ITC Architecture

Analyst

GUI

Data Storage

SUT

Emulator Bridge

CTCA Communications Middleware

Component

Component Wrapper

Component

Component Wrapper

Independent Test Capability

ivv-itr@lists.nasa.gov
Agenda

- Background
- Objectives
- Approach & Scoping
- Roles & Responsibilities
- Current Project Support
- Frequently Asked Questions
- Summary
BACKGROUND
### IV&V Current Capability

- **Verify and Validate Implementation** *(Technical Framework 6.0)*
  - Currently is performed via static analysis only

<table>
<thead>
<tr>
<th></th>
<th>Code Analysis (Manual and Auto)</th>
<th>Test Result Analysis</th>
</tr>
</thead>
</table>
| **Process**      | 1. IV&V receives Build N from Project  
                    2. Compare differences with previous builds  
                    3. (manual) Perform line-by-line walkthrough of code  
                    4. (auto) Static analysis tools exercised against codebase and examine output results | 1. IV&V receives test results from Project  
                    2. Examine actual test results against expected test results  
                    3. Identify any discrepancies  
                    4. Identify independent test scenarios |
| **Value**        | Provides an additional set of eyes on software components  
                    Can be applied early in the lifecycle  
                    (auto) Provides set of rules to execute against codebase to identify critical bugs such as memory leaks, buffer overflows, and NULL pointer dereferences | Confirms intended system behavior  
                    Provides input into test scenario development |
### IV&V Missing Capability (Dynamic Analysis)

<table>
<thead>
<tr>
<th>Static Analysis</th>
<th>Dynamic Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td><strong>Disadvantages</strong></td>
</tr>
<tr>
<td>• Finds weaknesses in exact location</td>
<td>• Can be time consuming</td>
</tr>
<tr>
<td>• Allows quicker turnaround for fixes</td>
<td>• False Positives and False Negatives</td>
</tr>
<tr>
<td>• Finds errors earlier in lifecycle</td>
<td>• Requires trained personnel</td>
</tr>
<tr>
<td><strong>Automated Tools</strong></td>
<td><strong>Automated Tools</strong></td>
</tr>
<tr>
<td>• Relatively fast</td>
<td>• Can scan all of code</td>
</tr>
<tr>
<td>• Can provide false sense of security</td>
<td>• Do not provide runtime vulnerabilities</td>
</tr>
<tr>
<td>• Only as good as rules they are using</td>
<td></td>
</tr>
</tbody>
</table>

NASA IV&V Program Independent Test Capability
• **Internal Research and Development Team**
  o R&D advances processes, tools, and knowledge through the exploration and integration of practical solutions.

• **Charter**
  o Develop, maintain, and operate an adaptable test environment for the IV&V program that enables the dynamic analysis of software behaviors for multiple NASA missions.
    o ITC = experts in simulation
    o IV&V Project = experts in systems
  o Provide a means to assess system dynamics through the perspective of IV&V’s Three Questions
    o Test what the system does
    o Test what the system is not supposed to do
    o Test what the system does under adverse conditions
OBJECTIVES, APPROACH, AND SCOPE
ITC Goals and Objectives

- Provide a simulation and test environment that enables the dynamic analysis of software through the integration of simulation tools, models and test articles

- A software test environment that is easily adaptable and reconfigurable for multiple projects to be used Program-wide

- Stimulate the developers’ software running on the intended hardware or emulated hardware

- APIs for use by development projects

- Common User Interface
Dynamic Analysis Approach

• IV&V’s dynamic analysis will focus on functionally testing the software delivered by the NASA projects.
  – Functional testing is defined in the NASA Software Safety Guidebook 8719.13 as a black-box type testing geared to functional requirements of an application.
  • Black-box testing is defined as testing that is not based on any knowledge of internal design or code. The tests are based on requirements and functionality.

• IV&V’s functional testing will be a complement to the existing testing performed by the NASA project.
  – The IV&V project will utilize the ITC framework in an attempt to consider the “Three Questions” against preselected behaviors/capabilities using independent tests developed by the IV&V analysts.
  – IV&V’s functional testing will be of limited scope based on risk assessments of the mission’s requirements and/or behaviors/capabilities.
Scope of Dynamic Analysis

• IV&V project should lead scoping effort as they are the system experts
  • Identify areas of test (based on previous IV&V work products)
  • Develop test scenarios/cases, test procedures, and test scripts

• Disclaimer
  – IV&V will not duplicate all of the Verification and Validation (V&V) of the NASA project’s requirements that have been tested prior to IV&V receiving the software. The scope of the IV&V’s testing will be established via IV&V’s risk assessments of the project.
  – IV&V tests will not be all inclusive of the software’s functionality. Software capabilities that are demonstrated during the NASA project’s V&V testing are not necessarily demonstrated during IV&V’s testing. IV&V selects certain behaviors/capabilities to test and will not duplicate all of the testing performed by the NASA project.
Example Test Areas for IV&V

• Areas where IV&V may perform testing
  – Verify in scope functional requirements (based on risk assessments)
  – Execute de-scoped tests that are desirable
  – Test software interfaces
  – Execute regression tests
  – Fault Injections
  – Off-Nominal Tests
  – Scenarios identified by IV&V analysts during requirements analysis work
  – Execute stress tests
  – Validate issues (TIMS) found from other IV&V activities
ROLES AND RESPONSIBILITIES
Roles and Responsibilities

- Generate Plan for Independent Testing
- Collect and Provide Artifacts
- Develop, Execute & Analyze Tests
- Integrate Developer Capabilities into ITC

** See backup slides for textual version **
Communication Triangle

ITC : Proj

- SW Development

ITC : IV&V

- Schedule
- Sim Capability
- Training
- IC&T Results
- Log Files

Proj : IV&V

- Artifacts

Proj : ITC

- Models
- ICDs/HW
- Specs
- Test Server
- Access
- Training

IV&V : Proj

- Test Plan
- Test Report
- TIMS
- Test Docs

IV&V : ITC

- Schedule
- Mission Info
CURRENT PROJECT SUPPORT
GO-SIM and GPM
GO-SIM Background

• Examined current IV&V projects for pilot study

• GPM Project Identified
  – Collaboration with GPM Operational Simulator Project
    • GSFC team investigating software-only simulation tools using ground simulator and spacecraft simulators
**GO-SIM Overview**

**Software-only Simulator**

<table>
<thead>
<tr>
<th>Components</th>
<th>Capabilities</th>
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<tbody>
<tr>
<td>• Wind River Simics</td>
<td>• Load and run unmodified flight software binaries</td>
</tr>
<tr>
<td>• Primary Instrument Simulations</td>
<td>• Execute flight scripts</td>
</tr>
<tr>
<td>• ASIST Ground System</td>
<td>• Single-step debugging</td>
</tr>
<tr>
<td>• Goddard Dynamic Simulator (GDS)</td>
<td>• Inject errors via ground system</td>
</tr>
<tr>
<td>• Wind River workbench integration</td>
<td>• Stress system under test</td>
</tr>
<tr>
<td></td>
<td>• Validate findings from other analyses</td>
</tr>
</tbody>
</table>
**GO-SIM Value**

<table>
<thead>
<tr>
<th>GSFC (GO-SIM)</th>
<th>IV&amp;V (ITC)</th>
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</thead>
<tbody>
<tr>
<td>Simulate long term operations</td>
<td>Increases IV&amp;V capabilities and Project relationship</td>
</tr>
<tr>
<td>Means to stress system w/o risk to hardware components</td>
<td>Increases understanding of system dynamics and related tools: ASIST, GDS, and Primary Instruments</td>
</tr>
<tr>
<td>Software-only simulator (\rightarrow) no hardware maintenance or acquisition and increases number of potential users</td>
<td>Earlier Identification of software issues</td>
</tr>
<tr>
<td>Reduce time &amp; functionality needed from FlatSat</td>
<td>Checkpoints</td>
</tr>
<tr>
<td>Means to validate new procs prior to use on observatory</td>
<td></td>
</tr>
<tr>
<td>Faster Procedure Development</td>
<td></td>
</tr>
<tr>
<td>Ground Ops Training Platform</td>
<td></td>
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</tbody>
</table>

**Checkpoints**

**GSFC Customer:** Mission Operations  
**ITC Customer:** IV&V GPM Team
GO-SIM Architecture

ASIST Ground System → Spacewire Simulated Bus → BAE Simulation

---- Interface via Spacewire (2) 1553

Instrument 1553 Interface → GMI Simulation

DPR Simulation → S/C 1553 Interface

GDS Model Simulation

Key

IV&V
Joint Effort
GO-SIM
ASIST Team

NASA IV&V Program Independent Test Capability
• Primary Instrument Simulations
  – Pack and unpack formatted messages and packets
  – Receive and respond to instrument commands and requests for data
  – Handle necessary telemetry components
  – Maintain state just like the real instrument
GPM IV&V and ITC Integration

• ITC member integrated with GPM IV&V project
  – Attends various meetings and is on team’s distribution list
  – Obtained access to multiple IV&V and GPM project repositories
    • GPM IV&V’s ECM and IMAP
    • GPM Management Information System (MIS)
    • GPM MKS (contains requirements, code, and test documentation)

• ITC team has established the initial simulation environment using GPM FSW and GPM ground system (ASIST)
  – Additional work is in progress to integrate Goddard Dynamic Simulator (GDS) and science instrument simulations for GMI and DPR.

• ITC provided initial draft of *GPM IV&V Test Plan* to IV&V project
• GPM IV&V project has included ITC efforts in FY 11 IPEP
• GPM IV&V is using previous IV&V work products to identify areas for functional testing
  – In the process of generating test scenarios, test procedures, and test scripts
Frequently Asked Questions
Frequently Asked Questions

• “My project already has a V&V program. Aren’t these IV&V activities just repeating the Project V&V team’s work? What added value are they providing?”
  – JPL Feedback: Obtain and utilize SoftSims for as many projects as possible.
  – Preferred method of verification is Test – IV&V does not currently have a means to Test FSW
  – Increases IV&V analysis capability → Yields better products → Decreases false findings → Decreases Project time spent
  – Helps IV&V identify vulnerabilities earlier in lifecycle
  – Provides additional value via additional testing (descoped tests; tests not identified by Project)

• “My project is already spending time providing IV&V with artifacts for its current analyses, and responding to IV&V findings. It will take additional time and effort to provide IV&V with the artifacts they need to do dynamic testing. What exactly is needed, and why should we spend extra time and effort on this?”
  – Software simulations provide the capability to test earlier in the lifecycle when easier and cheaper to fix, rather than later when more difficult and expensive to fix
  – GO-SIM effort is off to a great start since February 2010. Design-by-contract development approach to provide software-based simulation environment to mission operations and IV&V.
Frequently Asked Questions

• “This dynamic testing capability sounds pretty new. How mature is it?”
  – ITC Vision and Concept of Operations written beginning of FY09
  – GO-SIM effort is off to a great start. Effort began in February 2010. Design-by-contract
development approach to provide software-based simulation environment to mission
operations and IV&V.
  – ITC backend development initiated in February 2010. Front end development initiated in June
  2010.

• “Your facility has undergone a lot of changes in the last year. What if we spend
time and effort and the ITC gets cancelled? What kind of support do you have
from your sponsors for this activity?”
  – Independent Testing is part of new strategic plan and Technical Framework
  – IV&V Office (and Chief Engineer) strongly supports effort
  – IV&V Management has designated space in new office building for ITC test lab equipment and
  personnel (8-10 member team)
  – New organizational structure provides R&D capability as means to increase IV&V capabilities
  – Personnel: 8 FTE; GO-SIM effort funded through FY11
  – Hardware: 2 development servers, switch, workstations
  – Software: Wind River workbench licenses and Simics licenses
  – Training: ATI Training courses (July 2010); Simics training (August/September 2010)
Frequently Asked Questions

• “Project artifacts are often in the draft state when provided to the ITC. Will Project receive formal issues and observations from the ITC team on these artifacts?”
  – No, ITC members will not write issues or observations on the Project during simulator development stages. We recommend having an internal Test Readiness Review (iTRR) as a gate to kickoff independent testing as a means to communicate that both the Project and ITC are in agreement that the simulator is “good enough” to support testing of the software system for a given iteration.

• “Collaborating with IV&V on a dynamic testing capability is new. There would be lots of hurdles to overcome – technical, political, legal, etc. Is it worth the trouble?”
  – Yes! We will limit our scope and take small steps
Summary

• Reusable Simulation Components
• Common Interface across missions
• Integrate simulation tools across projects
• Potential to provide simulator to many IV&V analysts with no risk of “breaking” hardware
• Soft-Sim means no hardware maintenance
• IV&V dynamic analysis will focus on functional testing and is scoped by IV&V’s risk assessments and previous work products
• IV&V project is responsible for generating independent tests and executing the tests using the ITC framework
• Communication and information sharing between IV&V, ITC, and NASA projects is KEY to successful independent testing
• **ITC does not perform IV&V**
  – ITC provides IV&V with additional tools to perform their mission of independent verification and validation
Conclusion

- Background
- Objectives
- Approach & Scoping
- Roles & Responsibilities
- Current Project Support
- Frequently Asked Questions
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Roles and Responsibilities

<table>
<thead>
<tr>
<th>User / Stakeholder</th>
<th>User Description and Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV&amp;V Project Manager</td>
<td>The PM is a civil service employee that is responsible for the overall leadership and direction of the IV&amp;V efforts. The PM is responsible for establishing the goals and objectives of the IV&amp;V efforts, performing the RBA efforts, performing project management/financial management, project tracking and oversight and risk management of the IV&amp;V efforts. <em>The PM is to ensure that the ITC efforts are included in the IV&amp;V Project Execution Plan (IPEP) and communicated to the Project POC.</em> The Project Manager is also responsible for <em>identifying appropriate project points of contact for the ITC team and working with the ITC to determine the appropriate artifacts and resources needed.</em> The PM will need to have appropriate funding for the necessary testing tools and resources and will need to work with the ITC team to identify an appropriate schedule for the work to be done.</td>
</tr>
</tbody>
</table>
## Roles and Responsibilities

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<th>User Description and Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITC Team</td>
<td><strong>(Developer)</strong> The ITC team is <em>responsible for the development and maintenance of the simulation testing environment (ITC framework)</em>. The ITC team consists of a Lead, Software Developers, Testers, and Quality Assurance personnel.</td>
</tr>
<tr>
<td></td>
<td><strong>(User)</strong> During initial efforts on the GPM project, it is assumed that the ITC team will aid in performing the initial testing activities in order to provide a full end-to-end solution to the IV&amp;V program to support dynamic analysis processes.</td>
</tr>
<tr>
<td></td>
<td><strong>(IV&amp;V Project POC)</strong> One ITC member will attend IV&amp;V project meetings, be added to project distributions, and serve as the single POC between the ITC team and the IV&amp;V project.</td>
</tr>
<tr>
<td>IV&amp;V Project Analyst</td>
<td><strong>(User)</strong> The IV&amp;V project analyst is the primary user of the ITC framework. <em>Project analysts are responsible for developing natural language test scenarios and test procedures as well as test scripts.</em> Project analysts will perform the testing to include regression testing, stress testing, and performance-based testing. Project analysts are responsible for executing the tests, analyzing the test results, and writing issues and observations against their findings.</td>
</tr>
<tr>
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<td><strong>(ITC POC)</strong> One IV&amp;V project member will serve as the single POC between the ITC team and the IV&amp;V project.</td>
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</tr>
</thead>
</table>
| **NASA Project Point of Contact (POC)**  | The NASA project POC serves as the designated Project interface for the IV&V efforts. Responsible for providing artifacts or access to artifacts and associated schedules in support of the IV&V efforts (electronic access is preferred). Responsible for review of IV&V analysis results and ensuring appropriate levels of coordination in terms of resolution of any shortcomings with the system/software as revealed from these analysis results.  

*The NASA project POC also helps ensure effective and efficient communications between the development project and ITC team members and timely delivery of all needed artifacts.*                                                                 |
| **NASA Project Software Developers and Testers** | *(Customer)* NASA project software developers and testers are the end customers of the issues, observations, and reports produced by the IV&V analysts.  

*The ITC has also found that having access to a software developer and/or tester for a given project increases effectiveness while decreasing time spent on some critical tasks.*  

Communicating with software developers and testers provides valuable insight to ITC team members on the technologies and techniques already being implemented on a given project.  

*(Potential ITC Developer)* Although most likely infrequent, NASA project software developers and testers could serve as valuable members of the ITC team if agreements are made early in the project’s lifecycle to collaborate on the development of simulation and test environments.  

*For the GPM project, this role is being addressed by members of the GPM Operational Simulator (Go-Sim) development team.* |

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