

Fuel explosion downed Landsat 6 satellite

How might police detectives unravel the cause of a death when they can't find the body or any eyewitnesses? That's the problem investigators faced in the case of Landsat 6, a satellite that disappeared during its launch on Oct. 5, 1993.

Now, after sifting through dozens of potential answers, two review boards have concluded that a fuel line exploded 7 minutes after takeoff, preventing the craft from reaching orbit. The \$220 million Earth-sensing satellite burned up as it plunged back into the atmosphere.

The joint report, released last week, came out of investigations conducted by the craft's builder, Martin Marietta Corp., and by the National Oceanic and Atmospheric Administration (NOAA), which oversaw Landsat 6's development. Although they did not determine culpability, the review boards concluded that propulsion systems like Landsat 6's require more extensive testing than the satellite had received.

The loss of Landsat 6 has hampered a broad community of researchers who rely on satellite images of Earth's surface. They must wait until 1998 for Landsat 7 to replace the partially disabled, 11-year-old Landsat 5.

In their investigations, the review boards focused on the propulsion system for Landsat 6, which used a fuel called hydrazine. For safety reasons, engineers had designed the system to keep pressurized hydrazine within storage tanks during takeoff. Onboard computers would later open a set of valves, allowing the fuel to reach four motors. The motors would separate Landsat 6 from the Titan 2 launch rocket and then control the satellite's orientation as its main engine propelled the craft to its final orbit.

The valves in the propulsion system are called pyrovalves. They work by firing a metal ram toward a plug in the fuel line. The ram knocks the plug out of the way, opening up the line.

The joint report concluded that the firing of one pyrovalve somehow ignited hydrazine in the fuel line. The explosion burst the half-inch-wide tube, preventing fuel from reaching the four orientation motors. As a result, the satellite tumbled out of control when its main engine fired.

The investigators reached that verdict because engineers witnessed an explosion during pyrovalve testing following the Landsat 6 loss. The scenario also explains why Landsat 6 pulled away from the Titan 2 much too slowly — a fact gleaned from radar observations.

Although common components of spacecraft, pyrovalves have been implicated in a number of failures, including the loss of the \$200 million AT&T Telstar 402 communications satellite on Sept. 8, 1994, and the disappearance of the \$487 million Mars Observer on Aug. 21, 1993. Martin Marietta's Astro Space division constructed both of these satellites, as well as Landsat 6.

The review boards recommended that "any newly designed hydrazine fuel-feed system should be tested extensively." Manufacturers should pay particular attention to the use of pyrovalves in these systems, they warn.

Michael Mignogno, chief of NOAA's Landsat Commercialization Division in Suitland, Md., said engineers did not conduct these kinds of tests on the pyrovalves and hydrazine system prior to launch of Landsat 6.

Because pyrovalve problems have surfaced only recently, some aerospace experts say they, too, would not have performed extensive pyrovalve tests. "I find it very difficult to be critical," says review board member Michael Griffin of Space Industries International in Washington, D.C.

— R. Monastersky