A new era in EMC analysis & prediction!

EMC - ANALYZER

Electromagnetic compatibility
analysis & synthesis software
for intrasystem-level solutions

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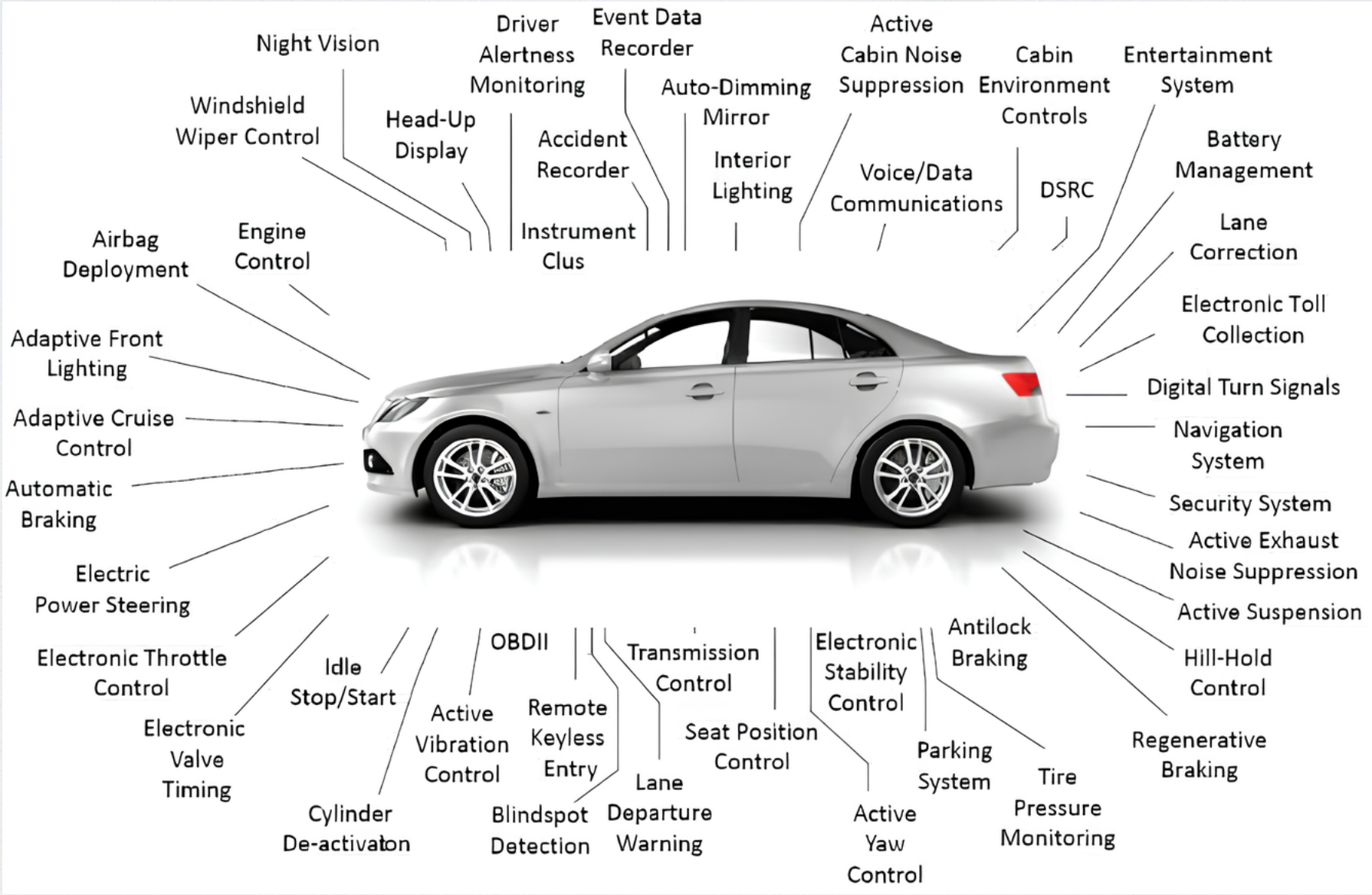
Intrasystem EMC (1)



From Todd Hubing presentation, Workshop, “EMC Europe 2012”, September 2-12, Rome, Italy

Intrasystem EMC (2)

Intrasystem EMC is a "painful" problem of the local ground multiservice radio objects operation and development

Roof of the Telecom building (Wroclaw, Poland)

Intrasystem EMC (3)

Intrasystem EMC design is one of the most complicated problems of the ship radioelectronic complex operation and development

Modern ship (Torpedo-boat "Guangzhou", P.R.C.)

Intrasystem EMC (4)

Intrasystem EMC design of Airborne Warnings and Control Systems (AWACS) is the most complicated part of Intrasystem EMC problems

AWACS (USA, NATO)

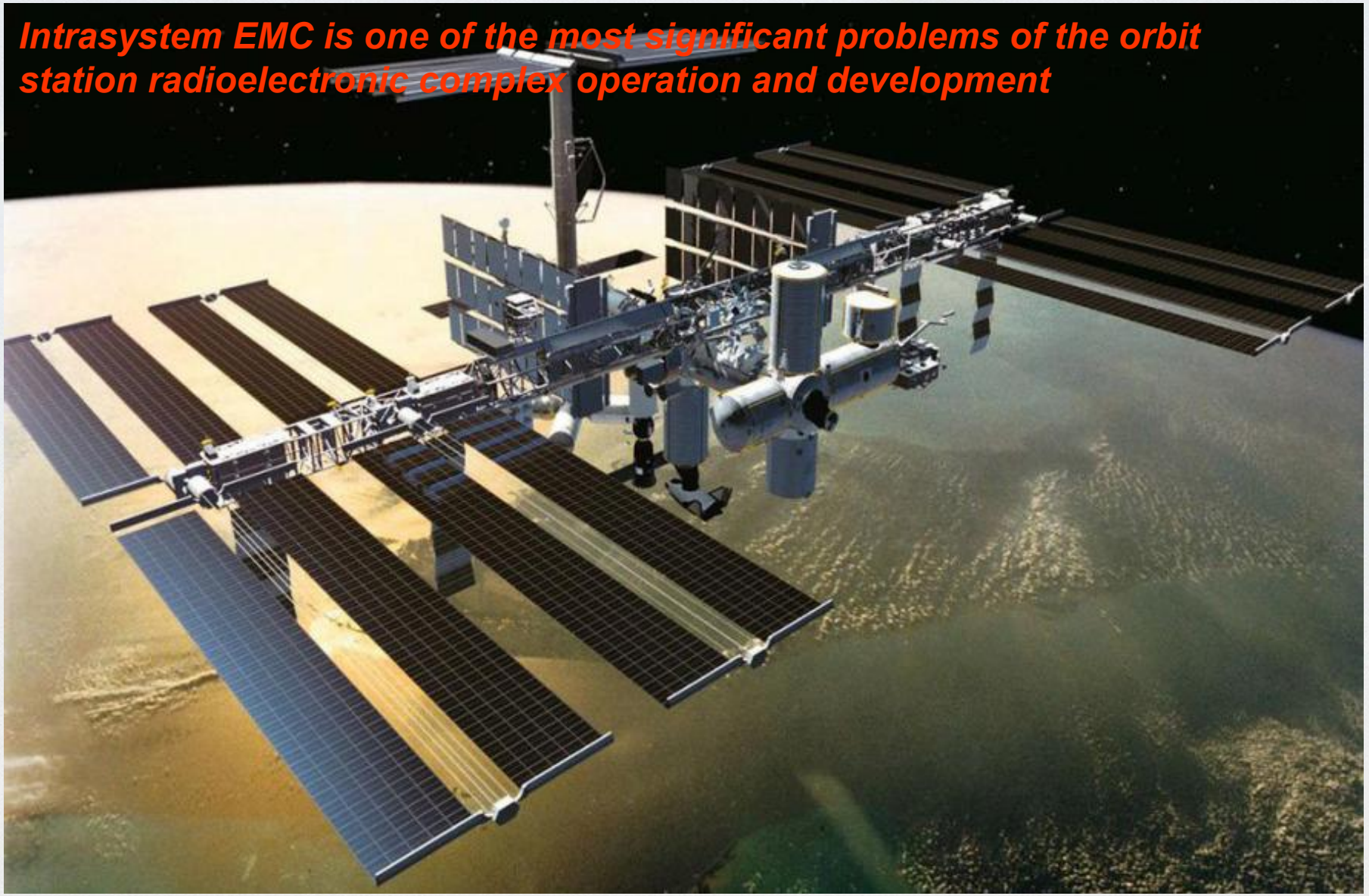
Intrasystem EMC (5)

Intrasystem EMC design is one of the most complicated problems of aircraft (helicopter, missile, etc.) radioelectronic complex operation and development

Cockpit of modern aircraft

Intrasystem EMC (6)

Intrasystem EMC is one of the most significant problems of the orbit station radioelectronic complex operation and development



Satellite

Intrasystem EMC (7)

Intrasystem EMC is an actual problem of the local ground radio systems and complexes operation and development

Local Ground Radio System

Intrasystem EMC (8)

Navy order (US aircraft carrier group)

Intrasystem EMC (9)

Anchorage

Intrasystem EMC (10)

Intrasystem EMC problem is an actual problem of local distributed radio sets (seaports, airports, etc.)

Seaport

Bugs in Intrasystem EMC (1)

A-380 (European project):
Losses up to 100 sales (up to 50 billion USD) during 2007-2008
(Intrasystem EMC problems)

Bugs in Intrasystem EMC (2)

Nimrod AWACS system (Great Britain):
Losses up to 4 billion USD during 1980-1990
(Intrasystem EMC problems)

Bugs in Intrasystem EMC (3)

Torpedo-boat destroyer “Birmingham”
(“Sheffield” type, Great Britain):
Losses up to 500 million USD on 1982 (Falkland conflict)
(Intersystem EMC problems as a reason of destruction by missile)

EMC-Analyzer

It is a comprehensive and powerful software tool for solving of electromagnetic compatibility (EMC) and electromagnetic interference (EMI) problems in a cost-effective way:

- in various local on-board and ground systems (groupings, objects, complexes, etc.),
- on intrasystem level by taking into account various types of on-board spurious couplings,
- at various phases of the system life cycle: from initial development to maintenance and modification of an existing on-board or ground system

Remember: the earlier you start to think about EMC/EMI, the less expensive and more efficient solutions you will get !

EMC-Analyzer

offers you a number of functions and possibilities:

a) Survey of different ground or on-board system's equipment for incompatibilities,
b) Substantiation of necessary changes (adjustments) in system during its development to achieve intrasystem EMC,
c) Automotive system specification generation for many kinds of equipment,
d) Detection and identification of linear and nonlinear interference sources,
e) Comprehensive nonlinear behavior simulation in severe electromagnetic environment (up to 1 000 000 input signals),
f) Easy integration of measurement results into EMC analysis and design,
g) EMC education and training

EMC-Analyzer

Main advantages:

a) Application of improved models and procedures used in the well-known “Intrasystem Electromagnetic Compatibility Analysis Program” (IEMCAP), USA

b) Pinpoint accuracy of spectra representation (up to 1 000 000 frequency samples),

c) Models in accordance with MIL-STD-461/462,

d) Special editors for block diagram, bundle structure, and geometry of a system

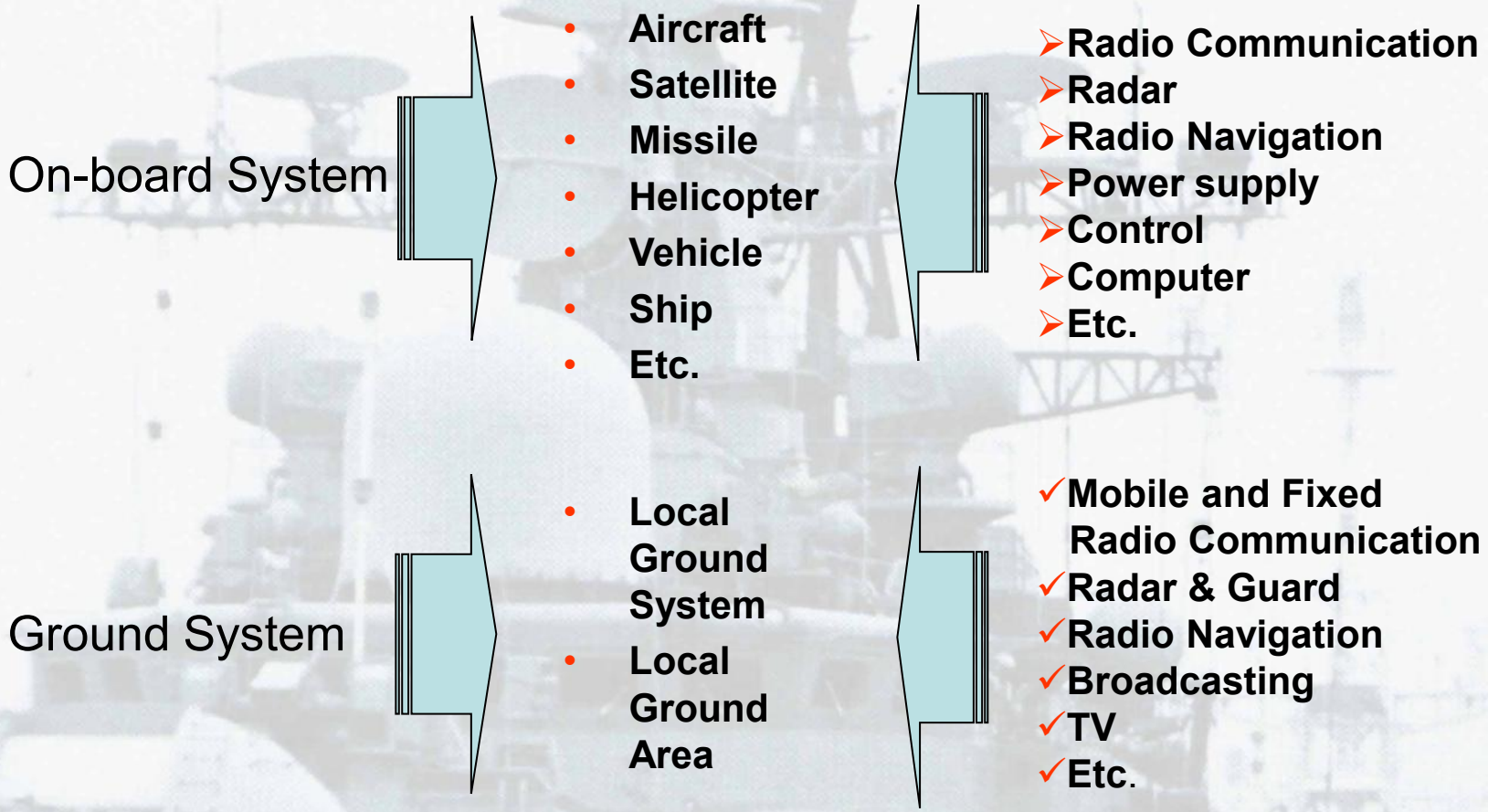
e) Developed Discrete Nonlinear EMC Analysis using Radio Receiver Behavior Simulation Technique,

f) User-friendly graphical interface,

g) Supported operating systems: Windows XP / 7 / 10 / 11,

EMC-Analyzer

Systems under Analysis:



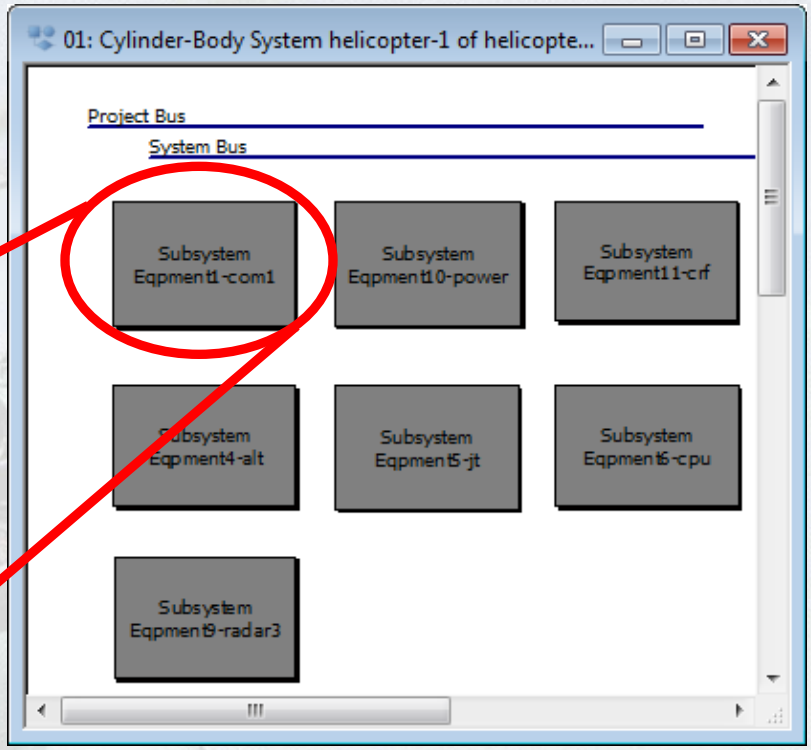
EMC-Analyzer

On-board System modeling includes the following steps:

1. Description of the System geometry and structure (including subsystem definition)
2. On-board allocation of equipment (transmitters, receivers, transceivers, antennas, power supply and control equipment, bundles, etc.)
3. Definition of on-board equipment parameters and characteristics
4. Definition of on-board equipment connections and spurious couplings

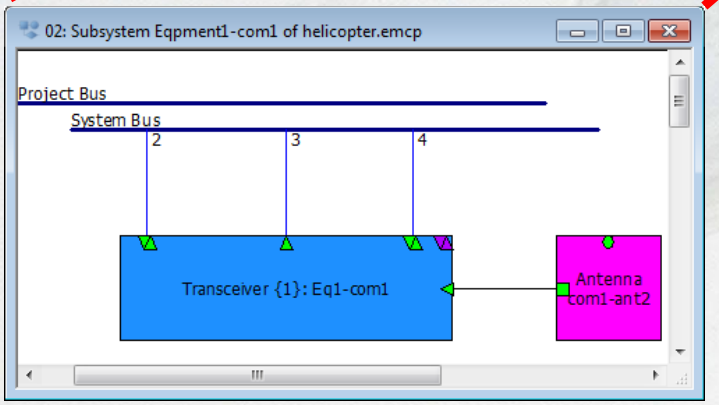
EMC-Analyzer

System structure:



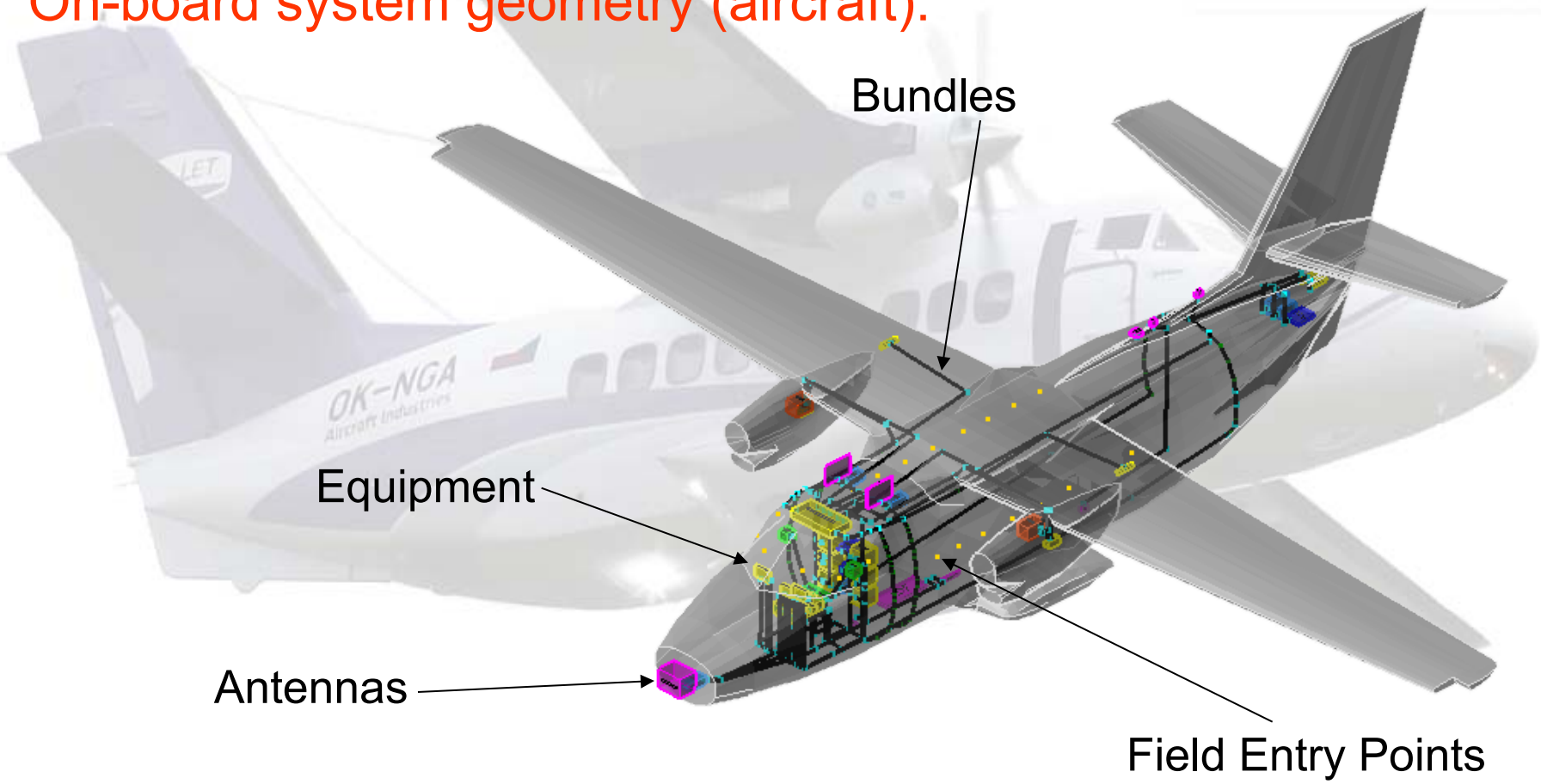
System

Subsystem



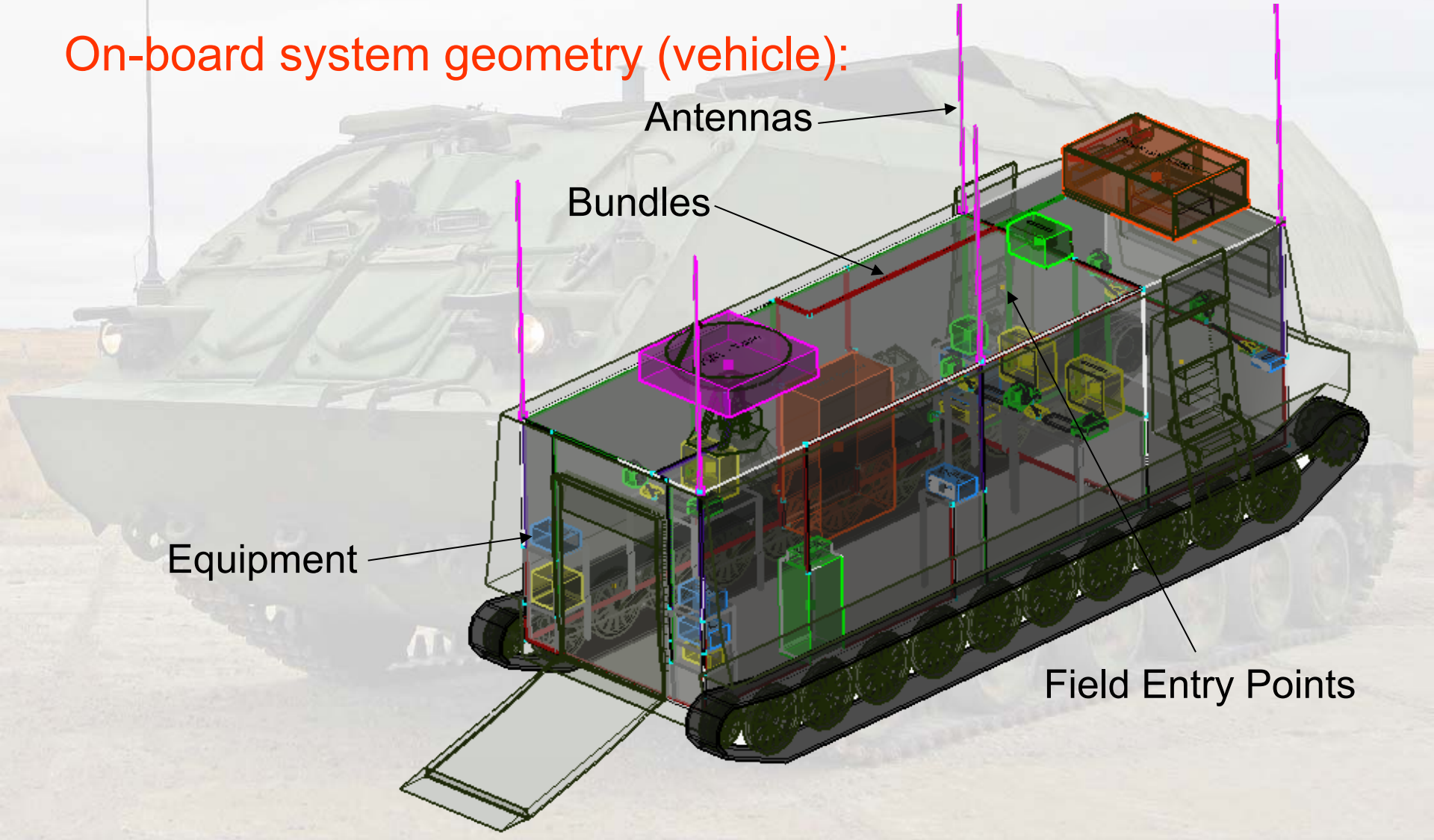
EMC-Analyzer

On-board system geometry (aircraft):



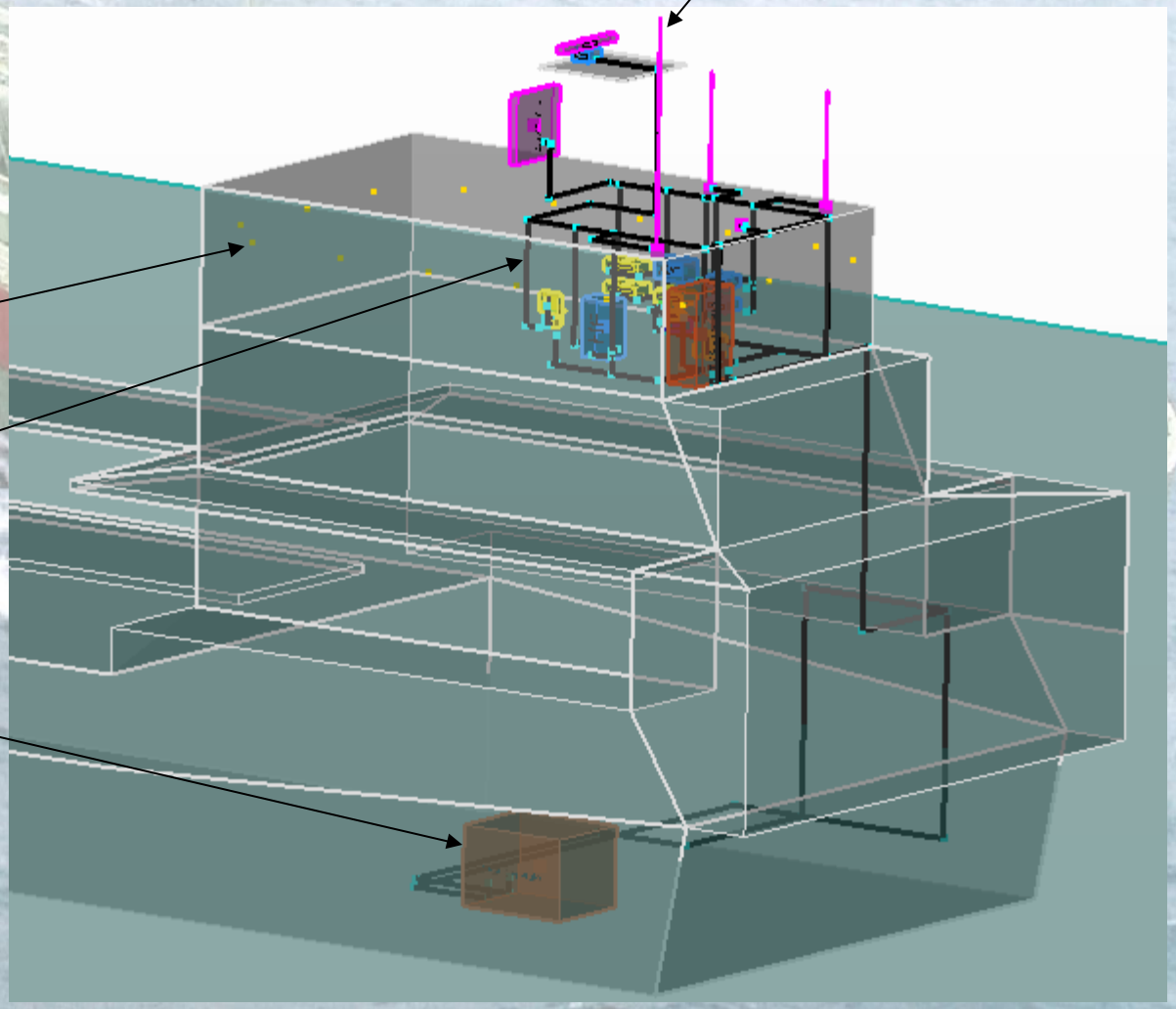
EMC-Analyzer

On-board system geometry (vehicle):



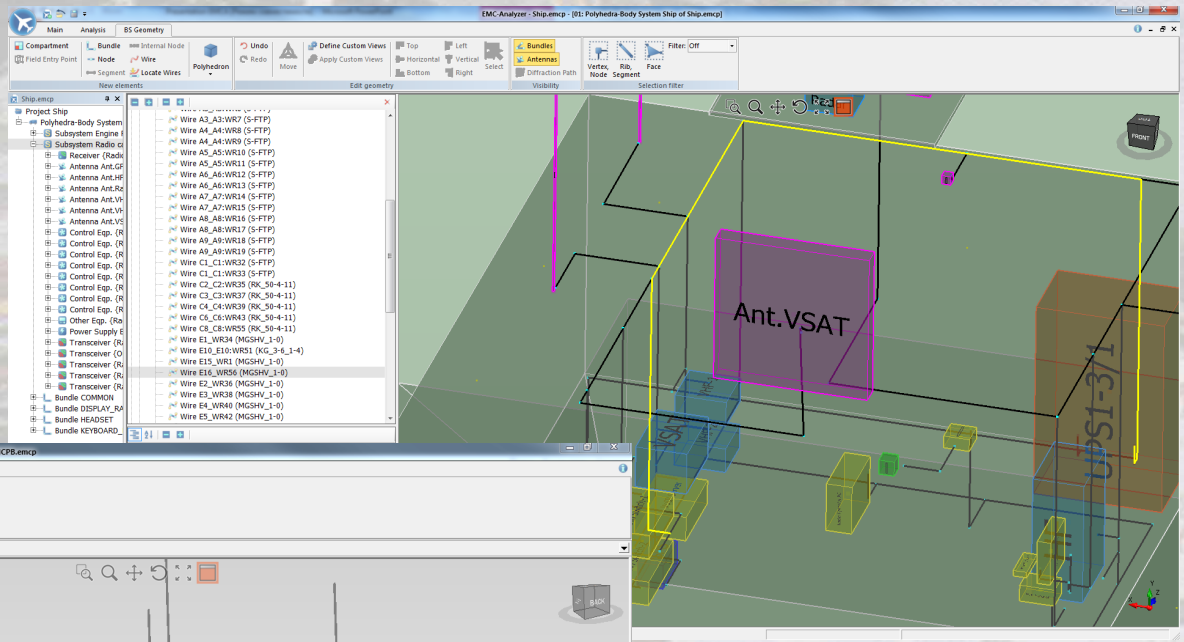
EMC-Analyzer

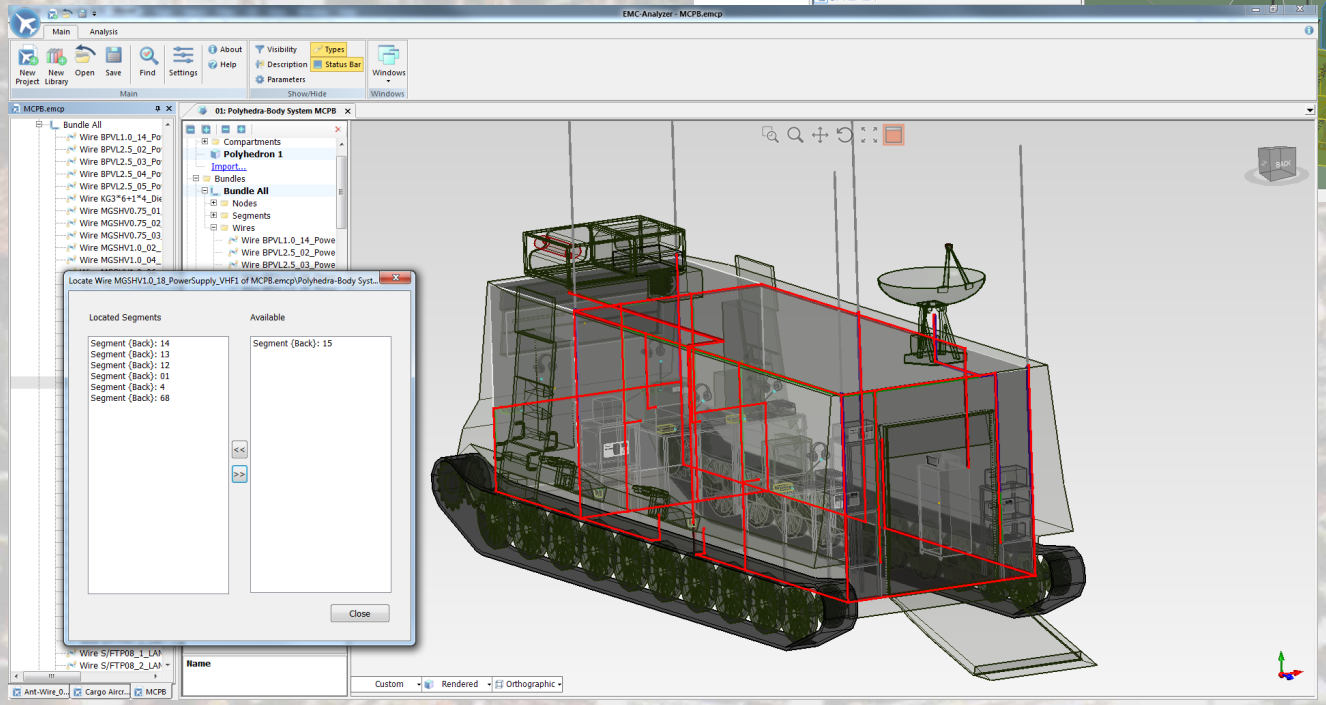
On-board system geometry (ship):



EMC-Analyzer

Wire Location:

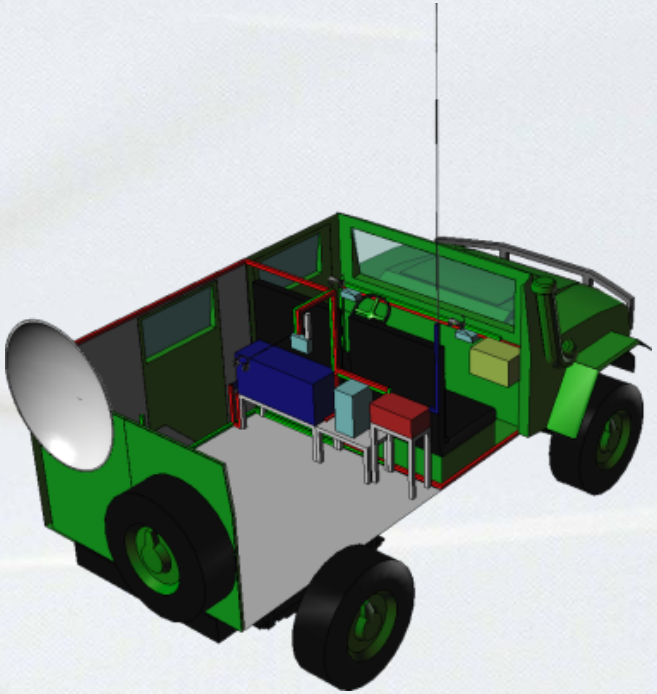


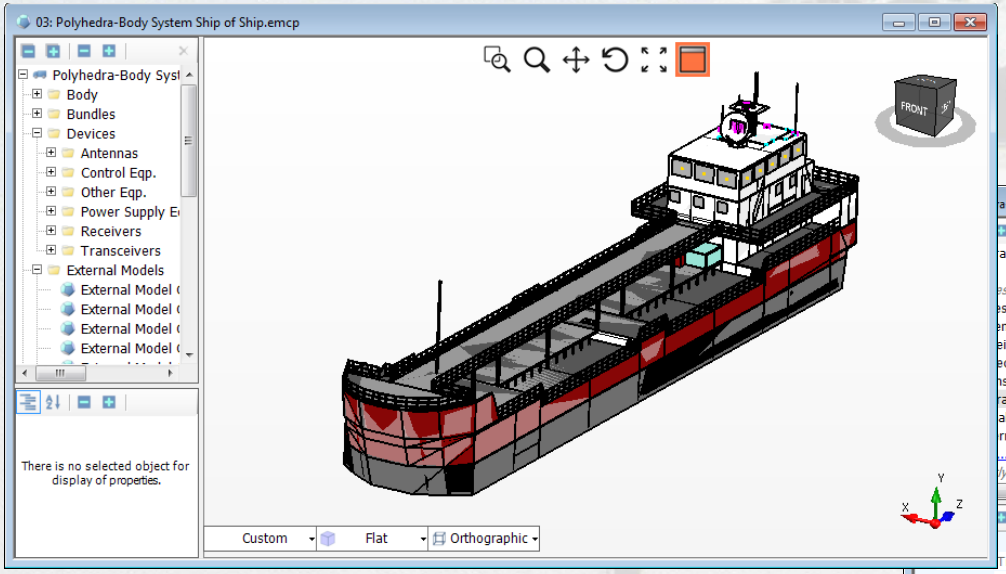


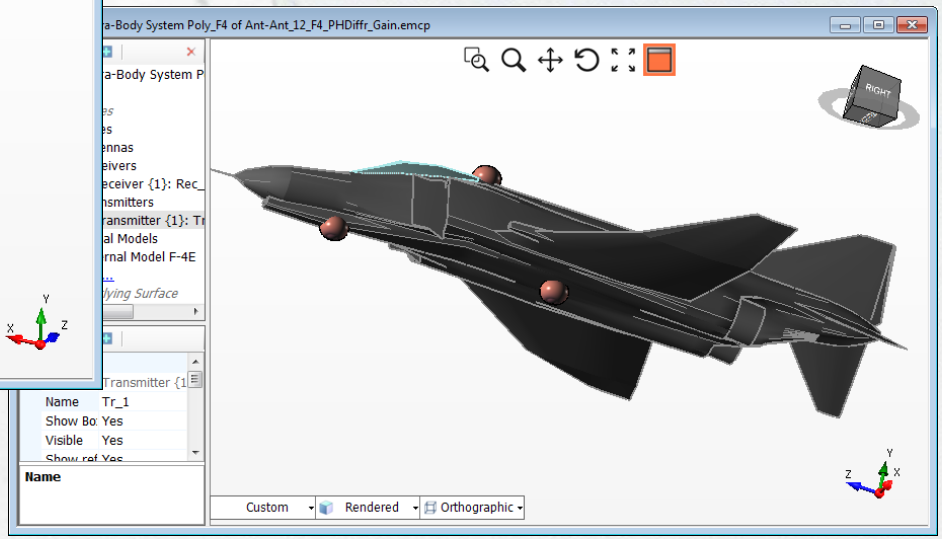
EMC-Analyzer

Interaction with CAD systems:

- **Import of system geometry**
- **Import of cable networks**
- **Export of system geometry**







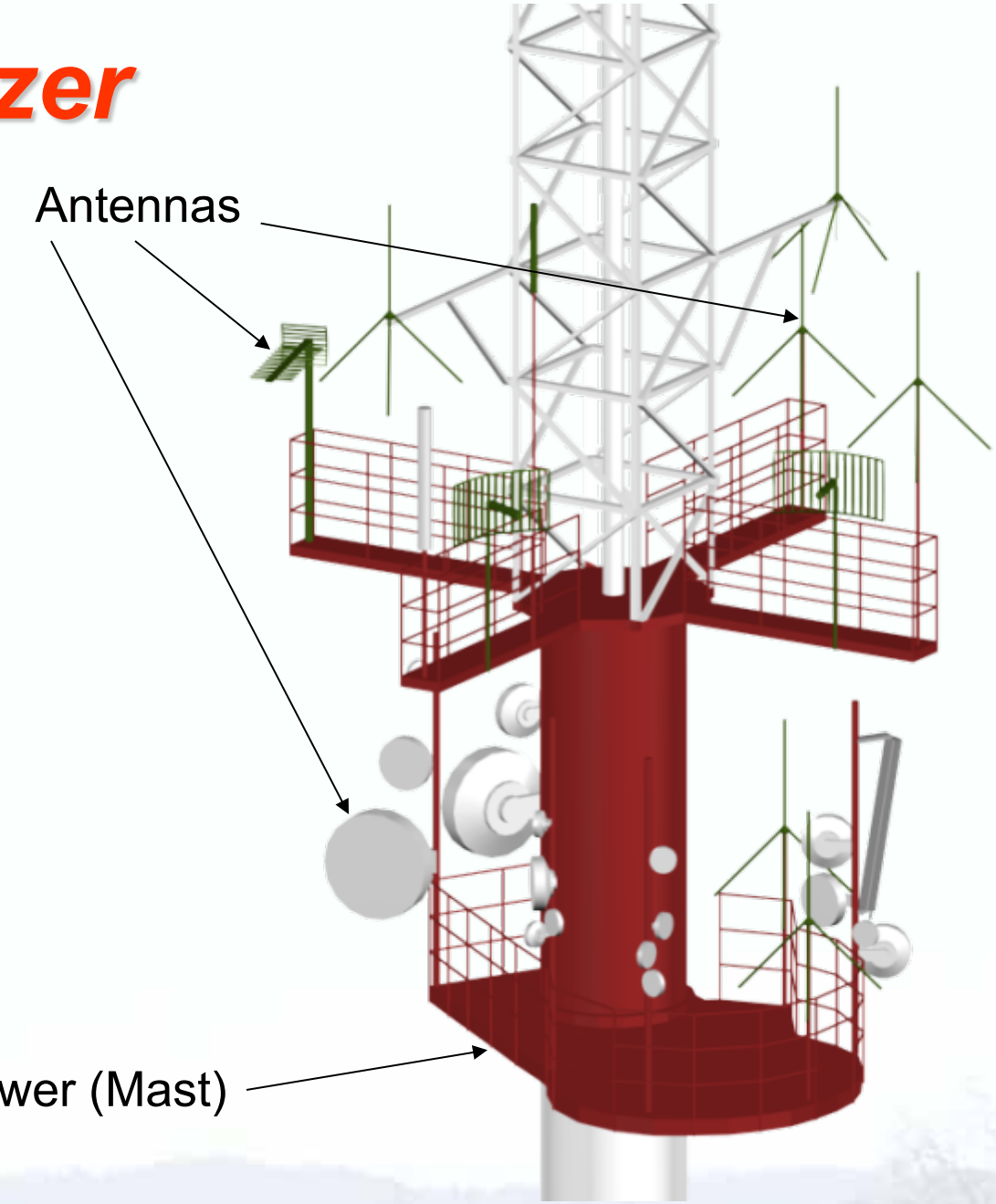
EMC-Analyzer

Ground System modeling includes the following steps:

1. Creation and design of Ground System Spatial model (building, tower or bounded area)
2. Allocation of equipment (transmitters, receivers, transceivers, antennas)
3. Definition of ground system equipment parameters and characteristics
4. Definition of ground system equipment connections and spurious couplings
5. EMFI analysis

EMC-Analyzer

Ground System Geometry:

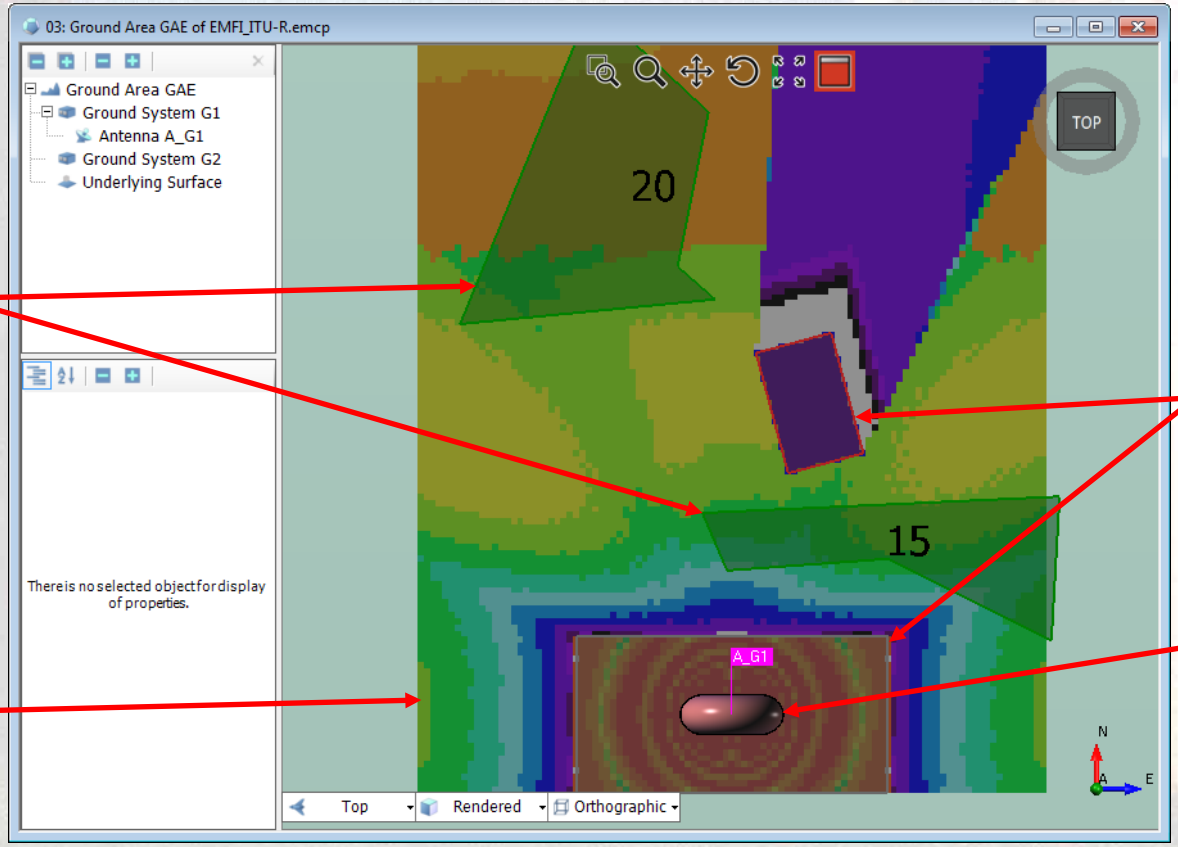


EMC-Analyzer

Local Ground Area Geometry:

Propagation models:

EPM-73
ITU.R – 526
ITU.R – 530
ITU.R – 833



Vegetation

Buildings

Antenna pattern

EM Field distribution (color map)

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Available equipment for Local On-Board Systems:

- Receivers
  - Transmitters
    - Transceivers
      - Antennas
        - Filters
          - Control unit
            - Power unit
              - Other devices

- Bundles

EMC-Analyzer

Spurious Coupling types for Local On-Board System:

- Antenna to antenna
- Field to antenna
- Antenna to wire
- Wire to wire
- Field to wire
- Equipment case to equipment case
- Field to equipment case

EMC-Analyzer

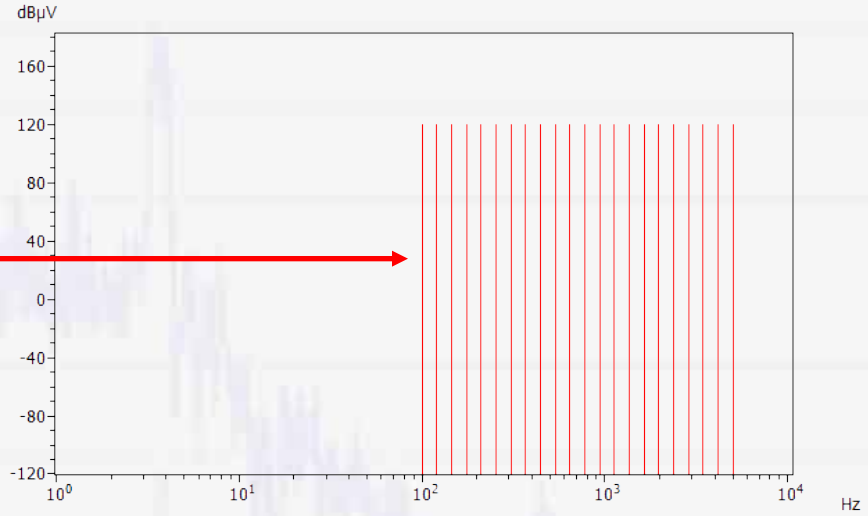
Main procedures:

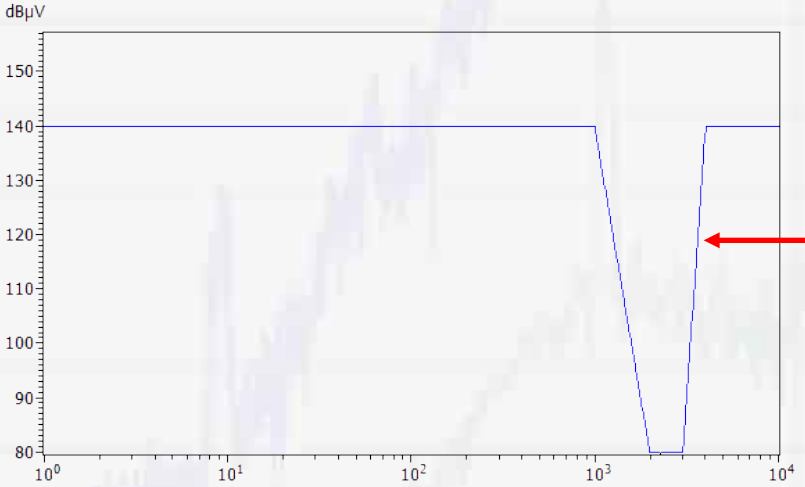
- Linear Analysis of EMC
- Emitter Adjustment
- Receptor Adjustment
- Specification Generation
- Nonlinear Analysis of Radio Receivers
- Analysis of EM Field Intensity Distribution

EMC-Analyzer

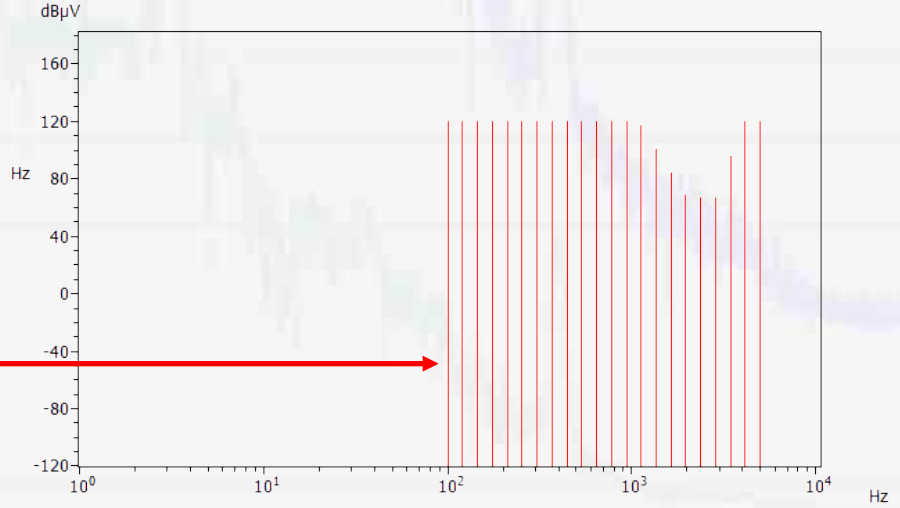
Emitter Adjustment:

Emitter spectrum





Receptor susceptibility

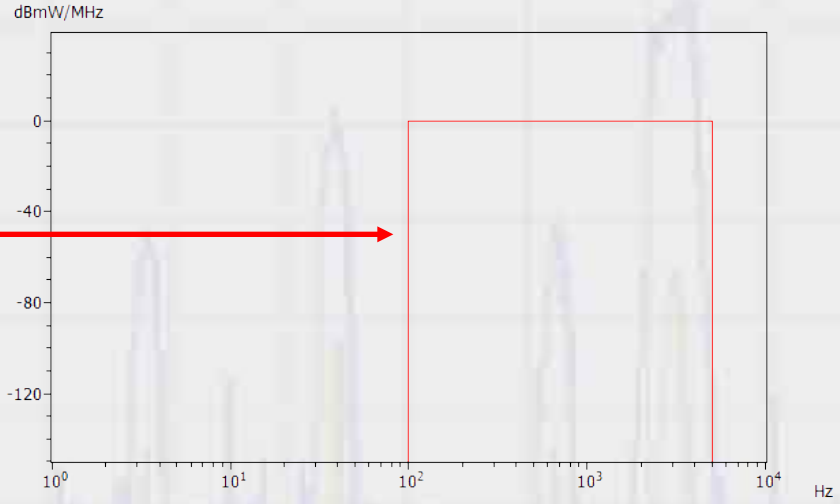


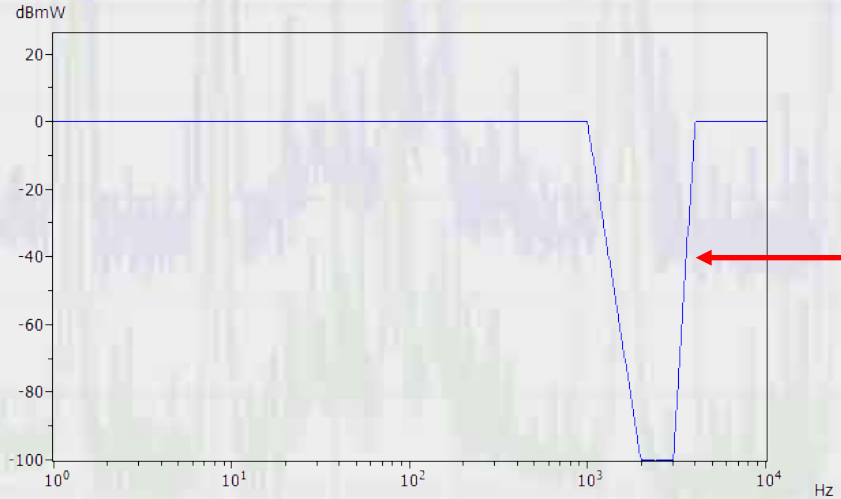
Required emitter spectrum (adjusted to fit receptor susceptibility for achieving the EMC)

EMC-Analyzer

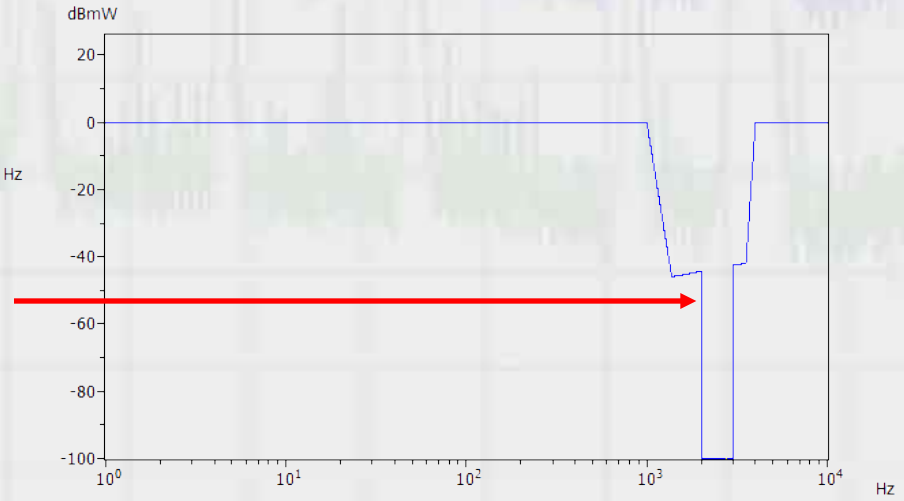
Receptor Adjustment:

Emitter spectrum





Receptor susceptibility



Required receptor susceptibility (adjusted to fit emitter spectrum for achieving the EMC)

EMC-Analyzer

Specification Generation:

Main idea:

Simultaneous Emitter and Receptor Adjustments to achieve EMC

(EMC Synthesis and Design)

Specification Generation Results are displayed in the report window (as the adjustment results)

----------Project Specification_Generation_1: Specification generation----------

Adjustment of emitter radiation spectra...

Emitter \Specification_Generation\T\Port T:
- Receptor \Specification_Generation\R\Port R:
There is unremovable interference
Narrow Band

Frequency, Hz	Before, V	After, V	dB
1126.531490	1	0.677221	3.38539
1357.208808	1	0.106026	19.4917
1635.121402	1	0.1	20
1969.941533	1	0.1	20
2373.322028	1	0.1	20
2859.301840	1	0.1	20
3444.794644	1	0.1	20

Spectrum modified

Adjustment of receptor susceptibility...

Receptor \Specification_Generation\R\Port R:

Frequency, Hz	Before, V	After, V	dB
1635.013535	0.0741478	0.446684	-15.598
1969.379591	0.0116087	0.446684	-31.7043
2374.310722	0.01	0.446684	-33
2859.865671	0.01	0.446684	-33
3444.718325	0.273328	0.446684	-4.26632

Susceptibility modified

Linear Analysis is started.
See the "Results" window for detailed information.
----------Project Specification_Generation_1.emcp: Linear Analysis----------
Start Analysis: 11.07.2023 08:42:44

Receptor \Specification_Generation\R\Port R:

-Emitter \Specification_Generation\T\Port T:
Coupling type: Wire to Wire
Emitting object: Wire T
Exposed object: Wire R

User-defined model of the spurious coupling is applied
IIM = -3.003087 dB

EMC-Analyzer

Nonlinear behavior simulation of radio receiver operation in severe electromagnetic environment

Analyzable nonlinear effects in radio receivers:

- Intermodulation
- Cross modulation
- Desensitization (signal blocking)
- Local oscillator noise and harmonics conversion
- AM-AM and AM-PM conversion

Main advantages:

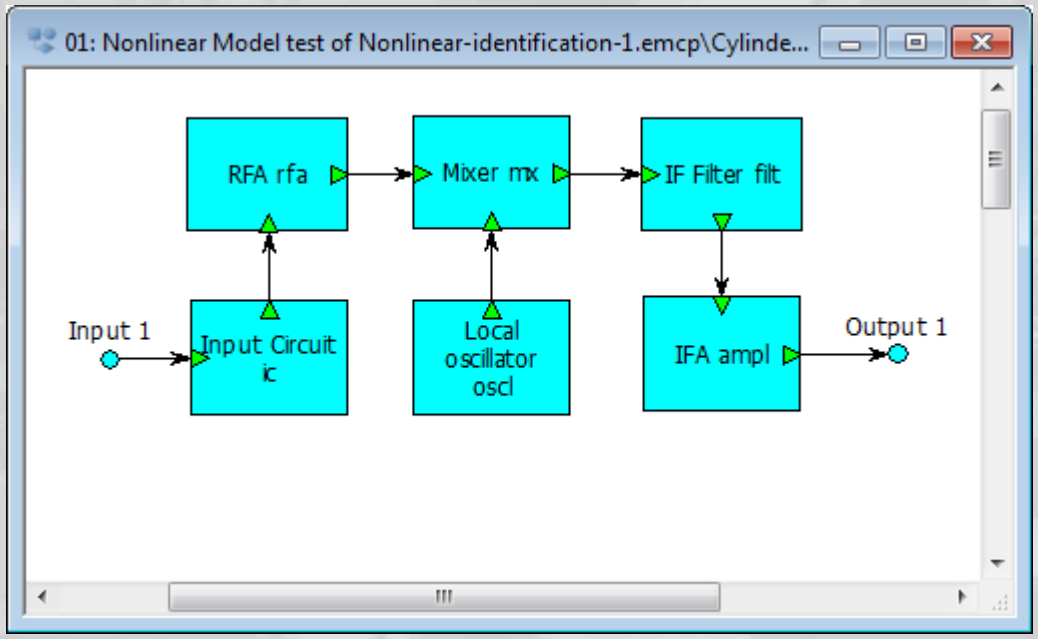
- **Original technology of discrete nonlinear EMC analysis**
- **High accuracy of radio receiver nonlinearity representation using high order polynomial models (up to 25-th order)**
- **Simulation of all nonlinear effects in a uniform work cycle**
- **Fast solutions in electromagnetic environment of any complexity**
- **Identification of sources of nonlinear interference**

EMC-Analyzer

Nonlinear model of radio receiver

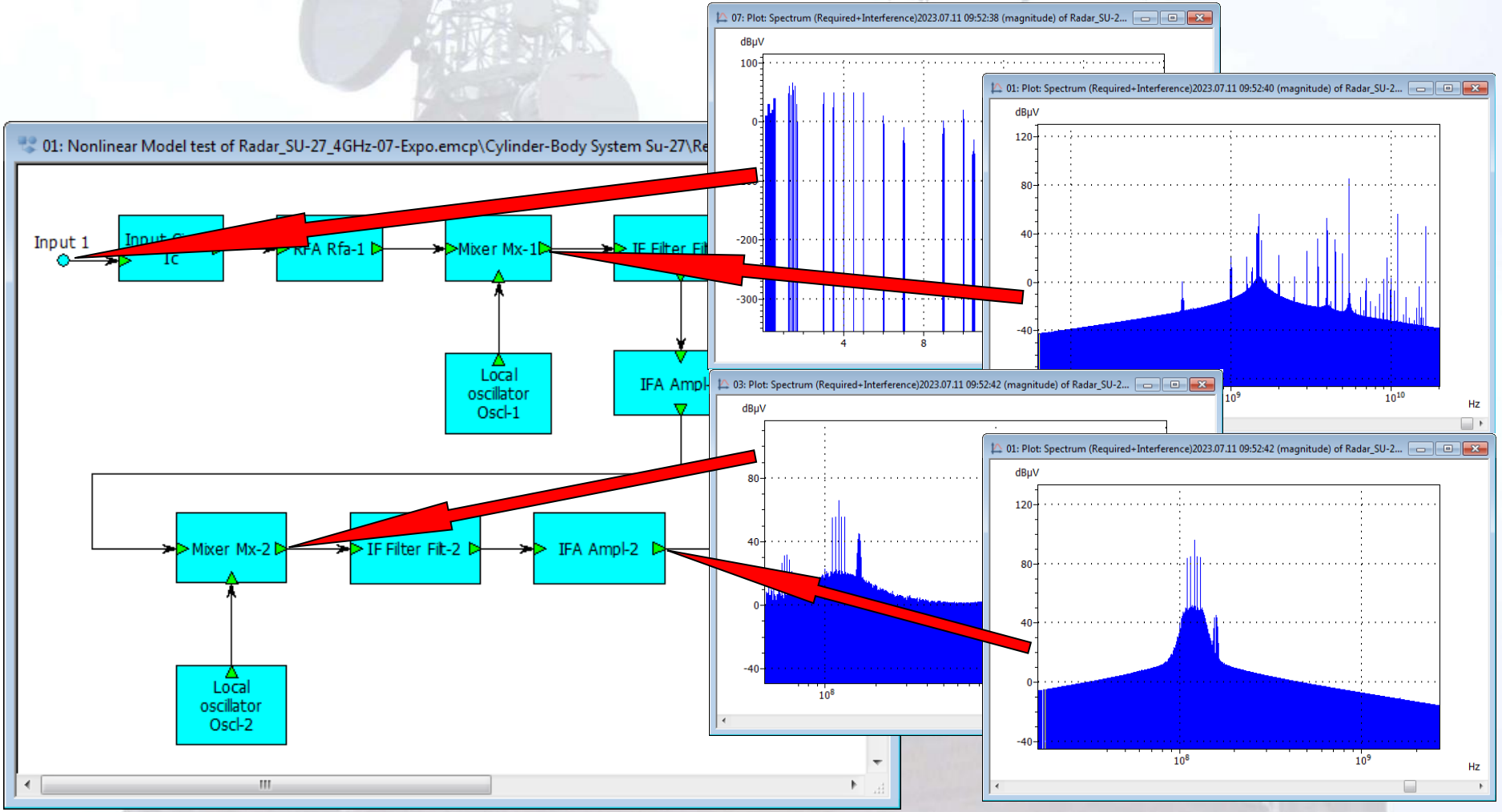
Elements:

- Input circuit
- Radio frequency amplifier (RFA)
- Mixer
- Local oscillator
- Intermediate-frequency Amplifier (IFA)
- Intermediate-frequency (IF) Filter
- Filter
- Decoupler
- Attenuator
- Noise Source
- SNIR Estimator



EMC-Analyzer

Results of receiver's nonlinear simulation



EMC-Analyzer

Application History

- Since 1998, EMC-Analyzer has been delivered to more than 50 companies in 10 countries of four continents (Europe, Asia, America, Africa)
- During these years, various versions of EMC-Analyzer have been used by a number of customers for system design, EMC analysis & simulation, frequency assignment, EMC education & training with reference to radio systems deployed at various sites (aircraft, helicopters, satellites, ships, cars, building roofs, antenna towers, airports, etc.)
- EMC-Analyzer developers contributed significant efforts to cater for high-grade testing of its new versions to achieve its high-quality functioning. Recently, the top quality of EMC-Analyzer has been recognized and acknowledged. Since 2000, there have been no claims against its quality.

The errors of the IEMCAP models

The "Antenna to Antenna" coupling

The examination of models on board the B-52:

190 out of 230 cases (or 83%) were correctly predicted.

17% of the cases included errors.

19 (8%) - the errors of the first type,

2 (0,8%) - the errors of the second type.

B-52 Analysis Matrix

Predicted \ Actual	NO EMI	EMI
NO EMI	171	2 (Errors of the 2nd type)
EMI	38 (Errors of the 1st type)	19

TOTAL COMBINATIONS: 230

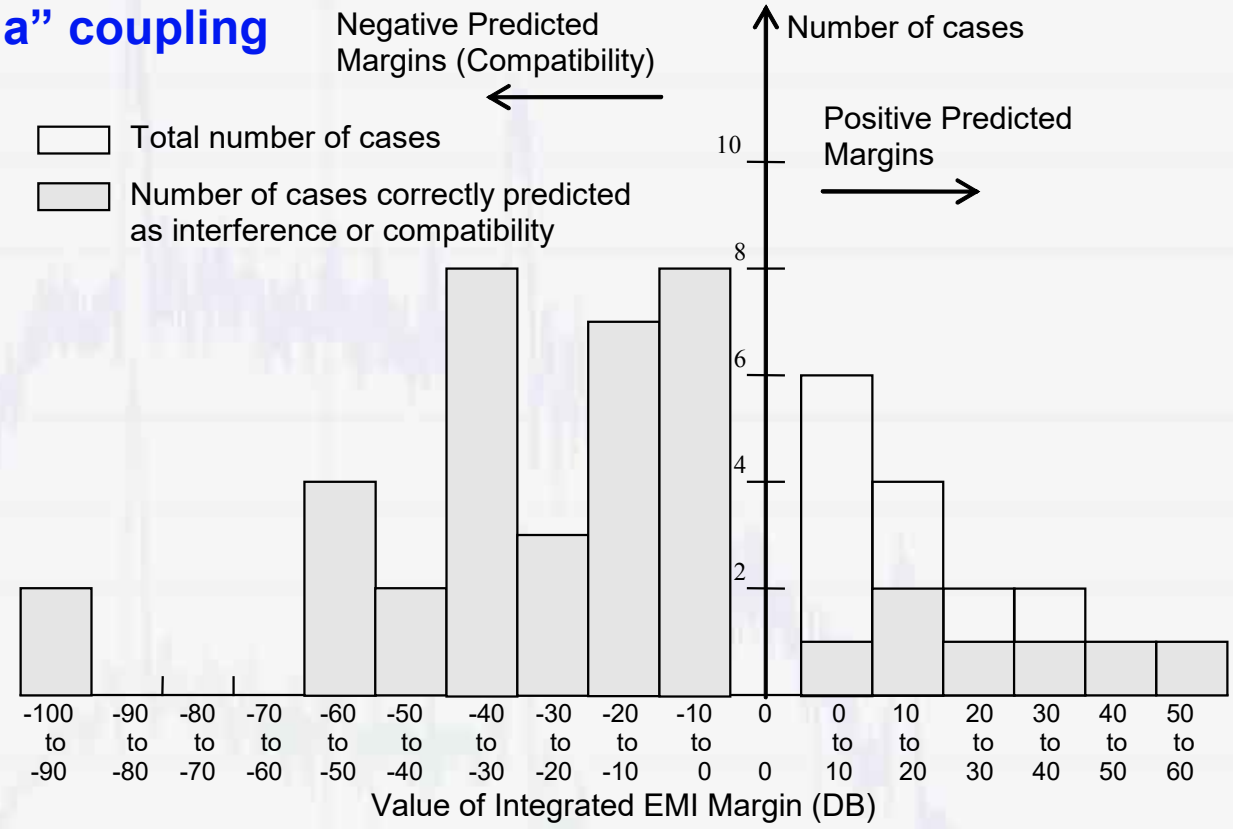
The errors of the IEMCAP models

The "Antenna to Antenna" coupling

The examination was carried out on board the **F-15**.

Out of 51 cases, 42 were correctly predicted, and 9 cases contained incorrect predications.

Out of 42 positive predictions, 35 did not contain the interference, and 17 did.



Distribution of Predicted Antenna to Antenna Integrated Margins

All 9 incorrect predictions were the errors of the first type. <u>There were no errors of the second type.</u>

It is an evidence of the fact that the models give the upper estimation of the interference level.

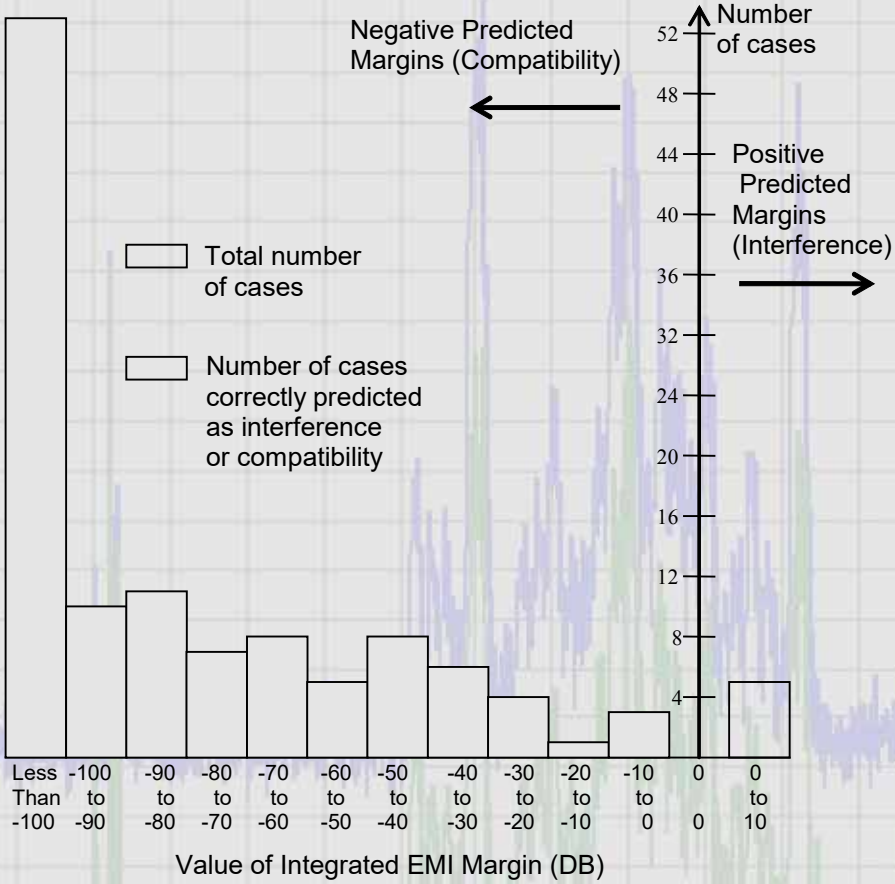
The errors of the IEMCAP models

The “Field to Wire” and “Antenna to Wire” couplings

IEMCAP predictions are accurate enough for low frequencies ($f \leq 10$ MHz) (more accurate, than these of many other programs).

The error is less than 10 dB for these frequencies. However, the error can reach 50 dB (near the resonance peaks caused by the fuselage and other metallic parts) for the frequencies $f > 10$ MHz.

The analysis for the **F15** board :
116 out of 121 cases were correctly predicted.
All 5 incorrect predictions were the errors of the first type.
Errors of the second type were absent!



Distribution of Predicted Antenna to Wire Integrated Margins

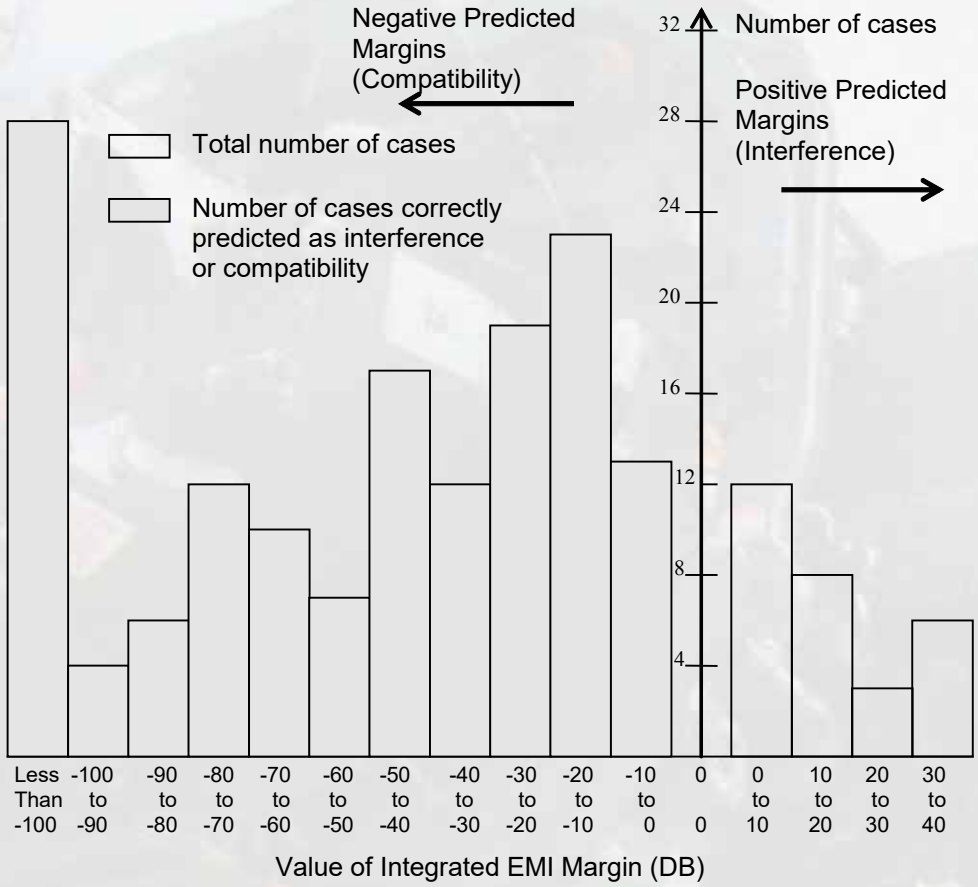
The errors of the IEMCAP models

The “Wire to Wire” coupling

The accuracy of *IEMCAP* models (defined as the ratio of the exact value to the approximate value) is ±10 dB for $L<0.1\lambda$, where L - wire length, λ - wavelength.

181 couplings were modeled.
152 correct predictions were made.
All 29 negative predictions were the errors of the first type.
The models give the upper estimation of the interference level, as shown in figure.

The increase in the quantity of errors for $L>0.1\lambda$ is caused by several reasons.
First, the standing waves appear at the sufficiently high frequencies (they are caused by reflections from the heterogeneities), and they are not taken into account.
Second, the interaction has resonance character at sufficiently high frequencies and capacitive and inductive couplings cannot be separated.



Distribution of Predicted Wire to Wire Integrated Margins

The errors of the IEMCAP models

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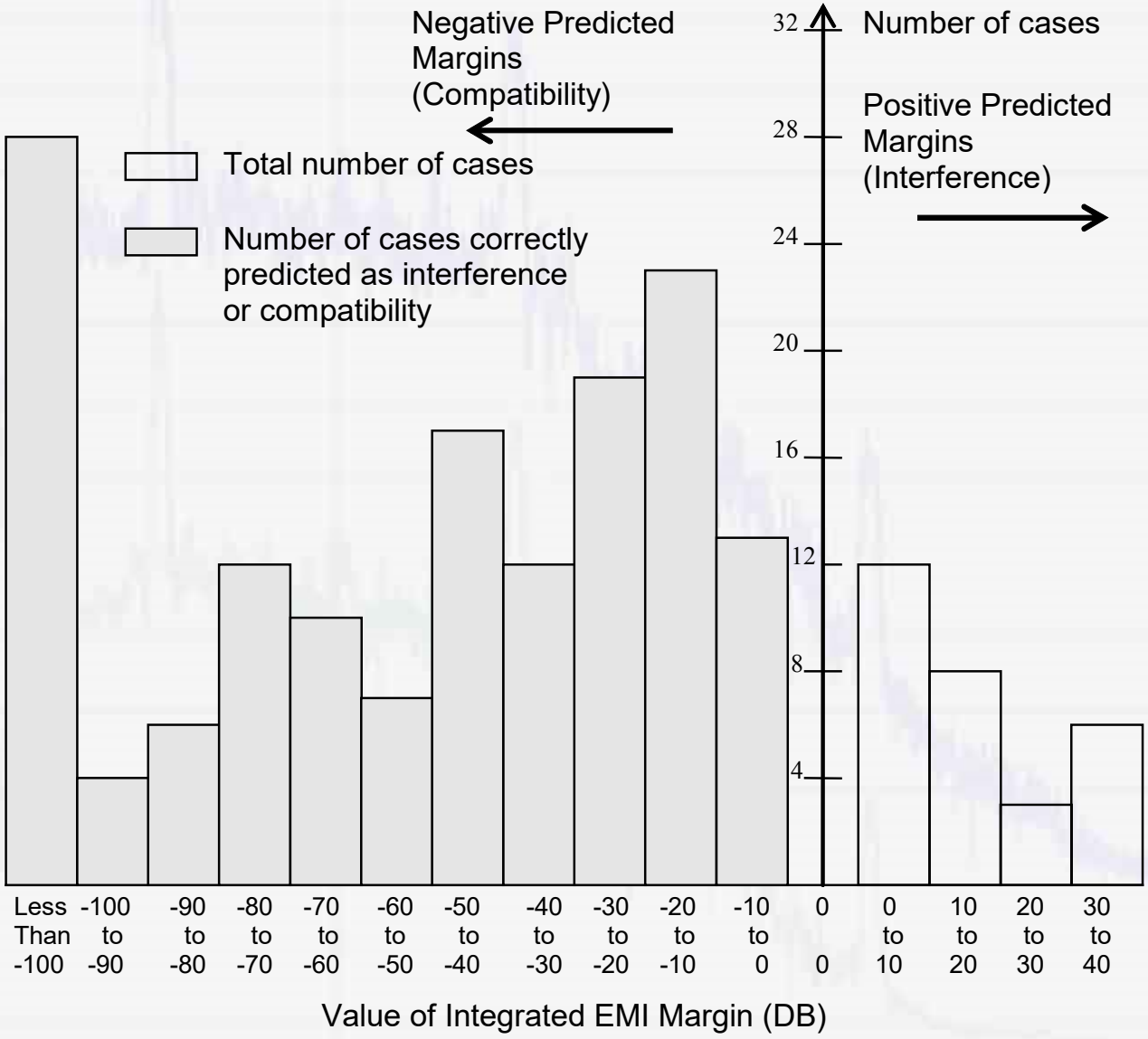

Distribution of Predicted Wire to Wire Integrated Margins

EMC-Analyzer

EMC-Analyzer is a specialized expert system for early diagnostics of Intrasystem EMC!

EMC-Analyzer is a result of scientific, technical, and industrial cooperation of the following organizations:

- Belarusian State University of Informatics & Radioelectronics (BSUIR)
- EMC Technologies LLP
- DAVY Networks LLP

EMC R&D Laboratory of BSUIR

Main research and development (R&D) trends and activities:

- Technologies, software products and specialized expert systems for analysis and synthesis of EMC in local on-board and ground radio systems (groupings of radio equipment)
- Technologies and software products for analysis and synthesis of intrasystem and intersystem EMC, spectrum management in space-scattered (territorial, regional, etc.) groupings of radio equipment with the use of digital area maps, GIS technologies and frequency allocation databases
- Approaches, technologies, and software products for discrete nonlinear modeling & behavior simulation of radio systems, devices, and elements (radio networks, systems, receivers, transmitters, amplifiers, mixers, etc.)
- Methods, technologies, and software products for optimal frequency planning of radio networks (mobile and fixed radio communication, digital TV, etc.) with arbitrary spatial topology
- Methods, technologies and software products for measurement and control of EMC characteristics of radio elements, devices, and systems
- Statistical theory of EMC in space-scattered radio systems and networks
- System ecology of cellular radio networks

EMC Technologies LLP

Main research and promotion activities:

Development and promotion to the world market of technologies and software in the field of radio system design and electromagnetic compatibility analysis & design, including the following:

- development and modification of codes and procedures in the “EMC-Analyzer” software for the intrasystem EMC analysis and design, further improvement and promotion of this software to the world market

- development and promotion to the world market of software of the “Microwave Radio Network Planning Tools” (MRNPT) series - “HOP-Designer”, “Network Frequency Planning”, “Network Frequency Allocation”, etc. for radio system EMC design and analysis using GIS-technologies

- development of software for nonlinear EMC analysis and radio receiver behavior simulation in complicated electromagnetic environment (EME) based on instantaneous quadrature technique

EMC-Analyzer, related papers (1):

- Baldwin T.E.Jr. and Capraro G.T. Intrasystem Electromagnetic Compatibility Analysis Program (IEMCAP), *IEEE Trans. on EMC*, v.22, pp.224-228, Nov. 1980
- V.I. Mordachev, Express-analysis of electromagnetic compatibility of radioelectronic equipment with the use of the discrete models of interference and Fast Fourier Transform, *Proc. of IX-th Intern. Wroclaw Symp. On EMC*, Poland, Wroclaw, 1988, Part 2, pp. 565-570
- S. L. Loyka and V. I. Mordachev, Identification of nonlinear interference sources with the use of the discrete technique, *Proc. of IEEE Intern. Symp. on EMC*, Denver, Colorado, 1998, pp. 882–887
- S.L. Loyka and J.R. Mosig, New behavioral-level simulation technique for RF/microwave applications. Part I: Basic concepts, *Int. J. RF Microwave Computer-Aided Eng.,* 10(4) (2000), pp.221–237
- V.I.Mordachev Automated Double-Frequency Testing Technique for Mapping Receiver Interference Responses, *IEEE Trans. on EMC*,Vol.42, No.2, May 2000
- V.Mordachev, P.Litvinko. Expert System for EMC Analysis Taking Into Account Nonlinear Interference, *Proc. of 16th Intern. Wroclaw Symp. on EMC*, Poland, Wroclaw, June 25-28, 2002, pp.265-270
- V.Mordachev, P.Litvinko. Nonlinear sensor method for EMC/EMI analysis in severe electromagnetic environment using EMC-Analyzer expert system, *Proc. of 17th Intern. Wroclaw Symp. on EMC*, Poland, Wroclaw, June 29-July 1, 2004
- V.Mordachev, E.Sinkevich, EMC Analysis of co-site RF/Microwave systems: simulation of signal demodulation, *Proceedings of International Symposium on Electromagnetic Compatibility "EMC Europe 2006"*, Spain, Barcelona, Sept. 4-8, 2006, p.624-629.
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