Today's Professional Airline Pilot: All the Old Skills — and More

Improved cockpit management and coordination can help reduce crew-related accidents caused by a failure to follow established rules and procedures.

by
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(Presented at the International Airline Pilot Training Seminar conducted by VIASA Airlines and the Flight Safety Foundation in Caracas, Venezuela, January 23-25, 1989.)

Our worldwide airline industry is just beginning its 30th year of turbojet operations. During that period we have experienced nearly 400 jet airplane accidents. We have killed nearly 18,000 of our passengers — an average of 44 passengers per accident. It is difficult to find much comfort in that record. It is especially difficult for a pilot (or a pilot manager) to find comfort in that record because, despite a generally improving safety record through these years, approximately 70 percent of these tragedies had crew-related causes. And while there is no question that the pilot is the "last line of defense" in the prevention of an accident, it is a distortion and a gross oversimplification to translate crew-related causes to simply "pilot error."

Knut Hammarskjold, who was then secretary general of the International Air Transport Association (IATA), made this point when he opened IATA's 20th Technical Conference and said in regard to pilot and controller error, "We now know beyond a shadow of a doubt that these descriptions of accident causes are at best misleading, and at worst irresponsible."

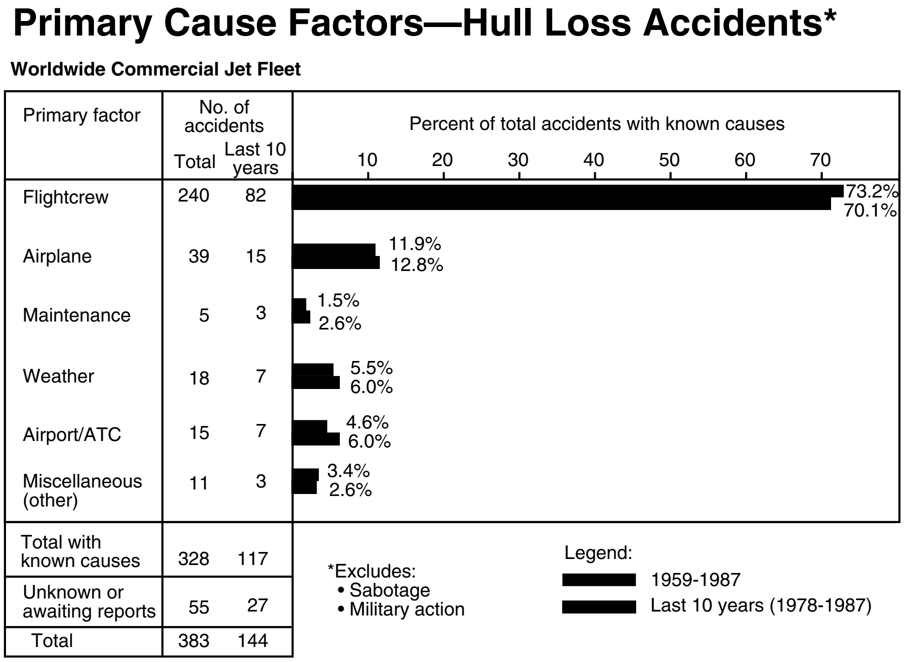
Many years before, Benjamin Howard, a long-time aeronautical engineer who made a study of air carrier accident causes in the early 1950s, had also put the question of pilot error in perspective when he told a group of aviation safety experts, "I submit ... we are evading responsibility when we charge a crash to pilot error when the pilot is only guilty of doing what other pilots have already established as something to be expected of a qualified pilot."

Today, if we are really going to make progress in better understanding and controlling crew-related accidents, those statements are worth remembering.

The actual record looks like Figure 1, taken from the Boeing Aircraft Company [now the Boeing Commercial Airplane Group] Statistical Summary of Commercial Jet Aircraft Accidents in Worldwide Operations 1959-1987. The solid top bar shows the record from the beginning of the jet era in 1959 to 1983, and immediately below it the shaded bar represents the 10-year period from 1974 to 1983. There has been virtually no change over the years.

Despite extraordinary accomplishments in other areas, our industry has simply not been able to do very much about the crew-related accident. The late Hugh Gordon-Berge very eloquently described our continuing frustration when he reviewed 1973 jet losses as chairman of the IATA Safety Advisory Committee (SAFAC) and confessed, "When looking at all the approach phase accidents, it is really possible to do no more than to remark once again on their seeming inevitability year after year; on their almost exact similarity year after year; on the airlines' apparent inability to prevent their numbers from increasing, let alone to reduce them; and on the continuing prominence of the human factor in the causal chain of events. It therefore seems pointless to go on repeating what has been said before … SAFAC at this, its twelfth meeting, can only look again at the very sorry list and at a deteriorating trend, then give the subject careful consideration in an attempt to offer possible guidance ... to the Technical Committee in this most pressing — and depressing — matter."

You might well protest that, despite our continuing problems with controlling crew-caused accidents, the



Primary factor	No. of accidents Total	No. of accidents Last 10 years
Flightcrew	240	82
Airplane	39	15
Maintenance	5	3
Weather	18	7
Airport/ATC	15	7
Miscellaneous (other)	11	3
Total with known causes	328	117
Unknown or awaiting reports	55	27
Total	383	144

Figure 1

overall safety record continues to show a gradual decrease in accidents, and certainly is not a deteriorating trend. And you would be right.

However, Figure 2, which is also taken from the Boeing summary, shows what Gordon-Berge was concerned with in 1973. It also shows a reversal of the deteriorating trend that concerned him beginning the following year.

Figure 3 shows the probable reason for the reversal of the deteriorating trend. It is taken from a paper presented by Loomis and Porter at the 1981 Symposium on Aviation Psychology in Columbus, Ohio, U.S., April 20-22, 1981. The paper was entitled, “The Performance of Warning Systems in Avoiding Controlled-Flight-Into-Terrain (CFIT) Accidents.” It shows the estimated implementation of the required Ground Proximity Warning System (GPWS) in the United States, and the almost immediate decrease of “Controlled-Flight-Into-Terrain” accidents.

Although the GPWS is undeniably a triumph of modern technology, as a pilot, I find little solace in the fact that I apparently need an electronic marvel to keep me from crashing a perfectly normal airplane into unfriendly terrain.

There is no question that GPWS (and MSAWS, the controllers’ minimum safe altitude warning system, was introduced about two years later) have saved many lives. There is also no question that in many, and probably most, of these potential accidents the warning these systems provided was preceded by a fairly gross operating error by the cockpit crew. Certainly, there is nothing in the decrease in the accident trend following the introduction of GPWS and MSAWS that suggests we have made much progress from a crew-behavioral standpoint.

I may be unduly optimistic, but today we at least believe we are finally beginning to squarely face the basic problem of why highly-trained and well-qualified pilots do not always perform as expected. The good news is that we also have some reason to hope that our additional knowledge and understanding may lead to significant improvements.

Within the U.S. airline community (which consists primarily of airlines, manufacturers, pilot organizations and regulatory authorities), there is a growing consensus that current training standards and practices should be reviewed. And that comes despite somewhat surprisingly, and until recently largely ignored, significant differences in the operating cultures in U.S. airlines. Now there is a pressing and overriding agreement to improve cockpit management and crew coordination.

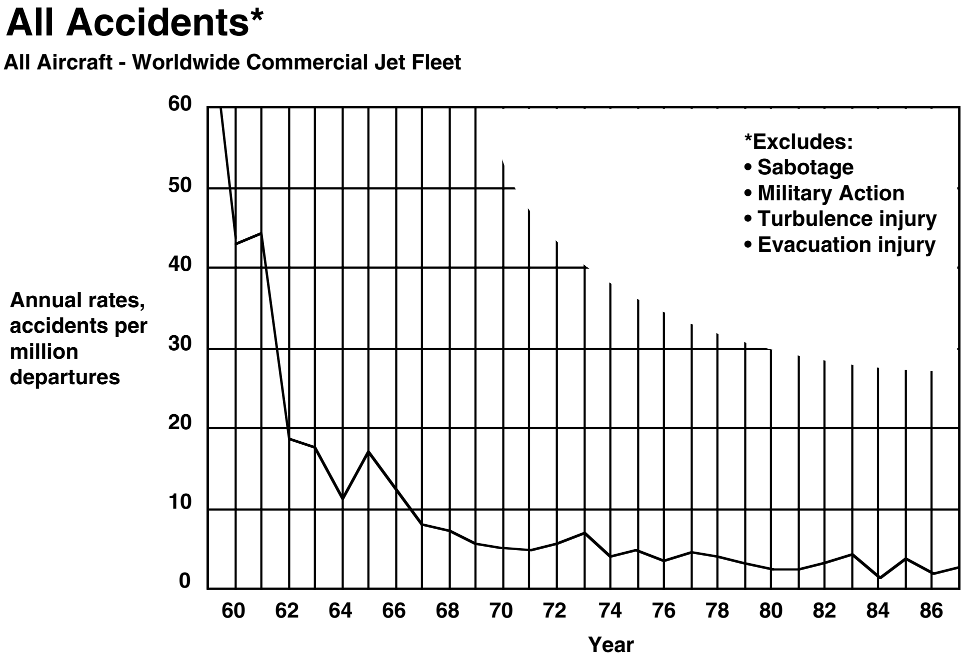


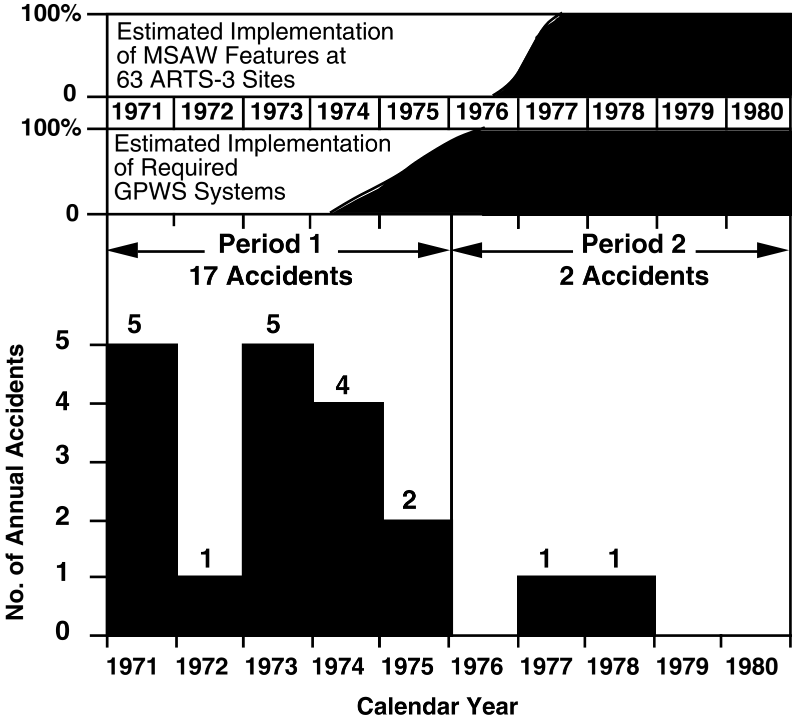
Figure 2

A variety of cockpit resource management (CRM) training programs have been developed to meet that demand. However, one of the premises on which most of these programs have been based is the assumption that pilots who are given such training are professional airline pilots who already have the appropriate skills and knowledge for their operating responsibilities. Unfortunately, there is considerable evidence that this has not always been a well-founded assumption. There is no question that they have highly developed manual handling skills and basic aeronautical knowledge, but that is no longer enough.

One of the oldest of our historic problems — and this one has been with us from the days of the DC-3 — is the failure of pilots to follow established rules and procedures. It is one of the most common casual factors in air transport accidents — and it happens year after year after year. Certainly it is still with us in the United States.

This is illustrated by three thought-provoking paragraphs from U.S. National Transportation Safety Board (NTSB) Member John Lauber's November 19, 1988 address to the U.S. Air Transport Association (ATA) Operations Forum:

"On August 16, 1987 a McDonnell Douglas MD-80 crashed on takeoff from Detroit, killing all but one small child aboard. Our investigation revealed that the flaps and slats had not been extended for takeoff, that electrical power to the configuration warning system had been disrupted for reasons we could not discern, and that the flight crew had engaged in extensive, 'non-pertinent' discussion during their taxi to the runway.



Frequency of Controlled-Flight-Into-Terrain Accidents Before and After GPWS/MSAW Implementation

Figure 3

"When the basic facts of this accident became known, one of the frequently heard questions from the public and professionals alike was, 'What will prevent this from happening again?' After the standard comments about improved procedures, improved training, better warning systems, etc., I usually threw in my 'clincher' — 'we won't see another accident like this for several years because of increased pilot awareness and the enhanced vigilance which inevitably follows an accident such as this.'

"I hope I was correct, but the Boeing 727 accident in Dallas of this year [1988] should give us pause. Let me state clearly that I am not prejudging the outcome of our ongoing investigation of this accident, and have no idea of what our probable cause will be. But the public docket opened two weeks ago contains, among other things, the following facts: there is physical evidence that at least the trailing edge devices were up at the time of impact, an intermittent fault was found in a switch which is part of the takeoff configuration warning system, and that the crew was engaged in extensive "non-pertinent" discussions during their taxi to the runway."

Unfortunately, the failure to follow established procedures seems to have become an increasingly critical failure as we have progressed from piston to turbojet operations. Equally unfortunate, it is a very old and persistent problem. Therefore, it may be worth discussing at least some of the reasons we continue to have problems with our standard operating procedures [SOPs].

I believe that the role of flight operations management has often been overlooked. And it is absolutely crucial. This is because a first requirement is a clear understanding by flight operations management of the way it wants its flight operations conducted — for example by fully utilizing the "crew concept" if that is its intention. It must then be willing to state this clearly and without equivocation. Equally important, its intentions must then be communicated effectively to the pilots.

A second management requirement is to ensure that training pilots, check airmen, other supervisory pilots and higher levels of flight operations management follow the rules and procedures that have been promulgated. In the elegant language of academicians, the "theory espoused" must also be the "theory practiced" whenever and wherever management is involved. This sounds relatively simple, but it does not always happen.

Flight manuals, equipment manuals and operational bulletins are important communications media. They should be useful documents that reflect the character and operating philosophy of the operator. These concepts should be stated clearly and should also be reflected in operational procedures. However, it takes considerably more than simply the issuance of manuals or directives from the top of an "operational Mount Olympus" to communicate these messages effectively to pilots.

Capt. Eric Jackson of Aer Lingus stated a basic principle of effective communication to pilots when he wrote:

"… there … is an absolute requirement to consult, discuss, justify and defend all procedures, changes and rules where the pilot is professionally and personally involved. This makes constant liaison with working groups, association councils and overall grouping necessary … with the maximum exchange of information, views and policies absolutely vital."

This accomplishes two important things. First, it ensures that pilots understand the reasons for their procedures, and second, it almost certainly secures pilot interest and hopefully, it encourages positive involvement in their utilization.

Yet, the problem of achieving a very high percentage of compliance with established procedures is not a simple one, because we have always had some pilots who rebel. However, regardless of the considerable differences in motivation, character, life-style, personal goals, personality and ego strength among pilots — regardless of the care with which they are selected, monitored and tested — we know that virtually all pilots have at least one thing in common. Each wants to be considered a good pilot by other pilots. Even more important, each does not want to be considered a "poor pilot" by his or her peers. Pilots, like the members of virtually all other groups, are sensitive to peer group pressure.

In order to take advantage of peer group pressure, a first requirement for a successful effort is to have well-developed and efficient operational procedures — including the use of checklists and required callouts. Lufthansa's Capt. Heino Caesar said it clearly: "SOPs must be realistic, advantageous, easy, and reasonable."

The message that has to get to flight crew members is that professional pilots follow established operating procedures for sound reasons they know and *understand*. It must be made equally clear that this is expected by flight operations management, by pilot representatives and by all flight crew members regardless of their cockpit position. Authoritarian pronouncements alone will not communicate this message effectively. To better understand why, it may be worth exploring some of the reasons for the subset of "willful deviations" from established policies. If one looks at some of the basic reasons for these deviations, it appears that many of the "willful deviators" can be expected to be particularly susceptible to peer group pressure. For example, some common reasons for willful deviations are:

- Pilot believes the established procedure is simply wrong.
- Pilot believes the established procedures are appropriate for the "average" guy but that he or she is different.
- Pilot believes "his" procedure is either just as good or better than the established one.
- Pilot believes the procedure is not important or not necessary — "not worth the bother" either just this once, frequently or always.
- In some instances, the pilot does not really object to the established procedure but consciously or subconsciously just wants to defy "them" (meaning management or authority in general). In this case, the pilot does not believe safety is jeopardized significantly, but even if safety is slightly jeopardized, that it is worth the risk because he is completely convinced that "it" (an accident) can not happen to him — at least not this time.

There can, of course, be other reasons for willful deviations and variations within them. However, with slight modification, the above reasons are well-recognized as underlying causes for rule-breaking in other areas. These causes also have at least three things in common, in varying degrees:

- Each one defies authority.
- Each one can mask a degree of insecurity that is frequently displayed by overcompensating — often with an overly "macho" image.
- Each one reinforces individual egos.

Any solution to the problem of willful deviations should at least recognize the needs expressed and, in addition, attempt to sublimate the hostility and, in some cases, the insecurity implicitly suggested in the defiance of authority. And although peer group pressure should not be considered a panacea, it does have elements which deal directly with these items.

There has been a significant change in the job of a professional airline pilot. It has been an evolutionary change and it started a long time ago. Without even getting into some of the issues involving advanced cockpit technology, today's pilots must know the technical aspects of their job (their airplane, procedures, aerodynamics, meteorology, etc.) and it has become increasingly important that they also know something about human behavior as it relates to the job of an airline pilot. At a minimum, they must recognize that both they and their fellow crew members are human beings with both human strengths and human limitations. Humans can and do make mistakes. They can and do forget. They can be distracted.

A prime task of today's truly professional pilots (and professional pilot managers) is to take advantage of human strengths to prevent or control human weaknesses (including outright mistakes) from adversely affecting the safety of their flight. I believe that, among other things, this means pilots must make the "crew concept" — and the "fail-safe crew" — do justice to those concepts in practice.

For example, it is implicit in the crew concept that a*ll* crew members must know what is and should be happening *with* and *to* the airplane at all times. This is a basic reason for following established procedures and standard flight profiles. If, for any reason, these are modified because of a particular situation, it is the captain's professional obligation to be sure that all crew members understand the planned deviation. The job of "professional" captains (and to a lesser extent all "professional" crew members) is to be sure that this is the way their flights are operated. It is not going too far to say that to do less is being derelict in their duty.

Because there have been some views to the contrary, a point worth emphasizing here is that the "crew concept" does not interfere with the chain of command. It does in fact, reinforce it.

An equally important area that I believe has not received the attention it deserves is operational monitoring, usually by the pilot-not-flying (PNF). It is critically important because, almost invariably, one can say three things about an air carrier accident:

- First, there was or should have been, a very clear indication in the cockpit at some point during the flight that things were not going well.
- Second, there was plenty of time to have saved the airplane.
- Third, there seems to have been little or no awareness of the real problem.

One can also say those same things about ground proximity and takeoff warnings. There is little question that a preventive monitoring failure by the PNF precedes a significant operational anomaly in virtually all cases. This is a particularly important point, for *from a system safety standpoint, this monitoring failure is as critical as the failure by the handling pilot.* It is really not a credit to our profession that operational monitoring has not been given specific status in flight crew training or in checking despite its crucial role in safety.

In still another area, pilot-flying (PF) and PNF duties need to be clearly delineated. It is no longer satisfactory to simply state that when the copilot is flying he will perform the designated captain duties. This approach is fraught with ambiguities. Unfortunately, a weak link in our safety chain seems to be the captain when he is performing PNF duties. This is reflected rather dramatically in the number of accidents that occur when the copilot is flying.

Based upon the preceding considerations, I suggest the following points be addressed:

- Probably one of the most important is that none of the things I have discussed costs money. None of them require "state-of-the-art" simulators or other expensive training aids. They need not involve the battle of the training budget. However, they may require considerable self-examination and effort.
- The only foundation upon which a solid operating performance can be built is the consistent utilization of well-developed and efficient operating procedures — including the use of checklists and required callouts.
- The importance of meaningful operational monitoring by the PNF and a clear delineation of PF and PNF duties deserves much more attention.
- This final one is taken from an early John Lauber statement, "The real importance of SOPs lies as much in the area of information transfer as it does with respect to the issue of the proper way to fly the airplane. Rigid adherence to SOPs helps to maximize information transfer in much the same way that the use of standard phraseology does." ♦

About the Author

Capt. Harry Orlady retired from United Airlines after 39 years as a pilot. He flew 10 different types of aircraft ranging from the Boeing 247 and the DC-3 to the Boeing 747. He has completed several studies in pilot ground and flight training as well as studies in human factors, aviation medicine and aviation safety.

Orlady was awarded several company and industry aviation awards, and has presented more than 80 papers and lectures on aviation operational safety. Since retirement from United, he has served as a senior research scientist for Battelle Laboratories, which operates the U.S. Aviation Safety Reporting System (ASRS) for the U.S. National Aeronautics and Space Administration (NASA) from its program office in Mountain View, California. He has also served as a research contractor to the ASRS, as an independent contractor to NASA/Ames and to private research firms, and as a consultant to the U.S. Federal Aviation Administration (FAA).

An elected Fellow of the Aerospace Medical Association, Orlady was a member of the Human Factors Study Group of the International Air Transport Association (IATA) and the Medical Study Group of the International Civil Aviation Organization (ICAO). He was also a member of the Steering Committee for IATA's Istanbul Technical Conference on Human Factors. Currently, Capt. Orlady is a member of the Human Factors Society, the Association of Aviation Psychologists, the Aerospace Medical Association, and the SAE Human Behavioral Technology and G-10 Committees.

Some Aviation Frequency Management Concerns

Future aviation safety and operational efficiency depend upon continued access to an electromagnetic spectrum that is besieged by growing demands for frequency allocations.

by
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At a recent meeting of the International Business Aviation Council (IBAC) governing board, the author was asked to prepare a paper on the "urgent need to preserve sufficient clear L Band spectrum and VHF allocations for aviation use…and to send it to all members for their use in efforts to insure preservation." What began life as a few paragraphs on L band and VHF issues quickly grew into a more detailed discussion of the complicated and not well understood art of radio frequency management.

Admittedly, the arcane art of frequency management generates all the excitement of a paint-drying contest. However, as aviation continues to demand newer, faster and better communications, the finite amount of electromagnetic spectrum (EMS) and the irrefutable laws of physics must be contended with. Solutions to these technical problems will, undoubtedly, result in more complicated communication systems in the future.

National and international aviation regulations have drastically increased the required communication between the aircraft and the ground. Presently, the vast majority of this is carried out in the VHF band from 108 MHz to 137 MHz. The types of services allowed in this band include:

- Air Traffic Control (ATC) is presently utilizing a significant portion of the VHF band (118 MHz-136 MHz) for voice communication. There are presently 40 separate channels per MHz in the aeronautical service — hence 720 channels are available in the band.

- Aeronautical Operational Control (AOC) allows the operator to maintain contact with its flights as is required by law for commercial operations. The United States and Canada share 75 channels between 128 MHz and 132 MHz, based on a formula of use and location relative to their mutual border. Other regions have similar arrangements. Presently AOC is done primarily by voice, but in recent years an increasing amount of traffic is being transmitted in the more efficient digital data form. More than 150 business aircraft in the United States are equipped to deal with this now.

- Navigation (both VOR and ILS) is provided in the 108 MHz-118 MHz portion of the band. Although voice can be transmitted on these channels, for technical reasons it is not normally used for voice transmissions.

Aviation users (both aircrew and passengers) are discovering additional needs for communication between aircraft and the ground. Not only are there the additional government-mandated requirements, but operators are discovering that having contact with the home and office via AOC (voice and data) and access to the commercial land telephone/fax/telex/computer (known as Aeronautical Public Correspondence [APC] and Aeronautical Administrative Control [ACC]) has many potential benefits. These trends have gained impetus during the past several years, due in large part to the widespread use of pagers and automobile-based cellular telephones.

The introduction of data communication links has unearthed amazing futuristic applications. For instance, with all of a modern aircraft's operating parameters already being transmitted in digital data format from their source (engines, fuel system, etc.) via data busses to the gauges in the cockpit, it is really a simple matter to connect these busses, via a radio communications link, to maintenance and engineering at the home base for almost real-time analysis and record-keeping. With most airline operations already maintaining schedules and dispatch information in computers, it takes little additional equipment to link such information to the aircraft.

In the very near future such information as weather, airport conditions and clearances (some of this is implemented in limited instances) will soon be done routinely by data link. An executive of Japan Airlines has stated that their future "flight engineer will be on the ground." It is ironic, if not surprising, that air traffic system administrators are frequently among the last to seriously consider the implementation of these promising technologies.

All this facile transmission of data is wonderful and contains the promise of increased safety and efficiency, but not without some technological problems that must be addressed. The largest problem, not surprisingly, is the limitation on the amount of available electromagnetic spectrum. The International Telecommunications Union (ITU-the agency of the United Nations that sets standards for radios), various state-run postal telephone and telegraphs (PTT) and other national regulatory bodies have the responsibility of doling out the available spectrum to an ever-increasing number of constituents — from broadcasters to telephone companies; from police to military; from taxi cabs to pizza trucks; and from pleasure boaters to civil aircraft operators.

We in the aviation industry tend to complicate the frequency management community's attempts to make more efficient use of electromagnetic spectrum. Demands from the various factions of the aviation community for additional channel designations in the VHF spectrum are not viewed as particularly reasonable when many of the channels between 118 MHz and 136 MHz that are presently available, the so-called quarter channels of .025 MHz spacing (25 KHz), are not being utilized.

The primary reason for this inefficient use of the available spectrum is that aircraft owners, those at the lower end of the general aviation spectrum, have historically resisted equipping their aircraft with 720-channel transceivers, citing the additional cost of equipment. It is a reasonable estimate that more than 35 percent of general aviation aircraft have transceivers with 360 channels (50 KHz spacing) or fewer. This is evident in the United States, although one domestic manufacturer alone has sold more than 150,000 hand-held 720-channel transceivers.

This issue becomes even more acute in light of the stated needs of others. There are more taxicabs in London than aircraft based in the United Kingdom and nearly as many pizza trucks in Los Angeles as there are aircraft based in the United States. Additionally there are approximately 10,000 public broadcast stations in the United States that provide a public service to their communities. Thousands of railroad cars and truck trailers are presently equipped with Loran C navigation receivers that transmit the vehicle's position to their home bases via satellite. Within a decade, the car without a telephone is apt to be the exception rather than the rule.

The aeronautical VHF band lies between 108 MHz and 137 MHz. The odd channels from 108 MHz to 112 MHz are presently assigned to the Instrument Landing System (ILS), which is slated to be replaced by the Microwave Landing System (MLS). This ILS spectrum is protected by international agreement only through January 1, 1998, and other potential users (not necessarily aviation) are lining up for this frequency spectrum that they hope will be vacated or at least no longer protected.

Public broadcasting stations, particularly those using the FM band, are now fairly universally utilizing the spectrum that lies immediately below the 108 MHz bottom of the aeronautical band. The high-power output of these stations (up to 100,000 watts vs. 15 watts for ILS), their antenna placement, poorly planned frequency assignment and, at times, less than ideal line and antenna maintenance, can cause a number of phenomena that affect ILS performance. Occasionally, these high-powered stations interrupt VHF communications. The United States has 4,000 FM stations, and European authorities, who have just opened up the top portion of their FM band, have predicated as many as 25,000 stations in the European community. Further, various control signals for power and cable television companies can, if not properly implemented, monitored and maintained, radiate spurious emissions into this band.

Very high frequency Omni-directional Range stations (VOR) utilize the even channels between 108 MHz and 118 MHz. Because of the problems mentioned previously, primarily FM broadcast interference, by January 1, 1998 aircraft must have receivers that meet higher "interference immunity performance" standards.

Beginning January 1, 1989, the 136 MHz to 137 MHz portion of the VHF Aeronautical Band became available exclusively for aeronautical use. This means that the industry will have to equip to utilize the additional spectrum in this band. The U.S. Federal Communications Commission (FCC) issued a notice of proposed rule making (NPRM) on frequency assignments in this band and the International Civil Aviation Organization (ICAO) sent a notice to member states that urges timely and coordinated implementation. This, of course, means the installation of 760-channel transceivers in aircraft. A quick check of manufacturers in the United States has shown that approximately 14,000 general aviation aircraft are equipped with radios tunable to 25 KHz channel spacing — a good start, but still less than seven percent of the total fleet.

The FCC has also published regulations that are designed to implement the agreements reached at the last Mobile World Administrative Radio Conference (MWARC). These regulations require that VHF transmitters have an increased frequency stability tolerance — from 5 parts per million to 3 parts per million (.003 percent). Manufacturers in the United States estimate the general aviation population of equipment manufactured with the old tolerances to be in excess of 90,000 units. There is a move afoot to convince the FCC to allow them to operate until they die of old age. The problem with this approach is that it would further delay the implementation of the 25-Khz channels since these older radios are more susceptible to interference.

There are other portions of the electromagnetic frequency spectrum in which the aviation community has a vital interest.

For example, L Band for aviation use includes the 1545 MHz -1600 MHz (1.5/1.6 Gigahertz-GHz) portion of the spectrum. It is in the L Band that the ITU allocated frequencies for communication between aircraft and earth stations via satellites. The services allowed on these frequencies include not only ATC and AOC, but also "non-safety and regularity of flight" (i.e., administrative control communications).

Initially, communications in this band will be APC and automatic dependent surveillance (ADS) which will give ATC information on aircraft position, determined by on-board navigation devices, via a satellite link. The initial implementation of ADS will most likely be in minimum navigation performance standards (MNPS) airspace over the North Atlantic and the Pacific.

A major problem with domestic regulations governing the use of the aviation frequencies in the L Band implementation is the requirement that the aeronautical portion of the L Band be shared among all mobile users, but with priority going to aviation services. On the surface, this would seem to be a sound means of getting the greatest use of the spectrum. However, there are many technical and institutional hurdles to overcome in order to make this scheme work. Just imagine sharing frequencies with the neighborhood pizza delivery truck.

The ITU took back four MHz of the still, unused aeronautical L band from aviation during the last MWARC and for all intents and purposes gave it to land-mobile interests. This has put the aviation industry in the difficult position of having to defend spectrum allocation which it is presently not using, but fully intends to use in the future. The U.S. government's position implies that there is more than enough L band spectrum to share with other mobile users.

Ultimately, international market forces will drive the solutions to this problem of shared use of the spectrum. If aviation uses all of the available L band spectrum, the problem will become moot. If it does not, however, it stands to have the same problems (in a somewhat different form) that VHF is experiencing today. Aviation interests are not well equipped to defend a spectrum that sits idle except for occasional peak periods.

Worldwide, more than 23,000 aircraft operate radio altimeters in the 4,200 MHz-4,400 MHz band. There are some services that would like to carve pieces out of this band as well. Safety and economic concerns would seem to preclude the reequipping of the aviation fleet with new radio altimeters, at least in the foreseeable future.

New issues will arise in the EMS as needs (real and perceived) continue to develop. It is important to monitor national and international regulatory bodies that mold frequency use and to maintain open lines of communication with them to prevent aviation's communications from being unduly constrained. ♦

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Previous to his association with NBAA, Stine was chief pilot of a commercial operation in Colorado where he flew and instructed in both rotorcraft and fixed-wing aircraft. He also was chief pilot for a civil engineering firm, worked on airport and facilities design and was a line pilot in a corporate aviation department. Stine holds an airline transport pilot certificate in both fixed-wing aircraft and rotorcraft and is a gold seal flight instructor.

A native of Ohio, Stine attended Culver Military Academy and Ripon College, and has a teaching certificate in aeronautical technology.

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Key Words
1. Airports — Runways — United States.
2. Airports — Design — United States.

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The AC provides design standards and guidelines for determining recommended runway lengths. The standard and guidelines contained in this advisory circular are recommended by the Federal Aviation Administration for use the design of civil airports. For airport projects receiving Federal grant-in-aid assistance, the use of these standards is mandatory.

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2. Air Traffic Control — Handbooks, Manuals, etc.
3. Air Traffic Control — United States.

Contents: History of Air Traffic Control — Navigation Systems — Air Traffic Control System Structure — Airport Air Traffic Control Communications: Procedures and Phraseology — Air Traffic Control Procedures and Organization — Control Tower Procedures — Nonradar En Route and Terminal Separation — Theory and Fundamentals of Radar Operation — Radar Separation — Operation in the National Airspace System — Oceanic and International Air Traffic Control — The Future of the National Airspace System — The Federal Aviation Administration — Glossary — Common Abbreviations — References — Index.

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Key Words
1. Airplanes — Cockpits — Design and Construction — Human Factors.
2. Airplanes — Piloting — Human Factor.
3. Air Pilots — Visual Perception.

Contents: The Senses — Vision and Visibility: The Pilot's Eye View; Orientation: The Spatial Senses / Training and Design — Training Environments: Instruction and Simulation; Human Factors in Cockpit Design / Performance Factors — Navigation and Communication; Stress, Fatigue, and Performance / The System Approach — Accidents, Human Abilities, and Pilot Errors; Social Psychology in the Cockpit / Conclusion — Perfect Failures / Glossary / Notes / References / Index.

Accidents and causes are viewed from four approaches: the senses, training and design, performance factors, and systems. The visual system, visual acuity, color vision, and visual tasks (avoiding collisions in midair, flying at night) are explored. The sector whiteout condition and the risk factor involved with head-up displays are discussed at length. The authors also cover the spatial senses: the ear, tolerance of gravity forces, effects of high positive and negative accelerations, disorientation, vestibular illusions, and spin recovery. Training environments, instruction and simulation, predicting pilot performance, cockpit design, navigation and communication, air traffic control systems, and stress are also covered. The social setting of crew performance and breakdowns in communication, cooperation, and coordination are analyzed. [overleaf]

Reports

*Airline Competition: DOT a*nd Justice Oversight of Eastern *Air Lines' Bankruptcy.* Report to the Chairman, Subcommittee on Aviation, Committee on Public Works and Transportation, House of Representatives. — Washington, D.C. : U.S. General Accounting Office*, February, 1990. Report GAO/RCED-90-79, 15p.

Key Words
1. Airlines — United States United States.
2. Airlines — Finance — United States.
3. United States — United States.
4. Eastern Air Lines, Inc. — Reorganization.

Actions by DOT and the Justice Department in the Eastern bankruptcy case fulfilled the agencies' responsibilities to protect airline competition. Both DOT and Justice have broad responsibilities to protect and promote airline competition which they may exercise during the course of an airline bankruptcy proceeding; however, neither agency is required to participate in a bankruptcy proceeding. Legislation is not needed to clarify or expand either Department's responsibility to participate in airline bankruptcy proceedings. Justice already represents the United States in the Eastern bankruptcy proceeding. However, if Justice was not a party, GAO review of past cases suggests that either Department would not have difficulty becoming a party because of their regulatory responsibilities to protect and promote competition.

Report on a Special Investigation into Air Traffic Control Services in Canada / Canadian Aviation Safety Board. — Ottawa : Minister of Supply and Services Canada, 1990. Report No. 90-SP001, iv, 51, 2p. ISBN 0-662-17693-6.

Key Words
1 Air Traffic Control — Canada.
2. Air Traffic Control — Evaluation — Canada.
3 Air Traffic Control — Management — Canada.
4. Air Traffic Controllers — Canada.
5. Work Environment.

Adopted 02 March 1990.

"The Board found that Canada has a generally safe ATC system; the system handles thousands of flights daily and serious risks of collision are infrequent. However, unsafe conditions do develop and are cause for continuing concern. ...

Safety deficiencies were identified in the areas of equipment, staffing and work-load, training, supervision, operating procedures, human performance factors, information transfer, and management. ... The most serious shortcoming in the ATC system is the shortage of qualified air traffic controllers. ... The report contains 48 Safety Recommendations [CASB 90-01 - CASB 90-48], addressed to the Minister of Transport, the Minister of National Health and Welfare, the Minister of Communications, and the President of the Treasury Board." [Press Release]

Contents: Executive Summary — Introduction — Equipment — Staffing — Workload — Training — Supervision — Operating Procedures — Human Performance Factors — Information Transfer — Management — Conclusion — Annexes.

Executive Summaries of the Aviation Accident Study. — Santa Monica, CA : Rand, The Institute for Civil Justice, 1988. Report RAND R-3684-ICJ, vii, 64p. ISBN: 0-8330-0921-4. $7.50.

Key Words
1. Liability for Aircraft Accidents — United States.
2. Aeronautics — Accidents — Liability — United States.
3. Aeronautics — Accidents — Costs — United States.

Contents: Forward — Costs and Compensation Paid in Aviation Accident Litigation / J.S. Kakalik et al — Dispute Resolution Following Airplane Crashes / E.M. King and J.P. Smith — Computing Economic Loss in Cases of Wrongful Death / E.M. King and J.P. Smith — Economic Loss and Compensation in Aviation Accidents / E.M. King and J.P. Smith.

Summary: This volume summarizes the Institute for Civil Justice (ICJ) detailed studies of litigation arising from commercial aviation accidents. Aviation litigation is different from most tort litigation: Aviation accidents are mass torts that usually involve multiple versus single defendants and plaintiffs; the dispute between plaintiffs and defendants generally focuses exclusively on the issue of the appropriate level of compensation versus what caused the injuries and who is liable. The plaintiff's economic loss is a new element in the research focusing on the amount of compensation. Previously, there was an absence of a generally accepted methodology of calculating economic loss. Each state has its own laws, and during the research, the standards being used by the courts to determine loss were changing. ICJ developed their own methodology, "designed to capture the principles underlying the tort system's compensation and deterrence objectives, providing a necessary benchmark for comparing levels of loss and compensation across accidents and jurisdictions."

Air Traffic Control: Status of FAA's Effort to Modernize the System. Fact Sheet for Congressional Requesters / U.S. General Accounting Office. — Washington, D.C. : U.S. General Accounting Office*, April 1990. Report GAO/RCED-90-146FS, B-239008.1. 30p.

Key Words
1. Air Traffic Control — Management — United States.
2. Air Traffic Control — Finance — United States.
3. United States Federal Aviation Administration.
4. National Airspace Systems Plan (NAS).

This fact sheet provides information on the overall status of the National Airspace Systems Plan in terms of projects completed and funds allocated, and the projected cost and schedule of the program's 12 major system as of January 1990. This report presents the funding history and schedule changes. GAO found that most projects are in production, but few are complete, and most are behind schedule. Information is included for the 12 systems: Advanced Automation System (AAS), Air Route Surveillance Radar (ARSR-4), Air Route Traffic Control Center (ARTCC) Modernization, Airport Surveillance Radar (ASR-9), Automated Weather Observing System (AWOS), Central Weather Processor (CWP), Flight Service Automation System (FSAS), Microwave Landing System (MLS), Mode S, Radio Communication Links (RCL), Terminal Doppler Weather Radar (TDWR), Voice Switching and Control System (VSCS).

Statistical Summary of Commercial Jet Aircraft Accidents: Worldwide Operations, 1959-1989. — Seattle, WA : Boeing Commercial Airplanes Product Safety Organization, March, 1990. Boeing Document D6-53810-89. 36p.; charts; ill. Available from: Product Safety Organization (B-210B), M/S 69-33, Boeing Commercial Airplanes, Seattle, Washington 98124 USA.

Key Words
1. Aeronautics — Accidents — Statistics.
2. Aeronautics — Accidents — Jet Planes — Statistics.
3. Aeronautics, Commercial — Accidents — Jet Planes — Statistics.

The accident statistics presented in this document are applicable to worldwide commercial jet operators for aircraft heavier than 60,000 pounds maximum gross weight, but do not include turboprop aircraft. Russian-manufactured or -operated aircraft and military operators of commercial-type aircraft are also excluded. Accidents resulting from sabotage, hijacking, military action, or experimental test flying, turbulence injury, or evacuation injury are not included. Statistical charts and tables are arranged according to a generic grouping of the worldwide commercial jet fleet. Charts include primary cause factors, flight phase, accidents per million departures, age of the jet fleet, more.

Annual Report 1989. — Ottawa : Canadian Aviation Safety Board, [March, 1990]. 58p.; charts; ill. ISBN: 0-662-57311-0.

Key Words
1. Aeronautics — Accidents — Canada.
2. Aeronautics — Statistics — Canada.
3. Aeronautics — Safety Measures — Canada.
4. Canadian Aviation Safety Board.

Partial Contents: Members of the Board — Statistical Overview — Activities — Investigations — Applications of Technology in Accident Investigation: Acoustic Analysis, Image Analysis, Document Analysis, Remote Sensing, FDR/CVR Analysis — The Confidential Aviation Safety Reporting Program — Human Factors — Communications — Findings — Major Occurrence Reports Adopted by the Board in 1989 — Recommendations and Safety Actions — Annexes / Auditor's Report, Organizational Structure, Historical Statistics.

Text in English and French; French text on inverted pages.

The number of accidents involving Canadian registered aircraft fell by about 3% to 487 during 1989, compared with 1988. It is estimated that there was a 3.5% increase in the total number of hours flown, resulting in a drop in the accident rate from 14.5 accidents per 100,000 flying to just under 13.6. This rate is slightly below the average over the last five years and well below the level of the 1970s and early 1980s. This annual report may be the last for the CASB, since a new agency, the Canadian Transportation Accident Investigation and Safety Board (CTAI&SB) will come into being in 1990, extending the aviation safety board concept to include marine, rail and pipeline transportation.

Search Request No. 1786: "Air Carrier Flight Crew Fatigue". — Mountain View, CA : Battelle ASRS Office ; Moffett Field, CA : U.S. National Aeronautics & Space Administration, ASRS; April 30, 1990. 1 volume [approx. 100 pages], spiral bound.

Key Words
1. Flight Crews — Fatigue.
2. Flight Crews — Duty Time.
3. Air Pilots — Fatigue.
4. Air Pilots — Workload.
5. Airplanes — Piloting — Workload.
6. Airplanes — Piloting — Fatigue.
7. Aviation Safety Reporting System.

A NASA ASRS search performed for Dr. Len Wojcik, Flight Safety Foundation.

The printout contains 93 reports involving air carrier flight crew fatigue situations related to extended flight hours, submitted to the ASRS database between 1983 and 1990. The ASRS database consists of reports voluntarily submitted; all reports are deidentified. Each report, one or two pages long, includes the month and year of occurrence, person's functions, flight conditions, aircraft type, anomaly, situation report subjects, narrative, other information relevant to the report. All 93 reports in this search were submitted by flight crew members who either experienced or observed the effects of fatigue on crew performance. Narratives in these reports report anomalies (altitude deviations, autopilot problems, excursion from assigned course, equipment problem, non-adherence to legal requirements, etc.) which might have led to serious incidents/accidents. According to the reporters, the anomalies resulted from crew error (lack of attention, confusion, etc.) attributable to crew fatigue, lack of crew rest, duty time, long flights, etc. ◆

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Aviation Statistics

Worldwide Airline Jet Transport Aircraft Fatal Accidents and Hull Losses

A Review of 31 Years of Operations

In the last year of the past decade, worldwide airlines operating jet transport aircraft (excluding U.S.S.R. makes and models) recorded a total of more than 20 million flying hours and were involved in 19 fatal accidents. Seventeen of the fatal accidents occurred during normal operations and two are suspected sabotage events. A total of 1,090 persons involved in the accidents were fatally injured and 14 jet transport aircraft were totally destroyed.

Worldwide, airline jet transport aircraft annual flying hours increased from fewer than 200,000 hours in 1959 to more 20 million hours in 1989 for a total of more than 318 million hours over the 30-year period, during which there were 334 fatal accidents. During the same period, the mean fatal accident rate per 100,000 flying hours decreased from 1.15 to 0.55.

The turbojet transport age began in the early 1950s when the British Comet entered airline service. Pure-jet air travel expanded significantly in 1959 when the Boeing 707, DC-8 and Caravelle became available for worldwide airline passenger service. By the end of 1959, there were approximately 150 turbojets in service, accounting for about four percent of the total airline fleet. The higher airspeed of the turbojet cut long-distance travel times by more than half and attracted more passengers. Airlines throughout the world competed vigorously for the passenger market with more and more turbojets replacing piston-engine or turboprop aircraft. In 1969, turbojets accounted for 49 percent of the worldwide airline fleet. The proportion of turbojets in the worldwide airline fleet continuously increased to 70 percent in 1979 and 77 percent in 1989. The four pie-charts in Figure 1 delineate the composition of the worldwide fleet in 1959, 1969, 1979 and 1989, and illustrate the changes in aircraft fleet composition by aircraft engine type.

The number of engines per aircraft also changed significantly during the past 30 years. In the beginning of the jet age, most turbojet aircraft, except the French-made twin-engine Caravelle, were equipped with four engines. In the mid-1960s, the three-engine Boeing 727 and a series of twin-engine jet transports were introduced into airline service. In the 1970s, widebody aircraft with three or four turbojet engines were manufactured for long-haul operations. As a result of the demand for fuel efficiency, more efficient turbofan engines were developed, and twin-engine air carrier aircraft become more popular.

By the end of the 1970s, twin-engine aircraft accounted for 57 percent of the total jet transport fleet, compared with only 34 percent at the beginning of that decade. The development of highly efficient, ultra-high-bypass turbofan engines has further reduced operating costs. Another important trend is the use of advanced cockpit technologies to permit operation by only two pilots. It appears that the twin-engine and two-crew trend will continue into the 21st century.

Changes of Worldwide Airline Aircraft Fleet by Aircraft Engine Type 1959-1989

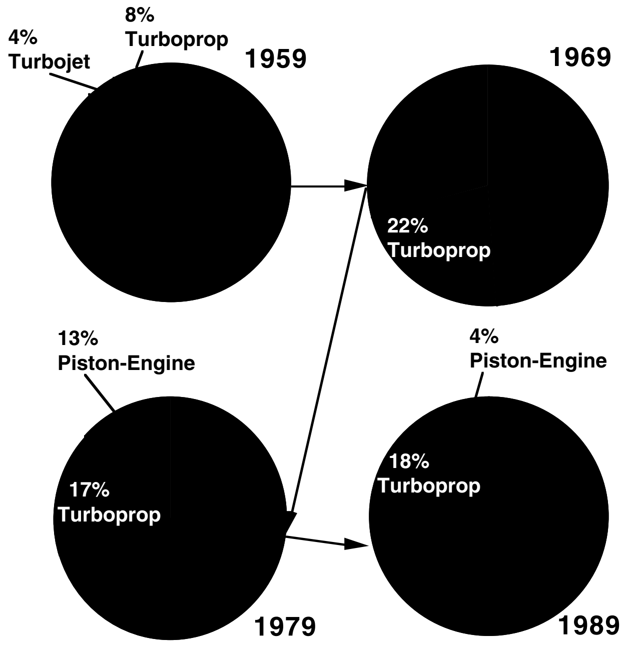

Figure 1

Table 1 - Worldwide Airline Jet Transport Aircraft Hours Flown in Thousands (By number of engines, 1959-1989)

	Aircraft In Service December		Annual Aircraft Hours Flown	Accumulative Total Hours Flown	
Aircraft Type	1980	1989	CY 1989	1959-1989	
Two-engine	2,191	4,734	11,690,000	117,373,000	
Three-engine	2,265	2,283	5,305,000	99,130,000	
Four-engine	1,576	1,365	3,354,000	102,186,000	
Total	6,032	8,382	20,349,000	318,697,000	
Two-engine	36.3%	56.5%	57.4%	36.8%	
Three-engine	37.6%	27.2%	26.1%	31.1%	
Four-engine	26.1%	16.3%	16.4%	32.1%	
Total	100.0%	100.0%	100.0%	100.0%	
1st generation	1,233	590	588,000	81,158,000	
2nd generation	3,693	4,620	10,506,000	160,217,000	1/
Widebody	1,106	1,603	5,082,000	57,244,000	1/
Efficiency	0	1,569	4,173,000	20,078,000	2/
Total	6,032	8,382	20,349,000	318,697,000	
1st generation	20.4%	7.1%	2.9%	25.5%	
2nd generation	61.2%	55.1%	51.6%	50.2%	
Widebody	18.4%	19.1%	25.0%	18.0%	
Efficiency	0%	18.7%	20.5%	6.3%	
Total	100.0%	100.0%	100.0%	100.0%	
Two-crew	2,286	4,874	12,000,000	118,617,000	
Three-crew	3,746	3,508	8,349,000	200,080,000	
Total	6,032	8,382	20,349,000	318,697,000	
Two-crew	37.9%	58.2%	59.0%	37.2%	
Three-crew	62.1%	41.8%	41.0%	62.8%	
Total	100.0%	100.0%	100.0%	100.0%	

1/ Readjusted since 1987.

2/ Efficiency jet includes Boeing 757, Boeing 767, MD-80, MD-81, A-310, A-320, F-100

Table 1 presents the number of jet transport aircraft in service at the end of 1980 and at the end of 1989 by three different groupings. It is likely that worldwide airlines intent on cutting operating costs will use more fuel efficient twin-engine and two-crew aircraft in the years to come.

The average daily utilization for jet transport aircraft, as shown in Table 2, is about seven hours. However, the early jet transports, including Boeing 707/720, DC-8 and Trident required more time for maintenance, so their utilization times are less. The daily utilization of all long-range, widebody jets, including the Boeing 767 and Airbus 310, averages more than nine hours. In some 30-day periods, the daily average utilization of the Boeing 747 has been as high as 15 hours; Airbus-310, Boeing 767, DC-10 and L-1011 utilizations have been as high as 13 hours daily. Note that except for the widebody jet category which increased 0.7 hours, the average daily utilization times of all types of aircraft in 1989 were slightly lower than in 1988. This is because more new aircraft were delivered to airlines in 1989. As a result, the airline aircraft fleet increased from 7,763 in 1988 to 8,382 in 1989, an increase of eight percent, while the total number of flying hours in 1989 was only six percent higher than in 1988.

Table 3 shows the distribution of worldwide airline fatal accidents and hull losses by phase of operation. The overall pattern remained fairly constant during the period from 1959 through 1989. The approach/landing phase has accounted for about 50 percent of all fatal accidents and hull losses throughout the entire period. Table 4 shows the distribution of fatal accidents, hull losses and rates by aircraft makes and models entering into service in different time periods.

Table 2 - Daily Utilization of Jet Transport Aircraft (By Aircraft Type, 1987-1989)

Aircraft Type	Average Daily Utilization (Hours)			
	1987	1988	1989	Change (1988-1989)
Two-engine	6.9	6.7	6.7	—
Three-engine	6.8	6.6	6.3	-0.3
Four-engine	6.9	6.8	6.7	-0.1
1st generation	3.2	2.9	1.6	-1.3
2nd generation	6.6	6.4	6.2	-0.2
Widebody	8.9	8.0	8.7	+0.7
Efficiency	7.9	7.4	7.2	-0.2
Two-crew	7.0	6.8	6.7	-0.1
Three-crew	6.8	6.8	6.5	-0.3

Table 3 - Fatal Accidents and Hull Losses (By Phase of Operations, 1959-1989)

Fatal Accidents					Hull Losses			
Takeoff/ Climb	Cruise	Approach Landing	Ground	Year	Ground	Approach/ Landing	Cruise	Takeoff Climb
14(43.8)	3(9.3)	15(46.9)	0(0.0)	59-64	1(2.4)	22(53.7)	4(9.8)	14(34.1)
14(25.5)	7(12.7)	34(61.8)	0(0.0)	65-69	6(8.1)	41(55.4)	7(9.5)	20(27.0)
18(24.0)	16(21.3)	41(54.7)	0(0.0)	70-74	11(11.0)	52(52.0)	12(12.0)	25(25.0)
16(28.0)	12(21.4)	27(48.2)	1(1.8)	75-79	6(5.7)	43(51.2)	11(13.1)	24(28.6)
15(27.2)	13(23.6)	25(45.5)	2(3.7)	80-84	7(10.3)	37(54.4)	8(11.8)	16(23.5)
5(45.5)	1(9.0)	5(45.5)	0(0.0)	1985	1(7.7)	6(46.1)	1(7.7)	5(38.5)
2(40.0)	1(20.0)	2(40.0)	0(0.0)	1986	1(11.1)	5(55.5)	1(11.1)	2(22.3)
4(30.8)	3(23.1)	6(46.1)	0(5.6)	1987	1(7.7)	5(38.5)	3(23.1)	4(30.7)
4(26.7)	4(26.7)	7(46.6)	0(0.0)	1988	0(0.0)	6(46.1)	2(15.4)	5(38.5)
8(42.1)	3(15.8)	7(36.8)	1(5.3)	1989	0(0.0)	7(46.7)	2(13.3)	6(40.0)
100(29.8)	63(18.8)	169(50.2)	4(1.2)	59-89	34(7.6)	224(54.0)	51(11.4)	121(27.0)

Table 4 - Worldwide Airline Jet Transport Fatal Accidents Hull Losses and Rates (1959-1989)

	Number of Fatal Accidents and Hull-Losses*							
	1st Generation		2nd Generation		Widebody		Efficiency	
	Fatal	Hull Losses	Fatal	Hull Losses	Fatal	Hull Losses	Fatal	Hull Losses
1959-1964	32	41	—	—	—	—	—	—
1965-1969	34	47	21	27	—	—	—	—
1970-1974	41	51(54)	30	37(41)	4(5)	3(5)	—	—
1975-1979	23	35(36)	26	36(37)	7	11	—	—
1980-1984	12	18	32	40	11	9(10)	—	—
1985	2	1	6	8	3	4	—	—
1986	0	1	5	7	0	1	—	—
1987	3	3	6	6	2	2	2	2
1988	3	3	7	7	1(3)	0(2)	2	1
1989	4	3	10	8	5	4	0	0
Total	154	203	143	176	33	34	4	3
	Accidents per 100,000 Flying hours							
1959-1965	.342	.438	—	—	—	—		
1965-1969	.115	.159	.197	.252	—	—		
1970-1974	.179	.236	.109	.135	.111	.082		
1975-1979	.133	.203	.075	.104	.062	.098		
1980-1984	.157	.235	.072	.090	.051	.050		
1985	.244	.122	.062	.084	.046	.063		
1986	—	.159	.047	.065	—	.014		
1987	.451	.451	.058	.058	.428	.428	.074	.074
1988	.519	.519	.070	.070	.002	—	.059	.029
1989	.680	.510	.095	.076	.983	.079		
1959-1989	.189	.250	.089	.109	.057	.059	.020	.015

*Aircraft destroyed by criminal activity or military force are excluded.

Table 5 - Worldwide Airline Jet Transport Fatal Accidents, Hull Losses and Rates (1959-1989)

(Hours in thousands)		Two-engine	Three-engine	Four-engine	Two-crew	Three-crew	All Aircraft
Fatal Accidents	CY 1989	9	5	5	9	10	19
	Cumulative as of 1989	117	68	149	106	228	334
Hours per Fatal Accident	CY 1989	1,299	1,061	670	1,333	835	1,017
	Cumulative as of 1989	1,006	1,457	685	1,119	877	954
Hull Losses	CY 1989	7	6	2	5	10	15
	Cumulative as of 1989	153	77	186	134	282	416
Hours per Hull Loss	CY 1989	1,670	844	1,677	2,400	835	1,356
	Cumulative as of 1989	767	1,287	549	885	780	766

Table 5 presents the fatal accident and hull loss rates by aircraft with different numbers of engines and different numbers of flight crew members. It is apparent that the latest aircraft makes and models have a better safety record than the ones built earlier. ♦

Accident/Incident Briefs

This information on accidents and incidents 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. The information may not be accurate.

Air Carrier

It All Started With a Delayed Descent

Boeing 747: Minor damage. No injuries.

Because of other traffic, the widebody had been held high on its visual approach to Manchester, U.K. Air traffic control then vectored the aircraft through the extended centerline to help the pilot lose the excess altitude prior to landing. During the approach, the pilots noticed that the captain's flight director gave no commands, although ILS raw data indicated one dot left and one dot high on the glideslope. The flight directors were turned off for the final stages of the approach that was stabilized at an indicated descent rate of 700 fpm.

The captain reported that a firm touchdown was made on a rise in the runway coincident with a ground proximity warning. After the aircraft was parked, a substantial quantity of water was observed to be draining from the fuselage. Inspection revealed that one of three 110-gallon water tanks had broken away from its mountings and the contents of all the tanks had emptied into the lower fuselage. The damaged water tank and the associated plumbing were removed from the aircraft and temporary piping was installed to provide an operable water system until permanent repairs could be made. A discrepancy notation was made. A heavy landing inspection was carried out but no other damage was found. After an operational check of the flight directors revealed no defects, the aircraft was released for service.

Eighteen days later an aircraft inspection revealed that some of the vertical support struts for the remaining two water tanks had also failed and that rope had been used to effect a repair. Neither the additional damage nor the fact that rope was used for the repair had been logged; further, the original discrepancy report had not been followed up and the aircraft had been allowed to operate in the jury-rigged condition for 38 flight segments. Another heavy landing inspection was made and permanent water tank repairs effected before the aircraft again was released for service. The failed support struts were examined by the aircraft manufacturer and were found to have failed due to excess loads, with no fatigue or pre-existing defects.

Investigation of the hard landing revealed that the flight data recorder contained poor data and the rate of descent and G forces at touchdown could not be determined; neither could it be established why there was a ground proximity system (GPS) warning and why the radio altimeter did not inhibit the GPS below a height of 50 feet. It was calculated that a vertical acceleration of more than nine Gs would have been required to fail the water tank support struts, but this also would produce other structural damage of which there was no evidence. The aircraft's maintenance history revealed no previous hard landings.

The incident was discussed in detail with the flight crew and maintenance personnel. The firm landing was attributed to the combination of an insufficient flareout and the touchdown being made where there was an upslope in the runway. In the maintenance area, a number of serious errors and irregularities involving both the repair and the documentation were addressed.

Everybody Up Front Is Only for Church

Boeing 757: No damage. No injuries.

The aircraft was departing from Belfast, Ireland, on the way to Heathrow, U.K. As the aircraft rotated, the captain found that an abnormally heavy force was required to raise the nose. During the initial climb stage, 6.1 divisions of nose-up trim was required — the trim had been set at 3.6 divisions according to aircraft loading information during pre-takeoff preparation.

As the aircraft approached its destination, an excessive amount of nose-up trim again was required, with 11.2 divisions being used by the pilot. The landing, however, was accomplished without incident.

Upon checking, it was ascertained that most of the 89 passengers had been seated in the forward section of the aircraft. The reason for this unbalanced loading was traced to the fact that free seating selection had been offered to the passengers during boarding at Belfast because the check-in computer had been out of service. No manual loadsheet had been filled out to replace the original computed one and there was no cargo in the forward hold.

A reconciliation of the aircraft's cargo load distribution, as weighed on arrival, revealed an actual trim error of 4.1 divisions nose-up instead of the 3.6 divisions nose-up that had been given to the flight crew prior to takeoff and which would have been within acceptable limits. The cause of the significant trim difference was attributed to the decision to allow the passengers to sit where they pleased when the computer failed. The incident was discussed with the involved dispatcher and a notice was published which requires that actual passenger seating conforms to the loading distribution indicated on the loadsheet.

Careless Paperwork Stowage Can Affect Safety

Boeing 737: No damage. No injuries.

As the aircraft was accelerating through 80 knots during the takeoff from London's Heathrow Airport, the captain's seat moved rearward on its rails. After the pilot's two unsuccessful attempts to restore the seat to its proper position, the first officer took control of the aircraft. Later, the seat fore-aft latching was found to operate properly.

The crew had checked seat position and locking during taxi-out. However, after inspecting the seat track area, the aircraft maintenance log was found located between the center pedestal and the seat. Maintenance personnel found no defect in the seat locking mechanism upon inspection. In an attempt to simulate the incident, a maintenance log was purposely placed between the left-hand seat and the center console; when it was moved rearwards, the log could move the seat fore-aft operating lever, causing the seat to move.

Confusion During Look-See

BAC One Eleven: No damage. No injuries.

The air carrier made a missed approach to London's Gatwick Airport from the decision height of 670 feet because of insufficient visual reference. A second radar approach was made at approximately midnight.

During the second approach, good vertical visibility was available before decision height was reached. With the cloud base at 600 feet, brief visual contact was made with the airport at decision height. The pilot kept the aircraft at decision height for a few seconds to evaluate the visibility. He felt the visibility was sufficient and descended; all of the airport could be seen with the visibility stated to be about 2.5 miles.

However, because the glare from the cloud base reflected the mass of ground lighting, there was some confusion over which was the landing area because of the similar lighting appearance of the runway and a taxiway. After the aircraft had descended to 400 feet and the runway still had not been positively identified, the pilot initiated a missed approach and diverted to his alternate.

Later discussions over the incident included the possibility of adding lead-in runway flashers, and a change was made to the centerline light intensity of the runway concerned. However, procedures still require an immediate go-around if visual reference is inadequate at decision height.

Air Taxi
Commuter

Flaps Not Set for Takeoff

de Havilland DHC-2 Beaver: Aircraft destroyed. Fatal injuries to three, serious injuries to one.

The aircraft was departing from a remote airstrip in Canada. A pilot and three passengers were aboard.

The flaps were in the landing position during takeoff. The aircraft lifted off but went out of control during the initial climb and entered a steep left turn from which the pilot was unable to recover.

Distractions Permitted, Checklist Items Omitted

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

The aircraft, with a crew of one and six passengers, was approaching its Canadian destination during the late afternoon in May. The weather was not a factor.

The pilot was interrupted during the landing checklist to respond to questions from a passenger. The aircraft landed wheels up.

Aiding in the pilot's downfall was the fact that the gear unsafe warning horn was not operable due to a broken wire.

Engine Problem After Takeoff

Piper PA-31-350 Chieftain: Aircraft destroyed. Fatal injuries to six, serious injuries to two.

The aircraft departed the Alaskan airport in the early morning of a late December day. Weather included a measured ceiling of 1,500 feet overcast, visibility seven miles in light rain and temperature 5.5 degrees C (33 degrees F), four degrees above the dew point. There were one pilot and seven passengers aboard.

Slightly more than two minutes after takeoff, the pilot reported to the flight services station (FSS) that he had lost an engine and was circling to return to the airport. The FSS specialist reported observing the aircraft losing altitude and descending below a tree line. She alerted the CFR equipment. The pilot of an aircraft waiting for takeoff observed the aircraft at about 300 feet as it turned on a downwind leg west of the airport, apparently either descending or flying away from the airport.

The aircraft descended into trees, becoming inverted just before impacting a house less than a mile west of the airport. Both the aircraft and the house were destroyed by the crash and subsequent fire. Two persons evacuated the house with minor injuries but the pilot and five of the aircraft's passengers were killed. Two passengers survived and were able to get out of the aircraft and the house before the aircraft exploded.

One survivor reported that it sounded like the left engine had exploded at about 300 feet. The other person heard what sounded like a loud backfire shortly after liftoff, but could not identify which engine it was. He thought both engines kept running but that one seemed to have more power than the other. During the descent, he heard the stall warning buzzer.

Investigation revealed that neither engine had been feathered and that both were operating at the time of impact. However, the power settings could not be determined. Upon teardown inspection, the right engine was found to have an extensive cylinder head crack, a partially disconnected intake pipe, and was capable of producing 55 percent of its rated power; the left engine had seven severely worn cam lobes. The rudder trim tab was found deflected to the full left position, consistent with counteracting a left yaw caused by higher power on the right engine. However, it was determined that the pilot could have misidentified which engine was backfiring and retarded the left throttle rather than the right one. Since the right engine could deliver only partial power, the pilot was unable to maintain altitude.

The investigation verified that, although the aircraft's weight was more than the pilot had calculated (because average passenger weight rather than actual weights were used during computations) and the center of gravity was 3.4 inches further aft than was plotted, the weight and c.g. were within limits. Further, an examination of company checklists revealed that several versions were in use, and that one aircraft had three different checklists aboard.

The probable cause of the accident was attributed to the failure of the number three cylinder of the right engine during a critical phase of flight and the pilot's mishandling of the emergency, during which he allowed the aircraft to descend and impact the terrain.

Corporate
Executive

Into the Trees And Back Out Again

Partenavia PN 68: Extensive damage to fuselage, right wing and right landing gear.

The aircraft was to make a business flight from Stansted Airport to West Malling, Kent, U.K. The left-seat pilot, a 350-hour private pilot with an instrument rating and 58 hours in the aircraft type, was a company director and owner of the twin-engine corporate aircraft. The only passenger was a 14,000-hour professional pilot with a current U.S. certificate who occupied the right-hand cockpit seat.

The pilot checked weather and filed by telephone, and received a weather report from the self-briefing facility, but did not get any terminal forecast because his destination did not provide them. However, he telephoned the airport and was told that the weather looked all right. Weather at the departure airport was slightly less than four miles visibility, rain, 5/8 cloud coverage at 1,200 feet and 7/8 at 3,000 feet.

The aircraft departed at 0826 hours on the mid-December morning and the pilot was granted a request to stop his climb at 2,000 feet to avoid clouds. Twelve minutes into the flight the pilot experienced a violent yawing and pitching, and disengaged the autopilot. He attributed the incident to clear air turbulence and re-engaged the autopilot. After another eight minutes the pilot told the Thames radar controller that he was at 1,800 feet and three minutes out from West Malling, and was granted a frequency change to contact the destination airport. After disengaging the autopilot, he began a descent intending to level off at 1,000 feet msl prior to making a visual landing approach.

The pilot made several unsuccessful attempts to contact the West Malling control tower, and before he was able to make visual contact with the airport the aircraft became engulfed in clouds and the pilot realized it was hitting the tops of trees. The passenger later recalled that, just prior to the tree contact, the aircraft yawed violently and that the pilot seemed to have trouble controlling the aircraft in the turbulence. Immediately after hitting the trees, the passenger pushed the propeller and throttle levers fully forward and helped the pilot control the aircraft. Although the aircraft had sustained major structural damage and a portion of a treetop was imbedded in the leading edge of the right wing, the aircraft managed to climb away from the trees that reached to 525 feet msl; the airport elevation was 325 feet.

The pilot transmitted a Mayday call to the Thames radar approach facility stating what had happened and requesting vectors to the nearest airfield. The aircraft's airspeed registered zero, the right fuel tank gauge indicated zero, the stall warning light illuminated and remained on, and there was a distinct smell of burning. Further, unaware to the pilots and the radar controller, the transponder antenna had been torn off during the encounter with the trees.

The controller mistook another aircraft, which was using the same transponder code, for the stricken aircraft which was no longer transmitting a transponder signal and was too low to produce a readable primary radar return. He directed the Partenavia on a heading that would send the other aircraft to nearby Biggin Hill Airport; it took the Partenavia toward Gatwick Airport, instead. The pilot of the damaged aircraft recognized Gatwick, however, and reported his position to the Thames controller. The latter quickly advised the Gatwick controller, who in turn had just given an emergency turn to an air carrier aircraft to avoid collision with an unidentified radar return that turned out to be the damaged twin-engine aircraft proceeding under the direction of the Thames controller.

By then, although he had been cleared to land on any runway at Gatwick, the pilot of the Partenavia lost sight of the airport in the poor visibility and was advised that he was one mile from Redhill Airport. Because he suspected that the collision with the trees may have damaged the aircraft's fixed landing gear, the pilot decided to land on the grass runway at Redhill. He saw the airport, contacted the tower and did a flyby during which ground observers notified the pilot of the damage. After circling the airfield once more the pilot landed, and the right landing gear collapsed. Rescue services had been alerted and arrived almost immediately. The occupants evacuated the aircraft without injury.

Examination of the aircraft revealed that the right wing leading edge had been penetrated in two places outboard of the engine, and in both locations the structure had been destroyed back to the main spar — which itself was slightly buckled at the point of the inboard tree strike. The electrical wiring and fuel lines also had been crushed in that area and the vane for the stall detector had been destroyed. There was some crushing damage to the right engine cowling and vegetation partially blocked the oil cooler. The tree impact had damaged the right main landing gear attachments and weakened them, resulting in the gear collapse during the landing. The nose section of the fuselage sustained some deformation of the outer skin and the leading edges of the horizontal stabilizer had some crushing damage, with the most damage on the right side. The right-hand cockpit windshield was cracked and a cabin window on the right side had been broken, possibly by material thrown by the propeller on that side. Although the right propeller spinner was dented severely, the propeller showed no signs of damage. The pitot tube had been completely blocked by vegetation and the transponder antenna had been scraped off the underside of the fuselage.

A check of the aircraft's pitot static system revealed no leaks and no operational or accuracy problems with the right hand altimeter. However, the pilot's altimeter, when tested in the laboratory, showed a lag in indicated altitude of approximately 85 feet during descents below 2,000 feet, which was reduced during vibration.

A weather aftercast showed a moist, potentially unstable warm sector in the area with outbreaks of rain, moderate at times. Visibility varied from slightly more than one half mile to more than five miles. Cloud cover included scattered, occasionally broken stratus at 600 feet, stratus possible between 300 and 400 feet where there was upslope air motion and broken to overcast stratocumulus with bases at 3,000 feet and tops at 5,000 feet. There were overcast layers between 6,500 and 12,000 feet with thin layers above. With the potential instability in the area, meteorologists stated there could have been embedded cumulonimbus in the area between 6,000 and 20,000 feet. Although no thunderstorms were reported, downdrafts of between 20 and 24 knots could have occurred in these conditions.

Rocks in the Clouds

Beechcraft Model 200 King Air: Aircraft destroyed. Fatal injuries to one.

The business twin was the first in a flight of two Model 200 King Air aircraft for a ferry flight in instrument meteorological conditions.

The aircraft climbed in trail formation to 4,500 feet msl and headed east through the San Gabriel Mountains in California. The ceiling was 1,000 feet above their altitude when the two aircraft entered the mountains, but it was lower to the east. The pilot of the lead aircraft reported to the following pilot that he had entered the clouds and was climbing.

That was the last communication received from the lead aircraft. The second King Air climbed through the clouds to visual meteorological conditions and landed at the destination with no incident. The wreckage of the first aircraft was found on a mountain two days later. It had been destroyed by impact and post-crash fire. The pilot had died immediately.

Other
General
Aviation

Check — and Recheck

Piper PA-28R: Substantial damage. No injuries.

The pilot, with two passengers aboard, was returning from a cross-country trip. He had flown retractable-gear aircraft only twice previously.

The U.K. control tower had cleared the pilot to enter the traffic pattern on base leg. Shortly after entering the pattern, however, the pilot was requested to make a spacing circle to allow another aircraft to complete an ILS approach. After he completed the orbit, the pilot was cleared to make a straight-in landing from his present position.

The aircraft landed gear up.

Punch in the Nose

Piper PA-28: Substantial damage. No injuries.

The pilot was approaching to land on a 1,600-foot-long U.K. runway he had not used previously.

On landing, the aircraft bounced and then porpoised with the nose wheel striking the runway. The pilot executed a go around and made another approach, this time using the short-field landing technique. When he lowered the nose wheel to the ground, the aircraft refused to respond to the pilot's nosewheel steering input. He used differential braking to maintain directional control. Later inspection revealed that the hard nose-first landing from the porpoise had caused substantial damage to the engine mounting frame and the nose landing gear.

Plastic Fuel Can

Homebuilt: Extensive damage. No injuries.

It was a warm, dry summer evening in England and the pilot had just completed a local flight. He decided to refuel the airplane before putting it in the hangar.

Using a plastic fuel can and a plastic funnel, the pilot started pouring the fuel into the airplane's tank. There was a sudden crack as a spark of static electricity occurred. The fuel vapor and the fuel quickly burst into flame and the airplane was extensively damaged by fire despite quick work with extinguishers on hand in the hangar.

Rotorcraft

Pitch Down Results in Helicopter Put Down

Robinson R-22B: Substantial damage. Minor injuries to one person.

The lesson for the day was simulated engine failures. The U.S. student pilot had practiced several simulated power failures with power recoveries. During the last power recovery following an autorotation, the student leveled the aircraft off with the nose pitched forward. The flight instructor tried to raise the nose but the aircraft struck the ground before he was able to arrest the descent. Both occupants evacuated the aircraft successfully but the helicopter sustained extensive damage. The student pilot was uninjured, but the instructor received minor injuries.

Obstruction Observed Too Late

Hughes 269A: Substantial damage. Minor injuries to two persons.

The rotorcraft was departing for a U.S. sightseeing flight on a warm August day. During the takeoff from a hover, the pilot noticed telephone wires in his flight path. He tried to accomplish a quick-stop maneuver to avoid the wires, but the helicopter rolled to the left and impacted the ground.

The aircraft was damaged extensively but there was no fire. The two persons aboard were able to evacuate with only minor injuries.

Seeing the Sights

Bell 206B: Aircraft substantially damaged. No reported injuries.

The aircraft was on a summertime sightseeing flight in the United States when the pilot pitched the nose down so the passengers could take photographs. However, when the aircraft was put into the nose-low attitude, the engine stopped and the engine-out horn sounded. The pilot successfully accomplished an autorotation into a plowed field. Upon touchdown, however, the helicopter rocked forward abruptly and the main rotor struck the tail boom, incurring extensive damage. The passengers and pilot evacuated the aircraft unhurt.

Checks of the helicopter after the accident revealed that there were about nine gallons of fuel aboard and that the boost pump was inoperative. ♦