Alaska Airlines Flight 261: Understanding the Systemic Contributors to Organizational Accidents

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Introduction

On January 31, 2000, at approximately 16:21 Pacific Standard Time, Alaska Airlines Flight 261 crashed into the Pacific Ocean off the California coast just west of Los Angeles. The crash killed all 88 passengers and crew members onboard. After an extensive investigation by the National Transportation Safety Board (NTSB), the cause of the accident was attributed to a failed jackscrew assembly controlling the horizontal stabilizer in the tail section of the airplane. This caused the plane to pitch nose-down, rendering it completely uncontrollable once the jackscrew failed.

Factors leading to the crash of Alaska Airlines Flight 261 uncovered in the NTSB report included Federal Aviation Administration (FAA)-approved lengthened inspection intervals; the use of unapproved tools and methods of measurement for checking the jackscrew assembly and assessing it for wear (endplay check); falsifying maintenance reports to show work had been completed when none took place; receiving approval for maintenance manual and procedural changes without consent from the FAA, director of base maintenance, or the director of maintenance planning and production control; and various interpretations by mechanics at different repair/inspection facilities without regards to proper inspection procedures of the jackscrew assembly.

We will analyze this crash, utilizing principles and organizational theories described by Reason (1997) which focus not on the technical failure of the mechanical components, but on the roles played by the human influence from upper management of Alaska Airlines and the FAA down to the culture of the maintenance crew involved. This analysis paints a clear picture of how minimal importance was given to safety in this organization and how unmonitored practices eventually breached the well-intentioned, but unjustifiably neglected, systemic defenses in place.

We summarize that the root cause of Flight 261's tragic end was not the failure of the jackscrew assembly, but rather the cumulative effect of both economic and organizational pressures acting on all levels of Alaska Airline's organizational hierarchy. We further propose that the true value of the lessons learned from Flight 261 lies in the importance of taking a comprehensive, systems perspective of organizational risks. Finally, we cite the Tripod-Delta Model as an example of a systems-based risk mitigation tool, though we also note that the need remains for more advanced tools capable of systematically mitigating core organizational risks identified.

Alaska Airlines Flight 261 departed from Puerto Vallarta, Mexico at 1:37pm on January 31, 2000. Two hours and forty-four minutes later it would crash into the ocean off the coast of California just west of Los Angeles. Following the crash, the National Transportation Safety Board (NTSB) traversed through standard protocol: examining the wreckage, interviewing maintenance crewmembers, pilots, and executives from Alaska Airlines, the FAA, and even NASA; and determined the cause of the accident to be "a loss of airplane pitch control resulting from the in-flight failure of the horizontal stabilizer trim system jackscrew assembly's acme nut threads."

While this approach provided a tangible error able to be remedied with additional, stringent regulations and standards, it focused attention solely on maintenance practices and standards; effectively placing the majority of the blame on lubrication intervals rather than considering the underlying, systemic contributors to the tragedy.

Case Overview

On January 31, 2000, Alaska Airlines' Flight 261, an international passenger flight traveling from Diaz Ordaz International Airport (PVR) in Puerto Vallarta, Mexico to Seattle-Tacoma International Airport (SEA) in Seattle, Washington was to transport a total of eighty-eight passengers and crew to their destinations on a McDonnell Douglas MD-83 aircraft. The flight departed PVR at 13:37 Pacific Standard Time (PST) en route to its scheduled stopover at San Francisco International. At approximately 15:49 PST, the captain of Flight 261 contacted Air Traffic Control (ATC) at SEA requesting permission to divert the flight to Los Angeles International Airport (LAX) due to a jammed horizontal stabilizer. At 15:57 PST, the captain deemed landing at LAX absolutely critical due to weather

and flight conditions. The captain then relayed his decision to ATC at SEA and requested an open channel to LAX ATC.

En route to LAX, at 16:07 PST, the flight crew began discussions with a LAX Alaska Airlines maintenance worker. A series of maintenance checks on the horizontal stabilizer and primary trim motor electric circuit breakers were performed during the five-minute conversation between the LAX Alaska Airlines maintenance worker and the flight crew. During these checks, unfamiliar noises were heard emanating from the aircraft. Shortly thereafter, the plane plummeted from an altitude of approximately thirty-one thousand feet to twenty-four thousand. The captain notified the maintenance worker of the aircraft's rapid altitude decent immediately after stabilizing the plane. Unable to explain what was causing the unusual noises, the maintenance worker suggested that the flight crew perform the same troubleshooting checklist for the horizontal stabilizer and primary trim motor circuit breaker at their own discretion.

The flight crew did not adhere to this request due to flight conditions encountered from the previous checks. Shortly thereafter, at 16:15, one of the flight crew members contacted a Los Angeles Air Route Traffic Control Center (ARTCC) controller requesting a descent altitude for preparatory maneuvers for landing. The ARTCC controller granted them an altitude of seventeen thousand feet and directed the flight crew to another ARTCC controller.

After receiving a new block altitude, heading, and frequency at 16:17, the last contact was made between an outside agent and the flight crew. In an attempt to slow the airplane and decrease altitude, the plane pitched nose-down and rolled over 180°. The captain and first officer tried in vain to right the plane, but their efforts failed. Flight 261 crashed January 31, 2000 at approximately 16:21 in the Pacific Ocean, 2.7 miles north of the Anacapa Islands, California. An investigation by the National Transportation Safety Board (NTSB) would later find the accident resulted from a failed jackscrew assembly controlling the horizontal stabilizer (see Figure 1).

During the period before the crash, the official industry documentation maintenance procedure was the Maintenance Steering Group 2 and 3 (MSG-2, MSG-3). The MSG-3 document contained decision logic and procedures for use in maintenance and inspection programs which coincided with the Federal Aviation Administration (FAA) requirements. The MSG-3 document was created to reduce the complexity of understanding the MSG-2 document and provide clear and concise guidelines on how to interpret the maintenance process outline. The decision logic behind MSG-3 is the cascading failure approach; better known as a "consequence of failure approach."

In 1985, Alaska Airlines released its own maintenance procedures in compliance with the guidelines in both the MSG-2 and MSG-3, but with stricter requirements. This document was known as the Alaska Airlines' Continuous Airworthy Maintenance Program and was approved by the FAA. This document listed time intervals stating when routine scheduled inspection and maintenance intervals on the planes shall be done. As years passed, Alaska Airlines adjusted this document without notifying the FAA in an effort to improve performance; focusing on meeting self-appointed criteria rather than the industry standards (see Table 1 for the chronological adjustments made to of Alaska Airlines' lubrication intervals).

Figure 1. Jackscrew from Flight 261 Horizontal Stabilizer (NTSB)

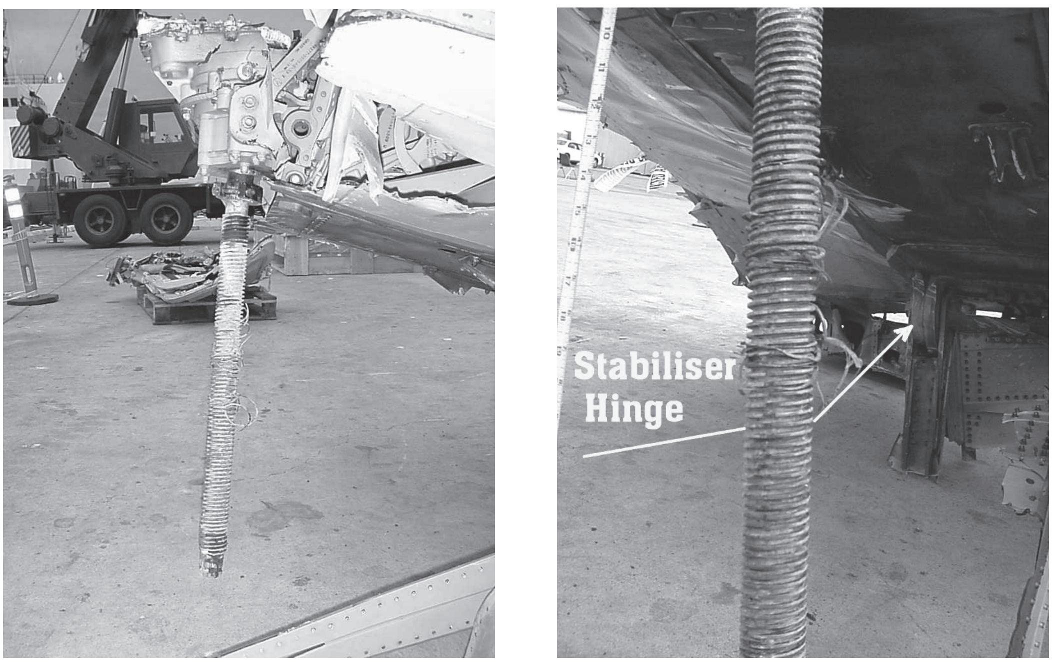


Table 1. Comparison of Jackscrew Assembly Lubrication Intervals (NTSB 2002)

MSG-2 MRB	MSG-2 OAMP	MSG-3 MRB	MSG-3 OAMP
Not included in logic diagram	600 to 900 flight hours	C check	C check
		(3,600 flight hours or 15 months, whichever comes first)	(3,600 flight hours)

Alaska Airlines 1985	*Alaska Airlines 1987*	*Alaska Airlines 1988*	*Alaska Airlines 1991*	*Alaska Airlines 1994*	*Alaska Airlines 1996 to April 2000*	*Alaska Airlines April 2000 to Present*[a]
Every other B check	B check	Every eighth A check	Every eighth A check	Every eighth A check	Time-controlled task card - 8 months maximum	650 flight hours
(700 flight hours)	(500 flight hours)	(1,000 flight hours)	(1,200 flight hours)	(1,600 flight hours)	(About 2,550 flight hours)	

a. All carriers currently meet this requirement

The National Transportation Safety Board's Investigation Report uncovered a vast array of maintenance red flags prior to the crash of Flight 261. It was this lack of proper maintenance, extended intervals between inspections, and possible missed lubrication intervals due to falsified work reports that led the NTSB to conclude the accident was the result of a waterfall of maintenance errors.

Case Study Approach

Within any organizational system, numerous underlying, potentially dangerous conditions exist capable of creeping into an organization's culture if left unmonitored. We believe it is the responsibility of the organization to ensure measures are in place to either intercept such risks prior to their becoming catastrophic accidents or, at least, minimize the damage created by these conditions' breach of the system's defenses. More specifically, we will explore and explain organizational issues related to:

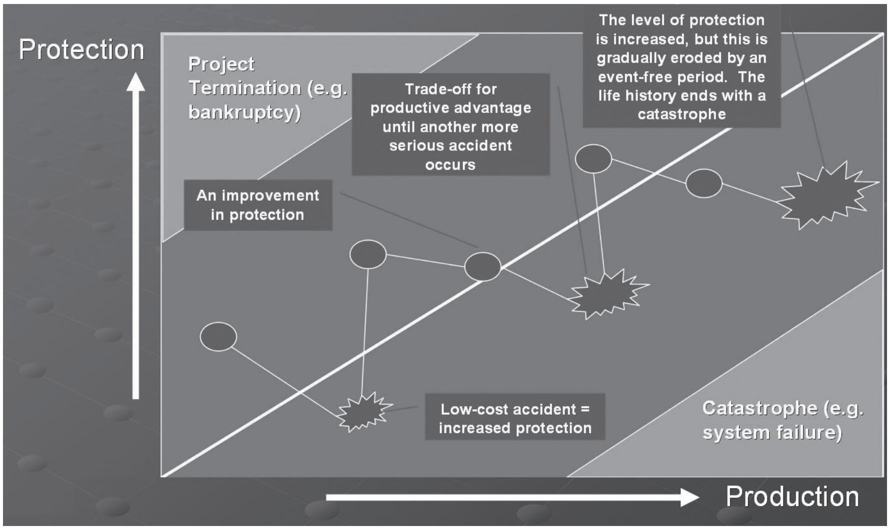
- The factors, outside of the technical failures, which combined to cause the crash of Flight 261.
- The identification of the key stakeholders and how they failed to recognize the system's warning indicators.
- How other organizations can utilize the lessons learned from Flight 261 to help prevent accidents of this magnitude from happening to them.

Far too often, analysis of major accidents concentrates on the final operators, mechanics, or points of failure in a system; it is always easier to place blame on an individual or group than it is to find fault with an organization as a whole. However, as explained by organizational theorists such as Reason (1997) (also see Perrow 1999), it is often these underlying, organizational systemic conditions which are most responsible for creating an environment in which disaster is all but inevitable. Applying this logic to Alaska Airlines Flight 261, we believe it is precisely such pervading, system-wide conditions which ultimately led to the flight's horrific end.

In general, the effect of the dynamic relationship between external and internal pressures leading to organizational accidents can be explained as a continuum between performance and safety organizations operate in (see Figure 2). During its lifetime, an organization faces constant pressure by both external and internal stakeholders to increase performance and improve on its metrics of success (in business organizations, this is typically akin to "the bottom line"). As explained by Reason, the result of this drive for performance is a tradeoff in safety.

At the top level of organizations, this tradeoff is often found in a marked decrease in risk aversion (for example, pursuing riskier opportunities with hopes of greater rewards). For middle and lower management, the increased emphasis on performance at the expense of safety is most often found in the reallocation of resources away from maintenance, security, and other safety measures and towards improving the effectiveness and overall output

Figure 2. The Production-Protection Space (Reason 1997)



of operations. Especially in business, this phenomenon is built into the nature of the system. Maintenance and safety offer no immediate, tangible return on investment; risk avoidance is extremely hard to quantify, and therefore increasingly hard to justify in times of strict budget constraints.

Initially, organizations are established with various layers of explicit and inherent defenses to help prevent the natural dangers of a system from creating accidents. However, over time, the aggregate effect of this tradeoff of safety for performance results in the formation of holes in the system's defenses. If these holes are left unchecked, it is only a matter of time before they will align themselves and allow the latent conditions to breach the system's defenses.

For a simplified example of this phenomenon, consider the following scenario of a typical small business: Initially, defenses are erected via training of operators, maintenance procedures, and an external regulatory agency. Within the company itself, there is pressure on the operators to perform at ever-higher levels. Further, the pressures to reduce costs eventually lead middle managers to shift resources away from maintenance (through decreased budgets and/or a reduction in personnel). Meanwhile, the external regulatory agency faces similar pressures (usually during a protracted time without major accidents); leading the agency to become more lax on its checks and potentially experience budget cuts and reductions in personnel as well.

In such a scenario, it easy to see how the danger inherent in day-to-day business operations will escalate as the pressure for increased performance continues to rise. Further, the defensive barriers provided by the maintenance staff and regulatory body will progressively succumb to other organizational pressures and eventually erode away. In time, this decrease in defenses and increase in danger will lead to a complete breach of defensive layers and result in either an organizational accident or near-accident (described by Reason as occurring when one of the final layers of defense prevents an accident through extraordinary measures). See Figure 3 for a visual of this phenomenon.

Once an accident or near-accident occurs, new defenses will be erected, policies put in place, and personnel hired. However, as described by the performance-safety continuum above, this emphasis on safety will, in time, give way to performance and the cycle will continue. In his book, Reason offers numerous historical examples of such phenomena occurring in industries as diverse as nuclear power and space exploration. Alaska Airlines Flight 261 also stands out in its similarities, both in terms of underlying systemic issues and ultimate outcome, to these catastrophic accidents resulting from failures in the organizational system.

Case Analysis

While placing blame on tangible, technical malfunctions is much easier to understand, it rarely addresses the root cause of the breakdown in a system's defenses. Reason discusses Pareto's Rule (the 80:20 rule); concluding that 80% of accidents can be traced back to human failures, while only 20% are the result of technical malfunctions. As the NTSB report reveals, sufficient defenses were originally put in place to prevent the series of events leading to the crash of Flight 261 from ever occurring. However, due to a series of human errors and "culture creep" spanning all echelons of the organization, by the time of the accident these defenses had been left unmonitored, circumvented, and stretched too thin to function effectively. See

Figure 3. The "Swiss Cheese" Model of Defense Layers Breached (Reason 1997)

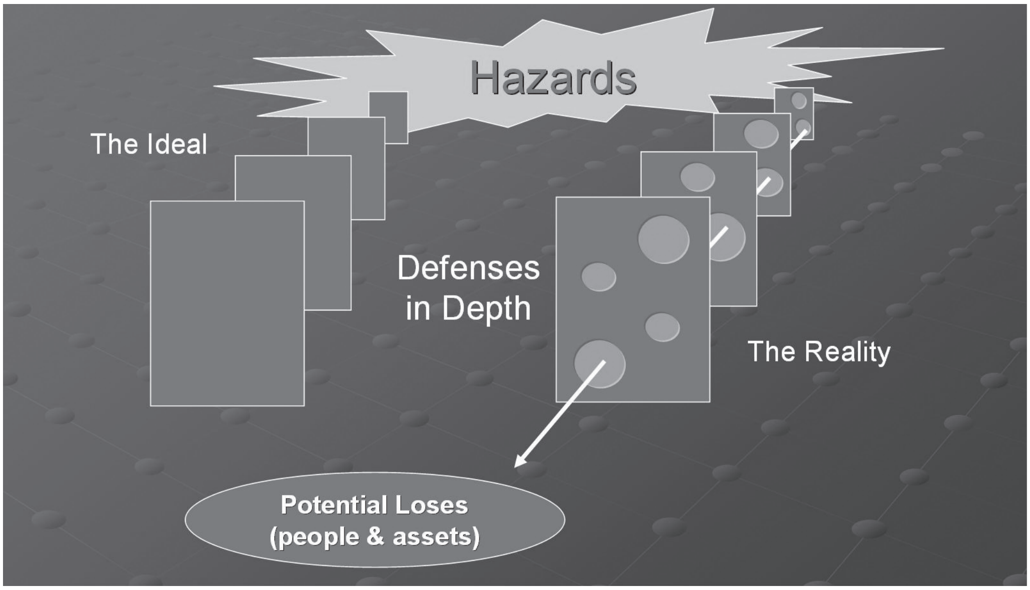
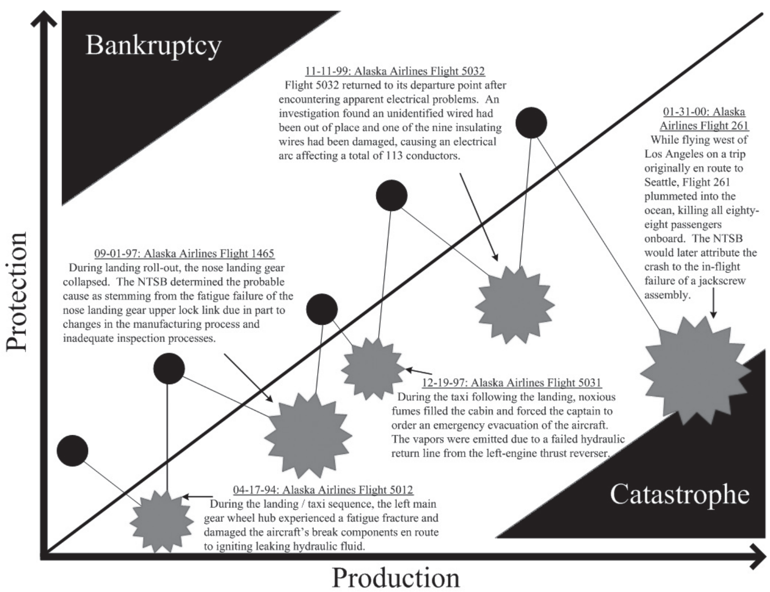


Figure 4 for an adaptation of Reason's Production-Protection Space representing the progression of Alaska Airlines along the production-protection continuum.

In order to determine the root cause of the Alaska Airlines accident, one must first consider the environment in which the airline operated. Acting as its own system of checks and balances, the Federal Aviation Administration serves as a watchdog over the airline industry. The airlines themselves are under constant pressure by the forces of a capitalistic market, with effective management of time and money providing the fundamental basis of their business success. These pressures were compounded by the aggressive expansion Alaska Airlines was undergoing just prior to the Flight 261 crash. To keep pace with the market, Alaska needed as many airplanes operational at a given time as possible. As explained in the Approach section above, this constant pressure for increased performance, coupled with the lack of tangible results safety measures are able to provide, created a focal point of pressure at Aviation Management Systems (AMS), the organization responsible for providing maintenance work to Alaska and other airlines (Miletich 2001).

Positioned at the highest level of the aviation industry, the FAA is responsible for overseeing every public airport in the United States, and therefore every airline and airplane manufacturer (including parts manufacturers). As a result, the organization's means of providing oversight is comprised primarily of stringent manuals for operations,

Figure 4. Alaska Airline's Production-Protection Space (NTSB Accident Reports)



maintenance, and other protocols sent to each downstream entity. However, the authority of the FAA is very limited; they have the responsibility of providing oversight without the power to enforce their decisions. This lack of explicit authority thus places the onus on the airlines and airplane manufactures themselves to incorporate the FAA policies into their individual General Maintenance Manuals (GMM). This passive regulatory stance is evident throughout all layers of the governmental organization, and is even found within its mission statement:

> "We provide technical and *advisory guidance* on airport planning and development; we inspect airports to help assure the safety of airport operations; we are responsible for environmental assessments of proposed construction and approval of noise compatibility programs; and we administer the Airport Improvement Program (AIP) and the Passenger Facility Charge (PFC) program. We also *monitor* airports to assure protection of the federal investment. We work extensively with airport owners, airport users, the aviation industry, and state and local governments to provide a safe and efficient system of airports for all who fly in the United States of America."

In the case of Flight 261, the systemic problems resulting from the lax oversight of the FAA is evident in numerous conversations with individuals involved with Alaska Airlines and Aviation Management Systems following the tragic crash. For instance, an FAA audit of Alaska Airlines after the highly-publicized accident found serious deficiencies in Alaska's maintenance program that had existed for months and even years before the crash, but went undetected by the FAA's regional headquarters in Renton, Washington. (Miletich 2001) This likely stemmed from the fact that FAA technicians neither have authority under FAA regulations to sign off on work completed nor work side-by-side with AMS mechanics and inspectors (Miletich 2001)—even though Alaska Airlines had explicitly requested an increase in FAA presence to meet the increased number of inspections required by their growing operations. (NTSB 2002)

As research into Alaska Airlines operations revealed, problems with the FAA's oversight approach impacted the airline industry far beyond the failure to adequately inspect maintenance operations; directly influencing the subsequent culture of aviation industry manufacturers, airlines, and maintenance workers. For example, the inspection of Flight 261 uncovered that one reason the damage to the jackscrew assembly was not recognized was that the tools used to analyze the assembly were created in-house by the maintenance staff themselves, and were subsequently not as accurate as manufacturer-made models. When questioned about this, the FAA responded that "the determination of equivalency for such equipment is the primary responsibility of the repair station or the air carrier, not the FAA" (NTSB 2002).

There is also evidence that the lack of meaningful oversight by the FAA led to complacency within the maintenance culture when dealing with suggested rules and regulations. Asked by an FAA attorney how supervisors could sign off for work done by mechanics, even when they hadn't performed the work themselves and when Alaska's maintenance manual states in capital letters that problems "MUST" be corrected and signed by the person doing the work, the maintenance manager questioned replied: "It doesn't say you can't" (Miletich 2001).

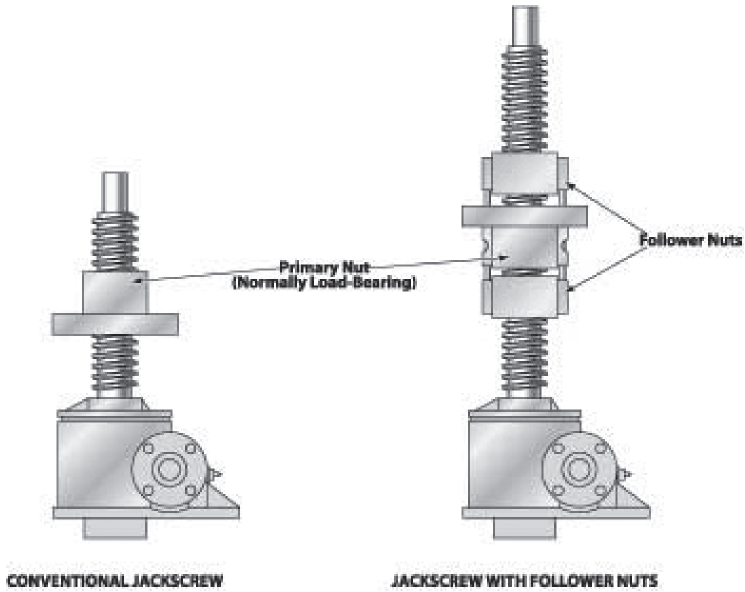
Even though such failures in the FAA's oversight clearly contributed to the fateful accident of Flight 261, to attribute all of the blame to the organization is neither fair nor representative of the multitude of forces involved. For instance, latent conditions contributing to the crash can be traced to the original manufacturer of the jackscrew assembly: Peacock Engineering (it has since been acquired by Trig Aerospace). (KSC Support) Although the company itself was not directly involved with the accident—the jackscrew assembly had been installed eight years prior to the plane's crash—the same underlying economic forces which impacted the FAA affected this manufacturer of jackscrew assemblies; ultimately leading it to continue producing and promoting a product without built-in redundant defenses capable of guarding against lapses in maintenance.

In 1998, nearly two years prior to the tragic crash of Flight 261, engineers at NASA's Kennedy Space Center (KSC) were made aware of the consequences of possible jackscrew failures during an incident involving the gaseous oxygen (GOX) vent arm. Even though it had already been prepared for the next launch, technicians at KSC decided to perform an additional test to verity proper arm alignment with the external tank (ET). During the test, the jackscrew nut threads sheared and the GOX hood fell from its position. If the failure had occurred on the next planned cycle, severe damage would have been sustained by the shuttle vehicle (KSC Support).

Alarmed, KSC formed a team to design an improved jackscrew assembly able to be more easily monitored by maintenance crew members and retrofitted with a fail-safe feature in case of damage to the primary jackscrew. This crew would find the solution to these objectives in a design based on redundant follower nut(s) as shown in Figure 5.

After devising the new assembly, this same task force was charged with determining whether a commercial market existed for the improved design. They quickly found that the pressures for economic performance constantly at work in commercial industries led only one of the manufacturers contacted to indicate a desire to consider licensing the improved design. As the group's findings describe: "Most modern commercial use of jackscrews occurs in applications where failure does not

Figure 5. Original and Redesigned Jackscrew Assembly (Fraley et al.)



physically endanger individuals. The majority of companies producing jackscrews and ballscrews were not interested in safety technologies for jackscrews…. No market drivers are apparent…" (KSC Assessment 2001).

Much like the FAA, the manufacturers of jackscrew assemblies placed the onus of maintenance and safety on the individual airlines rather than themselves. As described by an individual associated with the design of the jackscrew: "The major jackscrew manufacturers… (did not solve) the problem because they did not recognize it as their problem… Sentiments (were heard) that (the manufacturers) produce the jackscrew and the user must maintain it, and if the recommended maintenance procedures are followed then failure is unlikely" (KSC Assessment 2001). However, the NTSB investigation following the crash of Flight 261would result in the grounding of twenty-seven of Alaska Airline's jets due to potential problems with the jackscrew mechanism (KSC Assessment 2001). Clearly, passing responsibility to the airlines themselves was not an adequate safety solution.

Within Alaska Airlines itself, the systemic issues leading to the crash of Flight 261 seem to be the result of long periods of relatively safe operations leading the organization to adopt a culture centered on performance at the expense of safety. According to a panel of safety experts hired by Alaska Airlines to scrutinize its operations, there were "no glaring safety deficiencies. (Alaska Airlines) had all the programs and all the procedures in place, but the safety elements of the airline were too diffused" (Ayer 2000). However, we believe this observation is a natural outcome of the progression of Alaska Airlines along the performance-safety continuum. As noted by the analysts, all of the necessary defensive barriers were firmly established in Alaska's system. However, over time, the focus on safety gradually gave way to the need for performance, leading the "safety elements" to become diffused and ineffective. This concept is accurately described as "culture creep" by Enders Associates International as follows:

> "'Culture creep' can evolve into a rationale for operating beyond regulatory intent with, for example, deferred maintenance, excusing 'minor' procedural non-compliance on the flight deck and in ground operations and other procedures, etc. Conformity with a company's own stated policies and procedures can also be insidiously eroded if 'culture creep' is permitted to persist."

Much as with both the FAA and jackscrew assembly manufacturers, the economic pressures inherent in the airline market combined with a gradual shift in culture; ultimately leading to a sacrifice of safety for performance within Alaskan Airlines. This progression along the performance-safety continuum and onset of culture creep was ultimately focused within Alaska Airline's maintenance division. During its analysis of the various practices employed by Alaska's maintenance staff, the NTSB found startling discrepancies between the procedures outlined by FAA regulations, Boeing manufacturer data, and even Alaska Airlines' own General Maintenance Manual (GMM) and what was perceived as acceptable practices by the maintenance crew.

Relative to the jackscrew assembly, the NTSB found that maintenance facilities were using shop-made tools to perform the invasive end play check inspections to determine thread wear relative to the nut's design wear limit. When questioned on the tools and the procedure to determine end play, Alaska maintenance crew told the board that they would continually measure and re-

measure the jackscrew end play with the wrong tool until the "right" answer (within tolerance) was produced. At 40 thousandths of an inch slack, the assembly was within tolerance. At 41 thousands of an inch, the end play was deemed excessive and the jackscrew and acme nut had to be replaced with a matched pair (Air Safety Weekly 2002).

As described above, the Alaska maintenance crew routinely made their own tools to perform the end play checks rather than purchasing the more accurate, but also more expensive, Boeing-manufactured tools. When questioned about the use of this shop-made instrument, an Alaska Airlines' manager of tool control told investigators that "what the maintenance staff members were making 'wasn't even close' to Boeing's engineering drawing requirements," and that "we were directed to build the tools, and we did exactly what we were told" (NTSB 2002).

To further spotlight the extent to which organization-wide, systemic issues affected the culture of Alaska Airline's maintenance unit, consider the following examples of common maintenance practices uncovered by the NTSB investigation:

- Substituting Aerosol 33 for Mobilgrease 28 before FAA approval and having it receive Alaska Airlines Reliability Analysis Program Control Board approval without the required signatures of the director of base maintenance or the director of maintenance planning and production control.
- Mixing Aerosol 33 with Mobilgrease 28 with no lab data saying it was safe to do so (non-corrosive to the nut and/or jackscrew metals).
- Signing off on work that is not yet complete. (A senior Alaska Airlines mechanic admitted in court that supervisors regularly sign off on maintenance work that has not been completed.) (Channel 600)
- Performing maintenance in far less time than specified in Boeing's maintenance procedures (4.5 hrs vs. "a couple hours" at the Oakland maintenance facility vs. "approximately an hour" at the San Francisco maintenance facility).
- Maintenance crew admitting they did not know the correct procedure to maintain, measure, and lubricate the jackscrew assembly.
- Successfully petitioning the FAA to extend total maintenance C-Check intervals by 200% between 1985 and 1996 (see **Case Overview**). This inadvertently extended specific task end play check intervals to beyond acceptable levels (every 30 months, or ~9,550 hrs).
    - From the last end play check inspection in September 1997 to the crash, the wear rate of the nut threads was roughly 10 times what was expected with regular maintenance and use. Upon recovery of the wreckage, the acme nut threads showed wear of 90%. At the nut's wear limit (when the nut should be replaced) it should exhibit wear of 22%.

Conclusion

In its report, the National Transportation Safety Board (NTSB) identified the crash of Alaska Airlines Flight 261 as resulting from a failed jackscrew assembly. The blatant maintenance lapses within the airline were further noted as the primary contributor to the flight's tragic end. However, although the NTSB's report accurately described *what* happened, it could not explain *why* it happened. As the preceding analysis has described, the tragic end of Flight 261 was not the result of a sole failure by the maintenance staff to correctly diagnose the jackscrew's condition. Rather, the accident was the result of the combined pressures of economic forces and a period of incident-free flights gradually eroding away the systemic defenses built into Alaska Airline's operational system and facilitating breaching of these defenses by pervasive, latent conditions.

Having failed to address these systemic variables, the recommendations in the NTSB report have had little effect on any parties belonging to the airline organization. Comments from the NTSB members indicate that even after the accident, nothing has changed from the organization's attempt to improve Alaska Airlines' safety practices. The NTSB suggested that the FAA inspect the airline to evaluate whether "adequate measures have been fully implemented to sure the deficiencies identified in the FAA's April 2000 special inspection report" (NTSB 2002). This did not take place; the FAA cited an inability to divert already-stretched resources from other important tasks.

As further proof of the lack of adequate safety measures taken since Flight 261, as Alaska Airlines Flight 506 climbed above 10,00ft on March 25, 2000—two months after the crash of Flight 261—the plane failed to pressurize and the oxygen masks deployed. As the passengers began to use the masks, the pilots found they quickly depleted the emergency oxygen on board. The flight continued to its destination without injury, but the legal ramifications resulted in the flight's pilot losing his license for continuing to fly with no emergency oxygen left. It was later discovered that the pilots failed to notice that a "bleed air" switch was mistakenly left in the OFF position after it had been checked by maintenance and recorded as being placed back in the ON position. In this case, the ramifications were concentrated on the pilot and no actions were taken against the maintenance crew.

Even if actions had been taken against the maintenance crew—in the case of prior accidents, including Flight 261, such actions were—there would have been little lasting impact. Similarly, the answer to the issues plaguing jackscrew assemblies can not be resolved with the addition of an output device able to detect wear (as suggested by the Kennedy Space Center team which developed the redundant follower-nut design). (KSC) While such remedies are suitable for accidents arising solely from gross negligence

or incompetence on the part of a few, key operators at the final interface of a system, they fail to address such systemic issues as those affecting Alaska Airlines. Rather, the correct measures for overcoming the systemic actors contributing to the tragic end to Flight 261 must come from the organization's safety culture as a whole.

As expressed in the Approach section above, there are many forces inherent in capitalist business environments which resist *organizational* safety systems. When budgetary cuts are required, the first program affected is often the safety program. It is also the last program to receive additional funding when a company is experiencing profitable growth. As a result, cutting safety corners in an effort to increase the bottom line is a common attribute of unregulated industries. For Alaska Airlines, this unregulated shift is clearly evident in Judge Patrick Geraghty's frustration during a trial on the falsification of the airline's maintenance records in 1998: "(The flaws in the defense system exist) because the entire maintenance system is an honor system," the judge said. "So if the records aren't accurate the whole system collapses. And that certainly affects the flying public and air safety" (Miletich 2001).

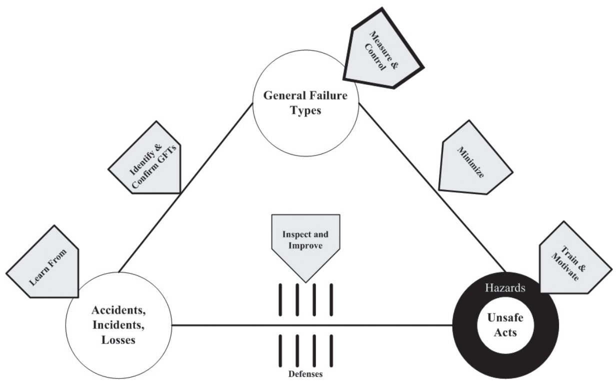
To overcome the dangers inherent in the airline industry, the NTSB recommendations should have focused on implementing organization-wide safety management systems to ensure that as holes develop in the various defensive layers, they are recognized, confronted, and repaired. The fallout of Flight 261 itself included recommendations similar to this approach, such as the view from John Enders and William Hendricks in their "Safety Assessment" report: "Essential to effective risk management is a risk assessment process by which risk can be identified, measured, evaluated and controlled. In other words, safety should be viewed as *a core production value* of the organization and, as such, a value that will accrue to the benefit of the airline, its employees and to its customer base. What better reputation could be forged than a solid, credible acceptance by the customers of the airline as a safety leader in commercial aviation?" (Enders and Hendricks 2005)

An example of such a safety management system currently in place to combat the systemic eroding of defenses can be found in Shell International Exploration and Production BV's Tripod-Delta project. Beginning in 1998, the Tripod project was developed around three core elements (Reason 1997):

- A coherent safety philosophy that leads to the setting of attainable safety goals.
- An integrated way of thinking about the processes that disrupt safe operations.
- A set of instruments for measuring these disruptive processes—termed General Failure Types (GFTs) —that does not depend upon incident or accident statistics (that is, outcome measures).

Before its introduction, Shell's principle safety metric was the number of lost-time injuries per million man-hours (LTIF). However, this system was only effective at diagnosing accidents ad hoc. Tripod-Delta, on the other hand, focuses on General Failure Types: the situational and organizational factors which, without intervention, would inevitably lead to lost-time injuries. See Figure 6 for a general overview of how the Tripod-Delta program operates.

Figure 6. Tripod Delta—Examining Types of Failures & Learning to Prevent Them (Reason 1997)



Similar practices can also be found in governmental agencies such as the Occupational Safety and Health Administration (OSHA). The very mission of OSHA's is to assure the safety and health of America's workers by setting and enforcing standards; providing training, outreach, and education; establishing partnerships; and encouraging continual improvement in workplace safety and health. Much like Tripod-Delta, this approach focuses not on preventing past injuries from being repeated, but preventing *future* types of accidents from ever occurring.

Herein lies the true lesson learned from Flight 261. So long as risks and accidents are viewed as singular events in need of correction, the underlying, pervasive conditions which facilitated their breaching of organizational defenses will remain unchanged. It is only after a more comprehensive, systems perspective is adopted can the true stimuli be uncovered. Utilizing such tools as the Tripod-Delta Model, these risks can then be overcome with standard mitigation techniques and other, yet undiscovered, tools capable of systematically mitigating the core organizational risks identified.

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