Interfacing WIPL-D with Mechanical CAD Software

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Abstract: This paper describes an algorithm for import of solid CAD models of complex geometries into WIPL-D Pro CEM solver. Solid models can be of almost any popular CAD format, e.g. IGES, Parasolid, DXF, ACIS etc. The solid models are processed (simplified) and meshed in GiD®, and then converted into WIPL-D Pro input file by simple Fortran or Matlab code. This algorithm allows the user to control the mesh of imported geometry, and to assign electric properties to metalic and dielectric surfaces. Implementation of the algorithm is demonstrated by examples obtained from the NASA Discovery mission, Phoenix Lander 2008. Results for radiation pattern of Phoenix Lander UHF relay antenna with effect of Martian surface, both simulated in WIPL-D Pro and measured, are shown for comparison.

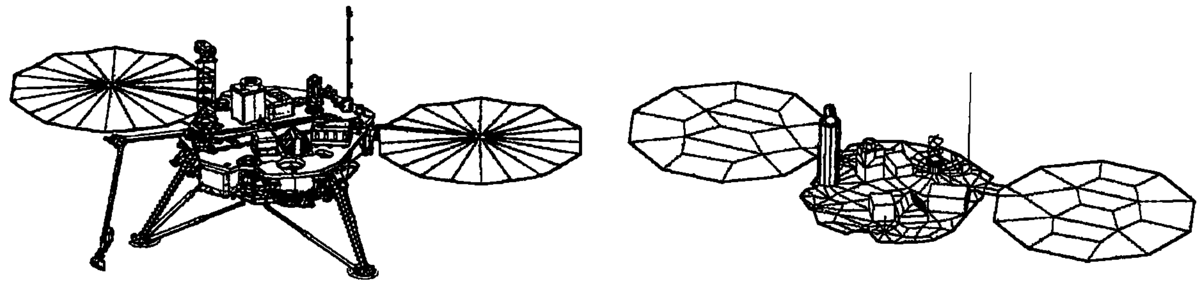
Keywords: CEM, MOM, WIPL-D Pro

1. Introduction

The use of computational methods for modeling various electromagnetic phenomena has increased dramatically in past few years. Analyzing complex and electrically large scatterers finally has become reasonable due to advances in computer hardware technology. For example, now one can solve a full-wave radiation problem for UHF, L, S and even X band antennas mounted on a vehicle or a complex ground platform using a single PC within several hours. However, it is often difficult or impractical to draw realistic geometries within CEM software interface, especially if solid CAD models are available.

There are several issues arising when one concerns about solid geometry import into any CEM tool [1]. From electromagnetic point of view, solid CAD models have excessive number of details. Experience shows that to "clean-up" such files automatically for EM analysis is almost impossible if dealing with complicated structures. As an example, solid model of Phoenix Lander versus significantly simplified EM model for analysis at UHF frequencies are shown in Figure 1.

Another problem is how to mesh the imported model. Many of the tools have internal meshing algorithm working only with the geometries created in their own interface. Furthermore, both commercially available and self-written MoM codes may require different types of mesh elements, such as triangular (FEKO etc.), quadrilateral (WIPL-D Pro [2]) or higher order elements (GRASP).



(a) (b)

Fig. 1. Phoenix Lander deployed on Mars surface:
a) solid model, b) simplified EM model for WIPL-D Pro input

In this article, we discuss the use of the pre-and post processor, GiD® [3] and simple self-written translating Fortran code to import complex solid models into WIPL-D Pro. Similar approach was described in [1] for FEKO software. Therefore, it is worth to mention that this algorithm can be applied for import of solid models into almost any analysis software that require surface or volumetric mesh.

2. GiD Overview

GiD is an easy-to-use geometric user interface and a powerful mesh generator. As mentioned earlier, GiD can assign structural and unstructural meshes to surfaces and/or volumes by using different types of elements. It has some useful and attractive features such as various file formats import and mesh export in custom format by using easy-to-program templates.

3. CAD Models

The most popular CAD/CAE/CAM (computer aided design, analysis and manufacturing) software suites in Aerospace industry are NX, previously known as Unigraphics, and CATIA. Both suites have capabilities of exchanging solid models with other CAD tools through various file formats, so there is always a choice which format to use to export the geometry. Based on our experience, IGES format appeared to be more flexible and reliable than other for import of solid models into GiD.

While importing IGES into GiD, one should be very careful with import tolerance settings in order not to oversimplify or corrupt the model. Necessary simplifications are easier to make manually. Also, it is desirable to break up CAD model of assembly into relatively small parts while exporting to IGES. GiD retains coordinate system information and supports combining projects, which we found very handy when dealing with big assemblies.

4. GiD Mesh Output and WIPL-D Pro Mesh Input

Due to its unique usage of high-order expansion functions, WIPL-D Pro has different mesh requirements for geometrical models. Unlike conventional RWG MoM implementations with triangular mesh elements and better than 10 elements per wavelength rule-of-thumb, in WIPL-D Pro surface mesh elements are quadrilaterals and can be as long as two wavelengths if they represent curvature of object surfaces correctly.

Therefore, there is no need to assign small mesh elements to flat surfaces that are relatively far from the source. We found out that the best results are obtained if in GiD a structured quadrilateral mesh is used. Advantages were minimization of both number of unknowns and computational time. Example of such structured mesh with large cells is shown in Fig. 1 (b).

One way to assign dielectric properties to surfaces in GiD is to move surfaces to different layers. Layer information will be passed to mesh elements. Then, in the GiD-to-WIPL-D Pro mesh translator code, one needs to assign dielectric domain indices to the corresponding layer mesh elements.

Thus, in GiD mesh output template, there will be three necessary loops on node coordinates, linear and quadrilateral elements connectivities with layers information. As a result, the GiD-to-WIPL-D Pro mesh translator will only rearrange nodes in quadrilateral elements according to WIPL-D Pro format and add information on frequency, domains etc.

5. Examples

As an example of import of solid CAD models of spacecraft to WIPL-D Pro by means of GiD, we demonstrate the measured and simulated radiation patterns of the UHF monopole mounted on the deck of the Mars Phoenix lander, scheduled for launch in summer 2007. Solid CAD model of the lander is shown in Fig.1. (a). Based on this model, the simplified mockup model in Fig.2. was manufactured specially to perform in-situ measurements of UHF relay antennas.

The pattern measurements were made at the arch antenna range at the Space Naval Warfare Systems Center (SSC-SD) facility in San Diego, see Fig.3. This range was used because it has conductive ground and does not require mounting the mockup on a moving tower. Therefore, we have measured antenna patterns for the Phoenix Lander mockup sitting on the conductive ground that more or less mimics Martian ground. More detailed description of measurement campaign can be found in [4].

Fig. 2. Phoenix Lander mockup deployed

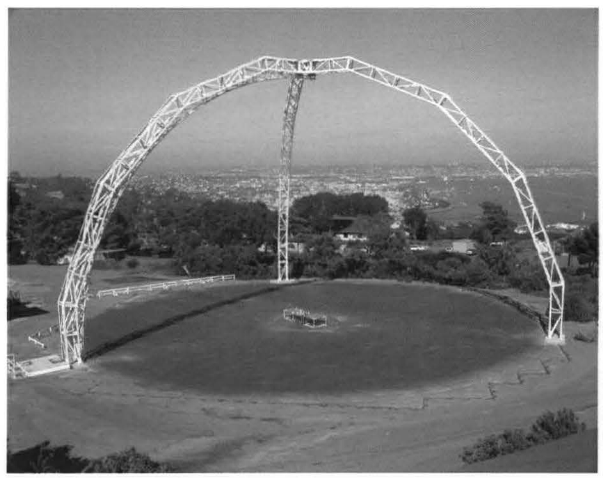
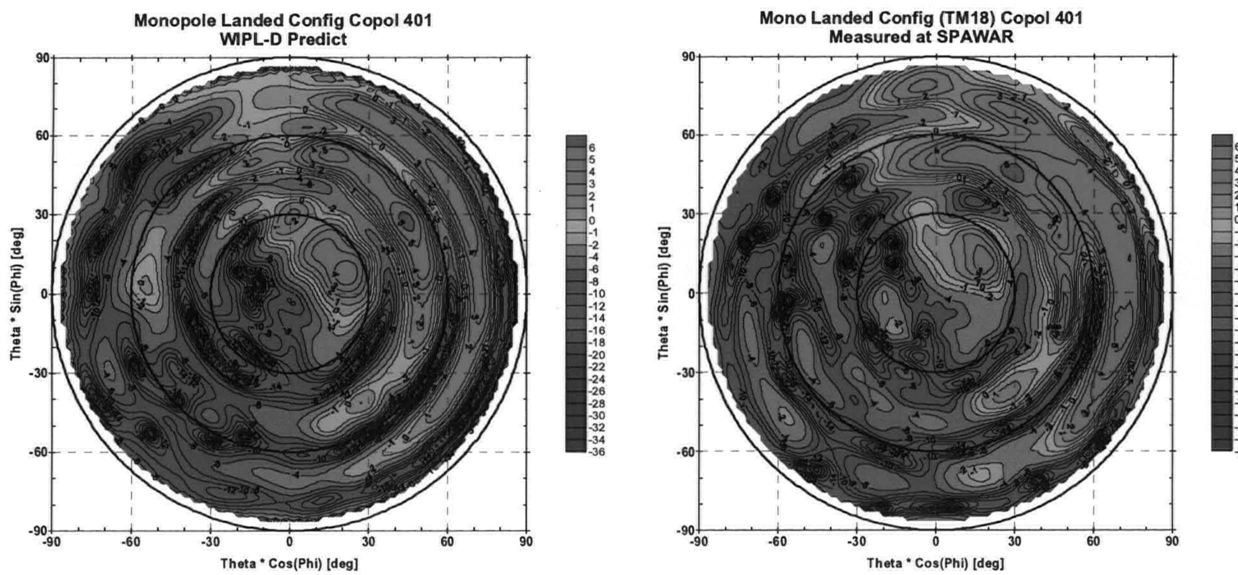


Fig. 3. SSC-SD arch antenna range in San Diego

In Figs. 4. (a) and (b) there are simulated and measured radiation patterns of a UHF monopole antenna mounted on the Lander Deck. The patterns are shown in *u-v* coordinate system. Although the monopole is linearly polarized, patterns are given in circular polarization. There are two antennas on the Lander deck, a quadrifilar helix and a monopole. The monopole is a back-up antenna covering only a north-west corner.

Mars Phoenix Lander GiD model is shown in Fig.1.(b). The conductive ground was modeled in WIPL-D Pro as a clump. Good agreement between measurements and simulations is observed. We believe that disagreement between patterns in Fig. 4. are because the conductivity of the range surface was not known exactly, and mockup and WIPL-D Pro model differed in details as seen in Figs 1(b) and Fig.2.



(a) (b)

Fig. 4. Phoenix Lander UHF monopole radiation patterns:
a) WIPL-D Pro simulated; b) measured

6. Conclusions

The relatively easy and inexpensive algorithm for import of solid CAD models into WIPL-D Pro CEM solver and possibly many other CEM software packages has been described. The main steps and pitfalls are outlined. The implementation of the algorithm is demonstrated in the results obtained for NASA Discovery mission, Phoenix Lander 2008.

7. Acknowledgments

The results shown in this paper were obtained at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not constitute or imply its endorsement by the United States Government or the Jet Propulsion Laboratory, California Institute of Technology.

The authors wish to thank Vaughn Cable, Peter Ilott, Jeff Harrel and Stan Butman for support in pursuing this task and providing measurement data.

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