Just What Are Flight Crew Errors?

An assessment of the major causes of large jet airliner accidents leads to specific recommendations for improvement.

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The "man" side of the man-machine-environment equation has become the leading cause of civil air transport accidents since the beginning of the jet era. Accidents caused by mechanical factors have been reduced because of the extremely reliable and well-engineered jet but the pilots' share of cause factors became greater. Depending on the data population base, it is generally agreed that flight crew errors are causal in more than 60 percent of large jet transport accidents while flying under U.S. 14 Code of Federal Regulations Part 121 rules. According to studies by Boeing Commercial Airplanes, on a worldwide hull loss basis, human errors account for as much as 80 percent of the cause factors.

Recognizing a problem that needed attention, the U.S. National Transportation Safety Board (NTSB) began a study to determine what were the errors that each flight crew member was making and what was the frequency and severity of these errors. From this, it might be possible to see all aspects of the problem and determine if the aviation community is spending its money wisely in looking for cures.

The NTSB data base was queried for a list of all the Part 121 turbojet accidents from 1982 through 1988 where a flight crew member was identified as causal. This produced mini-narratives of 43 accidents and screened out 14 in-flight turbulence injuries, eight ground operation or evacuation injuries and minor taxi damage accidents. What remained was a group of 21 accidents that occurred during takeoff and departure or during approach and landing, those critical phases of flight where air crew skills are most demanding and where errors are potentially catastrophic. For the purpose of this study, the accidents have been de-identified as much as possible, since the goal is to group errors by categories and not by particular events.

In general, the population of the study contains seven fatal accidents where 371 persons were killed. All occurred in the United States. There were 14 accidents during landing and seven during takeoff. Nine aircraft were destroyed. Fifteen air carriers were involved, some as many as three times. Six of the 15 carriers were post-deregulation start-ups. There had been recent growth, change and mergers within the remainder of the carriers.

There were several carriers with no accidents attributed to flight crew error during this period. Some of the companies were prospering and some were not doing as well financially. The frequency varied from one to eight accidents per year. The number of accidents by type of aircraft related closely to the number of takeoff-landing cycles. Three airports — Dallas-Fort Worth, Texas, Denver, Colorado and Detroit, Michigan — were the sites of eight of the 21 accidents. Weather was a factor in 15 of the 21 accidents, and mechanical trouble and communications confusion were involved in three each. Air crew member fatigue was involved in one case. There were four cases without stressful distraction. The captain was at the controls in 17 cases.

There were 14 accidents during landing and seven during takeoff.

Methodology Applied to the Study

The next task was to take these 21 accidents involving flight crew error causes and convert the event-oriented NTSB phraseology to short, individualized statements about crew members. Each individual human error identified in the probable and contributing cause statements was reconstructed onto a worksheet. Then the findings were reviewed to add those errors that occurred near the time of the accident event but were not mentioned in the cause statement. Not all accidents had final NTSB accident reports, so the docket records were also gleaned to amplify the number of distinct human errors identified in the investigation group reports. The factual and analysis sections of the reports were also examined for additional errors that did not appear in the findings or cause statements.

Although the NTSB causal statements identified 65 individual flight crew errors in the 21 accidents, the remainder of the narrative and docket records brought the total of human errors to 154, or an average of 7.3 per accident. When these were later categorized and compared, there were only slight differences in the ratio of types of errors uncovered by using only the cause statements versus adding the extra errors. The errors added to the value.

The next task was to convert the event-oriented, board-identified human errors to terms more useful in cataloging human errors. A human performance taxonomy, a classification that was originally intended to file and retrieve topical information from the U.S. National Aeronautics and Space Administration (NASA) and NTSB data bases, was modified slightly for this purpose. The modifications removed conflicts of overlapping and confusing uses of terminology for investigating and reporting human factors in accidents. Such words as "communications" and "coordination" or "judgment" and "decision making" had to be separated or merged in meaning. Others such as "procedural behavior," "flight-planning," "physiological," or "inter-actional" had to be tightly defined as they pertained to the study.

In this way, the transfer of terminology for the data would logically result in proper error categorization. Each identified error would fit into only one converted category to create the best observations on "just what are these errors." The taxonomy contains four levels. Level I identifies the human making the error, such as captain, first officer or flight engineer. Level II identified the major category of error such as *communication, flight-planning, procedural behavior, decision making, physiological, interactional, and organizational oversight*. Level III amplifies or divides each Level II item by such things as phase of flight or sub-area of concern. Level IV further amplifies Level III with more specific common areas of concern.

For purposes of this discussion, these are the taxonomical terms most needing tight operational definitions at this point:

- *Communication* involves information transfer from outside the aircraft (external).

- *Flight-planning* involves calculations/inspections prior to and during flight (rechecks).

- *Procedural behavior* involves performance using knowledge, rules, *U.S. Federal Aviation Regulations* (FARs), handbooks, *Airman's Information Manual* (AIM), company policy, etc. (by-the-book).

- *Coordination* involves procedural intra-cockpit verbal and visual communications between crew members (crosschecks).

- *Decision making* judgments involve uncertainties, probabilities, trade-offs, lack of rules, conflicting rules or information and even deliberate disregard of the proper, safest decision (least-worst choice).

- *Physiological* involves physical and mental health problems such as impairment, stress, fatigue, work overload, etc. (health).

- *Interactional* involves the interface of man-machine-environment such as cockpit design, airport congestion, etc. (workspace).

- *Organizational oversight* involves errors by management and support agencies outside the cockpit (the system).

Each taxonomical term was given a number or letter identifier to facilitate the subsequent combining of errors into specific groupings. Each of the errors from the 21 accident worksheets was assigned letter and number codes from the taxonomy using the author's judgment as to what the core human factors issue was in each taxonomy translated error identified by the NTSB.

Here is an example of the conversion stated three ways:

- *NTSB data base statement:* "Ice/frost removal from aircraft, not performed, captain."

- *Human Performance taxonomy:* "Captain, decision making, procedural behavior, safety first."

- *Plain English mini-narrative:* "Captain took chance, did not follow company procedure to remove frost from wings before takeoff."

When all 154 identified errors from the 21 accidents were converted to taxonomy codes, they were again unscrambled into taxonomy terms by groupings of phrases. The resulting data provides some useful information within the constraints of this simplified process and the small size of the accident population. It is probably close to being accurate and, with that caveat, useful to those trying to control human errors but not knowing where to wisely put their efforts.

General Results from the Study

When dealing with aircrew errors that occurred near the time of the accident, an overwhelming 90 percent involved procedural behavior or decision-making factors. Of the remaining 10 percent, communications and flight planning comprised seven percent of the errors. The NTSB mentioned only four physiological and interactional problems and no organizational oversight problems involving

Table 1
Major Crew Performance Concerns

Procedural behavior (flying by the book)	107	69%
Decision making (least worst-choice)	32	21%
Communications (external-source information)	6	4%
Flight planning (computations/inspections)	5	3%
Physiological impairment, fatigue, health)	3	2%
Interactional (workspace, external environment)	1	1%
Organizational oversight (company, FAA, Airport)	0	0%
Total	154	

Table 2
Major Individual Crew Member Concerns

Level II Area	Captain		1st Officer		Flight Engineer	
Procedural behavior	62	(60)	40	(93)	5	(63)
Decision making	28	(27)	2	(5)	2	(25)
Communications	6	(6)	0	(0)	0	(0)
Flight-planning	4	(4)	0	(0)	1	(13)
Physiological	2	(2)	1	(1)	0	(0)
Interactional	1	(1)	0	(0)	0	(0)
Organizational oversight	0	(0)	0	(0)	0	(0)
Total (grand total: 154)	103		43		8	

Numbers in ( ) are percentages by column.

the flight crew findings or causes in these accidents.

This general overview of the human factor (error) situation in jet transport accidents tends to reveal that the NTSB has uncovered two vast areas of concern: poor following of procedures and poor safe decision making. Air-ground communications and flight planning errors do not seem to occur very often. There have been great amounts of work and publicity related to physiological design and management oversight in air crew error accidents, but there has not been much said by the NTSB about this population of accident reports. Although there can be much more comment on this general point, the purpose of this study is to identify specific areas of concern for each flight crew position to determine what needs to be accomplished based on further breakdown of this data.

Table 2 illustrates how each crew member has been identified as having a different percentage of errors in each major problem area.

Captains accounted for 67 percent of the identified errors. They had 88 percent of the decision-making errors while first officers made 93 percent of their errors in the procedural behavior area. Captains made all the communications errors and four of the five flight-planning errors. Flight engineers were identified as making only eight errors, five procedural, two decision making and one flight planning.

Before proceeding, it may be worth commenting on the nature of the investigative process and capabilities at this point. It was noted that in comparing errors leading to fatal accidents (where the crew died) versus non-fatal accidents, the flight crew was identified with proportionately fewer decision-making errors (12 percent vs. 27 percent) and more procedural flying errors (80 percent vs. 62 percent) in the fatal accidents than in accidents where the crew survived. Being able to talk to the flight crew seems to provide more insight into the decision-making process in non-fatal accidents. When the crew has not survived, the investigators must place more emphasis on the facts contained in the rules pertaining to the event. Because the NTSB cannot read the crew's minds, its members properly cannot assume many of the judgments (chances) the crew may have made. As helpful as the cockpit voice recorder (CVR) is, it cannot be asked questions later. It is possible the decision-making count should be higher. In this type of study, however, we must use data, not assumptions.

The Major Factor — Procedural Behavior

As was illustrated in Table 1, by far the greatest number of errors that were identified concerned procedural behavior. Fully 107, or 69 percent of the 154 errors were from failing to fly by the written and trained rules according to the NTSB. Those procedural miscues by sub-areas and by individual cockpit crew member are presented in Table 3.

Here are mini-definitions for procedural behavior sub-areas:

- *Flying Skills.* Stick and rudder, airspeed, heading, altitude, tracking to standards.

- *Experience.* Applying rules based on past mistakes, results or lessons learned.

- *Training.* Behavior based on changes in procedures in new operation, aircraft or crew position.

- *Company crew management concepts.* Company's unique methods of operating in the cockpit.

- *Coordination.* Intra-cockpit crew communications, interactions using prescribed company procedures, FARs, etc.

- *Vigilance.* Watchfulness, wariness over time concerning safety of flight — infers professionalism.

By looking at the totals, we see that the order of procedural problems involves coordination, flying skills, vigilance and experience. But individually, the captain is cited most often for flying skills (22 errors) and vigilance (16 errors) while the first officer's biggest problem areas are coordination (20 errors) and experience (7 errors). The flight engineer was cited only five times in the 21 accidents and showed up in coordination only twice. The captain took the greatest share with 62 errors to the first officer's 40. Recall that the captain is always in command and was at the controls in 17 of these 21 cases.

What we have so far is a precise view of the four major individual and combined flight crew problems with procedural behavior. We can now take the analysis one step farther and discuss the largest individual subset of problems for each crew member by adding the Level IV modifying terms to their two biggest Level III problems. In this manner, all four of the largest Level III problems will be discussed.

Looking at Captain Procedural Behavior Problem Areas

The first most identified procedural problem for captains was displaying inadequate flying skills, which occurred 22 times in the accident reports studied. The closest descriptor words for their performance and the number of occurrences ( ) are as follows:

- *Degradation*, for improper flare, airspeed fast, landed long, etc. (9)

- *Instrument scan*, for excessive descent rate, not referring to radar altimeter, not holding gust additive speed, etc. (8)

- *Proficiency*, for unstable approach, improper touchdown point, improper trim, etc. (5)

(Other modifying terms not cited were recency, currency and interference as they related to the reason for flying skills problems.)

The study attempted to make these breakdowns based on the context of the actual scenario. Thus, some long landings could be labeled as due to the pilots' struggling with gusty winds and were classified under degradation while others may have been due to a long layoff period and thus be labeled a proficiency problem. The instrument scan category was chosen when reference to the instruments was expected and called for in that particular situation.

Table 3
Procedural Behavior

Level III Sub Area	Captain	1st Officer	Flight Engineer	Total
Flying Skills	22 (35)	4 (10)	1 (10)	27 (25)
Experience	12 (19)	7 (18)	1 (20)	20 (19)
Training	1 (2)	1 (3)	0 (0)	2 (2)
Company Crew	0 (0)	3 (8)	0 (0)	3 (3)
Mgt. Concepts Coordination	11 (18)	20 (50)	2 (40)	33 (31)
Vigilance	16 (26)	5 (13)	1 (20)	22 (21)
Total	62	40	5	107

Numbers in ( ) are percentages by column.

Flying skills were identified in 10 of the 14 non-fatal accidents and in only two of the seven non-survivable accidents. Again, testimony seems to bring out more detail than the flight data recorder (FDR) in the investigative and documenting process. (First officers were cited for degradation or proficiency in flying skills in two of the three accidents where they were at the controls.) Only one of these accidents involved low ceiling and poor visibility. Only one accident involved an engine failure. The carriers involved were both post-deregulation start-ups and they were flying older aircraft.

The vast majority of flying skills errors were made during gusty winds, thunderstorms, tailwinds, wet runways, crosswinds or during rushed approaches — scenarios not usually offered in older or small company simulators where flying skills are most often tested, trained and practiced. Simulators are best used for instrument and emergency skills training and it appears they have been successful. The flying skills procedures pilots train for in simulators do not often occur in accidents. As in simulators, problems usually are flown skillfully and the aircraft continues to fly.

A by-the-book-flown aircraft could have resulted in a non-event ... .

Our study found seven cases where the captain's flying skills were exceeded after making a decision based on chance to takeoff or land in marginal conditions such as icing, thunderstorms or crosswinds. Conditions were reported to be legal but it was the captain's choice based on other known complications. A by-the-book-flown aircraft could have resulted in a non-event, but the conditions and margins were exceeded. There were also seven cases where improper crew coordination procedures combined with flying skills problems, which led to an accident. The first officer was most often guilty of not performing the coordinating duties and inadvertently allowing the captain flying to exceed skills standards without comment. Two of these accidents were fatal.

Also found were three accidents where the captain displayed a lack of vigilance or wariness, leading up to or in combination with inadequate flying skills, prior to the accident. Because of the captain's lack of awareness, he did not even realize he was in trouble. Twice these were fatal accidents, one on takeoff and one on approach.

The Captain's Second Problem Was Vigilance

The second-most identified procedural problem for captains was in the area of vigilance or wariness, with 16 instances occurring in the accident reports studied. The term is a possible descriptor for what makes captains professionals — they are constantly on the watch for problems, not worried, but alert and ready. The eight Level IV modifying or sub-subjects for vigilance include: attention allocation; resource management; sterile cockpit; self-initiated double-checking; see-and-be-seen; formality/tone in communications/coordination; automatic behavior; and anticipation. These are many of the subjects that are constantly stressed in flight training and cockpit resource management training. They imply the need for having the "right stuff" to be an airline crew member. These are the major sub-problem areas for captains under the vigilance problem area.

Resource Management Is A Captain's Problem

Captains were identified as not having managed their crew resources properly in four fatal accidents. Citations such as "inadequate supervision," "overconfidence in personalities," "duties not established," or "took over flying duties in deteriorating weather" fit well with the resource management subject matter. All involve procedural behavior as well as vigilance. They all involve captains who had begun to believe they could rush, or not call for, the checklist; trust the first officer to do two or three things at once; rush an approach or takeoff; or literally fly without following procedures or monitoring callouts. They were flying solo with a multiple pilot crew. They were not following that old adage of "trust, but verify." They were not managing all of their resources according to the needs of the situation.

Attention Allocation Is A Cause for Concern

Attention allocation was deemed a topic helping to cause a fatal accident in three cases. In one case, the captain tried to accomplish the first officer's emergency procedural duties during an engine failure and stopped flying the airplane. A second example showed that the captain disregarded minimums approaching the airfield. In a third case, the captain was not following procedures by allowing distracting activities in the cockpit before takeoff. In these cases, the sense of the error is that the captains did not manage themselves well because of overconfidence. They did not stop, prioritize or regroup when things got rough or rushed.

Looking at Self-initiated Double-checking

Occurring in three cases, this sub-topic showed up most often under vigilance when combining all three crew members. First officers were cited twice and flight engineers once, making a total of six. It was identified four times in the seven fatal accidents and twice in the fourteen non-fatal accidents.

Typical situations for this sub-topic include not observing that the gear handle is down; the flaps are set correctly; the wings are clear of ice/frost; or that walk-around checks for ice/frost or trim tab checks have been made by all appropriate crew members. It implies the need for human redundancy, especially for safety of flight items, by all crew members. Often, redundancy requirements are not written checklist items but items that have always needed checking since the first training flight.

Other Vigilance Findings To Consider

- *Sterile Cockpit.* Two accidents involved the captain and one, the first officer. All were fatal accidents. The U.S. Federal Aviation Administration (FAA) requirement for confining cockpit conversations to operational matters during critical phases of flight is very valid.

- *Automatic Behavior.* One accident, both captain and first officer forgot to lower the gear when distracted. Lowering the gear is a lifetime habit for pilots.

- *Anticipation.* Two non-fatal accidents. One crew should have planned to use auto-brakes while another should have planned a missed approach earlier in a thunderstorm. Landing and takeoff briefings are often abbreviated or are glossed over.

In each case, there were many other errors found by the NTSB that caused or contributed to the accident dealing with other procedural, decision-making and communications areas. If, however, the captain had demonstrated the properly trained and disciplined "by-the-book" procedures, the chain of events leading to the accident would have been broken. It could have required more wariness and anticipation, so that his attention could have been properly placed.

First Officer Procedural Behavior Problem Areas

Fully half of the first officer's procedural behavior problems fall under the term "coordination." They had 20 of their 40 errors in this area; captains had a total of 11. Thirty-three of the total 154 errors in the study were termed coordination, making this the largest single-interest topic and numerical finding in the accidents studied.

(Recall also that coordination deals only with intra-cockpit information transfer or communications, verbal or visual. The goal is to have all members of the flight crew understand and agree what is happening. There is another area under communications dealing with air-ground or external radio matters which is kept separate for error counting and recommendation purposes.)

The main sub-topics for coordination as they relate to first officers are as follows:

- *Approach Cross-checking.* As pilot-not-flying, monitoring the pilot flying at the right time and place with the right phraseology and sense of urgency (7).

- *Disruptions/distractions.* Failing to perform more important duties while dealing with other matters (4).

- *Readback/hearback/callback.* Repeating verbally, understanding and properly reacting to other pilots requests or commands (3).

(Other topics dealing with coordination include authority structure, checks and balances, checklist, en route navigation monitoring, departure cross-checking, taxi/ground operations monitoring, synchronization, and directiveness. Each sub-topic attempts to cover certain types of errors or significant phases of flight where specific corrective actions may be helpful. Their definitions are self-explanatory and quite often overlap. They become data when topically most significant on a case-by-case basis.)

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Approach Cross-checking as Applied to First Officers

These seven errors occurred in one fatal and four non-fatal accidents. In each case, the errors were noted after distractions caused a hurry-up-to-catch-up situation. In the fatal accident, the first officer was 1,000 feet and five miles off with his callouts three different times. Two others involved flap or landing gear settings that were not stated or noted in the correct position. One first officer did not advise his captain of an excessive tailwind component and another remained silent on a high, fast and out-of-limits approach.

Captains erred twice while acting as copilot when the first officer was flying the aircraft. On one fatal approach, the captain failed to make an essential verbal callout to the pilot flying, while the aircraft was intercepting the glideslope, and on a non-fatal landing the captain failed to warn his first officer to expect possibly excessive cross-winds because a thunderstorm was passing the field. The control tower had reported the winds calm, but rapid change was imminent and should have been expected.

Cross-checking is often considered a necessary evil by flight crews. The rules are there; they are explicit and often complex to attain perfect compliance. Short-cuts and variations are usually considered acceptable behavior when utilized by captains, instructors and check airman because of the often uninteresting and repetitive information transfer required. It often becomes so routine that crews merely go through the motions, and messages often go in one ear and out the other. Unassertiveness and overbearingness often make the process less effective.

Perfect, by-the-book approach monitoring is difficult and rare, and often appears only when being monitored in the simulator or during line checks. The intent of monitoring, however, has prevented many an accident since its inception after many NTSB studies, recommendations and accident reports dating back 20 years. The newer ground proximity warning systems (GPWS) are a help in this regard because their voice altitude callouts are attention-getting and accurate, unless the system is inoperative.

Disruptions/Distractions Are the First Officer's Second Sub-topic

There are four errors in four accidents where distractions were a factor. Three of the accidents were fatal. Errors included: making a radio call instead of responding to a captain's request for information; being rushed with inconsequential matters instead of keeping up with approach monitoring duties; or responding to configuration change requests for flaps, trim or gear but not performing them when attending to simultaneous non-operational matters. Certain items must be 100 percent complete ahead of all other superfluous matters in a coordinated way so that all of the crew members are aware of the situation.

Readback/Hearback/Callback, the Third Flight Officer Sub-topic

These three citations also are rare but deadly coordination concerns. A captain, believing that he heard a proper response because of its normal routineness and expected behavior without challenge, can be tricked into trying to fly with an impossible configuration. Other examples are first officers stating that they performed a task but without looking to confirm their actions — or inactions; and misleading the whole crew, or remaining silent, when observing an out-of-tolerance situation after failing to properly configure the aircraft.

Coordinated intracockpit communications are incomplete until understood and acted upon properly. "Trust, but verify" is the guiding principle for all crew communications. Verification is also at the heart of self-initiated double checking for the vigilant crew member. Coordination is a learned collaborative process that has to follow established rules that have been formulated from experience. It is a process that is not often learned in early flying training because of the emphasis on solo flying and individual performance.

Flight crew coordination is easy to learn once the principles are accepted and understood. Disciplined compliance becomes routine as part of good cockpit management. Good coordination is a whole crew effort.

Experience Is a Factor for First Officers and Captains

This topic is the second leading sub-topic for first officers, with seven mentions. It is also the third leading topic under procedural behavior for captains, with 12 situational errors cited that were due either to inexperience or prior experiences (where they had been fortunate to avoid trouble) that were coming back to haunt them. Experience often intercepts the decision-making process and is cited under procedural behavior when the NTSB places more emphasis on experience than judgment. The main sub-topics for experience are:

- *Situation assessment* involves errors based on similar past successful but lucky experiences. Also, errors based on total lack of prior experience in current situation. Other errors often accompany or amplify decision-making errors.

- *Recognition of anomalous situation* is not realizing one is in trouble, with a resulting poor reaction.

Other sub-topics for procedural behavior experience errors with only one error each were timeliness of avoidance (delayed turn to avoid storm), familiarity (unfamiliar with airfield geography) and crew pairing (both pilots new to the aircraft). All of these situations have generated recommendations by the NTSB, but they are lingering problems, today.

Situation Assessment Application To First Officers

First officers were identified three times for more or less agreeing with their captains in increasingly marginal situations. Experience told them "I have seen worse," "other aircraft are making it" or "I can let him go a little bit longer and he'll still recover." Not in these three instances. Prior successful experience had induced risk-taking, and the odds were too great against another success. As mentioned in the mini-definitions used earlier, these errors all helped describe poor decisions on the part of the captain. Objections never came from the first officer.

Captains are even more prone to this form of error about twice as often as first officers. Captains were cited six times involving weather evaluation, disregarding GPWS warnings, improper crosswind on wet runway procedures or planning, over-flaring while new to the aircraft, lack of concern over de-icing in new aircraft, and improper engine problem reactions. Poor decision-making errors accompanied most of these assessment errors and help explain why they occurred.

Recognition of Anomalous Situation

First officers were mentioned for three anomalous situation errors, and captains for four, when they did not realize they were in trouble. In two of the three first officer cases, prior experience misled them into believing that the situation was not serious: "I know the rules say not to fly through thunderstorms and I saw lightning, but it will be off our course by the time we get there," or "I've seen late landing flares before, but the captain knows how to handle it." In the third accident case studied, which involved an engine problem, the first officer very likely had never experienced a real-world engine failure and did not assist properly in pointing the problem out to the captain when the procedure called for it.

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Captain-related examples occurred during accidents involving weather, mechanical problem assessment, landing descent rate and flare judgments. In another case, the captain did not realize the importance of quick spoiler and braking action procedures on a tailwind landing.

It is often said that experience is the sum of all of our mistakes. But in aviation, one cannot live with that definition. The secret to success for those who fly aircraft is to benefit from someone else's mistakes. This requires a vast, speedy network of communications and education that is not always graphic or thorough enough. Also, accident information may be dependent on rumor and innuendo because admitting to mistakes in accidents or close calls might lead to enforcement actions by the FAA, whose job it is to assure that regulatory procedural standards are maintained. The conspiracy of silence impedes the passing on of experience.

Summary of Procedural Behavior Findings

Procedural behavior or "flying-by-the-book" findings make up 69 percent of all the flight crew errors uncovered in large turbojet accidents. Captains were cited for about two thirds (62) of all errors, most often for flying skills (22) and vigilance (16), while first officers were cited most for coordination (20) and experience (7). Flight engineers received only five citations, two for coordination. As might be expected, these categories have been involved in many of the recommendations made by the NTSB to the FAA and industry for reducing human factors-related accidents. Before commenting further, we must add the effect of decision-making errors to the overall picture to ascertain whether the emphasis of the recommendations and new accident prevention efforts are proportional to the problems.

Decision Making — The Second Major Problem Area

Decision making, or judgment, comprises the second largest major problem area in aviation human factors involved in jet airliner accidents in the United States. The NTSB has found 32 errors (21 percent of the total errors) attributable to all flight crew members in the 21 accidents in this study sample. Because it goes with the job, captains were assessed with 28, or 88 percent, of decision-making errors, so they become the focal point of the comments on the subject. It is also important to note that when considered as a type of error, captains make more decision-making errors in accidents than any procedural sub-area, as Table 4 summarizes.

In many ways, this table could illustrate a possible priority order for aviation human factors accident prevention efforts. For the immediate purpose, it is intended to illustrate that although procedural behavior errors comprise 69 percent of all jet transport flight crew errors, *decision making is the single greatest problem area for captains*.

Table 4 Types of Captain Human Factor Errors

Decision Making	28	(27)
Procedural-Flying Skills	22	(21)
Procedural-Vigilance	16	(16)
Procedural-Experience	12	(12)
Procedural-Coordination	11	(11)
Communications	6	(6)
Flight-Planning	4	(4)
Physiological	2	(2)
Interactional	1	(1)
Procedural-Training	1	(1)
Total	103	

( ) is percentage of total errors cited.

Decision-making errors were classified into three major areas and four sub-topics which apply to all three areas (Table 5). The major areas were communications, flight planning and procedural behavior. The sub-topics were safety first, improper process, over confidence and flying skills.

Whenever a single procedure or rule was found to be involved in a decision, a procedural finding was assigned. Whenever a flight-planning assessment was made, it was a simple one-thought-process event. Decisions occur when making choices or judgments involving multiple uncertainties, probabilities, trade-offs, lack of rules, conflicting rules/information and even deliberate disregard of the proper, safest decision. It can be the "least-worst choice." It can also be "the decision not to decide."

Table 5 is a summary for captain's decision-making errors using the major and sub-topics listed above.

Procedural behavior and flight-planning decisions comprised the total sample. The term flight planning lends itself to the decision-making process by definition. Those flight-planning errors cited as non-decisions were those errors where choice, or many options, were not involved, such as "improper pre-flight," "planned poor approach," "planned to use auto-spoilers in windshear conditions" or "compensation for winds, not understood." These were basically poor planning from poor calculations, more than making choices based on multiple options or probabilities. There is a subtle topical difference in emphasis based on lessons to be learned. So it can be said that decisions involve mainly multiple calculations or rules application. Decision-making errors are mainly made by captains.

Because of their positive impact on lessons learned, it is tempting at this point to become anecdotal and provide mini-narratives of all 28 events where captains made poor decisions according to the NTSB reports. There may be much benefit in that type of approach, but this study attempts to group categories to ascertain problem areas, so we will present only

Table 5 Captain Decision-making Errors

Major Area	Total errors	Sub-topic	Errors
Communications	0		0
Flight Planning	13	Safety First	6
		Improper Process	4
		Overconfidence	3
		Flying Skills	0
Procedural Behavior	15	Safety First	8
		Improper Process	4
		Overconfidence	2
		Flying Skills	1
Total	28		28

a few typical examples to illustrate the highlights of our findings.

Overview of Decision-making Errors

Decision-making human factor errors occurred 22 times in the 14 survivable accidents and four times in the seven fatal accidents. There were 38 problem conditions requiring timely decisions on the part of the captain, as Table 6 illustrates.

There are training requirements, rules and standards designed to overcome all these circumstances. It appears, however, that rapidly changing wind, airfield and weather conditions often overwhelm captains, and rapid choices may be wrong, either due to overconfidence, improper process or more regard for schedule than for safety. In cases where failing to deice was involved, on-time departures and perhaps saving the company money superseded the principle of safety first for the decision maker. Only one error was made with intent to violate rules.

Flight-planning Represented Thirteen Errors

To illustrate a typical decision involving flight-planning and safety first, we will go through the process of converting NTSB computer phrases to the human performance classification/taxonomy phrases and plain English mini-narrative with a footnote on the situation as the author explores the subject captain's options based on information in the NTSB report.

- *NTSB base statement.* Continued flight into known adverse weather, flight crew.
- *Human Performance taxonomy.* Captain, Decision Making, Flight-Planning, Safety-First.
- *Plain English mini-narrative.* Captain elected to continue approach in sequence through thunderstorm with lightning.

Additional information: The field was open, the aircraft ahead were not reporting severe weather nor was the control tower. The missed approach course also would penetrate the storm. A visual turn away from the storm or a request for vectors could seriously affect the safety of other aircraft in the high-density area. The flight was on schedule. The other crew members did not object to continuing the approach. Only one crew member saw lightning.

What seemed like a reasonable safe decision based on the available information resulted in a fatal accident.

Table 6 Conditions Requiring a Captain Decision

Winds	11
Experience	2
Airfield Conditions	7
Mechanical	1
Weather	6
Communications	1
Confusion	6
Icing	4
Total	38

Procedural Behavior Accounted For Fifteen Errors

There are many examples of decision-making errors involving procedural behavior (rule-bending). Some occur when a go-around is not performed during an unstable approach below the 500-foot, by-the-book limit, or an abort is initiated at or after V_1 speed during takeoff. The rule has been routinely ignored many times before with the excuse, "I made it many times," or "The rule is too conservative." Other thoughts such as "I've taken off without de-icing after a delay before," or "The rules say he is current and qualified so he must be a good copilot" can mislead the captain decision maker due to insufficient information or overconfidence.

Sub-topic Concerns Offer a Further Breakdown

Sub-topic concerns of flight planning and procedural behavior, as indicated in Table 5, include safety first, improper process, overconfidence and flying skills. Safety first accounted for half the errors (14 of 28), when accidents occurred because the captain erred not on the side of safety. Questions arise such as might he be taking a chance to please his employer, to save money for a financially troubled carrier, for the sake of the schedule or because of peer pressure? All air carrier managements recognize the primacy of safety in the success formula for survival. But is the message getting through to the crew members?

Safety really implies "the absence of risk exposure." Risk without accidents is difficult to measure. Some airlines are now providing quality data to be used to assist cockpit managers — captains — to develop a feel for the risk in their jobs and become aware of the current safety problems.

Improper Process Involved Eight Errors

Eight times captains were identified as using an improper or convoluted process in arriving at a decision involving the rules or the flight-planning process. One example is the captain knowing of a circuit breaker problem on a warning system and failing to assure that it was reset. Another is the flight engineer deciding not to mention a warning light that illuminated during the takeoff roll. Then there is the captain who decides to abort a takeoff well after V_1 speed.

Overconfidence Is Cited in Five Errors

Citings of overconfidence involve situations when wind conditions are marginal, usually those that can be interpreted as gusty, and the captain elects to take off or land because of his perceived superior skill or a lack of fear that it cannot be done safely. The results are often hard landings, being towed out of the mud, minor damage or frightened passengers.

The Effect of Flying Skills

One lonely finding involved questionable flying skills in a decision-making, procedural-behavior accident. The captain allowed his first officer to remain at the controls after several mistakes which led to landing gear damage. Failure to say "I've got it" in time continues to be a problem today. Accident reports emphasize the sole responsibility of the captain in these situations.

And Then There Is the Other Ten Percent

Last, but not least, are a number of factors that, by themselves, may be an insignificant percentage, but are also important. They are:

- *Communications.* There were only six citings for external air-ground communications human factor errors in the population of this study. Two involved fatal accidents. One pilot misunderstood the tower's veiled warning of a low-altitude alert bell. Another illustrated the poor use of standard phraseology by a captain taxiing for a takeoff that proved fatal. Two other non-fatal errors involved misunderstanding the message in weather report updates. There were two in one accident, while landing to minimums, when the captain failed to assure that the tower received his report at the outer marker and later assumed he was cleared to land — another aircraft was still on the runway.

- *Flight planning.* There were only five flight-planning citations. On one fatal accident, a flight engineer should have noticed an out-of-trim situation on a flight control on his walk around that was either incomplete or not performed. In the other four, all non-fatal, captains failed to plan their approaches to account for airfield and wind conditions and to optimize their resources. The flight-planning process apparently did not include going around or waiting for better conditions. The results were landing short, long, hard or rolling off the end. These errors were associated with decision-making and procedural- behavior errors, also.

- *Physiological, Interactional and Organizational Oversight.* There were only three mentions of fatigue as a physiological problem in the accidents studied. The captain and first officer on a night freighter flight were thought to be tired because of their activities and commuting prior to the flight. On another, a captain was noted to have had cardiovascular surgery in the weeks following a minor landing accident. The one interactional finding involved the need for sunglasses in certain situations in the workspace environment. It was closely related to physiological problems and was not an eyesight problem. It involved low sun conditions in combination with difficult environmental and airfield conditions.

There were no crew performance citations under the major area of organizational oversight.

Looking for Conclusions

The five most often identified human factor error problem areas identified in these accidents are:

Captains

Decision making

Procedural behavior-flying skills

Procedural behavior-vigilance

First Officers

Procedural behavior-crew coordination

Procedural behavior-experience

From these findings we can develop a "most urgent" list of recommendations that could help reduce these problem areas. Many of the findings fortify existing NTSB recommendations and FAA-approved but optional training, educational and evaluation regulations and programs. The author's list of recommendations is:

1. Greatly expand the use of U.S. National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS) reports by air carrier crew members to assist others in learning from their decision-making experiences. NASA should also distribute its monthly "Callback" publications to all currently active pilots.

2. The FAA should require all air carriers to have an active flight safety department. The size and nature of the activities should vary with the number of the airline's departures. Similar to quality control organizations, the department should have oversight responsibilities and report to senior management. A national structure should be set up for free safety information flow for inter-airline safety information.

3. Make line-oriented flight training (LOFT) mandatory for all air carrier simulator training. Scenarios should place slightly less emphasis on emergency and minimums approach training and more on distractions and coordination in everyday unusual situations. VCR feedback should be encouraged.

4. Institute non-punitive flight data recorder (FDR) monitoring.

5. Require mandatory cockpit resource management (CRM) programs for all air carriers to include methods of improving cockpit coordination and ATC communications. Decision-making problem exercises should foster the concept of safety first and not fearing criticism for erring on the side of safety.

6. Establish within air traffic control the concept that controllers must provide safety services to the captain, as well as keep air traffic separation.

7. Establish a minimum number of hours of total line experience in type of aircraft before crew members can be assigned together. Line flying reinforcement should immediately follow initial or upgrading simulator training.

8. Make now optional advanced qualification programs (AQP) mandatory in some form for all air carriers, but continue strong emphasis on assuring flying skills proficiency on a continuing basis. Crew, not individual training and check-ride concepts should be mandatory in all aircraft simulator and line training.

9. Require new technical hardware advances such as color radar, ground proximity warning systems, collision-avoidance systems, air phones, etc. to be installed on all active fleet aircraft. Government technical and financial assistance should be considered for those carriers in need of it.

10. The FAA, NASA and NTSB should continue to improve the awareness of human factors problems related to flight crews by establishing a greatly expanded and more widely used database and make it readily available to all potential users.

This, then, is the author's "wish list" in the never-ending effort to reduce human factor errors in air carrier accidents. To accomplish it will require great effort on the industry with collaborative support from the government.

After continuing review, there may even be more innovative efforts required. However, the effort and money spent will be worth many times the price if lives and equipment are saved.

The key to all these efforts is for all of those on the ground to serve those who need help the most in preventing human factors accidents — the people in the cockpit who are ultimately responsible for the safety of the users of the air transportation system. ♦

About the Author

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Duke spent 30 years in the U.S. Air Force. He was director of safety of the Air Force Reserve, and managed a worldwide investigative and accident prevention program that won several awards. He has more than 11,400 hours of military and airline flying, and more than 16 years of active safety management.

Aviation Statistics

U.S. Civil Aviation Safety Records January-April, Calendar Year 1991

by
Shung C. Huang
Statistical Consultant

General Aviation

In the first four months of this year, U.S. general aviation recorded 545 accidents, 120 of which were fatal, accounting for 224 fatalities. Tables 1, 2 and 3 show the monthly distribution of accidents, fatal accidents and fatalities by kind of flying. Overall, personal, business and instructional flying accounted for 90 percent of total and fatal accidents.

A comparison of total accidents, fatal accidents and fatalities for the first four months of this year with those recorded in the same period of the past two years is shown in the following Table 4 which reveals that the safety performance of general aviation this year continues to improve. The total accidents in 1991 dropped six percent from 1990, 10 percent from 1989 and 15 percent from 1988. The fatal accidents and fatalities in the first four months, however, showed a slight increase. The increase appears to be a continuing trend following an increase in 1990, but it is still lower than that recorded in 1988.

For years, the monthly distribution of general aviation accidents displayed a bell-shaped pattern. Almost every year, a low frequency

Table 1
General Aviation Accidents
January-April 1989

Kind of Flying	January	February	March	April	Total
Personal	65	81	86	108	340
Business	10	11	12	4	36
Corporate/Executive	1	1	0	1	3
Aerial Application	3	4	6	7	20
Instructional	30	19	30	34	113
Other	11	5	8	12	36
Total 1/	120	121	142	165	545

1/ Detail may not add to the total because of aircraft involved in midair or ground collisions.

Table 2
General Aviation Fatal Accidents
January-April 1991

Kind of Flying	January	February	March	April	Total
Personal	35	36	46	42	159
Business	4	7	9	0	20
Corporate/Executive	0	0	0	7	7
Aerial Application	0	0	1	0	1
Instructional	3	11	2	3	19
Other	5	8	1	4	18
Total 1/	47	62	59	56	224

1/ Detail may not add to the total because of aircraft involved in midair or ground collisions.

Table 3
General Aviation Fatalities
January-June 1989

Kind of Flying	January	February	March	April	Total
Personal	65	81	86	108	340
Business	10	11	12	4	36
Corporate/Executive	1	1	0	1	3
Aerial Application	3	4	6	7	20
Instructional	30	19	30	34	113
Other	11	5	8	12	36
Total 1/	120	121	142	165	545

of accidents is recorded in January and February, then the monthly accident frequency increases gradually in March and April, reaches the peak in July, levels off in August and heads downward in September. The downtrend continues until December. A similar new cycle starts in January of the following year. Apparently the increase or decrease of general aviation accidents may be attributable to the seasonal change of general aviation traffic because the general aviation operations recorded at towered airports also display a similar bell-shaped pattern. Figure 1 shows the monthly distribution of accidents for the years 1987-1990.

Table 4
General Aviation Accidents, Fatal Accidents and Fatalities
January-June 1989

	1988	1989	1990	1991	88-91	89-91	90-91
Total Accidents	641	603	585	545	-15%	-10%	-6%
Fatal Accidents	123	110	115	120	-2%	+9%	+4%
Fatalities	231	195	200	224	-3%	+15%	+12%

U.S. Air Carrier

U.S. air carriers, including airlines, commuter air carriers and air taxi operators, during the same period, were involved in 40 accidents, 17 of which were fatal accidents, resulting in 114 fatalities. As compared with those for 1990, total accidents show a decrease of 25 percent but fatal accidents, and particularly the fatalities, show a substantial increase. The high number of fatalities in airline and commuter this year is the results of a ground collision involving both airline and commuter aircraft, in which 22 airline passengers and 12 commuter passengers were fatally injured. Table 5 is a breakdown of accidents, fatal accidents and fatalities by air carrier operating categories for the first four months in the years of 1990 and 1991.

Midair Collision Accidents

In the early and mid-eighties, there was an average of four to five midair collisions a month, approximately 65 percent of which were fatal.

Table 5
Air Carrier Total Accidents, Fatal Accidents and Fatalities
January-April

	Total Accidents			Fatal Accidents			Fatalities		
	1990	1991	(+/-)	1990	1991	(+/-)	1990	1991	(+/-)
Airline	10	7	(-3)	3	3	(0)	3	49	(+46)
Commuter	10	6	(-4)	2	3	(+1)	2	40	(+38)
Air Taxi	34	28	(-6)	10	12	(+2)	13	25	(+12)
Total	54	40	(-14)	15	17	(+2)	18	114	(+96)

Table 6
Midair Collision Accidents
January-April

	1986	1987	1988	1989	1990	1991	1986-90
Total	8	10	8	4	6	8	7
Fatal	5	6	5	3	5	4	5
Fatalities	6	22	7	13	9	20	11

Midair collision accidents have dropped significantly since 1987. In the first four months of the past four years, there was an average of fewer than two midair collisions a month. In the first four months of 1991, there were eight midair collisions, as compared to six midair collisions in 1990 and four midair collisions in 1989. The eight midair collisions recorded in the first four months in 1991 is the highest number of midair collisions to occur during the first four months in any year since 1988. Table 6 reveals that the number of total midair collisions and fatal collisions are close to the average but the fatalities were much higher than the average. ♦

Figure 1
Monthly Distribution of Total Accidents
General Aviation
Calendar Year 1987-1990

Graphic unavailable

U.S.S.R. Civil Aviation Flight Safety Analysis for 1990

The results of the U.S.S.R. civil aviation flight safety analysis for 1990 are shown in Tables 1-4. According to the figures, 1990 was worse than 1989, and in some aspects worse than the average values of the preceding four years. For example, the number of accidents increased 1.1 times and the number of fatal accidents increased 1.2 times compared to 1989 data. The number of fatalities increased nearly twofold.

The increase in the number of helicopter accidents (Table 5) had the most negative impact on the overall flight safety level in 1990. Compared to 1989, the number of helicopter accidents grew 16 percent, the number of fatal accidents was 1.3 times as many as in 1989, and the number of fatalities grew threefold. A substantial decrease in the helicopter flight safety level was recorded also in comparison with the 1986-1989 period.

For fixed-wing aircraft, the situation remains practically unchanged compared to 1989; moreover, for lightplanes the flight safety level has not changed at all. For large aircraft the number of fatal accidents equals, and the number of fatalities is lower than, the average figures for the 1986-1989 period.

Table 6 and 7 and the accompanying graphs present accident rates for five-year periods for large aircraft (scheduled passenger ser-

Table 1
U.S.S.R. Flight Safety Statistics for Civil Aviation
1986-1990, All Types of Aircraft

	1986	1987	1988	1989	Average 1986-1989	1990
All types of accidents	187	176	156	174	173	189
Fatal accidents	29	13	16	23	20	27
Fatalities	324	47	115	98	146	194
Passengers	257	17	85	49	102	128
Crew members	67	30	30	49	44	66

Table 2
U.S.S.R. Accident Statistics for Large Airplanes*, 1986-1990

	1986	1987	1988	1989	Average 1986-1989	1990
All types of accidents	22	21	23	24	23	25
Fatal accidents	7	3	4	3	4	4
Fatalities	246	26	64	57	98	86
Passengers	219	15	51	36	80	69
Crew members	27	11	13	21	18	17

*Il-86/76/62/14, Tu-154/134, Yak-42/,40, An-24/26/30, An-12

Table 3
U.S.S.R. Accident Statistics for Large Airplanes*, 1986-1990
(passenger services)

	1986	1987	1988	1989	Average 1986-1989	1990
All types of accidents	16	18	17	16	17	21
Fatal accidents	5	2	3	1	3	3
Fatalities	235	17	58	32	86	77
Passengers	216	11	51	27	76	69
Crew members	19	6	7	5	9	8

*Il-86, Il-62, Tu-154, Yu-134, Yak-42, Yak-40, An-24

Table 4
U.S.S.R. Accident Statistics for Light Airplanes*, 1986-1990

	1986	1987	1988	1989	Average 1986-1989	1990
All types of accidents	68	70	69	76	71	78
Fatal accidents	4	4	6	7	5	6
Fatalities	20	8	32	13	18	16
Passengers	12	1	22	4	10	6
Crew members	8	7	10	9	9	10

L-410, An-2, An-28

Table 5
U.S.S.R. Accident Statistics for Helicopters, 1986-1990

	1986	1987	1988	1989	Average 1986-1989	1990
All types of accidents	97	85	64	74	80	86
Fatal accidents	18	6	6	13	11	17
Fatalities	58	13	19	28	30	92
Passengers	26	1	12	9	12	53
Crew members	32	12	7	19	18	39

vices). Tables 8 and 9 and the accompanying graphs show accident rates for the last decade.

These data show that the flight safety level for the 1986-1990 period is higher than for the previous five-year period: The number of fatalities is 2.2 times lower and the number of accidents and fatal accidents is 10 percent lower.

Despite the decline of the safety level in 1990, on the whole the last five-year period shows a decrease in fatal accident rates and a significant (more than 3.5 times) decrease in fatalities. The flight safety level for large aircraft in scheduled passenger services in the U.S.S.R. is a bit higher than the average values for the ICAO member states, but lower than in the United States.

On the whole, examination of the results both for the long-term period and for the past five

Table 6
Fatal Accidents per 100,000 Flight Hours

	Average Rates for the Period 1971-1975	1976-1980	1981-1985	1986-1990
U.S.S.R.	0.24	0.17	0.09	0.08
U.S.	0.08	0.05	0.05	0.04*
ICAO (U.S.S.R. excl.)	0.26	0.17	0.14	0.13*

*1990 data for the USA and ICAO are preliminary

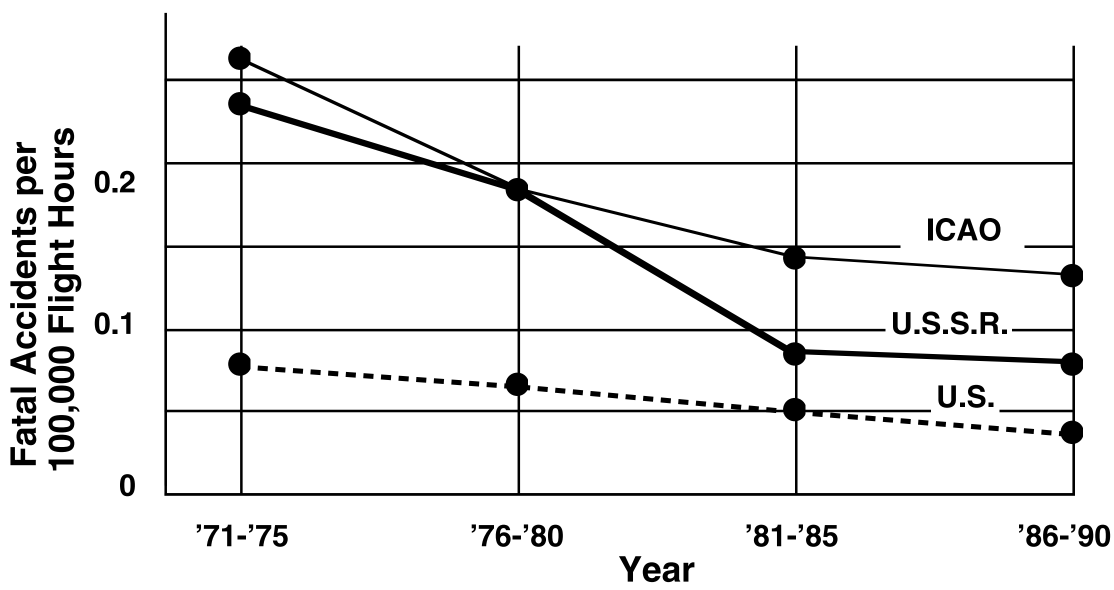


Table 7
Fatalities (crew and passengers) per One Million Enplanements

	Average Rates for the Period			
	1971-1975	**1976-1980**	**1981-1985**	**1986-1990**
U.S.S.R.	4.6	3.2	2.6	0.7
U.S.	1.2	0.7	0.5	0.4*
ICAO (U.S.S.R. excl.)	2.4	1.3	0.9	0.8*

*1990 data for the USA and ICAO are preliminary

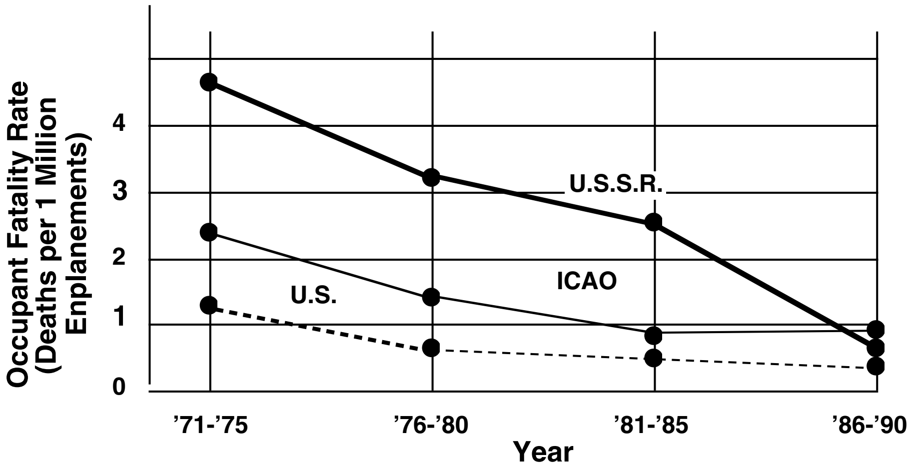


Table 8
Fatal Accidents per 100,000 Flight Hours

	1981	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
U.S.S.R.	0.11	0.09	0.07	0.10	0.09	0.12	0.05	0.08	0.03	0.07
U.S.	0.06	0.04	0.03	0.00	0.07	0.01	0.03	0.03	0.04	0.05
ICAO (U.S.S.R. excl.)	0.14	0.18	0.13	0.10	0.13	0.09	0.12	0.12	0.14	0.13

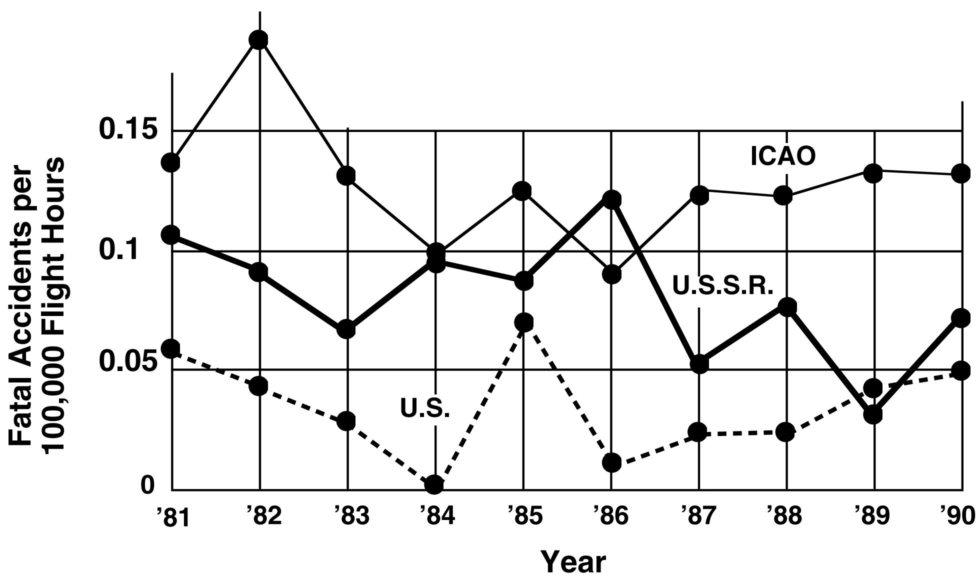
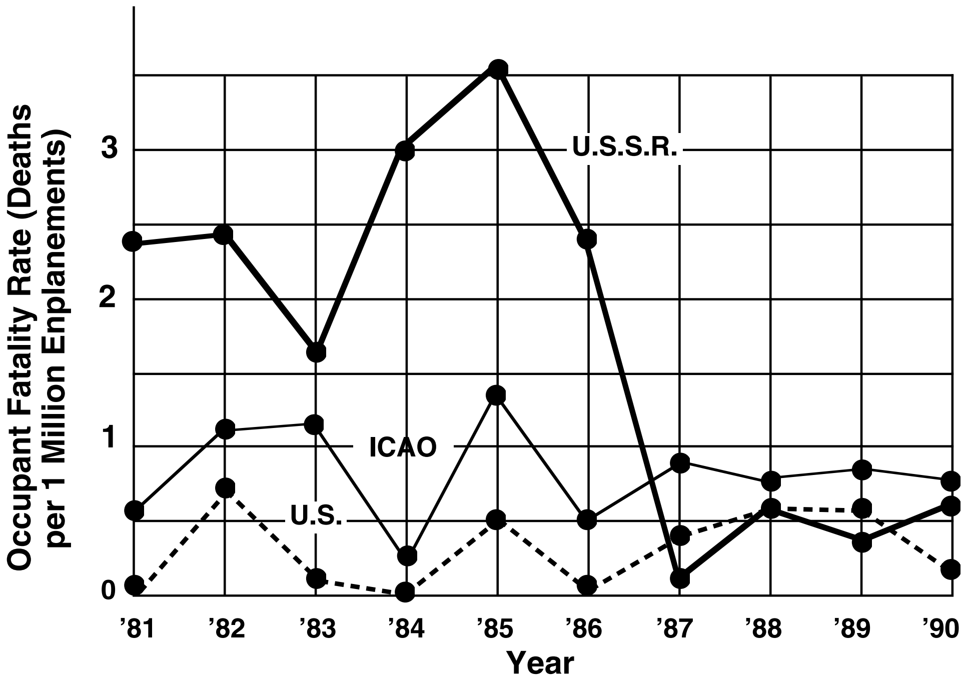


Table 9
Fatalities (crew and passengers) per Million Enplanements

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
U.S.S.R.	2.34	2.46	1.61	3.01	3.60	2.40	0.16	0.60	0.30	0.62
U.S.	0.01	0.78	0.05	0.01	0.54	0.01	0.41	0.60	0.60	0.20
ICAO (U.S.S.R. excl.)	0.56	1.16	1.18	0.29	1.35	0.50	0.90	0.70	1.00	0.74



years shows the following:

- Flight safety levels increased in the last five years, primarily beginning from 1987, mainly attributed to the decline in the accident rates and fatalities on the main type of air transportation services — scheduled passenger services on large aircraft; while the yearly number of fatal accidents remains practically the same, the number for the large passenger capacity aircraft decreased, (i.e. the number of potential fatalities reduced) and the survivability in fatal accidents increased.

- While the flight safety level for light aircraft is more or less stable, the tendency of the helicopter accident number to increase became quite evident in 1990.

- The tendency of large aircraft accident numbers to grow indicates that the potential of the whole complex of accident prevention measures undertaken during the last few years has been exhausted, which could lead to fatal accidents involving large passenger aircraft with an accompanying increase in human and material losses.

An analysis of the accident causes was carried out using generalized cause factors groups, characterizing the activities of the main branches of the air transportation system.

Interrelations of the accident rates are shown in Figures 1-4.

- For the 1986-1990 period, the number of accidents caused by human error, including flight crew errors, is practically stable for helicopters, tends to grow

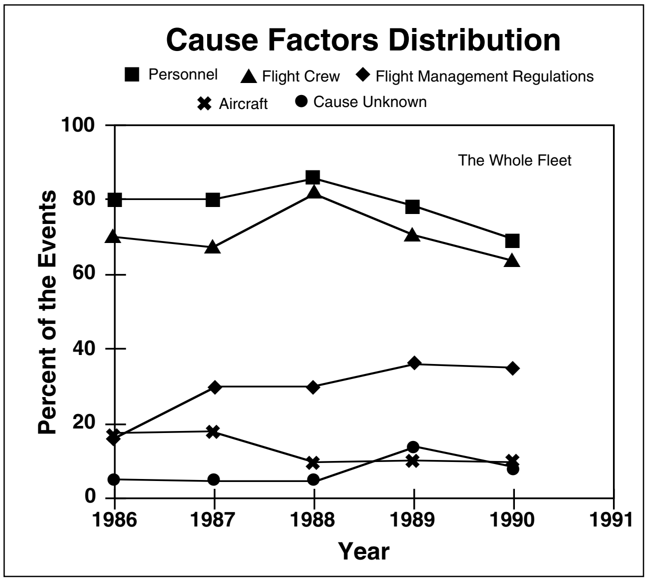


Figure 1

for large aircraft and tends to decrease for lightplanes. For the whole civil aviation fleet, these figures are more or less stable and represent 80 percent of the air transportation system personnel and about 72 percent for flight crews.

- The 1986-1990 period is characterized by a significant, two- to threefold increase in the number of accidents involving the aircraft types where the factor of faulty or inefficient flight management regulations has been identified.

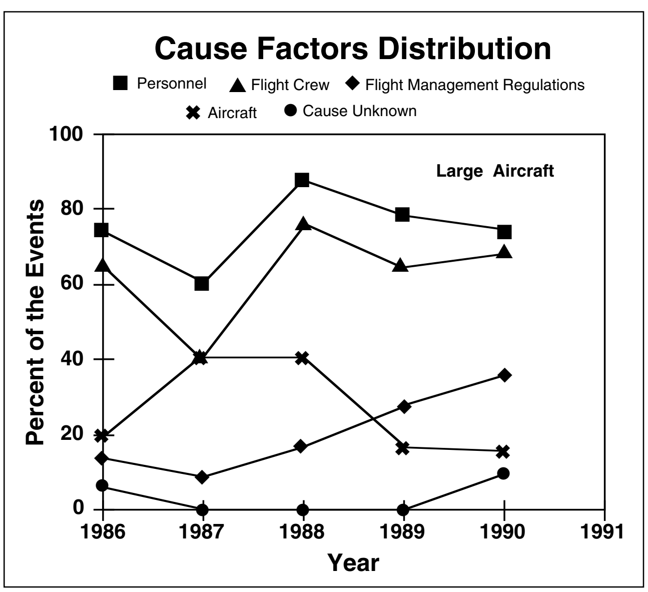


Figure 2

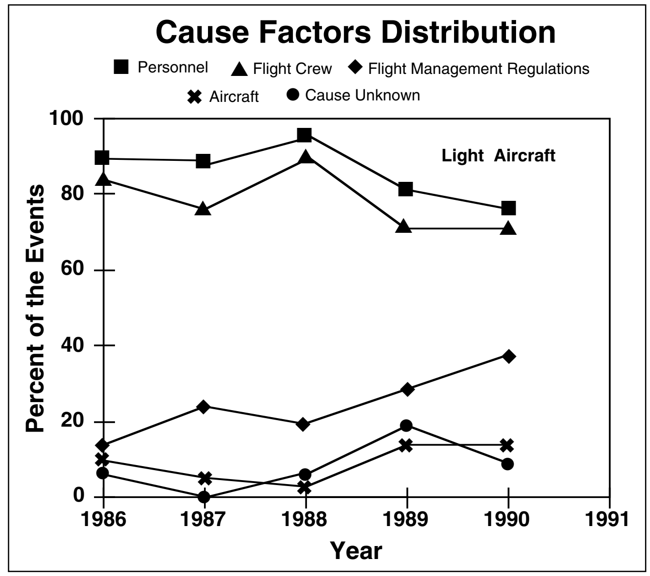


Figure 3

- The share of accidents caused by structural and manufacturing deficiencies remained practically unchanged during the 1986-1990 period and accounts for 12-14 percent for the whole civil aviation fleet. A decrease in the number of such accidents could be mentioned only for helicopters. For large aircraft, the number of accidents where structural failures were identified as cause factors is the most significant and averages about 25 percent for the 1989-1990 period.

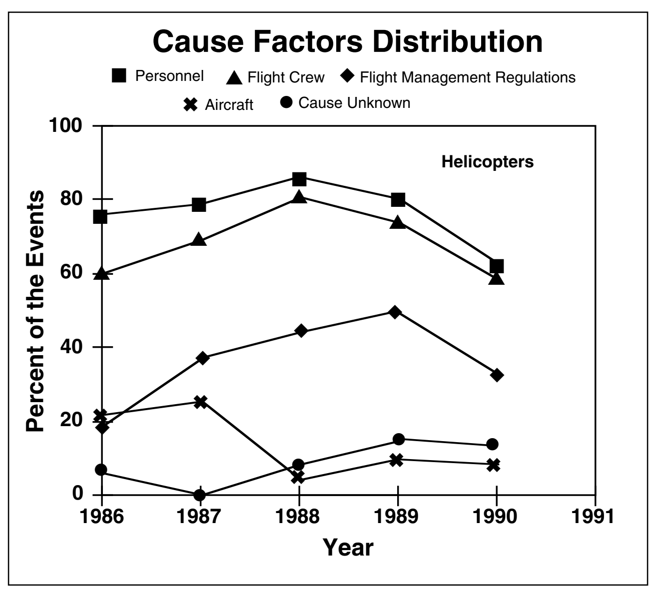


Figure 4

The comparison of the relative contribution of the main cause factors in the overall flight safety level shows that it was basically the same during the last few years. It once again confirms the fact that a certain balance of accident cause factors, formed during the last years, does nothing but reflect the degree of the influence of different air transportation branches on flight safety. ♦

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Advisory Circular 61-98, 03/26/91, *Currency and Additional Qualification Requirements for Certificated Pilots.* — Washington, D.C. : United States. Federal Aviation Administration, 1991, March 26. 30p. in various pagings.

AC 61098, "Scope and Content of Biennial Flight Reviews," dated September 1, 1987, is cancelled.

International Flight Information Manual, Volume 39. — Washington, D.C. : U.S. Department of Transportation, Federal Aviation Administration, Air Traffic Procedure Service, 1991, April. 3 hole punched; 1 1/2 inches thick. Available from U.S. Superintendent of Documents, Government Printing Office.

Key Words
1. Aeronautics — Law and Legislation.

Summary: This manual is a preflight and planning guide for use by U.S. nonscheduled operators, business and private aviators flying outside of the United States. The manual contains foreign entry requirements, a directory of aerodromes of entry, and pertinent regulations and restrictions. [Foreword]

Advisory Circular 20-122A, 01/29/91, Anti-Misfueling Devices: Their Availability and Use. — Washington, D.C. : United States. Federal Aviation Administration, 1991. 2 p.

Key Words
1. Airplanes — Refueling.
2. Airplanes — Fuel.

Summary: This advisory circular (AC) explains the benefits of fitting reciprocating engine-powered general aviation aircraft with anti-misfueling devices and the fitting of fuel dispensing equipment with special fuel hose nozzle spouts. [Excerpted from Purpose]

Advisory Circular 25-16, 04/05/91, Electrical Fault and Fire Prevention and Protection. — Washington, D.C. : United States. Federal Aviation Administration, 1991. 11 p.

Key Words
1. Airplanes — Electric Wiring — Law and Legislation — United States.
2. Airplanes — Electric Equipment — Law and Legislation — United States.

Summary: This advisory circular (AC) provides information on electrically caused faults, overheat, smoke and fire in transport category airplanes. Acceptable means are provided to minimize the potential for these conditions to occur, and to minimize or contain their effects when they do occur. These means are not mandatory. An applicant may elect to use any other means found to be acceptable by the Federal Aviation Administration for compliance with the Federal Aviation Regulations (FAR). [Excerpted from Purpose]

Reports

Utilization of Emergency Kits by Air Carriers. Final Report / J.R. Hordinsky and M.H. George (Civil Aeromedical Institute). — Washington, D.C. : United States. Federal Aviation Administration, Office of Aviation Medicine; Springfield, VA : Available through NTIS*, 1991, March. Report DOT/FAA/AM-91/2. 7p.

Key Words
1. Aeronautics, Commercial — Emergency Medical Care — United States.
2. Airlines — Emergency Medical Care — United States.
3. Airlines — Medical Kits — United States.

Summary: The Department of Transportation Emergency Medical Equipment Requirements Rule of January 9, 1986, mandated a period of 24 months (August 1986-July 1988) during which all air carriers flying under Federal Aviation Regulations, Part 121, would monitor medical emergencies and use of the prescribed medical kits. The reporting airlines were to provide descriptions of how the medical kits were used, by whom, and the outcome of the medical emergency. During the two year monitoring period, a total of 2,322 reports of medical emergencies were documented. Of the 2,293 actual uses of the medical kit, a physician was the provider in more than 85 percent of the cases. The most common presenting symptom was pain, with unconsciousness, impaired breathing, nausea and/or vomiting, and various myocardial diagnoses in descending order of frequency. High frequency recurrent complaints about kit adequacy were not noted during the two-year monitoring period. There were scattered references about the poor technical quality of the most frequently employed equipment; the medical kit content might selectively be expanded to include analgesics, antiarrhythmics, antiemetics and bronchodilators. [Author abstract]

Aircraft Accident Report — Partenavia P68 Observer, G-SPOT Near Vagar Airport, Faroe Islands, 6 July 1987 / Denmark. Aircraft Accident Investigation Board. — [Copenhagen] : Aircraft Accident Investigation Board, 1991. Report AAIB 1/91. 25 p. in various pagings. ISBN: 0902-8129.

Key Words
1. Aeronautics — Accidents — 1987.
2. Aeronautics — Accidents — Weather.
3. Octavia Air — Accidents — 1987.

Summary: The aircraft, operated by Octavia Air, Bristol, U.K., was chartered for traffic spotting, whale- and polar bear-spotting between the Faroe Islands and Greenland. The aircraft departed Kirkwall Airport, Orkney Islands, (EPGA) on 6 July 1987 at 1000 hours for a VFR flight to EKVG (Vagar). There were 1 pilot and 2 passengers on board the aircraft. As an approval for an IFR approach was denied due to weather conditions, the pilot decided to continue to Myggenaes (MY) non-directional beacon and "have a look." The last message from the pilot was at 1222 hours. After a collision with a mountain plateau, the outer portion of the right wing and the right wing-flap separated from the aircraft. The aircraft continued into the open sea, where it sank. Debris consisting of small airframe parts and personal belongings were found on the coastline of a small island at a distance of three kilometers from the point of collision. The aircraft and its occupants have not been located. Except for radio communication difficulties between the aircraft and EKVG, the flight appears to have been uneventful until the pilot decided to remain in the area and wait for improvement in the weather. Being aware of the weather conditions, the pilot exercised poor judgement when he attempted operation beyond experience/ability and initiated and continued a VFR flight into known adverse weather conditions (cause factor). The aircraft collided with a mountain plateau 515 meters (1690 feet) above sea level (cause factor). No recommendations were made by the board regarding this accident. [Synopsis, Conclusions]

Aviation Occurrence Report — Voyageur Airways Ltd Beechcraft King Air A-100 C-GJUL Chapleau, Ontario, 29 November 1988. — Ottawa : Transportation Safety Board (TSB) of Canada, February 12, 1991. Report Number 8800491. 35 p. in various pagings. [Communique TSB #10/91 to be released on 9 May 1991.] [FSF also has report in French.]

Key Words

1. Aeronautics — Accidents — 1988.
2. Aeronautics — Accidents — Altitude.
3. Aeronautics — Accidents — Investigation.
4. Airplane Ambulances — Accidents.
5. Cockpit Resource Management.
6. Flight Recorders.
7. Voyageur Airways Ltd. — Accidents — 1988.

Summary: The air ambulance Beechcraft King Air A-100, Voyageur 796, was proceeding on an instrument flight rules (IFR) flight from Timmins to Chapleau (Ontario) with two crew members and two paramedics on board to pick up a seriously injured person to be flown to Sault Ste. Marie, Ontario. On arrival at Chapleau, it overflew the airport at low altitude and crashed 1.5 miles southwest at 2301 EST. The aircraft was destroyed by the impact and the post-crash fire, and all occupants perished. The TSB determined that the flight crew descended below the minimum applicable instrument flight regulations altitude while approaching the Chapleau non-directional beacon. Why the crew allowed the aircraft to descend, in controlled flight, into the ground could not be ascertained. The investigation was hampered by the absence of a flight data recorder or a cockpit voice recorder. Neither was required by regulations. Consequently, the board has recommended to the Minister of Transport that Transport Canada expedite legislation for upgrading the flight recorder requirements for Canadian-registered aircraft. [Communique]

Aviation Safety: Limited Success Rebuilding Staff and Finalizing Aging Aircraft Plan. Report to the Chairman, Subcommittee on Transportation and Related Agencies, Committee on Appropriations, House of Representatives / United States. General Accounting Office. — Washington, D.C. : U.S. General Accounting Office*, April, 1991. Report GAO/RCED-91-119; B-243303. 20 p.

Key Words

1. Air Traffic Controllers — Selection and Appointment — United States.
2. Aviation Safety Inspectors — United States.
3. Airworthiness Inspectors — United States.
4. Airplanes — Airworthiness — United States.
5. United States. Federal Aviation Administration — Officials and Employees — Appointment, Qualifications, Tenure, etc..

Summary: This report provides information on the Federal Aviation Administration's (FAA) progress in (1) rebuilding the air traffic controller and aviation safety inspector work forces and (2) developing a plan to address aging aircraft problems. FAA has essentially rebuilt the air traffic controller work force since the 1981 strike, but the overall number of full performance level controllers remains below prestrike levels and it will be several years before FAA achieves prestrike controller capability. FAA is also increasing the size of the aviation safety inspector work force, but given budgetary restraints, FAA must use its current inspectors more effectively and provide them with better training. On the aging aircraft issue, although FAA has worked closely with the aviation community to address concerns, FAA has yet to complete a comprehensive plan to guide industry and government efforts to address this critical aviation issue. [Modified results in brief]

The Effect of Simulated Altitude on the Visual Fields of Glaucoma Patients and the Elderly. Final Report / Van B. Nakagawara (Civil Aeromedical Institute), George W. Fulk (Northeastern State University), Roger W. West (Northeastern State University). — Washington, D.C. : United States. Federal Aviation Administration Office of Aviation Medicine; Springfield, VA : Available through NTIS*, January, 1991. Report DOT/FAA/AM-91/1. 22 p.

Key Words

1. Glaucoma.
2. Visual Fields.
3. Altitude, Influence of.
4. Aged — Health Risk Assessment.

Includes bibliographical references.

Summary: This study tests whether mild hypoxia, that is typically encountered in civilian aircraft, causes temporary visual field defects in elderly persons or temporarily increases pre-existing defects in persons with glaucoma. Altitude was found to have no ef-

fect on the visual fields of subjects with glaucoma, age-matched normals, and younger subjects. No evidence was found to suggest a change in the present Federal Aviation Administration standards, which allow a special issuance certificate to persons with glaucoma who wish to obtain medical clearance to operate civilian aircraft. Nor was any evidence found that should discourage glaucoma patients from flying as passengers. [Author abstract]

"Flight Safety — An Endless Task," Proceedings of the 43rd Annual International Air Safety Seminar, November 19-22, 1990, Rome, Italy / Flight Safety Foundation. — Arlington, VA : Flight Safety Foundation (2200 Wilson Blvd., Suite 500, Arlington, VA 22201 U.S.), c. 1990. xx, 306 p., 26 p. ISSN: 0270-5176.

Key Words
1. Aeronautics — Safety Measures — Congresses.
2. Aeronautics — Human Factors — Congresses.
3. Airpilots — Training.
4. Airlines — Management.
5. Aeronautics — Accidents — Investigation.

Notes: Hosted by Alitalia Airlines; "Proceedings of the 43rd International Air Safety Seminar are dedicated to the memory of J.R. Riedmeyer 1928-1991".

Contents: Opening / Capt. Robert Weatherly — Welcome / Ing. Ferruccio Pavolini (Alitalia Airlines) — Response / Stuart Matthews — Your Flight Safety Foundation / John H. Enders — Keynote Address / Eng. Professor Federico Quaranta (Director General, Italian Civil Aviation). SESSION HEADINGS: The Aviation Safety Posture — Training: Targeted at Aviation Safety — Operational Considerations for Safety Enhancement — How Management Views Aviation Safety: A Panel Discussion — International Aspects of Aircraft Accident Investigation: Cross-border Coordination — Technology: Tool of Master? — APPENDICES.

Summary: "Fifty-four countries were represented by the more than 400 attendees. "Flight Safety — An Endless Task," the seminar's theme, is likely to remain timeless in our industry because safety demands never-ending vigilance, a point well-made in many of the presentations at this seminar." [Preface]

UK Airmisses Involving Commercial Air Transport, May-August 1990. — London : Civil Aviation Authority, Greville House, 37 Gratton Road, Cheltenham, England, April, 1991. 81 p. ISSN: 0951-6301.

Key Words
1. Aeronautics, Commercial — Great Britain — 1990.
2. Airplanes — Near Midair Collisions — Great Britain.
3. Airplanes — Collision Avoidance — Great Britain.

Contents: Introduction — Statistics — Commercial Air Transport Airmiss Reports (May-August 1990) — Appendices.

Summary: An "airmiss" is said to have occurred when a pilot considers that his aircraft may have been endangered by the proximity of another aircraft. Only the pilot of the aircraft can file an airmiss report. If the air traffic controller considers that flight safety has been hazarded, he will file an Aircraft Proximity Hazard report which will be investigated similar to but separate from the airmiss system. 34 incidents, involving 39 aircraft, occurred from May - August 1990, of which 7 were risk-bearing.

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Accident/Incident Briefs

This information is intended to provide an awareness of problem areas through which such occurrences may be prevented in the future. Accident/incident briefs are based upon preliminary information from government agencies, aviation organizations, press information and other sources. This information may not be accurate.

Air Carrier

Assumption Leads to The Wrong Runway

Boeing 737: No damage. No injuries.

The scheduled jet transport was approaching to land early in the summer evening. Visual landings were being made to runways 28R and 28L. Visibility was restricted because of haze and the setting sun which was almost directly in the pilots' eyes on final approach.

The first officer was flying the aircraft and the captain was handling radio calls. After approach control cleared the aircraft to land on runway 28L, the aircraft was vectored for additional spacing behind a corporate jet. The captain then switched frequency to the control tower and was again cleared to land on runway 28L. The pilots assumed they had been vectored to the proper runway and landed on the one directly ahead of them, newly opened runway 28R that was only 3,500 feet long and 60 feet wide.

The aircraft was stopped without further incident although the runway was substantially shorter than usual for jet transport operations. The crew was cited for missing a Notice to Airmen (NOTAM) advising that the new runway was operational and for not utilizing available navigational aids.

It Was a Dark And Snowy Night ...

Ilyushin IL-62: Minor damage. No injuries.

The aircraft was landing on a November night in Newfoundland during conditions of restricted visibility caused by snow and blowing snow. There were a crew of 10 and 125 passengers aboard.

The approach was to runway 04 and the control tower reported wind from 350 degrees at 22 knots, runway visual range (RVR) of 3,500 feet and a runway surface braking value that required an RVR of 4,000 feet for the crew to continue the approach. The aircraft was flown at between five and seven knots above the calculated target speed during the approach because of the crosswind. As the aircraft descended through a height of 200 feet at a distance of 3,000 feet from the runway threshold, the rate of descent increased to more than 1,200 feet per minute and the aircraft descended below the glideslope. The approach became unstable. Power was applied to adjust the rate of descent which, combined with the high rate of descent, resulted in an airspeed of 166 knots, about nine knots faster than the target speed.

The aircraft was flared for touchdown approximately 1,000 feet beyond the runway threshold. After the flare, the aircraft began to drift to the right but, because of the darkness and the blowing snow, the crew was unaware of it. The aircraft touched down to the right of the runway centerline about 2,100 feet from the threshold at a speed of 156 knots, 22 knots above target speed. After the aircraft touched down, the crew realized that it was drifting to the right and they immediately applied full left rudder. However, because the high landing speed made the aircraft retain more lift than normal, braking and directional control were not sufficiently effective and the aircraft continued to drift to the right until it left the runway. The crew was able to bring the aircraft back to the runway surface after travelling about 1,300 feet. Aircraft damage was minor, limited to superficial scratches and dents; three runway side marker lights were broken. No occupants were injured.

Causal findings — besides the slippery runway, crosswind and reduced visibility — included an RVR that was 500 feet less than that prescribed by the company for a crosswind landing; the higher than normal airspeed and unstabilized approach; the high touchdown speed; and the crew's failure to recognize that the aircraft was drifting to the right.

Air Taxi
Commuter

Downwind Taxiing Puts Aircraft in Ditch

Cessna 421: Substantial damage. No injuries.

The aircraft had just completed a flight with five passengers, had debarked them and was departing for another flight without passengers. The aircraft was taxiing to runway 07 on taxiway 25 parallel to it.

When the aircraft reached a point approximately 50 feet from the end of the runway, taxiing at a speed estimated at 9 knots, the pilot began a 180-degree turn to the right to line up in the runway. Before he could complete the turn, the aircraft began to head for the left edge of the runway. The pilots both applied heavy braking, and shut down the engines in an attempt to stop the aircraft on the runway, but it ran off the hard surface and into a ditch. The aircraft was substantially damaged but there were no injuries to the two crew members.

It had rained for three days previously, following which the temperature dropped and remained below the freezing level. At the time of the occurrence, the wind was blowing at 12 knots gusting to 25 knots from 50 degrees. The temperature was minus eight degrees Celsius.

The pilot reported that the brakes had operated properly after the previous landing and prior to departing the terminal area to taxi toward the runway. While taxiing the 3,000 feet toward the runway, he did not have to use the brakes, requiring them only when he attempted to reduce taxi speed prior to turning onto the runway. The brakes were tested after the accident and operated properly. The recovery team saw no skid marks on the runway, or no ice patches, although surface ice was considered a possible reason for the inability of the crew to stop the aircraft.

Another possible cause was the strong, gusting tailwind during taxiing that could have increased taxi speed thus requiring stronger braking action to slow down. The tailwind could also have tended to increase the aircraft's rate of turn, leading to a loss of control during the turn on to the runway.

Trees Block Flat Climb

Piper PA-31-350 Chieftain: Substantial damage. Serious injuries to one, minor injuries to two.

The medical evacuation charter flight was being conducted night VFR, with a pilot paramedic and a nurse on board. The aircraft was departing its home base to pick up a patient. The pilot had a total of 16,500 flying hours, 1,400 in type and 270 during the previous three months.

The takeoff was normal, but during the post-takeoff phase, the aircraft struck trees approximately 2,800 feet from the departure end of the runway at a height of 35 feet from the ground. It cut a swath for about 400 feet after which the pilot was able to climb above the trees for a short distance before descending through the treetops into a snow-covered field. The aircraft landed hard and turned 180 degrees before coming to rest. There was no fire but the aircraft was substantially damaged. The pilot sustained serious injuries and the two passengers received minor injuries.

The cause was determined to be that the pilot's takeoff procedure and instrument scan did not ensure that the aircraft was trimmed properly and established in a positive rate of climb. It was also noted that the pilot had diverted his attention to selecting gear and flaps up and setting climb power before he established a positive rate of climb. He mistakenly thought the aircraft was in a positive rate of climb because it had achieved the single-engine best rate-of-climb speed and his instrument scan did not prompt him to initiate a climb.

Long Sideslip Leaves Engines Without Fuel

Beechcraft C55 Baron: Substantial damage. Serious injury to one, minor injuries to two.

The aircraft had been on a VFR flight in the darkness of a fall evening with a pilot and three passengers aboard. It was approaching the airport at a height of 2,100 feet above the ground.

The pilot realized that he was too high during the turn to final approach and he sideslipped the aircraft to the right to increase the rate of descent. Maintaining power at 1,700 rpm, he put the aircraft into an angle of 30 degrees of bank for approximately 20 seconds. Then he reduced the power and sideslipped the aircraft to the left for another 15 to 20 seconds.

As the pilot leveled the wings and advanced the throttles to stabilize the approach, both engines stopped. He quickly tried to restart them by switching fuel tank selectors and turning on the fuel boost pumps, but to no avail. He raised the nose to avoid a road and a ditch that lay across the path of the aircraft and it stalled, striking the ground past the road and approximately 950 feet short of the runway threshold. There was no fire, but the aircraft sustained substantial damage. One passenger was injured seriously, and the other occupants received minor injuries.

It was found that, of the two fuel selector console lights, one bulb was missing and the other was inoperative. The pilot reportedly used a flashlight to determine the fuel selector position en route but was unable to visually check the selector positions during the approach, although he stated that he selected main tanks left and right before starting the landing approach. There was less than one-quarter tank of fuel in each main tank.

Conclusions indicated that both engines lost power due to fuel starvation because of the prolonged sideslipping with a low fuel quantity and that the engines failed at too low an altitude for successful restarts.

Moving the Wrong Lever Can Give the Wrong Result

Piper PA-31 Navajo: Substantial damage. No injuries.

The commercial-rated pilot of the twin-engine aircraft had a total of flying 711 hours. Of slightly more than 180 hours during the past three months, nine were in type.

Approaching the runway to land, the pilot had applied full flaps. During the landing flareout, he cut the power to idle. Immediately after touchdown, the pilot applied the brakes. The landing gear horn then began to sound, and the pilot realized that the aircraft was settling to the runway on its nose as the gear collapsed. There was no fire and the pilot left the aircraft without injury.

Maintenance personnel checked the aircraft after the accident and found that the landing gear lever was in the up position.

The pilot stated that he was very tired, that he lacked experience in that type of aircraft, that he usually retracted the flaps immediately after touchdown — and that he had inadvertently retracted the landing gear.

Other General Aviation

But the Gear Lever Was in the Down Position

Piper PA-30 Twin Comanche: Substantial damage. No injuries.

The airline transport-rated pilot had a total of 3,400 flying hours, with more than 200 hours in type. He was receiving currency training from an instructor pilot in the light twin-engine aircraft. It was midday in late winter; weather was not a factor. The procedure being accomplished was a simulated instrument landing system (ILS) approach.

As the aircraft intercepted the glide slope inbound, the student pilot put the landing gear selector in the down position. The instructor checked that the student had done so.

Neither pilot noticed that the green gear-down light was not illuminated. The approach to a full-stop landing was continued.

After being flared out over the centerline of the runway, the aircraft landed smoothly — wheels-up. The propellers and underside of the aircraft were damaged substantially but there was no fire. The two occupants deplaned without injury.

Examination revealed that the circuit breaker for the landing gear motor had opened. No reason for the opening of the circuit breaker could be found by maintenance personnel.

Low on Experience, Low on Prudence — High on Risk

Piper PA-28: Major damage. Minor injuries to one.

The private pilot had a total of 65 flying hours, eight of which were in the type aircraft he intended to fly that spring morning. He obtained weather information which indicated that he could expect a moderate surface wind of eight to 12 knots from the northeast at his destination airport.

The takeoff and en route portions of the flight were uneventful, and the pilot made an approach to runway 09 at the destination airport. The crosswind was from the left as expected and he crabbed into it on final approach.

Then things began to go wrong. The pilot flared slightly high and applied power to cushion the touchdown, after which directional control became difficult. The aircraft yawed to the left toward a field of crops, and the pilot elected to go around. He applied power but realized that the aircraft was about to collide with a fence, so he closed the throttle again.

The aircraft impacted the fence and the left wing was torn off. The aircraft continued into the field and overturned; there was no fire. The pilot, restrained by the shoulder and seat belts, was able to exit the aircraft suffering only minor injuries.

Practice Autorotation Proves Costly

Hughes 369: Substantial damage. No injuries.

The pilot of the rotorcraft was returning to his home base after completing a charter assignment. He had a total of more than 1,700 flying hours, of which 700 were in type.

Since he was scheduled for an upcoming proficiency flight test, the pilot had been honing his flying skills. He decided, now that he was alone in the aircraft, to accomplish a practice autorotation. However, at the end of the autorotation descent, the aircraft struck the ground hard and the main rotor blade struck the tail boom. There was no fire, but the aircraft sustained substantial damage. The pilot departed the aircraft without injury.

Off-target Toss Tumbles Helicopter

Bell 206B: Substantial damage. No significant injuries.

An external load was being connected while the helicopter was hovering. One of the ground personnel threw a control box for the external load mechanism into the cockpit for the pilot.

The box hit the cyclic control and caused the helicopter to drift to the rear. The main rotor blades struck a barrier and the pilot moved the aircraft forward, trying to avoid the person on the ground. The cable to the external load became taut and caused the rotorcraft to impact the ground. The ground person was hit by debris thrown by the crash of the helicopter but he received no significant injuries. The pilot safely escaped the downed helicopter, which was substantially damaged. ♦