Measurement and Simulation Comparison using Measured Source Antenna Representation of GNSS Antenna on Sentinel Satellite

L. J. Foged, M. Saporetti, L. Scialacqua, F. Saccardi
MICROWAVE VISION ITALY
Via dei castelli Romani 59, 00040, Pomezia, Italy
(lars.foged, maria.saporetti, lucia.scialacqua, francesco.saccardi)@microwavevision.com

J. Zackrisson
RUAG Space AB,
SE-405 15 Göteborg, Sweden
Jan.Zackrisson@ruag.com

D. Trenta, L. Salghetti Drioli
European Space Agency, ESTEC, The Netherlands
Damiano.Trenta@esa.int, Luca.Salghetti.Drioli@esa.int

***Abstract*— Recent publications have reported on an innovative technique in which measured antennas are represented as numerical sources in the accurate computation of antennas in complex environments [1-5]. The measured antenna is accurately characterized as a Huygens box in a format compatible with different Computational Electro-Magnetic (CEM) solvers. The numerical representation of the measured antenna is determined from an equivalent current expansion [1]. This technique enables computation of complex antenna scenarios in which the source antenna is physically available but the computational details are unknown. This is often the case in space applications in which antennas from different suppliers are integrated on a platform. Simulations and experiments on canonical flat plate structures have been used in preliminary validation of the technique [2-5]. In this paper, the validation of this technique in a realistic space application scenario is presented for the first time. The test object is a 1227MHz GNSS antenna mounted on a Sentinel satellite. The simulations of the sentinel satellite using the measured source technique are compared to measurement of the satellite mock-up model.**

Keywords—GNSS antenna; simulation; measurement; satellite.

I. Introduction

CEM solvers are important engineering tools for supporting the evaluation and optimization of antenna placement on large complex platforms such as satellites. In the case of small radiators on large and complex platforms, the overall accuracy of the numerical simulation is highly dependent on the accuracy of the antenna representation. In such cases it is good practice to use domain decomposition techniques in which the radiating antenna is analysed separately in detail. The full system is then accurately solved using the antenna solution as radiating source in the numerical simulation of the entire system.

The equivalent current (EQC) or inverse source technique is a measurement post-processing method that represents the measured antenna in equivalent electric and magnetic currents on a surface conformal to the antenna. The equivalent current representation is also a mean to subsequently derive an accurate Huygens box representation of the measured antenna in a format compatible with most commonly used CEM solvers. The highly accurate representation of measured antennas for complex environment analysis can be used for both suspended and flush mounted antenna [2-5]. Due to the conclusiveness and high reliability of actual measured data, this approach is often more accurate and desirable than building an equivalent electric model of the source antenna.

This paper presents the validation of the measured source concept. The validation object is a GNSS antenna placed on a mock-up of a Sentinel satellite [6]. The GNSS antenna and Sentinel satellite structure have been designed, manufactured and measured by RUAG SPACE [7-8]. The electromagnetic model of the measured GNSS antenna has been accurately determined at 1227 MHz by the inverse source technique as implemented in the commercial INSIGHT software [1]. The numerical simulation of the Sentinel satellite using the measured source antenna has been performed by a commercial CEM solver [9]. The simulation has been compared to measurement of the satellite mock-up to validate the technique.

II. Test Object and Complex Scenario

The GNSS antenna is characterized by a pencil beam type pattern, with +/-70° of coverage working at frequencies between 1227 to 1575 MHz. The antenna and measured radiated performances is shown in Fig.1. The complex scenario is represented by the antenna installed on a Sentinel [6] satellite mock-up as shown in Fig. 2.

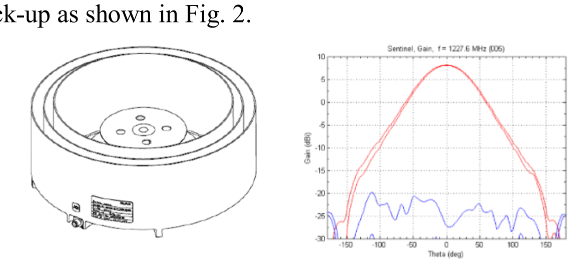

Fig. 1. GNSS antenna drawing (RUAG courtesy) and measured radiation pattern at 1227MHz.

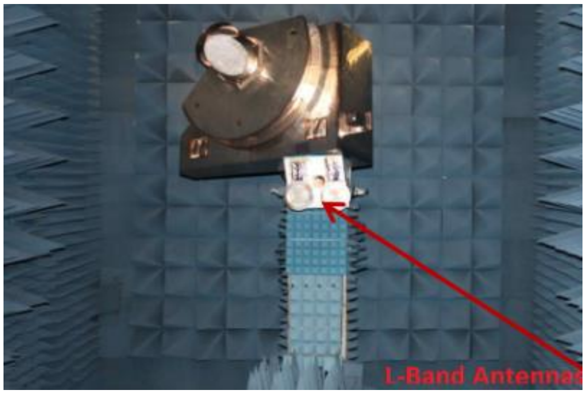

Fig. 2. Sentinel satellite mock-up (RUAG courtesy).

III. VALIDATION WORKFLOW

The EQC representation of the GNSS antenna on a box conformal to the antenna is shown in Fig. 3. The currents are determined from the measured radiation pattern at 1227 MHz by INSIGHT processing [1]. The measured source is imported in a commercial MoM solver, as a Huygens box, and placed in the correct position in the CAD model of the Sentinel satellite. The simulation has been compared to measurement of the satellite mock-up model to validate the approach.

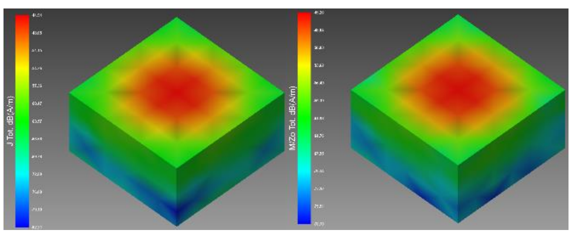

Fig. 3. Electric (left) and Magnetic (right) Equivalent Currents in form of Huygens box of the GNSS antenna.

IV. DISCUSSION OF THE RESULTS

The simulation, using the measured source, has been compared to measurement of the full satellite in Fig.4 (phi=0° cut) and Fig.5 (phi=90° cut). The Copolar and Crosspolar field components are reported with the weighted difference of the measured and simulated Copolar components [10].

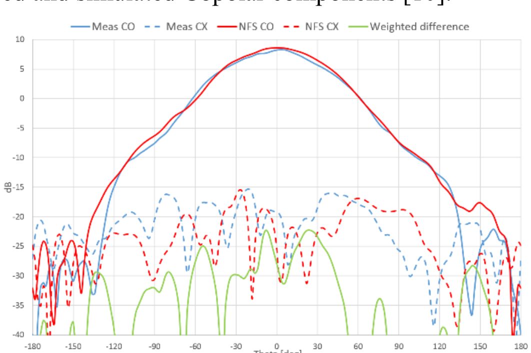

Fig. 4. Copolar and Crosspolar components at phi=0° of measurements (MEAS) and of simulation with INSIGHT NF Source (NFS) at 1227 MHz.

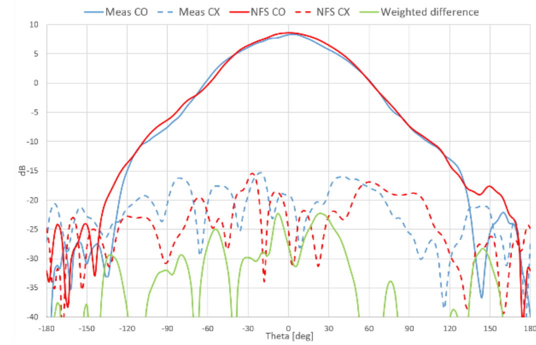

Fig. 5. Copolar and Crosspolar components at phi=90° of measurements (MEAS) and of simulation with INSIGHT NF Source (NFS) at 1227 MHz.

The visual good agreement is confirmed by the Equivalent Noise Level that is around -30 dB in both planes.

V. CONCLUSIONS

The RUAG GNSS antenna representation as INSIGHT NF source imported in commercial CEM solver has been computed in a complex scenario, represented by a Sentinel satellite mock-up. The validation has confirmed the accuracy achieved in recent validation activities.

ACKNOWLEDGMENT

The activity has been partly supported by ESA contract 4000116755 "Time Efficient satellite antenna testing technique based on NF measurement and simulation with controlled accuracy".

REFERENCES

[1] http://www.satimo.com/software/insight

[2] L. J. Foged, F. Mioc, B. Bencivenga, E. Di Giampaolo, M. Sabbadini "High frequency numerical modeling using measured sources", IEEE Antennas and Propagation Society International Symp, July 9-14, 2006.

[3] L. J. Foged, B. Bencivenga, F. Saccardi, L. Scialacqua, F. Mioc, G. Arcidiacono, M. Sabbadini, S. Filippone, E. di Giampaolo, "Characterisation of small Antennas on Electrically Large Structures using Measured Sources and Advanced Numerical Modelling", 35th AMTA symposium, October 2013, Columbus, Ohio, USA

[4] L. J. Foged, L. Scialacqua, F. Saccardi, F. Mioc "Measurements as Enhancement of Numerical Simulation For Challenging Antennas", EUCAP 2015 April 12-17, 2015.

[5] L. J. Foged, L. Scialacqua, F. Saccardi, F. Mioc, D. Tallini, E. Leroux, U. Becker, J. L. Araque Quijano, G. Vecchi, "Bringing Numerical Simulation and Antenna Measurements Together", IEEE Antennas and Propagation Society International Symposium, July 6-11, 2014.

[6] https://sentinel.esa.int/web/sentinel/home

[7] M. Öhgren, M. Bonnedal, P. Ingvarson, "GNSS Antenna for Precise Orbit Determination Including S/C Interference Predictions", European Conference on Antennas and Propagation, EuCAP, Rome, 2011

[8] P. Ingvarson, J. Zackrisson, "Swedish space antenna projects", European Conference on Antennas and Propagation, EuCAP, Gothenburg, 2013.

[9] www.cst.com, CST STUDIO SUITE™, CST AG

[10] L.J.Foged, M.A. Saporetti, M. Sierra- Castañer, E. Jørgensen, T. Voigt , F. Calvano D. Tallini, "Measurement and Simulation of Reflector Antenna", EuCAP, Lisbon, April 2015.