Independent Verification and Validation

Comparison of IV&V's Use of Non Verification Environments and Program Use of Verification Environments

2014 Annual Workshop on Verification and Validation
September 9-11, 2014

Presenter:
Ricky Beamer
frederick.m.beamer@ivv.nasa.gov

Additional Author:
Katie Warner
kcwarner@mix.wvu.edu

Agenda

Independent Verification and Validation

- IEEE-1012 Review
- Dynamic Environment Retest
- MPCV Overview
- Test Environment Overview
- Testing Methodology
- Process
- Results
- Forward Work

IEEE-1012 Review

Independent Verification and Validation

- IEEE *"Standard for System and Software Verification and Validation"*
  - Determine whether the development products conform to the requirements satisfies its intended use
  - Verification and Validation processes include Systems, Software, Hardware and Interfaces
  - Standard applies to systems, software, and hardware being developed, maintained, or reused
  - Verification and Validation processes include the analysis, evaluation, review, inspection, assessment, and testing of products

IEEE-1012 Review

Independent Verification and Validation

- IEEE 1012 Appendix C

  For system tools, technical independence means that the IV&V effort uses or develops its own set of test and analysis tools separate from the developer's tools. ***Sharing of tools is allowable*** *for computer support environments (e.g., compilers, assemblers, and utilities) or* ***for system simulations where an independent version would be too costly. For shared tools, IV&V conducts qualification tests on tools to assure that the common tools do not contain errors that may mask errors in the system being analyzed and tested.*** *Off-the-shelf tools that have extensive history of use do not require qualification testing. The most important aspect for the use of these tools is to verify the input data used.*

IEEE-1012 Review

Independent Verification and Validation

- Due to cost and schedule limitations and the nature of the EFT-1 flight test, conducting full qualification tests on the provided MPCV test environments was not pursued
  - IV&V MPCV executed supplied checkout and regression scripts to ensure that the installed simulators behave in a similar manner as the Program counterpart. This ensures that both systems behave in the same way for the same broad range of test scenarios.
  - This strategy has been used on other IV&V projects when full qualification tests were not practical

Dynamic Environment Retest

Independent Verification and Validation

- Dynamic Testing: a method of assessing the feasibility of a software program by giving input and examining output
- The purpose of IV&V's retest of the Program supplied test environments was:
  - Determine if test environments display anomalies which merit funding additional IV&V tests.
  - Establish environments' utility for future planned IV&V testing
  - Establish greater confidence in previous IV&V test results
    - Ensure observed behaviors of software under test (SUT) are due to SUT performance not due to test environment performance.
  - Begin process for future independent qualification of the environments

MPCV Overview

Independent Verification and Validation

- Multi-Purpose Crew Vehicle (MPCV) is based on the Constellation program's Orion design
- Capable of conducting regular in-space operations in conjunction with payloads delivered by the Space Launch System (SLS) for missions beyond LEO

Image Credit: NASA.gov

MPCV Overview

- Expected to launch in December 2014

Image Credit: NASA.gov

Test Environment Overview

Independent Verification and Validation

- SOCRRATES: **S**oftware **O**nly **C**rew Exploration Vehicle **R**isk **R**eduction **A**nalysis **T**est **E**nvironment **S**imulation
- Developed by Lockheed Martin (LM) for the purpose of MPCV Flight Software (FSW) development testing and verification procedure development (verification test dry runs)
- SOCRRATES has three main components
  - SOCRRATES Controller
  - MPCV FSW
  - OrionSim
- Emulates execution of the FSW on the Vehicle Management Computer (VMC) through Wind River Simics software only hardware models

Test Environment Overview

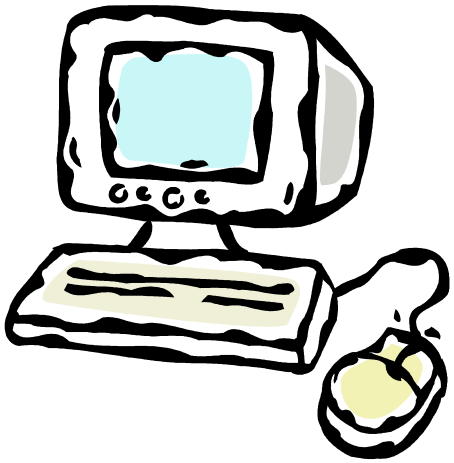
Independent Verification and Validation

- PLATO: **P**artition **L**evel **A**pplication **T**est for **O**rion
  - Software-based execution environment developed by NASA at the John Space Center that allows users to interact with the Orion FSW partitions at their sampling port boundaries
    - Sampling ports are shared memory within the partitioned environment used to pass information from ARINC 653 application partitions to other SW partitions or non partitioned software
    - MPCV uses for sampling ports include communication of commands, statuses, and responses via software that is assigned ownership of the communications bus
  - Simulation environment that executes the unmodified MPCV FSW on a Simics emulated target
  - Allows for stepping through the FSW minor frames and controlling interpartition data transaction timing

Test Environment Overview

Independent Verification and Validation

- Verification Test Environments
  - VTB – VMC Test Bench
  - ITL – Integration Test Laboratory
  - ATLO – Assembly, Test and Launch Operations
- Certified testing facilities
  - Allow for vehicle hardware and software testing
- Risk identification and mitigation facilities



Testing Methodology

Independent Verification and Validation

- Test case selection
  - Examine available test case and test procedure documentation
  - Examine available RFR data
  - Correlate test case and RFR data
  - Prioritize test cases
- Execute test cases
  - Modify test scripts as necessary for the testing environment
- Examine and compare test data
  - Note differences and similarities between RFR and IV&V test data

Process

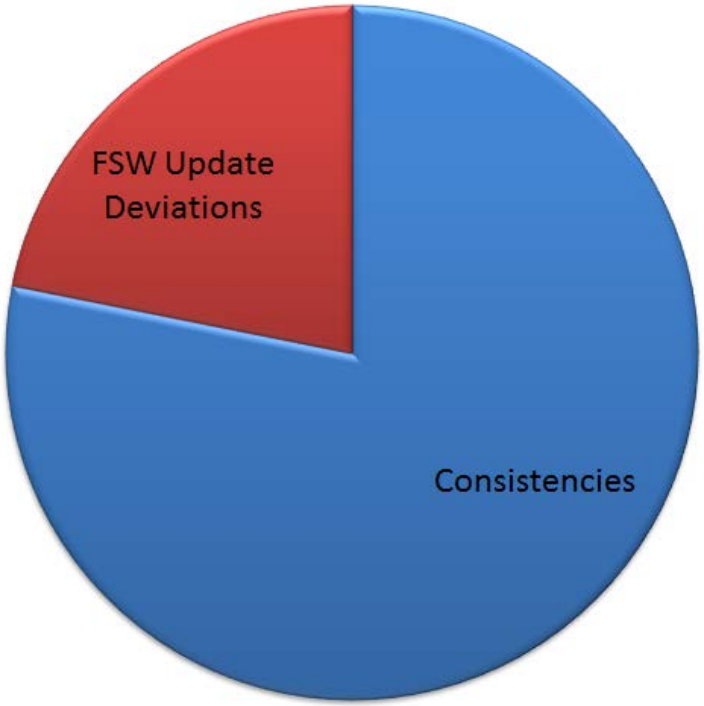
Independent Verification and Validation

- Re-executed the RFR test scripts
- All RFR data we were looking at was from several older versions of the FSW
- From this we knew that certain things, such as telemetry packet numbers, would change from build to build (observed from prior regression testing)
- Excluding that info, we looked to see if the data captured in the official RFR results was similar to our test results
  - Margin of error due to updated FSW and updated component models being used

Results

Independent Verification and Validation

PLATO



SOCRRATES

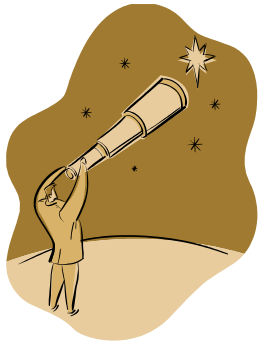
Results	Consistencies	FSW Update Deviations	Other Deviations	Total
PLATO	25	7	0	32
SOCRRATES	10	0	2	12

Results

Independent Verification and Validation

- Deviations
  - Due to more mature FSW being tested
    - In PLATO the FSW has changed to reflect different partition restart procedures. The test scripts have not been updated to reflect the altered logic
  - Development test system is unable to simulate all systems of systems
    - i.e. in SOCRRATES the component simulation system lacked the fidelity for the components under test
- IV&V's use of the PLATO and SOCRRATES testing environments will support meaningful FSW testing of IV&V test cases without depending on the MPCV Program for test execution or test analysis
  - These environments are not demonstrated to be suitable final testing for the EFT-1 mission and confirmation of results via other environments is presumed

Forward Work

Independent Verification and Validation

- Additional analysis of testing results
- Apply similar methodology to compare EFT-1 flight data and PLATO/SOCRRATES.
  - Establish OrionSim/PLATO/SOCRRATES representation of vehicle performance and software performance
- Examine the root cause for anomalies in flight data
  - Research if anomalous conditions were previously tested
  - Design test cases to recreate the anomalous condition
    - Test the test environment
    - Could the anomaly have been detected and mitigated prior to launch through dynamic testing?