Analysis of Data in accordance with Space Flight Mission Environmental Requirements

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Introduction

The Environmental Assurance Program sets forth standards to ensure that all flight hardware is compatible with the environments that will be encountered during a spacecraft mission. It outlines the design, test and analysis, and risk control standards for the mission and certifies that it will survive in any external or self-induced environments that the spacecraft may experience. The Environmental Requirements Document (ERD) is the most important document in the Environmental Assurance Program, providing the design and test requirements for the project's flight system, subsystems, assemblies, and instruments. This summer's project was to assist Environmental Requirements Engineers (ERE's) in completing the Environmental Assurance Program Summary Report for both the Juno Project and Mars Science Laboratory (MSL) Project. The Summary Report is a document summarizing the environmental tests and analyses of each spacecraft at both the assembly and system level. It compiles a source of all relevant information such as waivers and Problem/Failure Reports (PFRs) into a single report for easy reference of how well the spacecraft met the requirements of the project.

Juno Background

The primary objective of the Juno spacecraft is to understand the formation and evolution of the planet Jupiter.[1] By observing Jupiter's gravity and magnetic fields and atmospheric dynamics, scientists will be able to analyze the interior, atmosphere, and magnetosphere that determine Jupiter's properties. With Jupiter as the archetype of giant planets, this will provide

knowledge to understand the origin of our own solar system's evolution. Juno carries nine instruments and is powered by three solar panels.[2] The Magnetometer (MAG) will produce a map of Jupiter's magnetic field, while the Gravity Science (GRAV) will analyze the interior structure of the planet. The Jovian Infrared Auroral Mapper (JIRAM) will obtain high spatial resolution images of the upper levels of Jupiter's atmosphere, which will provide knowledge of the structure of the planet's atmosphere. The Jovian Auroral Distributions Experiment (JADE) will measure the flow of particles along Jupiter's magnetosphere, while the Juno Energetic Particle Detector Instrument (JEDI) will study the energy and distribution of ions; both instruments will help determine how the magnetic field is connected to the atmosphere. The Microwave Radiometer (MWR) will probe Jupiter's deep atmosphere and measure the amount of water beneath the top cloud layer. Waves will investigate the electric and magnetic fields, looking for currents within the aurora. Ultraviolet Spectrometer (UVS) and the Jovian Infrared Auroral Mapper (MIRAM) will use ultraviolet and infrared cameras to understand the structure of Jupiter's atmosphere and gases present. JunoCam will provide the first pictures of Jupiter's poles.

Juno Environmental Assurance Program Summary Report

The Juno Environmental Assurance Program Summary Report documents the environmental assurance program as planned and implemented. It involves a summary of the test and analysis program at both the assembly and system level and provides charts for the Waivers and Problem Failure Reports (PFRs) generated during such testing. The Juno Environmental Requirements Document (ERD) documents the environments Juno is expected to encounter during pre-launch operations, launch and ascent, cruise, and as well as during Jupiter orbit

phases. Such environments include Dynamics, Thermal, Electromagnetic Compatibility (EMC), Change of Pressure, Explosive atmosphere, and natural space environments. Juno's environmental testing will conform to the requirements set forth by the ERD through Tests and Analyses, which are documented in the Environmental Test Authorization and Summary (ETAS) or the Environment Analysis Completion Statement (EACS) forms. All the required environmental tests and analyses are captured in the Test and Analysis Matrix (TAM), which indicates the level of test was performed (Qualification, Protoflight, or Acceptance). When certain test requirements are not met, waivers are used and must provide rationale and information on which hardware will be affected. However, failure or malfunction of hardware during environmental testing must be reported in a Problem/Failure Report (PFR) and reported to the ERE.

Within the Environmental Assurance Program Summary Report is also the Assembly Program Metrics, which includes statistics on the different test and analyses performed. It shows the distribution of environmental tests organized by instrument and also includes information on the number of assemblies, ETAS's, and re-tests.

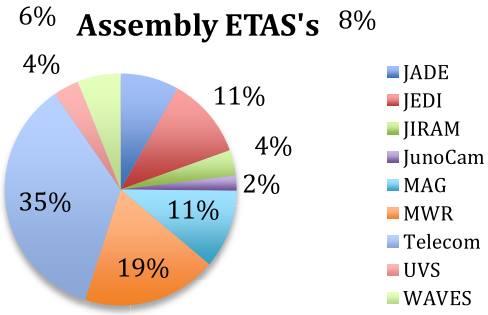

Figure 1: Distribution of Juno's Assembly ETAS's

Anomaly	Title	Failure occurred During	Item Name
13509	SDST x4: Vibe response measured on cantilevered portion of componenet	Dynamic Test - Random Vibration	SDST
13512	SDST x4 STE: Data Acq System Auto OFF	Thermal Vacuum Test - Mid Temp	SDST
13513	SDST x4: T-Vac Missing Data	Thermal Vacuum Test - Mid Temp	SDST
14060	ANTENNA STRUCTURAL PANEL TEST	Static/Quasi-Static Load Test	Antenna 1
14610	MWR EM Exceeds CE specification	EMC/EMI - Conducted Emissions Test	Electronics
14649	HC MECHANICAL TEST ASSY	Static/Quasi-Static Load Test	Antenna 1
14816	MWR (EM) Radiated Susceptibiltiy Failures	EMC/EMI - Radiated Susceptibility Test	Receivers
14944	Juno SDST SN102 TDL Test: Moisture Found Near Chamber Condenser	Characterization Test	SDST
14994	MWR receiver R1-R3 carriers exposed to temperatures above PF limit	Thermal Atmosphere Test	Receiver 1

Figure 2: Snapshop of Problem Failure Report (PFR) Spreadsheet

Figure 1 shows the distribution of tests that were performed on each of Juno's payload instruments. Figure 2 is a screenshot of the PFR spreadsheet that includes the test each failure occurred during and which hardware it affected. The Environmental Assurance Program Summary Report also contains the results of system level tests, where the entire spacecraft is put through another series of environmental testing before launch.

Mars Science Laboratory Mission Background

The primary objective of Mars Science Laboratory (MSL) focuses on the past and present habitability of Mars.[3] MSL will characterize the geology of the regions accessed by the rover and attempt to detect chemical building blocks of life on Mars. It will carry an analytical laboratory to study rocks, soils, and the local geological setting. By determining past habitability on Mars, MSL will give the scientific community a clearer understanding of whether Mars ever had an environment capable of supporting life. The spacecraft consists of four major elements: Cruise stage, Aeroshell, Descent Stage, and the Rover. Compared to MER's Spirit and Opportunity, MSL will carry a significantly larger payload and rover masses. It utilizes a different Entry, Descent, and Landing (EDL) system than previous missions in which it does not require a ground-generated command sequence, but acts autonomously.[4] MSL is scheduled to launch November 25, 2011.

MSL Environmental Assurance Program Summary Report

Similar to the Juno Environmental Assurance Program Summary Report, the MSL Summary Report summarizes the tests and analyses at both the assembly and system level. As noted in the MSL Environmental Requirements Document, MSL is expected to survive ground

operations, shipping and handling thermal environments, and launch environments. However, MSL differs from Juno in that MSL must withstand Mars' atmospheric temperature, pressure, and density during its entry and descent, along with Mars' surface environments during its science operations. Tables of Waivers and PFRs have been generated, along with the metrics for the assemblies. The MSL Environmental Assurance Program Summary Report is in the process of being completed.

Conclusion

This summer's project was to complete the Environmental Assurance Program Summary Report for both Juno and MSL. However, due to the time constraints, higher priority was placed on the Juno Summary Report, as it is nearing its final draft. The Environmental Assurance Program is vital to the mission's success, ensuring its survival in the environments the spacecraft will encounter. Without the necessary test and analysis requirements at both the assembly and system level, the spacecraft may not be able to carry out its science objectives.

References:

[1] Perkins, Dave. *Juno Environments Requirement Document*. Rep. no. JUNO-RQ-06-0053. Print.

[2]Stephens, Stuart K. *Juno Project Mission Plan*. Rep. no. JPL D-35556. Print.

[3] Forgrave, John. *Mars Science Laboratory Environmental Requirements Document*. Rep. no. JPL D-21382. Print.

[4] Baker, Charles J. *Mars Science Laboratory Mission Plan*. Rep. no. JPL D-27162. Print.

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