TARGETS FOR FIREFIGHTING SAFETY: LESSONS FROM THE CHALLENGER TRAGEDY

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The U.S. Forest Service has waged an impressive effort to reduce lives lost in wildland firefighting. The research has drawn on previous tragedies, extracting lessons for safety by scrutinizing decision making from the moment a fire is identified and resources are dispatched. My (1996) research on NASA's fatal 1986 Challenger launch decision suggests that safety also can be enhanced by identifying antecedent conditions that affect risky decisions in a crisis. In these pages, I will focus on two contributing causes of the Challenger disaster that seem relevant to wildland firefighting: 1) organizational actions and characteristics that preexisted NASA's launch decision, and 2) a pattern of early warning signs that were ignored or misinterpreted at NASA. First, I will identify some similarities between the NASA and the US Forest Service that make a comparison useful. Then, I will review the causes of the Challenger tragedy and its impact on the NASA organization. Finally, I suggest three targets for safety in firefighting: Decision making by top administrators, organization culture, and signals of potential danger.

RISKY WORK: NASA AND THE US FOREST SERVICE

NASA and the US Forest Service have much in common, both as organizations and in the risky work they do.

- Both are hierarchical, bureaucratic, government agencies with many scattered component parts. Dependent upon the federal budget for resources, their successes and failures are public and inherently political.
- Like firefighters in action, NASA (at launch and reentry) is preoccupied with fire, heat, and explosive conditions and assuring that equipment and personnel withstand heat, not cold. Weather conditions are always a concern.
- Top decision makers at both agencies are irrevocably responsible for safety because their policy decisions—goals, resource allocation, personnel—trickle down through the organization, affecting how work gets done and how decisions are made by others below them in the hierarchy.
- Ironically, firefighting and launching shuttles both go on in bureaucracies where rules proliferate, but require making risk assessments in circumstances where all conditions can never be known. So rules cannot be made to cover all situations. In both agencies, the people doing the hands-on work make decisions under conditions of uncertainty.
- Loss of life is always a possibility—more so in fighting fires than at NASA because NASA has unmanned scientific missions, although launch and landing are always hazardous.

In the crisis decision making conditions that produced tragedies for both agencies, there are many differences (for example, NASA decision makers responsible for launching the *Challenger* did not at any time feel their own lives were at risk—their jobs, possibly, but not their lives; also, their task was mental and verbal, with no physical exertion required). But in tragedy also, the agencies have a lot in common. For both, the greatest periods of learning occur after a tragedy, so learning about safety is error-driven and retrospective. Dave Thomas calls this the "deadly method of 'trial and error'." For both, loss of lives has resulted from mistake in using new technologies, interpreting natural environments, and interpreting the actions of co-workers. For both, post-disaster investigations have focussed [sic] primarily on the decisions made by people associated directly with loss of life. Consequently, efforts to increase safety targeted the people doing the risky work. Less attention has been given to historic decisions made by elites in the organization and in the political environment and their impact on those crisis decision making situations.

The following summary is to draw attention to how actions and conditions that preexisted the Challenger launch decision affected the behavior of the people who made it, in order to lay the groundwork for expanding targets for safety in firefighting.

THE CHALLENGER DISASTER

The Presidential Commission investigating the Challenger disaster revealed that the O-ring failure on the Solid Rocket Boosters that took the lives of the seven astronauts was preceded by questionable management actions and decisions that smacked of, at the least, incompetence, and at the most, evil. First, the incredulous Commission learned that in the years preceding the January 28, 1986 tragedy, NASA continued shuttle launches in spite of recurring damage on the O-rings. They were flying with known flaws, accepting more risk each time. Second, the Commission learned that NASA had been experiencing production pressures, so that the schedule took priority over safety at the space agency. Finally, they learned of a midnight hour teleconference on the eve of the Challenger launch, in which contractor engineers located at Morton Thiokol, Utah, protested launching Challenger in the unprecedented cold temperatures predicted for launch time the next morning. Nonetheless, NASA managers at Huntsville, Alabama overrode their protest. They proceeded with the launch, violating safety rules about passing information up the hierarchy in the process. An outraged Commission concluded that the disaster was not simply a technical failure, but a managerial failure of tragic proportions.

In the months following the disaster, the Commission's published report (1986) and myriad media accounts led the public to believe that managerial wrongdoing was behind the launch decision. Based primarily on the Presidential Commission's findings about production pressures at the space agency and repeated safety rule violations by Marshall managers responsible for the Solid Rocket Booster Project, the historically-accepted explanation was this: these NASA managers, warned that the launch was risky, succumbed to production pressures and violated safety rules in order to stick to the schedule. However, as my research went beyond readily accessible information into primary data stored at the National Archives, Washington D.C., I discovered that many of my most important assumptions about the case were in mistaken. Some examples:

- In the years preceding the Challenger teleconference, NASA had repeatedly launched with known flaws in the Solid Rocket Boosters. The public impression was that NASA managers had a history of overriding engineering concerns. Yet the same Thiokol engineers that protested the Challenger launch were the ones responsible for risk assessments and launch recommendations during those controversial years. Despite technical problems, they had repeatedly recommended that NASA managers accept risk and fly.

- On the eve of the Challenger launch, not all engineers were opposed. Some were in favor, but only the ones who were opposed were called to testify. Moreover, all but two agreed that the engineering analysis was flawed and unlikely to convince managers.
- Rumor had it that NASA managers needed to launch because of a planned hookup between the crew and President Reagan, who was making his State of the Union address the evening of the launch. But NASA never allowed outside communication with the crew during the first 48 hours in orbit because the crew were too busy. Moreover, every launch has two launch windows, morning and afternoon. If NASA managers truly believed they were making an unsafe decision, they could have launched Challenger in the afternoon, when the temperature was predicted to reach between 40 and 50 degrees.
- In the history of decision making on the Solid Rocket Boosters, 1977-1985, and on the eve of the launch, NASA managers abided by every NASA launch decision rule. With all procedural systems in place, they had a failure.

From the above insights, two things became clear. First, outsiders, viewing what happened at NASA retrospectively, saw key incidents and events very differently than insiders who were diagnosing problems as they occurred. In large part, this was due to retrospection. Equally important, outsiders had not been able to fully grasp NASA culture: the rules, procedures, and language that were key to understanding engineering decisions. Culture was even a barrier to the understanding of the Presidential Commission, which spent three months and enormous resources finding out what had happened. I concluded that only by learning NASA culture and only by reconstructing events chronologically to see how insiders assessed risk as the Solid Rocket Booster problems unfolded would I be able to understand the launch decision.

From my research, I concluded that the disaster was a mistake, not misconduct. But the answer to why this mistake occurred is complex. Most important, this was no anomaly—something peculiar to NASA, as the "managerial wrongdoing" theory suggested. It was a mistake that could happen in any organization, even one pursuing its tasks and goals under optimal conditions. Typically, accident investigations focus on individuals and the decisions they made, excluding other important factors that are harder to see: how organizations are shaped by history and politics, and how those external factors alter the organization itself, affecting individual decision making. Organizational and environmental factors help explain why individuals in organizations behave as they do. The Challenger disaster was a product of politics, organization history, organization culture and structure. First, we will consider how they affected the history of decision making prior to 1986. This history, and the factors that shaped it, were crucial to the disaster because past decisions shaped the sensemaking of many who were present at the Challenger teleconference.

The History of Decision Making: Normalizing Deviance

Why, in the years preceding Challenger, did NASA continuing launching with a Solid Rocket Booster that repeatedly was having problems? In formal risk assessments in the years preceding the Challenger launch, managers and engineers in the work group responsible for formal risk assessments of the boosters continually normalized the technical deviation that they found on the boosters after a mission. By "normalized," I mean that, in official decisions, information they initially viewed as a signal of potential danger—evidence that the design was not performing as predicted—was, after consideration, reinterpreted as acceptable and non-deviant. Based on engineering analysis showing that if the primary O-ring failed a second O-ring would back it up, they continued to believe it was safe to fly. In other words, the work group developed a cultural belief—a shared worldview—that the situation was safe despite mounting evidence that indicated otherwise.

What is astonishing is that the work group gradually expanded the boundary of what was, to them, an acceptable risk. The critical decision was the first one, when, expecting no damage to the O-rings, damage occurred and they found it acceptable. This started the work group on a slippery slope. As one manager told me, " Once you've accepted that first lack of perfection, that first anomaly, it's like you've lost your virginity. You can't go back." That initial precedent served as a basis for engineering risk assessments for subsequent launches. Gradually, in formal risk assessments, they accepted more and more risk. Each of these decisions, taken singly, seemed correct, routine, and, indeed, insignificant and unremarkable, but they had a cumulative directionality of which the decision making participants themselves were unaware—except in hindsight. Even as engineering concerns began to grow in 1985, the engineers assigned to the Solid Rocket Booster Project—including those who protested the Challenger launch—continued to come forward in official flight readiness decisions with recommendations that the boosters were an acceptable flight risk.

Why, if engineers were having concerns, did they normalize the technical deviation in official decisions? Two reasons: 1) information and its context and 2) the NASA organization and its political community.

Signals of Potential Danger: Information and its Context

The context mattered. They were working in an organization where having technical problems was expected and taken-for-granted, so to have problems was not itself a signal of potential danger. Problems were normal for a number of reasons. The shuttle design was unprecedented. Further, the technology was made of many component parts, made by different manufacturers, and had to be put together by NASA. Finally, the shuttle was designed to be reusable. Despite engineering lab tests, field tests, and calculations, engineers could never predict and prepare for all the forces of the environment that the shuttle would experience once it left the launch pad. They knew it was going to come back with damage that required new analysis and correction before it could be launched again.

Taking this into account, in 1981 NASA created a document titled "The Acceptable Risk Process," in which the agency acknowledged that after they had done everything that could be done, the shuttle would still contain residual risks. And that residual risk had to be analyzed prior to each flight to determine whether or not it was acceptable. The document articulated, in broad strokes, the directions that the Acceptable Risk Process must take prior to each flight. So, in the NASA culture, both having problems and taking risks was routine. Documents were full of the language stating "acceptable risk," "acceptable erosion," "anomalies," "discrepancies." To outsiders after the disaster, this looked like rationality gone wild. To insiders, it was normal, everyday talk.

The second important aspect of context that mattered to decision making about the Solid Rocket Boosters was the pattern of information as problems began to occur. What, in retrospect, looked to us as clear signals of potential danger that should have halted shuttle flight were interpreted differently at the time. Signals of potential danger were affected by the information context, so that they were mixed, weak, or routine.

Mixed Signals. A mixed signal was one where a signal of potential danger was followed by signals that all was well, convincing them that the situation was safe. To illustrate: When returning flights showed anomalies on the booster joints—a signal of potential danger—engineers analyzed and corrected the problem (a piece of lint on an O-ring was enough to cause damage to an O-ring). Subsequently, a number of flights showed no problems—signals that all was well.

Weak Signals. A weak signal was one that was hard to decipher or, after analysis, seemed such an improbable event that they believed there was little probability of it recurring. To illustrate: A launch in January 1985—a year before Challenger—showed the worst O-ring damage to that point. Cold temperature was thought to be a factor, because the vehicle was on the launch pad through three consecutive days of 19-20 degree overnight Florida temperatures. Knowing that Challenger was affected by the cold, we saw this as a strong signal. However, at the time, they had no evidence that temperature was responsible for the damage they found—many factors had been causing problems—and they believed such a run of cold temperatures was unlikely to happen again. There was, in the words of Morton Thiokol engineer Roger Boisjoly, "no scramble to get temperature data" because no one expected a recurrence. The vehicle was tested and designed to withstand extremes of heat, not cold. Cold temperature was, to them, a weak signal—until the eve of the launch.

Routine Signals. In mid-1985, O-ring erosion began occurring on every flight. After the disaster, outsiders were incredulous that flight continued. For insiders, however, multiple instances of erosion indicated not danger, but assurance that they correctly understood the problem. This deviation, too, was acceptable and normal to them. They had instituted a new procedure that guaranteed that the O-rings would be properly positioned. This procedure increased the probability of erosion, but because they believed the boosters were redundant, erosion was not viewed as a problem. Better they assure redundancy by getting the rings in proper position than worry about erosion, which was, in fact, occurring exactly as they predicted. What we saw as signals of potential danger were to them, routine signals showing the joint was operating exactly as they expected.

Organization Culture: NASA and its Political Community

After the disaster, analysts unanimously concluded that politics had altered the organization culture. They were correct. NASA's relationships with its connected communities—Congress, the White House, contractors—altered the organization culture, which was an important factor that explained the normalization of deviance. Contradicting the conventional wisdom that decision making at NASA was governed by a monolithic, production-oriented culture, however, I found three cultural imperatives which drove the normalization of technical deviation in the work group's risk assessments. The main lesson here is that political bargains and decisions - made by top administrators attempting to negotiate power and resources in an organization's external environment—trickle down, affecting the culture of the workplace.

The Original Technical Culture. The standards of engineering excellence that were behind the splendid successes of the Apollo era made up the original technical culture. That culture required that risk assessments be guided by scientific principles and rigorous quantitative analysis. Hunches, intuition, and observation, so essential to engineering, had a definite place in lab work. But when it came to decisions about whether to proceed with a launch or not, the subjective and intuitive were not allowed: flawless engineering analysis, based on quantitative data, was required. This original technical culture still existed at NASA during the shuttle program, but it was struggling to survive amidst two other cultural mandates.

Political Accountability. During the Apollo era, Congress gave NASA a blank check. When Apollo was over, the consensus for space exploration was diminished. NASA barely got the shuttle program endorsed, but did so by selling it to Congress as a program that would, to great extent be self-funded. The space shuttle would be like a bus, ferrying people and objects back and forth in space. It could carry commercial satellites, and at the projected launch rate, could produce enough income a year to support the program. Thus, the shuttle would survive as a business, and production pressures were born. Meeting the schedule became the key to continued funding from Congress. Consequently, performance pressures and political accountability lived side by side with the original technical culture. In addition, after the fourth shuttle flight, top NASA officials (aided by a ceremonial declaration by President Reagan) declared the program "operational," meaning the developmental or test period was over and henceforth space flight would be routine and economical.

Bureaucratic Accountability. The agency became bureaupathological. After Apollo, the growing NASA/contractor structure meant increased rule-following was required to simply put together and launch this very complex shuttle vehicle. In addition, the Reagan administration required increased accountability of all government agencies. As a consequence of both these developments, working engineers spent much more time doing desk work, filling out forms, and the entire launch decision process, normally guided by rigid rules for procedural accountability, was joined with burgeoning paper work of another sort. For each launch, 60 million components and thousands of count-down activities had to be processed. With the accelerated launch schedule, managers and engineers were working evenings and weekends just to turn around all the paperwork.

The original technical culture still existed, but engineers struggled to adhere to its tenets under the production pressures and pressures for bureaucratic accountability. This three-faceted organization culture affected work group decision making in the years preceding the Challenger launch. All three aspects of culture contributed to the normalization of deviance, so that even when engineers began to develop deep concerns, they continued to make formal risk assessments that recommended launching. Specifically, culture affected decision making as follows:

- Political Accountability. Production pressures and scheduling concerns were normal to engineers and managers assigned to the hardware. No one had to tell them the schedule was important; they knew.
- The Original Technical Culture. The original technical culture required that rigorous, scientific, quantitative engineering arguments back up engineering recommendations. As long as the managers and engineers in the Solid Rocket Booster work group had strong quantitative data showing that the hardware was safe to fly, they could not interrupt the schedule to do tests to see why it was operating as it was. Not only were engineering hunches and intuitions insufficient in light of the quantitative evidence, but once the shuttle was declared operational, developmental testing became impossible. Production pressures suffocated the intuition and subjective concerns that were basic to the R&D organization NASA was during the Apollo era.

- Bureaucratic Accountability. The sensemaking of managers and engineers was affected by the fact that they followed all the rules. The "can-do" attitude among the engineering ranks grew out of a proceduralism-based assurance that if they followed all the rules, all the procedures, then they had done everything they could to assure safety. This included following the rules and procedures of the original technical culture as well as the rules and procedures of the NASA organization.

It was not deviance that was at work at NASA in those years preceding the Challenger teleconference, as many post-disaster analysts suspected: it was conformity. As they tried to make sense of signals of potential danger, managers and engineers alike were conforming to all three dominant cultural mandates that governed their workplace. On the eve of the Challenger launch, this history of decision making and the belief in acceptable risk of the Solid Rocket Boosters was the all-important context against which new signals of potential danger were weighed. On the eve of the launch, the boundary of acceptable risk was expanded one more time.

The Eve of the Launch

The launch decision was the outcome of a two-hour teleconference between 34 people gathered around tables at Morton Thiokol in Utah, Marshall Space Flight Center in Alabama, and Kennedy Space Center in Florida. Uncertainty was extraordinary because the situation was unprecedented in three ways: the predicted cold temperature was below that of any previous launch; although teleconferences were routine at NASA, a launch decision had never before been made by teleconference; engineers had never before come forward with a no-launch recommendation on the eve of a launch. However, I did not find the launch decision explained by the actions of amorally calculating managers who threw caution to the wind and succumbed to production pressures in order to stick to the launch schedule. Production pressures had a tremendous impact, but on all participants, and not in the way most post-disaster analysts thought. Moreover, other factors were equally important. Altogether, information and its context, the politically-altered organization culture, and organization structure shaped the sensemaking of individual participants, and thus the final outcome. Here, in abbreviated form, is how these factors, so important in the past, mingled to create a disaster.

Concern about the cold temperature arose earlier in the day. Contractor engineers at Morton Thiokol in Utah were contacted. Production pressures operated early and invisibly on Thiokol engineers, who automatically set a deadline for a teleconference discussion to begin at 8:15 EST. They were used to working in a deadline-oriented culture deeply concerned about costs. They knew that if they could make a decision before 12:30 am, when the ground crew at Kennedy Space Center in Florida began putting fuel into the External Tank, they could avoid the costly de-tanking if the decision was "No-Go." NASA always de-tanked in the event a launch was canceled. De-tanking was an expensive, time-consuming operation. As a consequence of this self-imposed deadline, the engineers had to scramble to put together their engineering charts containing their risk assessments. They divided up the work of chart making, neglecting to look over the charts collectively before the teleconference began. Some people were putting together the final recommendation chart without seeing the data charts the engineers were creating. As each chart was completed, it was faxed to people in the other two locations.

As it turned out, the charts containing the engineering analysis were filled with inconsistencies that did not live up to the standards of NASA's original technical culture. The original technical culture required quantitative, scientific data for every engineering recommendation. Thiokol engineers argued that NASA should not launch unless the temperature were 53 degrees or better, because that was the previous coldest launch, and the one which had suffered the most O-ring damage. However, the charts contained mixed, weak, and routine signals. Thiokol set a limit of 53 degrees, but included data indicating the O-rings would hold at 30 degrees and data indicating they had problems at 75 degrees—the warmest launch (mixed signals).

Some of the charts were pulled from previous engineering presentations, where the same data had been used to recommend launches. Those data were routine signals because they had been seen before. Finally, the recommendation chart said, "Do not launch unless the temperature is equal to or greater than 53 degrees," a conclusion based on observational data, not quantitative data. Within the strictures of the original technical culture, the engineering analysis overall was a weak signal, insufficient to overturn the preexisting, positivistic understanding of how the joint worked that Thiokol engineers successfully had presented in risk assessments in the preceding years.

Production pressures appeared a second time, in the angry voices of Marshall managers who challenged these engineering arguments, intimidating the engineers. Marshall managers would be the ones who would have to carry forward the launch recommendation and defend the engineering analysis to top administrators in a system where schedule was important. They had stopped launches before, but this time it appeared they were going to have to stop it with engineering analysis that was, within the original technical culture, not only flawed, but based on an intuitive argument that was unacceptable. Moreover, production pressures were also at work. This particular 53 degree limit would stand as a rule, so that all shuttles hence could not go unless the temperature were 53 degrees—an awesome complication in a system required to meet a tight schedule. Under these circumstances, a tight engineering argument seemed particularly essential.

Hierarchical power and organization structure also had a devastatingly effect on the discussion. In three locations, people could not see each other, so words and inflections were all important. Midway in the teleconference, the people assembled at the Morton Thiokol in Utah held an off-line caucus. In it, a Thiokol administrator who knew little about the technology took charge, repeating the challenges of the Marshall managers. Without any new data to support their arguments, the engineers could not build a stronger data analysis.

Four managers in Utah reversed the original engineering recommendation, going back on-line and announcing that Thiokol had reexamined their data, reversed the decision, and recommended launch. When Marshall managers asked, "Does anybody have anything more to say?" no one spoke up, so people in the other two locations did not know that the Thiokol engineers still objected. Moreover, Thiokol engineers did not know that during the caucus, people at the other two locations believed the launch was going to be canceled. In fact, the top Marshall decision maker was making a list of people to call in order to stop the launch.

Bureaucratic rules and the culture's bureau-pathology also played a critical role in the outcome. In an unprecedented situation, all participants invoked the usual rules about how decisions are made. These rules were designed to assure safety. They included vigorous adversarial challenges to engineering risk assessments, insistence on scientific, quantitative evidence, allegiance to hierarchical procedures and norms about the roles of managers and engineers in engineering disagreements. Like firefighters who have a hard time dropping their tools in a crisis, teleconference participants failed to drop their "tools:" they invoked all the usual rules in an unprecedented situation where the usual rules were inappropriate.

Although quantitative evidence was required for a "go" launch decision, engineering concern and hunches should have been enough (we see in retrospect) in a "no launch" situation. Adversarialism was important to tighten up engineering analyses and insure there were no flaws, but in a situation of uncertainty with little available data, perhaps a cooperative, democratic, sleeves-rolled-up, "what can we make of all this collectively" decision making session would have produced a different outcome. Because hieraracy prevailed, people in other locations who had potentially useful information and opinions did not enter into the conversation because their position and rules about who was empowered to speak inhibited them from talking.

Impact: The Post-Disaster Period

Whenever organizations have tragedies that cost lives, post-disaster activities seem to follow patterns that have near ritualistic qualities: a public investigation; flaws and errors that led to the tragedy are identified; a set of recommendations to prevent similar incidents is made, followed by a period of implementation, change, and high-attention to problems. The public is quieted and business-as-usual resumes. NASA followed this pattern.

Initially, there was shock and grief. Grieving personnel automatically began to act in their organization roles, trying to figure out what had happened: saving and backing up console data; examining telemetry data; beginning a fault tree analysis for every possible source of the technical failure. At the same time, the agency was bombarded by an onslaught of questions from Congress, the White House, the astronaut families, the press, and an angry public seeking an explanation. Significantly, top NASA officials had not created a plan about how to respond to outsiders in case mission and crew were lost, and chaos reigned. The Presidential Commission was formed and an official investigation was conducted. The Commission's investigation created a huge extra workload, as relevant personnel were interviewed, documents predating the disaster were retrieved, photocopied, listed, and turned over, and post-disaster documents were created.

The time and attention of personnel to both internal and external investigations was of tremendous expense to the agency. But the emotional costs cannot even be estimated. Typical of other cases when organizational failures cost lives, the workload dramatically increased at a time when people needed to grieve. They grappled with the loss of their astronaut colleagues and their own possible contribution to their demise. Not knowing the answer themselves, they struggled to answer the questions of family and friends about why the astronauts had died. Most difficult were those of other astronauts and their own children, who had been watching the "Teacher in Space" mission in classrooms.

In retrospect, the official investigators, the public, and NASA personnel saw clearly the signals of danger that had looked so different to insiders as the problem unfolded. Emotionally exhausted, people in the Shuttle Program focused on the past, identifying turning points where they should have acted differently, passionately wishing they had said or done other than they had. They feared for themselves, their jobs, the agency, and the future. While they had understood all along that failure was always possible, the awareness that they had followed all the usual rules and procedures and still lost Challenger generated deep doubts about the organization, its mission and capabilities, and their own competencies. People dealt with their grief in different ways. Some have never resolved it. Unable to move forward, they still focus on the past, working it through again and again.

Besieged by other organizations and the public, the agency also was torn with internal conflict. Teleconference participants blamed each other, lodging responsibility for the disaster in the failure of other individuals on that fateful night. This adversarialism and finger-pointing was not just some combination of guilt and denial, although that must have had an effect. But it also happened because they were ignorant of many aspects of the telecon discussion in which they themselves participated. They were in three locations in which they could not see each other and for a critical part of the conference, they could not hear each other. The result was the engineers in Utah were unaware that they had support in the other locations, unaware that during the caucus people in the other locations were convinced the launch was going to be stopped, unaware that top decision makers at Marshall were making a list of people to call in order to cancel it; people at the Cape and at Marshall were unaware that engineers in Utah were still opposed to launching after the caucus. Afterwards, they were never called together for a collective discussion of what happened, perpetuating their blaming of one another. In addition, they remained insensitive to the historical, cultural, and organizational conditions that governed their actions on the eve of the launch.

Then the post-disaster ritual entered a different phase: the report of the official investigation and a series of recommendations that targeted the causes the Commission identified. In common with most post-disaster rituals, the investigation following Challenger focused attention (1) on the physical cause of the accident, and (2) on the individuals responsible for what, in retrospect, was obviously a flawed decision: middle-level managers at Marshall Space Flight Center. In light of this finding, the strategy for control was fairly simple: fix the technology, replace the responsible individuals, and tighten up decision rules.

Omitted from the glare of publicity were the top decision makers who made political bargains, established goals, and allocated resources that altered the culture of the agency by converting it from an R&D organization to a business, complete with production cycles, and schedule pressures. It was they who made the decisions to take civilians on shuttle missions as a means of manipulating public impressions of shuttle safety, not the teleconference participants. Also obscured from public awareness by the emphasis on individual middle managers was the true experimental nature of the technology, its unpredictability under even the best of circumstances, and the logical possibility of another failure. The final phase of the post-disaster ritual was complete when the Commission's recommendations were implemented, convincing the public that the disaster was an anomaly that would not recur. Space flight continued, leaving untouched many of the organizational factors that had contributed to the problem.

TARGETS FOR SAFETY: LESSONS FROM CHALLENGER FOR FIREFIGHTING

David Thomas has taught in workshops that firefighters must "actively search for firefighting safety." Karl Weick has stressed that a safety agenda requires a "constant struggle for vigilance." Far more than NASA, firefighters have been willing to do the painful work of confronting and analyzing the past in order to successfully and seriously maintain active search and vigilance as organization goals. One way the search for safety can be expanded is to examine preexisting factors in the organization and its political environment that might have affected decisions in a firefighting situation. I discuss two: elite decisions and organization culture. Then I examine the crisis decision making situation itself, targeting the sending and receiving of signals.

Target Elite Decisions:

In the years preceding the Challenger disaster, NASA top administrators made decisions that contributed to the tragedy. Top administrators of the US Forest Service must take responsibility for fire safety by remaining alert to how their decisions trickle-down through the organization, affecting the decisions of people at the bottom who do the risky work.

Negotiations with Congress have major impact. At NASA, budget cuts by Congress and the White House curtailed resources available for hardware, research, testing, and personnel. Also, bills requiring increased accountability for all federal agencies increased bureaucratic requirements for paperwork, so that NASA and contractor personnel spent much time completing reports and sending in requisitions that could have been spent on training and/or improving risk assessment strategies that would enhance understanding of the technology.

Policy must bring goals and the resources necessary to meet them into alignment. At NASA, goals (launching a specific number of shuttles each year) were impossible to meet with available resources. Resources include personnel, training, equipment, and all other factors necessary to effective firefighting. If current US Forest resources are inadequate to meet established policy about firefighting, then either the resources need to be increased or policy must be reassessed, eliminating some firefighting activities so that others can be conducted with utmost safety.

Administrative decisions significantly affect the culture of decision making for people doing the hands-on work. At NASA, top administrators developed a "can-do" attitude, promising Congress that NASA could launch a certain number each year with less resources. They stressed safety, but other actions and decisions convinced workers that schedule was a priority.

Altering the structure of an organization can also alter the culture. "Downsizing" is "hot" right now. Proposals to change structure should not be undertaken without research evaluating the effect on safety. In an agency like NASA or the Forest Service, where people's lives are on the line, top administrators' response to this political mandate should seriously weigh proposed changes, bring in consultants, and take seriously the views of experienced personnel at all levels. Avoid (and actively resist) those changes that have direct or indirect implications for safety.

Target Culture:

Don't make assumptions about organization culture. A major discovery in the Challenger research was that the culture was more complicated and its effects on decision making more subtle and hard to detect that even insiders realized. Research on organization culture can reduce risk. Members of an organization are sensitive to certain aspects of the culture, but ignorant of others. Some become taken-for-granted, so that its dictates are unquestioningly followed without workers realizing exactly what the culture is or its effects. These research suggestions are based on my comparison of NASA and wildland firefighting:

- Investigate the alleged "can-do" attitude among firefighters: Does it exist? If so, what is it and how does it affect safety? If not, what attitude prevails in the culture. Associated with the term "can-do" is an image of a macho culture that disregards safety considerations and forges ahead, no matter what the cost. At NASA, a "can-do" attitude prevailed, but top administrators' differed greatly from that of their managers and engineers. Top administrators possessed a "can-do" hubris that all things were possible and success was taken-for-granted, a policy-affecting attitude decidedly out of touch with the risks of their developmental technology. For those doing the risky work, however, "can-do" was based on strict adherence to rules and procedures, going by the book, and a belief in the long experience of personnel. But their rule-following "can-do" also was coupled with a sincere appreciation for and fear of their powerfully explosive technology and all the unknowns in every launch condition. Those who were religious prayed before every launch; everyone experienced a "gut check," or a nauseatingly tight stomach as countdown proceeded to its final stages. Macho risk taking was not in the cultural script of managers and engineers, and in proof of it are the many times they canceled launches prior to Challenger. The lesson is that where culture is concerned as in other matters, appearances can be deceiving, and the recent firefighting fatalities may have had an effect that should be identified.
- Wildland fire tragedy investigations typically include a search for rule violations associated with fatalities. This focus may produce misleading results. Rules—and whether to obey them or not—are part of an organization's culture. Research should examine both rule following and rule violating behavior in both routine and crisis decision making fire conditions. In an anonymous questionnaire, find out how extensive rule violations are and why people violate them. People violate rules for numerous reasons: a rule may be complex, so is violated out of lack of understanding; a rule may be recent, so people are unaware of it; a rule may be vague or unclear, so is violated because people don't see that it applies to the situation they face; a rule may be perceived as irrelevant to the task at hand, or in fact an obstacle to accomplishing it, so the rule is ignored; a rule may conflict with norms about how to behave to assure safety. Research on both conformity to rules and norms as well as deviations from them would be important in deciding how to alter rules to guide decision making. Perhaps the most challenging problem that we can extract from the Challenger tragedy is how to simultaneously instill rules to assure safety so that they are followed automatically when people are under great pressure and simultaneously preserve the ability to innovate, to be creative, to recognize the situation for which no rules exist and for which the existing rules do not apply.
- Fire crews are often a diverse social composite: gender, race, ethnicity, social class. Equally important, they often differ in firefighting experience and seniority. Research should also explore the effects of these differences on crew fire safety so that the results could inform training. Rosabeth Moss Kanter, in *Men and Women of the Corporation* (1977), has written an important book that is not solely about gender, but about common patterns that result between what she calls "dominants" (the numerical majority) and "tokens" (the numerical minority) in organizations. The book powerfully depicts how the dynamics between dominants and tokens undermine organization goals. Research on fire crews should explore how the relationship between tokens (read: temporary workers, women, blacks, less educated, or ethnic language-speaking, etc.) and dominants (read: permanent workers, men, whites, well-educated, or English language speaking, etc.) affects fire safety.

For example, how do tokens and dominants relate to one another, and what can be done to develop reliable working relationships. Do assumptions about tokens affect deployment of personnel and job assignments, so that tokens are underutilized as resources? Research could show whether tokens get the same feedback on their performance as dominants do. Such feedback helps improve and correct performance, and thus is integral to safety. If tokens are less likely to be "called on the carpet" for mistakes than those who are dominant, and therefore do not get equal criticism and negative feedback from supervisors, they do not have the same opportunity to correct their performance. Research could also show what happens when tokens give information, instructions, or assume leadership in a fire. Do work groups with mixed composition that are deployed to a fire respond in the same way to unanticipated conditions as those that are homogeneous?

Target Signals:

The Challenger disaster must be seen as one decision in a chain of decisions that show how the people responsible for risk assessment made an incremental descent into poor judgment. This is a common pattern in organization failures. Turner, in *Man-made Disasters* (1978), compared many different kinds of disasters, finding long incubation periods typified by signals of potential danger that were either ignored or misinterpreted. Not surprisingly, investigations of wildland firefighting tragedies show a similar history during a fire. Karl Weick has stressed the importance of sensemaking when fighting fires. Confirming his point, a key finding of the Challenger tragedy is that sensemaking was context-dependent. Information and its context affected how people constructed definitions of risk, and therefore the decisions that they made. Signals of potential danger were mixed, weak, and routine, qualities that enhanced their normalization. In a fire, each individual should be alert to him or her self as a signal-giver. Be aware that the characteristics of signals affect how others interpret the riskiness of the situation, and therefore, how they respond. Not only words and actions, but inflection, gestures, and body language affect how others make sense of what is happening. Remember Navon, at Mann Gulch, who stopped to take pictures—a signal to others in the crew that all was well.

Be alert to context as a factor in others' decisions. For example, when several fires are burning simultaneously, resource allocation depends upon all the other problems being confronted. Delay occurs because resources are scarce or already committed and priorities have to be assigned. Given resource scarcity, the total set of problems is used to determine the size and trouble promised in a particular location: The risk of fire "A" is compared to the risks inherent in fires "B," "C," and "D." Typically the person deploying resources is dependent upon many unseen others for information about all the fires. When communicating about fire conditions or firefighting needs, giving accurate and clear signals in a manner appropriate to the understood hazards of a fire is extremely important.

Avoid giving mixed signals. At Mann Gulch, the oft-cited example of Dodge getting worried and changing the direction of his crew (to them, a signal of potential danger) then immediately going upgulch to have lunch (to them, a signal that all was well) overall constituted a mixed signal, difficult to interpret.

Develop a method of giving a strong signal in conditions when explanation is not possible. Dodge's famous escape fire, ostensibly a strong signal because the foreman was giving it, apparently was interpreted as a weak signal because it did not fit within the context of what the crew knew about firefighting and what they observed and experienced in the conditions surrounding them. Perhaps technology (red light; a penetrating sound, loud and clear, that can be heard over a fire) can be of use in creating strong signals in such situations.

Minimize missing signals. Subordinates, tokens, and newcomers in all organizations often have useful information or opinions that they don't express. Democratic practices and respectful practices empower people to give signals, and everything possible should be done to develop such practices. Be aware, however, that some kinds of information will still be hard to pass on in a fire situation where crew survival depends to a great extent upon suppressing individuality to the collective well-being, to conformity, and to following the commands of a leader. More difficult even than passing on information contradicting what appears to be the leader's strategy or the group consensus is uttering the phrase "I want to go back" when everyone else just "keeps on keeping on." This is the equivalent of two engineers continuing to argue "don't launch" when all around them appear to want to go. Significant in the eve-of-launch decision were the many missing signals. There is nothing so deadly in a crisis as the sound of silence.

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