By Cheerie R. Patneaude

WSTF helps Odyssey Spacecraft surf the waves of the Martian atmosphere

With increased national interest in the success of NASA's 2001 Mars Odyssey Mission and the red planet in general, a White Sands Test Facility (WSTF) team is proud of its work on the pyrovalves aboard the Mars Odyssey spacecraft. The pyrovalves are single-use, explosively actuated isolation valves that initiate the flow of propellant to the various rocket engines aboard the spacecraft.

The Mars Odyssey mission is well under way and in a looping orbit around Mars of 18 hours and 36 minutes. The spacecraft will be literally surfing the waves of the Martian atmosphere in a process called aerobraking, which will reduce the long elliptical orbit into a shorter, two-hour circular orbit of approximately 400 kilometers (about 250 miles) altitude.

The WSTF pyrovalve team was formed in 1995, following the loss of the Mars Observer spacecraft in 1993, which stopped communicating just as its rocket engines were being activated for spacecraft orbit around the planet.

This failure, as well as the subsequent destruction of the Telstar 402 and LandSat 6 satellites, was strongly related to the actuation of these explosive pyrovalves. As early as 1996, WSTF testing revealed that the older type pyrovalves, such as used on the Mars Observer, could leak pyrotechnic constituents into the highly reactive hydrazine propellant system, triggering an explosion that could destroy the spacecraft.

NASA Headquarters established a Mars Observer Propulsion and Pyrotechnics Corrective Action Test Program with representatives from headquarters, WSTF and several other NASA centers and industry leaders.

WSTF was requested to perform testing and prepare documentation to support the corrective action effort. In response to the requests, they designed and built a dedicated pyrovalve test facility and laboratory to measure and analyze any tiny quantities of the pyrotechnic actuation charge, called "blow-by," which may escape from the valve into the stream of liquid propellant.

These state-of-the-art facilities include a laser-based velocity interferometer to characterize operation of internal components of the pyrovalves. WSTF also developed special processes in coordination with neutron-radiographic facilities to inspect internal seals and disclose the distribution of blow-by constituents inside the valves.

The program thoroughly characterized pyrovalve operation, identified the mass and chemical constituents of pyrotechnic blow-by and clearly demonstrated how the hot blow-by particles could cause the hydrazine to explode by performing system level simulations.

The WSTF work did not stop there though. They developed improved pyrovalve configurations and continued to work with manufacturers to develop safer and more reliable valves.

For example, the early pyrovalves used on the Mars Observer spacecraft could leak more than 20 milligrams of hot blow-by gas and particles into the propellant stream, whereas the redesigned valves typically leak as little as a 10,000th as much.

During WSTF blow-by testing of the valve configuration chosen for use on the Odyssey vehicle, one valve failed to open upon command. The valve manufacturer incorporated improvements following the WSTF failure, but analysis indicated that a failure might still be possible.

The risk of an Odyssey pyrovalve failure was considered low, yet the Odyssey Program wanted the risk mitigated since such a failure on the real vehicle could have meant the loss of the mission.

Since there was only two months until the planned launch of the Mars Odyssey mission, a joint NASA-Industry risk reduction team was rapidly assembled, which included the WSTF team personnel.

The valve manufacturer made design and material changes as directed by the risk reduction team, and testing at both contractor and WSTF facilities indicated the problem had been solved, leaving just enough time to install the new pyrovalve and interface the spacecraft to the launch vehicle.

"This was a great program for me," said Steve Schneider, NASA program manager. "When pyrovalve behavior is anomalous, a panic situation usually results."

The Mars Odyssey Mission was successfully launched April 7, 2001, as originally planned. Subsequent NASA programs directly benefiting from the WSTF work have included the Chandra X-ray Observatory, the Mars Surveyor 1998 spacecraft, the X-38 Crew Return Vehicle and other commercial projects.

Since 1995, highlights of the WSTF pyrovalve testing and analysis have been published in nine American Institute of Aeronautics and Astronautics (AIAA) journals.

Last year's presentation won best paper in the Energetic Components and Systems Technical sessions at the 36th annual AIAA/American Society of Mechanical Engineers/Society of Automotive Engineers/American Society of Engineering Education Joint Propulsion conference.

Current WSTF Pyrovalve Team members are Regor Saulsberry (NASA), Howard Julien, Max Leuenberger (Honeywell), and William Smith (Honeywell) and Aaron Paz (NASA Co-op).

"It was my pleasure to work on the test methodologies and new facilities for pyrovalves at WSTF with such a dedicated and capable group of people," Schneider said.

Paz enjoyed being part of the project. "My involvement in this project was to actually run some of the pyrovalve tests," he said. "As a NASA Co-op, I must say that it is extremely rewarding to know that the work I have done here has a very significant purpose."

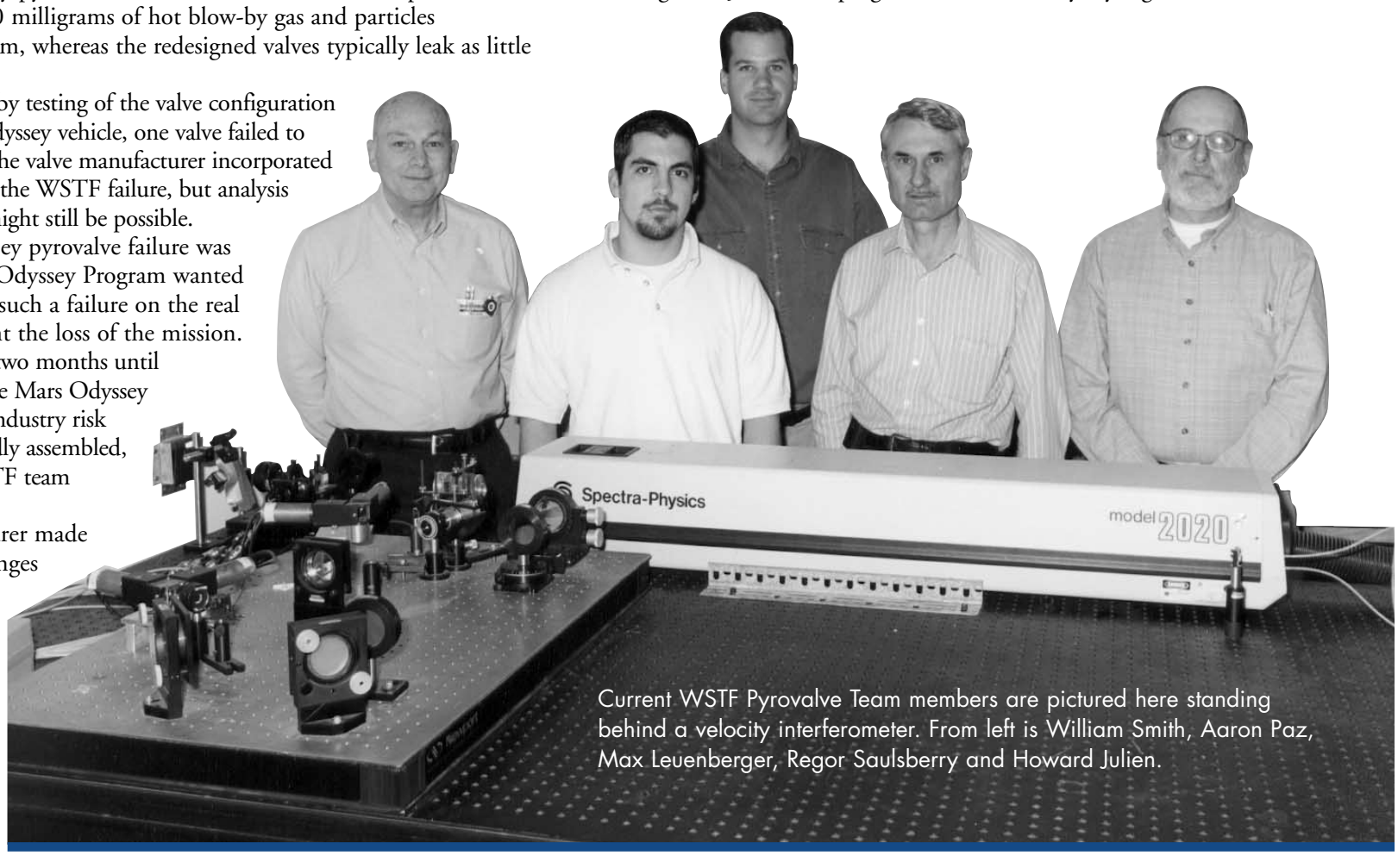
He added, "It has also been a great learning experience. My future plans are to design and test more advanced pyrovalves, which could reduce the amount of gas blow-by and improve spacecraft reliability."

The team is now working a NASA Headquarters request to refine pyrovalve test methods and develop improved valve designs and nondestructive test methods, as well as to create a pyrovalve applications handbook to enhance spacecraft safety.

"Having the Pyrovalve Blowby Analysis Laboratory and Pyrovalve Propellant Hazardous Test Facility at WSTF is important for NASA to address future pyrovalve concerns," Schneider said. "I learned a great deal about pyrovalves on this program, especially that the 'devil is in the details' when designing test apparatus and evaluating the data."

The team also continues to serve NASA and the propulsion industry at large as they remain vitally involved in the success of the pyrovalve operations aboard NASA spacecraft, such as the 2001 Mars Odyssey.

"We're really pleased to have been able to play some small part in the success of these missions," Saulsberry said, "and we look forward to the frequent reports coming from JPL on the progress of the Mars Odyssey flight." ❖



Current WSTF Pyrovalve Team members are pictured here standing behind a velocity interferometer. From left is William Smith, Aaron Paz, Max Leuenberger, Regor Saulsberry and Howard Julien.