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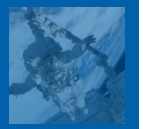

Trial by Fire:

Space Station Mir: On-Board Fire

Leadership ViTS Meeting

November 2011

Terry Wilcutt
Chief, Safety and Mission Assurance

Wilson B. Harkins
Deputy Chief, Safety and Mission Assurance

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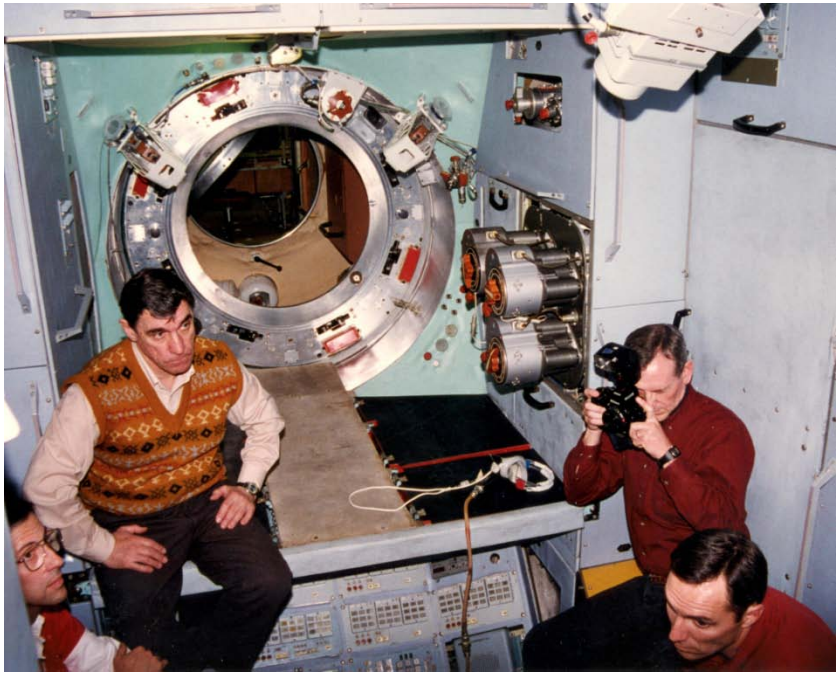
THE MISHAP

On February 24, 1997, six crew members on Space Station Mir faced significant danger when fire ignited in the solid fuel oxygen generator. The searing flame, which erupted from a fuel cartridge, cut off access to one of two Soyuz escape capsules. The module's narrow space made it difficult to fight the fire, but with teamwork and composure, the crew prevailed. Although the incident would raise tensions between the teams on the ground and on orbit, both sides would learn valuable lessons applicable to the design of the joint U.S.-Russian International Space Station.



Oxygen Generator

•*Mir* was equipped with two Elektron units which provided the station with enough oxygen to support a 3-man crew.

•Up to 6 crew members could reside on *Mir* at once, but the crew would then need a supplemental oxygen supply.

•During times of increased occupancy, crew members activated the Solid Fuel Oxygen Generator (SFOG), which was located in *Mir*'s *Kvant*-1 module.

•The SFOG worked by burning a cassette of Lithium Perchlorate. This reaction gave off a byproduct of oxygen, and the SFOG infused *Mir* with this supplement.

•Crew members usually burned three Lithium Perchlorate canisters per day.

Figure 1: The solid fuel oxygen generator in *Mir*'s *Kvant*-1 module can be seen on the wall to the right of the hatch. When the fire ignited, it blocked the path through the hatch to the *Soyuz*. After the fire, new operating procedures dictated that only the SFOG in the base block would be used.

WHAT HAPPENED?

Cartridge Replacement

•On the night of February 23, 1997, crew commander Valery Korzun asked Aleksandr Lazutkin to replace the cartridge in the SFOG just before bedtime.

•This maneuver had been executed without incident 1500 times on the ground and 2500 times on *Mir*.

•After Lazutkin replaced the cartridge, bright flames erupted from the SFOG.

•The flames were large enough to span the breadth of *Kvant*-1, cutting off access to one of two *Soyuz* escape capsules.

Firefighting Effort

•Thick smoke rapidly enveloped the entire station, forcing all crewmembers to don oxygen masks.

•Because of *Kvant*-1's limited space, only one person could fight the fire.

•Crew commander Korzun positioned himself at the *Kvant*-1 hatch and sprayed the fire with foam from three fire extinguishers, which were passed to him by the rest of the crew.

•By spraying the surrounding walls and equipment with foam, commander Korzun was able to prevent the fire from spreading.

•Although it lasted for several minutes, the fire was doused before it could significantly damage the spacecraft or injure the crew.

Burnt remains of the SFOG









PROXIMATE CAUSE

The fire consumed most of the SFOG and most of the oxygen canister, making it difficult to determine the exact cause of ignition. Almost two years after the incident, NASA scientists found that hydrocarbons in the Lithium Perchlorate canister increased the risk of problems. Using this information, Russian investigators reviewed production processes for a source of such contaminants. They zoned in on latex working gloves. In July 1999, tests showed that inserting four square centimeters of a latex glove in a SFOG cassette was enough to reproduce the blaze, finally leading investigators to a cause that had eluded them for nearly two years.

UNDERLYING ISSUES

Emergency Preparation

•After his return to Earth, Astronaut Jerry Linenger, who was on board at the time of the fire, debriefed NASA on his stay aboard *Mir.* During that discussion, Linenger highlighted lessons learned from the fire regarding emergency preparedness and crew safety, particularly in terms of warning systems, training drills, and post-crisis communication.

•*Mir's* master alarm served several functions that ranged from innocuous events such as wake-up calls to real emergencies such as the fire that occurred in February. Linenger reported that the master alarm could ring four or five times in a 24-hour period, essentially desensitizing the crew to crucial notifications.

•More effective warning systems could save several seconds of reaction time, which, in a crisis, could mean the difference between success and failure.

•Astronaut Linenger also recounted several post-fire communication lapses, where his and mission control's priorities did not align, and where NASA management did not learn about the fire until more than twelve hours after it occurred.

Safety Drills

•The crew did not practice dry runs or emergency drills simulating response to a fire, and the crew encountered unexpected difficulties when the real emergency arose.

•Launch brackets still fastened the fire extinguishers to the walls, and the crew needed screwdrivers and pliers to detach them, setting up a circumstance that practice might have eliminated.

•Safety drills could also have identified difficulties in evacuating *Mir* had evacuation become necessary. For example, both *Soyuz* vehicles would have used the same reentry coordinates, so a scenario in which both capsules evacuated the station could have resulted in a collision between the spacecraft during reentry.

FOR FUTURE NASA MISSIONS

•*Mir's* on-board fire was not the first of its kind, but was the worst that had ever occurred in space travel. Not only did the crisis emphasize the importance of practicing safety drills and formulating emergency procedures, but it also highlighted areas for design improvement.

•Developers did not hesitate to apply these lessons to the newest technological advancement - the International Space Station.

International Space Station

Space Station Mir

•As NASA begins a new journey toward deeper regions of the galaxy, it must not allow new difficulties and dangers to upset an established pattern of learning and application.

•International partnerships must include a common knowledge of shared equipment and facilities.

•Different organizations—international and commercial—have different cultures and understandings. Because cultural differences can give rise to communication lapses, NASA must find ways to overcome these differences to prevent weaknesses from creeping into joint systems and processes.