"The Fire" — A Case for System Safety

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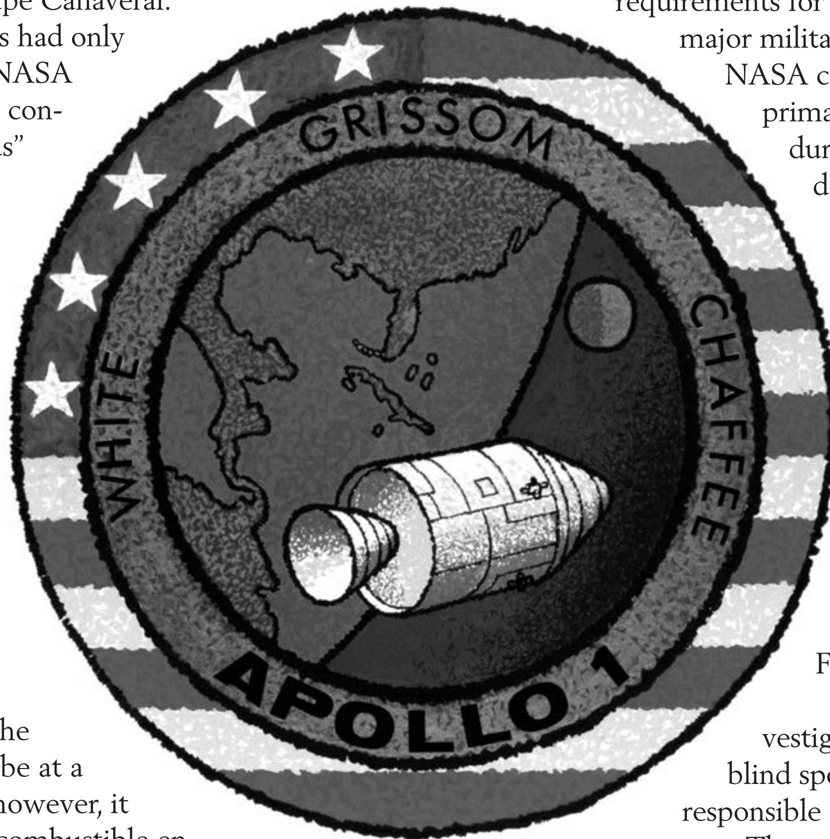
January 27, 1967 is a day that those of us involved with the Apollo 1 program will never forget. This was the day the command module fire at the "Cape" took the lives of three highly trained, experienced astronauts. This mishap occurred during a manned simulated space operation within the Apollo 1 space capsule while it sat atop the unfueled Saturn launch vehicle sitting upright on the launch pad at Cape Canaveral. Because the rocket tanks had only inert gases in them, by NASA safety protocol, this was considered a "non-hazardous" test event.

However, to provide a space-operational simulation and also to preclude the risk of crew member asphyxiation in the sealed cabin, the capsule was pressurized with pure oxygen at 16.7 PSI, rather than air or nitrogen. This was a normal atmosphere for a space capsule in orbit, when the oxygen pressure would be at a safe 5 psi. At sea level, however, it provided an extremely combustible environment that, when exposed to a tiny spark from a faulty electrical circuit, burst into a fireball. The fireball then ignited the flammable Velcro sticky pads that the crew used to keep notes and other items in place during orbit. Adding to this deadly scenario, no provisions were made to rapidly open the crew hatch from the outside. It took frantic ground personnel more than five minutes to gain access to the astronauts, who were killed in the intervening moments.



As with the tragic events of December 7, 1941 and September 11, 2001, its aftermath led to extensive investigations to find cause and identify accountability. To this day, veterans of NASA's moon program still refer to that event, which occurred 50 years ago, simply as *"The Fire."* I suggest that the findings of these investigations can be viewed as a strong case for the System Safety Concept.

In 1967, the formalized implementation of the System Safety Concept (SSC) was most fully implemented by the United States Air Force on the Minuteman III program, then in the preliminary design phase. Because of a history of costly design/subsystem interfacing-related missile accidents, the U.S. Department of Defense (DoD) was working to implement requirements for system safety on all new major military programs. But in the NASA community, "safety" was primarily considered a procedural process of implanting documented safety rules and procedure during maintenance and prelaunch operations. Experienced scientists and successful space program engineers were considered to be the best judges of "operational safety matters." This approach seemed to work well for NASA — up until "The Fire."

The post-accident investigations noted some "fatal blind spots" on the part of the responsible engineering and program managers. These investigations also found a lack of overview responsibility for resolving identified hazard risks. The blind spots noted were related to reliance on failure mode analyses (limited to the operational phases) and on past successes, as opposed to a rigorous hazard risk study for all program endeavors and/or changes, including ground tests.

It was reported (in the January 2017 issue of *Air and Space*) that top management from both the prime contractor (North American Aviation) and launch site operation contractor (General Electric) had strongly advised NASA that conducting this test in a pure-oxygen environment was extremely unsafe and that the "wall-to-wall" use of Velcro in the spacecraft was not appropriate in that ground test environment. NASA, however, relied on flammability studies it had conducted for the

See FIRE, Page 7

FIRE — Cont. from page 6

operational environment, which did not reveal the true flammability hazards presented in the sealed capsule during the ground test at 15 PSI. Therefore, a key fatal "blind spot" by NASA program management was not considered in connecting the dots of the fire hazard-related information and warnings they had before them. They assumed that the prescribed safety policy (use only fire-retardant materials) had been duly followed, and that postponing the test would not be appreciated by their boss, who was under Presidential mandate to get a man on the moon and back by the end of the decade. They therefore ignored these warnings and proceeded with the test as scheduled.

As a side note, the author was a participant in the post-fire investigation. At the time of "The Fire," I was a system safety engineering manager at the General Electric Missile and Space Group, leading the System Safety Program activities for the Minuteman lll Re-entry System project. I was assigned to provide support to the GE effort in the accident investigation of "The Fire." My primary input was the recommendation that NASA implement comprehensive system safety program requirements into its contracts that would result in the identification and tracking of hazardous situations across all project phases and subsystem interfaces. This was to counter potential fatal "blind spots" by program management. As can be attested by the many ISSS members who have since worked on NASA-funded system safety activities, recommendations arising from the ashes of "The Fire" have had positive benefits.