Making Human Spaceflight as Safe as Possible—Frederick D. Gregory

NASA's safety priorities.

From the first days of the Mercury program to today's efforts aboard the International Space Station, human safety has always been the primary consideration for human spaceflight.

Looking backward, consider NASA's first attempts to reach space without human crews. Rockets tipped over, rockets exploded on lift off, rockets careened off course . . . it sure didn't look safe.

Before we could put a life at risk, the rockets had to be made safer. How? Mostly through the application of brute-force engineering—essentially the "Fly, Fix, Fly" approach.

This approach did eventually lead to safer rockets; however, to produce a spacecraft intended for routine human flight into space, NASA needed to design safety into the vehicle, not just add safety on after a problem was discovered. This need drove NASA to become the home of some of the world's best design engineers and produced some of the best system safety, quality, and reliability engineers.

NASA demonstrated through the Mercury program that we could launch a human into orbit around the Earth and recover the astronaut and spacecraft safely. During the Gemini program, we perfected complex rendezvous and docking in space, and performed spacewalks. Both astronauts and equipment operated safely during longer durations in space. By the time the Gemini program ended, NASA was doing what was once thought impossible. Even with increasingly complex equipment and quick turnarounds between missions, the astronauts always returned home safely. Success was becoming routine and expected.

NASA experienced a rude awakening in January 1967, when the Apollo 1 capsule burst into flames during a preflight

ground test. The three astronauts performing the test perished in the blaze. The test had called for simulating a launch configuration, so the capsule was pressurized with 100 percent oxygen, and the hatch was sealed. Investigators determined that an electrical short sparked the fire. In a 100-percent oxygen environment, the fire quickly engulfed the capsule. But the test was being performed with an unfueled launch vehicle, so it was not considered hazardous! NASA never considered the possibility of a fire during the test—crew evacuation and fire suppression were not part of the test scenario.

NASA responded to this tragedy by strengthening safety oversight, clarifying responsibilities, improving communications, improving test safety analysis and emergency procedures, and making safety design enhancements to the Apollo spacecraft. Congress established the Aerospace Safety Advisory Panel to provide an independent review of the safety of NASA programs and operations. NASA established an Office of Flight Safety, independent of the flight program office, to review all aspects of design, manufacturing, test, and flight from a safety standpoint.

NASA recovered from this tragedy. NASA astronauts landed on the Moon six times and returned safely. The Apollo 13 mission demonstrated that NASA could recover from a serious technical mishap and return the crew safely to Earth. In the 1970s, NASA conducted the Apollo-Soyuz program and the Skylab program—logging more human spaceflight success.

For a period of time, America did not have a regular human presence in space. Throughout the 1970s, we were developing and building the next generation of [the] reusable space vehicle,

the Space Shuttle. In the mid-1970s, Agencywide advocacy for flight safety became the responsibility of the NASA Chief Engineer.

From 1981 to 1986, NASA flew twenty-four Space Shuttle missions. Although we experienced some anomalies along the way, the astronauts always returned home safely.

Again, success was becoming routine—until a cold January day in 1986, when the Space Shuttle *Challenger* suffered a major failure in the seals of one of its boosters and exploded 73 seconds after liftoff. All seven crewmembers were killed.

In the painful months that followed, there were indepth, critical reviews by NASA and external bodies. The Shuttle program was grounded, and each safety practice was dissected and examined. Safety goals and procedures were revisited; even organizational and individual attitudes were considered. The reviews found a number of management flaws. For example, O-ring seal problems in the boosters had surfaced on previous missions. However, this information was not widely circulated. Concerns expressed by safety engineers did not always reach management in a timely manner. Additionally, the magnitude of the risk and the associated ramifications may not have been fully understood by the decision-makers. There had been growing pressure on NASA to launch the Shuttle regularly and on schedule. No one believed that they had enough data to prove that the launch was not safe. A collective mindset evolved—if no one could prove that the launch was unsafe, it must be safe!

In the few years after the *Challenger* accident, NASA put in place a number of improvements to its safety program. These included:

- Creating an independent safety organization, reporting directly to the Administrator.
- Increasing the budget and staffing for safety, reliability, maintainability, and quality assurance.
- Improving communications. NASA created an additional avenue to communicate safety concerns in a confidential manner—the NASA Safety Reporting System.
- Strengthening risk-management programs and initiating significant problem reporting, trend analysis, and independent systems assessment capability.

These improvements form the basis for today's Safety and Mission Assurance Program, and since return-to-flight in 1988, every NASA Space Shuttle flight has flown and landed safely.

How has human spaceflight safety advanced over the past forty years? Well, for one thing, we know more. We know more about engineering, materials, and robotics. Safety and mission assurance tools are much more advanced. We have the capability of improved nondestructive evaluation, and we can do computer modeling and sophisticated "what if" scenarios.

Today, we know more about program management and more about what it takes to fly safely. We know that there are a million things that can go wrong, and we know that we can never become complacent. We will not allow ourselves to be bullied by schedules, and we won't let cost constraints make us skimp on safety.

We don't ask our engineers and managers and experts to prove it is *not* safe to fly. Rather, we ask them to prove that it is safe.

This is a philosophical change from the days before *Challenger* and a fundamental management principle for safety of flight.

Today's human spaceflight safety prelaunch assessment review process is independent and comprehensive. For each launch, NASA managers prepare a Certificate Of Flight Readiness—we call it the COFR. Before I sign the COFR, I must personally understand all the safety issues and their resolution. If I do not have confidence that everything has been done to make the flight as safe as it can be, it is my job to *not* sign the COFR. The Administrator would not have it any other way.

The International Space Station heralds a new era of space exploration for America. On this program, safety is NASA's highest priority. My staff performs continuous oversight and independent assessment on the design, development, and operation of the International Space Station.

In sum, I'd like to describe the illustration shown [on page 74]. This picture represents NASA's safety hierarchy. We articulated the safety hierarchy a little over two years ago, as part of our quest to be the nation's leader in safety and occupational health, and in the safety of the products and services we provide. The safety hierarchy stresses that we are all accountable for assuring that our programs, projects, and operations do not impact safety or health for the public, astronauts and pilots, employees on the ground, and high-value equipment and property.

When people are thinking about doing things safely, they're also thinking about doing things right. And for the past couple of years, we've had some pretty good results. In the time since the failures of the Mars 98 missions that occurred in late

1999, every NASA spacecraft launch has met the success objectives, and every Space Shuttle mission has safely and successfully met all mission objectives. Now I can't say that NASA's safety program is solely responsible for these achievements, but, as we like to say, "mission success starts with safety."

In the future, looking forward, we will continue to make spaceflight even safer. That is NASA's vision. That is NASA's duty to both those who will travel into space and the American people who will make the journey possible.