E3-Analyzer

A new era in analysis and prediction of Electromagnetic Environmental Effects

Belarusian State University of Informatics & Radioelectronics

What is the purpose of E3-Analyzer?

- Simulation of the impact of electromagnetic (EM) fields on complex radio-electronic systems
- Development of protective measures against EM impacts

Examples of systems:

Aircraft

Mobile command center

Ship

...

Sources of disturbances

Unintentional

Powerful radars

Lightning discharges

Powerful
radio stations

Intentional

EM terrorism

EM weapon

Affected objects

Medical equipment

On-board aviation systems

Industrial equipment

Land transport equipment

Dispatch control systems

On-board ship complexes

...

Consequences of EMF impacts

- Reduction of data transfer rate in communication channels
- Loss and/or distortion of received information
- Equipment failure

Examples:

- Plane crash at Sheremetyevo (2019)
  - The lightning strike caused electronics to fail and radio communication problems; emergency landing ended in tragedy
- Two warships nearly collided while they were sailing to Singapore (2000)
  - The radar of ship “Anzac” interfered with the steering gear of ship “Huon”; “Huon” became uncontrollable

Plane crash at Sheremetyevo (2019)

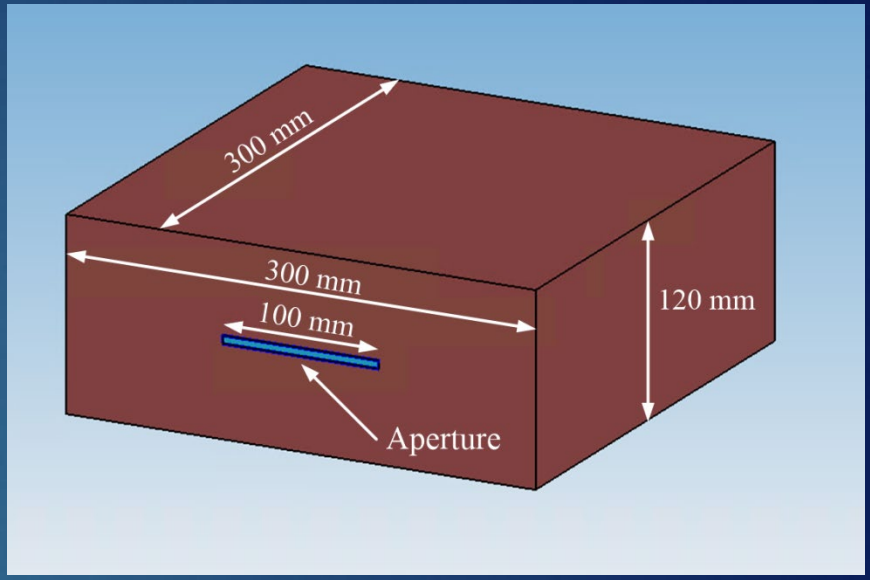
Possible outcome of a ship collision

Features of E3-Analyzer

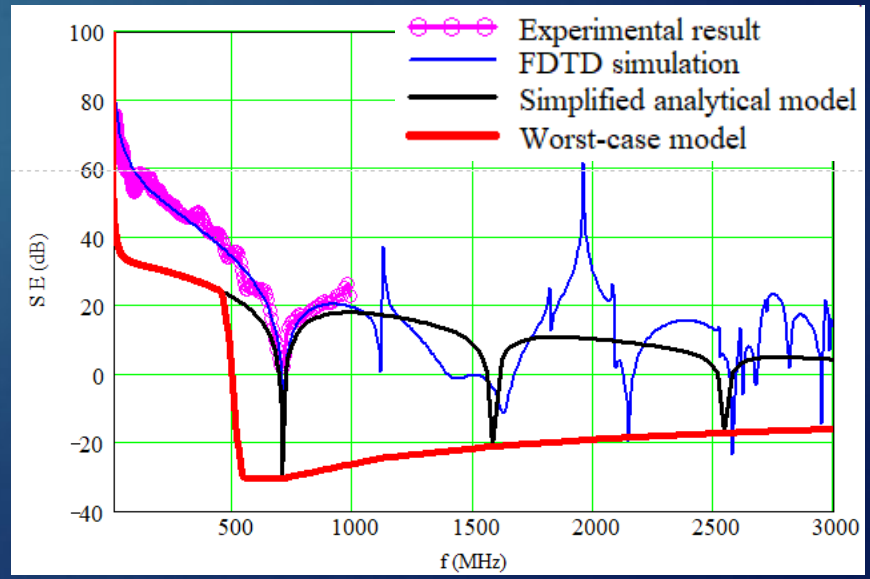
Use of pessimistic semi-analytical models

- Small amount of initial data
- Wide frequency range (from 25 Hz to 40 GHz) within one model
- Low requirements for computing resources
- No need to simulate multiple system versions to find the worst-case

Rectangular box (300x300x120 mm) with single rectangular aperture (100x5 mm)



Shielding effectiveness of box

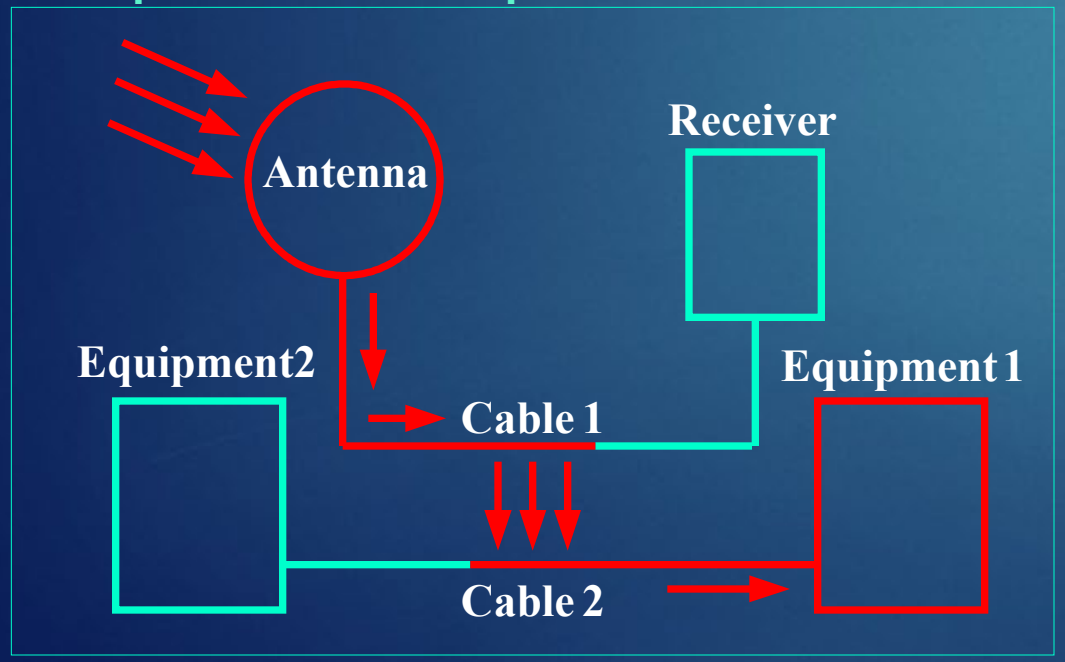


Features of E3-Analyzer

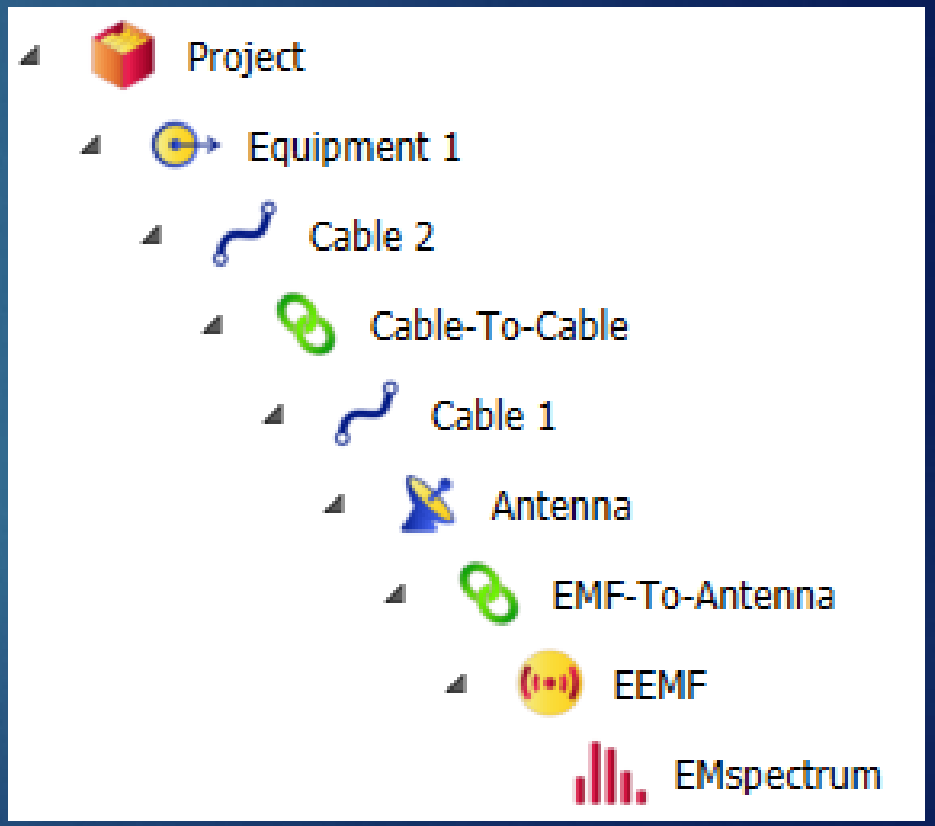
Modeling based on influence paths

- Simplifies the analysis of the causes of interference
- Simplifies the development of interference protection measures

Example of influence path



Visualization of influence paths in E3-Analyzer

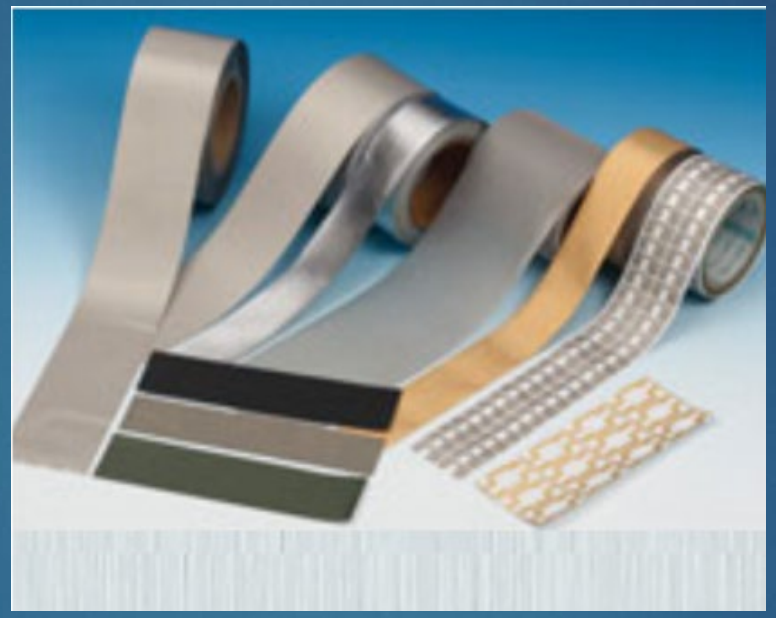


Features of E3-Analyzer

Different kinds of EM protection elements

Honeycomb vent panels

Conductive tapes



Conductive shielding gaskets

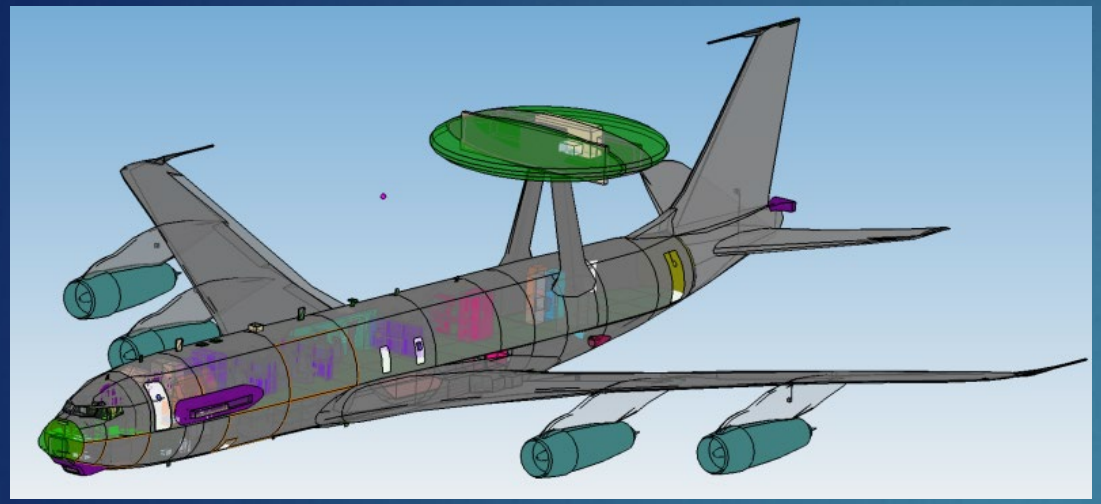
Other elements:

- Wire meshes
- Conductive films
- …
- Absorbers
- Filters
- …

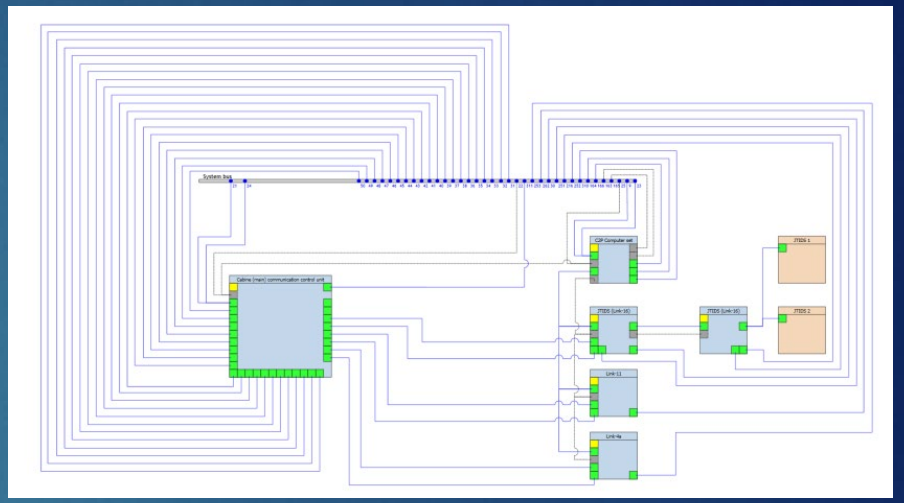
Complex example “AEW aircraft”

Aircraft model developed in E3-Analyzer

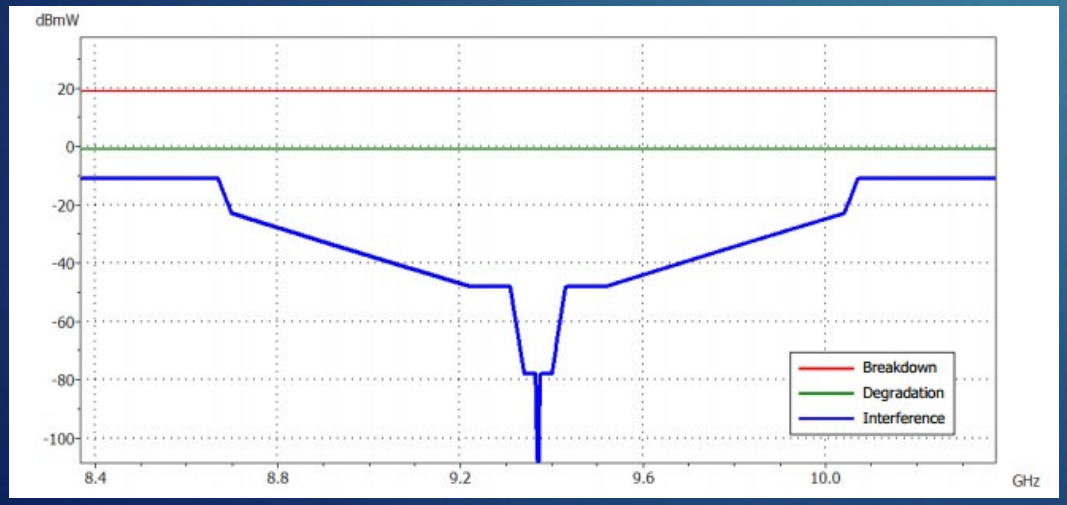
3D model of geometry



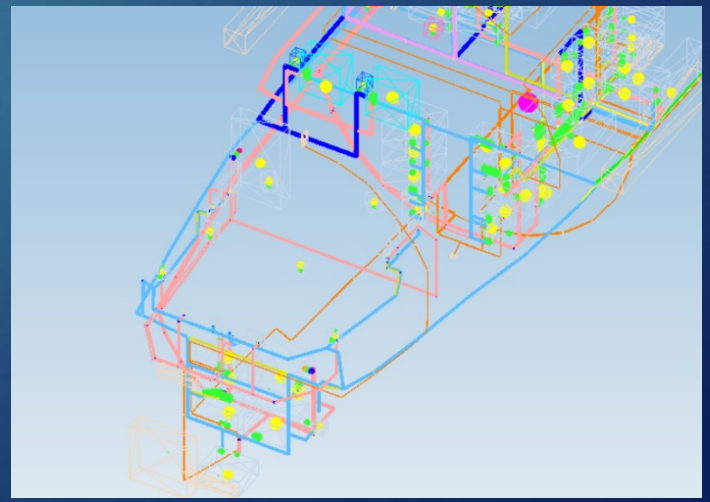
Block diagram



Equipment characteristics



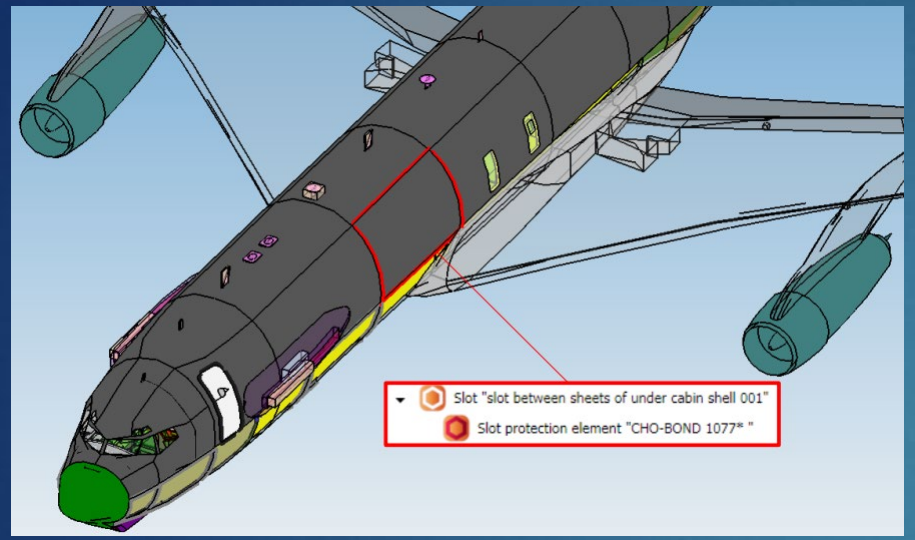
Cable network



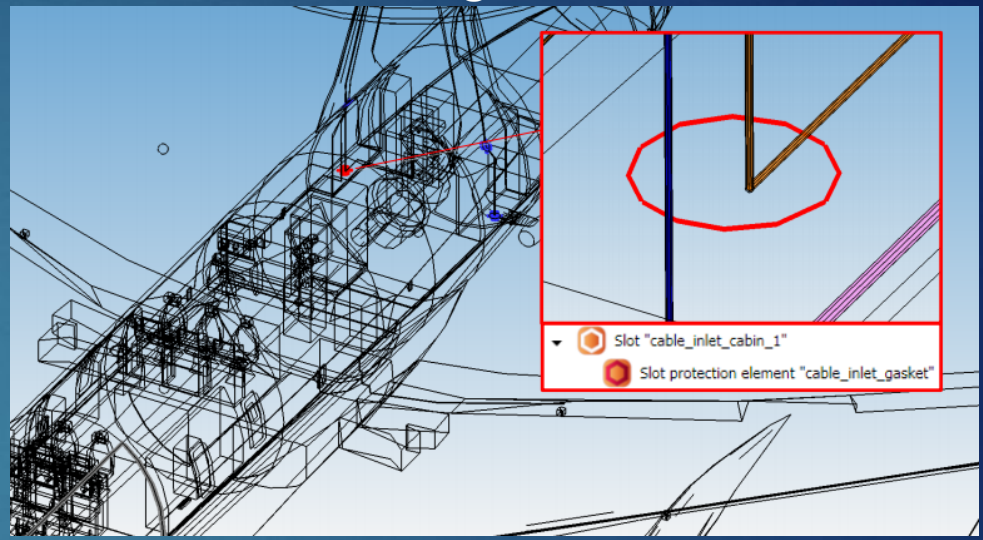
Complex example “AEW aircraft”

Models of EM protection elements

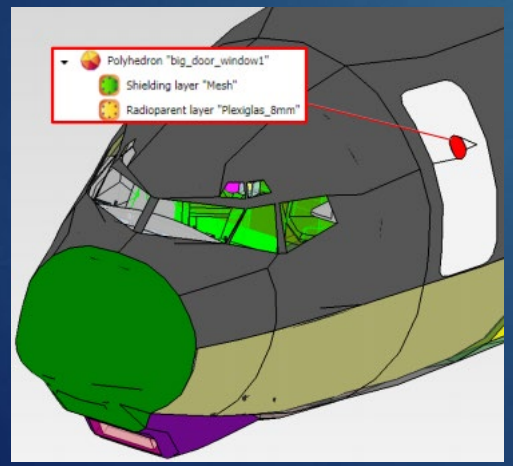
Conductive sealant



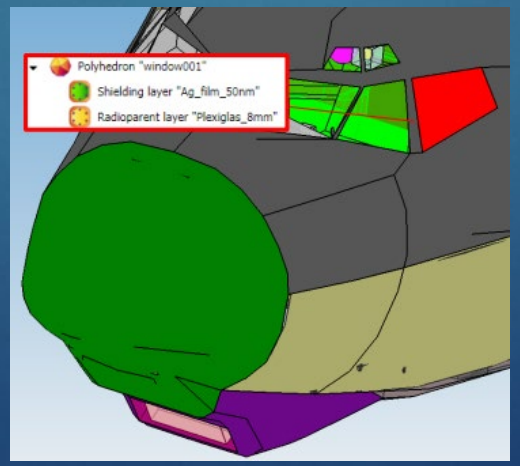
Conductive rubber gasket



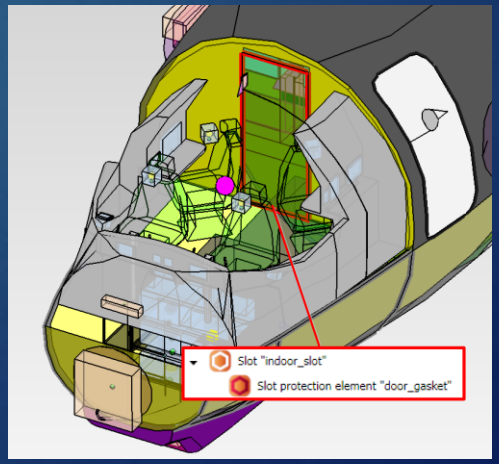
Conductive mesh



Conductive film

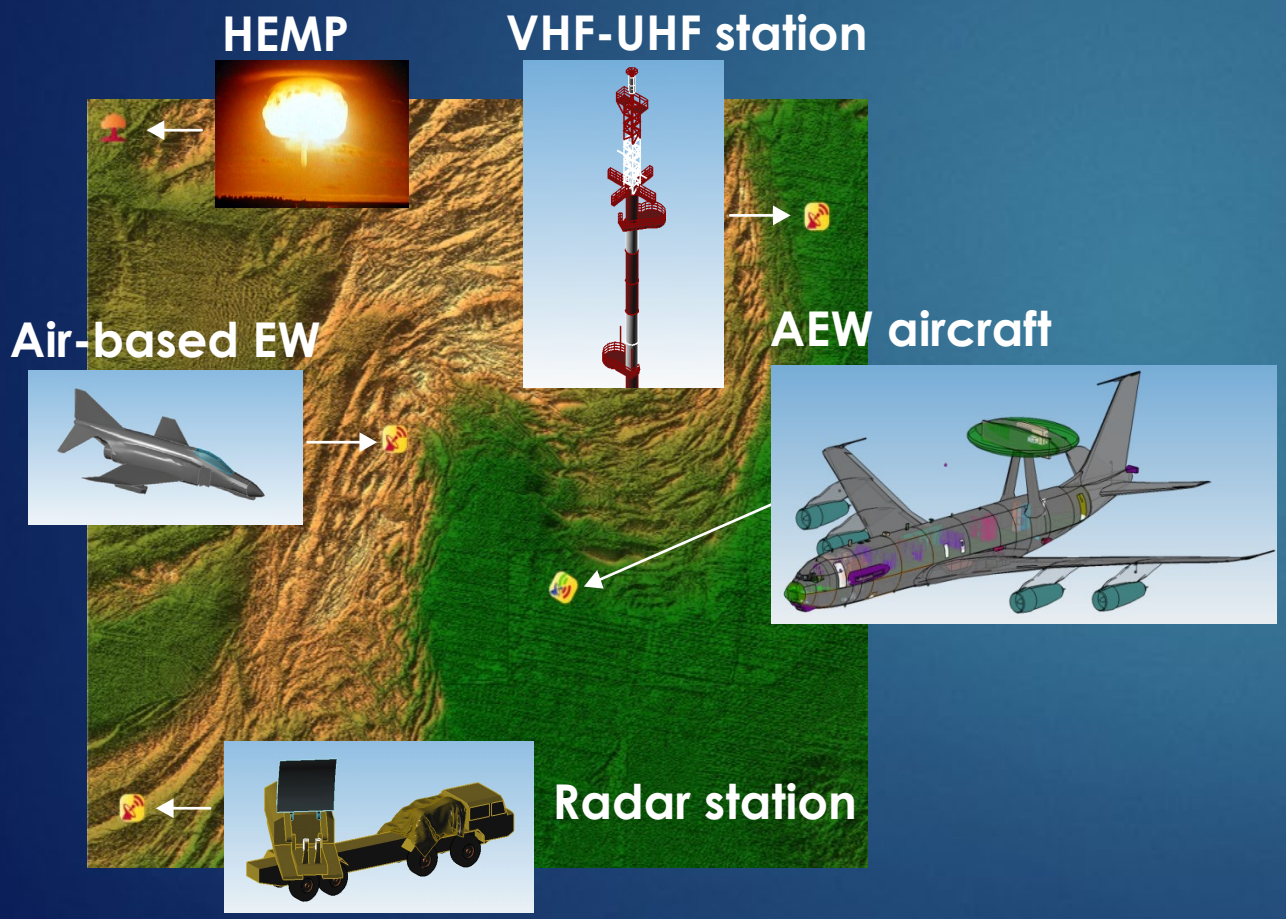


Finger spring gasket

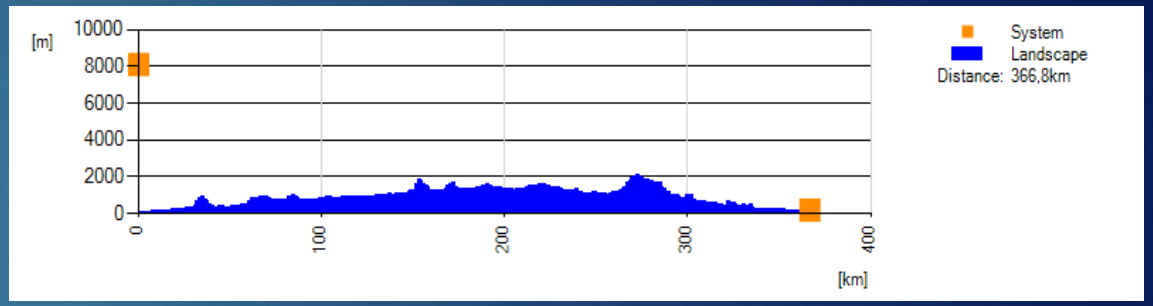


Complex example “AEW aircraft”

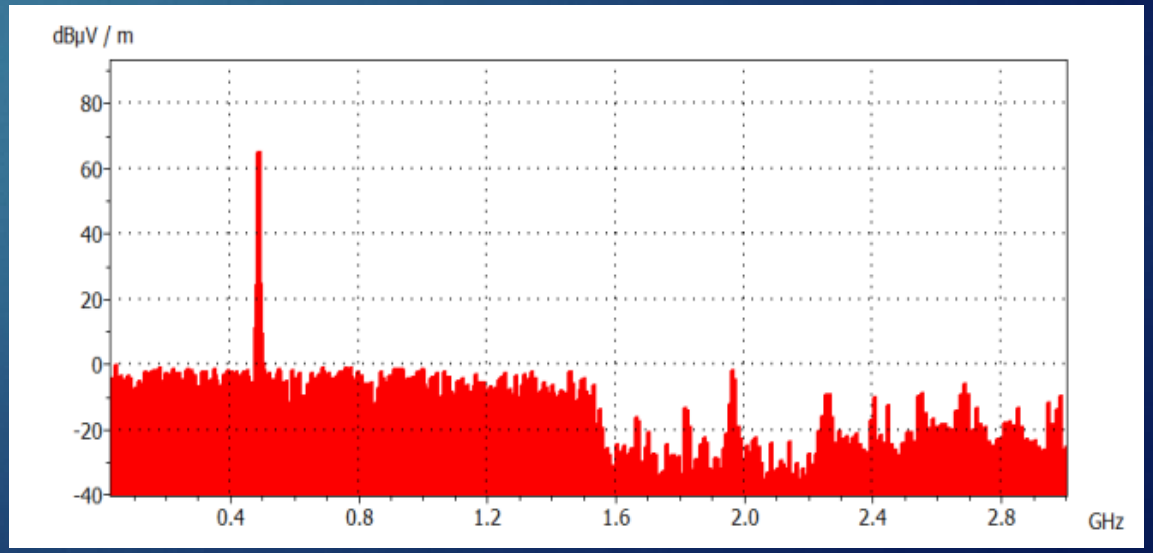
EME simulation using digital terrain maps



Terrain cut between AEW and VHF-UHF station

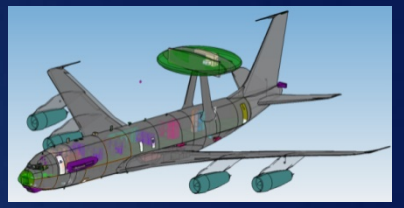


Amplitude spectrum of disturbance from VHF-UHF station

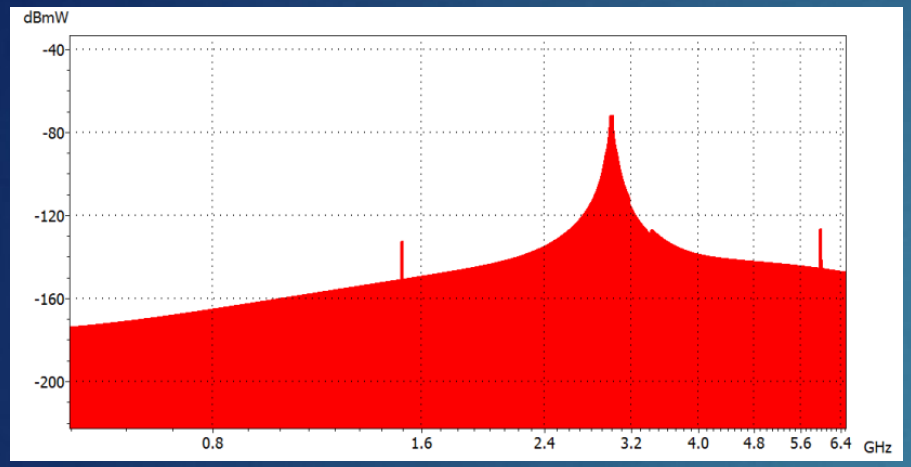


Complex example “AEW aircraft”

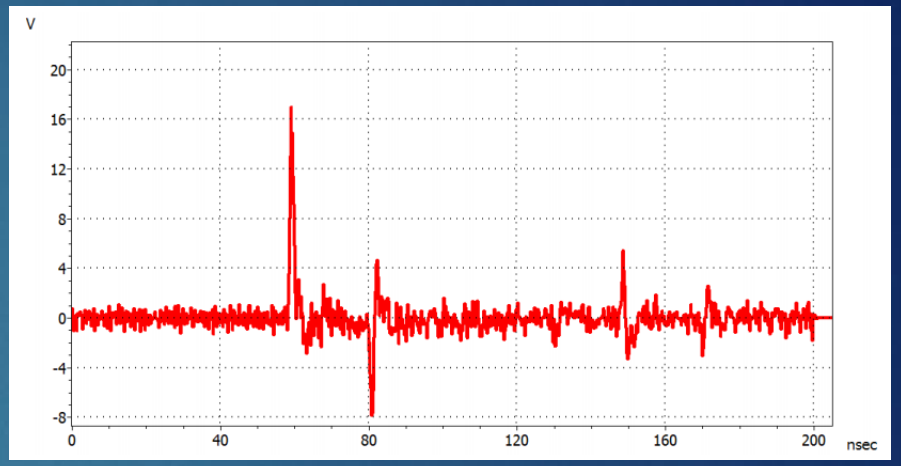
Simulation of the impact of EME on the aircraft



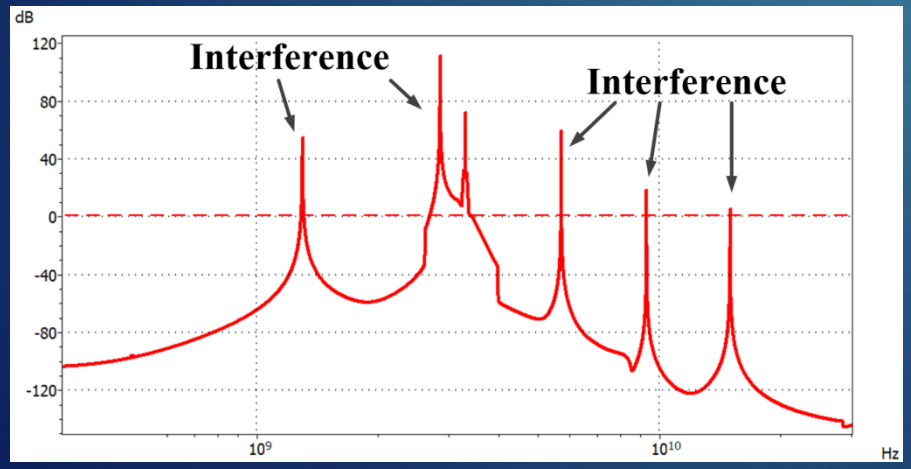
Amplitude spectrum of the disturbance at the RF port «EWR»



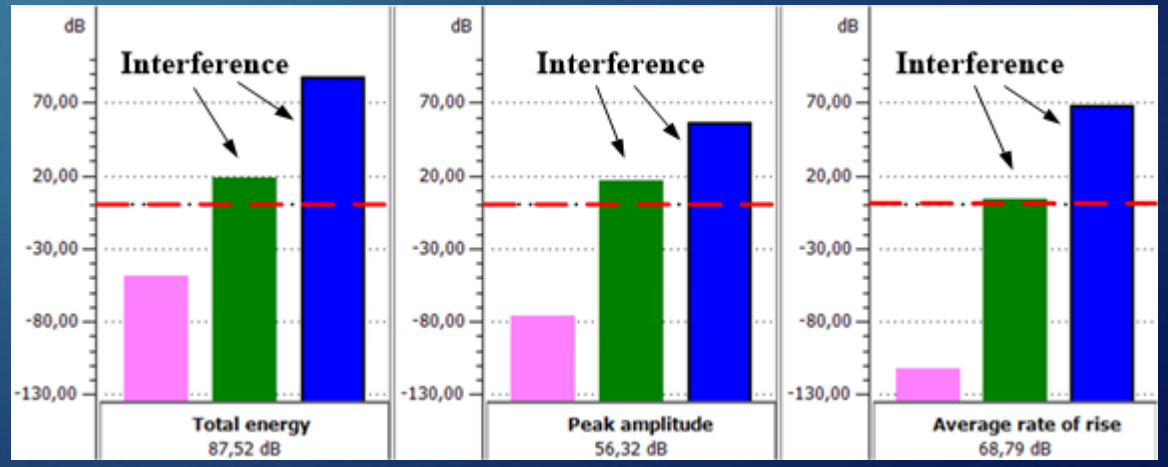
Waveform of the disturbance at the RF port «WR Transceiver»



Damage criterion in frequency domain (Interference margin) for the RF port «EWR»

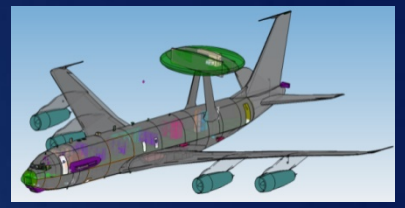


Damage criteria in time domain (Interference Index) for the RF port «WR Transceiver»



Complex example “AEW aircraft”

Analysis of simulation results



- Number of receptor ports: 480
- Number of influence paths: 6553
  - Breakdown: 748 influence paths
  - Degradation: 227 influence paths
  - Interference: 120 influence paths
  - No interference : 5458 influence paths
- Simulation time: 22 h 45 min

Visualization of port damage levels in E3-Analyzer

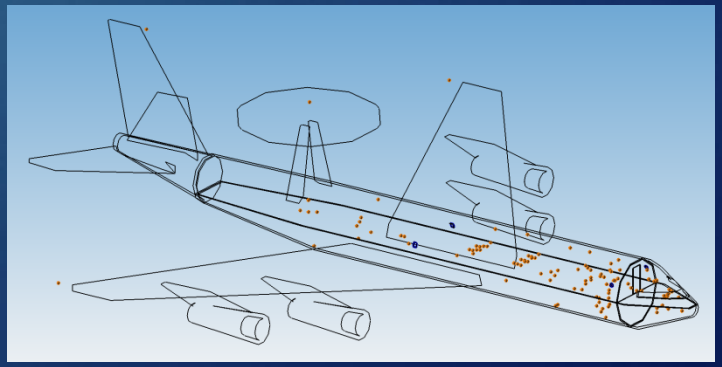
Example of performance evaluation

Assessment technique

- Computer for simulation: regular PC
  (CPU: “AMD Ryzen 5 3600” 3.59 GHz, RAM: DDR4 16 GB)
- Simplified geometry model of the aircraft is used
- Simulation of the impact of a plane wave on sensors
- Number of sensors:
  outside – 10, inside – 100

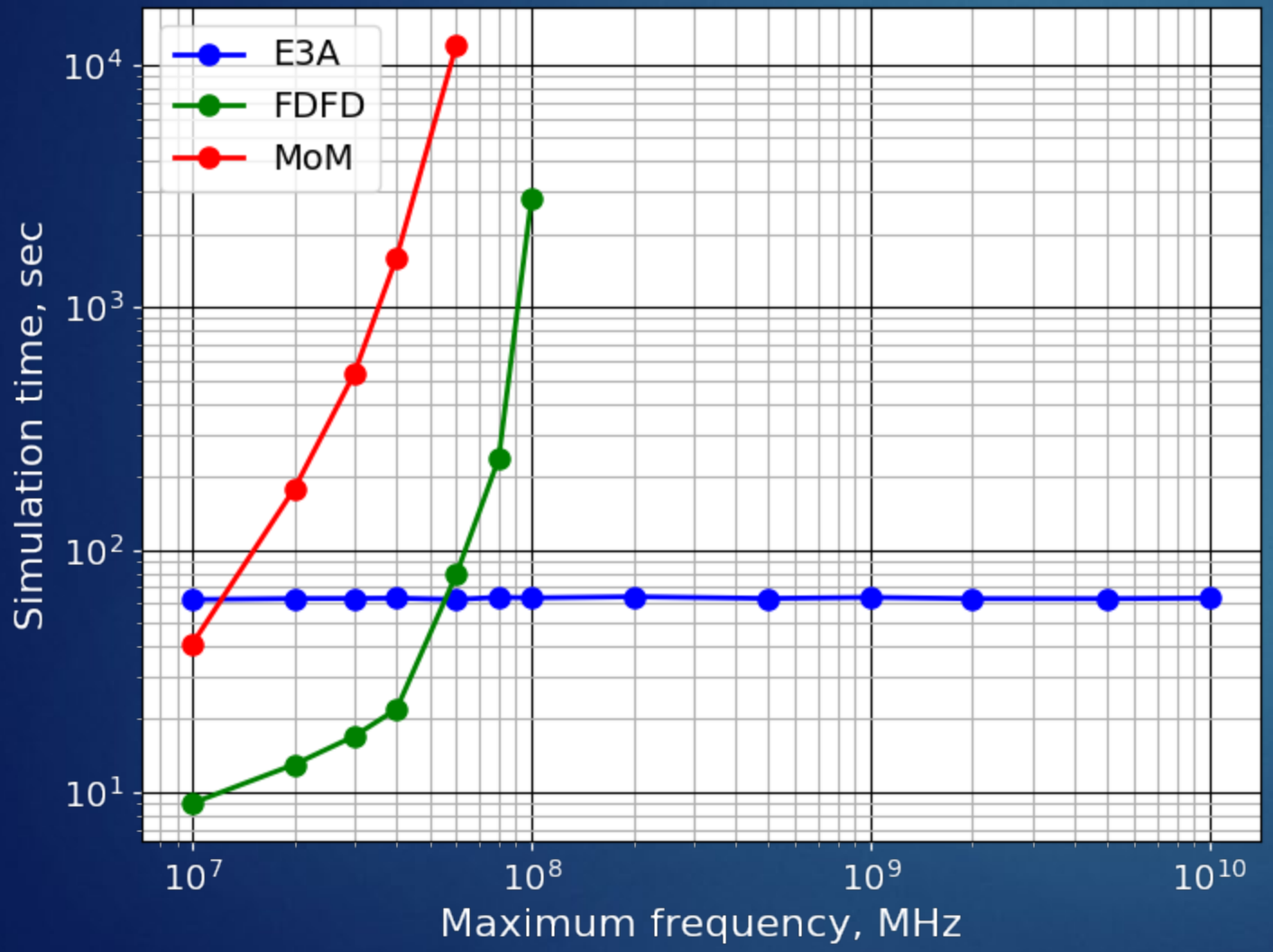
Simplified geometry model of the aircraft

Location of field sensors



Example of performance evaluation

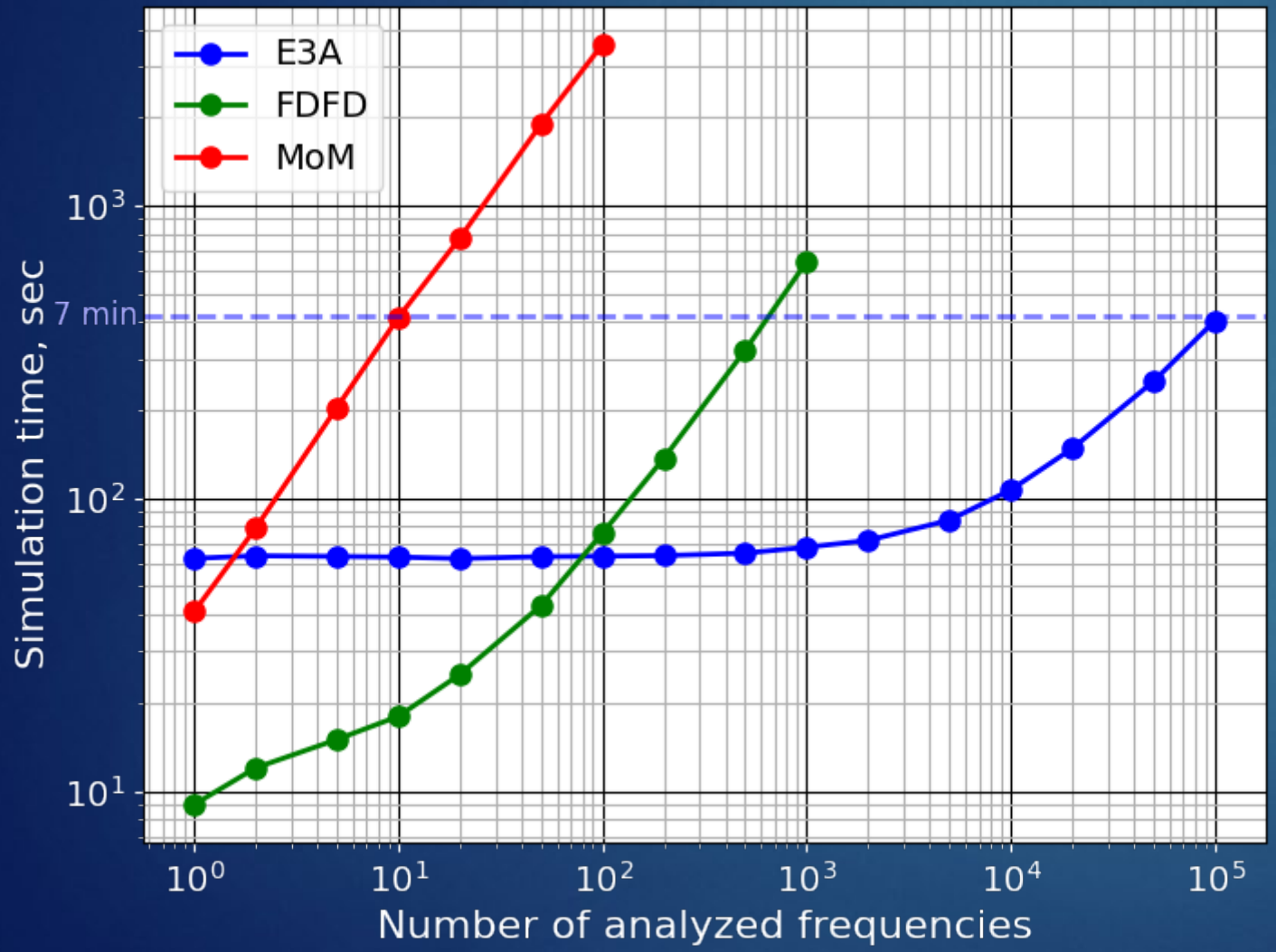
Influence of maximum frequency of analysis on simulation time



- **MoM** and **FDFD**: An increase in the frequency of the analysis leads to a **rapid increase** in simulation time
- **E3-Analyzer (E3A):** Simulation time **does not depend** on a frequency of the analysis

Example of performance evaluation

Influence of number of analyzed frequencies on simulation time



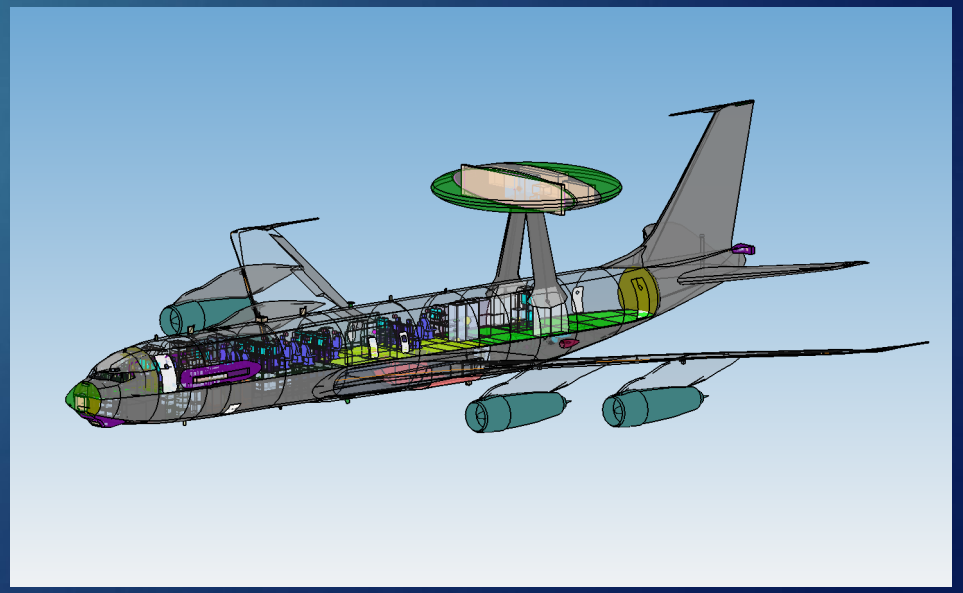
- **MoM**: **10** frequencies are analyzed in 7 min
- **FDFD**: less than **1000** frequencies are analyzed in 7 min
- **E3-Analyzer (E3A): 100 000** frequencies are analyzed in 7 min

Advantages of E3-Analyzer

- Practical opportunities of modeling of complex systems
- Minimum requirements for computation resources
- High speed of simulation
- Simulation in the frequency and time domains
- Wide frequency range of analysis (from 25 Hz to 40 GHz)
- Calculation of the damage criteria
- Convenience of design of protection against EM impacts

AEW aircraft

AEW aircraft model in E3-Analyzer



EMC R&D Laboratory

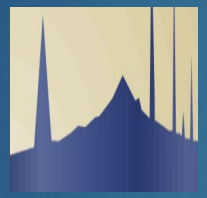
BELARUSIAN STATE UNIVERSITY OF INFORMATICS AND RADIOELECTRONICS

- Developments of the laboratory are used in more than 10 countries around the world

EMC-Analyzer

ADFTS

DLA-DNA



- More than 200 scientific publications in EMC journals and in proceedings of international symposiums

- "EMC diagnostics of complex systems": annual special session of EMC R&D Lab at the symposium "EMC Europe"

- BSUIR is a parent organization in Belarus in the field of EMI protection research and EMC design of radio-electronic systems

We are looking forward to collaborate!