NASA's Independent Verification and Validation (IV&V) Program was founded as part of the agency's strategy to provide the highest achievable levels of safety and cost-effectiveness for mission-critical software.

NASA IV&V's primary business is software verification and validation. The program has more than 150 full-time employees and also leverages the expertise of in-house partners and contractors.

THE CHALLENGE
Rising development and maintenance costs comprise the key business challenge of testing and verification for NASA IV&V. Because of their complexity and stringent safety requirements, most NASA projects take many years to come to fruition.

It wouldn’t be practical to perform traditional hardware-based testing and verification because of the cost of supporting and maintaining the hardware. Too much time and effort would be expended trying to find old boards that are no longer available in order to run tests. Then there’s the cost of storing inventory and the issues surrounding portability. It’s difficult to replicate hardware for multiple uses.

For these reasons, software simulations have recently become essential to the NASA IV&V test and verification process.

In 2010, the NASA IV&V Independent Test Capability (ITC) team joined forces with NASA Goddard Space Flight Center (GSFC) to develop a software-only simulator for the Global Precipitation Measurement (GPM) Operational Simulator (GO-SIM) project. The GPM mission is an international network of satellites providing next-generation global observations of rain and snow. GO-SIM includes the GPM ground system and database, flight software executables, and spacecraft simulators.

GO-SIM was designed as a high-fidelity simulator with no hardware dependencies. Its functions include loading and running unmodified flight software binaries, executing flight scripts, performing single-step debugging, injecting errors via the ground system, stressing the system under test, and validating findings from other analyses.

THE SOLUTION
Wind River Simics, simulating a BAE RAD750 processor, enables target software to run on the virtual platform the same way it does on physical hardware. Along with Simics' capabilities of

By using Wind River Simics, 80–90% of the simulation models can be reused for other missions, representing tremendous cost savings for NASA.
scripting, debugging, inspection and fault injection, it enables
users to define, develop and integrate their systems without the
constraints of physical target hardware.

Simics allowed NASA's ITC team to simulate their target hardware,
ranging from a single processor to large, complex, and connected
electronic systems, and build its GO-SIM product with all the
desired features.

Using this virtual environment, the ITC team can adopt approaches
and techniques not possible on physical hardware. For example,
developers can freeze, save, email, and restore the whole system;
they can view and modify every device, register, or memory loca-
tion; and they can run the whole system in reverse to find the
source of a bug. Simics equips the ITC team with a risk-reduction
toolbox capable of injecting errors anywhere in the system and
testing fault-management responses. This improves product qual-
ity and engineering efficiency.

With Wind River Simics, IV&V team members can identify flight
software issues that they can't find using other IV&V analyses.
They can verify expected software behaviors and increase their
confidence that flight software will work as expected and properly
handle adverse conditions. By incorporating science instrument
simulators, they can reduce risk for instrument-spacecraft inter-
faces and ensure internationally cooperative systems.

Simics is easily and quickly configurable. Setting up a particular
target system is much faster than on hardware. Configurations of
the virtual platform can be saved and accessed at a later point in
time, ensuring consistent hardware setups within a development
organization and customer support situations. Simics also sup-
ports rapid prototyping and the ability to quickly determine the
impact of a potential hardware change on software performance.

RESULTS

With Wind River Simics, NASA IV&V successfully met its goals to
develop a complete simulator with no hardware dependencies in
a reduced time frame and at lower cost than if it had been devel-
oped using traditional hardware simulations.

ITC team members now have test assets available when they need
them. Government agencies like NASA typically buy assets for a
five- to 10-year project upfront, and then by the time they need
them the requirements have changed and they can’t get the hard-
ware. Wind River Simics solved this problem. Engineers don’t have
to sit idle, waiting for the physical hardware to show up, before
they can work.

Simics has enabled NASA IV&V to enhance quality in two ways.
First, the ITC team can be confident in its ability to verify issues.
Second, during development the software simulations enable the
team to find bugs early in the process and fix them before they
advance to the next phase.

By using Wind River Simics, NASA IV&V enables 80–90% of
the simulation models to be reused for other missions, representing
tremendous cost savings. It’s far less expensive to use multiple
copies of the simulator than to create new ones for each project.
The ITC team reduces costs by 93% and can replicate a complete
instance of the simulator in a few hours. The development and
time savings will add up quickly as they continue to pull simulators
off the shelf to support future missions.

SUMMARY AND FUTURE PLANS

GO-SIM and its Wind River Simics components provided a suc-
cessful solution for the GPM mission, but the significance of this
project is much larger and more long-term than this one project.
GO-SIM was developed with reuse in mind and will continue to be
used to perform dynamic analysis of software running on multiple
spacecraft.

For example, components of GO-SIM are now being used in the
James Webb Space Telescope IV&V Simulation and Test (JIST)
project. In addition, NASA is looking into the possibility of com-
mercializing the solution beyond its own flight system applications.

The ITC team has also developed custom components for use
within its simulation environments that will likely be widely reused.
For example, the ITC Synchronous Bus (ITCSB) was created for
GO-SIM, but is being reused in JIST. This reusable mechanism
ensures consistent and correct data passing among distributed
components of a simulation system.

The same methods, interfaces, and mechanisms apply to a vast
majority of all embedded systems. NASA IV&V has many custom-
ers and potential customers that would benefit from many of the
GO-SIM components and GO-SIM architecture, and is anxious to
get out there and share how powerful it is.

For more information on GO-SIM, go to http://www.nasa.gov/
centers/ivv/jstar/ITC.html.

Wind River is a world leader in embedded software for intelligent connected systems. The company has been pioneering computing inside embedded devices since 1981, and its technology is
found in nearly 2 billion products. To learn more, visit Wind River at www.windriver.com.
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