"Even knowledge has to be in the fashion,

and where it is not, it is wise to affect ignorance."

Baltasar Gracian, *The Art of Worldly Wisdom*, 1647

Chapter 6 [Star Crossed Orbits, 2002]

Mir Breakdowns

The men knew that they were in trouble when they realized that their first reactions to the emergency were wrong. When a serious fire broke out on the *Mir* space station on February 23, 1997, the six men aboard—four Russians, a German, and an American—began a struggle for their lives. One of the Russians, familiar with electrical fires from back on Earth, fought back the overwhelming urge to open a window. Jerry Linenger, the American, instinctively sought to get down low on the floor, below the smoke. Within a heartbeat, he realized that there *was* no "down" in space. The smoke was spreading everywhere evenly.

The crisis caught American space officials off guard—maybe not immediately, but certainly 12 hours or so later when the Russians finally told them about it. And it shocked the world to learn that after so many years of apparently routine space missions, there could still be vicious surprises.

After all, the first three Americans to spend extended periods on *Mir* had had a relatively easy time of it. True, Norm Thagard may have gotten bored waiting for the Russians to deliver his research equipment on a robot freighter in 1995, and Shannon Lucid may have had to spend a few months extra in orbit in 1996 because of a shuttle launch delay, and John Blaha may have had personality clashes with his Russian commander. But they all felt safe in space. As the first Americans to spend more than two weeks in space since the *Skylab* astronauts in 1973–1974, they were reopening a flight regime that would be critical to the success of the

International Space Station.

But the nation's growing complacency was shattered by the near-catastrophe aboard the Russian station. The crew of six aboard *Mir* faced a ferocious fire that defied conventional wisdom. Its occurrence was completely inconsistent with NASA's image of the Russian space program.

At the root of the fire was the human need to breath oxygen. In space, oxygen is supplied in various forms, at a rate of about two pounds per day per crew member. Small amounts can be carried in pressurized bottles and bled out through valves and regulators that maintain the proper percentage in the cabin air. Long-term supplies can come from devices that use electric power to break the chemical bond of water—H_2O—and turn it into breathable oxygen and disposable hydrogen. But sometimes there's a need for supplemental oxygen from a source that that is safe and easy to store for long periods of time.

Certain materials give off oxygen during a chemical reaction. They've been used for decades in oxygen masks, in aircraft supplemental breathing systems, and on submarines. On *Mir*, the Russians installed the same system that they regularly used on submarines. Small cartridges of lithium perchlorate in special canisters called solid fuel oxygen generators are activated by striking a pin against a small igniter charge. One cartridge, called a "candle," provides enough oxygen for one crew member for about a day.

At the time of the fire, *Mir* was in the middle of a crew changeover, and three new cosmonauts had just arrived in a *Soyuz*. While overlapping with the old crew for about a week, they would familiarize themselves with the condition of the station and the layout of the equipment and supplies. One of the newcomers, a German scientist on a quick space visit, would then return to Earth with the old crew. The American astronaut, Jerry Linenger, had been dropped off by a space shuttle flight a few weeks before, and he would stay on board until the next shuttle docking,

three months in the future.

Mir was equipped with an aging Elektron oxygen producer, but it was operating at reduced efficiency. With *Soyuz* spaceships at both docking ports, there were no visiting *Progress* robot freighters, which normally contained high-pressure oxygen bottles. So the crew routinely activated a series of oxygen candles, about three per day, during the brief dual crew phase. They'd done it hundreds of times before.

But this time, something went spectacularly wrong. A cosmonaut loaded a candle into the unit, activated it, and turned away. Suddenly smoke and then flames began streaming from the device. Recalled Jerry Linenger, "molten metal and sparks exited from the flame." The passageway to one landing craft was blocked by the meter-long torch, which reminded Linenger of a sizzling flame from the space shuttle's solid rocket boosters. It was too painfully bright to look at directly.

"This was an impressive, life-threatening fire in a closed environment," Linenger wrote in his first report. One particularly nasty surprise was the "rapidity and uniform spreading of the smoke . . . far beyond what I would have expected." Later on, he elaborated: The smoke spread "a magnitude faster than I would expect a fire to spread on a space station. The smoke was immediate; it was dense. It was very surprising how fast the smoke spread throughout the complex."

Although there were some official attempts to downplay the incident ("Small Fire Put Out" was the title of the first NASA press release), Linenger's view was different. "Though a severe fire," he wrote only days after the event, "it was in many ways a best case scenario." The flame had been directed away from, not onto, the station's fragile hull, and the normally cluttered passageway had been cleared out only days before. It would have been very much worse if the fire had pierced the station‘s cardboard-thin aluminum hull. The air would have rushed out so fast that escape would have been impossible.

A few days later, Linenger smuggled home a letter to his wife with the returning Russian crew. She'd only heard NASA's all-is-well version of the incident. "I didn't realize how serious it was until I got the letter," she told the BBC the following year. It turned out that the extinguishers in some of *Mir*'s modules were still fastened to the walls with bolted restraints designed to withstand launching forces. The bolts should have been removed once the modules had been linked to *Mir*'s main section. But the Russians had been so complacent about the danger of fire that somehow neither the cosmonauts nor the experts at Mission Control who scheduled their daily activities ever got around to it. Fortunately, at the time of the fire, the tool kits for removing the bolts were quickly found, and the extinguishers were made available to the crew members with only a few moments' delay.

The fire damage turned out to be minimal. Four cables on the Vozdukh carbon-dioxide removal unit were damaged. One of them, which controlled a vacuum isolation valve, had to be removed, and this disabled automated operations, so that manual control would be required in the future. Also, the plastic switch cover was damaged, but the switch itself wasn't.

Several of the Russians were injured fighting the fire. Station commander Valeriy Korzun suffered burns on several fingers, as well as burns on his chest as white-hot spatters of molten metal burned through his shirt and into his skin. This was almost immediately confirmed by Moscow flight director Viktor Blagov, who told NASA officials that some of the cosmonauts "have light burns on their hands." Later, I heard from NASA doctors that the burns on two of Korzun's fingers were quite serious, raising questions about whether he would be able to don one of his spacesuit gloves for his upcoming flight back to Earth.

Photographs taken by Linenger after the fire show dark green stains on Korzun's fingers, and similar stains also appear on the hands of a second crew member, Aleksandr Kaleri. In another photo, Korzun bares his chest to show the burn spots, daubed with the green medicinal ointment the Russians call *zelyonka*. I saw these

photos, but when I requested copies for publication, NASA refused to release them on the direct order of *Mir* operations manager Frank Culbertson. The official grounds were "medical privacy."

"We are thankful that there were no injuries," Culbertson had announced on the day of the fire. "Nobody was hurt, thank God!" was NASA administrator Dan Goldin's comment. With no evidence to the contrary, especially without the photographs, nobody could prove that there was anything wrong with NASA's story.

I was shocked by the fire, but for different reasons from most of my colleagues'. What was appalling was not the accident itself, but how NASA officials could act so surprised by it, and how they did their best to misrepresent it. On national television, Goldin was confronted with a description of the flame slicing across the passageway leading to the aft docking port and the *Soyuz* spacecraft that was docked there. He brushed aside the danger with the comment, "One of the *Soyuz*es was blocked, but the other one was not, so the lives of the astronauts were not in danger at any point." Neither he nor his interviewer seemed to be able to count high enough to realize there were six men on board *Mir*, and that only three men could land in each *Soyuz*.

Goldin downplayed the hazard. "Even a real emergency situation like the onboard fire, " he later told Congress, "proved to be easily manageable by the cosmonauts because they were well trained and equipped for such an eventuality, with a nominal reliable way to return to Earth remaining available at all times."

The accident was a total fluke, space safety experts insisted. Tom Stafford, the retired *Apollo* astronaut who headed a special U.S.-Russian space safety panel, downplayed the accident in the following way: "The oxygen-generating canister is the standard canister that is used for Russian submarines, exactly. They have activated well over 10,000 of these canisters, and we had this one failure." A

memo by Stephen Tripodi, a flight controller in Houston, echoed this claim: “The safety history of the candles is excellent,” he wrote a month after the fire. “Around 2500 others have been safely used in the history of the *Mir* and *Salyut* programs without incident.”

I was shocked to see these claims. These statements, and the view that the fire was a rare freak event, were inconsistent with information I had already been collecting. In late 1994, six months before the first NASA astronaut was sent to *Mir*, I had been reviewing safety documents concerning the Russian modules for the International Space Station. As a senior operations engineer in the Flight Design and Dynamics Directorate, I had a wider familiarity than most with the different technical aspects of crewed space hardware. My assigned task was to identify safety issues relating to orbital flight—specifically, to rendezvous, docking, and separation. But I tried to keep the big picture in mind as well.

One document from the Russians was devoted to potential hazards on the Service Module, the improved version of *Mir* that Russia was building to provide life support and station control capability. As I skimmed through the pages, I came across a section on fire. In it was the first official list I’d ever seen of all the fire incidents aboard all the previous Russian space stations. It was a short list; actually, it was an empty list. The Russians were claiming that there had never been a single fire aboard any Russian space vehicle.

One minor incident involving an electrical short aboard a *Salyut* station was mentioned, but even there, the document asserts, "no fire occurred." Beyond that, there was a terse descriptor: "None." That seriously conflicted with what I’d heard elsewhere: from U.S. intelligence sources, from interviews with Soviet cosmonauts, and from reports of space-to-Earth radio conversations picked up by amateur radio listeners in Europe. Here was the basis of my dilemma: Unlike most of the other NASA engineers working on the project, I had independent access to information related to many of the fundamental assertions that the Russians were

making. And my sources were saying conflicting things.

Rumors of fires aboard Soviet space stations have been around for a long time. In the early 1970s, I heard a story about a difficult-to-extinguish fire aboard the world's first space station, *Salyut-1*, in 1971. I mentioned the incident in my 1981 book, *Red Star in Orbit*. But it took another decade—and the collapse of communism—before a memoir could be published in a Moscow newspaper about the smoky, smoldering electrical fire that the *Salyut-1* cosmonauts spent hours trying to locate and then control.

Cosmonaut Valeriy Kubasov had been on the prime crew for that mission, but he was dropped at the last moment because of a suspicious spot on his lung. He followed the whole flight from the control center, and in 1992, he further confirmed the occurrence of the fire to Dutch space historian Bert Vis. “It’s true there was a small fire on the space station,” he explained. “One of the electronic devices started to smoke and they disconnected it. They had fire extinguishers which they sprayed it with.”

More details came to light in Asif Siddiqi’s monumental book *Challenge to Apollo*. No sooner had *Salyut-1*’s crew boarded the station and turned on the air purification system than a powerful smell of something burning drove them back into their *Soyuz* ferry craft. The next day, the smell was gone and the crew returned to the station. Two weeks later, the burning smell returned more powerfully than before, and again the crew fled to their *Soyuz*. Denied permission to return to Earth immediately, they gingerly returned to the station and switched the power circuits on and off in an attempt to identify the cable that was burning. Eventually the smell faded.

There were stories about later occurrences, too. In 1988, in a small meeting room at NASA's Johnson Space Center, French cosmonaut Jean-Loup Chretien was sharing his experiences aboard a Russian space station with a group of astronauts

(and with me). He showed a series of slides taken on his mission, and discussed what he saw as the significance of the equipment and the procedures.

One slide showed a television monitor that looked like a purchase from a discount electronics store, right down to the holder on the back for the power cord. The monitor's case had nothing high-tech or sophisticated about it; indeed, one astronaut asked Chretien why the Russians had not even used a fireproof housing.

"They don't see any need for such precautions," Chretien answered matter-of-factly. "After all, they've had several fires aboard their space stations and found they're easy to put out, they're no big deal." The audience's jaws dropped in unison.

In 1978, two cosmonauts, the first crew aboard a new space station, *Salyut-6*, had been aiming to break the American space endurance record, set on *Skylab*. Cosmonaut Georgiy Grechko was the flight engineer, and 10 years later, while visiting NASA as a tourist, he told me about one of the secrets of the flight.

“I was in a seat by the main control panel,” he recalled. When his work schedule showed that it was time to activate a new scientific instrument, he turned on the power switch. “I was looking in front of me,” he continued, “and when I turned for something, I couldn’t see the other end of the station. It was in smoke!”

Leaving the fire extinguisher behind, Grechko tried to locate the source of the smoke. “I dove into the smoke, and understood it was the scientific device,” he explained. He doesn‘t recall seeing flames, but he clearly saw the source of the smoke. “I simply switched it off and went out of the smoke, because I couldn’t breathe in it. I switched on the ventilator, and the smoke got less and less, and everything was all right.”

He made no secret of the seriousness of the situation or of the alarm he had felt. When sitting on Earth, he explained, the sight of smoke is not alarming. “But when

you are in space! You haven't got a chance to jump out with a parachute! And when you can't see one half of your station because of smoke. . . ." He shrugged his shoulders and smiled.

Grechko laughed again and began to compare his experience with that of the next crew to visit the station. They had had another fire, but this time they went "by the book." They discharged the fire extinguisher, which short-circuited the electronics for several feet in all directions. "In order to save one control panel," Grechko grinned, "they destroyed maybe two or three others."

But that fire, which occurred on September 4, 1977, was more serious than Grechko's. The mission commander was Vladimir Kovalyonok, and he provided the following first-hand account: "We had a navigation complex on board," he explained. "There was a testing program, and without our approval, the control center was turning it on and off."

Kovalyonok and his flight engineer, Aleksandr Ivanchenkov, were exercising after listening to a concert beamed from the ground. Suddenly Ivanchenkov noticed a burst of smoke and flames from the control panel. "We started to flight the fire, switching off a number of systems," Kovalyonok continued. They switched off all the fans "in order to stop the air supply to the fire." Kovalyonok then grabbed the foam extinguisher and sprayed the burning unit.

"We took all the necessary precautions—we were ready to abandon the station," he added. "There were plenty of toxic gases in the air. We used gas masks to continue our work."

But these were anecdotes told in private; they were not written down, and they were not communicated to NASA. In the face of the official Russian silence on the question, folklore and fanciful legends spread. In the late 1980s, Russians privately told American colleagues that fire extinguishers had been discharged six times for

"smoke incidents." Soon afterwards, a Russian space official admitted to several small electrical fires that soon went out by themselves.

An official at NPO Energia, the Russian company that builds and operates crewed spacecraft, told foreign visitors in 1992 that on one occasion, the air in a space station had had to be changed after a fire left the station inert. In this case, the mythological event could be easily debunked, since it was a garbled combination of two events. The air had actually been changed aboard *Salyut-5* when it was feared that it had been contaminated by the photographic chemicals in the reconnaissance camera. Also, there really had been a visit to an inert station, where an on-board fire was only one of the theories for the station's failure. The problem turned out to have been caused by an electrical short, however.

Many of these rumors were hazy and insubstantial. Then, on October 15, 1994, another fire occurred aboard Russia's *Mir* space station, literally at the moment when I was reviewing the original Russian document on Service Module hazards.

A small fire broke out inside an oxygen generator. As flames and smoke streamed out of the unit, cosmonaut Valeriy Polyakov grabbed a nearby space uniform and covered the fire while turning off the unit's power. There were no injuries and no damage beyond some seared paint and a ruined uniform.

Then came the really frightening part. Back on Earth, the fire was also covered up. It was not mentioned to the news media, and Russia's new space partners heard only vague stories of "a few sparks," if they heard anything at all. Nobody in NASA’s astronaut office seemed to have heard anything.

The full story didn’t get out until Russian journalist Konstantin Lantratov wrote about the incident in *Space News*. The article was based on an in-flight radio interview with Polyakov and a postflight face-to-face interview with cosmonaut Talgat Musabayev.

Polyakov stressed that the fire aboard *Mir* was quickly detected and extinguished. "You can stop the sensation here," he urged Lantratov. The fire had been "terminated by quick and decisive actions," in his words.

"We obtained certain experience," Polyakov continued. "This is the most valuable because flight, whether we want this or not, is all the same an ordeal." When an *ABC News* team met with Polyakov in December 1997, he elaborated by saying that he had "often" experienced fires involving the oxygen canisters, but that he had never told the ground, only fellow cosmonauts. "It was so routine, it was no big deal," he shrugged. The main lesson he learned was to keep a wet towel at his side whenever using the unit, and to extinguish any fires as they broke out.

Polyakov's view that the original fire in November 1994 had taught the cosmonauts something useful, however, would prove false. The Russians did what they could to make sure that their space partners never learned anything. They simply never told NASA about the 1994 fire or any of the others.

Since I wanted to write about this incident for a space magazine, I asked NASA for an official answer: Had the Russians provided NASA with any information on the actual fire incidents aboard their spacecraft? On December 14, 1994, NASA shuttle/*Mir* official Jim Nise replied, "The Russians have provided information on fire incidents for hardware NASA considers relevant to the safety and reliability of joint U.S.-Russian operations [but he would not specify which hardware that was]. After reviewing this information as well as information provided by the Russians about their on-board fire suppression and warning systems, NASA is satisfied with the safety and reliability of Russian hardware."

It was no accident that the Russians kept their experiences with space fires to themselves. They probably realized correctly that Americans would never be nonchalant about space fire. Just mention the words *fire* and *crewed spacecraft* in

the same breath, and we react with an instinctive flinch. Remembering how Grissom, White, and Chaffee died during a launch pad fire in January 1967 still makes us shudder. Even after almost three decades, the horror of the *AS-204* (later called *Apollo-1*) launch pad disaster remains seared into memories, both professional and private.

The Russians, too, had plenty of reasons to fear fire. In 1961, at the height of the hide-the-blemishes communist propaganda, cosmonaut Valentin Bondarenko was killed by a fire at the end of a 10-day ground isolation period in an atmosphere of pure oxygen. The fire started when he dropped a swab that had been dipped in alcohol onto a hot ring. Although he got out alive, he died soon afterward in the hospital. The nature of his death was hidden, and years later, the *Apollo-1* astronauts died within minutes as a flash fire swept through a capsule with a pure oxygen atmosphere. Paying once for such a tragic oversight is bad enough, but Soviet secrecy and NASA complacency made us pay twice (a program manager told me years later that had he received news of the fatal Soviet fire, he was certain he would have paid more attention to fire safety issues for *Apollo*). And Jerry Linenger would very nearly have to pay a third time.

The two fatal fires in the 1960s were as serious as they were because of the pure oxygen atmosphere in the cabins. In contrast, all Russian space stations, and all NASA shuttle flights, use a mixed oxygen-nitrogen atmosphere closely approximating normal Earth air. Fire hazards are less, but clearly, they aren't negligible.

In early 1995, I talked with a NASA safety official about the reports of Russian fires. He told me that his Russian counterparts did indeed recall some incidents. In one case, when fire broke out behind a panel, the crew was ordered to abandon the station, but they decided to stay and fight the fire.

"But the flight crews don't usually tell them of this kind of stuff," he told me.

“They wind up being surprised by comments made to newsmen or in memoirs much later.” The Russian safety officials weren’t deliberately withholding information, my friend suggested, they really didn’t have the information. “They don’t vigorously debrief the crews,” he explained, “and the crews regularly withhold this kind of information.”

When I got nowhere through official channels, I wrote a newspaper article about the issue. This was permitted because I had been officially informed that “fires aboard Russian space vehicles” were *not* a part of my official duties. Hence, there were no restrictions. The article appeared in *Space News* in April 1995.

The way I saw it at the time, the big deal was not so much the fires in space but the smoke screens right here on Earth. I figured that if a topic as spectacular as crewed spacecraft fires could somehow be off limits to NASA’s curiosity, suspicions should be smoldering about what else we weren’t being told.

In *Space News*, I wrote that I was concerned about the future consequences of NASA’s ignorance for the health and well-being of tomorrow's spacefarers. American lives would quite possibly become dependent on full Russian disclosure of all safety issues, I argued, so the time for incomplete information was long gone. I concluded that only a full disclosure of all such incidents, and the resulting countermeasures, would be enough to foster the development of the earned trust that the International Space Station project would need as its foundation. Apparently, the many years of Soviet space experience had taught the Russians to be unconcerned about fires aboard crewed spacecraft. But their overfamiliarity with routine fires had taught them the wrong lesson. “The hazard the Russians failed to appreciate wasn't fire per se but a particularly hazardous material,” a NASA expert on life support systems explained to me. “A burning solid-fuel oxygen generator is a totally different animal from a normal fire; the fuel (commonly a ‘chlorate candle’) is basically solid rocket propellant with an excess of oxydizer.”

He added a personal note: “I've got a few chlorate candles in the garage I've fooled around with a bit. The flame is like an oxyacetylene torch, particularly if there's something else combustible around, and it isn't inhibited in 0-G because oxygen doesn't have to diffuse to the flame. When I read your piece, the description of the brilliant flame was very familiar; it looks nothing at all like a normal fire.

“However, the Russians weren't the only ones to fail to recognize they were ‘playing with fire,‘ not by a long shot.” he continued. “Essentially the same material destroyed ValuJet flight 592 on May 11, 1996, with 110 people killed. Despite all the finger-pointing later, I've never seen any mention before the crash that oxygen generators could be dangerous.”

Bringing the technology back full circle to the American space program, he told me something else I’d never known: “Incidentally, the astronauts experimented with a chlorate candle emergency breathing device,” he pointed out. “It is very light and produces oxygen for a full 15 minutes, but it was dropped because they couldn't be sure it wouldn't start a fire.”

When NASA’s Office of Inspector General (OIG) was conducting its own assessment of NASA’s safety evaluations, late in 1997, it found other fire-related documents in NASA files that somehow hadn’t been circulated. One memo, dated October 15, 1996 (four months before the *Mir* fire), dealt with fire-emergency training on *Mir*. One unnamed NASA astronaut who had already trained for *Mir* expressed concern that other astronauts might have a hard time locating fire extinguishers because their paint scheme blended into the background, especially in smoky air.

“Upon reviewing this debriefing,” wrote OIG official David Cushing, “an outside group applying appropriately rigorous safety standards may have questioned the adequacy of fire procedures and drills, raised questions about the availability and

suitability of the fire-fighting equipment, recommended the need for more fire drills, and specifically asked for details related to potential fire hazards." None of this happened because the memo was never made available to any of the independent advisory panels that NASA had set up to assess *Mir* hazards. It would not be the last time that NASA withheld critical safety-related information from the "independent panels" it had set up to review its safety standards.

Cushing's conclusion was blunt: "These issues are better raised before, not after a life-threatening event." But they never were. Jerry Linenger later told me that nobody had ever briefed him, before his visit to *Mir*, about the earlier fires on Russian space stations. Only after he got back, he continued, did he begin to hear the stories.

I was astonished to find that shuttle-*Mir* program manager Culbertson later denied knowing anything about the matter. "Nobody ever told me about earlier fires on *Mir*," he told ABC's Sam Donaldson in early 1998. Neither he nor anyone on his staff admitted to having seen my published articles on the subject two years before.

As I saw it, the only way they could have avoided knowing about the fires was to have consciously decided to remain ignorant. Worse, in order not to interfere with the cooperative projects, they had decided to rely on hope instead of sound hazard analysis. It was worse than merely not wanting to know about hazards. They seemed to want *not* to know about them.

When I raised this issue with my management and in wider discussions with the NASA Inspector General's office, a pattern developed: NASA would use and believe only the official Russian version of information about Russian space technology. It chose *not* to seek outside verification, and it chose to ignore any unofficial information that contradicted the Russian documents. In the areas that fell outside my professional duties (which dealt with orbital flight, rendezvous, docking, and separation), I was told that it was "not in your task description" to

comment on any inadequacies in the documentation. The problem was, it seemed that it was and would remain in *nobody's* task description.

NASA's spin on the fire was that the space program was lucky that it had happened. "One of the things we found out because of *Mir* is that we did not have the proper fire protection on ISS," NASA chief Daniel Goldin told numerous public gatherings in subsequent months. "Now what would have happened if we didn't go up to *Mir*?" he asked, conjuring up an image of a space station crew killed in a fire that was preventable only through safety measures learned on *Mir*.

Just the opposite actually happened. The Russian presence increased rather than decreased the fire hazard on the ISS. As early as 1992, solid-fuel oxygen generators (SFOGs) were suggested for use on the *Freedom* space station, recalled Keith Cowing, a space biologist. "I asked a safety officer from [NASA] if such items could be used to augment existing oxygen supplies in a contingency," he wrote. "He replied that they were too dangerous to even consider using inside a spacecraft and that such 'pyrotechnic devices' were prohibited by safety requirements." But after the Russians were given responsibility for the life support on the ISS, and even after the 1997 fire, NASA's safety requirements were modified to allow the devices on board.

If the fires on board *Mir* were such "good news," it's curious that NASA made no mention of a second fire-related incident during the next American astronaut's visit. Mike Foale's laptop computer started smoking and spitting sparks, but he didn't say anything about it until the private postflight debriefing. NASA didn't disclose it to the public, either.

One NASA public white paper in 1997 praised "specific design enhancements and modifications of the Space Station and other new knowledge based on Shuttle-*Mir* experience." At the top of the list was the assertion that "After the fire aboard *Mir*, software for the Space Station was modified so that a single command can stop

ventilation between modules." NASA administrator Dan Goldin often pointed to this specific item to prove the value of having had U.S. crew members aboard *Mir*.

Further, according to ISS engineers involved in building the NASA Laboratory Module, news of the *Mir* fire prompted them to add firewalls (partitions in cable runs to allow adequate concentration of fire-suppressing chemicals) along the standoff conduits that carry cables and plumbing along the length of the module. Steven D. Goo, Boeing's chief space station engineer at NASA's Marshall Space Center in Huntsville, Alabama, told the McGraw-Hill publication *Aerospace Daily* in November 1997 that the *Mir* fire sent his engineers "back to the drawing board" to improve fire-suppression systems.

However, these descriptions of improvements may be garbled, or at least exaggerated. Also, the role the Mir experience played in their development is not so clear-cut. First, according to space station engineers, there still was not going to be a single panic button. Although the fans in the U.S. modules are wired so that a smoke alarm or a thrown switch will trigger a shutdown, the fans and air ducts in the Russian modules are not connected in this way and must be shut off manually (this was confirmed four years later, when a false fire alarm struck the International Space Station in March 2001 and there was still no “all fans stop” button to push). A single cutoff button had been featured in the design of *Freedom* nearly 10 years earlier. Another such button had been installed on NASA's *Skylab* space station a quarter-century ago, so the idea is not new.

Nor were the firewall changes on the U.S. Laboratory Module for the ISS added because of the fire on *Mir*. "It was already in the design," ISS operations director Kevin Chilton told me in 1998. "We had a good design."

Fire wasn’t the only problem on board *Mir* in 1997. Potentially poisonous coolant was leaking from corroded lines; computers kept crashing; carbon dioxide purifiers and cabin dehumidifiers broke down again and again. The list of breakdowns grew

longer almost daily. NASA was urgently asked to explain how it could be sure that it was safe to keep sending Americans to *Mir*. NASA managers clearly *wanted* to continue the flights, both for the experience to be gained and to show the Russians that NASA was a reliable, courageous partner. But the risks they took—and got away with taking—would turn out to provide little, if any, payoff.

They developed various ways to make their preferred decision look logical. On April 15, for example, there was a teleconference between Russian and American program managers. In a summary of the comments, NASA headquarters official Jesco von Puttkamer (no, *he* didn‘t give me the copy!) wrote: “[Culbertson] wants the Russians to present/discuss their mission continuation/termination criteria. On Ryumin’s hesitation and comment that he sees no reason to terminate the mission, Frank said, he agrees with that but that they have to show to all other people what supports that decision.”

Culbertson elaborated on his request in an “informal note” faxed to Ryumin on April 22:“A part of the American approach to managing a spacecraft in flight is to develop a minimum equipment list which identifies the set of hardware that must be operational to initiate or continue the mission. Some of our managers expect us to provide such a list. We understand that the Russian side does not manage the *Mir* in that fashion.”

The note asked for an explicit description of the operating philosophy for all critical components on *Mir*, so that “we can keep our management happy without having to address every failure or change that occurs on the station.” In conclusion, he explained, “this activity is designed to show that we are proceeding with safety and health as the number one concern.”

The use of the verb *show* doesn’t have to imply deliberate falsehoods here, but it’s clear from other internal documents that officials at NASA still believed that the problems on *Mir* were flukes and there were no reasons to expect future trouble. A

memo from headquarters, dated April 18, 1997, stated: “No new risks have been identified, and no problems are foreseen.” In a Public Affairs Office interview with Scott Gahring, the NASA operations lead in Moscow, posted on NASA’s *Mir*/shuttle web site, when he is asked about *Mir*’s health, he replies: “Everything looks good. The systems are gradually being restored to more acceptable performance levels. It looks like we’ve gone through the darkest part and we’re headed toward the light.”

On May 26, 1997, after *Atlantis* returned Jerry Linenger from *Mir*, I took part in a PBS-TV *Newshour* with Charlayne Hunter-Gault. We were discussing future *Mir* problems with several NASA officials. Alan Ladwig, the associate administrator for plans, gave the party line: “We feel a degree of confidence that we have overcome these problems. We are very confident we are operating in a safe manner.”

I argued that there was a hope-for-the-best attitude at NASA that had led to a failure to perform classic safety assessments. Through a phenomenon that critics call groupthink, NASA officials barricaded themselves behind their “can-do” enthusiasm and were determined to charge ahead. Ladwig counterattacked: “I really have to take exception to his comment that we have some kind of ‘feel good’ management structure here to talk about safety. This is an insult to the three astronauts that led those three teams. We resent that.”

Ladwig was referring to the result of a safety assessment that had been signed off by American and Russian experts (although never released to the public). It had concluded: “The *Mir* complex is ready to support the beginning of the next increment of the U.S. mission with sufficient systems and redundancy to ensure a safe, healthy, and productive work environment.”

Michael Foale was already aboard *Mir* at that point. A taped interview with the astronaut was shown. Asked about the safety of *Mir*, he had replied, “I’m not

worried about it. The safety is perfectly assured." That's what NASA's best safety analysts had told him. He was about to find out if it was really true.

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NOTES

Linenger's first-hand accounts of the fire are taken from private email he sent down to NASA, which I have copies of. He also provided insightful descriptions for a BBC program ("Mere mortals") which aired the following year. [BBC-2 "Mere mortals", Apr 23, 1998]

I had access to all the on-board photography at NASA, but several of the images were refused public release.

Goldin's and Culbertson's public comments are from contemporary press reports. The comment on how "one Soyuz was blocked, but the other one was not, so the lives of the astronauts were not in danger at any point" was from CNN June 27, 1997. Goldin's assurance that the fire was "easily manageable" was in a statement to Congress, June 18.

Stafford's denial of any previous safety problems was from his written testimony submitted to Congress. Another similar claim, "2500 candles burned without incident", was in a memo from Stephen Tripodi, JSC-DF82 (EECOM), March 19, 1997, re 'Mir Status Meeting'

The official Russian report which denied any previous fires was "An Analysis of Off-Nominal Situations Associated with the Service Module (SM) of International Space Station Alpha", NPO Energia, September 1994. SS346/TTI/10/3/94/AM, p. 80.

Salyut-1 fire report: others were collected in interviews by Bert Vis and other European researchers. Chretien's account was in a 1988 NASA meeting which I attended and documented in my own notes at the time. The October 15, 1994 fire was documented in 'Novosti Kosmonavtiki', and my article on the issue was in 'Space News, April 12, 1995. The accounts of Russian comments with the ABC News team came directly from the segment producer, in personal communications with me. Cushing's Inspector General memo dated October 15, 1997, was posted on the NASA-OIG web site.

Culbertson's denial of any knowledge of previous fires was on an ABC "20:20" news story, which aired Apr 1998. The questionable claims about fire safety lessons from the incident were researched as part of an article for 'Spectrum' magazine. Quotations from internal NASA documents are based on my possession of copies of the actual documents.

Wolf's comment on no fire drills was from a report, 'Safety Debrief', posted on NASA WATCH, dated Apr 25, 1998.