NASA Technical Memorandum 80206

Analysis of General Aviation Single-Pilot IFR Incident Data Obtained From the NASA Aviation Safety Reporting System

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and Space Administration

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SUMMARY

Aircraft accidents, especially in general aviation single-pilot IFR operations, have increased rapidly in the past 10 years. These accidents usually result from one or more incidents involving unsafe flight operation. Although all such incidents do not culminate in accidents, the potential exists. Therefore, an analysis of incident data obtained from the NASA Aviation Safety Reporting System has been made to determine the problem areas in general aviation single-pilot IFR operations. The Aviation Safety Reporting System data base is a compilation of voluntary reports of incidents from any person who has observed or been involved in an occurrence which was believed to have posed a threat to flight safety.

This paper examines only those reported incidents specifically related to general aviation single-pilot IFR operations. The frequency of occurrence of factors related to the incidents was the criterion used to define the significant problem areas and, hence, to suggest where research is needed.

The data were cataloged into one of five major problem areas: (1) Controller judgment and response problems, (2) Pilot judgment and response problems, (3) Air traffic control (ATC) intrafacility and interfacility conflicts, (4) ATC and pilot communication problems, and (5) IFR-VFR conflicts. The relative significance of each of these problem areas was determined by the number of citations corresponding to each area. In addition, several points common to all or most of the problems were observed and reported. These included human error, communications, procedures and rules, and work load.

INTRODUCTION

General aviation accounts for approximately 15 million of the 25 million IFR operations occurring annually in the United States, and Federal Aviation Administration (FAA) forecasts show that by 1988 these operations will almost double to approximately 29 million. Reference 1 reports that more than 100 serious accidents per year (attributable to pilot error) have occurred in the past few years in general aviation single-pilot IFR (SPIFR) operations. This accident rate is expected to increase as the number of general aviation IFR operations increases.

A significant effort is under way within NASA to investigate general aviation SPIFR problems. One source of information used as an aid in identifying these problems is the NASA Aviation Safety Reporting System (ASRS) data base. The ASRS data base is a compilation of voluntary incident reports from any person who has observed or been involved in an occurrence which was believed to have posed a threat to flight safety (see refs. 2 to 9). This paper examines ASRS data for incidents related to general aviation SPIFR operations. In particular, all reports of general aviation fixed-wing aircraft flying under IFR in instrument meteorological conditions (IMC) are analyzed. The ASRS data base

does not specifically refer to SPIFR operations, but these types of operation typically involve SPIFR. The period covered by these incident reports extends from May 1, 1978, to January 1, 1979.

The frequency of occurrence of factors related to incidents of unsafe flight operations are determined through the analysis of the ASRS data. The implications of these factors are discussed, and specific problem areas are suggested for further investigation and research.

ABBREVIATIONS

ARTC	air route and traffic control
ARTCC	air route and traffic control center
ASRS	Aviation Safety Reporting System
ATC	air traffic control
ATCT	air traffic control tower
DABS	Discrete Address Beacon System
FAA	Federal Aviation Administration
FSS	flight service station
IFR	Instrument Flight Rules
IMC	instrument meteorological conditions
MVFR	Marginal Visual Flight Rules
SPIFR	single-pilot Instrument Flight Rules
SVFR	special Visual Flight Rules
TCA	terminal control area
VFR	Visual Flight Rules

DISCUSSION OF ASRS DATA BASE

The ASRS, which is operated by NASA in support of the FAA Safety Reporting Program, was designed for the collection, compilation, and storage of incident reports describing occurrences that pose a threat to flight safety. Participation is voluntary, and data represent the reporter's perception of the occurrence.

Facets of the system which may bias the data are (1) the reports are outcome oriented; (2) the reports may not reflect all the facts or details of the incident; (3) the reports may reflect the opinion of the reporter; (4) the reports are, on the whole, unverifiable; (5) the reporter is immune, in most cases, from disciplinary action related to the reported incident; and (6) not all incidents are reported. Even considering these limitations, simple statistical information on reported occurrences can be very useful. Obviously, the higher the frequency of the reported occurrence, the more likely it is to be a problem in the national aviation system.

A series of quarterly reports have been published from information provided by the ASRS data base. These reports (refs. 2 to 9) present general statistics on incident reports for all aviation operations encompassed by the ASRS data collected during the period extending from April 15, 1976, to March 31, 1978. In addition to this broad analysis, several specific problem areas are identified and analyzed. Many of these problem areas have a direct impact on general aviation SPIFR operations. The problem areas discussed in the quarterly reports encompass the data up to that particular point in time at which the report was published.

Reported Results

A major theme that is expressed, or is evident, in all the ASRS data is the frequent involvement of human error in the incidents reported. References 2 and 3, in particular, emphasize this point. Reference 3, for example, reports that as many as one-half of all the ASRS reports involve human error. The data further imply that human error may be an underlying factor in most, if not all, of the reported incidents. Incidents diagnosed as human error, however, can be misleading. Frequently, aircraft control, ATC facility or other involved systems, were simply not originally optimized from a human factors standpoint. Therefore, whenever human error is identified as a factor, possible system design changes that might have prevented the incident from happening in the first place should always be considered.

A particular flight phase that was found to be significant (refs. 1, 3, and 4) was the terminal area operations phase. References 3 and 4, for example, show that 50 percent of all the reports refer to incidents occurring in the terminal airspace. One-third of all the incidents reported, or two-thirds of those taking place in the terminal airspace, occurred during the approach and landing phase. Also, night operations conducted under restricted visibility during approach and landing posed special problems.

References 4 to 7 also refer to communications as a problem area. This area is particularly amenable to the human factors approach mentioned previously. Misunderstood communications, especially when related to either message confirmation or clearance interpretation, were found to be a major problem. A recurring report theme was the use of procedural shortcuts or nonstandard phraseology; these shortcuts were frequently associated with high density (high work load) operations. Communication problems may often lead to other problems, such as altitude errors and flight plan deviations (see ref. 7).

Various other problem areas, many of equal importance to the communications area, were also discussed in the quarterly reports: ATC facility coordination problems (refs. 3, 5, 6, and 9); pilot and/or controller perception problems (refs. 3, 5, and 9); procedural problems (refs. 3, 5, and 9); marginal VFR weather (i.e., VFR-IFR mix, ref. 8); and equipment malfunctions (refs. 4, 5, and 9).

FORMULATION OF INCIDENT DATA

The ASRS incident data analyzed in this report are limited to the general aviation operations typically involved in SPIFR. Since no specific category in the ASRS data base relates to general avaition SPIFR, the following criteria were chosen in interrogating the data base. All fixed-wing operations under air taxi, charter operations, utility operations, corporate aviation, personal business, pleasure flights, and training flights were selected for the analysis. All rotary wing operations were deleted. Also, only those flights on either an IFR or SVFR flight plan were used. These criteria produced 79 reports out of the total 2174 reports collected during the period from May 1, 1978 (the beginning of ASRS report reformatting) to January 1, 1979. Based on their sources, these 79 reports included pilot reports of flight crew errors (14 reports), ATC reports of flight crew errors (15 reports), pilot reports of ATC errors (16 reports), and ATC reports of ATC errors (34 reports).

The incident data reports obtained from the NASA ASRS project office consisted of a synopsis and several categories of factors related to the incidents. These categories included enabling factors, associated factors, descriptors, recovery factors, and supplemental key words. Only two of these, enabling factors and associated factors, were considered relevant to this study and were used in the analysis.

An enabling factor is an element that is present in the history of an occurrence and without which the occurrence probably would not have happened. An associated factor is an element that is present in the history of an occurrence and is pertinent to the occurrence under study, but which does not fulfill the requirements of an enabling factor. Examples of both enabling and associated factors are controller perception, intrafacility coordination, pilot discretion, and pilot vigilance. These factors, which are assigned as enabling or associated by subjective assessment of experts in the particular field related to the incident, are discussed in detail in the following section of the report. Reference 4 presents additional details on ASRS data formatting.

ANALYSIS OF THE DATA

The ASRS synopsis and various categories (see the section "Formulation of Incident Data") assigned to each reported incident were examined by the author to determine the types of problems suggested by the data. This review of the incident reports revealed five major problem areas that were considered to be general aviation SPIFR specific. These problem areas are (1) Controller judgment and response problems, (2) Pilot judgment and response problems, (3) ATC

intrafacility and interfacility conflicts, (4) ATC and pilot communication problems, and (5) IFR-VFR conflicts.

The factors from two categories, enabling factors and associated factors, were also reviewed. There were 40 different enabling factors and 58 associated factors listed in the 79 incident reports; these factors are described in table I. In the 79 reports, the 40 enabling factors were cited a total of 99 times; the 58 associated factors were cited 82 times. (A factor citing is a listing of that factor in the incident report.) These data imply that more than one factor was cited in some of the incident reports.

After preliminary review, each factor citing was determined to be related to each problem area either directly, indirectly, or not at all. A direct relationship between a factor and a problem area implies an obvious connection with that problem area. An indirect relationship implies a probable but not necessarily definite connection with the problem area. There were also some factor citings that could not be related to the problem area. These determinations were made by the author based on his analysis of the data. Consider, for example, the problem area "Controller judgment and response problems." The enabling factor "ATCT controller perception" is related directly to this problem area, whereas the factor "Federal Aviation Regulation" is indirectly related, and the factor "Aircraft parking procedure" is not related at all. This type of classification was determined for both the enabling factors (table II) and the associated factors (table III).

Enabling Factors

Table II shows the number of enabling factor citings that are related both directly and indirectly to each problem area. This relationship (also found in table III for associated factors) is used as the basis for the analysis and discussion in this report.

Table II shows that "Controller judgment and response problems" and "Pilot judgment and response problems" generated large numbers of directly related enabling factor citings. This reinforces the results noted in the review of the quarterly reports; that is, human error (pilot and controller) is involved in a majority of ASRS incidents.

An analysis of the incident data shows that "Controller judgment and response problems" can be primarily attributed to three elements: (1) excessive/impeding procedural requirements, (2) training/proficiency/experience related mistakes, and (3) equipment operational problems. Table IV lists the problem areas and the primary problem elements within each area. Similarly, "Pilot judgment and response problems" can be attributed primarily to three elements: (1) excessive/impeding procedural requirements, (2) training/proficiency flight infractions, and (3) limitations due to limited avionics. These problem elements can be used to determine the areas that need further research.

Table II also indicates that "ATC intrafacility and interfacility conflicts" and "ATC and pilot communication problems" were both represented by large numbers of indirectly related enabling factor citings. This once again

reinforces the results noted in the quarterly reports. The relatively fewer directly related citings were attributed to the nature of the particular problem. The ASRS data do not always indicate whether or not these particular factors could be classified as relating directly to the incidents. The data are outcome oriented, and the insidious nature of some of the factors is not always apparent. Communication problems, for example, may not always be apparent as the cause of an incident. Close scrutiny, however, will frequently show that communication problems frequently started a chain of events that resulted in the reported incident.

Four "ATC intrafacility and interfacility conflicts" problem elements were determined: (1) internal communication problems, (2) hand-off problems, (3) mixed departure and arrival conflicts, and (4) equipment operational problems. Problem elements determined for the "ATC and pilot communication problems" were (1) misunderstood instructions, (2) frequency congestion, (3) excessive frequency changes, and (4) excessive/impeding procedural requirements.

The last major problem area, "IFR-VFR conflicts," shows characteristics similar to those of the previous two problem areas. A large number of factor citings were related to this problem in an indirect relationship. The number of such citings is disturbing, especially when considering the potentially catastrophic results (midair collisions). The two primary problem elements for this problem area were (1) aircraft proximity at breakout, and (2) IFR flight in VFR and MVFR conditions.

Associated Factors

The associated factors were considered as an independent group of citings. Table III presents the number of associated factor citings that are related both directly and indirectly to each problem area. The associated factors data were used in two aspects of the analysis: (1) to determine whether additional emphasis should be placed on the previously discussed problems with respect to the enabling factors (i.e., whether more emphasis should be placed on certain problem areas), and (2) to better interpret underlying implications of some of the problem areas.

"Controller judgment and response problems" showed a large number of both directly and indirectly related associated factor citings. The implication here is that this particular problem is not only easy to determine for some incidents (see enabling factors, table II) but, because of the large number of indirectly related citings, could also be involved in many other incidents. "Controller judgment and response problems" appear to be a contributing factor more frequently than originally expected. These data suggest that a more in-depth analysis of this problem area is needed.

The results for "Pilot judgment and response problems" were as expected: in contrast to the large number of directly related enabling factor citings (table II), a small number of directly related and a large number of indirectly related associated factor citings were found (table III). These data imply that pilot judgment and response problems are usually easy to pin down.

"ATC intrafacility and interfacility conflicts" and "ATC and pilot communication problems" showed large numbers of citings in the indirectly related category. These problems are also possibly involved in many of the incidents. The results are due primarily to the outcome-oriented nature of the data collection process. "ATC and pilot communication problems," for example, seldom appear to be the principal causes of an incident (see directly related factors, tables II and III); however, they are frequently possible contributing causes (see indirectly related factors, tables II and III). A fair number of directly related citings (enabling (8), and associated (16)) were also made for "ATC intrafacility and interfacility conflicts." Internal ATC intrafacility and interfacility problems appear to be fairly prevalent, and should be resolved prior to considering the pilot problems in the ATC system.

The problem area "IFR-VFR conflicts" produced a relatively significant number of associated factor citings, both directly and indirectly related. The implications discussed earlier (in the "Enabling Factors" section of the report), are also relevant here; that is, the number of citings is disturbing when considering the potentially catastrophic results of this problem area.

DISCUSSION OF RESULTS

Table IV, which gives the five major problem areas and the corresponding problem elements, can be used to determine the areas needing further research. The relative significance of the problem areas can be determined from tables II and III by the number of citings listed for each. Table IV not only defines specific problems that need to be addressed, but also shows the interrelationship of these problems. For example, human error is shown to be implicit in most of the problems. This trend emphasizes the need for human factors considerations in both analyzing and solving the problems.

Another element common to the data is the communication problem existing between ATC controllers as well as between ATC controllers and pilots. This human factors problem was present in all areas requiring exchange of information. Current electronic technology suggests various approaches to solving this problem. One promising concept, currently being developed by the FAA, for example, involves a system called the Discrete Address Beacon System (DABS) (see ref. 10). DABS was designed as a data uplink/downlink capability independent of normal voice communication channels. This concept requires further testing, but it is a good example of the innovative technology that could be used in solving this problem.

Procedures, both ATC and pilot, appear to be in need of some revision. The present aviation system frequently uses procedures which were developed many years ago and often do not meet present-day demands and/or capabilities. An example is the common set of rules and procedures prescribed for pilots who have a wide range of proficiency and experience and who are operating in an equivalently wide range of aircraft classes and capabilities within the ATC system.

Another fairly common denominator in the data is excessive pilot and controller work load. This human factors problem is inherent in many of the

present-day pilot and controller tasks, and even though not always specifically mentioned, it is frequently implied in many of the reported incidents. Methods, techniques, and systems for reducing work load are drastically needed.

CONCLUDING REMARKS

The data in this report were obtained from the ASRS incident data base and were used to define problems and, hence, significant areas for research in the general aviation SPIFR environment. Five general problem areas were identified from the data: (1) Controller judgment and response problems, (2) Pilot judgment and response problems, (3) ATC intrafacility and interfacility conflicts, (4) ATC and pilot communication problems, and (5) IFR-VFR conflicts. Several elements were determined for each of these problem areas, and the compilation of these areas and elements can be used to define specific research programs. The relative severity and, hence the significance of each problem area, is defined and can be used as a reference for determining appropriate SPIFR research efforts.

A review of the problem areas also pinpointed several points common to all or most of the problems. These included human error, communications, procedures and rules, and work load.

It is also significant that the problems determined for SPIFR operations followed the same general trend noted in the NASA ASRS quarterly reports which include data from all categories of aviation operations.

Analysis of the ASRS data at continuing intervals would be beneficial in determining the future direction of problems in the national aviation system.

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August 26, 1980

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TABLE I.- FACTORS IN THE 79 INCIDENT REPORTS ANALYZED

(a) Enabling factors

Aircraft equipment problem/navigation

Aircraft parking procedure

Approach controller technique/radio communication

Approach controller vigilance

Arrival approach controller discretion

Arrival approach controller response

Arrival approach controller technique/communication

Arrival approach controller work load

Arrival-departure approach controller intrafacility coordination

ARTCC/ATCT interfacility coordination

ARTCC controller interfacility coordination

ARTCC controller judgment of traffic spacing

ARTCC controller perception

ARTCC controller response

ARTCC controller technique/minimum altitude assignment policy

ARTCC controller vigilance

ATCT/arrival approach controller

ATCT controller discretion

ATCT controller intrafacility coordination

ATCT controller perception

ATCT ground controller perception

ATCT local controller perception

Conflict alert activated

Departure approach controller discretion

Departure approach controller perception

Departure controller judgment of traffic spacing

Federal Aviation Regulation

Flight crew discretion

Flight crew perception

Flight crew technique/flying

FSS perception

Ground ATCT controller distraction/task

Instructor pilot perception

Maintenance activity

Military ATCT controller perception/discretion/technique

Nonadherence to ATC procedure

Pilot discretion

Pilot perception/nonadherence to ATC procedure

Pilot technique

Radio communication problem

TABLE I.- Concluded

(b) Associated factors

Aircraft maintenance problem

Aircraft under separate ATC jurisdiction

Airline management policy

Airspace configuration/proximity of airspace boundary

Airspace configuration/proximity of airway/ Olive Branch Route/TCA

Airspace configuration/proximity of control zone

Airspace configuration/proximity of multiple airports and/or military airports

Airspace configuration/proximity of TCA boundary

Altitude heading rules

Approach/ARTC controller interfacility coordination

Arrival approach controller interfacility coordination

Arrival approach controller work load

ARTCC controller perception

ARTCC controller vigilance

ARTCC interfacility coordination

ARTCC intrafacility coordination

ATC procedure

ATCT controller judgment of traffic spacing

ATCT controller technique/ATC

ATCT ground controller perception

ATCT intrafacility coordination

ATCT local controller work load

Clearance interpretation

Clearance readback

Communication problem

Departure controller perception

Distraction/audio

Distraction/task

FAA handbook

Facility management policy

Facility manning

Facility operational procedure

Familiarity with aircraft

Federal Aviation Regulation

Flight crew perception

Flight progress strip

Frequency congestion

Frequency guarded

Intrafacility coordination

Personnel availability

Pilot discretion

Pilot experience level

Pilot perception

Pilot response

Pilot technique, radio communication procedure while in the air

Proximity of thunderstorm

Radar coverage limitation

Radar equipment problem

Radar signal clarity

Radio communication problem

See-and-avoid concept

Similar sounding aircraft number

Taxi procedure

TRACON interfacility coordination

TRACON intrafacility coordination

Traffic volume/congestion

Visibility reduced/rain

Visibility reduced/haze

TABLE II.- RELATIONSHIP BETWEEN PROBLEM AREAS AND ENABLING FACTOR GROUP

Problem area	Factors cited	
	Directly related	Indirectly related
Controller judgment and response problems	56	8
Pilot judgment and response problems	30	0
ATC intrafacility and interfacility conflicts	8	56
ATC and pilot communication problems	5	86
IFR-VFR conflicts	0	38

TABLE III.- RELATIONSHIP BETWEEN PROBLEM AREAS AND ASSOCIATED FACTOR GROUP

Problem area	Factors cited	
	Directly related	Indirectly related
Controller judgment and response problems	34	32
Pilot judgment and response problems	8	16
ATC intrafacility and interfacility conflicts	16	49
ATC and pilot communication problems	9	42
IFR-VFR conflicts	15	24

TABLE IV.- PROBLEM AREAS AND PRIMARY ELEMENTS

Controller judgment and response problems
- -Excessive/impeding procedural requirements
- -Training/proficiency/experience related mistakes
- -Equipment operational problems

Pilot judgment and response problems
- -Excessive/impeding procedural requirements
- -Training/proficiency flight infractions
- -Limitations due to limited avionics

ATC intrafacility and interfacility conflicts
- -Internal communication problems
- -Hand-off problems
- -Mixed departure and arrival conflicts
- -Equipment operational problems

ATC and pilot communication problems
- -Misunderstanding of instructions
- -Frequency congestion
- -Excessive frequency changes
- -Excessive/impeding procedural requirements

IFR-VFR conflicts
- -Aircraft proximity at breakout
- -IFR flight in VFR and MVFR conditions

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15. Supplementary Notes

16. Abstract

An analysis of data obtained from the NASA Aviation Safety Reporting System (ASRS) data base has been made to determine problems in general aviation single-pilot IFR operations. The data examined consisted of incident reports involving flight safety in the National Aviation System. Only those incidents involving general aviation fixed-wing aircraft flying under IFR in instrument meteorological conditions were included in the analysis. The data were cataloged into one of five major problem areas. The significance of the related problems, and the various underlying elements associated with each are discussed. A review of previous ASRS reports covering several areas of analysis is also included.

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