Reviewing Aviation Safety in Japan

Efforts to improve the accident record will benefit from a reduction in the stresses that affect flight crew members.

by
Shun Takeda
Chairman, Japan Aircraft Accident Investigation Commission

(Adapted from a lecture delivered on May 22, 1990, in Osaka, Japan, as an annual event of the All Nippon Airways 3rd Aviation Safety Promotion Week.)

The rate of aviation accidents decreased year by year until the 1970s. In the 1980s, however, the downward trend slowed, and the number of accidents has been growing with the expansion in air transport. In an effort to curb the rebounding numbers and to improve aviation safety, efforts have been made in various areas, such as:

- Introducing flight and maintenance management techniques using computer and other electronic technologies.
- Reducing workload on cockpit crews by providing various pieces of information (flight information, malfunction warning, emergency procedures) on integrated displays using computers and CRTs.
- Improving check/inspection accuracies by introducing electronic devices.
- Improving crisis management capability of cabin crew members through means such as line oriented flight training (LOFT) techniques based on the cockpit resource management (CRM) concept.
- Reviewing the inspection and maintenance methods for aging aircraft.

Some of these techniques and technologies have been implemented and show promise toward improving aviation safety in the future. However, there are other issues to be addressed before a completely satisfactory improvement in safety is attained.

This discussion will analyze aircraft accidents and emphasize the relationship between accidents and human beings. It will consider safety problems from the viewpoint that removing or reducing "mental pressures," both explicit and implicit, on personnel engaged in flight operations can greatly help improve safety.

Analysis of Air Accidents

Aviation accidents are of an infinite variety depending on the types of aircraft, operations, missions and other factors. First, we will address the trend of accidents of large transport aircraft in scheduled service and helicopters used for various purposes.

Classification of accidents with large transport aircraft

Table 1 shows the breakdown of accidents involving large transport aircraft that took place

Table 1
Classification of Accidents with Large Transport Aircraft

Classification	Occurrences
Turbulence during cruise	12
Takeoff	2
Landing	14
During parking and taxiing	5
Death of passengers due to sickness	13
Other	3
Total	**49**

in Japan during 1979 to 1988. The average is three to four a year (excluding those involving death of passengers due to sickness).

One of the most noteworthy categories is the accident caused by turbulence during cruise. Most accidents in this category result in injuries to some passengers or crew members, or slight damage to small sections of the airframe. Many of these accidents occurred near cumulonimbus clouds or jet streams on international air routes, and near fronts or mountain waves on domestic air routes. This category's accident rate is expected to decrease as turbulence detection becomes more accurate with improved radar, and in the future, with new technologies such as laser-based turbulence detection.

Accidents during landing can be considered typical for operations with large aircraft, because they are significantly high in both the number of occurrences and the severity of damage. Landing accidents, which account for a large percentage of worldwide accidents, are also expected to be significant in Japan, a country that has a limited number of airports that are fortunate to have a good combination of conditions in terms of weather, site and environment.

Analysis of large transport aircraft accidents during takeoff and landing

A study was made of 16 accident reports (two at takeoff and the remaining 14 during landing) as shown in Table 1. The factors which are considered associated with the accidents are categorized in Table 2.

As shown, the classification "Factors associated with environment" formed the largest group with 24 occurrences, indicating that weather conditions were associated with most accidents. Large transport aircraft, mostly flying scheduled services, frequently are operated in poor weather conditions in order to maintain established flight routes and schedules.

Within the environment category, the majority of factors included rainfall, snowfall, snow contamination and the resultant deterioration of the field of view and visibility. These factors make if difficult to see the runway and other visual cues during takeoff and landing. They

Table 2
Factors Associated with Large Transport Aircraft Accidents During Takeoff and Landing

Classification	Occurrences
Factors associated with Environment	
Crosswind	3
Tailwind	2
Turbulence	2
Rainfall, snowfall	7
Snow contamination	5
Field of view, visibility	5
Total	**24**
Factors associated with equipment	
Damage, defects	4
Maintenance	2
Total	**6**
Factors associated with human beings	
Attitude Control (Pilots)	4
Speed control	2
Thrust control	4
Flight path	2
Corrective maneuvering	3
Others	6
Total	**21**
Other factors	
Air traffic control	1
Facilities	1
Support work	1
Total	**3**

also make runway surfaces slippery, another factor that leads to accidents. Another large group of associated factors is wind, including turbulence, which was involved in seven accidents. Winds affect the control of the aircraft's attitude, speed and flight path, thus adding to the workload on the pilots and possibly contributing to accidents.

The section associated with human beings also represents a large category, contributing to 21 occurrences. It seems that most of the accidents due to these factors are brought about by deterioration of crew adaptability when dealing with unusual conditions of weather, equipment and so on. Although pilots can be taxed with an extremely heavy workload when problems arise in other phases of flight, they are in especially difficult situations, both mentally and physically, when abnormal conditions occur during takeoffs or landings. As a result, pilots become less adaptable and have more difficulty in maintaining desired levels of flight safety.

Occurrences related to the last two categories, "Factors associated with equipment" and "Other factors" are relatively few. These categories have some bearing on non-crew personnel (those engaged in maintenance, inspections and air traffic control, for example), and many of them may be included in the section on factors associated with human beings.

The above analysis indicates that the crew has a bearing on almost all accidents with large transport aircraft during takeoff and landing. Yet, pilots and other crew members engaged in scheduled air transport services have high levels of knowledge, skill and experience; they are carefully selected persons who have undergone long and intensive education and training. In Japan, it is recognized that commercial air carrier pilots are under the dual burden of the mission requirement to safely transport a host of passengers to their destination as well as the mental demands involved in the responsibility for their passengers' well-being.

Classification of helicopter accidents

I have classified the 53 helicopter accidents in the accident reports published from November 1985 through January 1990. The accidents were grouped by type of mission as shown in Table 3. More than half of the accidents occurred during construction materials transport and aerial spraying, reflecting the primary helicopter uses in Japan.

Most helicopters transporting construction materials are operated in mountainous and remote sites where decent heliports are not easy to find, and in many cases severe weather conditions make the flights even more difficult. The aerial spraying mission also involves tough requirements: the pilots must accomplish 20 to 30 flights during two or three hours on an early, windless morning. They must also drop the chemicals over the correct area, often within complicated borders, while avoiding powerlines and other obstacles. These tasks impose large work loads on pilots, who are required to maintain high levels of skill under mentally demanding conditions.

Table 3
Helicopter Accidents by Type of Mission

Missions Involved	**Occurrences**
Construction materials transport	13
Aerial spraying	19
Mass media	4
Training, test	4
Others	13
Total	**53**

Analysis of helicopter accidents

There are 160 associated factors which are considered to have a bearing on the 53 helicopter accidents included in the accident reports mentioned earlier. The factors were classified in Table 4 by a different approach from that used for large transport aircraft.

The category relating to factors associated with human beings accounts for the largest section, of which "judgment/decision" is predominant, constituting 30 per cent of the total. During flight, the pilot must sometimes make judgments/decisions within a limited time under severe conditions. Mistakes that would be considered inconceivable under normal conditions can take place in an unusually severe environment. The process of judgment/decision is a mainstream function of human mental activity, but it also may be a weak one that is most sensitive to a severe environment. The 48 judgment/decision occurrences in Table 4 include cases associated with insufficient attention to safety, such as reckless behavior, insufficient confirmation of safety, and thoughtless change of flight schedule.

A considerable number of associated factors is seen in the maneuvering/operation category as well. Most of these reflect the inability to accomplish an appropriate operation at the necessary moment, revealing the human weakness under harsh conditions.

Table 4
Classification of Factors Associated with Helicopter Accidents

Associated factors	Occurrences	Percent
Factors associated with human beings		
Pre-flight conditions/preparation	14	9%
Knowledge/experience	11	7%
Information collection/recognition	18	11%
Judgment/decision	48	30%
Maneuvering/operation	32	20%
Sub-total	**123**	**77%**
Factors associated with equipment	15	9%
Factors associated with environment	22	14%
Total	**160**	**100%**

The information collection/recognition category is characterized by many cases where the pilot was distracted. During flights such as construction materials transport and aerial spraying, the pilot must pay a significant amount of attention to the visibility and instrument information related to flight safety, as well as considering various other pieces of information needed for the mission.

The factors under the pre-flight conditions/preparation category are attributable more to mistakes by personnel in charge of scheduling, preparation and support of the mission, rather than mistakes made by the pilots and mechanics who are directly connected with the flight.

Looking at the category on factors associated with environment, which accounts for 14 percent (22 occurrences), more than half of these are related to the difficulty in visual perception of the outside world (e.g., rapid deterioration in field of view, difficult visual perception against background lighting). Many of these factors are associated with accidents that occur when spraying chemicals. The second largest group of occurrences in this category is related to wind (tailwinds, turbulence). This is due to the fact that missions using helicopters are, in most cases, carried out at low altitudes and low speeds, including hovering, so they are prone to wind effects.

When we summarize the analysis of helicopter accidents, we notice a strong contrast with the scheduled transport operations using large transport aircraft, where flights are performed with strong cooperation from a staff of flight management, support and air traffic control. To the contrary, the helicopter pilot engaged with various business tasks must do all the work by himself and within a limited time. He often participates in planning as one of the responsible persons of the operating company, but once in flight he can expect almost no assistance from other personnel. Pressures from many aspects can affect the judgment and behavior of the helicopter pilot, and have some relation to accident occurrence.

Relationship of Human Performance to Accidents

Factors associated with human beings are responsible for a great portion of accidents, whether with large transport aircraft during takeoff and landing or with helicopters. The term "factors associated with human beings" describes **how** the pilot is related to an accident, not **why** the accident occurred. Probing to the bottom of the **why** requires deeper investigation and analysis of the human performance (behavior) in connection with flying aircraft.

Human (pilot) performance and its problems

Table 5 summarizes the items and problems which require attention in accident investigation and are related to human performance (behavior).

In the table, the pilot's performance is divided into three major areas: information acquisition/recognition, judgment/decision, and maneuvering/operation. The section "evaluation items associated with functions" represents the functional characteristics which are examined concerning pilots involved, while the "functional failure or mistake" section corresponds to the factors associated with human beings in connection with the accident occurrences described earlier. The items listed under "psychological situation affecting functions adversely" describe those psychological and physiological aspects of human beings which may have had a bearing on a functional failure or mistake. These items are greatly influenced by various mental pressures surrounding the persons and by diseases.

Mental pressures involving Large transport aircraft

Listed below are the mental pressures imposed on pilots engaged in scheduled air transport services using large transport aircraft (excluding personal and other pressures not related to the mission).

Pressures coming from efforts to maintain flight schedules:

Departure and arrival on schedule, arrival at destination airport, troubles resulting from rescheduling, solving problems resulting from troubles.

Passenger oriented pressures:

Excessive service, unreasonable requests from passengers, etc.

Pressures coming from pilot's frame of mind:

Sense of rivalry, superiority/inferiority, excessive sense of responsibility.

Pressures coming from pilot's frame of mind as a member of an operational organization:

Profit/loss to the organization, evaluation by the organization, consideration as a manager (responsible for flight), respect of colleagues.

Others

Mental pressures involving helicopters

The following list shows the mental pressures imposed on helicopter pilots engaged in construction material transport, aerial spraying, and other operations (excluding personal and other pressures not related to the mission).

Pressures coming from efforts to maintain schedule:

Completion of mission within schedule, schedule delay due to weather or other reasons.

Customer oriented pressures:

Excessive, unreasonable requests from customers.

Pressures coming from pilot's frame of mind

Sense of rivalry, superiority/inferiority, excessive sense of responsibility.

Pressures coming from frame of mind as a member of an operational organization:

Profit/loss to the organization, evaluation by the organization, consideration as a manager (responsible for flight), respect of colleagues.

Others

Some of the pressures that occur when flying large transport aircraft and helicopters are considered to be constant and may influence pilots' behavior. However, many of the pressures are usually latent, and they may come into play when a pilot must make a critical

Table 5
Items and Problems Associated with Human Functions

Human functions	Evaluation items associated with functions	Functional failure or mistake	Mental situations affecting functions adversely	Physiological situation functions adversely
Information acquisition/ recognition	Information quality and amount	Excessive or insufficient information	Insufficient or diverted attention	
	Information acquisition timing	Information missed or perceived incorrectly	Impatience	Fatigue
	Information adoption or rejection	Untimely information acquisition (too early or late)	Doubt, confusion	
Judgment/ decision	Knowledge/ experience	Insufficient or low-quality	Uneasiness	
	Judgment/ decision-making ability	Wrong judgment/ decision	Distrust	Languor
	Judgment/decision making timing	Deteriorated judgment/decision-	Failing or excessive confidence/will	Spatial disorientation
	Untimely judgment/ decision (too early or late)	Excessive strain/ relaxation		
			Overload and various stresses	
Maneuvering/ operation	Skill	Insufficient skill		
	Experience	Lack of experience	Various pressures from environment	
		Deteriorated maneuvering/ operational ability	(personal, home, organization, society, etc.)	
		Wrong maneuvering/ operation	Various diseases	

judgment/decision on a problem encountered during flight; these pressures may affect or delay his judgment/decision.

Problems in coping with crisis

Table 6 depicts the situations surrounding a pilot when coping with crisis. In an emergency (crisis), such as from aircraft damage resulting from a severe external disturbance, the characteristics of the operational system (including the aircraft) and the environment are disturbed and deteriorated; the pilot will have to struggle with the maneuvering and operational processes while dealing with the crisis, as well as ensuring the continuation of a safe flight.

The emergency itself represents a heavy pressure to the pilot, who develops mental and physical stresses. Also, the pressures described earlier, under human performance and its problems, come into his mind, with unfavorable influences that may reduce his abilities when they are most important.

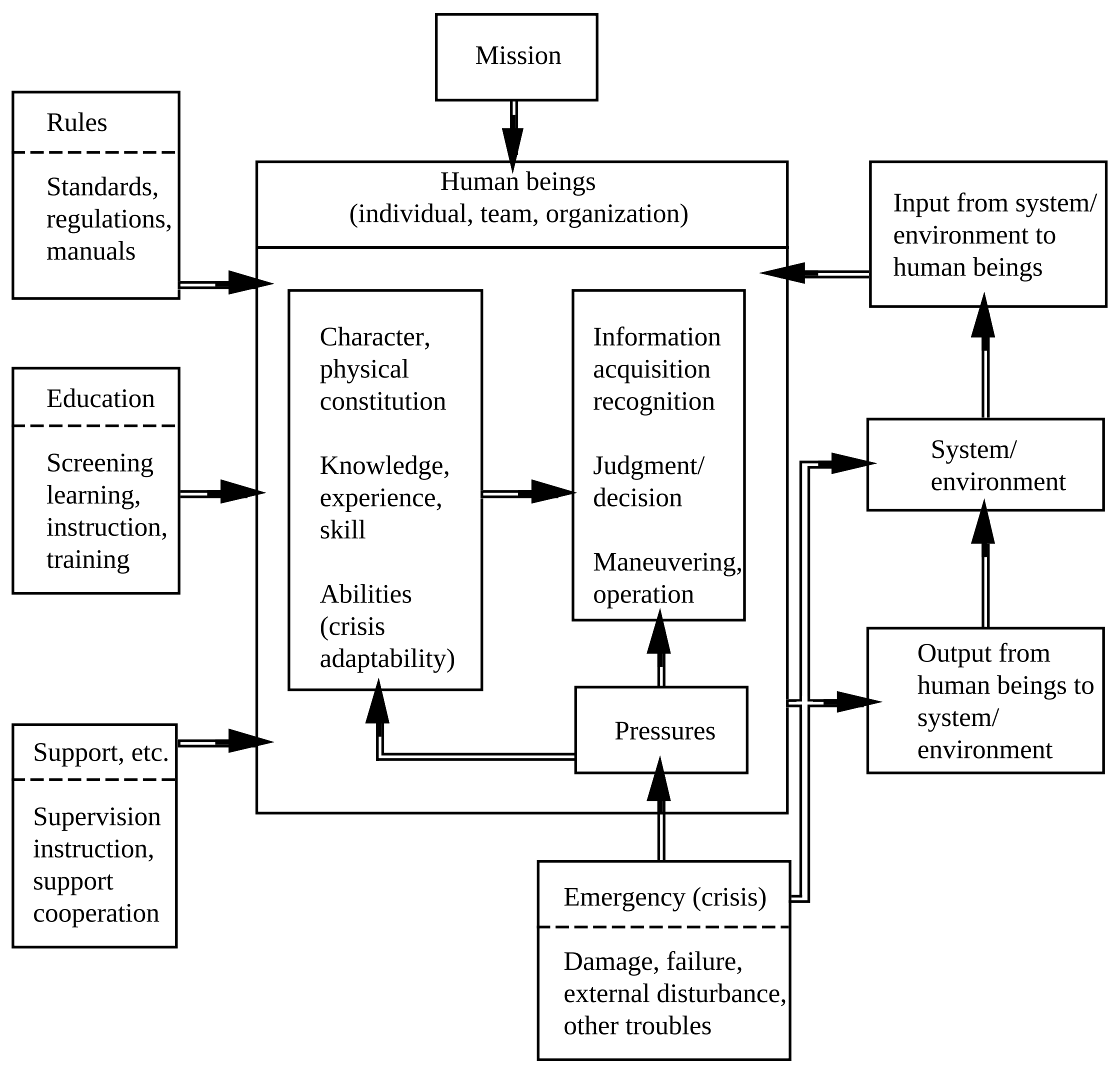
These influences put the pilot into a situation that deteriorates his crisis adaptability. Although individual differences defy generalization, the pilot may become excessively strained, extremely single-minded or prejudiced, and unable to bring to mind the knowledge and experience that is easy to call upon during normal, unstressed, conditions. Also, such pilots are likely to fail in judgment and decision making abilities, and even the functions of their muscles can deteriorate, making maneuvering and operation inadequate to the unusual demands of some emergencies.

How it could happen

Use an imaginary scenario to illustrate how an emergency can apply pressures that affect a pilot's performance and, consequently, influence the safety of flight.

The captain of the airline's last flight of the day was told, during preflight briefing at the departing airport, that the weather over the destination airport was becoming worse, and that visibility might become lower than the

Table 6
Problems in Coping With Crisis



permissible landing minima at the scheduled arrival time. After departure, the captain continued receiving weather information and learned that the weather over the destination airport was worsening; he informed the passengers of a possible landing elsewhere.

The captain received a report 30 minutes before his scheduled arrival time that an aircraft from another airline that was originally scheduled to arrive at the same destination airport 40 minutes ahead of his aircraft was in a holding pattern. Another report 15 minutes later informed him that the holding aircraft had managed to take advantage of temporarily improved visibility and landed 25 minutes behind schedule. The captain obtained permission to began an approach, but during the last stage of the approach, the visibility deteriorated and he was forced to make a missed approach and return to the holding pattern. Ten minutes later, the visibility recovered and the aircraft was cleared for another approach. There were no further problems and the aircraft landed safely.

While the above events were unfolding, the pilot was experiencing a number of pressures that affected his judgment and behavior. These included:

- The troubles anticipated in the event of a long delay in arrival (troubles with the passengers, alternate arrangements for the passengers, post-flight arrangements, etc.)

- Worry about his reputation in contrast to the successful landing of the preceding aircraft's pilot.

- Troubles anticipated by going to an alternate airport (troubles with the passengers, arrangements with the passengers, post-flight arrangements, etc.)

- Financial loss to the operating company because of arrival at an alternate airport.

- Uneasiness about the possibility of an unfavorable evaluation by the company and colleagues concerning his ability and skill level as a captain.

In the imaginary scenario, the visibility fortunately improved, so the pilot experienced essentially the same level of difficulty in landing, maneuvering and operation as usual, and was not confronted with additional pressure or stress of resorting to an alternate airport for landing. However, the visibility could have deteriorated again during the second approach and forced a return to a holding pattern. Then, if the fuel fell short during that hold and the pilot had to decide whether to wait or fly to an alternate airport, the resultant pressure might have affected his judgment and decision making ability, and he might have made an inappropriate decision in terms of safety.

Every pilot has a chance of facing an inflight crisis. In that event, he must cope with the difficulties in overcoming the crisis under pressure. That is, he must successfully apply the principles of "information acquisition/recognition," "judgment/decision," and "maneuvering/operation" described earlier. Because there have not been substantial studies made into methods for relieving pressures and stresses on pilots or for improving their ability to cope with these factors, practical countermeasures would greatly help enhance aviation safety in the future.

Two Proposals Offered

Two proposals are offered for consideration to improve safety (see Table 6). First is a reconsideration of pilot education. It is based upon the fact that the ability of human beings to succeed against pressures and stresses may be both congenital and acquired. Under this proposal, when screening a student pilot for the next step of training, his ability to counter pressure/stress would be evaluated in addition to the existing tests of knowledge, experience and skill. Enhancement of this ability could be included in subsequent learning, instruction and training processes. Since this is a delicate problem associated with human character and psychology, it should be studied prudently by professionals.

The second proposal constitutes a review of support and activities external to the pilot.

The pressure and stress created in a crisis may deprive the pilot of the proper judgment/decision which, even if made, may be delayed. Also, he may hesitate to request support because of various pressures and stresses. Positive instructions, support and cooperation from the personnel in charge of flight management, control and ground support can relieve some of the burdens on the pilot and reduce the pressure on him, thus minimizing stress development. This proposal, however, has an impact on the responsibility and authority of the pilot and requires many considerations before implementation. ♦

Aviation Statistics

A Decade of Development and Safety Performance Worldwide Civil Aviation 1980-1989

by
Shung C. Huang
Statistical Consultant

World Public Air Transport

During the past decade (1980-1989), worldwide civil aviation achieved a significant growth in public air transport, particularly in global airline scheduled services. The worldwide air carrier traffic statistics in terms of the number of passengers and in tonne-kilometers (km) carried for the decade are given in Table 1. In 1980, worldwide airlines carried only three-quarters of one billion passengers, but thereafter the number of passengers carried increased annually. It reached 1.1 billion in 1989, an increase of 47 percent. Worldwide airlines carried 130,000 million tonne-kilometers in 1980, increasing this to 233,480 million in 1989, an increase of 80 percent. The following are the average annual rates which are generally used to measure the growth of airline operations:

Passengers carried	+ 5.2 percent
Passenger-km	+ 7.0 percent
Freight tonnes	+ 6.9 percent
Freight tonne-km	+ 10.0 percent
Mail tonne-km	+ 4.2 percent
Total tonne-km	+ 7.6 percent

The growth of worldwide air traffic was affected by traffic growth in domestic and international operations equally. Over the years, worldwide airline domestic operations accounted for 78 percent of total passenger traffic and 54 percent of passenger-kilometers performed. On the other hand, worldwide airline international operations accounted for 78 percent of the total freight tonne-kilometers performed, 58 percent of total mail tonne-kilometers and about 55 percent of total tonne-kilometers performed. The annual traffic growth rates by domestic and inter-

Table 1
Worldwide Airline Traffic Statistics*
1980-1989
(All Scheduled Service)

	Passengers		**Passenger-km**		**Freight tonnes**		**Freight tonne-km carried**		**Mail tonne-km carried**		**Total tonne-km carried**	
Year	Millions	Annual increase (%)	Millions	Annual increase (%)	Millions	Annual increase (%)	Millions	Annual increase (%)	Millions	Annual increase (%)	Millions	Annual increase (%)
1980	748	-0.8	1,089,000	2.7	11.1	0.8	29,380	4.9	3,680	7.5	130,980	3.2
1981	752	0.5	1,119,000	2.7	10.9	-1.6	30,880	5.1	3,800	3.1	135,490	3.4
1982	766	1.8	1,142,000	2.1	11.6	6.0	31,540	2.1	3,870	2.1	138,460	2.2
1983	798	4.2	1,190,000	4.2	12.3	6.0	35,110	11.3	4,000	3.3	146,390	5.7
1984	848	6.3	1,278,000	7.4	13.4	9.4	39,670	13.0	4,310	7.7	159,200	8.7
1985	899	6.0	1,367,000	7.0	13.7	2.4	39,840	0.4	4,400	2.1	167,690	5.3
1986	960	6.8	1,452,000	6.2	14.7	6.9	43,190	8.4	4,550	3.3	178,800	6.6
1987	1,027	7.0	1,589,000	9.4	16.1	9.5	48,370	12.0	4,680	3.0	196,430	9.9
1988	1,081	5.2	1,705,000	7.3	17.3	7.5	53,360	10.3	4,830	3.1	212,080	8.0
1989	1,099	1.7	1,778,000	4.9	18.0	4.1	57,410	7.6	5,070	4.9	223,480	5.4

*Airlines of ICAO Contracting States
Source: International Civil Aviation Organization (ICAO)

national operations are given in Table 2. Of the six traffic indicators, the growth rate of passengers carried in domestic operations is much greater than that of international operations, but in terms of tonne-kilometers performed, the growth in international operations was faster.

Safety of Worldwide Air Carriers

During the decade, worldwide air carriers in scheduled service were involved in 230 fatal accidents, accounting for 7,045 fatalities. Of the total passengers involved in the fatal accidents, 38 percent or 4,428 survived. In other words, the chance of a passenger surviving a fatal accident was less than 50 percent. The number of fatal accidents, passenger fatalities and survivors for the 10 years in shown in Table 3. The safety records for 1984 show that worldwide airlines were involved in 16 fatal accidents resulting in 223 fatalities, the lowest in the decade. Figure 1 shows the passenger fatalities, fatal accident rates and passenger

Table 2
Worldwide Airline Traffic Statistics*
All Domestic and International Operations
1980-1989

	Passengers		**Passenger-km**		**Tonne-km of freight**		**Tonne-km of mail**		**Total tonne-km carried**	
Years	Domestic	International	Domestic	International	Domestic	International	Domestic	International	Domestic	International
1980/81	-1.0	6.0	0.3	6.0	0.7	7.1	2.4	4.0	0.5	6.5
1981/82	2.9	-1.8	3.4	0.4	-2.9	4.2	0.4	4.5	2.3	2.0
1982/83	4.9	1.7	5.2	2.9	11.2	11.4	2.9	3.9	5.9	5.6
1983/84	6.1	6.9	6.4	8.9	8.3	14.8	7.6	7.8	6.6	10.9
1984/85	6.3	5.1	7.6	6.2	-2.6	1.5	2.7	1.2	6.1	4.6
1985/86	8.0	2.2	9.2	2.2	4.9	9.7	4.6	1.5	8.5	4.8
1986/87	5.7	11.9	6.1	14.0	6.0	14.0	3.1	2.9	6.0	13.7
1987/88	4.0	9.6	4.7	10.8	5.3	11.9	3.5	2.4	4.7	11.0
1988/89	0.2	6.7	1.3	8.0	1.6	9.4	3.5	7.3	1.9	8.4

*Airlines of ICAO Contracting States
Source: ICAO

Table 3
Worldwide Airline Fatal Accidents, Passenger Fatalities and Survivors by Aircraft Type
All Scheduled Services
1980-1989

Classification	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	Grand Total
Fatal passenger accidents											
Turbojet	10	6	11	13[2]	2	7	8	10	11	10	88
Turboprop	4	10	10	7	9	10	9[3]	12	12	16	99
Piston-engine	8	5	5	-	5	5	5	4	4	2	43
Total	22	21	26	20	16	22	22	26	27	28	230
Passengers killed											
Turbojet	698	194	507	762	47	861	405	633	462	572	5,141
Turboprop	86	152	192	47	159	179	105	249	268	248	1,685
Piston-engine	30	16	65	-	17	26	36	19	5	5	219
Total	814	362	764	809	223	1,066	546	901	735	825	7,045
Passengers surviving											
Turbojet	595	30	1,094	346	109	93	177	116	440	905	3,905
Turboprop	11	71	66	47	39	24	90	15	26	61	450
Piston-engine	3	13	-	-	4	5	16	3	24	5	73
Total	609	114	1,160	393	152	122	283	134	490	971	4,428

1. Data for 1986, 1987 and 1988 include the U.S.S.R. Data for other years do not.
2. Includes one collision on the ground between two turbo-jet aircraft (counted as one accident).
3. Includes one mid-air collision between two turboprop aircraft (counted as one accident).

fatality rates of the airlines. The annual passenger fatalities were subject to wide fluctuations. There was not a clear up or down trend at all for the passenger fatality rate. The overall trend shows that the fatal accident rate declined in the first half of the decade but turned upward in later years.

Development of General Aviation

Although the annual airline traffic kept growing throughout the decade, the development of worldwide general aviation operations (civil aircraft activities other than airline operations) was very discouraging. Table 4 shows the changes

Table 4 - Worldwide Civilian Aircraft Pilots
By Pilot License 1/
Calender Year 1980-1989

	Private Pilot		Commercial Pilot		Commercial	Airline	
Year	Fixed-wing	Rotor	Fixed-wing	Rotor	Fixed-wing	Transport	Total
1980	647,550	14,120	259,700	35,480	11,450	122,700	190,950
1981	616,000	13,000	246,000	28,000	12,000	125,000	1,040,000
1982	600,000	12,770	224,200	27,600	21,500	133,700	1,019,000
1983	596,000	13,000	219,000	28,000	11,000	136,000	1,003,000
1984	598,000	13,000	220,000	28,000	11,000	141,000	1,011,000
1985	581,000	11,000	211,000	28,000	11,000	149,000	991,000
1986	571,000	11,000	205,000	28,000	11,000	156,000	982,000
1987	567,000	11,000	207,000	28,000	11,000	164,000	988,000
1988	564,000	11,000	207,000	27,000	10,000	172,000	991,000
1989*	563,000	11,000	208,000	27,500	11,000	174,000	994,500

1/ Excludes student pilot, free balloon and glider licenses
* Preliminary estimates
Source: *Civil Aviation Statistics of the World* (ICAO annual publication) and other publications.

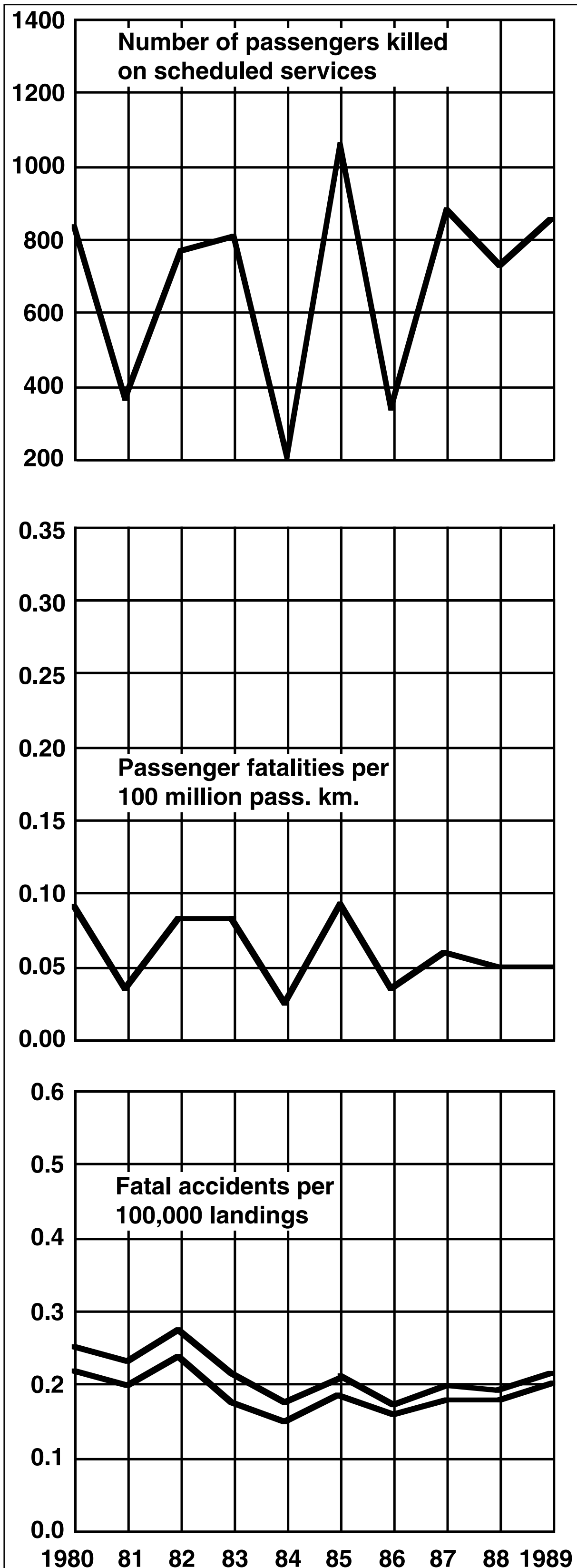
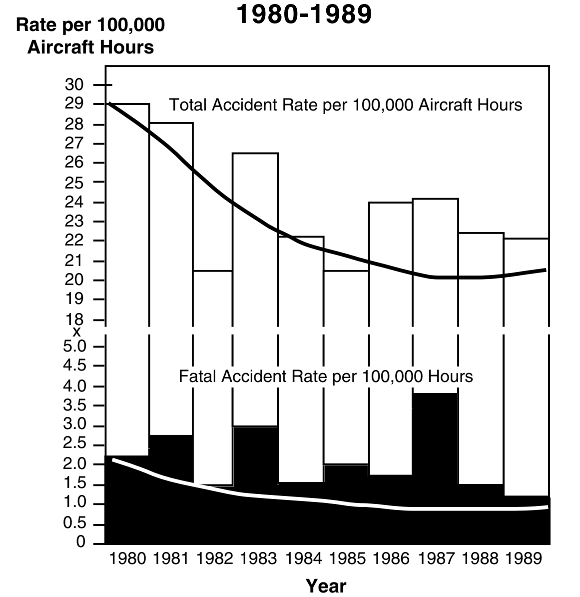


Figure 1
Worldwide Airline Fatal Accident and Passenger Fatality Rates All Scheduled Services 1980-1989

Figure 2
U. K. General Aviation
Total Accident Fatal Accidents and Rates 1980-1989



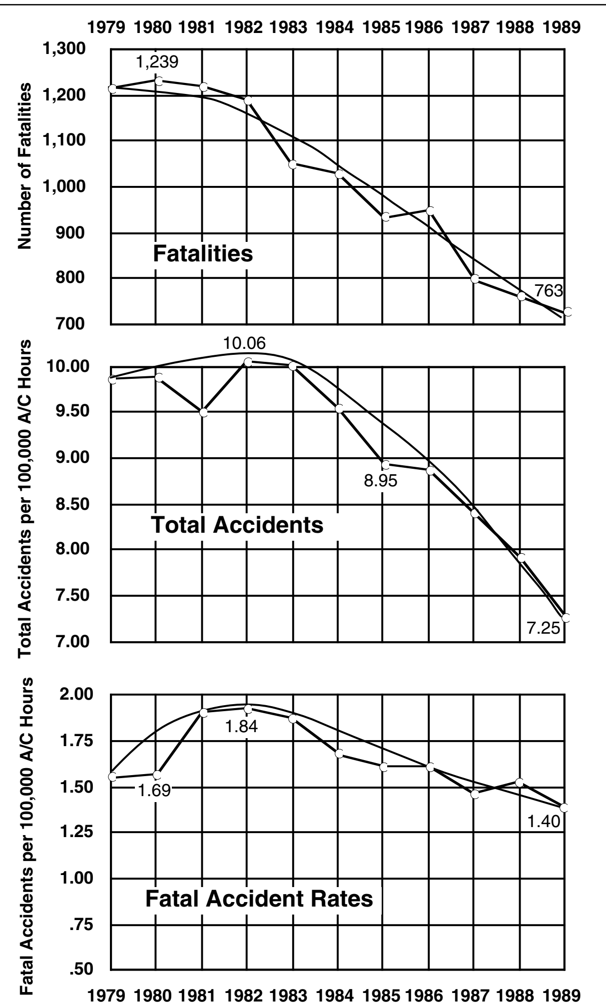


Figure 3
U.S. General Aviation Accidents, Fatalities and Rates

of the civil aviation pilot population by pilot license and Table 5 shows the number of airports available for public use and those for private use only. The continuing decrease of the private and commercial pilot population since 1981 is a reflection of the interest of the general public toward general aviation flying. Fewer active pilots and lower flying activity levels can hardly generate a demand for more airports. As a result, there has been no overall increase in public-use airports during a 10-year period. The most significant decline in general aviation is the slowdown in general aviation aircraft production and daily utilization. Although global statistics on annual general aviation aircraft shipments were not available for comparison, the annual shipment of new aircraft in the United States dropped from 17,000 units in 1979 to 1,500 units in 1989, a reduction of 91 percent in 10 years. As shown in Table 6, the annual total aircraft flying hours dropped from 53.7 million hours in 1980 to 46.5 million, a drop of 13 percent. The annual average use per general aviation aircraft decreased from 172 hours in 1980 to 134 hours in 1987 and increased slightly to 137 hours in 1989. Overall, average aircraft usage declined 24 percent. The real causes of the slowdown in general aviation activities can hardly determined, but the high price of new and used aircraft, skyrocketing insurance costs as well as higher maintenance and operational expenses may have had a combined effect to make general aviation flying too expensive to be affordable by most individuals.

Table 5
Civil Airports of the World
1980-1989

Year	Airports Open to Public Use: Land	Water	Heliport	Airports for Private Use	Total
1980	14,343	486	607	17,647	33,083
1981					
1982		— Not Available —			
1983					
1984					
1985	14,899	339	753	20,059	36,050
1986	14,895	339	753	19,934	35,981
1987	13,797	324	742	21,541	36,404
1988	13,817	322	716	21,343	36,198
1989	14,413	308	755	21,980	37,726

Source: ICAO Council annual reports and monthly bulletins

Table 6
Worldwide Civil Aircraft 1/
1980-1989

Year	Number of Aircraft: Airline (A/L)	Number of Aircraft: General Aviation	Hours Flown (000) by Airline: SD*	Non-SD	Other	(GA) General Aviation	A/C hours Flown Grd Total	Mean HRs per A/C: A/L	GA
1980	37,400	311,600	15,000	1,700	10,200	53,700	80,600	719	172
1981	38,300	323,200	14,600	1,600	10,500	51,400	78,100	697	159
1982	40,100	320,000	14,600	1,500	10,500	53,000	79,900	686	166
1983	40,100	318,600	15,100	1,600	10,600	47,900	75,200	681	150
1984	39,300	335,000	16,000	1,600	10,600	47,000	75,200	717	141
1985	39,000	337,000	16,800	1,600	10,600	46,800	75,800	744	139
1986	39,000	338,000	18,300	2,080	10,200	45,900	76,480	784	136
1987	39,400	339,299	19,400	2,200	10,400	45,300	77,300	812	134
1988	39,900	336,900	20,600	2,300	10,500	45,500	78,900	837	135
1989	40,500	338,000	21,400	2,300	10,500	46,500	80,700	844	137

Source: ICAO Digests of Statistics
* Airline category includes scheduled air service (SD), non-scheduled air service (non SD) and other commercial air transport operations.

Table 7
Accidents, Fatal Accidents and Fatalities (private operations) Canadian Registered Aircraft 1980-1989

Year	Accidents	Fatal Accidents	Fatalities	Total Hours Flown(1)	Total Accident Rate (per 100,000 hours)	Total Accident Rate (per 100,000 hours)
1980	329	35	58	1,300,427	25.3	2.7
1981	326	47	85	1,331,677	24.5	3.5
1982	301	29	49	1,212,206	24.8	2.4
1983	313	43	78	1,149,965	27.2	3.7
1984	272	31	58	1,027,218	26.5	3.0
1985	244	22	29	934,026	26.1	2.4
1986	265	35	61	764,235	34.7	4.6
1987	257	29	52	N/A	N/A	N/A
1988	254	24	40	N/A	N/A	N/A
1989	227	34	64	N/A	N/A	N/A

Source: Canadian Aviation Safety Board (CASB)

Safety of Global General Aviation

Complete statistical information is not available on global general aviation safety. However, it is estimated that the combined general aviation operations in Canada, the United States and the United Kingdom could account for about 70 percent of worldwide general aviation activities. To show the number of general aviation aircraft hours flown, accidents, fatal accidents and rates, for these three countries, may present a general view of worldwide general aviation safety although the actual accident rates may differ from country to country. Table 7 shows the total accidents, fatal accidents, fatalities and rates for Canadian-registered aircraft for private operations. Figures 2 and 3 show the total accidents, fatalities and rates for the United Kingdom and the United States. In Canada, the accident rate for the 10-year period shows a slight increase. In both the United States and United Kingdom, there is a continuing downtrend in the accident rate during the past 10 years. ♦

Reports Received at FSF Jerry Lederer Aviation Safety Library

Books

The Aircraft Cabin: Managing the Human Factors / Mary Edwards and Elwyn Edwards. — Brookfield, Vermont, U.S.: Gower Publishing Company, Old Post Road, Brookfield, VT 05036 USA, c. 1990. xiii, 258p, ill. ISBN:0-566-09056-2.

Key Words
1. Aircraft Cabins — Human Factors.
2. Aircraft Cabins — Design.
3. Aircraft Cabins — Safety Measures.

Contents: Part l: The Components of the Cabin. Human Factors? — The Evolution of Passenger Aviation — The Cabin — The Passengers — The Cabin Crew — the Scope of Human Factors. Part II: Emergencies. The Major Hazards — Hardware in Emergencies — Software in Emergencies — Livewear in Emergencies — After the Emergency — Human Factors in Design and Management — Appendix — Bibliography — Index.

Summary: "Effective design and management of the aircraft cabin demands the procurement and use of many resources in order to achieve high standards of safety and service. Human Factors is the technology concerned with people and the ways in which they interact with one another and with the world around them. The relevance of Human Factors to the cabin is introduced by employing the SHEL model which describes systems in terms of three types of resource — Software, Hardware, and Liveware - interacting together with their Environment." An understanding of Human Factors assists designers of the aircraft cabin to optimize their solutions and enables those concerned with the management of the cabin to ensure its safe and effective operation. The authors discuss the importance of human factors during both normal and emergency conditions. [Ch 1, overleaf]

Jane's All the World's Aircraft 1990-1991. — Alexandria, Virginia, U.S. : Jane's Information Group, 1990. 807p., ill. ISBN: 0-7106-0908-6.

Key Words
1. Aeronautics — Yearbooks.
2. Airplanes — Yearbooks.
3. Rockets (Aeronautics) — Yearbooks.
4. Space Vehicles — Yearbooks.

Summary: Current products of the world's aircraft manufacturers, civil and military.

Managing Pilot Stress / Michael Thomas. — New York : Macmillan Publishing Company; 1989. "An Eleanor Friede book". xiv, 210p. ISBN: 0-02-617760-9. $21.95

Key Words
1. Air Pilots — Health and Hygiene.
2. Air Pilots — Errors.
3. Stress (Psychology).
4. Stress (Physiology).
5. Pilot Stress Syndrome.

Contents: Part I, Pilot Stress: The Syndrome — Pilot Stress — Characteristics of Pilot Stress — Conscious and Unconscious Factors — Personality and Psychological Factors —Physiological Factors — Environmental, Experimental, and Sociocultural Factors — Life-Change and Acute Reactive Factors — Professional Pilots Speak on Stress — Part II, Managing Pilot Stress: Measuring Pilot Stress — Relaxation Techniques — Problem Solving — Interacting with Yourself and Others — Exercise and Nutrition — Conclusion — References — Index.

Summary: Examines the causes of stress among pilots of all levels of experience. The nature of pilot stress is exceptionally important, since the errors pilots make in the cockpit can lead to a geometric progression of the events that may endanger the safety of the flight. Addresses the nature of the stress and "burnout" unique to aviators, identifies the characteristics, causes, symptoms, and effects. It provides a practical approach to the management of this specialized stress, and describes techniques used successfully with airline, corporate, military, and general aviation pilots. [overleaf]

Reports

Aircraft Accident Report: USAIR, Inc., Boeing 737-400, LaGuardia Airport, Flushing, New York, September 20, 1989. — Washington, D.C. : National Transportation Safety Board; Springfield, Virginia, U.S.: Available through the National Technical Information Service*, July 3, 1990. Report NTSB/AAR-90/03, PB 90-91403. 98p.

Key Words
1. Aeronautics — Accidents — 1989.
2. Aeronautics — Accidents — Takeoff/Landing.
3. Aeronautics — Accidents — Rejected Takeoff.
4. Aeronautics — Accidents — Rudder Trim Control.
5. Aeronautics — Accidents — Pilot Training.
6. Aeronautics — Accidents — Runways.
7. Survival (after airplane accidents, shipwrecks, etc.)
8. USAir — Accidents — 1989.

Summary: On September 20, 1989, USAir, Inc. flight 5050 was departing New York City's LaGuardia Airport, Flushing, New York, for Charlotte Douglas International Airport, Charlotte, North Carolina. Six crew and 57 passengers were on board. As the first officer began the takeoff on runway 31, he felt the airplane drift left. The captain noticed the left drift also and used the nosewheel tiller to help steer. As the takeoff run progressed, the aircrew heard a "bang" and a continual rumbling noise. The captain then took over and rejected the takeoff but did not stop the airplane before running off the end of the runway into Bowery Bay. Instrument flight conditions prevailed at the time and the runway was wet. The NTSB determines that the probable cause of this accident was the captain's failure to exercise his command authority in a timely manner to reject the takeoff or take sufficient control to continue the takeoff, which was initiated with a mistrimmed rudder. Also causal was the captain's failure to detect the mistrimmed rudder before takeoff. The safety issues discussed in this report were the design and location of the rudder trim control on the Boeing 737-400, air crew coordination and communication during takeoffs, crew pairing and crash survivability. Two passengers suffered fatal injuries. Safety Recommendations A-90-104 through A-90-108 (megaphones, rescue coordination procedures, checklists, crew pairs and experience), A-90-111 (runways overruns), A-90-40 through A-90-48 (runway overruns/RJO), and reiterated A-85-49 (crew training for inadvertent water impact survivability). [Executive summary]

Report on the Accident to Boeing 747-121, N739PA at Lockerbie, Dumfriesshire, Scotland on 21 December 1988. — London : Department of Transport, Air Accidents Investigation Branch, [August] 1990. Aircraft Accident Report 2/90. vii, [123]p., ill, color photos. ISBN: 0-11-550981-x.

Key Words
1. Aeronautics — Accidents — 1988.
2. Aeronautics — Accidents — Explosion.
3. Aeronautics — Accidents — Bomb.
4.. Aeronautics — Accidents — Bagage Containers.
5. Aeronautics — Accidents — Cargo Area.
6. Airplanes — Airworthiness.
7. Pan American World Airways — Accidents — 1988.

Summary: "Pan American Flight 103 from London Heathrow to New York, had been in level cruising flight at flight level 31,000 feet for approximately seven minutes when the last secondary radar return was received just before 19:03 hours. The radar then showed multiple primary returns fanning out downwind. Major portions of the wreckage of the aircraft fell on the town of Lockerbie with other large parts landing in the countryside to the east of the town. Lighter debris from the aircraft was strewn along two trails, the longest of which extended some 130 kilometers to the east coast of England. Within a few days items of wreckage were retrieved upon which forensic scientists found conclusive evidence of a detonating high explosive. The airport security and criminal aspects of the accident are the subject of separate investigation and are not covered in this report which concentrates on the technical aspects of the disintegration of the aircraft. The report concludes that the detonation of an improvised explosive device led directly to the destruction of the aircraft with the loss of all 259 persons [16 crew, 243 passengers] on board and 11 of the residents of the town of Lockerbie. Five recommendations are made of which four concern flight recorders, including the funding of a study to devise methods of recording violent positive and negative pressure pulses associated with explosions. The final recommendation is that Airworthiness Authorities and aircraft manufacturers undertake a systematic study with a view to identifying measures that might mitigate the effects of explosive devices and improve the tolerance of the aircraft's structure and systems to explosive damage." [Synopsis]

Reference

Advisory Circular 20-110F, 3/29/90, Index of Aviation Technical Standard Orders. — Washington, D.C. : U.S. Federal Aviation Administration, March, 1990. 21p. in various pagings.

Note: Cancels AC 20-110E, August 29, 1988.

Summary: This AC describes the public procedure the Federal Aviation Administration (FAA) will use to develop and issue Technical Standard Orders (TSO's) for aeronautical products to be used on civil aircraft. The AC presents an index of the FAA TSO's which contain minimum performance standards for specified materials, parts, processes, and appliances used on civil aircraft.

*U.S. Department of Commerce
National Technical Information Service (NTIS)
Springfield, VA 22161 U.S.
Telephone: (703) 487-4780.

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

A Word of Caution Thrown to the Winds

Lockheed L-1011 TriStar: Minor damage. No injuries.

The widebody air carrier aircraft had landed without incident on runway 19. It was being taxied to the threshold of runway 01 where it was to make a 180-degree turn to backtrack along the runway.

During the turnaround, the flight engineer questioned the proximity to the runway edge lights, but the captain continued the turn without a visual check of the wheels in relation to the lights. The aircraft was taxied to the ramp. A check of the wheels revealed that both outboard tires on the left main landing gear had been damaged by impact with a runway edge light. One tire had a piece of metal, identified as part of a runway edge lamp assembly, imbedded in it and the other had a large tear in it. Both tires were replaced and the aircraft returned to service. The damaged tires had to be scrapped.

The captain was counseled on the requirement in the flight manual that the position of the wheels should be visually checked from the front door when maneuvering in confined areas.

Things That Almost Go Bang in the Night

McDonnell Douglas DC-10: No damage. No injuries.

The widebody aircraft arrived late for the nighttime turnaround. A crew change was made and the new crew was briefed by the previous captain and flight engineer about a malfunctioning engine rpm indicator and an autothrottle system that had switched off during the previous takeoff without apparent reason.

Despite the late arrival, the outbound captain tried for an on-time departure. The flight engineer did his checklist work while the technician replaced the faulty rpm indicator; however, while the instrument was being changed, he left out a checklist item. He could not compare the computed takeoff rpm settings with the bugs on the rpm indicator while it was being changed and did not backtrack to cover this item later. Unfortunately, the auto/manual knob on the rpm indicator remained in the manual mode and the bugs were preset to about 103 percent; therefore, the correct takeoff power setting of 113 percent was not automatically displayed by the bugs on the indicator.

The takeoff was begun at the 103 percent power setting. The autothrottles would have set the proper, computed power but the flight engineer disengaged them because he assumed they were overboosting the engines when the rpm went above the incorrectly set bugs on the rpm indicator. However, he became suspicious of the power setting and advanced the throttles to about 109 percent during rotation and the flight proceeded without difficulty.

A recap of the incident pointed to the pressure of time, urging by the captain for a scheduled departure despite the aircraft's late arrival; an instrument change during cockpit preparation for takeoff; a checklist mistake; and a preconceived opinion about a possible autothrottle malfunction. A further contributing factor could have been the effect on the crew of the 0100 hours departure time.

Air Taxi/
Commuter

Improper Loading Proves Fatal

Fokker F27 Friendship: Aircraft destroyed. Fatal injuries to two.

The cargo flight was arriving at 2225 hours, after an ADF approach in visual meteorological conditions. The copilot was flying the aircraft.

When the copilot lowered the flaps fully to 40 degrees on final approach, the aircraft pitched up violently requiring application of full forward control column. When power was added for a go-around the cargo shifted to the rear. The aircraft stalled and crashed 3,000 feet before the runway threshold.

The aircraft was destroyed and the crew of two both sustained fatal injuries. The load manifest prepared by the pilot indicated that the load was within center of gravity (cg) limits, but the one prepared by the loader indicated that the load exceeded the aft cg limit by 11 percent. The cargo was found to be incorrectly stowed and secured; the cg exceeded limits; flaps were set at 11 degrees instead of the recommended 26 degrees for the stage of flight; and the pilot was considered to have planned, monitored and made decisions incorrectly.

Lack of Sleep Affects Performance

Commander 690: Aircraft destroyed. Fatal injuries to one.

The pilot of the cargo flight was approaching his destination airport at 0532 hours on a spring morning. He had had two hours of sleep the previous night.

The aircraft was cleared to descend from 7,000 feet to 2,000 feet. At 0522 the pilot reported that the airport was in sight. He was cleared for a visual approach. Radar contact was lost 10 minutes later. The aircraft impacted the terrain three miles northeast of the airport and was destroyed. The pilot, the only occupant, sustained fatal injuries.

Factors included the pilot's lack of sleep, poor flight decisions and inadequate level off.

Corporate
Executive

Windshear on Final Bends Airplane

Gates Learjet 35: Substantial damage. No injuries.

The aircraft was making a night landing approach during adverse weather. It was dark and raining, and vertical gusts were present in the area. Occupants included the crew of two and three passengers.

On final approach in instrument meteorological conditions, the aircraft encountered windshear but the pilot continued the landing attempt. The aircraft landed with a high sink rate and a tire blew. Accompanying that, the wheel broke and the left engine separated from the airframe. The aircraft was damaged substantially, but the five occupants were able to evacuate the aircraft without injury.

Factors in this accident included the adverse weather and the failure to go around.

Too Low, Too Slow

Beechcraft King Air 200: Aircraft destroyed. Fatal injuries to four.

The aircraft had been cleared for an instrument approach in visual meteorological conditions to an airport near a high elevation lake surrounded by hills and instructed to report established on the approach. It was daylight in the early evening on an early summer day. A pilot and three passengers were aboard.

Radio and radar contact were then lost, and the aircraft was observed flying near one end of the lake, where the pilot owned property, at a low altitude and low airspeed. While in a steep left turn, the aircraft crashed into rising terrain. The aircraft was destroyed and fatal injuries were sustained by all four occupants.

Heart attack was considered a strong possibility. The pilot had a history of hypertension, hyperlipidemia and he had recently lost 40 pounds on a rigid weight loss program. An autopsy revealed severe arteriosclerosis. The pilot had been taking diazide intermittently for several years. Investigators concluded that he became incapacitated in flight.

Other General Aviation

Automatic Rough Over the Boondocks

Cessna 182 Skylane: Substantial damage. No injuries.

The aircraft, with the pilot and three passengers, was cruising at 6,000 feet when they encountered poor visibility in haze over a lake. The pilot flew away from the lake and descended to look for a clear area.

At about 500 feet above the ground, the pilot applied power to level off, but the engine began to misfire and run rough. He decided to make a precautionary landing. After overflying two roads that appeared unsuitable, he selected a recently mowed hay field and made an approach. The aircraft bounced on touchdown and then contacted the ground nosewheel first. The nose gear collapsed, and after rolling less than 100 feet the aircraft nosed over. The aircraft was damaged substantially, but the four occupants were able to exit without injury.

Investigation revealed that partial carburetor heat had been applied throughout the flight to raise the reading of the carburetor air temperature (CAT) indicator gauge to a point above the yellow arc. During the descent from 6,000 feet, the CAT again dropped into the icing range. At about 4,000 feet, the carburetor heat control was pulled half way out and at the bottom of the descent more carburetor heat was applied. When he decided to land, the pilot selected full flaps in preparation for an immediate landing when he found a suitable field.

The aircraft was found to have had adequate fuel and there were no mechanical deficiencies that would produce a rough-running engine. Investigators reasoned that the pilot's use of partial carburetor heat had permitted the CAT to drop into the icing range several times during the flight and that the risk of carburetor ice increased during the descent with reduced power. When the throttle was advanced to level off at the bottom of the descent, any ice that had formed in the carburetor melted and caused the engine to run rough. Further, the addition of full flaps at this time greatly increased drag and could have given the pilot the impression of an even greater loss of power.

Fuel on Board But None Available

Grumman G21 Goose: Substantial damage. Minor injuries to one.

The amphibian had floated on a lake, between flights, for about an hour during the mid-afternoon. The left wing floated lower than the other and the fuel selector was in the crossfeed position, allowing the fuel from the right wing tank to drain into the left wing.

The pilot took off for another flight and, while descending to land, both engines failed. The pilot switched the fuel selector to the tank with fuel, but it was too late and the aircraft struck the ground, causing substantial damage. The pilot was able to exit the aircraft with minor injuries. The vent to the right fuel tank was found to be blocked.

Rotorcraft

No Juice, No Go

Bell 47: Substantial damage. Serious injuries to one.

The rotorcraft, that had been on an aerial application mission, was observed by a ground witness descending toward an open field. The main rotor blades and the tail rotor blades were rotating, but the witness did not hear any engine noise.

The aircraft landed hard in a nearly level attitude and was substantially damaged. The pilot, the only occupant, sustained serious injuries.

Preliminary inspection of the rotorcraft wreckage revealed that about three gallons of fuel were in the fuel tank. There were no signs of a fuel leak either from the tank or from the fuel lines.

Too Low, Too Fast

Hughes 500C: Aircraft destroyed. Fatal injuries to five.

The helicopter was being flown at a low altitude over a lake. Aboard were the pilot and four members of a television camera crew. The aircraft struck unmarked wires strung between the shore and an island and crashed into the water. The helicopter was destroyed and all the occupants were fatally injured. The helicopter was not equipped with wire protection devices.

In its final report on the accident, the Canadian Transportation Accident Investigation and Safety Board (successor to the Canadian Aviation Safety Board) reported that it had been determined that the pilot operated the aircraft at high speed and low altitude without adequate pre-planning for the flight or reconnaissance of the area.

Although it was not cause-related, it was noted that the occupants were not wearing shoulder harnesses at the time of the accident, a practice the board stated is warranted during any low-level, special operations use except when the individual is unable to perform required duties with the shoulder harness fastened. Concern also was expressed in the report about carrying other than non-essential personnel during special purpose operations, pilot decision making and aircraft overloading. ♦