Normalization of Deviance: Ethics Lessons from NASA

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In the Spring 2020 issue of *ASPIRE*®, William Nickas, editor-in-chief of *ASPIRE* and I coauthored "Why Didn't They Just Close the Road?" about the ethical dilemmas faced by state bridge engineers when public safety is at stake. After that article, I thought my time in the writer's hot seat was done, but William and I have continued the ethics conversation, and recently facilitated some ethics discussions as part of the National Concrete Bridge Council's *Concrete Bridge Seminar: Concepts for Extending Spans*. The topic I've covered in those sessions is "Lessons from NASA," and I'd like to share those lessons with you.

I have been a bridge engineer since the late 1980s. I never worked at NASA, but when I was 5 years old, the United States put the first man on the moon in 1969. That was when my fascination with the space program took root, and that fascination continues to this day. My wife would probably tell you my fascination borders on obsession. There are very few books or documentaries about the space program that I haven't read or seen. I've read the biographies and memoirs of astronauts, both living and dead, and I've read official mission reports of some of the events I will be covering here. I am no expert on the space program, but I do have a deep appreciation for the history of NASA and what the bridge industry can learn from the space agency's experiences.

Space Shuttle Columbia

On February 1, 2003, the space shuttle Columbia disintegrated over Texas during reentry, killing all seven crew members. Why did this happen? Normalization of deviance is why. To understand normalization of deviance and what it has to do with the space shuttle Columbia, we have to rewind and look at the NASA organization. Some would argue that NASA represents the finest group of engineers, technicians, and other professionals ever assembled. However, I believe that many of you work for organizations that rival NASA in terms of talent and commitment. As excellent as the NASA engineers are, they are human and they do make mistakes.

NASA, the Early Days

NASA got off to a rocky start in the late 1950s and early 1960s with several epic rocket failures, but it didn't take long before the agency hit its stride. Let's look at some of NASA's early accomplishments.

On May 5, 1961, Alan Shepard became the first American to complete a suborbital flight. The United States had finally put a man in space. The mission was a success by all measures. On July 21, 1961, astronaut Gus Grissom flew a similarly successful suborbital mission. His capsule, the Liberty Bell 7, sank to the bottom of ocean a short time after splashdown, but Grissom was out of the capsule by the time that happened and was never really in any danger. Just seven months later, on February 20, 1962, John H. Glenn became the first American to orbit the Earth during the three-orbit Mercury–Atlas 6 mission. That mission was also a success and was followed by 13 more manned space missions of varying lengths and crews. There were a few hiccups, but nothing of great significance. The proof was in the pudding: NASA's safety program was working—or so it seemed.

Apollo 1

Then we come to January 27, 1967. On that day, Grissom, Ed White, and Roger Chaffee were doing a live test of their Apollo 1 capsule at the Cape Canaveral Launch Complex 34. It was a day that would go horribly wrong, not only for the three astronauts but also for

Photo: NASA.

NASA. As the crew sat in their capsule, frustrated with radio communication problems among the various facilities, an electrical spark occurred within their spacecraft. This spark in the 100% pure oxygen environment set materials inside the pressurized capsule on fire, creating an inferno that swiftly engulfed the entire crew compartment. By the time rescuers were able to open the access hatch, the entire crew had suffocated. How could this tragedy happen at an organization with some of the best and brightest engineers and technicians in the world? How could this happen for an organization whose safety program was working, as evidenced by 16 successful manned missions and countless tests? To answer these questions, we need to review those previous successful missions and tests.

During the Mercury and Gemini programs, which preceded the Apollo 1 program, engineers and technicians were vigilant about fire prevention inside capsules. Materials were rigorously tested for flammability, and their use was prohibited if they posed a fire risk: if it burns, it does not fly. But as more successful missions were completed and more live tests were performed, this prohibition was informally relaxed. Over time, mission after mission, flammable materials were allowed into the capsule as astronauts and technicians added Velcro and netting to keep small items in place. By the time of Apollo 1, Velcro was used extensively throughout the capsule and the capsule was described by one engineer as nearly wall-to-wall Velcro. Why was this change allowed? Why would NASA put known flammable materials into a 100% pure oxygen environment? The explanation is simple: The use of flammable materials was allowed in the Apollo 1 capsule because nothing bad had happened before. The previous Mercury and Gemini capsules also had pressurized oxygen environments, and they never had a fire.

This acceptance of flammable materials didn't happen overnight. Over time, the rule prohibiting such materials was relaxed, and the informal norm eventually became "We've always done it that way." This slow erosion of rules or practices has a name: "normalization of deviance."

Another issue with Apollo 1 that contributed to the tragic outcome originated during Grissom's suborbital mission in Liberty Bell 7. The Liberty Bell 7 capsule sank because the hatch opened too early. To prevent the hatch from opening prematurely, engineers designed the Apollo command module door to open inward, without consideration for the potential safety consequences. After the fire, it was discovered that White had tried to use the emergency procedure for opening the door, but the pressure of hot air in the capsule made it impossible to open the door.

The Apollo Program Continues

After the Apollo 1 fire, NASA removed the flammable materials from the redesigned command module. They also eliminated the 100% pure oxygen environment and redesigned the escape hatch to open outward. After a delay of more than a year, Apollo missions resumed. Crews on Apollo 7 through 10 flew successful missions of various designs and durations, culminating in the Apollo 11 moon landing in 1969. That historic event was followed by five more successful lunar landings and the establishment of a space station. Even the well-known Apollo 13, despite challenges, returned home safely.

Space Shuttle Challenger

On January 28, 1986, a date that is probably familiar to many, the space shuttle Challenger was lost 73 seconds into its flight and all seven crew members died. What happened? Most analysts will say that cold O-rings that did not seal properly caused the tragedy. This explanation is incomplete. On the one hand, it is true that the physical cause of the failure was damaged O-rings that allowed superheated gases to escape from the solid rocket booster and burn a hole in the larger exterior liquid fuel tank. The resulting explosion of the tank caused the orbiter to become unstable and break apart. On the other hand, this type of O-ring failure was a known problem. In 14 of 24 space shuttle missions prior to the Challenger explosion, there was evidence that the O-rings had been burned. In fact, O-ring failure, regardless of the temperatures at launch, was identified as a problem after just the second shuttle launch. However, the shuttle had flown successfully at low temperatures, and the air temperatures on January 28 were just a little colder than during the last really cold flight. Since nothing bad happened in the past, safety warnings about O-ring risks in cold weather were disregarded.

Back to Columbia

Now let's go back to the first NASA tragedy mentioned in this article—the disintegration of the space shuttle Columbia on reentry and the death of its seven crew members—and consider what happened in that event. During Columbia's launch, insulating foam came off the external fuel tank and struck and critically damaged the heat shield on the orbiter's left wing. As a result, the damaged heat shield was unable to protect the underlying wing from superheated gases generated by the friction of reentry. The gases burned through the wing, causing the orbiter to become unstable and break apart.

When foam hit the wing during Columbia's launch, did anyone know about it? Yes. Was foam coming off the tank and striking the orbiter during launch a common occurrence? Yes. This type of incident had happened on many missions. Were people concerned about this issue? Yes. NASA personnel did tests to evaluate the risks, and it was concluded that chunks of foam large enough to cause significant damage just couldn't happen. Foam had broken off on many missions and seemed to be just an annoyance. In fact, it was so common that when those who tried to raise the alarm that somehow this recent episode with Columbia was different, no one listened. After all, at this point the shuttle program had flown more than 100 missions without the foam causing a major issue. Nothing bad had ever happened.

The term "normalization of deviance" was coined by sociologist Diane Vaughan. In her book *The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA*,[1] Vaughan defines the term as "the gradual process through which unacceptable practices and standards become acceptable. As the deviant practice is repeated without catastrophic consequences, it becomes the social norm of the organization." To put it another way, normalization of deviance occurs when people become so accustomed to a deviation that they no longer consider it abnormal.

NASA Gets It Right

On June 5, 2024, astronauts Suni Williams and Butch Wilmore launched from Cape Canaveral in Florida aboard the Boeing Starliner. Although the launch was successful, five thrusters failed as the Starliner docked at the International Space Station. The cause of the failure was later identified through ground tests as heat buildup, but NASA could not fully understand why the thrusters malfunctioned. Therefore, NASA officials decided that it would be too risky to return the craft to Earth with astronauts aboard. The previous experiences with Challenger and Columbia were cited as contributing to this decision. Ultimately, Starliner returned unmanned on September 7, 2024, without incident. It would appear that NASA has learned from its history and decided that the "nothing bad has ever happened" approach isn't always valid.

What Have We Learned?

What does all of this NASA history have to do with our work in the concrete bridge industry? Everything. I assume that you work at an organization that resembles NASA in many ways: The engineers, technicians, and other professionals at your organization are among the best and brightest. Your organization also has a long history of success, where bad things rarely happen. You have a robust safety program and quality control/quality assurance (QC/QA) processes with policies and procedures that, when followed, yield amazing results. But also like NASA, you can't allow your past success to lull you into believing you're always doing things correctly. Have you tolerated relaxed safety procedures because nothing bad has ever happened in the past? Are all your QC and QA processes being followed, or do you skip a few steps here and there since you've never found errors in someone's work in the past?

We must always be mindful of the potential for normalization of deviance. I suspect there are probably things we have always done in a particular way that we shouldn't be doing but, because nothing bad has ever happened, we've informally decided that the status quo must be okay. "We've always done it that way!" isn't just a phrase we use to be critical of bureaucratic processes—it's also a potential killer.

Reference

1. Vaughan, D. 2015. *The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA.* Chicago, IL: University of Chicago Press.

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