
# Safety Cultures and Accident Investigation: Lessons Learned from a National Transportation Safety Board Forum

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## Abstract

A safety culture, as part of safety promotion, is recognized as one of the four pillars in the common model of a safety management system (SMS) and must exist in State aviation organizations and product and service provider organizations for safety management to be effective. Safety culture has been defined as, "the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management."[1] Given the perceived importance of developing and implementing a "good" safety culture to safe operational practices, and thus to SMS, the International Civil Aviation Organization (ICAO) Safety Management Manual characterizes a "healthy" safety culture as one that actively seeks improvements, remains vigilantly aware of hazards and utilizes systems and tools for continuous monitoring, analysis and investigation, all concepts that are integral to effective SMS programs. Despite the widespread acceptance of the need to develop an effective safety culture and implement safety management frameworks in transportation, accident investigations, including those by the NTSB, continue to reveal safety culture deficiencies in the practices of companies whose accidents the NTSB has investigated.

In September 2013, the NTSB convened a two-day public forum that brought together researchers, operators, and regulators to discuss their real-world experiences with trying to study, manage, and enhance safety culture. Forum participants gave firsthand accounts of implementing SMS programs, and associated programs like operations monitoring and voluntary reporting. Participants also discussed the role of operators and regulators in promoting safety culture. This paper describes lessons learned from the recent NTSB safety culture forum, as well as implications for investigating organizational safety issues during an accident or incident investigation.

## Introduction

The NTSB generally conducts public forums to focus attention or open a dialogue on safety issues of considerable importance. In September 2013 the NTSB convened a two-day forum on safety culture efforts in transportation, a forum that included presentations from 24 researchers, operators, and government agencies with expertise in the development and assessment of safety cultures across all modes of transportation, and other industries in which safety culture is an accepted concept. Although there is no universally accepted definition of safety culture, one researcher, quoting from an earlier work, defined it as, "the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management."[1]

Forum participants gave firsthand accounts of implementing SMS programs, and associated activities like operations monitoring and voluntary reporting systems. Participants also discussed the role of operators and regulators in promoting safety culture. The overall topics addressed included:

- Research and practitioner findings regarding current safety culture state of the art and suggested future steps needed to advance safety culture
- Attributes and characteristics associated with effective safety culture development programs and their integration and measurement within organizations (in both transportation and non-transportation industries).
- Current and suggested future goals for government to develop, maintain, and enhance safety culture within the transportation industry.

Additionally, the NTSB sought insight on how to fully investigate safety culture and whether current investigative techniques are adequate.

**Background**

Like other investigation organizations, the NTSB and its predecessor, the Civil Aeronautics Board (CAB), have been investigating the role of organizations' contributions to transportation accidents and incidents for more than 50 years. For example, a CAB investigation of a fatal accident involving a Douglas DC-3 in April 1962 cited both the pilot's failure to maintain airspeed on takeoff, and his poor judgment as causal to the crash. The investigation also addressed the actions of a company supervisor in knowingly dispatching an aircraft with an unqualified crew in order to complete a post-maintenance test flight.[2]

The concepts of organizational culture and climate became topics of safety research in the 1970s and 1980s—although most research into safety culture was conducted in settings that were not specific to transportation. For example, research conducted by the then newly-formed National Institute for Occupational Safety and Health (NIOSH) demonstrated the link between an organization's safety programs and its accident rate,[3] while other research attempted to define and measure elements of an organization's safety climate.[4] The British judicial inquest into the March 6, 1987, accident involving the ferry, *Herald of Free Enterprise*, which sank off the coast of Belgium with a loss of 193 passengers and crew, highlighted the role of organizations in the cause of transportation accidents.[5] The 1990 publication of Dr. James Reason's book, *Human Error*, increased attention to the role that organizations can play in errors of operators that result in accidents in safety-critical systems.[6]

In April 1997, following a series of accident investigations that identified organizational failures,[7] the NTSB convened a symposium on *Corporate Culture and Transportation Safety.* The symposium addressed all modes of transportation and included presentations by academic researchers, operators, and industry representatives. The symposium attracted numerous participants from the aviation, railroad, marine, highway, pipeline, and hazardous material industries and led to increased knowledge within the transportation industry of the role of companies in the safety of the operations they conduct. In addition, NTSB investigators used information gathered during this symposium to refine data they collected during an accident investigation and the analysis of those data to describe the organization's culture preceding an accident.

In the 15 years since the NTSB conducted its symposium on corporate culture, there have been notable advances in the recognition of the value of safety culture to the safety of operations in numerous high-risk industries. The importance of safety culture is now routinely discussed

across all modes of transportation. Many of the operating agencies of the U.S. Department of Transportation and modal industry groups now publish resources related to the role of safety culture in preventing accidents and injuries.[8] In aviation, safety culture has been recognized as an integral part of safety management in an organization. As noted, ICAO has endorsed the concept of safety culture and within the four areas in its SMS model (policy, risk management, safety assurance, and promotion), has specifically identified safety culture as part of promotion.

In accordance with Reason's model equating safety culture to an informed culture,[9] a variety of safety analysis and reporting systems and initiatives have been implemented in the aviation industry as a way to enhance operational safety. For example, hazard detection and analysis programs like Flight Operational Quality Assurance (FOQA)[10] use data from recorders onboard aircraft to monitor trends in operations and identify possible safety concerns, and non-punitive self-reporting programs like Aviation Safety Action Programs (ASAP)[11] allow individuals to report safety concerns without fear of disciplinary or enforcement action. These programs are in turn integral to the development of SMSs by transportation operators and service providers. Safety culture and SMS are interdependent, with a positive safety culture helping ensure that an SMS works in practice, and an effective SMS enabling a positive safety culture.[12] Further, variations of these practices have been implemented in other transportation industries as well. The 2013 forum revealed that some marine companies have implemented BOQA (Boat Operational Quality Assurance) to enhance the safety of their operations, also by proactively reading out and analyzing data from onboard vehicle data recorders.

International transportation authorities have promoted safety management efforts, or have taken an active role in providing safety culture guidance and oversight. For example, in an attempt to enhance the application of safety cultures in maritime organizations after the *Herald of Free Enterprise* accident, the International Maritime Organization (IMO) required internationally operating vessels to implement SMS.[13,14] As noted, ICAO produced a Safety Management Manual to describe, in detail, the elements of an effective safety culture and provide guidance for implementing effective safety management frameworks.[15] Before 2013, Annexes 1, 6, 8, 13, and 14 to the Chicago Convention included standards and recommended practices for all States to establish regulations requiring SMS for aviation operators and service providers, and since November, 2013 the new Annex 19 consolidates those standards and recommended practices for safety management by the States.

**Safety Culture and Investigations**

As accident investigators, we are charged with determining the facts and circumstances of accidents and incidents, and the factors that caused and contributed to them. Once determined, we must identify recommendations to prevent those accidents and incidents from reoccurring. Since safety culture has grown in prominence, it has become more of an issue during our investigations; however, investigating safety culture is not entirely straight-forward like investigating mechanical or regulatory issues are.

Despite being a common term, safety culture can be hard to define and even harder to measure. This can be seen in Dr. James Reason's opening presentation to the NTSB symposium

on corporate culture in 1997, where he observed that "few phrases are so widely used yet so hard to define as 'safety culture.'"[16] Dr. Reason's observation is as true today as it was then.

Many operators have avoided these academic concerns about defining or measuring safety culture and took a more pragmatic approach by implementing specific techniques that they believed, or others have demonstrated, can enhance operational safety. Consequently, rather than focusing on defining safety culture or the difficulties of measuring it, organizations that participated in the 2013 NTSB safety culture forum focused on the safety benefits derived from techniques they have implemented to enhance safety. Company representatives cited measures they implemented related to organizational communication and management structure, personnel selection and training, reporting and monitoring systems, risk management systems, and external reviews and audits; all of which are elements of an SMS and techniques that are typically cited as indicative of an effective safety culture.

In addition to discussing various efforts to improve organizational safety, participants in the NTSB safety culture forum were asked about techniques to investigate safety culture and organizational safety issues as part of an accident investigation. Forum presenters were quick to acknowledge the difficulties of assessing safety culture in an investigation. The researchers acknowledged the absence of both a universally accepted definition of safety culture and a commonly accepted measure of the effectiveness of an organization's safety culture. Safety attitudes and beliefs are typically assessed using questionnaires,[17] but after an accident, attitudes and opinions will no doubt be affected by the experience of the accident itself, and the results of any such attempts to measure safety culture could therefore easily be misleading. As Dr. John Carroll, professor of Organization Studies and Engineering Systems at the Massachusetts Institute of Technology's Sloan School of Management said in the NTSB forum, "there are difficulties with measuring the things that are easy to measure but may be of uncertain meaning."[18]

Investigators should be particularly cautious about attempting to assess safety culture after an organization has experienced an accident or incident. For example, Dr. Reason warns[19] of biases that will lead to overly negative assessments when investigating organizational factors after an accident, such as hindsight bias that can lead investigators to emphasize facts that an operator should have known or understood before an accident, but based on information that investigators learned after the event. Outcome bias may lead investigators to interpret pre-accident decisions as being inappropriate or unsafe. Finally, we may incorrectly conclude that deficiencies in organizational policies and procedures were causal to an accident when in fact they may just have been examples of imperfections that could be present in any similar operator. In the wake of an accident, an operator that was previously considered to have a good safety record can now be thought of having as a deficient safety culture, due to the evidence identified in an investigation.

Further, even if the safety culture of an organization that was in place before an accident can be objectively measured after that organization has experienced an accident, other difficulties emerge. Dr. Andrew Hopkins, author of several books on the organizational and cultural causes of major accidents, has argued that focusing on the way employees think and feel about safety is not very effective in any event. At worst, he warns that this may lead to a new

version of a blame-the-worker mentality, where we are led to believe that if only the persons or organization involved in the accident had thought differently or cared more about safety, the accident would not have happened. Hopkins suggests that a more effective approach to enhance safety would be to focus on a basic definition that is often offered for safety culture, "the way we do things around here." In other words, the focus should be on what people and organizations do rather what they think.[20]

Thus, as investigators, efforts to directly assess the quality of a company's safety culture may not provide an objective understanding of the actions a company took or decisions it made that led up to an accident. Following up on Hopkins, we suggest that, investigators document what people and organizations did or did not do before an accident, and then make recommendations about what they should or should not do to prevent future accidents. Organizational leaders can establish policies and procedures and set an example for their employees to follow. From this perspective of focusing on actions rather than thoughts, an effective safety culture does not need to be precisely defined or accurately measured as part of an accident investigation protocol.

Regulators can require operators to establish procedures and take certain actions, and then enforce those requirements. However, the role of the regulators in enhancing safety culture may be limited. NTSB forum participants were asked what an investigative authority or regulator can do to encourage an effective safety culture when problems are identified in the operations they oversee. Researchers and company representatives suggested that culture cannot be effectively regulated. For example, Dr. Gudela Grote, professor of Work and Organizational Psychology at the Swiss Federal Institute of Technology in Zurich, Switzerland, acknowledged that within any regulatory regime there will be elements of prescriptive regulation, but urged that the focus of regulation and oversight should be on safety management rather than culture.

> Hopefully, whatever we all do in any role that we have is to help people to control operations, to know what the right thing to do is and then to do it. And I would say regulators should guide companies in achieving that by working on safety management, and within those decisions on what does it actually take for good safety management… that would be much more of a contribution overall to safety than trying to define, monitor and enhance an organization's safety culture.[21]

Dr. Carroll offered a similar concern, stating that,

> [Safety culture] shouldn't be considered as kind of a gross generalization of something but rather that there are particular specifics involved that are important, and I think the focus of your reports rightly start off with what are the behaviors? What's the chain of events and what are some of the organizational precursors that led up to that?

and

> Investigations need to start with as clear an understanding of the behaviors and who and what created those behaviors as we can have. [22]

By focusing on company actions rather than employee "hearts and minds," the elements of an SMS can serve as a guide for investigators to examine the organizational factors that may

have contributed to an accident or incident by documenting company policies, procedures, oversight, and management of safety hazards. By examining actual company performance and documented policy, and reviewing the programs and procedures for safety risk management and safety assurance functions, a thorough investigation would document how well the operator managed the safety of its operations. Further, by examining employee selection and training records, and interviewing employees at various levels of the organization as appropriate, investigators can document the organizational actions that may have affected employee behaviors regarding safety. In this way, an investigation can collect objective evidence of otherwise subjective issues like social pressure or *just culture* concerns.

**Investigation Example**

To illustrate this approach, consider the example of an experimental Gulfstream G650 that crashed during takeoff from Runway 21 at Roswell International Air Center Airport, Roswell, New Mexico on April 2, 2011.[23] All four crew, including two pilots and two flight test engineers, were fatally injured. The accident occurred during a one-engine inoperative continued takeoff test. During the attempted takeoff, a stall occurred. The right wingtip contacted the ground and the airplane departed the side of the runway where it impacted a concrete structure and experienced a post-crash fire. During the investigation, the NTSB identified several deficiencies in Gulfstream's management of its flight test program.

In the area of technical planning and oversight, Gulfstream did not effectively separate and distribute the workload of the flight test engineers during the field performance flight test program. As a result, data from previous tests were not used to refine speeds before testing progressed. Additionally, program managers did not establish adequate controls to ensure that prerequisite tasks were completed before testing progressed, nor did they ensure that effective validation processes such as dynamic simulations were used to ensure the accuracy of takeoff speed calculations.

Gulfstream had established an ambitious schedule for the flight test program, but the program experienced frequent delays resulting in unachievable deadlines. They also lacked an organizational process for technical and safety oversight that could mitigate the effects of schedule pressure, reduce the likelihood of errors, and identify and correct errors. Gulfstream admitted that the schedule might have contributed to "a reluctance to challenge key assumptions and highlight anomalous airplane behavior during tests."

Gulfstream had established an FAA-accepted flight test risk assessment program for evaluating and minimizing risk during certification testing. However, this program had not identified low altitude stall or uncommanded roll as potential hazards for continued takeoff testing. Additionally, the company's safety program was lacking in the area of safety assurance. This deficiency played a significant role in the inadequate investigation and reporting of two previous takeoff stall events. Gulfstream did not have adequate policies and procedures in place so that these and other anomalous events would be formally reported and analyzed.

Based on the investigation, the NTSB determined that the probable cause of the accident was an aerodynamic stall and subsequent uncommanded roll during a one-engine inoperative

takeoff test, which were the result of: (1) Gulfstream's failure to properly develop and validate takeoff speeds for the flight test, and recognize and correct the takeoff safety speed, or V2, error during previous G650 flight tests; (2) the G650 flight test team's persistent and increasingly aggressive attempts to achieve V2 speeds that were erroneously low; and (3) Gulfstream's inadequate investigation of previous G650 uncommanded roll events which indicated that the company's estimated stall angle of attack while the airplane was in ground effect was too high.

Contributing to the accident was Gulfstream's failure to effectively manage the G650 flight test program by pursuing an aggressive program schedule without ensuring that the roles and responsibilities of team members had been appropriately defined and implemented, engineering processes had received sufficient technical planning and oversight, potential hazards had been fully identified, and appropriate risk controls had been implemented and were functioning as intended.

As a result of this investigation, the NTSB issued two recommendations to Gulfstream. The first recommendation asked Gulfstream to commission an audit by independent safety experts to evaluate the status of the company's safety management program and address any areas of concern. The second recommendation asked Gulfstream to share the lessons learned from the audit with aircraft manufacturers and flight test industry groups. In response to the accident report, Gulfstream stated that it accepted "full responsibility" for the accident and implemented corrective actions to preclude such an accident from reoccurring. One of these actions was to integrate SMS principles and practices into the company's flight test operations.

The safety outcome of this investigation could have been different. An alternative approach could have been to simply label the operator, Gulfstream, as being subpar and having a defective safety culture. This method would have left the operator without a clear road map of what actions to take in order to safely improve their operations.

As Dr. Grote observed during the forum, it is possible to identify,

> everything that needs to be changed in the organization without ever using the word culture or safety culture, and I think without making any attempt of trying to measure it. I think that is perfectly fine because obviously you can point to the weaknesses without actually pointing to culture.[24]

**Summary**

These are not new issues; accident investigators have been examining organizational factors in accidents and incidents for many years. But our investigations must keep pace as the international aviation community continues to integrate the SMSs of operators and service providers into state safety programs and a global safety plan. With regards to safety culture, our investigations must document organizational conditions and influences while taking care to avoid potential biases and counterfactual fallacies that may lead to evaluating any accident or incident as evidence of a deficient safety culture.

Consistent with accident investigation methodology, the approach to investigating safety culture issues must be structured, repeatable, and focused on the objective indications of what are otherwise subjective issues. By thoroughly examining an organization's performance on measurable safety management functions, accident and incident investigations can document safety culture concerns while avoiding difficulties of definitions or measurement. Further, this approach can provide support for concrete recommended actions to mitigate any safety issues without attempting to regulate thoughts and attitudes.

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