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NASA STTR 2019 Phase I Solicitation

T5.02 Electric field mapping and prediction methods within spacecraft enclosures

Lead Center: KSC

Participating Center(s): GSFC, JPL, JSC, MSFC

Technology Area: TA5 Communication and Navigation

NASA Launch Services program is responsible for ensuring the safety of NASA payloads on commercial rockets. This includes prediction and mitigation of hazardous electric fields created within the payload enclosure and similar areas of the rocket. NASA and industry have commonly used approximation methods to determine the average fields in enclosures. In the last decade the Launch Services Program has funded studies to support quantification of electromagnetic field characterization in fairing cavities due to internal and external sources. By accurately predicting these fields, acoustic and thermal blanketing can be optimized for RF attenuation and design changes can be quickly evaluated reducing schedule impacts. Cost savings can also be realized by reducing stringent radiated susceptibility requirements and reliability improved by accurately predicting signal transmission/reception environments within enclosures. This methodology can also improve Human exposure safety limits evaluations for manned vehicle enclosures with transmitting systems.

Initially studies focused on computational methods using the recent advances in computing power and the improved efficiency of matrix-based solutions provided by GPU computing. Results indicate solution of an integrated fairing is deterministic, but sensitive to small variation in structures, materials. As of yet, only the empty or sparse cavity can be reliably solved with 3D computational tools even with large computing systems and the use of non-linear basis functions. Results also indicate that computational approximation methods such as physical optics and multilevel fast multipole are not reliable prediction methods within enclosures of this scale because of the underlying assumption sets that are inconsistent with enclosure boundaries. More recently, LSP has concentrated on statistically formulating a compilation of test/computational results to produce a maximum expected environment. Preliminary results are promising in the area of statistical bounding of the desired solution. The researched methodology should offer the following advantages over 3D computational and standard volume-based approximation methods:

- Predict BOTH statistical Mean AND Maximum Expected E field and/or common mode current.
- Consider the over-moded (electrically large conductive cavities) and under-moded (electrically smaller damped enclosures).
- Consider complex materials with multiple joined enclosures.
- Applications of this prediction methodology are far reaching and include shielding effectiveness and prediction of fields within a cavity enclosure due to internal transmitters and operating avionics.

To enable bounded solutions in electromagnetic environment prediction, proposals are solicited to develop technology that does the following:

- Bounds the expected peak electric field environment inside enclosures such as rocket fairings, and spacecraft enclosures. The method should include the technology required, the technique as well as the necessary verification efforts.
- To develop a numerical or statistically based methodology for characterizing shielding effectiveness of enclosures with associated applicable apertures.
- To develop methods for field enhancement/reduction based on thermal/acoustic blanketing and metal/composite components such as avionics and PAF structures.
- Develop preliminary user-friendly modeling software that can be easily customized to support NASA-specific applications.

Phase I Deliverables - Research, identify and evaluate candidate algorithms or concepts for electromagnetic field mapping of typical spacecraft and rocket enclosures. Demonstrate the technical feasibility and show a path towards a computer model development. It should identify improvements over the current state of the art for both time/resource savings and systems development and the feasibility of the approach in a varied-enclosure environment. Lab-level demonstrations are required. Deliverables must include a report documenting findings.

Phase II Deliverables - Emphasis should be placed on developing usable computer model and demonstrating the technology with under and over moded conditions with testing. Deliverables shall include a report outlining the path showing how the technology could be matured and applied to mission-worthy systems, verification test results, computer model with user's and other associated documentation. Deliverable of a functional computer model with associated software is expected at the completion of the Phase II contract.

Relevance to NASA

All NASA payloads, particularly those with hardware sensitive to electric fields will benefit from launch and ascent risk reduction.

References:

Expected Electric Field Prediction methods in Fairing/Aircraft and Spacecraft Enclosures:

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- D. A. Hill, "Electromagnetic Fields in Cavities. Deterministic and Statistical Theories" John Wiley & Sons, Hoboken, New Jersey 2009
- J. Ladbury, G. Koepke, and D. Camell, "Evaluation of the NASA Langley Research Center Mode-Stirred Chamber Facility," NIST, Technical Note 1508, 1999.
- A. Schaffar and P. N. Gineste, "Application of the power balance methods to E- field calculation in the ARIANE 5 launcher payloads cavities," Presented at International Symposium on EMC, Long Beach, 2011, pp. 284-289.
- D.H. Trout, "Electromagnetic Environment in Payload Fairing Cavities," Dissertation, University of Central Florida, 2012.
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- Bremner, P.G, Vazquez, G., Trout, D.H and Cristiano, D.J., "Canonical Statistical Model for Maximum Expected Imission of Wire Conductor in an Aperture Enclosure", Proc. IEEE Intnl. Symp. EMC, Ottawa, October 2016
- G.B Tait, C. Hager, M.B. Slocum and M.O. Hatfiled, "On Measuring Shielding Effectiveness of Sparsely Moded Enclosures in a Reverberation Chamber", IEEE Trans. on EMC, Volume:55, Issue: 2, October 2012