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Aircraft Accidents Aren't — Part One

A risk denial syndrome, "it won't matter," allows the buildup of seemingly trivial events that collectively can create sufficient elements of risk to cause accidents. In this first of a two-part series, the author describes the syndrome and illustrates it with an example accident. Part two will analyze the chain of preventable events and suggest a curative approach.

by
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Recent media reports of airline crashes have called attention to a series of seemingly improbable events that have led to accidents. On first examination, the air transportation system may appear to be operated by irresponsible or incompetent professionals. It is particular disturbing to the travelling public that no professional group is immune to these blunders.

As reported by nearly every source in aviation, pilots are held responsible in 60 percent to 85 percent of crashes, references for which include Caesar (1987), Nagel (1988) and Lautman and Gallimore (1987). Prime examples are the well-publicized accidents of the McDonnell Douglas DC-9 and Boeing 727 no-flap takeoff attempts at Detroit and Dallas (U.S. National Transportation Safety Board, NTSB, 1989b and 1988a), the Boeing 737 and DC-9 trying to take off in icing conditions at Washington National Airport and Denver airport (NTSB 1982 and 1988b) and the DC-8 which ran out of fuel in Portland, Oregon (NTSB, 1979a).

Inadequate maintenance has also been suspect. For example, the accident of the DC-10 which lost an engine taking off from Chicago O'Hare International Airport (NTSB, 1979b). The Boeing 737 that lost a major portion of the fuselage structure while flying in Hawaii (NTSB, 1989a) is another. The most dramatic examples are the Boeing 747 which lost most of its vertical fin before crashing in Japan (Ministry of Transport, 1987) and the DC-10 which lost its center engine turbine and hydraulic control system in Sioux City, Iowa (NTSB, in press).

Management policies have also come under criticism for permitting the pairing of inexperienced crew members in the La Guardia Boeing 737 aborted takeoff (NTSB, in press), the DC-9 taking off in icing conditions at Denver (NTSB, 1988b) and the Fairchild Metroliner departing Raleigh-Durham in poor weather conditions (NTSB, 1988c). Management flaws were also cited in the Boeing 737 icing conditions takeoff accident at Washington National (NTSB, 1982). For detailed discussions of airline management factors see Andres (1951), Berlin (1967), Besco (1989c), Bruggink (1989, 1985 and 1975), Lederer (1989, 1987, 1985 and 1982), Lederer and Enders (1987), Miller (1988) and Nance (1986).

Public Distrust

The result has been a diminished public confidence in the air transportation system. The U.S. Congress has conducted several safety surveys as a result of this public apprehension (U.S. Congress, 1988). The headline-making nature of aircraft accidents has caused every catastrophe to receive immediate media documentation.

Investigative reporters will call any aviation expert with a listed phone number for an immediate explanation of the causes of the accident. The reporters' strong drive to identify the accident-causing culprits will lead them to pursue simplistic cause factors. Most experts will exercise prudence and refrain from drawing premature conclusions. The conservatism does not keep the investigative journalist from putting together several interviews to build a "media theory" of the accident. This writer has observed dozens of analysts stating an undisputed principle that an airline will experience a negative effect on revenues for at least three months after an accident.

This public distrust is growing even though commercial air travel is by far the safest mode of transportation (Dodson, 1989, Caesar, 1989, US Congress, 1988, Nance, 1985 and Lederer and Enders, 1987). The industry has developed operating systems and design philosophies that provide a much wider margin of safety than exists in other forms of transportation. The system is extremely resistant to single-point failures. A basic design practice has developed to keep one failure from causing even an emergency, let alone an accident. This writer has rarely seen an accident caused by one failure, mistake or oversight. The pilot training program prepares pilots to resolve almost every conceivable malfunction and anomaly.

Superlative flight crew performance does not require super humans. The more than 60,000 airline pilots in the United States are not physically distinct from the general public (Besco, 1990). The U.S. Federal Aviation Administration (FAA) does require a level of health and flight deck performance monitoring that does not exist elsewhere, even in medicine. The airline captain's health and skills are checked thoroughly every six months. Whenever a pilot is introduced to a new airplane, a thorough training program and proficiency demonstration are required.

Contributions of Psychology

Psychologists have made many contributions to this level of safety and pilot performance. In World War II, the contributions of Flanagan, Melton, Tiffin, Fitts, McFarland and scores of others helped develop selection and training programs that established the principles on which the industry still operates. Fitts, Williams, McCormick, Chapanis, Woodson and their colleagues pioneered the application of human engineering to aviation in WWII. Psychologists are being recognized for the value of their collective and individual contributions. There has been a recent reemphasis of the role that behavioral scientist have to play in preserving and promoting aviation safety. John Lauber was appointed by President Reagan to the NTSB. The U.S. Congress recently mandated the FAA to define a human factors research program with a budget of $23 million. Clay Foushee was recently appointed as the chief scientist and technical advisor in the FAA to administer this program.

The relatively high level of safety in aviation has been a mixed blessing. The comfortable safety margins permitted the development of a sense of complacency and risk denial by well-meaning professionals within the industry.

Risk Perceptions

The perceived risks of malperformance in aviation have developed over decades of denial that any single mistake can be critical. In fact, the principles of redundancy and protection from single-point failures have been carried out so effectively that simple errors and omissions will practically never cause an accident. When a performance anomaly does occur, there is no immediate feedback that the results are potentially disastrous. Aviation professionals, including pilots, are so reinforced in the perception that the system is so resistant to risk that a perception of immunity from simple malperformance is widespread.

Pilots have adopted an attitude of risk denial that has been developed and supported by the conclusions of prior accident investigations When the accident board concludes that the accident was caused by the unreasonable behavior of irresponsible or undisciplined pilots, other pilots will exclude themselves from that population. Since they perceive themselves, their crew and their company as being reasonable, disciplined and responsible professionals, the risks and dangers that caused the accident in question are perceptually not present when they fly. As a result, the entire industry is denied the opportunity to learn from the mistakes. We miss an opportunity to increase the sensitivity to risks because the accidents are attributed solely to factors which are perceived as being inapplicable to individual situations. The rate of pilot error accidents per flying hour has remained constant since the transition period of commercial jets (U.S. Congress, 1988).

This risk denial syndrome has another psychological payoff to active professional aviators. It is uncomfortable for anyone to face immediate and ever present risks and dangers. It is even more unsettling for professional pilots, who are charged with the responsibility for the safety of their passengers. Professional pilots find comfort, reward and reinforcement in the denial of risk. The aviation industry has done little to identify or to reduce this risk denial syndrome.

Not one word about risk denial in aviation was found in the literature survey for this paper. Psychologists in aviation are treating the study of risk denial and risk perception much as medical practitioners previously regarded preventive medicine and health maintenance. The general subject of risk perception is only recently coming under study by behavioral scientists (Krendel et al, 1988 and Slovic, 1987). The aviation risk management work of psychologists has focused on reducing emotional trauma after an accident has occurred (Little and Gaffney, 1989, Marison and Muir, 1988 and Williams, Dolomon and Barone, 1988).

Airlines are just now starting to recognize the benefits of an active aviation safety program focused on identification and reduction of risks (Simmons, 1988). The work and writings of the legendary Jerry Lederer (1989, 1988 and 1982) date from 1928 to the present. Lederer speaks of operationally and scientifically sound principles of improving human risk management performance. Bruggink (1989, 1987, 1985, 1982, 1979 and 1971), a former accident investigator at the NTSB, has given a notable example with his pioneering efforts in the direction of increased aviation risk awareness.

The Search for Reasons

Wiener (1989a) has been a current voice of reason in the flurry to identify why pilots make mistakes. Many others have come to the intuitively appealing conclusion that undesirable personality characteristics, traits or dynamics are at the root of pilot performance breakdowns (Dolgin and Gibbs, 1989, Pendarvis, 1988 and Foushee and Helmreich, 1988). In this writer's observation, no existing personality stereotypes can distinguish the low performing from the high-performing aviator. No scientifically defensible studies of personality traits were found which can even distinguish the population of professional pilots from the general population (Besco, 1989b and Dolgin and Gibbs, 1989).

The conclusions of the NTSB on the midair collision accident over Cerritos, California, placed the primary responsibility on several "systemic" factors (NTSB, 1987). This investigation, led by psychologist/board member Lauber, was landmark in looking beyond pilot error for preventive measures. Besco (1988) and Wiener 1989b) have also cited these systemic causes for pilot error throughout aviation. Amemiya (1981) and Reasons (1988) have developed conceptual models of error and risk that have potential to be valuable in aviation. Reasons compares systemic causes of accidents with the medical concept of pathogens (specific causal factors of diseases, such as bacteria or viruses). When the organizational climate is counterproductive and unsanitary, the pathogens concept is a powerful model. One of the pathogenically caused diseases in the aviation case is pilot performance breakdown.

Selection and training improvements have been sought after as panaceas for reducing pilot error. The concept is that we can provide near-perfect performance if we simply find the right pilots, give them adequate training and set up monitoring practices to insure compliance with procedures. This concept is intuitively appealing, but is flawed in two areas.

First, the selection procedures, which include aptitude testing, interviews and job performance testing, have had very modest validities. The selection procedures involving personality traits have had zero to negative validities (Dolgin and Gibbs, 1989).

Second, it ignores the pathogenic, systemic and organizational climate problems of the industry. The belief that pilot errors can be reduced to acceptable levels by selection and training is comforting to those managements that are responsible for initiating the poor personnel policies, principles, procedures and practices. It is comforting to an executive to conclude that the pilots must be changed, not the system. However, after several decades of this approach, the rate of pilot-caused accidents has not been reduced (U.S. Congress, 1988).

Misfortune has even been credited with causing accidents. If the accident cause can be rationalized and attributed to an unfortunate set of unlikely circumstances, then the responsibility for the damages can be attributed to bad luck or to "rogue events," (*Aviation Week & Space Technology*, 1989).

Aircraft accidents are not caused by chance. A malevolent deity does not strike down aircraft or hurl them to the ground with a mighty blow. Accidents require the coordinated occurrence of several flawed decisions, performance breakdowns or oversights. Rarely does one single error made by one person result in an aviation catastrophe (Besco, 1988, Bruggink, 1988, Lederer, 1982 and Schleede, 1970). Several people must overlook warnings, risks, anomalies, and mistakes by deciding that each observed potential problem is benign, trivial, or inconsequential. It is the accumulative effects of an "it won't matter" attitude that eventually will result in the accident. The following account (NTSB, 1973) is a classic example of the multiple intersections of a series of "it won't matter" decisions.

The Accident

It was fine night for flying — beautiful weather, unlimited visibility. Eastern Airlines Flight 401 was approaching Miami International Airport on December 29, 1972. Flight 401 had departed JFK International Airport at 2120 hours. On board the Lockheed L-1011 were 163 passengers, 10 flight attendants, three flight crew members, and one maintenance supervisor. The Captain, age 55, had been an Eastern Airlines pilot since 1940. He had almost 30,000 hours of flight time and 280 hours in the L-1011. The First Officer, age 39, with almost 6,000 hours of flight time and 306 hours in the L-1011, was at the controls. The Captain handled navigation and radio communications. The flight Engineer, age 51, had 15,700 hours as flight engineer. Sitting in the cockpit jump seat was a Senior Maintenance Supervisor for the Eastern L-1011 fleet.

One Little Light Bulb

As Flight 401 approached runway 9 left, the landing gear was lowered. However, the usual array of three green lights did not illuminate. The green lights were present for the left and right main gear, but the nose gear light fixture was blank. There was no unsafe signal from either the red gear warning light or the gear warning horn. It was possible that the nose gear was safely down and locked and the signaling devices had failed. The captain did not make this assumption without further checks.

The first officer (FO) removed the light fixture and gave it to the flight engineer (FE). Two new bulbs replaced the old ones. However, the FO could not reinsert the fixture, so the bulbs did not illuminate. At this point, the captain (Capt) decided they should abandon the approach and landing. The crew started a conventional, routine go-around. The captain intended to correct the situation on the downwind leg.

At 2330:05, the Capt stated they would have to circle the field because they did not have a light on their nose gear. The tower controller instructed Flight 401 to pull up to 2,000 feet and go back to the approach control frequency.

The captain contacted the approach controller and reported they were at 2,000 feet, right over the airport. "We've got to get a green light on our nose gear," he said. The approach controller acknowledged the transmission and instructed Flight 401 to maintain 2,000 feet and turn left to a heading of 360 degrees. He said he would give vectors to Flight 401 for a final approach to runway 9 left.

At 2335:38, the Capt and FE discussed the inability to get a green light for the nose gear. The Capt instructed the FO to turn on the autopilot and asked, "See if you could get that light out." The FO replied "All right." Eastern Flight 401 was now at 2,000 feet and in the process of making a left turn from a heading of 090 to 360. The autopilot was operating in the command mode. At 2336:27, the approach controller directed Flight 401 to turn left to a heading of 300 degrees. The Capt acknowledged.

At 2337:00, the Capt said, "You got to turn it one-quarter turn to the left." He then told the FE to go down into the forward electronics compartment to check the nose wheel visually. The FO said, "You got a handkerchief or something. I can get a little better grip on this, anything I do it with? It hangs out and sticks."

At 2337:48, the approach controller told Eastern 401 to turn left to a heading of 270 degrees. The Capt said to the FE, "Get down there and see if that _____ thing." The maintenance supervisor asked, "Try my way?" The Capt replied "Okay." The FO complained "This _____ won't come out, Bob. If I had a pair of pliers, I could cushion it with that Kleenex." The FE said "I can give you the pliers. But, if you force it, you'll break it. Just believe me." The FO replied "Yeah. I'll cushion it with the Kleenex." The FE stated "Well, we can give you the pliers."

At 2338:30, the Capt said, "To ___ with it. To ____ with this. Go down and see if it's lined up with that red line. That's all we care. ____ go around with that ____ twenty-cent piece of light equipment we got on this ____." There was a sound of a laughter in the cockpit at the Captain's frustrated observation.

The Capt stated, "Eastern 401 will go out, ah, out west just a little farther to see if we hear and, ah, see if we can get this light to come on here." The approach controller replied, "All right. We got you headed westbound there now Eastern 401." The Capt replied, "All right."

Going Downhill from Here

During the cockpit conversation at 2337:42, Eastern flight 401 had descended to 1,900 feet, 100 feet below the desired altitude. The continuing conversation in the cockpit concerned the crew's inability to get the bulb back in place. The Capt, "have you ever taken one out of there?" The FO, "Hadn't till now." The Capt, "Put it in the wrong way, huh?" The FO, "In there _____, looks square to me." The Maintenance Supervisor, "Can't you get the hole lined up?"

Until this point in time, the rate of descent for Eastern Flight 401 had been undetected at 90 feet per minute. The rate of descent then increased to 255 feet per minute (fpm), still undetected. The FO said, "I don't know what the ____ holding that ___ in. Always something. We could have made schedule." Overlapped with this statement was the sound of the altitude alert, signifying that they had deviated 300 feet or more from their selected altitude of 2,000 feet. The Capt said, "We can tell if that ____ is down by looking down at our indices. I'm sure it's down. There's no way it couldn't help but be."

The FE (from the forward electronics equipment bay) said, “I can’t see it down here.” The Capt replied, “Huh?” The FE restated, “I don’t see it.” The Capt queried him further, “You can’t see that indication for the nose wheel out? There’s a place there you could look and see if they’re lined up.” The FE replied, “I know — a little like a telescope.” The Capt confirmed, “Yes.” The FE responded, “Well-l-l-l?” The Capt asked, “It’s not lined up? The FE replied, “I can’t see it. It’s pitch dark and I throw [only a] little light. I can’t … I get a … nothing.” The maintenance supervisor asked “Are the wheel well lights on?” The FE replied, “Yeah, the wheel well light’s always on if the gear is down.”

At this point, the undetected rate of descent was increasing to 1,070 feet per minute. The Maintenance Supervisor volunteered to accompany the FE into the lower forward electronics equipment compartment to check visually that the nose gear was down and locked. It was then remembered that the nose wheel light switch was located up by the captain’s left knee, and he turned on the switch. The FE and the maintenance supervisor, in the lower equipment bay, confirmed that the nose gear was down and locked.

At 2341:40, the approach controller observed that his radarscope indicated that Eastern Flight 401 was at 900 feet and descending. Concerned with this altitude deviation, he queried, “Eastern 401, how are things coming along out there?”

The Capt assumed the controller’s concern was the landing gear and not the altitude and replied, “Okay. We’d like to turn around and come back in.” The FE and maintenance supervisor had confirmed that the nose gear was safely down and locked. The controller falsely assumed his radar readings were inaccurate. He ignored the altitude discrepancy and replied, “Eastern 401 turn left heading 180.” The Capt replied, “180.”

Sudden Realization, Too Late

As the airplane rolled into the left turn, the rate of descent increased dramatically. The FO said, “We did something to our altitude.” The Capt said, “What?” The FO replied, “We’re still 2,000, right?” The Capt said, “Hey, what’s happening?”

At 2342:10, the cockpit voice recorder recorded the sound of six beeps, indicating that the aircraft was dangerously close to the ground. The sound of the initial impact was heard at 11:42:12.

The captain and the first officer lost their lives in the impact and subsequent cart wheeling. The flight engineer lived for several days but died in the hospital of injuries sustained in the crash. The maintenance supervisor, seriously injured, survived the crash and returned to work at Eastern Airlines. Ninety-four passengers and three flight attendants also died (NTSB, 1973).

Not by Chance

This tragic result came about because of the highly improbable sequence of seemingly trivial, innocuous and benign events. It is a classic illustration of the centuries-old example: for want of a nail; the shoe, the horse, the rider, the skirmish, the battle, the war and the nation were lost.

The chain of events leading to this accident is typical of the sequence of mistakes, errors, and failures that have lead to most aviation catastrophes. Typical examples of multiple sequences of mistakes leading to catastrophes are:

- The challenger accident (Feynman, 1988 and Hurd, 1987)
- The DC-10 engine pylon and cargo door accidents (NTSB, 1979b & Dept. of Trade, 1976)
- The Boeing 737 accident in the Potomac River (NTSB, 1982)
- The Boeing 727, 707 and DC-9 no-flap takeoff accidents (Lauber, 1989, NTSB, 1989b, 1988a & 1969)
- The L-1011 DFW thunderstorm accident (NTSB, 1985)

For Eastern Flight 401, it took just over eight minutes for 15 events, perceived to be harmless, to combine in just the right sequence to cause this accident. The only malfunction with the airplane was the dual failure of two highly reliable and inexpensive light bulbs.

If any one of the 15 independent events had not occurred, the accident would have been prevented. The 15 events or errors will be classified in Part Two of this series under five types of anomalies. ♦

Part Two of this series will be presented in the next issue of Accident Prevention *and will focus on the errors in the causative chain of events and present a preventive process.*

Tips on Carbon Brakes

New technology brings advantages but it also sometimes requires operators to learn new procedures to get the best performance and product life.

(Adapted from Boeing Flight Operations Review*)*

A number of new model aircraft, such as the Boeing 747-400, 757, increased gross weight 767-200 and 767-300, are now fitted with carbon brakes as standard equipment. Use of this new technology allows a substantial reduction in the operating weight of the aircraft, but it has resulted in shorter brake life under operational conditions.

For steel brakes, heavy braking or high-speed braking normally will cause greater brake wear than light or low-speed braking. For carbon brakes, on the other hand, the number of brake applications largely determines brake life rather than the severity of brake application. The majority of carbon brake wear, then, occurs during taxiing to and from the ramp and it becomes more critical to observe recommended taxi braking techniques to maximize brake life.

Boeing recommends that pilots avoid "riding" the brakes to control taxi speed because this can cause excessive heat build-up; rather they should reduce speed with a steady brake application and then release the brakes to let them cool down. The following tips are offered by Boeing to minimize carbon brake wear, but they offer longer life for steel brakes as well:

- Anticipate traffic conditions to minimize braking needs during taxi.
- Avoid use of excessive engine thrust when accelerating during taxi or during sustained taxiing.
- Anticipate spool-up and spool-down characteristics of the engines to avoid overshooting the desired taxi speed.
- Keep brake applications to a minimum by planning ahead rather than "riding" the brakes while taxiing.

Boeing emphasizes that these are merely guidelines to optimize brake wear and states that safety and passenger comfort should remain the primary considerations. ♦

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