Journal of Air Law and Commerce

Volume 34 | Issue 3 Article 4

1968

State of the Art in Air Safety

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STATE OF THE ART IN AIR SAFETY

By C. O. Miller†

I. Introduction

THERE HAS BEEN unprecedented attention focused on air safety in recent years. Of that, there can be no doubt. Perhaps this attention has been the result of socio-technological evolution—a concern for fellowman's physical well-being amid astounding mechanical marvels which often seem incomprehensible to the point of being frightening. Perhaps it has simply resulted from communications media being more effective in bringing tragedy closer to the not-so-directly-involved personnel. Witness the reaction to the Apollo 204 accident. The philosophical reasons for the *why* of a change notwithstanding, it behooves society in general, and professionals in particular, to periodically pause, and ask, "Just where have we been; where are we; and what must we appreciate about the future?" This paper attempts to do just that for today's air safety art. Or call it air safety discipline if you will, depending on your standards of accreditation for a new field.

As part of the Symposium on Air Safety conducted by the School of Law at Southern Methodist University, this discussion extends somewhat beyond air safety per se. The purposes and practices of law and the purposes and practices of safety are not unrelated. Based on prior investigations by this author among others and a previous law-safety symposium, one might conclude that aviation law and safety are entwined much like separate vines in a dense forest, each striving for sunlight, but crawling all over each other enroute. When each truly recognizes the objectives of the other, and bends a bit to give a little more room, both prosper.[1]

Thus air safety will be discussed in terms of its state of development. But emphasis will also be placed on misunderstandings or unresolved problems in accident prevention that bear upon the law-safety interface.

II. Evolution of Safety

Within the span of two generations at best, aviation has transitioned from a "white scarf" barnstorming image to a rather integral part of our everyday life. Within this era, formalized safety efforts have evolved significantly, beginning with the licensing and regulatory procedures of the

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[1] Miller, *Legal Ramifications of Aircraft Accident/Malfunction Data*, I Proceedings of the IAS National Aerospace Systems Reliability Symposium (New York: AIAA 1962); Miller, *The Safety Information Challenge*, ASSE Journal, Sept. 1968 (Originally presented at the Flight Safety Foundation Seminar, New York, 15 Oct. 1964); Miller, *Aviation Law-Air Safety (A Symposium Report)*, Alumni Review (Aerospace Safety Division, Univ. of S. Cal.) Fall, 1964; Miller, *The Influence of Systems Engineering and Management on Aviation Products Liability*, Astronautics and Aeronautics, Sept. 1966 at 62; C. Miller, The Engineer, Lawyer, and Flight Safety, Presented at the SAE-ASNE National Aero-Nautical Meeting, Washington, D. C., 9 April 1963 (Flight Safety Foundation, New York, New York).

Bureau of Air Commerce in the late 1920's. A decade later the next major milestone in air safety evolved. Modern day accident investigation procedures are traceable to the Civil Aeronautics Act of 1938 with the first major investigation involving, as aviation buffs might suspect, a DC-3![2]

As World War II approached and was underway, however, safety was still something that impugned the ego of any red-blooded pilot. Persons suggesting that accidents were anything more than unfortuitous events were considered sissified. Certainly at that time, the moral motivation for protection of life in aviation was apparent; but luck was the name of the game. Only the most farsighted individuals viewed accident prevention as a specific technique that could be applied in a rational sense. With few exceptions, such as Jerome Lederer,[3] the names of these men have been lost in technology's cemetery of forgotten reports.

World War II had its effect on safety technology as it did in many fields. The accident scorekeepers were hard at work, and a few safety education posters were utilized for good measure. When the bent aircraft and broken people were tallied, however, far more losses were found due to accidents than to combat.[4] The fatality and destroyed aircraft rates as a function of flying hours were not bad when comparing stateside and overseas losses; but combat potential in terms of men and machines had been seriously compromised through sheer numbers of catastrophic accidents. As a result, a cry for professional flight safety work was noted early in 1946.[5] There was concurrent activity pertaining to civil aviation, as evidenced by the start of the Flight Safety Foundation near the close of the war.[6] Then a landmark paper by Steiglitz in 1948 clearly delineated the concept of a specialized approach to flight safety engineering.[7]

Thus, a major change in safety philosophy was born if a comparison be made of air safety with traditional modes of safety, *e.g.*, industrial or traffic. Air safety was cited as a means of enhancing mission accomplishment, whether that "mission" was delivering bombs or making a corporate profit while providing safe and sane air transportation. A suggested methodology breakthrough involved safety specialists plus an inherent duty of accident prevention resting on each man in every organization.

The 1950's saw at least two more fundamental developments. The first was the formation of the military safety centers at Norton Air Force Base, California, Naval Air Station, Norfolk, Virginia, and the United States Army's Ft. Rucker. Concurrent with these actions was the assignment of safety officers at all levels of command through all military services, *i.e.*, the implementation of safety specialists in the operational world. The

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[2] CAB, Report of the Investigation of the Accident Involving Aircraft of U.S. Registry NC 21789 Which Occurred Near Lovettsville, Virginia on August 31, 1940 (Washington, D.C. 1940).

[3] Former Chief of the CAB Bureau of Safety; Former Director of the Flight Safety Foundation; Presently Director of Manned Space Flight Safety, NASA.

[4] Address by Brig. Gen. C. B. Stewart before the graduating class, Aerospace Safety Division, U. So. Cal., Los Angeles, Cal., 17 Dec. 1965.

[5] A. Wood, The Organization and Utilization of an Aircraft Manufacturer's Air Safety Program, Unpublished Paper Presented to the IAS Meeting, New York, N.Y., Jan. 1946.

[6] Flight Safety Foundation, Inc., Certificate of Incorporation, Filed with the State of New York, 12 April 1945.

[7] Stieglitz, *Engineering for Safety*, AERONAUTICAL ENGINEERING REVIEW, Feb. 1948.

University of Southern California's safety education programs have provided over 5,000 graduates of 10 to 12 week intensive study programs aimed at these positions since 1953. Attendees have also included representatives of 50 foreign nations, and occasionally, civilian personnel. In recent years, airlines, business aviation, and other groups (including lawyers) have been provided similar education programs but on a reduced time scale. The evolutionary trend was one of changing the emphasis from accident investigation to accident prevention.

The second major impact of the 1950's was the realization of the economic motive for safety. Single seated aircraft were being delivered at more than $1 million a copy; others came much higher. The military realized that although lives remained important and that although mission accomplishment was its fundamental goal, economy was perhaps the greatest real world motivator for improved accident prevention. This trend has continued today when one realizes the annual "book" dollar loss of air vehicle accidents by the United States military services approximates $750 million.[8]

Safety specialist-oriented personnel were to be found in some airlines during the 1950's. Perhaps Carl Christenson of United Airlines was the most prominent. For the most part, however, the increasing complexity of the machines and the "system" had not fully arrived or had not been adequately recognized by the airline community. There are many who feel the early losses of the first (and second) generation jets by airlines fall basically into this area of explanation.

The influence of the missile and space age added still more dimensions to the safety art discipline. Not only did a new set of hazards arise (propellants, space navigation, and the like), but the flight crew was finally recognized for the tremendous contribution to safety that it really was. It was painfully recognized that without pilots aboard, air vehicles such as missiles had to be made right the first time; the term "system safety" had come into being.

Actually, there had been hints of the system safety concept in Stieglitz's 1948 paper and in early papers by this author in 1954[9] and 1957.[10] Also, an evolution in military weapon system procurement transpired in the late 1950's and early 1960's that further contributed to a definition of the system safety concept. But all in all, system safety truly differs from previous accident prevention efforts in only three ways, albeit these ways are highly significant improvements. These differences are:

(1) The "System" could encompass much more than just the aircraft. It could include support equipment, facilities, the people involved, and training programs. Or, it could be applied to any identifiable segment of the whole.

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[8] A given accident's "book" dollar loss entails essentially the cost price of the air vehicle as represented by the total procurement contract divided by the number of air vehicles purchased. Values of human lives and indirect costs are rarely ever discussed.

[9] C. Miller, Applying Lessons Learned from Accident Investigations Through a Systems Safety Concept, Presented at the first IAS Naval Aviation Meeting, San Diego, Cal., Aug. 1957.

[10] *Id.*

(2) The accident prevention scope involves planning and control on an entire life cycle basis, from conception of a system through its operational phase.

(3) There are specific safety tasks contracted in the engineering phases to supplement those conceptually similar efforts going on during operations.

By the mid-1960's, the system safety concept was observable in the Supersonic Transport program (by direction of the Federal Aviation Administration). Within the past six months to a year, it has been applied by at least one major transport aircraft manufacturer of his own volition. Interest by the airlines in application of this concept has been minimal although it was suggested to them specifically in 1966.[11] The evolution of air safety can thus be summarized as follows:

(1) The safety specialist has appeared at both the operational and engineering end of the system spectrum.

(2) Economic and mission factors have joined moral justification as basic reasons for improved accident prevention.[12]

(3) The approach to safety today is *prevention*, not just after-the-fact accident investigation.

(4) The system safety concept involving complex engineering, management, and operational relationships has become a part of aerospace life.

Although not germane to the air safety state of the art per se, it should be recognized that a major revolution is going on in relating various forms of safety activity to one another. Heretofore, industrial safety, traffic safety, missile safety, and nuclear safety have tended to pursue separate paths of technological development. As exemplified by major organizational changes in the military and industry, most of these areas are learning that accident prevention as a discipline can best be achieved by a major amalgamation of these splinter areas. The system safety approach may well be the methodology that brings these various groups closer together since it has application in all fields.

III. TODAY'S PRECEPTS CONCERNING ACCIDENT PREVENTION

Traditionally, one can identify principal approaches to safety as practiced by particular organizations or groups of people. They are the identifiable philosophies and *modi operandi*, albeit not necessarily the only ones to be found in the total group. They are interrelated. They are changing, since nothing about safety is static. Listed in Table 1 are these principal safety images in the minds of the groups shown—images that one will encounter. They go well beyond aviation safety, just as law goes well beyond

[11] C. Miller, The Application of System Safety and Management to the Civil Air Carrier System, Presented and Published in the Proceedings of the ALPA Air Safety Forum, U. So. Cal., Los Angeles, Cal., Oct. 1966.

[12] A rather strong case can also be presented for the prestige factor as exemplified by the Apollo 204 loss. Cost, mission, or people are not considered to be the principal reasons why NASA has done so much towards modifying its safety programs in the past year. A similar situation arose recently following the USAF B-52 accident near Thule Air Force Base in Greenland. Cessation of airborne alerts was influenced by world opinion (prestige) as much as anything else.

aviation law. They are shown in no particular order except that Public is first. The Public has had its thoughts shaped by a few million years of trying to avoid danger. It deserves to be first!

TABLE 1

1. The Public (P): Safety is restrictive: don't do this, don't do that. It is protection of person, not property. It is produced by a strange lucky combination of conscious and subconscious acts either *by* the individual or *for* him. (Ignorance is bliss!)
2. National Safety Council (NSC): Copious statistics must be kept so that everybody can be told how bad things are. Education is the main tool of prevention. People are the only answer; they are the last ones on the responsibility chain. (They are the easiest to blame!)
3. Department of Defense (DOD): Safety is a necessary part of mission effectiveness that involves both men and equipment. Put a number on it so that one may "scientifically" equate safety with other variables that affect decisions towards cost effectiveness. (When we try to find out what went wrong, the man who did the evaluations and made the decision has been transferred to a world bank, or somewhere!)
4. United States Air Force (USAF): Regulations must be issued to cover all eventualities. Then there must be detailed inspections and reports to assure that people follow the orders. (By the numbers . . . 1, 2, 3, 4!)
5. United States Navy (USN): Accountability is the middle name of the captain of the ship. He is the Chief Safety Officer—and chief everything else. Accident prevention is his responsibility. Anyone else working therein is just a crutch for a less than 100% commander. (Hallowed are the banks of the Severn!)
6. United States Army (USA): There is a group at the arsenal who have been building these things safe for a long time. Do the best with what is available. (Ya gotta expect losses!)
7. National Aeronautics and Space Administration (NASA): Prior to Apollo 204: Make it reliable, and it shall be safe. Instill constant awareness in highly selected and trained individuals, and the good guys will prevail. After Apollo 204: All the above plus special attention to system safety engineering and management. (Just how much does Congress expect?)
8. Federal Aviation Administration (FAA): Standards have been issued in accordance with authorities granted in the FAA Act of 1958. It is the FAA's duty to enforce those standards. All FAA work pertains to safety. (P.S. . . . Those are minimum standards.)
9. National Transportation Safety Board (NTSB): Senator Magnuson called NTSB the "Supreme Court of Transportation Safety." An overview safety job is needed for all tranportation modes. This includes what formerly were investigation functions of the Civil Aeronautics Board, Bureau of Safety. Objectives, prevention-oriented studies are also to be accomplished. (But how can this be done with only 184 people? There were 125 for aviation alone when under the CAB.)
10. Public Health Service (PHS): Accidental death is a leading cause of loss of life and ergo, a health problem. It is epidemic and therefore is subject to the epidemiological approach. (First, however, someone will have to research all aspects of the situation!)
11. National Highway Safety Bureau (NHSB): Until recently, accident prevention was a matter of "write an ordinance and enforce the law." (At least it produced revenue.) Today's program aims at the machine and environment as well as at the man, both before and after the impact.

(Thanks to Ralph Nader!)

12. Atomic Energy Commission (AEC): It is obvious that there must not be any accidents. Accordingly, there can be no question that AEC regulations must be followed to the letter. (Besides, who knows enough about this business to ask—or answer—questions?)
13. Air Line Pilots Association (ALPA): Pilot's opinion must be followed because, after all, they are up there, too. They are also a rather professional group. (Look at their salaries.) Given better training and better facilities, they can "hack" anything. (If some of them don't trip on their white scarfs!)
14. General Aviation (GA): "Flying safety is when an airplane operates according to the pilot's will, totally," from "Quest for the Great God Safety," *Flying*, June 1965. ("To be, or not to be . . . in the same sky as the airliners," from Shakespeare, 1603, and Miller, 1968.)
15. Flight Safety Foundation (FSF): Everybody needs a conscience. Somebody needs to be a catalyst. (But when it comes to soliciting memberships, the question arises, "Why did you have to rock our boat?")
16. Institute of Aerospace Safety and Management (USC): The name of the game is total system accident *prevention* through the interdisciplinary approach. Higher education plays a major role therein. (But how do you get a safety program through the curriculum committee without a hundred years of PhD. candidates?)
17. Aerospace Industry (AI): Tell us what you want in accident prevention, and you will get it. (For a price!)
18. American Bar Association (ABA): Punishment or threats thereof represent deterrents to accidents. Within a main objective of social justice our ethical practices produce the greatest good for the greatest number of people. (Assuming the attorneys are equal in capability and there are capable judges and juries!)

Despite these oversimplifications for the sake of emphasis (and the parenthetical observations that just could not be resisted), the fact remains that P + NSC + DOD + USAF + USN + USA +NASA + FAA + NTSB + PHS + NHSB + AEC + ALPA + GA + FSF + USC + AI + ABA + many others equals one tremendous amount of accident prevention motivation, dedication, and action, without which many of us would be lucky to be alive. The differences in approach, apparent in Table 1 (and the shortcomings implied), simply reflect the different origin, evolution, and environment applicable to a given segment of the accident prevention world. To suggest that any one approach is significantly superior to another, or that either can do the total job alone, would be quite foolhardy.

The previous discussion notwithstanding, there are certain accident prevention precepts that appear to enjoy near unanimous endorsement by safety personnel today. These endorsements include:

(1) Accident causation is a sequence of events describable in man, machine, media (environment), management, and other variables, depending upon the depth to which one wishes to take the analytical model. For optimum prevention activity, these variables are not describable by a single cause.

(2) Accident causal factors are seen repeated over and over again. Indeed, with the possible exception of rare hazards brought about by

highly advanced technology, one hardly ever sees a truly new safety problem.

(3) Although accident prevention is far from being an exact science, its analysis methodology has made remarkable strides in recent years that entail highly advanced technical approaches.[13]

(4) Management responsibility cannot and should not be denied relative to accident prevention. Man is ultimately responsible for his own survival. But when groups are formed to better effect given missions, safety becomes more than protection effected through the individual; group leaders must assume responsibility for safety of and created by the whole.

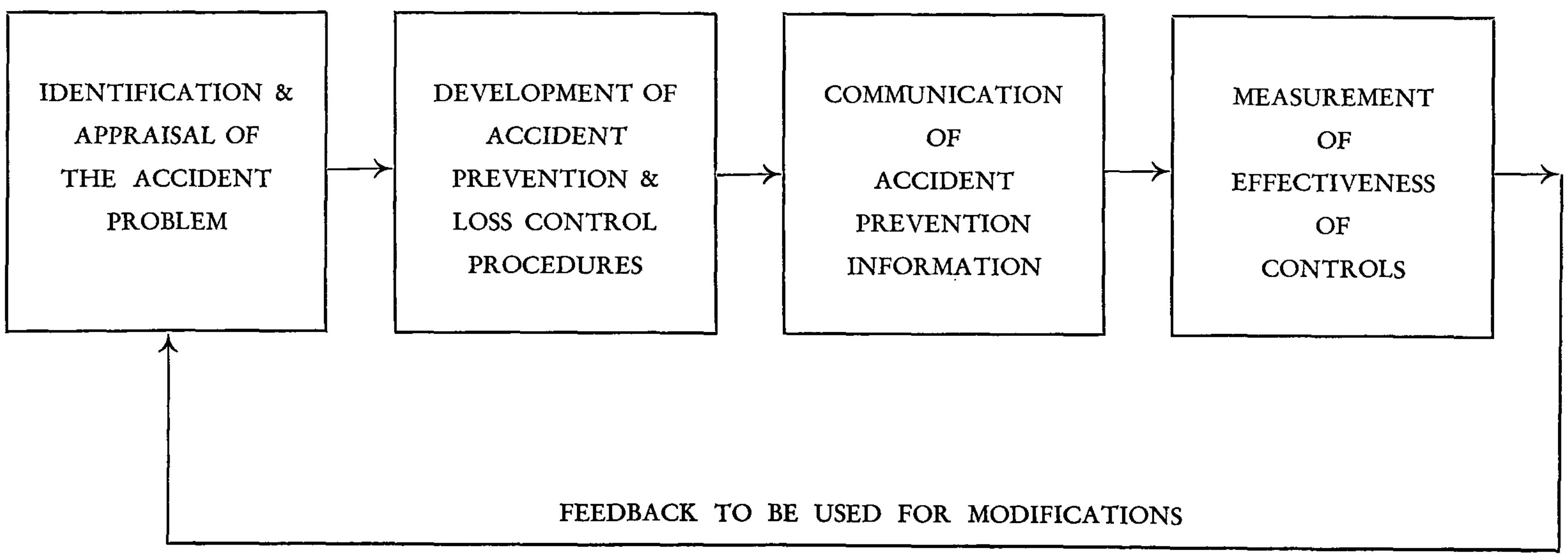
(5) At some level of task complexity and size of the organization, specialized approaches to accident prevention in addition to safety being everybody's job produces more accident prevention per unit of resource expenditure than safety simply being everybody's job. This entails *additional* obligation/accountability through the specialist, not merely his substitution for others.

Within this basic framework there have been efforts to clearly define the professional safety task. Table 2 reveals a generalized view as developed by the American Society of Safety Engineers.

[13] C. Miller, Hazard Analysis and Identification in System Safety Engineering, Presented to the AIAA/SAE/ASNE Reliability and Maintainability Conference, Institute of Aerospace Safety and Management, July 1968.

TABLE 2

THE PROFESSIONAL SAFETY TASK



On previous occasions, the author cited tasks in more detail as specifically applied in the aerospace field. These are shown in Table 3.

TABLE 3

System Safety Tasks
1. Develop and coordinate implementation of safety plans including program accident prevention, system safety engineering, accident/incident investigation and disaster control plans.
2. Assist in establishment of specific accident prevention requirements.
3. Conduct or participate in hazard analyses, including the control process related thereto.
4. Determine and/or review emergency procedures.
5. Participate in design reviews and similar milestone events during product development and use.
6. Maintain an accident/safety information data center.
7. Effect liaison with other safety organizations.
8. Provide recommendations for and/or conduct safety research, study, and testing.
9. Implement safety education, training, indoctrination, and motivation programs.
10. Participate in group safety efforts such as councils, standardization boards, and surveys.
11. Direct or otherwise participate in accident/incident investigations.
12. Follow-up all action resulting from accident/incident investigations.
13. Provide objective response to safety inquiry as a staff advisor, in the confidential sense when appropriate.

These tasks have been exposed in their original form for over three years to numerous critical groups (including almost 200 Advanced Safety Program Management students). Modern aviation safety effort can be described by one or more of these functions. Competent management, through the division of work principle, will assign such tasks to their personnel, safety specialists or otherwise.

IV. Unresolved Problems

There remain several major challenges or unresolved problems that face the safety fraternity. While keeping the discussion rather broad, and without any suggestion or priorities, these include:

(1) Lack of total understanding and/or acceptance by the layman of safety as an integral part of mission and cost effectiveness, and involving more than merely personal survival.

(2) Determination of the optimum level of system complexity or the nature of a given organization that merits a specialized approach to safety, *e.g.*, an identifiable system safety organization containing specially qualified personnel.

(3) An almost total lack of hard data bearing on the economics of safety. What really constitutes investments, losses, and returns associated with safety? Such information is needed by management to become more efficient in expenditure of funds towards accident prevention.

(4) Limited ability to assess the reason for "action failure," *i.e.*, the places between accident occurrence and similar accident recurrence where much of today's well meaning work falls down the proverbial crack.

(5) The pitiful state of safety information storage and retrieval. There have been countless safety lessons learned but their identification and use within time constraints present on new programs is seriously compromised by inadequate storage and retrieval systems in existence today.

(6) The need to provide a broad base safety education program to include professional development through the PhD. level.

(7) Determination of a method of investigating accidents from the human factors viewpoint—psychological as well as physiological.

(8) Better integration of the safety engineering and operational safety efforts, especially to ensure better test and indoctrination programs that minimize accidents during early parts of the learning curve on new vehicles.

(9) Expansion of the systems concept into non-aerospace endeavors (with appropriate modifications), as a process that can more readily handle the multi-factor basic nature of an accident than do current concepts.

(10) Conflict between legal requirements to establish fault during investigations and the need for delineation of all causal factors in the interest of more fundamental approaches to accident prevention rather than just enforcement.

Item (10) cannot be emphasized too strongly as being the basic factor underlying misunderstandings between the legal profession and safety specialists. The lawyer, in seeking social justice through tort litigation, for example, must establish a proximate cause as a fundamental part of his case. In most situations, proximate cause becomes a single factor, or at least is identified in the minds of the layman as a single factor. The required proof of standard of care (duty) and failure to meet that standard of care (breach of the duty) entail a concept of negligence that carries with it a "fault" label. This in turn, is interpreted by the layman as "who are they going to hang?" Suddenly the layman just does not want to become involved.

In accident investigation as a prevention task on the other hand, the purpose is not social justice, but rather it is protection of life, mission accomplishment or conservation of resources in general. It is a matter of trying to establish all factors as objectively as humanly possible. It is a matter of making recommendations and ultimately taking action on *any* factor that is determined to be potentially accident preventive in nature, consistent with resources and time available to take such action. There is no person or organization that is a target or a bastion to be defended. Any resemblance of these causal factors to the proximate cause as defined by law or determined by a judge or jury could be quite coincidental.

It is fully recognized that the accident investigator must go through the "cause" phase in his thinking, or more precisely, his cognitive process. There is even experimental evidence to this effect.[14] However, if professionally trained and motivated, he will not be satisfied to choose *the* cause and build his report or recommendations only around that finding. Unfortunately, the charter provided the NTSB Bureau of Aviation Safety as carried over from the FAA Act of 1958 demands establishment of *the* most probable cause, as most military directives insist on establishing *the* primary cause in their accidents. These become accident board functions as compared to the functions of an investigator in his fact-finding capacity. Hence, the conclusion is reached that most accident boards have been directed to be quasi-legal bodies regardless of their purported motives.

Despite the desire to think otherwise, this author believes that any accident deliberative body that is directed to find the most probable cause, the primary cause, or any similarly single factor oriented conclusion is not working optimally in the accident prevention field. If fault or proximate cause is required, let that be the function of a court of law or a military collateral investigation. If primary or probable causes are required for data classification purposes, let their determination be the prerogative of the data processing group. If primary causes are required for management data chart presentation to show priorities in required safety areas, let the chart preparers make the classification selection (they will probably distort them in any case to prove whatever they are selling!).

If accident prevention boards cannot be established with capability for attaining off-the-record evidence and developing preventive recommendations without having to decide on *the* cause, they had best be forgotten. Save the administrative expense of two types of hearings; go to the complete adversary system; and be satisfied with restricted data flow into and out of accident investigations. Be satisfied with deterrence being the principal mode of accident prevention. Of course, such action would come as a considerable shock to safety specialists who believe they have come quite a way from the red flag, hard hat and perform-safely-or-punish concepts.

V. The Aviation Safety Record

The question cannot be overlooked as to just why aviation accident prevention practices should be improved, if indeed they need to be improved. One argument states we are well within risks of normal living (whatever that is!). The other argument states we should be continuing to do *what* we can *where* we can to conserve our personal and material resources consistent with a progressive society (whatever that is!). Implicit in such discussions is a look at the past record and an attempt to project it into the future. Unfortunately, there is no measure that adequately provides a good index of accident prevention potential or even achievement on a short term basis. Accident rates as a function of flight hours may be the least of many evils in after-the-fact assessment. But everyone close to the

[14] Braunstein & Coleman, *An Information-Processing Model of the Aircraft Accident Investigator*, HUMAN FACTORS, Feb. 1967.

accident statistics field quickly recognizes that the power of the definition pen far outweighs the power of the plotted data.

Nevertheless, an undeniable improvement has occurred in aviation safety in the last twenty to thirty years, which is really the limit time span in which meaningful records have been kept. However, in our more or less immediate past that includes the jet transport era, the statistical rarity of airline accidents precludes any assessment of trends based on accident rates. General aviation on the other hand has been kind enough to try harder. They are having sufficient accidents that a trend does seem to be detectable, and it represents an improvement in the last three to five years compared to a plateau that existed in the previous decade. There has been a rather strong hint from the military accident records that the specialist approach to operational safety has paid good dividends in accident prevention between the early 1950's and early 1960's. It has also been suggested that this improvement has leveled off, much as a learning curve tends to level off.[15] This means that some major breakthrough will be needed to induce additional significant improvement. The system safety concept represents a possibility in this direction.

Obviously, rates do not tell the story. They tell little about exposure; they tell little about where the rates are going when the curves are relatively flat; they tell little about the impact of one or more particular kinds of accidents on the public. They tell nothing about the accident the observer may be worried about—the one he may be in.

The required perspective for state of the art in safety, however, is aviation in total. The total fatalities in aviation accidents these days (military and civil systems combined) are on the order of 2,100 people annually. This represents less than 2 percent of the total accidental deaths experienced in the United States each year and less than 4 percent of motor vehicle fatalities alone.

The total dollar loss in aircraft accidents has never been seriously tabulated to the author's knowledge. Using what data is available, however, this number is believed to be in the region of the $1.5 to $2 billion annually. This assumes certain book values for the machines and an estimate of some of the other definable costs. It does not include indirect costs which in the industrial safety field can run 3 to 5 times the direct costs of accidents.

To continue the comparison with the automobile safety field, the aviation accident economic loss is about 15 percent to 20 percent as large. Hence, it can be argued that in today's market, the cost proportion is significantly larger than that represented by fatalities, which only proves once again that statistics is the art of drawing a straight line between unwarranted assumptions and a prejudiced conclusion.

Actually, aviation's concern for safety is not merely based on the past but is far more concerned with the future. This concern could be expressed simply as the threatened single loss of 300 persons and $55 million

[15] C. Miller, The Role of System Safety in Aerospace Management, Jan. 1967 (unpublished thesis, U. So. Cal.).

in an "airbus." It could be the one-a-day brand major catastrophe of a civil airliner forecast by Lundberg for the 1990 period, assuming no major decrease in accident rate combined with increased operations by then.[16]

Philosophically, it is argued that we cannot morally stand by and permit the number of air fatalities to grow in the manner automobile fatalities have mushroomed. After all, now we have technology to apply toward further aircraft accident prevention—technology that was not even dreamt of at a comparable period of development of surface transportation.

VI. Concluding Remarks

The motivation for the past development of improved aircraft accident prevention methodology has not been personal protection alone. It has resulted from attempts to provide better air transportation or other forms of mission accomplishment at minimal cost in either lives or material resources. As society becomes increasingly complex in general, identification and solution of problems related thereto become similarly more complex. An evolutionary result which is by no means unique to the safety field, is specialization in tasks, specialization in personnel.

Interestingly enough for safety, however, this produces a paradox in view of the broad, interdisciplinary nature of accident prevention. Is the safety professional really a specialist, or is he a generalist? Actually, the safety professional is both. He is a specialist in attitude (accident prevention) and a generalist in knowledge and skills. This in turn produces an interesting comparison with members of the legal profession; a lawyer might be described as a specialist in attitude (social justice) and a generalist in knowledge and skills.

Hence, it is not surprising that the same set of facts as exhibited in an accident investigation are interpreted from two different viewpoints, each based on its own contribution to be made to society. Of course, the profession of law has been around for quite some time. The profession of accident prevention has just begun. This paper has hopefully provided the legal profession, as well as others, a better understanding of the new arrival.

[16] Lundberg, *Aviation Safety and the SST*, Astronautics and Aeronautics 29, Jan. 1965.