# EMC ANALYSIS BETWEEN ANTENNAS ON A SATELLITE PAYLOAD

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**Abstract**

Asymptotic and exact techniques used to estimate EMC between various types of antennas are presented. Typical geometries considered include patch array antennas and horn antennas.

## 1. Introduction

EMC calculation between antennas operating at centimeter wavelengths usually require the use of hybrid methods in order to cope with problems of large electrical size.

Such a method is presented in this paper taking as an example the coupling between antennas on the Skybridge payload. Several problems which combine exact (Method of Moments (MoM)) and asymptotic techniques are commented in this paper :

- the analysis of one single patch element,
- the far field calculation of a patch array antenna,
- the coupling between array antennas,
- the coupling between array and horn antennas.

Surfaces considered for the asymptotic analysis are described analytically. Skybridge payload may be described as a set of plates of various shapes and cylinders. This surface description simplifies the calculation and particularly allows a treatment of the scattering structure by contributors. These are the edges, the vertices and the creeping waves on curved surfaces. For each direction considered, the scattered field level is calculated and the contributors are identified.

The MoM technique is used both for the calculation of one elementary patch and for calculations on horn antennas. Any modes combination or wire probes with voltage sources arrangement may be considered. The MoM technique major drawback is related to the memory size required to perform the computation. However symmetrical properties of the structure may be considered in order to reduce this size.

## 2. Interactions between patch array antennas

Interactions between different array antennas may only be addressed using asymptotic techniques. As an example we consider hereafter the case of 2 antennas approximately 100 patches each and oriented in such a way that the second one may intercept a part of the pattern (sidelobes interaction) which may degrade the primary pattern.

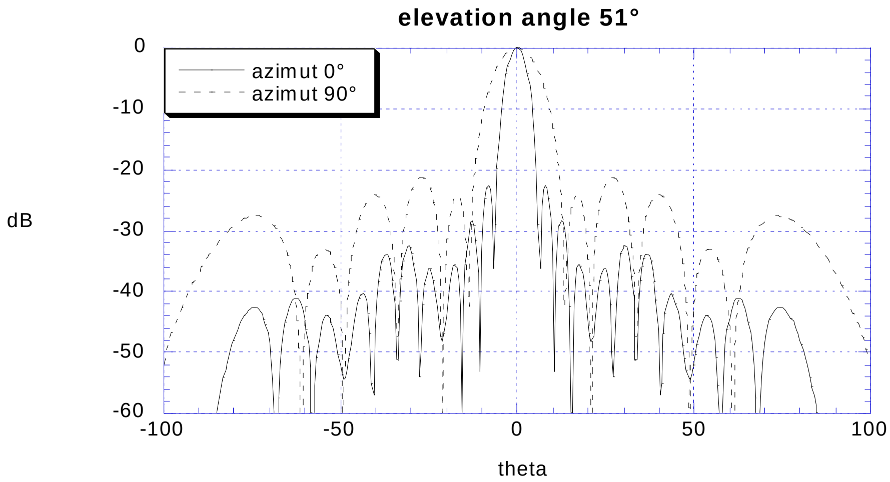
The pattern of the primary antenna is plotted below. It has been obtained by executing the successive steps:

- get the pattern of one elementary patch. The vicinity of this elementary patch is taken into account in order to take care of interactions with the nearest elements. This is done using the MoM technique.

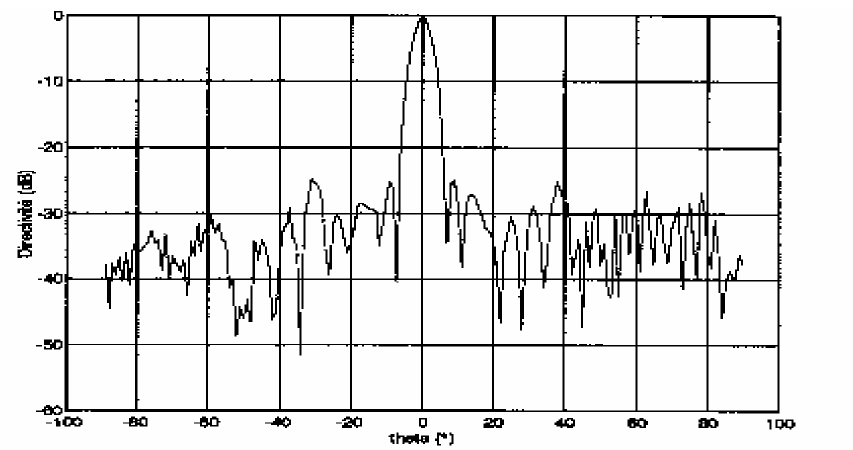
- approximate numerically the far field pattern of this elementary patch

- calculate the far field pattern of the array antenna reproducing the elementary pattern modulated by the proper feeding coefficients at the right location of each patch. The array amplification factor is in that way automatically synthesized.

For the result presented below, the transmitting antenna makes an elevation angle equal to 51° with respect to the reference plane supporting the different antennas.

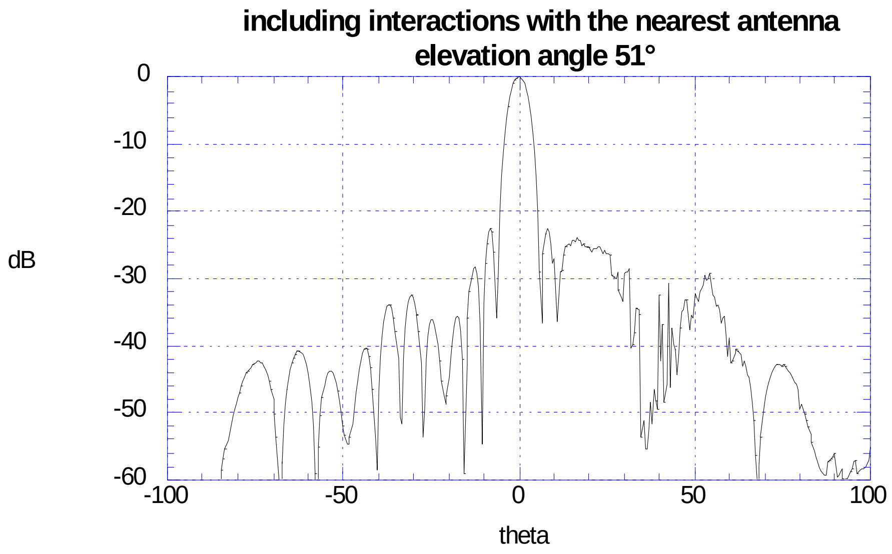



The measurement obtained for azimuth 0° is plotted below as a comparison.




The nearest antenna is described as a collection of simple shape elements : plates (elliptic and polygonals) and elliptic cylinders. Both reflected and scattered fields are considered. The calculation technique is either UTD or equivalent current technique depending on the specific geometry considered.

Considering one single patch of the transmitting antenna and the scattering by the overall nearest antenna may lead to a high level scattered field. Considering all the elementary patches together gives a result which doesn't degrade the main lobe pattern. This is due to the fact that the array amplification factor does not amplify the scattered fields which behave as random signals from one patch to the other. In particular the scattered field phase changes arbitrarily from one patch to the next one due to the fact that the scattering points are randomly distributed on the structure.




### 3. Interactions between an array antenna and a horn antenna

The field transmitted by the array antenna is still calculated using the technique presented above. The field transmitted into the horn considered as a receiving antenna is calculated by the MoM technique. In the method we have implemented all the s-matrix parameters are calculated.

In the case, the horn is considered as a transmitting antenna, the scattered field is given by equation :

$$E_S = -\int_{Sg}\left[ j\,\omega\,\mu\left( J_j\,G - \frac{1}{k^2}\nabla . J_j \nabla G \right) + \nabla\,G\,x\,M \right] ds$$

$$-\int_{o}\left[ j\,\omega\,\mu\left( (-n\,x\,h_O)G - \frac{1}{k^2}\nabla . (-n\,x\,h_O)\nabla G \right) + \nabla\,G\,x\,(n\,x\,e_o) \right] ds \qquad (1)$$

with Sg the horn surface and O a waveguide cross section where only transmitting modes corresponding to $e_0$ and $h_0$ are considered.

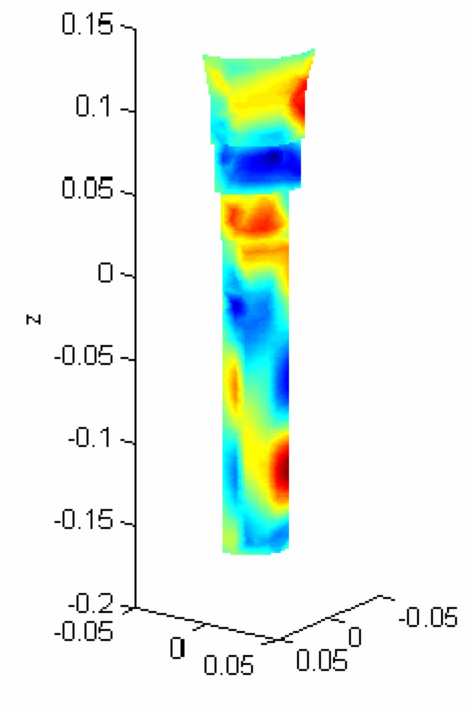
Forward and backward waves are calculated in order to obtain the VSWR obtained from the reflection coefficient Γ which satisfies the following equation :

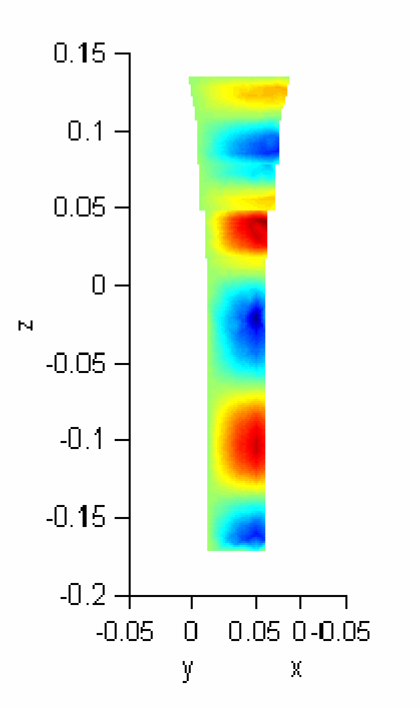
$$(1+\Gamma)\,E_0 = E_S \qquad (2)$$

In the case the horn is considered as a receiving antenna, the incident field radiated by the array antenna is calculated at each point of the triangular mesh. The transmission coefficient is then :

$$T\,E_0 = E_S \qquad (3)$$

The current variation along the horn is represented below. The skew appearance when the horn is in reception is related to the orientation of the z axis with respect to the main lobe axis of the incident pattern.

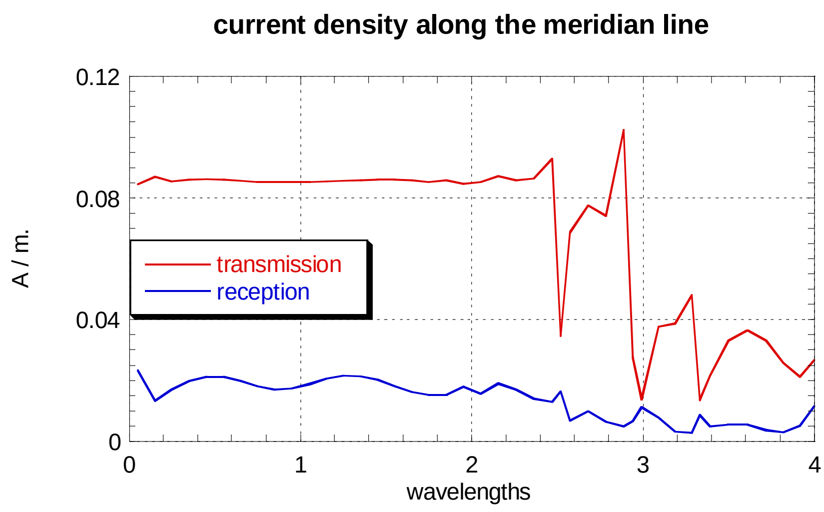



horn as a receiving antenna

horn as a transmitting antenna

The current density along the meridian line is plotted next figure for both transmission and reception cases. Current discontinuities are related to radius variations on the horn.




## 4. Conclusion

The methods presented allow to consider a large variety of problems. The asymptotic technique is used when the electrical size of the structure exceeds a significant number of wavelengths. The MoM technique allows to obtain the input impedances and/or the VSWR. Moreover the calculation of s-matrix parameters allow to include in the budget link additional devices such as an Ortho Mode  junction Transducer (OMT).

Regarding the budget link and the margins to be taken at different stages on the platform, the software presented constitutes a powerful tool from the system point of view.