The Practice of Aviation Safety

Observations from Flight Safety Foundation Safety Audits

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Foreword

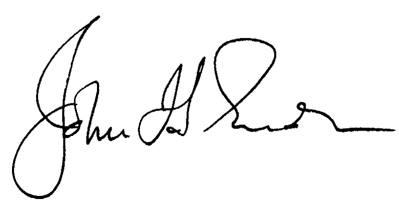
Flight Safety Foundation has conducted safety audits of its member organizations for more than 30 years. These audits, conducted by request, are client confidential and the reports are the property of the clients.

The Practice of Aviation Safety shares, in a nonattributive manner, some of the Foundation's accumulated audit experience acquired from 60 audits conducted worldwide during the past decade, from small corporate aviation operations to large international air carriers. The dimensions of both internal self-audits and external independent audits, including general guidelines for conducting them, are also addressed.

Although the audits revealed a satisfactory overall standard of safety, individual procedures or practices were sometimes observed to be below industry-wide norms. The process of identifying and correcting these unsatisfactory situations constitutes the on-going refinement of operational safety that has contributed to the high overall safety levels that the air traveller enjoys today.

It is the aim of this document, prepared by staff and audit team members, to provide operators with a perspective on how safety is or is not achieved; the recommendations and observations may be useful in self-examination of their own operations.

The Practice of Aviation Safety, funded by our sustaining members, is another resource through which the Foundation exerts a positive influence on aviation safety through the sharing of the experiences of its worldwide membership.



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Safety Audits and Operator Goals

Safety Audit Defined

The dictionary definition of an audit is a "… formal examination of an organization's or an individual's financial situation." By usage, this term has expanded well beyond the financial aspect and includes a formal examination of many aspects of an operation, including its safety practices. The words "review" and "evaluation" have been used by some who prefer to avoid the term "audit."

Regardless of the terminology given to the process, an aviation safety audit is a procedure whereby designated and qualified persons systematically and objectively look at the activities of an aviation organization in the context of that organization's own operating plans as well as in relation to industry practices and and applicable government regulations. Observations and findings, together with any recommendations, are then reported to the organization's management for their consideration and action.

"Operation" comprises the totality of the flight operation: management, operation of flights; training; crew fitness for duty; maintenance and engineering; design and procedures; ramp servicing; ground safety; and security.

A safety audit may sometimes be perceived as having negative overtones (e.g. criticism or punishment), but it is more commonly recognized as providing valuable information for management to act upon in the interests of improved safety.

The purpose of any safety audit is to assist the organization's personnel to carry out their duties and responsibilities more effectively and efficiently. An aviation safety audit may cover specific departments, divisions, stations, etc., or may, more comprehensively, cover all activities of the aviation organization, focusing on the safety aspects in each area.

Management will often employ an outside management consultant group to advise on organizational restructuring and adjustments to staffing in order to achieve desired operating efficiencies. Such examinations are often referred to as audits, and depend heavily upon quantifiable factors or measures of a company's operations, e.g., financial, production, work unit efficiencies, product rejects, etc. Safety audits as envisioned in this document, do not include this management function.

There are two types of safety audits:

- Internal self-audits are conducted by designated personnel within the company, but they are not a formal auditing group. Usually these people are not a part of the unit being audited, so that they can be more objective. These internal audits provide the normal ongoing surveillance which should be conducted within each unit.

- External independent audits are conducted by the company's formal audit group, or outside auditor(s), to confirm the effectiveness of the unit's internal audit process and that corrective action(s) have been taken.

Safety can be measured to a certain extent, but it does not usually have the benefit of quantifiable measures. It is a largely non-quantifiable process, dependent upon subjective human actions and responses, as well as individual skills in interpersonal relationships. Effectiveness of communication (both in assimilating information as well as in disseminating it), and the overall administration and direction of these attributes are paramount in achieving the greatest margins of safety.

A safety audit depends extensively upon the skills and competence of the audit team in properly observing individual actions and interactions with others, and on personal interviews of individuals across the entire organizational spectrum. Just as manufacturers and operators of machines and equipment test their products to determine if they continue to meet their standards of quality and performance, a safety audit is an objective quality assurance check of people — how they perform in accordance with company policies, established standards or industry practices, as well as their use of equipment, facilities and human resources.

Operator Goals

It is essential that each operating organization involved in aviation identify its safety objectives and goals and establish the procedures by which it can measure how effectively that they are being met. Because safety has both immediate and long-term impacts on the efficiency and the economic aspects of any organization, the establishment and appropriate distribution of its objectives and goals should receive high priority from all levels of management.

In striving to achieve the greatest margins of operational safety, each operator needs to address these six basic questions:

- Do our policies, procedures and practices provide us with the safety and efficiency that we want?
- Are we doing what our manuals, procedures and standards say we will do?
- Are the existing manuals, procedures, and standards valid for the current and projected operations?
- Is the support provided by other departments, outside organizations and contractors contributing to the safety, efficiency and economy of our operations?
- Is the coordination and support of the overall safety program the best that it can be?
- How can we monitor the operation to assure continued adherence to the established policies, procedures and standards?

Many organizations have learned that a safety audit, conducted by an independent organization, provides objective answers to the first five questions, and can assist the operator in developing an ongoing program of surveillance and analysis to answer the last question.

Depending on the size and structure of the aviation organization, some of the answers to the six basic questions can also be obtained through internal audits conducted by experienced and qualified personnel. They must be able to separate their personal opinions of the audit subjects from the process. Such personnel must be permitted to objectively evaluate the operation and to report their observations and findings without jeopardizing their future with the company.

In reviewing some aviation departments' internal audit reports conducted by corporate-wide safety departments, FSF found that many of them reflected an industrial orientation and frequently lacked the expertise to effectively evaluate flight operations. The backgrounds of their audit personnel have not prepared them to analyze the particular problems and issues affecting aviation safety. Some organizations have successfully included a person from outside the company who is experienced in flight operations as a member of the corporation's internal audit team. This is one means of providing objective flight operations experience on the team to assure proper consideration of the flight operations activities in the overall safety evaluation.

A Typical Aviation Safety Audit

The auditor should obtain beforehand as much information as possible about a company's organization, personnel, equipment, facilities, training and any other data that will help determine the size and composition of the audit team that will be needed, and the length of time required to complete the on-site audit activities. The team members must be highly-qualified personnel with overall operational experience relevant to the client's aviation activities. The audit must be carefully planned so that the client's needs are met. Desired emphasis can be managed through choice of audit team members (flight operation, maintenance, etc.).

The client's current policies and procedures manuals for flight operations, maintenance, ground support, and cabin services (where applicable) should be reviewed in advance. One of the primary functions of an audit is to determine the effectiveness of compliance with the established policies and procedures in actual practice, as well as with applicable government regulations; it is essential that the audit team be familiar with the appropriate materials relating to each department. When it is impractical to have access to the manuals prior to the on-site visit, time must be planned and allocated at the onset of the audit to review the manuals on-site. The manuals constitute an essential reference throughout the audit.

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The key benefit provided by an audit team is the ability to review and analyze policies and procedures from an experienced objective viewpoint. This not only provides a firm base from which to evaluate each operation, but also ensures that the team recognizes and assimilates new or improved methods and procedures which are observed in the course of their work. Typically, each FSF audit provides new insights or ideas to the audit team members, which are then shared non-attributively with other operators through subsequent audits, publications, workshops, seminars and safety assistance programs.

One of the most important audit activities is to conduct personal and confidential interviews with employees at all levels within the organization. The approval and support of top management is essential to the success of these interviews and the audit. Management should prepare its organization for the audit by publicizing the planned presence of the audit team. All employees should be encouraged to speak honestly with team members. They must be assured that they are not being disloyal to the company when they discuss problems and issues as they perceive them.

Interviews provide insight into problems, issues or areas that may require investigation in greater depth. From these interviews it is also possible to evaluate the morale of various groups as it affects safety, the reasons behind the morale, and the attitudes of different groups of employees.

The audit team's activities and emphasis will vary to accommodate the needs of the organization being audited. However, as a minimum they should include:

- Review and evaluation of all manuals and published polices, procedures and practices.
- On-site inspections of facilities, equipment, working conditions, safety programs, operating procedures and practices, and supervision at the different levels.
- Evaluation of training facilities, curricula, programs and instructors' qualifications.
- Review of representative samples of individual training and proficiency files. (not personnel files, which FSF recommends should be kept separately and not part of the safety audit.)
- Inflight observations (not proficiency checks) of flight procedures and practices; review of operating standards; review of crew communication and coordination; and a comparison with company standards, procedures and applicable regulations.
- Review of policies, procedures and practices of the maintenance department and supporting units, on all work shifts, if applicable.
- Evaluation of safety equipment and industrial safety programs applicable to hangar(s), shop(s) and ramp(s).
- As the audit progresses, reviews of the auditor's own observations and findings should be conducted to determine if all areas are being covered; if there are some needing further consideration; or if new areas of concern have been identified.

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Upon completion of the on-site activities, the team should present a verbal report of their observations, findings and recommendations to the client. A written, client-confidential report, detailing the information presented at the oral exit briefing, is prepared as soon as possible so that the client can further evaluate the recommendations and assign action items.

A safety audit should encompass all aspects of operations, maintenance, equipment, facilities and personnel as they might influence operational safety. It normally includes review, observation and analysis of the following areas, as applicable:

1. Operational Policies and Implementation

- Operations records, manuals and related documents
- Normal and emergency operating procedures
- Dispatching and flight control
- Communications, equipment and procedures
- Navigation equipment and procedures
- Aircrew scheduling
- Application of cockpit resource management concepts
- Flight and ground crew training, and

competence-review for contract or in-house training as applicable

2. Safety Management

- Management's policies and practices relative to safety
- Organization for safety
- Management emphasis on safety
- Safety training
- Managerial/supervisory qualifications and training
- Personnel safety
- Employee morale

3. Flight Operations

- Communication:
  - o Management/line crew communication
  - o Memorandums and bulletins
  - o Incident or event reporting, procedures and follow-up
  - o Manual revision procedures
- Initial and recurrent training
- Dispatch or flight-following procedures
- Standardization and discipline
- Flight crew and maintenance personnel coordination

4. Observation and Evaluation of Typical Flights

- Preflight and post-flight procedures
  - o Dispatch policies and procedures
  - o Weather briefing facilities and procedures
  - o Inflight crew coordination, procedures and communication
  - o Flight path control
  - o Cabin safety and emergency procedures
  - o Passenger briefing
  - o Cabin attendant activities, if applicable
- Aircraft configuration:
  - o Cockpit safety equipment
  - o Cabin safety equipment
  - o Galleys and storage facilities
- Off-base or station:
  - o Security
  - o Passenger control
  - o Ground services
  - o Overall safety procedures and practices

5. Aircraft Maintenance

- Manuals, policies and procedures
- Aircraft maintenance and servicing
- Aircraft maintenance records
- Quality control
- Personnel training programs

6. Aircraft Support Equipment

- Emergency equipment
- Support equipment, procedures and practices

- Shop and stockroom tools and equipment
- Servicing

7. Airport, Hangar, Ramp and Facilities

- Runways, taxiways, ramps
- Lighting
- Obstructions and obstacle clearance
- Foreign object debris FOD control
- Crash, fire and rescue (CRF) facilities and procedures
- Security procedures and practices
- Handling and storage of flammables, oxygen, solvents, paints, etc.
- Qualifications and training of support personnel
- Observation and evaluation of ground service personnel's safety practices

8. Security

- Facilities, equipment and ramps
- Cargo/baggage control
- Aircraft and personnel security procedures

It is FSF practice for audit teams to present only their observations, findings and recommendations. We recognize that it is the prerogative and the responsibility of the client to evaluate the information presented and take whatever action is considered to be appropriate.

Lessons Learned from Safety Audits

Although it would be impossible to list all of the significant items observed during audits of the past decade, a review of de-identified summaries of reports submitted to each client disclosed that many comments fell into similar categories. A few situations, although uncommon, are significant enough to warrant inclusion.

Twelve categories cover most activities in which problems or solutions have been identified. These are:

- Organizational characteristics
- Policies and procedures
- Communication
- Morale issues
- Organizing safety activities
- Training
- Flight operations
- Cabin services
- Maintenance and engineering
- Inspection and quality control
- Ramp activities and ground operations
- Aircraft, facilities and equipment

The "experience pool" of ideas, procedures and practices have significantly contributed to the validity of audit team recommendations.

Organizational Characteristics

When auditing airlines and corporate flight departments, we have learned that occasionally the operation has outgrown the existing organizational structure. One which was valid for many years may no longer be effective for an expanded scope of operations.

As an example, at one major air carrier many individuals we interviewed had been retained in redundant positions following a series of mergers and acquisitions. No one was terminated, transferred or demoted, nor were the departments reorganized to effectively use the available talent and to manage the expanded operation. Compassionate management was inadvertently creating a chaotic situation in both the flight operations and maintenance departments. In flight operations, there were seven levels of management and supervision between the senior vice president of flight operations and the line pilots. There were no well-defined communication channels or assigned responsibilities for specific functions. Although FSF audits do not normally address such managerial aspects, in this instance the organizational structure was adversely affecting safety, due to confusion of authority and ineffective communication. A recommendation was submitted to redress the safety shortcomings through an organizational evaluation.

Management's Impact on Employee Effectiveness

Some management personnel fail to realize how corporate policies, procedures or practices can create potentially unsafe situations or that their personal actions might contribute to an accident. We also found that many organizations do not recognize what impact their managerial and supervisory employees' actions can have on the achieved margins of safety.

For example, the manager of a corporate aviation department was explaining how every member of the department was important to the safety program. He interrupted his description to announce over the hangar speaker that a certain executive would be arriving in three minutes. A minute later we saw a mechanic standing by a boundary gate in drizzling rain waiting to open it so that the executive could be driven directly to the aircraft. The expected three minutes became 15, but the mechanic continued to stand there until the limousine arrived, the executive boarded and the driver drove back out.

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The mechanic was outside for 22 minutes in inclement weather. We could only assume that he would not immediately return to the same level of mental concentration and technical skill as before his regular tasks were interrupted. Later that day, it was determined that the mechanic had been on a hardstand replacing component seals in an aircraft engine when he was called to open the gate. The manager apparently did not view this interruption of a highly-technical task as having any effect on the department's practice of safety.

Deficiencies in adhering to organizational structures and chain-of-command have been found to occur at all levels, from top executives to below middle management. In some corporate aviation operations, there is a tendency for some top executives to bypass the chain-of-command and deal directly with individual members of the department.

In one instance, we learned that the chief executive officer's (CEO) personally preferred pilot did not use the established standard operating procedures. This pilot did not understand why he needed to follow the procedures since "his boss" did not object. Neither did the pilot recognize that he was a negative influence, not only in promoting company standards, but also in maintaining good morale within the flight operations department.

The CEO was unaware that he was personally contributing to a lower margin of operational safety by his favoritism and his tacit acceptance of non-standard operating procedures.

In several examples of audited airlines, department heads or middle-managers have been observed circumventing the first level supervisor. Bypassing the chain-of-command causes confusion and frequently disrupts planned activities or work in progress. This practice undermines the entire purpose of operating policies and procedures. As a result, operations are exposed to greater opportunity for error or omission.

One extreme example was observed during an audit of a small airline where the president consistently injected himself into situations involving the line maintenance personnel, and in some instances, even changed the instructions or work projects previously issued by the assigned supervisor.

Inter-department Working Relationships

The personnel of some corporate operations and small airlines tend to become isolated from other industry activities. A chief pilot or a maintenance manager may attend a few industry seminars and conferences, but the exposure of other personnel to new developments and other operators' experiences is often less than adequate. Rotating the assignments to attend training and safety seminars, followed promptly by having the attendees conduct in-house reviews or discussions of the seminar subjects, would provide greater benefits in transferring industry experience to the group.

During the last decade we have seen a definite change in the basic attitudes toward maintenance personnel. In many aviation organizations the "mechanic" concept has changed to that of a "maintenance technician." The level of education and specialized training required to service and maintain the more complex aircraft, engines and components has also raised the perceived status of maintenance personnel. Our auditors have consistently referred to personnel as maintenance technicians or avionic technicians rather than mechanics or radio mechanics. We recognize that these personnel are key members of the organization and are as important to achieving the margins of safety as are the pilots who fly the aircraft.

The change in professional status of technicians is further reflected in the relationships between pilots and technicians. In the past, it was quite common for pilots to think of the mechanic as merely "the guy with the dirty hands and the white socks." Similarly, many mechanics perceived the pilot as "a prima donna with leather jacket and white silk scarf." Working relationships were often strained and even adversarial. We seldom see such extreme relationships anymore, but wide variations in attitude between these groups continue to be discovered during audits.

Audits have confirmed that organizations which have deliberately fostered an attitude of mutual respect between various categories of employees enjoy a higher level of morale, and a positive correlation between such factors as operational reliability and maintenance standards. Although it is difficult to define specific actions that are most effective in promoting good working relationships, anything which encourages interaction between groups, such as pilots and technicians, is beneficial in increasing operational and maintenance reliability.

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A key point is to keep different working groups interacting with each other. In smaller organizations, combining groups (e.g., pilots and maintenance personnel) for training sessions and/or periodic meetings has been effective in preventing small disagreements from becoming major points of contention. Social activities in which pilots and technicians participate together often further fosters positive interaction.

In large organizations, it is more difficult to combine functions, such as training meetings or social activities. Procedures which require a face-to-face interchange during working activities, rather than just allowing an inanimate piece of paper to exchange data, have been effective in breaking down barriers. Where group size precludes combined meetings or training sessions, assignment of a few key individuals to participate on a rotating basis in each other's meetings can be effective in promoting cooperation.

We have observed situations where one aggressive and opinionated individual has set the tone for the relationship between different departments, usually to the disadvantage of both. In most instances, calling the situations to the attention of responsible managers were sufficient to instigate prompt corrective actions.

Supervision and Delegation of Authority

Finding qualified personnel for promotion to supervisory and management positions was found to be a nearly-universal problem. We also learned that many companies do not make the best use of their available resources by providing evaluation and training opportunities to future management candidates; responsibilities should be delegated to them when it is appropriate.

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Opportunities for training and evaluation exist when the regular manager is to be absent for a planned interval. Many operators simply leave the job undone in the absence of the regular manager, or tell a senior individual to "watch the store while I'm gone," without officially delegating the authority and responsibility to act in his or her absence.

Many reports have included a recommendation to incorporate a program of formal delegation of responsibilities and the authority to act during every absence of a supervisor or manager. Such a program gives both employee and company an opportunity to evaluate each other and to consider a possible promotion without making a long-term commitment.

Policies and Procedures

Established policies and procedures are the basic guidelines for any organization. Without specific policies it is impossible to develop the required procedures for ensuring that operations are producing the desired results. After the policies have been established, and the operational procedures are spelled out in the various operational manuals, it is necessary to establish methods for ensuring that the policies and procedures are being complied with in actual practice. It is equally important that policies and procedures be reviewed. Ongoing surveillance and periodic audits of the organization will determine the effectiveness of the procedures and practices .

Manuals

Manuals are the documents that set forth the priorities and goals of the organization, and state the methods to be used by the various units in supporting them. Manuals provide written statements of the organization's policies and procedures which it expects its employees to comply with. They also provide the standards to which the actual practices can be compared. In conducting a safety audit, it is essential that each auditor become familiar with the organization's policies and procedures as set forth in manuals and other documents, before attempting to evaluate and analyze the situations and practices. A well-organized, unambiguous and comprehensive manual that is understood and accepted by the organization's personnel not only minimizes the likelihood of mistakes due to lack of guidance, but also provides protection to the organization in the event it is ever involved in litigation resulting from some operational event.

FSF audit teams have reviewed manuals ranging in quality from excellent to useless. We have also noted a general improvement in the material contained in flight operations, maintenance and cabin service manuals of all operations. In particular, we have noted a substantial improvement in manuals used by corporate aviation departments.

In reviewing policy and procedure manuals, we have learned that a common fault is being too dependent upon the performance of a specific individual, rather than being "system oriented." Procedures should always be developed, written and implemented in such a manner that the effected unit functions regardless of the presence or absence of any individual. This system orientation is critical to maintaining adequate safety margins.

The actual wording or style of various manuals has also been a factor in their effectiveness. Some manuals have been vague and ambiguous, and often use terminology such as "the pilot should" or "the mechanic should." This type of manual leaves doubt, and presents opportunity for error or omission in what might be critical functions. FSF audit reports have encouraged some operators to develop and publish procedures which simply state "who does what." One air carrier's manuals were found to be extensive and excessive. It was as if each segment of the organization had written its portion without regard to others. Overlapping procedures had not been coordinated and there were conflicts and omissions between various operating departments.

Procedures should always be developed, written and implemented in such a manner that the effected unit functions regardless of the presence or absence of any individual.

One of the more serious deficiencies, for example, was uncovered during the review of an air carrier's pilot and cabin crew emergency evacuation procedures. The pilot operations manual and the cabin crew operations manual had been written by separate offices and had not been adequately coordinated. After comparing the two manuals, we discovered a conflict in duties. An emergency might have resulted in a failure to perform certain critical steps of an evacuation. Since the actual emergency procedures training of flight deck and cabin crew was also conducted separately, and not as a complete crew, these conflicts had never surfaced and they had not been recognized by the manual writers, instructors, flight crews or cabin crews. When these conflicts were identified, the company took immediate steps to correct them.

Operations manuals are not required for corporate aviation departments operating under U.S. Federal Aviation Regulations (FARs) Part 91; however, many corporate operators have developed and published policy and procedure manuals tailored to their particular operating requirements. Others have simply purchased basic "boilerplate" manuals, but have neither modified the contents to meet their operations, nor operated to the criteria stated in the manual. These do not provide realistic guidance to the aviation department personnel and they undermine the essential operational discipline that is necessary to maintain high levels of safety awareness.

Some companies may begin with good, relevant procedures, but do not revise their manuals to reflect the impact of changes in personnel, organization, operating limitations, type of equipment or managerial philosophies. We have found procedures used on a day-to-day basis which have evolved from operational experiences that justified deviations from the applicable manual material. A manual should not be a static document, but the policies and procedures in the manual must be in agreement with those actually being used, and vice versa. All departments should review their policies and procedures annually to ensure that the desired practices, procedures and regulations are in compliance with each other. It is recommended that manuals be a loose-leaf type and include a method of ensuring that revisions are received and recorded.

We audited one organization and learned the operations and maintenance manuals had not been revised in 11 years. During this time one aircraft referred to in the manual was removed from the inventory. In fact, it had been absent so long that another aircraft had come and gone without ever being referenced in the manual. The organization was operating jet airplanes, while the manual still contained references to piston-prop aircraft. Although it was found that this operator was achieving acceptable margins of safety, discussion with the company's management emphasized the potential risk involved. After reviewing the status of their manuals, the company's management recognized that, in the event of an accident they would have been less vulnerable to litigation with no manuals, rather than with the ones they had.

Risk Management

The increasing use of leased aircraft, leased crews, or both is exposing many operators to nonstandard cockpit configurations and system differences between aircraft in their fleets, as well as to differences in operating procedures among crew members. Maintenance standards and approved programs have also been found to differ when leased aircraft are brought into the fleet. Some operators have not adequately addressed these differences and have mistakenly accepted the premise that another operator's approved standards will meet all of their own requirements and standards.

Corporate operators must establish policies and procedures requiring inspection and approval of contract charter operators to ensure that they meet the equivalent high standards of their own flight departments.

Corporate operators are often faced with requests to provide executive transportation beyond their in-house capability. To accommodate such requests, many organizations use outside charter operators. FSF audit teams have found, however, that although a corporate operator may have very high standards for their own pilots and equipment, they often have no policy or procedure to assure that the charter operators meet the same high standards.

One corporation, operating a well-equipped and state-of-the-art aircraft to high operational standards, was allowing their top executives to be transported on occasion in very marginally equipped aircraft. Another corporation, which had a requirement for considerable experience for its pilots, was using a charter operation which hired inexperienced pilots as captains or used even less experienced pilots in the co-pilot position.

Corporate operators must establish policies and procedures requiring inspection and approval of contract charter operators to ensure that they meet the equivalent high standards of their own flight departments.

Although the corporate aviation segment of the industry enjoys a good overall safety record, it is prudent risk management to limit the number of key executives travelling on a single airplane. This matter has been overlooked by some corporations. In fact, some corporations tend to do just the opposite and use the aircraft as a mobile conference room for a group of key executives. Several accidents on record have demonstrated the downside of this risk exposure; entire top managements have been lost.

An even greater exposure exists during ground transportation prior to or following the flight. Some companies, which had a policy limiting the number of key executives on the same airplanes, would load several key executives from different flights into a single limousine or helicopter.

One corporate organization had a strict policy of not flying certain key executives on the same company jet airplanes. However, during the audit, two jet airplanes delivered the six top executives to an airport. The six executives boarded a less-sophisticated piston-powered aircraft and were flown together to a remote unimproved landing strip, where all boarded the same bus for a trip over a local mountain road. Companies should evaluate risks and establish a strict policy relative to the number and classification of key executives who may travel together in any aircraft or ground vehicle.

Minimum Equipment Lists

The minimum equipment list (MEL) has been one of the most important methods of providing worldwide airlines with a means of knowing that they could operate their aircraft with both actual and legally recognized margins of safety within controlled parameters, even with some components inoperative, by meeting certain additional limitations or restrictions. Technical representatives of the manufacturer, regulatory authorities and aircraft operators cooperate in developing a master minimum equipment list (MMEL) for each new aircraft. This covers the equipment, systems and components that the manufacturer has incorporated into the aircraft at the time it is certified and establishes the limitations for continued operation. The individual airline or corporate operator can then apply to the regulatory authorities for approval of an MEL, which incorporates the MMEL, but is tailored to include the auxiliary equipment, systems or components that were installed for the specific needs of the operator.

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The use of MELs has been common practice with airlines for more than 40 years, and with the issuance of recent U.S. FARs, this practice has moved to corporate and other general aviation operators. This is an area where safety margins can be adversely affected if procedures are not closely monitored and restrictions observed. The problem most often found among scheduled airlines is multiple open MELs which go uncorrected for too long a period. Non-U.S. carriers appear to be more lenient and the pilots-in-command do not take the initiative to demand more prompt corrective action. At one international airline, we found several instances of violations of the MEL provisions, due in part to a lack of direction for coordination between the flight crew and technical staff.

As more sophisticated electronic systems and equipment are installed in aircraft, the MEL becomes more complex. Many pilots and maintenance technicians lack a clear understanding of the interrelated functions of these complex systems and the intended application of the MEL provisions. A simple, yet mandatory part of the MEL procedure, calls for installing an "inoperative" placard on the affected switch, control, instrument, etc. in the cockpit. This regulatory requirement has been loosely enforced or totally ignored by several operators, which resulted in aircraft being operated outside MEL parameters. Specific training for both flight and technical staff, covering the use and application of MELs, should be conducted by operators to ensure that they are in compliance with technical and regulatory requirements.

Since MEL components can and do affect the operational capability of the aircraft, it is critical that coordination between flight dispatch, pilots and maintenance be ensured in monitoring MELs. In many cases, the current MEL status of the aircraft MEL item is not available in the dispatch office for use by pilots and dispatcher to plan flights. For example, pressurization or instrumentation items may restrict altitude; fuel system items may restrict range and available alternates; antiskid items may restrict runway performance, etc. Application of proper compensation factors established by the MEL ensures maintaining the desired margins of operational safety, if they are properly enforced.

In one case, it was discovered that an aircraft should have been restricted to visual flight rules (VFR) due to an instrument malfunction, but it was operated for several days under instrument flight rules (IFR). Such practices insidiously reduce the margins of operational safety and must not be condoned. Management must be alert to any unintentional, implied or perceived pressure, or evidence of complacency in the administration and control of MELs.

Corporate operators are relative newcomers to the use of MELs; however, many have approved programs. Of those corporate operators having approved MELs, we generally found them to be conservatively applied and most items are promptly corrected. Corporate operators have allowed items to go uncorrected for extended periods if the required parts are not readily available. An open MEL item reduces the back-up or redundant system capability of the aircraft and each item should be considered the same as a potential aircraft-on-ground (AOG) situation when acquiring the parts needed for correction.

FSF has found increasing reluctance on the part of corporate operators to undertake the frustrating task of getting an MEL developed and approved.

The problems in the U.S. Federal Aviation Administration's (FAA) approval process of corporate MELs has proven to be a severe stumbling block. FSF has found increasing reluctance on the part of corporate operators to undertake the frustrating task of getting an MEL developed and approved. As a result, these operators are continuing to operate without the guidance and legal protection of an MEL. Recent efforts by the FAA, including excellent clarification briefings at Flight Safety Foundation's recent annual Corporate Aviation Safety Seminars (CASS), are addressing this matter and the situation is expected to improve.

Communication

Perhaps the most important single factor in any organizational structure is effective communication. Virtually every audit conducted by FSF teams has uncovered problems in communication. Indeed, communication deficiencies may be the impetus for requesting an audit.

Effective Vertical Communication

Effective communication is particularly important in the aviation industry where many functions cannot be carried out under direct supervision. Communication is effective only when the intended message is conveyed, understood and produces the desired result.

For example, an organization management that only issues edicts and directives from the top down is not benefiting from the knowledge and experience in the lower levels of the organization. This has been a chronic problem in many organizations and its remedy requires constant management awareness and attention. All too often the upper levels of management do not really know how their organization is functioning because they have not succeeded in establishing effective two-way communication.

We have found many examples where written communication was not understood or interpreted as intended by the writer, thus confirming the need for a continuing review of all written material for clarity and understanding.

An FSF safety audit of the U.S. air traffic control system in 1982, following the strike of air traffic controllers, found similar vertical communication problems; top-down communications were frequent but bottom-up communications were rare, with a resulting gulf of mistrust and misunderstanding between controllers and management.

Benefiting from Subordinates' Suggestions

The head of one airline operations department advised that he had all available chief pilots in for a meeting at least once a week, but never received any suggestions from them. During subsequent confidential interviews with each chief pilot, the audit team repeatedly heard that he never implemented any of their suggestions. They also commented that if they initiated any direct information-exchange with the other chief pilots he accused them of attempting to undercut his authority. The line pilots also said that he never accepted any idea unless he could make it appear that he originated it. He wanted all communication between chief pilots to be in writing and to pass through his office "so I know what is going on." His procedures were actually stifling intradepartmental communication. This department had an extreme communication problem and the department head did not recognize it.

Effective communication requires that supervisors and managers listen astutely to the persons that they supervise and manage. During interviews our audit teams often heard complaints from employees about not receiving any response from their suggestions Therefore, they saw no use in making further suggestions. Experience has shown that more than half of all problems identified by FSF audit teams had already been identified by employees, but no action had been taken to correct them.

FSF has frequently recommended that a formal suggestion program be established and each suggestion from an employee be acknowledged. Each suggestion should be given an objective evaluation and the submitter should be advised of the results of the evaluation. If the idea is accepted, the submitter should be advised when the action will be taken. If the suggestion is not accepted, the submitter should receive an objective and courteous explanation of the rejection. Every employee is entitled to a response to each suggestion, ideally in the form of a memorandum or letter. This not only supplies a hard-copy record of the proposed action, but it also provides a manager with the means for periodically reviewing how effective the unit has been in carrying out commitments.

Morale Issues

Morale has been a significant factor in every safety audit that the Foundation has conducted. In some audits, high morale was evident in all aspects of the employees' work. In others, morale was so low that it produced an adverse effect on operational safety and efficiency. Morale was also found to vary in different groups within the same organization. For example, pilot morale might be acceptable, while maintenance morale was very low, or vice versa.

Communication as a Factor in Morale

During private interviews, the reasons behind the level of morale would often surface. We repeatedly heard that the inability to effectively communicate with upper levels of management and its failure to keep promises, were two significant factors behind low morale.

The very nature of aviation activities commands that only above-average performance, and near perfection, is considered acceptable. While employees may understand this, we often found that they felt they were "taken for granted" or "not appreciated."

Our findings indicate that those companies that have a program to recognize and publicize the individual contribution of employees, enjoy a higher level of morale, less employee turnover and reduced absenteeism. The successful programs are usually not financially significant and more importantly, they provide a means for recognition among peers, with resultant strengthening of self-esteem.

The safety audit teams have frequently seen the beneficial effects of providing a receptive ear. Many times at the end of confidential interviews, employees have commented that it was the first time since they joined the company that someone had taken the time to listen to their concerns. While the persons being interviewed were aware that, because of the confidentiality of the interviews the team members could not help them individually, they very frequently indicated that they felt better after having had the opportunity to discuss problems and issues. We have also seen cases where the therapeutic effects of the interview sessions were evident in the attitude and morale of certain individuals during the remainder of the on-site visits.

All aviation personnel benefit from participation in technically-oriented associations or professional organizations, which bond personnel through their common expertise and professional pride. Many airlines and corporations have also developed programs that utilize in-house resources for input to their managerial, operational, maintenance or promotional policies and procedures. Examples include safety committees, professional standards committees, speakers' organizations and participation in community projects. We have learned that those companies providing strong support for such groups enjoy better working relationships and higher morale within the entire staff, than companies that have no such support.

Employee Relationship to the Corporation

The particular relationship of a flight department to the overall corporate structure, where the airport and flight operations facilities are isolated from all other corporate facilities, has been a strong factor affecting morale and feelings of security among flight department employees.

Poor morale was cited as a major problem within the flight department of one multi-national corporation. One of the reasons for this was determined to be that some employees at the airport were not included in the normal personnel department functions and they were also unaware of their benefits and privileges under the corporate policies. Flight department management had simply overlooked this aspect of their managerial duties. Management had focused only on getting the employees into productive work and thereby contributed to a significant demoralizing factor.

Organizing Safety Activities

The safety organizations of airlines and corporate aviation departments have been found to vary from well-organized independent departments, staffed with qualified safety personnel reporting directly to high levels of management to no safety organization at all. We have also found safety departments that were only "paper" organizations with minimal effectiveness.

Independence of the Internal Audit Team

Every unit within an organization should continually review and analyze its activities, equipment, facilities and use of personnel. However, experience has proven that additional benefits accrue from periodic audits, from within the organization, or by qualified people from outside the company.

The audit team must be able to function independently and without concern for any recrimination or job security. An internal safety audit team should report administratively to top management, but each member must have a background of experience that enables him to recognize any conditions or situations which could affect the margins of safety in the various units under review. Unless the audit team can function independently, it is very difficult to be objective.

In one airline, the team carrying out an internal audit reported to the person heading up both flight operations and maintenance. Any reported deficiencies were interpreted as reflecting adversely on him, so the results of the team's findings were stated so mildly that very few of the reported items were ever corrected and they were identified during subsequent internal audits. This internal audit group was identifying what needed to be corrected in order to increase the margins of safety. The team head was doing the airline an injustice because he did not objectively report observations and findings and make specific recommendations which could become remedial action items.

Management personnel at all levels must recognize that any audit is aimed at identifying those situations and factors that may be contributing to a lower margin of safety or operational efficiency than the organization believes exists or desires to maintain. It is essential that an audit not be conducted to substantiate a specifically desired situation.

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The head of one aviation organization told the FSF audit team on the first day of an audit that he wanted a good safety report so that "he could negotiate a lower insurance rate." He was promptly advised that the team's actual observations and findings would be reported, but the team could not promise that the insurers would consider the report justification for a reduced premium.

Flight Safety Foundation does not usually know clients' responses to its audit reports and recommendations. We have received subsequent action-item reports from some clients indicating what they had done with each of the recommendations. Some corporate aviation departments and airlines have requested repeat audits at approximately two- to three-year intervals. This has enabled FSF to learn how the client evaluated the observations, findings and recommendations previously presented, and to analyze the results of the actions taken as a result of the prior audit. A company's desire for periodic safety reviews of its aviation operation reflects a healthy and positive attitude toward improving its safety performance.

Coordinated Safety Programs

A deficiency identified in some airlines was the lack of a coordinated safety program. A coordinated safety program requires that one office be responsible for the overall administration and direction of safety activities throughout the company with specific procedures for coordinating safety-related activities among affected units or departments. Some companies have assigned safety personnel in maintenance, flight operations, cabin services, ramps and terminals, but were apparently unaware how much the activities of one department interrelate with and affect safety in another department. Solutions to safety problems in one area could be contributing to a problem elsewhere. The sharing of safety-related information in a coordinated safety program contributes significantly to an organization's efficiency and reduces duplicated or uncoordinated activities.

Accident and Incident Investigation

The proper organization of an accident/incident investigation procedure is paramount to the effectiveness of any safety program. Some operators were neglecting investigation and follow-up on events if no damage or injury occurred, or completely ignoring "the accident which almost happened." Such an occurrence was discovered during the audit of a large air carrier. A taxiing wide-body jet left the paved surface and came within a few meters of going over an embankment due to loss of brake hydraulic pressure. Prompt action by a crew member to restore hydraulic pressure averted a major accident. Because there was no damage or injury, the occurrence was not investigated.

Such a situation, where all the participants and witnesses are available, none of the evidence is lost or distorted by subsequent damage, and no individual is personally at risk, can be a good source of potential safety improvements. Every such occurrence should be fully investigated and analyzed, not to find fault, but rather to determine the contributing factors and recommend actions to preclude any similar occurrences.

One international company's employees were so concerned about reporting any incident for fear of recrimination, that the Foundation recommended a well-publicized internal "immunity" program for all involved parties, unless there was evidence of outright fraud or deliberate negligence, in order to obtain information about incidents and unsafe situations. The recommendation was presented to the chief pilot who stated "I expect all pilots to report their errors to me and then I will determine their penalty." Such management philosophies are counterproductive in promoting safety.

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FSF has learned that there are usually several factors contributing to an incident or an accident. The difference between a situation ending in a minor incident or a major catastrophe can depend on the last factor in a long chain of events. The events that contributed to each situation, even though it may not have resulted in an accident, should be investigated, analyzed and the information distributed to all who could potentially be in a similar situation. Effective communication, along with objective and thorough investigation, are the keys to preventing accidents and incidents.

Identifying and Eliminating Root Causes of Unsatisfactory Situations

A vital part of the corrective or preventive actions by any safety organization should be to identify the basic contributing factors to each event and disseminate the information to all affected parties. FSF has also observed that the most effective airline safety organizations have a system of alert bulletins and periodic information bulletins, which are distributed directly to individuals in each affected group. However, a weakness commonly found in such bulletin systems is in maintaining current information. Revisions or changes in published procedures or standards should be identified and the revision date noted. All bulletins should have an effective date as well as an expiration date.

An example of the underlying causes of a particular problem was discovered during the investigation of an airline's ramp environment. One busy station had experienced an excessive number of aircraft dents and damage by ramp vehicles. When the incident/accident reports were reviewed, we noticed that several aircraft had been struck by belt-loaders, which had driven up to the cargo doors without coming to a complete stop before approaching the aircraft, contrary to published ramp procedures.

While watching the ramp operations during a peak activity period, we saw that only two belt-loaders were shifted between nine airplanes. Further investigation disclosed that a third unit was undergoing repair and three others had been parked from three weeks to five months waiting to be fixed. In an attempt to get flights out on time, ramp personnel were driving faster than posted speed and they not complying with the procedure for approaching an aircraft.

When we visited the ground support equipment repair shop and spoke with the two men working there, we learned that they were attempting to maintain more than 100 units. They conceded that they usually prioritized their maintenance schedule in accordance with the amount of pressure being put upon them by the various users. They said that the ramp supervisor had never told them that they needed all belt loaders during peak periods. No systematic preventive maintenance program had been established for any of the units. Although these two men were conscientious workers, there was no way they could maintain that much equipment.

Top management must actively and overtly support the safety organization's activities if they are going to be effective.

The airline's management had failed to recognize that inadequate maintenance capability in this single, small and remote shop was contributing to equipment damage and potential injury on the ramp, as well as significantly affecting on-time operation.

One of our recommendations was to assign the highest possible priority to get all ramp loaders back in service and then to emphasize the reasons for the established ramp procedures. A second recommendation was to increase the overhaul and maintenance capabilities of the ground support equipment shop, either in-house or through contract agencies.

Safety Organizations and Personnel

The responsibility for monitoring safety programs, facilities and personnel safety of some organizations has varied from very effective, well-organized, separate safety departments reporting directly to top management, to one person being assigned as safety officer as a collateral duty to primary responsibilities, without a budget, resources or training to carry out safety requirements

When the team was attempting to identify the safety organization in one corporate aviation department, the chief pilot said "Well, I guess I'm the safety officer."

The audit progressed without finding a safety bulletin board or any safety information service such as publications or videos. No one had ever attended a safety workshop or seminar, and we wondered if the chief pilot might be just occupying space in an organizational chart for the benefit of higher management. We have seen several instances where such casual assignment of this important function has led to false expectations by corporate management and blame has been assigned unfairly when an accident occurred.

A good chief pilot is not necessarily qualified to be a good safety officer. In a small aviation department, the chief pilot might be an effective monitor of the margins of safety, if he has the time and training. It would be much better to have a defined safety program handled by someone who receives safety training and is allocated specific time and a budget for safety activities. Top management must actively and overtly support the safety organization's activities if they are going to be effective.

Safety personnel need training in management skills to be most effective. A good safety department or safety officer is able to establish comprehensive safety awareness programs by developing both the confidence and the integrity of workers and management, without creating opposition or resentment. The most effective safety personnel have, first of all, a genuine interest in promoting safety and a willingness to work hard. They must be trained in safety analysis, accident prevention, accident investigation, safety management, etc. They must develop an objective philosophy of "what if" when looking at the many situations involving the aviation activities. Safety is a career that can be rewarding, stimulating and sometimes frustrating, but never dull.

Audit teams have seen aviation departments that rotated the responsibilities of the safety officer. In one company, it was assigned for a two-year period, then passed on to another pilot. One of the deficiencies that we identified in this procedure was that by the time the individual was sufficiently trained and experienced to feel effective in the safety program, he was reassigned.

During confidential interviews we learned some safety personnel considered their job to be a chore rather than a challenge. Invariably these people did not feel that they had the commitment or active support of top management; they were ineffective and unable to get identified safety problems corrected; and they lacked an adequate budget. Quite often, these safety people were unable to participate in safety seminars, industry activities or courses for keeping current with the changes in aviation. The company's choice of safety personnel also may have been indicative of a lack of corporate commitment to safety.

Corporate Safety Awareness

All successful aviation organizations recognize that safety is essential to an effective and efficient operation.

We have learned that most top managements really believe that they are promoting the necessary safety programs within the company, although they may in fact, be doing little or nothing in direct support of the program. In the airline environment, it is often difficult to determine how effectively the safety program espoused or mandated by top management is functioning in actual practice.

We believe that an effective safety program must ensure an adequate margin of safety and on-going elimination of incidents that invariably lead to accidents. With proper emphasis on the importance of safe practices and programs from each manager and supervisor, a genuine concern for safety should exist all the way from "top to bottom" in the organization. Unfortunately, we seldom found this to be true.

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In some of these organizations the audit teams learned that top management did not actively support their safety personnel. When speaking with the president and CEO of one airline, we discovered that he did not personally know anyone in the safety department, although administratively they reported directly to him. This certainly contributed to the safety department personnel's feelings of frustration and ineffectiveness.

Conversely, our audit teams have observed other organizations where the CEO personally attended safety meetings from time to time to show his active support for the program. One highly motivated and effective executive vice president is a very active chairman of the company's safety promotion committee. Such visible participation by top management is invaluable in building the prestige and respect of the safety group in any organization.

One of the reasons for the lack of management effectiveness is that upper levels of management may not realize what is required, in both manpower and funding, to ensure that the required margins of safety are achieved.

A second reason is that the rank and file employees do not see sufficient evidence of a dedicated personal interest through the progressive levels of management in the specific activities necessary to maintain a safe working environment.

For example, the president of one airline was a strong advocate of safety programs at all levels. However, we found the vice presidents and directors in the operating departments to be heavily involved with the airline's expansion and the introduction of a new type of aircraft. Safety was delegated to a single individual in each department. During the interviews with supervisors and line employees, it was evident that they had received little emphasis on safety policies, procedures or practices, but there had been much information about the pressure to introduce the new aircraft into service.

By this time the team had seen considerable evidence throughout the organization of the reduced emphasis on safety practices. As an example, while we stood talking to a maintenance supervisor in the hangar we observed two hoses that were not in use, but they were releasing water across the floor. The maintenance technicians stepped on or over the hoses, and in the water on the floor, while they worked on the wing flaps. At the same time, we also observed three maintenance personnel working on the horizontal stabilizer of a wide-body airplane without any guard rails on their highstand.

During the supervisor's discussion about the pressure of the work, he reached back and struck a match on the hangar wall (to light a cigarette) just below one of the many "NO SMOKING" signs in the hangar.

Apparently, the emphasis on safety had deteriorated through each level of management to the point that the supervisor was not really aware that he, or his workers, were involved in unsafe practices. Yet, the CEO really believed that the airline's first priority was safety.

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Management/Employee Relations

The day-to-day relationships between the managers and line employees, and the management styles of key executives, have a profound effect on employee attitudes, morale and their interest in safety. Although there may be differences of opinion and opposing forces, such as those that occur during industrial disputes, negotiations, etc., we have found that a properly structured and adequately staffed safety department can still function effectively in these environments.

During our audit of an international airline, the pilot group was negotiating a new wage agreement with management. Although the day-to-day relations were somewhat strained between management and pilots, the professional posture of the personnel in the safety division and the respect accorded the safety programs by all parties, enabled it to continue functioning effectively.

Very few organizations made the most effective use of employees' safety recommendations. Of all the items affecting safety that are discovered during a typical audit, the majority are usually known to someone within the organization; they had been identified to supervisory and lower-level management, but had not effectively reached the attention of higher management or had not generated corrective action. A comment often heard in confidential interviews is, "What's the use, they never do anything about it anyway." Frustration with such failures should always be of concern to management.

One example was uncovered on an international airline. Many flight attendants had reported the overloading of galley service carts that reduced the margins of safety, but they were unable to get the practice stopped. We learned that maintenance had determined that the deterioration of aisle floor panels and excessive maintenance required by the service carts was caused by overloading the carts.

During a landing, a service cart broke free from its floor-locking device in a wide-body airplane and it traveled halfway down the aisle before striking a passenger seat armrest. Fortunately, the seat was unoccupied and no one was injured. On other flights, cabin crews were observed to be struggling to push the overloaded carts up the aisle when cabin service was started during the climb to the initial cruise flight level.

No one in management seemed to recognize that by exceeding the cart manufacturer's weight limitations by more than 150 percent, the margins of safety were reduced, the potential hazards to passengers and cabin crews were increased, and the cost of maintenance and operation were increased. Management instead, believed that the airline could expedite service and duty-free sales by increasing the load on the service carts.

Personal involvement in safety programs and personal compliance with safety rules, regulations and practices by all levels of supervision and management are essential to developing good safety habits in all employees. One aviation department had prominent signs "Please pick up F.O.D. [foreign object debris]" but during one week of on-site observations, we never saw anyone pick up anything. In fact, supervisors, managers and vice presidents were observed to step over debris without picking it up and placing it in the empty, conveniently-placed refuse containers. The time-proven principle of setting the example was, unfortunately, completely ignored.

Internal Surveillance and Analysis

A critical element to maintaining the desired margins of safety is that of conducting internal checks and monitoring functions to assure compliance with the published standards. Very few of the operators audited by FSF during the past 10 years have had a totally effective internal audit program, and some had no program at all. Of those having an internal surveillance and analysis program, a common weakness has been insufficient support of these internal activities by higher levels of management. Although conditions were found and reported, these survey and analysis groups lacked the authority and support of upper management to initiate prompt and effective corrective action of identified deficiencies.

A critical element to maintaining the desired margins of safety is that of conducting internal checks and monitoring functions to assure compliance with the published standards.

FSF audit teams take advantage of internal surveillance and analysis reports where they exist and conduct follow-up reviews of previously reported deficiencies to assess the effectiveness of these programs. It is not unusual to find items that have been reported several times by internal surveillance groups that had not been corrected; when these same items were brought to the attention of upper management by the "outside" FSF audit team, they received prompt attention. This suggests that more authority and support must be given to the internal surveillance and audit process.

Many operators lacked any documented policies or procedures for investigating the errors of maintenance technicians, or of the accidents and incidents which occurred in the maintenance area. One large airline did have a procedure for investigating an accident, but only if someone was injured and required hospital treatment. In one or two instances, it was learned that such investigations were perceived as only a procedure to determine who was to be blamed and fired.

Every aviation organization should develop a formal accident and incident investigation procedure with representatives from the working group and management, as well as the representative of the safety organization. These procedures should be published and include an analysis of findings and actions to prevent recurrence of similar incidents, regardless of the severity of the original occurrence.

Training

During the past decade FSF has observed a continued improvement in the training of flight crews. Pilot training syllabi are usually modified to incorporate the latest procedures for coping with such phenomena as windshear, microbursts, icing, etc., as knowledge of these hazards expands. Simulator training is used extensively by airlines and corporate aviation for those aircraft for which simulators are available. Line oriented flight training (LOFT) has been incorporated into many airline and corporate aviation department curricula. More companies are including periodic line checks as a fundamental component of the continuing evaluation of flight deck crews. Many organizations include various concepts of crew resource management (CRM) as a part of their training programs. While training is improving, human factor faults still contribute to 70 percent of all aviation accidents. The need to stress professionalism remains one of the industry's foremost tasks.

Training of cabin attendants has also continued to improve. Many airlines have added cabin mockups or realistic cabin simulators, some with motion capability, to their training capabilities. Increased emphasis is placed on cabin attendants to cope with inflight and post-crash emergencies, although we find passenger service and onboard sales also receiving considerable attention. We have been pleased to learn that corporate aviation departments that utilize cabin attendants are providing them with initial and recurrent training to cope with a full range of emergencies.

We have also observed an increase in emergency training and drills for executives and other travelers on company aircraft.

Maintenance and Engineering

FSF has learned that airlines and corporate aviation maintenance departments are providing airworthy aircraft. The formal training of maintenance personnel is often less when an airline holds the maintenance certificate and all individual technicians do not need the equivalent of an airframe or powerplant license to work on the aircraft or its components. We also learned that maintenance personnel in corporate aviation departments are well-qualified in general, but frequently lack recurrent training.

Although aviation maintenance technicians are exposed to more health hazards than ever before in the course of their normal work, very few of the audited operators have a program of medical monitoring examinations for maintenance personnel. Turbine aircraft present potential problems to hearing; higher workstands increase the potential injuries from falls; and hazardous chemicals that threaten good health, represent a few of the hazards in today's environment.

Operators have a threefold interest in assuring that a technician's health remains good:

- The employer has a considerable financial investment in the highly trained technician.

- The proper functioning of the senses of the technician are critical to the performance of his duties.

- There may be liability to the employer should the technician fail to perform properly due to a physical deficiency.

Technicians should receive a complete medical examination at least each 24 months. Those engaged in actual run-up or taxi operations of aircraft, should receive annual physical checks.

The importance of medical examinations was demonstrated when a technician became unconscious while working inside an opened wing fuel tank. The assumption was that he had been overcome by residual fumes. However, as the result of a complete medical examination, it was found that he had not disclosed a known condition which caused occasional fainting spells. This same individual also conducted run-up and taxi checks. Obviously, there was safety risk for both the company and the individual under these circumstances.

The training of maintenance technicians has steadily improved over the last decade; however, the standards of training still lag behind that of flight crew members.

The training of maintenance technicians has steadily improved over the last decade; however, the standards of training still lag behind that of flight crew members. Airline training is generally more thorough than corporate training because of regulatory requirements. Yet, we observe considerable variance in the stringency of airline maintenance training programs throughout the world. In several instances, the training of non-U.S. airline operators exceeded that of the average U.S. carrier.

Recurrent technician training is probably the weakest link in aviation operations. Most operators take advantage of initial training offered by manufacturers, but few offer a regularly scheduled recurrency program for their technicians.

Avionics and electronics training are areas most in need of attention. Present-day aircraft have more electronic systems than ever before, and mechanics initially trained in the 60s and 70s need recurrent training to be technically updated. A lack of updating contributes to a lowering of overall quality and efficiency with resultant economic penalties, including the increased risk of an incident or accident.

Training in run-up and taxi operations for maintenance technicians has been less than optimum at many operations. We have observed that much of the run-up and taxi training is conducted by maintenance personnel and does not include adequate emergency procedures training. Where possible, this training should be provided in the simulator and check pilots should conduct periodic recurrent checks of the maintenance technicians to ensure proficiency. FSF recommends that two qualified individuals be in the cockpit whenever the aircraft engines are operated.

Run-up operations of helicopters pose some special problems, because any operation above idle RPMs is a potential lift-off. One operator suffered a costly ground accident when the helicopter became light on the skids during a maintenance run-up and moved off the dolly. We now recommend that engine run-up of rotary-wing aircraft be restricted to idle power when being operated by maintenance technicians.

Management Training

Most large corporations have programs to provide management training and career-advancement opportunities for their employees. The aviation department is, however, sometimes not included in these programs. In some instances, it was observed that the physical isolation of the group from primary facilities was the primary reason. In other cases, the flight department management was aware of company resources, but neglected to urge employees to take advantage of them. While most airlines provide adequate technical training of employees, our audit teams have learned that the same manager who demands a high level of technical training, often overlooks a need for managerial training of pilots, maintenance technicians and employees from other groups who are moving into supervisory or management positions. Management training is essential to develop and maintain competent supervisory and management personnel.

Contract Training

Nearly every audited operator has used outside contractors to provide training of pilots and technicians. In many cases, the operators tend to accept whatever the agencies provide on the basis that they are "approved." From analysis and observation of actual training sessions we have learned that more effective training can be provided if the operator takes the initiative to provide constructive criticism and to require custom tailoring of the programs to suit individual circumstances and environment.

Reviews of operator records and flight reports have frequently pinpointed areas of weakness or repetitive problems, which should have been addressed in recurrent training sessions. Outside training agencies may be unaware of an operator's specific problems and they are dependent upon operators to keep them up-to-date on current problems and trends occurring in actual operation. It is to the operator's benefit to interact constructively with the training agency so that both may derive maximum benefit from the training.

Flight Operations

Flight operations is the most visible aspect of any airline, corporation or fixed-based operator. It is also an area in which it is often difficult to determine if policies, procedures and practices are being complied with, because many of its activities are conducted without direct supervision. This is particularly true of flight crews; therefore procedures and practices must be well-developed to provide the optimum margins of safety. They must be thoroughly understood and supported by the flight crews, who are spot-checked periodically to ensure that standardized procedures are being used.

Cockpit Techniques

From observation flights, we have learned that some corporate pilots develop individual techniques and procedures that deviate from a company's established procedures. Sometimes, this seems to have occurred without their being aware of it; other pilots apparently made unilateral decisions to develop their own techniques and procedures. We have recommended to many non-airline operators that periodic jump seat line checks be conducted at least annually, as is required by the regulations for air carriers, to ensure that standardized procedures are being used. Pilots utilized to conduct line checks should also receive specific training to properly perform this function. A standardized line check guide should be used by all check pilots.

In an operation that had recently converted from several single-pilot twin-engine airplanes to jets, we learned the two pilots were sitting together in the cockpit, but they were mentally and physically operating independently. For example, each pilot would do such things as change radio frequencies without coordinating with the other; the pilot not flying would "Roger" for an air traffic control (ATC) directive; and the pilot-not-flying would reset the altitude alert without calling it to the attention of the pilot-flying. Until the audit team identified the lack of coordinated crew action to the pilots, they did not realize that those single-pilot habits and techniques were not positively contributing to a two-crew cockpit.

Furthermore, since this operator sent only one pilot at a time to the manufacturer's simulator for initial and refresher training, the simulator instructor had no opportunity to identify or correct the potentially unsafe practices resulting from poor cockpit coordination. A proper check flight by the chief pilot also could have identified this problem.

Most pilots of major airlines, as well as those of corporate aviation departments operating turbine powered aircraft, receive periodic training in simulators. However, some commuter airlines do not have simulators, either because their fleet is too small to justify owning one or a simulator has not been produced for the aircraft being used. Consequently, training is conducted in the line aircraft. Some of these training programs have been sub-standard. In one instance, the training period was interrupted on two consecutive days because the airplane was needed for a scheduled flight. Although the training checksheet items were finally checked, the effectiveness of the observed training periods was questionable. At other times, shortcuts that were taken with procedures or maneuvers were justified to reduce cost of operation or the need to complete the training period.

The most effective pilot training takes place when pilots participate as a full crew while using their organization's own checklists and standardized procedures.

The most effective pilot training takes place when pilots participate as a full crew while using their organization's own checklists and standardized procedures. Proper crew coordination is enhanced when all crews receive semi-annual line checks from a standardization pilot. During observation flights with pilots trained under this concept, it was easy to recognize the well-managed, coordinated cockpits where each crew member was constantly in the loop and contributed to the safe and efficient conduct of the flight.

Pilot Perception of Management's Intent

Published airline schedules expose the pilot-in-command to outside influences to complete the mission. Such influences may produce pressure that may be real or perceived. Management's attitudes toward compliance with documented limits and procedures have been found to be a vital factor in supporting the policies and procedures which maintain the desired safety margins, and it is vitally important that flight crews are comfortable with exercising their professional judgment, even in cases where such actions do not support meeting a schedule.

Some operators have conservative standards and operational limits published in company manuals, yet senior and even supervisory pilots deviated from these procedures. When less-experienced pilots see senior pilots operate outside the published limits, there is inference that this is an acceptable, or even expected, operational procedure. The fact that management allows such deviations connotes their acceptance, results in a serious compromise of overall safety margins and undermines established professional standards. Management must not tolerate any deliberate deviations or exceptions to established policies, regardless of the seniority or experience of the pilot. Top management should meet with the flight operations department staff to insist on full compliance with published operating standards and limitations.

During confidential interviews we have been told by corporate pilots that they have felt subtle pressure from some executives to complete flights under conditions of operational safety with which they were not comfortable. Situations were described where the executive would emphasize during each segment of the flight his need to be at a certain destination at a specific time. Some pilots said that they felt such pressures from certain executives more than others, and it was not necessarily a factor of where the executives ranked in the organization. Most pilots found it difficult to identify why they sensed these subtle pressures.

No pilot said that he had been ordered to fly after he advised the passengers it was unsafe to continue. However, several said when they advised the flight would have to be interrupted because of some malfunctioning equipment, they had been challenged as to why they could not continue with the remaining equipment. Some pilots conceded that they had continued operating with malfunctioning components when they were carrying certain personnel because they had learned from previous experiences that they would be challenged.

The very nature of corporate aviation exposes the pilot, whose position in the overall corporation is often viewed as a relatively insignificant one, directly to top corporate management. Under these circumstances, a mere question may be perceived as an order. An expression of dissatisfaction from a CEO may be perceived as a threat to a pilot's future job security. Because of the possibility of such pressure, either real or perceived, the flight department manual should contain a preface committing the support of the corporate organization to compliance with published operating standards and conservative safety decisions. This, of course, should have the visible endorsement of the CEO.

Contract Pilots

Some airline and corporate operators use contract pilots at various times in their operation. These temporary employees tend to be well-experienced, but they may be more interested in getting the job done than in complying with company policy.

In one instance, the pilot, hired on a six-month contract, was using the operating procedures of his previous employer, which differed considerably from those of the company for whom he was under contract. This was particularly detrimental to his employer, a small airline, because he was flying as pilot-in-command with newly qualified co-pilots. Because they did not fly with the same captain for more than one trip sequence, they were not developing standardized cockpit procedures.

Contract pilots can provide the same levels of operational safety, efficiency and reliability as full-time pilot employees, if they are trained to their new employer's procedures and standards. They should receive periodic line checks to ensure that they understand and comply with established policies and procedures, and that they are meeting the company's operational standards.

Cabin Services

Airline Operating Standards

The cockpit configuration standards for the audited airline operators were usually found to be good, and the cabin emergency equipment has, with a few exceptions, been adequate. While the audit teams have been favorably impressed with the advances in cabin crew training, we continue to find a high number of hazardous situations within the cabin involving equipment, such as galley appliances, and operating practices, such as baggage stowage. The audit teams have observed unsafe conditions and they have also uncovered difficult-to-use equipment and poorly located emergency equipment.

The competitive economic environment and increased passenger loads have emphasized the sales aspect of the transportation business, and often place undue pressures on the operational staff, especially the cabin attendants.

One of the most common potential hazards observed is the overloading of galley carts to provide more cabin service. This has been a fairly chronic problem, particularly on short flights where the cabin attendants sell alcoholic beverages, complete a food and beverage service and prepare the cabin for landing — all during flights as short as 1 1/4 hours.

Some carriers have combined all the service requirements on each cart or trolley by substantially increasing their loaded weight over the design weight. This results in increased difficulty for the cabin attendants in moving the carts up the aisles, causes early deterioration of the aisle floor panels and increases the required maintenance on the carts. It also reduces maneuverability of the carts during unexpected turbulence in flight.

The economic benefits from onboard sales seem to have caused several airline cabin service departments to ignore the potentially unsafe practice of stowing galley and duty-free sales merchandise in areas not designed for such use. One airline was routinely stowing wine in metal boxes packed with cracked ice in front of the floor-level mid-cabin exits on wide-body airplanes during the departure and take-off phases of long-haul flights. When questioned about this practice, the cabin attendants said that there was simply no other available space. They advised that they served the wine and emptied the ice-water before landing; however, the empty bottles and metal containers continued to present a stowage problem.

Another air carrier was carrying so many duty-free sales items on certain flights that two aft lavatories were literally stacked to the ceiling with merchandise. They were secured merely by closing and locking the lavatory doors prior to take-off. In the event of a take-off deceleration crash the boxes of duty-free items could have broken the door latch and become potentially lethal projectiles throughout the cabin. It was also observed that more than half the total flight time was used in taking, filling and distributing passenger orders for the duty-free items. By the time the flight landed, the glass bottles of liquors and perfumes were distributed throughout the cabin, but many items were not properly stowed and were still potential projectiles in the event of a crash. Some airports, e.g., Singapore's Changi International Airport, offer duty-free items on arrival, thus offering an alternative to onboard carriage of these items.

A major international airline recently standardized the location of all cabin crew emergency equipment among the various types of aircraft in its fleet. In addition to reducing confusion as to the location of fire extinguishers, loud hailers and other equipment for emergencies, the cabin crew training cost was reduced, thus the costs of the relocation modifications were recouped within a short period.

Baggage in the Cabin

The stowage of carry-on baggage has become the most common complaint heard from airline cabin attendants and many airline safety staffs throughout the world. Passengers seem to be attempting to avoid the delays in baggage delivery at their destination by using carry-on luggage. The luggage industry contributes to the problem by catering to passengers' desires with maximum capacity designs for carry-on baggage. While laudable from a product design viewpoint, there is little concern shown for maximizing cabin safety and understanding the problems created by carry-on baggage.

The stowage of carry-on baggage has become the most common complaint heard from airline cabin attendants and many airline safety staffs throughout the world.

There is a considerable lack of uniformity among airlines relative to the control of carry-on luggage. Unfortunately, the cabin attendant usually has to resolve the problems with little assistance from passenger service personnel or airline management. We have frequently seen passengers come aboard aircraft with boxes or luggage that could not possibly go under the seats or in the overhead bins, and then argue with a cabin attendant that they had carried the same material on a previous flight.

Carry-on baggage should routinely be checked for both size and weight before the passenger leaves the departure lounge. Some airport security authorities perform this service by not passing luggage that fails to fit within a defined template. This practice is commended by FSF and contributes to a cabin crew's ability and effectiveness in carrying out safety responsibilities in the event of an emergency.

On one international wide-body flight, a past-middle-age couple was observed attempting to lift a package into the first overhead bin after they entered the economy section. The two of them were unable to lift it into the bin and they had to ask a person to assist them. The three of them were able to place it into the bin and force the door closed. The couple then proceeded toward the rear of the aircraft, leaving other passengers to sit in the seat below that heavy object — after finding some other place to stow their own belongings.

The operators of many short-haul and commuter aircraft do not provide adequate cargo space to accommodate the physical size or total quantity of cargo scheduled for some of their flights. We have seen excess cargo stacked in empty passenger seats and in the space between seats, without any type of restraint. In the event of an accident, this cargo could cause passenger injury or block the aisle from passengers attempting to evacuate a burning aircraft. Other operators have provided various types of effective restraint systems which enable cargo or baggage to be safely stowed in the cabin.

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Design and Installation Deficiencies

On some airlines, galleys were discovered that had received more attention during design to fit into a specific space, than to the potential for injury that was created by the design. In one installation, there was insufficient room below the coffee maker to fill the serving container unless the coffee maker was unlocked and slid more than halfway out. Several cabin attendants reported they had been burned when attempting to fill the serving pot.

In another installation, four food service carts protruded up to 14 inches into the space adjacent to a primary floor level exit and were secured only by a strap around the carts.

It was observed that in one of the latest generation of commuter aircraft, the aft forward-facing foldup seat for the cabin attendant was installed so high that many of the flight attendants could not place their feet on the floor when the seat belt and shoulder harness were properly fastened. We were told that this had been done so that the cabin attendant could see the passengers better while seated; however, the installation prevented them from bracing themselves during takeoff, landing or turbulence.

On another carrier, a portable fire extinguisher had been installed on the inboard, forward side of a very narrow galley. As cabin attendants turned away from working in the galley, they frequently struck the fire extinguisher or its supporting clamp. We were advised that on two occasions cabin attendants had inadvertently released the clamp and the fire extinguisher had fallen to the floor. Several shorter cabin attendants also said that they had struck their eyes on the extinguisher unit as they turned away from the galley.

Coordinated design planning with personnel experienced in cabin service, as well as with human factors specialists, could eliminate badly engineered installations.

The smaller fuselage of some commuter airplanes, together with the operator's desire to utilize all available space for more passengers, has taxed the technical ingenuity in some fuselage installations. Unfortunately, some stowage facilities and installations have interfered with cabin service as well as presenting potential for personal injury. In one installation, the collapsible service cart could strike the back of the two aft passengers' heads unless special care was used in stowing it. Because it was difficult to visually determine if the cart was properly stowed, we were told that in several incidents passengers had been struck during descent and landing.

On one airplane model recently introduced, the main entrance door actuating mechanism failed soon after entering service and continued to fail at frequent intervals until designed. The manual operation of this door increased cabin attendant exposure to personal injury and reduced the door's usefulness as an emergency exit. This indicated that some manufacturers either lack a functional understanding of a door's use or they are not performing adequate reliability testing on heavy-usage items.

... observations suggest that manufacturers are not coordinating designs with future operators or users of their airplanes.

On this same airplane type, the cargo bin access doors were found to have protruding brackets and fittings which presented the possibility of injury to loading personnel and damage to baggage. Other doors and fittings involving frequent use by catering and ground handling personnel were found to be distorted or damaged beyond use within a few weeks of initial service introduction.

Such observations suggest that manufacturers are not coordinating designs with future operators or users of their airplanes. This situation appears to be more critical for commuter-type airplanes and may be due, in part, to the fact that these smaller operators may not have an adequate engineering staff to properly analyze the intended design. Aside from safety considerations, economic penalties of redesign and repair can be costly. Operators of new airplane types should ensure that user personnel become involved early in the design phases in order to ensure the safety and reliability of equipment as delivered.

Maintenance and Engineering

Record Keeping

The greatest deficiencies that we find in maintenance and engineering departments are in record-keeping procedures and practices. Many operators have not provided their maintenance personnel with adequate training in completing the various maintenance and airworthiness records.

Most use computerized programs to some extent in their maintenance records. Some rely totally on the computerized programs for planning and alerting functions. Few of them do any cross-checking or monitoring to assure that the computerized record is not flawed. The alerting system is thus subject to a "single point failure."

We frequently learn that intended limits have been exceeded, usually due to operator carelessness in monitoring the "maintenance due list." Such mistakes emphasize the necessity for having someone monitor or cross-check to preclude a single individual's failure.

There is a tendency among corporate operators to put too much reliance on computerized records. Computer records are not acceptable by the U.S. FAA as the total record-of-compliance with required maintenance; they must be supported by adequate paper or microfilmed data to substantiate the automated program entry.

Records showing compliance with U.S. airworthiness directives (ADs) have been the subject of much controversy as a result of FAA inspections during the past few years. In reviewing various operators' records of AD compliance, many entries have been found which would be judged inadequate under the current interpretation of the U.S. FARs. With aircraft being bought and sold worldwide, adequate records have become a serious international problem.

Operators must recognize that the responsibility for airworthiness rests with the operator ....

Conversely, some operators have a tendency to retain old methods of record-keeping that usually require considerable paperwork, although newer methods have been developed that use more efficient computers. Mergers, consolidations and acquisitions have created additional problems. Maintenance departments had considerable duplication and transcription of data from one record form to another, which multiplied the exposure error of commission or omission.

After reviewing maintenance log entries and responses to pilot write-ups in aircraft logbooks, we uncovered a tendency to refer corrections to a third party, such as "item referred to manufacturer, will be corrected when data and parts are available." Operators must recognize that the responsibility for airworthiness rests with the operator and that such entries are not a valid corrective action entry.

Maintenance Analysis

Another problem area is that of swapping components for the purpose of trouble-shooting. Although this is a common practice, operators have been cautioned that such swapping of components can lead to serious problems. If the component is faulty, it could cause associated components to fail in the tested system. Legal and airworthiness liabilities could arise if a failure should occur after such a swap.

We have also found a tendency to not accomplish adequate surveillance and analyses. Several times a review of past records disclosed serious chronic discrepancies of which management was unaware. For example, we found that on one airplane an oxygen cylinder had been replaced 88 times in a 90-day period due to low pressure. Obviously there was a system leak; however, no one was dealing with the cause, but treating only the symptom. This indicates a lack of an effective surveillance and analysis effort, a regulatory requirement for airline operations and can be useful for any operator.

The tendency to put completed documents in the file and out of mind has been further identified by a lack of follow-up on deferred discrepancies which require "parts on order." Microcomputers and database software make trend analysis and tracking of related actions relatively simple.

On one large air carrier, it was learned that some items had remained uncorrected for several weeks and the only action was a logbook write-up of "part on order." Subsequent to the check of logbook records, and after questions why it took so long to make the repair, follow-up action was initiated and the part was available within a few days. Our reports frequently include a recommendation for an operator to develop a system to follow-up on deferred items. Follow-up must not be dependent upon any individual; it must function effectively regardless of the presence or absence of any single person.

Information Distribution

There is a lack of feedback to technicians about the effectiveness of their corrective actions. In corporate aviation departments and smaller air carriers, a corrective action is usually to remove and replace a component. Although technicians may know immediately that a replacement was effective in correcting the symptoms observed, very seldom do they receive any feedback relative to the actual problem found with the component that was replaced.

In small organizations, the repair or overhaul of the component may be handled by a nontechnical purchasing office in corporate headquarters. In a larger operation, there may be a follow-up by an engineering or reliability function; however, as in the smaller organizations, information about the actual cause of malfunction or failure is usually never communicated to the technician. As a result, the technician may never know if his troubleshooting analysis was valid, and if not, it is subject to mistakes in the future.

Smaller organizations should establish a procedure to review the results of a component tear-down with the entire maintenance crew. In larger operations, the technical training staff should be included in the distribution of the findings of the reliability section, so that future training sessions or bulletins can inform the entire maintenance force.

Evaluation of service bulletins and modifications issued by the manufacturers has been recognized as a weak area, particularly within the small airline and corporate operators. In several instances, information affecting flight operations has not been coordinated with the manager of that function. In one company, an alert bulletin received by the maintenance manager had an operational limitation but it was not brought to the attention of the chief pilot.

With the exception of a few large airlines, most of the operators had no procedure to assure a coordinated analysis of service bulletins and to document the final action decision. A "paper trail" is becoming increasingly important, not only in the interest of good safety practice, but also in view of litigation and more stringent record-keeping requirements by regulatory authorities.

Inadequate Spare Parts

In a related but different aspect of airline operations, we have discovered an increasing tendency for operators to introduce new aircraft with inadequate provisions for spare parts. Manufacturers and suppliers are no longer stocking spare parts in quantity and delivery lead times of 180 days or more are routine. Although reliability of the current generation aircraft and systems is generally good, the statistical projections may be overly optimistic when compared with actual experience.

Inspection Quality Assurance

The use of quality assurance (QA) procedures, where production workers have primary responsibility for quality of the work performed rather than a designated inspector, is growing in popularity. While we have found the concept of this QA procedure to be valid, such a procedure tends to reduce the authority of a designated inspector, who is sometimes restricted or restrained in his ability to perform random or sample checks of work in progress. The inspector needs more autonomy and authority to call for specific checks or to require that specific operations be performed under his surveillance, in order to provide the proper checks and balances. The designation of required inspection items (RII), which must always require an inspection by a second individual, is an important factor in this concept.

Under U.S. FAR Part 91, which governs many corporate operators, there is no regulatory requirement for an inspection function. However, most operators have an effective system of checks and balances by using senior maintenance technicians to double-check the work of others. However, many of these operators do not have a documented system which mandates items that will be double-checked. We recommend that all maintenance departments develop RII lists.

Selection and Training

Many operators choose inspectors primarily on the basis of seniority. Under some labor contracts, seniority is the sole basis of inspector selection. While experience is and should be a factor in selecting the inspection staff, the mere fact that one technician may be the most senior does not necessarily make him the best qualified person to be an inspector. Another weakness in this area is the lack of training for inspectors; only the larger air carriers had effective training programs for newly assigned inspectors.

Most audited operators were not performing adequate surveillance of their contract vendors and suppliers.

Experience has proven that some individuals make better inspectors than others. Innate curiosity, a tendency to be a perfectionist and the self-confidence to question another technician's work are a few of the factors in the make-up of an efficient inspector. Industry studies of inspection techniques and individual capabilities have identified the importance of, and the difficulties associated with, the proper selection and training of inspectors. Specific physical capabilities required by the job, such as visual acuity, must be considered too. FSF recommends that operators establish a system of evaluation and selection of technicians to be promoted to inspectors. This should also include specific training, qualification and recurrent training programs for inspection personnel.

Quality Control of Outside Agencies

Many operators contract with outside agencies for various types of services for which they lack facilities or personnel to accomplish themselves. It is common practice for operators to use the services of certificated repair stations for component repair and approved training agencies for pilot and maintenance technician training.. However, many operators have the mistaken impression that this regulatory approval assures them of a given quality and standard of performance.

Most audited operators were not performing adequate surveillance of their contract vendors and suppliers. The development and operation of surveillance programs should be under the direction and control of the inspection/quality control function of the organization. FAA regulations hold U.S. operators responsible for the overall airworthiness of their aircraft, including that work which is contracted to an outside agency, even when that agency is an FAA certificated repair station.

The reliability of certain components received by one operator was very poor and faulty workmanship had been discovered on components returned from a particular vendor. With the agreement of the operator, the members of the FSF team visited the vendor's shop and conducted a brief review. The visit confirmed that this primary support vendor had neither adequate equipment nor personnel to perform the work which was being contracted with it. The operator had been relying on the fact that the vendor was a U.S. FAA certificated repair station, so they had not performed any direct surveillance or spot checks utilizing their own inspection staff, but were relying on the inferred FAA surveillance. The audit report included a recommendation that the operator establish a close surveillance system and a random sampling program to monitor vendor performance and quality control.

Providers of services such as ground handling, loading and fueling are not currently required to be certified or licensed. Oversight and surveillance by any regulatory agency therefore varies from very limited to non-existent. Although the burden of responsibility for these services rests with the operator, we have learned that many operators provide no surveillance of such contractors. The competition among fueling providers is such that employees actually performing the service tend to be among the lower-paid, lesser-trained and consequently, higher-turnover personnel of all aviation activities. As a result, one of the most frequently-reported safety hazards is that of improper use of the safety devices provided for aircraft fueling.

Internal Surveillance and Quality Control

Many of the deficiencies in quality control found during FSF audits could have been identified and corrected by an adequate internal audit process. During confidential interviews, auditors have found that inspectors are aware of the problems, but have chosen to take the path of least resistance rather than confront a supervisor unless the hazard is of serious consequence. Operators should ensure that specific responsibilities and authority are assigned to the inspector to observe and report any deficiencies or hazards in the workplace and that the production supervisor is required to take prompt corrective action of identified deficiencies.

Audit teams have learned that identified deficiencies were previously reported by internal personnel, but nothing was done about them; corrective action was taken immediately when reported by an outside auditor. For example, gross deficiencies were found in the battery shop of an international airline. A review of previous internal records disclosed that these same conditions had been reported as much as two years earlier by shop technicians, as well as by an internal audit by quality assurance representatives. Within four weeks after the FSF team's visit, the majority of these deficiencies had been corrected.

Ramp Activities and Ground Operations

Ramp Safety and Security

Some operators apparently place low priorities on ramp safety and security, and on the margins of safety in their ground support operations. While this may not be intentional, we have seen many cases of inadequate enforcement of existing rules. There are many kinds of accidents that could occur on ramps because of inadequate control or supervision.

For example, a fueling truck was observed to drive between the aircraft and the terminal while passengers were crossing the ramp to board. They had to open up their line to let the truck through.

In another example, an airline passenger crossing the ramp under an umbrella to board a turboprop airplane walked into an unguarded stationary propeller and received a severe cut on his head. The ramp was not painted with walkways and the stanchions and lead-lines for directing the passengers to the loading steps had not been put in place. The ramp agent had started loading without adequate safeguards in order to not delay the departure.

Some airlines and corporate operators tend to assume that all baggage that comes to an aircraft on the ramp belongs to the passengers, company employees or guests, and therefore is not suspect. Many general aviation and some airline ramp areas are virtually unsecured. Modern, long-range jet airplanes operated by many corporations could be vulnerable to hijack by terrorists, or executives could be taken hostage for ransom.

Fueling Practices

Many potential accidents and injuries are created by the negligence of the operator's own personnel or by their contract vendors, such as caterers and fuelers. For example, fuelers have been observed locking down the deadman control on the fueling truck and leaving the area for a period of time. Over-pressurization of airplane wing tanks has caused structural damage when automatic shutoff systems have malfunctioned and the fueling was not being monitored. Although most operator manuals state that a mechanic or crew member shall observe and direct refueling activities, we have learned that this responsibility is often ignored.

Quality control procedures to assure that fuel going into the aircraft is free of any contamination is also the responsibility of the operator. Many operators have been lax in monitoring the quality control checks of fuel purchased for their aircraft. One operator's underground fuel tank used for turbine fuel had not been inspected for more than 40 years and had actually floated out of the ground on at least two occasions. The fuel vendor personnel had never been trained on quality control procedures and the fuel truck in use was actually a dump truck which had been converted by installing a tank, pump and filter.

An example of an employee taking action without thinking of the potential consequences was observed during the audit of a cargo operation involved in transporting bulk gasoline in tanks installed in the airplane cabin. During a ground loading operation, an outside hose connection seal failed under pressure and sprayed a heavy mist of raw fuel in a fan-shaped pattern onto the fueler and the ramp. Instead of shutting off the pump, one fueler asked a man in the aircraft to throw him some wrenches to tighten the seal; he tossed two steel wrenches onto the gasoline-soaked area of the concrete ramp. The FSF audit team sprinted across the ramp away from the potential conflagration when the wrenches were tossed onto the concrete ramp. Fortunately, the wrenches did not spark on contact or the fuel could have ignited, the man on the ramp could have been engulfed in flames and the airplane could have been destroyed.

Cargo Handling

Potential hazards have also been observed involving bulk loading of cargo where loading personnel did not install adequate cargo restraint straps. Although flight crew members were tasked with the responsibility to inspect the load and restraint system, this was frequently observed to be only a cursory check. Bulk cargo loading and restraint is not adequately monitored by some airlines. In one instance, the operator's engineering office had designed a proper system of nets and straps. On-site observations disclosed that these devices were not being used and a mixture of inadequate ropes and straps were used instead.

Hazardous Materials

Several operators had not provided adequate safeguards for transporting hazardous materials. Air carriers are required by most regulatory authorities to have adequate training and control programs for shipping hazardous materials. Most have been found in compliance with these regulations; however, in some less-sophisticated international operations we discovered the handling of hazardous materials to be marginal with little oversight by the authorities. Although most carriers have some manuals with information relative to this subject, the understanding and compliance at the working level was found to be inadequate due to the absence of proper training and supervision.

A comprehensive hazardous materials program must include a thorough training of loading personnel and flight crews in areas such as:

- Material identification and labeling
- Loading and combination limitations
- Freight forwarder responsibilities
- Emergency reaction to spills or mishandling

Most corporate operators have adopted a policy stating that no hazardous materials will be carried onboard aircraft. In actual practice however, we have found that some operators do carry hazardous materials, but have not recognized them as such. This is most common for operators involved in oil field activities where passengers may be carrying items such as core samples, chemicals or test equipment which fall into the hazardous material category.

Aircraft, Equipment and Facilities

Workplace Safety

FSF audit teams have observed a general improvement in the standards of safety in the workplace. More commonly used equipment, such as ladders and workstands, have shown a steady improvement, due in part to the influence of such organizations as the U.S. Occupational Safety and Health Administration and its counterparts in other countries. Deficiencies most often found include:

- Lack of clear access to portable fire extinguishers
- Improper portable fire extinguisher type for most-likely fire risk
- Inadequate eye-wash stations
- Lack of a full-body shower facility in the work area
- First aid kit improperly maintained
- Lack of first aid training
- Lack of fire drills or emergency exercises

Personal Safety

One problem repeated in many small operations is that of a single maintenance technician working alone, usually in a late night situation after the remainder of the facility is closed. One corporate operator found a unique solution to monitor the well-being of a lone worker by using the motion detection capability of the security system to alert a central security station if the technician did not move within any ten minute period.

Other operators however, have not found a suitable solution for this situation and it continues to be a hazard to personnel safety as well as representing a potential risk to equipment and facilities. This type of risk was graphically demonstrated several years ago when a lone cleaning employee accidentally ignited cleaning fluid and the ensuing fire destroyed the aircraft and hangar.

Sometimes there is a lack of concern for flight crew comfort and safety in cargo operations. Some operators lose sight of the needs of the crew when passengers are not involved. Ex-passenger aircraft converted for bulk cargo operations have been found lacking in crew rest and comfort facilities, draft protection, proper stowage of required equipment, etc.

Some crews were inadequately trained to observe and direct cargo loading and were under inferred pressure to accept less than adequate load-restraint and tie-downs of their load.

More serious is the lack of proper tie-down and load-restraint equipment for bulk-loaded cargo. Some crews were inadequately trained to observe and direct cargo loading and were under inferred pressure to accept less than adequate load-restraint and tie-downs of their load. Many of the loads being carried would have penetrated the cockpit in the event of a deceleration accident.

Sub-contracting by large cargo operators to small operators tends to produce a competitive situation. In one company's zeal to compete, standards of cockpit instrumentation and configuration were eroded. The cockpit instrumentation of one operator was found to be marginal for night operations in instrument meteorological conditions. Smoke detectors and fire protection devices for the cabin and cargo hold were also determined to be substandard for the risks involved in these converted aircraft.

Maintenance Stores and Shops

The stores areas of most audited facilities have been found acceptable. The most common deficiency has been inadequate storage facilities for flammable solvents, paints and lubricants. The audit teams inspect facilities from a "what if" viewpoint. Many items have been identified that were not previously considered potential hazards by the operator. Few of them have ever experienced a fire or serious incident in their maintenance facilities. Unsecured high-pressure storage cylinders, ungrounded electrical equipment, untested hoisting equipment, trip-and-slip hazards, etc., are often overlooked as potential causes of personal injury or property damage.

For example, a 20-pound CO_2 fire extinguisher on the edge of a ramp was accidentally knocked over. The neck broke when it struck the curbing around the fueling facility, and the extinguisher bottle became a powered missile. After spinning around a few times it launched across the ramp and actually became airborne, narrowly missing an aircraft being fueled as it ricocheted off the ramp again. It finally struck a tow-tug more than 100 feet away.

This extinguisher could have ruptured an above-ground fuel tank, caused the loss of an airplane or injured personnel on the ramp. The replacement extinguisher was secured to a low post on the edge of the fueling unit in a quick-release clamp. It was available in an emergency, but it was securely fastened until it was needed.

The single most common item found in maintenance shops is inadequate eye protection at cutting and grinding tools. In many cases, the tool is placarded "use eye protection while operating," yet there were neither shields nor goggles available, and management had allowed the equipment to be used without enforcing the policy.

Another example of the "what if" circumstance was brought to light in reviewing a new hangar facility not yet occupied by the operator. It was determined that the vertical fin door above the main hangar doors had no manual backup for the electrical operation, thus exposing the operator to trapping the aircraft in the hangar in the event of power failure or malfunction of this single component.

Corporate Aircraft Standards

When initiating an audit of a corporate operator, the FSF audit team reviews why each corporation has chosen to establish an aviation department. In most cases, we have learned that the corporation desires transportation for executives at a standard of convenience and safety equal to or better than that available with scheduled airlines. With that goal in mind, the team reviews the equipment and procedures, and makes whatever recommendations may be appropriate to maximize the opportunities to attain that goal.

Nearly every potential hazard is known and identified by someone, but for whatever reason has not been communicated (or was communicated but not acted upon) to the individual capable of correcting it.

Although the audit team usually finds that the avionics, navigation and cabin amenities are outstanding, they often discover that some basic safety items have been overlooked. Among those items that have been cited as less than airline standard are:

- Interior material flammability and toxic smoke standards
- Lack of Halon portable fire extinguishers
- Use of undesirable dry powder portable extinguishers in the cabin
- Lack of portable oxygen bottles with supplemental medical capability
- Lack of restraint for galley items and equipment
- Inaccessibility of emergency and ditching equipment
- Differences in cockpit configuration and the location of cockpit and cabin emergency equipment between aircraft of the same type in the operator's fleet

Summary

Of all the lessons learned in conducting these audits, a single factor appears in nearly every instance: communication. The lack of communication or the mis-interpretation of a verbal or written communication, is all too frequently the underlying cause of an accident or incident. Nearly every potential hazard is known and identified by someone, but for whatever reason has not been communicated (or was communicated but not acted upon) to the individual capable of correcting it.

Appendix

You may wish to adapt the guidelines presented in this manual to your organization's specific needs, expand your internal audit capability or revise operating policies procedures, by reviewing additional material.

Other aviation organizations have developed guidelines for conducting internal audits and some of them are listed below:

"A New Look at Accident Contributors and the Implications of Operational and Training Procedures." Richard L. Sears. Boeing Commercial Airplane Company. *Proceedings of FSF's 38th International Air Safety Seminar*. 11/4-7/85. Boston, Mass., U.S.

"A Safety Audit Structure for Airlines." (Doc.Gen/2875). International Air Transport Association. 2000 Peel St., Montreal, Quebec, Canada H3A 2R4

"Assuring Value from Independent Safety Audits." Noel G. Preston. *Hospital Aviation*. June 1989.

"Aviation Safety Assistance Program Safety Surveys as Conducted by the Flight Safety Foundation." Presentation to Air Carrier Committee of the National Air Transportation Association.

"Awareness: Safety's Challenge." Jaap Boom. KLM-Royal Dutch Airlines. *Proceedings of FSF's 34th International Air Safety Seminar.* 11/9-12/81. Acapulco, Mexico.

"Control of Crew Caused Accidents." L.G. Lautman & P.L. Gallimore. Boeing Commercial Airplane Company. *Boeing Airliner*, April-June 1987.

"Flight Standards Internal Evaluation Guide." Working paper prepared under contract No. DTFA01-88-C-00064 for U.S. DOT FAA. Washington, D.C. July 1989.

"Helicopter Safety Program Management." Kenneth K. Woolnough. Helicopter Association International. *Proceedings of FSF's Regional Aviation Operations Safety Workshop*. 11/26-27/84. Rio de Janerio, Brazil.

"How to Initiate a Safety Awareness Program." J.S. Ross. Qantas Airline. *Proceedings of FSF's 31st International Air Safety Seminar.* 11/6-9/78. Caracas, Venezuela.

"How to Investigate and Report Ground Accidents". Donald N. Black. PAA. *Proceedings of FSF's 31st International Air Safety Seminar.* 11/6-9/78. Caracas, Venzuela.

"How to View Loss and Accident Prevention." Patrick Harnist. VIASA Airlines. *Proceedings of FSF's 31st International Air Safety Seminar.* 11/6-9/78. Caracas, Venzuela.

"IATA Checklist for Auditing Quality in Engineering and Maintenance Organizations." DOC.GEN/2700. July 1988. International Air Transport Association.

"Incorporating a Safety Program into the Management Structure of a Flight Department." Stephen S. Lamont. 195 Broadway Corporation. *Proceedings of FSF's 26th Corporate Aviation Safety Seminar.* 03/29-31/81. Denver, Colorado.

"Organizing for Safety — Making a Safety Program Work." Capt. L. Homer Mouden. *Proceedings of FSF's South American Regional Aviation Operations Safety Workshop.* 06/8-10/82. Rio de Janerio, Brazil.

"Organizing for Safety — The South American Experience." Hortencio G. Morsch. VARIG Airlines. *Proceedings of FSF's South American Regional Aviation Operations Safety Workshop.* 06/8-10/82. Rio de Janerio, Brazil.

"Responsibilities for Conducting Accident Prevention Programs." Lawson C. White. IATA. *Proceedings of FSF's 31st International Air Safety Seminar.* 11/6-9/78. Caracas, Venzuela.

"The Safety Audit." Arnold Lewis. *Business and Commercial Aviation.* July 1979.

"Use of Quality Assurance Audits as a Practical Tool in Civil Aviation Flight Safety Inspection Work." Arne Leibing. Joint Scandinavian Flight Safety Office, Stockholm. *Proceedings of FSF's 39th International Air Safety Seminar.* 10/6-9/86. Vancouver, Canada

Reports Received at FSF Jerry Lederer Aviation Safety Library

Reference

Advisory Circular 20-135, 2/6/90, Powerplant installation and propulsion system component fire protection test methods, standards, and criteria. — Washington, D.C.: U.S. Federal Aviation Administration, February, 1990. 15p. in various pagings.

Key Words
1. Airplanes — Engines — Fire Protection.
2. Airplanes— Powerplants — Fire Protection.

Summary: This Advisory Circular (AC) provides guidance for use in demonstrating compliance with the powerplant fire protection requirement of the Federal Aviation regulations (FAR). Included in this document are methods for fire testing of materials and components used in the propulsion engines and APU installations, and in areas adjacent to designated fire zones, as well as the rationale for these methods.

Advisory Circular 20-136, 3/5/90, Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning. — Washington, D.C.: U.S. Federal Aviation Administration, March, 1990. 40p. in various pagings, charts.

Key Words
1. Lightning Protection.
2. Airplanes — Electrical Equipment.

Summary: This advisory circular (AC) provides guidance on how to comply with the requirements of the Federal Aviation Regulations (FAR) relating to protection of aircraft electrical systems from the effects of lightning. It describes acceptable methods of compliance with the regulations applicable to all categories of airplanes and rotorcraft.

Advisory Circular 61-89C, 3/6/90, Pilot Certificates: Aircraft Type Ratings. — Washington, D.C.: U.S. Federal Aviation Administration, March, 1990. 13p. in various pagings, charts.

Key Words
1. Air Pilots — Certificates.
2. Airplanes.

Summary: This advisory circular (AC) provides pilot certificate designations adopted by the Federal Aviation Administration for aircraft type ratings. It incorporates all revisions to previous listings, including new designations for aircraft type certificated as of June 1, 1989.

Advisory Circular 39-6N, 3/15/90, Announcement of Availability — Summary of Airworthiness Directives. — Washington, D.C.: U.S. Federal Aviation Administration, March, 1990. 5p. in various pagings.

Summary: This Advisory Circular (AC) provides information concerning how to obtain the latest edition of subject publications. An airworthiness directive (AD) contains information regarding an unsafe condition which exists in an aircraft, aircraft engine, propeller or appliance when that condition is likely to exist or develop in other products of the same type design. No person may operate a product to which an AD applies, except in accordance with the requirements of the AD. All ADs are summarized and published in both paper copy and microfiche editions.

Advisory Circular 91-45C, 2/1/90, Waivers: Aviation Events. — Washington, D.C.: U.S. Federal Aviation Administration, February, 1990. ix, 53, 32p. in various pagings.

Key Word
1. Air Shows.

Cancels AC 91-45B, Waivers — Air Shows/Contests/Races, dated August 5, 1981.

Summary: This Advisory Circular (AC) provides prospective aviation event sponsors and other interested parties with information necessary to assist in planning and conducting a safe aviation event. In addition, it provides information on the application process for a Certificate of Waiver or Authorization.

Reports

Airline Scheduling: Airlines' On-Time Performance. Report to Congressional Requesters / U.S. General Accounting Office. — Washington, D.C.: [U.S. General Accounting Office, P.O. Box 6012, Gaithersburg, MD 20877 U.S., Telephone: (202) 275-6241], June, 1990. Report GAO/RCED-90-154; B-197119. 19p.

Key Words
1. Airlines — Time-Tables — United States.
2. Air Travel — Statistics — United States.
3. Aeronautics, Commercial — Passenger Traffic — United States.
4. Scheduling (Management).

Summary: "GAO assessed whether (1) airlines had increased scheduled flight time to keep reported delays at a minimum in response to the Department of Transportation's (DOT) on-time performance reporting requirement and (2) DOT verifies that flights omitted from the on-time data because of mechanical problems have in fact experienced mechanical problems. To address these issues, GAO interviewed DOT, Federal Aviation Administration (FAA), and airline industry officials, and analyzed statistical data maintained by DOT on airlines' on-time performance. ... To improve on-time performance, airlines adjusted scheduled time and streamlined flight operations. However, the data do not show a trend toward better on-time performance... . While DOT does not routinely verify flights affected by mechanical problems, it has investigated this issue. Beginning in 1988, DOT's Office of Consumer Affairs surveyed flights omitted from the on-time data."

Aviation Safety for ATC and Airport Personnel / Aage Roed. Forslov, Sweden: Aeroroed Consult, November 1989. vii, 100p.

Key Words
1. Aeronautics — Safety Measures — Handbooks, Manuals, etc..
2. Aeronautics — Accidents — Prevention.
3. Aeronautics, Commercial — Safety Measures.

Table of Contents: Transport Aviation Development — the Design of a Jet Transport — Aerodynamics, Performance, Stability and Control — Aircraft Loads — Practical Operations Problems — Accident Prevention and Investigation.

Summary: This book has been written to give air traffic controllers and airport personnel a basic understanding of aviation safety problems. In many of the hundreds of accidents I have investigated, I have found that mishaps could have been prevented had only those involved had a better understanding of the more common safety problems. ... Even the best trained controller or airport employee will make mistakes if he does not understand the pilots' problems.

Aviation Occurrence Report — Canadian Airlines International Limited, Boeing 737-275C, C-GFPW, Near Prince George Airport, British Columbia, November 24, 1987. — Ottawa: Canadian Aviation Safety Board, February 20, 1990. Report CASB 87-P74128. 46p. in various pagings. [Communique #06/90 to be released June 13, 1990].

Key Words
1. Aeronautics — Accidents — 1987.
2. Aeronautics — Accidents — Navigation Errors.
3. Aeronautics — Accidents — Cockpit Design.
4. Aeronautics — Accidents — Human Factors.
5. Aeronautics — Accidents — Pilot Training.
6. Airplanes — Cockpits — Warning Systems.
7. Canadian Airlines International — Accidents — 1987.
8. Cockpit Resource Management.
9. Ground Proximity Warning System (GPWS).

Note: This report was completed by the CASB just prior to the changeover in responsibilities to the Canadian Transportation Accident Investigation and Safety Board on March 29, 1990. Responsibility for making the report public and processing any associated safety recommendations rests with the new board.

Summary: The aircraft, with 96 persons on board, was on an instrument approach at Prince George. While the aircraft was flying in cloud, the ground proximity warning system (GPWS) twice sounded an alert. After the first alert, the crew climbed to a safe altitude. They believed the first warning was invalid and resumed their descent. Four minutes later, the airport controller warned the flight crew that the aircraft was well east of the approach track and at about the same time, the GPWS sounded again. The aircraft again climbed to a safe altitude. Another approach was flown and the aircraft landed without incident. It was determined that the captain mis-selected the VHF navigation radio transfer switch and the pilots did not confirm that the selection had the desired results, nor did they use all the available navigation aids during the approach. Contributing factors were the inadequate visual indicators of the source of the navigation information, the crew's lack of familiarity with the cockpit configuration, and inadequate training and operational guidance by the company. Also, air traffic control did not ensure timely notification to the crew of the aircraft's deviation from course. CASB issued Recommendations 90-53 through 90-56 on the subjects of cockpit resource management, navigation systems, cockpit voice recorder (CVR) recording time, and standardization of cockpit configurations as a result of this incident. ♦

Aviation Statistics

An Inferential Analysis of Safety Performance of U.S. General Aviation Fixed-wing Aircraft 1978-1987

by
Shung C. Huang
Statistical Consultant

From 1978 to 1987, U.S. general aviation fixed-wing aircraft (excluding gliders) were involved in 29,056 accidents, 5,284 of which were fatal and accounted for 10,734 fatalities. During the same period, fixed-wing aircraft logged a total of 309,739,000 flight hours, an average of 31 million hours per year.

The source of accident data used for this analysis is the U.S. National Transportation Safety Board (NTSB) annual review of general aviation aircraft accidents; the exposure data source is the U.S. Federal Aviation Administration (FAA) annual General Aviation Aircraft Activity and Avionics Survey. Since the formats of presenting the annual accident data in the NTSB annual review were not identical to the FAA report, some adjustments to accident data formats were made in order to fit the purpose of this study. In the analysis of the accident types (first occurrence), only the FAA data for the years from 1983 to 1987 were used because the similar data in the NTSB annual review for the years prior to 1983 were not available.

Statistical techniques, including frequency distribution and Chi square distribution, were applied in this inferential analysis to investigate the safety performance of general aviation aircraft by the following aircraft powerplant types: single-engine reciprocating, multi-engine reciprocating, turboprop and turbojet. The object is to ascertain whether the difference in safety performance of aircraft by type of engine is statistically significant.

Analysis

The annual total and fatal accident rates of U.S. general aviation fixed-wing aircraft for the 1978-1987 period is shown in Figure 1. The overall trends for both indicate a slight improvement. The total accident and fatal accident rates by aircraft engine type are shown in Figures 2 and 3. Although there is a slight decreasing trend in total and fatal accidents involving reciprocating-engine aircraft, the trends for turbine-engine aircraft show no improvement.

Table 1 presents total accidents, fatal accidents, fatalities and rates by aircraft type. Note that the single-reciprocating-engine aircraft were involved in more than 88 percent of total accidents but accounted for only 78 percent of the total flight hours, whereas turbojet-engine aircraft were involved in fewer than one percent of total accidents but accounted for more than four percent of the total flight hours. As a result, the total accident rate for single-reciprocating-engine aircraft in terms of flight time was 11 times higher than for turbojets, four times higher than turboprops and almost double that of multi-reciprocating-engine aircraft. Although the fatal accident rate for single-reciprocating-engine aircraft was still higher than that for turbine-engine aircraft, the ratio of single-reciprocating-engine aircraft involving fatal accidents was smaller; in terms of fatal accidents as a percent of total accidents, the ratio for single-reciprocating-engine aircraft was one in six, as against one in three for multi-reciprocating-engine and turbine-engine aircraft. In other words, once an accident occurred, the chances of fatalities for multi-reciprocating-engine or turbine-engine aircraft

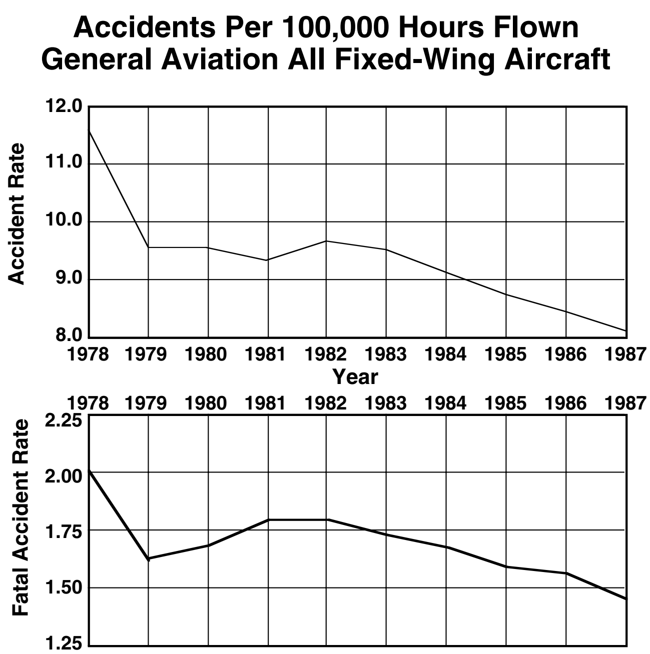


Figure 1

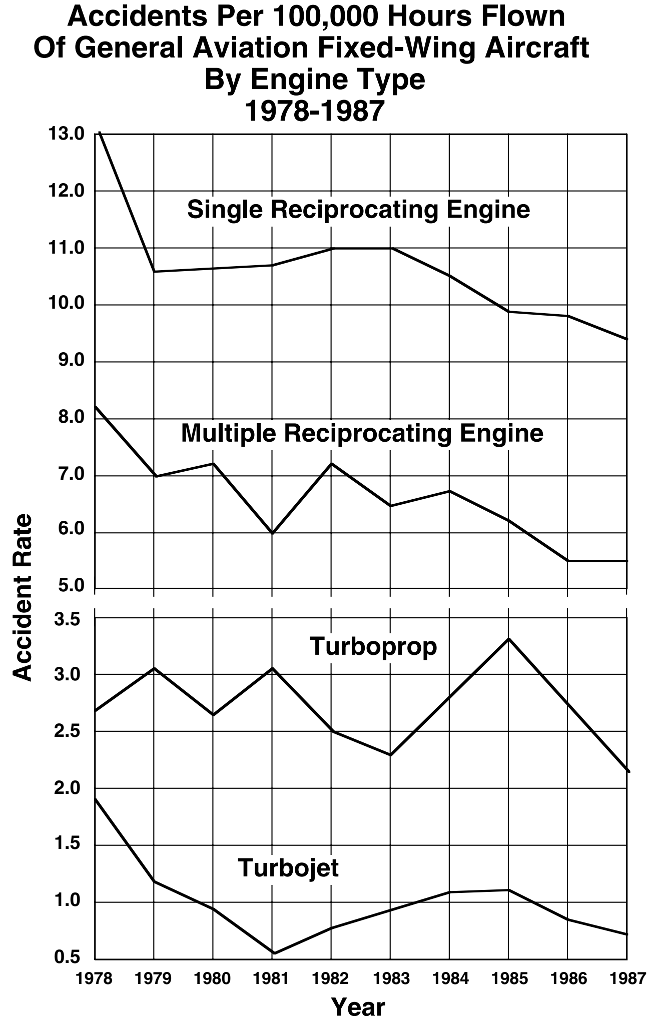


Figure 2

are almost 100 percent higher than for single-reciprocating-engine aircraft.

Based upon past experience and for the purpose of this analysis, it is assumed that there exists a linear relationship between exposure and the frequency of accidents. In other words, once an aircraft is in operation, there is a risk of accident. The longer an aircraft is in operation, in terms of aircraft hours flown, the probability for that aircraft involving an accident is higher. Therefore, the frequency of aircraft involvement in accidents in a function of aircraft operations in terms of time.

Table 2 presents the qualitative analysis of safety performance by the four different engine types.

The value "F" represents the actual frequency of total accidents. The value "f" is the theoretically expected frequency of total accidents which is computed based upon the ratio of the aircraft hours flown for each type of aircraft to the total hours for all types times the total accidents for all types.

If F = f, the observed frequency and expected frequency of accidents agree exactly. If (F-f) > 0, the actual occurrence of accidents is greater than number of accidents which are expected to occur; if (F-f) < 0, the actual occurrence of accidents is less than the expected frequency.

Given that the Chi square (F-f)2/f probability value is greater than the critical value at less than 0.001 significant level (10.84), it can be inferred that the difference of the safety performance of the four types of aircraft is statistically significant. Single-reciprocating-engine aircraft were high in accident occurrences while turbine-engine aircraft were low in both total accidents and fatal accidents.

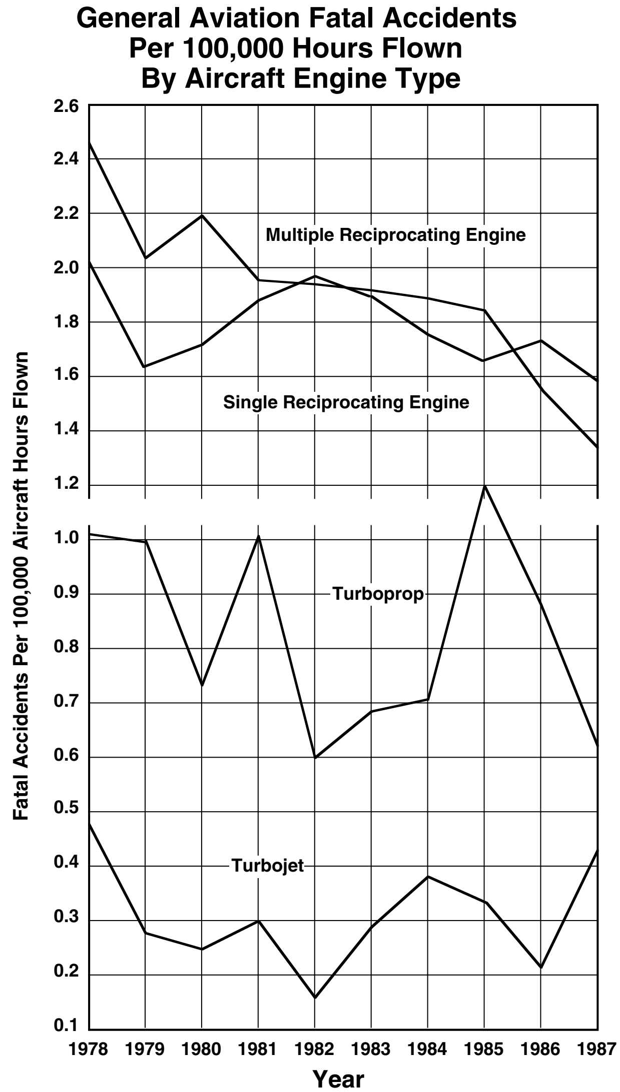


Figure 3

Table 1 - General Aviation Fixed-wing Aircraft Accidents, Fatal Accidents and Rate By Type of Aircraft Engine 1978-1987

	Single-recip Engine	Multi-recip Engine	Turboprop Engine	Turbojet Engine	Total
Total Accidents	25,791	2,746	390	129	29,056
Percent of Total Accidents	88.70	9.45	1.34	.44	100.0
Fatal Accidents	4,315	807	122	40	5,284
Percent of Total Accidents	76.60	18.70	3.55	1.45	100.0
Fatalities	8,222	2,007	381	124	10,734
Aircraft hours flown (000)	241,057	41,145	14,394	13,143	309,739
Percent of Total	77.89	13.25	4.63	4.23	100.0
Fatal Accidents as percent of Total Accidents	16.7	29.4	31.3	31.0	18.7
Fatalities per Fatal Accident	1.9	2.5	3.1	3.1	2.03
Total Accidents per 100,000 Aircraft Hours	10.70	6.67	2.71	0.98	9.38
Fatal Accidents per 100,000 Aircraft Hours	1.71	1.96	0.85	0.30	1.71

Table 2 - General Aviation Fixed-wing Aircraft Accidents and Fatal Accidents by Aircraft Type

	Single-recip Engine	Multi-recip Engine	Turboprop Engine	Turbojet Engine	Total
Aircraft Hours Flown (000)	241,957	41,145	14,394	13,143	310,639
Percent of Total Accidents	77.89	13.25	4.63	4.23	100.0
Total Accidents (F)	25,791	2,746	390	129	29,056
Expected Accidents (f)	22,631	3,850	1,345	1,229	29,056
(F - f)	3,160	-1,104	-955	-1,100	
(F - f)2/f	453	443	1,284	984	3,164
Fatal Accidents (F)	4,315	807	122	40	5,284
Expected Fatal Accidents (f)	4,116	700	245	243	5,284
(F - f)	199	107	-123	-203	
(F - f)2/f	9.62	16.35	61.75	169.58	257.3

(“>” means greater than; “<” means less than)

However, once a turbine-engine aircraft is involved in an accident, the chance of the accident involving a fatality would be much greater than in a single-reciprocating aircraft as shown by the Chi square values along the bottom row of Table 2.

Tables 3 and 4 present the results of

Table 3 - An Analysis of General Aviation Accidents by Type of First Occurrence Calendar Year 1983-1987

Type of First Occurrence	Single-recip Engine		Multi-recip Engine		Turboprop		Turbojet		Total Accidents
	F	f	F	f	F	f	F	f	
In Flight Collision w/Object	659	648	59	73	16	13	6	6	740
In Flight Collision w/Terrain	523	571	102	64	17	11	10	6	652
On Ground Collision w/Object	248	252	26	28	11	4	2	3	287
On Ground Collision w/Terrain	179	175	15	20	4	3	2	2	200
In Fight Encounter w/Weather	761	767	93	86	13	15	9	8	876
On ground Encounter w/Weather	62	55	1	6	0	1	0	1	63
Mid-air Collision	148	154	13	17	8	3	7	2	176
Loss of Power	661	642	65	72	3	12	4	7	733
Loss of power (total) Mech Failure /Malfunction	514	479	21	54	8	9	4	5	547
Loss of power (partial) Mech Failure/Malfunction	206	226	46	25	4	4	1	2	257
Loss of power (total) Non-Mech Failure/Malfunction	1,041	1,020	106	114	12	19	3	9	1,162
Loss of power (partial) Non-Mech Failure/Malfunction	161	182	43	20	3	4	1	2	208
Gear Collapsed	22	30	12	3	0	1	1	1	35
Main Gear Collapsed	52	74	27	8	5	2	1	1	85
Nose Gear Collapsed	51	69	25	8	1	1	2	1	79
Complete Gear Collapsed	23	46	22	5	5	1	3	1	53
Forced Landing	27	28	3	3	1	1	2	1	33
Hard Landing	495	475	43	53	2	9	2	5	542
Nose Over	161	144	1	15	0	3	0	2	164
Undershoot	124	126	14	15	4	2	2	1	144
Overrun	263	294	54	33	9	6	10	3	336
Airframe/Component/System Failure/Malfunction	361	395	68	44	13	8	9	4	451
Fire	66	76	19	7	1	2	0	1	86
Abrupt Maneuver	64	85	31	10	2	2	1	1	98
Loss of Control-Inflight	1,196	1,036	72	127	19	22	10	12	1,297
Loss of Control-On ground	1,156	1,075	50	121	16	21	6	11	1,228
Total	9,224		1,031		179		98		10,532
Accidents as Percent of Total Accidents	87.58		9.79		1.70		.93		100.0

Chi square analysis for the four aircraft categories by type of accident. The objective of this analysis is to investigate the difference of accident involvement of the four aircraft categories by accident type. For this purpose, two Chi square values were used to create a rating scheme as follows to identify the extent of accident involvement of a particular type of aircraft:

Chi square = 3.82(P = .050) and Chi square = 10.84 (p = .001)

If (F-f) is negative and the (F-f)2/f>10.84, a very low (VL) rating is given; if (F-f) is positive and the (F-f)2/f>10.84, a very high (VH) rating is given; if (F-f) is negative and 10.84>(F-f)2/f>3.82, a low (L) rating is given; if (F-f) is positive and 10.84>(F-f)2/f>3.82, a high (H) rating is given; and if (F-f)2/f<3.82, a rating average (A) is given.

For example, the (F-f) for multi-reciprocating-engine aircraft involving collision with terrain in flight is positive and (F-f)2/f is 22.5 which is greater than 10.84, a rating of VH (very high) is given. Under this scheme, it should be noted that the very high and very low ratings indicate that the difference would have a probability P = .001 of occurring by chance. Although the probability of "high of low" ratings is defined between 0.050 and .001, some may have probability of less than .001.

Where the "F" (observed accidents) represents total accidents that actually occurred; the "f" (expected accidents) is the number of accidents expected to occur which is obtained by: (Total accidents of each accident type) X (percent of accidents of each aircraft type involved in total accidents).

The results reveal that, in general, multi-reciprocating-engine aircraft are rated very high in accidents relating to landing gear but very low in accidents related to loss of control in flight as well as on ground. Turbine-engine aircraft are rated high or very high for midair collision accidents but low in inflight collision with ground or terrain. It appears that high-speed aircraft are susceptible to overrun accidents because the aircraft with more power and high speed are rated very high for overrun accidents, while the aircraft with single-reciprocating engines are rated average in all these accidents. ♦

Table 4 - An Analysis of General Aviation Accidents by Type of First Occurrence Calendar Year 1983-1987

In Flight Collision w/Object	A	L	A	A
In Flight Collision w/Terrain	L	H	A	A
On Ground Collision w/Object	A	A	VH	A
On Ground Collision w/Terrain	A	A	A	A
In Fight Encounter w/Weather	A	A	A	A
On ground Encounter w/Weather	A	L	A	A
Mid-air Collision	A	A	H	VH
Loss of Power	A	A	A	A
Loss of power (total) Mech Failure /Malfunction	A	VL	A	A
Loss of power (partial) Mech Failure/Malfunction	A	VH	A	A
Loss of power (total) Non-Mech Failure/Malfunction	A	A	A	L
Loss of power (partial) Non-Mech Failure/Malfunction	A	VH	A	A
Gear Collapsed	A	VH	A	A
Main Gear Collapsed	L	VH	H	A
Nose Gear Collapsed	L	VH	A	A
Complete Gear Collapsed	VL	VH	VH	H
Forced Landing	A	A	A	A
Hard Landing	A	A	L	A
Nose Over	A	VL	A	A
Undershoot	A	A	A	A
Overrun	A	VH	A	VH
Airframe/Component/System Failure/Malfunction	A	VH	A	H
Fire	A	VH	A	A
Abrupt Maneuver	L	VH	A	A
Loss of Control-Inflight	A	VL	A	A
Loss of Control-On ground	H	VL	A	A

(The Rating of accident involvement is based on the Chi square value computed as follows: Chi square = (F-f)2/f)
A — average H — high L — low VH — very high VL — very low

Accident/Incident Briefs

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

Flaps Came Up Instead of Gear

BAC One Eleven: No damage. No injuries.

The aircraft was taking off on a segment from Frankfurt, Germany, to Birmingham, England. As the aircraft was passing through 100 feet, the captain called for gear retraction and the first officer raised the flaps instead.

Full power was immediately selected. Since the aircraft was already above the minimum flap speed of 159 knots, it was able to continue the climbout normally. The flight was completed without further incident.

Discussions with the first officer regarding the inadvertent flap retraction revealed that the previous turnaround had been a hectic one because of technical defects with the aircraft and a requirement to reroute the upcoming flight segment due to air traffic control restrictions. Additional problems occurred when there was an intermittent engine indication defect during the takeoff run when the aircraft had reached a speed of 100 knots. The resulting pressures resulted in the first officer centering his attention on monitoring the engine instruments and inadvertently selecting flaps up instead of raising the landing gear.

Inadvertent Flight Into Turbulence

Boeing 767: No damage. Moderate injuries to one.

The air carrier aircraft had been en route at flight level 300 between Brisbane, Australia, and Christchurch, New Zealand. Approaching its destination, the aircraft was descending through flight level 140 at an indicated airspeed of 320 knots when severe turbulence was unexpectedly encountered.

The captain immediately reduced airspeed by selecting full speed brake and leveling off. He advised the cabin crew members who were not yet strapped in for the landing to secure themselves. Because there had been no warning of the turbulence, several unrestrained passengers and all of the cabin crew were thrown about the cabin. Three passengers and six cabin crew members were later admitted to the hospital for observation. One passenger had received back and neck injuries. The aircraft was checked for turbulence damage but no structural problems were found.

Weather at the time of the incident included a low pressure system passing south of New Zealand and a cold front with strong northwest winds was approaching from the southwest. Surface wind at Christchurch was gusting to 25 knots. The aircraft had been descending in instrument meteorological conditions through stratiform clouds with no significant weather returns evident on radar. The major portion of the turbulence lasted five seconds, during which approximately eight distinct gust loadings occurred.

At the time of the incident, the aircraft was flying on a magnetic course of 110 degrees, with a mountain and a pass approximately six nautical miles on the left. General height of the terrain below and behind the aircraft was about 6,000 feet.

Who Has the Runway?

Airbus A320 and Mooney lightplane (unspecified model): Substantial damage to both aircraft. No injuries reported.

The air carrier aircraft was completing an instrument landing system (ILS) approach to runway 26 at a French airport. It was daylight but the visibility was poor with a reported runway visual range of about 1,000 feet.

As it rounded out for touchdown, the widebody aircraft struck the lightplane that had been lined up on the runway ready to take off. During the subsequent rollout, the air carrier's nose gear, which had been damaged during the collision, collapsed. The aircraft slid to a stop on its nose, sustaining substantial damage as the engine cowlings struck the ground. The 138 passengers and six crew members on the A320 evacuated with no reported injuries; there was no indication of injuries to the occupants of the Mooney.

Air Taxi
Commuter

Fickle Winds Fracture Airplane

Swearingen SA 227: Substantial damage. No injuries.

The two crew members were the only occupants aboard as the aircraft was being returned to home base from a charter flight in New Zealand. The reported surface winds at the destination were from 130 degrees at 30 knots. Because the airport was noted for turbulence with strong easterly wind conditions, the pilots anticipated a rough landing approach and maintained a high approach profile.

The pilot made a wide right base leg for runway 20 and turned final at 1,500 feet, slightly above the glide path as shown on the approach slope indicator. The turbulence was as expected, at times requiring full control deflection to keep the aircraft under control. The reference speed was 103 knots but the approach was flown at 125 to 130 knots indicated airspeed. The aircraft crossed the runway threshold on glideslope and the pilot reduced the throttles to bring the airspeed back to the reference number. As the pilot began the flare at a height of about 30 feet, the aircraft rapidly sank and landed heavily to the right of the centerline.

Inspection revealed that the hard landing had resulted in damage to the left engine nacelle, cracks in the left landing gear leg and fuel leaks from the center wing tanks. Although none of them had blown out, all main gear tires were replaced as a precautionary measure. The aircraft's flight manual noted that the maximum demonstrated crosswind component was 20 knots.

Wet Runway Causes Grief

Fokker F.28: Aircraft destroyed. No injuries.

The aircraft had made a normal approach to the Argentinean airport. Weather was reported as wind from 150 degrees at 10 knots with visibility of a mile and a half in rain. The runway was wet.

After an uneventful touchdown on 4,900-foot-long runway 10, the aircraft failed to stop. It overran the runway and immediately entered an area of soft ground. Shortly after leaving the asphalt surface of the runway, the aircraft's nose gear and right main gear sank in the soft earth and were torn off. The aircraft came to rest 350 feet beyond the end of the runway and fuel spilled from a fractured right wing, ignited and caught fire. The 85 passengers and five crew members evacuated the aircraft quickly and no serious injuries were sustained. The aircraft did not fare so well, however, and was destroyed by the ensuing fire.

Abort after Liftoff

Lockheed JetStar 731: Aircraft destroyed. One fatality.

The aircraft had made an apparently normal takeoff from runway 09 at Miami International Airport, Florida, U.S., headed for Dallas, Texas. Reportedly, it was being operated as a ferry flight with three of its four engines operative. When the aircraft reached a height of 25 feet, the number two engine reportedly began registering an overheat condition. The pilot elected to abort the takeoff at that point and land on the remaining length of the runway.

After the aircraft touched down, the pilot could not stop it before it ran off the end of the runway. The aircraft traveled through a series of approach light fixtures and came to rest in a construction site approximately 1,000 feet beyond the lights. Fuel spilled from ruptured tanks, caught fire and the aircraft was destroyed. One crew member received fatal injuries in the accident.

Forgot to Refuel?

Beechcraft Model 60 Duke: Aircraft destroyed. Serious injuries to two.

The twin-engine business aircraft, with a crew of one and one passenger, was departing the Texas, U.S., airport in mid-morning. Weather included a low cloud base.

During climbout one engine failed — then the remaining engine also failed. The pilot attempted to accomplish a forced landing but struck a tree during touchdown. Neither propeller was feathered. The aircraft was destroyed by the impact and the two occupants aboard were both seriously injured.

There was no fire — no fuel was aboard.

Distraction Leaves Murphy at Controls

Piper PA-28-161 Warrior: Substantial damage. Minor injuries to one.

The aircraft was taking off from the New Zealand airport on a solo training flight. The wind was off the aircraft's nose 10 degrees from the right at five knots.

After the aircraft had accelerated to approximately 50 knots on the takeoff roll, the pilot shifted his attention momentarily to the radio. When he looked up again, he realized that the aircraft had turned about 30 degrees to the left. He attempted to straighten the aircraft with right rudder application but this did not prove effective and the pilot closed the throttle when a collision with a fence appeared inevitable.

The aircraft went though the fence, lost a wing and came to rest inverted. After some difficulty opening the door, the pilot was able to evacuate the aircraft with only minor injuries.

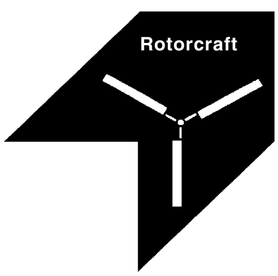
No defects were found with the nosewheel steering, wheels or brakes; although the left tire was worn through in one area it had not deflated. The rudder trim was found in the full left position. Skid marks found on the runway and grass beyond the point at which the aircraft had swung to the left indicated braking from the left wheel only. The pilot, a long-legged person, had adjusted his seat forward enough to reach the throttle easily. Investigators reasoned that when he quickly applied right rudder pedal to correct the left swing after he returned his attention from the radio, the pilot's right toe may have inadvertently applied left toe brake at the same time, exacerbating the swerve to the left.

Pull a Tiger's Tail And You Get Bit

Beechcraft 18: Aircraft destroyed. Fatal injuries to 10.

The twin-engine aircraft had taken off from an airport in Montana, U.S., for a flight to Idaho. There was a crew of one and nine passengers aboard.

Approximately 10 minutes after it had taken off, the aircraft made a low pass along the shore of a lake where a musical group had performed. Following that maneuver, it was seen to enter a steep climb and perform what appeared to observers as a hammerhead stall or a wingover. During the recovery, the aircraft struck trees in a 15-degree nose-down and 15-degree right-wing-down attitude. The aircraft was destroyed by impact and fire. All occupants were killed.



Downwind Turn Close to the Ground

Messerschmitt-Bolkow-Blohm BO 105: Aircraft destroyed. Fatal injuries to two.

The aircraft was on the way from Bay City, Michigan, U.S., to Saginaw in the late afternoon. There was a pilot and one passenger aboard. It was daylight and the winds were from 250 degrees at 18 knots with gusts to 23 knots.

Shortly after liftoff, the pilot made an abrupt, steep downwind turn at low altitude. The right landing skid and the main rotor blades struck the ground during the turn, causing the pilot to lose control of the helicopter. The aircraft impacted the ground out of control. The helicopter was destroyed by the impact and post-crash fire. Both occupants sustained fatal injuries.

Heavy Load Leads to Trouble

Bell 205A: Aircraft destroyed. Fatal injuries to one.

The helicopter was being used in a logging operation. The helicopter was observed to pick up three logs and begin to fly them to a drop site. The pilot made a radio call that the load was too heavy and that he was going to abort the lift.

The helicopter made a 180-degree turn and returned to the pickup point at a logging lane where the logs were released from the external load hook. At this point, the pilot uttered an expletive and the rotorcraft began to rotate rapidly to the right, rolled to the left and fell to the ground. The helicopter impacted in a 110-degree left wing down, level pitch attitude and was destroyed by the impact. There was no fire, but the pilot sustained fatal injuries. Investigation revealed that minimal rotational damage had occurred to the main rotor blades and that the main rotor hub had separated but was still inserted over the main rotor mast. ♦