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# General Aviation Safety Research Issues

Robert J. Ontiveros

FEDERAL AVIATION ADMINISTRATION

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Final Report

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16. Abstract

This report is a compilation of general aviation safety research issues extracted and summarized from recent studies conducted by the Federal Aviation Administration (FAA), other government agencies, and the aviation industry. It offers an overview of conclusions and recommendations that highlight current and future problem areas in general aviation. The report addresses the expressed needs as defined by these studies which counsel research and development relevant to the interrelationships of man, machine, and environment to effectively improve the general aviation safety record.

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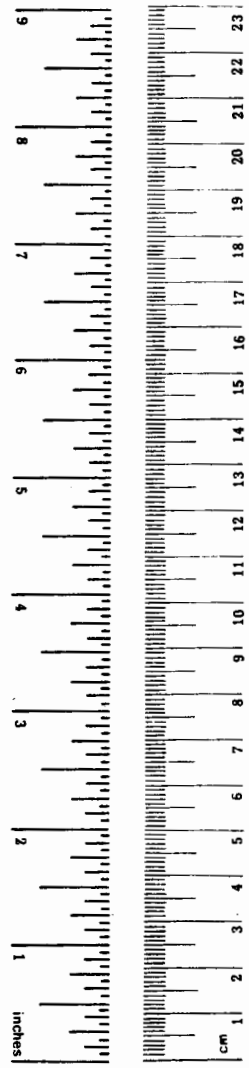
# METRIC CONVERSION FACTORS

## Approximate Conversions to Metric Measures

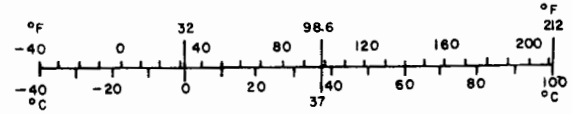
| Symbol | When You Know | Multiply by | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| in | inches | *2.5 | centimeters | cm |
| ft | feet | 30 | centimeters | cm |
| yd | yards | 0.9 | meters | m |
| mi | miles | 1.6 | kilometers | km |
| | | **AREA** | | |
| $in^2$ | square inches | 6.5 | square centimeters | $cm^2$ |
| $ft^2$ | square feet | 0.09 | square meters | $m^2$ |
| $yd^2$ | square yards | 0.8 | square meters | $m^2$ |
| $mi^2$ | square miles | 2.6 | square kilometers | $km^2$ |
| | acres | 0.4 | hectares | ha |
| | | **MASS (weight)** | | |
| oz | ounces | 28 | grams | g |
| lb | pounds | 0.45 | kilograms | kg |
| | short tons (2000 lb) | 0.9 | tonnes | t |
| | | **VOLUME** | | |
| tsp | teaspoons | 5 | milliliters | ml |
| Tbsp | tablespoons | 15 | milliliters | ml |
| fl oz | fluid ounces | 30 | milliliters | ml |
| c | cups | 0.24 | liters | l |
| pt | pints | 0.47 | liters | l |
| qt | quarts | 0.95 | liters | l |
| gal | gallons | 3.8 | liters | l |
| $ft^3$ | cubic feet | 0.03 | cubic meters | $m^3$ |
| $yd^3$ | cubic yards | 0.76 | cubic meters | $m^3$ |
| | | **TEMPERATURE (exact)** | | |
| °F | Fahrenheit temperature | 5/9 (after subtracting 32) | Celsius temperature | °C |

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.




## Approximate Conversions from Metric Measures

| Symbol | When You Know | Multiply by | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| mm | millimeters | 0.04 | inches | in |
| cm | centimeters | 0.4 | inches | in |
| m | meters | 3.3 | feet | ft |
| m | meters | 1.1 | yards | yd |
| km | kilometers | 0.6 | miles | mi |
| | | **AREA** | | |
| $cm^2$ | square centimeters | 0.16 | square inches | $in^2$ |
| $m^2$ | square meters | 1.2 | square yards | $yd^2$ |
| $km^2$ | square kilometers | 0.4 | square miles | $mi^2$ |
| ha | hectares (10,000 $m^2$) | 2.5 | acres | |
| | | **MASS (weight)** | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.2 | pounds | lb |
| t | tonnes (1000 kg) | 1.1 | short tons | |
| | | **VOLUME** | | |
| ml | milliliters | 0.03 | fluid ounces | fl oz |
| l | liters | 2.1 | pints | pt |
| l | liters | 1.06 | quarts | qt |
| l | liters | 0.26 | gallons | gal |
| $m^3$ | cubic meters | 35 | cubic feet | $ft^3$ |
| $m^3$ | cubic meters | 1.3 | cubic yards | $yd^3$ |
| | | **TEMPERATURE (exact)** | | |
| °C | Celsius temperature | 9/5 (then add 32) | Fahrenheit temperature | °F |



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## EXECUTIVE SUMMARY

This report is a compilation of general aviation safety research issues extracted and summarized from recent studies conducted by the Federal Aviation Administration (FAA), other government agencies, and the aviation industry.

The purpose of the report is two-fold:

1. To provide an overview of the discussions and findings extracted from the information sources that underscore current and potential problem areas in general aviation.

2. To summarize the expressed needs resulting from these studies that counsel research and development to improve general aviation safety.

The studies reviewed do not represent an aggregate of general aviation safety problems. However, they do display a commonality of opinion that touches on some of the major issues that deserve attention, consideration, and action.

The conclusions and recommendations offered by these studies categorically establish the priority for needed research addressing the man (pilot), environment (weather), and the machine (aircraft), in that order.

1. Man: The pilot is the major cause/factor responsible for approximately 80 percent of all general aviation accidents. This statistic alone underscores a paramount requirement for training and educating the pilot/flight instructor; improving pilot proficiency, certification, and judgment in order to reduce human error as a prime causal factor in general aviation accidents.

2. Environment: Environmental weather, as a related factor, accounts for approximately 45 percent of general aviation accidents. The order of priority established within the environment category calls for research to improve: (a) Weather forecasting and the dissemination of real-time weather information; (b) air traffic control (ATC) system traffic movements, equipment, pilot-controller communications, and ATC controller workload; (c) flight service station weather/communications equipment and weather information dissemination; and (d) low visibility runway visual guidance, low cost visual approach equipment and weather equipment installation at general aviation airports.

3. Machine: Given the improvements in aircraft performance and utility leading to increased use of general aviation aircraft for business and pleasure flying, research in the following areas is needed to keep pace with the evolution of general aviation technology. The priorities are: (a) Fuel systems standardization and equipment (fuel gauges) reliability; (b) improved aircraft handling qualities and performance, stall/spin improvements; (c) cockpit design guidelines for new generation integrated flight systems and standardization of in-cockpit displays and equipment; (d) improved structural crashworthiness and torso restraints, information/training methodology relevant to aircraft ditching techniques and crash survivability; and (e) information and format improvements to pilot operating handbooks.

# INTRODUCTION

This report is a compilation of general aviation information extracted from several recent studies, seminars, and workshops as reported by industry, the Federal Aviation Administration (FAA), National Aeronautics and Space Administration (NASA), and other government agencies.

## PURPOSE.

The report's purpose is two-fold:

1. To provide an overview of the findings extracted from the information sources that underscore existing or potential problem areas in general aviation.

2. To summarize the expressed needs resulting from these studies that counsel research and development (R&D) to improve general aviation safety.

## BACKGROUND.

Improvements in aircraft performance and utility over the past few decades have contributed to an increased use of general aviation aircraft for pleasure and business flying. The steady growth of general aviation by its nature has been accompanied by a multitude of several problems involving, or induced by, the pilot (man), the aircraft (machine), or system (environment). The severity of these problems is often mirrored in general aviation accident data compiled and published by the National Transportation Safety Board (NTSB), FAA, NASA, and other safety information system sources. It is only through the ongoing and concerted efforts of the aviation industry, government agencies, and private institutions through exhaustive studies, investigations, and exploratory research that numerous problems have been attacked and resolved. The present low-level accident rate of general aviation attests to the effectiveness of those efforts.

Consider the following: The FAA Statistical Handbook of Aviation for 1962 (reference 1) indicates the general aviation fleet consisted of 82,121 aircraft with an attendant pilot population of 528,147. Combined pilot/ aircraft operations for that year accounted for 14.5 million aircraft flight hours. For the year 1981, the same data source indicates a general aviation fleet of 213,267 aircraft, 831,650 pilots, and over 43.5 million aircraft hours flown. Thus, in a span of two decades, the fleet has more than doubled, the pilot population has increased 57 percent, and operational flight hours have tripled.

An examination of the general aviation accident data over that same time span indicates that, since 1962, the total accident rate has decreased 70 percent from 33.4 accidents (per 100,000 flight hours) in 1962 to 10.0 in 1982. Similarly, the fatal accident rate has decreased 40 percent from 3.0 in 1962 to 1.8 in 1981.

The significant decline in the accident rates, while encouraging, is still considered unacceptable when compared to the accident rates of air carrier or other transportation modes. Even at the low 1981 general aviation accident rates cited, those figures translate into 3,760 accidents. Of that total, 674 were fatal accidents that resulted in 1,251 fatalities. Pleasure flying alone consistently accounts for more than 50 percent of the total and fatal accidents, although this type of flying represents only 25 percent of the total aircraft hours flown.

The 1979 NTSB Annual Review of Aircraft Accident Data for General Aviation (reference 2) listing accident cause/factors provides the following information.

"In accidents where fatalities occurred, 6 out of 10 leading causal citations involved some type of human failure/error while 4 involved environmental conditions. No mechanical difficulty or aircraft malfunctions were involved in the top 10. In accidents where no fatalities occurred, 5 out of the leading 10 causal citations involved some human failure/error while 3 involved material/overload/or powerplant failure for undetermined reasons and 2 involved environmental conditions. Pilot cause/factors continue to predominate the fatal accidents, 84.37 percent while weather related cause/factor citations remain second at 45.0 percent."

Needless to say, the FAA, NASA, other government agencies, industry, and the aviation community are, and will continue to be, concerned with the growth of general aviation with its concomitant accident record and a variety of complex issues not necessarily rooted in or defined by the accident data.

The efforts of all organizations are directed to the recognition, identification, and definition of future as well as existent problem areas in the many aspects of general aviation. Such areas of concern are approached, investigated, and if not resolved, at least identified through the expedients of empirical research, aviation seminars, workshops, flight clinics, and the like.

The results of these activities generally culminate in a technical report or working paper. These findings, the conclusions drawn, and the recommendations addressing the issues relevant to the operational complexities and interrelationships of man/machine/system are made available to the aviation community.

This report is a compilation of summarized information extracted from five recent studies and workshops described below. Its intent is to present an overview of those findings, conclusions, and recommendations to identify and help prioritize potential areas of R&D in a continuing endeavor to improve the general aviation safety record.

## REPORT ORGANIZATION AND SCOPE.

The aforementioned opinions, conclusions, and findings are extracted from five separate studies addressing general aviation safety issues and constitute the discussion section of this report. The reports used are as follows:

1. "1981--Test Pilots Aviation Safety Workshop," SETP/AIAA Proceedings (reference 3).

2. "Proceedings of the Second General Aviation Safety Workshop," (reference 4).

3. "NTSB--Annual Review of Aircraft Accident Data," (reference 2).

4. "Evaluation of Safety Programs with Respect to the Causes of General Aviation Accidents," (reference 5).

5. "A Study of General Aviation Safety," (reference 6).

The studies do not represent an aggregate of general aviation safety problems. However, they do display a commonality of opinion that touches on some of the major

issues that deserve attention, consideration, and action. To that extent, they should be viewed as a small but significant sample of problem areas supporting the continuing need for aviation research that focuses on the man, the machine, and the system.

The studies reported herein and the major areas of discussion are listed in sequence.

1. "1981--Test Pilots Aviation Safety Workshop," SETP/AIAA Proceedings.

    a. Aeromedical Safety
    b. Air Traffic Control
    c. Cockpit Design

        (1) Integrated Cockpit Systems
        (2) Aircraft Crashes/Ditching
        (3) Aircraft Fuel Systems

    d. Flying Qualities and Performance
    e. Pilot Operating Handbooks
    f. Weather

2. "Proceedings of the Second General Aviation Safety Workshop."

    a. Aviation Safety Economics
    b. Flight Instruction
    c. Pilot Written Examinations
    d. Weather Related Accidents
    e. Aviation Safety Data
    f. General Aviation Aircraft

3. "NTSB--Annual Review of Aircraft Accident Data."

    a. Statistics
    b. Pilot
    c. Weather

4. "Evaluation of Safety Programs with Respect to the Causes of General Aviation Accidents."

    a. Mechanical Error Fault Tree
    b. Environment Error Fault Tree
    c. Human Error Fault Tree

5. "A Study of General Aviation Safety."

    a. Flight Risk Rates based on estimated operational exposure rates

An overview of the discussed general aviation research issues is provided in the SUMMARY/CONCLUSIONS section of this report. Those issues are delineated under the assigned categories of Man, Machine, and Environment, and represent the research needs defined by all five studies as they relate to each category.

No attempt is made to establish a rank order of priority for the specific issues identified under the categories. However, if the accident data were to be used as a measure indicating the serious nature of the problem, some semblance of priority can be assigned. As applied to the main categories of Man, Machine, and Environment, the priority established becomes Man, Environment, and Machine.

## DISCUSSION

"1981--TEST PILOTS AVIATION SAFETY WORKSHOP" - SETP/AIAA PROCEEDINGS.

The referenced proceedings reflect the opinions of the various subcommittees formed to review and discuss general aviation issues or problems including, but not limited to, those pertinent to pilots, aircraft, and systems. (Note: This publication makes clear that, "The ideas, concepts, and opinions expressed herein are those of the authors or subcommittees and not the official position of the Society of Experimental Test Pilots (SETP) or the American Institute of Aeronautics and Astronautics (AIAA))."

AEROMEDICAL SAFETY COMMITTEE (SETP/AIAA). Comments offered by the Aeromedical Safety Committee cited the need for pilot education in the general aspects of medical health. Commencing with flight and ground training, pilots need to have a fundamental but sound understanding of the biological, sociological, and psychophysiological factors that may influence their ability to fly. The adverse effects of alcohol, drug usage, and smoking should be stressed. Consonant with this learning, pilots should be exposed to initial and recurrent training to develop an awareness of the body's response to nutrition, fatigue, vertigo, accelerations, fitness, and disorientation. Furthermore, during the training process, emphasis should be given to survival training, cardiopulmonary resuscitation (CPR), ditching/ water survival, and emergency medical care.

The committee identified the need for improved hearing protection and communications equipment.

THE AIR TRAFFIC CONTROL (ATC) SYSTEM COMMITTEE (SETP/AIAA). Committee findings indicated the ATC system and a majority of major airports are inadequate and less than acceptable to meet current and future airspace utilization. This conclusion has its basis in a variety of existing problems and on near future FAA projections of 50 and 40 percent increases, respectively, for general aviation and air carrier operations.

Specific examples of ATC problems cited include: Near mid-air collisions, ground and airborne delays, complex communications between pilot and controller, and enforced noise abatement arrival and departure procedures which may compromise safety. The committee expressed its belief "that the increasing complexity and system malfunctions are, in good part, the result of a maldistribution of control. As the burden of control has been increasingly lifted from the pilot and shifted to the controller and the control system, they (pilots) and it (control system) have become overburdened, overloaded, and increasingly vulnerable to failure."

As suggested by the committee, the use of ground based computer-aided radar systems, coupled with the continued development and implementation of in-cockpit

displays, may be an initial approach to problem solutions. This could result in a redistribution of "load" from controller to pilot by providing him with the necessary tools and information to control his own flight and as a consequence lay the foundation for maximum system flexibility.

COCKPIT DESIGN COMMITTEE (SETP/AIAA). Summary comments and conclusions of the committee involved:

1. Integrated cockpit systems including head-up displays (HUD) — The emergence of the multi-purpose display, computer controlled "glass cockpit" will impact general aviation. As stated by committee member Mr. Peter Dickens, "The cockpit environment display format and amount of information available to the pilot will change markedly by the year 2000. The rapid technological advancement in computer hardware such as microprocessors and cathode ray tubes (CRT) places the "glass cockpit" within the realms of not only air carrier aircraft but also the general aviation industry. The decreasing manufacturing costs of such systems and the competitive marketing of aircraft and display systems should ensure that the "glass cockpit" will be operational on a large scale in the period 1985-2000."

Expected implementation of sophisticated cockpit systems and displays in the not too distant future necessitates research in the following areas: A need to develop and define proper standardization for integrated systems. This would entail color usage, symbology, warning(s) standardization, keyboard design, presentation formats, and logic of operation. With specific regard to HUD, the committee emphasized the need for research to define optimum inputs, symbology standardization, provisions for failure monitoring, and eye accommodation. The group recommended that the development of HUD should be "as an integrated part of the total cockpit system and not as an entity in itself."

2. Aircraft Crashes/Ditching — The comments of the committee in these areas stressed the need for pilot training in crash survivability, ditching procedures, and water survival. There is a need for improved restraints including upper torso restraints. Correlation should be established between aircraft attitude and "G" loading at impact with statistics relating to human survivability.

3. Aircraft Fuel Systems — Recognizing that fuel mismanagement contributes significantly to engine failure/malfunction accidents, the committee emphasized that, ". . . fuel gauging accuracy, low-level warning and fuel-gauging standardization are all inadequate in the general aviation industry."

FLYING QUALITIES AND PERFORMANCE COMMITTEE (SETP/AIAA). The committee reported on the interrelationship between flying qualities, performance, and pilot training. The essence of the numerous observations and comments made focused on situations or aircraft configurations which contribute to the dissimilitude of handling and performance characteristics across the spectrum of general aviation aircraft. The thrust of these comments centered on "how flying qualities and performance differences between airplanes can affect safety and effectiveness of training."

Some of the different aircraft handling characteristics addressed included: High angles of attack; aircraft trim changes with power changes and activation of flaps, spoilers and landing gear; high altitude handling versus low altitude handling; and variations in landing flare, touchdown, and roll-out.

Different aircraft performance characteristics cited included: Takeoff and climb variations, high density altitude conditions, capabilities, and differences in the degree of aircraft control during the landing approach.

Following are the findings and recommendations extracted directly from the committee's report. The findings of the committee are:

1. The observations made herein on flying qualities and performance will continue to hold true in the foreseeable future: the airplanes of the General Aviation fleet will undergo little fundamental change. Therefore, the pilot training process will have to continue coping with deficiencies and airplane differences in flying qualities of performance.

2. There exists a serious lack of information and experience transfer to the instructor and to the trainee concerning flying qualities and performance.

3. The present system of training and certification does not insure adequate understanding and competency of the instructor nor of the trainee.

4. Better training is required at high angles of attack beyond the stall.

5. Better training is required for pilots transitioning to unfamiliar airplanes with different flying qualities and performance.

6. The present fleet of primary training airplanes is adequate for teaching basic airmanship, provided advantage is taken of exposing the trainee to a range of flying qualities and performance through use of means already in hand. As an example, center-of-gravity variations cause a significant change in flying qualities.

7. Deficiencies in General Aviation airplanes and in flying qualities and performance, and desirable changes for correction were called out in the Workshop '80

Report of this subcommittee. These factors, affecting safety and training, continue to offer significant improvements if implemented.

The recommendations of the committee are:

1. As pointed out by the report from Workshop '80, improvements in the flying qualities and performance of airplanes should receive continued emphasis from the aviation community. However, since changes will evolve slowly, current airplanes will be in use for many years. Therefore, training must be made adequate to prepare the pilot to cope with the demands imposed by these airplanes.

2. The variations in flying qualities and performance which can be exhibited by current airplanes should be exploited to improve training. For example, changes in center of gravity can produce significant changes in both stability and stall characteristics, and operation at reduced power can simulate performance degradation by high density altitude.

3. Better information and training materials on flying qualities and performance should be made readily available to instructors and trainees to promote better understanding of the basic principles affecting the way the airplane flies.

4. Completeness and accuracy of information contained in the Pilot's Operating Handbook (POH) should be the responsibility of the company flight test organization if not already the case.

5. Actual experience should be required of instructors and trainees to cover the range of flying qualities and performance associated with:

a. transition to different airplanes with correspondingly different characteristics, and

b. flight at high angles of attack through and beyond the stall. To accomplish this, instructors should be required to be proficient in both incipient and developed spin recovery.

PILOT OPERATING HANDBOOK (POH) COMMITTEE (SETP/AIAA). The committee underscored Pilot Operating Handbook weaknesses from the standpoint of future needs in the year 2000, given an expected increase in aircraft, aircraft complexity, a reduced airspace environment, and more restrictive regulations by that time. The group's opinions were founded on known and defined shortcomings that abound in current operating handbooks.

Among the deficiencies cited were its large size, small print to allow for more information per page, unsuitable format for handbook use in the cockpit, a lack of ready access or indexing of specific information in the handbook, and a lack of a method to determine if the POH contained the latest revisions. The general conclusion drawn was that, despite the defined weaknesses, POH's are and will continue to be adequate for the next several years. However, they lack the structure, format, and informational content to be compatible with the operational environment of the year 2000.

As stated by the committee, "The aviation handbook has come a long way. However, in the next 20 years, even greater change is needed and must be implemented."

Recommendations of the POH Committee as extracted from their report are as follows:

1. Reverse the trend toward bigger handbooks and checklists. This would require a change in format and a change in medium of presentation. State-of-the-art electronics should be used to present some of the information; i.e., electronic check lists, emergency procedures checklists, and performance data for in-flight use, all presented on a cathode ray tube (CRT) or other electronic means.

2. Strive for standardization for similar systems both in handbook format and in operational procedures.

3. Create an information exchange process between users of similar airplanes and systems.

4. Optimize the utility of the handbook by changing the scope and depth of information contained in "The Handbook." Handbooks should be specifically tailored for ground training, operational training, and in-flight use.

5. Provide more definitive system training information in the ground training handbooks.

SECOND GENERAL AVIATION SAFETY WORKSHOP 1981 PROCEEDINGS.

This workshop was sponsored by the FAA and the Aircraft Owners and Pilots Association (AOPA) for the express purpose of improving the general aviation safety record. Held at the FAA Technical Center, Atlantic City Airport, New Jersey, it was a follow-on to the First General Aviation Safety Workshop held in 1979 at the Ohio State University and sponsored by AOPA and the General Aviation Manufacturers Association (GAMA).

The second workshop was attended by representatives of the various airframe, avionics, and engine manufacturers; aviation associations; educational institutions; insurance companies; the National Weather Service (NWS); the FAA; NASA; and NTSB.

Six working groups were established to examine, discuss, and offer recommendations in: Aviation Safety Economics, Flight Instruction, Pilot Written Examinations, Weather Related Accidents, Aviation Safety Data, and General Aviation Aircraft.

A considerable number of opinions and recommendations were submitted by the various committees, a number of which do not necessarily involve extensive experimentation, test, or evaluation. A complete list of recommendations made by the working groups is included in the appendix. Some of the more interesting and specific recommendations on designated work areas are summarized below.

AVIATION SAFETY ECONOMICS COMMITTEE. The discussions of the group centered primarily on one topic; namely, "What information is available to both public and private decision makers which can be used to allocate aviation system resources?" To properly address this question, the group focused on the need for information which correlated beneficial results in terms of safety, with the funds invested in those programs. Lacking these data, the first recommendation made was that additional research has to be accomplished that relates directly to the cost effectiveness of any research undertaken to fulfill program objectives. Developed information would benefit private and public sectors. The FAA could make use of that information in allocating its limited resources while the flying public could use that data source to support decisions on aircraft equipment purchases. The committee urged that this research be undertaken by both the FAA and the aviation industry, and that the resultant information be disseminated in a manner which is intelligible to the individuals who need it.

FLIGHT INSTRUCTION COMMITTEE. The Flight Instruction working group examined what they considered to be four priority subgroup areas of interest. Those areas related to: )a) The flight training media; (b) the quality control of the certified flight instructor (CFI); (c) primary failures of current flight training; and (d) the BFR. The recommendations pertaining to flight training media consisted of the following:

a. The emphasis on defined aircraft hours for training should be minimized. Pilot training should incorporate the best and most effective training methods available. Aircraft hours should not be the criterion for pilot certification. The training media, or tools for learning, should include but not be limited to lectures, textbooks, audio-visual materials, examinations, computer assisted instruction, training devices, and simulators.

Training effectiveness should be evaluated and credited on the basis of meeting training objectives and not on the sophistication of the training.

Research is needed to support a greater equivalent training exchange; i.e., on-ground credit in lieu of actual aircraft hours. Standards for evaluating and crediting of training media should be established to counter today's inflationary trends and to meet the demands of energy conservation. These two prevailing conditions by their nature will tend to restrict the aircraft hours flown and ultimately will decrease the amount of flight time normally devoted to flying for training purposes, maintaining flight proficiency or updating re

b. The fundamental objective of CFI quality control was to ensure that all CFI's be subject to a review of their performance, as an instructor, upon certificate renewal. Such an approach would be distinct from the current practice of certificate renewal which is accomplished by attending flight clinics. (N.B. A review of CFI instruction records and performance is not a requirement for certificate renewal at present.)

The recommendations to meet the above-stated objective were: A review of CFI instructor performance, conducted at the General Aviation District Office (GADO) level, upon renewal of the CFI certificate. As an adjunct to this need, establish a data base that would allow for the identification of substandard performance of flight instructors.

c. With regard to "primary failures" in our existing training system, the group cited the problems associated with the private pilot training programs. The high accident rate record of the 100-300 hour private pilot group supports the need for improved training with an overall higher proficiency for private pilot certificates. Furthermore, it was recommended that a greater emphasis should be placed on instrument training for that certificate including trainee exposure to actual or simulated weather.

d. Discussions and opinions on the BFR issue yielded three recommendations. Currently, the BFR expires 2 years from the date on which it was taken. It was recommended that: (1) The BFR expiration date be aligned with other FAA regulation cycles that are generally based on a calendar month, such as submission date requirements for medical certificate; (2) aligning the BFR expiration date with the Airman Medical Application would provide the FAA with information on the successful completion of the BFR, information that at present is not recorded other than in the pilot's logbook.

The group agreed that the existing methods of conducting the BFR are extremely broad, since it is well known that the content of the BFR is left to the discretion of the individual giving the BFR; (3) the BFR be structured and conducted in a manner that will allow the pilot to demonstrate an aeronautical knowledge and flight capability commensurate with the specific level of certificate he/she holds.

PILOT WRITTEN EXAMINATION COMMITTEE. The committee felt that extensive improvements have been made to the pilot written examinations in terms of clarity, coverage, and information content. Nevertheless, the committee agreed that the evolving nature of aviation must be paced by new examination material that relates to that evolution with respect to increased technology, equipment developments, and aircraft improvements. Some of the major recommendations made for changes to the written examinations were as follows:

1. The fundamental knowledge required of all pilots should be iterated in all written examinations for appropriate certificates and ratings as a method of continual updating of pilot aeronautical knowledge.

2. Questions on written tests should incorporate material relating to pilot judgmental factors, since the consensus of the committee was that pilot judgment is very difficult to assess objectively.

3. The aeronautical knowledge required to prepare for the various written examinations is contained in numerous and different FAA publications. The committee recommended that the FAA Examination Standards Branch develop a means to incorporate the essential exam preparation material in fewer volumes that would be readily available to the flight community.

WEATHER RELATED ACCIDENT COMMITTEE. The committee considered three major areas of concern; (1) how best to educate the flying community about weather and weather phenomena; (2) improved, accurate weather observations and forecasting; (3) methods to expedite dissemination of weather data to pilots.

Among the numerous recommendations developed from discussions of these areas, the following are listed:

1. A comprehensive, well structured program for aviation weather education must be developed that will allow anyone desirous of acquiring this knowledge to use it.

2. A program must be developed for the systematic collection and dissemination of weather observations to pilots in a manner that will make available the latest information when it is needed.

3. The FAA should reevaluate the current criteria for the implementation of automated weather observation equipment to be purchased under the Airport Development Aid Program (ADAP) in order to provide the best use of this equipment for general aviation purposes.

4. Continue the development of airborne (in-cockpit) equipment to provide accurate real-time weather data.

5. The FAA should investigate the feasibility of establishing a system of high powered nondirectional beacons to transmit continuous transcribed weather broadcasts.

6. The FAA should provide for the nationwide implementation of the High Altitude Enroute Flight Advisory Service.

AVIATION SAFETY DATA COMMITTEE. The committee's objective in addressing this issue was for the improvement of quality and quantity of useful aviation safety data. The committee discussed the resultant status of aviation safety data recommendations that were reported at the First General Aviation Workshop. They noted substantial accomplishments in several key areas, some of which, were: Significant progress in the method of focusing more attention on the human aspects and factors surrounding an accident; recommended trend analyses developed from the NASA Aviation Safety Reporting System (ASRS) which have been carried out, and the capabilities of the NASA ASRS that have received publicity but not to the extent desired.

A comprehensive review of the aviation safety data elicited the following recommendations:

1. All aircraft accidents should be investigated, on site, by trained accident investigators. The recommendation was based on the fact that, while all aircraft accidents are documented, there are occasions when accidents are "essentially desk audited by third party investigators or reporters" due to unavailable resources and "extreme variance and severity of the accidents."

2. Consonant with that recommendation, the committee recommended that "all civil aircraft accident investigators should be certified under some formal system approved by the National Transportation Safety Board (NTSB)."

3. Accident investigation data should be expanded to take into account "the perception of causal factors, human performance information, crashworthiness, and the survivability aspects of the accident." This depth of investigative action would improve the quality of the investigation.

4. A central repository of general aviation safety research data and findings should be established to assure that these data are current, well publicized, and accessible to the community. This recommendation was based on a finding that "there is a need for those who maintain accident data systems to identify and better publicize the availability of this information."

5. Finally, the committee recommended that a two-step research program be initiated to determine the feasibility of collecting pilot behavioral data which would enhance the general aviation accident prevention program. The merit of collecting such data could be determined by analyzing behavioral data as accumulated by the commercial and military aviation sectors. Should this prove successful, the second step would be to determine what pilot behavioral data could be used and how to exploit this information in an endeavor to improve the general aviation safety record.

The committee arrived at a finding, rather than a recommendation, that would prove beneficial to the collection of aviation accident data. The committee offered its opinion that the installation of an inexpensive, lightweight, flight data recorder

(FDR) or cockpit voice recorder (CVR) in complex general aviation aircraft would add significantly to the data of aircraft accidents. The feasibility of implementing this suggested need was not pursued. The question of "IF" and "HOW" this action might be brought about was left to future discussions.

GENERAL AVIATION AIRCRAFT COMMITTEE. Committee discussions concentrated on new technology, the evolution of basic systems, and crew interrelationships that pertain to handling qualities and performance characteristics of general aviation aircraft. Those discussions yielded the recommendations below:

1. Encourage the NASA and FAA activities to continue "in the investigation and systematic development of an accident analysis concept that could provide detailed insights into accidents which may be assigned to handling quality problems."

2. In this same vein, the NTSB, in conjunction with interested research organizations, should coordinate their accident research data to define the "why" of an accident occurrence and not just the "how."

3. NASA, FAA, and industry should "jointly coordinate new technology applications and operations . . . and communicate design, development, operational, and maintenance programs with each other."

4. There is a need for the Federal Aviation Regulations (FAR), both old and new, to be written in the context of new technology implications. Furthermore, current FAR's which appear to impact innovative design should be carefully reviewed.

5. Finally, NASA should be encouraged to continue their stall/spin research and provide industry with the data as rapidly as they can.

NTSB--ANNUAL REVIEW OF AIRCRAFT ACCIDENT DATA.

This document is an annual publication containing substantial information and comprehensive statistical analyses of general aviation accident data in the form of an overview, cause/factor tables, accident and rate tables, injury and analytic tables, and diverse charts and graphs. The analyzed data encompass all general aviation accidents including specific sections devoted to operational accidents of small fixed-wing aircraft, large fixed-wing aircraft, rotorcraft, gliders, and collisions between aircraft. It is from this vast source of recorded general aviation accident data, coupled with the systematic applications of statistical techniques, that problem areas become manifest in quantified dimensions that attest to the significance or serious nature of those problems. Areas of concern are often identified demographically, or in terms of accident type, operational phase or type of flying. To illustrate the foregoing, selected data are cited.

For the year 1979, the NTSB reported on 4,063 aircraft accidents resulting in the destruction of 1,055 aircraft (25.97 percent) and substantial damage to 2,956 aircraft (72.75 percent). Six hundred and seventy-eight (678) of 4,023 accidents proved fatal, and serious injuries were sustained in 395 accidents. The total number of accidents involved 7,983 persons including 1,367 fatalities and 700 who were seriously injured.

The top three most frequent types of accidents were engine failure/malfunction (24.30 percent), ground water loop swerve (10.51 percent), and hard landing (6.23 percent).

Collision with ground water controlled (17.63 percent), collision with ground water uncontrolled (16.18 percent), and engine failure/malfunction (11.56 percent) lead the list for most frequent fatal types of accidents. Approximately 40 percent of all accidents occurred during the landing phase while 62 percent of the fatal accidents occurred inflight.

The facts revealed by data analyses show that, where fatalities occurred, 6 out of 10 leading causal citations involved some type of human failure/error while 4 involved environmental conditions. The leading cause/factor in nonfatal accidents was cited by NTSB as "pilot-inadequate preflight preparation or planning." The leading cause/factor in fatal accidents was cited as "weather-low ceiling."

The pilot continues to be the prime cause/factor in fatal accidents (84.37 percent), while weather as a related cause/factor remained second (40.71 percent).

From these data and additional information derived from the accident cases, the NTSB offered the following opinions and comments:

". . . The most significant aviation safety improvement possibilities remain in the area of human factors and weather knowledge. Weather and pilot are the predominant cause/factors of general aviation accidents. Proper preflight preparation and inflight procedures related to weather conditions could have a positive influence on aviation safety and provide the most worthy achievement possibilities for future accident prevention programs. A simple maneuver of reversing course and landing at another airport, thereby avoiding an encounter with weather conditions beyond the capability of the pilot in command, would prevent numerous fatal accidents every year."

Areas that should receive special emphasis include a comprehensive understanding of engine operation, fuel system management, safe airspeed control, takeoff and landing procedures and techniques, and well thought out plans to handle emergency procedures. As an example, the apparent lack of pilot proficiency/skills in handling engine failures in light twin engine aircraft was underscored as a significant contributing factor to accidents of that type. That information alone signifies that good fundamental and recurrent training in emergency procedures would improve the general aviation safety record.

## EVALUATION OF SAFETY PROGRAMS WITH RESPECT TO THE CAUSES OF GENERAL AVIATION ACCIDENTS.

The overall purpose of this comprehensive study was to assess established FAA safety programs to determine the extent to which those programs were aligned against general aviation accidents. Specific objectives were: (1) To identify safety programs that, singularly or in combination with other programs, are aligned with accident causes and are effective in mitigating these causes; (2) to identify safety program needs including redirection of existing programs and description of program gaps associated with mitigation effectiveness and/or nonaligned accident causes; and (3) to identify accident safety information needs that would facilitate continuing aviation safety program planning, analysis, and evaluation.

From a total of 104 FAA safety programs compiled, 90 active programs were selected and analyzed on the basis of the following criteria:

1. The primary objective of the program was safety oriented.

2. The program was listed under a safety related category in its reference document.

3. The program reflected a distinct effort to improve safety.

4. The program contained elements which contributed to safety although its primary objective served some other purpose.

The 90 safety programs were structured to address the six functional categories of: (1) Facilities and Equipment, (2) Safety Research and Development, (3) Operations Safety, (4) Regulatory Programs, (5) Capacity Programs with Safety Contributions, and (6) Management and Administrative Programs with Safety Contributions.

The data base formulated and used to examine the restructured programs (i.e., partitioned by the above functional categories) was comprised of:

1. The NTSB general aviation accident base with particular reference to probable causes, contributing factors, and accident type classifications.

2. The economic quantification of those accidents in terms of life loss, injury, and property (hull) damage in dollar values developed and assigned by the FAA.

3. FAA general aviation activity statistics relevant to primary use and aircraft type.

The analysis and evaluation of the accident data as correlated with the aviation safety programs resulted in the unique creation of error fault trees centered on those attributable to the human (man), mechanical (machine), and environment (system) (reference figures 1, 2, and 3). The effectiveness of the FAA safety programs was examined with respect to eight general aviation aircraft type/use subpopulations; i.e., business, commercial, corporate, personal, aerial application, etc., each subpopulation being analyzed under the three types of assigned error fault trees. For simplicity and brevity, the findings and recommendations of this study are reported in terms of the total population of aircraft use/type as assessed and defined by the three error fault trees, human, mechanical, and environment.

A preponderance of evidence indicates that, ". . . the FAA has done a commendable job in organizing, coordinating, and monitoring a vast array of safety programs. These programs have been successful in diminishing the accidents of a mechanical and weather/operating nature. The aviation industry (having solved most of the straightforward problems) is now approaching a safety level where the control of human error is the major safety problem in the system."

The foregoing statement was based on the findings described by the three error fault trees which assign a value of less than 7.0 percent of the total causal citations due to mechanical error. For environmental error, weather as an accident cause was assigned a value less than 3 percent, but as a factor, a high value of 45 percent was cited. In contrast to these values, the human error assigned value ranged from 65 percent for corporate aircraft operations to 84 percent for single/multi-engine piston driven aircraft.

More directly, the evidence of low mechanical failures is indicative of highly effective mechanical safety programs and is supported by the relatively low number of safety programs addressing the mechanical accident causation issue.

Similarly, the environmentally-oriented safety programs divided into the system and meteorological elements were revealed to be effective. However, the caveat stressed was that "current accident reporting practices are not conducive to revealing the true role played by weather and system factors in inducing accidents. . . . The conclusion that environmental safety programs have been effective must be viewed as highly qualified."

A final conclusion drawn was that "existing safety programs relating to human error are totally ineffective in mitigating the human error oriented causes of accidents." This finding may be attributed to the lack of understanding the role of pilot/crew error in accident causation.

The following recommendations were made on the basis of these findings, and are comprised of three major problem areas concerning: (1) The quality and quantity of

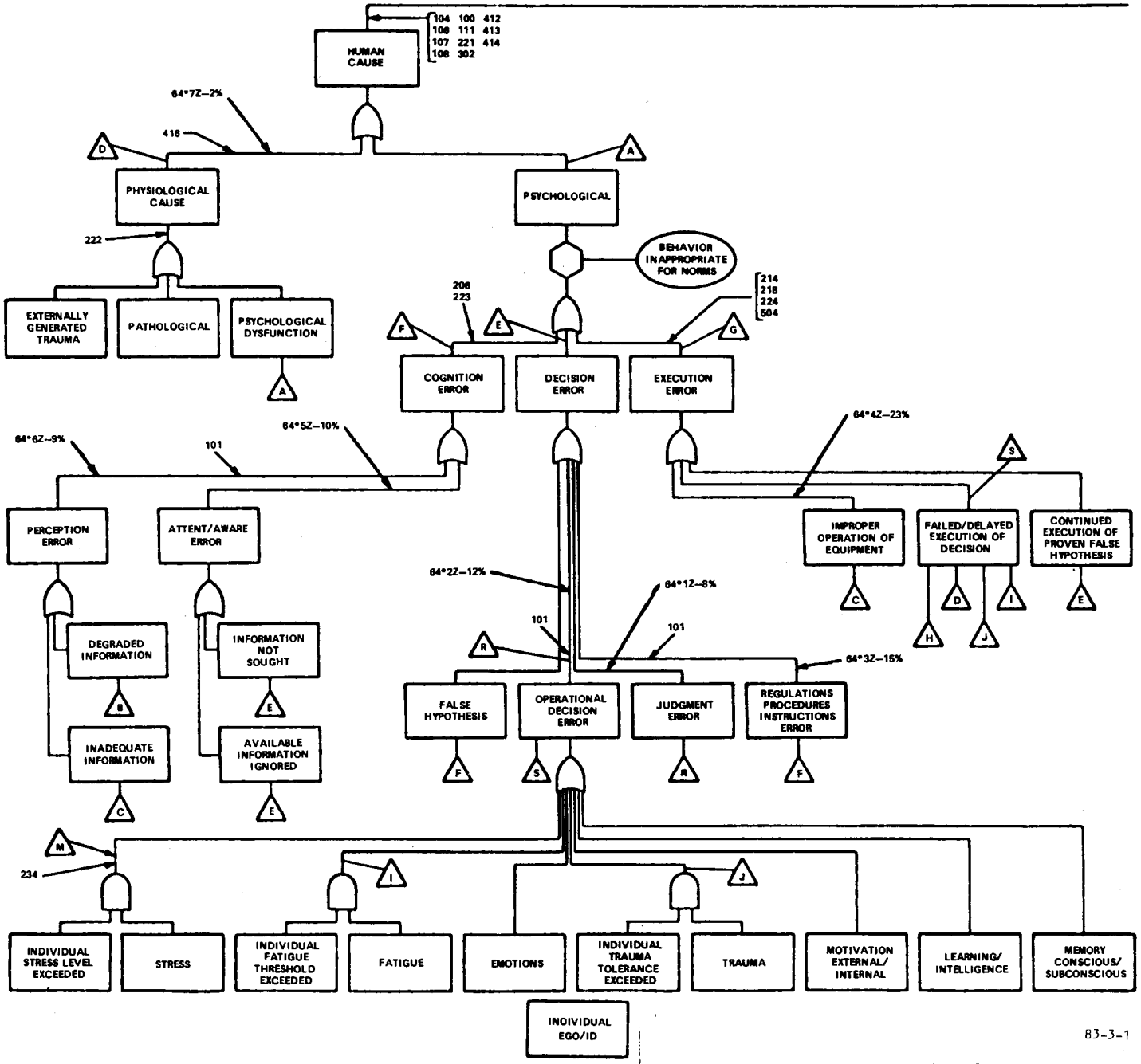


FIGURE 1. PLACEMENT OF SAFETY PROGRAMS IN HUMAN ERROR FAULT TREE AND PERCENTAGES OF MAJOR CAUSE/FACTOR OCCURRENCES

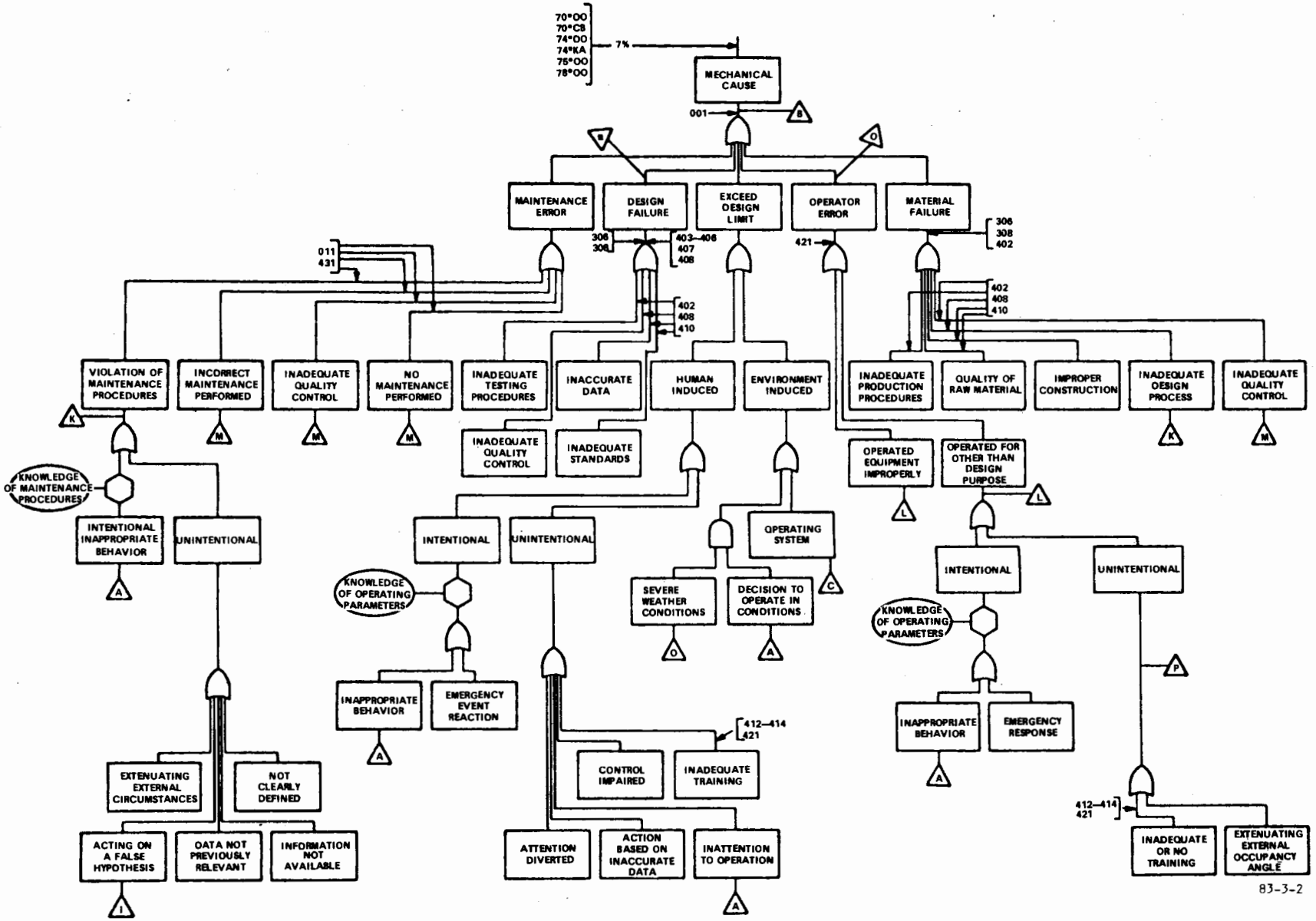


FIGURE 2. PLACEMENT OF SAFETY PROGRAMS IN MECHANICAL ERROR FAULT TREE AND PERCENTAGES OF MAJOR CAUSE/FACTOR OCCURRENCES

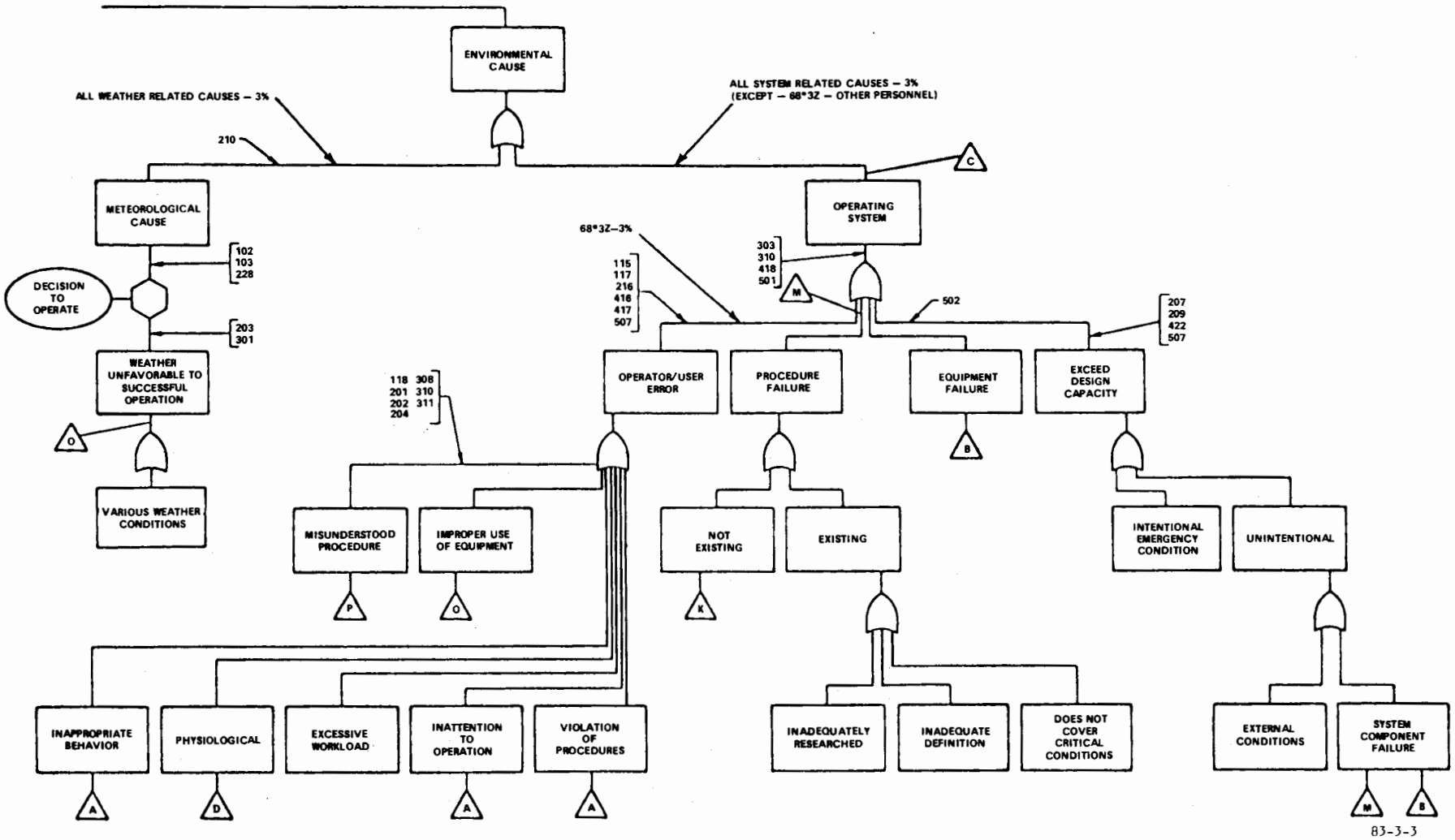


FIGURE 3. PLACEMENT OF SAFETY PROGRAMS IN ENVIRONMENTAL ERROR FAULT TREE

collected aircraft accident data; (2) the lack of a coordinated program for collection and retention of safety related information; and (3) determination of the extent the variables of economics, training, technology, and regulation affect the safety benefits of a given general aviation subpopulation.

Those recommendations were:

1. Expand the investigation emphasis from one which directs almost all investigatory resources at fatal accidents to one which treats selected fatal and nonfatal accidents equally.

2. Increase the quality and quantity of the data from the accident reports. This can be accomplished by conducting an intensive investigation of a selected number of accidents.

3. Conduct a complete study of accident data with the idea of developing a comprehensive inventory of useful data, determine what new data will be needed to fill in existing gaps, and determine how the new data can be converted to safety use.

4. Develop a comprehensive single source data system which would encompass the integration of all accident, incident, and regulatory safety data; develop a standard safety lexicon for all around use, communication and understanding by those interested elements of the FAA, NTSB, NASA, DOD, and aviation industry; retain the data for a long term (5-10 years) to improve the analytical quality of the safety system.

A STUDY OF GENERAL AVIATION SAFETY.

(Unpublished Draft Report)

There exists no definitive information on general aviation rates of accidents under various interrelated combinations of pilot, aircraft, and system since exposure rates to those conditions are difficult if not impossible to determine.

This draft study concentrated on establishing estimable accident rates as extrapolated from a theoretical estimation of exposure rates; i.e., a measure of the hours of flight operation (exposure) under specific conditions. Given this information, a variety of risk situations could be identified, and as a result, improvements to the general aviation safety record could be expected.

The factors considered involved an examination of FAA and NTSB accident data bases as they related to combinations of aircraft type, operational category (e.g., personal, business instruction, etc.), weather, light conditions, and pilot certificates and ratings. From these data, the author was able to assign "risk values," with defined confidence limits, as a function of the exposure rate applied to the aforementioned variable factors of aircraft, pilot, weather, and type of operation.

The study, of a preliminary nature, offers no recommendations, but from the conclusions drawn, insight is gained in the possible areas of potential research to enhance general aviation safety. The findings extracted from the report are listed as follows:

1. The relative exposure in general aviation can be estimated by type of aircraft, weather conditions, light conditions, pilot certificates and ratings, and pilot experience from the relative incidence of accidents whose occurrence is not related to these factors. Absolute exposure estimates can then be made based on total exposure data solicited from aircraft owners.

Dangerous/hazardous activity accounts for one-third of single-engine fatalities. These accidents can be avoided by those who only want transportation.

2. Excluding hazardous activity flights, the fatality rate per passenger mile for daytime single engine visual flight rule (VFR) operations by non-instrument rated pilots is roughly 6 times greater than that for interstate highway automobile transportation. Under daytime instrument flight rule (IFR) conditions, the rate is nine times as great. This finding assumes an unanticipated IFR weather encounter by the noninstrument rated pilot.

3. Under daytime IFR conditions, the estimated fatality rate for nonrated pilots flying single-engine aircraft is 360 times greater than the automobile accident rate; for instrument rated pilots flying single-engine aircraft in daytime VFR conditions, the fatality rate is four times greater than that occurring in automobiles and increases to 80 times greater under daytime IFR conditions.

4. The fatal rate per hour for twin engine pilots, both instrument rated and noninstrument rated, flying under daytime VFR conditions parallels that of single-engine operations under those conditions.

5. The average rate of fatal accidents per hour due to engine failures in twin engine piston aircraft is double that occurring in single-engine aircraft.

6. In single and twin engine operations, the fatality rate for instrument rated pilots equates with that of night VFR operations. Noninstrument rated pilots flying single-engine aircraft experience twice the fatality rate of twin engine aircraft under identical conditions.

7. Instrument rated pilots flying twin engine piston aircraft in IFR night conditions have a fatality rate 140 times greater than occurs for automobile transportation.

8. Sooner or later, single engine noninstrument rated pilots will encounter IFR conditions and pilot training, charts, and all aircraft equipment should reflect this reality better than they do because the fatality rate increases from six times the automobile rate under daytime VFR to 360 times the automobile rate under daytime IFR. For noninstrument rated pilots flying twin engine piston aircraft, the corresponding increase jumps from four to 85 times that of the automobile rate.

## SUMMARY/CONCLUSIONS

A general realignment of the reported general aviation safety issues results in the structure of table 1. As illustrated, the emphasis on assigned research priorities is directed to Man, Environment, and Machine. The established order is supported by the reviewed reports and has its basis in the accident data of table 2 indicating the pilot as the major cause/factor responsible for approximately 80 percent of all general aviation accidents. The environment (weather) category together with system (ATC) related causes accounts for 6.0 percent as a prime cause, but weather as a contributing or related factor increases that percentage to 45 percent of the total accidents. The machine or aircraft category is cited as a prime cause/factor in approximately 7.0 percent of the recorded accidents.

An incremental refinement of the generalized safety issues of table 1 which underscores the requirement for continuing safety research in those major categories of Man, Environment, and Machine is summarized in table 3. Viewed in this format, the recommendations for research, as products of the five studies, appear to be rather extensive, if not overwhelming, given the notion that these findings represent but a fraction of the expressed needs for aviation research as manifested by a multitude of other supportive technical and scientific reports. Fortunately, investigative endeavors continue to keep pace with the proliferation of general aviation problems through the means of constant systems monitoring and the reassessment of Man, Machine, and Environment interrelationships as they impact the general aviation safety record.

TABLE 1. GENERAL AVIATION SAFETY ISSUES

| MAN | ENVIRONMENT | MACHINE |
|---|---|---|
| 1. Pilot Training and Education | 1. Metorological | 1. Fuel Systems |
| 2. Pilot Error | 2. ATC System | 2. Flying Qualities and Performance |
| 3. Aeromedical Safety | 3. Airports | 3. Cockpit Design |
| 4. Accident Investigation | 4. Flight Service Stations | 4. Crashworthiness |
| | | 5. Handbooks |

TABLE 2. GENERAL AVIATION ACCIDENT DATA - ASSIGNED CAUSE

| MAN | | ENVIRONMENT | | MACHINE | |
|---|---|---|---|---|---|
| Psychological | 78% | Weather Related | 3% | Mechanical | 7% |
| Physiological | 2% | System Related | 3% | | |
| TOTAL | 80% | TOTAL | 6% | TOTAL | 7% |

(Contributing Factor 45%)

TABLE 3. INCREMENTAL REFINEMENT OF GENERAL AVIATION SAFETY ISSUES

I. MAN

1. Pilot Training
   - Proficiency
   - Certification
   - Examinations
2. Pilot Education
   - Accident Awareness - Development Program
   - Accident Data Feedback Development Program
     - -- Error Propagation - Decision, Execution, Cognition Determination
   - Crew-Cockpit Coordination/Discipline
     - -- Man/Environment (System) Interface
   - Weather Training
3. Aeromedical Safety
   - Psychological Training
   - Physiological Training
4. Pilot-Flight Instructor (CFI) Interface
   - Training and Proficiency Programs (CFI)
5. Accident Investigation
   - Investigator Training and Certification

II. ENVIRONMENT

1. Meteorological
   - Weather Forecasting
   - Weather Information Dissemination - Methods
2. ATC System
   - ATC - Air Traffic Movements
   - Improved Equipment

TABLE 3. INCREMENTAL REFINEMENT OF GENERAL AVIATION SAFETY ISSUES (Continued)

- Communications - ATC/Pilot
- ATC Reduced Load

3. Flight Service Station
   - Improved Equipment - Weather Dissemination
   - Improved Weather Communications - Flight Planning
4. Airports
   - Low Visibility - Runway Visual Guidance Equipment
   - ADAP Funding Automated Weather Equipment

III. MACHINE

1. Fuel Systems
   - Equipment - Standardization/Reliability
2. Flying Qualities and Performance
   - Aircraft Information
   - Pilot Awareness -- Hands-on Experience
   - Stall/Spin Improvements - Information
3. Cockpit Design
   - Integrated Systems
   - Standardization
   - Cockpit System Design Guidelines
   - Recorder Equipment - FDR/CVR Low Cost Feasibility Studies
4. Crashworthiness
   - Restraints
   - Survivability - Ditching Training
5. Aircraft Handbooks
   - Improvements

These endeavors are reflected in corollary studies recently completed by or for the FAA as exemplified below and listed in the reference section of this report.

Man

1. Pilot judgment training and evaluation — an innovative approach to teach, instill, improve, and assess the decisionmaking process of pilots (reference 7).

2. Human factors problems in general aviation — a comprehensive descriptive analysis of the human factors problems as they relate to the pilot in terms of task demands dictated by man/man, man/machine, and man/environment (reference 8).

3. Contact flight skill degradation — an in-depth study of those pilot skills that degrade over time and proposed methods to counter cognitive and procedural flight skill loss (reference 9).

4. Instrument rating requirements — an empirical research study to reduce instrument rating flight experience requirements as a means of reducing accidents attributable to noninstrument rated pilots inadvertent flight into instrument meteorological conditions (reference 10).

Machine

1. Human factors guidelines — general aviation electronic flight displays — a descriptive task analysis report of operational flight requirements in terms of new improved in-cockpit electronic technology (reference 11).

2. Digital systems technical analysis — a study concerned with the reliability and maintainability of general aviation and commercial digital avionics (reference 12).

3. Enhanced head-up display (HUD) system — a flight test plan for validating HUD symbology and control laws via flight test (reference 13).

4. Safety benefits of general aviation cockpit standardization — a study quantifying the costs of accidents attributable to fuel system mismanagement and misuse of powerplant controls and countermeasures to reduce these accident causal factors (reference 14).

5. Digital computer program "KRASH" — a developmental study for crash analysis of general aviation aircraft structures (reference 15).

Environment (Weather)

1. Lightning and electromagnetic interference — a series of reports highlighting in-flight direct lightning strikes, lightning effects, and electromagnetic measurement data of lightning strikes on aircraft (reference 16).

2. Icing — a series of reports addressing test, operation, and simulation technology of aircraft operations, both on ground and in-flight under the environmental conditions of icing (reference 17).

3. Thunderstorms — a series of papers on flight hazards in or near thunderstorm activity (reference 17).

Envrionment (Airport)

1. Visual guidance — a series of experimental studies examining the effectiveness of runway markings in snow, enhanced threshold lighting systems for approach lighting system-equipped runways and evaluations of newly developed visual approach slope indicator systems; development and testing of retroreflective markers in touchdown and taxi areas; development and evaluation of standard low cost lighting and marking systems for use at unpaved general aviation airports (references 18, 19, and 20).

These examples of completed general aviation studies are but a small sample of the ongoing efforts responsive to the needs for research proposed by the studies reported herein. They are indicative of the work that has been and will continue to be the major means of eliminating, or at least minimizing, the accident causal factors attributed to the Man, the Machine, or the Environment, and as a consequence, produce results leading to an improved general aviation safety record.

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# APPENDIX A

## SUMMARY OF RECOMMENDATIONS FROM THE SECOND GENERAL AVIATION SAFETY WORKSHOP

SUMMARY OF RECOMMENDATIONS FROM THE
SECOND GENERAL AVIATION SAFETY WORKSHOP

## I. AVIATION SAFETY ECONOMICS.

1. Additional research to be done which focuses directly on the dollar pay-off underlying any given action regarding safety.

2. Both the FAA and industry need to disseminate cost/benefit information in a manner that is intelligible to the persons who need it — the pilot, the instructor, etc.

3. Develop a systematic way to integrate social issues into the decision-making process of everyone — public and private sectors alike.

## II. FLIGHT INSTRUCTION.

4. Establish standards for the accreditation of simulators as well as training materials for training, proficiency, checking and certification/recertification of pilots and not to be limited to or defined in terms of aircraft hours.

5. Require that CFI's who renew their certifications be subject to review of their performance as an instructor (this to be accomplished at the GADO level).

6. Use of remedial training by FAA in cases of pilot certificate suspensions and penalties, and in cases of the "deferred suspension" sanction.

7. Require an overall higher proficiency for the private certificate; including greater proficiency, with emphasis in instrument flying. As feasible, expose each trainee to actual or simulated weather.

8. Align the BFR date or expiration with other FAA cycles, such as calendar months.

9. Report completion of BFR on medical application.

10. BFR is too vague and discretionary; therefore, require a review of subject areas of appropriate aeronautical knowledge for each level of certificate held.

11. Allow completion of FAA's Pilot Proficiency Award Program to serve as meeting requirements for the BFR.

12. Work out a methodology to have the insurance companies recognize completion of the FAA's Pilot Proficiency Award Program by offering some form of financial incentive.

## III. PILOT WRITTEN EXAMINATIONS.

13. Additional material to be added in the area of navigation and meteorology to the commercial pilot written examination.

14. Private or CFI written examinations should include specific questions to determine the student's understanding of the causes of accidents. There should be more emphasis on developing test questions which will incorporate known accident causes.

15. FAA should develop a written exam for operators of ultra-light aircraft to be administered by industry associations or by the FAA.

16. Regards the theoretical versus the practical questions on tests: develop and use practical test questions in lieu of purely academic or theoretical questions is highly desirable.

17. Questions on written tests should contain more judgmental factors.

18. Sectionalization of the written exam is desirable.

19. A panel of experts should be assembled to provide technical information to the FAA Test Writing Branch (the Examinations Standards Branch in Oklahoma City).

20. Appropriate individuals from organizations such as colleges and universities should be approved as "designated written test examiners" so testing can be done on evenings or weekends.

21. Written examinations should be established as part of the Biennial Flight Review process.

22. The Examination Standards Branch of FAA should determine a better way to include "essential material" as reference material for the written exams in fewer volumes.

## IV. WEATHER-RELATED ACCIDENTS.

23. Some organizations should take on the task of coming up with a structured program for aviation weather education to be used by anyone who deemed it appropriate to pursue.

24. Under the auspices of the Federal Meteorological Coordinator, a program for the systematic collection and dissemination of PIREPS to pilots be developed.

25. FAA should reevaluate the current criteria for the implementation of automated weather observation equipment to be purchased under the ADAP program; this to provide for the use of this equipment at more general aviation airports.

26. Initiate programs for the continued development of equipment aboard aircraft to provide real-time weather data, (includes in-flight T.V. relay, onboard weather radar, and data up-link systems).

27. Expand the present Voice Response System (VRS) nationwide as soon as practicable.

28. High altitudes EFAS discrete frequencies be implemented nationwide.

29. The National Weather Service should investigate the feasibility of putting certain aviation information on the NOAA weather radio network system.

30. FAA should investigate establishing a system of high powered, non-directional beacons to provide constant coverage of transcribed weather broadcasters.

31. Help foster the expansion of the AM Weather program on the public broadcasting service, plus a method to help traveling pilots know what station and when this program is aired in specific locations.

32. The FAA Research and Development Group should explore the feasibility of providing EFAS positions with traffic presentations to help them in locating aircraft and in providing and requesting pilot reports.

33. An ad hoc committee composed of representatives from industry/government and the user groups to transmit the recommendations from this workshop to appropriate officials and to follow-up on a frequent and timely basis.

## V. AVIATION SAFETY DATA.

34. Need to focus on more of the human elements and factors surrounding an accident. (Expand the scope of aircraft accident investigations to include incidents as well as accidents.)

35. Need a better way to notify parties of an accident.

36. Need for a centralized storage and dissemination of accident data, including a better quality of rate and other data alternatives to accidents per passenger mile. Improved data classification and standardization of terms and definitions (Note: Most of this is "well in hand" and is in process of being completed).

37. Publicize the capability of NASA's Safety Reporting System in the sense that trend analysis could be made of this data, and although NASA is doing a lot of this, it is not being utilized by other parties as much as it could.

38. All aircraft accidents should be investigated on site by trained accident investigators.

39. All civil aircraft accident investigators should be certified under a formal system approved by the National Transportation Safety Board.

40. None of the data now being collected during the course of an accident investigation should be deemed unnecessary, but the quality of investigation needs improvement, especially as regards the depth of the investigation, the perception of identifying causative factors, human performance, crashworthiness, and survivability of the accident itself.

41. Inexpensive lightweight FDR or CVR for complex general aviation aircraft is needed to provide recording of valuable data relating to aircraft accidents.

42. There is a need for those who have data to identify and better publicize the availability of their existing (and nonexisting) accident data base sources, such as insurance companies, workman's compensation boards, etc.

43. There is a need to establish a central repository of general aviation safety and safety research data and findings, and to assure that these resources are publicized, are current, and are easily accessible.

44. Publicize both the existence of, and potential uses of, NASA's Safety Reporting System. Not enough people know about or are making use of the information in this data base.

45. Emphasizing the need for, and potential benefits of, FAA's General Aviation Safety Analysis Workshops. These should be made available to the aviation staff community at least on a semiannual basis.

46. Explore the need for, and means of, data communication of third party trends and experience data to regulatory and research activities, manufacturers, as well as trade associations and professional groups.

47. Determine the feasibility of collecting pilot behavioral data for use in general aviation accident prevention by following two progressive steps — determine the merits of collecting pilot behavioral data by researching the previous use of this data in the commercial and military aviation sectors — determine what pilot behavioral data can be used, as well as to show how it can be used to improve general aviation safety.

## VI. GENERAL AVIATION AIRCRAFT.

48. Encourage NASA and FAA R&D activities in this area to continue.

49. Investigate and systematically develop an "accident concept" which could provide detailed insight into accidents which may be assigned to handling quality problems.

50. DOD and industry should coordinate their accident safety data reporting efforts to enhance research information needed, to explain the why of the accident occurring — not just when it occurred.

51. NASA, FAA, and industry should jointly coordinate new technology applications and operations and to communicate design, development, operational and maintenance programs with each other.

52. FAR's should be written (and old ones rewritten) with new technology implications in mind, including a review of those current FAR's which appear to impact innovative design.

53. Fuel-efficient general aviation aircraft designs are restricted because the engine stall speed of 61 knots (as a limitation). To improve efficiency and performance, NASA should be encouraged to continue their R&D activities in this area. If results warrant, FAA should amend Part 23 to relax this restriction.

54. A specific stall-spin workshop be held by the FAA general aviation lead region (which would be cosponsored by industry to explore and study critical spin-safety issues such as assessment of the spin recovery requirement, the stall speed requirement of 61 knots, and other related aircraft stall/spin issues.

55. NASA should be encouraged to continue their stall/spin research and to provide industry with the data as rapidly as they can.