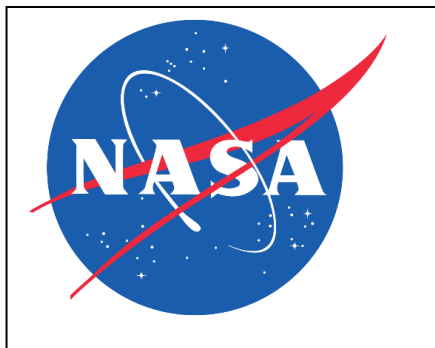# Customer Avionics Interface Development and Analysis (CAIDA)

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Software Developer for Avionics Systems

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The Customer Avionics Interface Development and Analysis (CAIDA) supports the testing of the Launch Control System (LCS), NASA's command and control system for the Space Launch System (SLS), Orion Multi-Purpose Crew Vehicle (MPCV), and ground support equipment. The objective of the semester-long internship was to support day-to-day operations of CAIDA and help prepare for verification and validation of CAIDA software.

Nomenclature

CAIDA	Customer Avionics Interface Development and Analysis
DP	Data Packet
GFAS	Ground and Flight Application Software
GNC	Guidance Navigation Controls
ICPS	Interim Cryogenic Propulsion Stage
KSC	Kennedy Space Center
LCC	Launch Control Center
LCS	Launch Control System
MPCV	Multi-Purpose Crew Vehicle
NASA	National Aeronautics and Space Administration
NIFS	NASA Interns, Fellows, and Scholars
SCCS	Spaceport Command and Control System
SLSE	Space Launch System Emulator
SS	Software Simulator
TRR	Test Readiness Review
V&V	Verification and Validation
XML	Extensible Markup Language
XTCE	XML Telemetry and Command Exchange
USRA	Universities Space Research Association

I.   Introduction

Becoming familiar with the development and operations of CAIDA and the flight software was accomplished in order to support CAIDA through the Verification and Validation (V&V) process during this NASA Interns, Fellows, and Scholars (NIFS) internship. CAIDA's purpose is to support user testing of interface displays for LCS, Ground and Flight Application Software (GFAS), and Spaceport Command and Control System (SCCS) systems with ground to flight simulations and testing in the Launch Control Center (LCC). CAIDA has multiple ways of generating telemetry for customers: Software Simulator (SS), Space Launch System Emulator *(SLSE)*, Data Packet (DP) generation and modification. The main focus of this internship was to update, modify, and maintain the custom developed software for DP generation. CAIDA is going through the process of V&V so it is imperative that all requirements, procedures and test cases are correct and function optimally. Since CAIDA is a subsystem for MPCV,

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SLS and the Interim Cryogenic Propulsion Stage (ICPS), CAIDA's V&V is on the critical path for V&V of the other systems.

The telemetry generated by the DP generator has a defined format. DP generation is used mainly for LCS or GFAS testing. DPs contain information that allows them to be uniquely identified. This allows set operators in the firing rooms to make use of a particular DP. Set operators reserve a set, which is in a specified configuration for receiving telemetry and then check the accuracy of their displays in the LCC's firing rooms. CAIDA is responsible for generating the telemetry. If the set operator does not receive telemetry or the telemetry is not being received as expected, CAIDA operations personnel will use software to troubleshoot for the set operators. Control commands are sent to the DP generator by the set operator and should provide responses that allow the user to evaluate their displays and interfaces. This testing is an integral and important part of preparing to launch EM-1, EM-2, and missions to follow. All flight software must be accurate, providing the highest amount of assurance that all communication systems for the launches will be successful.

II.   Operations

CAIDA's daily operations consist of teamwork between the developers of CAIDA hardware and software, and effective communication between CAIDA operators and operator's working alongside the set operators. CAIDA is a subsystem, which by design, is not directly related to flight hardware or software, however, allows testing of other directly related systems and interfaces. Subsequently, CAIDA must pass through the V&V processes first before it may be used in the V&V process of other systems.

A. Requirements and Procedures
During this semester long internship, I was primarily responsible for supporting DP generation as CAIDA was preparing to enter the Verification phase. The first task was to go through the files of the DP generator and become familiar with the syntax and then comment the code appropriately. I was tasked with performing code reviews for both the DP generator and DP modifier as part of fulfilling software engineering requirements for CAIDA. Concurrently, I learned how to operate the debugging software used in the CAIDA lab. The debugging software is used on a daily basis and it is a vital component of supporting CAIDA's telemetry customers in the firing rooms. The debugging software can display the rates of DPs, plot and even record telemetry, all independently from the customer's set. CAIDA can support many set users simultaneously, which allows for several users to test flight hardware during a shift. The debugging software displays were updated, generally due to changing identifiers, however some were corrected during the process of evaluating test cases and procedures. The identifier values must be updated in the database. The database contains information that is vital to setting up the debugging software display, which is essential for the customer and for CAIDA's V&V process.

Another task that was integral in supporting CAIDA's preparations for V&V was to run DP generation and DP modification test cases and to update the procedures that will be used during the V&V process. The test cases use automated scripts that are intended to produce certain outputs in either the DP generator or debugging software. The test cases are run and the outputs are confirmed against the procedures. Changes are made where needed and submitted

for evaluation by my mentor. Several inconsistencies were found and corrected and this resulted in a much smoother course for verification.

If the DP generator is found to be out of compliance with requirements when users test their interfaces, the user can submit a nonconformance. There were a few that required code modification. One instance of this was where the customer was trying to issue a command to change a value and the expected response was not correct. The code was modified, the output was confirmed, and the nonconformance was closed. Currently, the DP generator is being modified to include separate command response changes for Orion. This has involved updating numerous DP generator files and adding functions and commands for Orion. There are XML Telemetry and Command Exchange (XTCE) files that must be parsed and need to contain the correct information for the program. Additionally, the program must be able to accept the commands separately for Orion.

DP modifier was also modified and updated to reflect the needs of current uses which are similar to the code in certain parts of the DP generator. If commands or syntax were incorrect, modifications were made to allow the DP modifier to proceed to the next step in the process of V&V. The DP modifier also checks that the test cases produced desired outcomes against procedures and corrections in the procedures were made as necessary.

The CAIDA Software User Guide was in need of updates in order to reflect the current state of the software. Most of the steps and images that a user would be referencing for instruction on how to bring up a set and send commands were outdated. There had been several updates to the software and many displays had been modified or simplified since the last update of the user guide. During one customer's set time, while using the DP generator, screen shots of the new displays were captured and the user guide was edited in accordance with the process the set operator currently follows. Much of the information in the user guide had to be modified as the displays and a great deal of the process had changed. The user guide was part of CAIDA's V&V process as well and had requirements that needed to be met in order to pass V&V.

B. Verification

Verification is the process of determining and proving through the use of test cases that the software meets the design requirements. The verification process will determine if the CAIDA software complies with specifications. Verifying software shows that the software was designed and built correctly and that it will produce expected results. Results are confirmed by the use of test cases. This internship began near the end of the development phase as the software has already been an asset to customers developing user interfaces and displays for Guidiance and Control (GNC) and other users. Several modifications were made to the existing code for the DP generator in order for the code to meet these testing requirements. Some of the modifications were due to nonconformances, where the expected result was not received. After trouble-shooting all other possible areas that could be affecting the displays' outcome, such as a networking issue, modifications weree made in the code for the end-user. At this point the code was examined for any possible updates needed, such as updating identifiers, adding pertinent statements to the code to compensate for users' requests, debug or to confirm that software updates are compliant. CAIDA has completed the process of verification in the pedigree process escribed to class-A software application.

C. Validation

Validation in software development is the process of determining that the verified software actually meets the customer's needs as outlined by the customer. This testing follows verification due to the fact that software must first be confirmed to have been designed properly. CAIDA will begin validation testing next. Once the customers have confirmed the software's requirements have been met, CAIDA will have completed the validation phase. The validation testing Test Readiness Review (TRR) process is awaiting several document updates, which should be complete in a minimal timeframe. As CAIDA successfully proceeds through the processes of V&V, there will likely be further tasks requiring some improvements. However, changes cannot be made to the software itself during the V&V process, otherwise the verification process would have to be reentered. The completion of those tasks will be integrated into CAIDA as the other tasks and projects have been. The team work and level of commitment, intelligence and ingenuity that the CAIDA developers and operators brings to the Mission to Mars vision will undoubtedly complete the validation phase.

III.   Conclusion

The updates to the CAIDA software systems were necessary to support the role that CAIDA plays as a supplier of telemetry for the customer testing. Ensuring that CAIDA has completed verification and will be ready to complete validation is fundamental for launching the SLS for EM-1 as well as future missions to come. CAIDA has gone through software verification and the updates to the procedures and test cases were made to the DP generator. In support of this process, display debugging and identifier updates as well as effective modifications allowed the process to run seamlessly during verification. CAIDA is now prepping for the validation phase of its pedigreed tests for their software applications.

Acknowledgments

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