

NEW APPLICATIONS OF ANSA IN CEM

Pavel Tobola*, Ivo Grác

Evektor, spol. s r. o., Czech Republic

KEYWORDS – Electromagnetic threats, computational electromagnetics, FDTD & MTLN solver, pre-processing,

ABSTRACT – Environmental electromagnetic threats of an aircraft and its vulnerable systems are examined by Evektor using methods of Computational Electromagnetics (CEM). As an airframe shall provide an inherent systems' protection against the threats (indirect effects of lightning and HIRF), an intensity of internal electromagnetic field as well as responses on cable bundles in this internal environment are to be evaluated to quantify them. The full-wave FDTD (Finite Difference Time Domain) and MTLN (Multi-conductor Transmission Line Network) models with appropriate solvers are used for this purpose.

Although the mentioned above solvers have their devoted special pre-processors usually used for airframe geometry simplifications and meshing, we use ANSA as the universal pre-processor that is irreplaceable for us whenever any effective creation as well as modification of the electromagnetic (EM) model geometry is necessary. Then the devoted special pre-processor is used only for three-dimensional quantisation of the airframe geometric model together with its close surrounding wrapped into unechoic layers with special boundary conditions and when implemented the wire structures on that the responses of cable bundles are to be calculated. The airframe geometry as well as geometries of the mentioned above wire structures are processed together using ANSA to match them each to other before their individual imports into the special pre-processor that makes the EM model treatable by the mentioned FDTD and MTLN solver.

Participating on the HIRF-SE collaborative project (7-th Framework Programme of EU) where a common platform of the EM model data (AMELET) is established to match the data format for various EM solvers (both the existing and future ones), Evektor is interested in continuance to use ANSA as the most powerful tool for creating of EM models and to integrate it into the HIRF-SE framework as an organic part making possible an effective pre-processing for any solver. To achieve this daring goal, we are prepared to create a necessary software sub-module for this purpose in a future close cooperation with BETA CAE Systems S.A.

TECHNICAL PAPER -

1. ELECTROMAGNETIC THREATS OF FLIGHT SAFETY

The recent technical progress in civil aviation brought a successive substitution of classical flight instruments by a modern avionics. Output signals of necessary sensors are digitally processed and displayed using colour LCD screens giving an overview about basic parameters of an aircraft and its flight. Avionic systems become more complex and integrated and they execute more functions that are critical with reference to the safety of a flight.

Unfortunately, all the modern avionics is more vulnerable by electromagnetic interferences than the classical instrumentation. The interferences are caused partly by unwanted radiations of other systems installed on the aircraft and partly by environmental effects as lightnings and high intensity radiated fields (HIRF). At the first, we talk about an intersystem electromagnetic compatibility (EMC) and at the latter one about the environmental electromagnetic compatibility (3E-compatibility) of the airplane systems.

If an aircraft is struck by a lightning (with the probable frequency of one strike per year) or it meets a strong RF transmitter or radar (several times during a flight), hazardous responses (voltages and currents) are forced into the internal wiring of the aircraft. The cable bundles excited by this way become unwanted sources of an electrical energy that is distributed through the airframe. The responses (transients in case of lightning and modulated RF signals in case of radiated fields) may reach such energetic levels that input/output circuits of sensitive instruments connected to the wiring may be destroyed or a functional upset may occur on them. Consequences of these incidents may be fatal if the injured avionic system carries out critical functions with reference to the flight safety.

The above mentioned situation is more complicated by a frequent use of new composite structural materials that are known not only by their excellent mechanical properties, low weight and low manufacturing costs, but unfortunately also by their low shielding effectiveness in a comparison to metallic materials used formerly. If these composite materials cannot provide a quite reliable inherent protection to aircraft systems, they must be appended by special protection layers, especially when used for an aircraft skin covering critical systems.

Other complication of the situation is a continuous increase of radiated power on transmitters and radars that may be probably met during a flight and a growth of requirements for an operation of wideband portable electronic devices (WPEDs) to be used by passengers inside airplanes during a flight.

An effective protection for an aircraft and its critical systems against these electromagnetic environmental effects (3E) is established by aviation regulations and must be demonstrated when any new aircraft is certified for the business as well as general aviation. This demonstration is usually done by an experimental way using EMC laboratories. An internal intensity of electromagnetic field as well as wiring responses are measured when the aircraft is radiated by a high intensity RF field or excited by conducting of current waves (simulated lightning transients) through the airframe. This experimental aircraft testing requires a special instrumentation, skilled personnel and it is usually executed inside an anechoic room of extreme dimensions. If only several laboratories in the world are accredited in this

experimental EMC testing on airplanes, their pricings are not too competitive and the costs for these tests may become unacceptable for a majority of small aircraft manufacturers.

There is a paradox in the general aviation, that the smaller is the aircraft the smaller is the consideration paid to these environmental threats, but contrarywise, the greater is the hazard caused by them when considering current densities on a small aircraft connected as a part of a lightning channel or airframe skin thickness of a small aircraft exposed to a strong radar radiation. Taking into consideration a big aircraft (e.g. Airbus or Boeing), the problem seems to be resolved now, because the costs for demonstration of compliance with regulations using tests represent only an insignificant part of a budget of a new aircraft development project. In case of a new small aircraft certification, we cannot consider any cost reduction for this demonstration especially when using the airframe of composite materials and installing modern (and more vulnerable and critical) avionic equipment. The costs for compliance demonstration by experimental testing grow to percentually significant part of the project budget and this may be a cause of the project unsuccess.

Having considered the reasons mentioned above, Evektor, spol.s r. o. is looking for inexpensive EMC tests and certification methods for small aircraft using the following concepts:

- substitution of experimental test methods by simulations using means of computational electromagnetics (CEM).
- use of new structural composite materials with well specified or certified electromagnetic properties (prepregs) to create a predictable airframe internal environment for electromagnetically sensitive installations and systems,
- use of software for electromagnetic field visualization in time as well as frequency domain and computing of induced response levels in wirings situated in this environment using an aircraft digital mock-up data for materials and spatial arrangement,
- verification of a maximum error between the data obtained by simulation and measurement,
- embodiment of an electromagnetic visualization into a software which is normally used for creating of aircraft digital mock-up as well as cabling inside or outside the digital model (problem of antennas' layout on a small aircraft body).

2. ELECTROMAGNETIC FIELD AND WIRING RESPONSE SIMULATIONS

The fundamental idea to examine the action of electromagnetic environmental effects (3E) on an aircraft and its systems using computational models is not quite new at our company. Finite element method (FEM) has been used in Evektor especially for structural analysis (*mechanical strength*) calculations since 1995. These activities were begun by our hire engagement in some aircraft projects of Aero Vodochody (Ae159 and Ae270) as well as other airframers (Raven) and continued by our involvement in the Czech automotive industry (Skoda-Volkswagen) since 2000.

The PAM-CRASH software of ESI-Group has been used by this company since 2003 when combined (especially for pre-processing and meshing) with the ANSA universal pre-processor. We can say we have more than 12-year's experience in a creating of FEM models for mechanical engineering in our company and our colleagues in the automotive crash department were the first pioneers using ANSA as a powerful tool for the FEM models' preparation. Having taken into consideration their best experience with ANSA for the years, it became the most irretreivable tool for us also at the beginning activity in the CEM field, when the PAM-CEM FDTD solver in suite with the CRIPTE MTLN tool were purchased by Evektor in 2008.

FDTD Solver

This solver is used for calculations of individual electric (E) and magnetic (H) field intensity components inside and in close proximity of aircraft electromagnetic model as well as appropriate surface currents that are excited by radiation on the aircraft skin.

In general, the fundamental mathematic model of electromagnetic field is represented by the Maxwell equations. Computational electromagnetics includes many various ways of their numerical solutions that can be classified for example according to the facts, if they are solved in their differential or integral forms or if the solutions are in the time or frequency domains. Finite differences time domain method (FDTD) is only one of the groups of possible numerical solutions, but it has the widest spectrum of applications and commercial software implementations in spite of that it was firstly published by Yee already in 1966. The following brief explanation can be found in [3].

When Maxwell's differential equations are examined by this way, it can be seen that the change in the E-field in time (the time derivative) is dependent on the change in the H-field across space (the curl). This results in the basic FDTD time-stepping relation that, at any point in space, the updated value of the E-field in time is dependent on the stored value of the E-field and the numerical curl of the local distribution of the H-field in space. The H-field is time-stepped in a similar manner. At any point in space, the updated value of the H-field in time is dependent on the stored value of the H-field and the numerical curl of the local distribution of the E-field in space. Iterating the E-field and H-field updates results in a marching-in-time process wherein sampled-data analogs of the continuous electromagnetic waves under consideration propagate in a numerical grid stored in the computer memory.

Illustration of a standard Cartesian Yee cell used for FDTD, about which electric and magnetic field vector components are distributed, is in the left part of the Fig. 1 (Yee 1966). Visualized as a cubic [voxel](#) (volumetric pixel), the electric field components form the edges of the cube, and the magnetic field components form the normals to the faces of the cube. A three-dimensional space lattice is comprised of a multiplicity of such Yee cells. An electromagnetic wave interaction structure is mapped into the space lattice by assigning appropriate values of permittivity to each electric field component, and permeability to each magnetic field component.

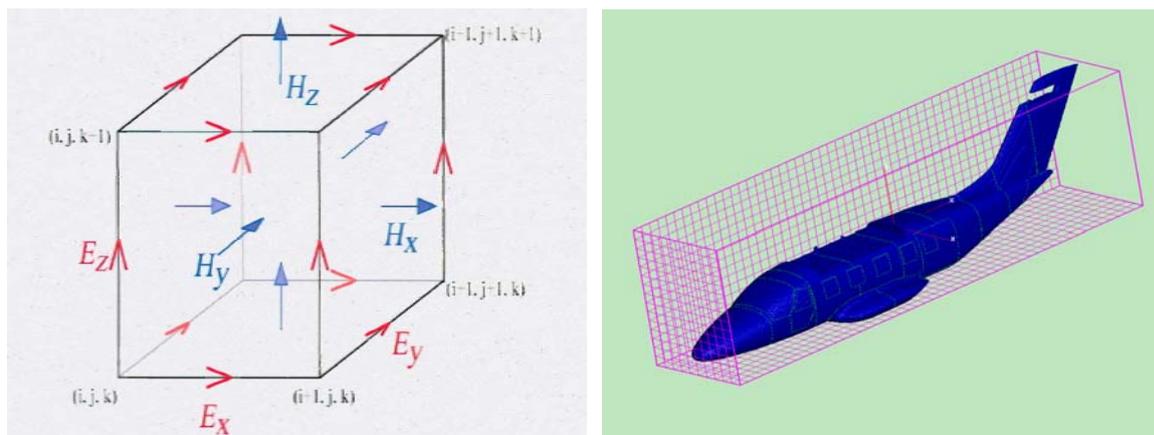


Figure 1 – Left: Illustration of a standard Cartesian Yee cell used for FDTD. Right: Volume discretization of an aircraft fuselage EM model and its adjacent space into the Yee lattice.

This description holds true for 1-D, 2-D, and 3-D FDTD techniques. When multiple dimensions are considered, calculating the numerical curl can become complicated. Kane Yee's seminal 1966 paper in IEEE Transactions on Antennas and Propagation proposed spatially staggering the vector components of the E-field and H-field about rectangular unit cells of a Cartesian computational grid so that each E-field vector component is located midway between a pair of H-field vector components, and conversely. This scheme, now known as a **Yee lattice**, has proven to be very robust, and remains at the core of many current FDTD software constructs.

Furthermore, Yee proposed a leapfrog scheme for marching in time wherein the E-field and H-field updates are staggered so that E-field updates are conducted midway during each time-step between successive H-field updates, and conversely (Yee 1966). On the plus side, this explicit time-stepping scheme avoids the need to solve simultaneous equations, and furthermore yields dissipation-free numerical wave propagation. On the minus side, this scheme mandates an upper bound on the time-step to ensure numerical stability (Taflove & Brodwin 1975). As a result, certain classes of simulations can require many thousands of time-steps for completion.

MTLN Solver

This solver is used for calculations of the responses on wiring structures embedded in the above mentioned aircraft EM model. It uses the model based on the multi-conductor transmission line networks (MTLN) stressed by an electromagnetic field. The wiring structures (models of cable bundles) can be very large complex, they can be shielded or not and also dielectric insulators can be taken into the account. The following brief explanation can be found in [4].

The MTLN solver is based on electromagnetic topology (EMT) that relies on computations through multi-conductor transmission line network (MTLN). The networks defined through the code consist of cable lines (tubes) connected each to other through junction. The junctions here represent avionic units or any other components of the system under examination. The measured S-parameters or their equivalent computed values are fed through the tubes to the junctions as an input. The code thus analyzes the network, which has been "volume decomposed" into junctions and tubes. The effect of network radiation is simulated by introduction of external RF sources on the cable network.

For large electrical systems, the EMT solution method offers a strategy to handle the complexities associated with electrical wiring in systems under examination. The first and most important aspect of EMT is the assumption, that volumes can be decomposed into subvolumes that can interact each to other through a "preferred path" such as apertures and cables. The assumption is based on the premise, that there is enough shielding between the volumes and there is no energy transfer through the shielding.

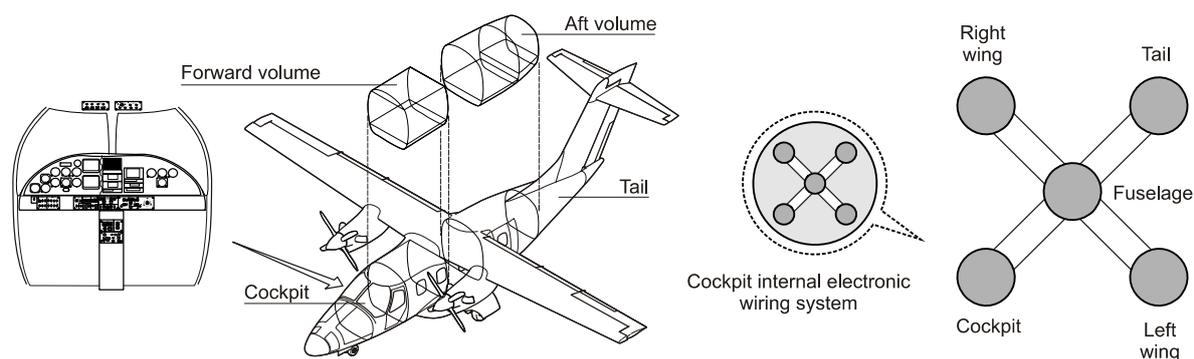


Figure 2 – Left: Volume decomposition diagram. The entire system is topologically broken down into different volumes. Right: Topological network consisting of the external and internal levels, included within each other.

As mentioned above, the topological networks that result in an EMT circuit are essentially composed of junctions, tubes and sources. Junctions are elements that terminate or connect transmission lines. Common types of junctions are open-circuited, short-circuited, 50-ohm and matched loads. Another example of junctions is an n-port device that can be defined by scattering parameters (S-parameters) or by any similar n-port parameters. Tubes represent the connections between junctions and can be defined from transmission line per length unit values (resistance per meter, capacitance per meter, inductance per meter and conductance per meter). Parameters of junctions and tubes can be derived from formulas, tables or measured values. Sources can be defined by the results of the FDTD analysis and they can be either voltage sources (derived from the local components of E-intensity) or current sources (derived from the local components of H-intensity).

Consider a large electrical system such as an aircraft shown in Fig. 2 (Left). Assume that the entire system can be decomposed into sub-volumes. The aircraft in Fig. 2, for example, can be decomposed into such volumes as cockpit, lower forward, wing, tail and aft volumes which can interact each to other through an interaction path such as apertures and cables. Inside the cockpit, there are situated critical and electromagnetically vulnerable electronic instruments (e.g. computers and LCD displays) and wiring cables as main constituents of the avionic system of the aircraft. The topological networks that represent the system interaction are essentially composed of junctions and tubes. Junctions that represent volumes are elements that terminate or connect transmission lines. Tubes represent the connections between junctions and can be defined by transmission line per unit parameters. Inputs for junctions and tubes can be derived from formulas, tables, measured values or simulated results. Fig. 2 (Right) shows the diagram of the topological network of the aircraft shown in Fig. 2 (Left). There are 5 main junctions and 4 tubes that form the upper-level network consisting of the cockpit, the wing, the fuselage and the tail. There exists inside the cockpit junction the lower-level network of the cockpit avionics and cable wirings.

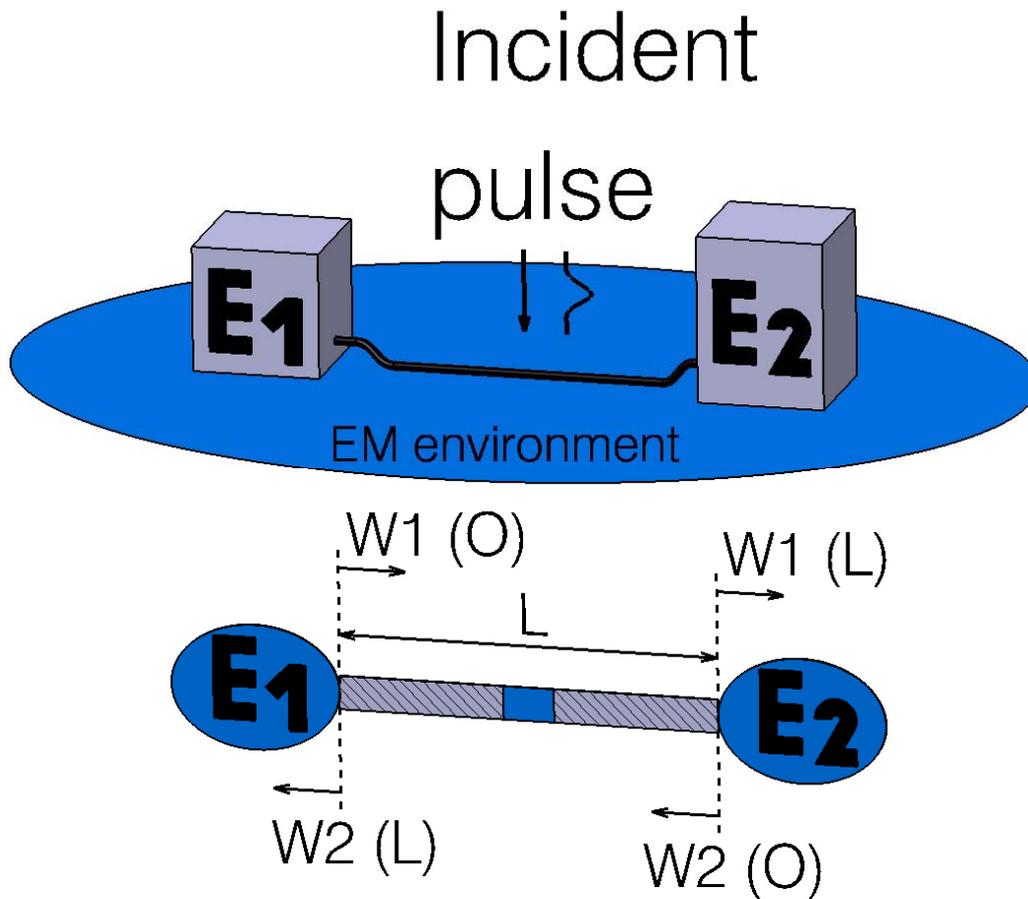


Figure 3 – Two avionic units E₁ and E₂ connected together by a cable (affected by an outer field) and their EMT representation.

For topological network equations, consider a simplified sub-component of the large electrical system. Fig. 3 above shows two avionic units in a subsystem that is represented by two circular junctions connected by a tube-like structure. At the junction of E₂, vectors for both the incoming (W₁(L)) and outgoing (W₂(O)) waves are related by the junction scattering matrix (S₁₂) through the scattering equation, expressed as

$$(W_2(O)) = (S_{12}) (W_1(L)). \tag{1}$$

For multi-conductor lines, the incoming and outgoing waves at the junction of E₂ can be represented, respectively, by (V)+(Z_c(I)) and (V)-(Z_c(I)) where (V) and (I) are voltages and currents at each port at each port of the junction and Z_c is the characteristic impedance. The scattering parameter (S) can be written in terms of the admittance matrix (Y) as in equation [2] with the characteristic impedance matrix at the junction of E₂ with N₁ conductors along tubes is represented through equation (3):

$$(S) = [(1) - (Z_c)(Y)] [(1) + (Z_c)(Y)]^{-1} \tag{2}$$

$$(Z_c) = \begin{matrix} \begin{matrix} Z_{c1,1} & \dots & Z_{c1,N1} \\ \vdots & & \vdots \\ Z_{cN1,1} & \dots & Z_{cN1,N1} \end{matrix} \\ \tag{3} \end{matrix}$$

Propagation of the incoming and outgoing waves along the tube in the opposite directions with an equivalent distributed source (W_s) can be characterized by a propagation matrix (Γ). The resulting propagation equation becomes

$$(W_1(L)) = (\Gamma)(W_1(O)) + (W_s). \quad (4)$$

Signals on an entire transmission-line network is expressed through the BLT (Baum, Liu and Tesche) equation, which is in essence, the multi-conductor transmission line (MTL) network composed of the incoming wave vector, the outgoing wave vector, and the source wave supervector (vector of vectors), respectively shown above as $[W(O)]$, $[W(L)]$, and $[W_s]$. The network scattering and propagation supermatrices (matrix of matrices) are represented, respectively, by $[S]$ and $[\Gamma]$. Using the supervector and supermatrix forms shown by (1) and (4), the BLT equation can be expressed as:

$$\{[1] - [S][\Gamma]\} [W(O)] = [S][W_s], \quad (5)$$

where $[1]$ is the identity supermatrix.

Solution of the BLT equations (5) have been incorporated into the electromagnetic topological code CRIPTE developed by French national aerospace research centre ONERA since 1990. It allows calculations of the response of complex cables' networks in a frequency range up to several GHz. It was completed by the LAPLACE tool that allows the calculation of L and C matrices of cable crosssections.

Evektor purchased a license for the CRIPTE and LAPLACE solvers in suite with the FDTD solver PAM-CEM of the French company ESI group in 2008 when seeing a necessity to verify in-house created EM models of our aircraft.

3. USE OF ANSA FOR ELECTROMAGNETIC MODEL CREATION

When trying the first CEM simulations using the above mentioned FDTD and MTLN solvers, we created simple geometry shapes and wiring structures using a special devoted pre-processor obtained as a part of the PAM-CEM suite. The EM models, created directly using this pre-processor by linking of simple entities at a level of school examples, were seemed perfect for meshing and consequential EM simulations on them.

A ball-shaped body of metallic material radiated by a planar wave showed a predictable arrangement of surface currents on its radiated hemisphere as well as EM field intensities in its close environment. Simulation results of simple antenna dipole were predictably shown by the same way and we had a naive idea simply to substitute these trivial geometric shapes by an aircraft model and then we are prepared to solve any interaction of this aircraft with a severe electromagnetic environment.

Our initial enthusiasm was quickly turned to an absolute gloom, when importing the aircraft CAD model transferred using the neutral IGES format and the special pre-processor announced more than ten thousands errors that prevented its subsequential processing. If the special CEM pre-processor was seemed to be suitable for healing of the above mentioned simple structures, its use for healing of the real aircraft might be considered as a real bottle-neck in whole the process of any CEM simulation.

Fortunately, we had an opportunity to see our colleagues, who prepare FE models for static calculations, crash simulations, etc., as they create their models using the universal pre-processor ANSA. We asked them for a help to clear-out the bottle-neck of the EM model pre-

processing. After the above mentioned experience with the import directly to the special CEM pre-processor, it was seemed as a miracle, when our transferred large-scale aircraft model was imported into this universal pre-processor with no error and using not only the neutral IGES format, but also using the native CAD format (CATIA). When the powerful tools of ANSA were consequentially used for simplification and healing, we have obtained a quite superior EM model that was meshed and exported using a mesh format (NASTRAN) for an import into the special CEM pre-processor.

If the imported model is simplified, healed and meshed, there was a more reliable way open for us - to import the meshed model into the special CEM pre-processor with a minimum of possible errors, by means of that the consequential required processing (surface & volume meshing and EM simulation) might be prevented. When using an imported model prepared by such a way, we meet only a few problems with imported geometry and these residual problems are well definable on the imported meshed structure, so we can return to ANSA for a repair of non-importable items only that is very quick and comfortable for us.

Pre-processing of geometric models

The universal pre-processor ANSA became the most powerful tool for us during the aircraft EM model preparations. Preparing a geometric model, we proceed in the following three steps:

- pre-processing using an original CAD,
- pre-processing using the universal pre-processor ANSA,
- pre-processing using the special pre-processor CEM.

The first step of the EM model pre-processing consists in a removal of non-essential details (screws, rivets, small holes, faceted edges, sliver edges,...) of substructures. The non-essentiality of any detail of the pre-processed substructure depends on the maximum frequency of the model applicability (for the full-wave model, i.e. FDTD solver, it can be 1/12 up to 1/10 of the minimum wavelength).

The simplified substructures are imported into ANSA and the second step of pre-processing is initiated. The model substructures are associated with the information about materials and material domains are created on them. The material domains are homogenous "watertight" closed volume bodies of the same material (as interpreted by the FDTD solver)

The following processing of the material domains depends on the kind of an associated material now. In case of thin metallic materials (sheets), the domains are substituted by middle faces and in case of thick metallic or dielectric material, they are interpreted as volume bodies using outer surfaces (upper and lower ones if necessary)

A special way of pre-processing is required for multi-layer composite materials that may be provided by an additional protective metallic layer (e.g. expanded copper foil). For the purpose of integration of these materials into the FDTD model, we decided to substitute any composite material by a fictive one-layer material with a constant thickness and with the relative permittivity and loss angle corresponding to the reflection and transmission coefficients measured on samples of the original composite material. If the constant thickness of the material domain in the direction of aircraft radiation is necessary, only the outer surfaces of these domains can be matched to a smooth aircraft surface and the internal surfaces of these material domains are leaved unmatched.

Then the various material domains are joined each to other and their adjacent contact surfaces are matched by such a way, when there is no unwanted contact-less part among them. The model created by this way is meshed and exported to the special CEM pre-processor for the third step of pre-processing.

Having imported the geometric structure of the aircraft into the special CEM pre-processor, an automatic checking of the EM model correctness is necessary. If the special pre-processor discover any errors preventing the subsequent processing, it is advisable to return with the model to ANSA and to make the necessary corrections there. A healing of a model geometry using the tools of special CEM pre-processor is very laborious and time consumable.

If the EM model is errorless, the following operations have to be carried out with it in the third stage of the pre-processing:

- addition of a model of examined wiring structures (see hereinafter) into the geometric aircraft model,
- setting of a volume discretization of the model and its close environment (application of the Yee lattice as shown in Fig. 1),
- surrounding of the model and its close environment by unechoic layers. This significant improvement was brought into the FDTD method by Berenger in 1994 and it makes a simulation of an infinite space around the examined model to prevent disturbing reflections of radiated field at the marginal cells of the Yee lattice.
- setting of a time discretization for the FDTD calculations,
- setting of a radiation direction,
- setting of boundary conditions.

Having finished the third step of pre-processing, the EM model is prepared for a surface and volume meshing, by means of which the volume discretization is really executed as a necessary condition for the subsequential running of the FDTD solver.

Pre-processing of wiring structures

When cable bundles are embedded inside the airframe and we examine the responses of a field radiation on them using the MTLN solver, the model of an examined cable bundle is created in the similar three steps as the pre-processing of the EM model geometry:

- pre-processing using the original CAD,
- pre-processing using the universal pre-processor ANSA,
- pre-processing using the special pre-processor CEM.

The first step of a wiring structure pre-processing in the original CAD consists in cancellation of unwanted branches of the examined cable (the parts of the bundle, where no critical signals are transmitted between aircraft equipment) and export the cable bundle model into the universal pre-processor ANSA, where the geometric model of the aircraft is already prepared.

In the second step we have an opportunity to check, if some cable paths are not in a collision with the geometry of aircraft. This check using ANSA is very valuable for us, even if the aircraft and cable geometries enter into the special CEM processor separately. Having repaired any collisions of the aircraft and cable geometries, the cable geometry is imported into the special CEM pre-processor as mentioned above.

For the specification and calculations of the BLT equation (5) by the MTLN solver, the imported cable structure is defined using the tubes and junctions and boundary conditions are subsequently defined for them. Also the electrical properties of the cable (resistance, capacitance, inductance and conductivity) per unit of the cable length are to be entered in this third step of the wiring structure pre-processing. If these cable parameters are not available by measurement for their direct entrance, they can be calculated from the geometric arrangement of the cable crosssectional structure using the LAPLACE tool.

Processing of the EM model in its entirety

If the examined aircraft model as well as its internal wiring structure are prepared for the next processing by the above mentioned pre-processing steps, the surface and volume meshing is executed on this entire EM model.

The FDTD solver calculates all the E and H field intensities' time histories at the edges and surfaces of all the Yee cells (Fig. 1) situated in the room (of the above mentioned unechoic layers) with the examined model inside. The calculated E and H field intensities and surface currents can be displayed using a suitable post-processor. An example of E-field intensity lay-out at a small aircraft is shown by the Fig. 4.

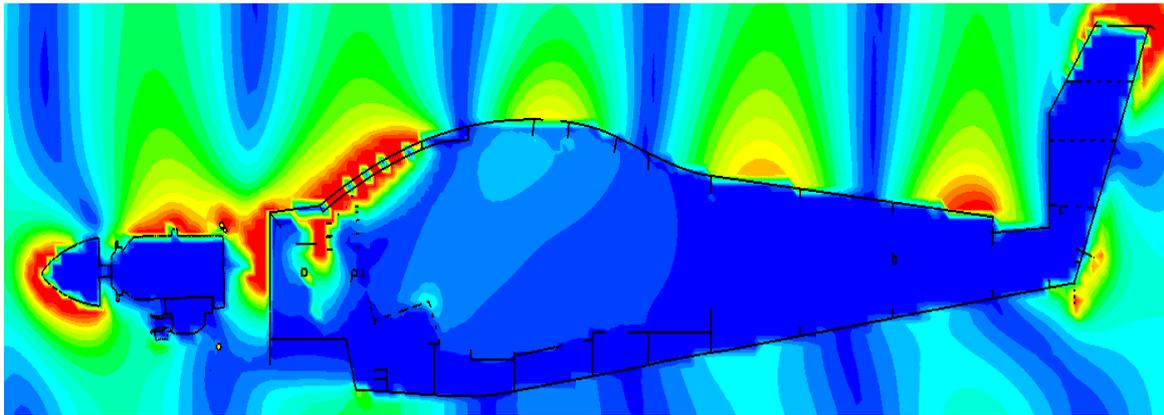


Figure 4 – E-field intensity lay-out at the small aircraft VUT100 Cobra when radiated by a surface wave with the frequency of 100 MHz.

When the job of the FDTD solver is finished, the system knows the field intensities in the neighbourhood of the examined wiring structure. When using them for the BLT equation solution, the MTLN solver can calculate required responses of the wiring structure for the radiation. These responses could be also displayed by a suitable post-processor. An example of cable response display is shown by the Fig. 5.

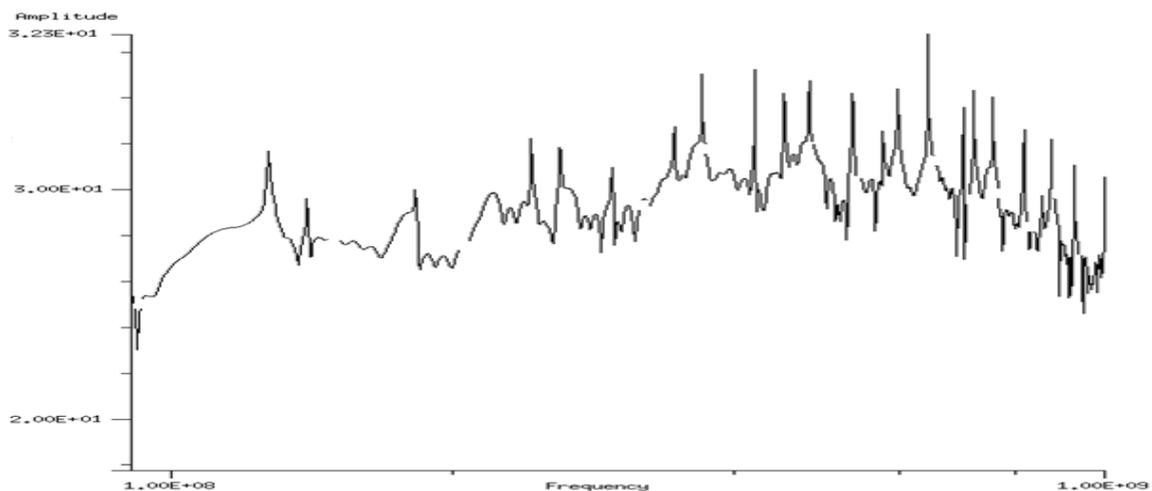


Figure 5 – Frequency characteristic of current amplitude calculated on the cable embedded in airframe when radiated by a high intensity radiated field (HIRF) in the band of 100 MHz up to 1GHz.

4. POSSIBILITIES OF A FUTURE DEVELOPMENT

As mentioned above, the universal pre-processor ANSA became the most valuable tool used for preparation of aircraft EM models in Evektor, spol. s r.o. If we take into the consideration a future use of other existing and currently developed EM solvers and models (as an applicability of the FDTD method is limited due to its frequency range up to a few GHz), ANSA and the skilled engineers operating with this tool are the fundamental assumptions of the CEM division's activities in our company.

A participation of Evektor in the HIRF-SE collaborative project (7-th Framework Programme of EU) where a common platform of the EM model data (AMELET) is established to match the data format for various EM solvers (both the existing and future ones), Evektor is interested in continuance to use ANSA as the most powerful tool for creating of EM models and to integrate it into the HIRF-SE framework as an organic part making possible an effective pre-processing for any EM solver as well as computational model. A foreseen strategy is to create a data transmission wrapper (software submodule), by means of which the ANSA output files are to be arranged in a structured XML format with a structure to be specified by our partners within the HIRF-SE project. Output script of ANSA is to be developed using the above mentioned given data structure and [5] in a close cooperation and with a necessary help of BETA CAE Systems S.A.

Another question of the future development is a post-processing of solvers' data outputs. If we use the FDTD and MTLN solvers purchased in the suite of PAM-CEM, there is only a possibility of result post-processing using the post-processor PAM-VIEW included in this suite. If we consider the above mentioned use of existing and developed EM solvers in the common platform, there seems to be no problem to read the output data of solvers plugged in the HIRF-SE framework by the META post-processor and to use its unique properties for EM observables' post-processing. There might be used a similar strategy of XML data transfer from the common platform AMELET into the META post-processor as in the case of ANSA-AMELET data transmission mentioned above. If the META postprocessor is plugged in the HIRF-SE framework, we can use the well-proven experience of our engineers to upgrade the EM result display and presentation (see Figs 4 and 5) at the same level as in case of other simulations of physical reality (virtual strength tests, crash simulations, etc.), where a direct interface from solvers to META exists.

5. CONCLUSIONS

The first and competitively used advantage of the application of universal pre-processor ANSA for CEM is the possibility, when up to 25 skilled engineers can be used simultaneously when creating a large-scale EM model at the Evektor spol. s r. o.

The second great competitive advantage that we wish achieve with a help of the international cooperation within the HIRF-SE project is a possible consequent processing of any created EM model using various (existing as well as newly developed) EM solvers. The solvers will be based on a common platform and plugged in the above mentioned HIRF-SE framework. It is the most important facility, when there is no general-purpose EM solver in CEM up to now, by means of which all the requirements necessary for evaluation of electromagnetic threats of flight might be satisfied. We expect a precipitous research and development of various

methods and solvers in the field of CEM in the next future and the effective creating of EM models using ANSA makes our reliance to be successful in this field.

As the universal pre-processor ANSA became a standard “de-facto” for effective creation of simulating models in Evector, we are pleased to use this opportunity and to express the best our experience with this powerful and reliable tool.

REFERENCES

- [1] ANSA version 12.1.5 User’s Guide, BETA CAE Systems S.A., July 2008
 - [2] META PostProcessor version 6.2.0. User’s Guide, BETA CAE Systems S.A., June 2008
 - [3] Finite-difference time-domain method. From Wikipedia free encyclopedia (http://en.wikipedia.org/wiki/Finite-difference_time-domain_method), June 2009
 - [4] Islam, N. E., “Application of Advanced Concepts and Techniques in Electromagnetic Topology Based Simulations: CRIPTE and Related Codes”, Research Report No. TR-08-0522, University Missouri of Columbia, December 2008
 - [5] ANSA Scripting language, version 12.x. User’s Guide, BETA CAE Systems S.A., July 2008
-