Investigating the Management Factors In an Airline Accident

The significance of management's role in the sequence of events ending in accidents is examined and suggestions are advanced that the influence of management be included in accident investigations.

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The management factor in aircraft accident investigation has emerged as a relatively recent phenomenon, at least in civil aviation. The absence of a specific investigative protocol is only part of the reason. General lack of understanding of what constitutes safety/accident prevention management is prevalent throughout many parts of the aviation community.

This discussion essentially is a follow-up to two papers on accidents and management published previously. The first (1984) was a challenge to managements, airline or otherwise, to become more attentive to accident prevention management for reasons of potential personal liability of executives, as separate from corporate liability in the event of accidents.[1] The second (1988) was a discussion of management factors in aviation safety with a hint of possible directions to pursue in accident inquiries.[2] Since that time, accident prevention management has received significant endorsement from U.S. investigative and regulatory bodies. For example:

"Highest on my personal list [of airline safety efforts] is a corporate commitment to aviation safety in the form of a vigorous, viable and visible proactive flight safety program. … In addition to providing an organizational home for flight safety, management must also conduct other safety related activities… ." Dr. John Lauber, member, U.S. National Transportation Safety Board (NTSB).[3]

"I want to encourage executives of airline companies to monitor personally the safety of their operations as closely as they monitor their bottom line. … It means providing continuous review and oversight of policies, practices, procedures and systems to maximize safety. This may involve designating a safety auditor or setting up separate department reporting directly to the CEO (chief executive officer)." James Busey, administrator, U.S. Federal Aviation Administration (FAA).[4]

Some organizations have been proponents of improved safety management in recent years. The fact remains, however, that the investigation of accidents in civil aviation does not have a procedure or protocol that will encourage examination of management failures in a causal sense. For example, whereas the NTSB has never been bashful about criticizing the FAA, the airlines or manufacturers (the three principal managing agencies), its approach seems to be more oriented towards a specific shortcoming identified with individuals or a given organizational segment (e.g., pilots, operations, maintenance, design). The management system leading to the deficiency often goes unchallenged. That is another way of saying that examination of the agency or company's accident prevention efforts, or lack thereof, seems to take a back seat to establishing after-the-fact causation.

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A recent exception to this situation came from the NTSB in its examination of "Delta DFW-2." The occurrence of "Delta DFW-1" was the L-1011 windshear approach accident on August 2, 1985 at the Dallas/Ft. Worth airport, whereas number 2 was an attempted takeoff of a Boeing 727 with retracted flaps on August 31, 1988. In the earlier accident, the board did not examine the airline's safety management structure (it was examined in subsequent litigation).

In Delta DFW-2, the Board recommended that the FAA "initiate a joint airline industry task force to develop a directed approach to the structure, functions and responsibilities of airline flight safety programs with the view toward advisory and regulatory provisions for such programs at all Part 121 (relatively large, scheduled) airlines."[5] The FAA responded to the board's recommendation on April 12, 1990, when the administrator cited FAA's urging of the airlines to have an internal evaluation (audit) program and the FAA's strengthening of its own enforcement actions as a response in full to the board's recommendation.[6]

Review of the FAA's proposed evaluation advisory circular (AC)[7] reveals the FAA is really calling for an extension of its own inspection authority, not unlike, in principle, the "delegated option authority" applied to design certification at some manufacturers. Calling this initiative an audit program fails to address the safety meaning of the term.

Further indication that management factors investigation is an ad hoc procedure at best throughout the world rests in the absence of any management factor sections in existing civil aviation accident investigation manuals or in regulations such as International Civil Aviation Organization (ICAO) Annex 13.[8]

Accordingly, this discussion examines the significance of management's role in accident sequences of events, recognizing it has a role in all accidents. Suggestions are offered for some specific steps that could be accomplished to readily improve the situation.

Background to Management Factors In Mishap Occurrence or Prevention

Effective accident prevention can be linked inalterably to effective management. This precept will be found in the earliest safety textbooks that were developed in the industrial safety field. It also can be found in the attitudes and practices of some airlines as early as the late 1930s. W.A. Patterson, ultimately United's board chairman, was frequently cited for putting particular emphasis on safety to his senior management staff.[9] Some of the airline accident investigations in the 1930s identified so many air navigation problems and questions of investigation objectivity, that the Air Safety Board was formed in the United States along with the Civil Aeronautics Administration (CAA), the predecessors to today's NTSB and FAA. These were governmental management corrective efforts.

The earliest teachings in accident investigation at U.S.C. in the 1950s concentrated upon man, machine and environmental factors, and began to discuss safety programs.

The next decade saw the initial development of "Advanced Safety Management" and "Command" courses, first from the U.S. Air Force, then U.S. Navy, and later adopted by all U.S. military services. The classes were significant because they were comprised of higher ranking officers than the safety officers who implemented safety programs at the working level (including the investigation specialists). These ranking officers then had access to very senior commanding officers, something which would be somewhat difficult for the lieutenants.

These new safety programs were significant also because they forced those of us who were teaching the courses to approach accident prevention more from management's point of view than we had done previously. Appendix I, starting with what has been sometimes called the "5-M diagram," is an example of this. It portrays symbolically the overview role that management must play in accident prevention or, conversely, where causation may lie in the event of an accident. The Man-Machine-Medium (Environment) fundamentals were retained from the past to which another factor, Mission, was added. This was to emphasize that in a military or civil endeavor, admitted to or not, one does not practice safety professionally just to prevent injuries or death. The mission, be it delivering ordnance or providing a viable air transportation system, is an important piece of the safety package.

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Appendix I also shows the interrelationships of these various factors to stress and illustrates that one should not, for example, examine man or machine factors independently — the man-machine interface depicted by the overlapped areas between the two variables must be studied, too. Similarly, when one asks the question what most influences the combined Man-Machine-Medium-Mission, the answer most logically is Management; hence its top position.

What Is Real World Safety and Accident Prevention Management?

The foregoing description of management's role in accident prevention or investigation notwithstanding, why do we not see more formal recognition of safety/accident prevention management in civil airline activity? It has been suggested that perhaps not enough airline executives have had the benefit of command or advanced safety management training — only about 50 percent of U.S. airlines now have identifiable safety departments.[10]

Nevertheless, the airline safety record of most developed countries is nothing to be ashamed of, albeit not all carriers try to improve always and in all ways. Also, at least independent investigating organizations such as the NTSB generally have had little difficulty identifying inadequacies of the regulating organizations, such as the FAA in the United States, because the board's charter from the U.S. Congress is quite specific in demanding oversight of the adequacy of Federal Aviation Regulations (FARs). The board has begun only recently to consider other agency or company management factors in accidents. The reasons for these seemingly ambivalent perceptions of airline safety are certainly not simple and probably have many explanations. One explanation, however, is confusion about what really constitutes safety/accident prevention management. Two theories are advanced, the classic (sometimes thought of as "traditional") and the safety program approaches.

The classic management approach argues that applying classic functions of basic management will inherently provide optimized safety. These functions include effective planning, staffing, organizing, directing, coordinating, controlling, evaluating, decision-making, motivating, communication, standardization, leadership, etc. Take any classic management text and certain of these terms will be found and emphasized as a function of when the book was written. Not too facetiously, the theory goes that these principles apply as well to running the local drug store or a major government agency, airline or manufacturing company. Translated to the subject under discussion here, it can be argued, and often has been, that adequate safety levels are reached by each person or organizational segment (e.g., pilots or operations departments) simply doing their thing; that is, managing professionally. Safety is everybody's responsibility. The safety program approach has no quarrel with traditional fundamentals of management, but suggests one should not stop there, given the complex technical and sociological nature of aviation today.

A relatively recent publication is available that addresses the real world of aviation accident prevention and management (*The Practice of Aviation Safety: Observations from Flight Safety Foundation Audits*).[11] This report summarizes the impressions of three qualified aviation professionals while conducting private audits of airline and corporate operators during a 10-year period. Audits here equate to safety surveys; that is, information gained from non-attributive interviews and observations reported in such a way that accident prevention, not retribution, is the objective. The role of management is stressed in this report with concomitant safety shortcomings being identified at one time or another at all levels and in all departments. Interestingly enough, the authors found it was rare that managers were aware of such problems as were identified until brought to their attention by these outside observers.

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A safety program involves specialized accident prevention efforts in addition to safety being part of everyone's job. Thus, a descriptive title might well be "Accident Prevention Program." It is based upon proven accident prevention tasks, accomplished by appropriately qualified personnel. Each of us in the business any length of time has developed such a task list, formally or otherwise.

Considering the Difference Between Task and Function

A fine-line differentiation between task and function is necessary here. In simple terms, a task is work assigned to a person, something management normally does under the doctrine known as "division of work." Function, on the other hand, is generally a broader term, being a normal or characteristic action.[12] The task phraseology is usually in a form that managers better understand. It is something for which they authorize the expenditure of funds and that they understand.

The IATA safety program is also task-oriented, albeit the program elements are called "functions" as shown in Appendix III.[13] They are classified into four major areas; organization of accident prevention programs, collection/analysis/communication of safety information; technical and training safety coordination; and corporate emergency response procedures. Further explanation of this material can be found in a paper presented by United Airlines' Capt. David Simmon Jr. who was also the chairman of the IATA Safety Advisory Committee, the group from which the policy developed.[14]

A recent study, "Airline Accident Prevention Management Factors" by Capt. Homer Mouden (reference 10), similarly established tasks and areas of greatest accident prevention importance based upon interviews with 53 persons representing 13 airlines of varying sizes and seven relevant aviation organizations. Major categories of effective accident prevention action included communication, training (including cockpit/crew resource management), standardization and flight data analysis. Many of those interviewed were chief executive officers.

Many of the pronouncements about safety programs through the years tend to equate the term "safety program" with "safety officer" or "safety organization." This may come to pass with many, if not most, agencies or companies. However, as stated earlier, the important matter is that appropriate tasks be performed by appropriate people. Depending upon the size of the organization, its cultural and business mores, a formal safety organization as pictured on an organizational chart might not be the best or most practical solution. It is important in an organizational theory sense to be certain all dimensions of an effective organization, safety or otherwise, are in place; namely, the line or decision dimension, the staff or advisory dimension, the informal dimension and the interdepartmental dimension. Mouden's report deals with this area effectively; the study should be mandatory reading for all senior airline, regulatory and aircraft manufacturing officials.

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Short-range Possibilities for Accident Prevention Management — Investigation After the Mishap

Given the options of the "classic/traditional" and "program" approaches to management factors investigation, the latter approach should be used, at least as the investigation community begins to undertake such effort formally. This view is taken on the belief that it is relatively easy to provide task descriptions as standards compared to some of the broader based terminology associated with old-line management theory. For example, one could easily cite a task for an airfield inspection program, using any number of existing publications as a description of what should be done specifically. Conversely, given something like "coordination," the scope thereof would be quite difficult to establish standards for but it could be evaluated post-accident.

The current safety literature will readily show a commonality of tasks that could be synthesized into a common format in some form of investigation manual. The lists should include key reference documents much the way that aerospace recommended practices are written by the Society of Automotive Engineers (SAE). Another approach would be that of an FAA Advisory Circular; however, this may not be as promising, because ACs relate to specific regulations. The detail required for safety/accident prevention management tasks would not be amenable to detail regulations — far too much variation among airlines exists. To even imply that such tasks should be universally mandatory through regulations would be a mistake. In any case, whatever guideline documents are decided upon would have to be prepared by a cross-section of experts from within the affected fields either through research funding or a committee of some professional society like the International Society of Air Safety Investigators (ISASI). In the interim, however, Appendixes II and III plus references 12 and 13, when combined with local knowledge, could be used as the protocol for near-term forthcoming investigations.

Of course, one thing is to know what to do — the tasks; it is another matter how they should be approached procedurally and with what kind of personnel. A parallel would seem to be present within aviation accident investigation methodology that applies here. It was not too many years ago that human factors investigation was comprised only of crash injury survival and rescue factors plus some toxicology data. This human factors concept was expended to include "human performance," so much so that some investigating bodies like the NTSB have isolated the survival and performance factors investigators organizationally. To some, the human performance function was opposed on the basis it was stepping on the turf of the operations personnel — and sometimes it did. What eventually stabilized the separation of the two was the realization that human performance was of sufficient importance in itself that it demanded separate, identifiable attention and it required the introduction of otherwise absent technologies; e.g., behavioral specialists.

And so it is expected to be with safety/accident prevention management investigation. A separate group structure would be expected to be created as part of the investigating body's team in most airline accidents, coordinating with the operations, witness, records groups and others. Hopefully, the investigating agency personnel and the members of the management factors group would have the necessary professional safety experience and training to do the job right, and that means understanding what a safety program is all about. It would seem this type of group would be the logical investigation assignment for the participating airline's safety director (if one exists) and not let his or her talents be wasted just effecting coordination with the investigating authority as is frequently done now.

Are the necessary skills available today? The answer is yes if investigation-experienced people are involved in safety activities. The answer is no if someone thinks that just because he or she is an experienced pilot, engineer or whatever, he is sufficiently knowledgeable about safety/accident prevention management to do a highly credible job on the investigation.

Again, taking a lesson from mistakes made in the introduction of human performance investigations, if management factors groups are formed, specific training is essential for prospective group members. This is what the NTSB finally did for its investigators.

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One alternative, for investigating agencies or participating parties to the investigation, is to locate persons in their organizations who have had military safety officer training. The chances are good that they can speak the safety program language because their training has probably included it under the general heading of accident prevention.

As to training curricula, again the selected task list becomes paramount. Take safety policy for example. Policy is usually referenced in the early part of all plans. Personnel who have taught accident/incident prevention, including investigation, can describe what constitutes an effective safety policy — hence, an effective plan — with examples to illustrate specific principles. For instance, a company's safety policy which simply states "safety is our total priority" is not facing reality. It may do so with a shock when the hard facts of compromises come to light in an investigation — compromises deemed necessary during day-to-day operations.

Another policy shortcoming frequently seen is the chief executive officer saying that he or she is the chief safety officer, without acknowledging delegation of accident prevention tasks which must surely be done to some degree. The CEO must create additional accountability with the intended result that all people in the organization realize their role in safety is not just to themselves but to others as well.

What about the distinctions between inspections, audits and surveys — do personnel people understand the differences? The "black hat" (bad guy) check of rigid adherence to established rules (inspections) becomes confused with the "white hat" (good guy) non-retribution inquiry (survey) or vice versa … with audits falling sometimes in-between but mostly closer to, if not equivalent to, surveys. If and when such confusion does occur, the task will not be as effective as it could be.

One of the IATA safety program tasks is "participation in industry safety activities." However, do managers, especially CEOs, know why this is important? An informal poll was taken of the audience at a recent International Society of Air Safety Investigators (ISASI) seminar. They were asked if they knew of an accident that occurred 18 months earlier.

The accident involved the reluctance of two flight attendants who were advised by two well-informed passengers of a serious pretakeoff snow/icing hazard. The flight attendants failed to notify the cockpit crew because of prior negative experiences with cockpit cabin communication. The aircraft crashed with a loss of 24 lives, including those of both pilots and one of the flight attendants.[15] No more than one-third of the attendees had heard of the accident and fewer had heard of the lesson that was available.

"Learn from the mistakes of others; you'll never live long enough to make them all yourself." The original source of this statement is unknown, but it was brought to the aviation safety community's attention by Jerry Lederer, president emeritus of FSF. Lederer also commented more than once, in keeping with the basic thrust of this article, that "the first person called to testify at every major accident investigation hearing should be the airline CEO."

Interviews on management factors during an investigation might find their way to the very top of a given organization. Investigators must be professional and be able to communicate with top management. Some persons have also suggested that as the interviews proceed up the corporate ladder, the interviewer should become one of the higher-ranked personnel on the investigating team. Officers and CEOs of airlines and other organizations may tend to prefer discussing things with people of essentially equivalent rank. This is one way to prevent bypassing of the field investigators by corporate officials in favor of contacting the review and decision-makers directly.

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Two top level procedural or regulatory changes also are recommended. The first is to modify Annex 13[8] to account for the role of a management factors group in the international process of investigating accidents. Similarly, an appropriate chapter in the ICAO *Manual of Accident Investigation*[16] should reflect the same thinking. These thoughts are not revolutionary when one recognizes that the ICAO *Accident Prevention Manual*[17] already has a discussion of management's importance to safety, and the ICAO *Accident/Incident Reporting Manual* already has a good start on management factors.[18] Action on these items rests with the NTSB in the United States and with its counterparts in other countries.

The second action should be a regulation requiring written definition of a safety/accident prevention program by each airline. Each program would be modified as necessary by the airline and periodic reports would be submitted to regulating authorities at discrete intervals (every year or two). Their purpose would be to assure the attention of top company officials to their safety programs. Companies with existing programs would adapt them to the required format.

The Longer Range Challenge

The safety debate accompanying deregulation in the United States provides a case history of what investigators face when trying to evaluate shortcomings in traditional management factors following an accident. In accidents such as the Air Florida accident in Washington, D.C., in 1982[19] and the Continental DC-9 takeoff accident in Denver in 1987[20], issues of crew capability were paramount. Deficiencies and related factors were attributed by many observers to deregulation's effects on staffing. Lack of appropriate windshear training surfaced in the Delta DFW-1 accident, during a period of rapid growth in operations. The subject of maintenance shortcuts and poor, if not fraudulent, record-keeping arose in several accidents in the 1980s, especially among some smaller carriers.

Fundamental questions like these became related to the financial viability of the carrier in a period of intense competition. Who could tell for sure why corporate decisions were made (e.g., elimination of safety and engineering departments)? Were communications inadequate because of poor leadership? Was coordination bypassed in the name of expediency? These are difficult, if not impossible, questions to answer in a cause-effect sense. Time and funds available to conduct most investigations are limited.

Accident investigation is an art, with certain areas having become highly scientific.

Furthermore, to examine classic management functions post-accident would require additional and markedly different types of skills than are found usually among accident investigators. Such disciplines as accounting, personnel selection, labor relations and law (corporate and contract) would have to be included. For these reasons, investigations using the classic management factors approach appear to be impractical, at least for the immediate future.

An Art and a Science

Accident investigation is an art, with certain areas having become highly scientific through experience gained over the years. But art, as well as science changes, especially if initiatives are taken based upon lessons from the past including lessons from sources other than the particular business one is in.

The aviation community has seen remarkable changes in attention to human performance problems in civil aviation from points of view both before and after the accident fact. Some authorities in the field will say the time delay from human performance knowledge gained to knowledge applied to accident prevention should be measured in decades, not just a few years. The same can be said about safety / accident prevention management.

If we look back on the 1980s as a period during which the civil aviation community awoke to human performance as a specific challenge, perhaps it is not too much to ask that a similar challenge should be recognized for the 1990s regarding safety / accident prevention management.

More specifically, if a given airline has a defined safety / accident prevention program, it should make sure it is effective by referencing the kinds of tasks cited in this paper and implementing those tasks with qualified personnel. If the airline does not believe it can develop such a program, it should look to trade associations like IATA, Air Transport Association (ATA) and the Regional Airline Association (RAA). Assistance in program development may also be sought from consultants.

Government authorities should take steps to introduce safety / accident prevention management investigation into the accident inquiry and require broadly stated safety programs (although not all the same kind) for all carriers. ♦

Appendix I
System Safety Factors

Experience has demonstrated that Man-Machine-Medium-Management-Mission factors represent a valuable model for examining either accident causation or accident prevention (5-M diagram). That is, when one seeks causal factors or preventive/remedial action, the diagram of the intertwined circles becomes a meaningful checklist for fact-finding and analysis to ensure that all factors are considered.

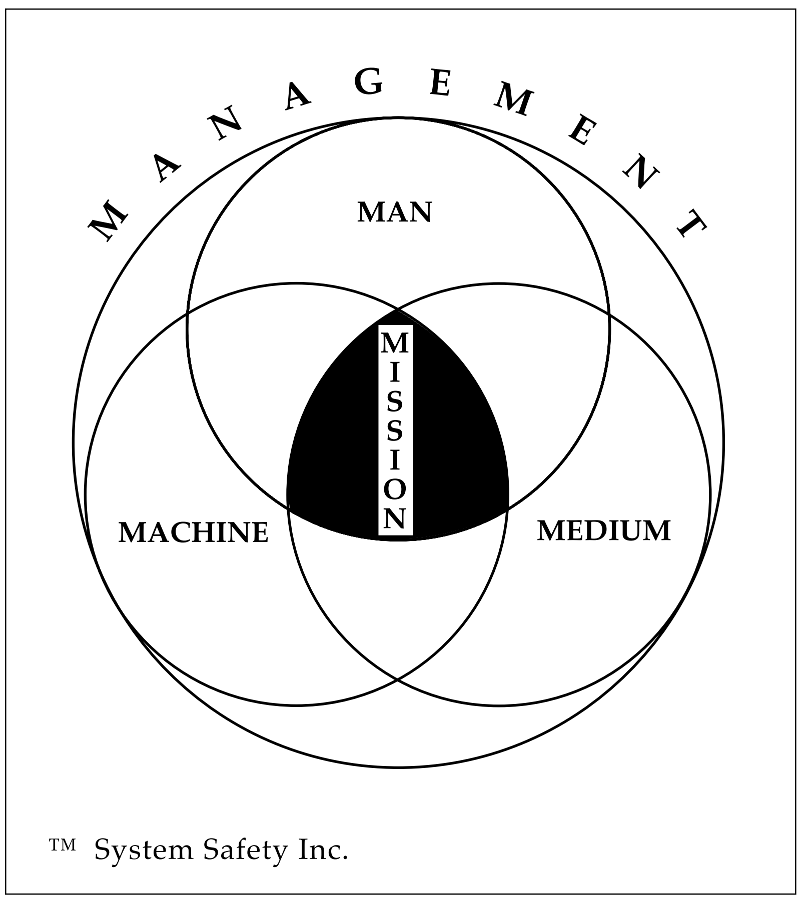
The five factors are closely interrelated, although it can be argued that management plays the predominant role. Mission is located as the target or objective to emphasize that effective mission accomplishment is implicit in professional system safety work.

This concept evolved when T.P. Wright of Cornell University first introduced the man-machine-environment (medium) triad into the aviation safety language during the late 1940s; he was influential in the development of the Cornell-Guggenheim Aviation Safety Division of the University College, University of Southern California (U.S.C.). Follow-on instructors used the 3-M (man — machine — medium) terminology.

The author first provided an illustration of the fourth M, management, circa 1965, at U.S.C., when developing and teaching the school's initial advanced safety management and system safety courses. This appeared in his 1966 text, *The Role of System Safety in Aerospace Management*. In 1972, Vernon L. Grose, who subsequently taught the system safety course at U.S.C. and later for the U.S. National Aeronautics and Space Administration (NASA), introduced the diagram approach (right). That emphasized the interrelationships between the man-machine-medium factors and their subset relationship to management.

The mission factor had been discussed at military oriented U.S.C. courses, but was not introduced into the diagram until 1976 at the suggestion of E.A. Jerome, consultant, writer and former staff member with Flight Safety Foundation. A sixth M, money, was suggested at about the same time, perhaps not too facetiously, by John J. Carroll, formerly chief of the accident prevention branch of the NTSB and later managing director of the Flight Safety Foundation.

The 5-M diagram is a classic example of safety ideas being perceived, reviewed, modified, amplified and hopefully, improved, but in any event, communicated.



The 5-M Diagram

Appendix II
System Safety Tasks

1. Develop and coordinate implementation of safety plans.

2. Assist in establishment of specific accident prevention requirements.

3. Conduct or participate in hazard analyses, including the resolution control process related thereto.

4. Determine and/or review emergency procedures.

5. Participate in program reviews and similar milestone events during system development and use.

6. Maintain an accident/safety known-precedent center.

7. Effect liaison with other safety organizations.

8. Provide recommendations for and conduct safety research, study and testing.

9. Implement safety education, training, indoctrination and motivation programs.

10. Conduct or otherwise coordinate safety surveys, audits and inspections.

11. Participate in group safety efforts such as councils and standardization boards.

12. Direct or otherwise participate in accident/incident investigations.

13. Develop and follow-up recommendations resulting from investigations.

14. Provide objective response to safety inquiry as a staff advisor, in confidence when appropriate.

Notes Concerning System Safety Tasks in Aviation

1. Safety Plans

A top-level secret of safety/accident prevention management is planning. Several kinds of formalized safety plans are found in today's complex aviation system. They include program accident prevention, system safety engineering, accident/incident investigation, disaster control and security plans. One would expect to find in all these plans a clear statement of management's safety policy to protect people and conserve other resources.

2. Requirements

U.S. Federal Aviation Regulations (FARs) are but one type of safety requirement and they are minimum requirements, at that. Other types include, but are not limited to, in-house standard operating procedures or even self-imposed operational criteria. Accident prevention requirements come mainly from the bitter lessons of the past, but they must be combined with understanding of the people involved, their capabilities and limitations. Requirements are also more effective when people who must observe them participate in their development.

3. Hazard Analyses

History has provided volumes of known precedent concerning accident causation. Application of precedents with new knowledge is the hazard analysis process. Literally dozens of analysis techniques have been documented and can become as sophisticated as the budget allows. Unfortunately, analysis of the people part of the equation leaves much to be desired and awaits closer coordination between human behavioral and safety professionals.

4. Emergency Procedures

Normal emergency procedures are those which best judgment and sometimes a fixed training requirement suggest will occur under a given set of circumstances (e.g., engine failure on takeoff). However, operations and training must consider the abnormal — the unplanned, unique combination of events, the less-than-perfect individual pilot or other crew member. Safety knowledgeable people can and should become involved personally in emergency procedure determination, because their experience will usually include an appreciation for the full scope of human reaction to complex, hazardous situations.

5. Program Reviews

Modern safety/accident prevention management includes periodic pauses to reflect progress — what lessons have been learned, what hazards exist and what is the best way to proceed. These are sometimes combined with other management reviews. In any event, the safety specialist can usually provide a relatively independent view on issues compared to line (decision-making) personnel. These reviews should occur over the entire life cycle of the system in question.

6. Known Precedent Center

Essential to every accident prevention program is a comprehensive safety database, or preplanned access to one. It must also be effective time-wise. The database could be large or small, a safety library or a simple list of who should be called for answers to certain questions. Without simplified and rapid access to the mistakes of the past (known precedent) no one would be able to "learn from the mistakes of others … ."

7. Liaison

This is closely allied to the known precedent task immediately above. However, nothing substitutes for personal communication in safety matters. The subject of safety can be sensitive, as well as complex. Thus, it is wise to become acquainted with knowledgeable personnel in the field who are cooperative and participative. Seminars such as those provided by the Flight Safety Foundation and the International Society of Air Safety Investigators foster such liaisons.

8. Safety Research, Study and Testing

Chief engineers, flight inspectors and chief pilots usually think they are right — and most of the time they are. Unfortunately, life is filled with assumptions that precede every decision or action. If those assumptions are incorrect or incomplete about hazards, it follows that some safety research, study or testing should be conducted to validate assumptions bearing upon those hazards and/or explore other solutions. A key corollary to this item is to realize there is a difference between testing safety and testing safely.

9. Safety Education, Training, Indoctrination And Motivation

These four activities, influencing human behavior, are different from one another. Education is teaching people to think. Training is developing skills so that one can perform certain tasks. Indoctrination is the application of education and training to the new situation. Motivation is an attitude development process, often most successful when it leads the person being influenced to think it was his or her own idea. Unless these processes are performed at the right time and with minimum confusion between them, they might even have a negative learning effect. Also, the place to start is with oneself.

10. Surveys, Audits and Inspections

An occasional "outside" look is traditional in the practice of management. This is particularly vital in safety if objectivity is the target of the examination, because emotions and sensitivities often run high when the stakes include the physical well-being of people or their livelihoods. Surveys and inspections represent opposite ends of a spectrum of outside reviews. Surveys are relatively informal and non-retributive (white hat) while inspections specifically check against stated requirements with potential penalties for non-conformance (black hat). Audits may fall somewhere between depending upon how they are defined. Both extremes are usually necessary, but for optimum effectiveness they should not become confused either by the evaluatees or the evaluators.

11. Group Safety Effort

Another well-known principle of management is that group dynamics can produce more effective output than that represented by a mathematical sum of the number of participants. In air safety work, group effort becomes more significant because hazard alleviation is rarely the province of a single discipline or part of the aviation community. Safety councils, committees, panels, etc., when properly conducted with safety professionals present, contribute to accident prevention in ways not otherwise achieved.

12. Accident/Incident Investigations

Were man's requirements, decisions and operations perfect, no air safety problems would exist. When something does go wrong, the meaningfulness of the remedial action is dependent upon the accuracy and timeliness of the investigation of the unwanted event. Socio-legal reasons for accident investigations exist as well. Consequently, aviation needs a means not only to answer immediate post-mishap questions, but also a method to enhance known precedent as described above. Incidents, of course, are simply accidents minus defined levels and methods of injury to people or damage to property (where more investigations should be accomplished than are taking place today).

13. Recommendations

Knowing what has happened to cause an accident/incident is one thing; developing practical remedial actions is quite another matter. The mettle of management is tested here because of the classic performance-cost-schedule tradeoffs that become involved. Furthermore, it is necessary to have some specific follow-up system to track recommendations accepted in good faith but which tend to fall through bureaucratic cracks when the commotion and emotion settles down.

14. Staff Advisor

Everyone needs an expert to turn to for answers that exceed his or her personal knowledge. For aviation safety, and depending upon the size of an organization, that person might be a qualified safety specialist on the staff or an employee of the FAA, a friend or consultant. Besides safety expertise per se, however, a requirement also exists for someone who can be approached confidentially and without fear of recrimination. Unintentional mistakes are often incompatible with company or government rules; hence, if future prevention benefit is to be derived therefrom, an unofficial communications channel must be encouraged. Sometimes this is called the "chaplain" function in safety / accident prevention management.

Appendix III
Flight Safety Functions
Per IATA Technical Policy Manual
OPS Amendment No. 37, 1 July 1989

Organization of Accident Prevention Programs

Independent internal investigation of incidents and accidents with provision of appropriate safety recommendations to management.

An overview function comprising appropriate safety assurance and quality assurance programs.

An airfield inspection program.

Comprehensive safety training programs focused on specific safety objectives.

A flight data recorder exceedance program.

Developing management objectives to reverse undesirable safety trends.

Collection/Analysis/Communication of Safety Information

Maintaining a flight safety data base to record and preserve operational safety incident information.

Participation in industry safety activities.

Internal analysis of incident trends and periodic reviews with senior management, including the CEO.

Communication to crew members of appropriate safety information, including the publication of a safety magazine, incident summaries, safety bulletins, technical letters and safety articles.

Operation of a confidential crew member incident reporting system.

References

1. Miller, C.O., "Safety Management: A New Cause of Legal Action?" presented at the Professional Development Conference of the National Safety Management Society, Washington, D.C., U.S., April 26, 1984.

2. Miller, C.O., "Management Factors Following Civil Aviation Mishaps," International Society of Aviation Safety Investigators *ISASI Forum*, September 1988.

3. Lauber, Dr. John, member, U.S. National Transportation Safety Board (NTSB), in a speech before the Aero Club of Washington, Washington, D.C., U.S., March 28, 1989.

4. Busey, James, Administrator, U.S. Federal Aviation Administration (FAA), in a speech before the Aero Club of Washington, Washington, D.C., U.S., March 27, 1990.

5. *NTSB Recommendation A-89-130,* resulting from the Board's investigation of the Delta Air Lines Boeing 727-232 Accident, August 31, 1988, 1988, Dallas/Ft. Worth Airport, Texas, U.S.

6. Busey, James, FAA Administrator, letter to James L. Kolstad, Chairman, NTSB, April 12, 1990

7. FAA, "Air Carrier Internal Evaluation Programs," *Draft Advisory Circular 120-X*, initiated by AFS-200. (comments were due December 30, 1990.)

8. International Civil Aviation Organization (ICAO), *International Standards and Recommended Practices for Aircraft Accident Investigations, 7th Ed.*, revised to May 1988 (Annex 13 to the Chicago Convention on International Aviation in 1944).

9. Numerous personal communications with Jerome Lederer.

10. Mouden, Capt. L. Homer, *Airline Accident Prevention Management Factors*, a study funded by the Aviation Research and Education Foundation of Herndon, Va., U.S. (In final editing and printing process, January 1991.)

11. Arbon, Capt. E.R., Mouden, Capt. L. Homer and Feeler, R.A., *The Practice of Aviation Safety: Observations from Flight Safety Foundation Audits*, Flight Safety Foundation, Arlington, Va., U.S., June 1990.

12. Webster's *New World Dictionary, Third College Edition*, 1988.

13. IATA, *Technical Policy Manual OPS-20*, Amendment No. 37, 1 July 1989.

14. Simmon Jr., Capt. David A., "Model Airline Safety Program," presented at the Flight Safety Foundation (FSF) 41st International Air Safety Seminar, Sydney, Australia, December 1988.

15. Air Ontario F-28 Accident, Dryden, Ontario, Canada, March 10, 1989.

16. ICAO, *Manual of Accident Investigation*, Doc. 6920-AN855/4, 1979 as revised.

17. ICAO, *Accident Prevention Manual*, Doc. 9422-AN/923, 1984. (See Sect. 3.3.)

18. ICAO, *Accident/Incident Reporting Manual*, 2nd Edition, Doc. 9156-AN/900, 1978. (From the section "Explanatory Factors")

19. NTSB, Report of the Air Florida B-737 Accident, Washington, D.C., U.S., January 12, 1982.

20. NTSB, Report of the Continental Airlines DC-9 Accident in Denver, Colo., U.S., November 15, 1987.

About the Author

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Aviation Statistics

An Annual Update of Worldwide Jet Transport Aircraft Fatal Accident and Hull Losses Calendar Year 1990

by
Shung C. Huang
Statistical Consultant

In 1990, worldwide airlines operating large jet transport aircraft (excluding those jet transports built by the U.S.S.R.) recorded 11 fatal accidents and seven hull losses accounting for 357 fatalities. The preliminary information on the fatal accidents and hull losses was published in the February 1991 issue of *Flight Safety Digest*. The following seven tables and a graph provide updated information on the worldwide airline annual, monthly and daily aircraft utilization, and delineate the associated safety records.

Table 1 is a comparison of jet transport aircraft flight hours by U.S. airlines and all non-U.S. airlines. The data for U.S. airlines are based on the monthly U.S. "Air Carrier Aircraft Utilization and Propulsion Reliability Report," which is compiled and published by the U.S. Federal Aviation Administration (FAA) from data furnished by individual air carriers. The information for those jet transport aircraft fleets and hours flown for non-U.S. airlines was provided by aircraft manufacturers, news media and other sources. Overall, worldwide airlines flew a total of 20.163 million hours in 1990, a decrease of about one percent as compared with data for 1989.

Actually, worldwide jet transport operations in 1990 had a good start. In the first seven months of the year, the monthly hours flown and aircraft utilization showed a steady increase. Airline traffic began slowing down only after the Iraqi invasion of Kuwait in August. When the military confrontation in the Persian Gulf appeared unavoidable, terrorists worldwide, who supported the Iraqi invasion, increased their threats against individuals and institutions who were against the Iraqi plans. Consequently, airport security and flight safety became a worldwide issue. As a precaution, many air travelers and corporations either postponed or cancelled their travel plans.

Table 2 shows the monthly changes of U.S. jet transport aircraft in use and the hours flown

Table 1

Worldwide Airlines Jet Transport Aircraft Hours Flown
Calendar Year 1989-1990

	1989	1990	Changes
Worldwide Airline Total	20,349,000	20,163,000 -	186,000 (0.9%)
U.S. Airlines	9,885,000	9,774,000 -	111,000 (1.1%)
Non-U.S. Airlines	10,464,000	10,389,000 -	75,000 (0.7%)

Table 2

U.S. Airline Jet Transport Aircraft
In Service and Hours Flown by Month
Calendar Year 1989 and 1990

	Aircraft in Service		Hours Flown(000)		Changes	
Month	1989	1990	1989	1990	Aircraft	Hours
January	3,807	3,859	858,657	887,621	+ 52	+ 28,964
February	3,714	3,910	760,048	813,201	+ 196	+ 53,153
March	3,392	3,910	726,417	910,365	+ 518	+183,948
April	3,677	3,951	870,576	873,050	+ 274	+ 2,474
May	3,622	3,832	821,910	877,455	+ 210	+ 55,545
June	3,697	3,971	835,066	891,583	+ 274	+ 56,517
July	3,502	3,962	809,599	920,216	+ 460	+110,617
August	3,825	3,661	898,497	861,473	- 164	- 31,024
September	3,710	3,669	823,686	810,773	- 41	- 12,913
October	3,745	3,671	841,399	845,468	- 74	+ 4,069
November	3,848	2,734	828,748	560,189	-1,114	-268,559
December	3,864	2,472	874,018	523,571	-1,392	-350,447

Source: U.S. Air Carrier Aircraft Utilization and Propulsion Reliability Reports for calendar year 1989 and 1990. Note that the monthly flight hours for the first seven months in 1990 were higher than those in the same period of 1989. Since August 1990, the number of U.S. jet transport aircraft in use was reduced from 3,962 aircraft in July to 3,661 in August and 2,472 in December, a decrease of 45 percent; the flying hours also dropped from 920,216 hours in July to 523,571 in December, a drop of 43 percent. Although worldwide data is not available at this time, the Gulf War and terrorist threats brought worldwide air travel to a near standstill for months.

Table 3 presents the average number of aircraft in service and flight hours at the end of 1990, and the accumulative hours flown since 1959. To reduce operational cost, more fuel efficient, twin-engine jet transport aircraft have joined the worldwide airline fleet. As of the end of 1990, more efficient, twin-engine, and two-crew jet transports account for more than 20 percent of the fleet and 25 percent of total jet flight time.

Table 3

Worldwide Airline Jet Transport Aircraft Hours Flown in Thousands By Number of Jet Engines 1959-1989-1990

Aircraft Type	No. of Aircraft in Service Dec. 1990	No. of Aircraft in Service Dec. 1989	Annual Aircraft Hours Flown CY 1990	Accumulative Total Hours Flown 1959-1990
Two-engine	5,055	4,734	12,520,000	129,891,000
Three-engine	2,285	2,283	4,475,000	103,605,000
Four-engine	1,334	1,365	3,168,000	105,364,000
Total	8,674	8,382	20,163,000	338,860,000
Two-engine	58.3%	56.5%	62.1%	38.3%
Three-engine	26.3%	27.2%	22.2%	30.6%
Four-engine	15.4%	16.3%	15.7%	31.1%
Total	100.0	100.0	100.0	100.0
1st generation	480	590	531,000	81,689,000
2nd generation	4,732	4,620	9,652,000	169,869,000 [1]
Widebody	1,645	1,603	5,083,000	62,327,000 [1]
Efficient	1,817	1,569	4,897,000	24,975,000 [2]
Total	8,674	8,382	20,163,000	338,860,000
1st generation	5.5%	7.1%	2.6%	24.1%
2nd generation	54.6%	55.1%	47.9%	50.1%
Widebody	19.0%	19.1%	25.2%	18.4%
Efficient	20.9%	18.7%	24.3%	7.4%
Total	100.0	100.0	100.0	100.0
Two-crew	5,219	4,874	12,798,000	131,415,000
Three-crew	3,455	3,508	7,365,000	207,445,000
Total	8,674	8,382	20,163,000	338,860,000
Two-crew	60.2%	58.2%	63.5%	38.8%
Three-crew	39.8%	41.8%	36.5%	61.2%
Total	100.0	100.0	100.0	100.0

[1] Readjusted since 1987.
[2] Efficient jet includes B-757, B767, MD-80, MD-81, A-310, A320, F-100.

Table 4

Daily Utilization of Jet Transport Aircraft by Aircraft Type Calendar Year 1987-1990

Aircraft Type	Daily Utilization (Hours) 1987	1988	1989	1990
Two-engine	6.9	6.7	6.7	6.7
Three-engine	6.8	6.6	6.3	5.3
Four-engine	6.9	6.8	6.7	6.6
1st Generation	3.2	2.9	1.6	1.8
2nd Generation	6.6	6.4	6.2	5.6
Widebody	8.9	8.0	8.7	8.5
Efficient	7.9	7.4	7.2	7.4
Two-crew	7.0	6.8	6.7	6.7
Three-crew	6.8	6.8	6.5	5.9

Table 4 shows the average daily utilization in hours by aircraft type. In 1990, the average daily utilization in hours is shown by aircraft type. In 1990, the average daily utilization of three-engine jets was 5.7 hours which was the lowest in the past four years. This is because daily utilization of the Boeing 727, as reported by the FAA and the Boeing Commercial Aircraft Group, were substantially lower than in 1989. There are still a few hundred first generation jets in service, but their daily utilization averaged less than two hours a day. It is expected that the first generation jet will be phased out in the next three or four years. The daily utilization of widebody jets averaged nine hours worldwide, and that of new, efficient jets was about eight hours a day. However, some Boeing 747, 767, Airbus A-310 and Lockheed L-1011 aircraft were used by U.S. airlines at utilization rates as high as 14 hours per day.

Table 5 shows the distribution of worldwide airline fatal accidents and hull losses by phase of operation. Overall, 30 percent of the fatal accidents occurred during takeoff, approximately 50 percent during approach and landing, and 18 percent in cruise and two percent during ground operation.

Table 6 presents the distribution of fatal accidents, hull losses and rates by aircraft make

Table 5

Fatal Accidents and Hull Losses By Phase of Operation 1959-1990 In Number of Accidents (percentage)

Takeoff/ Climb	Cruise	Approach/ Landing	Ground	Year	Ground	Approach/ Landing	Cruise	Takeoff/ Climb
14(43.8)	3(9.3)	15(46.9)	0(0.0)	59-64	1(2.4)	22(53.7)	4(9.8)	14(34.1)
14(25.5)	7(12.7)	34(61.8)	0(0.0)	65-69	6(8.1)	41(55.4)	7(9.5)	20(27.0)
18(24.0)	16(21.3)	41(54.7)	0(0.0)	70-74	11(11.0)	52(52.0)	12(12.0)	25(25.0)
16(28.0)	12(21.4)	27(48.2)	1(1.8)	75-79	6(5.7)	43(51.2)	11(13.1)	24(28.6)
15(27.2)	13(23.6)	25(45.5)	2(3.7)	80-84	7(10.3)	37(54.4)	8(11.8)	16(23.5)
23(36.5)	12(19.0)	27(42.9)	1(1.6)	85-89	3(4.8)	29(46.0)	9(14.3)	22(34.9)
2(18.2)	1(9.1)	5(45.5)	3(27.2)	**1990**	2(28.6)	4(57.1)	0(0)	1(14.3)
102(29.4)	64(18.4)	174(50.2)	7(2.0)	**59-90**	36(8.2)	228(52.2)	51(11.7)	122(27.9)

and model in terms of first generation, second general generation, widebody and new efficient jet. Table 7 presents the fatal accidents and hull-loss rates by number of aircraft engines and number of flight crew members. The overall fatal accident rate for 1990 is .054 acci-

Table 6

Worldwide Airline Jet Transport, Fatal Accidents, Hull Losses and Rates 1959-1990

	1st Generation		2nd Generation		Widebody		Efficient	
	Fatal	Hull	Fatal	Hull	Fatal	Hull	Fatal	Hull
Number of Fatal Accidents and Hull Losses*								
1959-1964	32	41	—	—	—	—	—	—
1965-1969	34	47	21	27	—	—	—	—
1970-1974	41	51(54)	30	37(41)	4(5)	3(5)	—	—
1975-1979	23	35(36)	26	36(37)	7	11	—	—
1980-1984	12	18	32	40	11	9(10)	—	—
1985-1989	12	11	34	36	11(3)	11(2)	4	3
1990	2	2	8	4	0	0	1	1
1959-1990	156	205	151	180	33	34	5	4
Accidents per 100,000 Flying hours								
1959-1965	.342	.438	—	—	—	—		
1965-1969	.115	.159	.197	.252	—	—		
1970-1974	.179	.236	.109	.135	.111	.082		
1975-1979	.133	.203	.075	.104	.062	.098		
1980-1984	.157	.235	.072	.090	.051	.050		
1985-1989	.366	.305	.066	.070	.042	.042	.039	.029
1990	.376	.376	.082	.041	—	—	.020	.020
1959-1990	.188	.251	.089	.105	.052	.054	.020	.016

*Aircraft destroyed by force are excluded from computation of rates.

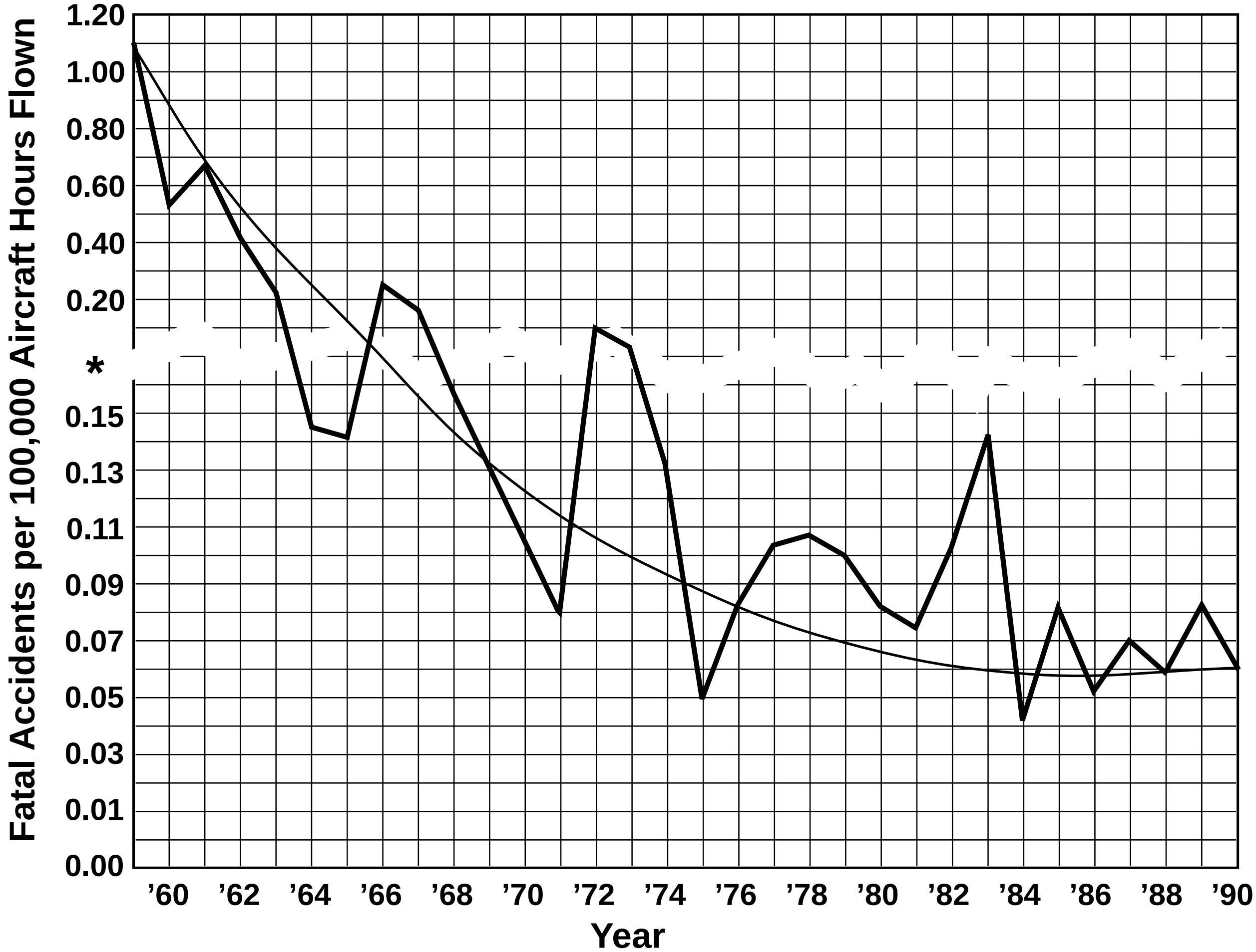
Table 7

Worldwide Airline Jet Transport Fatal Accidents, Hull Losses and Rates 1959-1990

(Hours in thousands)		Jet Transport Aircraft Two-engine	Three-engine	Four-engine	Two-crew	Three-crew	All Aircraft
Fatal Accidents	CY 1990	6	3	2	6	5	11
	Accumulative as of 1990	123	71	151	112	233	345
Hours(000) per Fatal Accident	CY 1990	2,083	1,491	1,584	2,133	1,473	1,833
	Accumulative as of 1990	1,055	1,459	697	2,173	890	982
Hull Losses	CY 1990	5	0	2	2	5	7
	Accumulative as of 1990	158	77	188	136	287	423
Hours(000) per Hull Loss	CY 1990	2,500	*	1,584	6,399	1,473	2,880
	Accumulative as of 1990	1,345	1,459	560	966	722	801

* No rate is computed because of no fatal accidents.

Figure 1 — Worldwide Jet Transport Aircraft Fatal Accident Rate and Trend Calendar Year 1959-1990



* The scale changes above the 0.15 accident rate.

dents per 100,000 flight hours and the hull-loss rate is .034 aircraft per 100,000 flight hours, as compared with .083 fatal accident and .073 hull-loss rates in 1989. Since worldwide airlines logged a total of over 20 million hours in 1990, these rates produced an average of 1.83 million flight hours per one fatal accident. Considering that the air distance between New York City and Paris is 3,144 nautical miles and the round trip flight time averages 16 hours by current subsonic jet transport, a person could take a round trip by a widebody jet transport aircraft from New York to Paris every day for more than 320 years before being involved in a fatal accident if the current airline safety rate prevails. Figure 1 shows the fatal accident rates and the trend for the 30-year period. ♦

Reports Received at FSF Jerry Lederer Aviation Safety Library

Reference

Advisory Circular 61-107, 01/23/91, Operations of Aircraft at Altitudes Above 25,000 Feet MSL and/or Mach Numbers (Mno) Greater than .75. — Washington, D.C. : United States. Federal Aviation Administration, 1991, January 23. vi, 29 p.

AC 91-8B, dated April 7, 1982, is cancelled.

Key Words
1. AirPilots — Training.
2. Private Flying.
3. Jet Transport — Piloting.
4. Airplanes — Turbojet Engines.

Contents: Recommendations High-altitude Altitude Training — Purpose — Outline — Ground Training — Weather — Flight Planning and Navigation — Physiological Training — Additional Physiological Training — High-Altitude Systems and Equipment — Aerodynamics and Performance Factors — Emergencies and Irregularities at High Altitudes — Flight Training. Mach Flight at High Altitudes — Purpose — Critical Aspects of Mach Flight — Aircraft Aerodynamics and Performance.

Summary: This advisory circular is issued to alert pilots transitioning to complex, high-performance aircraft which are capable of operating at high altitudes and high airspeeds of the need to be knowledgeable of the special physiological and aerodynamic considerations involved within this realm of operation. On September 17, 1982, the National Transportation Safety Board (NTSB) issued a series of safety recommendations which included, among other things, that a minimum training curriculum be established for use at pilot schools covering pilots' initial transition into general aviation turbojet airplanes. Aerodynamics and physiological aspects of high-performance aircraft operating at high altitudes were among the subjects recommended for inclusion in this training curriculum. These recommendations were the result of an NTSB review of a series of fatal accidents which were believed to involve a lack of flightcrew knowledge and proficiency in general aviation turbojet airplanes capable of operating in a high-altitude environment. [Purpose/Background]

Advisory Circular 61-65C, 2/11/91, Certification: Pilots and Flight Instructors. — Washington, D.C. : United States. Federal Aviation Administration 1991, February 11. 18 p.

AC 61-65B, dated August 6, 1984, is cancelled.

Key Words
1. Flight Training — United States.
2. Air Pilots — Certification — United States.
3. Air Pilots — Training — United States.

Summary: This advisory circular provides guidance for pilots and flight instructors on the certification standards, written test procedures, and other requirements contained in Federal Aviation Regulations (FAR) Part 61.

Code of Aviation Law (Greece): Greek Original Text and English Translation (Supplied by the Greek CAA). — Athens : Greece. Parliament, 1988, November 11. 105 p.

Key Words
1. Aeronautics — Law and Legislation — Greece.
2. Aeronautics, Commercial — Law and Legislation — Greece.
3. Airplanes — Law and Legislation — Greece.
4. Transport, Planes— Law and Legislation — Greece.

Notes:

1. Spiral-bound; photocopy of Greek text; typeset English translation.

2. Government Gazette of the Hellenic Republic, Athens, November 11, 1988, First Section, Issue No 250, Law No 1815, Ratification of the Code of Aviation Law.

3. This Law was drawn up by the Special Committee for drawing up the Code of Aviation Law, which was formed by virtue of Law 1400/1983 (Government Gazette No 156) and by virtue of decision No 2117/18.12.1983 of the Communication Minister.

4. "True translation from Greek of the attached original Government Gazette." Athens 20-2-1988, G.D. Goulanaris, translator.

Contents: Scope of the Code — Aircraft Traffic — Airports — Compulsory Acquisitions-Restrictions of Ownership — Aviation Schools-Diplomas and Licenses — Aircraft Register and Books-Nationality — Aircraft Airworthiness — Aircraft's Pilot — Aircraft's Ownership — Aircraft Mortgage — Aircraft Liens — Aircraft Hiring — Aircraft's Chartering — Transport of Persons, Baggage and Articles — Liability Stemming from the Operation of the Aircraft — General Average, Assistance and Salvage — Aircraft Insurance — Administrative Control with Respect to an Aircraft Accident — Administrative Sanctions — Limitations — Criminal Provisions — General and Transitory Provisions

Reports

Accident Facts, 1990 Edition / National Safety Council [Statistics Department]. — 70th ed. — Chicago : National Safety Council, 1990. 108 p. : ill., charts, tables, maps. ISBN: 0-87912-149-1.

Key Words
1. Accidents — Statistics — United States.
2. Industrial — Statistics — United States.
3. Violent Deaths — Statistics — United States.

Contents: All Accidents — Work Accidents — Occupational Health — Motor-Vehicle Accidents — Public Accidents [includes transportation] — Home Accidents — Farm Resident Accidents — Environmental Health — Other Sources — Glossary — Index.

Summary: A statistical review through 1989 (mostly United States) covering accident facts in several major categories. Includes historical data.

The FAA Altitude Chamber Training Flight Profile: A Survey of Altitude Reactions - 1965-1989 / Charles D. Valdez, M.P.H. (Civil Aeromedical Institute). — Washington, D.C. : United States. Federal Aviation Administration, Office of Aviation Medicine; Springfield, Virginia : Available through NTIS*, 1990, September. Report DOT/FAA/AM-90-12. iii/iv, 8 p.

Key Words
1. Altitude, Influence of.
2. Atmospheric Pressure — Physiological Effect.
3. Air Pilots.

Includes bibliographical references.

Summary: Reactions from 1,161 trainees out of 12,759 trainees subjected to the FAA altitude chamber training flights from 1965-1989 are annotated in this survey. Although there were some mild and expected reactions (including aerotitis media, aerosinusitis, aerodontalgia, hyperventilation, abdominal distress, claustrophobia, decompression sickness, apprehension, tingling, unconsciousness), these training profiles appear to provide a safe learning environment without compromising the student's health and safety. Inside chamber instructors did not fare as well, perhaps due to age and cumulative number of exposures, and recommendations are suggested for improved safeguards.

An Engineer's Perspective on the Air Transportation Industry: The Last Forty Years / Joseph F. Sutter (Boeing Commercial Airplane Company) and David C. Knowlen (Boeing Co.). — Warrendale, Pennsylvania : Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, Pennsylvania, U.S.. 15096-0001 U.S.; 1990. Report SAE SP-90/845. Report SAE 902012. 16p. ISBN: 1-56091-089-5.

Key Words

1. Boeing Airplanes — History.
2. Transport Planes — History.
3. Aeronautics, Commercial — History.
4. Aeronautical Engineers.

Seventeenth William Littlewood Memorial Lecture. Presented at the Aerospace Technology Conference and Exposition, Long Beach, California, October 1-4, 1990.

Summary: From his 40 years experience, as the industry made the transition from piston-driven to jet-powered airplanes, the author draws lessons on airplane design, business philosophy, and the role of the engineer. Few technical advances in aircraft design have been revolutionary. Most have been evolutionary and are the result of continuing to learn and apply lessons from previous designs. Sutter also cites examples where the success of an airplane could be traced to the willingness to approach a design from a fresh perspective. Another strength of Boeing products is long-term flexibility. Designs that can be lengthened or shortened or fitted with new powerplants make it possible to adapt models to changing market for more range or more payload long after the model has been introduced. Engineers should commit themselves to a broader role. The challenge of the future requires technically astute engineers with marketing and financial skills, who can work directly with customers, if they are to regain their position as leaders in the transportation industry.

Aircraft Accident Report: Markair, Inc., Boeing 737-2X6C, N670MA, Controlled Flight into Terrain, Unalakleet, Alaska, June 2, 1990. — Washington, D.C. : United States. National Transportation Safety Board; Springfield, Virginia, U.S. : Available through NTIS, 1991, January 23. Report NTSB/AAR-91/02; NTIS PB 91-910402. 85 p. : charts, graphs, maps.

<u>Key Words</u>
1. Markair, Inc.—Accidents — 1990.
2. Aeronautics — Accidents — 1990.
3. Aeronautics — Accidents — Approach.
4. Aeronautics — Accidents — Instrument Approach Charts.
5. Aeronautics — Accidents — Pilot Training.
6. Cockpit Resource Management.

Summary: On June 2, 1990, during a mid-morning positioning flight with only four crew members on board (two pilots and two flight attendants), MarkAir Boeing 737-200 descended prematurely during a localizer DME (distance measuring equipment) approach to runway 14 at Unalakleet, Alaska, U.S., and struck the ground about 7.5 miles short of the runway at 0937 hours local time. Instrument meteorological conditions existed at the time, and the flight was on an IFR flight plan. The flight was operated under FAR Part 121. The aircraft was destroyed but there was no fire. A flight attendant seated in the rear jumpseat received serious pelvic injuries. At the completion of the teardrop procedure turn, the crew seemed to mentally jump one stepdown ahead of the published approach procedures. Seconds before impact, the captain sighted the ground and initiated a sharp pull-up sufficient to align the aircraft with the rising terrain, spreading impact loads sufficiently to prevent the airplane's complete destruction at the point of initial ground contact. The report contains the cockpit voice recorder transcript.

The NTSB determines that the probable cause of this accident reflected deficiencies in flightcrew coordination, their failure to adequately prepare for and properly execute the nonprecision approach and their subsequent premature descent. The safety issues discussed in this report include cockpit resource management and approach chart symbology. The Safety Board issued a safety recommendation on approach chart standardization to the Federal Aviation Administration (A-91-15). Safety recommendations were also issued to MarkAir, Inc., on the subjects of cockpit resource management (A-91-16 through 17) and checklist usage (A-91-18). [Executive Summary]

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Accident/Incident Briefs

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

Air Carrier

Heavy Airplane Balks at Flight

Antonov An-24: Aircraft destroyed. Fatal injuries to one person on ground, minor injuries to one in aircraft.

The pilot did not follow flight manual procedures that call for limiting the weight of the aircraft according to the available runway length and environmental conditions. He also failed to accomplish a preflight briefing with the flight engineer prior to takeoff. The aircraft was prepared to take off at 1500 hours in daylight conditions from an airfield in Laos.

During the takeoff run, the twin-engine turboprop aircraft reached V_1 speed but did not lift off as expected. Without an order from the pilot, the flight engineer aborted the takeoff. The aircraft ran off the end of the runway and collided with a building. The aircraft was destroyed and one person on the ground was killed; one of the crew members sustained minor injuries. There were no passengers.

The pilot was cited for not checking maximum takeoff weight, forgetting the pilot's briefing, being careless about crew supervision and for uncoordinated decisions. The flight engineer was cited for not coordinating the aborted takeoff with the pilot, for other uncoordinated actions and for violating procedures. Recommendations were made relating to personnel actions, including that crew members should follow aircraft flight manual procedures and be trained periodically in theory as well as practical procedures.

Jet Blast, Unbraked Cart Result in Dented Aircraft

Boeing 737: Minor damage. No injuries.

Boeing 747: No damage. No injuries.

The Boeing 737 was parked at the terminal gate ready to depart. Passengers were aboard and final documentation was being processed.

A Boeing 747 had pushed back from a nearby gate and was beginning to taxi to the runway. As it passed the parked 737, the larger aircraft was required to make a 90-degree left turn from the parking apron to the taxiway; some power was added to number three and four engines to assist in the turn.

The resulting jet blast blew a number of containers and other loose equipment about the ramp area. A heavy baggage cart that had been left with the brakes off was blown across the ramp at a speed estimated to be more than 30 mph — it struck the engine nacelle of the Boeing 737 that had been ready to depart the gate which was then delayed until a deeply dented section of the nacelle assembly was replaced.

Buggy Airspeeds Bring Bumpy Landing

BAe 146-200: Moderate damage. No injuries.

Distractions began before the aircraft started its descent. A high volume of radio traffic caused a delay in contacting the carrier's handling agent at the airport. After the descent was initiated, the descent checklist was interrupted at the landing data item by a call from the handling agent which was answered by the captain, who was flying the aircraft. The landing data checklist item interrupted was a check of the landing speeds and that the positions of the airspeed bugs had been properly reset from the takeoff values to the landing speeds. The captain indicated to the first officer that he would return to the checklist after completing the call.

However, the captain's attention then became focused on air traffic control instructions and on flying the aircraft. He stated later that he may have repositioned the yellow outer bug from the takeoff setting but did not recall resetting the other bugs from their takeoff settings. The first officer stated that he looked across at the captain's airspeed indicator and thought the bugs were set correctly, although one of them was not visible from the normal right-hand seating position.

The aircraft was cleared for a visual approach; the runway had a short cliff on the approach end. After the aircraft was established on final approach with flaps set at 33 degrees a minute before touchdown, the first officer noticed that the airspeed was about 112 knots instead of the proper bug speed of 118 knots. He called "speed" to the captain who responded "on bug" to indicate that he was properly following his orange inner bug; however, this was still set at the takeoff setting of 111 knots instead of the 118-knot landing value which was properly set on the copilot's airspeed indicator bug. Airbrakes were then selected and the aircraft encountered a slight sink as it crossed over the cliff on short final leg. The captain allowed the airspeed to reduce further in order to cross the runway threshold at about 106 knots, the speed he had set on his next bug, which should have been 113 knots.

The captain estimated that the aircraft was slightly low coming across the threshold, but expected that the landing flare would lead to a normal touchdown about 600 feet along the runway. He closed the throttles and began the landing flare; however, there was no decrease in the aircraft's rate of descent and it landed hard on the paved undershoot area just prior to the runway. The pilot was able to taxi the aircraft to the parking ramp and the passengers were deplaned without further incident.

Inspection of the aircraft revealed extensive damage to the underside of the fuselage in the tail area that included a minor perforation of the pressure vessel. Marks on the overrun area prior to the runway were consistent with a moderately heavy landing in an excessively nose-high aircraft attitude. A check of the airspeed indicators revealed that the captain's instrument read high by two to three knots in the range between 80 and 120 knots. This could have further lowered the aircraft's actual airspeed from recommended values in addition to the incorrect setting of his bug speed.

Fuel Shortage Shortens Trip

Cessna Citation: Aircraft destroyed. Serious injuries to six.

The aircraft was completing a flight in the darkness of early evening on a November day in Finland. There were two crew members and four passengers aboard.

As the aircraft was being flown on an ILS approach to the destination airport at approximately 1825 hours, both engines failed at an altitude of 2,000 feet. The flight crew was unable to restart either engine and the aircraft made an emergency landing in a small field. The aircraft landed hard and skidded approximately 300 feet before it stopped. The aircraft was destroyed by the hard landing and all six occupants received serious injuries.

Investigators noted that the engines had failed due to fuel exhaustion. It was found that the tanks had contained 60 percent of the required minimum fuel for the flight prior to departure.

The pilot was cited for numerous instances of poor decisions, improper operation, wrong attitude, low experience in aircraft type and for selecting an unsuitable area for the unsuccessful forced landing. The copilot also was cited for poor decisions.

Corporate Executive

Demonstration Flight Got Carried Away

Gates Learjet Model 31: Substantial damage. No injuries.

The aircraft was being used for a demonstration flight and the demonstration pilot had allowed the other pilot, a non-Learjet rated pilot with limited jet experience in a Cessna Citation, to do the flying.

A landing was being made under the following marginal conditions: the landing distance required was 2,750 feet and the distance available was 2,674 feet; the required approach path angle was four degrees because of obstacles in the approach sector; there was both an up-slope and a down-slope to the runway; the demonstration pilot was preoccupied with the non-familiar approach and landing conditions; and there was little crew coordination.

The aircraft touched down with a high sink rate at idle thrust. The hard landing caused the supporting structure for the right engine to fail, causing substantial damage. There were no injuries to the four occupants aboard.

Contributing factors to the hard landing accident included faulty preflight planning and preparation by the demonstration pilot, faulty preflight planning by the aircraft manufacturer conducting the demonstration flight; poor landing judgment and execution; and lack of coordination between the two pilots.

Be Prepared for Clear Air Turbulence

Rockwell Turbo Commander 690: Substantial damage. No injuries.

The turboprop twin was cruising at 20,000 feet in visual meteorological conditions in the late mid-January afternoon over Argentina. The only occupants were two crew members.

The aircraft encountered severe clear air turbulence, pitched nose up, banked to the right and rolled inverted. It descended vertically and accelerated to a speed beyond the recommended never-exceed airspeed. The two crew members joined forces to recover and stabilize the aircraft at 13,000 feet.

After it was landed with no further difficulty, the aircraft was inspected for signs of structural damage. Both wings and ailerons had suffered substantial damage during the effort to recover the aircraft from the steep dive.

Other General Aviation

The Final Cause: Continued VFR Flight into...

Piper PA-32R-300 Lance: Aircraft destroyed. Fatal injuries to five.

The plan was to take three passengers from one Canadian airport to another airport for an ice fishing trip. Departure of the single-engine aircraft was scheduled for 1700 hours early in February. The pilot planned to drop off three of four original passengers and return to his home base with the remaining passenger.

There is no record that the pilot obtained a weather briefing and no flight plan was filed. Reported weather at 1600 hours for the airport included 2,500 feet broken, 7,000 feet overcast and visibility 15 miles with temperature and dew point of -9 and -13 degrees C. The area forecast included generally overcast weather with ceilings at 3,000 feet, three-to-five miles visibility in light snow with patchy light freezing drizzle and local ceilings down to 700 feet agl. Moderate clear icing in freezing drizzle was forecast for below 4,000 feet.

The aircraft was not equipped with anti-icing or de-icing equipment other than a heated pitot-static tube. The 400-hour pilot had a private license, authorized for day VFR flight. Although he had approximately 26 hours of instrument flight instruction, five hours of night instruction and 20 hours of solo night flight time, he was not endorsed for night flying and had no instrument rating. Log book entries indicated he had carried passengers at night previously.

The aircraft took off in darkness at 1740 hours and reported to the control tower when he departed the control zone to the north, but gave no indication of his intended altitude. Radar tracking showed that the aircraft made a 180-degree turn 29 nautical miles northeast of the airport. Shortly afterwards, 20 miles from the airport, the aircraft stuck a steel hydroelectric transmission tower and crashed in an open field. The aircraft was destroyed and all five occupants were fatally injured.

At the time of the accident, it was dark with low overcast skies and freezing precipitation. A lightplane pilot reported an hour earlier from the accident area that cloud bases were 2,800 feet agl with freezing precipitation. Clear ice had formed on his windshield which had totally frosted over.

The Canadian Aviation Safety Board determined that the pilot attempted a night VFR flight in unsuitable weather conditions. The board is preparing recommendations to reduce the number of accidents involving VFR flights into adverse weather conditions.

Ground Checked OK Flight Check NG

Cessna 310: Substantial damage. No injuries.

There were an instructor pilot, a student pilot and one other occupant aboard the light twin-engine aircraft during a single-engine training session. While the student pilot was flying the aircraft, the left propeller began an uncommanded return to flat pitch, producing heavy drag that caused the aircraft to yaw to the left. The instructor took control of the aircraft and made a precautionary landing in a field.

The instructor made a visual inspection of the propeller, performed an extensive run-up and determined that the propeller was functioning properly. He then taxied the aircraft to a dirt road and took off. When the aircraft reached a height of 20 feet, it yawed left and the pilot had to put it back on the ground. It landed hard and was substantially damaged. All of the landing gear legs were sheared off, both wings were damaged and the fuselage was twisted. There were no injuries to the three occupants.

Rotorcraft

A Case for the Visual Fuel Check

Enstrom F-28A: Moderate damage. No injuries.

The student pilot with almost 30 hours of rotorcraft flight time noted that the fuel gauge read 90 pounds and, with an instructor pilot aboard, took off in mid-morning for a dual lesson on quick stops that lasted about 20 minutes. After the final landing, the instructor confirmed with the pilot that there was enough fuel left for the student's intended 30-minute solo flight and left the aircraft.

During the following solo flight during which he practiced quick stops, the student monitored the fuel gauge to ensure that enough was available. After approximately 20 minutes of flight, while flying straight and level at a height of 40 feet and an airspeed of 60 mph, the rotor and engine rpm indicator needles split. The pilot applied full throttle but the rpm readings remained erratic so he closed the throttle and entered autorotation for a forced landing.

The pilot carried out a run-on landing during which the tail rotor struck the ground at approximately the same time he leveled the skids. The pilot was not injured and was able to shut everything down before leaving the aircraft.

The fuel gauge read 60 pounds. However, subsequent examination of the tanks revealed that they were empty. Due to poor communication, neither the student pilot nor the instructor had visually checked the fuel quantity prior to the flight.

Too Slow, Too Low

Bell UH-1B: Aircraft destroyed. Serious injuries to one.

The helicopter was being used for fire fighting. An external water drop bucket was being carried.

The aircraft was not properly aligned with the water drop site and the pilot was trying to maneuver it into the wind to make another attempt at a water drop. However, the helicopter was too low and slow and, according to witnesses, appeared to settle toward the ground with power on. It entered trees and descended nose down and to the right until it impacted the ground. The aircraft was destroyed and the pilot, the only occupant, received serious injuries. ♦