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A PROPOSED AIRCRAFT ACCIDENT PREVENTION
DOCTRINE FOR THE UNITED STATES AIR FORCE

A thesis presented to the Faculty of the U. S. Army
Command and General Staff College in partial
fulfillment of the requirements of the
degree

MASTER OF MILITARY ART AND SCIENCE

by
LEONARD R. PETERSON, Captain, USAF

Fort Leavenworth, Kansas
1966

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U. S. ARMY COMMAND AND GENERAL STAFF COLLEGE

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Name of Candidate Leonard R. Peterson

Title of Thesis A Proposed Aircraft Accident Prevention Doctrine

For The United States Air Force

Approved By:

James Riva, Research and Thesis Monitor

John O'Beirne, Member, Graduate Faculty

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Date 25 May 66

The opinions and conclusions expressed herein are those of the individual student author and do not necessarily represent the views of either the U. S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

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This thesis discusses the U.S. Air Force aircraft accident prevention program, its background, present status, and its weaknesses. It is concluded by offering suggestions for improving the efficiency and effectiveness of the program.

Chapter I describes the need for an effective accident prevention program. The need is divided into human aspects, loss in combat potential, economic considerations, effects of adverse publicity, and other inimical effects including those of the loss of time, political considerations, and morale. The chapter contains a prediction of the effectiveness of future accident prevention efforts. The author predicts that because of a reduction in pilot experience, changing missions, a modified force structure, changes in types of aircraft, and a reduced amount of proficiency flying time, the number of accidents will increase in the next several years.

The chapter concludes with a review of the limitations of the research. A definition of the terms used throughout the thesis is also included.

A short history of aircraft accident prevention is reviewed in Chapter II. The review begins with a description of early aircraft accidents. The organizational approach to aircraft accident prevention beginning from pre-World War I through the present is examined.

Chapter III examines the current Air Force aircraft accident prevention program. Six of the more important concepts forming a foundation for the program are explained. They are: (1) accident prevention, while vital, is subordinate to the mission; (2) accidents are not inevitable--

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they can be prevented; (3) the only acceptable accident rate is zero; (4) a job well done is inherently safe; (5) safety is a responsibility of every member of the Air Force; and, (6) accident prevention is a function of command. Each of these concepts is fully described and supported by several examples.

The military management of the accident prevention program is discussed with emphasis on the role of the commander and the flight safety officer. The responsibilities and duties of each are fully described. In addition, the qualifications, personal attributes, and desired training and education of the flight safety officer are reviewed.

The organizational structure of the Air Force supporting the accident prevention program is described. Specific attention is paid to the staff arrangement of the safety function at Air Force level, at the major air command, and at base level.

The accident prevention program is divided into two broad areas: before-the-fact and after-the-fact prevention. The following aspects of the before-the-fact prevention program are explained: (1) education and training; (2) literature and publications; (3) film program; (4) formal training of safety officers; (5) the safety survey; (6) Operational Hazard Reports; (7) the Flight Safety Council; and, (8) the materiel deficiency reporting system. The impact of the safety program on design of aircraft is also examined. A discussion of the after-the-fact accident prevention program includes information pertaining to accident investigation procedures and policies.

Aircraft accident prevention philosophies and concepts are described in Chapter IV. The following concepts, important in an understanding of accident causation and prevention, are explained: (1) sequence

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of events concept (which states that an accident is usually the result of a series of events rather than one catastrophic occurrence); (2) known precedent concept (the fundamental causes of accidents have remained the same throughout history--failures of men or their machines); and, (3) the man-machine-media concept (which holds that both safe, efficient flight and aircraft accidents are a result of the integration of the many elements of man, machines, and the environment).

Several philosophical aspects of accident prevention are also discussed. The negative and inhibitory approach of some accident prevention efforts is probed. A discussion of the "crime and punishment" and accident proneness theories are explained. The chapter closes with a discussion of the relationship which should exist between accident prevention and uncompromised mission accomplishment.

Chapter V describes some of the more important weaknesses in the current aircraft accident prevention program. The author suggests that the most important degrading factor is the system of reporting and classifying aircraft mishaps. The specific deficiencies include the requirement that accident investigation boards determine a "primary" cause of a mishap. The result of this procedure is undue emphasis on correcting the primary cause with a consequent lack of emphasis on the "contributing" causes. Other weaknesses include frequent changes in reporting criteria, disproportionate emphasis on reporting mishaps involving damage, and mechanical aspects of reporting data discovered during aircraft accident investigations. Suggestions for correction of these weaknesses are offered.

The problem of inadequate accident investigations is also discussed. Poor quality accident investigations, the author concludes, are due primarily to the qualifications and limitations of accident investigation

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boards, improper conclusions from facts discovered during investigations, and inconclusive results from teardown deficiency reports. The author makes recommendations to improve the quality, thoroughness, and accuracy of accident investigations.

A discussion of the "privileged" status of aircraft accident investigation reports, human factors as causes of accidents, and the feasibility of improving aircraft accident prevention through a tri-Service aviation safety organization is presented.

The author concludes that the current U.S. Air Force aircraft accident prevention program, while successful, must be improved to conserve critical men, money, and materiel resources.

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I am grateful to the United States Air Force for allowing me to work in such an interesting and challenging field as flight safety. I also deeply appreciate the opportunity offered by the U.S. Army Command and General Staff College to participate in graduate-level efforts, while at the same time, being profoundly enriched by the regular course work.

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CHAPTER I

INTRODUCTION

The Need For Aircraft Accident Prevention

The air is an alien and hostile environment. Men who fly and fight in powered, heavier-than-air craft must invade, and therefore must meet the challenge of, a medium which can be inimical and is always unnatural to them. The price of survival in this environment is like the price of liberty: eternal vigilance. Partly because of these fundamental reasons, the United States Air Force (USAF) has a large and dynamic aircraft accident prevention program.

Air Force operation in the vast ocean of air surrounding us represents a significant portion of the military strength of this nation. The primary mission of the Air Force is to support national aims and objectives through the use of aerospace power. This job is of such magnitude and importance that any inability to fulfill this mandate seriously compromises this Air Force mission and might well affect the survival of the nation. To accomplish this mission we must not only begin with an adequate amount of high quality equipment, well-trained aircrews and qualified support personnel, but we must also safeguard these resources from avoidable losses.

This is the raison d'etre for safety.

Losses resulting from preventable aircraft accidents have been

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a serious and continuing problem since the first year of powered flight. They continue to be a serious problem today.

One can obtain an impression of the terrible toll that aircraft accidents have taken throughout the history of the Air Force when one learns that between 1921 and 1964, 28,605 military personnel were killed in 87,350 aircraft accidents.¹

There has been a general and continuing trend in reducing the number of accidents (per 100,000 flying hours) each year throughout the history of the Air Force. (See Table 1) From a high of 502 accidents per 100,000 flying hours in 1922, the number has dropped progressively to 4.4 in 1964.² There were a few occasions when this trend was reversed. The rapid expansion of airpower before both World Wars and the mission of flying the mail (given to the Army in 1934) are examples of times when such reverses occurred. These examples will be examined more closely in Chapter II.

The Air Force can take pride in the substantial reduction in the number of aircraft accidents per year. Our most recent accident experience, in terms of the number of accidents per 100,000 hours of flying, is not discouraging. The actual losses, nevertheless, are staggering. When one looks at the actual figures in terms of fatalities, major injuries, and aircraft destroyed, it becomes clear that these figures represent a substantial loss to the Air Force in men, money, and materiel.³

¹U.S. Department of the Air Force, 1964 USAF Accident Bulletin, (Norton AFB, Calif.: Directorate of Aerospace Safety, 1965), p. 2.

²Ibid.

³U.S. Department of the Air Force, Summary and Evaluation of Aircraft Accidents and Fatalities, (Norton AFB, Calif.: Deputy Inspector General for Safety, USAF, n.d.), p. 3.

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TABLE 1

U.S. AIR FORCE AIRCRAFT ACCIDENTS, 1921-1964

YEAR	MAJOR ACCIDENTS		FATAL ACCIDENTS		FLYING HOURS
	NR	RATE	NR	RATE	
1921	361	467	45	58	77,351
1922	330	506	24	37	65,214
1923	283	430	33	50	65,750
1924	275	281	23	24	97,834
1925	311	207	30	20	150,319
1926	334	211	27	17	158,402
1927	227	161	28	20	140,906
1928	249	136	25	14	182,902
1929	390	148	43	16	263,381
1930	468	144	37	11	325,223
1931	456	115	21	5	396,961
1932	423	114	32	9	371,254
1933	442	102	28	7	432,966
1934	412	110	35	9	374,235
1935	453	101	33	7	449,583
1936	430	83	42	8	518,749
1937	358	69	27	5	520,493
1938	375	63	38	6	598,907
1939	389	53	32	4	729,225
1940	478	51	46	5	937,922
1941	1,515	63	143	6	2,388,046
1942	10,090	71	1,116	8	14,246,366
1943	20,389	64	2,264	7	32,064,789
1944	16,128	45	1,936	5	35,503,205
1945	6,661	44	804	5	15,052,224
1946	2,194	61	274	8	3,624,792
1947	1,555	44	205	6	3,516,141
1948	1,783	40	243	5	4,437,509
1949	1,731	37	245	5	4,699,897
1950	1,774	36	266	6	4,780,949
1951	2,184	33	370	6	6,660,848
1952	2,274	29	399	5	7,972,482
1953	2,075	24	433	5	8,498,019
1954	1,873	20.2	377	4.1	9,159,967
1955	1,664	17.1	343	3.5	9,626,662
1956	1,466	14.7	312	3.1	9,845,906
1957	1,193	13.6	271	3.1	8,671,970
1958	894	10.4	253	3.0	8,446,787
1959	672	8.2	184	2.2	8,110,947
1960	426	5.8	110	1.5	7,249,764
1961	380	6.3	124	1.8	6,812,603
1962	380	5.7	133	2.0	6,606,664
1963	288	4.4	116	1.8	6,564,375
1964	295	4.4	105	1.6	6,730,902

^a1964 USAF Accident Bulletin, (Norton AFB, California, Directorate of Aerospace Safety, 1965), p. 2.

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Human Aspects

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Air Force concern about aircraft accidents evolves initially because of the humanitarian aspects involved. In our philosophy of life, the human element receives precedence over the factors of equipment and facilities. The full impact of aircraft accidents on people cannot be measured except in a very general way. We do record, of course, a number of facts pertaining to people killed or injured in aircraft accidents. In any qualitative sense, however, our losses can never be measured. In order to do so, we would have to penetrate the facade of statistics and determine the value of a person, and who can say how much a person is worth? We get an inkling of the basic human issues involved when we remember that each man lost in an aircraft accident might be a husband, father, brother, or son -- an important member of someone's family. It is helpful to think in terms other than statistics when we try to visualize the magnitude of the loss, although statistics do give us one way to measure these losses.

What, then, do statistics tell us of our losses in terms of people? In 1964, 333 military persons were killed in Air Force aircraft accidents.⁴ Of these fatalities, 125 were pilots.⁵ The grim statistics also show that since 1947, when the Air Force became a separate Service, 11,311 people lost their lives in 22,929 Air Force aircraft accidents. Over 5,000 of these fatalities were pilots.⁶

⁴U.S. Department of the Air Force, 1964 USAF Accident Bulletin, p. 2. This was a sharp increase over the previous year's record low of 219 fatalities. This large increase was due primarily to a transport aircraft accident early in 1964 that claimed seventy-nine lives.

⁵Ibid.

⁶Ibid.

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There have been many attempts to set a monetary value on a human life. It is impossible to do so however, because of variables such as the cost of education, training, potential earning capacity, experience, present and future potential to the Air Force, the number of dependents, and a myriad of other factors. Computation of a dollar value on a human life is thus, from a practical standpoint, impossible.

If we assign some "reasonable" values to the variables mentioned above, the average cost to the Air Force is at least a quarter of a million dollars per pilot lost.⁷ If we use such a figure, we find that the U. S. Air Force lost over eighty-three million dollars worth of manpower due to air accidents in 1964. Actually, the \$250,000 figure used in the calculation is low.⁸ It has been pointed out that it cost the government \$616,000 to train a bomber pilot.⁹ Using the more conservative \$250,000 cost, the Air Force has lost over three billion dollars worth of military manpower from aircraft accidents in its seventeen-year history as a separate Service.

In addition to these huge (and obvious) costs, there are other unseen costs which result from fatalities. Additional costs result from the requirement to train replacements. During 1963, for example, 1,659 pilots graduated from flight training.¹⁰ It cost over \$86,000 to train

⁷Eugene B. Konecci, Physiological Factors and Flying Safety, A Report to the USAF Physiological Training Officers' Symposium, School of Aviation Medicine, USAF, Gunter AFB, Alabama, 2-6 December 1957, (Norton AFB, Calif.: Directorate of Flight Safety Research, n.d.), pp. 20-21.

⁸Ibid.

⁹J. G. Norris, "SAC Trained Technicians: SAC's Achilles Heel," Air Force Magazine, XXXIX (April 1956), p. 47.

¹⁰Letter, Flight Safety Division, Deputy The Inspector General, to flight safety officers, no subject, August 1964.

each graduate.¹¹ During this same period 138 Air Force pilots were killed and an additional fifty-five were suspended from flying duties because of injuries caused by aircraft accidents.¹² This loss represents approximately twelve per cent of the total pilots graduating from flight school in 1963 and an additional twelve million dollars in training costs. About one out of every nine pilots who graduated from pilot training in 1963 was required to replace someone killed or seriously injured in aircraft mishaps.

The equivalent percentage loss of pilot graduates during 1963 is not substantially different from other years. The greatest loss since 1950 occurred in 1951 when 438 Air Force pilots were killed and another 150 suffered major injuries. This was equivalent to thirty-one per cent of the pilot graduated that year. The smallest percentage occurred in 1955 when 399 pilots were killed and 151 were injured while 5,738 graduated from flight training. This was the largest number of pilots to graduate from flight training in recent years. Therefore, the losses, while high, represented only nine per cent of the graduates.¹³

There are other important loss factors. The cost of training replacement aircrew members is very high. The \$86,000 cited above pays for only the first of many years of training required to obtain a highly qualified pilot. The loss is not in dollars alone. It may take as much as ten

¹¹Interview with Mr. C. Niblock, Office of Deputy Chief of Staff, Comptroller, Hq., Air Training Command, Randolph AFB, Texas, 25 Jan 66.

¹²Letter, Flight Safety Division.

¹³Joseph D. Caldara, Impact of USAF Accidents, (Norton AFB, Calif.: Directorate of Flight Safety Research, 1956), p. 26.

or more years of experience and training to achieve the degree of competence necessary to fulfill today's highly complex aircraft duties. Time, while of great value, is one commodity we cannot purchase.

The impact of fatalities damages the USAF in terms of public reaction. The effect on our public image of fatalities due to aircraft accidents cannot be assessed but may be of even greater significance than the monetary loss.¹⁴

Finally, fatal accidents tend to erode the esprit de corps and morale of Air Force aircrew members. Every fatal accident tacitly reminds the aircrew member that he is not invincible and that he is engaged in a hazardous occupation. This is not a pronounced consideration because most aircrewmembers learn to live with the thought, but it does cause some student pilots to eliminate themselves from training.¹⁵ More experienced pilots sublimate the fear and it probably does no harm greater than a temporary decrease in efficiency.¹⁶ The effect of fatal aircraft accidents on morale should not be overstressed; while the over-all effect is degrading, it is not debilitating.

Loss In Combat Potential

Safety of flight is of vital concern to the Air Force not only for

¹⁴U.S. Department of the Air Force, Summary. . .of Aircraft Accidents. . ., p.4.

¹⁵Victor E. Schulze, Jr., Airsickness, Fear of Flying and Lack of Motivation in Student Pilots, A Report to the UPT Commander's Conference at Randolph AFB, Texas, 19 September 1961, (Randolph AFB, Tex.: Office of the Surgeon, Sep 1961), pp. 1-4.

¹⁶Nicholas A. Bond, Glen L. Rigney, and Joseph W. Warren, Aviation Psychology, (Los Angeles, Calif.: University of Southern California, 1962), pp. 8-7, 8-10.

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the substantial humanitarian reasons and the enormous economic loss but also for the very practical consideration of conserving our combat potential.

Accidents, almost by definition, involve losses. Each time we experience an aircraft accident there is a decrease in the resources we have to fulfill our mission. Each of these losses detracts from our flexibility and our strength.¹⁷ Each detracts from our combat power. It becomes necessary, then, to prevent accidents in order to avoid an unnecessary dissipation of our combat potential.

Several simple examples will illustrate this loss in combat potential. A fighter aircraft destroyed by an aircraft accident will, obviously, never be able to intercept an invading bomber. Until it is replaced, the Air Force's ability to conduct a defense of the nation is reduced. Likewise, a B-52 that crashes will never be able to fulfill its mission of strategic warfare. It can never again stand alert and serve as a convincing deterrent to war.

An aircraft does not have to be destroyed, however, to cause a loss in combat potential. Even relatively minor damage can put an aircraft out of commission for long periods of time. Suppose, for example, that a B-52 pilot inadvertently taxies his aircraft into an obstacle and damages a wing tip. Sufficient damage may be caused to require two months for repair. While the aircraft was not destroyed, for the period of time that it is under repair, it cannot be used. In terms of combat potential, for the period of time it is out of commission, it might well have crashed

¹⁷Blueprint for Safety, (Ent AFB, Colo.: Hq. Air Defense Command, 1958), p. iv.

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since it cannot fulfill its purpose.

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Perhaps this appears to be a simplification of the case, but it probably is not. Between 1957 and 1961, 1,290 fighter aircraft were destroyed in non-combat accidents. This is a loss equivalent to fifty-one fighter squadrons. In addition, there were 235 bombers (equivalent to sixteen squadrons) as well as 740 transport and trainer aircraft destroyed.¹⁸ These aircraft cost over 2.2 billion dollars. In different terms, of the 7,200 aircraft accepted into the inventory during the same period of time, thirty-one per cent were destroyed in peacetime aircraft accidents.

Has this percentage improved in recent years? Indeed, it has not. In 1963, for example, 732 aircraft were accepted from manufacturers. Aircraft industry production efforts were only sixty-five per cent effective, however, because during the same year 235 aircraft were destroyed by accident.¹⁹ During 1964, 261 aircraft were destroyed.²⁰ This represented an increase both in the number of aircraft destroyed as well as in the ratio of aircraft losses to new input.²¹

Since 1954 more than 5,000 USAF aircraft have been destroyed.²²

¹⁸U.S. Department of the Air Force, Summary. . . of Aircraft Accidents. . ., p. 5.

¹⁹Wimberly, p. 1.

²⁰U.S. Department of the Air Force, 1964 USAF Accident Bulletin, p. 1.

²¹Caldara, p. 6. The relatively stable number of aircraft destroyed in recent years has enormously increased the total cost of aircraft accidents for the USAF. Aircraft have a greater unit cost than ever before. A trainer which cost \$28,000 (T-6) has been replaced by one costing over two million dollars (F-4C)

²²U.S. Department of the Air Force, 1964 USAF Accident Bulletin, p. 2.

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This number of aircraft would constitute an air force ranking as the third largest in the world, surpassed only by our own and that of the Soviet Union.

We can relate these losses in still another way to combat power. During the Korean Conflict we were able to maintain an air superiority over enemy aircraft in a ratio of fourteen to one in combat kills. That is to say, for every fighter lost in combat, we destroyed fourteen of the enemy's. During 1955, we lost an equivalent of eighteen fighter squadrons because of aircraft accidents.²³ Assuming other conditions were equal, had these eighteen fighter squadrons been available and used in combat, they might have accounted for an additional 6,000 enemy aircraft losses.

Economic Losses

The Air Force is suffering monumental economic losses due to aircraft accidents. In the nuclear age, with the advent of aircraft costing as much as twenty-five million dollars each, the aircraft accident has taken on new meaning in terms of the national economy. Indeed, a large number of accidents involving modern aircraft represent a challenge to the economy of the nation.

In 1964, peacetime aircraft accidents cost the Air Force \$386,858,489.²⁴ This loss, over one million dollars a day, includes only the value of the aircraft at the time of loss and is usually referred to as a "direct" cost. It does not include minor accidents, incidents

²³Caldara, p. 15.

²⁴U.S. Department of the Air Force, 1964 USAF Accident Bulletin, p. 2.

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non-reportable damage, replacement, investigation, administration, compensation, training, liability, or other costs. It is very difficult to calculate these "indirect" expenses. The Air Force estimates that indirect costs are approximately four times the direct costs of the accident.²⁵ If this is an accurate estimate, the cost of non-combat accidental loss to the U.S. Air Force in 1964 was over one and one-half billion dollars.²⁶ This represents over seven per cent of the Air Force's budget and three per cent of the Department of Defense budget for the same period of time.

From 1961 to 1964 aircraft accidents cost the Air Force over 1.7 billion dollars in "direct" costs and approximately seven billion dollars in "indirect" costs.²⁷

These are massive losses. It is difficult to visualize what even one billion dollars is, let alone seven billion dollars. It is made somewhat easier if we translate this loss into what it will buy in weapons systems. If, for example, we could have prevented two-thirds of the aircraft accidents that occurred in 1964 and used the savings of one billion dollars to buy more weapons systems, what could we have purchased? We could have had an additional forty B-58s and operated them with their required tankers for a period of five years, or, we could have purchased an entire wing of B-52s (forty-five aircraft) and operated them with their tankers for a period of five years. We could have had an additional 150 Minutemen missiles and their hardened sites and operated them for a period of five years. If we wished, we could have used the money to buy six

²⁵U.S. Department of the Air Force, Accident Prevention Handbook AFM 32-3 (Washington: U.S. Government Printing Office, November 1962), p. 1-2.

²⁶It is interesting to compare this to the entire War Department Budget in 1938 of \$630 million.

²⁷Air Force Times, 1 April 1964, p. 40.

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Polaris submarines with their ninety-six missiles (approximately sixty-four missiles on station at any one time) and operated them with their crews for five years.²⁸ It is incredible to think that we could have bought this much combat power with the savings resulting from preventing only two-thirds of the accidents of one year. It is important to know, in this respect, that 1964 was the Air Force's best year in terms of accident prevention.

In terms of the overhead cost of accidents, we are required to add \$57.47 to the cost of each flying hour to compensate for accidents. This is a very heavy expense and is as much of an operating cost as any other item of overhead.

Money, perhaps, is not as important to us as are the men and materiel lost in aircraft accidents. Nevertheless, the supply of dollars cannot be taken for granted. The cost of maintaining the Department of Defense is high. Expanding technology and increasing sophistication of our military weapons systems may require us to spend sums of money for national security which could make significant changes in our national way of life. All of these considerations contribute to the conclusion that we have limited resources to waste.

Adverse Publicity

Aircraft accidents are newsworthy events. Despite the fact that they kill less people than influenza each year, they generate far more interest. Some think this interest is due to the large number of people killed in single accidents. In a sense this is true. There have been some tragically spectacular aircraft accidents which have killed a large

²⁸U.S. Department of the Air Force, They'll Ask You, (Washington: U.S. Government Printing Office, n.d.), p. 10.

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number of people at one time. One such example and the most recent was the crash of an All-Nippon Air Ways Boeing 707. The aircraft fell into Tokyo Bay while making an approach to the airport. Over 130 people were killed in the accident making it history's most costly aircraft accident in loss of human lives.

There are relatively few accidents of this type in Air Force operations. During the ten-year period from 1953 through 1962, only eighty-one of the several thousand accidents which occurred involved ten or more fatalities in a single accident. These eighty-one accidents, however, accounted for 1,600 fatalities. The remainder, for the most part, were killed one at a time. During the same period, it is interesting to note that almost 6,000 military people were killed in Air Force aircraft accidents.²⁹

Another factor causing public interest in Air Force aircraft accidents is the high cost of the losses. Aircraft are expensive, Over a million dollars worth of accidents each day "buys" a lot of newspaper space; it "buys" time on all commercial radio frequencies; it assures coverage in newscasts on all television channels. There should be little reason to wonder why the average taxpayer is interested in the economics of Air Force aircraft accidents. A B-52 costs eight million dollars. The average American family pays \$692 in federal income taxes each year.³⁰ One B-52, then, is purchased by combining the yearly taxes of 11,561

²⁹Anchard F. Zeller, "One At A Time," An address presented at the 54th Air Force/Industry Conference, 16-18 September 1964, at Palm Springs, California, (Norton AFB, Calif.: Directorate of Aerospace Safety, January 1965), p. 2.

³⁰U.S. Department of Commerce, Statistical Abstract of the United States, (Washington: U.S. Government Printing Office, 1964), p. 397.

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families.

What is the net result of the publicity that accompanies an aircraft accident? Generally, it is not favorable. The effects of public opinion are not easily determined. It may be good. It may be bad or indifferent. It is never non-existent (except to those few who are not exposed to current events.) It is also clear that every time a newspaper story is read concerning an aircraft accident, public opinion is affected in some way. Let us examine a few examples to see how public opinion, formed or modified as a result of Air Force aircraft accidents, eventually affected the Air Force itself.

In 1955 at Wold-Chamberlain International Airport in Minneapolis, Minnesota, a number of closely-spaced aircraft accidents created a great deal of public interest and indignation. On 5 June an accident involving an Air Force aircraft killed three persons; a Navy accident on 9 June killed eleven; another Navy accident in September was without fatalities; in October an F-80 crashed, killing the pilot, and caused considerable civilian property damage. Finally, there was an F-89 accident in which two were killed. Within one year, and at this one airport, there were five major aircraft accidents which killed seventeen people.³¹ By the end of the year, real estate values of nearby property were threatened; and the Veteran's Hospital about one-half mile away expressed concern for its safety. Newspaper headlines indicated the interest: "Senator [Thye May Ask [the President of the United States] for Wold Relief." The feeling of a part of the public toward the safety of flight at Wold-Chamberlain was

³¹Daniel M. Lewis, "Aircraft Accidents and Public Opinion," An address delivered to the Air Force/Industry Conference, 18 September 1957, (Norton AFB, Calif.: Directorate of Flight Safety Research, 1958).

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summed up by the expression of a woman who lived near the field: "We're moving away from Wold-Chamberlain as soon as we can, if we can get out alive."³² Eventually, the Air Force, Marine Corps, and Navy withdrew all military flying activity from the airfield.

In 1958 there was great concern about the number of persons who lost their lives in aircraft accidents, particularly in mid-air collisions. On 1 February, forty-eight persons were killed when a military air transport and a Navy Neptune bomber collided over Los Angeles. In April, an F-100 flying from Nellis AFB, Nevada, collided with a civil aircarrier near Baltimore, Maryland. Twelve persons lost their lives in the crash.³³

Mid-air collisions are partly the result of the vastly increased use of the nation's airspace. In 1939 there were only 29,000 military, commercial and private aircraft in the United States. Few of them flew over 150 miles per hour. In 1964 there were approximately 125,000 aircraft flying in virtually the same amount of airspace as was available in 1939. Moreover, modern aircraft are capable of flying at much greater speed and at higher altitudes than those in 1939. Not only has the number of aircraft increased four-fold in twenty-five years but, additionally, their hourly utilization has expanded.³⁴ So the problem is partly that of a greater density of aircraft in the available airspace which increases chances of a mid-air collision.

While the problem of increased air traffic and its associated

³²Lewis, p. 3.

³³"More Crashes in the Air--Drive on for New Controls," U.S. News & World Report, Vol XLIV, No. 22 (30 May 1958), pp. 25-26.

³⁴The Electronic Web, (Norton AFB, Calif.: Directorate of Aero-Safety, Jan 1965), pp. 2-3).

hazards is recognized, it does not ameliorate the public attitude when an aircraft accident occurs. After the three mid-air collisions occurred in 1958, an appropriations subcommittee of the House of Representatives, chaired by Representative Prince Preston (Democrat, Georgia) demanded that the Civil Aeronautics Administration improve and increase its air safety regulations. Mr. Preston was reported to have said that "flying today resembles Russian roulette."³⁵

Adverse publicity appeared in a great many newspapers and national magazines. One article, for example, in U.S. News & World Report entitled "More Crashes in the Air--Drive On For New Controls," had these comments:³⁶

An organization representing 65,000 pilots and aircraft owners [Aircraft Pilots and Owners Association] protested Air Force plans for a mass flight of 20 jets over Washington, D.C., at Memorial Day ceremonies. A spokesman asked: "what sort of madness is this anyway?"

.....

Military planes, on the other hand, can use airways almost at will during good weather, without notifying ground-control centers or sticking to prescribed courses or altitudes. Many such planes are jet fighters flying at blinding speeds. Often, civilian pilots complain, military jets engage in acrobatics near giant airliners, despite Air Force crackdowns on "stunting."

That these charges were not wholly true and were further slanted by use of such emotional terms as "blinding speed," "acrobatics near giant airliners," and "crackdowns on 'stunting'" is nugatory in this discussion. The point is that a widely-read and influential national news magazine reported the story in the way it did. The public was concerned, and in some cases, outraged.

Did public opinion and reaction make a difference? It certainly

³⁵"More Crashes In The Air . . .", p. 25.

³⁶Ibid., pp. 25-26.

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did. Later in the year, Air Force regulations and flight rules were changed in several areas. Some of the changes probably resulting from this series of accidents were: (1) training flights were no longer allowed to operate under Visual Flight Rules (VFR) conditions on or along airways; (2) jet penetrations (descents) were required to be conducted off airways; (3) jet aircraft were prohibited from landing at civil airports except when on "official business" and with approval of the major air command.

Still more recently (17 January 1966) another accident occurred that caused considerable public interest and at this writing might still jeopardize a part of the Air Force's operational capability. On that date a B-52 bomber and a KC-135 tanker collided while refueling over Palomares, Spain, a tiny coastal village on the Mediterranean Sea. Two valuable aircraft and seven aircrew members were lost. While this loss alone was sufficient to cause public interest, the greatest concern was centered around the four nuclear weapons that were reported to have been carried aboard the B-52. Three of the weapons were recovered shortly after the accident but the fourth was not recovered for nearly three months.

The total impact of this accident is not yet clear, but it probably will reduce the Air Force's operational flexibility in that part of the world. Twelve days after the accident the Spanish Government prohibited U.S. aircraft from flying over its country while carrying nuclear weapons. An Associated Press dispatch on 30 January reported that "Information Minister Manuel Fraga Iribarne told a Cabinet meeting the ban was 'without time limit and covered all types of flights, both

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refueling operations and otherwise."³⁷ Whether this will affect the usefulness of the three \$100,000,000 B-52 airbases the Air Force has in Spain is not clear. If the ban has real meaning then stationing bombers in Spain (which are not allowed to carry bombs) would be pointless. It would be a contradiction in terms.

Earlier in this chapter there was a discussion of the great costs of aircraft accidents. The costs resulting from the B-52/KC-135 collision cannot be totaled yet but they certainly will be substantial. The loss of two aircraft valued at over twelve million dollars, and seven highly-trained and valuable crew members is only the beginning of a long list of expenses created by this accident. The costs associated with the search for the missing weapon are, alone, very high. A national news magazine reported that more than a "dozen" Navy ships are involved in the search in addition to "700 airmen, soldiers, sailors, civilian technicians and Spanish troops."³⁸ The article reports that over 800 acres of land are cordoned off for examination of residue radioactive materials. The value of the produce awaiting harvesting is "about \$2 million, which the U.S. will have to pay if all the crops are lost."³⁹ In addition to the cost of the search there are other expenses to be borne. The investigation is not closed and the status of the bases is not clear.

From the few examples that we have discussed it can be seen that the full impact of aircraft accidents is difficult to measure. We can

³⁷Leavenworth Times (Kansas), 30 January 1966, p. 2.

³⁸Richard Oulahan, "The Case of the Missing H-Bomb," Life, Vol 60, Nr 8, (25 February 1966), p. 106B.

³⁹Ibid.

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calculate with accuracy the direct costs of an accident. The indirect or unseen costs are nebulous and difficult to assess. What is clear is that these indirect effects are diverse and potentially very serious. This knowledge gives rise to an uneasy feeling among many safety officers that was aptly expressed by Colonel Daniel M. Lewis, former Chief, Safety Education Division of the Directorate of Flight Safety Research, when he was addressing an Air Force/Industry Conference in 1957. He said:

There is a continual nightmare in this business and it goes like this: Chicken Little, that's the public, is going on down the road and an acorn--that's a B-52--drops on its head. "The sky is falling" the chickens begin to yell--and who can blame them. We've lost a handful of B-52's, a mere five or six--but at eight million dollars a throw, that's 40 to 48 million dollars right there. We have another nightmare in this business that's even worse. A MATS liner--let's say a BRAND NEW DOUGLAS C-133--15 million dollars worth of aircraft--loaded with people--slides into the sea. What then? Or how about the next military aircraft of any vintage of any type, that slides through the next school-yard in America? And this isn't our nightmare alone. It is yours [the aircraft industry] also. Have you ever stopped to think of the implications involved in the crash of a C-135--a military version of the first jet transport to go into passenger service? Need we point out the effect of crashed Comets on the profits of BOAC?⁴⁰

The problem, unfortunately, is likely to continue. As long as aircraft are involved in major crashes, there is the probability public concern and reaction will undoubtedly be adverse. This idea was expressed in an article in a national news magazine in the following way:

For the future, the prospect is that, as long as military planes must fly to defend the country, and as long as military air bases are located in or near metropolitan areas, even the best of safety programs will not eliminate the headlines that chronicle military air crashes from day to day.⁴¹

⁴⁰Lewis, p. 8.

⁴¹"21,000 Accidents, 6,010 Killed in Military Planes," U.S. News & World Report, Vol XLV, Nr 6, (8 August 1958), p. 29.

The point should be clear: a safety program that will reduce the number of aircraft accidents will, perforce, reduce the impact of adverse publicity accompanying the crashes.

Other Adverse Effects

Earlier in this chapter we alluded to the importance and value of time, especially in respect to the time required to train aircrew replacements. Time is important in another way. This is an age of compressed time. Events move quickly and must be acted upon or countered with speed. Our complex, computerized command and control systems were designed specifically to permit decisions to be made with greater speed and facility. We have recognized that time moves inexorably and decisions might be required within the framework of a twenty-minute intercontinental ballistic missile flight.

All of this is well-known and is recounted only to point out that in case of general war it is probable that we would be required to react with those forces immediately available. It is largely for this reason that we have been required to keep large military forces on active duty since the Korean Conflict. We have lost the flexibility of mobilizing and training large numbers of men to meet the immediate needs of a general war. It also suggests that every man killed, every machine, facility, and weapon that is damaged or destroyed in our extant force degrades our posture and critically damages us in terms of a commodity we cannot buy: time.

Our mission, however, continues. If we lose men or machines and cannot immediately replace them, we still must perform the mission despite

reduced resources. Doing a task with less equipment or men than was intended means that the remaining resources must do more than was intended. This leads to inefficiency. Flights must be rescheduled and flown by crews that already have missions assigned. Aircraft will accumulate flying hours at a greater rate and will, in turn, require maintenance and overhaul at shorter intervals. Increased maintenance requirements result in a greater workload for maintenance personnel and a higher consumption of parts. All of these factors increase the cost of fulfilling the same basic mission that was assigned. In brief, it is inefficient.

We should also consider the capacity of the nation to provide the men, money, and materiel to operate an effective national defense system. The tools and people essential to provide a strong military force can be taken from the nation's abundant resources, but at the same time it should be remembered that these resources are not limitless. We cannot have profligateness in their use. There are, for example, only a limited number of men who possess the necessary physical ability, intellectual acumen, interest, and desire to become pilots. Even after careful selection, less than seventy-five per cent are expected to graduate from flight training.⁴² This is only one of many critical resources we must safeguard from unnecessary loss.

There are, of course, investigation and other administrative costs as a result of aircraft accidents. Investigation costs include expenses for tools and equipment, wages, travel, office, and overhead and

⁴²U.S. Department of the Air Force, Program Flying Training (FOUO), PFT 67-1, (Washington: Department of the Air Force, 17 February 1965), pp. I-18, I-18.

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investigation training. Administrative costs include such expenses as survivor benefits, hospitalization, litigation and judgment awards, shipping and storage costs, redesign of parts, increased maintenance time, and other considerations almost ad infinitum. Costs in these areas that are associated with aircraft accidents could, of course, be eliminated if there were no accidents.

Finally, there are political considerations. These can be international as well as national in character. An aircraft, especially a military aircraft, crashing in a foreign land can sometimes be a distinct political disadvantage.

One recalls the international tension and concern over the U-2 incident. The cancellation of the summit conference was but one of the consequences of the loss of the U-2 reconnaissance aircraft in the Soviet Union. The U-2, of course, was shot down and did not crash as a result of the accident. (It is interesting to know, however, that it was shot down only after having descended to a lower altitude because of a malfunction in the oxygen system.) What is revealed by this example, however, is that if we use such aircraft to fly over foreign nation's terrain without their knowledge or permission, the need for a reliable aircraft is paramount. It would be totally unacceptable to have such an aircraft crash in unfriendly territory as a result of an accident.

In January 1966 an SR-71, the aircraft designed to be a successor to the slower U-2, crashed in northeastern New Mexico. The SR-71 is a result of a program started in June 1964 that has cost over one billion dollars. The aircraft, which is reported able to fly in excess of 2,000 miles per hour at an altitude of greater than 80,000 feet, was on a test

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flight when it crashed. One pilot was killed in the accident. Another pilot survived and reported: "everything was going fine and suddenly--whoof!"⁴³ The author does not know the cause of this accident. He merely suggests that we cannot permit any unreliability in the reconnaissance man-machine combination that would allow an aircraft to be flying over unfriendly terrain when "suddenly--whoof!"

We have already discussed the B-52/KC-135 mid-air collision over Spain. In addition to the political turbulence that might be caused by the Spanish Government's refusal to allow U.S. aircraft to overfly Spain with nuclear weapons aboard, there were other political effects. In February 1966, the Soviet Union charged that the United States violated the international agreement which prohibits introducing nuclear contaminants into the atmosphere. While this charge is spurious, it does not prevent the Soviet Union from attempting to achieve maximum propaganda value from the accident.

There is still another observation to make regarding the relationship between accident-free operation and political considerations. When our diplomats are engaged in discussions around a conference table, certainly a part of their ability to reinforce their statements and to maneuver to obtain desirable options is dependent upon the military strength of this country. Every loss in military power reduces to some degree the foundation for convincing and persuasive discussion. This, perhaps, seems remote, but diplomats do depend on a viable military force to lend credibility to their statements made in the international arena.

⁴³"Everything Was Fine And Suddenly--Whoof!," National Observer, Vol 5, Nr 5 (31 January 1966), p. 9.

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A Tentative Look Into The Future

We have recounted the very significant reduction made in aircraft accident rates. Even with these successes we cannot allow ourselves to relax. The accident rate is a reflection of the dynamics of flight itself. So long as we continue to fly, the man-machine-environment will present opportunities for error, and error will eventually lead to accidents. We are still facing many problems which must be solved before we can approach our goal of unqualified success in accident prevention.⁴⁴

The future of aircraft accident prevention is uncertain. The Air Force predicts that the number of accidents will probably rise from the present 4.4 per 100,000 flying hours to 6.5 or even 7.0 in the next few years.⁴⁵ This rise will occur despite the present emphasis on accident prevention. There are several reasons behind this grim prediction.

The first, and most important, cause of the expected increase in the aircraft accident rate is the decreasing level of flight experience of pilots in the Air Force. This conclusion might appear to be a paradox when one reviews recent data without, at the same time, looking at the projection concerning pilot population for the next few years.

The level of pilot experience has varied markedly within the last ten years. In 1955, twenty-six per cent of the pilot population had less than 1,000 flying hours. In 1963, only eight per cent had less than 1,000

⁴⁴Charles L. Wimberly, "The Need For Improved Accident Investigations," An address to the Fourth Annual USAF Safety Congress, at Sandia Base, New Mexico, 26 August 1963.

⁴⁵U.S. Department of the Air Force, Effect of Change in Pilot Population, (Norton AFB, Calif.: Directorate of Aerospace Safety, February 1964), p. 9.

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hours. Again, in 1955, only five per cent of Air Force pilots had flown over 5,000 hours while in 1963 this percentage had increased to seventeen per cent.⁴⁶ These figures indicate that there has been a considerable increase in the level of experience among Air Force pilots. Indeed, the pilot flying time average increased from 2,200 hours in 1953 to 3,500 hours in 1963.

What is the significance of this increased average flight time of pilots? Basically, it means that there should be fewer aircraft accidents. More flying time leads to greater proficiency in flying; this, in turn, results in fewer pilot-induced accidents. The Air Force has discovered that, with rare exceptions, increased flying experience is accompanied by decreasing accident rates.⁴⁷ This conclusion is supported by the accident rate itself, as well as several extensive studies, the most significant of which are those of Zeller and Moseley.⁴⁸ Moseley,⁴⁹ in a study of 2,400 pilot error accidents, and Zeller.⁵⁰ in another study, showed that pilots with 500 to 3,000 flying hours experienced a marked decrease in their

⁴⁶U.S. Department of the Air Force, Effect of Change. . . , p. 4.

⁴⁷Ibid.

⁴⁸Anchard F. Zeller, et al., Current Flying, Age, Experience and Non-Jet Accidents, (Norton AFB, Calif.: Directorate of Aerospace Safety, February, 1963), pp. 1-3.

⁴⁹H.G. Moseley, An Analysis of 2,400 Pilot Error Accidents, A Report presented at the 27th Annual Meeting of the Aero Medical Association, Chicago, Illinois, (Norton AFB, Calif.: Directorate of Flight Safety Research, 1956), pp. 1-2.

⁵⁰Anchard F. Zeller, Current Flying and Accident Potential, A Report presented at the Aerospace Medical Association Annual Convention, Chicago, Illinois, 24-27 April 1961, (Norton AFB, Calif.: Deputy Inspector General for Safety, 19 April 1961), pp. 7-9.

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accident rates.⁵¹

These conclusions appear entirely logical. Flying is essentially a very complex motor skill. The more experience one has in the manipulation and control of the machines, the more he should be able to use the machine effectively and without error.

Unfortunately, this high level of experience is expected to decrease as greater numbers of experienced pilots retire or having their flying requirements waived or exempted.⁵² Increasing numbers of pilots in recent years have been placed in "Code 3" status. "Code 3" is an administrative category which requires that pilots be physically qualified for flight but, at the same time, these pilots are not required to actively participate in flying tasks.⁵³ This means that there is an increasing percentage of new and relatively inexperienced pilots in our operational flying units.

We have already stated that a problem exists in the increasing number of "low-time" pilots. There are certain time-honored correlates which must be considered in our analysis. Two of the best known of these are youth and inexperience. Singly, and more pronouncedly in combination, they are well-known accident cause factors. By the very nature of the human element, there is no escape from these factors.

There is an aphorism which concisely states: "good judgment comes from experience, and experience comes from bad judgment." If this be

⁵¹Emmert C. Lentz, "Human Factors in 'Cause Undertermined' Accidents," Aerospace Medicine, Vol 36, Nr 3, March 1965, p. 220.

⁵²U.S. Department of the Air Force, Effect of Change. . . , p. 4.

⁵³Letter, Flight Safety Division, Deputy The Inspector General, to flight safety officers, no subject, July 1964.

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true then there are many pitfalls on the way to good judgment. It is these pitfalls that give safety officials concern. It is not without reason that insurance companies consistently charge higher rates for male vehicle drivers under twenty-five years of age. This younger population is generally untrained or minimally trained. This will be a "particular problem to the Air Force within the next few years because the balancing seasoned and experienced personnel component has reached the retirement age."⁵⁴

Pilots with less than 1,000 flying hours are generally referred to in the Air Force as "young" or "inexperienced." Only eight per cent of the Air Force's pilots are now included in this "inexperienced" category. By 1968, this percentage is expected to increase to twenty-five per cent or more.⁵⁵ This will approximately equal the same percentage of young inexperienced pilots that the Air Force has in its flying population in 1955 when the aircraft accident rate was 17.1 per 100,000 flying hours. During that year about half of the accidents resulted in destruction of the aircraft involved and one-quarter of the accidents caused fatalities.⁵⁶ This is not to say, of course, that because the inexperienced pilot level increased to the 1955 figure that, ipso facto, the accident rate will equal that of 1955. A great many changes have taken place since 1955 that have helped in reducing the accident rate. A few of these

⁵⁴Anchard F. Zeller, "One At A Time," An address presented at the 54th Air Force/Industry Conference, 16-18 September 1964, at Palm Springs, California, (Norton AFB, Calif.: Directorate of Aerospace Safety, January 1965), pp. 4-5.

⁵⁵U.S. Department of the Air Force, Effect of Change. . ., pp. 8-9.

⁵⁶U.S. Department of the Air Force, 1964 USAF Accident Bulletin, p. 2.

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factors are improved operational procedures, maintenance programs, quality control, accident prevention programs, installation of safety devices, and replacement of single-engine fighters and trainers with twin-engine models.

Because of such factors as retirement of officers, waived and exempted flying requirements, and an increasing use of aircraft that require more than one pilot, the Air Force estimates that there will be a substantial increase in pilot requirements in the next few years. Since 1960, Air Training Command has graduated in the vicinity of 1,400 pilots each year. Unless pilot production far exceeds this level, by 1968 there will be a deficiency of about 6,200 pilots. The number of officers receiving pilot training has already increased and will continue to do so. It is estimated that 2,700 pilots will graduate in 1968. Table 2 below shows an estimate of US Air Force pilot requirements and anticipated production.⁵⁷

TABLE 2
PROJECTED PILOT REQUIREMENTS AND INVENTORY

Fiscal Year	Requirement	Inventory	Over/Under	Comment
1964	41,724	42,176	+ 452	Actual
1965	40,387	38,139	-2248	Actual
1966	38,214	34,730	-3484	
1967	38,440	33,049	-5391	
1968	38,498	32,268	-6230	

Table 3 shows the number of pilots that are expected to graduate

⁵⁷U.S. Department of the Air Force, Program Guide, PG-65-3, (Washington: U.S. Department of the Air Force, June 1963).

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from flight school until 1968.

TABLE 3
PILOT PRODUCTION⁵⁸

Fiscal Year	Nr. Pilots Produced	Nr. Entries
1965	2,015	2,480
1966	1,986	3,604
1967	2,689	3,634
1968	2,698	3,625
1969	2,699	3,625

Not only will the number of young pilots increase but the number of hours which these pilots fly will also increase. It has been Air Force experience that young pilots fly, on the average, one and one-half times as many hours as older pilots.⁵⁹ The records also show that the young (or inexperienced) pilots have about twice the accident rate of the older group of pilots.⁶⁰ It is likely there will be no significant change in ratios by 1968.⁶¹

Concurrent with this large input of inexperienced pilots, the amount of flying time authorized for proficiency flying (which is a minimum hazard category of flying) will be reduced. Approximately seven million flying hours are programmed each year from 1964 through 1968.⁶²

⁵⁸U.S. Department of the Air Force, Programmed Flying Training, PFT 67-1, (Washington: U.S. Department of the Air Force, February 1965), p. I-11.

⁵⁹U.S. Department of the Air Force, Effect of Change. . . , p. 8.

⁶⁰Zeller, Current Flying. . . , p. 2.

⁶¹U.S. Department of the Air Force, Effect of Change. . . , p. 8.

⁶²Zeller, "One At A Time," p. 5.

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This represents a slight yearly increase based on the past five years during which the average annual flying time was about 6.6 million flying hours.⁶³ Inexperienced pilots will be flying a substantial portion of this time.

In recent years, jet fighter and jet trainer flight time has constituted thirty-five to thirty-seven per cent of total Air Force flying. During fiscal year 1968, it is predicted that jet fighter/trainer flight time will constitute nearly one-half (47%) of the total flying hours.⁶⁴ Significantly, the combined accident rates of fighters and trainers has been four times that of all other aircraft combined.⁶⁵ The conclusion is inescapable: we can reasonably expect increased numbers of accidents to accompany the low level of experience coupled with traditionally hazardous fighter/trainer flying.

Not only is it probable that the total number of aircraft accidents will rise, but the total number of fatalities (especially pilots) will increase. Again, inexperienced pilots contribute to the fatal accident rate is an amount disproportionate to their numbers. Based on 1960-1961 data, we find that young pilots⁶⁶ suffer fatal injuries almost twice

⁶³U.S. Department of the Air Force, 1964 USAF Accident Bulletin, p. 2.

⁶⁴U.S. Department of the Air Force, Effect of Change. . ., p. 16.

⁶⁵U.S. Department of the Air Force, 1964 USAF Accident Bulletin, p. 1.

⁶⁶In a study of the pilot population the group is frequently divided into categories based on rank, i.e., lieutenants, captains, field grade, colonels. We find that lieutenants are almost wholly within the "young" pilot category. Field grade officers are almost wholly within the "experienced" category and captains are divided between the two.

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(1.7:1) as frequently as all other pilots. Their fatality rate is well over three times as great as that of field grade pilots.⁶⁷

Another factor makes the future uncertain. Aircraft are becoming increasingly complex and sophisticated. They also fly higher, faster, and weigh more. How do these characteristics affect aircraft accident prevention? First, we should recognize that the factors are interrelated. Increased performance, for example, generally is a result of larger and more powerful engines. Engines which produce more thrust usually use more fuel which, in turn, dictates greater fuel capacity. This results in a larger, heavier, and more complex structure. It follows, almost without exception, that the aircraft becomes more expensive.

Weight, alone, can be important for several reasons. Its importance is associated with kinetic energy, which can be described, essentially, as the result of mass in motion. Consider, for example, the crash of a B-58 which collides with the ground at 600 knots and at a weight of 90,000 pounds. At the instant of impact, 1,296,000,000 foot-pounds of kinetic energy must be dissipated. (This is equivalent to the destructive force of 1,250 pounds of TNT.) This tremendous amount of energy is partially absorbed by the structure of the aircraft and results in almost total destruction of the machine. The massive damage leaves few clues from which an aircraft accident investigator can determine the cause of the accident. If the lack of physical evidence should result in the accident being classified "cause undetermined," little (or no) corrective action can be taken to prevent similar accidents. We thus might suffer several more accidents of the same type before the basic cause(s) is

⁶⁷U.S. Department of the Air Force, Effect of Change. . . , pp. 9-13.

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found and corrected. In an aircraft accident, weight, coupled with speed, will cause high-energy crashes. For this reason, it will probably be more difficult in the future to discover the causes of many of these accidents.

Weight is also important in determining the design characteristics of an aircraft since it largely determines the lift requirements. There are several variables involved but weight generally increases the wing loading of an aircraft. In simple terms, this means that more lift must be developed by the wing to support the weight of the aircraft. This condition leads to higher takeoff and landing speeds unless there are high-lift devices incorporated in the aircraft. Examples of some of the types of high-lift devices currently used on Air Force aircraft are boundary layer control (BLC), leading edge flaps, the more conventional trailing edge flaps, and a variable sweep wing (such as is found on the F-111). These devices not only require increased mechanical complexity but, should they fail, demand a very high degree of pilot skill to land the aircraft safely. The F-104 fighter illustrates the difficulties that such failures cause. The pilot's flight manual states that landing without the trailing edge flaps is considered an emergency procedure and requires that speeds in the traffic pattern be increased forty to forty-five knots above normal. This increase the touchdown speed from 145 knots to 190 knots and requires a runway at least 10,000 feet long. The problem is not solved entirely by a longer runway. The increased kinetic energy, developed as a result of the higher approach speed, must be dissipated to stop the aircraft. This can be done in one of several ways: aerodynamic braking, drag parachute or wheel braking. Aerodynamic braking is most effective

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only during the upper twenty per cent of the landing speed.⁶⁸ The remaining speed must be dissipated by conventional wheel braking or drag parachute devices, or both. This puts a severe strain on the brakes, tires, and landing gear and can cause their failure during the emergency landing.⁶⁹

Performance augmentation systems, an example of which is the high lift device, constitute only one group of the many systems on modern aircraft whose failure may cause great difficulty or hazard for the pilot. Other systems include stability augmentation, ratio changes and auto-trims, engine afterburner and compressor controls, engine air duct controls, inertial navigation systems, air data computers, and complicated air, hydraulic, fuel, and electrical systems. All of these systems not only add to the cost, complexity, and weight of the aircraft, but they significantly increase the pilot's workload and requirements for attention.

It might seem anomalous to suggest the future aircraft will require not only improved performance but simplification as well. The two are not really incompatible; indeed, they are necessary.⁷⁰ By simplification, we refer to a better arrangement and combinations of new and existing flight and engine instruments, gages, valves, switches, levers, buttons, wheels, knobs, and gadgets that fill the interior of any modern aircraft; in short, we need a better understanding and application of the principles of human engineering and the interrelationship of the man-machine combination.

⁶⁸Harry H. Hurt, Jr., Aerodynamics For Naval Aviators, (Los Angeles: University of Southern California, 1960), p. 195ff.

⁶⁹Ibid.

⁷⁰Paul Evans, Aviation Physiology, (Los Angeles: University of Southern California, 1956), pp. 4-5.

In this age of rapidly increasing technology we dare not forget that man has many limitations, some of which are rather severe. In Chapter IV we shall discuss more fully some of man's physical, psychological, and physiological limitations. It is sufficient here to suggest that man can only see so well, hear within a limited range of frequencies, and can learn only so fast and so much; he is affected by atmospheric pressures, gravity forces, noxious substances, and a variety of other environmental conditions. The Director of Aerospace Safety has stated that we have reached the level of technical competence to produce an aircraft that can exceed the control ability of the pilot.⁷¹ Unless we take this fact into consideration when designing an aircraft, we can produce an impasse in accident prevention due to excessive demands on the pilot.

Another factor that will compound the problems of the future is the trend toward an increasing percentage of accidents resulting in fatalities and totally destroyed aircraft. Simply, accidents are more serious today than a few years ago. In 1957, for example, fifty-five per cent of the aircraft involved in accidents were destroyed. By 1962, out of 100 accidents, eighty aircraft were destroyed. In other words, while there is less chance of being involved in an aircraft accident (due to the decrease in the total number of accidents) the chances are (when an accident does occur), that in four out of five cases, the aircraft will be destroyed.⁷²

The trend toward increasing severity in aircraft accidents also

⁷¹Ibid.

⁷²Donald H. Frank, (Chief of Bomber/Transport Branch, Flying Safety Division, Directorate of Aerospace Safety), untitled speech, (Norton AFB, Calif.: Directorate of Aerospace Safety, n.d.), p. 10.

reveals itself in the number of fatalities. The percentage of aircraft accidents that involve fatalities is increasing.⁷³ One out of three accidents now results in a fatality.⁷⁴ It should be noted that the number of fatal accidents remained fairly constant during the years prior to 1954. That year the aircraft accident rate began a precipitous decline. The fatal accident rate, on the other hand, remained relatively constant.⁷⁵ Intensive efforts by the Air Force since 1954 reduced the rate to 1.6 fatal accidents per 100,000 flying hours.

It is difficult to determine if this trend will continue. If it should, we are approaching an all-or-nothing concept.⁷⁶ That is, a mishap will either result in little or no damage or will culminate in a destroyed aircraft and fatalities.

Another problem associated with the increasing complexity of aircraft is the growing frequency of accidents attributed to materiel failure. The trend indicates a decreasing percentage of accidents due to pilot factor and an increasing percentage in accidents caused by materiel failure.⁷⁷ Thirty-one per cent of the aircraft accidents in 1964 were said to have been caused by pilots and thirty-nine per cent were attributed to a

⁷³Ibid.

⁷⁴U.S. Department of the Air Force, Summary and Evaluation of Aircraft Accidents and Fatalities, (Norton AFB, Calif.: Directorate of Aerospace Safety, n.d.), p. 4.

⁷⁵Ibid. p. 2.

⁷⁶U.S. Department of the Air Force, Summary and Evaluation of Aircraft Accidents and Fatalities, 1 Jan 58 through 31 Dec 1962, (Life Sciences Group), (Norton AFB, Calif.: Directorate of Aerospace Safety, n.d.), p. 2.

⁷⁷Wimberly, p. 1.

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materiel factor.⁷⁸

Some reasons for the decline in pilot factor accidents include the following: (1) improvement in the quality of flying personnel through more careful selection, better and increased amounts of training; (2) closer supervision and enforcement of flying regulations; (3) improvement in the mechanical reliability of aircraft, and increase in their structural strength; (4) better maintenance; (5) development of numerous aids to assist the pilot; and (6) medical research, which has aided in understanding human reliability and the capabilities and limitations of man.⁷⁹

When dealing with percentages as they relate to aircraft accident prevention, there must always be an increase in some category of cause factor to account for reduction in others. In analyzing aircraft accident causation, the percentage of accidents caused by materiel failure is increasing. Some of the possible explanations for this increase are: (1) better investigation and recognition of causes through increased knowledge; (2) change in reporting and classifying procedures; (3) increasing complexity of aircraft; and (4) increasing age of certain types of aircraft being flown.⁸⁰

Future roles and missions of the Air Force will also affect the aircraft accident rate. The author does not have the prescience to determine specific force levels, or roles and missions of the Air Force

⁷⁸U.S. Department of the Air Force, 1964 USAF Accident Bulletin, p. 1.

⁷⁹Evans, p. 4.

⁸⁰U.S. Department of the Air Force, Summary and Evaluation . . . , p. 5.

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in coming years. There are, however, trends that would lead one to some conclusions as to the possible impact of these changes on flight safety.

There is a trend toward increased reliance on a strategic missile force with a concurrent decrease in the manned bomber fleet. Although procurement will begin on the B-111 (a modification of the TFX which is scheduled to replace the B-52 and B-58), the main emphasis is on a large force of Minuteman and Titan II missiles. By fiscal year 1968, it has been announced that the Air Force should have approximately 1,000 missiles standing alert in fifty squadrons.⁸¹

The number of tactical fighter aircraft is growing (adding about 1,400 F-4Cs alone, for example) along with expanding airlift requirements. Additional funds were requested in the current budget to step up the production of the C-141 and to continue development of the C-5A. There is also interest in developing an aircraft solely for counterinsurgency purposes.⁸²

The changing emphasis on missions and the composition of the force structure leads to several tentative conclusions. An important consideration is the expected decrease in the number of Air Force aircraft. In 1961 there were 16,905 aircraft in the inventory. This number dropped to 14,875 in June 1965. Despite an increasing number of fighters and transport aircraft being manufactured, the total number of Air Force aircraft is expected to continue to decline to an estimated 14,042 in June 1966, and to 13,785 in June 1967.⁸³ The number of aircraft is decreasing

⁸¹"Record \$70 Billion Asked for Arms," Air Force Times, Vol XXVI, Nr 25, 2 February 1966, p. 1ff.

⁸²Ibid., p. 26.

⁸³Ibid., p. 26.

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due to the reduction in strategic bombers and the retirement of obsolescent aircraft of other types. The net result of the changing force structure is similar to the result of other factors we have discussed: an increasingly expensive (as a result of greater unit cost) and complex fleet of aircraft. Additionally, in the case of fighter aircraft, they will be intrinsically more hazardous to fly.

Air Force records show that fighter aircraft experience about four times as many accidents as other aircraft.⁸⁴ In 1964, for example, fighters were involved in 209 of the 295 jet aircraft accidents.⁸⁵ The disproportionate accident rate of fighter/trainers may be partially offset in the future due to the fact that most of our newer fighter/trainers are twin-engine models. In the past most of this type of aircraft were single-engine types. Comparison of current accident statistics indicates that twin-engine models of fighter/trainer aircraft have a decidedly lower accident rate. However, all new models tend to have relatively high accident rates and jet fighter/trainer operations will by their very nature result in an accident rate substantially above that of other aircraft.⁸⁶

Brig Gen Jay T. Robbins, Director of Aerospace Safety, gave voice to the Air Force's recognition of the problems brought about by these changes. In an address to the Fourth Annual USAF Safety Congress in 1963, he said:

⁸⁴U.S. Department of the Air Force, 1964 USAF Accident Bulletin, p. 1.

⁸⁵Ibid., p. 2.

⁸⁶U.S. Department of the Air Force, Effect of Change. . ., p. 16.

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. . .I believe there are two things which have pushed us down what I consider a relatively new road--technological advancements and the ever-changing posture and characteristics of our military forces. During the past few years they have wrought very significant changes in our military mission, our equipment, and our theories of operation and training. It would be remarkable indeed if in the face of all this change, safety had remained the same. Of course, it has not and could not.⁸⁷

More recently, Colonel Charles L. Wimberly, Chief of the Education Division of the Directorate of Aerospace Safety, in a letter to all flight safety officers, echoed the same theme:

Currently complex weapon systems, changing requirements and varied operating environments greatly increase the AF accident potential. In spite of these adverse factors, the overall AF accident rate has decreased to its lowest point in history.⁸⁸

In summary, some of the problems the Air Force will face in the next few years in aircraft accident prevention are these: (1) there will be a significant increase in the inexperienced pilot population and the percentage of the total flying hours flown by these pilots; (2) there will be a changing force structure and mission emphasis which will result in a reduced bomber force and an increase in fighter and transport operations; (3) there will be a programmed reduction in flying time authorized for proficiency purposes; and, (4) finally, aircraft will become increasingly complex and sophisticated.

The Directorate of Aerospace Safety has examined the problems that might be faced in the future and has made tentative predictions about accidental aircraft losses in two problem areas: those resulting from the

⁸⁷Jay T. Robbins, "The Changing Role of Aerospace Safety," An address to the Fourth Annual USAF Safety Congress, at Sandia Base, New Mexico, 26 August 1963.

⁸⁸Charles L. Wimberly, A letter to all flight safety officers, (Norton AFB, Calif.: Directorate of Aerospace Safety, July 1964), p. 1.

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increase in inexperienced pilot population and those resulting from the increase in jet fighter/trainer flying operations. These predictions, which are forecast for the next several years were based on the assumption that the present aircraft accident prevention program would be fundamentally unchanged. The results of this study are summarized in the tables below.

TABLE 4

TOTAL PROJECTED INCREASES IN AIRCRAFT ACCIDENTS
(FY 1964 THROUGH FY 1968)

Reason For Increase	Nr Accidents	Aircraft Destroyed	Loss (Millions of dollars)
Shift in pilot population	322	256	322
Increased per cent of jet fighter/trainer flying operations	63	51	63
TOTAL	385	307	385

TABLE 5

FIVE YEAR ESTIMATES IN AIRCRAFT ACCIDENTS INCLUDING
PROJECTED INCREASES DUE TO SELECTED FACTORS
(FY 1964 THROUGH FY 1968)⁸⁹

Reason For Increase	Nr Accidents	Aircraft Destroyed	Loss (Millions of dollars)
Accidents occurring at present rate	1,750	1,400	1,750
Additional increase due to selected factors (See Table 4 above)	385	307	385
TOTAL	2,135	1,707	2,135

⁸⁹U.S. Department of the Air Force, Effect of Change. . ., p. 18.

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The magnitude of the inexperienced pilot problem is clearer when it is noted that the Air Force prediction of the net cumulative increase in accidents, due to this problem alone, is 322, and these accidents will result in the loss of at a cost of \$322 million through 1968. These figures were based on the anticipated increase of flying activity by greater numbers of pilots with a low experience level (and a high accident potential). It is expected that four out of five of the aircraft involved in these accidents will be destroyed.

The foregoing data were arithmetically projected based on the most recent Air Force aircraft accident experience and trends. They should be considered as a very conservative analysis of the available facts because they do not account for planned reductions in proficiency flying, the possibility of new and more hazardous mission assignments, the increasing complexity of modern aircraft, the fact that student pilots (non-rated) with a very high accident potential are implicitly included in the low experience group, and, finally, (it should be understood) that minimal costs were used in the calculations.⁹⁰

The predictions (based on the data) presented paint a grim picture. We can foresee increasing aircraft accident rates, higher percentages of aircraft totally destroyed, still higher direct and indirect accident costs, and more pilot fatalities.⁹¹

The central theme in this chapter should be self-evident: the Air Force must have an effective aircraft accident prevention program. The price of anything less than a maximum effectiveness of such a program

⁹⁰Ibid., p. 19.

⁹¹Ibid., p. 2.

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is too great to be ignored or passed over lightly. We have made great improvements in the speed, range, altitude and mission capabilities of our aircraft, enabling us to have a superior defense force and greater national security. All of this costs a great deal and obligates us to account for this investment. In the 1967 fiscal year budget the Department of Defense is asking for \$58.3 billions, of which the Air Force is slated to receive \$19.8 billions. Certainly it follows that our nation is entitled to an Air Force that represents the maximum in deterrent effect for the dollars spent. We can provide the "dividends" on this investment by continually striving to provide the maximum in-being force of operationally ready aerial weapons systems functioning at peak effectiveness. We cannot accept monumental losses due to aircraft accidents and still fulfill this obligation.

The Inspector General, USAF, expressed this view when he said:

In view of the greatly expanded cost of modern fighting aircraft and the highly trained crews which man them, every expediency must be adopted, every last vestige of imagination and ingenuity applied, and every effort exerted to eliminate those accidents which can be categorized as preventable. The public welfare, as well as national security, is of concern to us as we approach the problem of reducing aircraft accidents.⁹²

The goal is clear: "prevention of avoidable aircraft accidents is essential to the successful accomplishment of the Air Force mission."⁹³

Purpose of Thesis

Before going further, perhaps it would be well to briefly discuss

⁹²U.S. Department of the Air Force, Report of Worldwide USAF Safety Conference, (Norton AFB, Calif.: Directorate of Flight and Missile Safety Research, 1959), p. 4.

⁹³U.S. Department of the Air Force, Accident Investigation, AFM 62-5, (Washington: U.S. Government Printing Office, 1956), p. iii.

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the basic purpose of this thesis. The author would emphasize at the outset that he thinks the Air Force flight safety program has been effective, not to the extent that it might have been or can be, but nevertheless, effective. Most of the indicators of an effective accident prevention program confirm the basic soundness of the methods and the diligence of the efforts of flight safety personnel: the number of accidents are decreasing, fatalities have been reduced, and accident rates are smaller. It is, simply stated, safer to fly in the Air Force than ever before. Indeed, one could expect to fly 22,728 hours without being involved in an accident (this is the equivalent of about five flying careers).⁹⁴

There are countertrends, however. The cost of aircraft accidents, as we have already noted, is increasing. The improvement in accident rates is showing signs of stagnation. The improvement in accident prevention which we have experienced in recent years is beginning to level off. One of the reasons for this apparent stagnation is that it is unquestionably easier to reduce the accident rate from twenty to ten than it is from five to zero. Even one point gain in the accident rate at the current low level represents a major achievement.⁹⁵ This idea was expressed by Major General Joseph D. Caldara, former Director of Aerospace Safety, in an address to a graduating class of flight safety officers at the University of Southern California, when he said:

I am the first one to recognize that the lower the accident rate gets, the more difficult it becomes to lower it further and this results in

⁹⁴"Pilot's Deaths Decrease, Accidents Rise," Air Force Times, Vol XXV, Nr 34, 7 April 1965, p. 4.

⁹⁵U.S. Department of the Air Force, USAF Mid-Air Collisions, (Norton AFB, Calif.: Directorate of Flight Safety Research, November 1958), p. 5.

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the concern for the steadily diminishing safety improvement rate.⁹⁶

The same idea was expressed in a recent publication by the Directorate of Aerospace Safety in these words:

In any activity that demonstrates a prolonged period of continuous improvement, a slowing down or a plateau--a period of no improvement-- is inevitable. This is true because of the law of diminishing returns and because of human fallibility. We can anticipate from extrapolation that soon accidents will be so infrequent that yearly differences in accident rates will be a matter of chance variation and will be insignificant. This means that the Air Force Flying Safety Program is rapidly reaching the point where improvement will be in small increments or will be at a standstill, unless new elements are introduced into the program or heavy accent is placed on familiar existing elements.⁹⁷

This observation is supported by statistics. There has been a significant reduction in the number of accidents per 100,000 flying hours since 1955. In 1955 the accident rate was 17.1; in 1963 and 1964 it was 4.4. On the other hand, it should be noted that there has been relatively little reduction during the last five years of this ten-year period (the rate was 5.8 in 1960). More importantly, in 1963 and 1964 the rate was stable, and in 1965 it rose slightly to 4.5. It would appear that the conclusion reached by General Caldara and the more recent Air Force report is accurate.

In simplest terms, it appears that the present Air Force aircraft accident prevention program is arriving at the alluded to point of diminishing returns. That is to say, the safety program is failing to continue to force the accident rate downward and thus will require new

⁹⁶Joseph D. Caldara, "The Diminishing Safety Improvement Rate," Alumni Review (University of Southern California), Vol I, Nr 1, Summer, 1964, p. 1.

⁹⁷Reuben A. Baer and Kenneth E. Pletcher, Survey of USAF Pilot Attitudes Toward Air Traffic Control Services, (Norton AFB, Calif.: Directorate of Aerospace Safety, July 1961), p. 4.

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emphasis or direction in order to restore its effectiveness and continue to reduce losses.

How should this be accomplished? The Air Force has recognized the problem, however, rather meager guidance is offered as to an effective solution. One view is that the accident rate will continue to remain at the present level "unless new elements are introduced into the program or heavy accent is placed on familiar existing elements." The need for new ideas in order to achieve success is supported by an aeronautical research laboratory chief who said:

Economics [demands] that there must be a basic innovation in safeguard procedure if a further improvement [is] to be achieved in a reasonable time and at a reasonable cost. Without this innovation, the prospect of much improvement after about 1970 [is] very poor. The rate of improvement of air safety will continue to diminish so long as further improvement is sought principally by the more traditional means.⁹⁸

Proponents of the "more traditional means" of achieving an acceptable accident rate suggests that improvement might be obtained by a little-tried, yet feasible, approach consisting of improvement in areas that are assumed or generally thought to be satisfactory.⁹⁹ The idea, of course, is to refine an already good operation into one of near perfection.

So far, these points have been established: (1) the rate of improvement in flight safety is steadily diminishing; (2) the cost of accidents is increasing; and (3) the present safety program is showing signs of impotency in its ability to further depress the accident rate.

⁹⁸Caldara, ". . .Diminishing Safety. . .," p. 1.

⁹⁹U.S. Department of the Air Force, Survey of Air Traffic Controllers Toward Pilot Assistance in Air Traffic Control, (Norton AFB, Calif.: Directorate of Aerospace Safety, March 1964), p. 3.

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The fundamental aim of this thesis is to suggest several "new elements" and improvements in "familiar existing elements" in an effort to enable the Air Force to prevent additional aircraft accidents. The author would emphasize, in this regard, that an effective aircraft accident prevention program is very wide-ranging and complex. It includes considerations from the design and fabrication of an aircraft to its retirement. It is concerned with the intricacies and variations of man; his selection, motivation, limitations, and functions. To be balanced, it must include such factors as weather, missions, the operational environment, and a multitude of other facets. It would be a sizeable task to know thoroughly, much less write about, all the aspects of such a program.

Thus, in order not to be presumptuous and incomplete, we must arbitrarily limit our discussion and examination of the Air Force aircraft accident prevention program. In general, the discussion is approached from the operational/wing-staff level flight safety officer's viewpoint. It is centered around problems associated with the man-machine-environmental combination. The focus of the paper is to attempt to give voice to a concept that will achieve the optimum relationship between mission accomplishment and accident-free operation in Air Force flight operations.

The scope and complexity of the items constituting a dynamic and effective flight safety program preclude an in-depth discussion of its entirety. Some considerations will be discussed fully, others will be mentioned indirectly and by suggestion, still others will not be discussed at all. The author does not possess sufficient perspicacity to develop an entirely new accident prevention program. Indeed, a program severed from tradition and our present foundations would be neither necessary nor desirable. What is offered are several suggestions that involve a change

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of emphasis coupled with several new procedures and concepts. This supplement to the present prevention program, it is hoped, will increase the success of the Air Force aircraft accident prevention program.

Definitions and Limitations

Before continuing with the discussion of the Air Force flight safety program, it would be well to define several terms that we will be using in the remainder of the thesis. A clear understanding of these terms is necessary because the Air Force system of reporting and classifying aircraft mishaps is largely based on a precise use of these terms.

The first word we shall define is "accident." In the Air Force, an accident is

an unexpected or unsought event that does damage to persons or property and is not caused by enemy action. . .this term is used in specific contexts as it relates to aircraft, explosives, ground missile, and nuclear mishaps. The specific terms that apply in each safety area are stated in AFR 127-4 "Investigating and Reporting USAF Accidents/Incidents."¹⁰⁰

To emphasize the specific application of this word in Air Force usage, notice that in order to be classified as an accident, an aircraft mishap must result in damage. The reporting system is thus focused on damage rather than hazard. The effect of this factor on the effectiveness of the accident prevention program will be pursued in a later chapter. Notice also that the definition specifically excludes losses due to enemy action. Accident statistics, therefore, include only non-combat losses. This is important to remember when statistics reflecting the number of aircraft destroyed or the cost of accidents appear in the text of the paper

¹⁰⁰U.S. Department of the Air Force, Investigating and Reporting USAF Accidents/Incidents, AFR 127-4 (Washington: U.S. Government Printing Office, 25 February 1963), p. 2.

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"Aircraft" are defined by the Air Force as "all manned weight-carrying devices or structures designed to be supported in flight by buoyancy or dynamic action."¹⁰¹ The term accident includes both manned and unmanned (drone) vehicles.

An "aircraft accident" is defined as:

a mishap which results in minor/substantial damage to, or destruction of an Air Force aircraft; which results in fatality(s) or major injury(s);. . .which results in fatality(s) or major injury(s) caused by parts/stores dropped from aircraft in flight; or which results in property damage over \$10,000, caused by parts/stores dropped from aircraft in flight.¹⁰²

Aircraft accidents are divided into two categories: flight; and non-flight. An "aircraft flight accident" is a mishap which "results in minor/substantial damage to, or destruction of, one or more USAF aircraft, when intent for flight exists."¹⁰³ An "aircraft non-flight accident" is a mishap resulting in "minor/substantial damage to or destruction of an Air Force aircraft not in operation, or in operation when no intent for flight exists."¹⁰⁴ Unless otherwise noted in the text, all aircraft accident data shown in this thesis are for flight accidents only.

To indicate the severity of a mishap, aircraft accidents are termed either "major" or "minor." A mishap is classified as a major accident when the aircraft is destroyed or receives substantial damage.¹⁰⁵

An aircraft is "destroyed" when it has been damaged to the point

¹⁰¹Ibid., p. 3.

¹⁰²Ibid.

¹⁰³Ibid., pp. 3-4.

¹⁰⁴Ibid., p. 4.

¹⁰⁵Ibid., p. 5.

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of possessing no further value except for possible salvage of parts. It includes reparable aircraft which must be abandoned or salvaged because of impracticability of moving the aircraft from the scene of the accident, or because the man-hours or cost of repair exceeds the standards for economical repair.¹⁰⁶

"Substantial" damage results when damage to a major component requires its removal and replacement with a new component, or when the total man-hours to remove, repair, and replace the damaged component(s) exceeds a man-hour limitation for the specific type and model of aircraft as outlined in AFR 127-4. What constitutes a "major component" is itself a rather complex issue, but in general, this includes such items as wing center sections, vertical stabilizers, slab tails, helicopter rotor heads, and landing gear.¹⁰⁷

"Minor accidents" are mishaps that, logically, result in minor damage. "Minor damage" is damage which is less than "substantial" but is sufficient to exceed a specific number of man-hours for repair for the type and model of aircraft as outlined in the regulation.¹⁰⁸

A "fatal accident" is one in which any person receives fatal injuries. A "fatal injury" results in death due to major injuries or complications arising therefrom, regardless of the length of time intervening between receiving the injury and death.¹⁰⁹ The statistics in this thesis include all persons killed and/or missing as a result of US Air Force

¹⁰⁶Ibid.

¹⁰⁷Ibid., p. 5ff.

¹⁰⁸Ibid.

¹⁰⁹Ibid., p. 2.

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aircraft accidents. Statistics which show pilot fatalities include only US Air Force rated pilots.

A "major injury" is one which requires hospitalization and medical treatment for five or more days, or injury which results in unconsciousness, fractures (except simple fractures of the nose, fingers, or toes), lacerations involving muscles or which cause severe hemorrhages, injuries to internal organs, or second/third degree burns to more than five per cent of the body.¹¹⁰

A "minor injury" is one which requires a person to be marked "sick in hospital" or "sick in quarters" for more than a day (but less than four days), or which results in a simple fracture of the nose, fingers or toes.¹¹¹

An "accident rate" is a statistical device used to measure the accident experience of the Air Force. It is computed on the basis of the number of accidents occurring per 100,000 flying hours or 100,000 landings. The formula is: $\text{Rate} = \text{accidents} \times 100,000 \div \text{flying hours (landings)}$.

Almost all mishaps involving Air Force aircraft, other than major or minor accidents, are classified as "incidents." Specific exceptions are made for mishaps involving aircraft undergoing research and development testing, damage due to enemy action, failures due to "fair wear and tear," and intentional jettisoning of doors, hatches, tanks, canopies, and other externally carried items.¹¹²

After investigation of an aircraft mishap, the investigating

¹¹⁰Ibid., p. 3.

¹¹¹Ibid.

¹¹²Ibid., pp. 4-5.

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officer is required to determine the cause factors. He may select from ten causative factors: (1) Operator error; (2) crewmember error; (3) supervisory personnel error; (4) maintenance personnel error; (5) other personnel error; (6) materiel failure or malfunction; (7) airbase or airways; (8) weather; (9) miscellaneous unsafe conditions; and, (10) undetermined.

He must also decide the relative importance of each cause factor by determining a "primary cause" and as many "contributing causes" as he thinks are necessary. "Primary causes" are defined as "those factors which made the mishap most likely or inevitable." "Contributing" causes are "those acts, events, conditions, or circumstances which when considered by themselves did not cause the mishap but increased the likelihood of its occurrence."¹¹³

It can be seen from this discussion that a term like "accident" which appears to have a simple meaning, is really quite complex and involved when it is applied to an Air Force mishap. Perhaps an example will illustrate how a determination is made in a specific mishap. Suppose a B-52 and a KC-135 collide while engaged in aerial refueling. A wide range of possibilities of damage is present from something so slight as a scratch to the complete destruction of one or both aircraft.

If either of the aircraft were destroyed, a major accident, obviously, would have occurred. If either received substantial damage (in this case, 900 man-hours for repair of either aircraft, as stated in an attachment to the regulation) the mishap would be classified as a major

¹¹³U.S. Department of the Air Force, Aircraft Accident/Incident Report, AF Form 711b, (Washington: U.S. Government Printing Office, December 1962), p. 2.

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accident. If the aircraft received damage requiring at least 150 man-hours for repair but less than the 900 hours stated above it would be classified as a minor accident unless there were damage to a major component sufficient to require its replacement. If such were the case, the mishap would be a major accident regardless of the man-hours involved. Finally, if the damage were less than 150 man-hours and a major component were not involved, it would be classified and reported as an aircraft incident.

The terms we have defined do not exhaust the list of special meanings in the vocabulary of the flight safety officer. They are sufficient, however, to serve as a basis for the effective communication of ideas in this paper. They also suggest the relatively complexity and specificity of the classifying and reporting system.

One note of caution before we conclude the chapter. Statistics should always be examined with judiciousness. It is as true in this thesis as it is elsewhere. The author, of course, has attempted to be honest and objective in his use of statistics. But statistics themselves are susceptible to inherent and subtle deficiencies. Those that deal with aircraft accidents, for example, are the synthesis of hundreds of individual events, investigated by thousands of officers, in all parts of the world and under varying environmental and organizational pressures. In an attempt to avoid oversimplification of a complex area, it should also be pointed out that these data are fraught with the possibilities of changing classifications and interpretations.

There have been changes in definitions and in the classification and reporting system. This, in itself, probably has contributed to the

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decline in major accidents.¹¹⁴ It is sufficient to say here that statistics should be used as a "yardstick" of performance to measure the aviation hazard experienced.¹¹⁵ As a statistical device the rate allows us to follow what is happening over an extended period of time.¹¹⁶

With these preliminary considerations completed, we are now ready to examine in greater detail the history of aircraft accident prevention and the present Air Force flight safety program.

¹¹⁴U.S. Department of the Air Force, Summary and Evaluation. . ., p. 2.

¹¹⁵U.S. Department of the Air Force, Special Report 31-56, Testimony of Gen Caldara Before the House of Representatives, (Norton AFB, Calif.: Directorate of Flight Safety Research, 1956), p. 2.

¹¹⁶Joseph D. Caldara, Impact of USAF Aircraft Accidents, (Norton AFB, Calif.: Directorate of Flight Safety Research, 1956), p. 2.

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CHAPTER II

A SHORT HISTORY OF USAF AVIATION SAFETY

Man's first successful attempt at flying a heavier-than-air, powered machine occurred on 17 December 1903 over the sandy dunes near Kitty Hawk, North Carolina. Wilbur and Orville Wright had finally succeeded in building a craft that would leave the earth under its own power. They thus served, as it were, in the capacity of midwives at the birth of the age of powered flight. While they undoubtedly gave it little thought, the need for flight safety was born at the same time. Aviation and flight safety came into the world as twin brothers and have been closely associated since that day.

While the Wrights were eating lunch following their successful flight, they were contemplating a four mile flight along the Atlantic coast. The day had been cold and raw and a gust of wind came up and upset their machine. A bystander, John T. Daniels, who was close to the machine, grabbed it in a futile attempt to prevent it being turned over. He was unable to do so; the machine turned over several times and caused Mr. Daniels to be severely bruised. He, thus, became the air age's first casualty as a result of an aircraft mishap. The machine was so badly damaged that it never flew again.¹ The events of that winter day presaged

¹Carroll V. Clines, Compact History of the United States Air Force, (New York: Hawthorn Books, 1963), p. 50.

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the future of aviation: flying, injury, and damage to property were to be closely related to one another.

History recorded, then, on 17 December 1903, the first successful flight in a powered heavier-than-air craft, the first aircraft mishap, the first casualty caused by a powered craft, and the first lesson to be learned in flight safety: If you do not want your aircraft to be damaged by the wind, tie it down.

The first aircraft accident involving military personnel occurred on 17 September 1908 at Fort Myer, Virginia. Mr. Orville Wright, in one of the first Wright "Flyers," was flying his machine before a number of officers from the Signal Corps as a part of a series of acceptance test flights for the Army. Lt. Thomas F. Selfridge was aboard in the capacity of an official observer. The aircraft was circling above the parade ground when, without warning:

. . . one of the props broke, the machine being at that time about 75 feet from the ground. The machine side-slipped and nosedived, striking the ground with such force as to fatally injure Lieut. Selfridge and break Mr. Wright's leg. Cause of the accident: Breaking of the propeller and consequent loss of lift in the machine. Lieutenant Selfridge's death can in no way be connected with any question of the type of machine or skill of pilot.²

It was a grim historical paradox that the first military man to fly in a powered heavier-than-air craft should also be the first to die in an aviation accident. Mr. Wright was not able to fly for more than a year because of his injuries.

It was a tragic beginning; many military aviators were to die in future years as a result of preventable aircraft accidents. The first

²Memorandum, Chief Signal Officer, USA to Chief of Staff, Subject: "Mortality in Army Aviation," 28 February 1914, p. 1.

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few years of Army aviation were to prove to be especially hazardous. From 17 September 1908 until early February 1914, the Army's air arm, which was under the Signal Corps, suffered heavily because of accidents. During this period there were eleven fatal crashes which resulted in the death of twelve officers, one non-commissioned officer, and one civilian.³ An insight into the frequency of these accidents can be obtained when one realizes that in 1911 only 64.83 hours were flown between fatal accidents. In 1912 the number of hours between fatal mishaps increased to 74.98, and in 1913 it was up to 105.56 hours.⁴ Neither pilots nor their craft flew very long before they met with destruction. This ratio of fatalities to hours flown can be compared with current losses of one person for each 22,728 flying hours.⁵ Table 6 below shows the flying experience of the pilots involved in the eleven fatal accidents mentioned above, while Table 7 shows the age of the aircraft that were involved in the same crashes.

³Ibid., p. 3.

⁴Ibid., p. 13.

⁵"Pilot's Deaths Decrease, Accidents Rise," Air Force Times, Vol XXV, Nr 34 (7 April 1965), p. 4.

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TABLE 6

EXPERIENCE OF PILOTS KILLED IN EARLY ARMY AIRCRAFT ACCIDENTS^a

Name of Pilot	Hours in Air	Total Nr of Flights	Certificate
Lt. G.E.M. Kelly	No record	No record	No record
Lt. Rockwell	13.40	100	P
Lt. Park	36.98	175	P-MA
Lt. Call	16.98	53	No record
Lt. Love	12.25	52	P
Lt. Rich	21.58	60	P
Lt. Ellington	86.85	469	P-MA
Lt. Post	59.83	245	P-MA

P--F.A.I. Pilot

MA--Military Aviator

TABLE 7

NUMBER OF FLIGHT HOURS AND FLIGHTS OF AIRCRAFT
INVOLVED IN EARLY ARMY AIRCRAFT ACCIDENTS^b

Type of Aircraft	Flight Hours	Number of Flights
Original Wright*		
Curtiss D	Record incomplete	Record incomplete
Wright C*		
Wright B	26.03	149
Curtiss Flying Boat	21.60	59
Curtiss D	Record incomplete	Record incomplete
Wright C	23.68	132
Burgess	31.40	178
Wright C	8.10	68
Wright C	.21	2
Wright C	10.40	49

*Not property of government; undergoing acceptance tests.

^aChief Signal Officer to Chief of Staff, 28 February 1914, p. 15.^bIbid., p. 14.

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In retrospect, a modern aircraft accident investigator would probably conclude that the accidents were a result of a combination of factors including the distinct lack of experience of the pilots and the primitive construction of the flying machines. The conclusions which were drawn at the time, however, were quite different. In a memorandum to the Chief of Staff, the Acting Chief Signal Officer of the U. S. Army said:

. . . It is evident that the machines in which the accidents occurred were not old and the pilots were not novices. . . . In my opinion, nearly every one of the above accidents was due to the pilots and not to the machines.⁶

Beginning with the first accident a board of officers was convened to investigate the mishap, find its cause, and make recommendations to prevent future and similar accidents. This practice continues to the present day. To assist investigation boards in their tasks, rudimentary records were maintained listing such information as the names of the pilot and passenger, type of aircraft, flying time, and altitude reached during the flight. It was hoped that such records might offer a clue to the cause of future accidents.⁷

As a result of some of these early investigations it was concluded that the aircraft were structurally weak and needlessly complex! As early as February 1911, attempts were already being made to simplify aircraft design as well as to build them stronger to resist the effects of poor airmanship.⁸

As the First World War approached, Army aviation began to grow.

⁶Memorandum, Chief Signal Officer, p. 15.

⁷Ibid., p. 11.

⁸Claude Grahame - White and Harry Harper, The Aeroplane; Past, Present, and Future, (Philadelphia: Lippincott Co., 1911), p. 106.

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On 18 July 1914 the Aviation Section of the Signal Corps was formed, indicating the increasing importance of Army aviation. Along with its growth came increasing frequency and severity of accidents. On 17 August 1917, the first major U.S. military mid-air collision occurred. This accident happened while training pilots to participate in World War I and was the first of a very large number of mid-air collisions to follow it. Indeed, those who think that mid-air collisions are a product of recent aerial congestion will probably be surprised to learn that in 1918 there were forty-five mid-air collisions resulting in twenty-two fatalities.⁹ This large number of mid-air collisions was associated with the rapid expansion of airpower during World War I. With the de-emphasis on military flying that followed the close of the war, the number of mid-air collisions dropped and the peak of forty-five was not exceeded until 1941.¹⁰

The rapid increase in airpower during World War I resulted in a large number of other kinds of accidents as well. Non-combat fatalities numbered three times those due to enemy action.¹¹ There was one accident for every 241 hours of flying and one fatality for each 721 flying hours. Ninety per cent of the accidents were due to pilot deficiencies.¹²

Despite the large number of losses there still was no single agency or organization that was directly responsible for the promotion of

⁹U.S. Department of the Air Force, USAF Mid-Air Collisions, (Norton AFB, Calif.: Directorate of Flight Safety Research, 1 November 1958), p. 2.

¹⁰Ibid., p. 2.

¹¹Paul Evans, Aviation Psychology, (Los Angeles: University of Southern California, 1956), p. 3.

¹²Ibid., p. 3.

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air safety.¹³ There was a growing awareness, however, that accident prevention increased aviation efficiency and that increased efficiency should be the basic motivation behind all air safety activity.¹⁴ But it would be several more years before the Army had an organization that was responsible for air safety.

The accident prevention picture continued to look bleak: In 1920, 150 military aircraft were destroyed in accidents. In the Annual Report of the Chief of the Air Service, it was estimated that these aircraft cost \$750,000. In addition to aircraft that were destroyed, another 162 were severely damaged.¹⁵ The following year, in the first six months alone, 150 aircraft were involved in accidents and ninety-four were destroyed. These accidents cost more than \$500,000 and forty-one lives.¹⁶

The number of accidents then began to soar. In 1922, the highest rate of accidents the U.S. military has ever experienced was recorded: 506 major accidents per 100,000 hours of flying. A better appreciation of the seriousness of these losses can be gained by realizing that between 1920 and 1926 one in every four living pilots was killed. That can be compared to the Air Force's losses in 1964 of one out of every 1600.¹⁷

¹³Development of Safety in Military Aviation; World War I-1943, (Maxwell AFB, Ala.: Archives Branch, Historical Division, Research Studies Institute, 1944), p. 1.

¹⁴Ibid., p. 1.

¹⁵Air Service, Annual Report of the Chief of the Air Service for the Fiscal Year Ending June 30, 1921, (Washington: War Department, 1921), p. 26.

¹⁶Ibid.,

¹⁷Jerome Lederer, The Problem of Human Error in Maintenance, (Norton AFB, Calif.: Directorate of Aerospace Safety, July 1964), p. 1.

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There was still no organized program to counter these losses. The U.S. Congress, however, was showing keen and increasing interest in the military air safety problem. During 1925 and 1926 there were eleven major Congressional actions involving military aeronautics, each of which devoted a considerable discussion to some phase of flying safety.¹⁸

Aviation in the Army continued to expand, and on 2 July 1926, the Army Air Corps was formed.¹⁹ It was not until the following year that the Development Section of the Inspection Division of the U.S. Army began a study of the entire safety problem. This study examined accidents beginning in 1917 and concluded by stating that ". . .during more than 10 years not much had been learned, in a scientific way, of the nature or causes of accidents. Moreover, no records had been kept that would permit retrieving the lost experience."²⁰ It was clear something needed to be done. A number of things were done, although in many respects it was, perhaps, a hesitant and faulty beginning. It was unfortunate, for example, that each accident was thought to be the result of a single cause.²¹ The complexity of causes and the interaction among many factors in accident causation, which the Air Force now thinks is a more useful and accurate concept, were not accepted and understood until several years later. Another example of administrative procedure that hampered military air

¹⁸Development of Safety. . ., p. 4.

¹⁹U.S. Department of the Air Force, "The Air Force Has Been Developing For Some 58 Years," Supplement to the Air Force Policy Letter for Commanders, (Washington, U.S. Government Printing Office, May 1965), p. 28.

²⁰Development of Safety. . ., p. 2.

²¹Ibid., p. 41.

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safety was a regulation requiring that accident reports be attached to the War Department Report of Survey when property damage was a result of the mishap. In most cases, where the accident report showed that the pilot was at fault, the survey would recommend that the pilot pay for the damage. The result of this shortsighted policy was that (after the investigating officers lost their naïveté) reports no longer showed pilot error. Accidents were consistently blamed on materiel failures, rough landing fields, or weather.²² Until this was corrected, statistics accumulated from the investigations were meaningless.

There was some progress, however, in the attempts to make flying safer. Most of the activity during this early period was concerned with research and development of an accident analysis technique.²³ Accident reporting and record keeping were still inadequate, and until 1929, the Air Corps never compiled accident records with sufficient statistical data to permit an annual comparison.²⁴

Despite the many difficulties in developing a workable flight safety program, the accident rate continued to drop from the high of 506 accidents per 100,000 hours in 1922 to 102 accidents per 100,000 hours in 1933.²⁵

In 1934, however, the first serious reversal in the rate occurred. The number of accidents began to increase at a substantial rate. This is

²²Ibid., pp. 19, 38.

²³Ibid., p. 2.

²⁴Ibid., p. 22.

²⁵U.S. Department of the Air Force, 1964 USAF Accident Bulletin, (Norton AFB, Calif.: Directorate of Aerospace Safety, 1965), p. 2.

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explained, in part, by the fact that President Roosevelt gave the Army Air Corps the mission of flying the mail. It was a task that the Air Corps was ill-equipped to accomplish. The equipment, the terminal and enroute facilities, and the pilots were unequal to the task. The frequency of accidents increased.²⁶ Public and Congressional interest began to mount due to the number of accidents associated with flying the mail. The press had a field day reporting the unpleasant details of each accident. A Congressional investigation ensued, and Maj Gen Benjamin D. Foulois, Chief of the Air Corps, temporarily suspended the air mail operation. He changed operational procedures and tightened restrictions on who would fly the mail. However, when operation resumed, several more accidents occurred almost immediately. Public confidence was shaken, and in May the Post Office Department let new contracts to civil aircarriers. In June 1934, after only five months of operation, the Air Corps was relieved of its mission of flying the mail.²⁷

While the operation was very costly (and in many respects tragic) there were some positive results. It illustrated to the public and Congress, more clearly than anything short of war, that the Air Corps was inadequately equipped and obsolescent.²⁸ The realization that United States air power was in last place among the world's leading nations

²⁶Joseph D. Caldara, Impact of USAF Aircraft Accidents, (Norton AFB, Calif.: Directorate of Flight Safety Research, 1956), p. 3.

²⁷Development of Safety. . ., p. 29.

²⁸Glines, p. 132. For an interesting account of the air mail incident, see, for example, Eldon Downs, "Army and the Airmail--1934," The Airpower Historian, Vol IX, Nr 1, Jan 1962, pp. 35-51; and, William M. Grabbe, Jr., "The Army Airmail Pilots [sic] Reports!; An Account of the 1934 Experience of Eastern Zone Officers," The Airpower Historian, Vol IX, Nr 2, April 1962, pp. 87-94.

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eventually led to the establishment of the General Headquarters Air Corps on 1 March 1935.²⁹ Improved equipment, facilities, and training were to follow.

Congressional and public interest in aviation (especially the accident aspect) continued to be strong. Between 1933 and 1936 there were twenty-six Congressional actions involving aeronautical investigations. More than half of these were concerned with dirigible disasters and accidents resulting from the air mail contracts.³⁰

Despite a number of setbacks, there had been significant advances, both in aviation and flight safety, from World War I to 1940. The improvements during the period can be summarized as: (1) organizational development; (2) growth of safety doctrine; and, (3) application of safety techniques.

Outside factors affecting aviation safety during the period included: (1) public and Congressional interest which resulted in investigations, laws and hearings affecting military aviation; (2) strides in safety made by civil aviation; and, (3) the relationship between technical progress in aviation and the air safety program.³¹

Because of its submerged status, it is difficult to trace the evolution of the flight safety program before World War II. As an indication of its subsidiary nature, it is interesting to note that prior to 1939 the word "safety" was not used in connection with military aviation

²⁹Department of the Air Force, "The Air Force Has Been Developing For Some 58 Years," p. 28.

³⁰Development of Safety. . ., p. 5.

³¹Ibid., p. 9.

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activities.³² While the organizational frame is indistinct, the insistent need for a flight safety program was becoming increasingly clear. The Army's air arm was rapidly increasing in size. With the threat of war just over the horizon, the requirement to preserve the combat potential of airpower was imperative. The development of a formal flight safety program was sure to come, as indeed it did. In 1941, at the personal direction of the Chief of the Air Corps, Maj Gen H. H. Arnold, such a program was founded. On the first of July, Capt Sam Harris, who had "first-flighted" over 200 newly manufactured aircraft without an accident, was made head of the "Safety Section" in the office of the Chief of Staff of the Air Corps. To help him with his tasks, he had a staff of two officers and six civilians.³³ Gradually, under Captain Harris' leadership, this small staff developed a somewhat scientific system of aircraft accident analysis that possessed "its own logic and vocabulary."³⁴ The members of the Safety Section started a systematic sifting and weighing process, with a view toward determining "the foundation of flying safety regulations, instructions and advice."³⁵

On 1 August 1941, Harris (recently promoted to major) moves his office to Bolling Field, near Washington. His staff increased in size

³²Ibid., p. 67.

³³U.S. Army, The Flight Control Command, History of Organization: Report of Command Progress from 1 July 1941 to 31 March 1943, (Maxwell AFB, Ala.: Archives Branch, Historical Division, Research Studies Institute, 1944, p. 1.

³⁴Development of Safety. . ., p. 20.

³⁵U.S. Army, The Flight Control Command, History of Organization: . . ., p. 2.

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with the addition of twelve more civilians.³⁶ During these preliminary activities in aviation safety, Major Harris developed a safety philosophy that emphasized accident prevention. His approach had four major aspects: (1) examination in the field; (2) analysis and interpretation of the accident experience; (3) application of the analysis to the prevention program; and, (4) measuring the effectiveness of the prevention program.³⁷

1942 - A Significant Year in Flight Safety

By February 1942, the Safety Section, which was under the Inspection Division, was designated as an "operating" organization. It was given instructions to base its method of accident prevention on positive action.³⁸

During the remainder of 1942 the flight safety office expanded and reorganized several times. On 9 March, the Safety Section was placed under jurisdiction of the Director of Technical Inspection. On 17 April 1942, another reorganization took place. The Safety Section was given a new title and additional functions. It became the "Directorate of Flying Safety" and was given a somewhat more independent status; it was still under the Directorate of Technical Inspection, but only for administrative purposes. The new Table of Organization authorized thirty-four officers and ninety-six civilians. "This latest reorganization was in official recognition of the inexorable increase of accidents in AAF flight training"³⁹

³⁶Ibid., p. 2.

³⁷Development of Safety. . ., p. 97.

³⁸Ibid., p. 3.

³⁹U.S. Army, The Flight Control Command, History of Organization: . . . , p. 3.

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The increased functions included prediction of future accidents based on previous experience. This was a sharp departure from traditional safety responsibilities. This added responsibility provided a base for future expansion. On 20 August, another reorganization was completed which raised the strength to 108 officers and 261 civilians.⁴⁰

These multiple reorganizations and increases in personnel reflected the dynamically growing Army Air Force (AAF). During the first nine months of 1942, the AAF flew one and one-half billion miles within the continental United States alone. This represented 135 per cent more than the AAF flew during the entire ten year period from 1930 to 1939, inclusive. The number of accidents increased along with the number of flying hours. During 1942, aircraft accidents cost the AAF \$95,000,000. This dollar loss would have bought an equivalent of 678 B-25s and 1727 P-40s. Altogether, there were 1403 aircraft destroyed during the year in non-combat accidents.⁴¹

There were still two major changes to be seen in the operation of the safety office in 1942. Under provisions of a new regulation, the Directorate of Flying Safety was made a separate directorate and removed from jurisdiction of the Director of Technical Inspection.⁴² One of the reasons for this change was the difficulty experienced by the Directorate

⁴⁰U.S. Army, The Flight Control Command, History of Organization: . . ., pp. 3-4.

⁴¹Directorate of Flying Safety, Accident Data Notebook, (Maxwell AFB, Ala.: Archives Branch, Historical Division, Research Studies Institute, 4 March 1943), p. 2.

⁴²U.S. War Department, Army Air Forces, Directorate of Flying Safety, AAFR 20-1C, (Washington: U.S. Government Printing Office, 22 August 1942), p. 1.

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of Flying Safety in coordinating the air safety program AAF-wide while being administratively responsible to the Director of Technical Inspection.⁴³ Concurrently with this change in November 1942 the directorate moved to Winston-Salem, North Carolina. Flight safety was still in an embryonic stage and concerned, in the main, with gathering facts and developing accident analysis techniques.⁴⁴

The last major change of the year came in December. The Directorate of Flying Safety was again renamed, became more diverse, and assumed greater responsibility. It was called the Directorate of Air Traffic and Safety and included three sub-directorates: Flying Safety, Safety Education, and Flight Control.⁴⁵

During this year an important regulation (AAF Reg 62-14) was issued concerning accident investigation. As indicated previously in this chapter, the decision to attach the aircraft accident report to the War Department Report of Survey was considered unfortunate. It was finally realized that this procedure resulted in inaccurate reporting of accident causes. Consequently AAF Regulation 62-14 was issued. This regulation separated accident investigation reporting and property damage liability. The philosophy as stated in one paragraph of this regulation persists today:

The facts established, the testimony of witnesses, statement of investigation personnel or higher authority, the AAF Form No. 14 (accident investigation report) and attachments or correspondence pertaining thereto will not be used in connection with any

⁴³Development of Safety. . ., p. 130.

⁴⁴Ibid., p. 2.

⁴⁵U.S. Army, The Flight Control Command, History of Organization: . . . , p. 9.

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investigation leading to disciplinary action.⁴⁶

1943 - 1964: Further Development and Refinement

On 29 March 1943, accident prevention came into its own with still another reorganization. The Air Traffic and Safety Directorate was redesigned the Flight Control Command, still under direction of the same man, Sam Harris, now a colonel.⁴⁷ This command had broad new responsibilities: it now included not only Flight Safety, Safety Education, and Flight Control, but also Air-Sea Rescue and the former directorates of Communications and Weather. "From an organization of a few hundred persons it became overnight a command responsible for many thousands."⁴⁸

The Flight Control Command was short-lived lasting only six months. It was replaced by the Office of Flying Safety in Headquarters Army Air Forces on 1 October 1943.⁴⁹ Colonel Harris was again appointed as head of the office, and by 31 October there were 1,295 personnel assigned.⁵⁰

It must be remembered that this rapidly changing organizational structure and increasing size reflected the dynamic increase in the size of the AAF during the period. The air arm increased in quantum jumps of

⁴⁶U.S. Army Air Force, Accident Investigation, AAFR 62-14, (Washington: U.S. Government Printing Office, 26 May 1942), p. 20.

⁴⁷U.S. Army, The Flight Control Command, History of Organization: . . . , p. 9.

⁴⁸Ibid.

⁴⁹AAF Headquarters, Summary of Progress from 1 Oct 1943 to 31 Oct 1943, (Maxwell AFB, Ala.: Archives Branch, Historical Division, Research Studies Institute, Nov 1943), p. 1.

⁵⁰Ibid., p. 9.

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10-, 100-, 1,000-fold compared to its pre-war size^{51,52} This growth spawned many problems. These included great numbers of new aircraft, untrained men, and a new organization. The inevitable result was a substantial increase in aircraft accidents. Military flying hours in the continental United States jumped from 937,922 in 1940 to 35,503,205 in 1944.⁵³ Accidents increased even more rapidly than flying hours. In 1940 there were 478 major aircraft accidents. During 1943, when the Air Force was training more pilots than ever before or since, non-combat accidents increased to 20,389. In March of 1945, the AAF had 2,136 aircraft accidents in one month alone. The number of aircraft that were damaged or lost equaled fifty-three per cent of the total aircraft delivered to the AAF during the same period.⁵⁵

The flying safety organization and the number of people engaged in safety efforts, alone, did not stem the tide. It was concluded that there would have to be a change in philosophy regarding accident causation and prevention. This change in approach was reflected in the air safety policy announced in 1945. The Office of Flying Safety stated that their specific air safety policy was

to examine the systems and processes by which the AAF accomplishes its mission, and to report the degree of inadequacy which can be

⁵¹Glines, p. 151.

⁵²Caldara, p. 3.

⁵³U.S. Department of the Air Force, 1964 USAF Accident Bulletin, p. 2.

⁵⁴Ibid., p. 2.

⁵⁵Memorandum, Office of Flying Safety to Division Chiefs, 23 April 1945, Subject: "AAF Flying Accidents," (Archives Branch, Historical Division, Research Studies Institute, Maxwell AFB, Alabama Library), p. 2.

measured by accident loss. In other words, it had finally been concluded that it is impractical for a safety organization to use the big stick of positive action, because safety in its broadest sense cuts across all lines of command endeavor.⁵⁶

This concept suggested that a "job well done is inherently safe," a view which we hold today. There was also an implication that the degree of success in accident prevention depended upon the commander's interest and successful management techniques. This was thought to be true since safety did cut "across all lines of command endeavor," and the commander was, therefore, the lowest level at which all of the various functions of the command are focused. Judged in terms of the accident rate, this approach was sound. The rate dropped from a high of seventy-one (per 100,000 flying hours) in 1942 to forty-four in 1945.⁵⁷

At the end of the war, there was a call for a rapid demobilization. Activities of the AAF were severely reduced. The number of hours flown by the AAF dropped nearly eighty per cent in one year.⁵⁸ A large number well-qualified and experienced pilots and ground crews returned to civilian life. There was, as a result, a general reduction in the level of supervision and air discipline.⁵⁹ Predictably, the accident rate increased once more.⁶⁰

⁵⁶Development of Safety. . ., p. 3.

⁵⁷U.S. Department of the Air Force, 1964 USAF Accident Bulletin, p. 2.

⁵⁸U.S., Department of the Air Force, 1964 USAF Accident Bulletin, p. 2.

⁵⁹Caldara, p. 3.

⁶⁰U.S. Department of the Air Force, Summary and Evaluation of Aircraft Accidents and Fatalities, (Norton AFB, Calif.: Deputy Inspector General for Safety, n.d.), p. 2.

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On 26 July 1947, the National Security Act of 1947 was passed and the Air Force was established as a separate service. The flight safety activities were moved to the Office of The Inspector General and have remained there since.

While considerably increased in scope and complexity, the accident prevention program still retained as one of its primary objectives the prevention of pilot error accidents, historically the predominate cause of aircraft mishaps.⁶¹

In this era (1950-1954) a significant and disturbing trend began to appear. While the Air Force could note with pride that the total number of accidents was diminishing, the cost of accidents was increasing.⁶²

In an attempt to counter the rising costs of accidents in 1950, the Director of Flight Safety Research (as it was then called), Maj Gen Victor E. Bertrandias, announced a significant change in the approach to accident prevention. This change is described in the History of the Office of the Inspector General as:

Still recognizing the importance of personnel error in aircraft accidents, increased emphasis was placed on maintenance engineering and design as cause factors. One of the more outstanding of the channels which this theory of accident prevention takes is that of preventing the incorporation in new aircraft of design faults which may cause accidents. And this approach is not only from the mechanical angle, but from the angle of preventing acceptance of a design which might induce personnel error.⁶³

⁶¹U.S. Department of the Air Force, History of the Office of the Inspector General, United States Air Force, 1 July 1949-30 June 1950. (Maxwell AFB, Ala.: Archives Branch, Historical Division, Research Studies Institute, 1950), p. 3.

⁶²Ibid., p. 20

⁶³U.S. Department of the Air Force, History of the Office of the Inspector General. . ., 1 July 1949-30 July 1950, p. 6.

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This new approach resulted in a closer Air Force relationship with industry and included Air Force monitoring of aircraft design and fabrication. Increased stress was also placed on aircraft maintenance and its relationship to flight safety.

Judged in terms of the accident rate the concept was a success. In 1950 there were thirty-six accidents per 100,000 hours of flying; by 1956 this was reduced to seventeen.⁶⁴

In 1956, General Bertrandias was replaced by Brig Gen Joseph D. Caldara. Under this man's dynamic leadership, the concepts of "a job well done is inherently safe," and "we do not believe in safety for safety's sake" were emphasized and constituted an important part of the USAF aircraft accident prevention philosophy. Addressing members of the House of Representatives during a session of a subcommittee of the Committee on Appropriations, he said:

In any military operation, safety cannot be necessarily of primary importance. Certainly we can stop all accidents by staying on the ground or by flying only under completely circumscribed "safe" conditions. However, the Air Force has a mission which has been assigned by the Congress and the people of the United States. Our primary job is to accomplish the mission.⁶⁵

He thus put into proper perspective the relationship of aviation safety to mission accomplishment. Flight safety, while absolutely essential to efficient use of the nation's airpower, is secondary to performing the mission. This concept is a cornerstone in the present USAF flight safety program that we shall examine in Chapter III.

⁶⁴U.S. Department of the Air Force, 1964 USAF Accident Bulletin, p. 2.

⁶⁵Directorate of Flight Safety Research, Special Report 31-56: Testimony of Gen Caldara Before the House of Representatives, (Norton AFB, Calif.: Deputy The Inspector General for Safety, 1956), p. 1.

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From 1956 to 1966 there were no major changes in the flight safety organization within the U.S. Air Force. With the exception of several changes in titles of the organization, the changes that occurred involved minor internal reorganization. The changes in the name of the organization reflected the growing scope of Air Force activities. From the Directorate of Flight Safety Research, it evolved to the Directorate of Flight and Missile Safety Research in 1957 and finally to the Directorate of Aerospace Safety in 1961.

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CHAPTER III

THE PRESENT U.S. AIR FORCE AIRCRAFT ACCIDENT PREVENTION PROGRAM

The Philosophy of Prevention

Air Force experience in aircraft accident prevention can be distilled into a philosophy which the author thinks can be expressed in the following simple concepts:

1. Accident prevention, while vital, is subordinate to the mission.
2. Accidents are not inevitable; they can be prevented.
3. The only acceptable accident rate is zero.
4. Safety is a responsibility of every member of the Air Force.
5. A job well done is inherently safe.
6. Accident prevention is a function of command.

We shall examine each of these concepts in greater detail to better understand their foundation and significance in the aircraft accident prevention program.

The idea that accident prevention, while vital, is subordinate to mission accomplishment dominates all other ideas in Air Force thinking about flight safety. We conclude in an earlier chapter that accident prevention is very important in Air Force operations. It should, nevertheless, be put into a proper perspective. The Air Force does not believe in "safety first." The mission is paramount. General Caldara, in his

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appearance before a subcommittee of the House of Representatives, effectively expressed these views when he said:

In any military operation, safety cannot necessarily be of primary importance. Certainly we can stop all accidents by staying on the ground or by flying only under completely circumscribed "safe" conditions. However, the Air Force has a mission which has been assigned by the Congress and the people of the United States. Our primary job is to accomplish that mission.¹

The aphorism which suggests "to avoid accidents, don't fly" is clearly unacceptable.

Military requirements of the mission introduce hazards that cannot always be eliminated or avoided. The Air Force must be prepared to carry out its mission in all kinds of weather; aircrews must be prepared to fly whenever and wherever the global mission requires. The successful accomplishment of the mission must be the deciding factor, even at the expense of compromising safety by taking calculated risks.²

To preclude controversy in this matter, a pattern of thinking has emerged which places safety in this correct relationship. It is one of mission support. Safety should facilitate the accomplishment of the mission; it should not restrict or inhibit the operational capability of the Air Force.³ It is essential to understand this basic relationship. On some occasions in the past some commanders tried to make accident prevention the primary goal of their units.⁴ By doing so, they detracted

¹Directorate of Flight Safety Research, Special Report Nr. 31-56: Testimony of Gen Caldara Before the House of Representatives, (Norton AFB, Calif.: Deputy The Inspector General, 1956), p.1.

²Chief of Safety, Air Defense Command, Blueprint For Safety, (Ent AFB, Colorado.: Headquarters, Air Defense Command, 1958), p. V.

³Chief of Safety, ADC, Blueprint. . ., p. 7.

⁴U.S. Department of the Air Force, Accident Investigation, AFM 62-5, (Washington: U.S. Government Printing Office, 1 February 1956), p. 1. (obsolete).

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from their unit's operational capability, for example, by unwarranted grounding of aircraft, restricting the use of essential equipment, or by impractical recommendations which required action beyond the limits of available resources. Such overemphasis of safety is wholly undesirable.

The word "safety" denotes more than is desired by the Air Force in its aircraft accident prevention program. It is almost incongruent when used in the phrase "flying safety." "Safety" as defined by Webster, is "freedom from danger or hazard." Flying is fraught with danger. The term "flying safety" is a misnomer, for it does not truly express the scope and objectives of the accident prevention program. One major air commander expressed the idea in these words:

The primary concern is not safety merely for safety's sake, but acceleration of mission accomplishment through increased operations effectiveness. Therefore, let us define safety as "the product and integral part of an efficiently planned, supported, and executed mission."⁵

Aircraft accident prevention is understandably subordinate to the accomplishment of the assigned operational mission. It is, at the same time, secondary only to the assigned mission.⁶ With such a high priority for the interest, efforts, and resources of the Air Force, it is not surprising that aircraft accident prevention gets the emphasis that it does. General Caldara said:

No other program in the Air Force receives more attention from as many people as that of accident prevention. Flying safety cuts across practically all fields of endeavor, and is necessarily an integral part of the entire air operation.⁷

⁵Chief of Safety, ADC, Blueprint. . ., p. V.

⁶U.S. Department of the Air Force, Accident Investigation, p. 6.

⁷Directorate of Flight Safety Research, Special Report Nr 31-56, p. 2.

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Gen William H. Blanchard, the Air Force Vice Chief of Staff, has this to say about the importance of flight safety:

Next to our primary wartime mission, we can do more here to save lives, materiel, and the nation's wealth than through any other medium available to the Air Force. That's something to think about, if you'll ponder it for a moment.⁸

Another fundamental idea is that "accidents are not inevitable; they can be prevented." This might seem to be a fairly obvious conclusion; however, it was not always thought to be true. In the early days of flying, aircraft accidents were regarded as the inevitable result of taking to the air in the first place. This age of aviation, which might be called the Lindbergh era, was characterized by a philosophy of predestination. This philosophy was expressed in such statements as: "If a man were meant to fly he'd have been born with wings," and "anybody foolish enough to get into one of those fool machines deserves to fall out of the sky."

There are probably still a few people who hold these views. It is unfortunate that some people, either through ignorance or misunderstanding, believe that accidents are the inevitable result of unchangeable circumstances or fate. These beliefs are not only false but they are illogical. They fail to consider the essential relationships of cause and effects, the basic ingredients of all accidents.⁹ In other words, accidents do not happen without a cause. The identification, isolation, and control of these causes are the underlying principles of all accident

⁸William H. Blanchard, "Let's Get With The Program," An address presented to the members of the Second Annual USAF Safety Congress at Sandia Air Base, Albuquerque, New Mexico, 25-29 September 1961.

⁹U.S. Department of the Air Force, Accident Prevention Handbook, AFM 32-3, (Washington: U.S. Government Printing Office, 5 November 1964), p. 1-1.

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prevention techniques.

If we know that accidents are caused and we can determine what these causes are, we should be able to prevent accidents from occurring in the future. A logical question arises. Can we expect to prevent all accidents? It is a goal that many people think is unattainable. The Air Force thinks the objective can be achieved and it is the focus of the aircraft accident prevention program. Numerous statements appearing in Air Force publications affirm this conclusion:

Many people feel that we have reached the irreducible minimum, and the only way we can further reduce the number of accidents is to quit flying. A close examination of individual accident reports reveals that this is not true. Too many accidents occur which could and should have been prevented.¹⁰

We will never relax and accept a premise which condones an irreducible minimum number of accidents which is greater than zero.¹¹

Other than zero, we do not know what the irreducible minimum is, but certainly from a daily reading of accident reports we know that we are not even near it.¹²

. . .the Air Force will go a long way in realizing its goal of a zero accident record.¹³

The question of whether all accidents can be prevented is guaranteed to provide a basis for discussion among Air Force personnel. It is the author's experience that nearly all will argue (with good reasons for their thesis) that "you cannot prevent all accidents because of human fallibility and 'Acts of God.'" The Air Force's goal of preventing all

¹⁰Letter, Flight Safety Division, Deputy The Inspector General, USAF to flight safety officers, untitled, August 1964.

¹¹Letter, Directorate of Aerospace Safety to flight safety officers, untitled, May 1964.

¹²Directorate of Flight Safety Research, Special Report Nr 31-56, p.4.

¹³Letter, Flight Safety Division, p. 2.

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accidents is as much (perhaps more) philosophy as practicability. To set as an objective anything less than a zero accident rate means to arbitrarily limit the capacity to conserve our resources and facilitate our mission.

Another fundamental concept in Air Force accident prevention efforts is expressed in the phrase "safety is everybody's business." A large part of the Air force mission is accomplished by flying. Everyone is connected in some way with that goal. It follows that everyone has a responsibility for insuring that the mission is accomplished in the most effective manner possible. Thus each has a responsibility in the aircraft accident prevention program.¹⁴

Pilots and other aircrew members are in a position to recognize their role in accident prevention. Others, whose jobs are not so closely associated with flying, do not always understand their responsibility to flight safety or see how they can contribute to the effectiveness of the accident prevention effort. Each man in the Air Force, however, can and must contribute to aircraft accident prevention.¹⁵

The accounting and finance office, for example, might appear to be sufficiently distant from flying operations to have no effect on flight safety. Such is not the case. Timely and accurate payment of an individual's salary is important to morale. If, because of disinterest, carelessness, or oversight, finance personnel make errors that result in haphazard and inefficient pay operations, the persons affected might be

¹⁴U.S. Department of the Air Force, Aircraft Accident Prevention, (Norton AFB, Calif.: Directorate of Flight Safety Research, June 1956), pp. 1-2.

¹⁵Eugene B. Konecci, "Physiological Factors and Flying Safety," A Paper presented at the U.S. Air Force Physiological Training Officers Symposium, School of Aviation Medicine, Gunter AFB, Alabama, 2-6 December 1957.

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preoccupied and inattentive in flying or performing maintenance. A distraction need not be overwhelming to be important--only sufficient to prevent a person from keeping his whole attention to the immediate task being performed. Such distractions predispose an individual to error. Error can lead to accidents.

Another example might be a civil engineer employee who operates a ramp sweeper. If he is not interested in doing a thorough job of sweeping the ramp and taxiways, he could easily overlook a stone or other debris. The stone might not cause any damage until it is ingested by the engine of a passing aircraft. In that event, the engine is likely to be severely damaged.

General Caldara expressed the view that everyone has a responsibility toward safety when he said:

What is the philosophy on which we must base our efforts? Deal with people in such a manner as to convince each individual, whether he be sweeping out the trash of an aircraft plant, designing a critical part, building a key component, operating at Mach three or four, or cleaning a bird after the flight, that he is as important as any other individual--if the over-all operation is to be a success.¹⁶

Flight safety means doing everything that you are supposed to, every time--every minute of every hour.¹⁷

Remember--our mission is to conserve the combat capability of the Air Force. The only way we can do this is to have every pilot, every member of the Air Force, do everything that is supposed to be done--as it is supposed to be done and when it is supposed to be done. The end result desired requires participation by each member of the Air Force in a dynamic flying safety program.¹⁸

¹⁶Joseph D. Caldara, "The Diminishing Safety Improvement Rate," Alumni Review (University of Southern California), I, Nr 2 (Summer 1964), p. 4.

¹⁷Joseph D. Caldara, Impact of USAF Aircraft Accidents, (Norton AFB, Calif.: Directorate of Flight Safety Research, 1956), p. 1.

¹⁸Ibid., pp. 17-18.

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Another idea forming a part of the foundation of the aircraft accident prevention program is "a job well done is inherently safe." Accidents are generally an indication of ineffective management. There are many factors, such as environment, types of aircraft, experience of pilots, and mission, to be considered when one analyzes the efficiency of an Air Force unit. Nevertheless, the Directorate of Aerospace Safety believes that over a period of time, say six months or a year, the number of accidents indicates the quality of management.¹⁹ They have said:

We can positively state that an excessive number of mishaps is a direct measurement of effectiveness of local management. The assessment of management in your organization results from the sum total of accident experience in all areas of safety.²⁰

Military Management of the Accident Prevention Program

In the final analysis, the commander is responsible for everything his command does or fails to do. This responsibility extends, of course, to the aircraft accident prevention program and provides the basis for the idea that "safety is a function of command."²¹ The Commander is obligated to exert "constant consideration and vigorous effort" in the prevention of accidents.²² He also has a moral responsibility to prevent accidents and is specifically bound to this effort by Air Force

¹⁹Intercom, (Norton AFB, Calif.: Directorate of Aerospace Safety, March 1964), p. 3.

²⁰Ibid., p. 3.

²¹U.S. Department of the Air Force, Investigating and Reporting USAF Accidents/Incidents, AFR 127-4, (Washington: U.S. Government Printing Office, 25 February 1963), p. 2.

²²U.S. Department of the Air Force, Aircraft Accident Prevention and Investigation, AFM 127-4, (Washington: U.S. Government Printing Office, 20 September 1963), p. 8.

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regulation.²³

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To indicate the emphasis placed on the commander's responsibility and reveal the broad scope of his involvement in flight safety matters, we shall review portions of regulations concerned with aircraft accident prevention. The basic Air Force directive is AFR 127-1, "Responsibilities for USAF Aerospace Accident Prevention Programs."

The objective of the Air Force is to discharge its assigned missions and tasks in a professional manner with a minimum loss of personnel and materiel resources. . . .To meet this objective, the Air Force has a dynamic, continuing, accident prevention program throughout all Air Force commands and agencies, at all locations where Air Force military or civilian personnel are stationed or employed, and wherever Air Force equipment or property is utilized in Air Force operations.

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Accident prevention is the responsibility of all commanders throughout the Air Force, including those of the active and reserve forces. Command emphasis and direction on an Air Force-wide basis is essential to the success of the Air Force safety program. Each commander, his staff members, and any person who takes part in the use or support of aircraft, missiles, space vehicles, ground and explosive material or components, ground equipment or facilities, must strive for the attainment of maximum practicable safety of his area of responsibility. Each major air commander will:

a. Maintain an integrated, aggressive, and effective accident prevention program; and insure that supporting programs are implemented by all appropriate subordinate commanders.

b. Organize and man consolidated safety staffs and give essential priority to safety functions within his own headquarters, at all subordinate echelons through wing/base, and at lower echelons as appropriate, to fulfill the accident prevention needs of his particular command and mission. . . .

c. Insure that each reportable accident/incident occurring within his command is reported and investigated according to applicable directives. Act promptly to preclude the development of unsafe conditions and unwarranted hazards in the operations and maintenance of facilities and systems and other commodities; maintain a follow-up

²³Directorate of Flight Safety Research, Special Report Nr 31-56, p. 4.

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system to eliminate or minimize identified safety deficiencies.

d. Authorize waivers of safety criteria only when operational emergencies and mission requirements justify the calculated risk. This provision is especially applicable where circumstances and the time element is such that approval of higher authority is not practicable.

e. Monitor safety programs at contractor-operated facilities where necessary and according to applicable instructions.

f. Direct safety surveys at least annually to determine unsafe practices, hazardous operating conditions, and inadequacy of safety planning and programming.

g. Maintain a continuing safety education program.

h. Provide for appropriate staff consideration and coordinated action on basic safety matters, including the integration of medical and bio-environmental aspects into the safety program through coordination with surgeons and directors of medical services.

i. Consistent with the requirements and responsibilities set forth in applicable mission directives, provide Air Force-wide support through the development and implementation of accident prevention training, standards, and procedures; to include such matters as safety instruction in training courses, safety considerations in managerial developments and ground and airlift of materiel and personnel supporting Air Force-wide accident prevention training projects.²⁴

The responsibilities placed on the commander by this regulation are broad, continuing, and important. It should be noted that the directive applies to all areas of safety: flight, ground, missile, and nuclear. The regulation that is concerned solely with the aircraft accident prevention program is AFR 62-8, "Flying Safety--Responsibilities For Aircraft Accident Prevention Programs." Portions that pertain to the commander's responsibility have been extracted and appear below.

The prevention of aircraft accidents and the establishment and maintenance of aggressive and effective programs to insure this goal are command functions. Commanders on every level must give their personal attention and direction to the establishment and enforcement of these

²⁴U.S. Department of the Air Force, Responsibilities For USAF Aerospace Accident Prevention Programs, AFR 127-1, (Washington: U.S. Government Printing Office, 20 April 1965), pp. 1-3.

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programs. To achieve this objective, they may use necessary facilities, personnel and material, consistent with the accomplishment of the primary missions of their respective organizations. However, the designation of accident prevention as a command function does not relieve any individual concerned with the maintenance and operation of aircraft of the responsibility of striving for the greatest possible degree of safety.

.....

The commander of each major air command, numbered air force, wing and equivalent organization is responsible for aircraft accident prevention in his command. He will appoint a qualified flight safety officer, or a staff assistant for aircraft accident prevention matters, who is a rated pilot on flying status. He may also appoint additional technical assistants as required to assist in the performance of the following functions:

- a. Develop and conduct an effective aircraft accident prevention program.
- b. Supervise the investigation and reporting of aircraft accidents prescribed in AFR 62-14 with particular emphasis on the thoroughness and accuracy of the reports.
- c. Monitor progressive training programs to prepare pilots and crews to operate aircraft with the maximum of safety.
- d. Conduct accident studies, making investigations and inspections as needed and initiating any necessary safety practices. In this regard he will conduct an aircraft accident prevention survey of the organization at least once each year. . . .
- e. Take necessary steps to promote air discipline in accordance with policies established by Headquarters, USAF.
- f. Notify the Director of Aerospace Safety of the desired distribution of safety publications issued by the directorate, which are listed in AFR 5-33, and insure their most effective use.
- g. Maintain constant supervision and frequent inspections to insure compliance with all flight regulations and accident prevention policies.
- h. Review all safety measures currently in force and make any additions and revisions, not inconsistent with directives from higher headquarters to accomplish the purposes of this regulation.
- i. Forward to the Director of Aerospace Safety accident prevention material and methods of presentation which have been used locally with success and which are considered worthy of consideration for use throughout the Air Force.²⁵

²⁵U.S. Department of the Air Force, Flying Safety--Responsibilities For Aircraft Accident Prevention Programs, AFR 62-8, (Washington: U.S. Government Printing Office, 9 December 1955), pp. 1-2.

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The regulations which have been cited above do not constitute the total guidance given the commander. Additional instructions are found in AFR 127-4, "Investigation and Reporting USAF Accidents/Incidents," and in AFM 127-1, "Aircraft Accident Prevention and Investigation." The purpose in reproducing portions of the regulations above is not only to show the ample instructions given to the commander, but also to indicate that accident prevention is a priority task of the commander.

The basic reason the commander is given the responsibility for the program is because he, alone, can provide the necessary motivation which will insure a dynamic, effective program. By defining objectives and policies he can spell the difference between success and failure.²⁶ Thus command interest is essential. The Air Force has observed a direct correlation between accident rates and the degree of command interest in the aircraft accident prevention program.²⁷ They have found the effectiveness of safety programs is dependent upon, and reflected by the attention, direction, and enforcement personally exerted by the unit commander.²⁸

The scope of the commander's responsibilities requires that he assign authority for managing some of the details of the flight safety program to other people in his command. Much of the program is initiated and supervised by his staff officers and subordinate commanders. He does have people on his staff who are extensively trained and experienced

²⁶U.S. Department of the Air Force, Aircraft Accident. . ., AFM 127-1, p. 3.

²⁷Donald H. Frank, Untitled speech, (Norton AFB, Calif.: Directorate of Aerospace Safety, n.d.), p. 5.

²⁸Ibid.

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in safety matters. A typical safety staff might consist of these positions at wing level: a director of safety (major), two or three flight safety officers (captains), a ground safety officer (GS-10, a flight safety technician (MSGT), a ground safety technician (MSGT), and two secretaries (GS-3 and GS-5). If required there will also be a nuclear safety officer (captain) and a missile safety officer (captain). This is a sizable staff and provides the commander with professional assistance in managing an effective accident prevention program.

We shall now turn our attention to the flight safety officer and examine his contribution to the military management of the flight safety program. We will consider his duties, qualifications, and selection.

The primary duty of the flight safety officer is to assist the commander in preventing aircraft accidents.²⁹ The statement of his mission is simple; the implications of his duties are broad and complex. In some respects the safety officer is an efficiency expert and aids the command in identifying, predicting, and analyzing areas of substandard performance which can cause accident potentials.³⁰ He must perform his varied tasks within the framework of "mission first and safety second" that we have previously discussed. He, therefore, tries to assist the organization in achieving and maintaining an optimum relationship between aircraft accident-free operation and an uncompromised accomplishment of the assigned mission.

His job requires that he be able to isolate and identify problems before they create difficulties. He must advise the commander on the

²⁹U.S. Department of the Air Force, Aircraft Accident. . ., AFM 127-1, p. 5.

³⁰Chief of Safety, ADC, Blueprint. . ., p. 5.

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status and adequacy of the accident prevention program to meet the threat posed by these problems. If necessary he should present definitive, acceptable, and fully coordinated recommendations for changes in operations procedures, supervision, facilities, or any other activity that bears on the aircraft accident prevention program. He is, in this regard, a "trouble-shooter" whose interest and efforts encompass all factors which may contribute to aircraft accidents. If, as we have suggested, every activity on an airbase has some effect on the aircraft accident prevention program, then the safety officer must be interested in all those activities. For this reason the performance of his duties takes him to every office and every part of the airbase.

He has a large number of other tasks to accomplish. Some of the more important ones listed in his job description are: (1) establish policies, standards, and procedures designed to promote safe operations and reduction of accident rates; (2) monitor activities concerned to insure compliance with safe practices, accident prevention policies and standardized training and operations procedures; (3) conduct accident prevention surveys; (4) maintain a continuous study of flight operations to correct conditions detrimental to flight safety; (5) prepare reports on results of surveys and investigations to assure corrective action; (6) participate in aircraft accident investigations; (7) plan and schedule classes, lectures, and indoctrination periods pertaining to safe operation and accident prevention; and, (8) fulfill important administrative responsibilities such as maintaining records, charts, graphs, and files on the aircraft safety activity.³¹

³¹U.S. Department of the Air Force, Officer Classification Manual, AFM 36-1, (Washington: U.S. Government Printing Office, 15 April 1963), p. 19-5.

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What qualifications must an officer have to meet the challenge of these important and diversified tasks? The general requirements for a safety officer are found in AFM 36-1, "Officers Classification Manual."

They are:

Knowledge of Air Force and Federal Aviation Agency flying regulations; and fundamentals of aircraft and manned space vehicles structure and design, capabilities and limitations, and emergency procedures is mandatory.

Knowledge of performance characteristics, capabilities, and limitations of air-launched missiles; storage, movement, inspection, and maintenance of nuclear warheads; and storage and handling of solid, cryogenic, noncryogenic, and exotic propellents is mandatory for Flying Safety Officers assigned supervisory responsibilities for nuclear and air-launched missile safety programs.

Bachelor's degree, preferably in aeronautical or electrical engineering, is desirable.

Experience in supervising and directing safety programs; investigating aircraft accidents; preparing reports; using aircraft technical orders; using and caring for personal equipment; and utilizing communications facilities is mandatory.

Experience in aircraft and manned space vehicle operations or maintenance is desirable.

Completion of Air Force pilot training is mandatory. Completion of a flying safety officer's course or four years' experience as a Flying Safety Officer is mandatory.

Currently effective aeronautical rating, current flying status orders, and active flying status as a pilot are mandatory.³²

Further, the commander is enjoined to select an officer for this job who possesses certain qualities and attributes of character and personality.³³ It is especially important that the safety officer should have an interest in his job. This is a fundamental requirement because

³²Ibid., pp. 9-6; 9-7.

³³U.S. Department of the Air Force, Aircraft Accident. . ., AFM 127-1, p. 42.

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the results of the safety officer's efforts are frequently intangible. It can only rarely be positively demonstrated that the safety officer prevented an aircraft accident. A declining accident rate suggests that his efforts have been worthwhile and effective but he can seldom say to himself, "I prevented an accident today." A high degree of interest and motivation on the part of the safety officer is essential to success.

Another quality the safety officer should have is curiosity. He must, without external pressure, seek to understand the complex inter-relationships that exist between and among the man-machine-environmental combination. He must be alert and sensitive to the subtle indicators of both ineffectiveness and potential hazard and pursue them to determine their significance. He cannot contribute to a dynamic accident prevention program by passively waiting for information to come to him; he must actively seek it.

He must have sufficient perserverance to ferret out every significant factor before arriving at a conclusion or making a recommendation. Half-hearted efforts which culminate in "probable" causes do little for accident prevention; indeed, they frequently delay an effective solution by diverting effort at solving the true causes of a problem.

He must be patient. Much of the safety officer's work involves education. He attempts to change or modify people's behavior through training and education.³⁴ The results of education might not be observed by the safety officer for months after the training is given. His work constitutes a long term investment and he must have patience to await the dividends at a future date.

³⁴Intercom, (Norton AFB, Calif.: Directorate of Aerospace Safety, March 1965), p. 6.

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He should also have good judgement, tact, and diplomacy. These are qualities that all officers should have, of course. They are particularly important attributes of the safety officer. He speaks, on safety matters, for the commander and works with commanders and staff officers who are senior to him. He frequently requires information from aircrew members, support and supervisory personnel who, because of their association with, or contribution to, a problem are reluctant to provide it. Furthermore, he must persuade commanders and supervisors involved to take corrective action to eliminate areas of an accident-producing nature. All of these factors demand that he be tactful, diplomatic, and have the judgement to discern the significant aspects of a problem.

A most important quality of the safety officer is integrity. He must be above influence of any kind from any source and must concentrate on the truth alone. He cannot allow personal relationships to alter the conclusions he makes or his recommendations to the commander. He must also learn to rely on facts and guard against the temptation of "educated guesses" and suppositions. It would be less than candid, if the author did not admit that, in his experience, it is far easier to write about this quality of complete honesty than it is to always fulfill it. The influence of interpersonal relationships and desire to avoid taking action that might result in difficulty for others occasionally make a policy of unbending integrity burdensome and difficult. However, it is important to be honest. We can never hope to solve our problems unless we are willing to admit that we have them and determine what they are.

Training and experience in various techniques and a wide range of technical knowledge is required to properly manage an aircraft accident prevention program. It is desirable to have an officer with a wide

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academic and technical background including academic training in such subjects as aeronautical engineering, aircraft design and structures, aerodynamics, psychology, physiology, electronics, physics, human engineering, and communicative skills. Additionally, he should possess the personal attributes and characteristics perviously mentioned.

Obviously, officers who possess (in a proper balance) all of the qualifications and personal characteristics we have discussed are rare. Few flight safety officers are paragons; seldom do they meet the standards in every respect. The point is, the commander should select competent, aggressive officers to assist him in his accident prevention program.

A final observation on the safety officer's selection: he is usually on the commander's personal staff and is therefore personally selected by him. Incidentally, with the exception of his aide (if any) the safety officer is normally the only staff member on the commander's personal staff. This organizational relationship has many advantages. First, it shows that safety is an important program. Secondly, it permits the commander and his safety manager to develop a close, day-to-day working relationship. Thirdly, it tends to cause a greater personal influence of the commander in accident prevention matters, hence allowing him to fulfill his many responsibilities to the flight safety program. And finally, it results in an accident prevention program responsive to the whole command and to the senior commander. It is well known that a person is usually most responsive to the individual who writes his efficiency report. When a safety staff is at an echelon subordinate to the staff of the overall commander, the effectiveness of the program tends to be reduced.

In summary, the flight safety officer is the commander's manager of the aircraft accident prevention program. In general terms his duties

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are encompassed in a mnemonic frequently used by safety officers;

ALARM.

The safety officer must anticipate the many changes that occur in the dynamic Air Force. He should foresee changing missions, equipment, people, operational procedures, and accident potentials.

He must learn the weaknesses, inadequacies and substandard areas that exist in operations, training, communications, maintenance, servicing, administration, airfield facilities, traffic control, and other functions supporting the flying operation.

As a result of learning these weaknesses he analyzes the problems and determines the actions necessary to rectify each situation or condition.

He recommends appropriate action to the commander through a well-coordinated and fully considered plan or program.

Finally, he must maintain constant surveillance to determine if the recommendations and corrective action taken were adequate and effective.

Next to the commander, the safety officer is the key to a dynamic and effective aircraft accident prevention program.

The Air Force Safety Organization

We have examined the general concepts under which the U.S. Air Force aircraft accident prevention program operates and the broad responsibilities of the commander and his safety assistant. We will now discuss the organizational structure in the Air Force that is responsible for guiding the program and aspects of the program itself.

At Air Force headquarters-level the accident prevention program is centralized in the office of Deputy The Inspector General (DTIG).

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DTIG is the senior representative of the Air Force staff in the field of safety. In this capacity he develops, directs, and insures implementation of safety programs for the U. S. Air Force. To assist him in this broad and continuing task he established the Directorate of Aerospace Safety (DAS) at Norton Air Force Base, California. The Directorate is divided into several functional divisions: Flight Safety Division, Ground Safety Division, Missile Safety Division, and Nuclear Safety Division. There are, in addition, several groups whose activities cross the functional lines of the divisions. They are the Life Sciences Group, the Records and Statistics Group, and the Education Group.

An organizational structure that places safety at the highest level in the Air Force has several advantages and insures the proper functioning of an aggressive accident prevention program. First, because it is a staff responsibility of the Inspector General, it is assured of effective input into Air Staff activities and decisions. Secondly, it recognizes that safety (whether flight, ground, missile, or nuclear) is broadly-based and impinges upon all Air Force activities and programs. It therefore requires central direction and control. Finally, it provides for a central repository for the records of accident experience in the Air Force. DTIG provides the local commander, major air commanders, and the air staff with guidance, assistance, and information. He also serves as a focal point of information exchange and liaison with the other Services and industry. Additionally, he conducts special studies, investigations of selected aircraft accidents, safety surveys and staff visits. He also provides for and monitors standards of aircraft accident investigations, disseminates accident prevention materials, analyzes accident data and

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materiel failure reports, reviews design features for safety implications, and maintains liaison with aircraft, engine, and subsystem manufacturers.

Major air commands, likewise, have all safety activities consolidated under the supervision of the Inspector General. The safety effort is divided into its functional areas and each has a staff to accomplish the major air commander's accident prevention program. The major air command's safety activities are not so broad as those of the Directorate of Aerospace Safety. They are oriented to the command's mission and types of aircraft.

We have already discussed the base's safety organization except to note that it is not associated with The Inspector General. Until 1960, safety activities were a responsibility of the Wing Inspector. The safety office was removed from his jurisdiction in order to reduce the aura of "inspection" that surrounded it under the previous staff arrangement.

Aircraft accident prevention efforts in the Air Force are generally divided into two parts: before-the-fact and after-the-fact. Before-the-fact prevention includes all activities and programs that are implemented before an accident occurs. The objective is to prevent an accident from happening. The application of knowledge obtained from an accident investigation is known as after-the-fact prevention.

Before-The-Fact Accident Prevention

Education and Training

Safety can neither be legislated nor ordered. Safe practices result when people understand and believe in what they are doing. This understanding and these beliefs are a result of their education and training.

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Directives and regulations may contribute significantly to improving safety in flight, but people who do not understand or subscribe to the intent of such directives frequently comply with them only half-heartedly or may even try to circumvent them. The cause of aviation safety is not advanced in either event. The problem for the safety officer, therefore, is to educate or persuade such people that the prescribed method of accomplishing a task is an obligation.

It is pertinent to note that nearly all accidents are caused by materiel failures and human acts or factors.³⁵ Human factors are involved in nearly every accident.³⁶ The flight of an aircraft is the result of the efforts of a great number of people--design engineers, industrial workers, aircrew members, maintenance personnel, weather forecasters, air traffic controllers, and countless others. Each is subject to making errors. It is well known that people are fallible; inherent limitations in each of them are potential sources for error that may first become apparent in a damaged or destroyed aircraft.

It should, at the same time, be understood that an error need not always result in an accident. Whether an error causes an accident depends on many factors including its seriousness and context. In many cases an error is corrected or counteracted before it can lead to more serious consequences. Examples of such corrective action and countermeasures are emergency procedures, supervision, inspection, and flying proficiency. These actions become effective only through the continuing

³⁵U.S. Department of the Air Force, Summary and Evaluation of Aircraft Accidents and Fatalities, (Norton AFB, Calif.: Deputy Inspector General for Safety, n.d.), p. 5.

³⁶H.G. Moseley, "Is Toxicology Important In Aircraft Accidents?," A Paper presented to the Aviation Medicine Symposium, Headquarters, Air Materiel Command, 6-7 November 1957, at Wright -Patterson AFB, Ohio.

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education and training of the people responsible for them.

Education, therefore, has two fundamental reasons for being included in an aircraft accident prevention program. First, it provides a base of knowledge which should help a person avoid making an error; and secondly, it aids in the correction or counteraction of an error once it has been committed. For these reasons, education and training is an important part of the flight safety officer's duties.³⁷

Several kinds of education media are used in this task. They can be classified into three general types: (1) literature and publications; (2) motion pictures; and, (3) formal training.

Literature and publications.--The best known publications are two monthly safety magazines: Aerospace Safety and Aerospace Accident and Maintenance Review. Both are professionally produced by the Directorate of Aerospace Safety. The Aerospace Safety magazine is designed primarily for officers who are aircrew members, supervisors, and operations-oriented. The other magazine, as the name implies, is directed toward maintenance and support personnel and their supervisors. It is generally considered by enlisted men to be their magazine. Nearly 100,000 copies of these magazines are distributed to Air Force personnel worldwide.

Another regular publication is of special interest to the flight safety officer. The Directorate of Aerospace Safety, on a bi-monthly basis, distributes a Flight Safety Officers Special Study Kit to each safety officer. It is a portfolio of specially prepared material designed to assist the safety officer in conducting an interesting, varied, and

³⁷U.S. Department of the Air Force, Accident Investigation, p. 9.

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effective program. It contains, for example, accident investigation and prevention tips, pertinent accident briefs, technical articles, and information of a similar nature. It is, in short, a compendium of significant help for the safety officer.

In addition to these continuing and regular publications the Directorate produces highly effective posters on special subjects and a series of cartoons featuring a fictitious accident investigator, Rex Riley, and Lou Snutt, a maintenance worker. The posters and cartoons illustrate specific cause factors of accidents and stress preventive action.

Finally, a great number of special studies, reports, and miscellaneous pamphlets are produced and distributed by the Directorate. These are designed to inform and advise on specific subjects, usually current safety problems. They are sent to commanders and safety officers and vary from a one-page analysis to a book-length report of a weapons system.

Motion pictures.--The Directorate has produced a large number of highly effective safety films, many in color. The program was started in 1959 with a quarterly safety report which was intended primarily for the safety officer's use. The first films were so successful the program expanded to include production on a bi-monthly basis. There are now over 125 films in the inventory and others in production or planning

Formal training.--The training referred to here is that given to upgrade the quality of the safety officer by providing him with a wide and sound professional education. The Air Force, recognizing the increasing complexity of accident causation, asked the University of Southern California to establish a university-level, professional training course designed to provide the safety officer with the necessary technical background to be a specialist in accident prevention and investigation.

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In 1953 the ten-week course, conducted by a newly formed division of the university, was initiated. The course, for which the student earns thirteen college credits, includes instruction in aeronautical engineering, aviation psychology, aviation physiology, aviation law, aircraft accident investigation and reporting, aircraft structures, electronics, communicative skills, and business administration. There is a similar ten-week course for ground safety officers at New York University. In 1963 the University of Southern California increased the scope of its educational programs by offering a bachelor's and a master's degree in Aerospace Safety Management.

The purpose of education and training in the flight safety officer's repertory is to present material so clearly and convincingly that each recipient will try to accomplish his task in the best possible manner. In essence it is an application of the concept that "a job well done is inherently safe."³⁸

Safety Survey

The safety survey is an effective technique to determine the specific conditions that detract from the aircraft accident prevention program. It is a detailed analysis of each operation on an airbase. The safety officer uses a checklist, which consists of a series of questions, to assist him in a thorough review of the area he is examining. Most of the questions derive from some condition that has previously caused an accident elsewhere. The Safety Officer asks himself in effect "Does the same hazard prevail here?" The survey, therefore, is of great assistance in determining those areas that require corrective action.

³⁸Aircraft Accident Prevention, (Norton AFB, Calif.: Directorate of Flight Safety Research, June 1956), p. 1.

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The safety survey is a continuous task of the flight safety officer. Each activity on the airbase is surveyed at least once each year. Critical areas, such as operations and training, maintenance, and air traffic control, are examined more often. A detailed report of the safety officer's analysis with recommendations for corrective action are circulated to interested staff officers and commanders.

Operational Hazard Reports

Many things happen in the process of accomplishing the mission that are hazardous and represent a threat to safety. Deficiencies and hazardous conditions which do not result in damage or injury might never come to the attention of the safety officer. If these weaknesses are not known by him, he obviously cannot initiate action to correct them. The Operational Hazard Report (OHR) was designed to bring hazardous conditions to the attention of the safety officer and other responsible officials in order that they might be corrected before they cause an accident.

Air Force Regulation 62-7, "Reporting Operational Hazards," requires any person observing or having knowledge of conditions inimical to safety of flight to report it to the safety officer of his unit.³⁹ The report may be submitted anonymously. Typical examples of operational hazards are deficiencies in: (1) operation of weather service and facilities; (2) aircraft maintenance or inspection; (3) aircraft ground services; (4) navigation aids; (5) procedures, techniques, instruction, or regulations; (6) flight publications; or, (7) near collisions in flight.

³⁹ U.S. Department of the Air Force, Reporting Operational Hazards, AFR 62-7, (Washington: U.S. Government Printing Office, 6 June 1962), p. 1.

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After the report is received by the flight safety officer, he investigates the circumstances of the hazard and determines its cause. After he insures that corrective action is taken, he circulates a copy of the completed report to interested commanders and staff officers. He also insures that a copy of the report is returned to the individual originally reporting the discrepancy. The safety officer maintains a record of all OHRs and periodically reviews this record to discover trends and to determine the possible need for additional action.

The most important advantage of the Operational Hazard Report is the opportunity to prevent an accident. A hazard is exposed without loss of resources, damage to equipment, or injury to people. The report can contribute substantially to the success of an accident-free operation.

Flight Safety Council

The Flight Safety Council is a special committee composed of members of the staff and subordinate commanders who periodically meet to discuss flight safety problems. After their examination of a problem they present a coordinated recommendation for an effective solution to the wing commander.

The agenda for these sessions, which is prepared by the flight safety officer, usually consists of information gained from recent safety surveys, accidents, near-accidents, trends discovered as a result of OHR analysis, and deficiencies in the operation of the unit.

Minutes of the meetings are circulated among the members and are forwarded to the commander. They are also sent to higher headquarters so that problems that cannot be resolved at the organizational level are passed upward for assistance. Thus, both higher and lower echelons are

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notified of the unit's safety problems, accident potentials, requirements, and accident prevention program accomplishments.

There are several advantages in having a Flight Safety Council. First, when the staff meets as a special safety committee, they are oriented on one general problem--accident prevention. Their preparation and participation in the meeting are not diluted by special interests of their own activities. Secondly, a face-to-face meeting of the staff can result in a better understanding of the basic safety problems, less paper-work, and quicker results of staff action. Finally, it requires that members of the staff, other than the safety officer, actively participate in the accident program.

Materiel Deficiency Reporting System

The purpose of the materiel deficiency reporting system is to identify parts that fail before the end of their predicted service life, to determine the reasons for the failure, and to recommend action to insure increased materiel reliability. The collection, evaluation, and reporting of materiel deficiency reports is the responsibility of the maintenance officer but the safety officer is interested because of the increasing involvement of materiel failures as a cause of accidents.

Part of the increase in the number of accidents attributed to materiel failure is due to the increasing complexity of the aircraft the Air Force has in its inventory.⁴⁰ The C-47, an example of a pre-World War II aircraft, is a rather uncomplicated plane. Its parts catalog has 550 pages of illustrated parts and nomenclature listing, and can be placed

⁴⁰Frank, speech, p. 12.

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in one standard technical order binder. The F-106, an example of a current aircraft, has a catalog (printed in the same format) which requires 1,898 pages and three binders to hold. This increased complexity shows up on the number of accidents charged to materiel failure. In 1964, twenty-six per cent of the C-47 major aircraft accidents were caused by materiel failure.⁴¹ On the other hand, materiel failure in the F-106 caused sixty-six per cent of the major accidents.⁴² The percentage of accidents caused by materiel failure for some of our other modern aircraft in 1964 were: sixty-four per cent for the B-58⁴³ and fifty per cent for the F-105.⁴⁴

Parts fail for basically three reasons: (1) they are improperly designed or manufactured; (2) they are improperly maintained; or (3) they are improperly used. The safety officer is interested in determining not only what parts fail but why they have failed. A frequency of part failures greater than predicted or an unusual pattern of deficiencies should alert the safety officer to problems that could lead to aircraft accidents. Failure of some parts and components in flight can be very hazardous and might lead to the loss or damage of an aircraft. Reliability of materiel, particularly critical components, is essential to assure mission success.

⁴¹T-39/C-131, T-39, C-47, C-119, C-123 Aircraft Accident Summary: 1 Jan 64--31 Dec 64, (Norton AFB, Calif.: Directorate of Aerospace Safety, 1965), p. 1.

⁴²F/TF-102, F-106 Aircraft Accident Summary: 1 Jan 64--31 Dec 64, (Norton AFB, Calif.: Directorate of Aerospace Safety, 1965), p. 9.

⁴³B-47, B-52, B-58 Aircraft Accident Summary: 1 Jan 64--31 Dec 64, (Norton AFB, Calif.: Directorate of Aerospace Safety, 1965), p. 23.

⁴⁴F-105 Aircraft Accident Summary: 1 Jan 64--31 Dec 64, (Norton AFB, Calif.: Directorate of Aerospace Safety, 1965), p. 1.

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The Air Force has developed several techniques for identifying parts before they fail. One method is called "predictive analysis."⁴⁵ One example of the use of predictive analysis is a procedure for determining when a jet engine failure is imminent, permitting the engine to be changed before a failure occurs. The method is a result of the knowledge that jet engine failures are progressive in nature. A bearing failure, for example, rarely occurs without some warning. The problem is to detect the warning in order to become aware of the progressively failing engine.

The predictive analysis procedure consists of monitoring three basic parameters of engine performance: oil consumption, time to coast-down after shutting the engine off; and, in the case of variable exhaust nozzle installations, nozzle positions at full power. The principle is that variations in either or all of these parameters indicates imminent failure.

Another method of predicting the failure of an engine is a spectrographic analysis of oil samples from an engine. On a periodic and scheduled basis, engine oil is examined for metal contaminants with a spectrograph. Excessive metal contamination indicates the engine is wearing at an unacceptable rate. The oil of the suspected engine is examined at increasingly short intervals until the contamination reaches a "critical level." The engine is then removed and overhauled.

These examples are but two of the many methods the Air Force uses to improve the reliability of its equipment. By preventing materiel failures, the materiel deficiency reporting system contributes substantially to the Air Force's aircraft accident prevention program.

⁴⁵Organization and Operation of the USAF Accident Prevention Program, (Norton AFB, Calif.: Office of The Inspector General, 1958), p. 15.

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Influence of Safety On Aircraft Design

Poor design of an aircraft or its systems have caused or contributed to a large number of accidents.⁴⁶ Under some conditions, such as multiple emergencies and adverse weather, the situation and aircraft demand more than the pilot can do. A design that results in an excessive pilot workload or multiple and simultaneous attentive demands frequently results in an aircraft mishap. It is paradox that aircraft designers have both recognized and failed to recognize man's limitations in the design of an aircraft. They have recognized his limitations by including a multitude of augmentative or intermediate control devices between the pilot and his aircraft. On the other hand they have proceeded in aircraft design in a manner that would indicate that they are unaware of the average pilot's limitations. Dials, gauges, switches, lights, handles, radar scopes, levers, and knobs have been added to the cockpit with little consideration of what man's capabilities are.⁴⁷ Designers often fail to consider what psychologists call "negative transfer" or "habit interference." These failures in sound aircraft design frequently cause the pilot to respond with in appropriate or even hazardous actions. A fundamental consideration in aircraft design is, that while aircraft design may change, man is basically the same now as he was in medieval times. No matter how high, how far, or how fast man may eventually fly, his basic limitations are not likely to change. Unless his limitations are understood and considered in aircraft

⁴⁶Perry B. Griffith, "The Safety of Combat Potential, Air University Quarterly Review, Vol XIII, Nr 3, (Spring 1962), p. 21.

⁴⁷Emmert C. Lentz, "Human Factors in 'Cause Undetermined' Accidents," Aerospace Medicine, Vol 36, Nr 3, (March 1965), p. 12.

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design he cannot help but destroy both himself and the intricate machine he flies.⁴⁸ Thus, safety of man and his machine must be designed and built into the machine itself.

The Air Force has recognized man's limitations and the need for sound human engineering in aircraft design. They have provided the aircraft industry with basic design considerations in a directive known as the Handbook of Instructions for Aircraft Designers (HIAD). The instructions are, for the most part, simple directives designed to achieve a greater degree of standarization among different types of aircraft. For example, one instruction requires that all levers, switches, or devices that cause an increase in the power or speed of an aircraft or which result in a "cleaner" aerodynamic configuration should be activated by moving forward along the longitudinal axis of the aircraft. A simple application of this principle is the throttle, which should be moved forward to increase power. Likewise, to raise the flaps the switch controlling them would be moved forward. Conversely, the HIAD states, all devices used to reduce speed, power or to cause a "cluttered" configuration should be activated in a rearward direction. In addition to the throttle and flaps such devices as thrust attenuators, drag parachutes, and flap-erons illustrate the application of this instruction. The simplicity and logic of these instructions is apparent; it would be confusing and dangerous if, in some aircraft, the pilot were required to retard the throttle to increase power.

It might appear that such instructions are self-evident and aircraft

⁴⁸H.G. Moseley, Human Factors That Cause Aircraft Accidents, A Report presented before the Society of Automotive Engineers, Inc., New York City, 12 April 1956, p. 7.

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manufacturers would not need guidance to include them in the design of their aircraft. Unfortunately, experience has indicated that this is not the case. The HIAD requires, for example, that the cowl flap control switch be activated in a forward direction to close the cowl flaps. (Cowl flaps are devices found on most reciprocating engines that control the amount of cooling airflow around an engine. Thus, at low airspeeds, the cowl flaps can be opened to prevent an overheated engine; at high airspeeds they can be closed to avoid an inadequate engine temperature.) Most manufacturers have complied with this instruction. Not all have, however, and the result of such a failure can be seen in the following example:

A big silver stratocruiser, bound from the west coast to New York, trundled into runup position. To the 6 member crew and 34 passengers everything was routine. Clearance was received and the flight engineer called out "cowl flaps--Set for takeoff." The captain, 15 year veteran with the airline, guided his plane out on the active runway and started his takeoff roll.

Takeoff was normal and at an altitude of 1,000 to 1,200 feet, power was reduced and wing flaps retracted from takeoff setting. The airspeed indicator read 145 knots. Immediately upon flap retraction a severe buffeting was encountered. METO power was set. Clearance was requested and received to return to the field.

The captain believed the severe buffeting was due to a split-flap condition. Because of continuing control difficulties he decided against attempting a turn. The aircraft continued losing altitude.

Four minutes after takeoff, 4.7 nautical miles from the end of runway, the aircraft was ditched at 120 knots indicated airspeed. Twenty-eight passengers and 5 crew members survived. They were rescued from 42° water within 30 to 35 minutes. The aircraft sank approximately 15 minutes after it was ditched.

A complete investigation was initiated which included raising the aircraft from its resting place 432 feet below the surface of the bay. No. 1 engine had separated from the aircraft and was not found.

One unusual condition was obvious. The cowl flaps on engines 2, 3, and 4 were in the approximate full-open position.

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Study of records disclosed that the captain had a total of 14,030 hours, 1,577 in this type of aircraft. The first pilot had a total of 7,297 hours of which 1,143 had been logged in this type of equipment. The flight engineer had a total of 1,384 hours, 236 in this type of aircraft, 1 hour and 40 minutes of which had been during the last 90 days.

The flight engineer, who was currently qualified in two other types of aircraft used by the airline, stated that during the preceeding year most of his time had been attained in these aircraft rather than the type that was ditched. On one of these aircraft the cockpit cowl flap controls operate in the opposite direction from those in the aircraft that was ditched and at the hearing the engineer testified that it was possible he had moved these controls in the wrong direction prior to takeoff.⁴⁹

There are a number of factors that contributed to this accident. The pilot evaluated the sensory input incorrectly. The flight engineer did not realize that he was making a manipulatory error in activating the cowl flap switch incorrectly. The basic cause, however, remains--a design deficiency in that the operation of the system did not take into consideration the problem of transfer of learning and habit interference.

Another example will illustrate inadequate aircraft design and cockpit standardization. It also involves habit interference and negative transfer of learning. It is pertinent to note that aircraft may be the same in general ways but still have subtle or gross differences. Some times there is a reversal in the control-display relationships which cause difficulties. The Air Force has had, until recently, three aircraft which had the control sequence on the throttle quadrant arranged as follows:

<u>Aircraft</u>	<u>Left</u>	<u>Center</u>	<u>Right</u>
B-25	Throttle	Propeller	Mixture
C-47	Propeller	Throttle	Mixture
C-124	Mixture	Throttle	Propeller

⁴⁹"Splash," The MATS Flyer, (Andrews AFB, Washington, D.C.) Vol IV, Nr 3, (March 1957), pp. 18-19.

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It requires little imagination to realize the difficulties faced by a pilot who operates more than one of these aircraft. Suppose, for example, such a pilot is taking off in poor weather with a heavily loaded aircraft. Moments after becoming airborne, while entering the clouds, a propeller overspeeds. The emergency procedure requires him to attempt to control the overspeeding propeller by manipulating the propeller lever or feathering the engine. Under this stressful, anxious condition the pilot must react to the emergency with speed--his response must be almost instinctive in nature. The chances are good the pilot will cut the mixture or throttle controls when he intends to reduce the RPM.

One final example will serve to illustrate the point that design deficiencies cause or contribute to aircraft accidents. The Air Force has had, and continues to have, a very serious problem in aircraft fire detection and warning systems. One of the worst hazards a pilot can face is a fire aboard an aircraft. Most aircraft, because of this reason, have a fire warning and/or extinguishing system.

The fire warning system usually consists of sensors in the most critical fire hazard areas, with associated wires running to the cockpit, and warning devices in the cockpit. Fire extinguishing systems usually consist of the installation of fire extinguishers with manifolds in critical areas, and control devices in the cockpit.

In theory, a fire detecting-warning-extinguishing system sounds rather simple. There are problems associated with the system, however. Basically, the problems are these: (1) there are fire warnings without fires; and, (2) there are fires without fire warnings. The Air Force has experienced difficulties in both areas. In fact, the problems became so

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severe in B-47 bombers that their fire warning systems were disconnected.⁵⁰ The problem continues today--even in our most advanced and sophisticated fighter--the F-4C. An Air Force report concerning flight safety problems in the F-4C states that unless the deficiency in the fire warning system is corrected it might result in the "loss of aircraft and/or pilots if [the] system fails to indicate [an] overhear; [also the] loss of confidence in the system if false overhear signals persist."⁵¹ The problem also affects the F/RF-101,⁵² and the newest jet trainer, the T-38.⁵³

In the T-38, for example, there were 184 reportable incidents caused by false fire warning lights in 1964.⁵⁴ Each of these occurrences resulted in the engine being shut-down, the mission discontinued, and an extensive amount of investigation and maintenance. The loss of a T-38 (which resulted when the pilots ejected after believing they had a fire when none actually existed) was even worse.⁵⁵ A million dollar aircraft was lost because of the failure of a system that shows inherent design deficiencies.⁵⁶ It is incredible to think that a nation which has the technical skill to put a man into orbit and safely recover him cannot (or

⁵⁰Fire Warning Lights, (Norton AFB, Calif.: Directorate of Aerospace Safety, Sept 1964), p. 1.

⁵¹F-4C Aircraft Accident Summary: 1 Feb 64--31 Dec 64, (Norton AFB, Calif.: Directorate of Aerospace Safety, 1965), p. 6.

⁵²F/RF-101 Aircraft Accident Summary: 1 Jan 64--31 Dec 64, (Norton AFB, Calif.: Directorate of Aerospace Safety, 1965), p. 1.

⁵³T-37, T-38, F5A/B Aircraft Accident Summary: 1 Jan 64--31 Dec 64, (Norton AFB, Calif: Directorate of Aerospace Safety, 1965), p. 11.

⁵⁴Ibid.

⁵⁵Ibid., p. 6.

⁵⁶Ibid., p. 12.

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has not) designed a system that will reliably report a fire in an aircraft.⁵⁷

One of the problems of accident prevention is to insure that the deficiencies designed and built into aircraft do not cause accidents. These deficiencies were not purposely engineered into a hazardous component or procedure, but as a result of oversight (or lack of foresight) some operational systems are less safe than they should be.⁵⁸

Another problem is the difficulty or impossibility of correcting the safety deficiency when it is discovered after the aircraft is in the active inventory.⁵⁹ It is very costly to redesign and retrofit an aircraft to eliminate a deficiency. Minor problems can be corrected by means of an engineering change proposal (ECP) or a technical order change (TOC) compliance. A more effective answer, however, is to avoid the problem by sound design in original engineering.⁶⁰

A study was conducted by the Directorate of Aerospace Safety to determine the feasibility of requiring certain safety considerations to be designed into a piece of equipment. The result of this analysis was a Military Specification prepared by the Air Force Systems Command entitled "General Requirements For Safety Engineering of Systems and Associated Subsystems and Equipment" (MIL-S-38-130). This document requires contractors to "apply safety engineering principles during design, development

⁵⁷Thomas J. Slaybaugh, "Fire Warnings," Aerospace Safety, Vol XIX, Nr 10, (October 1963), p. 1.

⁵⁸Griffith, p. 17.

⁵⁹Hidden Information, (Norton AFB, Calif.: Directorate of Aerospace Safety, Feb 1965), p. 1.

⁶⁰Jay T. Robbins, "The Changing Role of Aerospace Safety," Aerospace Safety, Vol 19, Nr 9 (September 1963), pp. 18-20.

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test and inservice changes to aerospace systems."⁶¹ Brig Gen Jay T.

Robbins, former Director of Aerospace Safety, expressed his thoughts about the effects of the directive on aircraft design:

It is clear that safety engineering must be adopted as a way of life--for top management, engineers, and designers. As products become more complex the need for early recognition of safety engineering becomes increasingly important.

Finally, the idea behind safety engineering, stated as simply as I can state it, is this: A "what if" attitude on the part of the designer can prevent more accidents than 30 ECPs made farther down the road.⁶²

Prior to being awarded a contract, a manufacturer must submit a Preliminary System Safety Engineering Plan (PSSEP) to the Air Force for approval. The plan must include an analysis of safety requirements, procedures for conducting a safety analysis, failure mode analysis, and actions programmed by the contractor to eliminate or reduce any hazards identified in the system.⁶³ Since this plan must be presented and approved before the contract is awarded, it means safety considerations can be one of the many criteria on which a contract awarded is based.

The Air Force considers this document a "safety milestone." It is expected to reduce the damage to equipment and injury to personnel by using inherently safer equipment.

Another technique used recently in Air Force industry efforts at sound aircraft design is the institution of the "Murphy Team" concept. "Murphy's Law" is a military expression which states that "if something

⁶¹George P. Haviland, "MIL-S-38-130: A Safety Milestone," Aero-Space Safety, Vol 20, Nr 2 (February 1964), p. 22.

⁶²Robbins, p. 20.

⁶³Haviland, p. 23.

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can be done wrong, somebody will do it wrong."⁶⁴ The "Murphy Team" is a group of flight safety officers and aircraft designers whose purpose is to examine an aircraft design to detect possible areas where "Murphy's Law" might later have effect. One example of their efforts includes the designing of a flight control system in which it is impossible for the flight controls to be installed in reverse during maintenance. Incredible as it might seem, we still have aircraft accidents which result from incorrectly installed flight controls.

The "Murphy Teams" have also required that hydraulic connections near each other have differing diameters to eliminate the possibility of incorrectly connecting them during maintenance. Other suggestions adopted concerned the location of switches, levers, and doors.

This concept, first used during the design and manufacture of the T-38, has proved to be a very successful one. It has been also used during the production of the F-111 and the C-141. The work of the "Murphy Team" has significantly reduced the possibility of improper maintenance resulting in an aircraft accident.

After-The-Fact Prevention

The purpose of the aircraft accident prevention program is, of course, to prevent an accident before it happens. Unfortunately, the prevention program has not been completely successful. Accident statistics eloquently confirm this conclusion. When an accident does occur we must learn as much as we can about it in order to apply the knowledge to the

⁶⁴"Murphy's Law" can also be stated as: "if a part can be installed incorrectly, somebody will install it incorrectly." The author suggests a corollary to this "law" might be: "the easier it is to do it wrong, the more often it will be done wrong."

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prevention of future accidents.

The basic purpose of accident investigation is the prevention of future accidents. This prevention, however, is by no means limited to the particular type of accident under investigation. Only rarely do the circumstances of a particular accident duplicate themselves exactly.⁶⁵ With the knowledge provided by facts discovered during an investigation, it is possible to deduce other areas, which by their very nature, require corrective action to avoid accidents of a similar nature. We cannot permit an accident of every specific type to occur before we take corrective action. If we did, we could never hope to decrease our accidental losses.

Accident investigation, thus, is recognized as a fundamental part of the accident prevention program. The greatest single gain in accident investigation is the determination of the causes of accidents so these causes can be corrected and thereby prevent future accidents. Unless the cause of an accident can be determined, we learn nothing from the accident having occurred.⁶⁶

Most aircraft accident investigations are conducted at base-level. The Commander to whom the involved aircraft is assigned is normally responsible for determining the extent of the investigative effort required to find the cause.⁶⁷ He can, for example, have the investigation completed

⁶⁵U.S. Department of the Air Force, Aircraft Accident Investigation and Reporting, (Norton AFB, Calif.: Directorate of Flight Safety Research June 1956), pp. 1-2.

⁶⁶U.S. Department of the Air Force, Report of the Fourth Annual USAF Safety Congress, (Norton AFB, Calif.: Directorate of Aerospace Safety, n.d.), p. 5.

⁶⁷U.S. Department of the Air Force, Investigating and Reporting USAF Accidents/Incidents, AFR 127-4, (Washington: U.S. Government Printing Office, 25 February 1963), p. 12.

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by one officer or a board of officers. When a serious accident occurs or one which involves more than one safety area the commander normally has a board of officers conduct the investigation.

The commander is required to have a qualified board of officers on orders at all times to participate in accident investigations. The minimum composition of the board, for which the commander is expected to select his most highly qualified personnel, is: (1) a president, who must be a pilot on unconditional flying status; (2) a pilot, who has wide experience, preferably qualified in the type and model of aircraft involved (3) an officer qualified in aircraft maintenance and engineering; (4) an experienced Air Force flight surgeon; and, (5) an aircraft accident investigator who is a pilot on unconditional flying status. The investigator must also have at least five years pilot experience and should be a graduate of the USAF Flight Safety Officers' Course.⁶⁸

When communications, weather, nuclear weapons, or aircraft from another command are involved, there must be representation from these functions on the investigation board.

Members of the investigation board are relieved of other duties during the accident investigation. They are instructed to become thoroughly familiar with all directives pertinent to investigation and are to personally participate in the investigation and preparation of the accident report. Their task is to collect all the facts pertaining to the accident, to determine all the factors which caused or contributed to the accident, and to make recommendations for the prevention of similar accidents.

The commander may also ask for expert assistance to augment his own

⁶⁸Ibid., pp. 14-15.

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capability to complete an investigation. He may request consultants from other Federal agencies such as the CAB, FAA, or FBI. He also may have civilian consultants from the manufacturers whose products are involved in the accident. In addition, he can ask for technical assistance from other Air Force agencies. Experts in the engine, airframe, or other subsystems involved may be sent from the Air Force Systems Command or Logistics Command to participate in the determination of the accident's cause. If a part needs a laboratory examination, he may have it sent to an Air Force depot for a Teardown Deficiency Report (TDR) analysis.

The investigation board has thirty workdays in which to complete the investigation and accident report. The deadline for the report may be extended by the major air commander, although it is not normally done. The report should not be delayed, for example, pending receipt of a laboratory analysis or teardown deficiency report. Administrative provisions are made so that the results of TDRs and laboratory reports can be included in the accident report by higher headquarters.

Copies of the accident investigation report are forwarded to the Directorate of Aerospace Safety, the major air command involved, the pilot's assigned organization, and other agencies having an interest in the cause of the accident or the corrective action recommended. One copy of the report is routed to the Directorate of Aerospace Safety through each intermediate commander. Each commander is required to indorse the report and indicate if he agrees or disagrees with the findings and recommendations. If there is disagreement among intermediate commanders, the DAS makes the final determination and notifies all interested persons of their decision.

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Occasionally, the Directorate of Aerospace Safety will investigate the accident, although this is not normally done. In 1962, for example, DAS participated in less than fifteen per cent of all major aircraft accident investigations.⁶⁹ The present policy of DAS is to participate in more accident investigations. The purpose of this participation is to "assist the investigating board; and also provide us with first-hand information regarding the conduct of the investigation; and first-hand information of the factors involved."⁷⁰

Participation by DAS in an investigation can vary from one or two project officers to an Air Force/Industry Investigation Board. The latter is a very large and intensive investigation board. It might consist of 100 or more specialists from the Air Force and manufacturers of systems involved. Normally, such a board is convened only when the accident under consideration involves a new aircraft or one in which there is likely to be a great public interest.

⁶⁹Charles L. Wimberly, "The Need For Improved Accident Investigations," A speech to the Fourth Annual USAF Safety Congress, Sandia Base, New Mexico, 26 August 1963.

⁷⁰Ibid.

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Chapter IV

APPROACHES TO ACCIDENT PREVENTION

In developing and planning an accident prevention program it is helpful to prepare a useful system of concepts and philosophies. This assists in understanding the foundations and mechanisms of accident causation and leads to the construction of an effective program to counter the losses caused by accidents. In this chapter we shall discuss some of the more important concepts and philosophies concerned with accident causation and prevention.

The "Sequence of Events" Concept

An aircraft accident only rarely results from one catastrophic occurrence. Accidents are almost always the result of a long and continuous series of minor incidents--a chain of events of which the final event is the accident itself.¹

The fact that an accident is usually the result of a series of events affects the prevention as well as the investigation of an accident. Insofar as prevention is concerned, we need to be able to identify the links in this chain, isolate them, and then break the chain, thus preventing the accident.² This chain of events concept is implicitly

¹U.S., Department of the Air Force, Aircraft Accident Investigation and Reporting, (Norton AFB, Calif.: Directorate of Flight Safety Research, June 1956), p. 1.

²Joseph D. Caldara, "The Diminishing Safety Improvement Rate," Alumni Review (University of Southern California), Vol I, Nr. 1, (Summer 1964), p. 9.

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recognized in the Air Force system of countering inflight aircraft malfunctions. When a part or system of the aircraft fails inflight the pilot normally applies corrective or counteractive measures to isolate the difficulty, minimize the hazard, and prevent further damage. These corrective measures are called "emergency procedures" and the pilot is required to thoroughly know and practice them before flight. We have learned from experience that inflight malfunctions rarely correct themselves. Repair of defective parts inflight is very limited or impossible. We have also found that one malfunction often precipitates another and the problem grows worse.³ For these reasons, the Air Force emphasizes the procedure of making an emergency landing as soon as practicable after an inflight malfunction.

We isolate the link in the chain of events by applying corrective emergency procedures. We break the chain by landing the aircraft to have the malfunction corrected.

The sequence of events concept also helps in aircraft accident investigation. During an investigation a large number of isolated, seemingly unrelated facts are discovered. They can be made to reveal their true worth if they are evaluated with reference to what they contributed to the sequence of events. Each fact becomes relevant when the history of the flight can be determined.

Although this concept is helpful in accident investigation it presents a particular problem to Air Force accident investigators. The problem is one of determining a "primary" cause of the accident. It will be remembered that the primary cause, as defined in chapter I, is "that

³Guy L. Palumbo, "Declaring and Conducting Emergencies," Aerospace Safety, Vol 20, Nr. 6, (June 1964), pp. 16-17.

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factor that made the accident inevitable." It is a difficult task for the investigator to determine the point in the sequence of events that the accident was no longer preventable.

Perhaps a fictitious example will illustrate the sequence of events and will show its relationship to accident causation and the difficulty faced by the Air Force accident investigator in determining the "primary" cause of the accident. While reading the example keep in mind two questions: (1) did a specific act or event represent a link in the chain of events?; and, (2) at what point was the accident inevitable?

Let us suppose that Lieutenant Smith, on the evening before he is scheduled to fly a cross-country flight with his student, takes his wife for dinner at the officers' club. Before dinner he and his wife have several cocktails. The rich lobster thermidor, which he ate for dinner, upset his digestive system. As a result, he spent a restless night and awoke fatigued. The next morning, Mrs. Smith took the opportunity to inform him of her latest purchases and to complain that other men made more money than did he. A discussion ensued about the merits of thrift and management and Lieutenant Smith left home, without his breakfast, in an agitated emotional condition.

When he got to his squadron the commander called him in and unjustly blamed him for something over which he had very little control. He was now quite upset and barked at his student, "Come on; let's get out of here!" They proceeded to base operations and began planning for the flight. While calculating his fuel requirements, Lieutenant Smith made some arithmetical errors that he did not discover. After completing his plan and filing a clearance, Lieutenant Smith and his

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student went to the aircraft, preflighted it, and turned on the radio to await his flight clearance from air traffic control.

In a few minutes a voice from the control tower said, "Your clearance is on request; you are cleared to taxi to runway 18." He started the aircraft's engines and taxied to the end of the runway. The clearance was delayed and they had to wait ten additional minutes for it. This unexpected delay made Lieutenant Smith uneasy because each minute spent on the ground with the engines running meant seven less miles in the range of the aircraft. When the clearance was finally received, they were instructed to fly a Standard Instrument Departure (SID) which was unsuited to their flight plan. To achieve air traffic control and separation they were told to make their climb in a direction opposite of their intended flight route until they had reached half of their cruising altitude, then to reverse the turn and report over the radio station at cruising altitude. Lieutenant Smith complained to the tower that it was not the clearance for which he had filed. The tower responded by stating the pilot could refuse the clearance but if he did he would have an additional wait while a new clearance was requested and approved.

He finally accepted the clearance and quickly estimated that the SID would add at least twenty minutes to his hour and one-half flight. After he was airborne and on the route to his destination, Lieutenant Smith began calculating his ground speed and revised fuel requirements. His navigation equipment was limited to a VOR, and he needed to fly past two radio stations to get a good "fix" on his ground speed. It was less than he had calculated in his preflight planning; he concluded that the wind velocity was much greater than predicted by the weatherman.

His revised calculations indicated that he was going to have con-

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siderably less fuel when he arrived at his destination than he first thought. In fact, it was now possible that he wouldn't have enough fuel to get to his alternate airfield if he was unable to land at the intended destination. He radioed the air traffic control center for the terminal weather and found it had deteriorated. It was still adequate for an instrument approach but much worse than the weatherman had told him it would be.

After they arrived at the terminal radio station they were given permission to descend and begin an instrument approach. Lieutenant Smith realized that once he descended from his cruising altitude he would probably be committed to a landing since the fuel remaining was insufficient to take him to his alternate airport. On the radar final approach, in minimum weather conditions, the ground controller informed him that the approach would have to be abandoned because of a malfunction in the radar. The loss of the radar more than doubled the minimum ceiling and visibility requirements of an instrument approach. He discontinued the approach and began flying toward the alternate airfield. About half-way to the alternate, the engine flamed out because of fuel starvation. The pilots ejected and the abandoned aircraft crashed and was destroyed.

Perhaps this example seems improbable or farfetched. It is, however, essentially the history of flight of an aircraft accident the author investigated. What is involved in this example was a series of events, each somewhat separate, and yet, a part of the overall occurrence. None of the events, by itself, would have made the accident inevitable; together, and in this special context, they caused the loss of an aircraft.

What caused the accident? Would it have made any difference if Lieutenant Smith had chosen steak instead of lobster? Would his judgment

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have been better if he had not been troubled by the discussions with his wife and commanding officer? If he had discovered the error in his pre-flight fuel planning, might he have realized the fuel reserve was insufficient for the intended flight? Should he have refused to accept a departure which was undesirable? Would the accident have been avoided if the wind and weather predictions proved to be more accurate? Finally, might all have been saved if the radar had proved to be more reliable? How much agreement would you get regarding the cause of the accident from a marriage counselor, a prohibitionist, a weatherman, an air traffic controller, a communications-electronics specialist, or a pilot with 3,000 flying hours? What, precisely, caused the accident? What was the primary cause?

The point of this discussion can be summed up in these ideas:

- (1) an accident is a sequence of events: (2) unless the chain of events is broken existing conditions tend to deteriorate instead of improve; and, (3) we must recognize the individual events in the sequence in order to apply corrective action and prevent an accident.

"Known Precedent" Concept

The known precedent concept simply states that "accident causes, like history, tend to repeat themselves." Causes of accidents have remained the same throughout history: they are caused either by people or things. Aircraft models have changed, but being machines they still malfunction and fail; people continue to make basically the same errors now as they did when flight was born in 1903.

In Chapter II we described the accident in which Lieutenant Selfridge was killed. It will be remembered that the propeller broke on

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the airplane in which he and Mr. Wright were conducting a test flight. The portion of the propeller which separated severed a guy wire supporting the wing; the wing failed and the aircraft plummeted to earth. Remarkably similar accidents still occur. A C-124, cruising at 7,500 feet, lost a propeller blade on one of its engines. The propeller pierced the fuselage of the aircraft and severed the elevator control cables. The aircraft fell into a spin and crashed, killing all aboard.

In slightly more than one-half century of powered flight the capabilities of aircraft have increased from forty miles an hour to over 4,000 miles an hour, and altitude has increased from a few hundred feet to over 300,000 feet. They have vastly increased their complexity and versatility. When viewed in terms of these tremendous changes, it is striking to note the similarity of the two accidents cited above.

Two aircraft accidents that occurred more than fifty years apart will further confirm that "there is nothing new under the sun"--that the causes of accidents remain very much the same now as they always have been.

The first accident in our example occurred in 1912. The following is an extract from the proceedings of a board of officers who met on 2 October 1912 to determine the cause of one of the earliest military aircraft accidents:

Immediately after the accident, the Board proceeded to examine the wrecked machine and upon this examination found that the control wires were all intact. From the testimony of eye-witnesses, the Board is of the opinion that the accident was caused by the aviator misjudging his height from the ground and his failure to bring the machine out of the glide in sufficient time to clear the ground.

Probable Cause of the Accident: Error in judgment on part

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of pilot in not straightening up machine before striking the ground.⁴

The more recent accident occurred in 1964. The resumé of the accident, which appeared in an Air Force aircraft accident summary, was:

During a night landing by the IP [instructor pilot] who was in the rear cockpit, the aircraft landed hard and short of the approach end of the over-run. The IP allowed a situation of high sink rate to develop during the final portion of his approach from which he could not properly recover in time to avoid a hard landing short of the over-run.

Cause Factors: Pilot factor on the part of the IP. A possible contributing cause was the lack of approach or over-run lights on the runway involved.⁵

The known precedent concept is so strong that the basic sequence of events which leads to the next Air Force accident is already in DAS files. All that need be changed are the details; the basic accident story is already known.

This knowledge should be helpful to the safety officer in his management of the aircraft accident prevention program. His prevention efforts need not be concerned with highly improbable events so much as with every-day, commonplace circumstances that lead to accidents. It requires that he emphasize the fundamental aspects of accident causation. It also suggests that unless a cause factor is fully corrected, it will reappear to cause difficulty. He cannot disregard a hazard while thinking it will do no harm. Finally, it suggests that because a set of circumstances did not cause an accident in one context, it will not cause one later. We have had more than enough experience in sixty years'

⁴Memorandum, Chief Signal Officer, U.S. Army to Chief of Staff, 28 February 1914, Subject: "Mortality in Army Aviation, (Washington: War Department).

⁵T-37, T-38, F5A/B Aircraft Accident Summary: 1 Jan 64--31 Dec 64, (Norton AFB, Calif.: Directorate of Aerospace Safety, 1965), p. 9.

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of aircraft accidents to prevent most future ones.

"Man-Machine-Media-Mission" Concept

This concept simply states that the efficient accomplishment of a flight or an aircraft accident is caused by the interaction of several aspects always present in a flight situation. Since each of these factors begins with the letter "M" the safety officer frequently refers to them as the "four Ms." They are Man, Machine, Media, and the Mission. The way the factors and characteristics of flight, as represented by the four Ms, are handled has a great deal to say about how well a flight is conducted and how successful it is. We will examine this concept in greater detail, concentrating our attention on Man, since in some way he is responsible for nearly every accident.

Man

During the period of recorded history there is little evidence to indicate that man has changed in any major respect. Because man does not change, the kinds of errors he makes do not change. This changeless quality of man is at once a curse and a cure in accident causation and prevention. It is a curse because man keeps on making fundamentally the same errors as he has made in the past and to help him avoid these errors we must constantly train, educate and allow him to practice. It is a cure because it implicitly suggests we can predict the errors he will make by the errors he has made in the past. A careful study of his past errors should lead to positive future accident prevention.

We must remember that even in the space age, man still prefers a sea-level, shirt-sleeve, moderate-temperature, moderate-humidity

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environment. He functions most efficiently under these conditions. When he is placed in a machine that is affected by movement in three dimensions, and is buffeted by turbulence and gravity forces; when he is dressed in a special pressure suit, a parachute, restraining devices, a helmet, and gloves; when he is required to breathe oxygen under pressure; and when the aircraft is inherently complex and difficult to operate, we must expect his performance will be degraded. We can logically expect that, at times, his cockpit workload requirements will be greater than he is able to fulfill.

For convenience, man's limitations can be divided into four general categories: physical, physiological, psychological, and time. We shall examine each limitation briefly with the hope the reader will gain additional insight into accident causation.

Physical limitations.--Man is a physical and mechanical structure. His skeleton and muscles are a superb system of levers, weights, balances, counterbalances, and motive power. This system, as fine as it is, has rather fixed and well known limitations. He can lift only so much. He can reach only so far. He can see only so well. He can hear only so well.

All of these limitations are well known. Their importance lies in the fact we cannot design a machine (or ask a person to do a job) that will require him to exceed them. To do so is to invite disaster. A clear understanding of these limitations and the application of the principles of human engineering to design are essential if we are to reduce the number of accidents for which man is responsible.

Physiological limitations.--Man is not only a machine, he is also a sophisticated bio-chemical laboratory, as it were. His efficient

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functioning is partly due to complicated chemical reactions that take place within the body. Blood is pumped through the body carrying with it chemicals and food to nourish the tissues. This nourishment makes possible the proper functioning of the muscles and bones and the "machine" aspects of the body. The sensory and nervous system is permitted to remain alert. Under these conditions decisions can be reached and action can be accomplished in a timely and efficient manner. If the delicate bio-chemical balance is disturbed, man loses efficiency and his ability to make decisions and take action is degraded.

Another condition that can reduce man's efficiency is fatigue. While fatigue might be partly psychological, it is physiologically based. When a man becomes fatigued, metabolic waste products are built up in the bloodstream and muscles. This adverse bio-chemical effect is enhanced by boredom or distractions. Hypoxia coupled with fatigue is a particularly dangerous combination. When a man is tired his efficiency is decreased, and he is more prone to make errors. Sometimes these errors go unnoticed and, therefore, are not corrected. Although fatigue is very difficult to prove as a cause of an aircraft accident, it has been shown to contribute to a large number of Air Force aircraft accidents.⁶

Another factor reducing man's efficient performance is illness. Illness is ordinarily not a great problem among aviators because ill pilots usually do not fly. There are, however, two problems which must be considered when discussing a pilot's performance and temporary illness. The first problem is that the pilot might develop a severely

⁶U.S., Department of the Air Force, Medical Summary of USAF Aircraft Accidents, (Norton AFB, Calif.: Deputy Inspector General for Safety, November 1960), 1ff.

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diverting symptom from such conditions as headaches, ear aches, gastroenteritis, or sinusitis. The second is he may take medicines which will adversely affect his performance in flight.⁷ Even common medicines such as antihistamines, nose drops, aspirin, and antibiotics can be very hazardous to the aviator if taken without the close supervision of a flight surgeon.⁸

Finally, man is adversely affected by a wide variety of noxious substances commonly found in the atmosphere of an aircraft. Oil vapors, smoke, gasoline fumes, carbon monoxide, carbon dioxide, fire extinguishing agents, and oxides of nitrogen are some examples of such irritants, toxicants, and narcotic agents. Concentrations of these substances can be sufficient to cause loss of consciousness or even death.

Psychological limitations.--One of the most important areas in man's psychological limitations is his ability to learn. Man is not born with knowledge; he must learn nearly everything he knows. He learns only so fast and so well, and what he does learn he forgets at a measurable rate.⁹ Additionally, there are significant differences in the time required by individuals to learn. When one considers the number of judgments, procedures, and interpretations a pilot must master, it is not surprising a considerable amount of time is required to adequately

⁷H. G. Moseley, "Aero Medical Investigation of Aircraft Accidents," A Paper read at the Aviation Medicine Symposium at Headquarters, Air Materiel Command, Wright-Patterson AFB, Ohio, 6 November 1957.

⁸Paul Evans, Aviation Physiology, (Los Angeles, Calif.: University of Southern California, 1956), p. 73.

⁹U.S., Department of the Air Force, Man and Safety--Physiological Limitations, AF Film Nr. TF 5522d, (Norton AFB, Calif.: Directorate of Aerospace Safety, n.d.).

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train him. There is a requirement not only to complete the original training that he needs to learn a job, but also there is a need for continuing proficiency training to maintain the skills acquired. Finally, there is transition training required when an individual learns to do something new.

Another important psychological factor associated with training is habit interference. We briefly mentioned the effects of habit interference in a previous chapter. We will now discuss the psychological reasons for it. Although we do not clearly know what learning is, once a person has learned a pattern of actions through many repetitions, this pattern becomes a relatively permanent part of his response system.¹⁰ A person, however, may be required to make a different reaction or response under different circumstances, to the same stimulus. The human is adaptable and learns to make most of these responses with relative ease. In an emergency, however, when his attention is distracted and he is required to make a new response to the same stimulus, he will frequently revert to the former habit pattern which is now the wrong response. The result of such behavior is often without effect although sometimes it is inimical. It is a built-up limitation that can be demonstrated in the laboratory as well as in practice.¹¹

Another limiting psychological factor is that fact that people have emotions, desires, and feelings. Emotional disturbances, as they affect

¹⁰Nicholas A. Bond, et al., Aviation Psychology, (Los Angeles, Calif.: University of Southern California, 1962), pp. 6-1; 6-4.

¹¹Anchard Zeller, Human Factors In Aircraft Accidents, (Norton AFB, Calif.: Directorate of Flight Safety Research, 1956), p. 11.

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most people in the Air Force, are quite normal and universal. Examples are anxiety and fear. Such disturbances are rarely incapacitating and lead, in most cases, only to inefficiency and minor errors. Fear in a new and unfamiliar situation, for example, is a normal response. Increased experience and successful accomplishment ordinarily cause fear to decrease in intensity. It is only when an individual fears that the demands of the situation are close to the upper limits of his accomplishment that fear becomes a factor of major consideration. In such cases, fear may resolve itself through a psychosomatic illness or may disrupt a person's normal responses completely (as in panic). This, of course, would be a major concern if it occurred in flight.

Some person's behavior is so deviant they are said to be "emotionally ill." Fortunately, persons who exhibit such instability are infrequently found in the Air Force owing to the careful selection of personnel. There are, however, a few individuals of this type and they have caused accidents as a result of unauthorized low level flying, looping bridges, or equally unacceptable behavior.¹² Severe family or financial conditions have also been cited as the cause of aircraft accidents.¹³ Emotional disturbances, like fatigue, are very difficult to identify as the cause of an accident.

Time limitations.--Man operates within a framework of time. Time interacts with the physical, physiological, and psychological limitations of man and can contribute to his inefficiency and failure. Every action a person takes follows a sequence and takes a measureable amount of time. This

¹²Emmert C. Lentz, "Human Factors in 'Cause Undetermined' Accidents," Aerospace Medicine, Vol 36, No 3 (March 1965), p. 218.

¹³Lentz, p. 218.

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time sequencing of man's behavior can break down and result in inaction or a delayed response. If a man is presented with too much information he must mentally sort it out, evaluate it, and make a decision before he can take action. If he is presented with too little information a decision may be impossible in the time available. If the information is uncoordinated or presented in an unsystematic manner, the resulting confusion can result in a delayed decision or reaction.

It should be remembered that the aviator is one part of a dynamic combination the very speed of which allows little time in which to make a decision. Under these conditions, a correct decision which is late can be as disastrous as a faulty decision that is timely. Additionally, some decision should be made as default can be as disastrous as a bad decision.

The limitations imposed by time may be less obvious but they are certainly no less important than are man's other limitations. A few examples will illustrate this point. One of the important problems associated with the avoidance of mid-air collisions is time. We operate in the Air Force almost entirely under the "see and be seen" concept of collision avoidance. That is, the pilot is expected to see another aircraft and take action to avoid colliding with it. With the high rates of closure between aircraft in flight, however, it may be impossible to avoid a collision.

The time it takes for a pilot to see an object in the air, analyze what it is, determine that it is a threat to him, make a decision, operate his flight controls, and allow the aircraft to alter its flight path may be more than that required for a collision to take place. Some idea of the times involved in this recognition-decision-reaction sequence as it relates to the mid-air collision problem is illustrated in the table on the

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following page.

There are still other limitations such as reaction time involved in the man-time combination. For example, if a pilot, looking inside the cockpit, looks outside the aircraft and then refocuses his eyes on the instrument panel, it will take approximately two seconds. A lateral movement of the eye of twenty degrees will take approximately five-hundredths of a second.¹⁴

¹⁴Zeller, p. 5.

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TABLE 6
INFLIGHT COLLISION REACTION TIME^a
(Estimated Minimum Times For Significant Behavioral Processes, Related to Aircraft Speeds)

Operation	Time, in seconds	Distance traveled, in feet		
		600 mph	1800 mph	
	For operation	From 1st Sighting	During Operation	From 1st Sighting
Sensation (light traveling from retina to brain)	0.10	88	264	264
Focusing with Central Vision	0.			
Motor Reaction to Prearrange Eye Movement	0.175	154	462	726
Eye Movement	0.05	44	132	858
Focusing with Fovea	0.07	62	185	1043
Perception (minimum recognition)	0.65	572	1716	2759

^aAdapted from "Jet Collision Reaction Time," A poster, nr. 62-11-2F, (Norton AFB, Calif.: Deputy Inspector General For Safety, n.d.), and Bond, et al., p. 7-5.

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TABLE 6, continued

Operation	Time in seconds		Distance traveled, in feet		
	For operation	From 1st Sighting	During Operation	From 1st Sighting	From 1st Sighting
Deciding what To Do	2.0	3.045	1760	2680	8038
Operating Controls	0.40	3.445	352	3032	9095
Aircraft Changes Flight Path	2.00	5.445	1760	4792	14,375

NOTES: If two aircraft flying at 600 mph are approaching each other on a collision course and are 1 1/3 miles apart, they are 4.0 seconds from impact. If all of the steps in the sequence, i.e. human-machine, perception, response, were executed precisely, a collision could be avoided. If excessive time were taken in any of these steps a collision would be inevitable.

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Pilots receive information not only through their vision but also through their other senses such as hearing and touch. The interpretation and evaluation of the information of all the senses coupled with the manipulation of the controls require still more time. The conclusion is apparent: the high closure rates of modern aircraft and the reaction time of the pilot make the "see and be seen" collision avoidance concept inadequate. To illustrate this we need only examine several of the recent mid-air collision accidents. In 1962, four of the author's friends (in two F-102s and a T-33) collided in a clear sky, 25,000 feet over West Texas. Although all three aircraft were destroyed miraculously none of the pilots was seriously injured. Significant comments appeared in Aerospace Safety magazine about the accident.

This accident was bound to happen. It's just as possible today. When two jets happen to be on a head-on collision course one of the greatest deficiencies of the "see and be seen" theory is exposed. The rate of closure was 1326 feet per second. This meant that detection had to be made at over three miles for even a possibility of avoidance. At anything less collision becomes inevitable.

There are other factors that makes such accidents as this inevitable when aircrew members alone are responsible for avoidance. Consider such things as pilots momentary glancing at their instruments, (F-102 Lead: "I checked my altimeter and heading. At that very instant. . .") windscreen obstructions, reduced visual acuity and other human factors that decrease the ability to detect aircraft at distances of three miles and beyond.

The narrow head-on profile of T-33 and F-102 aircraft makes it virtually impossible for pilots to detect such aircraft at more than three miles.¹⁵

The question that logically comes to one's mind when he reviews the numerous and severe limitations of man is, "What can be done about them?" The answer is: essentially nothing. Even with more intense and

¹⁵ "Head ON!" Aerospace Safety, Vol 18, Nr. 10 (October 1962), p. 12.

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better quality training than the Air Force now accomplishes, we cannot expect to substantially modify man's basic limitations. There are a number of ways in which we can avoid exceeding them, however. This thought leads into the second of the four Ms--the Machine.

Machine

If man is to fly, he must (obviously) have a flying machine. The safety officer is interested in the machine because it, in combination with man, is responsible for a large number of accidents.

The primary requirement of an aircraft is that it operate effectively and be capable of performing its intended mission. It is designed to possess certain performance characteristics as a result of its mission. To a degree, an aircraft's weight, speed, range, fuel and crew requirements depend upon its planned use. The increasing complexity of aircraft, of which we have spoken several times before, affects the efficiency of mission accomplishment and the chances of having an accident in at least two ways: First, as aircraft become more complex, the probability for mechanical failure increases. Secondly, the possibility of exceeding the limitations of the operator is significantly increased.

A consideration in aircraft design, then, is that the aircraft be within the control means of the operator. The information presented to the pilot by the instruments must be immediately accurate. Similarly, controls must be effective but their operation ~~must~~ be within the capability of the operator. In fact, the entire aircraft must be designed with full consideration for the limitations of man.

These limitations include not only those of the operator but also those of the maintenance personnel who must keep the equipment in operation.

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No matter how successful a machine is in its functional operation, if it cannot be easily serviced and maintained, its usefulness is severely limited.

Future design must attempt to keep the workload requirements and demands upon the pilot to an acceptable level. The successful accomplishment of a mission by the man-machine combination can be looked upon as the integration of two variables: one of these is the level of the operator's ability; the other is the level of the demands of the situation. So long as there is an adequate margin between the two, the probability of successful accomplishment is high. As this margin decreases, an increase in the demands of the situation or a decrease in the individual's ability will probably result in a condition where the individual cannot adequately respond to the situation. This observation seems confirmed by the fact that in 1964, fighter aircraft while flying approximately one-sixth of the total Air Force flying time accounted for over one-half of the major accidents.¹⁶

We must also consider the environment in which the aircraft operates when we discuss the combination of factors that produce safe flights or aircraft accidents. Aircraft, of course, operate in the air. They also operate on the ground and on the sea. Each of these media has characteristics that affect flight. We use the term "medium" in this paper in its broadest sense to include all factors exclusive of man and his aircraft. In these terms, a great many factors must be considered. Smooth runways of adequate length, navigation aids, landing devices, and maintenance/operations facilities, and weather conditions must be considered and understood.

¹⁶U.S. Department of the Air Force, 1964 USAF Accident Bulletin, (Norton AFB, Calif.: Directorate of Aerospace Safety, 1965), p. 4.

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The purpose of teaming men with machines is to perform a mission.

Different missions have differing requirements. Each has a differing set of hazards associated with it. The missions of the Tactical Air Command and the Air Defense Command, for example, are inherently more hazardous than that of Air Training Command. A requirement does not exist to train student pilots when there is a 500-foot ceiling and one-half mile visibility. Pilots of the Air Defense Command may be required to fly under far worse weather condition to fulfill their mission of aerial interception.

There can be compensation among the four factors. If the mission is inherently more dangerous and it is conducted in adverse weather, we can compensate, to a degree, by providing the best men and machines to accomplish the mission. Likewise, if man is the weakest of the factors, as is the case with student pilots, we can compensate by requiring that he avoid flying in severe weather and providing him with a reliable aircraft to operate.

It should be clear: safe and efficient flight which leads to mission accomplishment is the result of a great many factors. What is equally clear is that excessive workloads, poor environmental conditions, inadequate equipment, and insufficient supervision can lead to accidents. If a job is to be accomplished successfully, full consideration must be given to the limitations of man, his machines, and the medium in which he operates.

The Philosophy of Prevention

Many people think that safety is essentially negative in character. They suggest that safety advice and directives are fundamentally "thou shalt not" in nature. Unfortunately, there is substance to the charge. While we emphasize the positive aspects of safety in the Air Force, at the same time,

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we must acknowledge that many of our restrictive regulations have their genesis in accidents. Too often action taken to prevent accidents is little more than a directive prohibiting certain activities.

Safety should not inhibit the operational flexibility of units or the freedom of action of individuals. It is contrary to a person's basic nature to be told not to do something he wishes to do. If the "shall not" directive comes from a source of authority the recipient will frequently respond with a grudging acquiescence.

Some of the negative aspects of safety undoubtedly come to us from our childhood. From an early age, safety is presented to a child in an almost wholly negative way. For example, we say to a child, "don't cross the street; you might get hit by a car." Or, "don't climb that tree; you might fall and break an arm." Sometimes a parent tells a child, "Don't go in that water; you might drown." Each of these admonishments inhibits the child's natural urge to climb, to explore, and to enjoy his surroundings.

A positive approach to the same problems would be: "let me show you how to cross the street safely, so you can visit the neighborhood kids;" or, "let me teach you how to climb a tree so you can look out over the neighborhood," or, "let me teach you how to swim well so you can enjoy the water." Applied to the flight safety problems the same approach would suggest: "let me teach you how to fly well, so that you can effectively do your job, and at the same time, enjoy flying."

The "thou shalt not" approach to accident prevention is one of the oldest, and perhaps the worst, way to prevent accidents. It is one of the easiest methods which probably accounts for its wide-spread use. It is easier to tell someone he is not permitted to do something than it is to teach him how to do it properly and well. This approach does not solve the basic problems in accident causation, however. Why? The

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reasons is that we will continue to cross streets, climb trees, swim, and fly aircraft. Unless we learn to do these things well, we are bound to err.

The problem of safety and conservation of resources are further complicated by the fact that many of these inhibitory procedures are neither fully considered nor thoughtful approaches to elimination of the basic difficulties. Several years ago, because of the fear that the canopy and seat ejection system would be actuated on the ground, multiple safety pins were installed. After this procedure was instituted, the record began to indicate there were more people lost because of pins that were inadvertently left in the seat than were saved because of their installation. Recognition of the greater hazard caused the procedure to be changed and the use of only one safety pin was reinstituted. In the interim, several people lost their lives as a result of this stop-gap, inhibitory, negative approach to safety.¹⁷

The overall result of such misdirected efforts at accident prevention has caused some very poor attitudes among people to whom the safety program is directed. An article written by three pilots, entitled "Is The Flight Safety Program Hurting Combat Readiness?," had these comments about the aircraft accident prevention program:

Serving from a unique position they [safety] officers act as the authority for a long list of required committees, meetings and reports. In their fields they have become masters, not the servants, of their unit commanders. The tail has outgrown the dog. The Flight Safety Program is wagging combat readiness.

.....
And the list of safety restrictions grows longer every day. More emphasis is put on what the pilot can't do safely than what he

¹⁷Intercom, (Norton AFB, Calif.: Directorate of Aerospace Safety, March 1964), p. 2.

can do. This tends to create an attitude of hesitancy approaching fear in come pilots.¹⁸

Another pilot had this caustic comment about the flight safety program:

Flying Safety is just a number to be called in case of an accident and ¹⁹a person who lists a few "don'ts" at a one-a-month mandatory meeting.

Colonel John F. Sharp, former Chief of Safety of the Air Defense Command, had these criticisms of the Air Force aircraft accident prevention program:²⁰

The age of specialization has restricted the philosophy outlook, and Flight Safety today, rather than operating throughout the realm of TOTAL CONCEPTION, is, by directive committed to a system of "blame and correction." Regardless of how thin one slices the interpretation, the USAF approach to accident prevention is negative, and no amount of verbal defense can justify Air Force accident frequency.²¹

.....
Every act taken which is designed specifically to prevent aircraft accidents is restrictive to some degree. Corrective measures born of known deficiencies then compound upon each other and create an environment conducive to substandard performance. Such an environment in any language inhibits the mission and reeks with accident potential.²²

.....
A flight safety program, then, is the expression of an activity that has no place in the scheme of success. It is a non-productive and the only negative influence strong enough to challenge the very

¹⁸D. C. Wolfe, Mark Jones, and A. W. O'Donnell, "Is The Flight Safety Program Hurting Combat Readiness?," Flight Safety Officer's Special Study Kit, (Norton AFB, Calif.: Directorate of Flight Safety Research, November 1962), quoting from Marine Corps Gazette, 1962.

¹⁹Leland R. Wood, "No Flying Safety!," And There I was. . ., (Norton AFB, Calif.: Directorate of Aerospace Safety, n.d.), p. 15.

²⁰Colonel Sharp made these remarks in a thesis at the Air War College in 1957. Interesting, upon graduation from AWC he was assigned as Chief of Safety, Air Defense Command. The views expressed in his thesis are revolutionary.

²¹John F. Sharp, "Flight Safety" Function & Concept," (Unpublished thesis, Air War College, Air University, 1957), p. 6.

²²Ibid., pp. 12-13.

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fundamentals of combat operations. . . . As previously discussed in this paper, the strength of the flight safety activity is ever increasing. It is not beyond the realm of possibility that already the Air Force has achieved enough "success" within this field to assure that pilots taking the runway for take-off are masters of WHAT NOT TO DO. The mission? Oh yes, they ought to know how to do that too.²³

This is strident, acerbate criticism. These comments could be dismissed if they did not represent the feelings and attitudes of a sizeable number of people in the Air Force. Even General Caldara acknowledges that safety has a negative approach.

For some reason--the word safety has a negative connotation. Don't fly. Effective flying safety cannot be negative, flight inhibiting, operations limiting program.²⁴

Why is the safety officer's shield tarnished? It is one of the paradoxes of being engaged in flight safety work that we are trying to sell what should be an easily salable product--the safety of an individual and the conservation of equipment. Unfortunately, it is not easy to sell safety in the military (or for that matter the civilian) aviation community. One of the reasons for this, the author believes, is the negative approach so often taken in accident prevention.

Another reason is that safety may be ego-involved and for a person to acknowledge he is safety conscious is to admit a loss of virility and manhood. One aviation psychologist, Mr. Chaytor Mason, says:

One of the curious curses of our culture is the conclusion that anyone interested in his own safety is far too frightened to play the game well or give the job its fullest measure and therefore should be sacked on the spot.

This is a sad but realistic truth relating to Man's own appraisal of -- Manhood.

²³Ibid., pp. 18-19.

²⁴Caldara, p. 2.

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When it comes to "being a man," the average proud male cannot satisfy himself with buckling his biceps, or even by looking at the handsome progeny his seed has begotten.

Some secret spark of pride also directs that, should the occasion demand, the Man will also be willing to conduct himself like an utter Boob, disregarding all precautions--expressed or implied--in the performance of almost anything that will prove he isn't a Sissy.²⁵

He supports his thesis, in part, with examples of the public reluctance to accept protective equipment in baseball, football and other sports. When Charlie White, for example, first introduced the baseball glove he was laughed off the playing field with a chorus of ungenerous comments concerning his manhood and courage. Mr. Mason offers several additional examples and argues convincingly for his proposition. Indeed, upon reflection, each of us could probably think of similar examples which would be but variations of the basic theme.

The extent and influence of a negative approach to aircraft accident prevention are complex and sometimes emotional issues. The author has concluded the following about it: (1) part of the Air Force's safety program is negative in character, i.e., the restrictive regulations and the "thou shalt not" procedures and instructions; (2) the negative aspects of safety are deeply ingrained within our society, due in part to tradition and, perhaps, ego-involvement; and, (3) the negative portions of the accident prevention program should be supplanted, where possible, with a positive, permissive attitude which emphasizes "a job well done is inherently safe."

"Crime and punishment." --Another set of ideas that is very damaging to the accident prevention program is what the author terms the "crime and

²⁵Chaytor Mason, "Manhood vs. Safety," Aerospace Safety Alumni Review, (University of Southern California), Vol 2, Nr 1, (1965), p. 3.

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punishment" approach to safety. This view, whether expressed or not, holds that an accident is somehow a "crime" and the person responsible is a "criminal" and must be punished. Of course, it is not phrased in such blatant terms. The effect, nevertheless, is the same.

An example of a ground mishap will serve to illustrate this point better than a flight accident. (The reasons for this will be clear later.) Suppose, for example, an airman is driving home from work. In his haste, he makes a faulty judgment and passes another automobile without sufficient highway space. A head-on collision is narrowly avoided but the cars are severely damaged in a sideswipe with one another. The airman is painfully, though not seriously, injured. As a result of the mishap, the airman is by the state patrol for "improper passing" and "reckless driving resulting in an accident." He pleads guilty to the charge and is fined \$125. His insurance premium is subsequently increased fifteen per cent because of his accident record. His car is under repair for three weeks and he must find other transportation to and from his work. He is painfully sore from his injuries. His domestic serenity is strained by the heavy and unexpected expenditures. Finally, he is disciplined by the Air Force. He is administered non-judicial punishment and, in addition, he is required to attend a twenty-hour drivers's education course (conducted by the safety officer). Somehow (and it is not difficult to understand) the ideas of "safety," "accident," and "punishment" become interfused in his mind.

There are good reasons why a person should be disciplined for damages caused by his carelessness. It appears that there are equally good reasons for not disciplining a person for having an accident. Rational people do not intend to have accidents. It is incomprehensible to suggest that a normal person would intentionally involve himself in

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an accident such as the one in our fictitious example. We can only conclude that there is no motive--no intent--to cause damage or injury. If we agree that people who are properly selected, adequately trained, and sufficiently motivated attempt to do an honest job, then we should also admit that if they make a mistake (and cause an accident) it was an honest mistake and does not deserve punishment.

From a pragmatic viewpoint, the author thinks that punishment damages the Air Force safety program. People resent discipline following what they regard as an honest error. They usually express this resentment and dissatisfaction, and it infects other people's attitudes. The Air Force does not entirely agree with this view. Curiously, the Air Force has a double standard with regard to punishment as a result of accidents. This dichotomy is apparent in the basic philosophy as well as in practice. Punishment is permitted following a ground or explosives accident but is prohibited after an aircraft accident. This difference in philosophy is pointedly apparent in the following paragraph found in the directive pertaining to accident investigation:

Appearance of witnesses before an investigator or board appointed to investigate an Air Force accident/incident will be governed by the following:

a. The use of truth serums or other hypnotic drugs is prohibited in any USAF accident investigation or inquiry.

b. Witnesses will not testify under oath and will not be sworn.

c. Witnesses will be advised prior to testifying that:

(1) The sole purpose of the investigation is to determine all factors relating to the accident/incident, and, in the interest of accident investigation, to preclude recurrence.

(2) The investigation will not be used as evidence, or to obtain evidence for use in disciplinary action; to determine pecuniary

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liability or line-of-duty status, or to revoke commission or to support a demotion, or to remove from the active list under provisions of AFR 36-2; or for use before a flying evaluation board.

NOTE: With the exception of a above, this paragraph does not apply to ground and/or explosives accident/incident investigations.²⁶

The implication of enforcement and discipline is also found in the ground safety manual:

Usually accidents can be prevented through adequate safety engineering and education. However, there are some people who are a hazard to themselves and others because of their failure to comply with accepted safety standards. It is these persons for whom the strict enforcement of safety practices is necessary, backed by prompt corrective action. No organized accident prevention effort can be successful without effective enforcement, because accidents are frequently the direct result of violations of safety principles. . . .²⁷

If one accepts the basic Air Force premise that all accidents are caused either by actions of people or failure of materiel, it would appear that the same basic prevention program could be applied with equal success whether the accident involved ground or air vehicles. The author cannot justify, or even account for, the dichotomous philosophy of the Air Force in this area.

Accident proneness.--When research began on the causes of aircraft accidents (especially pertaining to human factors) an intriguing hypothesis, called "accident proneness," was advanced which stated that some people by their very nature were more susceptible to accidents than others. The theory suggested that a person who has relatively stable and continuing characteristics which predispose him to having an accident is "accident

²⁶U.S. Department of the Air Force, Investigating and Reporting USAF Accidents/Incidents, AFR 127-4, (Washington: U.S. Government Printing Office, 25 February 1963), p. 15.

²⁷U.S. Department of the Air Force, Accident Prevention Handbook AFM 32-3, (Washington: U.S. Government Printing Office, 5 November 1962), p. 1-4.

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prone."²⁸ Great hope was held that by identifying these people and preventing them from flying the aircraft accident rate would be substantially reduced.

Unfortunately, the early evidence for accident proneness was superficial and fallacious. Much was made of the fact that some individuals had several accidents and only a small percentage of pilots were responsible for all of the aircraft accidents. The concept of accident proneness is persistent and one occasionally hears it being discussed today. To support such an idea, one would only need point out that in 1964, out of approximately 38,200 Air Force pilots, only 100 were responsible for "pilot error" aircraft accidents.²⁹ This kind of presentation of statistics is persuasive but is not accurate.

In the first place, an analysis of the underlying mathematical theory of the problem shows that some of the pilots, purely by chance, should have more than one accident. Chance is defined here as "a combination of circumstances, not systematically associated with any one individual."³⁰ Another factor to be considered is there are far more pilots than there are accidents. Thus, of necessity, there is a concentration of accidents in a minority of pilots. The theory of accident proneness can be supported only if the number of accidents a pilot has are significantly greater than could be accounted for by chance.

A number of studies were conducted to determine if the theory could be supported on a scientific basis. The most notable of these

²⁸Bond, et al., p. 3-9.

²⁹U.S. Department of the Air Force, 1964 Accident. . ., p. 1.

³⁰Bond, et al., p. 3-10.

studies was the one conducted by Webb and Jones in 1949.³¹ They examined the distribution of accidents among nearly 18,000 pilots against a distribution of accidents on a chance basis (Poisson distribution). They concluded there was no distinguishing factor that could be related to accident causation among the pilots to an extent beyond what could be attributed to chance. The study results supported the point of view that accident proneness, if it exists, is a very complex matter and there is no simple way to identify persons that might be accident prone.³²

Relationship of Accident Prevention to Mission Accomplishment

As a matter of review we would repeat that an effective aircraft accident prevention program should not interfere with the accomplishment of the primary operational mission. It also must not inhibit flying personnel by fostering a fear of flying.

The sole purpose of aircraft accident prevention is TO ACCELERATE ACCOMPLISHMENT OF THE AIR FORCE MISSION THROUGH INCREASED OPERATIONAL EFFECTIVENESS by reducing to a minimum the loss of lives and aircraft from accidents.³³

If everyone in the Air Force would realize safety is subordinate to the mission of the organization we would not hear comments such as these:

³¹Wilse B. Webb, and Edward R. Jones, "Repeater Pilot Accidents In the United States Air Force," (Department of Psychology, Washington University, St. Louis, Mo., August 1952).

³²E.R. Jones, and W. B. Webb, "Is The Repeater Pilot Regulation Justifiable?," A Report prepared for the Medical Safety Division, (Norton AFB, Calif.: Director of Flight Safety Research, 15 March 1951).

³³U.S. Department of the Air Force, Accident Investigation, AFM 62-5, (Washington: U.S. Government Printing Office, 1 February 1956), p. 1.

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. . .Some commands have made the attainment of a low accident rate their primary goal. A unit's safety record becomes the measure of its performance. When this occurs, realistic training is avoided because it is presumed to involve higher risks. Pilots are warned to avoid getting near the operating boundaries of their aircraft. Instrument flights are performed only under carefully chosen conditions so that the squares on the training syllabus board can be filled with minimum risk. Good fuel control training, using safety criteria, is to require a pilot to plan his flight to land with a large, excessive fuel reserve. Night flying is cancelled where there are clouds in the sky or the moon isn't up. Pulling out early in a gunnery run becomes more important than getting hits. These practices are inconsistent with achieving a high state of combat readiness.³⁴

If the conditions described actually exist, something is seriously wrong with the Air Force aircraft accident prevention program as it applies to that unit. Someone has made a grave error in his judgment of values and priorities when he established the supremacy of safety over mission. Accident prevention and mission accomplishment can be compatible if one understands the proper relationship that should exist between them.

This feeling of incompatibility between the two sometimes leads people to statements such as: "When we get to combat the flight safety program will be deemphasized or eliminated." It is the author's opinion that if the safety program is discarded or substantially modified under combat conditions, it was defective in the first place. A properly conceived and planned aircraft accident prevention program will be as effective in combat as in peacetime. In fact, it is probably more important in combat than elsewhere. We cannot afford to lose even one aircraft in combat for accidental reasons. An aircraft represents too much combat power to allow it to be wasted. In addition, it is not easily

³⁴Wolfe, et al., p. 2.

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or quickly replaced. The commander and safety officer who design and operate an accident prevention program must make it compatible with the mission to prevent it from being discarded when the unit transfers to combat.

The problem of justifiable risk enters when one discusses "realistic and combat simulated" training. We have already made a strong point of the fact that safety should not inhibit the mission. On the other hand, we cannot use this philosophy to justify the assumption of unnecessary risks.³⁵ Losses sustained in peacetime represent a constant and unacceptable drain on the resources upon which the nation depends for its security. The cost of modern aircraft and the value of the people flying and maintaining them makes it mandatory that we consider their conservation in the planning and execution of each mission.

It is very difficult, but we must attempt to reach the delicate balance between the confidence necessary to wage combat and the foolishness that saps our fighting strength by needless accidents. Safety officers and commanders can assist in achieving this balance if they point out to their aircrews the unnecessary risks without bringing undue attention to the unavoidable hazards of flying.³⁶

Exposure and risks.--The definitions and categories of exposure and risk used in the Air Force are these:³⁷

³⁵U.S. Department of the Air Force, Organization and Operation of the USAF Accident Prevention Program, (Norton AFB, Calif.: Directorate of Flight Safety Research, 1958), p. 2.

³⁶U.S. Department of the Air Force, USAF Ejection Escape Experience, (Norton AFB, Calif.: Directorate of Aerospace Safety, December 1965), p. 2.

³⁷Blueprint for Safety, (Ent AFB, Colo.: Headquarters, Air Defense Command, 1958), pp. 8-9.

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a. Minimum risk: The conduct of required operations which are justifiable only under selective circumstances at lowest exposure. Examples are: administrative flying, proficiency flying, etc. The basic idea involved is that we can select the conditions under which we are going to fly. If all of the conditions relating to the combination of man-machine-mission-and media do not appear favorable, we will not fly. Thus, we are exposed to the hazards of flight only under the most favorable conditions.

b. Calculated risk: The conduct of required operations which are justifiable under semi-selective circumstances at limited exposure. Examples are: combat crew training, all-weather interceptions, and aerial refueling at night or in weather.

c. Tolerable risk: The conduct of required operations which are justifiable under non-selective circumstances at positive exposure. Examples are: the prime missions of the combat commands (SAC, TAC, and ADC) such as a scramble intercept mission under any condition of weather, with or without a selected alternate or recovery airfield, in order to achieve the necessary mission accomplishment.

d. Intolerable risk: The conduct of operations which are non-justifiable under the circumstances or exposure. Conditions are so severe that it would be futile to attempt the mission.

An understanding of these categories will permit each flight to be evaluated in terms of what it contributes to the overall accomplishment of the mission and the risk involved. Thus, a compatible relationship between aircraft accident prevention and the mission can be achieved.

In this chapter we have discussed some of the more important

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concepts and philosophies of aircraft accident prevention and causation. An understanding of the "Sequence of Events," "Known Precedent," and "Man-Machine-Media-Mission" concepts will permit a logical and effective accident prevention program to be developed. The philosophies discussed were concerned with accident proneness, negative approaches to accident prevention, the theory of "crime and punishment," and the relationships between the safety program and mission accomplishment.

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CHAPTER V

WEAKNESSES IN THE AIR FORCE AIRCRAFT ACCIDENT PREVENTION PROGRAM AND SUGGESTIONS FOR IMPROVEMENT

Thus far we have examined various aspects of the U.S. Air Force aircraft accident prevention program. In Chapter I we noted that while the number of aircraft accidents has decreased in the past several years, the losses in men and aircraft are still substantial. The dollar loss is very large and represents a significant portion of the Air Force budget. In Chapter II we briefly examined the history of the flight safety program and noted its metamorphosis from the beginning of the century. We discussed the current Air Force aircraft accident prevention program in Chapter III. Some comments were made in the chapter which suggested a need for changes in some aspects of the flight safety program. In Chapter IV we became familiar with some of the more important concepts and philosophies pertaining to aircraft accident causation and prevention. These ideas give us a broad framework in which we can further develop and modify the current Air Force flight safety program in order to increase its effectiveness and success.

In this chapter we shall discuss several weaknesses or deficiencies in the current flight safety program. Suggestions to improve the quality of accident prevention in the Air Force will also be made.

It should be stated at the outset that the author's present views of the Air Force aircraft accident prevention program, its strong points, its weaknesses, and suggestions for improvement are not precisely the same as they were before this research began. They are not nearly so dogmatic and positive; they are somewhat tentative and have a greater appreciation of the complexity and interrelationships which exist among many factors which produce safe and efficient flight. Indeed, the author is not certain that his suggestions, if adopted, would solve many of the weaknesses in the flight safety program. It probably would be presumptuous to think they would.

The Air Force has a large and highly qualified staff of safety specialists working in the Directorate of Aerospace Safety. Many of these people have spent a large portion of their careers working with safety problems. It would be a disservice to them to suggest they have not realized most of the problems and tried to solve them. On the other hand, since the problem of preventing aircraft accidents is so complex, perhaps the author's suggestions for corrections in the safety program will prove useful. It has been said that "nothing has the power of an idea born at the proper time." Perhaps the time is now propitious.

Of the very large number of problems in flight safety that could be discussed, the author has selected several which he regards as the most significant. The solutions might not appear to be revolutionary or even new. In this respect the author agrees with General Caldara when he said:

. . . Those who hope for some tremendously effective panacea, some great big single solution, some powerful capability to wrap up aircraft accidents in a neat little package that can be resolved

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and then put away, are living in a never-never land.¹

We must, on the other hand, continue to make necessary modifications in the accident prevention program to continue to reduce preventable losses. Because the problem is great and the answers seem remote is insufficient justification not to offer suggestions for correction of deficiencies when they appear to exist. As a Chinese proverb states: "A journey of a thousand miles begins with one step."

Reporting and Classifying System

The most serious weakness in the Air Force aircraft accident prevention program, in the author's opinion, is the accident reporting and classifying system.

The primary purpose of investigating accidents is to identify their causes so that action can be taken to prevent future accidents of a similar nature. Not only must the accident be thoroughly investigated and the cause(s) determined, but the resultant information must be properly processed and reported. Information derived from an investigation is of little value unless it can be put into a useable form. If this information is improperly or inadequately reported, when it is translated into statistical summaries by the Directorate of Aerospace Safety, the statistics will be in error and the value of the entire accident investigation program will be diminished. What is worse, individuals (not knowing the statistics are in error) will form conclusions concerning Air Force safety problems and the need for corrective action by examining these statistics. Their conclusions must, perforce, be in error.

¹Joseph D. Caldara, "The Diminishing Safety Improvement Rate," Alumni Review (University of Southern California), Vol I, Nr. 1, (Summer 1964), pp. 3-4.

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Cause factors and sequence of events.--A part of the problem is the requirement to report aircraft accidents by selecting "primary" and "contributing" causes. By definition, there can be only one primary cause. It is somewhat of a Procrustean bed. Procrustes, the reader will recall, was a mythical innkeeper. He had beds in his inn only of one length so if a guest was too tall he cut off his legs to make him fit the bed. If he was too short Procrustes put him on a stretching device to make him taller so he would properly fit the bed.

The primary cause is similar. We recognize that an accident is almost always the result of a great many individual incidents or events. When these events combine they can cause an accident; when they are separate and unrelated an accident usually will not occur. The requirement to determine a primary cause does not sufficiently consider this concept. The investigating board is required to find one event that made the accident inevitable. It is a very difficult task for the investigation board to determine which event in the sequence of events made the accident inevitable. As a result the most significant event is usually called the primary cause. This tends to emphasize one event to the detriment of the others.

How does this disproportionate emphasis on cause factors affect the accident prevention program? When the results of hundreds of aircraft accident investigations are forwarded to DAS they consolidate the cause factors and translate them into statistical form. Thus, at the end of the year they report that thirty per cent, for example, of the year's accidents were caused by "pilot factor," forty-three per cent were caused by "materiel failure," and so forth. Because of the disproportionate emphasis on cause factors the statistics are incorrect

and we cannot determine what our problems are with any degree of accuracy. It is doubtful that the statistics truly reflect the causes of Air Force aircraft accidents.

The difficulty of the investigation board in arriving at a valid primary cause of an accident was illustrated in the fictitious example concerning Lieutenant Smith found in Chapter IV. It is probable that a board of officers investigating that accident would have concluded that the primary cause was "pilot factor." If we want to prevent accidents of a similar type we must realize that it is insufficient to merely recognize that Lieutenant Smith erred; we must identify all of the factors that contributed to the accident.

Aircraft accident reports sometimes do not give adequate consideration to the sequence of events. As a result the primary cause sometimes appears to be unsupportable when all of the events in the accident sequence are considered. The following accident summary illustrates this conclusion.

This accident concerns a pilot of an F-84F. He was number 6 in an eight ship formation flight on a long range navigation mission. Two in-flight refuelings were accomplished. The cabin heater malfunctioned during the flight so that the cockpit was extremely hot during the entire flight. This caused profuse sweating and also destroyed the greater portion of the pilot's in-flight food supply which consisted of candy bars. As a result, the pilot had only one-half of a candy bar and a half of cup of water during the entire flight. The six hour flight was complicated by 1 hour and 30 minutes of actual weather. Forty minutes from destination the generator failed. The pilot cut off the battery to reserve power but lost cabin pressure so he cut the battery back on to maintain pressurization at 12,000 feet. He made no further attempts to use the radio or fuel gages, etc., in order to reserve the battery.

During the landing the pilot set up an erratic pattern, made one pass over the base, initiated a go-around and on the second pass landed approximately 4,300 feet down a 6,000 foot runway. The aircraft continued off the end of the runway through the boundary fence and struck a civilian automobile killing one occupant. The

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pilot was uninjured.

It was concluded by the flight surgeon that a major contributing factor to this accident was the fatigue associated with the longest jet flight to date accomplished by the pilot, together with anxiety precipitated by a great number of minor emergencies, none of which in themselves were of great importance. This accident was charged to the pilot for inadequately setting up a final approach pattern. However, the contributing causes offer the only areas for remedial action.²

If corrective action is centered around the primary cause of this accident very little positive action can be taken.

The reader might ask if all the subsidiary causes have corrective action taken also. The answer is yes, but usually with less emphasis and positive results. Any system that establishes priorities, such as the primary and contributing cause system does, usually results in the greatest emphasis on the first priority, i.e., the primary cause. Contributing causes frequently do not receive sufficient corrective action even though they are sometimes as important as the primary cause in the prevention of future accidents.

The author's opinion is supported by other safety officers in this respect. During a worldwide flight safety officers' conference in 1956 the participants discussed this problem. They concluded:

It is the opinion of Seminar Group 9 that cause factor terminology now being employed is a problem in that it adversely affects unit and command accident prevention efforts. Present terminology lends itself to lumping accident cause factors under broad area terms such as "operator error" and "maintenance error," etc. This tends to place unwarranted blame on individuals for factors or conditions which are frequently beyond their capabilities

² U.S. Department of the Air Force, Notes To the Flight Surgeon, (Norton AFB, Calif.: Directorate of Flight Safety Research, March 1958), pp. 6-7.

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to correct and causes an unwarranted degree of stigma to be attached to the personnel involved ³

Senior officers who are directors of flight safety in major air commands also agree that the present system of classifying accidents is deficient. Colonel Clayton Peterson, Director of Safety, United States Air Forces in Europe said:

Maybe it's time to re-orient our purpose. Maybe we should step back a few paces and see what we are building. Maybe all of us--the line man, the safety man, the supervisor, the commander, should take a piercing look into our accident investigation program to see if it meets the simple formula: Find the cause and correct it.⁴

Unless we consistently "find the cause and correct it" our investigation program will be weak and inadequate. All of the facts derived from an investigation must be distilled into manageable statistical data. These data are compiled and analyzed which allows corrective action to be taken throughout the Air Force. In the words of the Directorate of Aerospace Safety,

The greatest single gain derived from statistical evaluations of aircraft accidents had been the delineation of cause factors involved in accidents. These evaluations have resulted in pointing out the areas of failure in which there is a need for study and appropriate corrective action. Although the direct cause and effect relationship is not always proven, it appears that investigation, analysis, and dissemination of information has been responsible for the decrease in aircraft accidents.⁵

³U.S., Department of the Air Force, Report of Worldwide USAF Flying Safety Officers' Conference, 1956, (Norton AFB, Calif.: Office of the Inspector General, 1956), pp. 34-35.

⁴Clayton L. Peterson, "An Overseas Workshop: USC Stages First . . . For Aviation Safety," Aerospace Safety Alumni Review (University of Southern California) Vol II, Nr 1, (April 1965), p. 2.

⁵U.S., Department of the Air Force, Summary and Evaluation of Aircraft Accidents and Fatalities, (Norton AFB, Calif.: Deputy Inspector General for Safety, n.d.), p. 5.

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It is pertinent to note that it is sometimes difficult or impossible to take corrective action on the primary cause. Other cause factors in the same accident may be readily correctible, and their correction might prevent future accidents as effectively as correction of the primary cause.

Another difficulty in assessing a primary cause is the different interpretation placed on the significance of specific occurrences in the sequence of events. It is sometimes very difficult for accident investigation board members to agree on what made the accident inevitable. Even after a thorough investigation, considerable discussion, and compromise among board members, occasionally the convening commander or higher organizational echelons do not concur in the primary cause of the aircraft accident.

After an intervening period of time the board members themselves often do not agree with their earlier decision. One study showed that in a review of accident reports after a six-month interval, board members agreed with their previous decisions only about fifty per cent of the time.⁶ In another study two groups examining the same data were in agreement about the cause factors in only twelve per cent of the accidents.⁷ Thus, the analysis of cause factors (especially the determination of the primary cause) is a highly individualized matter and is frequently decided upon by the board based on their experience (both as investigators and in their specialities), the type of aircraft

⁶William I. Stieglitz, "Notes on Aircraft Accident Investigation," Interceptor, Vol 4, Nr. 9, (September 1962), p. 14.

⁷Robert L. Thorndike, et al., Human Factors in Aircraft Accidents, (Pittsburgh, Pennsylvania: American Institute for Research, October 1950, p. 26.

involved, the experience of the aircrew, the severity of the accident, the rank of the people involved, the command, and other unknown factors.⁸

The difficulty in determining a cause factor that will be mutually agreeable to all who review the accident report is alluded to in comments by members of the Directorate of Aerospace Safety. They have said, for example:

There is reason to believe that some of our accidents which are officially listed as materiel failure were in reality personnel error induced.⁹

Another problem in this same area of valid findings concerns the investigating board's ability--or more specifically their integrity--to call a spade a spade. We, at Norton, are convinced that many of the accidents that are charged to materiel failure are, in fact, maintenance induced or even pure maintenance error. Many times, this fact is very elusive and quite difficult to pin down; however, I am aware of too many investigation reports that imply maintenance error, or point directly at a maintenance factor involved, and then conclude materiel failure as the cause factor. Gentlemen, if it looks like a duck, and quacks like a duck--let's call it a duck."¹¹

There is an implication in the latter quotation of Colonel Wimberly that there may be subterfuge in the findings of some accident causes--that accident investigation boards are less than completely honest in their evaluation of causes. On the other hand it should be

⁸Ibid., p. 145.

⁹Letter, Brig Gen Jay T. Robbins to flight safety officers, January 1963, Subject: none, (Norton AFB, Calif.: Deputy Inspector General For Safety).

¹⁰William H. Blanchard, "Let's Get With The Program," A speech presented to the members of the Second Annual USAF Safety Congress at Sandia Air Base, New Mexico, 25-29 September 1961.

¹¹Charles L. Wimberly, "The Need For Improved Accident Investigations," A speech presented at the Fourth Annual USAF Safety Congress at Sandia Base, New Mexico, 26 August 1963.

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recognized that it is sometimes very difficult to determine the reason for the failure of a part, for example. Did the part break because it was improperly designed or manufactured? Or did it break because it was improperly maintained or used?

These comments from Air Force officials cast serious doubt on the validity of the statistical data upon which we take corrective action at Air Force level. If there is doubt as to the causes of accidents, corrective action based on the faulty data may be misplaced or haphazard. The Air Force recognizes the critical need for an accurate determination of accident causes. A sentence in the accident investigation manual states: ". . . only when the true causes of accidents are known can positive action be taken to prevent future accidents."¹²

Let us briefly examine the details of an accident in which the author participated with seven highly qualified and experienced officers. Many of the details will be summarized in order to conserve space.

The accident involved a T-33 jet trainer flown by a major and a first lieutenant. They were making an administrative flight from Tinker AFB, Oklahoma, to Biggs AFB, Texas, to participate the following day in an Air Defense Command exercise. The weather was excellent and flight distance was about half of the cruising range of a fully-fueled T-33. Due to the short distance the crew did not compute the fuel requirements for the trip. About halfway to their destination, and about ten miles west of Webb AFB, Texas, the engine unexpectedly flamed out. The pilot immediately turned toward Webb AFB and began to make

¹²U.S., Department of the Air Force, Aircraft Accident Prevention and Investigation, AFM 127-1, (Washington: U.S. Government Printing Office, 20 September 1963), p. 42.

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an emergency transmission over the radio to notify the tower of their plight.

Before the first transmission was completed, they experienced complete electrical failure. It was then impossible to use the radio or to air start the engine. The pilot arrived over the runway (about 12,000 feet long, including overruns) at an altitude of 8,000 feet. He maneuvered the aircraft to complete a flamed out approach to the runway.

The flameout approach proceeded satisfactorily until final approach. The pilot then thought he was going to overshoot the runway. He attempted to lower the speed brakes to slow the aircraft's speed. (He did not know they were electrically actuated and would be inoperative without electrical power.) When he realized they did not function he attempted to slow the aircraft by S-turns. During one of the S-turns he landed adjacent to the end of the runway but about 500 feet laterally displaced from the centerline. The terrain was rough and the landing gear sheared during the rollout. The aircraft sustained damage sufficient to preclude it being economically repaired.

The accident investigation revealed several significant facts:

- (1) the pilot was very confident in his proficiency to make a flame out approach despite the fact he had only 125 flying hours in the T-33 which was accrued over a ten year period;
- (2) the pilot's self-confidence notwithstanding, his supervisors restricted him to daylight, visual flight rule (VFR) flying only, because of his lack of proficiency;
- (3) unaccountably, they also certified him to be an instructor pilot in the T-33!;
- (4) the tip and fuselage fuel tanks were empty;
- (5) the main wing and leading edge fuel tanks were full (an indication that the pilot failed to transfer fuel properly during the flight which caused

fuel starvation); (6) there was some water in the fuel system filters; (7) the remainder of the fuel system was intact and post-accident tests showed it could function properly; (8) the aircraft was operated before this flight by a ground crew which used about 100 gallons of fuel (the aircrew did not make an in-tanks inspection during their preflight); (9) the battery was long overdue an inspection and contained so little fluid that a specific gravity test could be accomplished only in one cell; and, (10) the co-pilot was totally unqualified.

The accident investigation board members discussed the causes of this accident at length. The problem in their coming to an agreement was, as usual, the decision concerning the primary cause. The board had considerable difficulty in agreeing about the point in the sequence of events at which the accident became inevitable. They finally decided the primary cause of the accident was operator error because the pilot's judgment was faulty in attempting to S-turn on final approach when he was in an ideal position to make a landing from a flame out approach. The major air command disagreed with the findings. They said the primary cause was maintenance error because the battery was improperly maintained and inspected. They argued that if the battery had been in good condition the pilot could have started the engine and the accident could have been avoided. The Directorate of Aerospace Safety did not concur with either the investigating board's findings or those of the major air command. They concluded the primary cause was supervisory error because the organization permitted two unqualified pilots to fly the mission.

It is interesting (and disturbing) that three groups of officers, all highly qualified and experienced, should disagree so fundamentally

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on the primary cause of the accident. Each group came to its decision using the same detailed and verified data.

The point is that probably none of the causes determined by the three groups actually represented the "straw that broke the camel's back." This accident, particularly, was caused by the combination of a large number of factors. Thus, to prevent future accidents of a similar kind corrective action would be required in an equally large number of areas. Determination of a primary cause in this accident was not very helpful in preventive actions.

Many civilian agencies have abandoned the primary cause determination in aircraft accident investigation. The International Civil Aviation Organization (ICAO), for example, makes this comment in their accident investigation manual:

Causal factors of an accident may be defined as any act, omission, condition or circumstance which contributed to the accident. They are frequently subsidiary and may be concealed and they qualify as causal factors only if it is resolved that the absence or omission of any one would have been instrumental in preventing the accident. The treatment of these factors has shown a marked change in recent years and the arbitrary division of causal factors into "primary" and "secondary" is no longer considered to be good practice. Experience has shown that the method tended to focus undue attention upon the primary cause with the result that the secondary causes were often neglected to the serious detriment of accident prevention and air safety programmes. The investigation must clearly reveal all relevant causal factors in order that they can be properly analyzed.¹³

The author agrees with this approach and thinks that abandonment of the Air Force system of classifying accidents by their primary and contributing causes would eliminate most of the difficulties previously cited.

¹³International Civil Aviation Organization, Manual of Aircraft Accident Investigation, (Montreal, Canada: International Civil Aviation Organization, 1959), p. 47.

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The author's suggestion for a solution to this basic problem is simple: the reporting system must be revised to show causes of an accident. References to "primary" and "contributing" causes would be eliminated. Causes would appear in order of their occurrence or in the sequence of events without priority of their importance indicated. All causes would be identified and, therefore, all causes could be given corrective action without undue emphasis on the "primary" cause. Useful statistical data and identification of trends could be obtained by noting the frequency of certain cause factors. A vastly increased number of potential cause factors could be used. This would result in a more specific definition of the aircraft accident experience in the Air Force.

A sample of how this system might be devised is shown below. It illustrates some of the subfactors in the general cause of "pilot factor" accidents. The numbering system shown could be integrated into present computer systems.

CAUSE FACTORS

1.1 Pilot Factor

- | | |
|-------------------------------|---|
| 1.1.1 Misuse, engine controls | Includes misuse of the engine from a mechanical standpoint and misuse or failure to use throttles, superchargers, cowl flaps, carburetor heat, moisture controls, blowers, etc. |
| 1.1.2 Misuse, propellers | Includes misuse of feathering mechanism, pitch controls, reverse pitch controls, propeller de-icing equipment, etc. |
| 1.1.3 Misuse, brakes, ground | Includes improper use or non-use of brakes, emergency braking systems, etc., when operating aircraft on the ground. |

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- | | | |
|-------|---------------------------|---|
| 1.1.4 | Misuse, flight controls | Includes improper use or non-use of ailerons, elevators, trim tabs. |
| 1.1.5 | Improper use of flaps | Includes improper use or non-use of flaps in air, or landings and take-offs or on ground. |
| 1.1.6 | Premature gear retraction | Retraction of gear during take-off prematurely or before the aircraft has definitely become airborne. |
| 1.1.7 | Failure to extend gear | Includes cases of failure to extend gear correctly by regular or emergency systems. Includes failure to make required checks of gear down and locked. |

* * * * * *

This sample of a system to record cause factors is sufficient to illustrate the possibility of documenting specific cause factors. It would need to be rather extensive to cover other factors as weather, maintenance errors, materiel factors, violations of human limitations, and others.

Reporting Criteria.--In any accident reporting system there is a basic decision as to what should be reported. A system might have the reporting of such things as damage, injury/death, cost, or the significance and seriousness of the occurrence as its basis. The Air Force, as we noted in Chapter I, uses a combination of these factors. Basically, the Air Force system of reporting aircraft accidents is based on the extent of damage based on the number of manhours to repair the damage.

The author visualizes the possibility of the several problems arising when a reporting system is based on a manhour criteria. First, the number of manhours to repair the damage is based on someone's estimate of the time required for repair. Secondly, there is the

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possibility of manipulating the accident rate by varying the criteria of the mishaps to be reported.

The first problem (that of estimating manhours) can be explained simply. If a mishap is on the borderline between a major and a minor accident the manhours estimated for repair will usually be adjusted to reflect the minor accident category. These adjustments can be made by: (1) estimating the hours required by using experienced and fast repair crews; (2) replacing parts instead of repairing them; (3) not charging time for removal and replacement of undamaged parts to facilitate work on the damaged components.

At Air Force level the aircraft accident rate can be manipulated by changing reporting criteria. For example, if the Air Force decides that a T-37 mishap will be classified as a major accident when 800 manhours are required for repair (instead of the present 500 manhours) the accident rate can be suppressed without, at the same time, reducing the number of mishaps. We, thus, eliminate some mishaps from being reported as major accidents and statistically it would appear that the accident prevention program was increasingly successful.

This is precisely what has happened in the Air Force. It is clearly seen by examining the reporting regulations between 1958 and 1963. Some of the changes in manhours required to classify a mishap as a major aircraft accident are shown in the table below.

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TABLE 7

CHANGES IN MANHOUR CRITERIA FOR MAJOR AIRCRAFT

ACCIDENTS BETWEEN 1958 AND 1963

Model of Aircraft	1958	1963
T-33	300	500
T-37	300	500
T-38	300	800
B-52	750	900
C-133	750	900
C-135	750	900
U-3	75	400

Some of the increases in manhours were substantial; in no case were the hours reduced in the 1963 version of the regulation. These changes inevitably depress the major accident rate.

On the other hand, the same regulation change potentially included a number of mishaps that were not previously reported as major accidents. Prior to 1963 damage to an aircraft caused by bird strikes, turbulence, hail, lightning strikes, or ice thrown from propeller or de-iced surfaces were reported as aircraft incidents regardless of the number of manhours required for repair.¹⁴ Such mishaps are now reported according to the damage incurred. This change precludes such ironies as occurred in 1958 at Webb AFB, Texas. While the author was a flight safety officer there, one of the aircraft experienced hail damage which required approximately 2,400 manhours for repair. The aircraft was not economically repairable because of the extensive damage--

¹⁴U.S., Department of the Air Force, Flying Safety: Aircraft and Missile Accidents, AFR 62-14, (Washington: U.S. Government Printing Office, 21 July 1958), p. 6.

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in effect, the aircraft was destroyed. The mishap was not reported as a major accident, however, because the damage was caused by hail.

One major problem caused by changing classification criteria is the fact that we cannot examine the statistics of either the accident rate or the number of accidents and accurately determine our past experience. This has been recognized by the Air Force but it has not resulted in significant changes in the classification system.

It should be noted that the reduction in major accidents and major accident rates has come about at least partially because of changes in accident definitions. Major accident definitions in the governing regulation have been changed from time to time, as dictated by logic and current concepts.¹⁵

Critics of the accident prevention program have also noted the effects of these changes. They charge that the manipulation of the accident rate casts doubt on the motives of the accident prevention program. In a magazine article several pilots expressed their opinion in these terms:

The definition of major accidents has been modified at frequent intervals to keep the accident rate moving down. This may impress outsiders but inside the program it creates distrust of the motives of the program.¹⁶

This allegation may not be wholly true. Nevertheless, any change in the classification criteria which causes fewer mishaps to be reported as accidents lowers the accident rate and it becomes difficult to defend the system against such accusations.

The accident rate could also be modified by changing the formula

¹⁵U.S., Department of the Air Force, Summary and Evaluation . . . , p. 2.

¹⁶D.C. Wolfe, Mark Jones, and A.W. O'Donnell, "Is The Flight Safety Program Hurting Combat Readiness?," Flight Safety Officers' Special Study Kit, (Norton AFB, Calif.: Directorate of Flight Safety Research, November 1962), quoting from Marine Corps Gazette, 1962.

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by which the accident rate is computed. The Air Force accident rate is based on the number of mishaps per 100,000 flying hours. We could reduce the accident rate by increasing the number of flying hours used in the computation. Suppose we wanted to reduce the accident rate to one-tenth of its present value in ten years. Each year we could decrease the number of flying hours in the formula by 10,000 hours so that at the end of ten years the rate would be based on the number of mishaps per 10,000 flying hours. Without any change in the number of mishaps we would have reduced the rate to one-tenth of its former value. This, of course, would be a transparent deception. It is mentioned here only because it illustrates that a rate is meaningless unless one knows the factors included in the formula. The U.S. Navy, for example, has a major accident rate comparable to that of the Air Force; however, it is computed on the basis of the number of accidents per 10,000 flying hours.

Two definitions which have not changed throughout the years of aircraft accident reporting are those for "totally destroyed aircraft" and "fatalities." These two factors cannot be manipulated because of the magnitude of the loss and the fact that manhours for repair have no meaning. These two factors, therefore, probably represent a truer picture of the success of the accident prevention program than do other factors which can be varied with a change in the classification criteria.¹⁷

Accident rates as a measure of efficiency.--Another problem that arises because of the Air Force system of classifying and reporting

¹⁷Jay T. Robbins, "The Changing Role of Aerospace Safety," A speech to the Fourth Annual USAF Safety Congress at Sandia Base, New Mexico, 26 August 1963.

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aircraft accidents concerns the use of accident rates as a measure of a unit's efficiency. The Air Force reporting and accident investigation regulation states that accident rates should not be used as a factor in comparing one unit with another.

Since accident statistics are not in and of themselves evidence of command/unit efficiency, they should be interpreted judiciously. Such factors as the type of local or command facilities, mission, type of equipment assigned, personnel, location, and other variables must be considered in evaluating an organization's accident prevention program. Recording an accident/incident to a command does not fix responsibility on that organization; the resulting statistical tabulations merely show the unit/command that possessed the equipment or, in the case of ground accidents, the unit or command to which the persons were assigned.¹⁸

In practice, however, it does not appear that the use of accident statistics is nearly so objective. The Air Force and major air commands commonly publish statistical summaries showing unweighted accident rates. Strategic Air Command is compared with Tactical Air Command without regard for the differing missions, types of aircraft, and the many other factors that influence the aircraft accident rate.

The same practice prevails within major air commands. Comparisons are usually made on the basis of total flying hours and the number of major accidents alone. In explaining a new system of comparing combat wings in the Strategic Air Command, for example, an article in Combat Crew, the SAC flying safety magazine, said:

The annual "Wing of the Year" trophy will be awarded to the wing having the highest number of accident-free flying hours, regardless of the type of aircraft flown A major accident at any time during a calendar year, charged to the wing or one of its units, will automatically remove the wing from the com-

¹⁸U.S., Department of the Air Force, Investigating and Reporting USAF Accidents/Incidents, AFR 127-4, (Washington: U.S. Government Printing Office, 25 February 1963), p. 17.

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petition for the remainder of that year.¹⁹

If for no reason other than unit pride, an organization would want to appear on such "honor rolls." More importantly, the unit's position on these lists implies the efficiency (or ineffectiveness if it does not appear) of the organization.

Editors of publications which feature "honor rolls" reported that organizations were very jealous of their reputations and complained immediately if for any reason their name failed to appear. The Commander feels that his organization has performed on a par with similar organizations and should not be slighted. He also realizes that his personal effectiveness may well be measured here. . . . Since service publications are relegated to a command audience, it is apparent that the readers know of achievements--both positive and negative--of other units within the command. The fact that any unit's name fails to appear is, in itself, a form of censure indicative of sub-standard effectiveness.²⁰

Most of these "honor rolls" compare units' major aircraft accident rates; minor accident rates and incident rates are not generally used. This emphasis on the major accident rate tends to cause commanders to do all they can to avoid reporting major aircraft accidents. This leads to such deceptive practices as underestimating the number of manhours required to repair damage or changing a major aircraft component without reporting it.²¹ The author is aware of at least ten instances wherein by use of these methods major aircraft accidents were not reported. It is difficult to document these occurrences because

¹⁹"New Rules For Flying Safety Standings," Combat Crew, Vol XIV, Nr. 7, (January 1964), p. 30.

²⁰U.S., Department of the Air Force, Notes From the Congress, (Norton AFB, Calif.: Directorate of Aerospace Safety, December 1961), p. 2.

²¹U.S., Department of the Air Force, Report of the Fourth Annual USAF Safety Congress, (Norton AFB, Calif.: Directorate of Aerospace Safety, n.d.), p.7.

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the participants are naturally reluctant to acknowledge their contributions to these falsities. There has, however, been official recognition that such practices occur and may be more common than heretofore acknowledged. The following paragraphs are samples of Air Force comments on unit failures to report mishaps.

I have reason to believe that much valuable reporting is being withheld for one reason or another, consequently the unsafe conditions remain. I don't know whether this is true or not but I've heard through the grapevine that there have been two wheels-up landings in the CH-3C. People have been concerned about this accident potential because there is no gear-up warning system incorporated. FSOs, believe me, we'll go on operating the helicopter for a long time without a gear warning system unless you report the mishaps.²²

It occurred to us recently that there was an extreme paucity of physiologic incident reports. Not only are they infrequent, but those that are submitted come in surprisingly high proportions from a few sources. This indicates that either some bases have more such problems or these bases are more diligent in reporting. It appears that the latter is the case, because a number of reports of fatal accidents at other bases cite previously unreported incidents as a basis for believing that a similar such incident caused the fatal accident.²³

Conscious and deliberate failure to report mishaps is, of course, both dishonest and damaging to the aircraft accident prevention program. The pressure to maintain a low (or zero) accident rate is so great that in some circumstances it is probably less damaging to a commander to fail an annual inspection or an operational readiness inspection than it is to have a major aircraft accident. The emphasis, it should be noted, appears to be concerned with the accident rate rather than flight safety as a result of efficient mission accomplishment.

²²"Hidden Information," Flight Safety Officers Special Study Kit, (Norton AFB, Calif.: Directorate of Aerospace Safety, February 1965), p. 1.

²³"Physiologic Incidents," Notes To The Flight Surgeon, (Norton AFB, Calif.: Directorate of Aerospace Safety, November 1964), pp. 1-2.

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It goes without saying that in order to have an effective aircraft accident prevention program we must determine the deficiencies and hazards present in the man-machine-media combination. Honest, thorough, and accurate investigations and reports reveal these deficiencies. The reporting and classifying system should be devised to encourage voluntary reporting of information for accident prevention purposes. Only secondarily, if at all, should the statistics resulting from these reports be used as a basis for comparing units. The ICAO accident investigation manual, which the Air Force uses to supplement its own, states:

Since no investigation is possible without knowledge of an occurrence, this knowledge must be brought to light by the active encouragement of air safety programmes in which remedial rather than punitive measures are so stressed that pilots and operators will be willing to co-operate without being embarrassed as a result of information which is volunteered.²⁴

This fact is as true of units as it is of individuals.

The solution to the problem is difficult. Our discussion implies that accident rates should not be used as a basis for comparison of the efficiency of units. This might appear contrary to the fundamental concept of "a job well done is inherently safe" discussed in an earlier chapter. It really is not contradictory. We suggest only that accident rates not be used as an indication of the efficiency of organizations without compensation for types of aircraft, environmental conditions, experience of pilots, types of missions, and other factors.

A system that would compensate for all of these factors would probably be very complex and administratively unworkable. On the other hand, a system which did not consider all of these factors would

²⁴International Civil Aviation Organization, Manual . . ., p. 15.

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be unfair to organizations rated. It is a dilemma: a system which is simple is unfair and a system which is fair is unworkable.

It appears that Air Force aircraft accident prevention would be better served if the practice of using accident rates to compare units was deemphasized or eliminated. If Air Force officials find this proposal unacceptable perhaps the comparison could be limited to fatal accident and destroyed aircraft rates. Unequal hazards experienced by organizations affect these rates the same as they do the major accident rate. This makes this suggestion less than completely satisfactory.

Another suggestion to improve the reporting system involves the elimination of the categories of "major" and "minor" accidents. One classification, i.e., an "Air Force aircraft accident," would eliminate the tendency to selectively fail to properly classify mishaps. Such a system would be a profound departure from present practice and creates extensive implications and ramifications. It would require a great deal of study to determine the results of such a change. It is offered here as a suggestion for future Air Force study.

Consideration should be given to revising the present reporting system to require a greater number of mishaps which do not cause damage to be formally reported. Some non-damage incidents are presently reported under the provisions of the operational hazard reporting system or as aircraft incidents. The present system, however, is oriented toward mishaps which cause damage. If it emphasized reporting non-damage mishaps it would be a breakthrough in accident prevention. The Air Force has recognized the importance of this concept as indicated

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by the following comments:

There are, however, many incidents occurring daily where no injury or damage is suffered but in which the safety of the aircraft may be seriously endangered. These would include the successfully resolved in-flight emergencies mentioned in the Foreword. The thorough investigation of all such incidents frequently provides more basic information which can be used for the purpose of accident prevention than may be provided by the exhaustive investigation of an aircraft disaster.²⁵

Accident Investigation has frequently brought to light previous incidents which were dismissed as insignificant at the time of their occurrence. The knowledge acquired in retrospect from the accident investigation has demonstrated that these incidents, if properly investigated and interpreted, could have supplied the basis of remedial action which would have prevented the occurrence of the accident under investigation.²⁶

The lack of a requirement to report many seemingly insignificant non-damage mishaps can lead to a lack of basic data which would be useful in accident prevention. The Air Force has recently been studying the problem of turbulence in flight. The report of this study noted that because Air Force regulations do not require reporting turbulence unless damage or injury results there was insufficient information on which to base fully-considered recommendations.²⁷ Information as basic as the number of turbulent air encounters is lacking because there has not been a requirement to report it.²⁸

The Air Force acknowledges that "accidents are not the sole

²⁵Frank G. Andrews, Aircraft Accident Investigation and Reporting, (Los Angeles, Calif.: University of Southern California, 1957), p. 15.

²⁶Ibid.

²⁷U.S., Department of the Air Force, Flight In Turbulence: Aircraft Accident/Incident Summary: 1 January 1959-1 December 1963, (Norton AFB, Calif.: Directorate of Aerospace Safety, n.d.), p. 1.

²⁸H.D. Smithson and Fred J. Curtis, Flight In Turbulence: Aircraft Accident/Incident Summary, (Norton AFB, Calif.: Directorate of Aerospace Safety, May 1964), p. 1.

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clues to the existence of accident potential."²⁹ We can learn from all hazardous occurrences, whether they cause damage or not. This is especially important when one understands that once the sequence of events is concluded the result, whether a fatal, major, or minor accident, an incident, or not reportable, is a matter of chance and favorable circumstances.³⁰

The present system, by dwelling on mishaps involving damage, can thus unnecessarily delay the Air Force in taking positive corrective action. There is a tendency to delay taking corrective action until it can be positively shown that an adverse trend exists. In some respects, this policy is sound. We probably should not take corrective action until we determine we have a problem of significant proportions. Waiting until a trend develops can lead to what the author refers to as "paralysis by analysis," however. When dealing with critical resources it may not be wise to wait for a well established trend to develop. The loss of just one C-135 loaded with dependents or the crash of one twenty-five million dollar SR-71 is a trend in itself. We, therefore, must be sensitive to all indications that a problem exists--not just those that cause damage.

The need for data from all mishaps is clear when one considers the amount of justification required to make major modifications in air-

²⁹U.S., Department of the Air Force, Accident Investigation, AFM 62-5, (Washington: U.S. Government Printing Office, 1 February 1956), p. 4.

³⁰U.S., Department of the Air Force, AFM 127-1, p. 29.

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craft or other major items of equipment. The following statements support this conclusion.

A definite need to know usage and failure rates for many items of equipment has been obvious for some time, in view of questions directed to us from developmental and using organizations. Such rates cannot be determined unless reporting improves.³¹

Let me remind you that in most instances we need to build a case to correct an unsatisfactory condition on a weapon system. Unless I get reports as mishaps occur it becomes next to impossible to justify MIPs [materiel improvement programs] and ECPs [engineering change proposals].³²

In this day and age it is almost impossible to get funds to correct safety of flight or operational problems unless it is possible to support a requirement. Statistical data which can be validated is one of the best ways it can be done. Need we say more?³³

This problem can be solved by requiring a greater number of mishaps to be formally reported and by modifying the reporting and classification system so that organizations will freely report hazardous conditions and mishaps without fear of reprisal, embarrassment, or adverse reflection upon their efficiency.

Accident Investigations

A major weakness in the Air Force aircraft accident prevention program is the poor quality of accident investigations. Colonel Charles Wimberly, Chief of the Flight Safety Division, Directorate of Aerospace Safety, in a speech to the delegates of the Fourth Annual USAF Safety Congress, had this to say about accident investigation:

We are all aware of the fact that the only fruitful return from an accident is the identification of a deficiency. Whether

³¹Notes To The Flight Surgeon, (Norton AFB, Calif.: Directorate of Aerospace Safety, February 1965), p. 1.

³²"Hidden Information," p. 1.

³³UR's, AFM 66-1 Data and AFR 127-4 Reports, (Norton AFB, Calif.: Directorate of Aerospace Safety, February 1965), p. 1.

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this deficiency involves pilot factor, maintenance error, materiel failure, or any other factor, it must be accurately and specifically identified or the investigative effort expended is of limited value. Simply stated, we must identify the problem if we expect to solve it. And this is exactly what we expect of the investigative phase of our safety program.³⁴

The Directorate of Aerospace Safety has concluded that too often aircraft accident investigations are not thorough and accurate and the information obtained is inadequately and improperly reported.³⁵ They have further stated "the big problem today is that accident records are weaker on the "Why" and "How" of accidents than they are on the "Who," "What," and "When."³⁶

Inadequacies of the majority of accident investigations is revealed in the number of "cause undetermined" accidents the Air Force experiences. In the ten year period from 1953 to 1963 over 1,400 major aircraft accidents were classified as "cause undetermined." From 1960 to 1963, 140 major aircraft accidents were of undetermined causes at the cost of \$166,361,130.³⁷ During the same three years, in an additional 210 major accidents the investigation boards concluded that some system failed but were unable to determine why or what component of the system malfunctioned. These accidents constitute almost one-third of all major accidents during this three year period.³⁸

³⁴Wimberly, p. 40.

³⁵U.S., Department of the Air Force, Summary . . ., p. 9.

³⁶U.S., Department of the Air Force, "Accident Records," TIG Briefs, Vol. XIV, Nr. 19, (14 September 1962), p. 4.

³⁷U.S., Department of the Air Force, Report of Fourth . . ., p. 9.

³⁸Wimberly, p. 40.

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Aircraft accident investigation techniques have not advanced at the same rate as aircraft development.³⁹ The investigation of accidents involving current supersonic, complex aircraft requires special training for investigators. The number of "cause undetermined" accidents, improper findings, and invalid data will not be significantly reduced until thorough, accurate, and scientific investigations are conducted.

Present methods--base appointed boards, depot assistance, factory assistance, and Norton assistance, are only half measures. The requirement exists for full time, primary duty professional investigators.⁴⁰

As stated in Chapter III, most Air Force aircraft accident investigations are conducted at base level by a specially selected board of officers. The key man on the investigation board is the accident investigator. The proper and thorough conduct of the investigation and the validity of the board's findings and recommendations are directly related to his qualifications.⁴¹ At the present time we are critically short of qualified aircraft accident investigators within the Air Force.⁴² Each year we lose about thirty per cent of the officers trained in accident prevention and investigation techniques.⁴³ These losses are due to career progression, retirement, and changes in primary duty. This loss of highly trained specialists is a serious problem. The experience of the investigator is an especially important factor that cannot be

³⁹U.S., Department of the Air Force, Report of Worldwide . . ., p. 14.

⁴⁰Ibid., p. 14.

⁴¹U.S., Department of the Air Force, Report of Fourth . . ., p. 6.

⁴²Wimberly, p. 41.

⁴³U.S., Department of the Air Force, Report of Fourth . . ., p. 7.

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replaced. Accident investigation, in the words of Colonel Wimberly, is "an exacting science that requires experience, operational knowledge, technical skill, preparation, and a hell of a lot of hard work."⁴⁴

The specific deficiencies cataloged by DAS which result in poor accident investigations can be grouped into three general areas: (1) the thoroughness and accuracy of the investigation; (2) the conclusions based on the facts discovered; and, (3) the reporting of the facts, conclusions, findings, and recommendations.

Thoroughness and accuracy of the investigation.--The inherent limitations of a base level accident investigation board often result in an inadequate accident investigation. This frequently leads to a "cause undetermined" accident. Seldom in any member of the investigation board, except the investigator, trained in the techniques of accident investigation. As a result they often overlook subtle but important clues to the accident's cause. Because of their lack of knowledge some investigation boards have actually destroyed valuable evidence while searching for the causes of an accident.

In many cases, base level investigation boards are neither qualified or permitted to disassemble and inspect modular components (black boxes) which are suspected of contributing to an accident. If the investigator needs detailed information about one of these components he must send it for laboratory analysis or TDR. Although TDRs are given priority handling the inevitable delay in returning the conclusions of the analysis often detracts from the quality of the investigation.

The increasing frequency of high energy crashes also complicates

⁴⁴Ibid., p. vi.

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the investigation of an aircraft accident. High energy accidents usually result in massive disintegration of the aircraft. The investigator therefore cannot determine the amount of fuel, oil, hydraulic fluid, or air pressure in any of the tanks or lines. He is frequently unable to determine the continuity of electrical, hydraulic, pneumatic, fuel, or flight control systems. In short, the heavy destruction masks or distorts evidence that might be valuable in the investigation.

The investigator knows, however, that Air Force statistics indicate that about forty per cent of recent accidents have been caused by materiel failure. Because of this he knows it is important to establish the condition of the various systems and determine if any malfunctioned. Without considerable experience and knowledge and the use of sophisticated tools and techniques the investigation board cannot relate the damage at the accident scene with the condition of the aircraft before impact. As a result, the conclusions of the accident board is often "cause undetermined."

Conclusions based on facts discovered.--Even if a thorough and accurate accident investigation is completed great care must be taken to insure that the board's conclusions are based on the facts revealed by the investigation. An Air Force investigation specialist stated the problem in these words:

. . . the single most important obstacle to scientific progress has been the unfounded conclusion, based upon "findings" not supported by valid evidence. The unwarranted conclusion, however reasonable and comforting at the time, too often has closed the door to inquiry and discovery of valid solutions which were just around the corner.⁴⁵

Two examples will illustrate this point. The first involves con-

⁴⁵Richard C. Sciebetta, "If I Were You," An address to the USAF Safety Conclave, November 1963.

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clusions and recommendations made as a result of many accidents in which the crew escaped the disabled aircraft by using the ejection seat. The first successful emergency ejection was demonstrated in 1949. From that point on, an increasing number of aircrew members have ejected from aircraft. As a result of these accidents and because aircraft were being developed to go higher and faster, there was a tendency for aircraft accident investigators to recommend improvements in the ejection system in the flight regime of higher altitudes and speeds. These recommendations were accepted and ejection capabilities improved at higher speeds and altitudes. History, however, has shown (and is still demonstrating) that the problem in successful escape is neither at high altitude or speed--it is at low altitudes and speeds. Designers and investigators are hesitant to accept this truth and development still continue in perfecting the ejection system for flight regimes where the problem is seldom met.⁴⁶

The second example is concerned with the mid-air collision problem. In a number of separate reports the Air Force has acknowledged the inadequacy of the "see and be seen" concept of avoidance of mid-air collisions. They have recognized that it is physically impossible, at times, for a pilot to avoid a collision. One report, for example, states:

The preceeding analysis of the mid-air collisions experienced by the USAF has indicated one predominant factor, namely, that the pilot visual perceptual reaction capability is not adequate for consistent avoidance of mid-air collisions. This is particularly true when high performance aircraft in a congested air space is [sic] considered.⁴⁷

⁴⁶Anchard F. Zeller, "One At A Time, An address presented at the 54th Annual Air Force/Industry Conference, Palm Springs, California, 16-18 September 1964.

⁴⁷U.S., Department of the Air Force, USAF Mid-Air Collisions, (Norton AFB, Calif.: Directorate of Flight Safety Research, 1 November 1958), p. 1.

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Another report acknowledges:

Visual search is inadequate for the certain detection of other aircraft in sufficient time to avoid collisions. This inadequacy is due to several conditions. These include: (1) poor brightness contrast between the aircraft and its background; (2) lack of relative movement of the aircraft in relationship to its background; and, (3) the periphery of the retina cannot detect targets or smaller angular subtense at the distances needed for detection and successful evasion.⁴⁸

Even base level flight safety officers, gathered in a worldwide safety conference, agreed that:

The increased mid-air collision potential makes it imperative that the present ATC/AFCS control procedures, aircraft instrumentation in regard to warning devices, clearance directives, and positive control area concepts be re-evaluated. New procedures, revised instrument installations, and better methods of handling aircraft in high density areas must be developed. The "see and be seen" concept of aircraft separation must be augmented with collision devices and new techniques of autopilot evasive action in conjunction with anticollision devices. Cockpit instrumentation must be designed to minimize pilot disorientation and inattention to flight instruments during the critical phases of flight. Experiments for improved methods of radio and radar decoder operation both in aircraft and ground stations must be developed. In addition, educational techniques must be developed which will keep pilots current on the capabilities of both aircraft and ground environmental systems.⁴⁹

With these thoughts in mind it seems incredible that the most recent comprehensive Air Force report on 357 mid-air collisions showed that pilots were charged with having caused 305; supervisors, 38; undetermined causes, 12; and unsafe conditions, 2.⁵⁰ The conclusion that pilots caused nearly all of the mid-air collision accidents in the past

⁴⁸George O. Emerson, Robert D. Metcalf, and Harold C. Glover, The Inadequacy of Visual Search in Avoiding Mid-Air Collisions, (Wright-Patterson AFB, Ohio: Air Research and Development Command, March 1956, p. 1.

⁴⁹U.S., Department of the Air Force, Report of the Fourth . . ., p. 11.

⁵⁰U.S., Department of the Air Force, USAF Mid-Air . . ., pp. 17-18.

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several years hardly seems warranted or useful in a program of positive corrective action.

Reporting of facts, conclusions, findings, and recommendations.--

Accurate and complete reporting of the facts, conclusions, findings and recommendations of the accident investigation, while rather mechanical in nature, is nevertheless, an important part of the overall reporting system. Unless the information learned in an investigation is properly documented and transmitted to higher echelons it loses its value.⁵¹

Sometimes the failure to report known data (because it is erroneously thought to be unimportant) can be very serious. One such example occurred several years ago and concerns the F-89 fighter. In every accident where the nose gear collapsed in that aircraft, the nose gear drag brace was forced upward, and caused a distortion or penetration of the cockpit floor near the pilot's feet. During a thirty-four month period there were twenty-four accidents of this type. In several instances pilots received leg injuries or were trapped in the cockpit. The most serious accident occurred when a wheels-down landing in a corn field trapped the pilot in the cockpit. He was otherwise uninjured. Three men vainly tried to extricate the pilot until a fire, which fatally burned the pilot, halted their efforts.

None of the instances of this deficiency was reported until the fatal injury occurred. It was only belatedly discovered that this condition existed during reinvestigations of past accidents.⁵²

⁵¹"The Epidemiology of Aircraft Accidents," Notes To The Flight Surgeon, (Norton AFB, Calif.: Directorate of Aerospace Safety, July 1964), p. 3.

⁵²U.S., Department of the Air Force, Aircraft Accident Investigation and Reporting, (Norton AFB, Calif.: Directorate of Flight Safety Research, June 1956), p. 6.

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Other reporting deficiencies include contradictory or inaccurate data and the omission of relevant information. Frequent comments are found in safety publications concerning this matter. Two examples are:

In recent months, quite a few cases have come to light in which some perfectly clear and logical discrepancy could not be validated or identified. Reason? Data in our reporting systems was either lacking or could not be correlated.⁵³

Psychological and physiological factors require a lot of thought. An unbelievable number of accidents attributed to pilot error have no psychophysiological factors reported.⁵⁴

Quality of Teardown Deficiency Reports.--As previously mentioned, many components involved in aircraft accidents cannot be analyzed at base level. They must be shipped to Air Force depots or laboratories for a determination of the significance of their involvement in the accident. Unfortunately, the quality of many TDRs is such that the results cannot be relied upon. DAS considers the quality and expected results of TDRs to be one of the major problems in accident investigations.⁵⁵ In some cases the results of a TDR are so late that the impact on the findings of an accident investigation is nullified. In other cases reports of TDR on suspected components are never received by any echelon with investigative responsibility.

The quality of the analysis is often substandard. Colonel Wimberly in a speech to flight safety officers, said:

These incomplete investigations apply to depot level analysis of a problem as well as in the field investigative efforts. The AMA's Air Materiel Areas in these, and many similar cases, have not provided the TDR results necessary to resolve a specific problem.

⁵³UR's, AFM . . ., p. 1.

⁵⁴"The Epidemiology . . .", p. 3.

⁵⁵Wimberly, p. 41.

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In this area, personnel qualifications, adequate facilities and equipment, and meaningful criteria are factors requiring additional attention in order to assist in the resolution of this problem. I recently visited an AMA and personally observed a TDR on a component which was suspect in an aircraft accident. I was shocked to discover the technician performing the TDR had no idea why the component was being analyzed. Further questioning revealed that the experience level of the technician performing the TDR was such as to raise doubts as to his ability to make a thorough analysis, even if he knew why he was doing it. This particular situation was corrected immediately, but I wonder how many similar instances have taken place in the past, or are occurring right now.⁵⁶

Not all TDRs are accomplished in Air Force facilities. Some components are sent to organizations which previously overhauled, modified, or manufactured the part. Such a practice casts doubt on the validity of the report rendered since, in effect, it constitutes self-inspection. Some circumstances could arise in which a completely objective report would not be rendered. Most components can be manufactured or assembled incorrectly. Unless they are rejected by an efficient quality control system they will eventually find their way into the field where they are likely to malfunction or fail. A TDR would probably not reflect these errors if the failed part were sent to the contractor that originally manufactured, modified, or overhauled the component.

What, in summary, do the problems of obtaining valid and complete information from aircraft accident investigations mean? Clearly, they mean that the quality and accuracy of accident investigation will need to improve if the number of "cause undetermined" accidents is to be reduced.⁵⁷ They also mean that it is becoming increasingly important to establish positive cause factors by the adherence to established

⁵⁶Wimberly, pp. 40-41.

⁵⁷Letter, Gen Jay T. Robbins to flight safety officers, January 1963, Subject: none, (Norton AFB, Calif.: Directorate of Aerospace Safety).

scientific investigative methods. And, finally, they mean that if the information derived from the investigation is to be wholly useful, it must be reported completely and without error in the investigation report.

The author makes several suggestions which he thinks will improve the quality of aircraft accident investigations. The first is the formation and use of command level, specialized, aircraft accident investigation teams. The teams could be composed of personnel selected from command resources. The advantages of having highly qualified and technically competent personnel investigating the command's accidents are obvious, especially if there are a large number of materiel failure or "cause undetermined" accidents within the command. This suggestion also makes good use of the relatively limited number of trained accident investigators. This concept visualizes that many accidents would still be conducted by base level investigators, especially those of a minor nature, not involving fatalities, or which do not appear as though they will result in a "cause undetermined" finding.

The second suggestion is that Air Force Headquarters should declare the Air Force Speciality Code (AFSC) 1925 (Flight Safety Officer) a limited resource speciality. This designation would require that a person possessing the AFSC would be retained in the safety field until released by permission of Air Force Headquarters. Thus, the training and experience acquired by safety officers would be retained in the safety career field.

A third suggestion to improve the quality of accident investigations involves the use of flight recorders. These devices record on metal tape several parameters of aircraft performance such as airspeed, altitude, heading, acceleration forces, and if desired, engine perfor-

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mance and condition. While flight recorders are expensive the cost should be measured in terms of the prevention of "cause undetermined" accidents. The prevention of one of these accidents involving a \$15,000,000 B-58 could pay for a creditable flight recorder program. It is pertinent to note that the Federal Aviation Agency has had considerable success with flight recorders required in civil aircarriers. In twenty-four out of the last twenty-eight civil air carrier accidents, flight recorder data either determined or substantiated the cause factors.⁵⁸ With a sufficient number of channels in the recorder it could also be used as a source of information for preventive maintenance purposes, for substantiating or refuting flight violations or near mid-air collisions, or as a check on aircrew performance.

Finally, it is recommended that TDRs be accomplished in Air Force facilities to insure a greater degree of objectivity. Air Force Logistics Command should be required to improve the quality of the analysis by providing qualified technicians and adequate laboratory facilities.

Miscellaneous Factors

Privileged status of information.--One aspect of the Air Force aircraft accident prevention program that is disturbing is the "privileged" status of aircraft accident investigation reports and associated documents. We noted in Chapter II the military, as early as 1943, recognized the need to keep accident investigation, which was designed to determine causes to prevent future accidents, from punitive or disciplinary investigations.

⁵⁸U.S., Department of the Air Force, Report of Fourth . . ., p. 9.

This privileged status is described in detail in Air Force

Regulation 127-4:

Reports and investigations of Air Force accidents and incidents made under provisions of this regulation, will be used only within the USAF to determine all factors contributing to the mishap for the sole purpose of taking corrective action in the interest of accident prevention.

These reports and their attachments will not be used as evidence or to obtain evidence for disciplinary action; as evidence in determining the misconduct or line-of-duty status of any personnel; as evidence before flying evaluation boards; as evidence to determine liability in claims against the U.S. Government; or as evidence to determine pecuniary liability.

These reports and their attachments will not be released to the Department of Justice, any U.S. attorney, or to any other person for litigation purposes in any legal proceeding, civil or criminal. This prohibition specifically includes any action by or against the United States.

These reports and their attachments, or copies, and extracts will be used solely within the USAF and will not be appended to or inclosed in any report or document including reports of claims investigations, unless the sole purpose of the other reports or documents is to prevent accidents.

Any investigation required to support disciplinary action, claims, or assessment of pecuniary liability must be conducted under AFR 110-14, "Collateral Investigations of Aircraft and Missile Accidents," and other appropriate AF directives, independently and apart from any portion of the accident/incident investigation.⁵⁹

Essentially, this "privileged" status means that the Air Force offers a witness in an aircraft accident investigation protection and immunity in exchange for truth. Many people claim that such an arrangement is essential to obtain truth in an accident investigation. Mr. David H. Holladay, an instructor at the University of Southern California's Flight Safety Officers' Course, stressed the importance of preserving this privileged status:

If we are to continue effectively the existing concept of

⁵⁹U.S., Department of the Air Force, Investigating . . . AFR 127-4, pp. 19-20.

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voluntary information provided solely for prevention purposes without the threat of punitive action based on information given, then we must carefully guard and preserve the privileged status of aircraft accident prevention reports. Command management can insure this protection of these reports by the simple procedure of maintaining positive and complete separation between investigations of accidents for prevention purposes as opposed to investigations conducted for other purposes. To do otherwise will inevitably compromise the safety program Military and civil management will, I believe, be wise in taking every possible action to separate the prevention from the judicial functions, since failure to do so will make a police action of safety management and identify it with assessments of blame, guilt and judgment.⁶⁰

The philosophy of privileged status of information is based on the theory that to gain the most information for accident prevention purposes, the investigation board must be given wide latitude in discovering the information, to voice their own opinions, and to make their findings and recommendations without being bound by any legalistic procedure. The promise of immunity from disciplinary or similar action, it is thought, will make possible the free and uninhibited testimony of witnesses. However valid or invalid this philosophy might be, it does present some practical problems in its administration.

From a legal standpoint, it is not clear that the Air Force has the right to declare its aircraft accident reports as "privileged." Mr. Lee S. Kreindler, a noted aviation lawyer, in his two-volume work entitled Aviation Accident Law has this to say about the privileged status of departmental reports:

. . . It must be borne in mind that the privilege currently claimed by the Air Force and Navy really divides itself into two separate elements. The first is the privilege of the executive to withhold information vital to the national security. Military secrets, for example, concerning the design of a new aircraft are clearly privileged and under no circumstances will plaintiffs in

⁶⁰David H. Holladay, "What Constitutes a Safety Program?," A speech to the First National Civil Air Patrol Aviation Seminar, Ellington AFB, Texas, 27 March 1961.

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accident litigation be entitled to receive them. This must be distinguished, however, from the privilege asserted by the Air Force or Navy with respect to the Aircraft Accident Report, where no military secrets are involved, but where the Service takes the position that it must maintain the sanctity of its investigative system, and that because of the investigative desire to obtain full and complete information it has assured witnesses, and others, that it will respect confidences and not reveal sources of information. The Air Force and Navy, through the Justice Department and the various United States attorneys, attempt to equate the preservation of the sanctity of the investigative system with the national security, in terms of advancing long-range aviation safety, but obviously, this asserted "privilege" is not the same as the privilege to preserve military secrets.

Attorneys in the Justice Department and in the various United States Attorneys' offices are well aware of the distinction between the two asserted privileges. They are also well aware of the weaknesses in the latter "privilege."⁶¹

In a notable court case (In re Zuckert) the Secretary of the Air Force tried to quash a subpoena requiring him to release a copy of an aircraft accident report. Mr. Zuckert did not assert "executive" privilege." He merely asked the court to quash the motion on the ground that it was unreasonable and oppressive. In his motion, however, he mentioned AFR 62-14 (aircraft accident investigation regulation) and indicated that the accident report was a privileged document and said that the regulation had the force of law. He did not cite the statutory basis for establishing the privileged status of the report.

Kreindler goes on to say:

The Court noted that 4 U.S.C. 22 was the statute usually cited as authority for withholding information. The court pointed out that in 1958, after the Air Force Regulation was promulgated, the statute was amended by the addition of a significant sentence. The statute reads:

"The head of each department is authorized to prescribe regulations, not inconsistent with law, for the government of his department, the conduct of its officers and clerks, the distribution

⁶¹Lee S. Kreindler, Aviation Accident Law, (Albany, New York: Mathew Bender and Co., 1963), p. 298.

and performance of its business, and the custody, use, and preservation of the records, papers, and property appertaining to it. This section does not authorize withholding information from the public or limiting the availability of records to the public."

The court also recited the legislative history making it clear that Congress did not intend the withholding of such information under 5 U.S.C. 22, pointing out that in certain areas where Congress did intend the Executive to withhold information it had enacted specific statutory authority.

As to the Government's argument that frank disclosure in accident investigations will be hampered unless the Air Force can give assurance that testimony will not be disclosed, the court pointed out that such assurances could not be given by the Air Force, anyway, because such reports have been held to be subject to discovery proceedings in cases in which the United States is a party.⁶²

It has been impossible for the author to document the fact that the Air Force has released aircraft accident reports to the court in some litigations. It would appear, however, that this has happened.⁶³ After very serious accidents, usually involving collisions between Air Force aircraft and civilian aircarriers, Aviation Week often reports the results of the investigations. In an accident involving a mid-air collision between a T-33 and a Capital Airlines Vicount near Brunswick, Maryland, the magazine quoted what purported to be an Air Force aircraft accident investigation report.⁶⁴ The author was not able to determine if, in fact, the quotations were from an Air Force investigation report.

The privileged status can be a problem in the safety officer's day-to-day activities. To obtain information necessary to conduct the accident prevention program he often offers immunity, as authorized in AFR 127-4, to obtain this information. Unfortunately, it has been the author's experience that a safety officer cannot be certain the immunity

⁶²Ibid., pp. 246-247.

⁶³Ibid., pp. 242, 294.

⁶⁴"CAB Probes Vicount-T-33 Collision," Aviation Week and Space Technology, Vol. 69, Nr. 1. (20 May 1958), p. 39.

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he offers will be honored. In several instances, after offering immunity for information, the author has learned that adverse action was taken against the individual. In one case a pilot was summarily grounded by his commander after the commander learned what occurred in the preliminary investigation report. In another, and more serious, case the author began to seriously doubt the value of the protection offered by the "privileged" status of the accident report. This case involved the pilot of the aircraft accident at Webb AFB described earlier in this chapter. The pilot was assigned to another command. Several months after the accident report was completed, the author learned that on the basis of the report, the pilot was given two "proficiency evaluation" flights. As a result of these flights, it was reported, the pilot was permanently grounded. A Flying Evaluation Board was not convened.

Action taken against a participant in an accident need not be as severe as permanent grounding to violate the spirit of the regulation. One safety officer, supporting this view, said:

. . . Such action need not be "disciplinary" as defined in the judicial code, but any personnel action which threatens an individual's position, pride, morale, or standing among his contemporaries is a threat . . .⁶⁵

The solution to this problem is either to eliminate the privileged status of the accident report or to obtain statutory authority to insure that information can be maintained for accident prevention purposes only. It is basically dishonest to offer immunity to a

⁶⁵John F. Sharp, "Flight Safety: Function or Concept?", (unpublished thesis, Air War College, Air University, 1957), p. 12.

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witness if such immunity cannot be guaranteed. Misuse or violation of the privileged status will result in a loss of naïveté and information is, as a result, likely to be slanted or reluctantly given. If the privileged status is withdrawn, investigations can be conducted under legal procedures with a greater reliance on the rules of evidence.

On the other hand, witnesses are generally more responsive if they know what they say will not be held against them. The privileged status of the reports probably does make the job of the accident investigator easier. It would seem, however, that in order to maintain this privileged status it would be necessary to obtain statutory authority from Congress to do so.

Human factors as causes.--Another factor that detracts from the aircraft accident prevention program is the fact that in the designation of cause factors no differentiation is made between, for example, what a pilot cannot do and what he did not do. If an accident is caused because the pilot's physical limitations are exceeded it is classified the same way as an error in his judgment--pilot factor.

Pilots deeply resent the term "pilot error," especially when it follows a requirement for which the pilot could not reasonably be expected to adequately respond. This lack of differentiation thus unnecessarily detracts from the accident program while contributing very little to our knowledge of why rather than who causes accidents.

This problem was discussed by flight safety officers during the 1956 worldwide conference.

Accident cause factor terminology now being employed lends itself to misinterpretation by command authorities in that it directs their efforts more toward the individual involved rather than the reasons WHY the individual was involved. In general, it was agreed

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that an improvement of present terminology is required. Such changes or improvements satisfy established requirements for statistical analyses and at the same time provide terminology which would eliminate the unwarranted stigma that is now often attached to the individuals involved.⁶⁶

Joint safety organization.--There is one final suggestion that might improve the quality of the accident prevention program. Since the safety problems of all the Services are similar--basically, difficulty with man or machines--it would seem profitable to investigate the possibility of a joint or tri-Service safety directorate. An organization that would operate in much the same manner as the Defense Supply Agency or the Defense Intelligence Agency might prove workable. It would require a considerable amount of study to establish the disadvantages as well as the advantages of such an organization. There has been some standardization among the Services concerning safety already so perhaps there is some movement in this direction.

In summary, it should be restated that the U.S. Air Force has made considerable progress in the prevention of aviation accidents. Even with this progress the losses due to aircraft accidents are great. To make further progress we must continuously examine the effectiveness of the aircraft accident prevention program and make changes as they appear necessary.

The weaknesses and deficiencies in the current Air Force aircraft accident prevention program that are discussed in this paper are those that appear to be the most significant based on the author's eight years' experience as a wing flight safety officer. The solutions to these problems are those he thinks will correct the deficiencies

⁶⁶U.S., Department of the Air Force, Report of Worldwide . . ., p. 34.

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and create a greater effectiveness in accident prevention. They are not simple or easy to implement. They are necessary if we are to perform our mission with the greatest amount of efficiency and the least loss due to accident.

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