



How software
affects the world.
How the world
affects software.

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UNDER PRESSURE, NASA RENEWS IV&V CONTRACT

AFTER FOUR YEARS OF RESISTANCE, the National Aeronautics and Space Administration has decided to keep the independent validation-and-verification effort for its space shuttle program's flight software. The IV&V program has cost NASA about \$3.2 million per year, or three to four percent of the space shuttle's software-development costs.

NASA had planned to let the contract with Intermetrics, which performs the IV&V work, expire on September 30, the end of the fiscal year. But under strong pressure from three federal agencies — the US House of Representatives' Committee on Science, Space, and Technology, the National Research Council's Aeronautics and Space Engineering Board, and the General Accounting Office — NASA decided to renew the contract with Intermetrics (which subcontracted some work to Smith Advanced Technologies) and even expand its scope.

According to a NASA memorandum, "The space shuttle program will make provisions for flight software IV&V as a required activity in all future budget allocations."

NASA had objected to the IV&V effort because its primary flight-software contractors — IBM, Rockwell International, and Rocketdyne — have their own internal V&V procedures. NASA considered the independent procedures to be an unneeded expense, particularly since NASA's budgets have been criticized for waste in the last several years.

NASA argued that the benefits of the IV&V effort on the flight-software system were not appreciable enough to justify its cost. However, officials in the oversight agencies, like the GAO, have insisted that the effort was well worth the money, since the cost of a critical error could rise into the billions if a space shuttle is damaged or destroyed.

PROGRAM PRAISED. Ironically, all the agencies that have investigated NASA's IV&V efforts have praised NASA for doing IV&V well. Although NASA's IV&V implementation is "not typical, this implementation is very well implemented from the

start — they [Intermetrics and the primary contractors] work as a team," said Martin Kaszubowski, the ASEB's study director on the investigation. The interim ASEB report also praises NASA: "Despite the limited resources, the committee has found that the current implementation of IV&V in the shuttle program is valuable and effective."

The IV&V effort has been particularly useful in detecting problems in the interface between various software modules, especially between modules developed by different contractors, Kaszubowski said. And, according to the ASEB report, the IV&V effort has found 15 Severity 1 errors — errors that could lead to the loss of a shuttle or its crew — since the IV&V effort began four years ago. (Errors are ranked by severity, not likelihood of occurrence.)

Despite the discovery of these errors, several people involved in the oversight agencies say the flight-control software program has been well managed and well implemented overall. The argument with NASA has been about whether IV&V is necessary insurance, not about the quality of NASA's software-development effort, said several federal officials who declined to be identified.

Although the focus of the oversight agencies has been to encourage IV&V across the board as an affordable technique to prevent catastrophic losses later, at least one contractor has taken issue with the claim that there were severe errors to be found. IBM, which is the primary contractor for the flight-software's avionics components, rebutted the ASEB's interim report in a letter sent to several individuals and agencies. In the letter, IBM questioned the severity of the errors found and implied that IBM's own verification effort — not the IV&V effort — found the errors.

"Everyone agrees that IBM writes decent software," Kaszubowski said, "IV&V is a separate thing, and it shouldn't be a threat to anyone writing software." Sources said that in fact IBM's code was well implemented and not an area of concern.

FAILURES CITED. To explain its insistence that NASA use IV&V, Congressman Howard Wolpe

The agency had
considered the effort
to be an unneeded
expense because its
flight-software
contractors have their
own V&V programs.

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(D-Mich.), chair of the House Subcommittee on Investigations and Oversight for the science and technology committee, cited several software failures in recent shuttle missions.

The most recent occurred in May 1992, during the maiden voyage of the Endeavour shuttle. In that incident, the IBM rendezvous software failed to compute the correct vectors for the shuttle's thrusters in the attempt to position the shuttle to capture the Intelsat F6/3 satellite for repair. The error was caused by the use of single-precision numbers in one program module and double-precision numbers in another, sources said. Wolpe told NASA that "the failure led the flight director

to question the correctness of the entire orbiter [shuttle] guidance, navigation, and control software."

Wolpe is also urging NASA to adopt IV&V efforts for the space station and Earth Observing System programs. (EOS is planned as a series of probes and satellites to study Earth.)

NASA began using IV&V on the space-shuttle flight software in May 1988, but sought to discontinue the effort in 1990. Since then, several oversight agencies have urged NASA to continue the IV&V program. The latest agency to do so was the NRC, through its Aeronautics and Space Engineering Board. Nancy Leveson, a com-

puter-science professor at the University of California at Irvine, chaired the ASEB's committee, which had planned to issue its report in March 1993.

However, because NASA decided to discontinue the IV&V effort by October 1992, the board took the unusual action of issuing an interim report in July that strongly urged NASA to continue the IV&V efforts. In August, Wolpe urged NASA to accept the ASEB interim report's recommendations. On September 11, three weeks before the Intermetrics/Smith IV&V contract was set to expire, NASA announced that it would continue the effort and expand the IV&V contract.