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Human Performance And Aviation Safety: Some Issues and Some Solutions

The author notes that if we are to make significant improvements to an already well-tuned system, we must make a concerted attack on human performance problems, and develop and implement practices and procedures which will minimize the occurrence of human error accidents.

by

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It is sad but true that human error is by far the largest single cause of catastrophe in aviation operations, and for that matter, in the operation of any technologically-complex system. Chernobyl, Bophal, and closer to home, Three-mile Island serve as chilling examples that we must maintain an appropriate degree of humility and constant, unswerving vigilance in our endeavors to harness nature's forces for what we almost always intend to be the greater good of mankind. Regardless of our specific personal role in these activities, we must remember our vulnerability — individually and collectively — and never cease looking for better ways of doing things.

Before I deal with specific issues, let me briefly touch upon a philosophical issue that causes much grief in this business. The problem stems from a blurring of the distinction between incident and accident **causes** on the one hand, and legal, economic, and moral **responsibility** on the other. In our culture, we seem to be unable to deal with problems of any importance without assessing **blame,** and perversely will happily march over the cliff if we are certain that we know who to blame for our imminent demise.

All too frequently, our search for someone to blame takes real priority over our search for solutions, and this seems especially true in matters of aviation safety.

The headlines that banner, and presumably describe, our determinations of probable cause, frequently do a real injustice to individuals and organizations, and most importantly, often obscure the root causes of accidents. Every accident, regardless of seeming simplicity, is the result of multiple causes and factors. Similarly, every human error, regardless of how grievous, is a product of multiple causes and factors. While the actions of individual pilots, controllers, maintenance personnel, or others do occasionally **cause** accidents, **responsibility** for these accidents rests with all of us — the performance of individuals never takes place in a vacuum, but always occurs within an organizational and cultural context. If we fail to understand this, we too are doomed to repeat the mistakes of those who went before. It is in that spirit that I address the following specific issues.

Pilot Performance and Professional Standards

Of all of the aviation safety issues that tend to elicit emotional responses, "pilot error" is premier on the list. The flurry of headlines generated during various phases of our investigation of the Northwest Flight 255 accident in Detroit quickly converged on the flight crew, and climaxed with the representative "NTSB Blames Pilots" headlines following our public meeting in May 1988. What we really said in our statement of probable cause was that the pilots failed to run a critical checklist, and thus failed to detect that the flaps and slats had not been configured for the takeoff. We also cited the interruption of electrical power to the takeoff configuration warning system as contributing to the accident.

To some, this may sound like what lawyers like to call a distinction without a difference. I contend that there is a great deal of difference, and that thoughtful reading of our final report on the accident will reveal plenty of distributed responsibility for the accident, including issues having to do with the design and certification of the aircraft, flight crew operating procedures, flight crew training, and even, at a very global level, economic disturbances in the airline industry.

Space doesn't permit me to develop all of these themes here, but suffice it to say that this accident contains lessons for all of us — we all share the blame — and that I would hope that it caused each of us to reflect upon how we might improve our own related performance. I would point out that we at the NTSB are no exception to this, and that the accident and its aftermath caused extensive internal review and debate of how we conduct and manage an accident investigation.

But let me return to the specific issue of pilot performance and professional standards. Our investigation revealed that a critical error occurred early in the taxi sequence — the failure to position the flaps and slats — which was allowed to propagate, undetected and uncorrected, throughout the remainder of the flight. In large part, this situation occurred because the flight crew was distracted at critical moments during the taxi operations, and these distractions interfered with and interrupted performance of a fundamental and critical crew task. While some of these distractions were normal operational events, such as looking up runway specific performance data, taxiway routing, and receiving the cabin report from the flight attendant, other distractions were induced by the crew themselves through conversation on subjects unrelated to the matters at hand.

This issue of "non-pertinent" conversations in the cockpit is not new, and has been seen in subsequent accidents as well. It was noted and discussed our our report on the Continental DC-9 takeoff accident at Denver in November 1987, and I note with dismay the presence of extensive "non-pertinent" discussions on the CVR transcript from an accident currently under investigation.

I have no idea what we will eventually decide regarding the causal relationship between this conversation and the accident itself, but independent of that issue is the question of professional conduct raised by such behavior that often reflects an attitude not compatible with the rigorous demands of safe flight operations. There is a fine line separating a relaxed and easy atmosphere in a cockpit from a lax one where distractions can result in critical failures. Professionalism may be described as knowing the difference between the two.

These are not easy matters to deal with. Attitudes reflect much of an individual's personal and cultural history, and thus tend to be resistant to change. And yet, because attitudes condition much of skilled performance, it is critical that we attempt to affect them in positive ways.

Although formal training can be of some benefit here, ultimately this becomes an individual responsibility — the buck stops with each of us. In this regard, I note especially the efforts of Capt. James McIntyre, Chairman of ALPA's Professional Standards Committee, and strongly encourage additional activities of this sort. The airline pilot is, to borrow a concept from neurophysiology, the "final common path" for safety in flight operations, and as such, bears a unique individual and personal responsibility for the safety of the travelling public.

Management Commitment to Safety

Although individual line pilots have a direct and ultimate role in assuring the safety of flight operations, their performance takes place within a context and "corporate culture" defined largely by management. Although not quite so direct, the roles and responsibilities of management are no less critical for achieving acceptable levels of safety in the operation of our aviation system. Attitudes reflected in management actions are just as important for conditioning the performance of individuals as flight crew attitudes.

Les Lautman and Peter Gallimore of Boeing have published the results of several studies of human performance accidents in commercial jet transport flight operations. Basically these studies addressed the question of what distinguishes "safe" operators — those with accident rates significantly lower than average — from the rest of the industry. Although many factors emerged from their analysis, first and foremost on Lautman and Gallimore's list was "management emphasis on safety."

There are many ways that management attitudes can be translated into concrete action. Most obvious are the fundamentals: the provision of well-equipped, well-maintained, standardized cockpits; the careful development and implementation of, and rigid adherence to standardized operating procedures; and, a thorough training and checking program that ensures that the individual pilots have the requisite skills to operate the aircraft safely. These actions build the foundation upon which everything else rests.

Other activities may not be so obvious, but are none-the-less important. Highest on my personal list is a corporate commitment to aviation safety in the form of a vigorous, viable, and visible proactive flight safety program. Such programs provide an organizational structure for a company and its employees to carry out its safety activities. These programs should report to the highest levels within the corporation, and should be given the charter to carry on a thorough, hard-hitting quality control effort.

In my opinion, the often-heard expression that ". . .in my company, safety is everybody's responsibility," is true, but when offered as an excuse for not having a separate flight safety organization within the company, falls flat. No generalized, diffuse corporate will to "do good" can substitute for a formal, structured flight safety department.

In addition to providing an organizational home for flight safety, management must also conduct other safety-related activities. Examples include the support of and participation in industry-wide safety programs, such as trade association safety committees, and in conferences and workshops sponsored by organizations such as the independent Flight Safety Foundation. I would also mention here the conduct of special internal safety audits, and the establishment of a formal safety relationship between major and commuter partners in code-sharing arrangements as additional examples of management responsibilities for dealing with the human error issue.

Pilot Training, Pilot Experience, and Pilot Supply and Demand

Another factor we have seen in some of the accidents we have investigated at the Board is the question of pilot experience and training. Given the near- and long-term projections for supply and demand of pilots, it is possible that this will become an increasingly worrisome issue in the future. Already we have seen accidents where low levels of pilot experience played a role.

In our investigation of several commuter airline accidents, we have noted such factors as limited experience, high personnel turnover, and related problems associated with the selection, hiring, and qualification of pilot personnel. We also cited the problem of pairing inexperienced crew members in our investigation of the Continental accident at Denver, and recommended that steps be taken to prevent such scheduling practices.

This is a fundamental human performance issue — no amount of training can entirely compensate for inexperience, and it is necessary to recognize that for a period immediately following training, whether it is for a new position or a new piece of equipment, a process psychologists call consolidation takes place where the new knowledge and skills learned are put into more permanent memory. During this period of time, individual performance is slower and more deliberate, and is more prone to "blunder" type errors. For this reason, I think it is very important to put some sort of operating and scheduling restrictions in place to prevent the pairing of neophytes in routine flight operations.

Scheduling After Training

In addition to these restrictions, it is also necessary to impose some controls on scheduling practices for newly-trained pilots during the immediate post-training period. In the Denver accident, for example, the copilot flew one line trip, accumulating approximately seven hours of flight time following his training, and then was put on reserve and was given no flight time for the next 27 days. The accident flight was the copilot's second line flight following completion of his training a month earlier. This had the effect of literally wiping out much of the skill and knowledge acquired during the training program — psychologists have long known about rapid forgetting immediately following training unless the skills are exercised.

The lowering of experience levels in our pilot work force does not necessarily mean, as some have suggested, a decrease in aviation system safety. However, it does mean that certain compensatory changes must take place if we are to maintain present levels of safety. In addition to the ones suggested above, some others that I believe are worthy of consideration include the development of better selection methods; increased use training aids, devices and simulators in Part 135 training programs; increased use of Line Oriented Flight Training (LOFT); and more widespread training in the principles and practices of effective cockpit resource management.

We recently completed our investigation of an accident that demonstrated in a positive way the effectiveness of such training; this was the Horizon Air accident last year at Seattle. In our final report, we commended the flight crew for their behavior in handling a very dangerous situation. Quite clearly, industry-wide application of these and other training and checking techniques will require an upgraded, updated regulatory structure, an effort that is already underway within the FAA.

There is a belief prominent in some circles that the solution to the human error problem is automation. If we simply eliminate the human, we will likewise eliminate the error according to the proponents of enhanced reliance on new technology to solve old problems. I don't share their unbridled optimism, and in fact, see some real drawbacks to conventional approaches to cockpit automation.

In 1984, an SAS DC-10 overran the runway at JFK and ended up in the mud. The aircraft landed long and fast, following an automatic approach during which the crew allowed the autothrottle system to maintain a speed well above reference speed. It was the first time, to my knowledge, that the Board cited "overreliance on automation" by the crew as a factor; other more recent accidents have revealed similar problems, including the near-loss of a China Airlines Boeing 747 over the Pacific.

One of the unwanted byproducts of the conventional approach to cockpit automation is a potential loss of situation awareness — where you are, where you are going, and where you want to be — caused by "being along for the ride." This is a subtle and insidious effect, and often no one becomes aware of the problem until something goes wrong and the pilots are suddenly forced to take over from the automatic systems. It has long been known that people don't serve well as monitors of low frequency events over long periods of time, yet this is precisely what we are requiring them to do during routine cruise operations.

New Philosophy Needed

It is becoming increasingly recognized that we are in need of a new "philosophy of automation," which defines the respective roles of humans and computers in cockpit systems. We need to recognize that the primary reason we have people in our cockpits is because of their unsurpassed abilities as problem solvers — people can creatively solve hitherto unknown problems using incomplete and ambiguous information in ways that computers cannot and will not be able to do in the foreseeable future. There are many examples that illustrate this, but one need only ask the 342 surviving passengers and crew on board United's Flight 811 what they think about the abilities of a trained, professional flight crew to quickly devise effective solutions to unanticipated problems.

I am pleased to note that there is considerable effort underway by government and industry groups to deal with these technology-related human factors issues — in fact, this is one of the central elements of NASA's aeronautical human factors research program. In the meantime, we need to be wary of the traps and pitfalls, and make sure, through training and educational efforts, that flight crew members are aware of the potential difficulties associated with some of the new technology.

Human Factors Outside The Cockpit

Significant progress has been made in the last couple of decades in broadening the traditional "knobs and dials" focus of classic human engineering to include cognitive and social factors as well. Most of this effort has concentrated upon cockpit issues. However, we are becoming increasingly aware of the importance and criticality of human performance issues in other elements of the aviation system, and I want to mention two particularly important areas here. One of these areas is air traffic control, and the second is inspection and maintenance.

Let me start with ATC. In August 1986 I had my first experience as a Member of the Board with a major aircraft accident, specifically, the midair collision over Cerritos, Calif., between an Aeromexico DC-9 and a Piper PA-28. The accident happened when the non-Mode C (altitude reporting) PA-28 entered the Los Angeles Terminal Control Area without clearance. Recorded radar data clearly revealed the presence of the PA-28, and yet the controller involved stated that he did not see a target in the vicinity of the DC-9.

The cynic will say that the controller was lying to us. The cynic is wrong. By all accounts, this controller was first-rate; he was experienced, dedicated, and a genuine aviation enthusiast, active as a pilot as well as a controller. Reviewing the tapes, it is clear he was performing his duties in a professional manner, and yet he failed to see the target — a target which most certainly was visible on his radar scope. Unless and until we appreciate how this can happen — why physical energy can hit the retina and yet not get processed by the brain as a "seen" image, we are likely to have similar accidents in the future. Indeed, we had one that was virtually identical six months later at Salt Lake City.

I don't have time here to develop the fundamental human factors issues involved here, but I do believe I can build a good case that there were two basic problems. First is a sort of schizophrenia represented by the fundamental basis of our ATC system which is, simply stated, that the system exists for one purpose only, and that is to separate IFR aircraft from all other IFR aircraft — everything else is done on a "time permitting" basis. In effect, two unequal classes are created by this — the "players" (IFR aircraft) and everyone else. This may seem unimportant, but it cannot help but affect the attitudes of controllers and other.

Psychologists have known for a century or more that attitudes, expectations, “mental sets” and other factors have a powerful influence on human perception. These accidents merely replicate some classic findings from psychological research. (I would note as an aside that ATC systems in some other countries take a different approach. Australia, for example, states the fundamental purpose of ATC to be the separation of IFR aircraft from all other aircraft.)

The second problem is related to the first. Part of the reason the controller didn’t “see” the PA-28, I believe, is due to the fact that the PA-28 transponder did not have altitude-reporting capability. Because of this, the controller could “assume” that any target in the geographic area where the collision occurred was, in fact, traffic operating beneath the floor of the TCA. I don’t mean to imply that the controller consciously made such an assumption, but that it is a characteristic of the human perceptual system, which in effect filters or pre-processes sensory information, so that only “relevant” or “important” information gets through. As an example of such filtering, how many times have you suddenly become aware that someone has been saying something to you, but because you are “thinking” about something else, you didn’t “hear” what was said. Your ear heard it, but your brain didn’t. The controller’s eye saw the target, but his brain didn’t.

In the absence of information to the contrary, the controller’s central nervous system filtered the target by classifying it as one of those operating below the floor of the TCA — something the controller must have seen thousands of times in his career. This is one reason I am an unabashed unswerving advocate of Mode C transponders. I basically believe that every air carrier operation ought to be in Mode C airspace. Period. (I will also say, for the record, that it is time to review the allocation of such airspace — simply expanding the volume of Mode C airspace is not an optimal solution to this problem. We are learning that we must seek smarter ways to use increasingly limited resources — airspace is a limited resource, and must be managed accordingly.)

The Aloha accident last year has underscored human performance issues of still another kind — the human factors of inspection and maintenance an area that has received even less attention than ATC. Although we have not yet completed our investigation and report on this accident, it is clear that inspection and maintenance are central issues, and that these raise some significant human performance questions. It is a fact of life, for example, that most aircraft inspection and maintenance work takes place at night. Thus, shift work, fatigue, and circadian performance factors loom large.

Furthermore, the monotony and boredom associated with the repetitive performance of simple tasks, such as those associated with visual and other methods of finding corrosion and cracks, can lead to high error rates. The aging aircraft fleet is clearly imposing mounting demands upon those who inspect and maintain these aircraft. We must make sure that we understand these demands, and that we have provided the proper equipment, procedures, and training to the personnel involved. (Incidentally, many of these very same considerations apply to another area of increasing concern: airport, aircraft, baggage and passenger security screening.)

Some Promising Signs

It is clear that we have our work cut out for us. If we are to make significant improvements to an already well-tuned system, we must make a concerted attack on human performance problems, and develop and implement practices and procedures which will minimize the occurrence of human error accidents. The last decade and a half have seen significant attention directed to these problems, and I think we now have a pretty good understanding of what the issues are. Solutions may be more elusive, but there are some promising signs.

The Aviation Safety Research Act of 1988 has earmarked significant resources to be devoted to human factors research. NASA has augmented its human factors R & D programs. The industry — manufacturers, operators, and pilots — and government have developed a pretty good long-term plan for addressing many of these issues. I am referring here to the draft “National Plan to Enhance Aviation Safety Through Human Factors Improvements” which was spearheaded by the ATA Human Factors Task Force. And the FAA has appointed a chief scientific and technical advisor for human factors to coordinate agency-wide human factors efforts.

Because of these activities, I believe we are poised to make significant inroads upon what was termed “the last frontier of aviation safety” at IATA’s 20th Technical Conference 15 years ago. ♦

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