Hybrid Simulation for Electrically Large Antenna Platforms

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2016-04-12

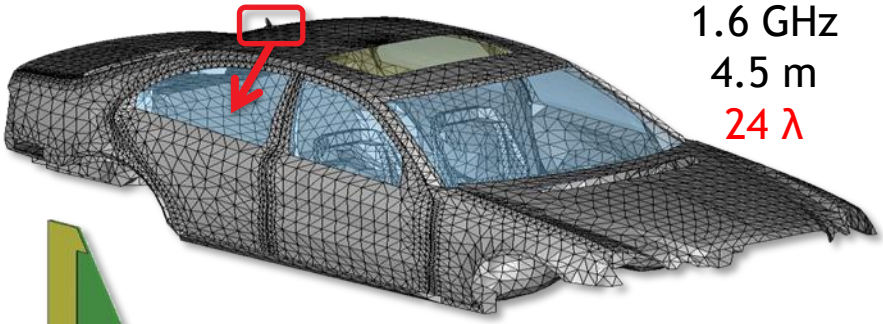
HITECH RF & Microwave solutions

CST

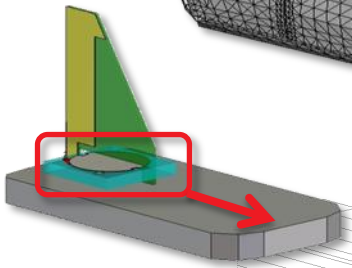
Outline

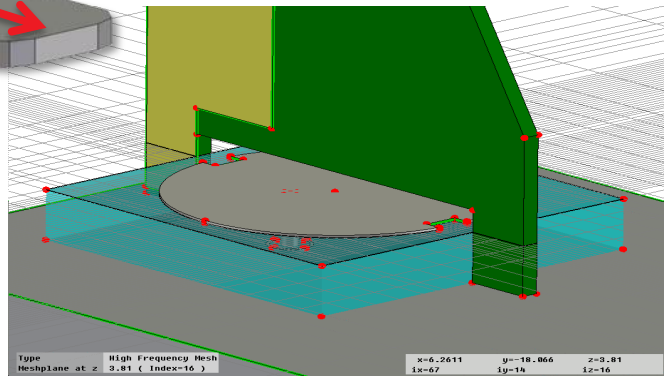
- Introduction to hybrid simulation
- Selected antenna platform examples
- Conclusions

The problem…

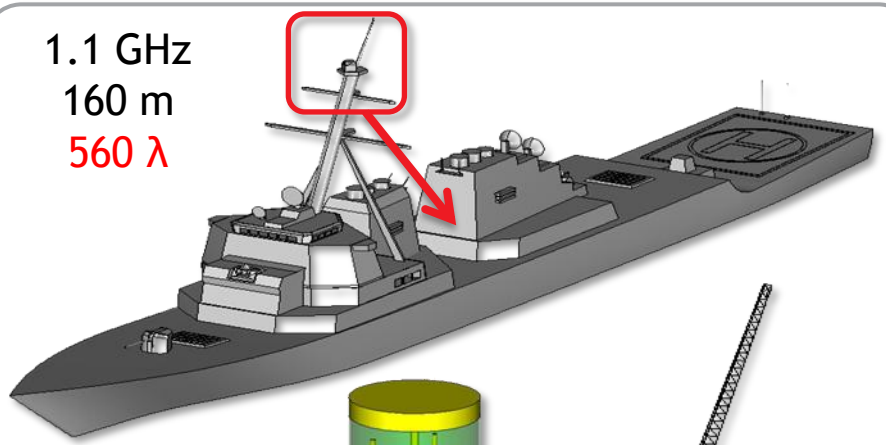


1.6 GHz
4.5 m
24 λ



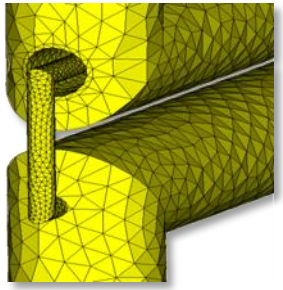


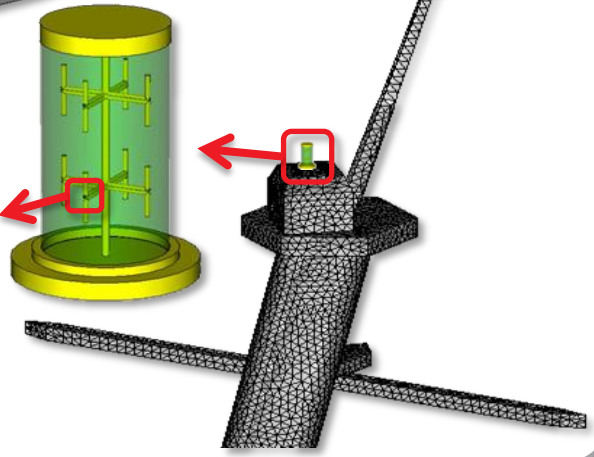
features:
1 mm



1.1 GHz
160 m
560 λ

features:
0.5 mm





A Range of Solvers…

CST MWS solver choice

Volumetric Mesh | Surface Mesh

Full Wave | Ray Tracing

Time Domain

FIT, TLM
Hexahedral Mesh
Conformal (PBA)

Frequency Domain

FEM
Tetrahedral Mesh
Curved

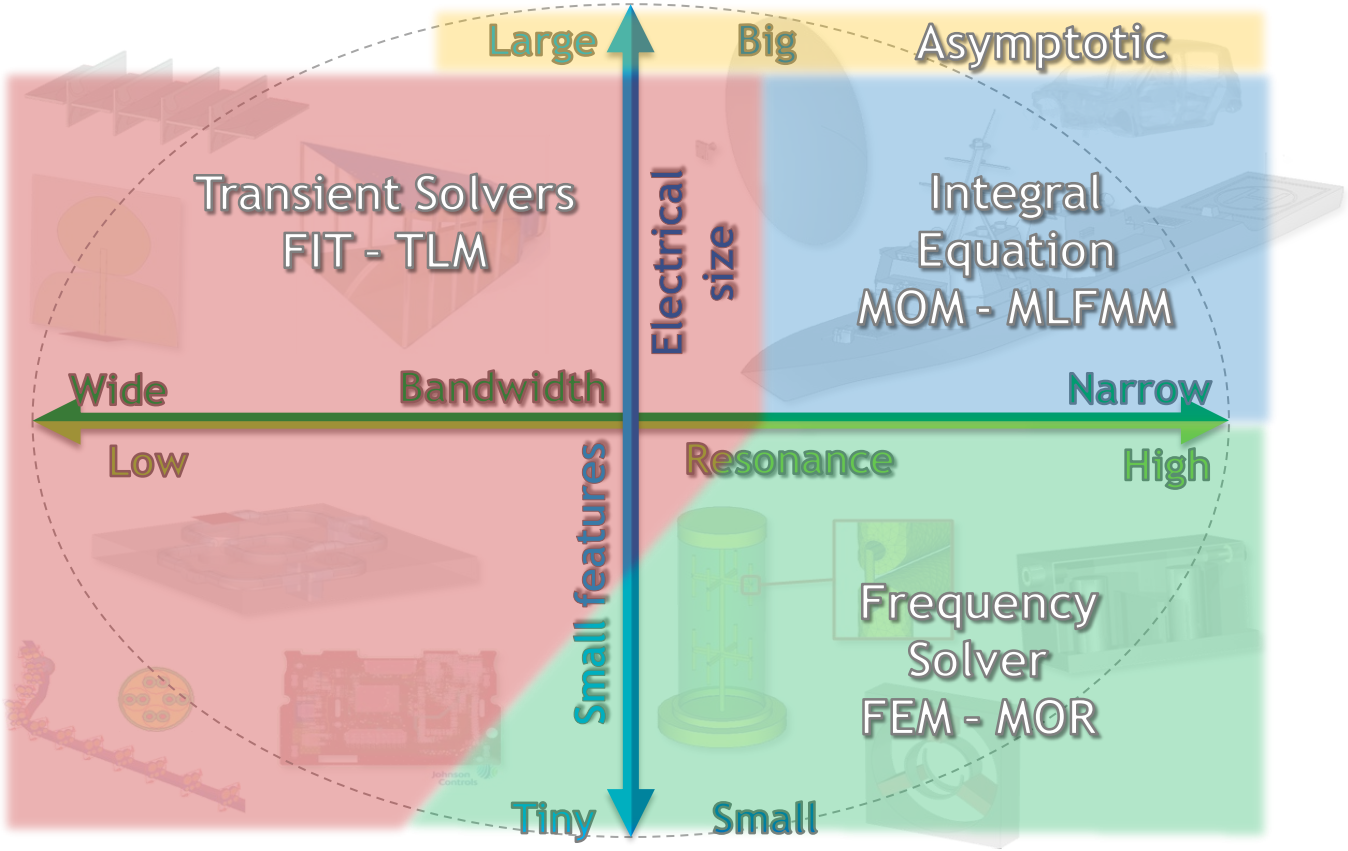
Integral Equation

MOM, MLFMM
Surface Mesh
Curved

Asymptotic Solver

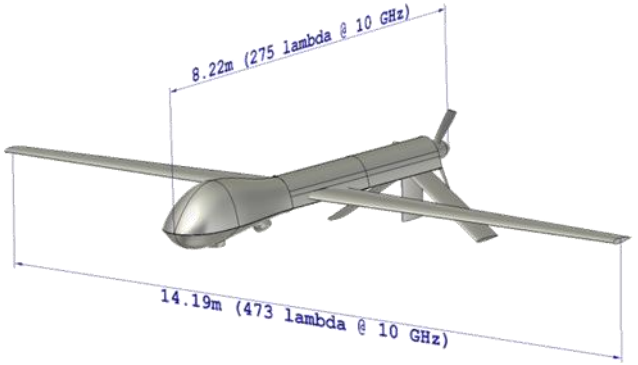
SBR
Surface Mesh
Curved

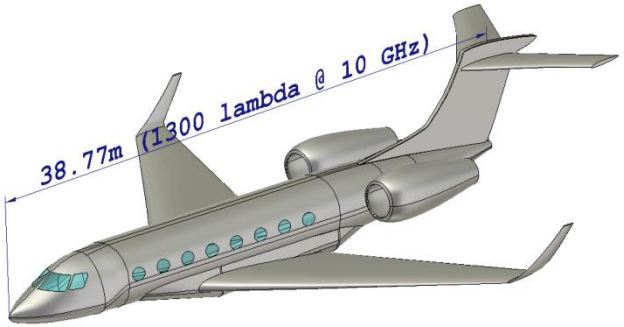
…for a Range of Applications



Platform Electrical Size

	MoM			MLFMM	
El. Length	F	I	T	I	A
1λ	↓	↓	↓		
10λ				↓	↓
100λ					
1000λ					
10000λ					

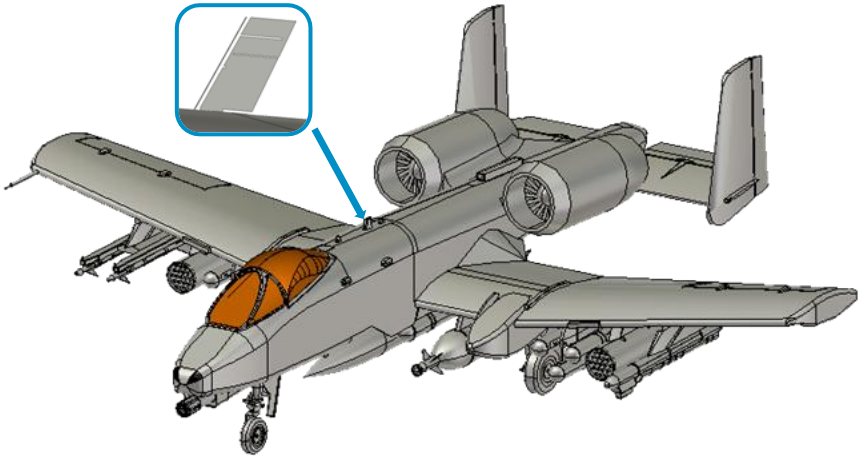




1. Installed Antenna Scenario

2 GHz blade antenna positioned on aircraft

2 GHz
17.4 x 4.5 x 16.2 m
116 x 30 x 108 λ
375,840 λ^3

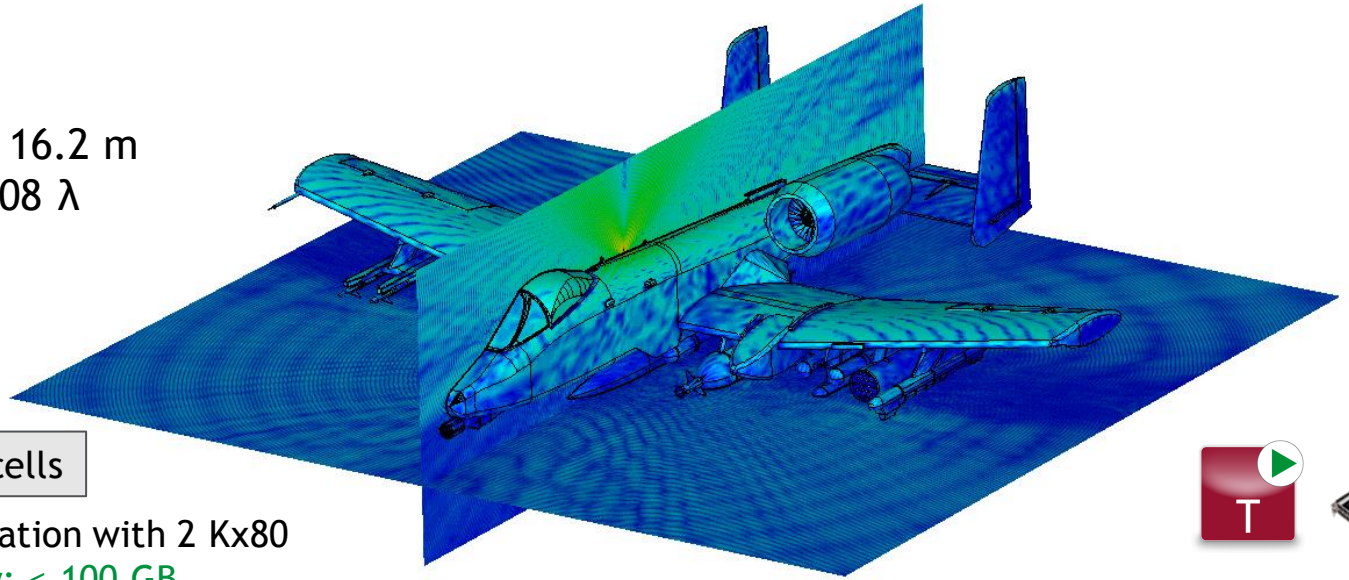


660 million cells

1. "Brute Force" Simulation

2 GHz blade antenna positioned on aircraft

2 GHz
17.4 x 4.5 x 16.2 m
116 x 30 x 108 λ
375,840 λ^3

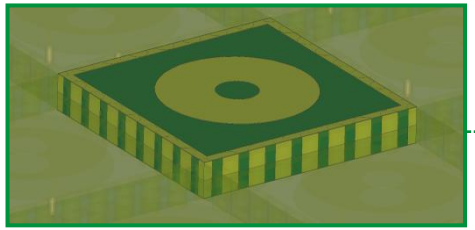


660 million cells

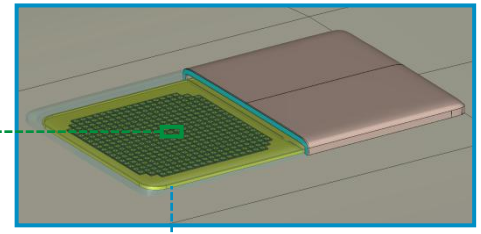
Single workstation with 2 Kx80
Total memory: < 100 GB

Broadband calculation time ~ few hours

2. What if the challenge increases?



element: fine geometry



array(s): 100s of elements

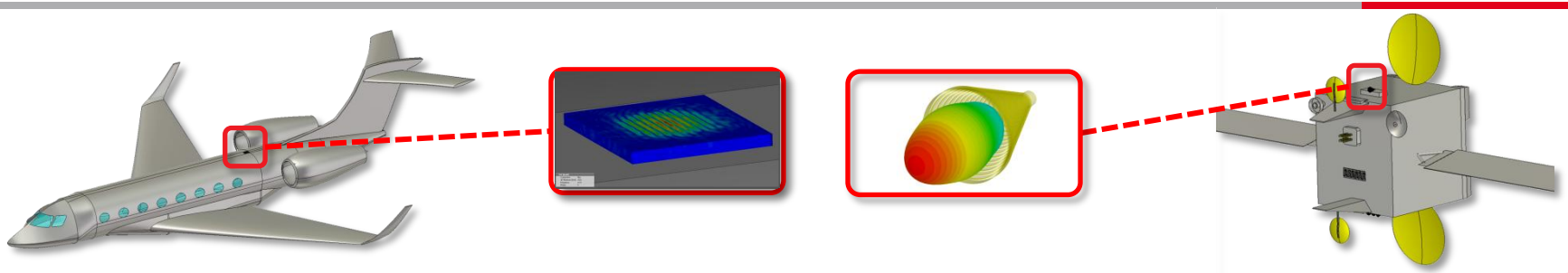
via

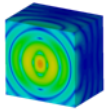
Impossible to simulate using only one solver!

aircraft length = 42.6 m
(>2000 λ @ 14.5 GHz)

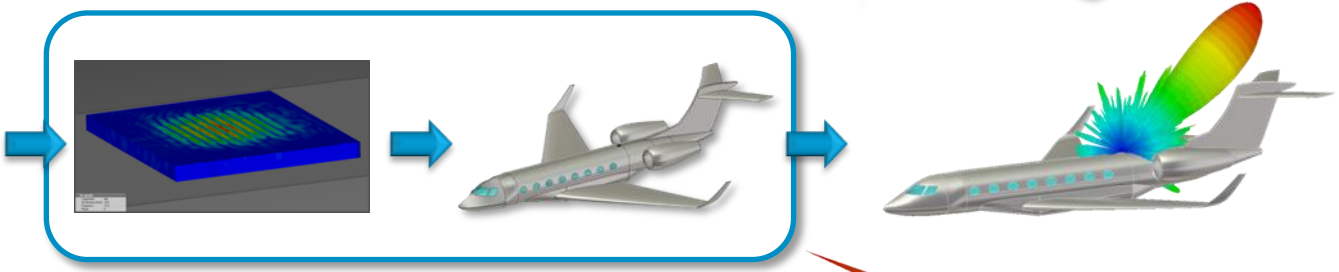
Several hundred billion cells

Hybrid: sMALL → BIG

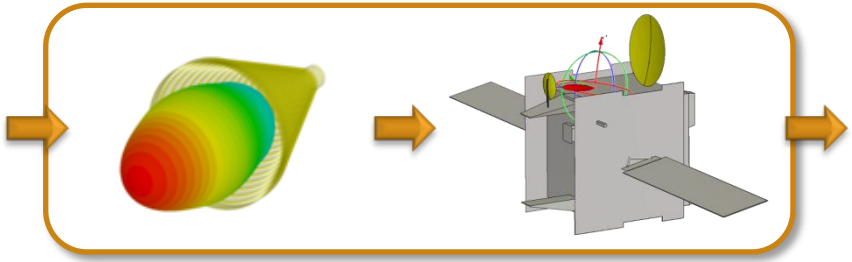


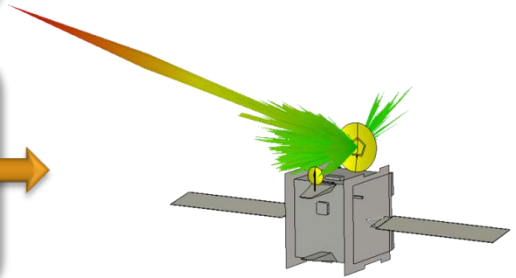


near field source
(equivalence principle)



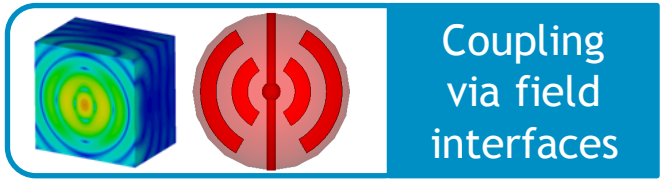
farfield source

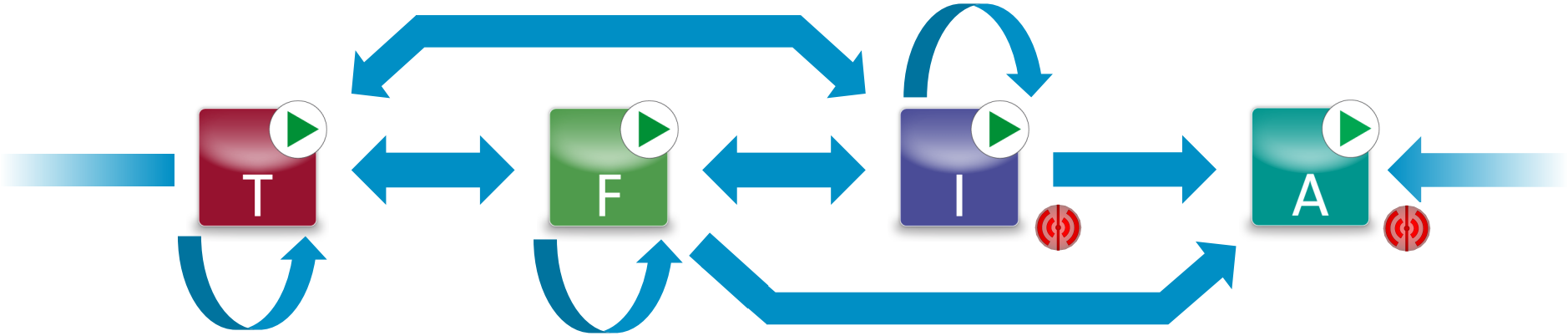




CST MWS Solver "Coupling"

1. Combination of different solvers.

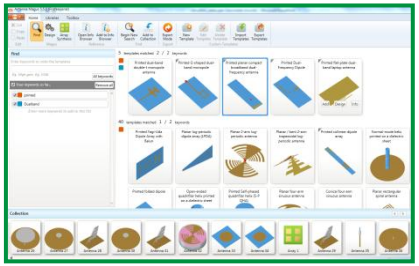




2. Loop over the same solver.

Antenna Placement Workflow

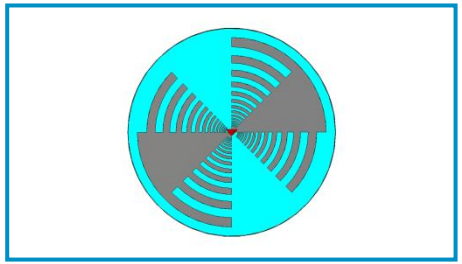
Antenna choice/synthesis



Of interest:

- Antenna Specifications
  - Operating frequency
  - Farfield
  - …
- Suitable topologies

Antenna simulation



Of interest:

- Integration with other antennas
- Matching circuit
- Radome

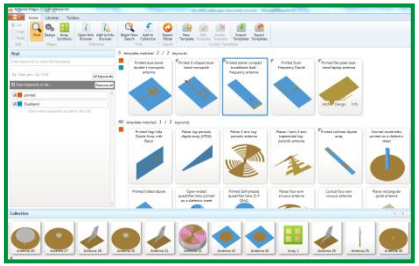
Antenna placement

Of interest:

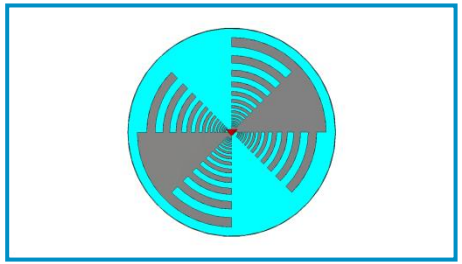
- Installed farfield
- Coupling with other antennas
- Nearfield calculation

Antenna Placement Workflow

Antenna choice/synthesis



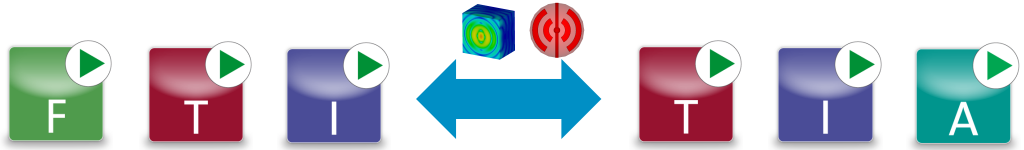
Antenna simulation



Antenna placement

Different tool/solvers available at each stage…

AntennaMagus

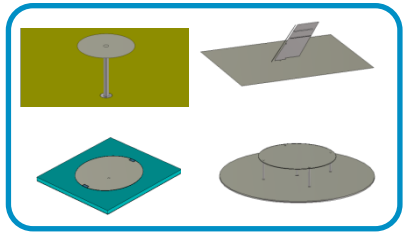


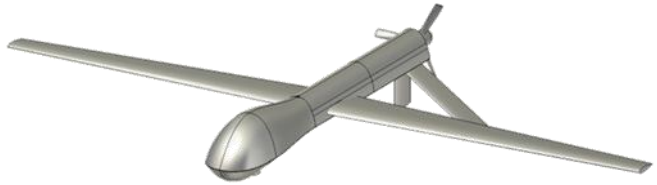
Outline

- Introduction to hybrid simulation
- Selected antenna platform examples
- Conclusions

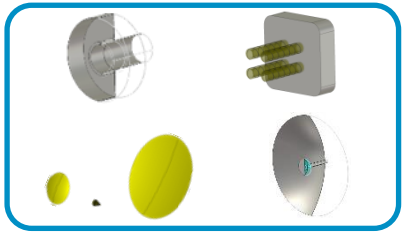
Three Installed Antenna Examples

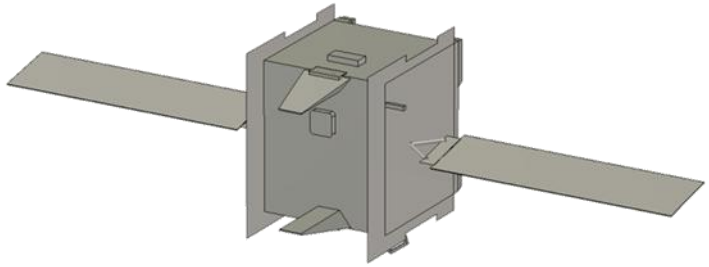
1. UAV



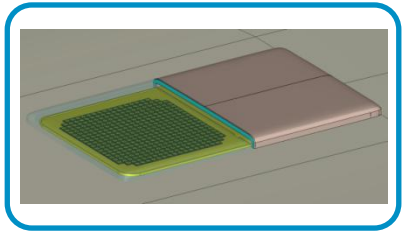


2. Satellite



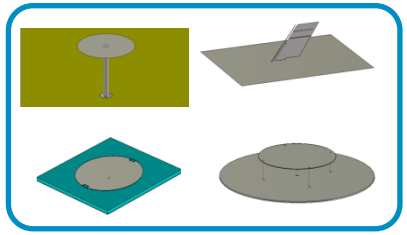


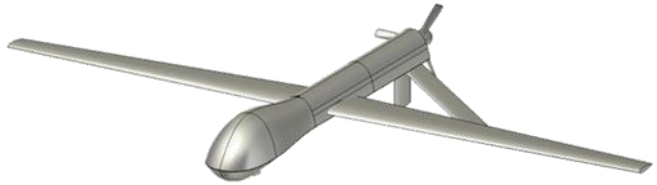
3. Aircraft



Three Installed Antenna Examples

1. UAV





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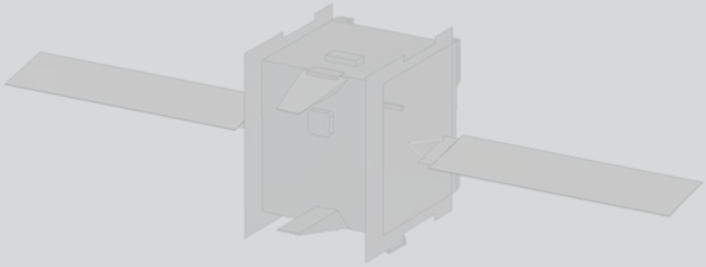

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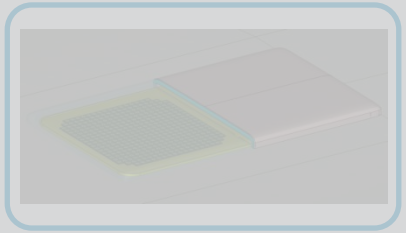
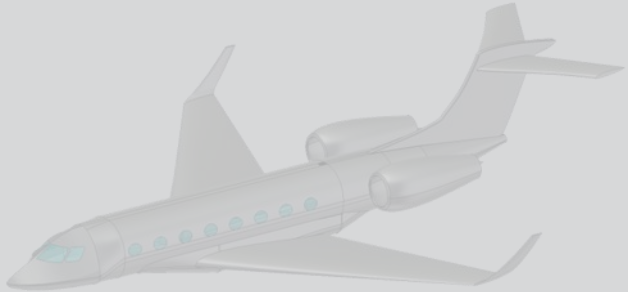




UAV Possible Scenarios

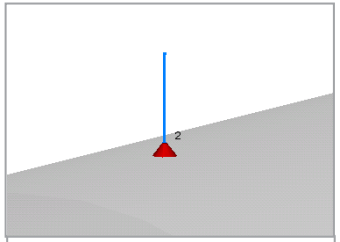
a) Antenna placement @ lower frequencies

+ Simple antenna topologies (easy to build from scratch).
+ EM problem not electrically large.

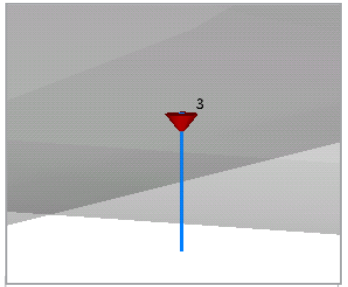
b) Antenna placement @ higher frequencies

– More complex antenna topologies (more difficult to build from scratch).
– EM problem electrically large.

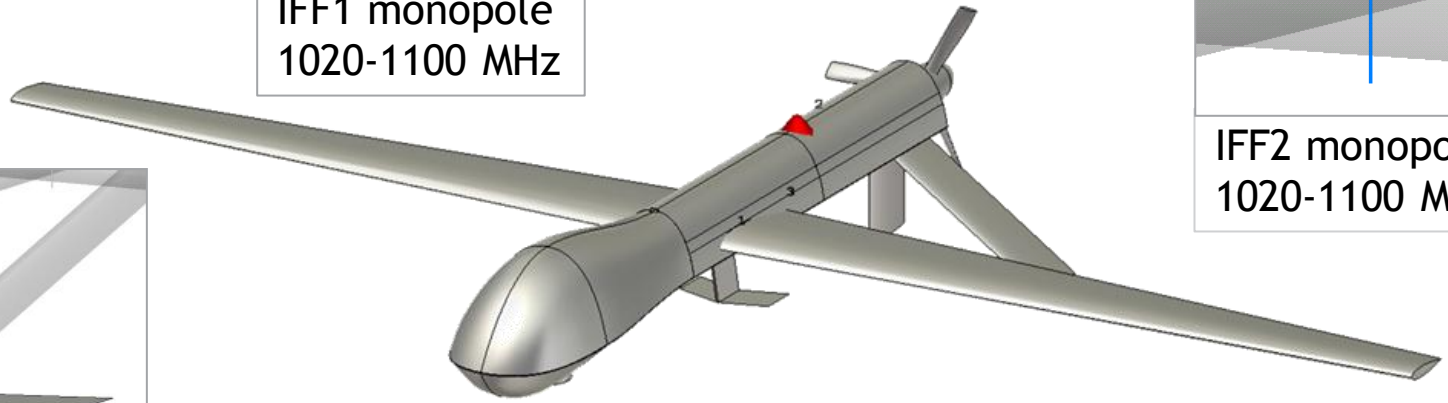
a) Lower Frequencies

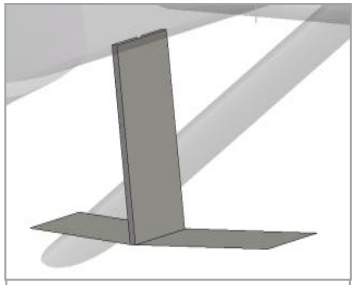


IFF1 monopole
1020-1100 MHz



IFF2 monopole
1020-1100 MHz



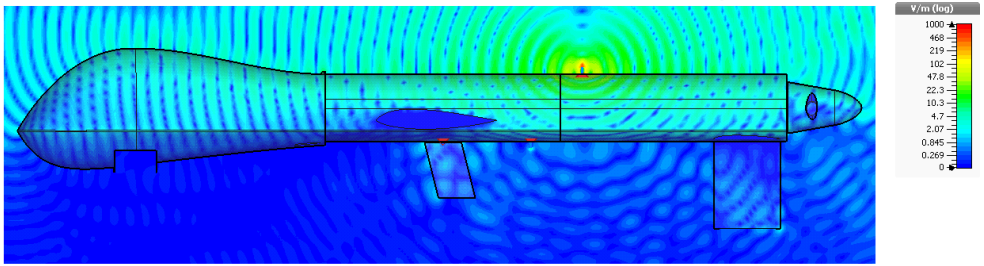


VHF blade
30-100 MHz

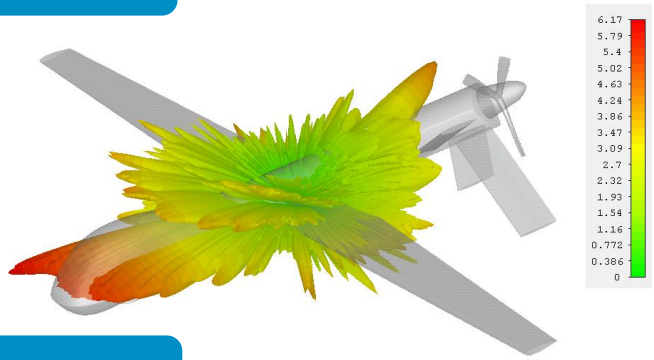
Excitation: Lumped ports @ 50 Ohm

Brodband Analysis using FIT

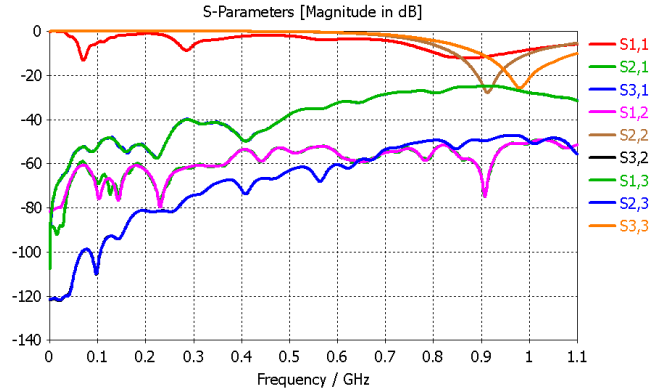
Calculation time ~ 7min



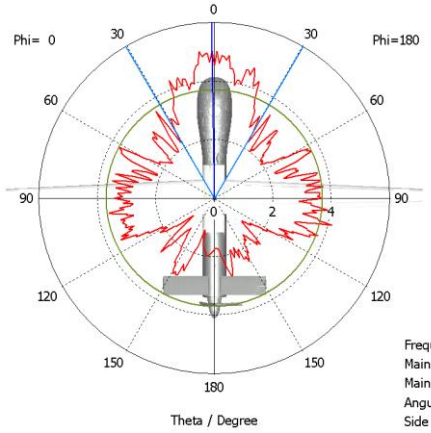
E-Field @ 1.06 GHz (IFF1)



Farfield @ 1.06 GHz (IFF1)



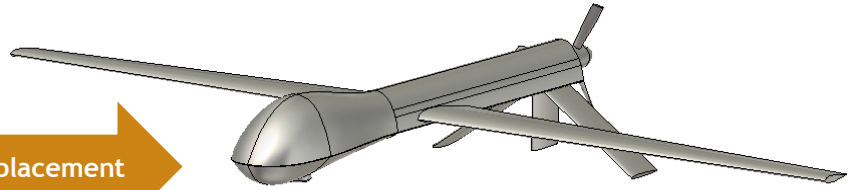
Polar plot with structure overlay



b) Higher Frequencies

	Antenna specification	Frequency [GHz]
1	TACAN	1.08
2	GPS	1.575
3	Communication	1.8
4	SATCOM (UHF)	2.3

placement

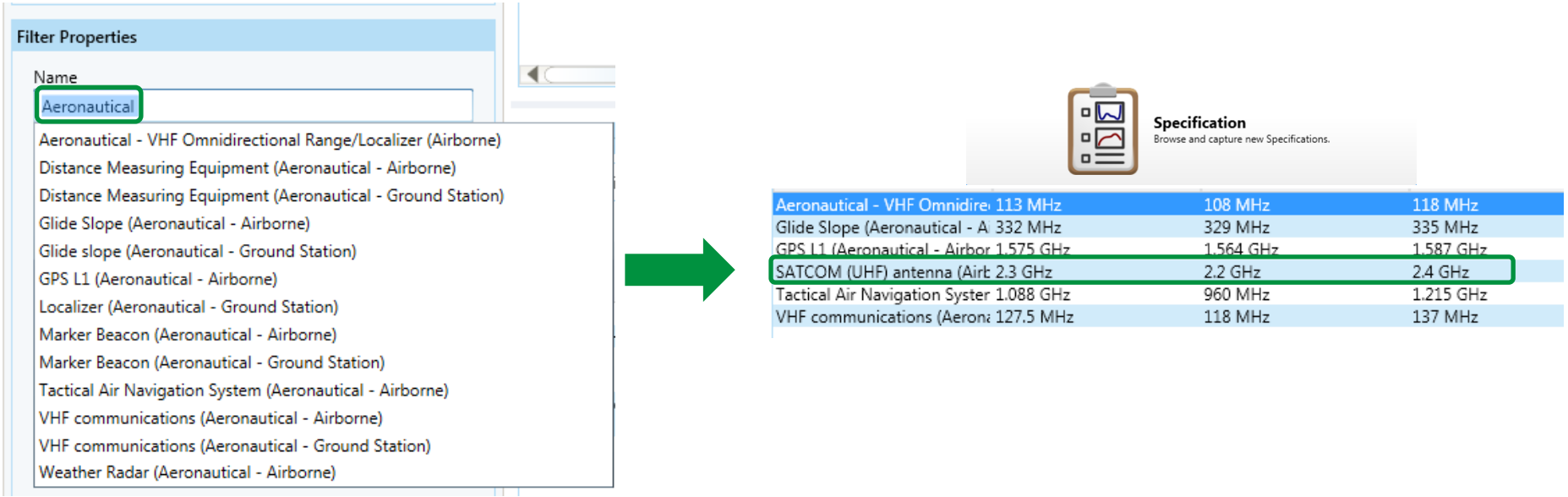


Antennas from 3rd party → **CAD of the antennas not available!**

Solution 1 → AntennaMagus (extract representative antennas)

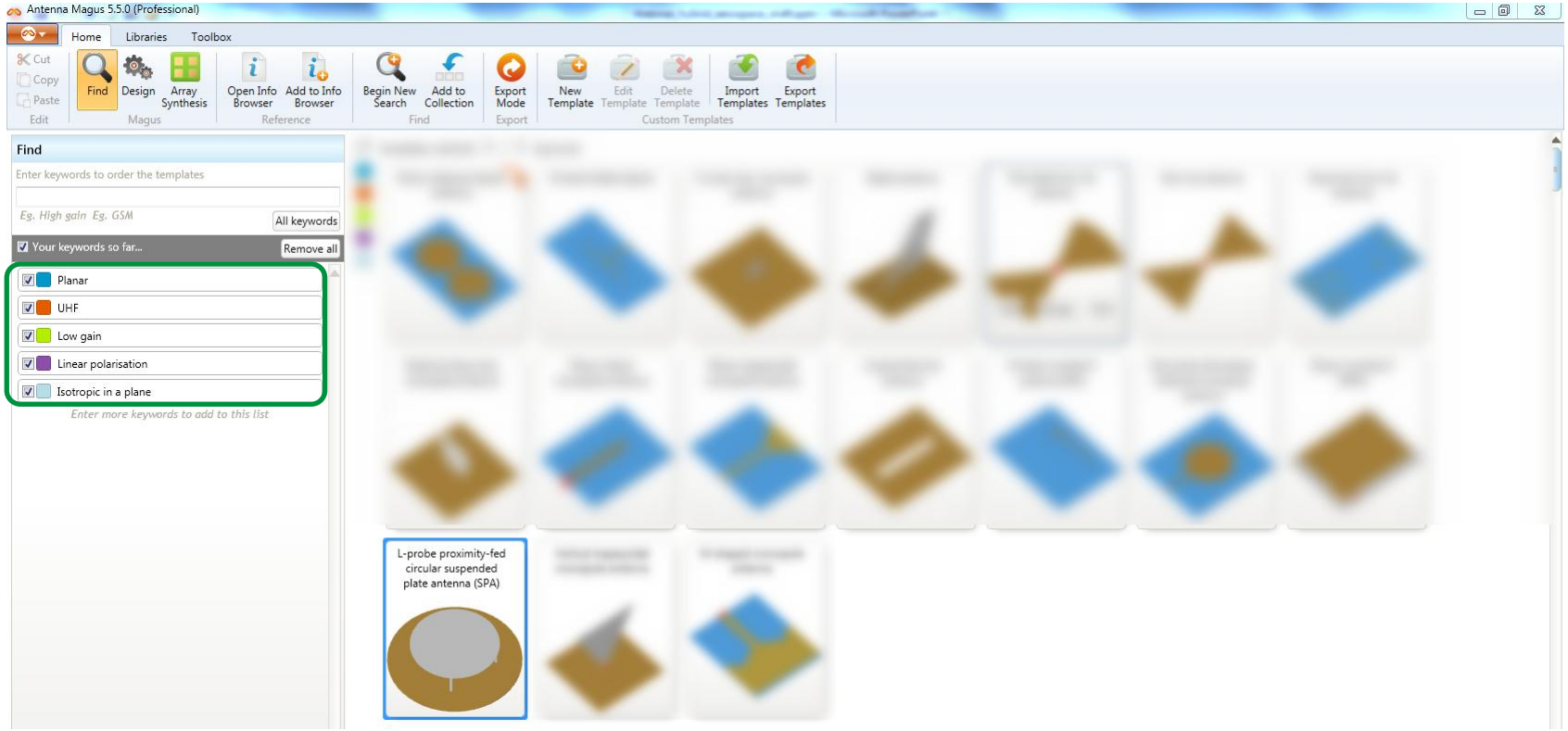
Solution 2 → Use antenna measured data (i.e from MVG).

Specification Library

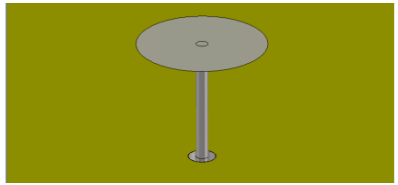
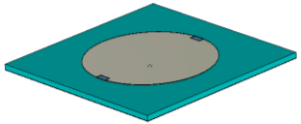
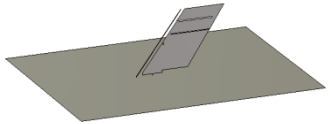
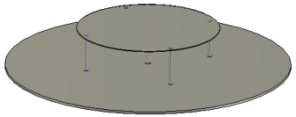


- A lot of predefined "Aeronautical" antenna specifications.
- Specifications can be used to look for suitable antenna topologies inside Antenna Magus database.

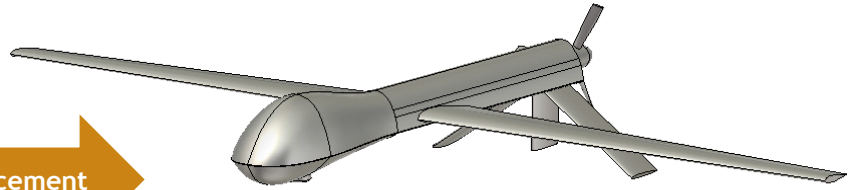
SATCOM Antenna Topologies



4 Parametric Antenna Models + UAV

1	TACAN	
2	GPS	
3	Communication (1.8 GHz)	
4	SATCOM (UHF)	

placement

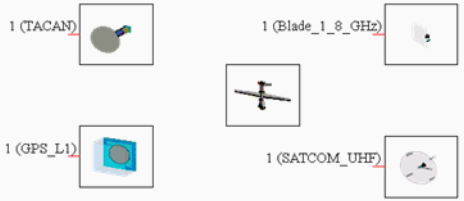


Extra requirements:

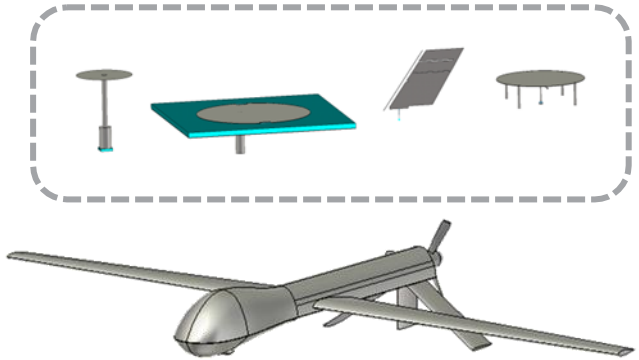
- Keep geometrical parameters of each single project.
- Place the antennas on predefined (parametric) positions.

System Assembly and Modelling

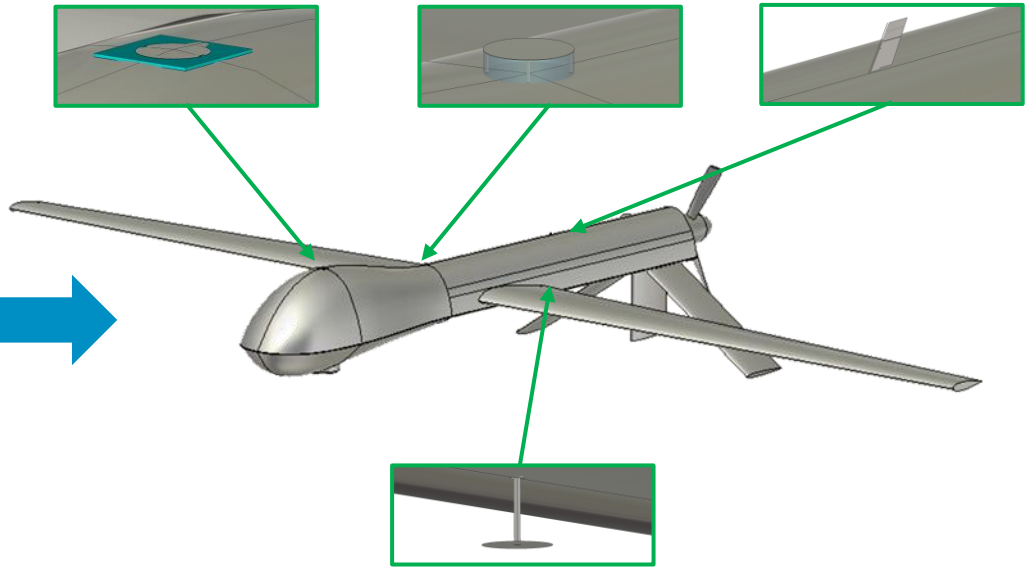
Schematic



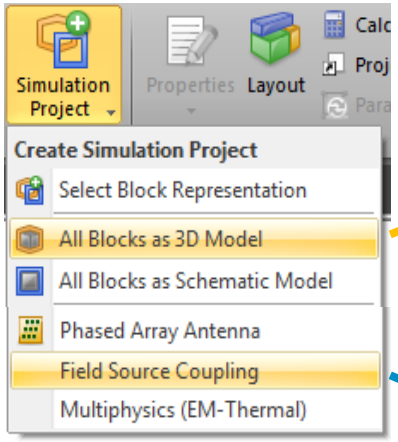
3D Layout



3D Layout
(aligned antennas using anchor points)



Setup of Simulation Projects



Option 1

Brute force approach

MLFMM

Option 2

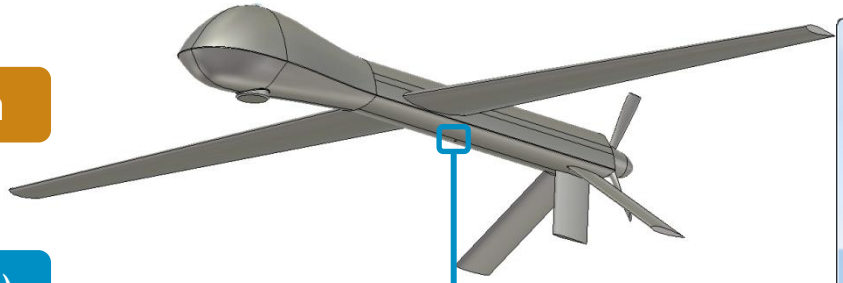
Field decomposition approach

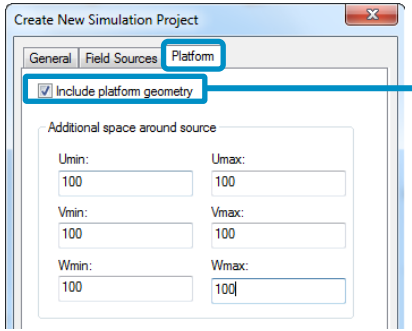
Installed Antennas using SAM FSC

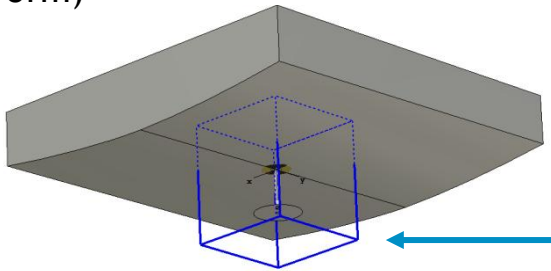
1. Platform

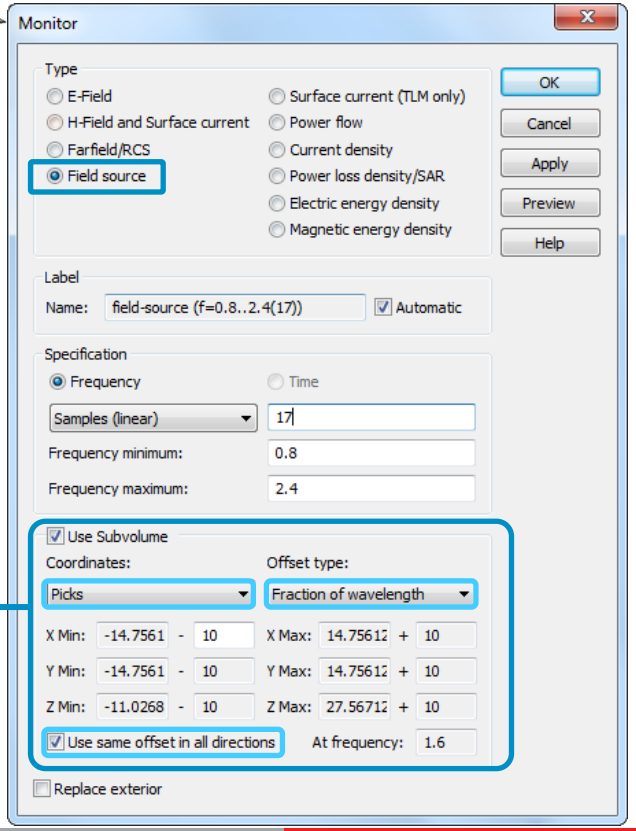
2. Source(s)

(including part of the platform)









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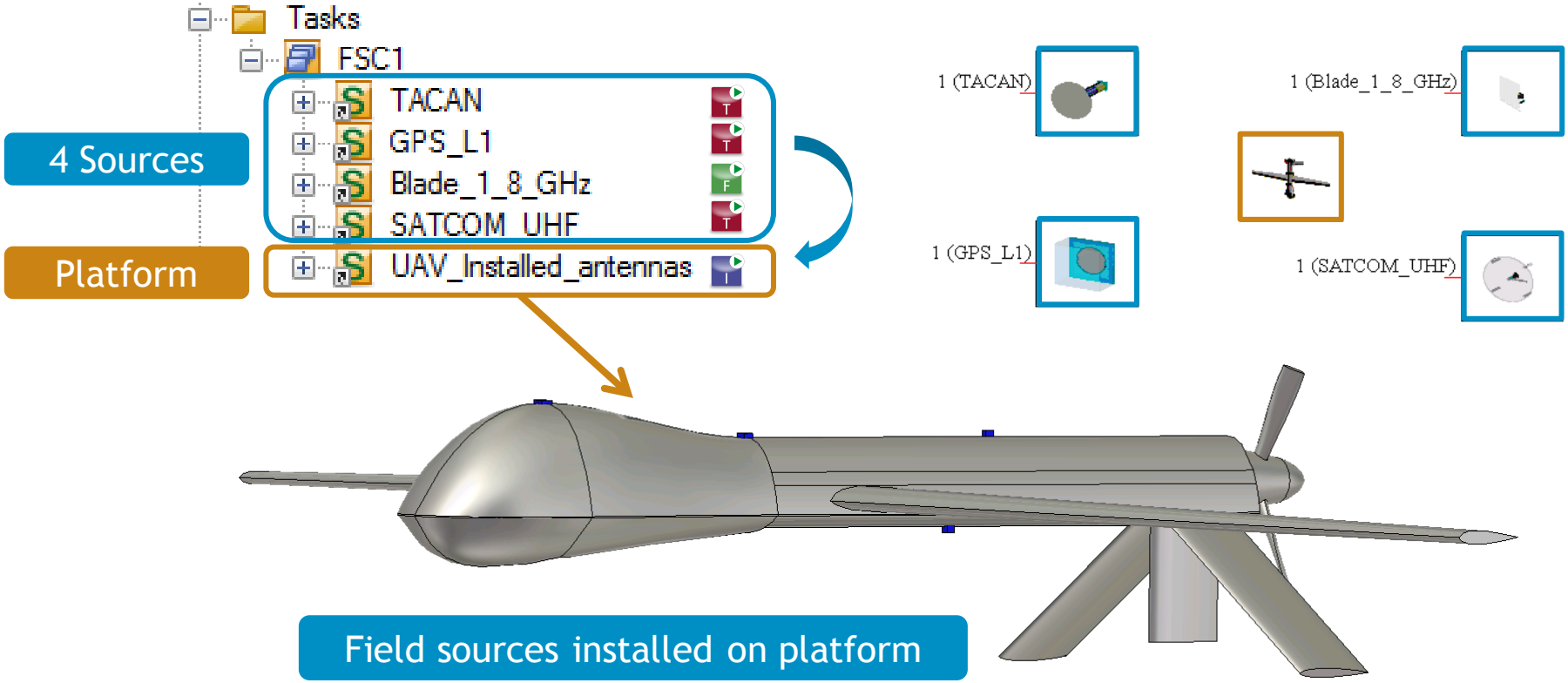
New Feature 2016

Installed antennas on UAV

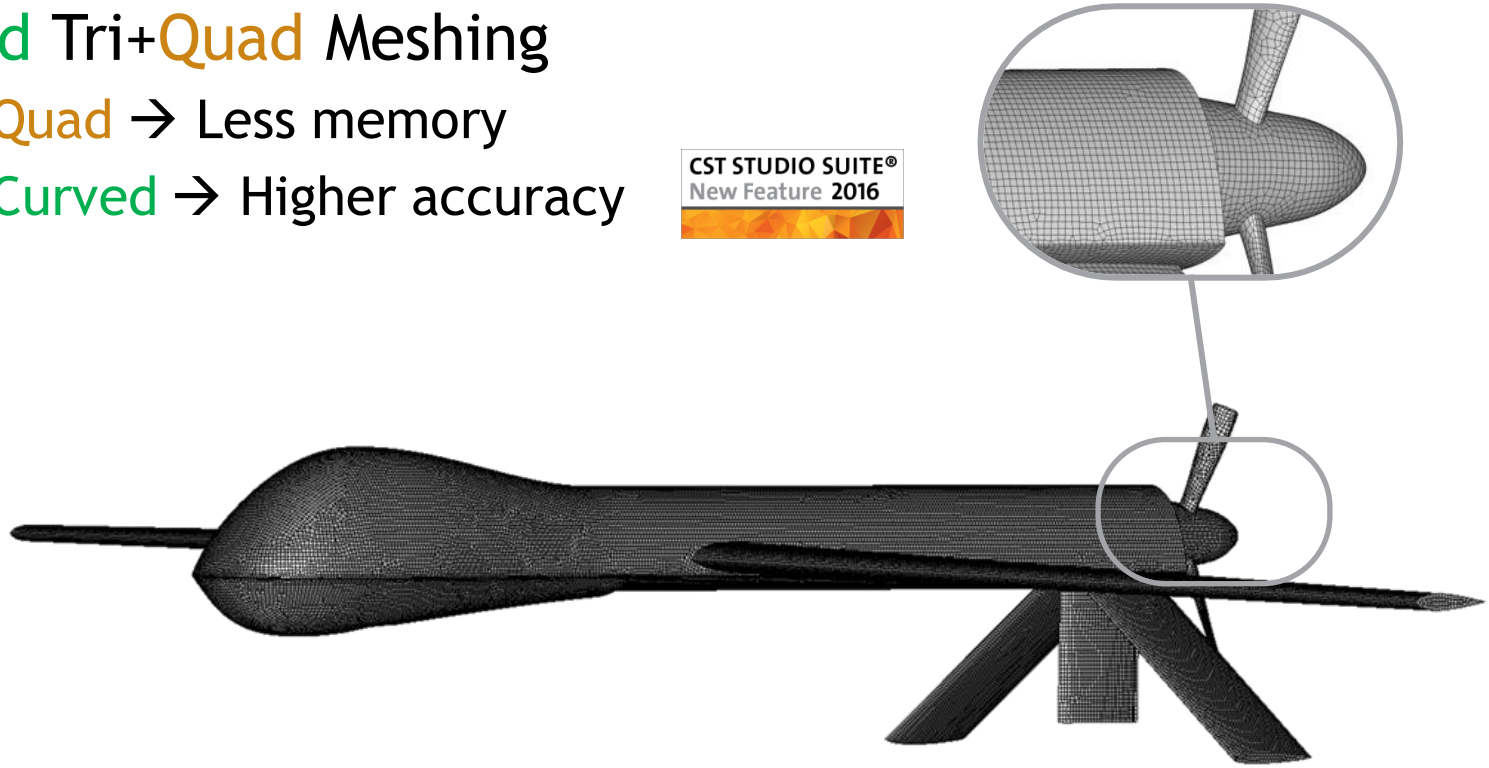


Surface based meshing

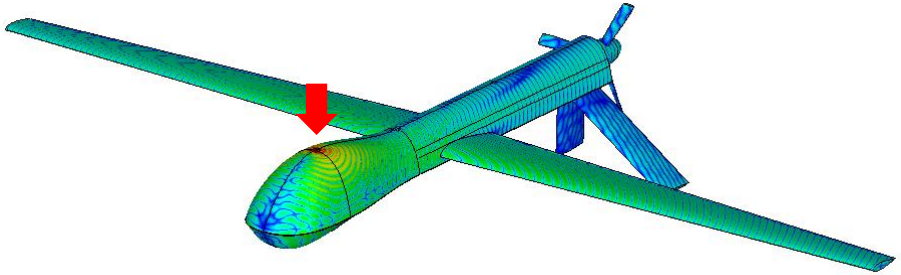
Curved Tri+Quad Meshing

- Quad → Less memory
- Curved → Higher accuracy

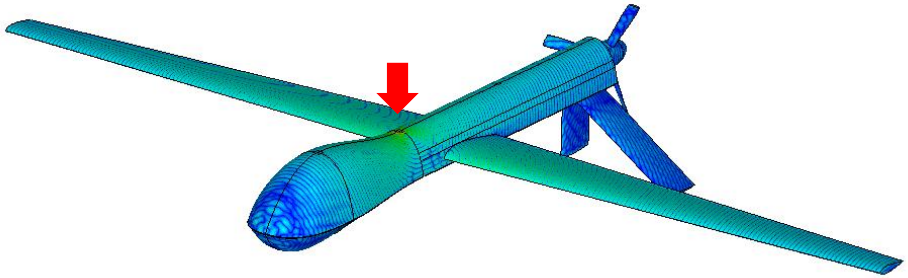
CST STUDIO SUITE®
New Feature 2016



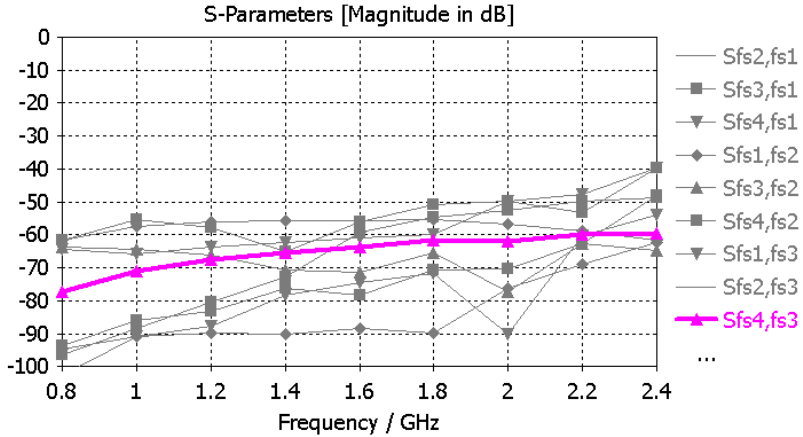
Available outputs



E-Field @ 1.575 GHz (GPS)



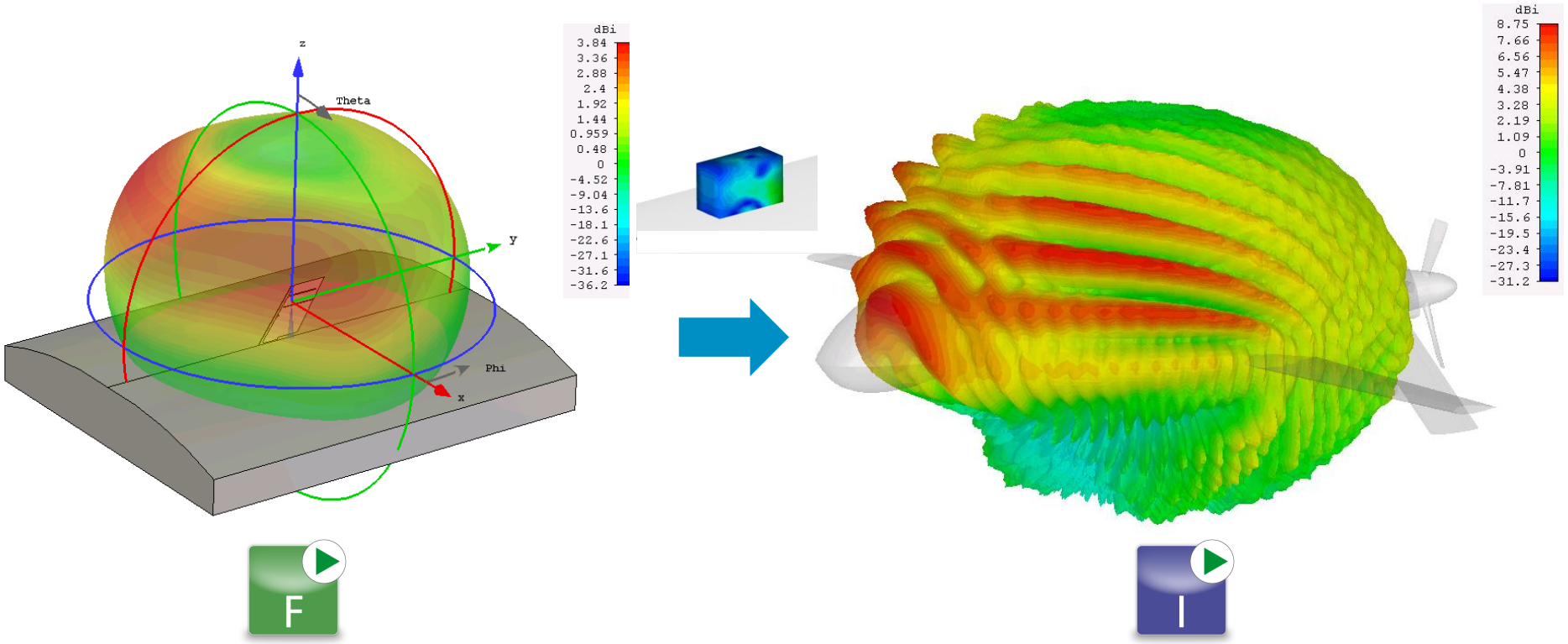
E-Field @ 2.3 GHz (SATCOM)



Broadband antenna to antenna coupling

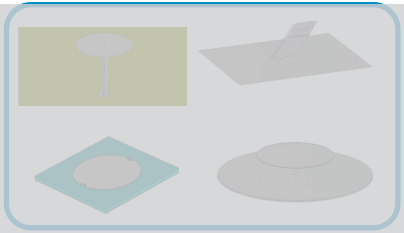
GPS (fs3) → SATCOM (fs4)

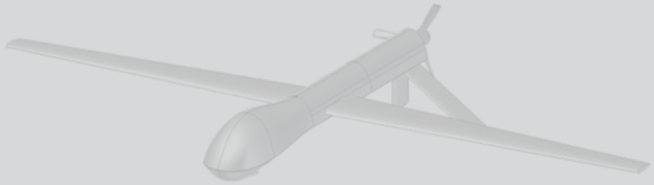
Installed farfield @ 1.8 GHz



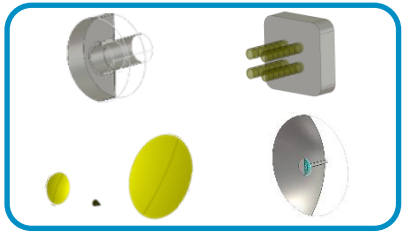
Three Installed Antenna examples

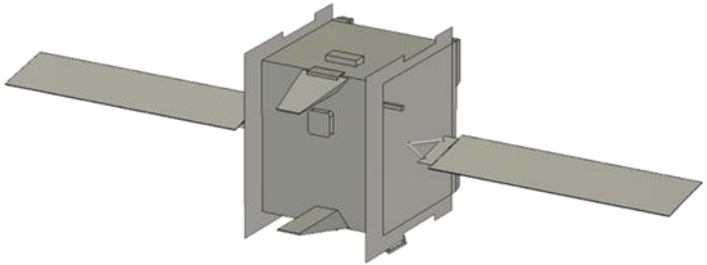
1. UAV



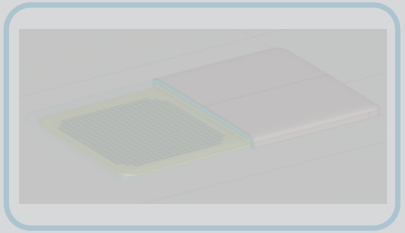


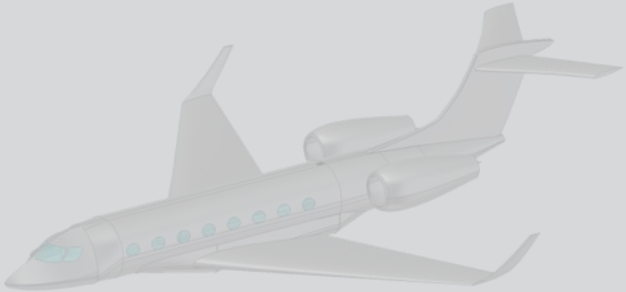
2. Satellite





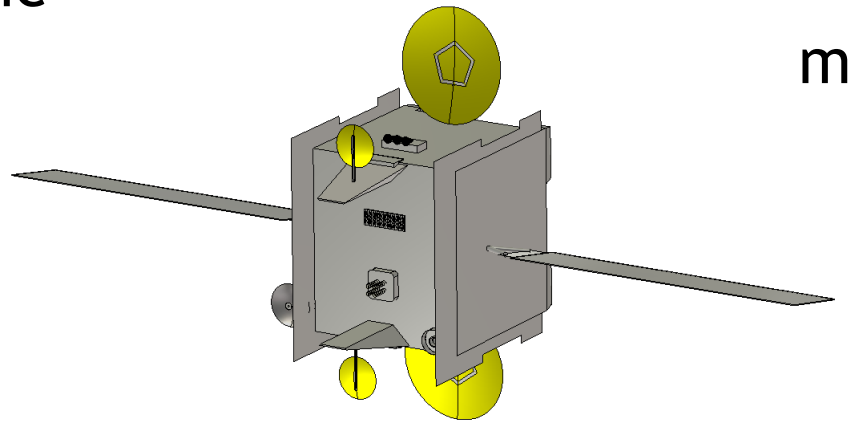
3. Aircraft





Design Issues ⇨ Simulation Issues

Electromagnetic design



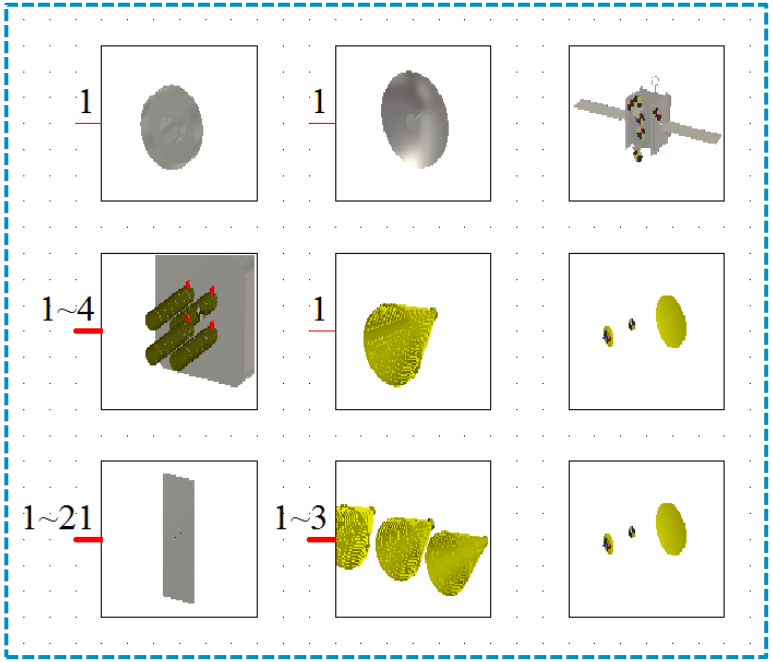
Coexistence of multiple antennas

Installed performance

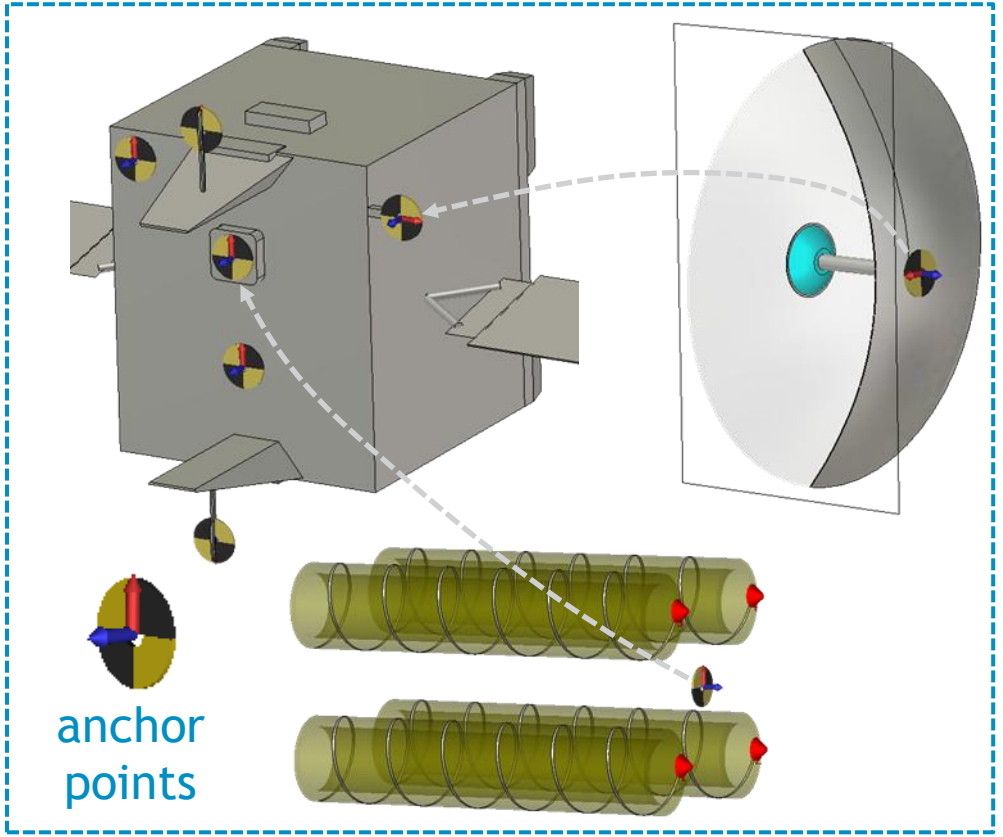
Thermal / Mechanical issues

Construction of Model

Schematic



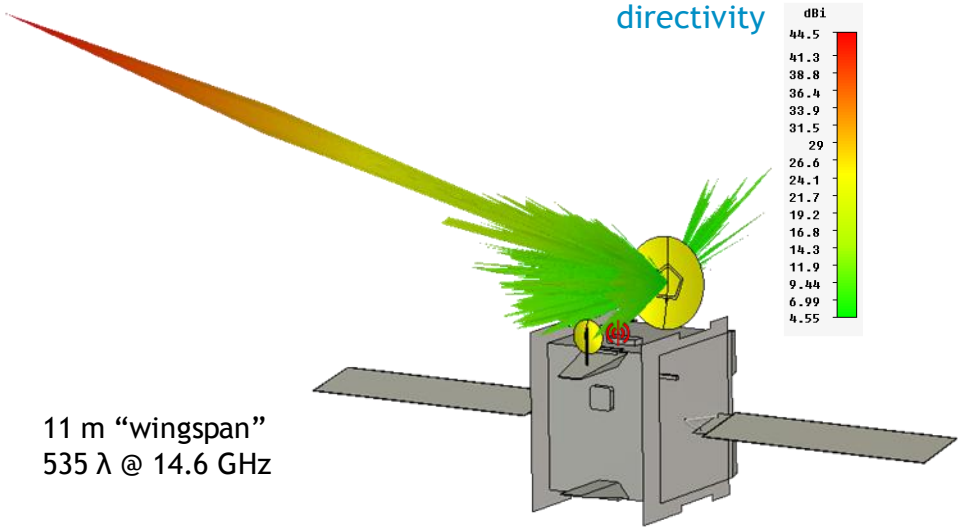
3D Layout



Reflector Installed Performance

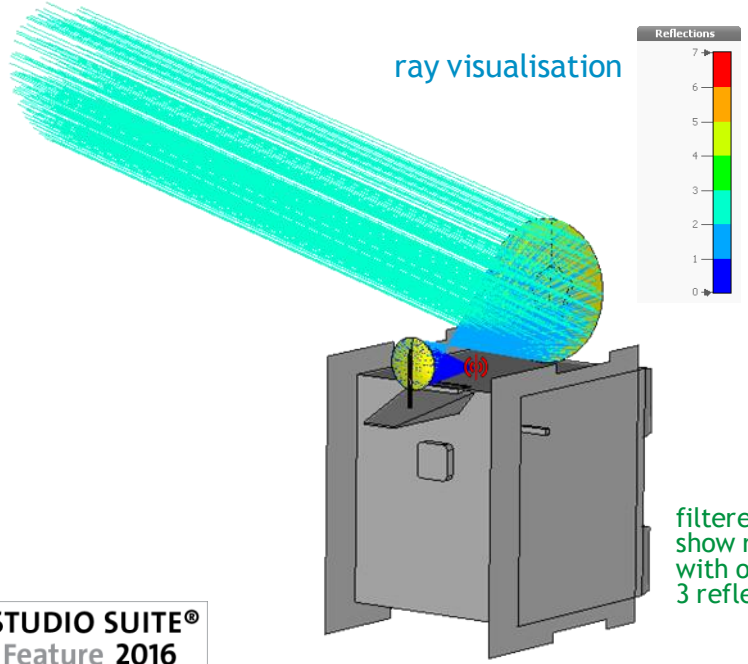
Ku band offset Gregorian reflector (14.6 GHz)

directivity



11 m “wingspan”
535 λ @ 14.6 GHz

ray visualisation



filtered to show rays with only 3 reflections

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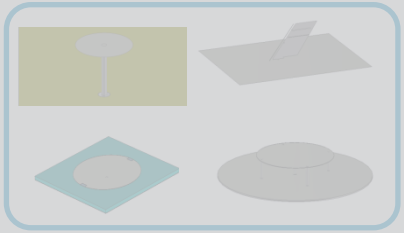
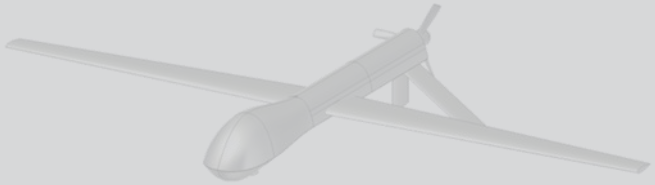
New Feature 2016

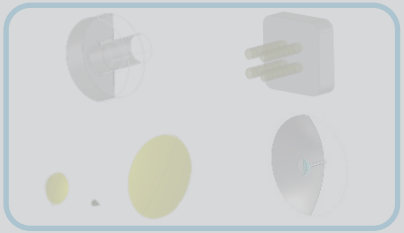
Three Installed Antenna Examples

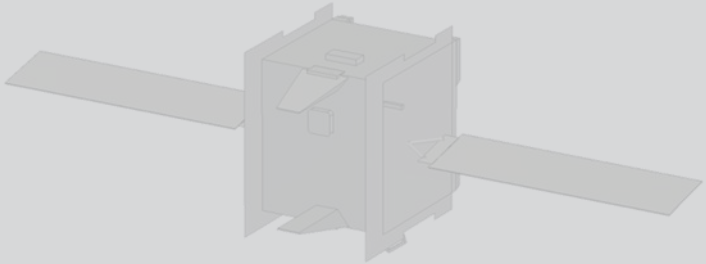
1. UAV



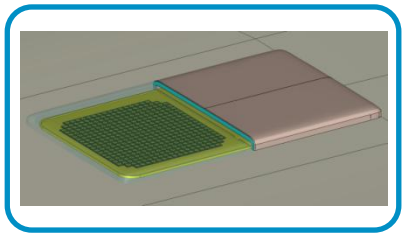


2. Satellite

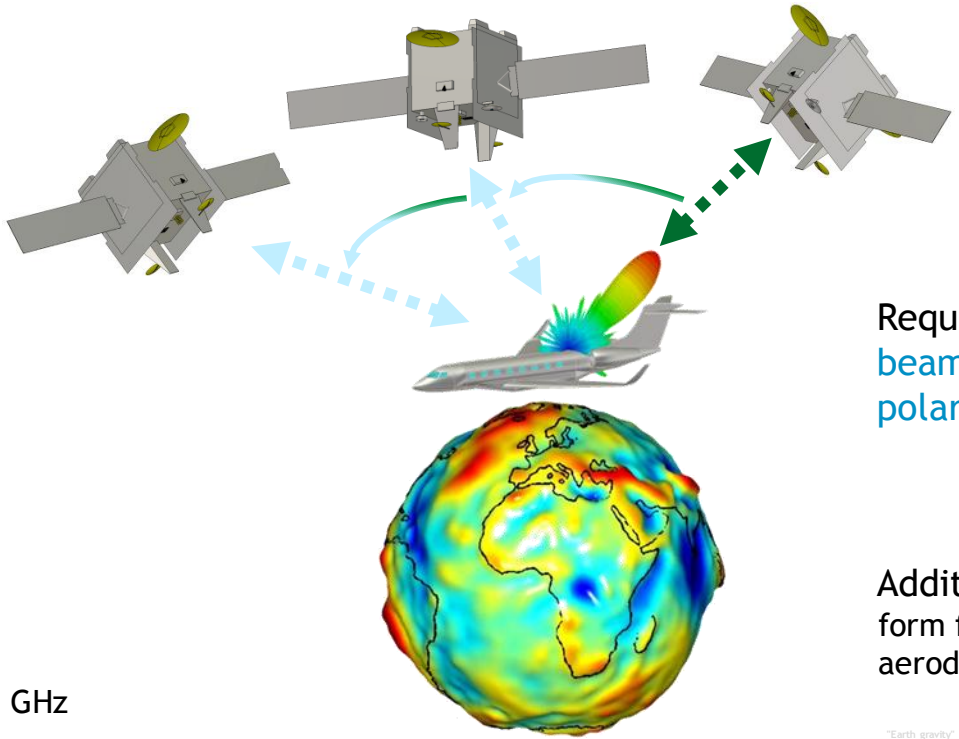




3. Aircraft



Example: Airborne SATCOM

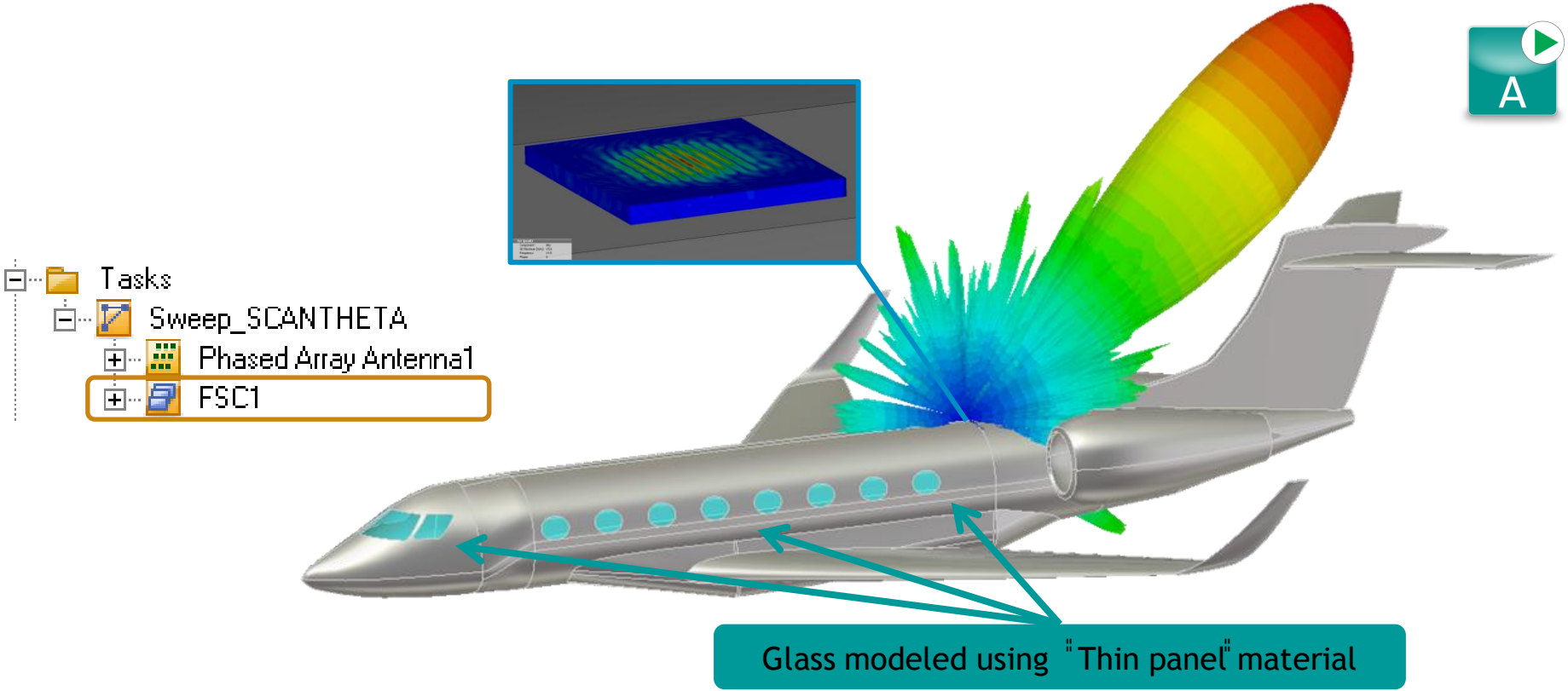


Required:
beam steering and
polarization tracking

Ku-band SATCOM:
- linear polarization
- Uplink: 14.0 – 14.5 GHz
- Downlink: 12.25 – 12.75 GHz

Additional antenna constraints:
form factor, mechanical stability, aerodynamics, weight

Installed Performance of Phased Array



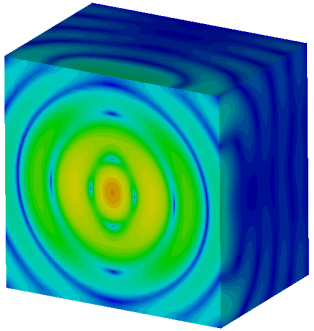
Outline

Introduction to hybrid simulation

Selected aerospace examples

Conclusions

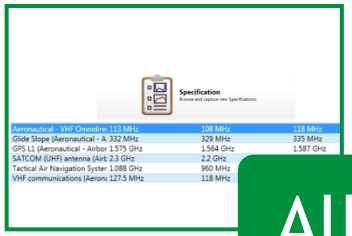
Advantages of Hybrid Approach

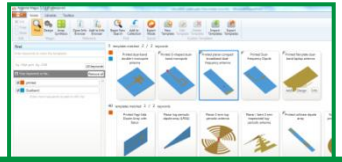


- Decomposition of a big volume into subvolumes :
  - SMALLER (Source) → fine features can be accurately simulated (e.g details of radiating source)
  - SIMPLIFIED (Platform) → mesh can be relaxed for the full model containing the imported source (e.g. increase time step, speed-up method convergence).
- Simulate source with appropriate mesh and solver.
- Import external (measured) fields.
- No knowledge of antenna structure necessary (IP).

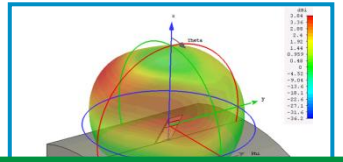
Summary

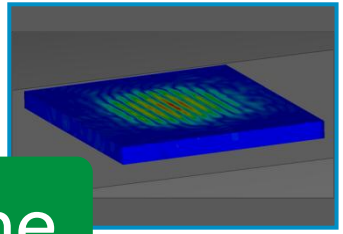
Antenna synthesis



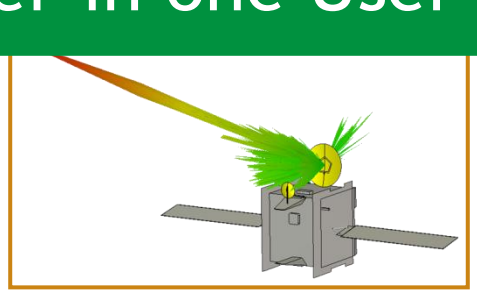


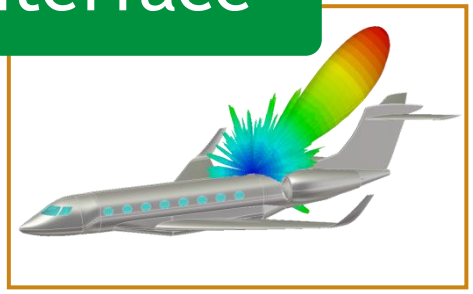
Antenna /Array design





All antenna design stages with the best solver in one User Interface





Antenna Installed performance

Hybrid Simulation for Electrically Large Antenna Platforms

Jim Creed

2016-04-12

Thank you for your time!
We'd be happy to answer any questions.

HITECH
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