HUMAN FACTORS IN AIRCRAFT ACCIDENT INVESTIGATION

SECOND ANNUAL SEMINAR

LOS ANGELES
OCTOBER 26-28, 1972

UNIVERSITY OF SOUTHERN CALIFORNIA

THE SOCIETY OF AIR SAFETY INVESTIGATORS

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THE INSTITUTE OF SAFETY AND SYSTEMS MANAGEMENT

UNIVERSITY OF SOUTHERN CALIFORNIA

LOS ANGELES, CALIFORNIA

PROCEEDINGS OF

SECOND ANNUAL SEMINAR

The Society of

Air Safety Investigators

HUMAN FACTORS IN AIRCRAFT

ACCIDENT INVESTIGATION

Edited by
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FOREWORD

The Institute of Aerospace Safety and Management of the University of Southern California and the Los Angeles Chapter of the Society of Air Safety Investigators jointly hosted a Seminar on the Human Factors in Aircraft Accident Investigation in October 1971, at Los Angeles, California.

Special thanks and recognition are given to the Officers and Members of the Los Angeles Chapter of the Society of Air Safety Investigators and to the University of Southern California's Dr. Herold Sherman and Harry H. Hurt whose encouragement made this Seminar possible. Recognition is also extended to the National Officers of the Society of Air Safety Investigators who participated to the fullest extent.

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TUESDAY, 26 OCTOBER 1971

8 a.m. Registration

9 a.m. Session 1

Chairman: Donald Kemp, FAA, National President SASI

Welcome - Robert Griffin, L.A. Chapter President, Dr. Harold Sherman, USC, Mr. Russell Watts, ICAO

Statement of the Problem - David Hall, USC, Seminar General Chairman

Magnitude of the Problem - Representatives of the various national authorities will briefly cover each nation's statistics regarding human factor causes.

Policies and Procedures - C. O. Miller, Director, Bureau of Aviation Safety, NTSB

Human Factors in Aircraft Accident Investigation in Mexico - Dr. Luis A. Amezcua, Jefe de los Servicios de Medicina de Aviacion Direccion General De Aeronautica Civil, Republic of Mexico

The Vertignon - James Harris, CAMI, FAA

12 noon

Luncheon

Hosted by SASI Corporate Members

Speaker: Dr. Charles I. Barron, Medical Director, Lockheed - California Co.

2 p.m. Session 2

Chairman: Gerard Bruggink, NTSB

Validity of Witness Statements - Gerard Bruggink, NTSB

Awareness - Gestalt and the Improved Accident Investigator - David Holmes, U.S. Army Board for Aviation Accident Research

Hypnosis - Chaytor Mason, USC

Interview or Interrogate - Dr. Robert O. Besco, Allied Pilots Association

The Complete Witness Statement - Lawrence J. Galardi, Attorney at Law

THE PROBLEM IN HUMAN FACTORS IS HUMAN

DAVID S. HALL

Lecturer, Accident Investigation
University of Southern California

Good morning, Ladies and Gentlemen. It's a real privilege to welcome you to Los Angeles and the start of what we all hope will be a profitable and enjoyable three days of learning and sharing in the field of Human Factors relating to accident investigation.

I think we all can agree that the topic is one which needs attention. We have developed useful and powerful tools in the engineering aspects of our field and it is not often that a piece of broken hardware escapes our grasp. The equipment that will be on display in the next room attests to the state of the art in materials testing and related subjects.

At the close of last year's meeting Mr. Russell Watts pointed out several areas which needed further attention, including the human factors area. This need was also apparent to the SASI Board of Directors when they picked this topic for us and it's obvious from the attendance today that we investigators are aware of that need.

But we didn't want a session in which we just listed our problems or gripes; the demand was for answers to the problems already before us. In our program committee meetings the decision was made to start the Seminar off with a general problem statement and proceed directly with the discussion of solutions and the privilege fell to me to make this statement of of the problem.

Gentlemen, the Problem in human factors is Human.

The first part of the problem is defining human factors.

Look for a moment at the ways in which human behavior affects aircraft operations.

Humans design components.

Humans make the components.

Humans assemble the components into aircraft.

Humans operate the aircraft, its support and service facilities.

Humans train other humans to do their jobs in aviation.

Humans make the regulations to which other humans must attempt to conform.

Humans communicate bits of intelligence to each other in the course of operating the aviation system.

The list is obviously endless.

If I may draw an example from the accidents of the past, many of you will recall an airliner which was destroyed when the propeller oversped in flight, cutting the fuselage in two. The cause of the propeller failure was metal fatigue, brought on early by excessive wear of an internal component due to a lack of adequate surface hardness. No pilot error here, purely mechanical accident mechanisms. Yet a thorough study of the many acts and conditions which preceded the accident made it clear that the real causes were related to people. There were humans who designed the part, manufactured the part, inspected the part, assembled and tested the part, maintained, serviced and periodically certified it to be airworthy. There were humans who managed the system by which all this was done and others who inspected the management system. When we record an accident as any kind of material failure, how can we possibly separate out the man from the material he makes and uses? In short, human factors are an infinitely complex set of variables influencing system design, operation and efficiency.[1]

Another major problem area is determining the true cause/effect relationship between human behavior and accidents. Consider the traditional admonition to pilots to eat a good breakfast before the day's flying. We tell them that no breakfast leads to low blood sugar, leading to reduced alertness, leading to accidents. No one really believes that the absence of breakfast is all that is necessary for an accident, or that proper feeding of all crewmembers will eliminate all accidents due to reduced alertness, but we admit to a relationship worthy of attention. But what constitutes "low blood sugar" for a given pilot? How do we record its value at the time of the accident? What is the plotted curve of Human Alertness vs. percent Blood Sugar? What is the repeatability of analysis between any two investigators (or by any one for that matter) regarding the effect of alertness on a given accident?

This relatively simple example shows areas where further investigation is needed. We will see some new data on alcohol and pilot flying qualities later in the program as an example of the type of research needed in this area.

A third major problem is a practical one. How deep do we go in the human factors investigation? We all live within real world limits of manpower, time, money, return on investment, etc. We have fairly good data on the crew's physiological conditions, but what can we afford in determining the crew's psychological makeup, both long term and present state data? How many people do we need this data on? Pilots, controllers, dispatchers, maintenance men, supervisory personnel, all these can lead an aircraft into an accident. One example is the FAA's psychological testing of controllers. This was a long term program and it took a lot of study and a fatal accident to help establish any standard of measurement. Where are we and where do we go from here?

To what extent can we go in family and peer group relationships, given the individual's desire and need for privacy, and given that domestic problems and sexual activities have a significant effect on present state of mind? We will hear an example later of a pilot who was disliked by his peers and this was felt to have a relationship to the accident.

How many related personnel can we interview; wives, children, managers, supervisors, girl friends? How far back in time do we go in recording and studying activities, 24-48-72 hours, one month, 60 years? At what point, if any, does past behavior cease to have an effect on current behavior? How high in management do we go, remembering that we are interested more in the "why" than the "who"? To what extent can we go, given the state of the legal environment in which we exist? How do we draw the line between "need to know" and "like to know"? How do we get the truth, when it hurts?

To what limit do we go in the autopsy, given the situation to be described later in which technical need clashed with local custom? How do we train the large numbers of people like local coroners and medical examiners, police officers and fire fighters who play so important a role in an investigation, but so infrequently as to not be very interested in learning?

It would seem that this is a challenge of substantial proportions for the manager.

There is a fourth problem that needs to be addressed here. What are the effects of the investigator's behavior on the investigation? What are the characteristics of a good investigator? Managers, what do you look for when you are hiring?

We will talk about rationalization by witness and investigator, and about the effects of leading questions especially during hypnosis and narcosynthesis. What kind of training is required for interviewers; sensitivity training, legal training, technical training? How do we measure the honesty and integrity of the investigator, does he want truth or just "good enough"?

One final area of problems, (a list by no means complete), relates to the results of our work. What increases in the level of safety are, or can be obtained in aircraft operations? Are we actually influencing the system's development? What is the positive measure of safety achievement? Just what constitutes "practicable" safety? What are the risk vs. gain tradeoffs which must be applied? Often other system outcomes are valued over safety by some portion of our industry. (The military has a need for effectiveness in combat; in a civil situation it may be profit or no business at all.)

Is risk-taking foolhardy or fundamental to human nature? Dr. Grimaldi of New York University indicates that the inclination (or need) for chance taking may be fundamental to daily living and that our venturesomeness may be as responsible for human progress as the quality of the intelligence that employed it.[2] To what extent can the investigator go, beyond the identifying of what happened, and recommend changes in an environment not his own?

I don't promise you a solution to any of these problems during the next three days but I would like to suggest a way to increase our knowledge and capability to solve them. I submit that Air Safety Investigators must adopt the professional approach to professional growth.

Vollmer and Mills have outlined the characteristics of a profession in their book "Professionalization."[3]

1. Professions have a systematic body of theory. Preparation for a profession is a lengthy training period requiring both intellectual and practical experience with the specific body of knowledge.

2. A professional has an authority based on superior knowledge in his sphere of competence which is recognized by his clientele.

3. There is a broad social sanction and approval of the exercise of this authority. Control over entry into the profession is one example of the exercise of this authority.

4. There is a code of ethics regulating relations of professional persons with clients and with colleagues. Self-discipline is the basis of social control. An example of this is the Hippocratic oath of the medical profession.

5. There is a culture sustained by organizations.

A thoughtful study of the attributes listed would indicate that Air Safety Investigators, as a group, do not as yet qualify as an ideal profession, but we are obviously moving along the continuum from an occupational category to a true profession. Of course many of our members belong to the older established professions, such as medicine and law.

Meetings such as this provide the vehicle to collect and disseminate our specific body of knowledge, to propose theories and develop experiments to verify them, to provide some intellectual experiences for our professional growth. Never before has "Safety" been so popular or so well funded. Now is the time to show what we have learned in Air Safety that is applicable to this field and all other related safety fields. (If you look around you will see representatives of several ground safety organizations among us.)

SASI can be the organization which nurtures the development of our specific sub-culture, which relates us in a brotherhood that knows no national boundaries, and can provide both support, communications and strength during our growing years. This meeting will not answer all these questions, it may ask more than it answers. But if we all keep an open mind and participate in the formal and informal sessions that take place we will have moved a step along the path to removing a human problem from human factors.

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1. Refer to David Meister, Human Factors: Theory and Practice (New York: Wiley-Interscience, 1971) for an excellent definition of Human Factors.

2. John V. Grimaldi, "The Measurement of Safety Engineering Performance," Journal of Safety Research, (Sept. 1970) p. 139.

3. Howard M. Vollmer and Donald L. Mills, (eds), Professionalization, (Englewood Cliffs, N.J., Prentice-Hall, Inc., 1966) p. 9-19.

THE BUREAU OF AVIATION SAFETY VIEWS HUMAN FACTORS IN AVIATION ACCIDENT INVESTIGATION

C. O. MILLER

Director, Bureau of Aviation Safety,
National Transportation Safety Board

My portion of the program is to convey how we of the Bureau of Aviation Safety of the National Transportation Safety Board (NTSB) approach the human factors problem in the general sense of policies and procedures. It will be followed later by Jim Danaher, Chief of our Human Factors Branch, who will review matters more in detail.

There are two fundamentals I wish to bring out immediately, though. First, please appreciate that those of us in NTSB are really on the feedback loop of accident prevention. The FAA, the industry, operators, etc., are the mainstream effort; so everything we do really is in the portion of the loop which tries to feedback the bitter lessons of the errors everybody makes at one time or another. We are not inventing new ways to prevent accidents. We try to see accidents in the total sense and report them accordingly. Secondly, permit me to touch upon this thing called probable cause. With all due respect to Mr. Serling sitting in our audience, I wish he would write his next book and call it "The Probable Cause<u>s</u>," because until we adopt and understand an attitude that no accident has <u>a</u> probable cause (singular), I personally believe we waste much of our time making statistical tables which, at best, only tell us areas to work in, based solely on numbers.

In any case, if one goes to the textbooks of safety, one will find the so-called traditional three E's of accident prevention: Engineering, Education, and Enforcement. People have tried to point out over the years, going back literally many decades, that these three ways exist to prevent accidents. You can engineer the vehicle better, you can educate the operator better, and you can rap people's knuckles or throw them in jail if they don't do what they are supposed to do. Observe that this approach is taken from what I would call from the outside in. In other words, person "A" is trying to tell person "B" to engineer it, educate somebody, or enforce something. I think when we are talking about human factors involvement in accident prevention, it's about time we take a look at at this thing from the inside out.

Figure (1)--just a tickler in this direction. Three items are shown on the left side: skill, judgement, and personality. If I am thinking what I can do to prevent an accident as a pilot, I ought to have certain skills; I ought to have or be able to make certain judgements; and I ought to have the right personality, which, if you like a different term, might be called attitude. How do I gain this? What is the mode of accident prevention enhancement of the individual? Note the right-hand column of Figure (1).

First, let us make a distinction between training and education, as differentiated from Education used in the three E's. Training refers to skill development aimed at a particular task. Education, on the other hand, is teaching somebody to think, either through the formal process or experience, but usually through the formal school process. In any case, there is a difference; training is aimed at skill improvement, education is aimed at judgement improvement.

Thirdly is this thing called personality, which can be and is enhanced by self-discipline. Managers will tell you it is enhanced by motivation programs. In any event, one must be careful which frame of reference is used when talking about improving overall human behavior. Think of it in terms of the individual, and how he views it as opposed to how you might be able to instill it or implement it from the outside in.

What has just been covered is rather philosophical, and is generally applied to accidents in their entirety. However, we must not worry only about preventing the accident, but we must also worry about preventing the injury or the deaths involved, assuming certain accident sequences of events. Mr. Danaher will cover this more later, but, appreciate that in the injury prevention business there are several phases: impact, evacuation, rescue, and survival. When we enter a human factors investigation, we must make up our mind what the total human factors investigation system is. If we get nothing else out of this meeting, I think this is what we have to do.

So much for the policy and background from human factors standpoint. Next, consider an overview of the organization that we have at NTSB, which, in a way, frames the procedures that we follow in human factors investigations. Figure (2) illustrates the overall Bureau of Aviation Safety-NTSB organizational relationship. For ourselves, as well as the surface transportation people, everything in terms of accident reports and recommendations goes through the full Board for final approval.

Figure (3) is the organization chart of our Bureau of Aviation Safety. As Director, I have certain key staff people, as well as line division chiefs. Staff positions include one for interdepartmental (and international) activities and one for administration matters. We also operate through an accident-inquiry-manager concept. This basically says that when we have a major investigation, we put one man at the Director's office level literally in charge of each major case, a project boss so to speak. The National Aviation Accident Investigation School also comes under the Director's office.

More pertinent to the subject of this presentation, however, is our organization of three major divisions. The Investigation Division, the Technology Division, and the Safety Analysis Division. The Investigation Division is comprised of, for all practical purposes, our investigators-in-charge, whether they operate through field offices or whether they operate out of the Washington headquarters. The specialists from the Technology Division and Safety Analysis Division are the ones who, among other things, provide the data discussed earlier in the program.

To place human factors work into more perspective, consider the Technology Division organization, Figure (4). Observe the logic to the grouping of our specialists here. You have the Human Factors Branch, the Aircraft Factors Branch, and the Operational Factors Branch. Those of you who have gone through the USC safety school will remember an investigation triad called man-machine-medium. That's exactly what we have done. We have organized our technical specialties into man factors, machine factors, and medium or operational factors. Hence, our approach to human factors investigations begins to be apparent. We will have an investigator in charge. We will provide him with whatever talent he needs to staff the particular investigation including human factors. We then also have technical supervision provided through the branches as shown in Figure (4). It is a combined project-functional approach to investigation management.

You will notice within the Human Factors Branch, we have categorized some four major areas of activity. Physiology, psychology, human engineering, and survivability. It is where we are today, and not necessarily where it will be tomorrow.

Observe also that under Operational Factors, there are things like flight operations and maintenance management. It is difficult, to put it mildly, to draw any kind of hard and fast line between what may take place under psychology, or what may take place under many operational factors tasks. Hence, the classification we have is relatively arbitrary. It would not be unusual, for example, on successive accidents, to have a training aspect at one time under the operations group, and maybe next time to put it under human factors because of the subtleties of the case at hand. And, in case it is not appreciated, flexibility is the name of our game in our shop these days--if for no other reason, we don't seem to have enough bodies to go around.

Unfortunately, there is something missing in our Technology Division organization. Dr. Sherman, of our host Institute, would certainly recognize it. You see a question could be asked, "who looks at the overall management of the whole package that you might see in a given operation?" To cite just an example: Consider the Wichita State tragedy involving charter operations. When we got into this thing, far and away, the biggest single problem was how everything was tied together, including the charter operator, the University, the FAA, the pilots, etc. What we really had to do was some kind of management investigation which had to be approached systems-wise and with a heavy human factors input. Without understanding human factors you can't do a good management job and vice versa. So what we know is missing from our organization is something that takes an overall look at how these various technologies, or these branches, if you will, are tied together. It is for this reason, that Martyn Clarke, who is the Technology Division Chief, has been trying to get approval for system safety specialists in his last two budget submissions. If and when we get approvals from OMB and the Congress, the system safety specialist's job will be to look at more of these things as tied together in a management sense.

In summary, I have tried to describe the basic philosophy we follow, the policies that we try to implement, and emphasize that we are in a growing state of implementing human factors activity at NTSB. By way of illustrations concerning the latter point, observe we have a representative from each of our field offices (at least one) here at this conference. The reason they are here is not just because we want each of our people to come to a SASI meeting. They are here in a training status. We feel, of all the priority efforts we have to have in the training of our people, they are in the human factors investigation field.

Let me conclude by saying that I think the human factors investigation methodology is the greatest single technological challenge facing those of us in SASI today. I look forward at this session to finding many, many answers to the questions that have been bothering me, and perhaps many others here.

ACCIDENT PREVENTION IMPLICATIONS

SKILL -- training

JUDGEMENT ------------------------------------ education

PERSONALITY -------------------------------- self-discipline

Figure (1)

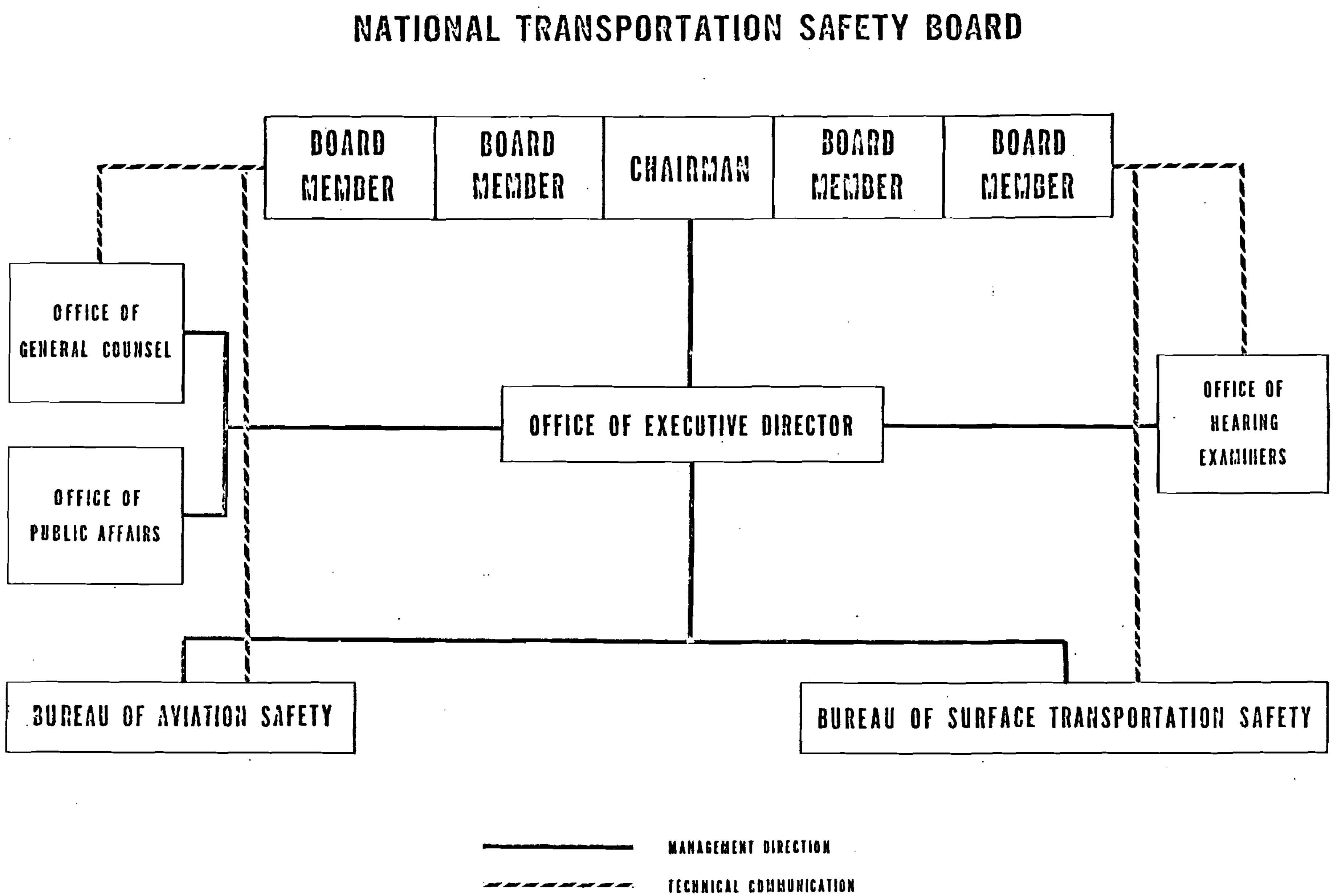
NATIONAL TRANSPORTATION SAFETY BOARD
BOARD MEMBER
BOARD MEMBER
CHAIRMAN
BOARD MEMBER
BOARD MEMBER
OFFICE OF GENERAL COUNSEL
OFFICE OF PUBLIC AFFAIRS
OFFICE OF EXECUTIVE DIRECTOR
OFFICE OF HEARING EXAMINERS
BUREAU OF AVIATION SAFETY
BUREAU OF SURFACE TRANSPORTATION SAFETY
MANAGEMENT DIRECTION
TECHNICAL COMMUNICATION

Figure (2)

BUREAU OF AVIATION SAFETY

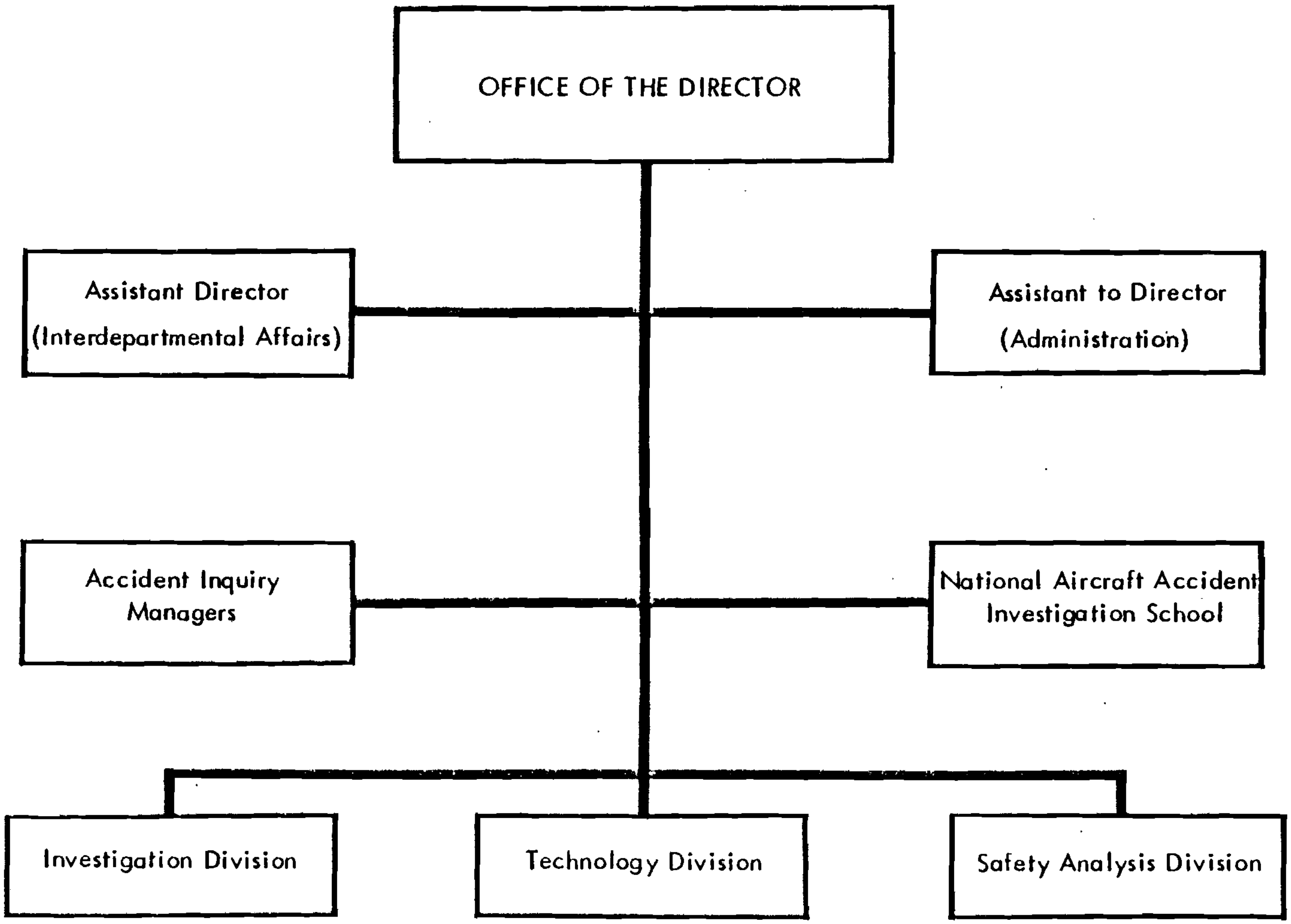

Figure (3)

TECHNOLOGY DIVISION

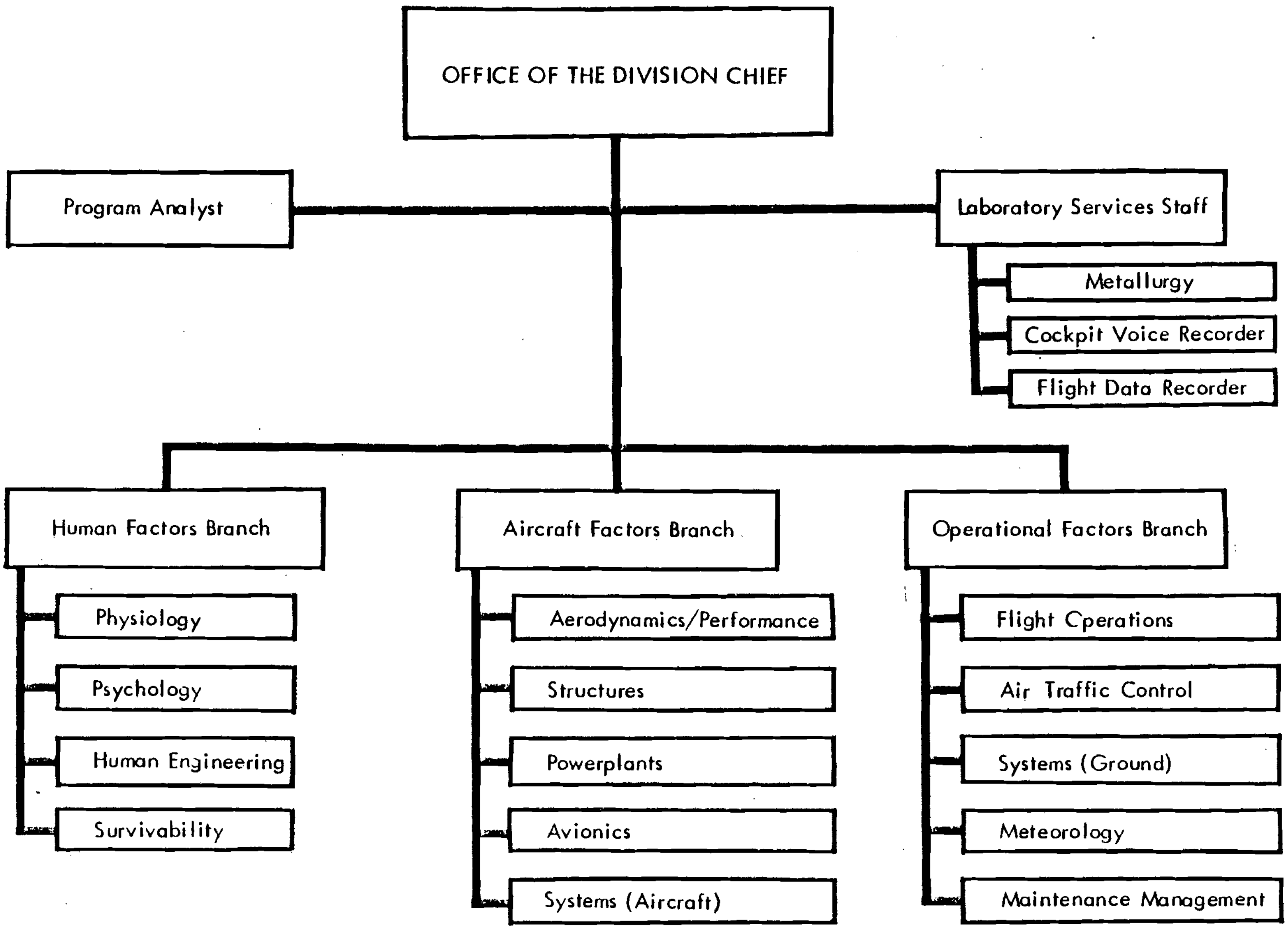

Figure (4)

THE VALIDITY OF WITNESS STATEMENTS

GERARD M. BRUGGINK

Air Safety Investigator,
National Transportation Safety Board

As an introduction to the first business session of this human factors seminar, I would like to make a few remarks about one of the more delicate communication barriers: rationalization. As accident investigators, we often have to rely on statements made by witnesses, be they crewmembers, traffic controllers, dispatchers, passengers, or any other type of observer. To better evaluate the validity of these statements, the investigator should have a working knowledge of the manner in which any given individual, including the investigator himself, may rationalize.

What is meant with this term? According to a liberal interpretation of the textbook definition, rationalization is a deliberate or unconscious mental process whereby we advance a socially or professionally acceptable explanation for our own, or somebody else's conduct, rather than the true reason. To put it more bluntly: rationalizing is a fancy name for trying to fool oneself, or somebody else, in order to avoid real or imaginary embarrassment. One might even say that rationalization is one of our constitutional rights; when we get in serious trouble we retain the services of a professional rationalizer; the criminal lawyer.

An accident investigator who practices self-observation should have no problem understanding that rationalization is a natural part of an individual's defense mechanism. As a matter of fact, in a so-called free society where a potential claimant lurks around every corner, rationalization is more natural than self-incriminating honesty. When dealing with witnesses we should never confuse this form of protective deception with lying; at worst, witnesses may offer a more elegant, rationalized explanation of misconstrued or unflattering events. Let me use some examples to illustrate the universality of this problem as well as the limitations it imposes on our fact-finding activities.

Suppose your car leaves the road and rolls into a ditch while you are transmitting a one-handed message to one of the kids in the back seat. What are you going to tell the highway patrolman? By the time he arrives you may already have convinced yourself that it was not so much your self-induced distraction as the bad condition of the pavement, or a wild driver in the opposite lane, that caused your swerve. The only caution you have to use when telling your story is that the kids don't overhear you; they don't understand why grownups have to rationalize.

I can resort to a stress-type confession to show you how this defense mechanism works in aviation. In 1947, while making a maintenance test-flight in a Spitfire, I lost the pneumatic brake system. I landed without problems, into the wind, on a large, grass-covered airfield. Toward the end of the rollout, I decided to nudge the aircraft to the right, toward the hangar, to save the groundcrew some work. This exercise in overconfidence and humanitarianism resulted in a classic groundloop, with all the trimmings. Since I kept my mouth shut, until now, I was never blamed for this accident. The eyewitnesses were very flattering about my ability to keep the aircraft rolling straight for as long as I did, and insisted that a right-crosswind did me in. In this case, I did not have to rationalize publicly: who wants to disappoint benevolent witnesses?

Rationalization comes into play mainly in mishaps with real or imaginary operational overtones, that is, any time a crewmember knows or suspects he has a reason to be on the defensive. When he overreacts to a preconceived notion of his own involvement, he may even divert the investigator's attention from design or operational factors that might exonerate him. Here is a real-life example.

During the investigation of an accident resulting from total electrical system failure, the pilot was asked whether he had noticed any abnormal readings or indications in the cockpit. The answer was negative; he was not aware of a serious problem until he lost radios and gyro instruments. The investigator, knowing that the electrical loadmeter should have given a timely indication of an unusually high generator output, asked the obvious question: what was the reading of the loadmeter prior to electrical-power loss?

I have to pause at this point to explain how we, as investigators can practically force crewmembers to rationalize by overquestioning them. If a man has just told you that everything in the cockpit was normal, while you have conclusive proof that one particular instrument had to be out of kilter, it would be unwise to ask him what the reading of that instrument was. You have put him in a position where he has a choice of only two answers: "I don't remember," or "The instrument reading was normal." The first answer would conflict with his original statement that there was nothing unusual, therefore, you end up with a foregone answer: the instrument gave a normal reading. In the process, you have created a most distasteful situation in that you can no longer openly speculate on the possibility that the pilot may not have seen the instrument at the critical time for any number of reasons. This is the quickest way to complicate an investigation and to lose friends.

A similar situation developed in the case in question. The pilot said that the loadmeter gave no indication of an impending failure. How could such a statement be reconciled with the known facts without embarrassing the pilot?

As it turned out, there was a very good reason why the pilot reported no unusual loadmeter reading; he could not see this miniature instrument in his normally seated position without twisting his neck in an awkward manner. This loadmeter was installed at the bottom of a modified instrument panel, immediately below a large, protruding navigational instrument that precluded the unobstructed monitoring of the loadmeter. This design deficiency was definitely a mitigating circumstance in the overall accident sequence. Of interest to us should be the fact that the presence of this deficiency was unwittingly camouflaged by the pilot, who was forced to rationalize by an overquestioning investigator.

I would like to reiterate that rationalizing is a very natural phenomenon. Even when people have no axe to grind, we have to remind ourselves that, at best, they can report only what they <u>thought</u> they saw, heard, or did; at worst, they may try to make their recollections coincide with what they <u>should</u> have seen, heard, or done. This is the main reason that interviews should be conducted as soon as possible after a mishap. Very few people are able to ignore the conditioning effects of newspaper stories, rumors, incomplete facts, and legal advice. Even an unbiased eyewitness may be inclined to rationalize when he suspects that his originally remembered observation might make him look ridiculous in the eyes of the interviewer.

It seems appropriate to conclude this discussion with the reminder that rationalizing is not limited to witnesses. The investigator is also susceptible to it, especially in the investigation of accidents involving decision errors that stem solely from hard-to-prove, judgement-degrading factors such as impatience, anger, haste, anxiety, and arrogance. When the investigator cannot pinpoint a probable cause and a remedy, he may be tempted to do some rationalizing of his own, in the form of an almost desperate search for design or system imperfections that can be converted into preventive recommendations. One reason for this need to grasp for straws may be a worldwide disregard for minor but inexcusable slips in personal performance, as long as there are no ill effects; as a result, it has become difficult to treat these slips for what they really are in actual accidents. This is a disturbing thought, since it shows how rationalization on anybody's part could lead to costly fixes that have little or no bearing on the true error mechanism. It is also in this area that the human factors investigator still has to make his greatest contribution to aviation safety.

I can summarize this layman's view of one of the most intangible handicaps in witness interviewing as follows:

1. Rationalization should not affect the validity of a witness' statement; when seen in the proper perspective, that is, from from the witness' viewpoint, every statement makes sense.

2. The deceptive and distracting effects of rationalization can best be avoided by an investigator who understands the nature of this defense mechanism.

3. Overquestioning or "cross-examining" can put a witness in a position where he can avoid embarrassment only with a rationalized answer.

4. Inability to pinpoint the underlying reasons for apparent operational errors may induce a tendency to rationalize on the part of the investigator.

5. Nobody can keep you from raising your eyebrows when a crew claims collective amnesia.

GESTALT, AWARENESS, AND THE IMPROVED AIR SAFETY INVESTIGATOR

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United States Army Agency for Aviation Safety

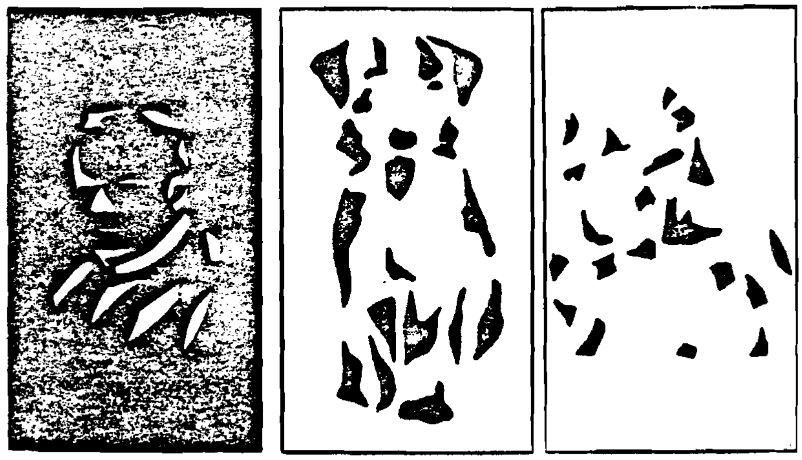
The foremost consideration of the Air Safety Investigator is the protection of life. Additionally in this day and age aviation lawsuits are universal and settlements are astronomical. Our work is being used more and more to decide the financial fate of individuals and major companies. Our failure in this age of the Airbus and 747 could be unimaginably catastrophic. We cannot afford to waste one directed moment with our senses developed to less than their fullest awareness capacity.

With this in mind let's look at the way the Gestalt concept can give the Air Safety Investigator better results for his time.

You probably are wondering how the Gestalt concept could ever relate to airplanes and Air Safety Investigators. The "shrinks" never heard of L/D max or Disc loading!! In the next few minutes we shall briefly examine the original Gestalt idea, its developments, and show you its direct application to our work. You will see how any ASI who becomes a student of Gestalt principles and applies them daily will multiply his effectiveness in Air Safety work and life in general.

The Gestalt concept originally began with the idea that the whole is more than the sum of the parts. For example, ninety-six notes do not make a tune and airplanes are more than just their total of 2219 aluminum, magnesium and other parts. It is the aircraft designer's <u>concept</u> of the arrangement of the parts that makes one aircraft more effective than another. The Gestalt concept is briefly, the <u>idea</u> of the arrangement is what makes the parts meaningful. More directly, it is an ASI concept of possible arrangements of the situation that will illuminate potential failures and reconstruct failure situations.

At this point let's examine Rorschach ink blots. These demonstrate visually the basic Gestalt concept.



You can see that it is only through our ability to mentally complete the picture that the dispersion of parts has any meaning at all. The ASI encounters this type presentation daily in his work and it is through the sensitivity which he has developed towards this kind of problem that he is able to see the situation in a reconstructed form.

Gestaltists call this illumination/sensitivity a figure-ground relationship but for our purposes we say simply that we get a "bright idea." I will show you later how we can increase our bright idea production through sensitivity training.

TRANSACTIONAL ANALYSIS

In recent years some Gestaltist thinking developed along the lines that perception is entirely an internal phenomena and by examining these internal mechanisms they developed a new area of psychology. This is Transactional Analysis.

A transaction is when the ASI says or does something to a witness or a member of the board and this individual does or says something in return. An examination of this transaction is a Transactional Analysis.

Before analyzing transactions it is necessary as background to look first at our own mental development. It has been proven by neurosurgical as well as psychological methods that our brain records every verbal and tactical stimuli which we receive and that the recall of these recordings is together with the feelings which we had with the formulation of our concept. For example, the teenage Cessna pilot will have an entirely different feeling to the word "ejection" than will the Navy Phantom pilot. An excessively adverse feeling associated with a brain recording will prevent its recall as is shown by Mr. Sam Phillips' investigations using hypnosis, and as is shown by our everyday "mental blocks." The important thing here is that our brain or data bank is continually recording information from different sources and updating/revising this data in a manner that reflects our maturity.

Personality Development

In the first five years of our life most incoming information is recorded straight and used unquestioningly. This data base forms a portion of every person's personality which we call the <u>Parent</u>. Parent is characterized by do's and don't's, prides and prejudices, embarrassment and shock, and all information recorded at an earlier date. Commensurate with the building of the Parent data set there is development of the Child in each of our personalities. This is characterized by "I can't," "I want," and superlatives like bigger, biggest, greater, greatest, and tears <u>as well as</u> endless creativity and imagination. The adult development begins with the onset of locomotion in the infant. The Adult is characterized by logical decisions that use all the data sources available at the time. We observe the onset of Adult actions when the child <u>decides</u> he had rather be in another place and ceases to cry and begins to crawl there. We can identify these characteristics in everyone with whom we come in contact.

Transaction Control

In any transaction each person is speaking from either the Parent, Adult, or Child (PAC). In the business of accident investigation our problem is most often to get people into their Adult position from which they will readily give direct answers to direct questions, i.e., get them to come on straight. Consider the following excerpt from an instructor pilot who had just allowed a student to apply too much aft cyclic and damage the tail boom: "--the tower notified us that our tail was hanging down so we shut the aircraft down. We have had lots of trouble with morale in the outfit since our new C.O. arrived. He is just an egomaniac. He pretended to be drunk one night and urinated on my leg in the club parking lot. But he wasn't drunk because I had been with him all evening and he hadn't had a drink." As interesting as it might be to a serial magazine, this type answer does nothing to forward the cause of the tail boom. This person was desperate for an audience for his personal problems and his Child had the full attention of the ASI. This person had been asked a question and he had replied from his Child. How often have you asked, "What did you see, in your own words?" and received, "It was just awful, just like the paper said. First, I heard this noise that sounded like it was sputtering and backfiring, then I saw all these people running and by the time I got there they had the fire out." The Adult answer would have been simply, "Nothing."

For an ASI to get people to reply with Adult answers he must:

1. Know the characteristics of complimentary and crossed transactions and be able to recognize them quickly.
2. Know how to guide people into their Adult.
3. Strengthen his own Adult.

1 a. The following four examples from different parts of our PAC will assist the ASI recognize complimentary transactions:

(1) This is a Parent-Parent transaction.

1st Civil Servant: "Looks like we're not gonna get that pay raise."

2nd Civil Servant: "We should get one evertime industry does."

1st Civil Servant: "We ought to have a lobby like theirs."

(2) The following is an example of Child-Child complimentary transaction:

1st Warrant Officer: "I wish I could get my hands on the people who built this hunk of junk helicopter."

2nd Warrant Officer: "I wish I had the money they made off the government."

(3) The following is an example of a Parent-Child complimentary transaction:

1st Engineer: "Those idiots at the office change the specs everytime I get them just about completed."

2nd Engineer: "They're just picking on us because jobs are scarce and they know we won't quit."

(4) An example of an Adult-Adult transaction is:

1st ASI: "Do you know why they used this particular extrusion on the landing gear?"

2nd ASI: "No, but Tom does and I'll give him a call."

Complimentary transactions cannot be taken out of context because quite often the participant's secondary message (the way he says it) says more than the words he uses. Even the pre-vocal child interprets accents and gestures independently of the words. An example of a secondary meaning complimentary transaction is:

Man to girl at Bar: "I'm new in town and I'd like someone to show me around."

Girl: "I've lived here quite awhile and I could spare the time."

Here is communication of a secondary message. In every transaction with a secondary meaning there is a lack of candidness and honesty, and it is a less efficient way of getting the message across than if direct questions were used.

1 b. The second type of transaction is the crossed transaction and it is characterized by the ceasation of any meaningful communication about the original issue. It is essential that the ASI recognize this immediately. Examples are:

1st ASI: "Do you have the sample bottles?"

2nd ASI: "I thought you were smart enough to take care of that."

Here we see an Adult-Adult question answered by a Parent-Child answer. The answer still leaves us wondering whether we have bottles or not. In this case you see an Adult inquiry answered by a person in the parent role answering "down" to the questioner's Child. At which point, the original questioner has to make a new inquiry for his information. The transpired time and energy has been wasted. The questioner's Child may be "hooked" and the original issue will then be obscured until the Parent-Child conflict is settled, i.e., they both become angry and cease communication.

1 c. When an ASI seeks to establish the role from which the other person is speaking, the following characteristics will help to recognize the Parent, Adult, or Child. These must be taken in context. The Parent will have physical cues like: furrowed brow, pursed lips, pointing index finger, horrified look, hands on the

hips, etc. and verbal cues like: "always," "never," "stupid," "ridiculous," "absurd," "How many times have I told you?," "Now what?," etc. The Adult may also choose to use all these words after he does in fact decide that it always happens that way.

The Child cues are pouting, shrugging shoulders, downcast eyes, teasing, squirming, words like "bigger," "biggest," "I wish," "I don't care!"

Adult cues are basically a vocabulary of why, what, where, when, who, and how, how much, in what way, probable, possible, I think, I see, and "It is my opinion.." The job of the ASI is greatly simplified when he deals with people who use an Adult vocabulary.

2. To get others to respond from their Adult we must (a) develop the Adult in ourselves so that others easily recognize us as one who makes reasonable and fair decisions. (b) Ask our questions using the Adult vocabulary. (c) Recognize crossed transaction responses and resist reacting to them. (d) Isolate the issues and be sure that the answer given is not about another issue, as in ulterior transactions. (e) Look further into works about problem ownership and learn how to decide who owns the problem. (f) Do not assume that there is a right and a wrong answer. (g) Do not feel that an idea proposed by yourself has to be defended. (If it won't stand on its own strength then it will fall in the absence of your personality.) (h) Look at alternatives from the "why not" standpoint.

3. Staying in our own Adult position is the result of continual effort to refrain from having our Child or Parent hooked. "Hookers" are when our ideas are received by "Impossible," "Absolutely not," "No way," and "That was a stupid thing to do." It is possible for us to strengthen our Adult and these are a few of the ways:

A. Learn to recognize your Child, its vulnerabilities, its fears, its principal methods of expressing these feelings.
B. Learn to recognize your Parent, its admonitions, injunctions, fixed positions, and principal ways of expressing these.

C. Be sensitive to the Child in others. Talk to that Child and appreciate its need to be creative.

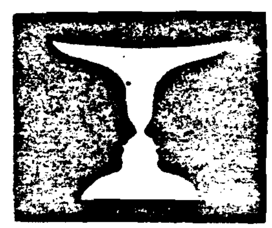
D. Count to ten.

The ASI who implements these will find his time spent much more rewardingly and his effectiveness with others will multiply.

AWARENESS

At this point let's lift our attention from the tools given to us by Transactional Analysis and examine another aspect of the Gestalt concept which is Awareness Training. The ASI's job is to "Tell it like it is." This has been said by many who failed to realize that before we can tell it like it is, we must be able to see it like it is.

Let's look at two other Rorschach blots.



Immediately we see one figure-ground relationship, however, there is another way of looking at the blots which reveals another meaning. In this set we have demonstrated our ability to see the alternative. The earlier set of blots demonstrated our ability to complete the incomplete situation. Both of these involve sensitivity to situations. It is the degree to which we are sensitive that we are aware. Gestalt Therapy by Goodman, Hefferline, and Perls provides a very detailed evolution whereby the ASI can attain increased sensitivity. An example of a Gestalt Therapy experiment is where we examine our eating habits. This is related to ASI in that in both eating and safety the problem is acquisition, assimulation, and utilization. How a particular person approaches his meals is very likely the way in which he approaches daily problems. Additionally, having directed attention to functions which he was heretofore unaware, the ASI has expanded his awareness. Another Gestalt experiment develops our awareness of our muscles as they feel with different people and different situations. Any muscle which is tense in a listening situation, i.e., your boss and you about a mistake which you make, is a physical indication of what your subconscious would like to be doing. Most likely your thigh muscles are telling you by their tenseness that you would like to run. We can increase our ability to recognize these internal resistances and tensions through the study of Gestalt Therapy. It is the recognition of these misspent energies and subsequent free choice ability attained which allows us to see the other alternatives present, as in the blots.

Examination of ourselves using the Gestalt concept equips us to meet each new occasion with optimum use of our faculties. It is the self-assurance of knowing of the effectiveness which we possess that makes our investigations more successful.

HYPNOSIS IN WITNESS INTERVIEWING

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Associate Professor, University of Southern California

On the 7th of March this year, late in the evening I received a phone call from an Eastern Coast Guard station. They told me that about a month before there had been a crash of an S-52 helicopter. It had a crew of three; they had been flying IFR air from an AFB in North Carolina to a Coast Guard station in North Carolina, but because of weather, they were diverted to a Naval Air Station in Virginia. The approach looked normal until about 900' and about one mile out when the airplane suddenly disappeared from the air controller's scope. The crew had survived, badly beaten, chemical pneumonias, and assorted fractures and bruises. But they had survived. The crewmen, after they were able to talk about the accident had given about the same information, that at about 900' they had lost control of the helicopter, six seconds later hit the water. Not only were they in the water, but the pilot and co-pilot were trapped for an appreciable period in the helicopter as it sank. The co-pilot got out first. The pilot remained in the helicopter for about two minutes under water, breathing from a small bubble of air, but he was able to kick his way out of the ship eventually.

The pilot and co-pilot and crewmen had told all that they could about the accident, but there wasn't enough information to go on. The accident board was indecisive as to what were the causes of this accident and they had several possibilities: that the pilot had lost control of it through vertigo or lost orientation and gone into the water. Secondly, that there had been engine failure, loss of engine power, and they hadn't auto rotated as they should have done. Thirdly, electric power failure. That something, possibly the crewman's hard hat had hit the main power switch, cut off the power switch, and thus the gyros had begun to degrade, the pilot flew them in. The fourth possibility was the runaway stabilization system. This particular helicopter has an automatic stabilization system, which at times, does go sour. Were there other possibilities? The pilot couldn't tell, the co-pilot couldn't tell, and the crewmen weren't much help either. It was too little time and what they gave the board was too little information.

The pilot had been in a class of mine at USC. In the Army class, we had a small quota of Coast Guard people in each class. He had been in the class about a year before, and he had heard me discussing the idea of using hypnosis in witness interviews in aircraft accidents. Since I had used it in about eight or nine cases by that time, most of which there had been pilot amnesia. That is to say that the pilot had suffered a loss of memory due to, or after the accident, and could not remember any of the events.

We talked in class about the use of hypnosis, about the type of technique, what was involved, about the lack of danger, and so on. He also heard me mention that I would like to use hypnosis with somebody who did not have amnesia, because I felt hypnosis could augment a person's memory under any conditions, for several reasons. First of all, the person often doesn't feel that what he is able to recall will be acceptable. He doesn't feel that he is a valid reporter for that matter. Various other factors keep a person from responding with all the information he has available. I have felt for some time that hypnosis, if nothing else, is at least a way of helping him find access to and yield that information.

So consequently, with great eagerness I caught the next "Red Eye Special" out of Los Angeles and in short order, in a snowstorm, I was in North Carolina. It had been a month since the accident. The accident happened the first week of February, this is now the first week of March.

The initial problem was to find out from the pilot what his feelings were about hypnosis. Obviously, there was some acceptance, or else he wouldn't have suggested the thing in the first place. On the other hand, people sometimes say they accept things, although they have reservations. So we talked about hypnosis a bit—his feelings about it, his ideas of it, his previous experience with it. He had none, although he had seen somebody putting on an act in the Officers Club. We talked about my ideas about hypnosis as a directed state of attention wherein a person is able to be completely oblivious to everything and everyone around him, including the questioner, and so consequently can pay more strict and close attention to his own thoughts and his own memories.

After this period of solving a couple of questions in his mind about hypnosis, we attempted the first hypnosis. This was the afternoon of the day that I arrived. And in a matter of about 20-25 minutes he had exhibited an arm levitation, which is to say that his arm rose, apparently effortlessly and automatically, and touched his face. He reported after the hypnosis he had no idea why it came up, he certainly wasn't trying to do it voluntarily and it surprised him that it even moved.

Second, what's known as catalepsy, wherein I suggest to him that his arm has become immobile, has become as rigid as a cast bar of iron, and that neither he nor I can bend it. He passed that test with flying colors, too, neither of us could bend it. But when I tried to bend it, I heard a pop and it worried me. But he assured me there was no problem there.

Third, some imagery and associations under hypnosis to see how well he could picture and fantasy under hypnosis. With that I brought him out. He was quite entranced by this because first of all, he assumed he had been under hypnosis for approximately 2 1/2 minutes, it had actually been more like thirty. (This is one of the first ways you can be sure there is a difference between the person's normal operations and his hypnotic operations because there is a gross distortion of time.)

After talking this over, he suggested that he wanted to have his co-pilot observe because he would like to have his co-pilot try hypnosis. His co-pilot was absolutely, completely against it. The co-pilot came in, and for the second trip in hypnosis, which was an age regression, the co-pilot observed. The co-pilot remained adamantly against it during the entire process; would have nothing to do with this "spooky" procedure. Although his being present was somewhat of a help in things that he was able to remember.

At this time we did an age regression to see whether he could regress back to the time of the accident so we went back to the age of eight years old. He reported various things that were going on around him. He reported the way the land was, the back yard, the sand pile that he had, the place he had torn in the hedge to get through in a hurry--childhood memories. And, after waking up he added many more things which he hadn't time to say. He was completely entranced by the process, he said he had never had such clear memories in his life. By that time it was growing late in the day, and so we put off any further work in hypnosis until the following morning.

The following morning at 9 o'clock we reconvened and began hypnosis age regression back to the time of the accident. The first hypnosis was with one board member present. He didn't want all the board present, he didn't want that many people in the room, and frankly didn't like a couple of people on the board anyway. One of them he would accept and so consequently that one sat in on the hypnosis. He went back through the accident several times (in hypnosis, you can bring the person back, you can shut them off at a point along the way and then bring them back). One of the restrictions the pilot had placed on me the night before regression was that "this regression was damned real" and as a result of which he certainly did not want to go through that actual crash again. He had been scared stiff being trapped in the airplane and never been so cold in his life and he wanted no part of being in the water again. I should not in any way let him hit the water. I was to stop the descent of the aircraft just before it hit the water. He would give me all information about the flight all the way down, but if I let him go into the water he wasn't going to like it and he would be out of it. I assured him he would be out of the hypnosis anyway since he would not go through the crash passively if that was the way he felt about it. So with this restriction we launched forward, ran through the accident, brought him down to the water, back up, and back down again several times, getting various engine readings and airspeeds and other readings.

The second time, finally, he said "what the hell, let the whole board listen." He didn't care, so the final hypnosis the whole board came in and listened.

The third hypnosis began in the afternoon of the second day and for the total board this somewhat edited that which was presented. I say somewhat edited because of the fact that in hypnosis there are frequently long pauses and there are most especially long pauses when I ask him a question which cannot be answered, for instance, "What were you trying to tell somebody?" I asked that question many times because one of the board members had an idea that he was trying to get some information across to somebody. Well, the question was meaningless at the time that it was put and so he couldn't answer it. Later it was discovered that it was a question he came up with when he was in the hospital and what he was trying to tell the board member was tell his wife that he was O.K. But it had been thought that this was something that had occurred during flight. This is how a typical hypnosis goes, I have included in it the induction procedures. Now obviously, they are much shorter than they would have been initially, but with each subsequent hypnosis a person takes less and less of the induction technique in order to arrive at a certain state.

OK, now let yourself relax completely and think of the soles of your feet, how relaxed they can be. The lower parts of your legs from the knees on down, how relaxed they are. Just let your feelings go completely to the interior parts of your body. Pay attention to them, to your normal body functioning. Just think of how relaxed you can be all over. OK, now the upper parts of your legs from the waist on down, your knees, just think about them, about how relaxed they can be. Think about your legs pressing up against the couch. Think about how warm and comfortable you can be. Just think about relaxation. All right, now your body is relaxed totally. Think about breathing--let that slow down. Any reaction, let that slow down, too, because during the time you are under hypnosis there will be much less natural work going on. Just let everything relax. Now your shoulders, your upper arms, your lower arms, and your hands--let them relax all the way. Just think about total relaxation. OK, completely relax now. Now your neck, your facial muscles, your scalp. Let everything relax there, maintaining no expression--total complete relaxation. Let your eyes relax as well. Just think about how relaxed you are. Your eyes will roll upwards slightly and you'll have a feeling of sort of drifting or floating. Going deeper. At the count of one now you're going deeply into hypnosis, 2, deeper, 3, deeper on the count of 4, 5, going deeper, 6, 7, 8, 9, you are now deeply under hypnosis, 10.

You'll notice the lack of technique and it's very obvious that I am using no special technique except trying to relax myself, which was somewhat difficult since the room temperature was something like 92-95°. He had after the crash been very, very cold and he couldn't keep the place warm enough and so consequently he wanted the room temperature up very hot. His wife complained about it, everybody that knew him complained about it, and I certainly wasn't about to complain about it and set up a negative situation between us so I sought out the floor. While lying on the floor in a comfortable manner, I was talking about relaxing and trying to do the best I could. Actually there are no gimmicks needed for hypnosis. The whirling discs, the flashing lights and the crystal balls and things like that are all totally unnecessary and mostly staging. Because what is really necessary to produce a hypnosis is a cooperative person, that's all. If he wants to be hypnotized and if the person that is doing it isn't a total clod, although you can hear from this some people can approach it very closely, then he will be hypnotized. Hypnosis is the person's desire to limit and direct his attention to or for a certain purpose. As long as that purpose is being satisfied he will remain in hypnosis. If the purpose is not satisfied or if something unscheduled comes up then he comes out of hypnosis.

> All right I'd like you to think about your right hand while you're deeply under hypnosis. Think about how light that hand can be. Light like it was tied to a set of brightly colored circular balloons and it would become very, very light and it would drift up off of your other hand, rising slowly upwards into the air, moving all the way upwards toward your face. It's getting very light now as you think about it, getting lighter, moving upwards higher and higher.

What I'm saying right there is that if his hand was tied to a pair of brightly colored balloons, at first I said it a little more descriptively, originally, that it would feel very light and begin to rise up. And often times if you get a person to visualize something which would make his hand light, then it helps the phenomenon along.

This is apparently not a voluntary movement. The person reports after the hypnosis that he was quite surprised that his finger came up at that point, and he didn't usually expect it to come that quickly. And it surprised me because I didn't know it was going to come up.

> You've talked to us before, you remember my voice, and when I ask you in a few moments a few questions about yourself, you'll be able to tell me various things that are going on with you, various things that are going on about you, what's being said, what you're hearing, what you're feeling, and everything else that comes to your consciousness. All right, the first question I have is what is your name?
>
> Answer: Jim
>
> Question: Jim, what's the date today?
>
> A.: Monday, February 8.
>
> Q.: OK, where are you right now?
>
> A.: In front of operations at the AFB.

Q.: OK, will you tell me everything that's going on right now?

A.: We're talking to the Air Force guy we met waiting for the weather where they get on the bus. Kidding him about seeing him back here because of the weather. It's really nasty today. Then we go out to the helicopter.

The actual date of the hypnosis was Friday, the 9th of March. Actually there are quite a few more questions in there but you shortcut a lot of nonessential information. Now we move him forward in time to 19 miles out on the approach to Norfolk. They've already made their initial contacts, they've bypassed the base and so on and now he's making his approach.

He'd been plagued by water dripping on the windshield. This particular type of helicopter is known for that. And all during the flight they were having to wipe off the windshield from the radio console. As a matter of fact it was because of this that the suspicion was that the crewman might have banged his hardhat against the main power switch and shut it off. In a previous hypnosis he had mentioned that the crewman had moved back between them and the door and from this portion of the flight, or actually a couple of minutes before that portion of the flight, onward, right down to the point that they lost if he had been back in the doorway and not sitting up between them wiping windshields.

Q.: OK, I'd like you to move forward in time to the point where you're 19 miles out from Norfolk. You've diverted from the base. And I'd like you when you arrive at that point for the forefinger on your right hand to raise. This will be a signal to both of us that you have the proper feelings for being at the point of flight of 19 miles out. OK, now will you tell me what position you are in flight right now?

A.: Four thousand feet straight and level.

Q.: OK, now will you tell me what's happening from now on. Progress through the flight. Tell me everything that occurs to you, everything you feel, everything that you hear people say to you, everything you think. And I may stop you at some points along the way here and we'll go into this feeling a little more. Tell me right now what's going on.

A.: I was talking to Bill and he was kidding me about he doesn't want a missed approach because he wants to pee. Then Billy talks to the controller and he clears us from 4 to 2. And I can't remember if he said to report 3. And he takes up on the radio so I can't talk on the ICS and we go from 4. Then we get to 2000.

Q.: All right, right now at 2000, I want you to stop. Hold the action right here. Are you scanning your instruments and can you tell me at this time what your instruments are showing at 2000 feet?

A.: 55% torque...97% on rpm...wings level...nose just below the horizon...2000 feet...72 knots.

Q.: Needle ball?

A.: Ball's in the middle--ball's a little right. Needle straight up. Rate of climb is zero. Contact, Billy calls up a GCA on the same frequency that we had Norfolk on. He squawks low. We turn and the water drips in and I wiped out that channel again. The controller clears us to 1000. And we turn onto final, level at 1000.

Q.: All right hold the action right here. You're level at 1000 now and will you tell me what instruments you are seeing right now and what they are saying--either if you can read them and tell me what the numerical indications are or if you can tell me if they're normal or not.

A.: 55% torque...wings level...1000 feet...74 knots...ball's in the middle...needle's up. Billy does the checklist.

He said there "Billy did the checklist." Now the point they go into their final glide slope, just the moment they tip over to the glide slope, this is where they lose it, and at that time this is where he says they lose it.

Q.: Do you have any lights on that you can see?

A.: No. Bill's turning on the landing lights because the controller said you ought to be showing landing lights looking the way you are. The red light is on.

Q.: Do you look directly at it or do you see it out of the corner of your eye?

A.: I looked down and saw Billy turn it on.

Q.: Which way did you turn your head to look at it?

A.: To the left--just look over there at the collective.

"Yeah stupid, can't you see it?" He was just surprised I couldn't see it. It was just shining out just as bright as ever over there.

A.: Heading is all right, we haven't changed it since we're really back there on final. No further transmissions. Glide slope set 40%. Then everything changes.

Q.: What did?

A.: Everything changes. We're in trouble and we're falling. I look at the attitude gyro and notice it's going down and we got left wing down. I'm trying to pull on the cyclic to make it come up and not helping. Pull back, and not responding. Pickle to ASE. Nose comes to nose up a little. Bottom the collective.

The ASE is the Automatic Stabilizing System which I mentioned and the question was whether he had done it. He couldn't remember after the crash whether he had done it or not. But when he was under hypnosis he mentions that he pickled or punched the thing off.

I asked him at that point what he was thinking about other than flying and he brought out the fact that he was thinking about getting a hamburger when he got down, being hamburger time again. He was a great eater.

Q.: All right, stop right now at this point. The nose has come up a little bit. Do you see this on the attitude indicator?

A.: Oh yes.

Q.: What do you see now? Holding at this point, what do you see on the attitude indicator--how much nose down?

A.: About 10^{o} nose down now.

Q.: 10^{o} nose down.

A.: The wings are level.

Q.: Wings level. Any problem with the collective?

A.: Nose falls again. I wonder if that collective is all the way down? The collective is down.

Q.: You look at it?

A.: I see my hand on the speed selector and we've got about 105% rpm and we got an engine. Billy said we got an engine. Lights are on.

Q.: All right, let's stop right at this moment. How many lights do you see over there out of the corner of your eye?

A.: The big one, the two green ones, and four or five yellow ones. Bill get on the controls and help me. In other words, it's really down now. And the left wing's down a little. There's not much bank--it's just down a little. It's all right, Bill said we got an engine and we got rpm.

Q.: Can you see what your rpm is right now?

A.: No, I looked at it before. I don't know what's wrong.

Q.: Do you ask Bill to get on it right now or do you see him getting on it?

A.: Out of the corner of my eye, God, he really grabs him and pulls same as me, back here. Up and back...help me.

Q.: OK, I think we'll stop right now. Come back to 2000 feet. When the forefinger on your right hand raises, that'll be a signal that you're back at 2000 feet again. You're still in flight, it's all white around you, the aircraft is in control. All right now your finger is raised and you're back at 2000 feet again. At the altitude of 2000 feet right now would you look at your air speed indicator and altitude indicator and tell me what you're seeing.

A.: Wings level...nose a little low...2000...water drips again. Be nice to go to the snack bar and get something to eat. It's hamburger time again.

Q.: OK, where are you right now?

A.: Leaving 2 for 1.

Q.: Leaving 2 for 1.

A.: Level at 1. And Bill gets the checklist, turns on the landing lights--wants the landing light with the wheels. Heading's all right. Glide slope set 40%. It changes. Everything changes--quick. We're in trouble; we're falling. Serious, nose down. Nose, wings down. They won't come up. Turn off the ASE. Nose is down again--it won't come up. Pull, it won't come up, it won't respond. Speed selector. Billy said the engine's running. It's at 105. 85 I can't get it. Get on the controls and help me.

Q.: At this point let me freeze the flight right now. You have seen some warning lights. You have seen how many warning lights?

A.: Yes, there's lights over there. There's a yellow one.

That is generally the process and generally the kind of thing you hear when you do hypnosis except as I say that I cut a lot of those dead places out because a person under hypnosis is not the same reactive person that he is consciously--he is much slower and his questions do take a lot longer sometimes because they're a lot more complete or his answers are a lot more complete than they would be otherwise.

So, on the basis of their own findings from the helicopter evidence and from the added hypnotic testimony of the pilot they concluded first of all that the pilot did not have vertigo. Secondly, that there was no indication of loss of electric power. Thirdly, that there was no indication of loss of electric power to the instruments. Fourthly, that the stabilization system probably was turned off by the pilot as he said. And lastly, that the loss of control was probably a consequence of the loss of the horizontal stabilizer of the aircraft which they had only found a part of at the wreckage. And that loss was either due to fatigue failure or to foreign object damage.

Now, what is the possibility of using hypnosis in accidents and for the people involved--the participants of accidents or witnesses. Well first of all, it is as I say a voluntary technique in which the hypnotist serves as a guide but he doesn't serve as the hunter to go out and do the shooting. That he leaves to the person being hypnotized. The hypnotist has techniques by which he can help the person direct his attention totally to the event that he wants to remember. This is the purpose of it. It has been accepted as a pre-trial examination technique by the American Association of Trial Lawyers. In the State of California here, as a matter of fact, it has been accepted by the California State Supreme Court in two murder cases as valid testimony. It has also been used in the past by NTSB in two accidents that I have participated in. Also in the Air Force, the Army, Navy, and Coast Guard.

There are fears about hypnosis. The fears mainly that I have heard seem to be the fact that it might be causing a person to testify against himself.

My own feeling on it is that a person under hypnosis will not testify against himself. First of all it is very easy for him to come out of hypnosis. As a matter of fact in this particular case here, in one of the previous runs through the accident, this pilot came down toward the water and he saw the water break in the plexiglass and he thought "that damn Mason, he'll let me hit the water again." Well just about that time I was starting to say the words to bring him out of it again. He was going to bring himself out. That's why he said the words "that damn Mason." He was already out. And so, the person has control. That, of course, is a disadvantage because if the person has something to conceal he can very well conceal it under hypnosis.

And it is also evident that if a person wants to lie, he can do so under hypnosis. Probably sounds just every bit as good as the person who is telling you everything he thinks is happening. How valid is the information? Frankly, I don't know, I don't think anybody can say. There are a lot of evidences experimentally that information recovered under hypnosis is quite valid but there are also some very disturbing experiments which would show that the information is totally invalid. So it is a matter that you must back up the information that you get from the hypnosis through the investigation of the accident material factors and so on. But on the other hand, it is a way of opening possibly locked doors. It is a way of focusing your attention on the facets of the accident you might not have thought of.

I do not claim that it is the ultimate technique of all accident investigation. In fact, I'm not even sure what hypnosis is. I don't think any of us are sure at the present time. But it is an interesting technique. It is even an exciting technique and I think you'll agree with me on part of that. It is a technique which I would certainly like to see exploited more in the future.

INTERVIEW OR INTERROGATE: THE PSYCHOLOGICAL DYNAMICS OF ACCIDENT INVESTIGATION INTERVIEWS

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The main question is whether to 'interview or interrogate,' and to answer that question we will explore the psychological dynamics of the accident investigation interview. First of all let us define our goals, i.e., what are we trying to accomplish. The goal of the accident investigation process is accident prevention. The investigator's goals are to prevent loss of life, injury, property damage, and reduce the risk involved in air transportation. In the accident investigation business we have to be very careful that we do not turn the investigation into a problem-solving exercise such as a Conan Doyle 'who dun it?' exercise.

Some investigators, particularly while interrogating or interviewing, suffer from a syndrome of misplaced emphasis that could be titled the "Sherlock Holmes Syndrome." It is possible to get so concerned with solving the key to this one particular puzzle that it is forgotten that the ultimate goal in the investigation process is to contribute data to the prevention process.

Too much emphasis is placed on solving this case and for putting responsibility somewhere: who is responsible, what is responsible, what is the cause or what are the causes of this case? This over-emphasis from an investigation standpoint is found particularly in witness interviewing.

The first point in dynamics is 'why are we concentrating on the sub-goal of solving the case?' sometimes to the detriment of the ultimate goal of accident prevention. It relates somewhat back to the murder mystery kind of thing. If we can find the culprit, whether it be a human or mechanical component or whatever it may be, we can then rest easy, remove, replace, retrain that particular culprit or faulty gadget and no longer have to expose aviation to that kind of a risk. We look for the removable items, the easily removable items. For instance, two dispatchers are talking to the control tower operator who is transmitting information very critical for the safe dispatch of an airplane. It is very easy to look for a mistake--a human error that one of the men made. It is much simpler to solve that human error or that mistake by retraining, firing, or replacing the man who made the human error than to look at the system, the poorly defined areas of responsibility, the methods of information transmittal, the language itself that we use, which could be at fault. We need to eliminate the scapegoats from our accident investigation results. Do we really need a scapegoat, and is it significant?

Now, let us analyze interviewing as it relates to the accident investigation and accident prevention process. The goal of the interviewing team is to permit each respondent to respond voluntarily and submit his own complete and unbiased factual description of what happened. We quite often lose sight of this particular goal in interviewing witnesses. In this area there is more room for improvement in permitting witnesses to give their complete and unbiased accounts than in any other area of accident investigation. This point agrees quite strongly with some of the points that Bruggink makes on how we intimidate witnesses. We use coersive techniques in interviewing both directly and implicitly. A lot of interviewing techniques result in this coercion. We use authority, our status as high-powered accident investigators and we intimidate our witnesses, be they professional aviators or Farmer Jones who saw the accident. I think that it is a sad commentary on the whole aviation safety concept in the accident investigation process when you find all professional aviation associations have policies of complete denial of information transmittal until the respondent has either a lawyer or a professional employee association representative at his elbow. Something is wrong with our whole investigation concept when people, professionals, dedicated, good men, are forced to live under this kind of an operating philosophy.

Let's look now to the dynamics involved with the investigator and the investigation process and the investigation team. Let's talk a little bit about the psychological dynamics of the respondents on the witness--I can use the word respondent for that covers both witnesses and people in the airplanes, people in dispatch, back on the drawing board, all people that get involved in these processes; someone responding to our interview, our call for information. Drawing heavily on Kahn and Cannell, I like to think of the psychological dynamics as involving barriers to information transmittal. These barriers can be classified into three categories: number one is fears; number two is goal conflicts, and number three is poor interviewing techniques. Now, let's talk a little bit about each one of these categories and give some examples of the barriers of complete and unbiased information transmittal that occur because of the psychological dynamics caused by them.

Number one example of fears in the accident investigation process is fear of reprisal. As long as there is a threat of reprisal for the information that this man is going to give you, you are not going to get complete and unbiased information. Now, what can we do about it? One of the things that we can do about it is to move the accident investigation interview into an area of privileged or sanctified testimony so that it won't become available to people for administrative action on the part of the man's employer, i.e., it won't affect his professional career, or the FAA can't yank his license. If and when there is a question of legal negligence as opposed to an honest mistake, civil aviation should explore the concept that the military tries to use, of two separate investigations, i.e., the collateral board for punitive action which must conduct its own independent investigation. This fear of reprisal is there in all participants and you know it is not paranoia when those sons of guns are really after you. Another fear that will cause a man to give you an incomplete or biased or a rationalized account is the fear that he will give you conflicting testimony with other witnesses or other people in the cockpit, or the dispatcher sitting beside him, or the engineer that worked on the board with him, or other people in the control tower. He will be clammed up by this. He is also concerned with internal inconsistencies in his own story. He is concerned if he gives you a large amount of detail that it is going to point up inconsistencies in his own story, either through his lack of memory or some things that he is deliberately hiding.

Another fear is revealing ignorance, and the fear that he will reveal his ignorance or incompetence in procedures that he should have known, such as, did he go through the proper emergency procedure? Unsophisticated observers will also suffer greatly from a fear of revealing their naivety or ignorance.

The second major category of psychological barriers to complete and unbiased information transmittal is <u>Goal Conflicts</u>. This happens when the investigation team and the respondent have goals in opposition. They aren't working toward the same goal and it's going to cause information to be lost. Protection of professional reputation is the first example of goal conflicts. This protection will cover yourself, your friends, your organization, and it has caused the loss of a lot of information.

The anti-establishment syndrome. We're talking here primarily about ground observers as witnesses when we talk of the anti-establishment syndrome. There is a lot of anti-establishment feeling in them. This anti-establishment feeling is present even in those of us who are over 30 years old.

The anti-airdrome syndrome is certainly a major factor in limiting the cooperativeness, the completeness, and the unbiasedness of the accounts which we are going to get. We talk to a lot of these people because the man who lives off the end of the runway is most likely to be our anti-airdrome man and is most probably the one who will see the aircraft just before or after the crash. We are quite likely to obtain all sorts of embellished stories, quite sincerely, from this man because of his point of view, his goals, are very, very different from ours.

Notoriety can be a goal of a respondent which conflicts with ours. Who hasn't been on an accident investigation team when somebody who had nothing to do with seeing the accident comes up and volunteers his statement to you.

Anonymity is another example of a conflicting goal. Who hasn't tried to get somebody to testify who says, "Oh, no, never mind me, I'm busy or my boss thought I was home sick or my wife thought I was bowling."

The goal of personal profit will certainly arise. This question should be resolved right away. People who saw the accident and are in a position to be a good witness for you will want to be a paid witness. They will expect you to pay them for their own personal time lost or for travel expenses.

And the last point on goal conflicts is professional biases. Personal biases can come in another way, not only in the personal prejudices which comes of life-style, or the racial thing; it can come in in terms of a technical preconception sense: "I know this kind of airplane, I know its problems well, I've been waiting to get this airplane for a long time because I know what's wrong with that thing. Here's an accident that looks just like that's what happened, boy, this time I'm going to let the chips fall where they may and get that airplane fixed." This technical professional prejudice can cause you to lead this witness, to shut him down when he doesn't support your contention. He'll be aware of your biases and will lose interest in your objectivity and your goals.

To define the third category of barriers to complete and unbiased information transmittal let's talk about some of the ways how not to interview, some of the poor interviewing techniques. Most of these barriers involve interviewer shortcomings, either hostile attitudes or lack of personal sensitivity.

Challenging attitudes. Puzzlement at what he is telling you or amazement or amusement can just shut that man down for you, cut off your channels of communication.

Variable attention levels. This is a very subtle thing. Your posture can give a man an indication of what it is you want to hear, and you can steer him with your body, i.e., shifting your posture. Give him an idea that you're interested in one line of testimony and he'll continue to elaborate on that line. It is very hard not to lead a witness, it is extremely easy to lead him. If you don't acknowledge these psychological dynamics you're just going to reduce the utility of the information that is collected. You are going to hear what you want to hear. It will be played back to you. You are going to hear what he wants you to hear--which is what he thinks you want to hear.

Structured questions. This is very dangerous in all interviewing situations but particularly in interviewing situations where narcotics or hypnosis is used. You have to be extremely careful on structured questions in terms of leading the witnesses or challenging his capability as a witness, either in questioning his powers of perception or his powers of recall. If you start asking in details before he is ready to give them to you, you are challenging him.

judices of the interviewer. I think that this point is so obvious that it needs no elaboration.

Now, what are we going to do about this, what can we do about these barriers, they are real, they are there, they exist, if you don't acknowledge them you are wasting your time. Just don't fail to interview people because you are not going to get good information.

Let's talk about the introduction to the respondent. Right off the bat, what is it you can do for this man to open up your channels of communication? In the introduction, you give him your name, and ask for his name. Your title, his title, his address, his background, his flying time, are not important at this point. Assume that you have accomplished preliminary screening and know that he has information of value so that you will not be wasting your time.

Now we can start going for the record. You identify him by name only. If you ask for his rank and if he is of a lower rank, you right away put him down. If he is a GS-4, we put this man down. If he is an airman first class, if his address is on the wrong side of the tracks, if we ask for his occupation and if it is a menial occupation or he is unemployed, we're going to put him down. And these things really just aren't important at this point. If he is a pilot and we ask how many hours he has in his airplane, we challenge him right off the bat, we put him on the defensive; we don't need that information at this time, we need it later, but not at this point.

Second step. State your function and purpose of the interview. Be factual. Exactly what is this investigation process all about? The procedures change--the functions, the purposes change somewhat, but recap it even if this man is a 55-year-old airline captain who has been head of ALPA safety committee for ten years. He's been involved in an accident and you're interviewing him, recap the function and purpose of the whole accident investigation process, tell him what it is all about; what are investigations, what do they report, what is the nature of this process. Give him information. If you don't give him information he will fill in his own. Most of the things he'll fill in will be a result of his fears and he is going to fill in a lot blacker picture than you've ever got to offer him.

Next, establish a common goal. Look for a common goal for you and this respondent; you personally and the accident investigation process and the respondent, and look for all common goals you can establish. Point these out to him, why you're here. You'll have problems sometimes with the anti-airdrome people but even there you're both interested in keeping those airplanes out of his backyard. And by investigating this accident we try to keep it from happening again in his backyard or somebody else's. Establish this common goal. Work at it. If you can't establish a common goal you're in trouble--real trouble.

Now, tell him how the interview information is to be used. By whom, who is to see this information; all the people. For what purposes. Recap again the functional purposes of the accident investigation process. What are we doing this for? Summarize the purposes again. What is it going to be used for? What about anonymity. Will his statement be anonymous? Tell him the truth. If you can't offer him anonymity, tell him so. Does it have to be signed? Will you need a legally sworn statement? Whatever the procedures of the moment, be honest and factual in telling him the rules affecting this investigation.

What about follow-up interviewing? Are you going to remind him if there is the possibility that you are going to want to talk to him later? Do you want him to come to the hearing? Is that a possibility? Let him know how he stands on this point. The last point on this: Tell him about what feedback he can expect. I think this is one area where we can make a positive change, particularly for respondents who are outside of the aviation industry. When they make a contribution to the investigation statement, somehow get this information back to them. When the press release is finally available after the hearing, put him on the mailing list--for all the information about this accident.

Tell him about that. This eventually is one of the ways that we can get over some of this anti-establishment and anti-airdrome syndrome with the accident investigation process.

Now, the next point is another subtle one and it is difficult to handle. Why is this respondent important to the accident investigation process? He should know that. Is he the captain of the airplane, the chief of dispatch, farmer that watched the airplane crash in his field? Tell him why he is important. He is the only one that saw the airplane just prior to the accident. He has valuable information for you. If he is a member of the crew on this aircraft--it is critical in establishing the sequence of events that happened. Tell him why he is important, tell him the truth again, don't ever deceive a respondent.

Deception, no matter how subtle, no matter how insidious, no matter how well intended deception might be, deception in the accident interviewing process might possibly be useful in your very last accident investigation interview, because you use it to trick someone. It will spread like wildfire throughout the entire aviation community that you tricked somebody and you will be through as an effective interviewer. You needn't talk to anyone in the aviation industry again.

Now, we're still on the introduction, follow up with the procedure that we are going to use in taking his statement. The format--tape recorder, written statement, whatever it is, let him know. Tell him the reason it is to be recorded. Tell him about how long it is going to take. Can he expect a fifteen-minute interview or a three-day interview? Give him some idea because a lot of times non-aviation people want to get home--they have a lot of things they want to do, they want to get on their way.

Now, what have we done so far? We have just set the stage, we haven't talked a thing about the accident itself, have we? We are trying to establish a rapport with this respondent.

What's the suggested format? I have one and try it, if it doesn't work come back and I'll give you your money back. This format, point number one on the format of the interview, how to do it is the introduction we just went through. Review that periodically. If you're going to be involved in interviewing witnesses--respondents--review that introductory procedure periodically.

In this introduction sit across the table from the respondent. Give him something to eat or drink, or smoke, share something with him. Establish this personal rapport. Give him a bag of peanuts to eat--share a can of peanuts with him. In addition to establishing rapport, there is some evidence that activity in the jaw and mouth encourages or facilitates talking--loosens the tongue so to speak. I'm not suggesting alcohol.

Then proceed with a line of questioning which I'll elaborate on as a separate point after we have gone through the format.

Your first question should be something on the nature--write your own--whatever you're comfortable with--tell me what you can about the events leading up and during this accident. Then sit back and listen.

Next point. Let him talk into a tape recorder, Put the tape recorder out of sight so he doesn't get hypnotized with the reels going around, or he doesn't see how much tape is left because that would be an indication to him that that is about how long a statement you want from him. Keep the microphone up in plain view, but put the tape recorder and reels out of sight. If you can't put it out of sight, put a cover over the top of it so he can't see the reels going around. Do him the favor of starting out with a fresh reel so you don't have to interrupt him to change the reels.

Let him run through his whole narrative, uninterrupted by you; don't interact with him. You're just an open slate. You're just as non-committal about his story as that tape recorder is. No raised eyebrows, no shifts in attention, no paper and pencils. If you start taking notes you can lead that man with the pencil and paper just as sure as you can lead him with all the other things we have talked about. Because when he sees you writing furiously there, he's going to go right up to that line of testimony.

Don't allow any interruptions. Don't allow your telephone to ring; take it off the hook. Don't allow anyone to come through the door--wherever you are. If you're off under a tree beside the scene of the accident, don't allow anyone else from the accident investigation team to come over and interrupt you. If something happens that is more important to you, stop the interview completely and tell him that you're sorry, very sorry, exactly why it is more important to go off after something else. But don't interrupt his testimony--answer some question, direct somebody else to some other area, then come back to him. Give him your complete and undivided attention.

When he's through with his story, let the respondent listen to his own story. Let his own story serve as a stimulus to aid further recall. If he hears his own story he can remember more events. He will remember things he left out. When he does, allow him to elaborate. Have a second tape recorder. Have another channel on stereo. This is where a good tape recorder comes in handy. When you've got to index it, you can index from one place on the tape to the other. Two channels or two separate tapes.

Then, recycle this, points three through five as many times as he wants to do it. Until he is satisfied completely that he has given you the whole story. Allow him to listen to his primary story, his amplifications, and listen to them as much as he wants to until he is satisfied that he has told you everything that he knows.

Then, proceed on to a hierarchy of questioning. If you still haven't gotten points you need covered from this witness, that he was in a position to have given to you, then you can proceed on to your second and third level of hierarchy in your questioning.

Now, let me talk about this hierarchy of specificity. The hierarchy of specificity refers to proceeding from very general to very specific questions. The first level of specificity is "tell me what you can remember--your own personal view." The second level: an example would be to refer to the approach path of the aircraft as you saw it coming by, "Can you tell me more about that?" Use of memory aids at this point can be a tremendous help. Models of the aircraft can be excellent memory aids with some of the various pieces missing that you are concerned about, or one model with gear up and one with gear down. Use these models as a stimulus, and gradually lead him down to the point in the gradual order. The last question that you ever want to ask that man is for a specific yes or no answer, or for readings like "What was the oil pressure?" or "Were the gear down?" If you ask that man that question, you back him all the way back into the corner--you've challenged his integrity, his powers of recall and his value to you as a witness.

If you have several lines of questioning for him to pursue, proceed on one level of this hierarchy at a time. If you have ten areas or lines of questions you need to pursue, ask the first general question in one of your areas. If you don't get satisfied, shift to another area. Go all the way across horizontally on the first level of the hierarchy. Then go down to the next level in the areas that you didn't get answered. Proceed through the hierarchy at the same level in all areas.

The last point is to obtain the personal items. Where does he live, what's his occupation, has he been drinking--what's your address, why were you out here? All you need to know about him personally to qualify him. If he is an aeronautical engineer he's going to tell you, you won't have to ask him. Anybody really doubt that? If he is a pilot, he's going to tell that, you won't have to ask him. If he has special qualifications he's going to volunteer them early in the interview. You don't have to ask somebody for these special qualifications because they are going to come out, all you're going to do is threaten a man who doesn't have them.

When we are talking of ways to keep the lines of communication open, the acknowledgement of these psychological dynamics will go a long way toward improving the quality of the information obtained in interviews. The primary culprit in closing off respondents is the threatening nature of the findings. However, at the investigator level we can do a lot to ease, reduce, and remove the fears, goal conflicts and poor interviewing techniques that have been introduced in the past.

The quality and quantity of information can be improved if you'll take the time to do it. Being bright and sincere but being unprepared won't do it. You can be bright and hardworking but you are going to lose interview information unless you very carefully prepare yourself to conduct this interview.

References

Bruggink, Gerard "Validity of Witness Statements," presented to the Second Annual Seminar at the Society of Air Safety Investigators, Los Angeles, 1971.

Kahn, R. L. and Cannell, C. F. "The Dynamics of Interviewing," John Wiley & Sons, New York, 1957.

WEDNESDAY, 27 OCTOBER 1971

9 a.m. Session 3

Chairman: Dr. Charles I. Barron, Lockheed - California Company

Human Factors Problems in Aircraft Investigation in Los Angeles - Dr. Thomas Noguchi and Dr. David M. Katsuyama, Coroner's Office, Los Angeles County

Advanced Automated Visibility Simulation - James Childs, NTSB and Dr. James L. Harris, Associate Director, Vision Laboratory, Scripps Institute of Oceanography

A Proposal for Radio Transmissions During Emergencies - John Margwarth, Lockheed - California Company

Some Psychological Aspects of An Accident Investigation - E. F. Harvie, Chief Inspector of Air Accidents, DCA, New Zealand

12 Noon

Luncheon

Speaker: Robert Serling, Author of Probable Cause and Loud and Clear

2 p.m. Session 4

Chairman: Dr. Robert O. Besco, Allied Pilots Association

Behavioral Science and Accident Investigation - Dr. Robert Alkov, U.S. Naval Safety Center

Investigation of HF in U.S. Army Aircraft Accidents - Sam Phillips, U.S. Army Board for Aviation Accident Research

Cabin Crew Involvement in Investigation - Mrs. Del Mott, Air Line Pilots Association

Philosophy of HF - Jim Danaher, NTSB

A Human Factors Questionnaire - Dr. Nolen L. Armstrong, Vice President, Flying Physicians Association

8 p.m. Banquet

SASI Awards Presentation - President Donald Kemp

Speaker: Capt. Carl Christenson, United Airlines (Retired)

Master of Ceremonies - Herb Green, KMPC Skywatch

HUMAN FACTORS STUDY IN LOS ANGELES
AS INVOLVING THE DEPARTMENT OF CORONER-MEDICAL EXAMINER
COUNTY OF LOS ANGELES

THOMAS T. NOGUCHI, M.D. and DAVID M. KATSUYAMA, M.D.

INTRODUCTION

From medieval English the Coroner represented the Crown, holding property of decedents which by death reverted to the Crown. His responsibilities included insuring that these were not appropriated by others. As time proceeded, his duties changed to investigating and determining deaths under certain circumstances and is now as noted (in appendices I and II). The Medical Examiner System is one where these duties are carried out by a doctor of medicine (trained in the field of Forensic Pathology).

Los Angeles County has a total population just over 7.2 million, 4,083.21 square miles with 77 incorporated cities, of which 34 contract with the Sheriff for Law Enforcement services. Sixty-five to seventy-five thousand deaths occur each year in Los Angeles and in about 25,000 inquiry to this office is made for one reason or another. Approximately 14-15,000 cases are taken into jurisdiction. Approximately 7-8,000 are autopsied.

Certification of death includes both the Cause of Death and the Mode of Death (how a person died). The cause of death is determined by investigation and autopsy and additional studies including toxicology, microscopy, and bacteriology. All information pertaining to the case is considered in arriving at the cause of death. This study may take only a day or two or may take several months or years depending upon the complicity of the problem.

The modes of death include: those occurring from natural causes; those resulting from an accident; suicide, or by the decedent's own hand; and homicide. They are usually self-explanatory. However, in many instances it is difficult to delineate accidents from suicides and many times suicides can be made to appear like accidents and occasionally an apparent natural death is reviewed as a suicide. To assist us, behavioural scientists are often called upon to investigate, evaluate, and render an opinion.

The Inquest is an inquiry under oath into the circumstance of death which may be ordered in select cases. This may be with only a Hearing

Officer or may include a Jury deliberating the facts presented and returning a verdict. As such, the Inquest can be considered an extension of the Investigation into death and may serve as a valuable instrument in determining the mode of death.

The Types of Aircraft Accidents investigated by our Department in the past several years are a rather interesting group. They include two passenger helicopter accidents; two airliners "down-at-sea"; one glider; one "para-kite"; one mid-air airliner-military plane collision; one collision of an amphibian with a private boat; and, many involving small private planes.

If the multi-passenger commercial carrier accidents are included, less than twenty-five aircraft related deaths occur in a given year, the number of accidents causing death numbering about a dozen.

The airliner-military fighter accident in June of 1971 brought the total for this fiscal year to nearly one hundred.

In 1968 the two helicopter crashes resulted in nearly fifty deaths.

In 1969 the two separate jet airliner accidents resulted in six cases handled by the Coroner-Medical Examiner.

Although many more fatalities occurred in these last two accidents, remains of the other victims were not recovered for the Department to handle. (In these instances Petition for Certification of Death is made to the Superior Court by the directly interested parties; i.e., attorneys for the next-of-kin and/or the carrier.)

The Disaster Identification System has been undergoing slow metamorphosis during the past several years, being improved and modified by each succeeding disaster.

The most recent series of disaster operations began with an arson-destroyed apartment complex involving eight deaths, followed by another arson-destroyed hotel with over fifty inhabitants of whom nineteen perished.

Then, early this year, the Sylmar earthquake shook down an aged hospital building resulting in almost fifty deaths. However, identification was simplified by the preservation of the remains from fire; quick recovery, etc.; and, the fact that all patients had wristbands and most hospital personnel had name tags on their outer clothing.

The recent airliner-military fighter collision placed the system through its severest test.

Since then, a tunneling operation explosion resulted in about twenty deaths and the remains of the last victim was not recovered until the past month, about four months after the incident.

The Investigation is a "team" effort including many agencies and have included the following:

A. Sheriff of the County of Los Angeles
B. Los Angeles Police Department
C. Other local City law enforcement agencies
D. National Transportation Safety Board
E. Federal Aviation Administration
F. Department of Defense
G. Fire departments, both City and County
H. Department of Harbors, both City and County
I. United States Coast Guard
J. Individual Commercial Carriers
K. Federal Bureau of Investigation
L. State Bureau of Criminal Identification and Investigation
M. Immigration and Naturalization Service
N. American Forces Institute of Pathology
O. Civil Air Patrol, and
P. Many others not immediately coming to mind

In each group are specialists with their fields and their training and know-how are utilized to carry out the responsibilities in their special fields.

The At Scene "team" includes:

A. Local enforcement agency for protection of scene, assistance in transportation, and supporting logistic requirements.
B. Recovery teams for locating remains, segregating and tagging parts as they are recovered.
C. Structured personnel who may or may not be at initial removal and their work may continue for prolonged periods at scene or elsewhere after recovery of remains has been completed.

Identification and Notification is dependent upon the number of decedents involved. If more than four or five persons are involved in the accident, the "Disaster System" is activated (see appendix III).

Two sets of files are begun:

1. An alphabetical one for all incoming information--from those reporting information or requesting information.

2. Another set of files based upon examination of the remains recovered.

The incoming file includes survivors and/or possible victims with pertinent data including as much medical information to assist in identification.

All calls are placed in file and if the disaster includes more than a dozen or so, a special information center may be set up.

Cross-files with other agencies to include survivors are also set up.

Notification of kin is performed by the Notification Officer prior to release of the information to the general public.

Identification is also dependent upon the extent of preservation of remains. If visual identification is possible, this may be the simplest and fastest.

Fingerprints are also very helpful but here the decedent must have been previously printed and these records easily located for comparing.

X-rays, both body and dental are another means of identification. Dental charts can assist greatly in a "closed group" whose members can be established by other means such as passenger and crew manifests. However, one may be hampered by the lack of such records or their unavailability. Requests to personal dentist or physician not to take X-rays have on occasion caused difficulty in establishing identity.

X-ray film may have identifying characteristics sufficient to be the sole basis of identification (several from the most recent local air carrier accident were established only by these films).

Identification by X-rays may range from easily compared configuration of dental fillings to more tedious comparison of root systems, shape of jaws, positions of teeth, etc. Comparison of shapes of bones, which may be individually characteristic, such as shape of lower jaw, the scapula, and the clavicle, have also been the basis of identification.

Microscopic examination of tissues may enable determination of sex. Antigen-antibody studies may extend well beyond the common ABO blood grouping and may materially assist in both aggregating severed parts and establishing identification. However, this is definitely dependent upon remains recovered in a condition that enables testing.

The extent of preservation has in these disasters ranged from excellent to very poor--to the extreme extent of shattered, incinerated fragments of bone recovered in close proximity to each other.

Toxicologic testing, again, is definitely dependent upon the state of preservation. In most of the aircraft fatalities, the remains have been badly mangled at its best and incinerated at its extreme. In most instances, blood is unavailable so other tissues are utilized for testing. Alcohol determination may be invalidated by decomposition occurring before remains are recovered.

Barbiturates and carbon monoxide are routinely tested for, and when circumstances indicate, further testing may include screening for other sedatives, hypnotic, tranquilizers, antihistamines, and narcotics.

Again, the tissues recovered will affect the testing we are able to perform. There may be still further investigation by behavioural scientists.

January 10, 1972
vw
Attachments

APPENDIX I

GOVERNMENT CODE, STATE OF CALIFORNIA, Section 27491, pertaining to the rights and duties of coroners:

It shall be the duty of the coroner to inquire into and determine the circumstances, manner, and the cause of all violent, sudden or unusual deaths;

Unattended deaths;

Deaths wherein the deceased has not been attended by a physician in the 10 days before death;

Deaths related to or following known or suspected self-induced or criminal abortion;

Known or suspected homicide, suicide, or accidental poisoning;

Deaths known or suspected as resulting in whole or in part from or related to accident or injury either old or recent;

Deaths due to drowning, fire, hanging, gunshot, stabbing, cutting, exposure, starvation, alcoholism, drug addiction, strangulation or aspiration;

Death in whole or in part occasioned by criminal means;

Deaths associated with a known or alleged rape or crime against nature;

Deaths in prison or while under sentence;

Deaths known or suspected as due to contagious disease and constituting a public hazard;

Deaths from occupational diseases or occupation hazards;

Deaths under such circumstances as to afford a reasonable ground to suspect that the death was caused by the criminal act of another, or any deaths reported by physicians or other persons having knowledge of death for inquiry by coroner.

APPENDIX II

Section 10250 (Health and Safety Code, State of California)

A PHYSICIAN, FUNERAL DIRECTOR, OR OTHER PERSON SHALL IMMEDIATELY NOTIFY THE CORONER WHEN HE HAS KNOWLEDGE OF A DEATH WHICH OCCURRED OR HAS CHARGE OF A BODY IN WHICH DEATH OCCURRED:

a. Without medical attendance.

b. During the continued absence of the attending physician.

c. Where the attending physician is unable to state the cause of death.

d. Where the deceased person was killed or commited suicide.

e. Where the deceased person died as the result of an accident.

f. Under such circumstances as to afford a reasonable ground to suspect that the death was caused by the criminal act of another.

DEPARTMENT OF CHIEF MEDICAL EXAMINER-CORONER
COUNTY OF LOS ANGELES

DISASTER VICTIM INFORMATION

SUBJECT ____________________

ADDRESS ____________________

SEX ______ AGE ______ WEIGHT ______ HEIGHT ______ HAIR ______ EYES ______

SCARS, DEFORMITIES, TATOOS ____________________

____

TONSILS - Yes ______ No ______ Circumcision - Yes ______ No ______

MEDICAL CONDITION ____________________

____

FINGERPRINTED? ______ WHEN AND WHERE ____________________

MILITARY? ______ WHEN ____________________

DENTIST NAME ____________________

ADDRESS ____________________

PHONE ______ CITY ____________________

JEWELRY ____________________

CLOTHING WORN ____________________

____

____

INFORMANT ____________________

ADDRESS ____________________

PHONE ______ CITY ____________________

CAN INFORMANT MAKE I.D. IF NECESSARY?

NEXT OF KIN ____________________

ADDRESS ____________________

PHONE ______ CITY ____________________

RELATIONSHIP ____________________

VICTIMS' NAMES WILL NOT BE RELEASED UNTIL POSITIVE I.D. IS MADE.

INFORMATION TAKEN BY ______ DATE ______ TIME ______

COCKPIT VISIBILITY PROBLEMS AND ILLUSTRATIONS OF ADVANCED AUTOMATED VISIBILITY SIMULATION

JAMES T. CHILDS
Air Safety Investigator
National Transportation Safety Board

It was with a great deal of pleasure that I accepted this opportunity to speak before you today on the very vital subject of cockpit visibility, and some of the variables associated therein. We in the National Transportation Safety Board have been conducting visibility studies associated with mid-air collisions for years, and have used these studies as one tool in the investigative process. Even though the methods employed in any visibility study are basic and standard from a factual standpoint, occasionally some mid-airs are surrounded by factors that create additional uncertainties.

The number of mid-air collisions is tragic, and the problem appears, statistically, to be increasing. During the period of 1956 through 1970, there were 333 reported mid-air collisions that took 966 lives.

In the eight-year period between 1956 and 1963 there were 139 mid-air collisions in which 71 were classified as fatal. (Figure 1) The following seven years, there were 194 mid-air collisions of which 105 were fatal. Discounting the difference of one year in the calculations, there was an increase of 55 accidents of which 34 were fatal. So, at least on the surface, the trend is upward. Additionally, the classification and analysis[1] of 2230 near mid-air collision reports received during 1968 resulted in 1128 of these reports being classified as incidents "Hazardous" to flight.

The number of mid-air collisions is tragic in the loss of lives; however, the potential for tragedy as illustrated in the near miss report, coupled with the passenger carrying capacity of new generation jets, is awesome. This brings me to the heart of my presentation.

Any visibility study, involving a mid-air collision, should be approached with doubts on the methods that would be suitable, followed by skepticism on the final results obtained by a purely mechanical function. E.g., if only distance between aircraft, and silhouettes in ideal

1 FAA Near Mid-Air Collision Report of 1968

visibility conditions with the pilot looking directly at the other aircraft are considered, it would seem that pilots in opposing commercial aircraft, or general aviation aircraft, could detect each other very readily while six or seven miles apart. But, unfortunately, pilots operate in a real world where the conditions are not always ideal. As they depart from CAVU, the threshold of vision decreases.

One mid-air collision in particular was very frustrating in that it could not be satisfied with the standard results of the typical visibility study. This mid-air involved a Convair 580 and a Cessna 150. There were so many variables surrounding this accident that it was impossible to reconcile routinely all the facts that were exhibited during the investigation. Some of the variables were; insect smears on the windshield of the C580, haze and smoke. Also, the clear liquid left by the insect strikes created a prismatic offset effect to vision from the cockpit of the C580.

Although the variables were many, the resultant scratch mark information was distinct on both aircraft (Figure 2). None of these variables could be integrated into the mathematical data used to plot the angles of vision associated with calculated distances between the two aircraft. So the results would be questionable as to the distance in which the pilot or pilots could have observed the opposing aircraft. An additional factor had to be considered. This concerned the fact that regardless of the relative speeds and headings of the two aircraft, on a collision course, their relative bearings remained practically constant from about one minute to impact. (Figure 3) With insect smears on the windshield, and the visual angle, or angle subtended by the viewed object, smaller than some of the smears, the possibility arose that the Cessna 150 could have been hidden until the two aircraft were so close that collision was unavoidable.

After these variables had been studied, the all important question now arises - "Could the pilots have seen each other, and if so, at what distance?"

It was difficult to understand from the facts relating to weather forecast, threshold of vision limitation, and assumed visual perceptive ability of pilots, why contact was not made. E.g., at 7,450 feet and 30 seconds before collision, the object subtended would have resulted in an arc of approximately 1.5 degrees. This angle is well within the calculated probability of detection where a vision arc of 1 minute is ample. Furthermore, under laboratory conditions,[2] the generally accepted minimum time of 10 seconds for maneuverability and avoidance was well within the 30 second time calculated for possible sighting between the two aircraft. This 10 second period is usually broken down into the following:

Perception	.3 second
Recognition	.5 second
Decision	3.0 seconds
Reaction	.4 second
Aircraft reaction	6.0 seconds

The adequacy of this time is still under study.

The uncertainty generated research with the primary objective of systematically studying every piece of literature that could be found dealing with the subject of vision. This turned out to be a monumental task that had to be curtailed due to the mass of textbooks, manuals, papers, and articles that had been prepared and published by universities, research institutions and individuals on problems with vision. E.g., the easiest part was the immediate compilation of a general bibliography in excess of 1,000 items from the Library of Congress. Reflected in these publications was general agreement of the vision experts, using laboratory techniques, that the human eye provides one of the most remarkable senses. However, it does have limitations when used as a collision avoidance tool. If a study begins with the conclusion of the experts, the question now uppermost is "What method can be devised to help create a better understanding of these limitations?"

All of this eventually led to Scripps Institute of Oceanography Visibility Laboratory, via the National Aeronautics and Space Administration (NASA). At Scripps, the first step, under sponsorship of NASA, Ames, was taken to present this problem pictorially.

The factual data taken from the Safety Board's Visibility Study Report, Figures 4 and 5, was computerized and transferred to a film strip by Mr. James L. Harris, Associate Director, Scripps Visibility Laboratory. The data presented by the film strip was directed toward a quantitative evaluation of the visual detection and recognition performance which should be expected from the flight crew. The calculation methods used make it

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2 Discussed during Annual Conference, Committee on Vision, National Academy of Science, May 1970.

possible to determine, pictorially, the manner in which performance is related to atmospheric clarity, windshield clarity, lighting geometry, field of view to be searched, closing velocities, aircraft size, and aircraft conspicuity.

The Visibility Laboratory staff at Scripps performed the following functions in producing the initial film strip:

1. A model Cessna was photographed on 35 mm film under lighting geometry which, to the best of our knowledge, simulated that involved in the actual collision. The model was photographed from the aspect angle appropriate to the collision geometry.

2. The 35 mm film was scanned with a photoelectric film scanner in which the transmission of the negative was measured at each of 4096 points on a rectangular array, 128 elements horizontally by 32 elements vertically. The 4096 numerical values were punched on a deck of IBM cards for input to the computer.

3. The card decks were read into the computer and knowledge of the characteristic curve of the film was used to convert each transmission reading to exposures, i.e., to make a positive for the negative.

4. The luminescence map from step 3 was converted to a contrast map by subtracting the background level from each picture element and then dividing each element by the background level.

5. Two arrays to numbers were generated on the computer to account for the windshield. The two important properties of the windshield are the beam transmittance at each point, i.e., the attenuation of the image forming light from the Cessna, and the path luminescence at each point, i.e., the light scattered by the windshield such that it appears to be coming from the Cessna. The path luminescence is dependent on lighting geometry, but the beam transmittance is not.

6. A computer program which magnifies or demagnifies an image was used to make the Cessna image have the proper angular subtense for a range corresponding to 30 seconds before

impact. The field of view represented by the 128 x 32 array of numbers is $10^{\circ} \times 2.5^{\circ}$.

7. Contract reduction due to the atmosphere was accomplished by multiplying (6) by the contrast transmittance associated with a visibility of 3 miles at the range corresponding to 30 seconds before impact.

8. The demagnified and contrast reduced array was converted back to a luminescence map, multiplied by the beam transmittance of the windshield and added to the path luminescence of the windshield.

9. The resulting image was displayed on a cathode-ray-tube and photographed with a 16 mm movie camera operating single frame.

10. Steps 6 through 9 were repeated for a range reduced by a time of 1/16 second, the time of a movie frame. The process was repeated at 1/16th second time intervals up to the point of impact.

The computer generated movie is a first demonstration of a technique. It should not be judged on the basis of lack of fidelity due to the 128 x 32 discrete array of numbers. The number of elements, and hence the fidelity, could be substantially increased.

What is probably more important is that calculation techniques have been developed which allow analytic treatment of the problems of visual search in the air-to-air situation. These tools can be used for a variety of purposes, such as meaningful specifications for windshield cleanliness based on acceptable degradation of visual performance. Another use of these techniques would be the ability to predict the visual search performance as a function of the angular uncertainty of the aircraft to be sighted, thus placing a logical foundation under decisions as to the resolution requirements for pilot warning indications.

After all is said and done, where do we go from here, and what does it all mean? Well, now that the ice has been broken, the following data from any mid-air collision can be used as inputs into the computer program by technicians at Scripps to produce an improved film depiction:

1. Complete flight profiles of both aircraft.
2. Information related to the paint scheme of the aircraft.
3. Atmospheric visibility.
4. Description and location of cloud formations.
5. Sun position and extent of obscuration.
6. Layout of cockpit visibility.
7. Information on the condition of the windshield if available.
8. Number of crewmen and estimate of percentage time they had available for search. Did they divide field of view between them?

Considerable interest was generated in this research by other members of the Vision Research community. For example, Mr. Harris presented the basic data in a discussion before the National Research Council Committee on Vision at the Annual Conference of National Academy of Science in May 1970. At the present time, the Federal Aviation Administration, through Dr. S. J. Gerathewohl, Chief, Research Planning Branch, Office of Aviation Medicine, is sponsoring a program to advance the present technique to encompass a full screen presentation in color to enhance conspicuity.

There is no doubt, statistically at least, that exposure to mid-air collisions is on an uptrend. Greater numbers of pilots are being licensed, and greater numbers of aircraft are being manufactured. This leads to one conclusion - more flying activity in the same airspace. With the present emphasis on collision avoidance from all segments of aviation, it is hoped that the pictorial research under development will objectively portray to anyone who operates an airplane that a little variable in the vision scan field can suddenly remove him from effective VFR conditions to a condition where the possibility of detection is seriously reduced.

James T. Childs
Air Safety Investigator

MID-AIR COLLISIONS

U. S. CIVIL AVIATION

1956-70

Year	Accidents Total	Accidents Fatal	Number Fatalities	Air Carrier / Air Carrier	Air Carrier / Gen. Aviation	Air Carrier / Military	Gen. Aviation / Military	Gen. Aviation / Gen. Aviation
				Number of Accidents by Segments of Aviation Involved				
1956......	17	11	161	1	1	0	1	14
1957......	15	6	19a/	0	0	1	4	10
1958......	16	12	86	0	0	2	2	12
1959......	13	10	20	0	0	0	3	10
1960......	26	10	152b/	1	4	0	2	19
1961......	20	10	22	0	0	0	0	20
1962......	19	9	27	0	0	0	5	14
8 yrs. 1963......	13 139	3 71	6	0	0	0	2	11
1964......	15	7	12	0	0	0	2	13
1965......	27	14	30	1	0	0	2	24
1966......	27	11	33	0	1	0	1	25
1967......	26	20	157	0	2	1	3	20
1968......	37	23	69	0	3	0	1	33c/
1969......	27	11	119	0	3	0	2	22
7 yrs. 1970 (Prelim)	35 194	19 105	53	0	0	0	5	30c/
TOTAL.....	333	176	966	3	14	4	35	277

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D. C. 20591
June 4, 1971

a/ Includes 3 persons on ground.
b/ Includes 6 persons on ground.
c/ Includes 1 U. S. General Aviation vs. foreign aircraft.

FIG. 1

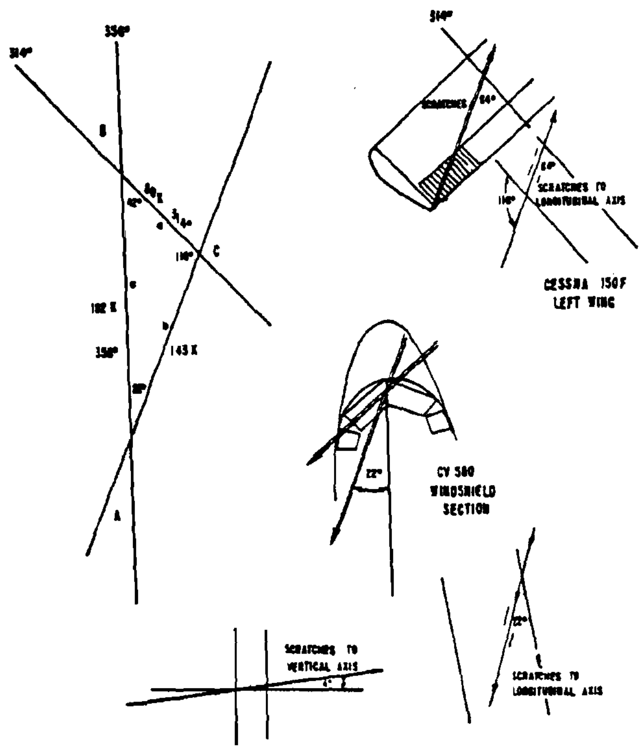
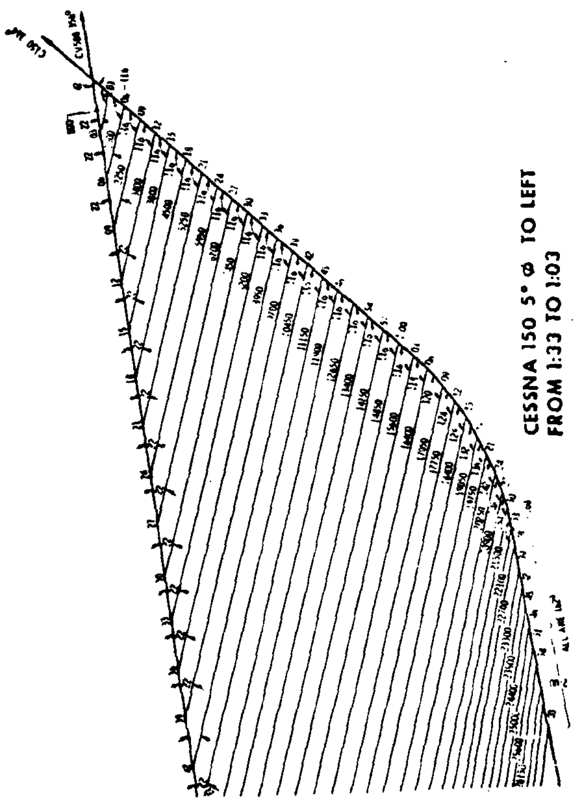

CESSNA 150F
LEFT WING
CV 580
WINDSHIELD
SECTION
SCRATCHES TO
VERTICAL AXIS
SCRATCHES TO
LONGITUDINAL AXIS

FIG. 2



CESSNA 150 5° ø TO LEFT
FROM 1:33 TO 1:03

FIG. 3

ATTACHMENT 7B

CALCULATED COPILOT'S VIEW - CV580
COPILOT'S FAA DESIGN EYE POSITION
30.5" ABOVE MIDMOST SEAT DEPRESSION
24" AFT INSTRUMENT PANEL

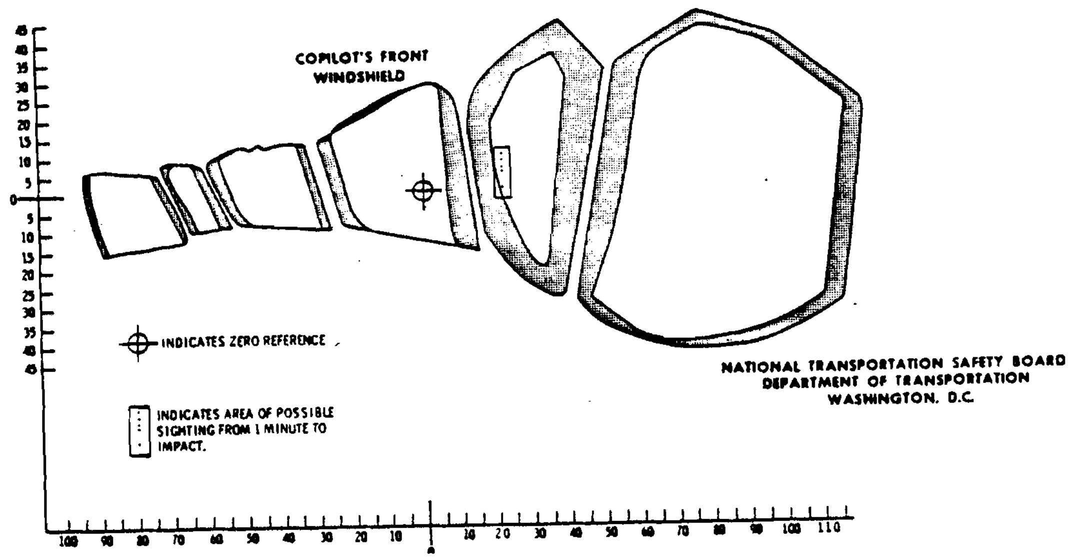


FIG. 4

ATTACHMENT 7A

CALCULATED CAPTAIN'S VIEW - CV580
PILOT'S EYE POSITION
42" ABOVE FLOOR
25" AFT OF INSTRUMENT PANEL

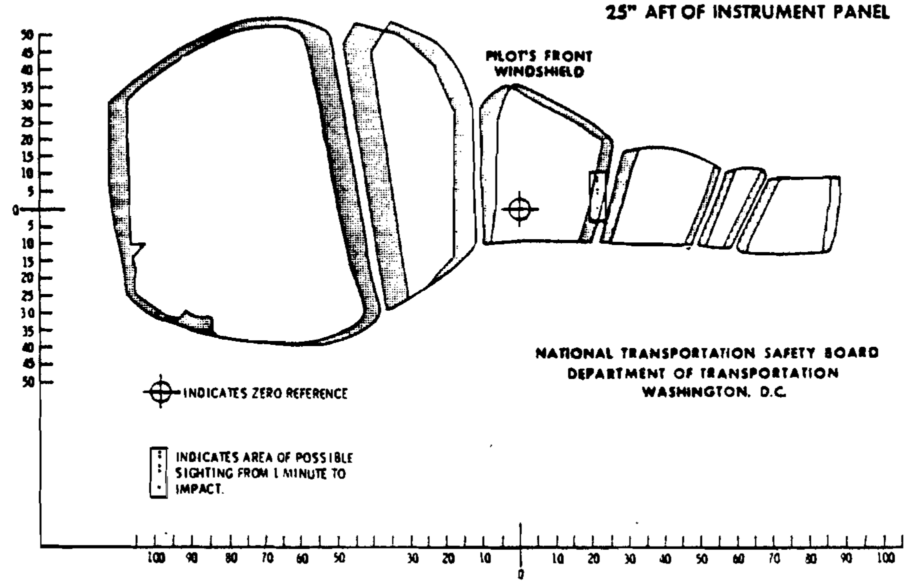


FIG. 5

ADVANCED AUTOMATED VISIBILITY SIMULATION

DR. JAMES L. HARRIS

CAMI, Federal Aviation Administration

I appreciate being given the opportunity to say a few words in connection with Jim Childs' presentation. He has already done one important job for me - I have been working with computer handling of pictures for about the past 12 years and you always start out with some kind of an apology about the resolution that is involved - it's kind of inherent in the job, and so he has done that for me and I appreciate it. The projectionist has already suffered the kind of problem that is frequently suffered when I present material, namely trying to focus the slides frantically, and finding that it really won't focus any better than that. If we could have the first slide.

You can see the problem he was facing. I made this picture purposely, as Jim Childs pointed out to you, the computer pictures that were in that little movie consisted of an array of numbers, 128 horizontally by 32 vertically, a total of 4,096 individual numbers. If you remember in Jim Childs' presentation, there was a photograph of the inside of the cockpit showing the window of a particular convair aircraft involved in that particular collision and this is a computer picture of that same scene shown with the same resolution, 4,096 picture elements, that were associated with the movie that was made. Jim Childs kindly pointed out that, as we have been saying for 12 years, that things can get better than this and the purpose of showing this slide is to say that finally things have gotten better than this and this one I think we can actually focus on, because this is a computer picture of the same scene with the changes that have been made since the time that the original movie was made out. This is an array of elements now, 512 horizontally and 512 vertically. We have increased the number of picture elements by a factor of 64 and it does make some substantial improvement in the apparent resolution of the scene.

Here is a little sketch that just depicts kind of graphically the problems involved in a visibility sort of calculation. In the first place, you have the object itself and it has certain three dimensional properties. It has reflectance properties also, which are, of course, dependent on the painting scheme and so forth. That object is imbedded in a lighting geometry which includes the sun, the sky, the ground lights, and so forth, and this is what generates what we refer to as an optical signal. The optical signal gets propagated to the observer and goes through the atmosphere and it is very important to be able to properly handle the degradation that it suffers in going from the object over to the eye of the observer. The eye of the observer is a very complicated thing - we usually think of the eye and the brain as being a kind of a combination and it has certain properties and it has certain thresholds. Visibility calculation is an attempt to try to put all these factors together to reach some conclusion about the probability that an object can be detected. The visibility laboratory has, for many years, conducted research trying to work on the various ingredients to this kind of a problem. For example, we have, in connection with an Air Force sponsored program, available to our laboratory a C1-30 aircraft which has been instrumented with some dozen or so optical instruments and a variety of meteorlogical apparatus that allow us to make passes through an atmosphere and make all the kinds of measurements that are required in order to be able to later calculate the contrast transmittance along any path of sight through the atmosphere. That is the purpose of this aircraft.

We have a current interest in problems associated with landing and particularly the short landing problem and right now the aircraft previously used to shut off all its instruments during landing just as a protection against the instruments. Now the instruments are running during landing and we are trying to collect atmospheric data in landing situations where the atmospheric data may have some explanation to offer with respect to short landing problems. We have other things in our laboratory like, this is a little picture that shows part of our vision research facility. This particular facility is a sort of large hemisphere where an observer can be placed. We can with this facility measure his contrast threshold at all parts of the periphery and as I'm sure you're all aware, the periphery of the human visual system is extremely important in problems of visual search because most of the initial acquisition is made peripherally followed by a direct full view fixation. So it is very important in these kind of calculations to know the threshold for the human visual system as a function of contrast, angular size of the target, and the location of the target as it falls on the retina of the human eye.

We have a dedicated computer facility. We have an IBM 36044 and a variety of scanners, both film scanners and an image dissector scanner which allows us to look directly at physical models. At any rate, these are devices for scanning objects and bringing them into the computer. Here, for example, is just some scan data that went into the computer, different orientations of an aircraft, the data going into the computer in connection with visual search calculations. The visibility calculation then is an attempt to take all these ingredients and put them together in a meaningful way.

Here I am just showing you some I sort of picked at random, an intermediate slide in a particular calculation and the slide just shows the bottom axis as stated in degrees, that is the angle within the field of view. Up the left hand side is an axis labeled probability and for a particular aircraft this happens to be a DC-3 viewed 45° from nose on and what we see is the probability of detection as a function of its position in angular space with respect to where the eye is fixated. For some different ranges of the aircraft, a range of 10 miles, the lower curve labeled R=10, a range of 7 1/2 miles and a range of 5 miles. Those of you who are familiar with visibility calculations are quite aware that the eye has dramatic variation sensitivity from the central phobia on out to the periphery and that in many search applications, although we sort of feel like one we make a fixation on an empty field, we're seeing the whole field in reality we are dealing with a sensitivity lobe. We refer to these as visual detection lobes, which is a sort of a pencil-like thing. You can see that for the condition of a range of 10 miles there is relatively small part of the visual field that has much bearing on detecting the aircraft at that range. The probability is very low for any peripheral sighting at that range. You see then the change in this visual detection lobe, the broadening as the aircraft comes into shorter range where the range is five miles, we have a fairly broad lobe available for detection. So a visual search calculation amounts to taking these visual detection lobes following some reasonable kind of search pattern with the lobe in the field and finding the probability of detection that results from a search calculation.

Here is just a sample result. This happens to be also that DC-3 at 45°. In this particular study there was a closing velocity of 360 kts.. We're seeing a plot of the cumulative probability of detection as a function of the range in nautical miles. The labels on the curves up there indicate the field of view required for search, that is, the curve to the furthest to your right, is a 450° square field. The next curve is 900 square degrees. The next curve is 1800 square degrees. This is part of a study that is going on related to pilot warning indicator systems and an attempt to couple these mathematical tools with the idea of what do you buy, for example, with a pilot warning indicator system, which gives you the various kinds of resolution, tells you within the field where to look for the object, what do you buy in terms of increased probability detection by confining your search. The final curve, that is shown, the little short one, says 1800 square degrees, that is also like the one above it, except now we are considering the condition where the crew has only 20% of the time available for search.

So these are calculations based on the same process that went into the movie, of being able to photograph the aircraft, scan that information into the computer, put in realistic atmospheres, put in real properties of the human visual system in terms of the thresholds, and make predictions. We feel that these sort of calculational aids can be of valuable help. This is sort of an augmentation to the sort of movie simulation that you have seen. We think the movie simulations themselves are valuable; we hope to make use of our new resolution capabilities to make some better looking movies than the one that you have seen and we feel that seeing a movie reconstruction of an actual accident is extremely helpful in trying to give you an intuitive feeling for what the accident was really like from a visual point of view. It's sometimes a little difficult to look at curves and graphs and numbers and so forth and it is sort of unsatisfying. The movie helps to really see it, but to back this up, we think it is important to be able to make meaningful calculations. Now, we don't know everything there is to know about the human visual system, there is a lot we need to know, so the calculations that are made right now represent the best we know how to make right now, we hope it will get better as time goes on. I have a personal conviction that, though it is very easy to use the label pilot error on any accident in which one aircraft does not see another aircraft, but it is a very damaging thing to do. In the first place, it is sort of an accusation of the pilots involved, but more serious than that perhaps, if it really is the case in which these kind of calculations would indicate that even if men were performing up to the best of their abilities, the probability was not high that they would have seen each other, then by putting the label pilot error on the accident we simply sweep under the carpet the basic problem that does exist. We hope that these kind of calculations can help in that respect. I think this pretty much concludes what I wanted to say. I would like to say that I am pleased to be given an opportunity to talk to this particular group of people. Our laboratory, in spite of the fact that it is a university laboratory, is very anxious to make our results practical, to give it direct applicability to the real problem. We welcome constructive criticism from any of you as to how you think we might best use these efforts and we certainly welcome the opportunity to be of assistance to any of you, should you have the occasion to need these kind of tools that we have described here today.

Thank you.

EXPANDING THE USE OF PRESENT AIRCRAFT RADIO EQUIPMENT TO SAVE LIVES AND REDUCE ACCIDENT INVESTIGATION COSTS

JOHN MARGWARTH

Lockheed - California Company

On February 18, 1969, a DC-3 disappeared enroute from Hawthorne, Nevada to Burbank, California. In the first 18 days of the subsequent search for the transport, approximately 300 ground vehicles, 78 ground teams composed of more than 1000 persons and 240 aircraft were employed in the hunt. Less intensive searching continued for the next five months. During that follow-on effort, one of the search aircraft crashed with resulting injuries to all three people on board. It wasn't until August 8, 1969, that the missing plane was found on the east slope of Mt. Whitney where all persons on board had perished from impact.

I mention this particular incident, not because it is unique, but because it is a tragic illustration of the delay too frequently encountered in the location of a downed aircraft.

It is true that prolonged search for a downed aircraft, as exemplified by the DC-3 crash, is an exception and not the rule. But lengthy searches, often less successful than the hunt for that aircraft are not rare. It is a matter of record that at the end of July, 1971, there were 85 people and 43 aircraft still missing in nine of the Western states.

The crashes of these aircraft and the attendant loss of life is a tragedy in its own right but the delay in locating them raises even more haunting questions: How many of the victims might have been saved had their downed aircraft been located promptly? How many accidents might have been prevented had the causative factors of the previous crashes been determined? How many will occur in the future for the same reason?

Most of us in this room are familiar with the common causes of delay in locating a downed airplane: No one knew that the airplane was in trouble at the time and failure of the aircraft to arrive home or at a destination was unknown for a matter of hours or days.

We also know many of the reasons why a pilot in trouble frequently does not report it to a ground station. The pilot didn't want to divert his attention from the situation at hand, being too busy to attempt a two-way radio conversation; someone else was using the frequency to file a flight plan and the pilot of the troubled aircraft didn't have time to concentrate on redialing to frequency 121.5; he hoped the situation would clear up; he didn't want to tell the whole world, of which the FAA is a part, that he might have goofed by getting into the situation in the first place.

Those of us who have been in a serious situation have asked ourselves the inevitable questions: Is it going to be so bad that I won't be able to walk away? If so, how long will it be before they discover I'm down? How long will it take them to find me? And, naturally, we all make one or more of the usual promises. The promises, unfortunately, do nothing to alleviate the immediate problem for the people you hope will find you.

Now for something which directly affects our field of activity--the investigation. Most of you have worked on a fatal accident during which you would have given a good deal to have heard voices or background noises which were audible within the cockpit. Instead that critical period sometime before the plane crashed too often remains a total blank in your assembly of the puzzle. Every such blank, in varying degrees, hinders or dooms to failure, our attempts as air safety investigators to prevent future accidents by solving the last one.

The answer to this problem would be greatly simplified if all aircraft were equipped with cockpit voice recorders that would always survive the crash and could always be retrieved. But we all know that dollar cost, weight and unending dialogue will make this type of installation an impossible goal in the foreseeable future--especially for General Aviation which is by far the largest segment of the aviation family. As you probably know, General Aviation aircraft in the USA number more than 130,000. (By 1982 this number is expected to reach approximately 232,000.) Fortunately, in my opinion, we already have equipment in most aircraft that would do a good job toward reaching this desired goal by the addition of a few ounces of hardware at a cost of a few dollars. The existing equipment is the aircraft radio.

The few ounces of hardware mentioned, in the simplest concept, are a cockpit area-type microphone and an on-off switch. The microphone I used in some preliminary tests was from a conventional telephone and was purchased (used) for seventy-five cents. Unlike standard aircraft radio microphones, it allows the engine noise (and other background noises) to be transmitted--which is a desired and important feature.

The circuitry entails connecting the area microphone to one of the aircraft transmitter microphone circuits so that actuation of the special guarded (or lever-lock) switch causes continuous broadcasting until the switch is deactivated. The result is the same as holding a mike button down, except the proposed area-mike would be essentially nondirectional and would transmit most background noises over the air, as well as crew voices.

The procedure for the flight crew entails tuning to a specially assigned and easily identified emergency frequency, and actuating the aforementioned switch. The frequency for VHF could be 121.4 so as to be near 121.5 for possible subsequent two-way conversation on 121.5. A white index mark on each radio knob and/or color coding the numerals 21 and .4 would make it easy to quickly set up 121.4 when under stress. Or the special frequency could be an end frequency such as 118.0 (or 126.9). If an end frequency was used, stops could be installed (at least on some radios) so that reading the numerals would be unnecessary when dialing the emergency frequency. A more sophisticated approach could be automatic switch actuation when the emergency frequency is selected. Or a system could be designed wherein the operation of a single switch would take care of everything--frequency selection and activation of the area mike. However, once you start getting sophisticated the cost increases and you stand more of a chance of never getting anything--or the probability of excessively long delays for implementation. In the meantime the emergencies and crashes do not wait. (I personally favor the idea of an index mark on each radio tuning knob as opposed to the other methods mentioned.)

Now--I have suggested that whatever the pilot (crew) has to do to put the system into operation must be reasonably easy, must not take much concentration, and must not require his time for more than a couple of seconds. Those of you who have had occasion to change to another frequency in a hurry, with two knobs to turn, may have experienced all or part of the following: You turned the knobs the wrong way, you overshot the number, you finally got on frequency, then the station didn't answer right away, you started to put the mike back on the hook to free your hand for other requirements, you dropped the mike on the floor, and by this time you were on your way to a spiral dive, inverted flight, or whatever. I could go on but I think the picture is clear as to why the above requirements are important.

In preliminary flight tests conducted to date (Cessna Models 150 and 172, Beech Queen Air, DC-3) the single telephone microphone worked quite well when installed on the aircraft center line near the top of the instrument panel. It worked equally well at two other center line locations. The directional characteristics were satisfactory in all three locations checked. In addition to engine noise and pilot voices, other noises were transmitted satisfactorily--noise such as that of a stall warning horn, an open window, bicycle bell, bicycle horn, coins shaken in a metal can, high velocity air noise and the bursting of a toy balloon. No effort has been made to date to acquire a better microphone. The possibility that a better microphone exists or could be developed warrants investigation. Frequency response, durability under vibration conditions, and a proper size resistor for compatibility with aircraft voltage are items to be considered.

Although the proposed system is oriented primarily to General Aviation aircraft, it would be valuable for other aircraft also, including large aircraft already having conventional voice recorders. Some points to consider for any aircraft are:

1. The cost is low.
2. The effect on aircraft weight and c.g. is negligible.
3. Reliability is high and extra maintenance is negligible.
4. A little effort by one member of the crew is required, but only for a moment.
5. The pilot does not have to identify himself if he has a reason to be reluctant.
6. Ground stations are immediately alerted on their monitors, by the continuous transmission and background noise, that an aircraft has a suspected problem, or is in fact in trouble and may go down.
7. By broadcasting continuously, ground stations having D.F. (Direction Finding) capability could in many instances fix the location of an aircraft in distress and from that determine the approximate location of the aircraft on the ground if it did go down. As a result, many search efforts would be shortened and many injured people would be rescued in time.

8. Immediate information from the area mike would in many cases shorten the investigation period and reduce investigation costs. In some cases it would put the investigation on the right track before needed evidence disappeared or was overlooked too long and lost forever.

9. The instant information provided in such a situation (voices and/or noises) would precede by days the eventual analysis of a cockpit recorder tape, if a recorder was installed, retrieved, and the tape survived in readable condition.

10. Ground stations could record emergencies on tape but this is not necessary to make the system worthwhile.

11. The proposed system could be used during hijacking attempts and this might occasionally prove beneficial.

12. Aircraft with two or more antenna systems for voice communication radios could carry on a two-way conversation on another frequency at the same time the area mike was transmitting continuous data. (Assigning an end frequency might prove advantageous relative to this point.)

One of the arguments that could be offered against the proposed system is that a pilot might sometime leave the switch "ON" after dialing to some other frequency, which assumes he didn't crash. Preventing this will require education, discipline, and care in the selection of a location for the switch. Furthermore, the pilot would soon be aware that the switch was on when he attempted to conduct two-way radio communication on the new frequency. And of course, a warning light could be installed which illuminates when the switch is in the "ON" position. This could be easily accomplished by using a switch of the double-pole variety. Another comment I have heard is — Suppose two emergencies occurred at the same time in the same general area? In my opinion that is not a big problem or even a small problem. I personally feel that 70% or 99% are good success numbers, and that saving any life at the cost of a few dollars is a very worthwhile achievement.

To summarize, there are problems which hamper search and rescue, permit the loss of lives that could be saved, permit certain aircraft accidents to go unsolved--and by the latter statement permit some accidents to be repeated which could be prevented. Cockpit voice recorders used in many large aircraft today solve some of these problems but their cost in terms of dollars and weight make their installation prohibitive in the greatest number of aircraft--the General Aviation group. I have outlined in this paper an inexpensive, lightweight solution to many of the problems mentioned. This idea does not require a long development span and therefore offers the opportunity for early implementation.

In conclusion, I recommend that the FAA and the armed services consider the idea in this paper for further testing and early implementation in all appropriate aircraft. I hope that everyone understands that by "early" I am not thinking in terms of years.

SOME PSYCHOLOGICAL ASPECTS OF AN ACCIDENT INVESTIGATION

E. F. HARVIE

Chief Inspector of Air Accidents, DCA, New Zealand

In darkness preceding the dawn of 13 January 1970, Polynesian Airlines' Flight 208B, a Douglas DC-3D with a New Zealand flight crew and carrying 29 Samoan passengers and a flight hostess, departed Faleolo airport, Western Samoa, for Pago Pago, American Samoa, to connect with an international flight.

After an apparently normal takeoff and during an early stage of the climb-out, the aircraft suddenly pitched nose upward, simultaneously turned left and lost height, and then assumed a descending flight path which became progressively steeper until the aircraft struck the sea. The fuel tanks exploded and fire consumed the wreckage to water level. One minute after impact, a severe and unpredicted tropical rainsquall passed through the airport terminal area from the direction of the active runway. All 32 persons on board the aircraft lost their lives.

Since it achieved independence, the State of Western Samoa, a developing South Pacific island nation some 2,000 miles northeast of New Zealand, has continued to receive various forms of technical and other assistance from that country, and because it has no facility of its own, the Government of Western Samoa asked New Zealand to make a formal investigation into the accident circumstances. That request was fulfilled and an accident report in the standard ICAO format was published in due course. This Society holds a copy and others are available to members who may wish to have them.

A wind shear and associated precipitation turbulence and the comparative inexperience of the flight crew were considered to have been contributory factors in the accident cause.

One of New Zealand's continuing responsibilities in Western Samoa is the provision of training in various aspects of civil aviation administration and control to Samoan nationals who are expected later on to assume responsibility themselves and to operate without outside guidance and help. At present, major airport functions are carried out by New Zealand personnel, people of European stock, while trainees and other airport workers are Samoans, Pacific islanders of Polynesian descent, customs and outlook.

In all his relationships, private and public, with people of another country - and especially with those of a developing nation - it is a distinct advantage for the "outsider" to have some knowledge, understanding and appreciation of that country's established way of life, customs and traditions, concepts of rights and wrongs, religious and other influences determining ways in which individuals and groups may act, and other national traits, all or any of which may be quite different from those of his own country and which form bases for his own precepts and practices.

It is seldom that the "outsider" is so forearmed and he may accordingly find himself unable to understand or accept any undesirable effects some actions instinctively resorted to by local people may have on the purposes and outcome of the work in which he is engaged. If irremediable "damage" has been done, he must perforce accept the situation as he finds it and make the best of it. But in continuing his work he must exercise great care and patience in outlining objectives which, with local cooperation, he is expecting to achieve and provide, at the same time, easily understood and acceptable explanations for proposed courses of action.

Like other Pacific island peoples, the Samoans place great importance on the interests of the ainga, the family. These people form a very closely knit community and are widely interrelated. Defense of the family and what are considered its traditional rights is to every individual a matter of pride and honor. Anything which may injure one member of the ainga inevitably injures all. Thus, in any emergency or disaster, an immediate reaction is "to look after one's own" and to disregard everything else, no matter what the consequences may be.

This must not be construed as adverse criticism of a group of people who acted in accordance with instinct in time of disaster but who, once things had settled down and they had understood what was wanted, why some things had to be done in particular ways, and how they themselves might best assist, gave willing and valuable help.

The Polynesian DC-3 struck shallow waters of a lagoon less than 75 yards offshore, close to the airport access road, and not far from the departure end of the active runway. The wreckage was thus readily accessible to the victims' many friends and relatives who had come out to see them depart and had watched the take-off from vantage points close to the accident site. Some reached the area even before the prompt arrival of crash-fire and rescue personnel and the rest joined them within a matter of minutes.

All immediately entered the water and waded out to the burning wreckage in a frantic effort to find and care for any of their kin who might have survived and to claim the remains and property of those who might not. In the general confusion created by a highly emotional situation, airport and other officials, European and Samoan, were quite unable to regulate crowd activity.

Fire fighting operations were hampered by a lack of response when assistance was called for and by damage to hoses which would otherwise not have occurred. Recovery of victims and accounting for them numerically became haphazard and, for an appreciable time, decentralized. Some parts of the wreckage of importance to the subsequent technical investigation but not obstructing access to victims' bodies, were seen to be needlessly disturbed and "played with" before being thrown casually aside. Some equipment was removed by unauthorized persons. None of these circumstances would have arisen had the accident occurred in a less accessible place.

In Western Samoa, there are no public burial grounds as we know them and the bodies of deceased persons are normally claimed by the _ainga_ and interred on their own properties in accordance with custom. Relatives therefore found it difficult to understand why all bodies were required to be taken to Apia General Hospital for formal identification and such purposes as examination by aeromedical specialists co-opted from "outside" and interested in crash survival studies and investigation of a possibility that inflight fire or explosion had occurred. Due to insistent demands for and physical attempts to obtain release of bodies from the mortuary, most postmortem examinations had to be drastically curtailed. The _ainga_ viewpoint appeared to be: "These unfortunate people are our own relatives, not yours. Why can't you leave them alone?"

Immediately after the accident occurred and before the wreckage was retrieved from the sea, a great many persons waded out to it and, probably more out of curiosity than from ulterior motive, picked up and "played with" some components, particularly instrumentation and parts of systems. Presence of an official guard did not always prevent this and guards' respect for _ainga_ "rights" may have obliged them to turn a blind eye to certain activity. Those who were able to approach the wreckage were, it was claimed, merely looking for their relatives' belongings. It was imperative, accordingly, to retrieve the wreck as quickly as possible, and to place it in effective custody at the airport.

I now refer very briefly to some instances of wreckage disturbance and infer how these militated against positive determinations being reached during the official investigation.

Immediately before takeoff, the captain of the aircraft had been given, and had acknowledged, a local QNH of 1011 mb. When examined, his altimeter was found set at 1013 mb.

Meteorological conditions had not warranted use of pitot heat, but the aft pitot heat switch was found "On."

When examined some hours after the accident, the captain's DI was found caged and set to a heading of 068, which approximated that of the aircraft when positioned on the ramp before it had moved off to the head of the runway. A few hours later still, it was found set to an entirely different heading.

The autopilot bank-and-climb and directional control units were found caged.

The main gear selector lever was found in an unusual configuration unattributable to impact forces and its pre-impact status was undeterminable. Unauthorized persons had been seen moving it before it was officially examined.

The significance of these and other instances of wreckage disturbance will be apparent to any investigator and particularly to those who study the accident report. I need make no further comment.

My principal objective has been to show that in a developing country where the established way of life, customs, traditional rights of the family, and codes of personal behavior are different from those to which the majority of us may be accustomed, individuals, small groups and even an entire community may react in ways difficult for the "outsider" to appreciate or understand.

"Education" in some spheres of activity may be all very well, yet, in my view, it would be morally wrong and indefensible to attempt to force changes in the national character - which has many admirable qualities - merely for the sake, to take one example alone, of protecting the requirements of a technical process.

ADDRESS TO THE MEMBERSHIP

ROBERT SERLING

Author of Loud and Clear and Probable Cause

It has been a little difficult to decide what to talk about because speakers at functions like this are supposed to tell the audience what is wrong with aviation, what should be done about it, who's making mistakes, who deserves the blame. Sort of a here's who was stupid in the past and here's me to tell you how to correct it. I used to cover the Washington Redskins. In fact, I covered them for 21 years, and I always wished that someday, when the fans were booing the hell out of the team, and particularly the quarterback, I wish old Sonny Jorgenson would jump up into the grandstand and grab the loudest booer and hand him the football and say, "OK loudmouth, here it is, get out there on the field and see what you can do with it." Because it is so easy to criticize from the grandstand.

I have been called an air safety expert. Any time I start believing that I deserve the title, all I have to do is think about somebody's definition of an expert. An expert is the guy whose wrong guesses have never been publicized. For the past five years, for example, I've been making speeches and writing articles denouncing cabin PA announcements as boring, repetitious, totally ineffective - well, damn it, they are! And what I have been saying for five years is that the airlines should be able to come up with safety announcements that passengers will listen to. Fine, there is nothing wrong with that. After all, I'm an expert. But a couple of weeks ago I got a letter from a vice-president of an airline, and the gist of it was, "OK loudmouth, you've been complaining long enough. Write us a few cabin PA's that will impress passengers, educate passengers, and still not scare the hell out of them." Ladies and gentlemen, I have written 6 books, 1 screen play, 2 television scripts, approximately 50 magazine articles, 3 pamphlets, and about 75 speeches. So I sat down and tried to compose the greatest cabin PA announcement in the history of commercial aviation, and I sent it in to the vice-president of this airline, and it was a beaut. It contained all of the vital safety information that a passenger would ever need, and it was written in hard-hitting no nonsense language as befits an expert. I only hope the airline never uses it, because, if they do, the stewardess is going to be landing by the time she gets halfway through the announcement.

You know, when I was with UPI, I was sort of a poor man's George Plimpeton. I was convinced that a reporter covering anything as specialized and complex as football and aviation, should get out there and try it himself, literally, so he can be a more effective critic. I did. From the sanctity of the press box I had called butterfingers every time a Redskin end dropped a pass from Sammy Baugh. So I went out to the practice field and I asked Sammy Baugh to throw me passes, just to see how it felt to catch a Sammy Baugh pass. He threw me one pass and dislocated my shoulder.

From the sanctity of my nonflying wire service desk, I had often wondered why some clown wearing 4 stripes should be making 40 grand a year flying 75 hours a month, while I was pulling down $10,000 for working a hell of a lot longer hours, and being an expert. My philosophy was that just because you put 4 stripes on a jackass doesn't mean you get a zebra. So I got a few airlines to let me fly simulators. The first one I was ever in was a Pan Am DC-7 and I crashed on the first five takeoffs. On the sixth takeoff, I got off the ground and I was feeling like John Wayne. I was congratulating myself on how easy it was to be an airline captain, and the instructor says, "Look, are you going to fly all the way across the Atlantic with your gear down?"

It was about this time I got critical about shortcomings in air traffic control. I couldn't get it through my head why controllers claimed they were the most overworked men in aviation, so I went out to FAA Controllers School in Oklahoma City and they let me work in a simulated control tower. In ten minutes, I caused three collisions, fourteen near misses, and I gave one flight clearance to land when they were already on the ground.

United let me go through an emergency evacuation test. For years I had been telling myself that if a real emergency ever occurred, I would be the calmest guy on the airplane, including the crew. Why not, after all I am an expert. I had visions of being the hero. The stewardesses are injured and I take over, bellowing commands in a firm but calm voice. But then came this emergency evacuation demonstration which I knew was a demonstration; it was make-believe, in a DC-8 parked in a hangar with the windows all covered up so it would simulate a crash at night. They had sound effects of a plane crashing, the metal hitting the concrete, some guy pops out of a blue room with a billows full of mineral oil smoke, and in about

4 seconds you couldn't see your hand in front of your face. Then the stewardess starts yelling, "This way, this way! Jump and sit, jump and sit!" I got out of that seat and headed for where her voice was. I knocked down two old women getting to the door. I went out of that airplane like I had a rocket tied to my fanny. Some hero; some expert.

But I have one unique asset as an expert, however. One very special quality. I'll admit when I'm wrong, and I'll readily confess I occasionally don't know what the hell I'm talking about. I wish the Ralph Naders, the Ruben Robertsons, and the William Proxmiers could make that statement. I have never heard Mr. Nader apologize, retract, or admit error, even when he has been proven wrong. And ditto is aviation expert, Mr. Robertson, whose latest stroke of genius was a demand that the airlines be banned from letting passengers make reservations by telephone. And as for Senator Proxmier, I can only recall that Bill Magruder once remarked, "If God ever meant man to fly, he never would have invented William Proxmier."

Who are the real experts in aviation? The Naders, the Robertsons, the Proxmiers, the editorial writers whose knowledge apparently comes from inhabiting ivory towers, or the aviation writers like the Bob Serlings, if you will, who never had to design an airframe, fly a trip with paying passengers, meet a payroll, plan a schedule to fit a couple of hundred airplanes, and whose initial contact with air accident investigation was throwing up at the first crash he covered.

I don't have to tell anyone in this room the climate in which aviation has been operating these past few years and not just in the United States. I think it is worldwide. The effort to make aviation a scapegoat for everything that is wrong with our society. The incredible defeat of the SST, a defeat based on a collection of outright lies, half truths, alleged scientific mumbo jumbo scare talk; the deliberate suppression of pro SST statements by a small but very influential minority of the news media - all of this is what defeated the supersonic transport. The phoniest aviation problem of them all, noise, which has been turned into a convenient political football for politicians, and a bonanza for every attorney who could talk an equally greedy homeowner into filing a lawsuit. The half-baked screwball proposals for solving some of aviation's problems such as pollution, proposals which can only be compared to demanding major surgery if you want to cure a head cold. The demands being made on aviation in the name of ecology, demands which if met will indeed end pollution, because there won't be any airplanes flying. Need I go on?

Who are the experts in aviation? They aren't the carping professional critics, the consumer protectionists who are so busy accusing that they never seem to be able to admit any kind of improvement. The scientists making claims on emotional prejudgement rather than factual investigation. The ecologists who have made the word technology stand synonymous with evil, forgetting conveniently that technology also means progress. That portion of the news media which so bitterly resents Agnews but which almost daily commits every sin of which the Agnews accuse them. No, they aren't the true experts, and neither are the writers like myself. Not even those of us who love aviation, who voice honest concern over aviation's weaknesses, faults, and failures, but who at the same time, don't lose sight of aviation's achievements. Yet this is one major source of aviation's troubles, letting men like myself who are not experts do most of the defending, the counter attacks, the dissemination of truth. Aviation's real experts include men like yourself, the men in this room. The experts in airline management, safety, training, testing, designing, investigating, regulating, flying, and sometimes dying. You are partly the reason for what has happened to aviation's image. You let stupid statements or asinine proposals or false claims go by unchallenged. If you are a government official or an airline executive you exhibit a very natural but deplorable fear of Congress, even when some chowderheaded politician is hitting you below the belt, you won't fight back. In all the years I have covered aviation, to give you an example, I can remember only one case in which an airlines president publicly and openly called a Congressman a liar, which incidentally, the latter was. How many men in this room have ever written a letter to a newspaper or a magazine or a broadcast station to protest some inaccuracy or untruth. Sometimes it is not fear, but just complacency, as it was when the SST was defeated. The mistaken belief that no one could possibly believe a bunch of crackpots, so why dignify them by attacking them, or the belief that someone else will do your fighting for you, or the supposition that victory will be won without fight, or forgetting that a lie is a hell of a lot easier to disseminate than the truth, because it is more dramatic, it has definite and deliberate motivation behind it, and usually it takes research and effort to refute. As that old adage says, "Rumor is halfway around the world before truth gets its boots on." I think you will agree with me, and I hope that no one in aviation can continue to ignore the assaults on aviation. I hope you will agree with me that it is time to stop regarding some of aviation's critics as sacred cows who no one dares to attack. That includes the Naders, not only the high priest of consumerism, but those who work for him who hide ignorance, inexperience, and pre-investigating bias under a blanket of idealism. That also includes the Proxmiers. Those who are caught in one falsehood will merely utter another.

I would like to read you something. It is an editorial which appeared in an airline newspaper. Published for employees, it is directed at airline people but I am reading it because frankly, I couldn't have written it better myself, and I think it goes with a message I am now in the process of delivering to you.

"For nearly a decade now, particularly during the last few years, the airlines have been suffering from their own peculiar brand of paranoia. Every day we plead guilty, almost happily, to some new sin of commission or omission. We are guilty of wantonly polluting the skies, we are guilty of making too much noise, we are guilty of being ecological villains, we are intent on destroying America's wildlife, we are guilty of being selfish and grabbing, you name it, we are doing it. At times it seems that we will gladly plead guilty to even the most farfetched, irresponsible, or deliberately malicious charges. We humble ourselves, we bow and scrape to pressure groups, and we run from self-styled aviation experts, most of them don't know a tri-jet from a tri-motor. We apologize and apologize some more and apologize some more. Well, let's stop apologizing. It's high time for the nation's airlines to stand up straight. We didn't defy nature and conquer the skies by being timid."

I, to some extent, would still apply that to practically everybody in aviation. And, while I say amen, I would like to make one brief addition. That editorial, as I said, is directed largely at airline management, airline rank and file, but it's message does apply to every man and woman in this room. You are all part of the aviation family. Now you have been and will be discussing subjects at this forum under the general theme of the human factor, and there is one human factor present at virtually every crash probe. You might call it a kind of a common denominator, namely the instinct for self preservation, even if it means telling a lie, hiding something, or rationalizing, or trying to put the blame on the other guy. Accident investigation, therefore, in its purest form is nothing but the search for truth. And accident investigators do rightfully resent any attempt to inhibit that search. So I ask you to extend that spirit to the equally important task of defending aviation. Even if it means abandoning SASI's adopted policy of noninvolvement in controversial issues. The crisis is that menacing and it's that important. I regarded the invitation to address you in a search for truth an honor I will always treasure. Thank you and Godspeed.

BEHAVIORAL SCIENCES AND ACCIDENT INVESTIGATION

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Behavioral scientists working in the field of safety research must base their recommendations for accident prevention programs upon data supplied by the accident investigator. The validity of the recommendations made depend upon the validity of the data provided by the accident investigation. Unfortunately, the behavioral scientist has been limited in his ability to analyze the behavioral causes of accidents because the investigators are not asking the kinds of questions which would supply us with the kinds of answers we want. This is not the fault of the accident investigator so much as it is the fault of the behavioral analyst for not providing the guidelines for asking the right questions in an accident investigation. It is my purpose here to provide you with some idea of the kinds of information which would be beneficial to the human factors analyst.

All too often we see accident boards assigning "pilot error" as the cause of the aircraft accident without further explanation other than vague statements such as "selected wrong course of action," "lack of judgement" or "poor pilot technique." Pilot error should be regarded as a result of precipitating factors rather than a cause of accidents. In other words, pilot error occurs as the culmination of a number of adverse events. The concept of causality is not useful to a scientist who is trained to be aware of the pitfalls of assigning causes to events. This can result in a "reductio ad absurdum" to talking about the deity as the "prime cause," for example. It is recognized that there are often legal requirements to affix blame for pilot error mishaps and I am not criticizing that practice. However, the human factors analyst needs to determine how similar pilot-caused accidents can be prevented in the future. The termination of the investigation with the placement of blame often precludes the collection of vital data on the pilot. What is needed is an in-depth pilot background survey to uncover information on precipitating factors.

An area that is frequently overlooked in an accident investigation is the effect of personal psychological stresses on the crewmembers' behavior at the time of the accident. Thorough investigations into these matters require extra effort, are time-consuming and personally distasteful to investigators who must probe delicate areas of personal factors with bereaved loved ones or close friends after an accidental death has occurred. Complicating the picture is the resistance of such witnesses who are aware of legal ramifications and culpability of aircrewmembers or their employers in such accidents. Therefore this type of investigation must be entirely removed from legal proceedings and such data must be considered privileged "for accident prevention purposes only." Furthermore, witnesses must be reassured that their information on these personal matters will be kept confidential and their anonymity preserved as far as the legal questions are concerned.

In the past, human factors analysts concerned themselves with the determination of personal factors pre-disposing an individual to "accident-proneness." The accepted definition of accident-proneness referred to a stable life-long personality trait--what a medical man would term a chronic condition. However, investigations into the personality factors which would be correlated with accident-proneness among professional aviators has proven fruitless in the past because of the rather stringent selection process to which these men are subject. Another difficulty was the identification of the accident-prone individual. Although it is well known that a small percentage of aviators have an inordinately large percentage of the accidents, having repeated accidents does not indicate accident-proneness. We must first know something of an individual's exposure to hazard and the other factors, which along with accident-proneness, constitute a person's accident liability.

In addition to constructing a hazard exposure index for each aviator we need to investigate these other factors which increase a person's accident liability. Rather than attempt to identify a chronic long-term condition which may not exist in our professional aviator population, we should be looking at the acute situational factors which may precipitate an accident. By their nature they are short-lived and hard to pin down. The confluence of all such factors may never have occurred before and may never occur again but at the exact moment of the accident they interact and combine to cause a human error.

According to Willard Kerr's adjustment stress theory of accidents, the majority of accident-precipitating behavior of an individual can be explained by personal stresses which cause a man to perform in such a manner as to increase his accident liability. These stresses may be produced internally or originate from the external world and are difficult to predict because of their transitory nature.

A relationship between routine stress and diseases in man has long been sought. The practical use of the stress theory of accident and illness causation has, however, been quite limited. The factors causing stress and the ability to handle it varies greatly from individual to individual. This variation makes it virtually impossible to quantify stress and to measure its effects in a statistically valid manner.

Studies done over the past several years at the Navy's Neuropsychiatric Research Unit in San Diego by Drs. Holmes, Rahe and others have demonstrated a correlation between changes in one's personal life and physical illnesses as well as accidental injuries. They first determined statistically that certain routine life events occurring in clusters called life crises have a significant influence on one's health. These life events consist of occurrences involving the individual or influencing his life style. They tend to center around social and interpersonal interactions with family relations, marriage, economy, occupation, residence, education, recreation, health and peer relationships.

Each of these life changes, whether positive or negative, have little effect taken by themselves but when they interact and combine into life crises they can have an adverse cumulative effect over the period of a year or so. Information on such life crises reported by accident investigators would enable us to determine their relationship to accident behavior when compared to the life changes normally expected in the life of the average non-accident aviator.

Subjectively evaluated according to severity by a large panel of judges, life changes were assigned different quantitative weights called Life Change Units (LCU). The life change judged most severe by the majority of judges was the death of a spouse. This was arbitrarily given the weight of 100 LCU's. Other life changes were rank--ordered below that and assigned weights based on the 100 point scale. (See Table 1.) When the LCU's of the people studied added up to greater than 150 the incidence of illness or injury was 37 percent. Those with 200 or more points had a 51 percent incidence of health change, while those with over 300 LCU's increased their chances of illness or injury to 79 percent.

It should be noted that some of these changes would normally be considered in a positive vein, such as marriage (50 points) or gain of a new family member (39 points). But all of these life changes add stress to the individual's personal life.

The knowledge that the emotionally stressed individual may be more prone to illness and accident is not new. It has long been known, for example, that over-stressed individuals often engage in irrelevant activities or rigid stereotyped behavior and experience loss of discriminative skill and mental efficiency. The safe performance of complex tasks (such as those demanded in aviation) is improbable in such a psychological context.

We are currently planning to undertake a research project at the Naval Safety Center to examine the impact of life changes on mishaps in the naval aviation community. A largely unresolved problem, however, is the lack of adequate background data on the personal lives of aircrewmembers involved in mishaps. If we then obtain this data from the people involved in aircraft accident investigations, hopefully the medical officer, we can analyze the impact of personal psychological stresses on the individual's behavior during accidents and make recommendations to preclude their adversely influencing the behavior of our aviation personnel during flight operations.

Table 1

	Life Event	Mean Value
1.	Death of spouse	100
2.	Divorce	73
3.	Marital separation	65
4.	Jail term	63
5.	Death of close family member	63
6.	Personal injury or illness	53
7.	Marriage	50
8.	Fired at work	47
9.	Marital reconciliation	45
10.	Retirement	45
11.	Change in health of family member	44
12.	Pregnancy	40
13.	Sexual difficulties	39
14.	Gain of new family member	39
15.	Business readjustment	39
16.	Change in financial state	38
17.	Death of close friend	37
18.	Change to different line of work	36

(Table 1, cont.)

	Life Event	Mean Value
19.	Change in number of arguments with spouse	35
20.	Mortgage over $10,000	31
21.	Foreclosure of mortgage or loan	30
22.	Change in responsibilities at work	29
23.	Son or daughter leaving home	29
24.	Trouble with in-laws	29
25.	Outstanding personal achievement	28
26.	Wife begins or stops work	26
27.	Begin or end school	26
28.	Change in living conditions	25
29.	Revision of personal habits	24
30.	Trouble with boss	23
31.	Change in work hours or conditions	20
32.	Change in residence	20
33.	Change in schools	20
34.	Change in recreation	19
35.	Change in church activities	19
36.	Change in social activities	18
37.	Mortgage or loan less than $10,000	17
38.	Change in sleeping habits	16
39.	Change in number of family get-togethers	15
40.	Change in eating habits	13
41.	Vacation	13
42.	Minor violations of the law	11

Admittedly, change is the part of the life style of the aviators, going on military deployments or flying across a continent, he is constantly on the move and perhaps he is better adapted than most for coping with these changes. After all, part of his reasons for being in aviation relate to the adventure and stimulation that come from travel and change. The personality of the average aviator demands this excitement. Certainly he would not be in the field as a profession if he were content to hold only a nine to five desk job.

The life changes involved in aviation are changes in residence, family separations, changes in working conditions, sleeping and eating habits, social activities and personal habits in general. These kinds of changes alone can add up to almost 250 points.

(See Table 2.) Their total effect may tax the ability of the aviator to cope even though he is adapted to it. Additional stresses brought on by life crises in one's personal life may add an intolerable burden to that already imposed by the job. Therefore, those in supervisory positions in aviation must be especially aware of the effect of life crises on the performance of personnel in their charge. This is not to suggest snooping, however, but an attempt by supervisors to get to know their people better.

Table 2

Change in responsibility at work	29
Change in living conditions	25
Revision of personal habits	24
Change in working hours or conditions	20
Marital separation	65
Change in residence	20
Change in recreation	19
Change in social activities	18
Change in sleeping habits	16
Change in eating habits	13
TOTAL	249

Of course, each person is an individual with his own unique personality and method of handling stress. Some people are more susceptible to the effects of emotional factors than others. These changes in an individual's daily style of living and personal family matters may have little influence on his performance until they add up to an unbearable psychological burden. It is incumbent upon those in supervisory positions to monitor and observe the effects of turmoil in the personal lives of their aviators on their performance in flight. If this performance is being affected, the individual should be referred to a medical officer. If necessary and upon consultation with the medical officer the aircrewmember might be temporarily grounded or provided with leave until his problems are resolved. If it appears that the problem is of a long-term nature it may be necessary to assign the individual elsewhere to preclude another "pilot error" accident from occurring.

With this in mind I urge the cooperation of the air safety investigator in providing us in the field of behavioral safety research with background data on the personal lives of those involved in "pilot error" or "human error" accidents. With this information perhaps we can take steps to reduce these errors and enhance safety in the aviation community.

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INVESTIGATION OF HUMAN FACTORS IN ARMY AIRCRAFT ACCIDENTS

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USABAAR is the acronym for the U.S. Army Board for Aviation Accident Research. This organization is the Army's counterpart to the Air Force and Navy safety centers for that portion of their activity which deals in aviation accidents and accident prevention. USABAAR is a Class II activity of Department of Army and responds directly to the Director of Army Aviation which is a directorate within the office of the Assistant Chief of Staff for Force Development. The board gathers aircraft accident information from aviation units on a worldwide basis. These data are evaluated and recommendations made to responsible agencies for correction of safety of flight hazards. Primarily, the board renders assistance to units in all areas of Army aviation accident prevention. This covers a broad scope of operations from logistical support to training and supervision of personnel.

One example of this service is in the field of accident investigation. We travel all over the world to render technical assistance to investigation boards in order to solve complicated aircraft accidents. This information is then used for recommended changes to improve the Army aviation mission capability.

The management of U.S. Army aircraft accident investigations is quite different from the usual course of action followed by the NTSB and the FAA.

Where the civil agencies use in-house specialists in the various fields of investigation, the Army must use its in-house investigation management expertise and rely on specialists from whatever sources that are available. This may require the utilization of specialists provided by the manufacturer, in the case of hardware or practicing psychologists in the human factors area.

This system creates some unique managerial problems. The high grade specialist works under the direct supervision of the investigator in charge as far as the accident is concerned. However, he does not have a monetary interest, nor is his future dependent upon his performance. There are certain benefits to the system in the area of productivity. Most manufacturers representatives or consulting psychologists who accept the challenge of participating in an Army accident investigation tend to leave no stone unturned, in their particular area of interest, until they have exhausted all possibilities for obtaining evidence.

With this background information as to the modus operandi let us look at a few cases in which human factors investigations were an important part of finding the cause factors of accidents.

An OV-1 Mohawk, twin engine, turbo prop surveillance aircraft was operating on a routine training flight. The object of the training was to demonstrate the procedures required on a maintenance test flight. A part of the demonstration included the intentional feathering, shut down and air start procedures of one of the engines.

The pilot experiences a complete loss of electrical power while trying to airstart the number 2 engine. He started a descent for home plate. About two miles out the awesome silence of total powerplant failure engulfed the cockpit. The aircraft was crash landed short of the runway and came to an abrupt halt on a railroad embankment. The pilot received major injuries to the spinal column in the lumbar region. Extensive investigation of the electrical system and powerplants of the crashed aircraft revealed no malfunction of any of these components. This effort satisfied the board that something had to happen within the cockpit procedures to set up the loss of electric power. The powerplant failure must then be related to this problem.

The members of the aircraft accident investigation board were allowed to interview the pilot after he had undergone extensive surgery. He was unable to recall the procedures he had used in the attempted restart of the feathered engine. A consultation with his doctors resulted in a decision not to use sodium amytal or sodium pentothal because of the nature of the injury and the possibility of convulsive movements of the patient while the procedure was being administered.

It was decided to attempt hypnotism as a means of obtaining recall of events. The patient agreed to the procedures. A professional psychologist from the University of Southern California (Dr. Chaytor D. Mason) was invited to perform the hypnosis. Members of the investigation team prepared a series of questions to be used during the interview. The hypnotist, excuse me, psychologist, was given a thorough briefing on the circumstances that were known at that particular time. There is a great deal to be said for thorough preparation prior to the interview.

The setting of the interview was a private room in a hospital. Selected members of the investigation team were allowed to observe the proceedings.

The psychologist easily gained the confidence of his subject and proceeded to hypnotize him with a very soothing manner. Once the subject was in a state of hypnosis, the psychologist started the interview by asking questions about his boyhood. The technique that was used gradually led up the flight under investigation. Finally the interview reached the stage of pre-flighting the aircraft. When questions were asked that related to his entering the aircraft for flight the patient became immediately wide awake. After a brief rest, the psychologist hypnotized the subject again. This second effort was not quite as effective as the first. However, some questions were answered that pertained to the flight in question. These were mostly questions which had been answered during the previous interview with the board. When asked to describe the step by step procedures used to restart the engine the patient again became fully conscious and did not recall the events.

Prior to the third effort it was decided to approach the problem from the negative side and attempt to determine what the pilot did not do rather than attempt to gain total recall of all actions he did perform.

The powerplant in question is equipped with a starter generator like most modern turbine engines. A toggle switch in the cockpit is arranged so that the pilot may initiate the crank sequence by moving the switch to the up position and releasing it. Spring loading returns the switch to neutral. In the case of a "light off" the crank sequence ceases. If a good start is not obtained the pilot is supposed to place the switch in the down position to interrupt the crank sequence. This procedure should be followed before subsequent restarts are attempted.

The third attempt to interview was made and the patient again reached a hypnotic state. The effect was approximately the same as the second effort. This time questions that had previously been answered satisfactorily were restated as a starting point in the interview.

The pilot testified both consciously and under hypnosis that he attempted the restart three separate time.

While under hypnosis for the last time he was asked if he had placed the crank switch in the "interrupt crank" position at any time. To this, he answered negative. Further attempts to obtain recall failed when the patient again became wide awake.

It was decided at this point in time to end the interview.

I think this experience made one point very clear. Although the pilot outwardly stated that he agreed to hypnosis, inwardly he rejected the idea as something that might make him admit to an error in procedure which caused the crash.

As a matter of fact, he did just that in his final interview. The use of this information in connection with other good investigative procedures resulted in the successful solution of this case.

One of our technical assistants set out to duplicate the starting sequence as related to us by the pilot. In the course of events he did get a light off on the feathered engine. He then placed the crank switch in the start position with the engine running. The electric load meter immediately hit the max limit. Other warnings of impending electrical loss were apparent. Attempts to reset the generator relays met with negative results. The high drain on the battery resulted in complete loss of electrical power in about ninety seconds. This led to the conclusion that the pilot obtained a light off during his second air start. However, he failed to recognize this fact and attempted the third restart without following proper procedures. This resulted in indications of impending loss of electric power, such as, generator light on, circuit breakers popped out, and load meter at max limit. At this point in time placing the start switch in the "interrupt crank" position would have alleviated his problem. However, we learned from our interview that he did not do this.

The loss of electric power resulted in failure of the fuel boost pumps in the main tank. This was really "no sweat" as long as the engine driven pumps kept functioning, and provided that nothing interrupted the fuel flow.

Testing of the fuel system revealed that the upper flapper valve in the aft boost pump failed to close properly. When exposed above the fuel level of the tank the valve allowed air to enter the lines and subsequently cavitate the engine driven pumps. This resulted in loss of power on both engines.

Now we can see just how important that bit of information pertaining to the interrupt crank switch became.

In summary the pilot induced the electrical power loss through improper cockpit procedures during an air start. This subsequently resulted in the manifestation of a malfunction in a fuel boost pump which caused the powerplants to fail because of fuel starvation. Further investigation as to the reason for this pilot's actions revealed that he had very little recent experience in the aircraft and therefore was not proficient in airstart procedures. This lack of recent experience also reduced his confidence and increased his level of difficulty in diagnosing his problem.

Our overall evaluation of the use of hypnotism in this investigation of human factors was that it was successful. We found certain weaknesses such as the subject stating willingness to submit to hypnosis and interview and really mentally holding reservations about the procedures. However, through a change in technique we were able to elicit some very important information from this interview.

Army investigators have also used sodium amytal as a tool in the investigation of human factors in aircraft accident. One such case involved the pilot of a TH-55A helicopter. This helicopter is a small two place aircraft used as a trainer.

The student pilot was practicing solo takeoffs and landings. There were several other aircraft in the traffic pattern. While flying the pattern for a landing, a traffic jam occurred at the turn onto the base leg. The engine quit while the student was maneuvering for spacing. The subsequent autorotation ended in a crash landing. The pilot received a cerebral concussion without skull fracture, a compression fracture of the lumbar vertebrae with spinal cord damage and other associated injuries. There were no witnesses to the sequence of events.

Interviews with the pilot revealed that he could not recall the sequence of events, nor could he recall the previous forty minutes of flight prior to the accident.

The investigation board could not establish the cause factors. However, through deduction they came up with a list of probable causes which were later proven to be accurate.

Three months after the accident occurred two flight surgeons, one from the Army and the other from the Air Force, obtained authority to conduct a sodium amytal interview with the pilot.

The preparation prior to the interview was somewhat extensive. The Army flight surgeon went to the investigation board and became completely knowledgeable of the accident. This included visits to the crash site, technical explanations of helicopter operation and interviews with people who were knowledgeable of the individual. Several visits were made with the patient to establish rapport and obtain his consent for the interview.

Prior to the interview, consultations were held with the pilot's physicians. There was a discussion as to whether the pilot's amnesia was organic or functional. Organic amnesia is caused by physical derangement of the central nervous system, whereas functional amnesia is caused by a psychiatric disorder. Memory loss due to an organic cause is very difficult if not impossible to recover whereas retrograde functional amnesia can be recovered by various means. Inasmuch as it is possible for both types of amnesia to be present at one time, the flight surgeons decided to go ahead with the interview provided there were no other contraindications. The pilot's physicians stated that the spinal column injury was stable and would not create a problem.

The interview was held in a darkened treatment room in the hospital. During the administration of the drug, the technique of interview included some small talk to determine the level of consciousness. After the proper level was reached, attempts to have the pilot describe the sequence of events from his own recall were not successful. The flight surgeons then decided to approach the problem with a hypothetical situation which paralleled the conditions at the time of the accident. While this may appear to be a method of leading the witness, it really was not when considered together with the recall that followed.

When given the hypothetical flight conditions and the question was asked concerning his actions - the pilot immediately admitted his fear. He began to talk about what he was doing in the present tense. With a few questions from the interviewer the pilot described his flight from the onset of the emergency until the time of the crash.

The interviewer then went back to the inflight situation. A few factual questions concerning throttle manipulation during the maneuver for spacing were asked. The pilot immediately responded in the present tense as to the actions he was taking. He stated that as he approached the turn on to the base leg of the pattern the aircraft ahead of him slowed to take spacing on another aircraft that had flown too wide in the turn. Our subject slowed his aircraft also. This action made him extremely conscious of his rotor rpm so he began to manipulate the throttle. In the effort to maintain spacing and cross check the tachometer he became erratic with the throttle movements. He stated that he had an overspeed condition. His next action was a violent movement to close the throttle. This resulted in fuel starvation and subsequent loss of power. The movements of his hands and right foot during the interview indicated that he was actually reliving the movements that he made. His description of the action left no doubt that he was erratic and overcontrolling the throttle during the maneuver. The pilot's description of his thoughts as to what he must do and how he reacted are very clear in the transcription of his statement. When he realized that he should lower the collective it was too late. He was caught in a very dangerous position with low airspeed and low rotor rpm. He described his fear and attempt to lower the nose to gain airspeed. He then executed the autorotative flare to build rotor rpm. However, he stated that when the maneuver was complete that he was too high above the ground. He knew then that he would crash. He saw a tree to his right front and attempted to steer the aircraft to it. He wanted desperately to break his fall onto that hard ground. However, he did not reach his target and crashed short of the tree. He stated that he was wet from perspiration and then everything went black.

Eight hours after the sodium amytal interview the pilot was interviewed again in a fully conscious state. He was able to relate the entire sequence of events as he did while under the drug. However, during this second interview the patient used the past tense instead of the present tense used in the first interview.

These interviews proved that the accident was pilot induced through a series of errors from throttle mismanagement to poor judgement of altitude during the flare prior to landing. A review of the records revealed that this student pilot had experienced difficulty with throttle control in his early training. He also had manifestations of fear during autorotations. Add to this the problem of trying to maneuver for spacing in a crowded corner of a traffic pattern where the level of difficulty caused a high degree of stress upon this not so confident student. The result was erratic throttle control and a poorly executed autorotation.

The overall evaluation of the use of sodium amytal as a tool in aircraft accident investigation shows that it is a valid means of obtaining data. One disadvantage to its use on injured patients is the length of time required for the individual to recover sufficiently for the drug to be used. One other disadvantage is the problem of finding qualified personnel to conduct the interview.

We will not attempt to make a judgement between the use of hypnosis versus narcosynthesis. Both are very good tools when properly used. However, it should be pointed out that information gathered in this manner should be combined with all other good investigative techniques to reach a successful solution to the problem.

The cases we have reviewed have one thing in common as far as human factors are concerned. Both pilots were in the low proficiency category in judgement and technique. The difference in experience levels had little effect on the outcome of the events. Both crashed and both were seriously injured.

How do we go about correcting the business of lack of proficiency? The military is a much more closely controlled environment than our general aviation counterpart. This means that command emphasis can be brought to bear to establish proficiency levels and enforce them. This will not eliminate all accidents from this cause but it will drastically reduce them. Similar pressures can be brought to bear in general aviation through higher penalties for violations of minimum proficiency standards. But how do you prosecute a dead man?

The object of the exercise is to create an environment of professionalism through astute management and supervision. However, if this effort is to be most effective, the problem must be clearly identified and defined by thorough and complete investigations of those accidents which do occur. This can be accomplished only through the use of all the known techniques.

The real challenge to the professional air safety investigator lies in development of new and better techniques that accomplish the job more efficiently and give proof positive information upon which decisions can be made.

This society furnishes a forum for the exchange of information between highly skilled professional investigators and I, for one, am extremely grateful for the opportunity to participate in these high-level discussions. May we continue to grow in strength through numbers and in power through increased knowledge. May this increased strength and power be used constructively for the benefit of mankind through increased safety in the air.

THE ROLE OF A STEWARDESS IN ACCIDENT INVESTIGATIONS

DEL R. MOTT

Staff Safety Coordinator, Engineering & Air Safety Department
Airline Pilots Association

"Even though transportation is a known killer and has been since the invention of the wheel, the number of accidents per person movement has decreased significantly over the years." These words were spoken by Captain Homer Mouden of Braniff Airlines in his introduction to the Accident Investigation Panel at the Air Safety Forum in Dallas this summer. Perhaps the major reason for this decrease in ratio of people traveling vs. people injured or killed is the thorough investigations which usually result in findings and recommendations to prevent similar occurrences for the future.

The establishment of the National Transportation Safety Board in 1966 with its prime reason for existence being accident investigation and determination of probable cause was the beginning of the renaissance in accident investigation. Today, their well trained and experienced investigators play the supreme role in accident investigation; and the dissemination of their valuable findings to the public has prevented many more accidents, injuries, and deaths.

Aviation being the conglomerate it is, presents daily facets which are obviously unsafe and need correction. In response to recommendations for improvement too often we hear, "We've never had any injuries because of this, and until we do, there is no need for a change--besides we don't have the money right now." This is not accident prevention, but a rationalization.

For years cabin conditions and environment for the flight attendant have been accepted as part of the dangers of flying and each stewardess simply took her chances--even though in an emergency hundreds of people depended on her abilities for their survival.

Accident investigations conducted during those years prior to 1965 seldom made mention of cabin conditions prior to, during, and after an incident or accident. Those investigations were primarily aimed at finding out why the airplane crashed. The in-cabin factors which affected the safe evacuation of the passengers and flight attendants were largely ignored.

In 1965 United Airlines had a tragic accident in Salt Lake City. It was perhaps coincidental that two well qualified flight attendants, one from United and one from Braniff participated in the investigation of this survivable accident and proved the value of their knowledge and unique qualifications. This tragedy and its resultant investigation caused a complete realization by appropriate authorities that the cabin conditions prior to and after such survivable accidents had a direct bearing on the number of survivors.

Perhaps it is also coincidental that many changes in cabin procedures and equipment are in effect today as a result of this team's recommendations. We know these changes have been made, but no one knows the numbers of lives saved as a result. These recommendations alone are not enough, we must continue to look ahead to future safety improvements, not only for new aircraft but also for aircraft currently in service which may fly for another 15 to 20 years.

In 1965 statistics were made available by the CAB to the airline industry and interested parties as follows: "During the period 1960-1963 there were four survivable air carrier accidents with 106 fatalities and 137 survivors." The CAB accident report data indicates that additional people could have survived if the passengers had been properly briefed or directed in the emergency evacuation of the airplane.

Following the 1965 Salt Lake City investigation, accident reports contained many more details about in-cabin conditions and passenger evacuation, and occasionally flight attendants were sent to an accident location to assist the investigating team. However, basically because of funds and manpower shortage, details contained in the accident reports from 1965 to 1968 were not utilized to the fullest extent possible.

In 1969 the St. Croix accident again emphasized the needless deaths and injuries caused by in-cabin and evacuation difficulties and problems. These were not unnoticed by the investigating team, members of the Board, or ALPA. All aspects of this accident were recorded in detail, studied and those specific recommendations which resulted will have a tremendous impact on aviation safety.

Then came the November 1970, military accident in Anchorage, Alaska. Through the efforts of the NTSB accident investigation team, in-cabin and evacuation difficulties were once again recorded in detail and studied for possible improvements. The Steward and Stewardess Division of ALPA also assisted in the team efforts by participating at the Public Hearing concerning this accident. Recommendations directed toward improved cabin safety were submitted to the authoritative agency.

It is now 1971. Two aircraft accidents have occurred this year which are of specific interest to the Stewardess Division--the 747 accident in San Francisco and the Convair 580 in New Haven, Connecticut. Flight attendants have assisted and observed with the investigation on both of these, with the hope that their efforts, knowledge and experience would enable more people to survive future accidents.

Perhaps some of you may question the value of flight attendants at an accident location. Let's see what their value really is. First, they are the girls who fly these aircraft daily. They know the interior of the aircraft like the back of their hands. They know the color and style of uniforms worn by the flight attendants, they know the amount of galley equipment utilized on the aircraft, the service required for that particular segment of flight, whether the flight attendant would have been serving or checking seat belts and where she would have been in the aircraft the specific time of the accident. These girls know the bell systems utilized during normal occurrences and emergencies, they know the flight attendant's duties and the particular problems she would encounter during any emergency.

Flight attendants are well qualified to assist an investigating team following an aircraft accident, but not every flight attendant can be utilized for this purpose--some are unable to withstand the emotional impact of the crash scene and the gory details. A flight attendant who is asked to assist at the site of an airplane crash must indeed have the unique qualifications of knowledge, common sense, and a strong character plus a need to know why she is there in the first place.

The ALPA Stewardess Safety Division has outlined set procedures for any stewardess participation, these are approved by the Vice President and the Executive Committee and are to be followed whenever a flight attendant's services are needed after an aircraft accident.

Each of 22 airlines represented by the ALPA S&S Division has a safety committee headed by the Central Safety Chairman. This Central Safety Chairman is appointed by the airline council to serve a term concurrent with the master executive chairman. She is a flight attendant who has usually spent several months or years as a Local Safety Chairman for her base and already knows the basic groundwork of a Safety Chairman's position.

As outlined in the ALPA S&S "Organization for Safety" booklet, a Central Safety Chairman may be called to assist with an accident investigation, and she is required to follow certain procedures which specifically authorize her participation. Upon arrival at the accident location she must report to the Pilot ALPA representative as well as the NTSB investigator in charge. As a general rule any stewardess representative is assigned to the Human Factors and/or Witness field investigation group. The Human Factors group is responsible for collecting statements from passengers and crew, attempting to determine where passengers were seated, which exits they used, and why. Medical reports are gathered to determine injuries and specific injury patterns. The participating stewardess continually reports to her group leader and attends a full briefing session daily. Instructions are always given to each member of the investigating team concerning voicing personal opinion or entering into probable cause conjecture relative to any accident.

The "Organization for Safety" booklet provides for her use a general guideline for questioning passengers and flight attendants. In questioning passengers, she would cover such things as: P. A. announcements, the passenger's notice of certain exits near him, whether he read the emergency card, types of seat belts, the passenger operation or problems involving the seat belt, the passenger seat, whether he assumed the brace position, whether he remained seated during the final impact, what exit he used and why, his seat location, amount of luggage he carried, whether luggage of any type was a problem in the evacuation, galley equipment he may have encountered, whether he assisted in the operation of an exit and how, whether he observed the outside of the aircraft prior to impact, where he saw fire, if he used a slide, did he remove his shoes and if so--why, problems involving the slide, whether he was injured during impact or during evacuation and whether at any time he was partially or totally unconscious. The questioning flight attendant may delete or add questions relative to the type of accident that has occurred. The same type of guideline questions are provided for questioning the flight attendants involved in the accident.

Factors that should be determined from the involved flight attendants are, of course, more detailed and more technical. They include:

prior warning that the aircraft was in trouble
the flight attendant's seating locations
use of shoulder harnesses
restraint systems and type of deceleration
problems involving carry-on baggage and galley equipment
what items were secured prior to the accident that became dislodged during the impact and any evacuation difficulties they may have caused
how many passengers on board
were there infants, what were physical defects of any passengers and did anyone else require special attention
how the passengers reacted, and how the stewardess handled the reactions
operation of exits and problems involving their use
did she feel her training had been sufficient to cover her particular situation
what communication or personal contact she had with other crew members
whether passengers operated emergency exits
how the lights operated
questions about megaphones and other emergency equipment

Following the questioning of flight attendants and witnesses the stewardess safety representative must compile her observations, suggestions and recommendations for submission to the investigator in charge for his approval, changes and distribution. Along with this she must submit additional reports to the ALPA Home Office for comments and assistance.

Past accidents have shown that history continues to repeat itself in certain areas. Deficiencies in in-cabin environment and procedures which have been prevalent over the past years both in accidents and regular flights and which urgently need recognition and improvements are:

1. Galley hazards - cabin attendants seated in galley jump seats have been struck by loose drawers, hot ovens, serving carts, and other items which were inadequately secured by their locking devices.

2. Jump seat design - seats fold up unexpectedly when occupied, detach from structures, are designed so poorly that they cause back or spine injuries (even on normal landings).

3. Poorly designed shoulder harnesses on forward facing seats and on many jump seats no shoulder harnesses at all.

4. Lack of padding above and around jump seats often results in head injuries during turbulence or other emergency situations.

5. Vision of passenger cabin is nil or limited because of the flight attendant seating area. Flight attendants usually have no view of the aircraft exterior.

6. Passenger complacency and ignorance in emergency situations. There is a desperate need for change in preflight announcements to gain the attention of the passenger so that he will familiarize himself with the safety features on the aircraft.

7. Better regulations are needed to enforce proper storage of heavy objects and carry-on items which become lethal weapons during emergency situations.

8. More qualified cabin attendants are needed per flight to provide the vital leadership needed during all emergency situations.

9. Standardized emergency equipment and seat belts for all aircraft.

10. Adequate provisions for incapacitated or handicapped passengers, either traveling alone or with an attendant who is physically able to assist, must be made and required seating locations should be delineated and enforced.

11. Better emergency lighting systems during evacuations.

All of these deficiencies must be investigated and corrected to improve the survival aspect of aircraft accidents. We believe that a flight attendant's participation in an accident investigation and her important life-saving recommendations can provide better cabin safety for everyone.

THE REPORTING OF HUMAN FACTORS INFORMATION IN AIRCRAFT ACCIDENTS

JAMES DANAHER

Chief, Human Factors Branch, Bureau of Aviation Safety
National Transportation Safety Board

In recent years, aircraft accident investigation has developed into a highly complex, thorough and incisive activity. Investigative efforts have frequently pointed the way to effective prevention programs in many areas of aviation safety. As a result, the over-all safety record in aviation has improved significantly. However, in spite of this general progress, pilot-related causes and factors continue to account for a major proportion of aircraft accidents. As Mr. Miller pointed out yesterday, pilot causes and factors are involved in approximately 83% of all General Aviation accidents.

This situation suggests that much remains to be done by way of reducing pilot involvement in the cause of accidents as well as in reducing the incidence of death and injury when accidents <u>do</u> occur.

One explanation for the limited success in prevention efforts in these areas is that we are not obtaining the right kind of information to identify the most needed prevention efforts.

As investigators, most of us would readily admit that collecting evidence on the human involvement in an accident is much more difficult than obtaining information on the nature of an engine malfunction or structural failure. Additionally, with the physical wreckage, an experienced investigator can calculate or infer the nature and sequence of an accident situation. But human behavior is not amenable to that sort of precision.

As a result, investigators frequently return from an accident site with many observations and impressions which may be difficult to document as factual, or which tradition has led them not to report or record. Additionally, the threat of being challenged by legal interests has constituted an effective deterrant to reporting any data which might not be readily and firmly verified. But it should be evident that if we are to reduce the number of pilot-caused accidents and if we are to reduce the severity of injuries that result from them, we must document these events.

Stated simply, in order to formulate more effective accident prevention programs we must accumulate more and better human factors data on aircraft accidents.

The need to accumulate accident data has been recognized for quite some time. The Safety Board, as well as various military services, has developed extensive data banks of accident information. Many man hours are devoted by investigators to collecting and recording accident data and by analysts in the coding and storing of such data. But in spite of these efforts the human involvement in accident causation seems to remain fairly constant.

The logical conclusion that follows is that we are either not compiling the kinds and amounts of human factors data to identify the problem areas, or we are not getting such data in a usable form. Accordingly, our human factors branch has initiated an in-house project to examine critically the current Safety Board system for collecting, classifying, and storing human factors data. We have two main objectives in this project: 1) We want to identify more specifically the shortcomings of the NTSB system for the collection, storage, and retrieval of human factors and crash-injury data; and 2) We want to formulate recommendations to improve and expand the present system. We hope that this project will enable us to identify problem areas and to develop prevention programs to reduce the pilot-caused accidents, fatalities, and injuries. To accomplish these objectives we will examine the accident data banks of the military services and other organizations concerned with aviation safety. Additionally, we plan to survey the most frequent users of Safety Board accident data to determine their needs and how our data bank can be improved to meet them more effectively.

Because this project is just now getting underway, I haven't much substantive information to pass along concerning particular areas which will be modified or procedures which will be changed. However, even a preliminary look at the present system has revealed some rather striking shortcomings which might be remedied with a relatively small amount of effort on the part of field investigators. I would like to spend the rest of my time this afternoon outlining some of these problem areas in which you can make a significant contribution.

Categories pertaining to human performance and crash-injury data already exist in the coding manual to permit the storage of certain human factors information. But because certain data for a given accident do not get stored and therefore cannot be retrieved, the prevention potential that might have resulted from a pooling of such data is lost.

Human factors data are missing both in the area of cause determination and in the area of crash-injury information. With regard to accident cause, too often our statements tend to be objective summaries of what happened rather than statements of the true underlying cause of the accident. In the case of crash-injury data, we are simply lacking specific details concerning impact dynamics, occupant restraint effectiveness, and related matters upon which to evaluate the human involvement.

In selecting examples of missing data, I have limited myself to categories pertaining to crash-injury matters because they more directly relate to the reporting of factual information. I have prepared a slide to show you some examples of crash-injury-related data, which frequently are missing.

Discussion of Slide- - - followed by:

First of all, I am sure you will notice the alarmingly low values for frequency of reporting. These values illustrate that vital information concerning some crash-injury aspects of accidents is being lost. However, it should also be recognized that these kinds of information may not always be available or relevant to report in some accidents. Thus, the practical upper limit for frequency of reporting may well be less than one hundred percent for all the listed categories on the slide.

Of course, it is possible that the listed values may indeed be accurate statistics on the incidence of these events; but the experience of many of our investigators certainly does not make these values seem very plausible. In any case, the point to be recognized is that their actual frequency of occurrence is not known, and presently cannot be determined from our data.

The question immediately arises as to where the data may have been lost. Was it at the source, when the field investigator failed to obtain or report it? Was it with the accident analyst in Washington who failed to code? Or was it with the computer operator who failed to enter it properly? The point in the sequence of operations at which the data "falls through the cracks" is not known at this time. Hopefully, our in-house project will identify such problem areas and will enable us to overcome them. One area which would seem to be a source of difficulty, and which will receive considerable attention is the standardization of terms as used both in accident reporting forms and in the coding manual. Unless a common understanding of terminology is achieved among investigators, accident analysts, and the ultimate users of the data, little hope for obtaining valid information exists.

In our attack on this problem, the Human Factors Branch will work with the Evaluation Branch, the Information Systems Branch, and Safety Board field offices in developing definitions of terms and user guidelines in order to achieve this commonality of meaning.

Regarding the missing data shown in my slide, it may well be that very little of it is actually attributable to errors or omissions on the part of investigators. But it behooves us, as professional Air Safety Investigators, to make every effort to ensure that we obtain and report each accident as accurately and completely as possible in order to avoid the loss of vital information at its source.

Our business is accident prevention and safety promotion. Our success in this field will ultimately be measured by our ability to collect, interpret and report the relevant information about aircraft accidents. In these accidents, human involvement is all-pervasive. If we are to reduce the extent of this involvement we must redouble our efforts to obtain and report the information which will point the way to fruitful prevention efforts.

Our joint efforts—yours of providing superior source data, and ours of developing an improved means for utilizing your data—will make this goal possible.

REPORTED FREQUENCY OF SELECTED HUMAN FACTORS DATA IN AIRCRAFT ACCIDENT REPORTS

1964 - 1969

SUBJECT		REPORTED	ACCIDENTS	PERCENT
SEAT FAILURE(S)	Gen. Aviation	177	31,827	0.6%
	Air Carrier	10	447	2%
SEAT BELT FAILURE(S)	Gen. Aviation	669	31,827	2%
	Air Carrier	8	447	2%
ANGLE OF IMPACT	Fatal Gen. Aviation *	15	1,339	1%
	Fatal Air Carrier	24	67	36%
DEATH FROM FIRE AFTER IMPACT	Fatal Gen. Aviation	71	3,579	2%
	Fatal Air Carrier	4	67	6%

* 1968 - 1969

THURSDAY, 28 OCTOBER 1971

9 a.m. Session 5

Chairman: Dr. Stanley Mohler, FAA

Tangible Evidence of Human Factors Involvement in Fatal General Aviation Accidents - Dr. J. Robert Dille, Civil Aeromedical Institute, FAA

HF in Accident Investigation - J. A. Johnson, Department of Civil Aviation, Sierra Leone

Honesty and Professional Integrity of the Pilot in Avoiding Aviation Accidents - Sr. Mario Romera Sandoval, Investigador de Seguridad Aerea, Bolivia

Human Factors in Air Safety - Reginald J. Fenner, L. J. W. Hall, Co-Author, Air Registration Board, United Kingdom

Review of Proposed HF Section, ICAO Manual - Russell Watts, ICAO

2 p.m. Session 6

Western Airlines General Offices - Los Angeles International Airport

Tour of Maintenance Facility - Flight Simulator

4 p.m.

Informal Summary & Return of Critique Papers - Donald Kemp, National President, SASI, David Hall, General Chairman, Russell Watts, ICAO, C. O. Miller, NTSB

TANGIBLE EVIDENCE OF HUMAN FACTORS INVOLVEMENT IN FATAL GENERAL AVIATION ACCIDENTS

J. ROBERT DILLE, M.D.

Chief, Civil Aeromedical Institute
Federal Aviation Administration

Pilot failure was found to be the cause of 90% of British aircraft accidents during the early stages of World War I--and two thirds of these (or 60%) were found to be due to physical deficiencies. The British established a Care of Flyer Service and reported that accidents due to physical defects dropped to 12% in two years.

Based largely upon this experience, the United States Army established new medical standards for pilots, a medical research laboratory, a school for flight surgeons under the research laboratory, a program of examination of all pilot applicants by specially trained and designated physicians, and an aircraft accident investigation program. Flight surgeons were further instructed to advise pilots and their commanding officers on such matters as rest, recreation, nutrition, exercise and when to temporarily refrain from flying.

In civil aviation today we still find that about 90% of the accidents are due to human factors. The approaches, too, are the same: standards; examination by designated, interested and specially trained physicians; research; education (of pilots and physicians); and accident investigation. Accident investigation is the primary means of identifying the causes of accidents, and thus the problems in aviation safety, but it also serves as a check on the adequacy of the standards and certification functions. While about 90% of general aviation aircraft accidents are still found to be due to pilot error, there has been a marked reduction in those due to physical defects. Only about 1% of accidents are presently due to physical incapacitation but we find a number of problems which are not usually found in military studies (alcohol, drugs, carbon monoxide, pesticides, insufficient training, and lack of experience) plus some others that are (disorientation, hypoxia, hyperventilation, fatigue, and psychological problems).

The earliest Flight Surgeon Monthly Report that I have seen follows:

"From: Flight Surgeon, Park Field, Tenn. May 31, 1918

"To: The Surgeon General, Washington, D.C.

Attn: Col. T. C. Lyster

"Subject: Monthly Report of Flight Surgeon

"1. Have systematically interviewed sixty-three cadets and officers since the 13th. Held sick call since May 27th. Helped to arrange a new schedule giving a rest period during the hours from 11 to 3. Arranged for recreation and athletic exercises twice a week. Arranged for sanitary drinking cups on the field and shade for the cadets.

"2. Investigated the three accidents occurring since I came here. None of these were fatal. One was due to inexperience, topography of the country and mechanical difficulties. Second: uncertain cause but patient thinks he hit his head on the cowl while doing a loop. Third: machine out of control while chasing a crow.

"3. Took up the matter of mess with the mess officer. Acted on several cases as a member of a special board to consider whether instruction of cadet should be continued.

ROBT. J. HUNTER
Capt. M. R. C.
Flight Surgeon"

Like this one month's experiences in 1918, I still estimate that about one third of our current general aviation fatal accidents are due to poor judgment, about one third are due to training and inexperience problems and about one third are due to more tangible physical factors. It is this latter category that I will discuss today.

As stated earlier, serious medical problems in flight are relatively rare with two to six heart attacks per year and occasional other serious medical problems. We think that this record speaks well for the adequacy of the current standards and medical certification system in deterring and screening those airmen with the greatest risks due to physical impairment. The standards are relatively strict where there is a high risk of impaired judgment or of sudden incapacitation; however, they are very liberal with static conditions such as loss of one eye, color vision defects, contact lenses, poor uncorrected vision, deafness, amputations, muscle weakness, etc., where the airman is usually given an opportunity to demonstrate his capabilities in flight before a final decision is made.

Accident investigation serves a positive purpose here, too, in determining that the accident was not caused by one of these defects. It thus establishes and preserves the right for thousands of pilots (over 4000 are one-eyed) to enjoy the privileges of flying without the penalty that more arbitrary standards might impose upon them.

The greatest single problem about which I shall speak is that of ethyl alcohol. This has been identified as a significant problem only since 1963 when Harper and Albers found ethyl alcohol involved in about one third of the fatal general aviation accidents that they studied. There was considerable controversy about their study concerning the alcohol levels reported, the selection of accidents for study (was it random?), and the discrepancy between their figures and those of the (then) CAB.

I will try to bring you up to date on this problem and to clarify rather than further confuse the issue.

Until quite recently, the CAB and NTSB used the legal level for driving an automobile in the state in which the aircraft accident occurred in assigning a causal role. Currently this level is 150 mg % in 23 states and the District of Columbia, 100 mg % in 21 states, 80 mg % in one state, and no level in 5 states. We have long maintained that these blood alcohol levels were too high for successfully piloting an aircraft. The current NTSB policy is reported to be determination of a "contributing factor" when the blood alcohol level is between 50 and 120 mg % and a "causal factor" when the blood alcohol level is greater than 120 mg %.

Two recent studies and our accident toxicology experience at CAMI should be of interest.

The Ohio State University recently completed an FAA contract study of "The Effects of Alcohol on Pilot Performance During Instrument Flight." They studied 16 instrument-rated pilots at four blood alcohol levels, 0, 40, 80, and 120 mg %. They found that:

At the lowest level of alcohol studied, 40 mg %, both groups demonstrated significant increases in the number and potential seriousness of their procedural errors. Minor decrements in ILS tracking were observed in the inexperienced pilots at this level.

At higher alcohol levels, performance decrements were observed in both groups; these were minor in the experienced pilots but became substantial in the less experienced pilots whose ability to track the vertical component of the ILS suffered severely. The number of major procedural errors continued to rise almost linearly in both groups.

At a level of 120 mg % of blood alcohol, catastrophic failures began to occur. The safety pilot was required to take control of the aircraft on 16 occasions during 30 flights at this level. Two pilots became incapacitated in flight as a result of severe vertigo, nausea and vomiting, while flying by reference to instruments.

It is concluded that significant degrees of performance impairment exist in qualified pilots under the influence of 40 mg % blood alcohol, half the minimum level accepted by any jurisdiction as evidence of intoxication. We have not determined a blood alcohol level at which no significant impairment exists in flight.

There have been many studies of the effects of alcohol on performance. Almost all prior to the Ohio State study involving testing subjects who were static (seated on a steady chair), i.e., none involved the real-world motion. In another recent study, this one a joint one between CAMI and the USN Aerospace Medical Institute, tracking performance while static and during angular acceleration was tested with blood alcohol levels from 0 to about 75 mg %. Subjects receiving alcohol did not make more errors than the controls at most test intervals when they were seated and motionless. However, in the dynamic situation, they usually made significantly more tracking errors than the controls.

Thus, it would seem that the legal level of blood alcohol while flying should be no higher than 40 to 50 mg %. In other studies, effects have been shown for several hours after the level has returned to zero. Therefore, no level can be said to be safe. An eight-hour rule was implemented in December 1970. This time interval assumes light social drinking and would not be adequate for many of the cases that we have seen.

We had performed blood alcohol studies on 617 fatal general aviation aircraft accidents at CAMI through 20 September 1971. We currently receive specimens from approximately one half of all fatal accidents. Of these, 12.3% had blood alcohol levels above 50 mg %. This cumulative experience for our Laboratory has dropped from about 25% to 15% to 12.3% over the past three years. However, lest we become complacent, this fiscal year, of 75 accidents, 17% have been above 50 mg %.

While we urge the collection of specimens before embalming, we can differentiate ethyl alcohol from embalming fluid.

One special technique which we have pioneered deserves mention. Since specimens may be delayed in collection, contaminated, and delayed in shipment, we culture all such specimens for the growth of ethyl alcohol producing bacteria under ideal conditions. A report sent out 23 September 1971, states: "Ethyl Alcohol (Gas Chromatography) 0.039% (39 mg %). A culture of the blood produced a moderate growth of E. Coli which in turn produced 0.031% (31 mg %) of ethyl alcohol." The quantities cannot be compared directly but the bacterial capability to explain the blood alcohol level is established and ingestion is not certain. We are finding this bacterial capability in about one half of the accidents with levels below 50 mg %.

The next most frequent physiological problem (12% in 1968) is spatial disorientation. This is not "tangible" but I mention it to highlight the paper, exhibit demonstration, and accident prevention program emphasis on this important problem in aviation safety.

Other drugs (alcohol is really one, too) are of concern in all forms of transportation accidents because of such undesirable effects as drowsiness, alteration of judgment, dizziness, slowed reaction time and reduced visual acuity. Often overlooked is the (often) more important question of why the drugs were taken, particularly for the psychotropic drugs.

We have found drug involvement in 3% of the 617 cases studied at CAMI.

Carbon monoxide is frequently mentioned. It does cause one or two accidents each year, and other close calls, usually from cracks in the exhaust manifold when used for heat. These accidents can be prevented by inspection, awareness of symptoms, and cockpit detectors, but they are not frequent enough to warrant further discussion here.

We have seen four levels above 10% without fire (0.6%).

A toxicity problem of greater concern to us is that of poisoning of aerial application pilots. In three small early surveys we found some evidence of poisoning in about 40% of these pilots who were involved in fatal accidents. This segment of aviation usually has the highest accident rate. Our recent experience has shown only about 10% with definitely lower cholinesterase values. The absence of baseline values and the presence of fire have complicated the interpretation for many accidents. This should not be dismissed as "no problem" because it was not looked for as one region has done. Many of the pesticides are extremely toxic and are readily skin absorbed. As little as two drops of the concentrated liquid shipping concentrations on the skin can be fatal.

While diluted for actual operation, there is still a hazard and extreme care on your part is indicated when investigating these accidents.

Care, medical surveillance, and protective equipment can make aerial application a relatively safe operation. Only California requires the medical surveillance of farm workers exposed to pesticides. We have an active educational program and often draw blood samples for free baseline cholinesterase determinations at the time of our presentations. Of greatest concern are our findings that most physicians and even many medical centers do not know about two effective antidotes, that many aerial applicator pilots carry one or both of the drugs, that many also take the drugs prophylactically, and that some even drink alcoholic beverages to "counteract the toxic effects."

Two relatively rare but classic physiological problems deserve mention--hypoxia and hyperventilation. They are not "tangible" in the usual sense, but they can be. One prominent scientist advocates the determination of the brain lactic acid level as an indication of hypoxia. We are not convinced and do not perform this test. Hyperventilation can cause spasm of the hand muscles, unconsciousness, and a residual reduced CO_2 level in the blood.

There are only one or two definite cases of hypoxia each year in general aviation. The facts that aircraft are flying higher and that numerous professional pilots do not know the dangers of hypoxia are of concern. One accident involved a test pilot. Statements by experienced pilots and prominent aviation figures at large aviation meetings include, in my experience:

"no oxygen is needed over the Rockies; the air is rich in oxygen due to updrafts from the plains";

"keeping vents closed eliminates any need for oxygen up to 18,000 feet";

"our aircraft reached 41,000 feet, unpressurized, and the pilot didn't even need oxygen";

"oxygen is not needed near the Equator" and

"I always fly at 15,000; it keeps the kids quiet."

Physiological training is offered at CAMI, 31 USAF chamber facilities and soon, we expect, at several USN and one NASA facility. It is strongly recommended for anyone who plans to fly above 10,000 feet.

Hyperventilation is due to anxiety. While not an identified fatal accident cause, it should be recognized by flight instructors and air traffic controllers as a sign of anxiety and used to prevent accidents when possible and understand them in other cases. One word of advice for such situations: have the pilot talk. You cannot hyperventilate and talk at the same time!

In closing, I would like to mention one other story from the past.

On September 17, 1908, Lt. Thomas Selfridge was killed, and Orville Wright was seriously injured, in the crash of the Army's first airplane. A Board of Inquiry determined that Lt. Selfridge suffered a fatal skull fracture when his head struck part of the airplane structure on impact. Attention was called to the need for the crew and passenger to wear safety belts and crash helmets in certain types of operations.

In addition to preventing accidents, we also attempt to make them more survivable when they occur. We have a great deal of on-the-scene experience and also research experience in determining human tolerances to impact, restraint effectiveness and the benefits of padding, yieldable materials and absence of pointed objects in the cockpit and cabin. It has long been observed that the use of upper torso restraint in general aviation aircraft would prevent at least one third of the accident fatalities.

HUMAN FACTORS IN ACCIDENT INVESTIGATION

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1. In spite of all the extensive sophistication being built into the modern family of aircraft, it is a fact that over 85% of aircraft accidents today are due to the human elements. The accident investigation more often than not is faced with very multiple problems, the least of which is not the cause but the circumstances leading to the cause so that a total preventive measure can be adopted.

2. Even with the best automatic landing systems, the flight crews are heavily tasked during the two most crucial stages of the flight and statistics have shown that more accidents occur during these phases than at any other time--taking-off and landing. Most of the time they can cope quite well. But at the odd times when the mind is not all geared to the task, the occasional accident always results.

3. The human mind is so fragile, yet can be so set or possessed that the subconscious usually takes advantage of the being. Already pilots have to follow a patterned form of life in order to minimize sudden lapses of the brain or the body. But is there a cure for the obsessed mind? Doctors can only make their observations which have to be conclusive by signs, symptoms and tests. Even where a psychiatrist's opinion is required, his findings can only be backed by the doctor's history plus his own tests and observations. In short there appears no direct formula for the troubled mind. Moreover, the morale of the traveling public will be ruined to discover that it was a necessity for all pilots to see a psychiatrist.

4. Aviation medicine doctors are most carefully selected and, as far as the neurological, pathological, physiological and all the other aspects of their responsibilities go, are not at all lacking. But they really cannot cope with the pilot's mind. Where human factor is a cause, it would be good to know exactly what was predominant in the pilot's mind before the crash or during the subject flight. If the best psychiatrist could be asked to interview the pilot of an aircraft which crashed as a result of bad handling before a flight, maybe there will appear some indication as to the predominant issues in his mind. Where these issues conflict with

his rationality, he could be prevented from manning the flight. But this cannot be a practical proposition because the world does not have as many expert psychiatrists, nor could the airlines afford such a system.

5. Electronically maybe pilots' brain analyses can be obtained during flight and such analyses can be compared with recorded normal brain patterns of such pilots before the accidents. The difficulty would then remain with interpreting these varied brain analyses. It would seem here that a research into this field is desirable.

6. Another vital aspect in this study is Flight Time Limitation - Duty Periods - . It is a known fact that pilots' handling and decision-making capabilities are badly impaired during fatigue. Alertness, a high standard of judgment and handling are the basic rudiments of any pilot. Nowadays airlines are particular about crews' duty periods, and some of them go to extremes to see that flight crews observe their full rest periods. What they are unable to do is to actually stay with them and ensure that they go to sleep. Some pilots have been known to carry out private flying duties during their rest periods. Pilots should be dissuaded from such practices. At other instances, pilots doing transatlantic routes find it difficult to retire to bed in time because they depart point A at say 7 p.m. local time, arrive point B at same 7 p.m., local time, forgetting that they have been flying for the last 9 hours say and wanting to participate in the usual night life. With this type of difficulty, pilots have to be convinced about having their rest and be thoroughly disciplined.

7. "Human Factors in Accident Investigation" is centered around the flight crews, most of all the pilots. Their responsibilities are tremendous. The modern flight deck displaying the numerous instruments does not lessen their task in any way, rather they demand much more concentration from both pilot and co-pilot. All such instruments are vital, and limiting them would doubtless jeopardise safety. In time we can only hope that an electronic brain will be able to assimilate all instruments' data, correlate and process them accordingly so that the pilot's task becomes less with no risk to the safety of the flight.

8. The subject is incomplete without dwelling on the art of Investigation of the Accident. The numerous spheres in accident investigation have to be ably manned in order to arrive at the correct, most probable or probable

cause of the accident. Human factors in this regard will include all the accident investigators and inspectors, their approach to and handling of the subject.

9. After a crash the first privileged to reach the scene are the firemen who sometimes play a vital role in the entire investigation. Although at times instead of contributing to the investigation, they destroy vital evidence. Today with more training and more developed skills, much help is rendered by firemen.

10. At the scene of the accident, the Investigating Team has to recreate the flight path from the wreckage and to determine whether parts of the structure of the craft failed, i.e., fell off before crash or not. The team should also be able to determine guide lines on which the investigation can be channeled. These on-the-scene activities carried out scrupulously can sometimes lead to quick determination of the accident's cause.

11. The Aviation Medicine Doctors, members of the team, always have big contributions to make. Whether fatal, seriously injured or non-fatal, these doctors can determine plenty by various on-the-spot observations and tests. In fact this topic, "Human Factors in Accident Investigation," is more exclusively the Aviation Medicine Doctor's field. They can most readily supply biographical data on any flight crew or passenger for that matter. It is very easy once the passenger's identification is established to refer to his or her own doctor for the relevant history - Doctor's Privilege. Autopsies on flight crews usually reveal a lot. The position of bodies, seats, and recognizable parts of the aircraft are so helpful to the investigation.

12. Today many public transport aircraft are equipped with flight and voice recorders and these reproduce manoeuvres and speeches before crash. From these data it is quite easy to determine whether the human factor is a main cause. Aviation Medicine Doctors are very quick in deciding probable human failure before the crash. In the same way they have their method of relating one failure to another and so arriving at the basic original cause.

13. When, for example, the crash recorder has indicated an obvious error in flight manoeuvring, the investigating team is left with the reason why that mistake was made. Disorientation has accounted for many of such accidents in the past. But here is an experienced pilot who is qualified

in every respect and most conversant with that particular situation, with the arrow pointing towards his mishandling the craft or misjudging the situation. The question is what indeed is responsible for that. Could the co-pilot have misinformed a decision speed, or called out some indication in error? There are records of such mistakes. All of these seem to point to the human factors.

14. Summing up I feel that the "State of the Art" on Human Factors in Accident Investigation can be improved by heeding the following suggestions:

(a) More than the usual information be available on flight crews, especially the pilot and co-pilot.

(b) That pilots be made to feel freer with their doctors, e.g., where domestic issues are dominant or disturbing, pilots must make a clean breast of things to the doctors without fear of any loss of face or morale to his profession, and doctors must also make recommendations without prejudice, fear or favour to either the pilot/co-pilot or airline.

(c) There was a touch on pilot's brain analysis. This I feel deserves to be pursued.

(d) Cockpit warning signals can be made more precise and positive. There have been recorded cases when these have been completely misunderstood by most experienced pilots leading to fatal accidents classed as "Human Factors."

(e) More direct measures in recognizing heights and weather minima.

(f) A more positive indication of appreciating the aircraft attitudes, e.g., sometimes pilots' sensations are contrary to what the instruments are indicating and their effort to take corrective measures usually results in another crash classed as "Human Factor." Being more positive here could mean a verbal indication of the aircraft's attitude, for example, a voice saying, "Aircraft attitude is precisely 8° dive at 2° bank to port," or the like.

The instruments on the aircraft today demand much of the pilot's vision initially before he could apply the other senses. Maybe it would help to employ the other senses.

(g) As mentioned in the text, a series of computers can assimilate and correlate all instruments' data and offer if possible just one verbal instruction to the pilot regarding correct manoeuvre.

(h) Flight recorders are not easy to handle, and they do not at the moment make use of all possible parameters. Maybe there is a way of increasing their use and simply obtaining data.

(i) The cabin staff can also contribute to Human Factors by not giving instructions to passengers at the correct time, or not giving the correct instructions. Another voice recorder in the passenger cabin could help the accident investigation.

15. The art of accident investigation is unlimited. Different accidents under the heading present different circumstances and each circumstance will have to be treated on its merit.

16. In conclusion I must be blunt to indicate that our limited experience in aviation generally cannot afford more than this meagre contribution. Indeed this State has been most fortunate as having no noticeable accident since the inception of Civil Aviation in 1947. The little that has been mentioned are those derived from other States' literature on the subject, from imagination and a bit of thought on the subject. It is therefore difficult to mention particular facts and figures.

A PILOT'S PROFESSIONAL ETHICS AND INTEGRITY FOR AVOIDING AVIATION ACCIDENTS

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Translated by Thomas H. Paskell

I. GENERAL FACTS PERTAINING TO THE ACCIDENT ON WHICH THIS WORK IS BASED

On the 26th of September, 1969, the Lloyd Bolivian Airline dispatched a special flight between the cities of Santa Cruz and La Paz. This flight was scheduled in order to accommodate passenger travel. A Douglas DC-6B, Bolivian registry CP-698, was scheduled for this flight with a crew of pilot, co-pilot, flight engineer and two flight attendants. With clearance requirements completed, the aircraft took off from Santa Cruz at 1410 (all times are Bolivian) carrying five crew members, 69 passengers, baggage and cargo, all within their respective compartments.

CP-698 made a position report over Vacas fifty minutes after takeoff. This is a point on the normal route of flight in VFR conditions. The aircraft was flying at 16,500 feet. At 1515 a position report was received as the aircraft passed over Cochabamba. The estimated time of arrival (ETA) at La Paz was 1600. This was the last contact with air traffic control made by CP-698. From 1600 hours, the ETA at La Paz, the La Paz control tower attempted to establish contact with CP-698. These attempts were unsuccessful and no emergency radio transmissions were received from CP-698.

The aircraft wreckage with its 74 occupants was found the following day at 2300 hours by a search party in an area known as La Cancha. This area is off the normal route from Cochabamba to La Paz.

Because of the lamentable loss of life, this was the worst aviation accident suffered by Bolivian aviation up to that time.

Recovery operations were begun. The terrain was such that the area was not easily accessible and therefore the recovery of the remains of the bodies required several days.

The Investigation Commission was formed with personnel from the Bolivian Department of Civil Aeronautics and two officers of the Bolivian Air Force acting as advisors to conduct the investigation. This author was a member of the Commission.

The crash site was located at 67° 37' West and 16° 55' South at an elevation of 15,500 feet above sea level. There were many large rocks in the area of the accident, some of which exceeded 7 feet in height. The aircraft first struck rocks 3 feet high, in a bank of some 15° to the left. Despite the quantity of rocks, evidence showed that the aircraft dragged along the ground without somersaulting. The left wing was destroyed on the first impact and could be identified only by the wing tip. The right wing was found upside down and at 90° in relation to the crash path. This wing was 360 feet from the point of initial impact. The fuselage, broken into many sections, was scattered along this distance. The tail section was intact. No. 4 engine was 450 feet from the initial point of impact. This was the total distance of wreckage dispersal.

The following paragraphs are taken from the Investigating Commission Report and give more clarity and continuity to this paper:

> "All of the components of the aircraft having been found, the Commission arrived at the conclusion that it was structurally intact before the impact. There was no evidence indicating fatigue since all broken parts indicated breaking from tension, torsion or compression recently applied. . ."
>
> "The body injuries indicated that part of the passenger cabin had undergone close to 40 G's while other parts of the cabin had undergone in excess of 40 G's. This observation considered with the type of terrain and the breaking up of the aircraft led the Commission to believe that the velocity of the aircraft was low and that the impact was foreseen. The aircraft being at least partially flyable . . ."

From the previous paragraphs and from other related aspects of the accident of CP-698, it was concluded that no fault existed in any of the engines or systems of the aircraft. At the same time, the possibility of having contacted any of the surrounding hills at the scene of the accident was investigated and discarded.

Atmospheric conditions in the area at the time of the accident were restricted visibility 1 to 1 1/2 miles due to smoke and winds of 15 to 20 knots from 260°. The wind and topographic characteristics created moderate to strong turbulence.

The investigation revealed that all operations rules and regulations governing this flight were complied with. At the same time it was proven that the aircraft maintenance services and its propulsion systems were adequate and complied with all rules and regulations.

According to witness testimony, the aircraft was following an unusual route to La Paz when it flew over Cochabamba. It was seen at 1535 flying at very low altitude over Picuny mine in the mountain range of Quimza Cruz. Visibility was restricted in this area by smoke. This area does not lie on a direct route from Santa Cruz to La Paz. At this time it must be noted that the flight plan presented by the company and accepted by the airport authority was inadequate. The VFR flight level assigned to the flight was 16,500 feet notwithstanding the fact that peaks existed up to 17,500 feet and more.

Now we shall analyze the human factors present in this accident. First we will deal with the crew members engaged in flying the aircraft:

The pilot in command was 39 years old holding an airline pilot's license. He had logged more than 11,000 hours of flying time of which close to 4,000 hours were in a DC-6B. He had flown the route in question many times. He had satisfactorily completed a medical examination two months before the accident. During the investigation it was determined that the pilot was apparently suffering from a very grave emotional crisis. This crisis developed from difficulties which he was having with several contemporaries. It was determined that the flight engineer originally assigned to the flight refused to fly with this pilot and he was replaced by another flight engineer. This incident greatly offended the pilot and moments before the fatal flight he commented this fact to another pilot. The pilot to whom the comment was made said that the pilot making the comment appeared to be "completely upset." The difficulties under which the pilot of CP-698 was suffering had their origin in the time when he was living with several of his contemporaries in the United States while they were receiving training in the Fairchild F-27 aircraft. This was being accomplished at the aircraft factory and was several months before the accident. During this time his co-workers had practically ostracized him due to his irritable and intolerant attitude. Once again, it must be said that this profoundly affected the pilot.

The co-pilot, 30 years of age, held a commercial pilot's license and had 3500 flight hours as a co-pilot of which 123 were in the DC-6B. His last medical examination was completed four months before the accident. Results of this examination showed that he was suffering from myopia and astigmatism and that he should use corrective lenses while flying. It was learned from testimony that the co-pilot never used corrective lenses.

It was established that the remaining crew members, the flight engineer and two flight assistants, were properly qualified for fulfilling the responsibilities of their positions. Their medical examinations had been passed with no limitations. During the investigation no factors were discovered which could possibly have had adverse psychological effects upon them. According to the final report of the investigation no one probable cause factor was indicated. However, contributing cause factors were listed, some of which follow:

1. Human Factor
   a. Psychological factor on the part of the pilot.
   b. Physiological factor on the part of the co-pilot.
2. Operational Factor
   The flight plan presented was not within the standards of the company nor within the standards of the government.
3. Meteorological Factor
   Reduced visibility due to smoke.

II. INVESTIGATION, ANALYSIS AND STUDY ON WHICH THIS PAPER IS BASED.

In the judgement of this author the probable cause of the accident of CP-698 was the attempt to conduct the flight under visual conditions at too low an altitude. We will analyze how and why this situation was reached.

At this time, it is appropriate to analyze the presentation and acceptance of the inadequate flight plan. The fact that the flight plan was presented and accepted for a direct flight Santa Cruz-Cochabamba-La Paz at flight level 16,500 feet cannot be considered as a contributing factor to the accident. A clearance filed for an altitude does not necessarily mean that the flight altitude was that altitude which was filed. The foregoing is proof in itself.

Several people were interviewed and several texts and works were consulted in order to study and analyze the accident of CP-698 and then to prepare this paper. The following definitive conclusions were reached:

Prior to the fatal flight the pilot was suffering from an emotionally difficult situation which originated from incidents which had happened to him in the United States and which were a direct result of the attitudes of his co-workers toward him. Several people commented that prior to the fatal flight he appeared to be upset and preoccupied. Testimony concerning the pilot's character revealed that he was "temperamental, nervous, and he had little tolerance." The fact that a co-pilot had refused to fly with him "hit him hard" (statement of another pilot of the same airline).

Other statments evidenced that the pilot of CP-698 displayed psychosomatic symptoms of fatigue. These symptoms included headaches, irritability and others. Dr. Stanley R. Mohler, for many years Director of the Civil Aeromedical Institute of the USA and holding a chair in the Federal Aviation Administration in Oklahoma City, mentions in his article, "Fatigue in Aviation Activities," that one of the causes which produces mental fatigue is personal difficulties with co-workers. Undoubtedly, this state of mental fatigue can easily manifest itself physically as a reduction in the affected person's abilities to react properly under stressful situations. The following paragraph is from the Aviation Accident Investigation Manual, document 6920-AN/855/3 of the International Civil Aviation Organization. It concerns establishing circumstances which might contribute to an unsafe act.

> "Crew members may not be aware of their loss of ability or of their errors or omissions when under excessive fatigue, lack of oxygen, poor health, or the effects of drugs and noxious gases. . ."

Along with this Dr. Harry G. Armstrong, Colonel, United States Army Medical Corps, in his book, "Principles and Practices of Aviation Medicine," mentions:

> "The term fatigue is an inexact expression used to describe either a sensation of weakness or a lessening of the capacity to carry out a task, or both, generally as a result of previous activity. However, even with an absence of previous work, fatigue can be present showing that it can come from purely psychic tensions or emotions. . ."

It has now been well established that the pilot of CP-698 was suffering greatly due to fatigue originating out of difficulties with his co-workers.

Turning now to the co-pilot we will again state that his last medical examination had brought to light conditions such which required him to wear corrective lenses. In this respect it was determined from statements that the co-pilot did not use corrective lenses. Some statements, however, indicated the contrary. The physical condition of the co-pilot's eyesight and the fact that visibility was reduced to 1 to 1 1/2 miles by smoke at the site of the accident could change the focal distance of the co-pilot's vision.

The article, "Myopia at Altitude," appearing in the January, 1968, issue of the "FAA News" magazine and concerning this possibility states:

> "When mountains and other distant points are not clearly delineated against the horizon the normal eye's ability to maintain a focal distance is debilitated. The focal distance of the viewer tends to recede toward himself after a short period of time when it cannot find and maintain fixed vision on a distant point. . ."

As stated earlier the atmospheric conditions certainly affected the flight of CP-698 and would have been even more serious if the co-pilot were not using his corrective lenses.

During the research for this paper it was determined from statements made by several pilots of the proprietary owned airline that the engineer on the fatal flight, also a co-pilot with a commercial license and with 3,000 flight hours of which more than 300 were in the DC-6B, when flying as co-pilot on this route would do it exactly the way in which it was done, flying in the deep canyons.

Flights were conducted through this sector, known to the residents as La Concha, so often that the pilots of the airline renamed this particular pass as Cat Pass. The engineer on the fatal flight and co-pilot of many other flights had the nickname of Cat and it was from him that the name was taken.

It is speculated that the reason for his conduct of flights such as this had an ego origin in that he desired to show off and demonstrate his ability to his co-workers.

The previous paragraphs indicate how and why CP-698 happened to be flying in the valleys. Evidence which has been gathered is basically in agreement and makes us presume that the pilot, suffering from mental fatigue and an emotionally disagreeable situation, completely disregarded concentrating wholly on the flight.

III. CONCLUSIONS

Dr. Reynaldo Agrelo, former professor with the faculty of the Medical University of Buenos Aires, Argentina, and a specialist in aeronautical medicine mentions in his book Aeronautical Hygiene the following in relation to fatigue:

> "Flight fatigue is difficult to define. It appears in the pilot who has minimum muscular work and who keeps his energy at all times, one who has lost the desire to work and forces himself to fly, one who has lost ambition, will, and pleasure, one who does not truly pursue to develop his profession, he suddenly hates his profession, and when he does fly, it is probable that he will become involved in an accident."

Commenting now on the fatigue of the pilot of CP-698 we can say that he was the only one responsible for the incidents affecting himself. We can also say that this fatigue could easily result in a purely personal indolence which would influence his attention to the conduction of the flight. We must also mention the co-pilot's myopia and the flight engineer's habitual trait of flying over canyons. We will not attempt to firmly locate these in the accident sequence. Rather we will talk about the general situation of crew members when they find themselves faced with fatigue and how this can influence an accident and finally, how it can be avoided.

No one is free from emotional problems and conflicts. Personal, economical, work situations, etc., can easily promote personal conflict which undoubtedly lessens a person's faculties, ability, reaction, attention, and others. It is unanimously agreed that these factors will be more or less important depending upon the type of work which must be completed. For example, a person who washes automobiles and who has a problem which affects him emotionally forgets to wash a side window. This act will not have a great deal of importance, however, when a pilot suffers from an emotional problem it is well known that his reactions will become less than adequate and that he is at least somewhat psychologically incapable of performing in a manner which is demanded of an aircraft pilot. In other words, this pilot should not be allowed to fly.

It goes without saying that at this point in time it is an impossibility to determine the psychological or physiological condition of each pilot prior to each flight. The pilot, a crew member himself, should be the one to make a personal analysis of his condition, being completely honest with himself and then acting accordingly. Professional ethics of a pilot demand that he make known to his supervisors problems and afflictions which are acting upon him, if not to attempt to find a solution then certainly to allow them to replace him during the time that he is affected.

It is granted that in daring professions or activities, that following what has been suggested is somewhat difficult. Few, if any, pilots would admit being incapable for a flight. Nonetheless, if we successfully complete the needed indoctrination and education of pilots concerning these points we may prevent in the future even greater catastrophies than CP-698.

It would be in their own best interests if the aeronautical authorities and airlines begin giving proper indoctrination to crew members concerning this point of prime importance. The crew members' personal integrity is a fundamental point which must be driven home to the crew member and must be well understood by him. He must then sufficiently analyze himself prior to his flights and honestly remove himself from the flight if he feels it is appropriate. The foregoing would be "A PILOT'S PROFESSIONAL ETHICS AND INTEGRITY FOR AVOIDING AVIATION ACCIDENTS."

HUMAN FACTORS IN AIR SAFETY

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Introduction

The Air Registration Board is conscious of the important influence which human factors have on air safety and the considerable contribution which these constitute as a cause of civil aircraft accidents.

Analysis of the causes of civil aircraft accidents occurring over the twelve-year period 1955 to 1967 indicates the following break-down of causes:

Factors involving crew	48.5 percent
Airworthiness factors	22.5 percent
Operational factors	29.0 percent

However, the airworthiness causes can be further broken down into maintenance and design deficiencies which are the end product of human factors which contribute 10.3 percent to the total 22.5 percent of airworthiness causes.

Thus we may say that 58.8 percent of the causes of accidents to British aircraft were due to human factors and we must also face up to dealing with this major cause in our approach to airworthiness and the control of air safety.

Statistical Data

We were invited to present at this Meeting our statistics on human factors in aircraft accidents and we have presented them to you in brief summary in our Introduction.

What we would like to present in addition, however, is a discussion of the sources of statistics which will best enable us to perform our task of (a) improving air safety by means of action at the design stage and (b) airworthiness control to ensure continuing safety.

While we recognize the importance of human factors in accident investigation, we are concerned that false conclusions may be reached if the normal pattern of behaviour of flight crews and the environment in which they operate are not well enough known.

We are also concerned that with the setting of ever higher safety targets with a consequent reduction in the rate of occurrence of accidents, the size of our statistical samples may be insufficient to draw useful generalizations on which to base remedial action for current aircraft or design standards for future aeroplanes.

Consequently, we are of the opinion that data relating to incidents which inevitably occur more frequently than accidents must become one of our major sources of data. We also foresee that such data have the advantage of a live crew to aid the investigation. It is with this objective in mind that in the United Kingdom a Civil Aircraft Airworthiness Data Recording Programme has been set up as a cooperative venture between airlines, pilots, safety authorities and research authorities.

Benefits of Operational Flight Recording

As was indicated earlier, the benefits which we expect to gain from such a programme are to provide an understanding of the behaviour of crews and a knowledge of their operational environment as an eventual aid to accident investigation and as an aid to the interpretation of the results of accident investigation.

The other benefit which we hope to achieve is the improvement of air safety as a result of knowledge of incidents. Thus, with all due deference to this audience, our eventual ideal is that we can eliminate the accident investigator and turn him into an incident investigator. We feel that this is a proper objective.

Illustration

An example of the benefits of such incident recording and investigation was the following:

An aircraft sustained an electrical failure. The crew as a whole devoted themselves to tracing the cause of the failure. As a result of the failure the autopilot disconnected and the aircraft gently entered a spiral dive. The crew failed to observe the progressive upset of the aeroplane until the overspeed warning sounded. The aircraft was recovered, without exceeding the design diving speed and without structural damage.

A design deficiency was that no noticeable warning of autopilot disconnect was given to the crew in this particular mode of failure.

A human factor was that, with the distraction of a major failure, the crew failed to notice the silent autopilot disconnect and did not monitor the motion of the aeroplane over a critical 35 second period. The aircraft, in common with others, is now fitted with an aural warning of autopilot disconnect. There are other examples but this one should suffice.

Conclusion

The importance of human factors in air safety is paramount and hence constitutes a cause in nearly 60 percent of accidents to British civil transports. We are of the opinion that one important source of statistical data on human factors is flight recording. In the United Kingdom we now have a cooperative system for obtaining such data. We hope that such sources of data and the resultant investigation of incidents will enable us to act to prevent accidents and ultimately make accident investigation a rarity.

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