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Pablo Narvaez is the subject matter expert for the National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL) in flight spacecraft Electromagnetic Compatibility and Magnetic environments (EMC/Mag). Pablo has held the title of Principal in the area of EMC/Mag for fourteen years and has continued to contribute and become a Laboratory resource in all aspects of Spacecraft Electromagnetic Compatibility. For his many accomplishments, he has been nominated for the JPL Fellow designation for the 2018 decision-making cycle. He is a Senior Member of the Institute of Electronic and Electrical Engineers (IEEE) and member of the EMC and IAS Societies. In addition, he is recognized in the professional community (government, NASA and industry) as a subject matter expert as evidenced by being selected as the Vice Chairman of the Institute of Electrical and Electronic Engineers (IEEE) EMC Special Committee (SC-7) on Aeronautics and Space EMC, and for membership on the IEEE EMC Standards Development and Education Committee. In addition, he represents the United States on the International Organization for Standardization (ISO) Technical Committee 20 Subcommittee 14 for Space Systems and Operations (SC14) and is the Project Lead for the international standards in EMC and Magnetics requirements and testing. Also, Pablo was elected to be one of twenty-five national committee members of the American Institute of Aeronautics and Astronautics
(AIAA) EMC Committee on Standards S-121, who oversaw the development and revision of EMC requirements for space systems, which was officially approved in December 2017 and released to the nation on January 2018. The AIAA EMC document sets the national standard for EMC requirements and testing and is the most referenced document by national aerospace and space companies. In addition to technical committee leadership, he is on IEEE EMC paper review committees and often chairs IEEE EMC symposium technical sessions. He is often invited to present papers, lead tutorial workshops and technical demonstrations at IEEE EMC international symposiums.

He led the EMC/Mag efforts for the following spacecraft and science instruments: Galileo Spacecraft (from 1985, up to launch in 1989; post-Challenger re-design for Venus Earth Earth Gravity Assist or VEEGA mission), Ulysses Spacecraft, instruments flown on the Shuttle (Shuttle Radar Topography Mission or STRM, Shuttle Imaging Radar or SIR-C, Lambda Point Experiment, Drop Physics Module), Cassini Spacecraft, Mars Exploration Rovers, CloudSat Spacecraft, Deep Impact Spacecraft, Dawn Spacecraft, OCO-2 Spacecraft, Aquarius/SAC-D Spacecraft, Juno Spacecraft and the just recently launched Grace Follow-On twin spacecraft.

He is currently overseeing the EMC/Mag efforts for of the following spacecraft: Europa Clipper, Mars 2020, Surface Wave Ocean Topography, and non-NASA projects.

Solving complex problems is an important facet of Pablo's accomplishment as a leader in his discipline. He consistently performs early project lifecycle developmental tests and analyses, which contribute to design decisions that enhance flight system EMC/Mag performance. Pablo leads all of the work done within the EMC/Mag discipline at JPL and maintains cognizance over the wide range of activities performed by the EMC/Mag team to assure exceptional support to all projects. In addition to leadership for flight projects, his expertise enables him to define new areas of research. An example is how Pablo has formed a lab-wide Signal Integrity working group to help address electromagnetic cross-talk impact to hardware performance issues early in the design phase. He is a Co-Investigator on strategic R&TD initiatives in the area of wireless technologies and power line communications since EMC is core to both.

As a result of his many contributions, Pablo received the NASA Manned Space Flight Awareness Honoree in September 2000, NASA Exceptional Service Award 2005, JPL Ranger Award for Outstanding Leadership on International Team 2009, JPL Explorer Award for Scientific and Technical Excellence 2009, JPL Magellan Award for Leadership and Excellence in a Field of Knowledge 2016, and the NASA Exceptional Engineering Achievement Award 2017.

EMC/Mag will be a critical area for JPL's future flight planetary, astrophysics and earth science missions' due to the high sensitivity of instruments and engineering subsystems to noise and interference. Pablo has been involved with the EMC/Mag design and testing for all JPL missions since the mid-1980s starting with Galileo. With the focus on radar missions with sensitive instruments (CloudSat, Aquarius/SAC-D, Soil Moisture Active Passive or SMAP, JASON series, Surface Water and Ocean Topography or SWOT, NASA-ISRO Synthetic Aperture Radar or NISAR) and missions with magnetometers (Galileo, Ulysses, Cassini, Juno, Insight, Europa Clipper, Psyche), his expertise is crucial to enable these sensitive instruments to acquire their science within the context of an observatory system. In particular for Europa Clipper, the combination of fluxgate and vector helium magnetometers on ICEMAG, the Plasma Instrument for Magnetic Sounding (PIMS) and the Radar for Europa Assessment and Sounding: Ocean to Near-surface or REASON radar (in addition to a large array of solar panels and batteries) makes the EMC/Mag design for that mission very complex. Pablo's expertise is crucial for ensuring its scientific success by establishing proper EMC and magnetic cleanliness requirements for the Europa mission.

Pablo's forte extends beyond the experimental application of EMC test and characterization. He is pioneering the approach of creating spacecraft EMC and magnetic models using state-of-the-art software tools to predict and understand instrument performance early in the design phase, thus helping instrument scientists conduct trade studies and fine tune functional specifications. It has been used to help formulate the design requirements for the mission and become a significant part in ensuring science goals are met. Pablo has advocated the use of models to help develop and tailor EMC requirements.

He is the technical supervisor of the EMC group and has recently been assigned the chief engineer role for the Reliability Engineering and Mission Environmental Assurance Section 513. He is focused on both hiring and training future engineers in the EMC area and on formulating the strategic implementation of the flight EMC infrastructure for JPL. Pablo implemented the innovative approach of adding a conductive cloth layer to thermal blankets to enhance their RF shielding attenuation characteristics and ensure that sensitive instruments are protected against external radiated emissions. This technique was employed on Dawn, Aquarius, and SMAP. He has steered the EMC group to standardize the early use of advanced EMC/Mag software tools to analyze preliminary physical system configurations for EMC issues. He has expanded the group's vision to develop expertise in new EMC-intensive, technical areas such as Power Quality analysis and testing, wireless communications and launch site lightning analyses and predictions. Pablo is currently working on an innovative approach to perform system level magnetic field tests that eliminates the need to "swing" a spacecraft. The present "swing" or pendulum approach is highly risky as it requires the spacecraft to be suspended on a crane and swung side to side to create a displacement as magnetic fields are measured. The new method eliminates the need for the "swing" movement and involves safely translating the spacecraft in place on a dolly into an apparatus composed of many measurement magnetometers. Pablo is pioneering techniques to minimize EMC issues by establishing new design guidelines for electronic signal integrity (SI).

Lecture Topics:

1. Mitigation of EM/RF Interference with Spacecraft GPS RF Subsystems

GPS RF subsystems perform critical functions for spacecraft navigation and positioning in orbit. Interference with the GPS RF subsystem is a critical concern. This lecture describes the mitigation approach employed on a JPL spacecraft to achieve EM/RF compatibility between the Spacecraft RF and electrical subsystems and the GPS RF subsystems. Extensive engineering investigations were performed to develop RE102 limits in the GPS operational bands, explore mitigation risks, and pursue EM/RF compatibility techniques.

2. Magnetic Testing, and Modelling, Simulation and Analysis for Space Applications Applied To Jupiter-bound Spacecraft Such As Juno And Europa Clipper Mission

Jet Propulsion Laboratory (JPL) implemented a comprehensive magnetic cleanliness program of the NASA/JPL JUNO mission which is currently orbiting Jupiter and returning invaluable scientific data. Without the implementation of the magnetic cleanliness program, key scientific instruments such as the magnetometer science instrument as well the Microwave Radiometer (MWR) instrument would not be able to perform in the presence of high magnetic fields from the spacecraft and Jupiter. The magnetic cleanliness program was applied from early flight system development up through system level environmental testing. The JUNO magnetic cleanliness program required setting-up a specialized magnetic test facility for testing the flight system and a testing program with a facility for testing subsystem parts and subsystems at JPL. The magnetic modeling, simulation and analysis capability was set up and performed in order to provide qualitative and quantitative magnetic assessments of the magnetic parts, components, and subsystems prior to or in lieu of magnetic tests.
Because of the sensitive nature of the fields and particles scientific measurements as well as the microwave radar instrument being conducted by the JUNO space mission to Jupiter, the imposition of stringent magnetic control specifications required a magnetic control program to ensure that the spacecraft's science magnetometers and plasma wave search coil were not magnetically contaminated by flight system magnetic interferences. With component and subsystem magnetic modeling, simulation and analysis as well as system modeling and comprehensive testing, the project accomplished a cost effective approach to achieving a magnetically clean spacecraft. The lecture will focus on the approach that was implemented and describe the the scientific results that benefited from the efforts to control spacecraft interference and magnetic contamination of science instruments.
This lecture presents lessons learned from the JUNO magnetic testing approach and modeling, simulation and analysis activities used to solve problems such as remnant magnetization, performance of hard and soft magnetic materials within the targeted space system in applied external magnetic fields and how these lessons learned are being applied to future Jupiter-bound spacecraft such as the Europa Clipper and Lander.

The NASA Europa Clipper spacecraft with its nine science instruments will orbit Jupiter's icy moon Europa to investigate whether the icy moon could harbor conditions suitable for life. Of those nine science instruments, there are two magnetically sensitive ones: the Plasma Instrument for Magnetic Sounding (PIMS) and the Interior Characterization of Europa using Magnetometry (ICEMAG). The two instruments will measure the strength and direction of the moon's magnetic field to determine the depth and salinity of its ocean, which hence leads to unique DC magnetic requirements. The lecture will also focus on the DC magnetic model analysis that was performed on Europa Clipper spacecraft to guide design trades and provide an early assessment for the spacecraft in order to ensure that the unique DC magnetic requirements can be met and validated by test in the future.

3. Control of Electric and Magnetic Radiated Emissions at Low and High Frequencies

The Jet Propulsion Laboratory has participated in multiple projects whereby implementation of proper electric and magnetic field shielding has been a key component in successful space missions free electromagnetic interference. This lecture presents detailed radiated electric and magnetic field shielding methods similar to those applied on JPL hardware for typical flight programs.

4. Electromagnetic Interference Avoidance Through Proper Signal Integrity Design: Modeling and Simulation Approach

With High Speed Printed Circuit Board (PCB) designs with pulse rise times reaching into the picoseconds region becoming more common place, a PCB's direct impact to the overall spacecraft system electromagnetic compatibility performance is becoming increasingly interrelated. For example, a subsystem with a poor PCB design that produce multiple signal integrity (SI) problems is directly related to the amount of electromagnetic interference (EMI) noise produced by that subsystem, thus affecting not only its own performance but also the performance of co-located RF receivers and other sensitive instruments such as may be the case with typical missions like Surface Water and Ocean Topography (SWOT) and NASA-ISRO Synthetic Aperture Radar (NISAR). A previous mission's surface operations were directly impacted by EMI, whereby the Mars Science Lab Curiosity needed to instill flight rules by not allowing EMI-noisy subsystems to operate during UHF passes to avoid loss of lock and false locks during critical telecom operations. These EMI problems need to be minimized from the start of a design cycle and correct them before a design is finalized and hardware is fabricated. The approach to minimizing system EMI starts with outlining how to correctly design for proper SI into a subsystem. This lecture provides a solution to signal integrity problems in digital systems by outlining the processes that are required to ensure complete SI through the use of early modeling and simulations of proposed designs. The process outlined will describe how to uncover potential problems, their causes, characteristics and effects, as well as solutions by outlining a set of rules and guidelines on the correct methods for instituting SI design rules and guidelines onto PCBs and other critical interconnecting devices (cabling, connectors etc.). A detailed step-by-step state-of-the art process will be outlined as part of the lecture that will guide designers on how to simulate and model their proposed designs that will assist them in uncovering typical and hard-to-detect SI problems early in the process. Multiple examples will be provided of typical design flaws and how to correct them using modeling and simulations.

Improving one's knowledge in Signal Integrity analysis addresses many of the present and future issues electrical engineers may face with direct EMI experienced by sensitive science instruments and radio receivers or any other electrical circuit board used on any system. By enhancing one's SI analysis capabilities, EMI could be addressed much earlier in the design process rather than late in the fabrication stages where problems impacting cost and delivery are uncovered after the hardware is designed and fabricated.

5. Development of Spacecraft Radiated Susceptibility Requirements From Modeling Methods

In defining radiated susceptibility requirements for a spacecraft with multiple number of receivers and transmitters in close proximity to each other, the main objective of an RF coupling analysis is to determine if the mechanical configuration of the receiver and transmitter antennas presents a risk to the functionality and safety of sensitive science instruments on the payload as a result of unintended RF coupling. Where there is a potential risk for interference or permanent damage, further analysis is required to evaluate the feasibility of mitigation schemes, such as mechanical reconfiguration of antennas or additional RF filtering. From these coupling analysis results, radiated susceptibility RS103 requirements are derived to better reflect actual requirement levels with adequate test margins.