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Railroad Crossing Accidents

by Ed Rhode, CPCU

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A driver is leaving work, from an industrial park, when he or she is struck by a train at a crossing. Permanent, disabling injuries occur to the driver. In the United States, railroad-road crossing accidents are common, resulting in approximately 2,000 deaths and serious injuries a year. It is difficult to imagine that a driver could miss an object as big and noisy as a train or the flashing lights, blowing horns, and bells, but it happens frequently and with catastrophic consequences.

Railroad crossing accidents occur for two reasons:

- The driver tries to beat the train to the crossing.
- The driver fails to see or hear the oncoming train or warning signals at the crossing.

In either case, the result is not good for the driver and passengers of the vehicle.

When approaching a crossing, a driver must decide whether he or she will arrive

at the crossing before the train. Accidents frequently happen because the driver does not adequately determine the speed of the approaching train and when it will reach the crossing.

This will happen for a number of reasons, which are beyond the scope of this document. Excellent sources on this phenomenon are Green, M. (2002), "Error, Accident and 'Inattentional Blindness,'" *Occupational Health & Safety Canada*, January/February, and *Occupational Health and Safety Magazine*, "Railroad Crossing Accidents," June 2002.

The attention of most drivers is usually elsewhere, looking for more common hazards, such as other vehicles or pedestrians, or perhaps the green light up ahead at the traffic signal, and anticipating if they will make it or not. Cell phone usage is also a major distraction of today's vehicle operators.

If it was in a colder climate perhaps the windows on the driver's car were closed or the stereo was at a high volume, so the bells and whistles cannot be heard.

Warnings at railroad-highway crossing are not as conspicuous or as effective as normal highway-to-highway intersections. Railroad warning signal installations need only provide for "ample" or "adequate" signaling under ordinary conditions.

An acceptable railroad-highway warning can be nothing more than the common crossbuck sign. The warning can also be active with a set of alternating red lights located at the crossing. This may not be the best design, as it is based on an old railroad tradition of a railroad employee swinging a red lantern back and forth, and not on sound engineering data.

These lights have several weaknesses:

- Low bulb wattage/brightness because they must operate on battery power if there is a power failure.
- The red, glass lens filters and reduces the level of illumination.

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Railroad Crossing Accidents

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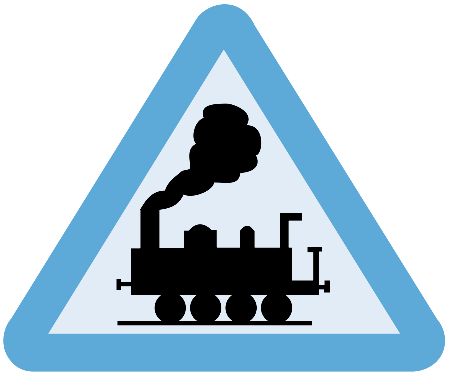

- Two percent of the male population has a form of color blindness and may not see the light.
- The lights are small—$8\frac{3}{8}$ inches in old installations, and 12 inches in diameter for newer installations.

For the warning to work, the driver must be able to see the light flash. Sunlight and reflections off the lens can make it difficult to see. Most signals have a hood that blocks direct light when the sun's elevation is high above the horizon. Reflection problems will occur when the sun is rising at dawn or setting at dusk, making it difficult for a driver to determine if the light is on or just a reflection of the sun.

Drivers also quickly become aware that the signal starts before the train arrives at the crossing and does not mean that a train is coming immediately. If the lights begin to flash too early, drivers learn that a train may not be coming soon, and that there is time to get across or beat the train. This can commonly occur at crossings near commuter line stations. This can create a situation where the flashing signal is not taken seriously. As a result, drivers may see the signal but cross the tracks anyway.

What Are the Railroad Crossing Standards for Private Roads?

The next question you might have is "what are the standards?" The response from the Federal Railroad Administration (FRA) was "There are no specific requirements for private crossings. In that the railroad grants passage over their right-of-way, it determines what safety devices will be necessary."

Further research found that the railroad is required to install and maintain grade crossing equipment in accordance with the Federal Railroad Administration and U.S. Department of Transportation (DOT) requirements. In 1996, the government published new revised standards on maintenance and operation of rail-crossing warning devices. The acceptable warning devices include the passive crossbuck sign without lights.

However, private crossings are different. The easement must first be at the property owner's request and when the permit is issued by the railroad, the steps to assure safety of the crossing should be outlined in the lease or easement provided. Most often the property owner will be responsible for maintenance and improvements, but the railroad must approve them first. The property owner must then maintain the crossing, or the railroad may do so and bill the property owner at its discretion.

So What Can Loss Control Do?

One of the key issues is, who has responsibility for the maintenance and upkeep of the crossing? Loss control professionals need to ask more questions. How are deeds, easements, and leases worded? Can copies be obtained, reviewed, and evaluated? Did competent legal counsel review the documents prior to signing them? These legal contracts have to be reviewed like all other contracts, and risk-transfer techniques should be implemented.

To access the degree of hazard involved we need to determine the exposure. Have there been other incidents in the area or at this crossing? What is the vehicular and pedestrian traffic flow like? How often do the trains pass by? Is there a need for flashing lights or gates? Need for vehicular and pedestrian gates? Has your client ever requested improvements to be made or has the railroad requested the client to make improvements? Were the improvements granted and completed? Has the railroad ever had to make improvements on behalf of the client and then bill him or her for the expense? Is there documentation on file for any and all of the above?

When these questions are satisfactorily answered, the information can assist the loss control professional in evaluating the exposure and determining if additional loss control or risk-transfer mechanisms are necessary. ■

References

1. Green, M. (2002), "Error, Accident and 'Inattentional Blindness,'" *Occupational Health & Safety Canada*, January/February, "Railroad Crossing Accidents," *Occupational Safety and Health*, June 2002.
2. What are the state laws? The following web site may be of assistance. Laws by state abbreviated: http://www.fra.dot.gov/pdf/cross_chp4.pdf
3. Finally, if you are interested in accident train/vehicle accident statistics try this web site: http://safetydata.fra.dot.gov/officeofsafety/

Is a Major Accident About to Occur in Your Operations?

Lessons to Learn from the Space Shuttle Columbia *Explosion*

by Fred A. Manuele, P.E., CSP

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The report issued in August 2003 by the Columbia Accident Investigation Board (CAIB) is revealing about how a lot of little things can add up to a big thing. This report provides SH&E practitioners a basis for reflection on the potential for the occurrence of major accidents in their operations. This article is presented in three parts. Part 1 reviews the origins of causal factors for accidents that result in serious consequences. Part 2 presents excerpts from Volume 1 of CAIB's report. Part 3 presents a discussion guide that can be used to determine whether latent hazardous conditions and practices that could be the causal factors for a major accident have accumulated in a given setting. This guide provides the basis for a cultural, organizational, and technical self-evaluation. It is for use by SH&E practitioners and, more particularly, for the executives influenced by those practitioners to undertake a review of major accident potential.

Part 1: Causal Factors

Major accidents—meaning low-probability incidents with severe consequences—typically result from an accumulation of what Reason refers to as latent conditions. Such latent technical conditions and operating practices are built into a system and shape an organization's culture. In *Managing the Risks of Organizational Accidents,* Reason discusses the long-term impact of a continuum of less-than-adequate safety decision making—which is a central theme in CAIB's report:

> Latent conditions, such as poor design, gaps in supervision, undetected manufacturing defects or maintenance failures, unworkable procedures, clumsy automation, shortfalls in training, less than adequate tools and equipment, may be present for many years before they combine with local circumstances and active failures to penetrate the system's layers of defenses. They arise from strategic and other top-level decisions made by governments, regulators, manufacturers, designers and organizational managers. The impact of these decisions spreads throughout the organization, shaping a distinctive corporate culture and creating error-producing factors within the individual workplaces (10).

In this paragraph, Reason cites many of the cultural and organizational shortcomings that resulted in less-than-adequate safety decision-making at NASA, which CAIB considered significant. In *The Psychology of Everyday Things,* Norman writes similarly about how major accidents occur:

> Explaining away errors is a common problem in commercial accidents. Most major accidents follow a series of breakdowns and errors, problem after problem, each making the next more likely. Seldom does a major accident occur without numerous failures: equipment malfunctions, unusual events, a series of apparently unrelated breakdowns and errors that culminate in major disaster; yet no single step has appeared to be serious. In many cases, the people noted the problem but explained it away, finding a logical explanation for the otherwise deviant observation (128).

What Norman says about "numerous failures" being typical when major accidents occur matches this author's experience, having reviewed many accident reports pertaining to severe injuries and fatalities. While reading the excerpts from CAIB's report later in this article, two key quotes should be kept in mind:

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> The impact of [top-level] decisions spreads throughout the organization, shaping a distinctive corporate culture and creating error-producing factors within individual workplaces (Reason 10).
>
> In many cases, the people noted the problem but explained it away, finding a logical explanation for the otherwise deviant observation (Norman 128).

SH&E professionals should review CAIB's entire investigation report, which is available at www.nasa.gov/columbia/home/CAIB_Vol1.html. While it is upsetting, readers are reminded that similar latent technical conditions and operating practices could exist in their operations.

The reality is that the following scenario is often repeated. A location does well for several years as measured by its safety statistics. Then, a major accident occurs and everyone is shocked that such an incident could happen in their operations. After all, wasn't the safety record commendable?

Unfortunately, what follows a major accident is well-described in CAIB's report.

Many accident investigations do not go far enough. They identify the technical cause of the accident, and then connect it to a variant of "operator error"—the line worker who forgot to insert a bolt, the engineer who miscalculated the stress, or the manager who made the wrong decision. But this is seldom the entire issue. When the determinations of the causal chain are limited to the technical flaw and individual failure, typically the actions taken to prevent a similar event in the future are also limited: fix the technical problem and replace or retrain the individual responsible. Putting these corrections in place leads to another mistake—the belief that the problem is solved. The board did not want to make these errors (CAIB 97).

SH&E practitioners who still profess that most work-related accidents are principally caused by unsafe acts of workers should seriously consider the report excerpts that follow. Perhaps their incident investigation procedures do not go far enough and should be extended to identify the real root-cause factors, as CAIB did.

■ *These highlights form a base from which stakeholders can assess whether there have been shortcoming in safety decision making.*

Furthermore, it is believed that the highlights of this report form a base from which operations managers and SH&E practitioners can assess whether there have been shortcomings in decision making in the past with respect to safety in the operations they influence. Such an assessment could determine whether these shortcomings have resulted in an accumulation of latent conditions and operating practices that may have serious injury potential. It will also result in an assessment of the organization's safety culture.

The verbatim excerpts from the 248-page Volume 1 describe cultural deficiencies that may exist in any operation. They also reinforce several premises:

- Causal factors for accidents that result in severe injuries are multiple and complex, and relate to several levels of responsibility.
- Accident investigations often blame a failure only on the last step in a complex process, when a more comprehensive understanding of that process could reveal that earlier steps might be equally or even more culpable.
- Accidents that result in severe injuries may not be random events; rather, their causal factors may derive from an accumulation over time of deficiencies in an organization's safety culture.
- An organization's culture with respect to safety decision making determines the incident experience obtained.

Part 2: CAIB Report Excerpts

The Board Statement

Our aim has been to improve shuttle safety by multiple means, not just by correcting the specific faults that cost the nation this orbiter and this crew. With that intent, the board conducted not only an investigation of what happened to *Columbia*, but also to determine the conditions that allowed the accident to occur—a safety evaluation of the entire space shuttle program.

It is our view that complex systems almost always fail in complex ways, and we believe it would be wrong to reduce the complexities and weaknesses associated with these systems to some simple explanation.

In this board's opinion, unless the technical, organizational, and cultural recommendations made in this report are implemented, little will have been accomplished to lessen the chance that another accident will follow (CAIB 6).

The Executive Summary

The board recognized early on that the accident was probably not an anomalous, random event, but rather likely rooted to some degree in NASA's history and the human space flight program's culture.

Accordingly, the board broadened its mandate at the outset to include an investigation of a wide range of historical and organizational issues, including political and budgetary considerations, compromises, and changing priorities over the life of the space shuttle program. The board's conviction regarding the importance of these factors strengthened as the investigation progressed, with the result that this report, in its findings, conclusions, and recommendations, places as much weight on these causal factors as on the more easily understood and corrected physical cause of the accident (CAIB 9).

[Note: The executive summary remarks extensively on the physical and organizational causal factors for the accident. In-depth comments about the causal factors are found later in the report.]

The Report Synopsis

We consider it unlikely that the accident was a random event; rather it was likely related in some degree to NASA's budgets, history, and program culture, as well as to the politics, compromises, [and] changing priorities of the democratic process. We are convinced that the management practices overseeing the space shuttle program were as much a cause of the accident as the foam that struck the left wing (CAIB 11).

CAIB Report Part One: The Accident

Chapter 1: The Evolution of the Space Shuttle Program

It is the view of the *Columbia* Accident Investigation Board that the *Columbia* accident is not a random event, but rather a product of the space shuttle program's history and current management processes. Fully understanding how it happened requires an exploration of that history and management. This chapter charts how the shuttle emerged from a series of political compromises that produced unreasonable expectations—even myths—about its performance, how the *Challenger* accident shattered those myths several years after NASA began acting upon them as fact, and how, in retrospect, the shuttle's technically ambitious design resulted in an inherently vulnerable vehicle, the safe operation of which exceeded NASA's organizational capabilities as they existed at the time of the *Columbia* accident.

To understand the cause of the *Columbia* accident is to understand how a program promising reliability and cost efficiency resulted instead in a developmental vehicle that never achieved the fully operational status NASA and the nation accorded it (CAIB 21).

The Challenger Accident

When the Rogers Commission discovered that, on the eve of the launch, NASA and a contractor had vigorously debated the wisdom of operating the shuttle in the cold temperatures predicted for the next day, and that more senior NASA managers were unaware of this debate, the commission shifted the focus of its investigation to "NASA management practices, center-headquarters relationships, and the chain of command for launch commit decisions." As the investigation continued, it revealed a NASA culture that had gradually begun to accept escalating risk, and a NASA safety program that was largely silent and ineffective (CAIB 25).

Chapter 3: Accident Analysis

The Physical Cause

The physical cause of the loss of *Columbia* and its crew was a breach in the thermal protection system on the leading edge of the left wing. The breach was initiated by a piece of insulating foam that separated from the left bipod ramp of the external tank and struck the wing in the vicinity of the lower half of reinforced carbon-carbon panel 8 at 81.9 seconds after launch. During re-entry, this breach . . . allowed superheated air to penetrate the leading-edge insulation and progressively melt the aluminum structure of the left wing, resulting in a weakening of the structure until increasing aerodynamic forces caused loss of control, failure of the wing, and breakup of the orbiter (CAIB 49).

STS-107 Left Bipod Foam Ramp Loss

Foam loss has occurred on more than 80 percent of the 79 missions for which imagery is available, and foam was lost from the left bipod ramp on nearly 10 percent of missions where the left bipod ramp was visible following external tank separation (CAIB 53).

The precise reasons why the left bipod foam ramp was lost from the external tank during STS-107 [the *Columbia* mission] may never be known. The specific initiating event may likewise remain a mystery. However, it is evident that a combination of variable and pre-existing factors, such as insufficient testing and analysis in the early design stages, resulted in a highly variable and complex foam material, defects induced by an imperfect and variable application, and the results of that imperfect process, as well as severe load, thermal, pressure, vibration, acoustic, and structural launch and ascent conditions (CAIB 53, 55).

The Orbiter "Ran Into" the Foam

"How could a lightweight piece of foam travel so fast and hit the wing at 545 miles an hour?" Just prior to separating from the external tank, the foam was traveling with the shuttle stack at about 1,568 mph (2,300 feet per second). Visual evidence shows that the foam debris impacted the wing approximately 0.161 seconds after separating from the external tank. In that time, the velocity of the foam debris slowed from 1,568 mph to about 1,022 mph (1,500 feet per second). Therefore, the orbiter hit the foam with a relative velocity of about 545 mph (800 feet per second). In essence, the foam debris slowed down and the orbiter did not, so the orbiter ran into the foam. The foam slowed down rapidly because such low-density objects have low ballistic coefficients, which means that their speed rapidly decreases when they lose their means of propulsion (CAIB 60).

Orbiter Sensors

Nearly all of *Columbia*'s sensors were specified to have only a 10-year shelf life, and in some cases an even shorter service life. At 22 years old, the majority of the orbiter experiment instrumentation had been in service twice as long as its specified service life and, in fact, many

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sensors were already failing. Engineers planned to stop collecting and analyzing data once most of the sensors had failed, so failed sensors and wiring were not repaired. For instance, of the 181 sensors in *Columbia*'s wings, 55 had already failed or were producing questionable readings before STS-107 was launched (CAIB 65).

Findings

[During re-entry] abnormal heating events preceded abnormal aerodynamic events by several minutes. By the time data indicating problems were telemetered to Mission Control Center, the orbiter had already suffered damage from which it could not recover (CAIB 73).

CAIB Report Part Two

Why the Accident Occurred

In our view, the NASA organizational culture had as much to do with this accident as the foam. Organizational culture refers to the basic values, norms, beliefs, and practices that characterize the functioning of an institution. At the most basic level, organizational culture defines the assumptions that employees make as they carry out their work. It is a powerful force that can persist through reorganizations and the change of key personnel. It can be a positive or a negative force.

At NASA's urging, the nation committed to building an amazing, if compromised, vehicle called the space shuttle. When the agency did this, it accepted the bargain to operate and maintain the vehicle in the safest possible way. The board is not convinced that NASA has completely lived up to the bargain, or that Congress and the administration have provided the funding and support necessary for NASA to do so. This situation needs to be addressed—if the nation intends to keep conducting human space flight, it needs to live up to its part of the bargain (CAIB 97).

Chapter 5: From *Challenger* to *Columbia*

The board is convinced that the factors that led to the *Columbia* accident go well beyond the physical mechanisms [previously] discussed. The causal roots of the accident can also be traced, in part, to the turbulent post-Cold War policy environment in which NASA functioned during most of the years between the destruction of *Challenger* and the loss of *Columbia*.

The agency could not obtain budget increases through the 1990s. Rather than adjust its ambitions to this new state of affairs, NASA continued to push an ambitious agenda of space science and exploration, including a costly space station program.

The space shuttle program has been transformed since the late 1980s implementation of post-*Challenger* management changes in ways that raise questions . . . about NASA's ability to safely operate the space shuttle. While it would be inaccurate to say that NASA managed the space shuttle program at the time of the *Columbia* accident in the same manner it did prior to *Challenger*, there are unfortunate similarities between the agency's performance and safety practices in both periods (CAIB 99).

Space Shuttle Program Budget Patterns

In Fiscal Year 1993, the outgoing Bush administration requested $4.128 billion for the space shuttle program; five years later, the Clinton administration request was for $2.977 billion, a 27 percent reduction. By Fiscal Year 2003, the budget request had increased to $3.208 billion, still a 22 percent reduction from a decade earlier. With inflation taken into account, over the past decade, there has been a reduction of approximately 40 percent in the purchasing power of the program's budget, compared to a reduction of 13 percent in the NASA budget overall (CAIB 104).

Conclusion

[T]his is hardly an environment in which those responsible for safe operation of the shuttle can function without being influenced by external pressures. It is to the credit of space shuttle managers and the shuttle workforce that the vehicle was able to achieve its program objectives for as long as it did. An examination of the shuttle program's history from *Challenger* to *Columbia* raises the question: Did the space shuttle program budgets constrained by the White House and Congress threaten safe shuttle operations? There is no straightforward answer. At the time of the launch of STS-107, NASA retained too many negative (and also many positive) aspects of its traditional culture: "flawed decision making, self-deception, introversion and a diminished curiosity about the world outside the perfect place." These characteristics were reflected in NASA's less-than-stellar performance before and during the STS-107 mission (CAIB 118).

Chapter 6: Decision Making at NASA

A History of Foam Anomalies

The shedding of external tank foam—the physical cause of the *Columbia* accident—had a long history. Damage caused by debris has occurred on every space shuttle flight, and most missions have had insulating foam shed during ascent. This raises an obvious question: Why did NASA continue flying the shuttle with a known problem that violated design requirements? It would seem that the longer the shuttle program allowed debris to continue striking the orbiters, the more opportunity existed to detect the serious threat it posed. But this is not what happened (CAIB 121).

Original Design Requirements

Early in the space shuttle program, foam loss was considered a dangerous problem. Design engineers were extremely concerned about potential damage to the orbiter and its fragile thermal protection system, parts of which are so vulnerable to impacts that lightly pressing a thumbnail into them leaves a mark (CAIB 121).

Findings

Foam-shedding, which had initially raised serious safety concerns, evolved into "in-family" or "no-safety-of-flight" events or were deemed an "accepted risk" (CAIB 130).

NASA failed to adequately perform trend analysis on foam losses. This greatly hampered the agency's ability to make informed decisions about foam losses (CAIB 131).

Discovery and Initial Analysis of Debris Strike

In the course of examining film and video images of *Columbia*'s ascent, the Intercenter Photo Working Group identified, on the day after launch, a large debris strike to the leading edge of *Columbia*'s left wing. Alarmed at seeing so severe a hit so late in ascent, and at not having a clear view of damage the strike might have caused, Intercenter Photo Working Group members alerted senior program managers by phone and sent a digitized clip of the strike to hundreds of NASA personnel via e-mail. These actions initiated a contingency plan that brought together an interdisciplinary group of experts from NASA, Boeing, and the United Space Alliance to analyze the strike. So concerned were Intercenter Photo Working Group personnel that on the day they discovered the debris strike, they tapped their chair . . . to see through a request to image the left wing with Department of Defense assets in anticipation of analysts needing these images to better determine potential damage. By the board's count, this would be the first of three requests to secure imagery of *Columbia* on orbit during the 16-day mission (CAIB 166).

[Note: Thirty-two pages in Volume 1 are devoted to decision-making pertaining to analysis of the initial foam strike. Under the caption "Missed Opportunities," the report discusses eight situations whereby management personnel might have decided to arrange for the requested imagery. Comparable comments are also made in Chapter 2 concerning the absence of positive responses to requests of the Intercenter Photo Working Group and the Debris Assessment Team for the Department of Defense to photograph the orbiter's underside.]

Shuttle Program Management's Low Level of Concern

The opinions of shuttle program managers and debris and photo analysts on the potential severity of the debris strike diverged early in the mission and continued to diverge as the mission progressed, making it increasingly difficult for the Debris Assessment Team to have [its] concerns heard by those in a decision-making capacity. In the face of mission managers' low level of concern and desire to get on with the mission, Debris Assessment Team members had to prove unequivocally that a safety-of-flight issue existed before shuttle program management would move to obtain images of the left wing. The engineers found themselves in the unusual position of having to prove that the situation was unsafe—a reversal of the usual requirement to prove that a situation is safe (CAIB 169).

A Lack of Clear Communication

Communication did not flow effectively up to or down from program managers. As it became clear during the mission that managers were not as concerned as others about the danger of the foam strike, the ability of engineers to challenge those beliefs greatly diminished. Managers' tendency to accept opinions that agree with their own dams the flow of effective communications.

After the accident, program managers stated privately and publicly that if engineers had a safety concern, they were obligated to communicate their concerns to management. Managers did not seem to understand that as leaders they had a corresponding and perhaps greater obligation to create viable routes for the engineering community to express their views and receive information. This barrier to communications not only blocked the flow of information to managers, but it also prevented the downstream flow of information from managers to engineers, leaving Debris Assessment Team members no basis for understanding the reasoning behind Mission Management Team decisions (CAIB 169).

The Failure of Safety's Role

Safety personnel were present but passive and did not serve as a channel for the voicing of concerns or dissenting views. Safety representatives attended meetings of the Debris Assessment Team, Mission Evaluation Room and Mission Management Team, but were merely party to the analysis process and conclusions instead of an independent source of questions and challenges. Safety contractors in the Mission Evaluation Room were only marginally aware of the debris strike analysis (CAIB 170).

Summary

Management decisions made during *Columbia*'s final flight reflect missed opportunities, blocked or ineffective communications channels, flawed analysis, and ineffective leadership. Perhaps most striking is the fact that management—including shuttle program, mission management team, Mission Evaluation Room, and flight director and Mission Control—displayed no interest in understanding a problem and its implications. Because managers failed to avail themselves of the wide range of expertise and opinion necessary to achieve the best answer to the debris strike question . . . some space shuttle program managers failed to fulfill the implicit contract to do whatever is possible to ensure the safety of the crew (CAIB 170).

Chapter 7: The Accident's Organizational Causes

Organizational Cause Statement

The organizational causes of this accident are rooted in the space shuttle program's history and culture, including the original compromises that were required to gain approval for the shuttle program, subsequent years of resource constraints, fluctuating priorities, schedule pressures, mischaracterizations of the shuttle as operational rather than developmental, and lack of an agreed national vision. Cultural traits and organizational practices detrimental to safety and reliability were allowed to develop, including:

- reliance on past success as a substitute for sound engineering practices (such as testing to understand why systems were not performing in accordance with requirements/specifications)
- organizational barriers that prevented effective communication of critical safety information and stifled professional differences of opinion

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- lack of integrated management across program elements
- the evolution of an informal chain of command and decision-making processes that operated outside the organization's rules (CAIB 177)

Understanding Causes

In the board's view, NASA's organizational culture and structure had as much to do with this accident as the external tank foam.

Given that today's risks in human space flight are as high and the safety margins as razor-thin as they have ever been, there is little room for overconfidence. Yet the attitudes and decision-making of shuttle program managers and engineers during the events leading up to this accident were clearly overconfident and often bureaucratic in nature. They deferred to layered and cumbersome regulations rather than the fundamentals of safety.

As the board investigated the *Columbia* accident, it expected to find a vigorous safety organization, process, and culture at NASA bearing little resemblance to what the Rogers Commission identified. NASA's initial briefings to the board on its safety programs espoused a risk-averse philosophy that empowered any employee to stop an operation at the mere glimmer of a problem. Unfortunately, NASA's views of its safety culture in those briefings did not reflect reality (CAIB 177).

The silence of program-level safety processes undermined oversight; when they did not speak up, safety personnel could not fulfill their stated mission to provide "checks and balances." A pattern of acceptance prevailed throughout the organization that tolerated foam problems without sufficient engineering justification for doing so (CAIB 178).

Chapter 8: History As Cause: *Columbia* and *Challenger*

Echoes of *Challenger*

The constraints under which the agency has operated throughout the shuttle program have contributed to both shuttle accidents. Although NASA leaders have played an important role, these constraints were not entirely of NASA's own making. The White House and Congress must recognize the role of their decisions in this accident and take responsibility for safety in the future (CAIB 195-196).

Failures of Foresight: Two Decision Histories and the Normalization of Deviance

NASA documents show how official classifications of risk were downgraded over time. Program managers designated the foam problem and the O-ring erosion as "acceptable risks" in flight readiness reviews (CAIB 196).

System Effects: The Effect of History and Politics on Risky Work

The board found that dangerous aspects of NASA's 1986 culture, identified by the Rogers Commission, remained unchanged (CAIB 198).

Pre-*Challenger* budget shortages resulted in safety personnel cutbacks. Without clout or independence, the safety personnel who remained were ineffective. In the case of *Columbia*, the board found the same problems were reproduced and for an identical reason: When pressed for cost reduction, NASA attacked its own safety system. The faulty assumption that supported this strategy prior to *Columbia* was that a reduction in safety staff would not result in a reduction of safety because contractors would assume greater safety responsibility. Post-*Challenger* NASA still had no systematic procedure for identifying and monitoring trends (CAIB 198-199).

Organization, Culture, and Unintended Consequences

At the same time that NASA leaders were emphasizing the importance of safety, their personnel cutbacks sent other signals. Streamlining and downsizing, which scarcely go unnoticed by employees, convey a message that efficiency is an important goal. The shuttle/space station partnership affected both programs. Working evenings and weekends just to meet the International Space Station Node 2 deadline sent a signal to employees that schedule is important. When paired with the "faster, better, cheaper" NASA motto of the 1990s and cuts that dramatically decreased safety personnel, efficiency becomes a strong signal and safety a weak one. This kind of doublespeak by top administrators affects people's decisions and actions without them even realizing it (CAIB 199).

History as a Cause: Two Accidents

The organizational structure and hierarchy blocked effective communication of technical problems. Signals were overlooked, people were silenced, and useful information and dissenting views on technical issues did not surface at higher levels. What was communicated to parts of the organization was that O-ring erosion and foam debris were not problems (CAIB 201).

NASA's safety system lacked resources, independence, personnel, and authority to successfully apply alternative perspectives to developing problems. Overlapping roles and responsibilities across multiple safety offices also undermined the possibility of a reliable system of checks and balances (CAIB 202).

Changing NASA's Organizational System

Leaders create culture. It is their responsibility to change it. Top administrators must take responsibility for risk, failure, and safety by remaining alert to the effects their decisions have on the system. Leaders are responsible for establishing the conditions that lead to their subordinates' successes or failures. The past decisions of national leaders—the White House, Congress, and NASA headquarters—set the *Columbia* accident in motion by creating resource and schedule strains that compromised the principles of a high-risk technology organization (203).

Part 3: Discussion Guide

An SH&E professional will need both considerable tact and diplomacy to convince management to review the history of safety decision-making in order to determine whether, over time, latent technical conditions and operating practices have accumulated, which could be the causal factors for a major accident. To generate interest in such a review, the author recommends that SH&E professionals send this article up through the organizational chain.

To facilitate such a review, it would be valuable to develop an outline of subjects to be discussed. An initial outline follows. It pertains specifically and only to the content of the CAIB report and, therefore, is not complete. However, it can serve as a framework for developing a discussion outline suitable to a particular operation.

1. How does management view its safety culture? How does management's view compare with the perception of employees? Does senior management's view of the safety culture reflect reality?
2. Does a gap exist between what management says and what management does?
3. Has the staff reporting directly to the senior manager been held accountable, in reality, for a high level of safety decision-making?
4. Does the organization's culture gradually accept escalating risk?
5. Does the organizational structure enhance safety decision-making?
6. Do organizational barriers prevent effective communication on safety, up and down?

7. Have streamlining and downsizing conveyed a message that efficiency and being on schedule are paramount, and that safety considerations can be overlooked? Does this result in "doublespeak" by management?
8. Are technical and operational safety standards at a sufficiently high level?
9. Has it been the practice to accept performance at a lesser level than that prescribed in technical and operational standards?
10. Have known safety problems, over time, been relegated to a less-than-adequate status and, thereby, become "accepted risk"?
11. Have safety-related hardware and software become obsolete?
12. Are certain operations continued with the knowledge they are unduly hazardous?
13. Have budget constraints had a negative effect on safety decision-making?
14. Has inadequate maintenance resulted in an accumulation of hazardous situations that have gone unattended? For example, is detection equipment adequate, maintained and operable; are basic repairs to structures and equipment awaiting action?
15. For the opportunity to apply early interventions, has adequate attention been paid to near-hit incidents that could, under other circumstances, result in a major accident?
16. Are SH&E personnel encouraged to be tactfully aggressive when expressing their views on hazards and risks, even though their views may differ from those held by others?
17. Has it been acceptable that accident investigation stops at the first identifiable causal factor (referred to in the *Columbia* report as "the immediate technical flaw or individual failure")? Or, are accidents investigated in depth to identify the real root-cause factors so that appropriate safety interventions can be applied?
18. Has the firm relied too heavily on outside contractors (outsourcing) to do what they cannot do effectively with respect to safety?
19. Are purchasing and contracting procedures in place at a level to ensure that hazards are not introduced to the workplace?

Responses to these questions would be evaluative. What resources might an SH&E practitioner use to determine the related best practices? These publications (all available through ASSE) are a starting point:

- *Accident Investigation Techniques: Basic Theories, Analytical Methods and Applications* by Jeffrey S. Oakley.
- *Analyzing Safety System Effectiveness, Third Edition* by Dan Petersen.
- *Innovations in Safety Management: Addressing Career Knowledge Needs* by Fred A. Manuele.
- *Managing for World Class Safety* by J.M. Stewart.
- *On the Practice of Safety, Third Edition* by Fred A. Manuele.
- *Safety Engineering, Third Edition* by Richard T. Boehm.

Safety management systems do not often include provisions for identifying and minimizing the potential for major accidents. It seems that there is opportunity here for the enterprising. ■

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Highly Effective Loss Reduction Strategies for Workers Compensation

by James J. Moore, ChFC, AIC

Editor's Note: This article is excerpted from "Keys to Cutting Your Workers' Comp Costs."

■ **James J. Moore, ChFC, AIC,** is president of J&L Insurance Consultants, Inc., a workers compensation premium and reserve consulting firm (www.cutcompcosts.com) whose mission is to reduce employers' WC premiums by using time-tested techniques.

Moore has more than 20 years of experience in insurance claims and underwriting, specializing in WC. He has adjusted, supervised, and managed the administration of WC claims in 20 different states. His work experience includes being the director of risk management for the North Carolina School Boards Association. He created a very successful WC Rehabilitation Unit for school personnel in North Carolina.

Moore's educational background, which centered on computer technology, culminated in earning a master's of business administration (MBA), and an Associate in Claims designation (AIC). He is a Chartered Financial Consultant (ChFC) and a licensed financial advisor. He has been certified as an insurance instructor by the North Carolina Department of Insurance.

He is affiliated with a number of civic, business, and insurance/risk management organizations and associations. Moore is on the Board of Directors of the North Carolina Mid-State Safety Council. He has published a manual on WC, three different claims processing manuals, and has been quoted in various articles on reducing WC costs for public and private employers.

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WC Supplements

One of the most popular subjects in workers compensation (WC) is employer supplements. This subject seems to come up in risk management meetings and seminars very often.

Supplements involve the employer offsetting the reduction in pay an employee allegedly experiences when he or she is on WC benefits.

The first area concerning supplements is the waiting period. This is usually the first three to seven days that the employee is out of work. The waiting period is not paid until the employee has been out of work for a certain amount of days. For example, the first seven calendar days may not be payable until an employee is out of work for more than 21 days.

The main reason for a waiting period is to encourage the employee to rapidly return to work. If the employer pays the first week of benefits, this built-in encouragement is eliminated.

The basic function of WC benefits (as with most insurance) is to make the employee "whole again." Most states require the WC insurer to pay two-thirds of the employees' average weekly wage subject to a maximum. The benefits are paid *tax free*. In Table 1, the employee is receiving $600 per week as an average weekly wage. The WC weekly benefit rate is $400. The employer has decided to provide a supplement of $200 (taxed) per week to raise the employee's wages back to his or her pre-injury wage. The after-tax rate of the supplement is $135. When added to the WC weekly benefit rate, the employee is receiving $535 tax free. Converting the employee's pay back to a taxed rate, the employee is now receiving $750 per week taxed. The employee is now receiving a larger pay rate without having to work.

The employee has little or no motivation to return to work (RTW). The WC supplement has eliminated the employee's motivation to return to work. I recommend the avoidance of providing WC supplements for this very reason.

The Four Secrets of Saving WC Dollars

I have been asked so many times what I would consider the main cost-saving measures an employer can put into place to save WC dollars. The following four secrets have been compiled after having claims experience as an adjuster, supervisor, and director of risk management in 20 different states. The four secrets will work with little modification in almost any state. The four secrets make the adjuster's job much easier with your WC claims. Any time an adjuster's job has been made easier, the reserve levels will be lower.

Table 1
Employee's Loss of Earnings(?!)

Employee is restored to pre-injury wage:

• .6667 of pre-injury wage	(tax free)
• pre-injury wage	$600 week (taxed)
• comp rate	$400 week (tax free)
• employer supplement	$200 week (taxed) $135 week (tax free)
• employee receives	$535 week (tax free) $750 week (taxed)

Where is the motivation to return to work?

1. ASAP First Reports—The adjuster cannot begin investigation into a WC incident without the First Report of Injury (FROI). Studies have shown a delayed FROI will usually cause much higher payouts on a claim. If an insurer has an online claims reporting service, report all injuries online. If online reporting in unavailable, e-mail the FROIs to your insurer. If your insurer does not provide emailing FROIs, at least fax them as soon as possible. The use of snail mail delays the receipt of the FROI and goes into the enormous piles of mail an adjuster receives daily. The bottom line is getting the FROI in front of the adjuster. Call the adjuster within one business day of reporting the claim online, by e-mail, or fax to verify the claim was received and to determine if there were any extenuating or questionable circumstances about the claim.

2. Doctor Network—*This is the most critical part of any WC claim without question.* One very important point to remember is the industrial boards and commissions in each state that oversee WC claims consider the medical providers, especially the treating physician, *as the only impartial parties/witnesses in the WC claim.* Some states require that a medical panel be available to all employees so that all employees have immediate and proper medical care. All employers in all states should have a panel of physicians. Some states allow employers to choose medical providers for their employees, while others allow the employees to choose their own physician. However, studies have shown that employees in states that allow the employee to choose the physician will usually attend the paneled physician.

   The treating physician makes the determination of what medical costs will be incurred, the length of time the employee is out of work, and if the employee has any permanent disability. A good industrial-minded physician in the local area is very important to your WC program. I recommend a walk-in clinic or an urgent-care clinic to initially treat all injuries. A large number of WC urgent-care centers are cropping up around the United States. The most important physicians for the more serious injuries are the level-two physicians. These physicians are usually surgeons (orthopedic, neurosurgeon, etc). The level-one physicians should know who your preferred level-two physicians are before a referral is made. If an injury is very serious, the employee should be taken to the emergency room at the nearest hospital. It behooves the employer to know the nearest industrial-minded orthopedists, neurologists, orthopedic surgeons, and neurologists in the general area (within 150 miles). The physician network often has to be expanded beyond the local area due to availability of medical providers.

3. Return-to-Work Program—All the medical providers should know that you have a return-to-work program in place. This is another critical area to reduce your WC costs. Recently, one of our clients reduced its experience modification factor from 1.6 to 1.1 in two years by initiating a RTW program. The medical providers will return an employee to work much faster if they know you will reasonably accommodate a light-duty RTW. The employees should know that you have a RTW program in place. The employees should be expected to tell the medical providers that the employer has an RTW program in place.

4. Employee Treatment—I added this area after the original three, as it has become a critical area in saving on WC. With the legal environment in place as it is today in most states, the treatment of the employee post-injury has taken on more of a monetary component. Only 3 percent of claims starts out as fraudulent, but more than 30 percent have some element of fraud by the conclusion of the claim. Poor treatment by the employer is the usual cause for an employee to seek legal help. Electronic cards are a wonderful and free or almost free way to send employees a card after their injury. Most people now have some type of e-mail address. If not, then a card in the mail will usually help the employee stay out of the legal system. Calling the employee after each doctor appointment lets the employee know you care and is a great way to keep up with the status of a claim.

A statistical study that I conducted on more than 7,000 claims concluded that *not* initiating these four secrets resulted in an increase of 800 percent in claims costs compared to companies that had put them in place. ■

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