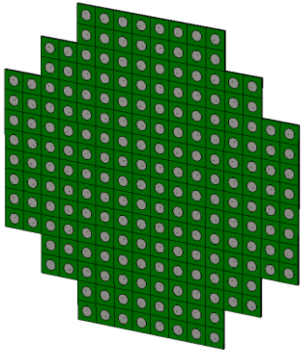
Active element pattern for all frequencies and scan angles



Layout (2D/3D)
Amplitude
Phase


Untitled_0:Full Array1 - CST Studio Suite 2021 - Beta Version - [In-house License]
File
Home
Modeling
Simulation
Post-Processing
View
Search (Alt+Q)
View Options
Copy View
Export Image
Add to Report
Options
Exchange
Hide
Show
Axes
Bounding Box
Text and Labels
Visibility
Wire Frame
Working Plane
Dimension
Drawing
Rectangle Selection
Selection
Zoom
Pan
Rotate
Dynamic Zoom
Rotate in Plane
Mouse Control
Reset View
Orthographic
Axes Scaling
Select View
Change View
Cutting Plane
Normal: X
Position: 0
Sectional View
Windows
Tile Horizontally
Tile Vertically
Tile Three
Window
Navigation Tree
Search
Components
Groups
Materials
Faces
Curves
WCS
Anchor Points
Wires
Voxel Data
Dimensions
Lumped Elements
Plane Wave
Farfield Sources
Field Sources
Ports
Excitation Signals
Field Monitors
Voltage and Current Monitors
Probes
Mesh
1D Results
2D/3D Results
Farfields
Tables
Untitled_0*
Full Array1
3D
Schematic
Parameter List
Name
Expression
Value
Description
PAA_UC_THETA = 0 0 Unit cell sca
PAA_UC_PHI = 0 0 Unit cell sca
PAA_FA_SCAN... = 0 0 Full array sc
PAA_FA_SCAN... = 0 0 Full array sc
PAA_FA_FREQ = 3.600000000000... 3.60000... Full array op
<new parameter>
Result Navigator
3D Run ID
0: Current Run
Progress
Untitled_0
Full Array1.cst
Messages
Raster=50.000
Normal
mm GHz s K

Domain Decomposition (DDM) Performance



Circularly Polarized Phased Array (208 elements)
Narrowband (10.1 – 10.3 GHz)
Four repetition groups of model domains
Simultaneous excitation (array scanned to θ=30˚, φ=-45˚)

Full PCB simulation
Narrowband (9-10 GHz)
82 ports

Hardware: 2 x Intel Xeon Gold 6248 (2 x 20 cores)

Phased Array	FD-GP	FD-DDM
Solvertime per sample	± 3 minutes	± 1 minute
Meshcells		…n
Total Runtim…		
Memory (peak)	219 GB	34 GB

Speedup factor: 6x
Memory usage: -84%

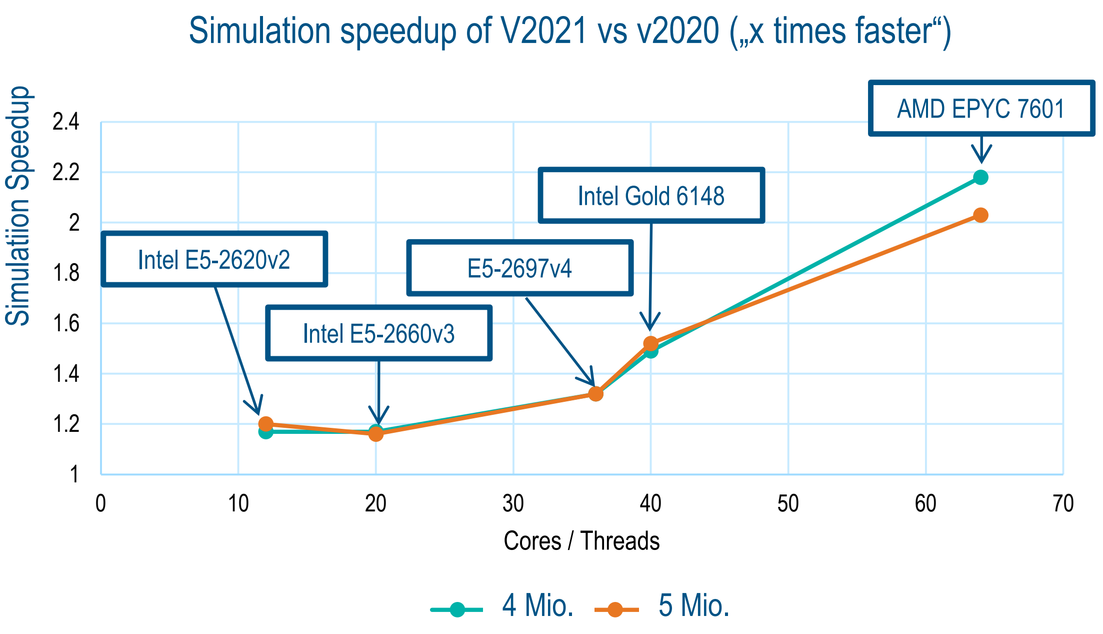
PCB	FD-GP	FD-DDM
Solvertime per sample	± 33 minutes	± 11 minutes
Meshcells		…usand
Total Run…		…5
Memory (peak)	40 GB	58 GB

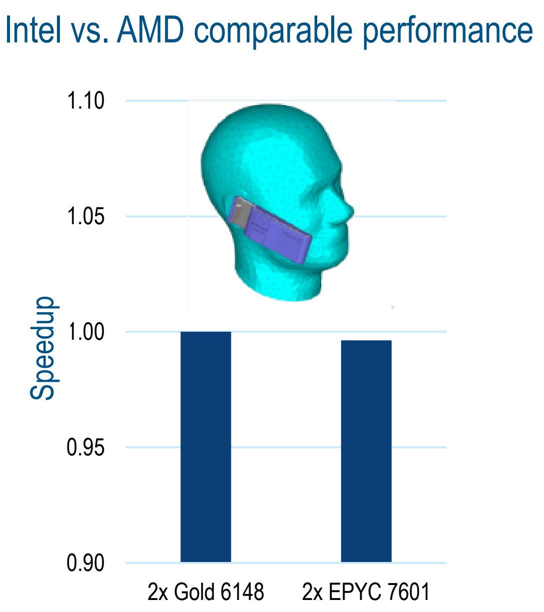
Speedup factor: 3x
Memory usage: +45%

* Note that due to the usage of repeated domains, the Domain Decomposition method spends less time on waveguide port calculations and mesh adaptation than the General Purpose (GP) method.

Improved Support for Many Core Systems

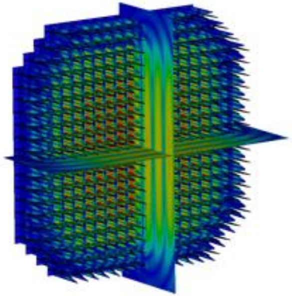
Better simulation performance for open boundary problems (PML boundaries) with FIT-TD solver



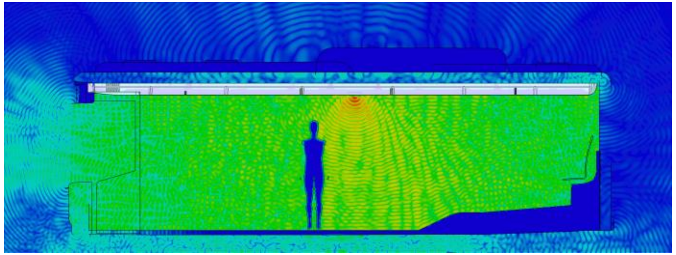


Automated MPI-CPU Setup for Large Projects

- Simulations with mesh sizes greater than 2 billions:
  - Automatic MPI setup without user interaction
  - Previously only possible with manual MPI setup



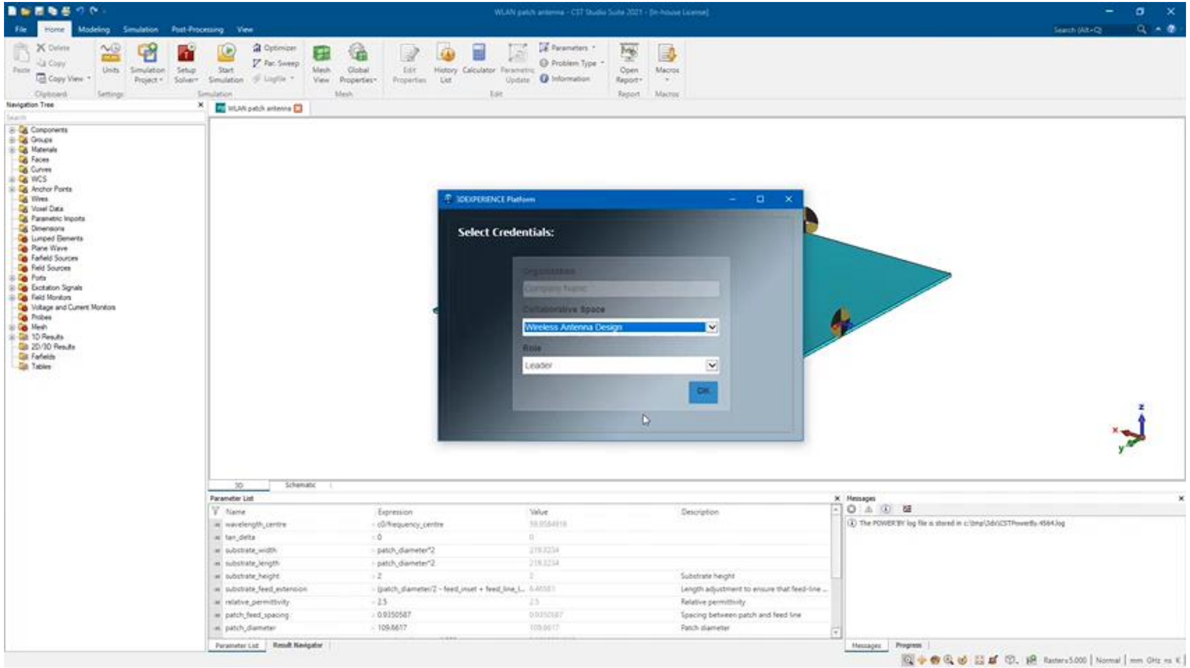
- MPI will be enabled automatically if the limit of 2 billions is exceeded
  - Local MPI in case of regular simulations
  - Several simulations per compute node in case of MPI simulations



- Available for FIT-TD and Wakefield solver

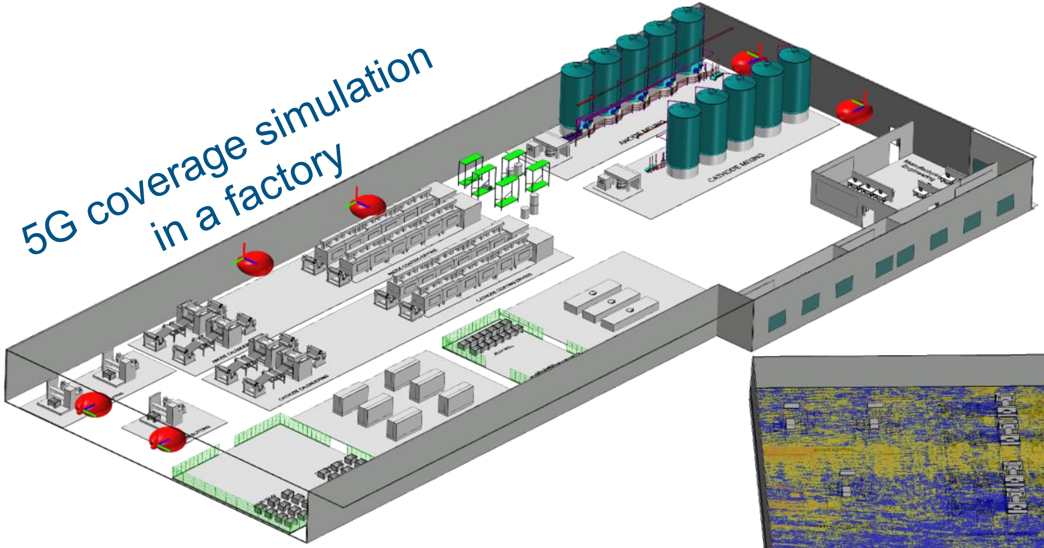
SIMULIA Electromagnetics Cloud Compute

R2021x FD04 as Controlled Availability and in R2021x FD05 as Global Availability

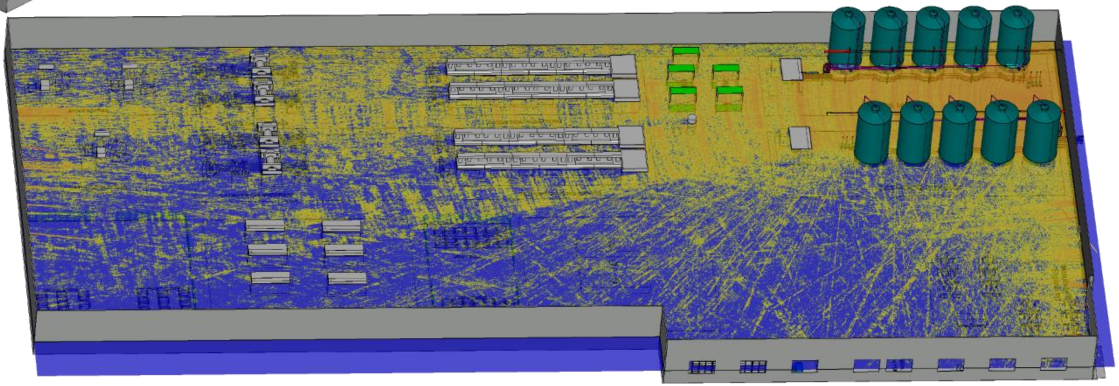


Ray Based Field Monitor (GO)

Obtain 2D near field results using Geometrical Optics (GO) which is much faster compared to the Physical Optics analysis.



Electric field magnitude at 3.6 GHz at height of 1 m above factory floor



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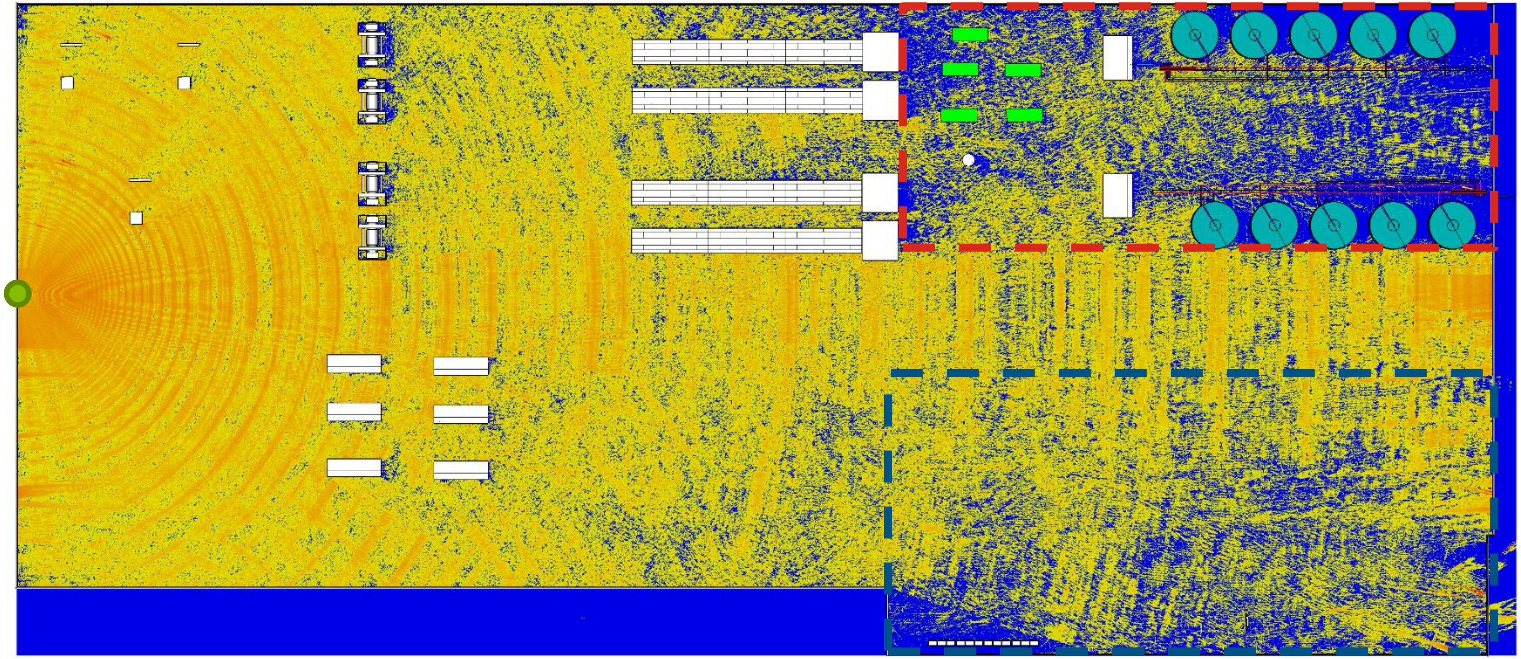
Indoor Network Coverage

2D Ray Based Field Monitor (Geometrical Optics much faster compared to the Physical Optics)



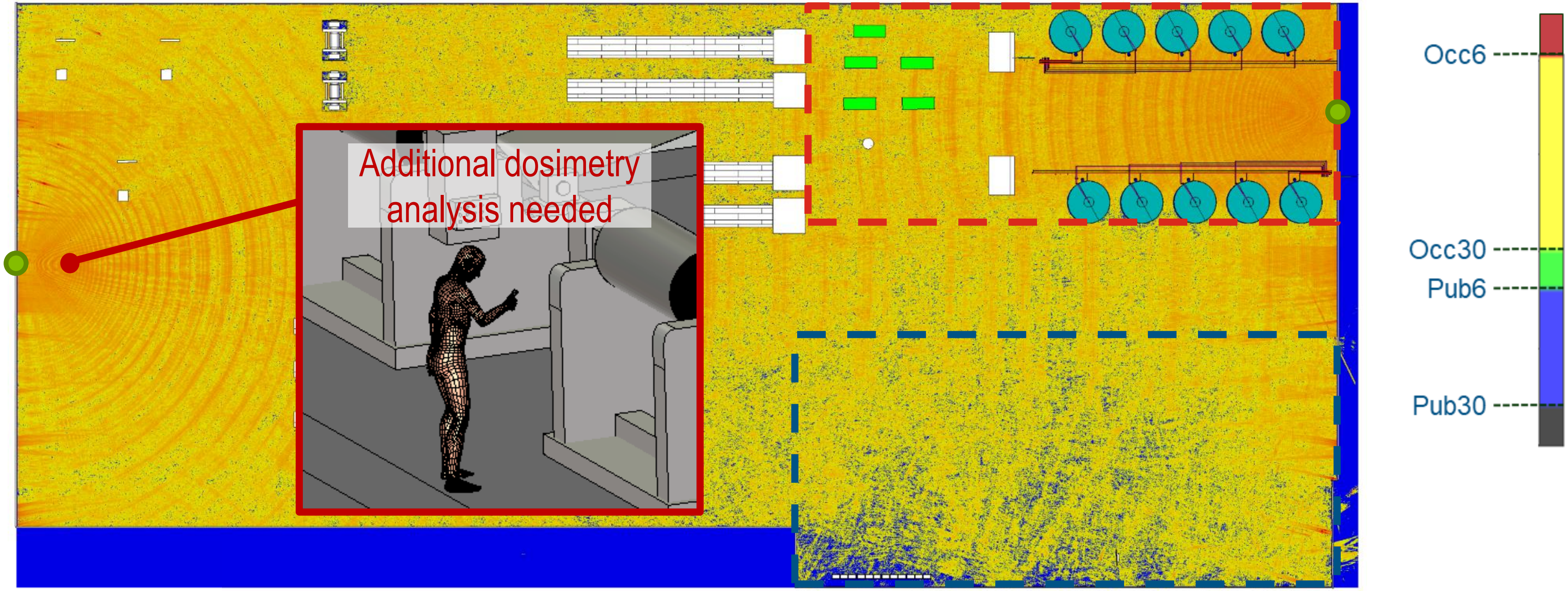
Electric field magnitude at 3.6 GHz at height of 1 m above factory floor

Wireless Access Point location

Areas of potential poor coverage

Indoor Network Coverage

Electric field magnitude at 3.6 GHz at height of 1 m above factory floor

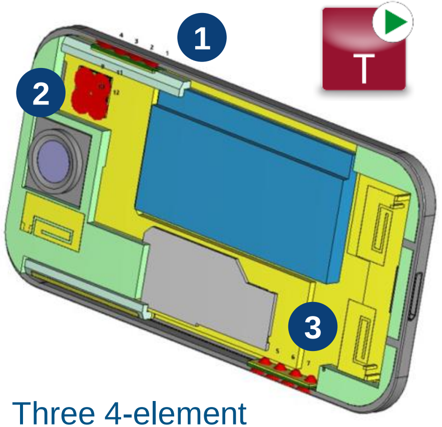


Wireless Access Point location

5G mm-Wave Antenna Postprocessing

5G mmWave CDF+sPD

Simulate all mm-wave ports



Three 4-element mm-wave arrays

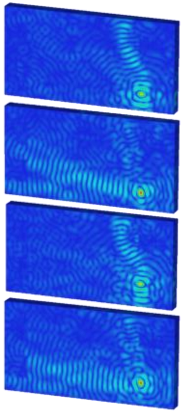
5G mmWave CDF+sPD

mmWave CDF+sPD

5G mmWave antenna cumulative distribution function and spatial-average power density

Element fields

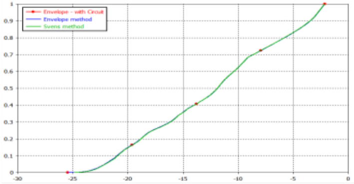
1.1
1.2
1.3
1.4

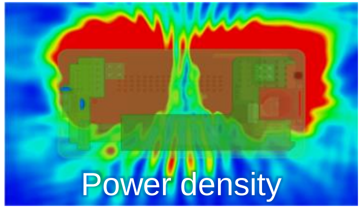


Codebook: beam set-up

```
+ tsp1 beam1 beam2 beam3
+ tsp2 beam4 beam5 beam6
#
! beam1
p1  module1 on  6   0    27.5
p2  module1 on  6   0    27.5
p3  module1 on  6   0    27.5
p4  module1 on  6   0    27.5
! beam2
p1  module1 on  6   0    27.5
p2  module1 on  8   45   27.5
p3  module1 on  8   90   27.5
p4  module1 on  6   135  27.5
! beam3
p1  module1 on  0   0    27.5
p2  module1 on  0   -45  27.5
p3  module1 on  0   -90  27.5
p4  module1 on  0   -135 27.5
! beam4
p1  module1 off 0   0    28.35
p2  module1 on  8   0    28.35
p3  module1 on  8   0    28.35
p4  module1 off 0   0    28.35
```

Outputs: TSP, CDF, EIRP





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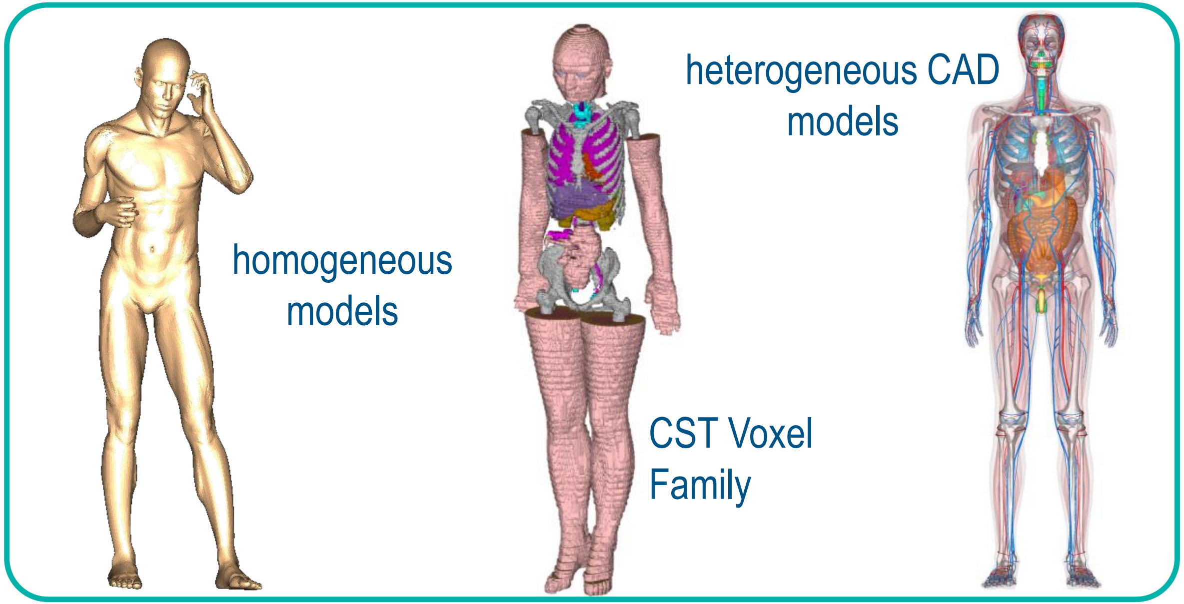
DASSAULT SYSTEMES

Human Simulation Models

The right choice of biological model is essential for the reliability of a medical simulation

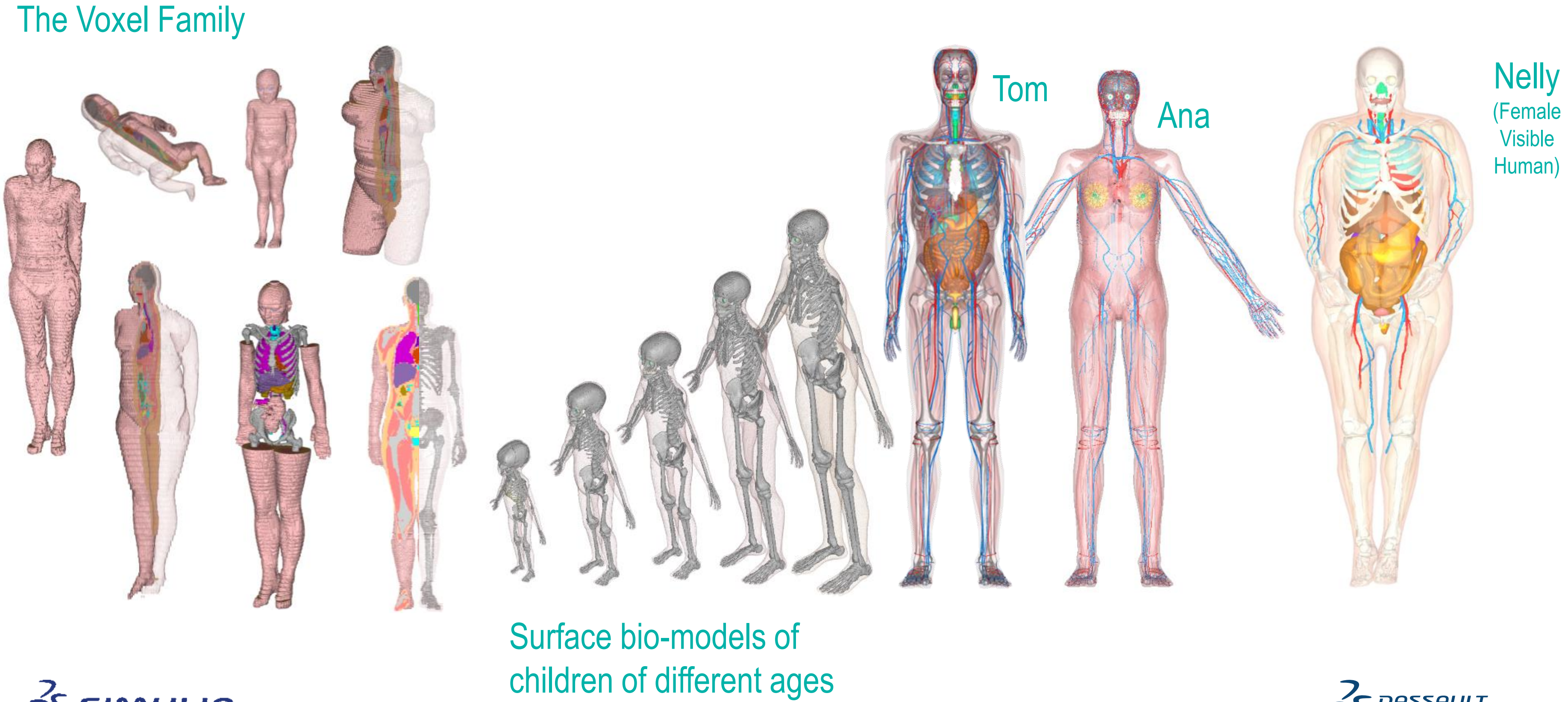
Anatomical details:



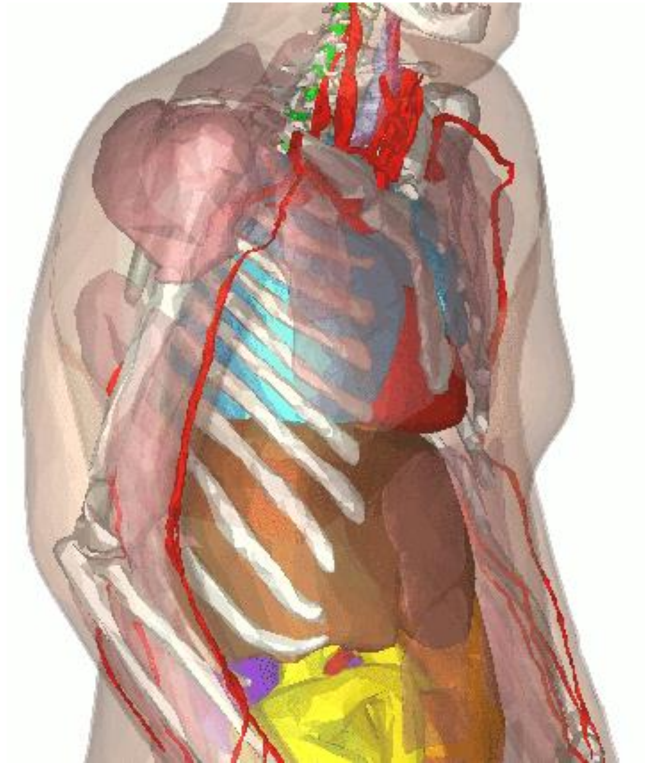
Material properties:

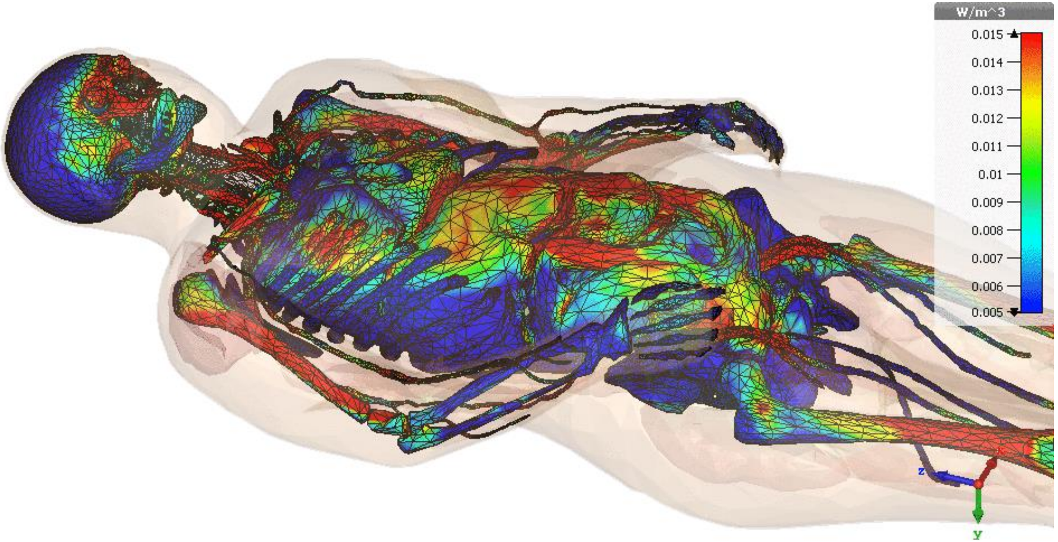
- Frequency dependent EM properties (Cole-Cole)
- Temperature dependent EM properties
- Temperature dependent thermal properties

Population Model Library



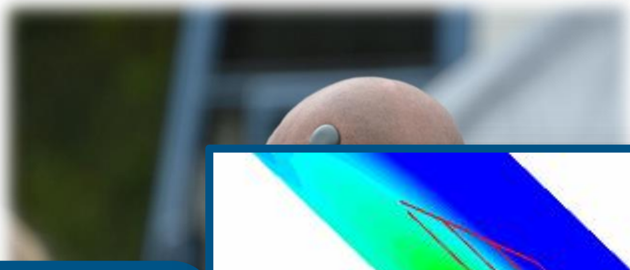
Female Visible Human – Breathing Sequence





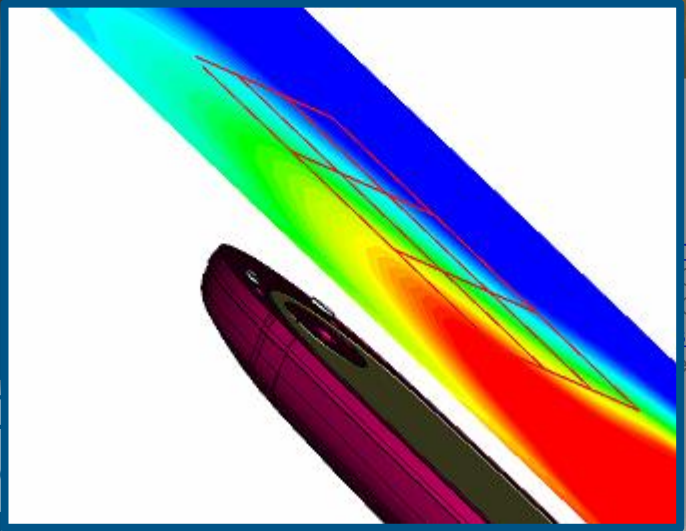
Power loss density @300 MHz due to plane wave front

Posable Ear for Tom Model & Cochlea

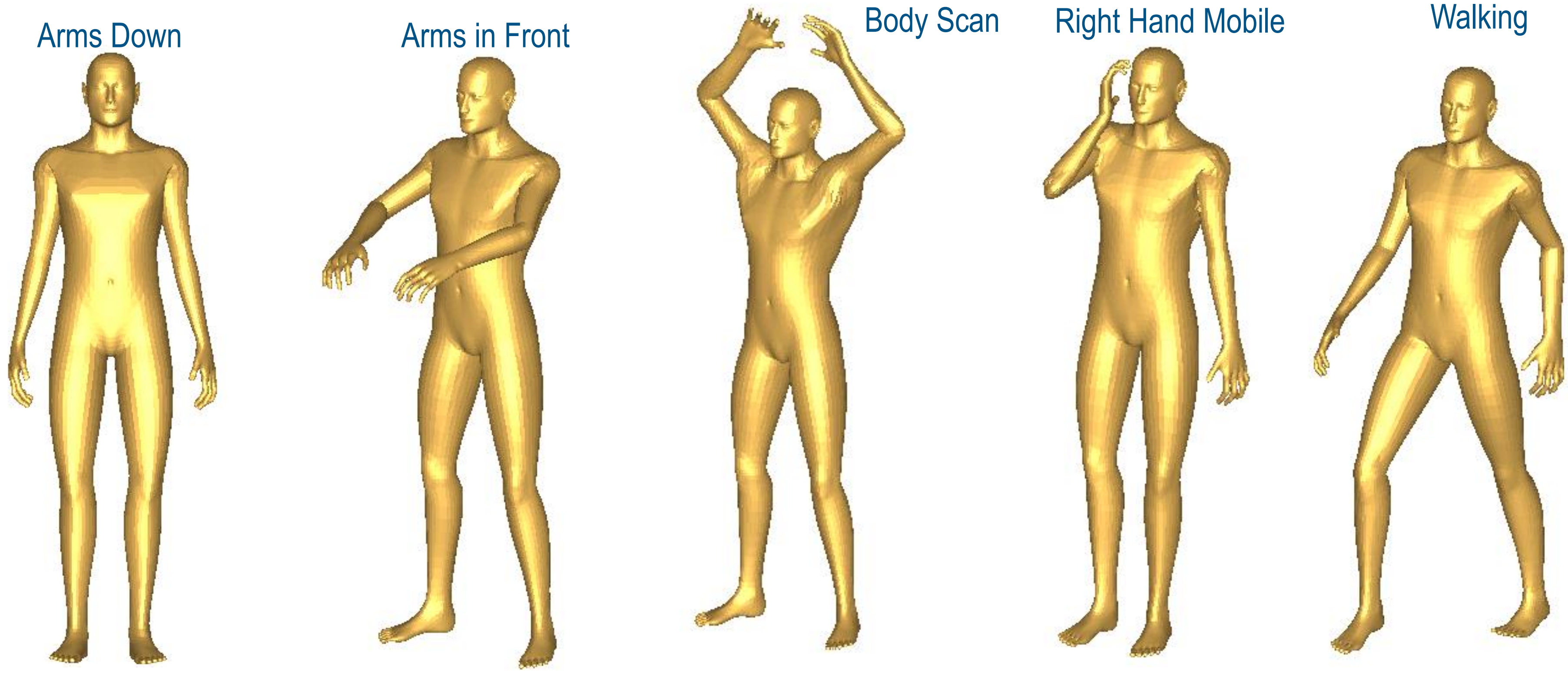


Hearing Aid Compatibility of Mobile Phone according to ANSI standards

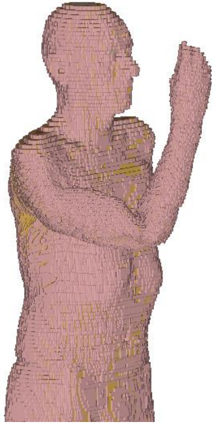
Hearing Aid D
simulations b
canal and det... cochlea models

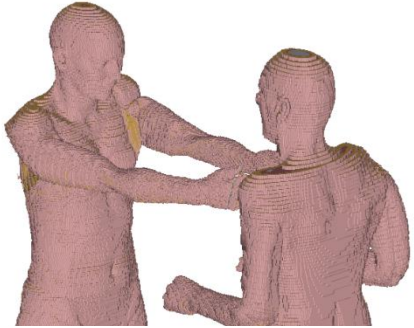


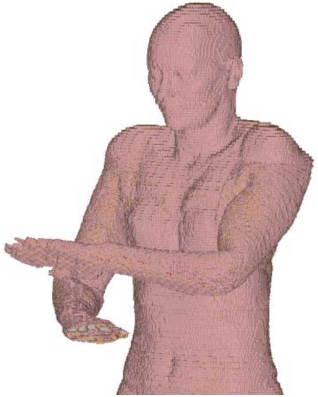
New Posed Homogenous Male Models

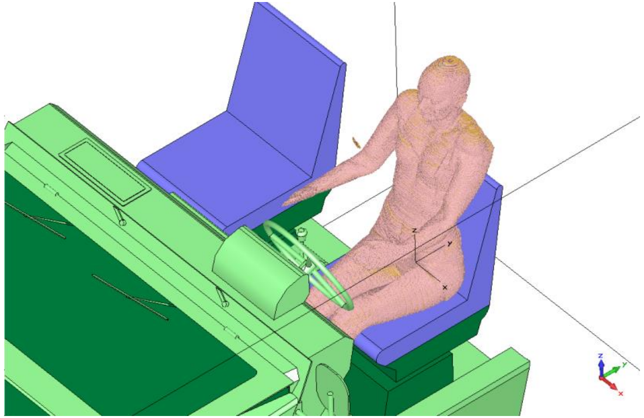


Voxel Model Posing



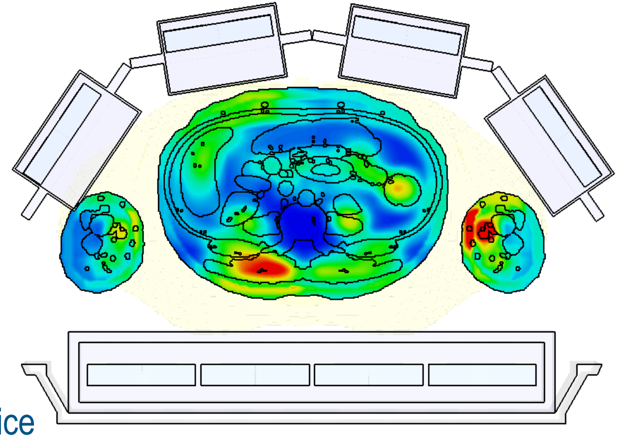


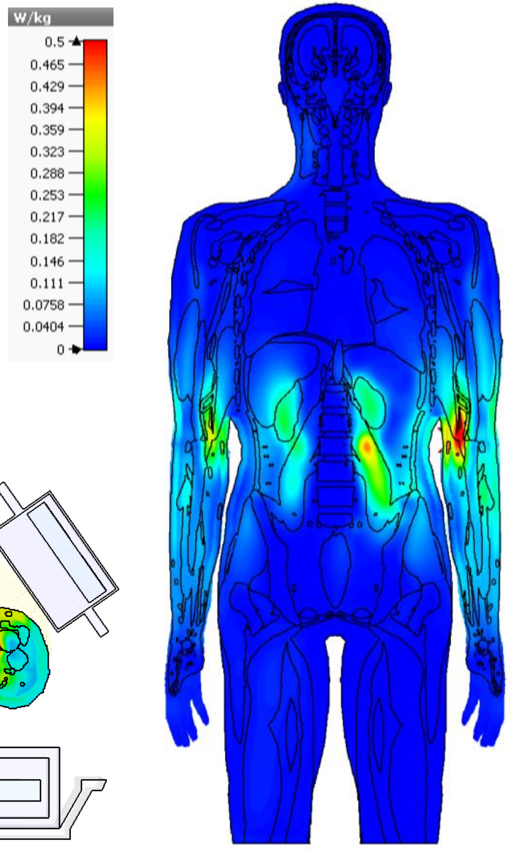




Specific Absorption Rate (SAR)

- Maximum **local SAR** located in left arm
  - SAR limit (extremities) = 20 W/Kg
  - Max. permissible input power P_{in} = 103 W
  - Input power scaled to SAR limit for subsequent temperature simulation
  - **Virtual Observation Points (VOP)** for real time SAR evaluation





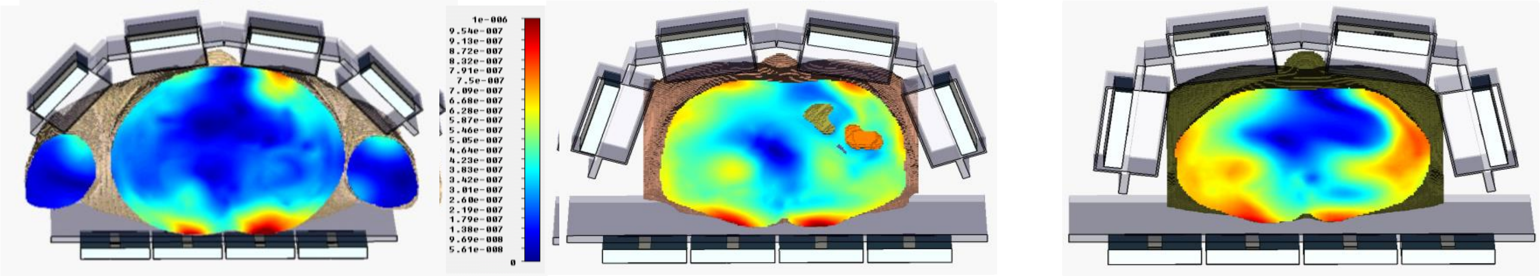
10g-averaged SAR in coronal and transversal slice

Images courtesy of Erwin L. Hahn Institute of MRI and DKFZ (German Cancer Research Center)

Simulation vs. Measurement

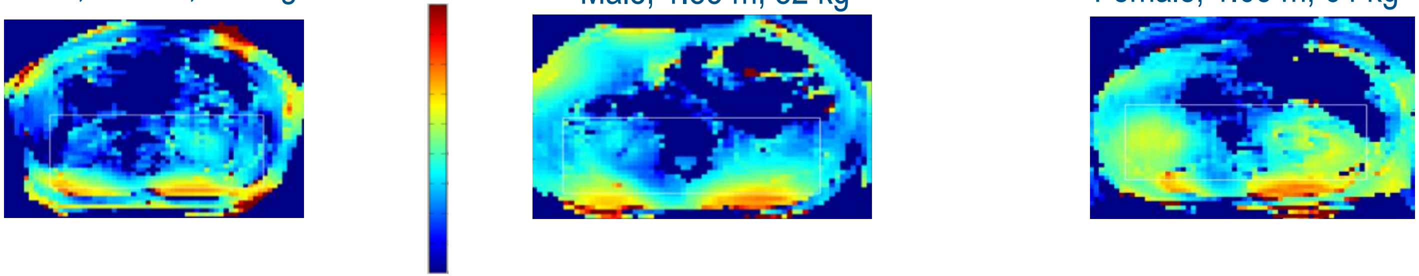
Simulated phase shims, |B1+|, in µT

Male, 1.85 m, 95 kg Male, 1.74 m, 70 kg Female, 1.6 m, 58 kg



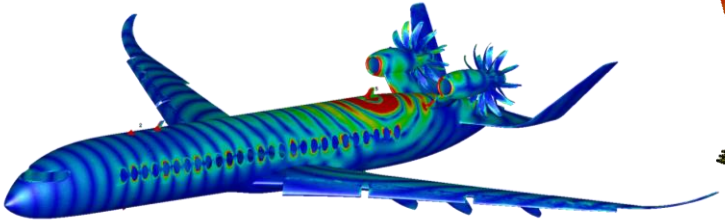
Measured actual flip angle distribution in degrees

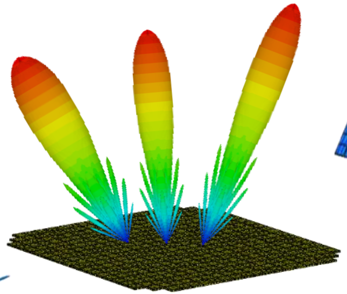
Male, 1.86 m, 100 kg Male, 1.83 m, 82 kg Female, 1.65 m, 64 kg

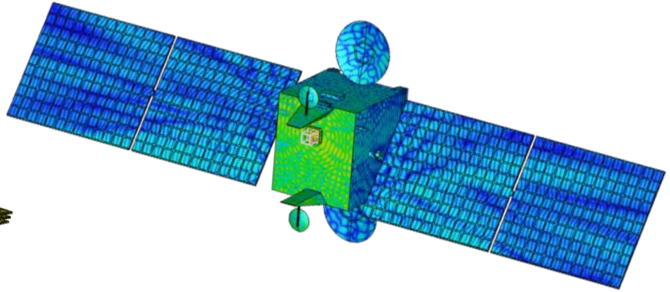


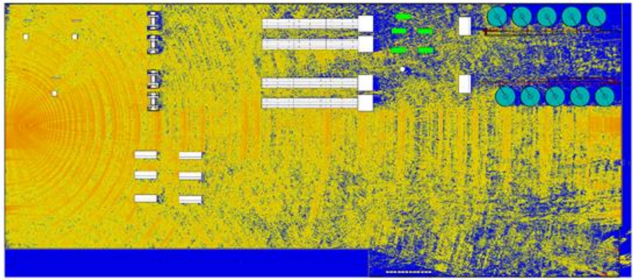
Images courtesy of Erwin L. Hahn Institute of MRI and DKFZ (German Cancer Research Center)

Summary



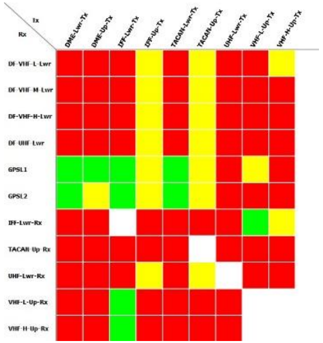


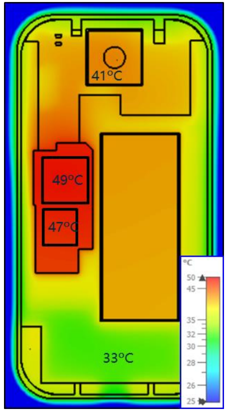




Network Coverage

Electromagnetic Dosimetry





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