

Iridium Satellites Stay in Orbit with Wind River

Wind River Simics Simulates In-Orbit Wireless Communications Satellite Constellation

Iridium Communications Inc. is a satellite communications company that advances the way global enterprises conduct mission-critical activities. With a strong track record as an innovator, Iridium offers the only truly global coverage for satellite communications for anywhere on Earth—including oceans, airways, and polar regions.

Iridium's mobile voice and data communications solutions serve a wide range of industries and are supported by a global communications network. Iridium features the world's largest commercial satellite constellation—consisting of 66 low-earth orbiting (LEO), cross-linked satellites operating as a fully meshed network and supported by multiple in-orbit spares. The Iridium constellation architecture ensures high reliability and low latency.

Inheriting a Strong Product with Technical Challenges

Iridium Communications Inc. was formed when a group of investors purchased a bankrupt satellite-based communication network company. The investors realized that although the prior company had failed, it provided critical services to customers requiring communications services in remote places where no other communications were available.

Iridium faced a daunting challenge: How could it develop and test new software for a constellation of satellites already in orbit? How could it react with software updates to address changes to the in-orbit satellite hardware due to radiation exposure and age? How could it guarantee the required levels of mission-critical quality and reliability?

"Without access to the original development platforms used to develop the satellites and limited resources, we explored several options to solve these problems," says Joe Pizzicaroli, vice president of satellite and launch operations at Iridium.



"Having no physical access to in-orbit Iridium hardware on the ground makes developing flight software to mitigate in-orbit issues very difficult. Simulating the satellite hardware with Simics enables us to accelerate development and validations of flight software modifications."

—Joe Pizzicaroli, Vice President, Satellite and Launch Operations, Iridium

Company Profile: Iridium Communications Inc.

- Global mobile satellite communications company
- Headquarters in McLean, VA
- Approximately 170 employees worldwide

Industry

- Satellite communications

Solution

- Wind River Simics

Results

- Mitigated risks by providing virtual hardware for debugging and testing before uploading software to satellites
- Enabled modeling of specific behavior characteristics of each satellite to ensure uploaded software functioned properly
- Significantly lowered capital expenditures (CapEx) and development costs
- Enabled development and testing of the full software stack, ensuring engineers can "fly what they test and test what they fly"

"We could have relied on our small number of test beds, but these didn't match the current state of the hardware in space. This would have made testing software patches to address specific hardware issues very difficult and risky because the test beds wouldn't have matched the in-orbit hardware exactly."

One option for Iridium was to create a physical replica of the in-orbit satellites, but since each satellite is slightly different, it would have had to develop more than 60 physical replicas and change each of them as the in-orbit hardware changed. This was clearly cost prohibitive and impractical.

Other options included using either a reference board that had a similar processor as the one on the satellites or doing host-based development. Both options were unacceptable to Iridium because the development target was substantially different from the actual target, the satellite. This would prevent Iridium from fully testing software before uploading it to the satellite.

The company decided the best solution was to implement a virtual replica of the in-orbit satellites. This virtual platform would need to simulate a heterogeneous hardware platform. It would also need to simulate not only a processor but other digital devices that make up the hardware platform. The virtual platform would need to run the full target software stack. Finally, it would need to be modifiable so Iridium could change it to match the unique hardware characteristics of each orbiting satellite.

Iridium Chooses Wind River Simics

Iridium found that the only solution that could fulfill all of these requirements was Wind River Simics.

With Wind River Simics, Iridium was able to run the exact same flight software on the virtual replica of the satellite as on the physical satellite because Simics is able to simulate not only the processor but other devices of the physical hardware as well. Furthermore, Iridium was able to modify each Simics virtual platform to match the specific hardware characteristics of each satellite.

"The virtual platform works by modeling the exact current state of the components of the target satellite—enabling the replication to avoid the whole 'close-enough' question," Pizzicaroli says. "By building a virtual platform model that included the full satellite and not just an instruction set simulator or other subset, we could develop and test the full software stack, ensuring engineers can 'test what they fly.'"

Satellite Environment Challenges

In addition to the typical software development challenges for legacy embedded systems, harsh space environments provided additional challenges for the satellites. One issue was single event upsets (SEUs), which, when combined with the satellites' limited shielding, produced an environment where electronic components occasionally suffered permanent failures.

"Because the target system was comprised of a constellation of satellites rather than a single satellite, the challenge was multiplied because no two satellites were likely to have exactly the same random failure set," Pizzicaroli says.

A second challenge of operating in the space environment is physical access. Unlike a terrestrial environment in which you can reload the system if a new software image doesn't work, at 485 miles removed, engineers couldn't simply hit the reset button.

"This sort of problem is traditionally solved by uploading a new software image without deleting the old one and setting a watchdog timer to auto-reboot using the old image if the new image doesn't finish booting and clear the timer," Pizzicaroli says. "In this case, several of the satellites' failure sets included a degradation of storage such that there was no longer room for two complete images."

If a satellite failed to reboot, engineers had no way to move it out of its orbit to bring in a spare. This resulted in a dead spot in the global network, leading to a critical communications failure for a customer with no backup.

Iridium addressed these issues by again implementing a virtual platform with Wind River Simics to model the current state.

"This was particularly relevant because some of the target systems in question had suffered permanent hardware failures, and few COTS parts support selective functionality degradation," Pizzicaroli says. "We dramatically lowered costs since a single virtual platform could be configured to match any of the satellites, while a different physical platform would have needed to be maintained for each."

Since the virtual platform included the ability to replicate the exact failure set of each target, Iridium could conduct extensive testing to ensure that the reboot would always work. With the virtual platform, all possible subsystems and combinations could be made to "fail," allowing for complete coverage testing.

Full System Simulation Enables Global Communication

Iridium's answer to software development for a legacy system from a location with no access to the target hardware was to implement a software development process combined with a virtual platform, using Wind River Simics. This combination has provided a dedicated team of engineers with the tools they need to maintain and improve an aging, existing constellation of satellites with higher productivity and lower costs than they achieved during initial development.

For additional information about the products mentioned in this case study, visit

www.windriver.com
www.iridium.com

