SMAP Verification and Validation Project – Final Report

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Background & Motivation

In 2007, the National Research Council (NRC) released the Decadal Survey of Earth science. In the future decade, the survey identified 15 new space missions of significant scientific and application value for the National Aeronautics and Space Administration (NASA) to undertake. One of these missions was the Soil Moisture Active Passive (SMAP) mission that NASA assigned to the Jet Propulsion Laboratory (JPL) in 2008. The goal of SMAP[1] is to provide global, high resolution mapping of soil moisture and its freeze/thaw states. The SMAP project recently passed its Critical Design Review and is proceeding with its fabrication and testing phase.

Verification and Validation (V&V) is widely recognized as a critical component in system engineering and is vital to the success of any space mission. V&V is a process that is used to check that a system meets its design requirements and specifications in order to fulfill its intended purpose. Verification often refers to the question "Have we built the system right?" whereas Validation asks "Have we built the right system?" Currently the SMAP V&V team is verifying design requirements through inspection, demonstration, analysis, or testing. An example of the SMAP V&V process is the verification of the antenna pointing accuracy with mathematical models since it is not possible to provide the appropriate micro-gravity environment for testing the antenna on Earth before launch.

Objectives

SMAP design requirements must be verified before launch. The objective for this summer was to assist in the SMAP V&V process by verifying project and system level requirements, developing validation plans, investigating anomalies, and developing SMAP V&V tools. The following summarizes the tasks performed this summer:

1. Developed V&V verification reports for project and system level requirements: the Mass Report, and the System Design Inspections Report
2. Developed V&V test plans for two scenarios: the Spacecraft Checkout Scenario Test Plan, and the Observatory Checkout Scenario Test Plan
4. Investigated testbed time anomaly
5. Developed SMAP V&V Wiki

Approach

The purpose of the Mass and System Design Inspection report is to provide verification evidence and closure rationale of project and system level requirements. The reports were developed through attending V&V meetings and collecting verification evidence (mechanical drawings, electrical circuit diagrams, interface control documents) from team members. After analyzing and/or inspecting the verification evidence, closure rationales were developed and documented per SMAP V&V verification report standards and approved by the appropriate stakeholders.

To prove that the right system has been built, test plans are created to validate the system design for the different mission scenarios. Test plans consist of information on the scenario's initial and final conditions, event sequences, and validation test approaches. In turn, test engineers use the test plans to develop detailed test procedures to validate the spacecraft system. The Spacecraft and Observatory Checkout Test Plans were developed through an iterative process of reading project documentation, meeting with mission system engineers, and analyzing the validation requirements. The final results were then

compiled per SMAP V&V test plan standards, reviewed by peers, and approved by the appropriate stakeholders.

The SMAP avionics testbeds are used to verify and validate the avionics components of the spacecraft. However, it is often the case that during testing, testbed anomalies occur. The most recent case is the discovery of unsynchronized timestamps among the testbed telemetry files. In order too properly correlate the testbed telemetry and test results, the telemetry time must be either synced or well understood. A repeated process of meeting with test engineers to identify possible tests, performing tests, and analyzing the data was used to characterize the anomaly.

The SMAP V&V wiki was created to provide a V&V resource hub for SMAP team members. As the project moves into the testing and integration phase, verification and validation activities will increase, driving the need for a centralized location of V&V information. The wiki was created using JPL Confluence which includes key information on V&V concepts, processes, report templates and documents as requested by the SMAP V&V team.

Results & Discussion

By the end of the summer, the verification reports, test plans, and wiki were developed and approved by the SMAP V&V team. A considerable amount of time was spent in understanding the flight system and developing test approaches for the scenario test plans. Although the testbed telemetry anomaly was not resolved by the end of the summer, a substantial amount of time and work was put into characterizing the time discrepancy among the testbed telemetry. The following figure displays an example of the analysis performed to characterize the anomaly.

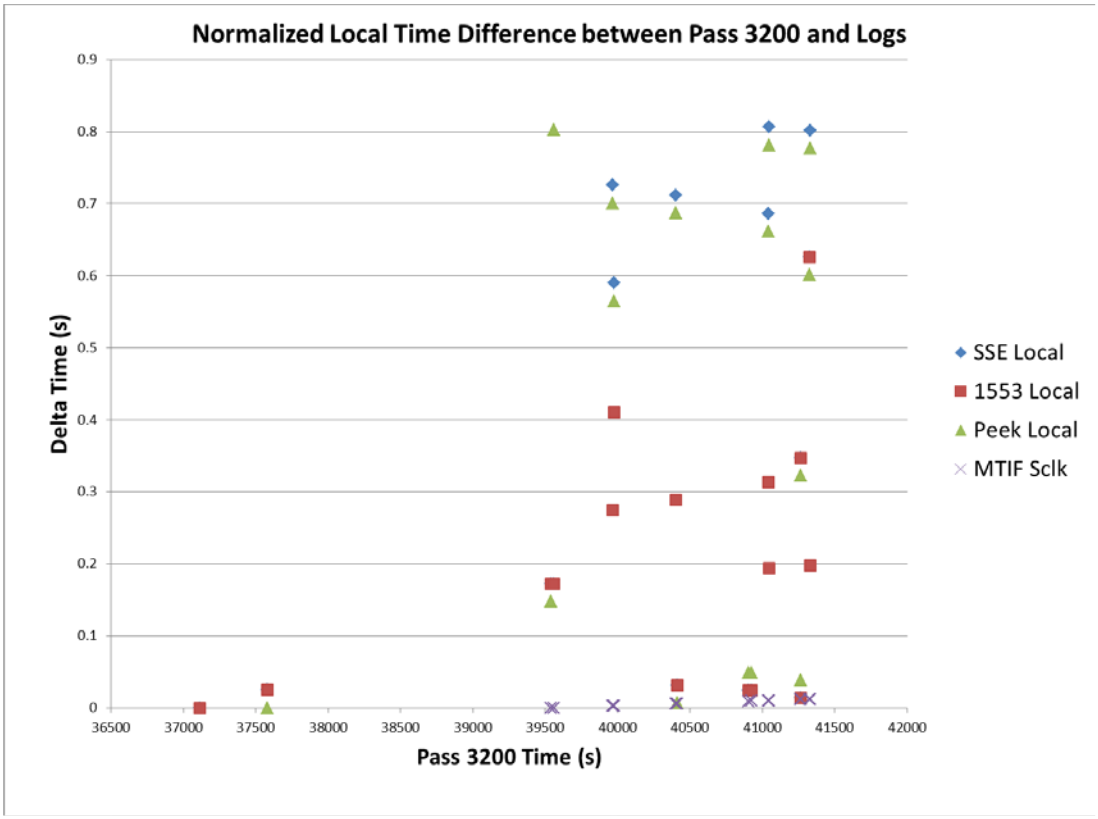

Figure 1. Anomaly Characterization Example

Figure 1 shows the normalized time difference between a truth time and each telemetry log time. An Excel based script was developed to parse and analyze the data. The significance behind the plot is that it serves as a tool for characterizing the anomaly. Figure 1 shows how telemetry drifts over time and the rate of the log file time drift. From here, an engineer can identify which telemetry log files are in sync and which are not; thus narrowing down the sources of the error. For example, it can be seen in Figure 1 that the MTIF SCLK time difference remains close to zero compared to the other telemetry files over time. This suggests that the hardware generating the MTIF telemetry is not a source of error.

Conclusion

Initially, the author was tasked with three action items at the beginning of the summer. By the end of the summer, the action items grew to six. The author played an integral part in the SMAP V&V process and contributed substantially to the flight project. Extensive experience in the V&V process, anomaly resolution, and system engineering was obtained throughout the summer. Lessons in technical engineering and communications practices were also learned.

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References

[1] National Research Council (NRC). 2007. Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond (Executive Summary), http://www.nap.edu/catalog/11820.html. National Academy of Sciences, National Academies Press, Washington DC, 35pp.

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