Risk Indicators and Their Link With Air Carrier Safety

The relationship between risk indicators and safety is explored by comparing the accident rate of air carriers with the characteristics of those carriers at the time of an accident. Based on these analyses, a number of risk indicators are identified.

by
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This article is based upon the results of a study undertaken by Sypher:Mueller International[1] for Transport Canada to evaluate the use of risk indicators for monitoring aviation safety in Canada and targeting resources to improve safety. It only considers the safety of commercial operations and focuses on the larger operators who carry the vast majority of the passengers. The feasibility of using the resultant indicators to identify high-risk operations is demonstrated.

Aviation Safety Measuring Methods Examined

The primary bench mark of passenger transportation safety is the probability of death, or injury, as a result of traveling[2]. Fatality and injury rates are estimates of these probabilities based upon past experience. While fatal commercial airline accidents are rare events, a single accident can result in a large number of deaths significantly altering the fatality rates. Consequently, trend analysis of fatality or injury rates requires data over long time periods (up to 10 years or more in Canada). In addition, the data give poor indications of changes in risk from year to year.

Examining less serious accidents can be of great value because the differences between the sequence of events leading to a major disaster and to a minor accident are often small. The minor accidents may be the result of problems that could eventually lead to a serious accident[2]. Aircraft accident rates based upon number of departures rather than hours flown are a better measure of safety, because most accidents occur during the taxiing, takeoff/landing and ascent/descent phases of flight[3]. Accident rates based on hours flown can be misleading, especially when comparing different types of operations. The infrequency of accidents also makes analysis by numbers of them difficult, but there are enough jet aircraft accidents to allow trends in safety to be identified over three or four years in the United States and over five to seven years in Canada.

Alternative Measures of Safety Explored

With the deregulation of the airlines and perceptions of its possible effect on the safety of airline operations, there has been an increasing need for improved understanding of the factors affecting safety, as well as the ability to predict areas where safety may deteriorate. This, combined with restrictions on resources available for aviation inspection and enforcement, and the need to make better use of those resources, has led to the development of alternative ways of measuring safety. These involve the concept of the *margin of safety* and the use of *risk indicators* [2,3,4,5.]

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The aviation system is comprised of a number of components that include airport operators, the air navigation system, weather services, aircraft operator personnel and management, aircraft and aircraft manufacturers. Aircraft accidents are rare events that are typically the result of several concurrent mechanical, human or technological failures in components of the aviation system. Any slight deterioration in the separate components increases the probability of failure (or error) and eventually leads to an increase in the accident rate. However, it may be years before changes in the accident rate due to the component deterioration can be separated from random fluctuations in accident rates.

Accidents, despite being the result of a number of failures in system components, do not provide adequate early warning of deterioration in the system components. Alternative measures are required to identify changes in the safety level of each component as they occur. To develop these measures, the concept of the margin of safety is employed.

Aviation safety does not rely on the total elimination of failures and errors in mechanical, human or technological components of the system. A margin of safety is built into the system allowing component failures (or errors) to occur without an accident necessarily resulting. The margin of safety is the extra cushion in the system to avoid accidents, which would not be needed if everything worked as planned. To the extent that the system becomes less tolerant of failure, or one in which failures occur more frequently, the margin of safety decreases and the risk of an accident increases.

The margin of safety concept provides an alternative method of assessing changes in the level of safety. Unlike accident and fatality rates, characteristics used to measure the margin of safety relate directly to system components. This makes them useful for monitoring purposes, identifying the causes of changes in safety levels and evaluating actions to improve particular system components. Also, since the characteristics relate to system components, and component failure rates are greater than accident rates, safety problems can be identified in a more timely manner.

Indicators measuring the margin of safety should be related to safety. After some period of reliable, consistent data collection, it should be possible to establish a link between the indicator and accident, fatality or injury rates.

Identify Risk Indicators

Potential safety indicators must be measurable factors associated with or causally related to accidents, fatalities or injuries. Non-accident data can be divided into two types:

- Incidents — events where the safety of the aircraft and passengers was affected, but no accident occurred (e.g., engine shutdown, forced landing due to mechanical difficulties, severe turbulence, etc.), and
- Business stress or “leading” indicators — properties of an operator or the system which may affect safety (e.g., financial performance, mixture of aircraft types, etc.).

Incidents are events where a failure or error occurs in a system component, but no accident occurs. By their very nature, incidents are more frequent than accidents and provide more timely evidence of changes in safety levels. However, there are a number of problems with incident indicators. Despite their obvious link with safety, little correlation was found between incidents and accidents by the U.S. Aviation Safety Commission[2] and Office of Technical Assessment[6]. This could be due to the desirable effect of identification of incidents leading to improvements in the safety of that component and therefore fewer accidents, or due to problems with current incident data. Incidents comprise a large set of component failures that vary greatly in the degree to which they affect safety. Subjective judgment is often used in determining when to classify an event as an incident, and this affects the consistency of reporting the incident. In addition, the reliability is dependent upon accurate reporting of the incident which varies greatly with the type of incident and the reporting requirements.

Leading indicators could be used for identifying areas where safety may be deteriorating before an accident occurs. These indicators can, for example, take the form of measures of business stress (e.g., financial indicators), properties of carriers (e.g., mixture of aircraft types and frequency of recurrent pilot training) or characteristics of the air traffic control (ATC) system. As with incident indicators, consistency and reliability of reporting should be considered when choosing properties to be used as indicators.

One approach to improving safety is to determine the characteristics of the various components that are associated with high-risk operations. Identification of these undesirable properties can be used to improve regulations and operating and training procedures. Knowledge of these characteristics can help air carriers to structure their businesses into safer operations. The identification of high-risk groups can also be used to target inspections and audits to carriers most likely to have safety problems, thus improving the effectiveness of the inspection program.

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Risk indicators are only useful if they are related to safety and, at least in the long term, a link can be established between them and the accident rate. Following are the results of analyses investigating the relationship between a number of risk indicators and the accident rate of air carriers. An analysis of flight crew characteristics related to safety could provide valuable evidence for assessing risk indicators as the flight crew are by far the most common casual factor in accidents[6,7]. However, insufficient data were available on which to assess the effect of pilot characteristics on accident risk.

Air Carrier Characteristics and Accident Risk Linked

Air Carrier Data

An analysis of air carrier characteristics and their accident rates was conducted using 21 Canadian air carriers during the years 1983 to 1988. Carriers were selected solely on the basis of number of passengers — not their accident rates, financial status, types of aircraft operated, etc. These carriers included all major jet (Canadian level 1) carriers during years 1983 to 1987, all commuter (level 2) carriers in 1987 and four large contract/charter (level 3) carriers (Statistics Canada levels given in "Canadian Civil Aviation," Statistics Canada Catalogue 51-206). The 21 carriers and their relevant statistics are listed in Table 1. Accident data for these carriers were obtained from the Air Safety Investigation System (ASIS), an accident/incident database maintained by the Transportation Safety Board of Canada (TSB). The operational data were obtained from Statistics Canada (an agency of the Canadian government).

A set of possible risk indicators was chosen based on a literature review (References 2,6,9,10 and 11) and interviews with aviation safety inspectors and experts. The availability of reliable data for calculating these indicators was determined, and the set was narrowed down to the characteristics of the air carriers given in Table 2. In the papers reviewed, there were no conclusive findings regarding the use of financial indicators. However, the proportion of total expenditure on maintenance was found to be a misleading indicator of safety. Some characteristics of the air carrier's fleet, for example, the effect of 10 different aircraft types, would be much less for a carrier with 100 aircraft than for a carrier with 20 aircraft.

Aircraft fleet data were obtained for each year from the aircraft registry database, and financial data were provided on a confidential basis by Statistics Canada (1988 data was unavailable until the end of the study). Company merger or split activity and the maturity of the carrier were obtained from Air Carrier Operations Branch of Transport Canada.

Pilot characteristics for a carrier were not considered in this analysis due to a lack of pilot-related data.

Analysis Procedure Detailed

The characteristics given in Table 2 and the number of accidents and departures were determined for each carrier for each year it operated between 1983 and 1988. Carrier-year was used as the basis unit of analysis.

Initially, each characteristic was investigated separately by assigning each carrier-year to two or three groups based on values of a characteristic and comparing the accident rates for the carrier-years in each group. The division point for each characteristic was chosen either at a natural breaking point or so that carriers with unusually high or low values would be isolated, depending upon whether high or low values are likely associated with greater acci-

Table 1. Air Carriers Considered in Analysis*

Carrier	Level (1987)	No. of Aircraft in Fleet	Average A/C Wgt (kg)	Departures	Enplaned Passengers (000)
Air Atlantic	3	7	18,810	19,540	335
Air B.C.	2#	28	13,390	46,140	836
Air Canada	1	110	94,040	159,840	13,075
Air Nova	3	5	14,320	14,568	235
Air Ontario	2	54	14,400	49,506	625
Austin	2	22	9,880	32,540	127
Bradley Air	2	26	16,380	22,300	178
Canadian	1	63	74,150	106,050	6,312
Eastern Prov.	1	10	49,590	25,530	1,029
Nationair	2	7	152,600	2,205	312
Norcan Air	2	8	25,540	13,302	215
Nordair	1	18	51,660	41,746	1,402
Northwest Terr.	2	10	39,330	6,066	68
Pacific Western	1	28	54,910	81,147	3,300
Quebecair	1	12	27,930	20,321	409
Soundair	3	29	7,730	22,125	24
Time Air	2	13	16,770	37,010	655
Trans-Provincial	2	16	3,800	87,432	194
Voyageur	3	16	5,380	12,535	37
Wardair	1	12	236,110	10,713	1,830
Worldways	2	6	172,670	4,818	797

* Values given for 1987 or last full year of operation
# Air B.C. was a level 2 operation in all years except 1987 when it was level 1.

dent risk. Significance levels were calculated assuming that the number of accidents followed a Poisson distribution (a commonly used statistical method for this type of application).

Table 2. Characteristics of Air Carriers Considered

- Level of carrier
- Number of aircraft owned or leased by carrier
- Average weight of aircraft in fleet
- Percentage change in fleet size in current year
- Ratio of number of aircraft types to fleet size
- Ratio of number of aircraft makes to fleet size
- Company merger of split activity in current year
- Region of headquarters of carrier
- Maturity of carrier (number of years in business)
- Ratio of retained earnings to total assets
- Ratio of total liabilities to total assets
- Ratio of depreciation expenses to total assets
- Ratio of current assets to current liabilities
- Net profit to total assets ratio
- Ratio of operating revenue to operating expenses
- Net loss in previous year
- Net loss in both previous and current year
- Proportion of departures of charter services.

The analysis did not try to establish a linear relationship between the characteristic and the accident rate, because it was considered that many of the relationships may be highly non-linear. For example, there is little evidence to suggest that the safety of profitable operations would increase as they became more profitable. However, consider an operation in critical financial trouble which can only stay in business by cutting costs in areas affecting safety. In these situations, the company would accept the risk of a loss in revenue due to the unlikely event of an accident since, by not cutting costs, it would go out of business anyway. This is a very simplistic analysis of a complex situation, but it does illustrate how the effect of some indicators will be non-linear.

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The air carrier characteristics, departure and accident data were then used to identify interaction between characteristics and high-risk groups. The analysis procedure involved partitioning the accident-departure data into groups such that the accident rates within a group were similar, but rates between groups were significantly different. Each new group was then partitioned in a similar way. Partitioning ceased when no characteristics could be found to partition the remaining groups into groups with significantly different accident rates. The calculation of significance levels takes into account the fact that the partition with the highest significance level is used to form the groups. The results can be displayed in the form of a tree which facilitates interpretation of the results.

Results of Analysis

A number of air carrier characteristics were found to be associated with significantly different accident rates (significant at least at the 0.95 level). These are shown in Table 3 in order of difference in accident rates.

Some of the characteristics are highly correlated and divide carriers into similar groups. Also, some characteristics are not themselves directly related to safety, but are associated with safety-related properties. Carriers with the greatest accident risk are those operating, on average, small aircraft and those in level 3. Fleet size was also found to be a good indicator, but not as strong as average aircraft weight or level of carrier. The significance of these characteristics could be due to a number of factors, including the more stringent airworthiness standards of larger aircraft, greater experience and better recurrent training of pilots on larger aircraft, and the maintenance practices of the large carriers. In Canada, these are usually reflected in the Operating Specifications of the

Graphic not available

Table 3. Significant Characteristics and Accident Rates

Operating Certificate.

A large mix of aircraft types or makes in relation to aircraft fleet size was also found to characterize carriers with above average accident risk. Of the financial indicators considered, carriers with a relatively high depreciation expense and those with greater operating expenses than operating revenue had a higher accident rate. A number of other financial indicators characterized carriers with very different accident rates but, due to the unavailability of financial data for 1988, greater differences were required for them to be statistically significant.

Carriers offering a mixture of charter and scheduled services (at least 10 percent of both) had a significantly higher accident rate than carriers offering primarily one type of service (accident rate of 1.62 compared to 0.61 accidents per 100,000 departures). However, the percentage of charter services was not related to the accident rates of level 1 carriers.

The interaction between significant characteristics is displayed in the form of a tree in Table 4. The top of the tree shows the set of all 44 accidents and 3,823,000 departures for the 21 carriers considered in this study. This initial group is partitioned into three groups on the basis of average aircraft weight: the small, medium and large aircraft having accident rates of 4.8, 1.5 and 0.6 accidents per 100,000 departures, respectively. For the operators of small aircraft (left of tree), the level of the carrier is the most important characteristic. No characteristic was found to be significant for operators of the medium-sized aircraft. Operators of large aircraft were found to have a significantly greater accident rate if their net profit to assets ratio was less than one percent, and an even worse rate if they had a net loss in the previous year. The accident rate of these financially troubled carriers was 2.2 compared to 0.2 for the other operators of large aircraft. Other significant characteristics of operators of large aircraft, not shown in the tree, were the ratio of the number of aircraft types and makes relative to the fleet size.

Another interesting partitioning of the data is with the first split made on the basis of level of carrier, as shown in Table 5. For level 1 carriers, the ratio of the number aircraft types to fleet size is the most important characteristic. Those with a large proportionate mix of types have an accident rate six times that of the other level 1 operators. Of the level 1 carriers with a low mix of types, those with a net loss in the previous year have significantly greater accident rates. Other significant financial indicators for level 1 carriers (not shown in tree) were the ratio of net profit to assets, the ratio of operating income to operating expenses, the ratio of retained earnings to assets and company merger or split activity. The financial indicator, ratio of current assets to current liability, was found to be important for level 2 carriers and average aircraft weight was important for level 3 carriers.

A number of other groupings of the data, all involving significant splits of each group, were analyzed. Other initially significant characteristics, such as region of headquarters and maturity of carrier, were not found to have a significant effect on safety.

Generally, it can be concluded that the large carriers and those operating large aircraft have a lower accident rate than other operators, but that their accident rate varies significantly with:

- Number of aircraft types and makes relative to fleet size, and

- Financial position of carrier.

Characteristics of medium carriers (level 2 or average aircraft weight between 5,700 kg, 12,500 pounds, and 45,500 kg, 100,000 pounds) were not closely related to their accident rate, with only one financial indicator found to be significant. For the small carriers (level 3), aircraft size was found to be the most important

Graphic not available

Table 4. Partitioning of Air Carrier Data into High- and Low-risk Groups — First Partition Average Aircraft Weight

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Table 5. Partitioning of Air Carrier Data into High- and Low-risk Groups — First Partition Level of Carrier

characteristic.

Testing the Indicators Using Recent Data

Following the completion of the study, financial data was published by Statistics Canada for the level 1 carriers in 1988. Rather than revise the analysis including the new data, the data was used to test the validity of the partitions and risk indicators listed in Table 3. There is no value in considering the partitions in Table 4 because it only considers loss in the previous year and, therefore, does not use 1988 financial data.

Only three level 1 Canadian carriers operated during 1988, and these are referred to as carriers 1, 2 and 3. All three had average aircraft weights of more than 45,500 kg (100,000 pounds) and are, therefore, in the right-side group of the first partition in Table 3. The accidents, departures and ratio of net profit to total assets in 1988 are given in Table 6. Both carriers 1 and 3 had a net profit to total assets ratio of less than one percent. The ratio for carrier 2 is greater than one percent. Therefore, considering the partitioning of operations given in Table 3, both carriers 1 and 3 fall into the group of carriers operating large aircraft that have a high accident rate, while carrier 2 in 1988 falls into the group with lower accident rates. The accident rate for the group with the low profit ratio is, from Exhibit 3, 1.2 accidents per 100,000 departures. This compares with the accident rate for carriers 1 and 3 in 1988 of 1.17. Carrier 1 had no accidents in 1988 and, therefore, had a zero accident rate compared to a rate of 0.2 per 100,000 departures for the more profitable operators using large aircraft.

The closeness of the accident rates in the two groups is, to some extent, a coincidence because the standard deviation of the accident rates in the more and less profitable groups is 0.12 and 0.40, respectively. However, the comparison indicates that the relationship found between financial characteristics of air carriers and safety using 1983 to 1987 data continued to hold during 1988.

Table 6. Data for Level 1 Air Carriers in 1988

Air Carrier	Departures*	Accidents	Net Profit Total Assets
1	153,000	2	0.06%
2	171,000	0	3.02%
3	18,000	0	-1.55%

* Departures estimated based on hours flown.

Conclusions Are Drawn

The following conclusions were drawn from the investigation of risk indicators, their usefulness and their links with air safety.

1. Insufficient accidents occur for accident rates to be used for monitoring short-term changes in the level of safety of the various components of the aviation system. For this purpose, indicators based on incidents and properties of components of the aviation system related to safety are required.

2. Indicators can be meaningless, if not misleading, if based on data that is unreliable, inconsistent or incomplete. Care must be taken to minimize any subjective judgment in reporting and to ensure reporting is compulsory.

3. The characteristics of air carriers most strongly related to safety are the size of aircraft operated, level of carrier and the mixture of aircraft types and manufacturers.

4. Financial indicators such as loss in previous year, ratio of net profit to total assets and ratio of operating revenue to operating expenses are related to the accident rate of carriers operating large aircraft and level 1 carriers.

5. More data on pilot characteristics are required, both in accident and exposure data in order to identify high-risk elements of this major factor in the accident causal chain and to evaluate pilot-related safety programs.

6. Air carriers can be assigned to high- and low-risk groups on the basis of the characteristics of the carriers and the aircraft they operate. Inspections should focus on those groups of carriers with the greatest accident risk.

7. A number of leading indicators for assessing safety were identified and linked with safety in this study. Further, indicators for assessing the safety of each component of the system could be found if a number of improvements are made to the data collection systems.

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About the Authors

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Australian Civil Aviation

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Australia has for years been ranked eighth worldwide among the International Civil Aviation Organization (ICAO) contracting states in terms of both tonne-kilometers and passenger-kilometers performed. In 1990, Australian airlines recorded 5 billion tonne-kilometers, three-quarters of which were performed in international operations and 40.4 billion passenger-kilometers, more than two-thirds of which were performed in international operation. Australian aviation operations, particularly the airlines, have maintained high levels of safety, with an average of 10.68 accidents and 1.04 fatal accidents per 100,000 hours during the most recent four-year reporting period ending with 1989 results.

Australian civil aviation administration is unique in its function as well as its relationship with other industries. The Civil Aviation Authority of Australia (CAA), which was established in July 1988, is a fully-fledged "government business enterprise" and is closely linked with Australian aviation industries. The objective of the CAA is to enable more people to benefit from a safe air transportation system.

To support safe aviation operations, the CAA provides the aviation industry with operational facilities and services. The industries, in return, provide the CAA with financial resources through user fees. Although the federal government also pays the CAA to support its safety service, the CAA's revenue primarily comes from the aviation industries; of a total revenue amounting to nearly $556 million (Australian) in 1990, the government paid almost $75 million (Australian). Any cost-effective measures taken by the CAA to increase aviation activities, lower operational costs, reduce flight delays and improve flight crew proficiency obviously also benefits the authority.

Table 1
Summary of Australian Accident Data 1986 to July 1990

	1986	1987	1988	1989	1990	Avg 86-89
Total accidents	211	233	254	265	152	240.75
Fatal accidents	19	19	29	27	15	23.5
Fatalities	43	31	61	63	33	49.5
Hours flown (000)	2,077.9	2,159.9	2,369.0	2403.2	1,465.12*	
Accidents/100,000 hours	10.15	10.79	10.72	11.03	10.37*	10.68
Fatal accidents/100,000 hours	0.91	0.88	1.22	1.15	1.02*	1.04

(Excludes gliding and other sports aviation. Estimates [*] are based on three-year rolling average over four years 1986-89)
Source: CAA

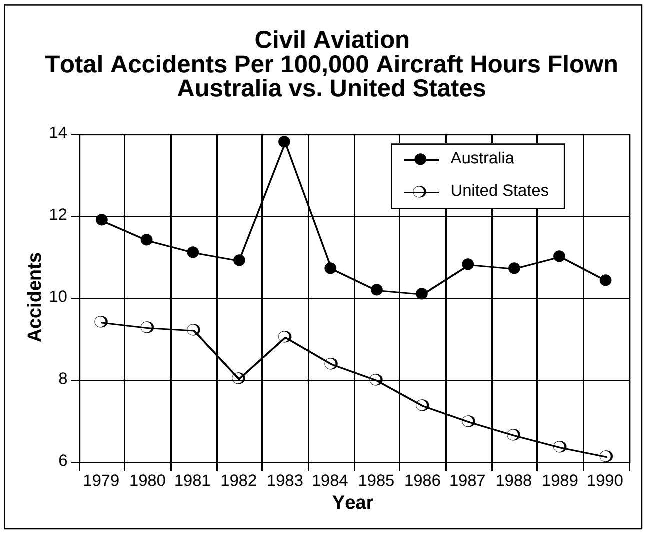

Figure 1

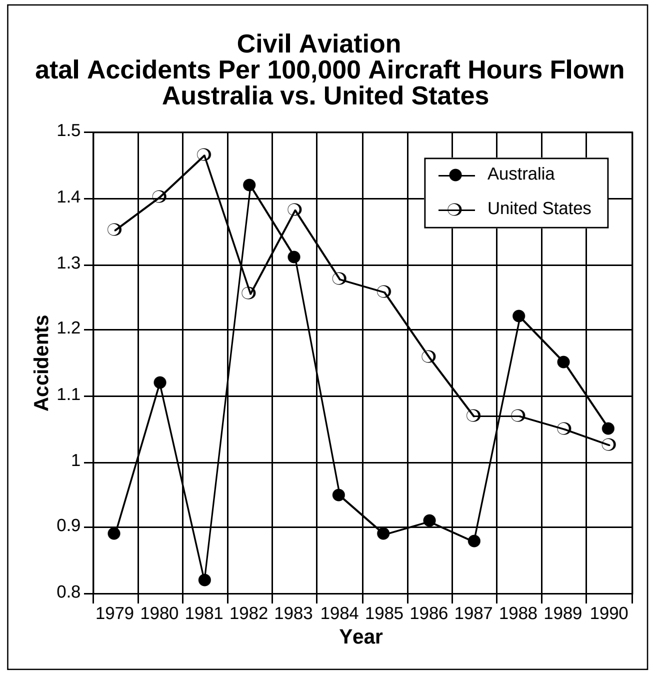

Figure 2

In exercising its responsibility for safety regulation of Australian-registered aircraft, one of the CAA's major tasks is the granting and issuing of airman licenses and associated ratings, as well as the regulation of operational safety.

During the past five years, Australian civil aircraft were involved in an average of 240 accidents a year, approximately 23 of which were fatal, accounting for nearly 50 fatalities. CAA safety performance indicators for fatal and reportable accidents are shown in Table 1.

Based on a three-year rolling average, a four-year period is covered from 1986 to 1989. The comparison of Australian and U.S. total accident rates and fatal accidents for the period 1979-1990 is presented in Figures 1 and 2. During the past 12 years, the total annual number of Australian civil aviation accidents declined, while fatal accident rates fluctuated greatly, with an obvious upward trend. ♦

Reports Received at FSF
Jerry Lederer Aviation Safety Library

Reference

Federal Aviation Administration (U.S.) Updated Advisory Circulars:

Number(s)	Mo/Da/Yr	Subject
140-2T	Oct 1991	List of Certificated Pilot Schools
147-2Z	Oct 1991	Directory of FAA Certificated Aviation Maintenance Technician Schools
183-35C	Sep 1991	FAA DAR, DAS, DOA, and SFAR Part 36 Directory
150/5320-15	Feb 1991	Management of Airport Industrial Waste (cancels AC 150/5320-10)

150/5340-1F	Aug 1991	Change 1 to Marking of Paved Areas on Airports
150/5340-18C	Jul 1991	Standards for Airport Sign Systems

National Transportation Safety Board (U.S.) Safety Recommendations:

Number(s)	Mo/Da/Yr	Subject
A-91-27/31	06/12/91	Eastern Airlines Boeing 727 and Epps Air Service Beechcraft King Air A100 collision, Atlanta, Georgia, U.S., January 18, 1990
A-91-33/36	06/24/91	Avianca Airlines Boeing 707 crash, Long Island, New York, U.S., January 25, 1990
A-91-37/38	06/24/91	Avianca Airlines Boeing 707 crash, Long Island, New York, U.S., January 25, 1990
A-91-39	05/31/91	Northwest Airlines Boeing 727 and Northwest Airlines McDonnell Douglas DC-9 collision, Detroit, Michigan, U.S., December 3, 1990
A-91-40/41	05/05/91	Designated Pilot Examiner quality assurance programs and national data base
A-91-42/44	06/11/91	Ryan International Airlines Boeing 727 rejected takeoff, Hartford, Connecticut, U.S., May 3, 1991 Pratt & Whitney JT8D engine disk corrosion
A-91-45/48	07/03/91	Lauda Airlines Boeing 767 crash, near Bangkok, Thailand, May 26, 1991
A-91-49/51	07/12/91	ERA Helicopters Inc. Aerospatiale AS-355-1 crash, Gulf of Mexico, November 4, 1988
A-91-52	07/19/91	Floor proximity emergency escape path marking systems on passenger safety briefing cards

Transport Accident Investigation Commission (New Zealand) Safety Recommendations:

Number(s)	Mo/Da/Yr	Subject
001-004/91	03/06/91	Cessna 421 ZK-WLG at Auckland Aerodrome, January 11, 1991 (Airport markings)
005-010/91	04/10/91	Hughes 369 ZK-HXA at Fox Glacier, May 2, 1989 (helicopter operators conducting scenic air transport operations)
011-015/91	04/08/91	DHC6 5W-FAU at Pango Pango, American Samoa, March 22, 1991 (training procedures for security personnel, airport lighting)
016-021/91	04/23/91	Robinson R22 ZK-HDD at Cape Brett, February 21, 1991 (inspection of flexible star plate, start switch)
022-025/91	05/09/91	Fletcher FU24-950M ZK-BIX near Waimanga, December 11, 1990 (ailerons jamming)
026/91	06/24/91	Robinson R22 ZK-HDC near Whangarei, January 4, 1991 (hazards of inducing a low "g" flight condition in helicopters)

Reports

Flight Service Specialist Initial Qualifications Course: Content Validation of FAA Academy Course 50232. Final Report / Dana Broach (Civil Aeromedical Institute). — Washington, D.C. : United States. Federal Aviation Administration Office of Aviation Medicine; Springfield, Virginia, U.S. : Available through NTIS*, April, 1991. Report DOT/FAA/AM-91/4. 20 p.

Key Words

1. Air Traffic Controllers — Training — United States.
2. Air Traffic Control — Study and Teaching — United States.
3. Flight Service Specialists — Training — United States.

Summary: This study evaluates the content validity of the Initial Qualifications Course provided to flight service specialists (FSS) by the FAA Academy. The purpose of FSS Initial Qualifications Course (FAA Academy course 50232) is to predict the student's probability of attaining certification as a full performance level controller in field facilities. Three job functions are taught in the FSS Initial Qualifications Course: (a) flight plan processing; (b) orienting lost aircraft; and (c) weather analysis. Overall, eight of the ten graded components of FAA Academy course 50232 appeared to adequately sample the knowledge and task domains associated with these three FSS job functions. [Modified author abstract]

International Aviation: Implications of Ratifying Montreal Aviation Protocol No. 3. Report to the Chairman, Committee on Foreign Relations, U.S. Senate / United States. General Accounting Office. — Washington, D.C. : U.S. General Accounting Office**, December, 1990. Report GAO/RCED-91-45; B-241737. 18 p.

Key Words
1. Liability in Aircraft Accidents — United States.
2. Damages — United States.
3. Compensation (Law) — United States.

Summary: GAO examined how Protocol No. 3 and its companion supplemental compensation plan would work in the United States liability system under three scenarios: if the Protocol were adopted, if the Protocol were rejected and current international agreements remained in effect, or if no international agreements existed. Overall, American victims of international aviation accidents and their families would be better compensated under Protocol No. 3 and the proposed supplemental compensation plan than they would be if the current international agreements remained in effect or if no international agreements existed. Among the reasons: timeliness of compensation would be increased by eliminating the need to prove the airline was at fault; claimant's cost would be reduced because most cases would be settled without a trial; level of compensation would increase by significantly raising the airlines' liability limit. Implementation of Protocol No. 3 is not likely to jeopardize airline safety. Adverse economic impacts due to aviation accidents and government safety regulations — not fear of litigation — are the primary incentives for airlines to operate safely. [Modified Results in brief]

Job Task-Competency Linkages for FAA First-Level Supervisors. Final Report / Jennifer G. Myers and Thomas M. Stutzman (Civil Aeromedical Institute). — Washington, D.C. : United States. Federal Aviation Administration Office of Aviation Medicine; Springfield, Virginia, U.S. : Available through NTIS*, April, 1991. Report DOT/FAA/AM-91/5. 49 p. in various pagings; charts, ill.

Key Words
1. United States — Federal Aviation Administration — Officials and Employees — Appointment, Qualifications, Tenure, etc.

Summary: A study was conducted to determine the linkages between the job tasks and competencies of first level supervisors in the FAA. A sample was drawn from each of nine job groups: Flight Service, Terminal, En Route, Regional Office/Headquarters, Air Traffic, Aircraft Certification, Security, Airway Facilities, Flight Standards, and Other. Of the 2,412 first-level supervisors surveyed, 853 responses were usable. Statistically significant differences were found between job groups on the time spent, importance, and competencies variables. Considering statistical and practical significance of the results, it was concluded that the task make-up of the job varies among the job groups but that the competencies required for the different jobs are quite similar. [Modified author abstract]

Selection of Air Traffic Controllers for Automated Systems: Applications from Current Research. Final Report / Pamela S. Della Rocco (Civil Aeromedical Institute), Carol A. Manning (Civil Aeromedical Institute), Hilda Wing (Federal Aviation Administration). — Washington, D.C. : United States. Federal Aviation Administration Office of Aviation Medicine; Springfield, Virginia, U.S. : Available through NTIS*, November, 1990. Report DOT/FAA/AM-90/13. 38 p.

Includes bibliographical references.

Key Words
1. Air Traffic Controllers — Selection and Appointment — United States.
2. Air Traffic Control — Automation — United States.
3. United States Federal Aviation Administration — Officials and Employees — Appointment, Qualifications, Tenure, etc.

Summary: The Federal Aviation Administration's future plan for new automated systems will change the air traffic control specialist's (ATCS) job as many of the current controller's tasks become automated. The purpose of this paper was to review the findings from current research on selection of ATCS's that may guide the design of selection systems for future controllers. A study completed in 1987 estimated that 48 of 337 job tasks of the enroute controller would be substantially changed with implementation of the new system. Evaluation of the changes projected in the job over the next two decades suggested that a selection system similar to the current performance-based system could maintain utility through implementation of the new system. However, implementation of the more advanced automation may significantly change the cognitive skills and abilities required for successful performance. Thus, work toward selection for the advanced automated environment should begin immediately. [Modified author abstract]

Aircraft Accident Report: Runway Collision of Eastern Airlines Boeing 727, Flight 111 and Epps Air Service Beechcraft King Air A100, Atlanta Hartsfield International Airport, Atlanta, Georgia, U.S., January 18, 1990/United States. National Transportation Safety Board. — Washington, D.C., U.S. : U.S. National Transportation Safety Board; Springfield, Virginia, U.S. : Available through NTIS*, Adopted May 29, 1991, Notation: 5458. Report NTSB/AAR-91/03; NTIS PB 91-910403. v, 95 p.

Key Words
1. Aeronautics — Accidents — 1990.
2. Aeronautics — Accidents — Air Traffic Control Procedures.
3. Aeronautics — Accidents — Airplane Lighting.
4. Aeronautics — Accidents — Runway Incursions.
5. Eastern Airlines — Accidents — 1990.
6. Epps Air Service — Accidents — 1990.

Summary: On January 18, 1990, about 1904 hours, an Eastern Airlines Boeing 727, Flight 111, while landing on the runway in night visual conditions, collided with an Epps Air Service Beechcraft King Air A100, N44UE, at the William B. Hartsfield International Airport, Atlanta, Georgia. The King Air had been cleared to land on runway 26 right immediately ahead of the Eastern flight and was on its landing roll. It was struck from behind by the Boeing 727, which had also been cleared to land on runway 26 right. The Boeing 727 sustained substantial damage, but none of the 149 passengers or 8 crewmembers on board were injured. The King Air was destroyed as a result of the collision. The pilot of the King Air sustained fatal injuries, and the copilot, the only other occupant, sustained severe injuries. The NTSB determines that the probable causes of this accident were human factors in air traffic control and air traffic controller procedures and compliance with requirements for final approach separation and clearance to land. Other safety issues raised in the report include (1) conspicuity of airplane lighting, (2) limitations of the "see and avoid" principle in the night landing, final approach environment, and (3) effectiveness of airport surface detection equipment. As a result of this investigation, the safety board made five recommendations (A-

91-27 through A-91-31) to the FAA intended to prevent runway incursion accidents. [Modified Executive Summary]

Book

Airport Regulation, Law, and Public Policy : the Management and Growth of Infrastructure / Robert M. Hardaway ; with contributions by James Spensley ... [et al.]. — New York : Quorum Books, 1991. xv, 248 p. : ill. ; 25 cm.

ISBN: 0899304745.

Key Words
1. Airports — Law and Legislation — United States.

Includes bibliographical references (p. [237]-239) and index.

Contents: Preface — Introduction — History of Airport Regulation — The Power to Regulate — Airport Planning — Airport Financing — Operations and Certification — Noise Regulation — Airport Security — First Amendment Freedoms — Civil Rights — Economics of Airport Regulation — Antitrust — Conclusions — Select Bibliography — Index.

Summary: Beginning with a review of airport regulations from 1903 onward, the author examines aspects of regulatory power, including federal and local authority, local proprietorship, and citizens' concerns. Chapters on airport planning, financing and operation are included. The question of civil rights in employment and marketplace competition is also considered. Other topics addressed include noise regulation; responses to the terrorist threat; the airport as a public forum for free speech and the exercise of religion; the economics of regulation; and the impact of anti-trust legislation. [Modified overleaf abstract]

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Accident/Incident Briefs

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

Descended Below Clearance Altitude

Douglas DC-3: No damage. No injuries.

The aircraft was approaching to land in the Northwest Territories, Canada, on a spring evening. Weather was reported as a scattered base at 1,500 feet, overcast at 6,000 feet, light snow and winds from 010 degrees at 15 knots, gusting to 25 knots. The aircraft was flying under instrument flight rules (IFR) with a crew of three and 21 passengers.

The pilot was cleared to descend and maintain 3,500 feet above sea level (asl) by air traffic control (ATC) and was given the option of either proceeding direct to the nondirectional beacon (NDB) for a full instrument landing system (ILS) approach or of flying to the NDB via the 12-mile distance measuring equipment (DME) arc from his present position. The pilot chose the latter.

The controller told the pilot to hold south on the localizer upon reaching the NDB, and was given an expected approach time. The controller did not restate the cleared altitude when the clearance was issued; the controller's manual did not require it. The pilot acknowledged the holding clearance but did not read it back, which was required.

Nine minutes later, the pilot reported at 1,900 feet, the minimum en route altitude from the DME arc transition. The controller then advised the pilot that his last assigned altitude had been 3,500 feet. The pilot acknowledged the proper altitude, climbed to 3,500 feet and reported level. The aircraft continued the approach and landed without further incident.

Had the pilot been *cleared* for an approach for runway 33, a descent to 1,900 feet would have been permitted. The pilot, however, was instructed only to *plan* for an approach for runway 33. The clearance to the NDB and the subsequent holding clearance required the pilot to maintain 3,500 feet until he received the approach clearance or until he was assigned a new altitude. An occurrence report stated that the pilot descended to the minimum en route altitude because he assumed he had approach clearance.

Hurried Departure Goes Nowhere

Boeing 757: Minor damage. No injuries.

The aircraft was being prepared for departure on a regular passenger flight scheduled to leave at 1500 hours. During the loading of baggage and cargo, the forward freight hold had received minor damage from contact by a luggage conveyor, and the airside police had informed the air carrier that they wished to inspect the damage before the aircraft was released to meet an actual departure time of 1519.

The captain was informed of the damage when the flight crew boarded the aircraft at approximately 1440 and was advised that the airport police would inspect it prior to departure. Late boarding of the passengers was completed at 1505 and two airport police officers entered the flight deck at 1510 to report to the captain that the inspection had been accomplished. The officers left the aircraft but, unknown to the flight crew, the dispatcher was still on board the aircraft checking on the location of the police officers.

With the departure time of 1519 approaching, the crew requested engine start clearance at 1511 and air traffic control advised them to expedite the departure or to expect a lengthy delay. Pushback clearance was obtained at 1512 and the ground technician reported that everything was clear and the pushback was commenced. As soon as the pushback began, a scraping sound was heard from the left side of the aircraft and the pushback was halted.

It was discovered that the left front entrance door had been left open and that the boarding pier had not been retracted. Damage was sustained by the aircraft door trim and seals and by the boarding pier side curtain and leveler. The aircraft was removed from service for repair and the passengers were disembarked.

Air Taxi Commuter

Frequency Confusion Leads to Collision With Mountain

Cessna 421: Aircraft destroyed. Fatal injuries to three.

The aircraft was inbound at night for an instrument landing system (ILS) approach in instrument meteorological conditions (IMC). While turning inbound, the aircraft collided with a mountain 12 nautical miles (nm) northeast of the airport. The aircraft was destroyed and the two pilots and one passenger were killed.

One of the aircraft's very high frequency omnidirectional radio range (VOR) receivers was set to the destination ILS frequency, while the second was set to an en route VOR 51 nm west of the destination. The en route and destination VOR frequencies were 117.1 and 117.7, respectively. The control head for the second VOR receiver was located in the lower right portion of the instrument panel and was difficult to read. The distance measuring equipment (DME) was set to the destination frequency.

The outbound course for the destination ILS was 088 degrees, the same as the radial of the en route VOR that the accident occurred on. The experienced pilot was not current in this aircraft.

Incomplete Training Leads to Fatal Encounter

Cessna 208 Caravan I: Aircraft destroyed. Fatal injuries to one.

The aircraft was in cruise at 11,000 feet mean sea level (msl) slightly after 0400 hours local time. The pilot reported encountering severe turbulence and stated that her altitude varied by as much as 2,000 feet. The pilot's last communication was that she was returning to her departure airport. Radio and radar contact were then lost.

The wreckage of the aircraft was found scattered over an area of 300 feet near the airport. The pilot had been killed.

Another pilot that evening had reported one large thunderstorm cell area of red (intense) returns on the aircraft weather radar. The recently hired pilot of the crashed aircraft had completed the operator's ground and flight training program in the aircraft. The training, however, did not require the pilot to demonstrate proficiency in unusual attitude recoveries or to have knowledge in the operation of the aircraft's weather radar.

Causal factors included inadequate training, use of radar not understood, disorientation, fatigue and flight continued into adverse weather.

Corporate Executive

Lack of Practice Leads to Repairs

Beech B55 Baron: Substantial damage. No injuries.

The pilot was en route to a business meeting. During the initial climb after takeoff, and after retracting the landing gear, he noticed that his speed was slower than normal. The pilot also noticed that a red warning light was illuminated, indicating that the landing gear was not fully retracted. He attempted unsuccessfully to lower the landing gear, and then called a flight service station (FSS) to report that he was returning to his point of departure.

The pilot engaged the autopilot, disengaged the landing gear motor and attempted to lower the gear manually, using the handcrank. After turning the crank in both directions and still not getting an indication that the gear was down and locked, he cancelled his landing request and made another attempt to lower the landing gear using the landing gear retraction motor. After a fly-by for verification from a FSS employee that the gear still was not down and locked, the pilot performed a gear-up landing. The aircraft slid for 500 feet before stopping on the runway. The aircraft was substantially damaged, but the pilot was not injured.

The accident report stated that there were two causal factors involved. The first was that the brushes of the electric landing gear motor, which were supposed to have been replaced during the last inspection, had probably been reinstalled improperly and led to failure of the system. The report's second finding was that the pilot, although checked out in the aircraft, had not been able to operate the emergency gear mechanism correctly. An inspection of the gear system after the accident revealed that the manual emergency landing gear extension mechanism functioned normally.

Medical Flight Flew Too Low

Beechcraft King Air A-100: Aircraft Destroyed. Fatal injuries to four.

The aircraft was on a medical evacuation (Medevac) flight to pick up a seriously injured person. The evening flight took place after 2230 hours. The cloud base varied between 700 and 1,200 feet above the ground (agl), and snow showers were spread across the region and had been in the area for the past hour. There were two crew members and two medical personnel on board.

The aircraft overflew the airport where it was to pick up the patient and headed toward the local nondirectional beacon (NDB). The aircraft descended below the minimum applicable altitude while approaching the NDB and crashed 1.5 miles southeast of the airport. The terrain elevation at the accident site was 1,590 feet above sea level (asl). The aircraft was destroyed, and the pilots and medical personnel aboard were killed on impact.

Other General Aviation

Formation Flying Blind

Oldfield Baby Great Lakes: Extensive damage. No injuries.

Oldfield Baby Great Lakes: Moderate damage. No injuries.

The two sport biplanes took off independently from the same airfield and joined in a loose formation on a recreational cross-country flight. Separation between the aircraft was approximately 300 feet. At the start of the second leg of the trip, which was over less familiar terrain, both pilots began referring to their charts to navigate. The pilot of the second aircraft looked up from his chart and saw the lead aircraft approximately 10 feet away at the same height and closing fast.

The pilot of the second aircraft pushed his control stick forward but was not quick enough. The two aircraft collided. The second aircraft entered a spin from which the pilot recovered. When he landed the aircraft in a nearby field, the left landing gear leg snapped in the soft soil and the plane cartwheeled, coming to rest inverted. The pilot was uninjured in the landing, but cut his wrist getting out of the aircraft. The pilot still in the air returned to the departure airport and landed without further incident.

The aircraft that was forced to land in the field had the rudder and one elevator destroyed in the air in addition to extensive damage to the wings, fin and fuselage during the forced landing. The other aircraft received damage to the leading edges of both starboard wings, the underside of the starboard lower wing and the fuselage. Other than the cut wrist received by the pilot who force-landed, there were no injuries.

Out of Fuel Leads to Out of Control

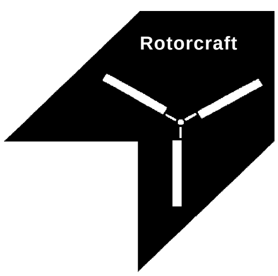
Cessna F150F: Aircraft destroyed. Fatal injuries to two.

The aircraft had taken off at 1250 hours in visual meteorological conditions (VMC) with fuel tanks half full (approximately 12 gallons). The pilot had attempted to refuel but was unable to do so because the airport's lone fuel pump was locked. The pilot originally planned a long-distance navigation flight but said he would change his plans when he found he could not fuel the aircraft.

The pilot, with a passenger, took off and flew a series of navigation exercises until 1359 when air traffic control (ATC) advised him of an approaching weather pattern. The aircraft was returning to the airport at 1440 when the pilot made a Mayday call and reported to ATC that he was low on fuel and "seemed" to have an inaccurate fuel gauge. The controller asked the aircraft to squawk 7700 but the Cessna was not transponder-equipped. The last transmission from the aircraft was at 1441:30. The message was unintelligible other than the callsign.

Several people on the ground saw the aircraft crash. The nose rose steeply, the left wing dropped and the aircraft nosed into the ground. Flames filled the cabin area after impact. The aircraft was destroyed, and the two occupants sustained fatal injuries.

The accident report stated that the aircraft, because of its attitude when it hit the ground and the lack of ground track indications, was probably in a partially or fully developed spin when it collided with the ground. The flying controls were examined in detail and were considered to be serviceable at the time of the impact, according to the report. The pilot had a total of 116 hours of which 31 were in this type of aircraft.



Loose Tarpaulin Becomes Wet Blanket

Bell 204: Substantial damage. No injuries.

The aircraft was to pick up survey crews. Construction of the landing area from which the flight would depart had not been completed.

There were no buildings to store the construction equipment, so it was placed in boxes on the ground and covered with plastic tarpaulins to protect the contents from the elements. Fuel drums were also placed along the edge of the landing area. Earlier on the day of the accident, a tent had been delivered in which to store the equipment.

The pilot lifted off in the helicopter and was hovering at about five feet above ground level (agl) when a plastic tarpaulin that had been left loose on the site was picked up by the rotor wash and contacted the tail rotor. The tail rotor shaft failed and directional control was lost. The helicopter rotated 90 degrees before the pilot could land it. The occupants all exited the aircraft without injury, but the helicopter sustained substantial damage.

According to the report, the pilot did not ensure that the takeoff area was suitable and clear of obstacles for takeoff.

Protruding Pipe Puts Helicopter Down

Aerospatiale AS 355 Twinstar: Substantial damage. No injuries.

The pilot made a practice landing approach to an abandoned concrete building foundation. While hovering after the landing, he executed a 90-degree, right-pedal turn and the tail rotor struck a reinforcing bar that protruded 18 inches out of the concrete. The aircraft spun 90 degrees when anti-torque control was lost, and the helicopter landed hard. The aircraft sustained substantial damage, but the pilot was not injured.

Cause factors included selection of unsuitable terrain for landing, inadequate lookout and poor flight crew decisions. ♦