Near Field 3D Reconstruction of the Search and Rescue Antennas on the GALILEO Satellite

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***Abstract*—The 3D reconstruction algorithm of DIATOOL is applied to the Search and Rescue antennas (SARANT) mounted on the GALILEO satellite, recently measured by the planar near-field scanner of the Hybrid ESA RF and antenna Test Zone (HERTZ) at ESTEC. SARANT operates in L and UHF band, and is one of the many antennas sitting on the GALILEO satellite. The measured field showed a pattern deformation that could be due to the presence of the other antennas on the satellite Earth panel. The purpose of this paper is to investigate this antenna coupling with the DIATOOL software, and compare the results obtained previously by the Insight software, identifying similarities, advantages and limitations of the two algorithms.**

***Index Terms*—antenna measurements, equivalent currents, antenna farm.**

I. INTRODUCTION

DIATOOL from TICRA and Insight from the Microwave Vision Group are the two commercial software tools that were developed in the past years in order to compute the extreme near-field, or equivalent currents, of an antenna from its radiated measured field. Both software are based on a 3D integral data equation relating the measured field with a set of unknown equivalent electric and magnetic currents located on a closed surface around the antenna. By enforcing as boundary condition that the field radiated by the unknown equivalent currents is zero inside the reconstruction surface, the unknown equivalent currents coincide with the physical currents one would measure on the reconstruction surface, see [1]-[4]. A discrete set of equations is obtained by using a standard Method of Moments discretization. It is noted that the 3D formulation described above is an inverse source problem, which is challenging and inherently ill-posed, meaning that small variations on the measured field produce large variations on the reconstructed currents. Although more demanding in terms of memory usage and computation time as compared to microwave holography, these 3D reconstruction methods allow one to reconstruct the field on an arbitrary 3D surface and give the possibility to study and solve traditional as well as new antenna diagnostics problems in a more accurate way.

The two reconstruction algorithms implemented in DIATOOL and Insight are similar in their formulation, but present also some differences in the discretization scheme, the enforcement of the a-priori information, and the regularization method, see [1] and [3]. In particular, the discretization adopted by DIATOOL is based on higher order basis functions and higher order geometry modelling, which provide a smooth description of the currents and geometry and a far smaller number of unknowns, relative to the traditional RWG functions on flat triangular faces used by Insight [3]. Second, the regularization scheme embedded in DIATOOL allows one to use the a-priory knowledge of the boundary condition independently from the data equation, with the advantage of weighting the two set of integral equations differently, depending on the noise of the measured data. Thanks to these differences, DIATOOL provides high accuracy and strong robustness against noise, and, even more important, a spatial resolution in the reconstructed equivalent currents that can be better than the traditional half a wavelength, [2].

The DIATOOL software has been extensively applied to measured data acquired in the Spherical Near-Field Antenna Test Facility at the Technical University of Denmark, see for example [2] and [5]-[7], showing very detailed field reconstruction, advanced array diagnostics and estimation of support structure effects, with a spatial resolution higher than half a wavelength. In all these examples, only one single antenna was mounted on the AUT tower and the radiated field was always measured on a full sphere with good sampling in theta and phi. The DIATOOL software has never been applied to measured data acquired in a planar near-field scanner and on antenna farms configurations where one antenna radiates in the presence of others as well as of the satellite. An interesting application of the Insight software to the above was, on the other hand, presented at the EuCAP conference in 2015 [8], where the near-fields of the SARANT antennas of the GALILEO satellite were reconstructed from planar near-field measurements.

It is therefore the purpose of the present paper to investigate the field reconstruction capabilities of DIATOOL when applied to the same measured field and antenna configurations presented in [8]. This will allow identifying similarities, advantages and limitations of the two software packages.

II. GALILEO SEARCH AND RESCUE ANTENNA (SARANT) DESCRIPTION

On top of the primary navigation payload, the European Global Navigation Satellite System GALILEO embarks a Search and Rescue payload, which has the objective of accurately identifying the position of people in distress situations. According to the COSPAS-SARSAT frequency allocation for MEOSAR, SARANT receives in UHF-band and transmits in L-band. In particular, SARANT RX is an array of six helixes working at 406.050 MHz, while SARANT TX is a short back fire antenna located at the center of the helixes array and working at 1544.1 MHz, as depicted in Fig. 1.

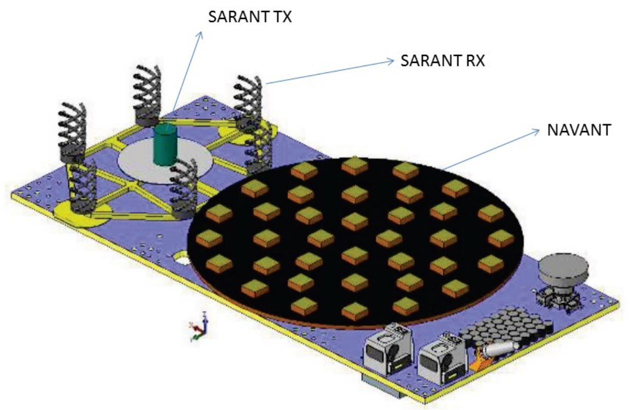

Fig. 1. SARANT TX and RX antennas on the GALILEO satellite side, in presence of the NAVANT antenna.

The antennas sit on the GALILEO satellite, and are located very close to the Navigation antenna (NAVANT), a large patch array working at a different frequency. The SARANT TX and RX antennas were mounted on the GALILEO satellite and measured in the planar scanner of the HERTZ antenna test facility at ESTEC, as depicted in Fig. 2. The SARANT RX antenna was measured on an approximately 6 m by 6 m plane, located at about 2 m from the base of the helix array, with a near-field sampling of half a wavelength. A similar set-up was used for the SARANT TX antenna, where the distance between the scanning plane and the base of the short back fire antenna was reduced to approximately 1 m. The measurement set-up is drawn in Fig. 3.

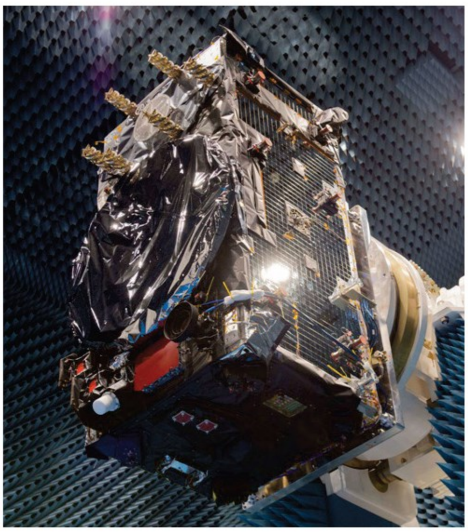

Fig. 2. The GALILEO satellite mounted on the AUT tower of the HERTZ facility at ESTEC. The SARANT RX and TX antennas, as well as the NAVANT covered by MLI, are visible.

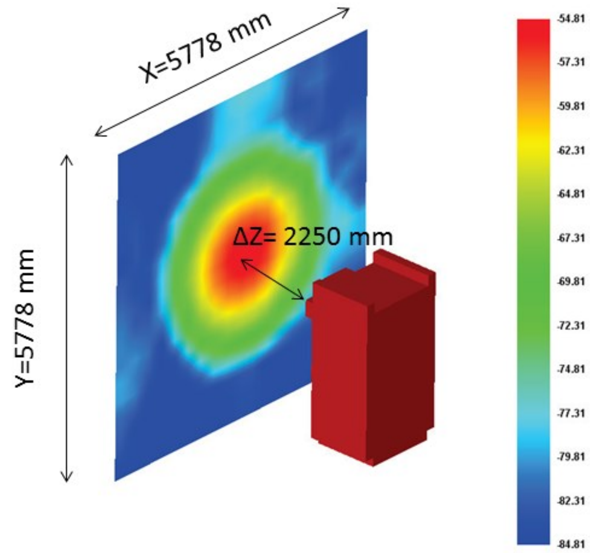

Fig. 3. Measurement set-up for the planar near-field measurements of the SARANT antennas on the GALILEO satellite: the SARANT RX set-up is shown.

III. Equivalent Currents Reconstruction of the SARANT RX Antenna

The measured field of the SARANT RX antenna showed a clear asymmetry and beam squint relative to its designed pattern, as it can be seen in Fig. 4. The use of the Insight software on these measured data indicated that the pattern was disturbed by the NAVANT antenna, see [8].

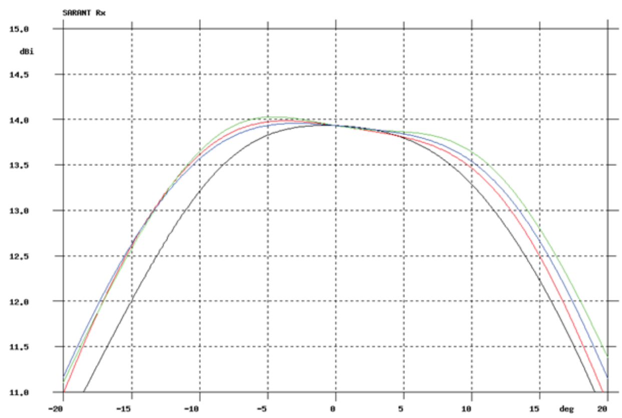

Fig. 4. Measured pattern of the SARANT RX antenna obtained at the HERTZ facility.

The amplitude of the co- and cross-polar components of the measured field on the scan plane for the SARANT RX antenna is shown in Fig. 5.

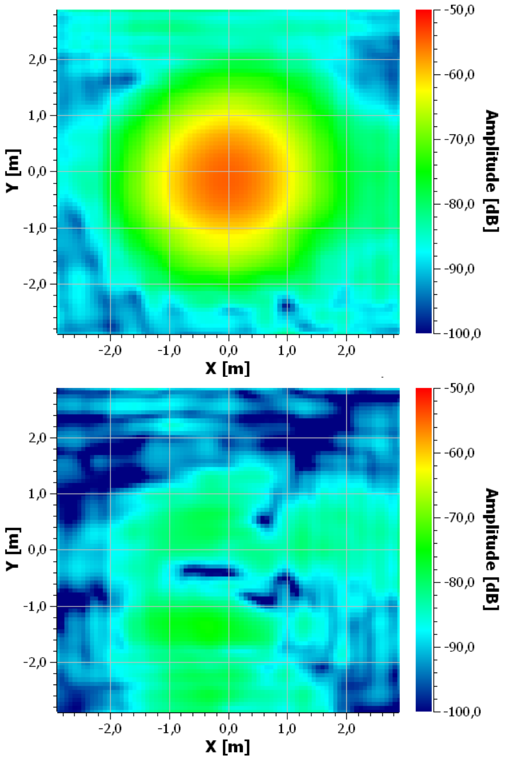

Fig. 5. Amplitude of the co-polar (RHCP) and cross-polar (LHCP) components of the measured field on the scan plane, for the SARANT RX antenna.

The measured field was given as input to DIATOOL in order to reconsruct the equivalent currents and tangential field on a closed reconstruction surface that was conformal to the GALILEO satellite. Two versions of the reconstruction surface were used, first a simple combination of boxes, as seen on the left in Fig. 6, and later a more detailed reconstruction surface where the SARANT antennas and the NAVANT antenna were highlighted, as seen on the right of Fig. 6.

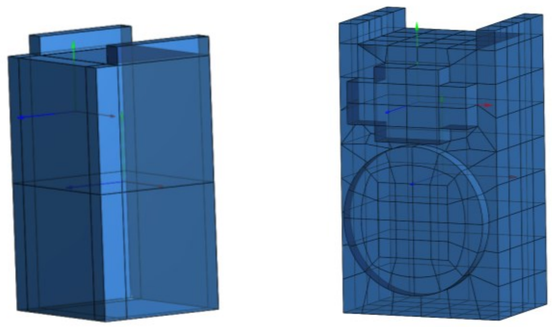

Fig. 6. Closed reconstruction surfaces around the GALILEO satellite used in DIATOOL.

The amplitude of the total tangential field computed by DIATOOL on the two reconstruction surfaces is plotted in Fig. 7 in the same color scale and with a 30 dB dynamic range. It is seen that the strongest field is located where the SARANT RX antenna is positioned. However, a distinctive field is also present on the NAVANT antenna. This is in very good agreement with the results reported by Insight in [8] and shown in Fig. 8.

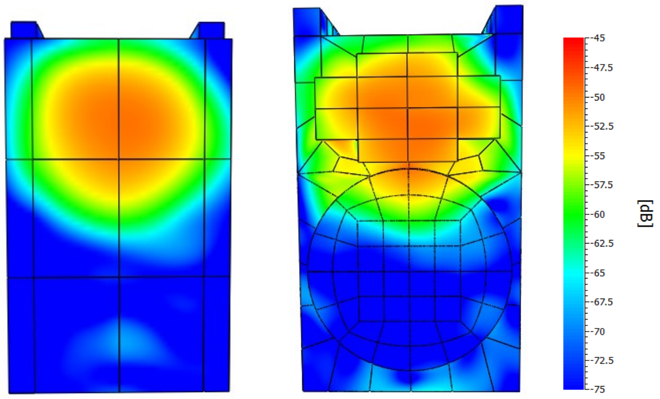

Fig. 7. Amplitude in dB of the total tangential electric field reconstructed by DIATOOL for the SARANT RX antenna (30 dB dynamic range).

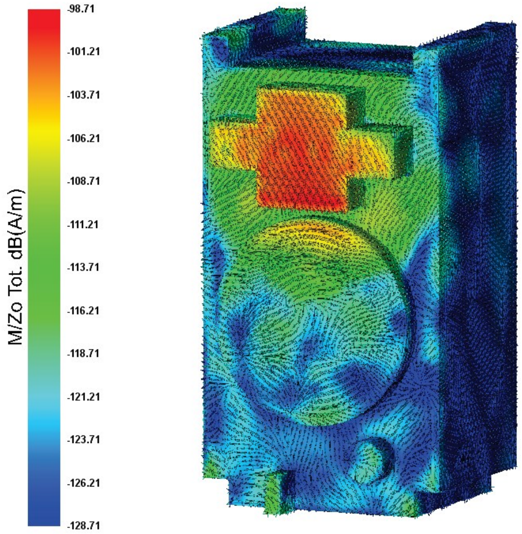

Fig. 8. Amplitude in dB of the total tangential electric field reconstructed by Insight for the SARANT RX antenna (30 dB dynamic range), see [8].

IV. Equivalent Currents Reconstruction of the SARANT TX Antenna

The amplitude of the co- and cross-polar components of the measured field on the scan plane for the SARANT TX antenna is shown in Fig. 9. The measured field was given as input to DIATOOL and the equivalent currents were reconstructed on the same reconstruction surfaces used for the SARANT RX antenna, see Fig. 6, producing the result shown in Fig. 10. It seems that the SARANT TX antenna radiates in a more circular and confined area and is less disturbed by the NAVANT antenna. The result is again in good agreement with the field computed by Insight in [8] and shown in Fig. 11.

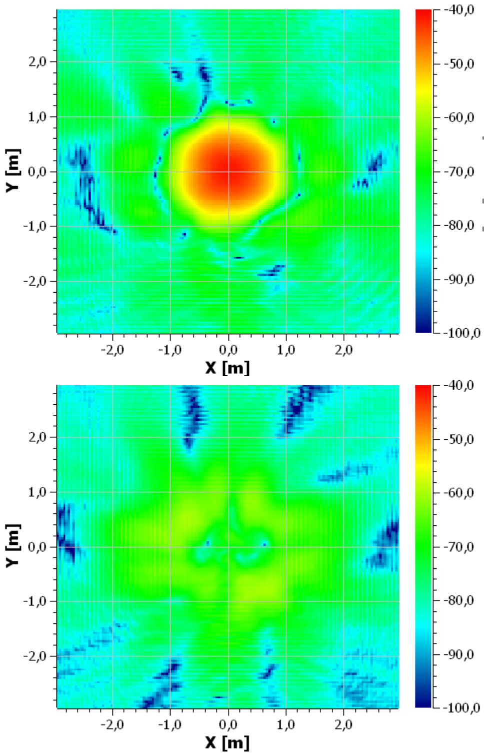

Fig. 9. Amplitude of the co-polar (LHCP) and cross-polar (RHCP) components of the measured field on the scan plane, for the SARANT TX antenna.

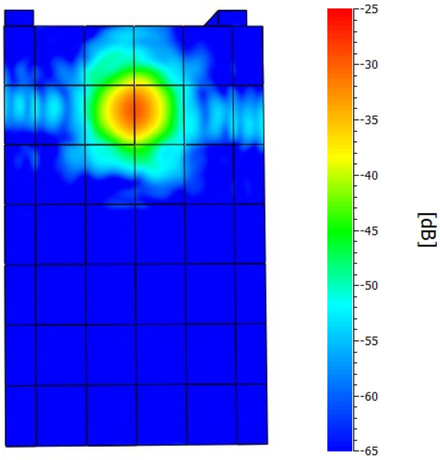

Fig. 10. Amplitude in dB of the total tangential electric field reconstructed by DIATOOL for the SARANT TX antenna (40 dB dynamic range).

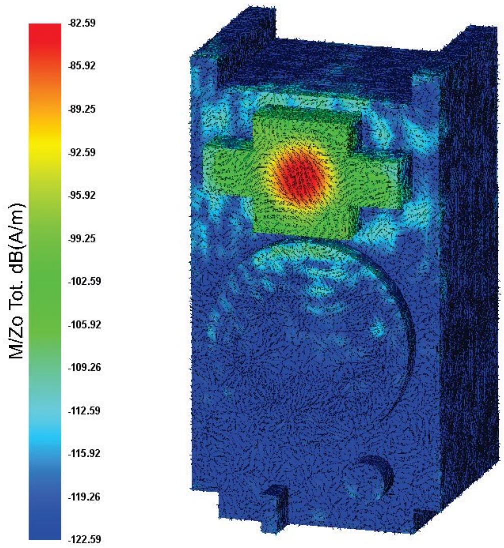

Fig. 11. Amplitude in dB of the total tangential electric field reconstructed by Insight for the SARANT TX antenna (40 dB dynamic range), see [8].

V. Conclusions

The 3D reconstruction algorithm of DIATOOL was applied to the Search and Rescue antennas (SARANT) mounted on the GALILEO satellite, recently measured by the planar near-field scanner of the Hybrid ESA RF and antenna Test Zone at ESTEC. The field was reconstructed on a closed surface conformal to the antennas and the satellite. The results computed by DIATOOL were in good agreement with the ones computed by Insight in [8], and showed that the SARANT RX antenna radiates partly on the neighbouring NAVANT antenna, producing a field which is not perfectly circularly symmetric. The SARANT TX antenna is less disturbed by the NAVANT antenna.

References

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