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A STUDY OF ASRS REPORTS INVOLVING GENERAL AVIATION AND WEATHER ENCOUNTERS

By Thomas H. Rockwell,
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and
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56

TABLE OF CONTENTS

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TABLE OF CONTENTS
(Continued)

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by

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SUMMARY

This report describes a study of material in the ASRS data base dealing with weather-related incidents in General Aviation. Factors leading to such incidents are discussed and analyzed. Consideration is given to the nature and characteristics of problems involving dissemination of weather information, use of this information by pilots, its adequacy for the purpose intended, the ability of the air traffic control system to cope with weather-related incidents, and the various aspects of pilot behavior, aircraft equipment and NAVAIDS affecting flights in which weather figures. It is concluded from the study that skill and training deficiencies of GA pilots are not major factors in weather-related occurrences, nor is lack of aircraft equipment. Major problem causes are identified with timely and easily interpreted weather information, judgement and attitude factors of pilots, and the functioning of the ATC system.

INTRODUCTION

Analysis of general aviation aircraft accidents indicates that pilots often fail to deal effectively with weather-induced problems. The National

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Transportation Safety Board's tabulation of 1978 general aviation accidents,* published in its annual review of accident statistics, indicated that weather-related accidents led all other types of causes. There were 150 fatal accidents resulting from pilots encountering bad weather; whether this is the result of inaccurate forecasts, deteriorating weather, or poor pilot judgement, constitutes an important safety problem for general aviation.

The question is often posed about the ability of general aviation pilots to cope with weather problems. What is not known is the extent to which such problems are due to inadequate weather information systems, inadequate aircraft capability, lack of sufficient training for general aviation pilots, or lack of responsiveness of the air traffic control system.

STUDY OBJECTIVES

The ASRS data base on General Aviation weather-related incidents was examined to shed light on how human or systems problems link with weather to create unsafe conditions. The overall objective of this study was to determine if patterns emerge which would explain more fully current accident reports and to suggest appropriate counter-measures. The ASRS data were examined to ascertain:

1. The nature of the weather problem in the related incident. Factors considered included the weather condition at the time of the incident, the pilot's use of information systems available to him, the adequacy of the weather information for planning purposes, and the ability of the air traffic control system to provide weather information.
2. The characteristics of the weather-related incident. Did an unsafe condition result, and how serious was it? What types of aircraft are most often involved?
3. The types of pilot and system problems contributing to the incident.

*As reported in AOPA Pilot, December 1980, p. 88.

4. The nature of pilot and system attributes which contributed to the problems, e.g., pilot experience.

APPROACH

The basis for this study was all reports of incidents from the ASRS system covering the period from May 1978 to September 1980. The search procedure involved selection of all incidents which met the following criteria:

a. The incident was weather related, i.e., weather was considered a contributing factor in the cause or consequence of the incident; weather, for purposes of this report, could be instrument meteorological conditions (IMC), i.e., visibility below three miles and/or ceilings below 1000 ft. (agl) in controlled airspace; marginal VMC, i.e., visibility 3-5 miles and/or ceilings 1000-3000 ft., visual meteorological conditions (VMC), i.e., visibility greater than 3 miles and ceilings above 3000 ft. (agl) in controlled airspace and visibility one mile and clear of clouds in uncontrolled airspace. Mixed IMC and VMC (MXD) could also be a factor as will be shown later.

b. The incident involved at least one aircraft which was not an air carrier or military aircraft. This embraces all general aviation aircraft from small aircraft (SMA-less than 5000 lbs.) to small and medium transports. In the case of a potential conflict between two aircraft, military and air carrier could be involved if one of the aircraft involved "General Aviation" operations. This term embraces all flight operations except air carriers and military, and includes pleasure, business, corporate, and air taxi.

One hundred seventy-seven reports met the above criteria.

It was evident at the outset of this study that these reports were not homogeneous with respect to their characteristics, e.g., weather, type of aircraft, location, etc. Thus, it was decided to classify these reports into six categories as follows:

a. Single aircraft under IFR flight (27 reports).

b. Single VFR aircraft in adverse weather (52 reports).

c. Less than standard separation (LTSS) or potential conflicts (or in the extreme case, near midair collision events) between two aircraft operating on IFR flight plans (IFR/IFR); (34 reports).

d. LTSS or potential conflicts between two aircraft, one of which was presumed to be VFR and one of which was usually on an IFR flight plan (mixed flight rule operations). (43 reports).

e. Weather services which, while not involving a specific in-flight event, were included because of complaints about the weather information system or the inadequacies of the FSS system and ATC system (14 reports).

f. Balloons (5 reports).

Because of multiple reports for the same incidents, there were 27 incidents for the single IFR aircraft, 52 for the single VFR aircraft, 23 for the IFR/IFR and 42 for the mixed flight rule two aircraft incident. Thus, the 177 reports actually described 163 separate incidents for all six categories.

Setting aside the balloon and weather service reports, the basis for the four major classifications can be seen in Figures 1 to 7. Figure 1 shows that the four categories are quite different in terms of the involvement of small general aviation aircraft (less than 5000 lbs.) which was one of the main interests in this analysis. In the IFR/IFR cases, small general aviation aircraft were virtually non-existent. Yet, for the single VFR aircraft incidents, 90 percent were small general aviation aircraft. Figure 2 indicates that over half of the single IFR incidents occurred under 1000 ft. agl while virtually none (4 percent) of the IFR/IFR incidents occurred at or below this altitude. Where human error was assigned by the ASRS analyst, Figure 3 shows that flight crews were indicated in 80 percent of the mixed flight rule incidents as compared to 50 percent of the single VFR and 35 percent for both the single IFR and IFR/IFR incidents. Figure 4 indicates that IMC conditions existed in 75 percent of the single IFR incidents, but in only 45 percent of the single VFR incidents. Here marginal VMC and MXD weather was reported in 41 percent of the incidents. Even the time of year varies across these categories as shown in Figure 5. Note that 26 percent of the single IFR incidents involved summer months, while 50 percent of the two-aircraft incidents occurred in the summer months. This fact supports the

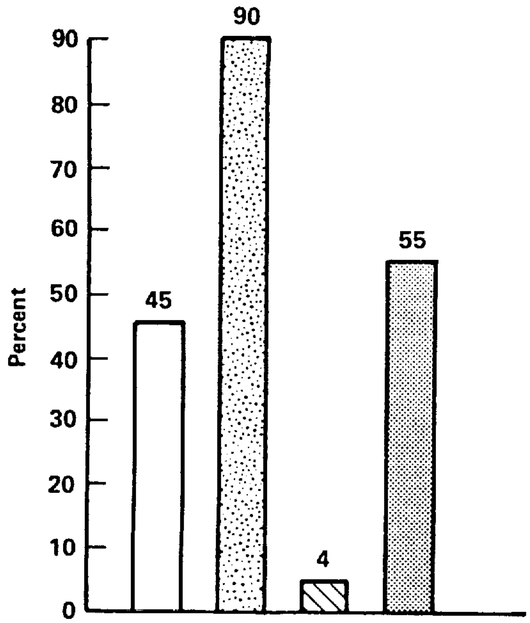


FIGURE 1. PERCENT SMALL AIRCRAFT (SMA)

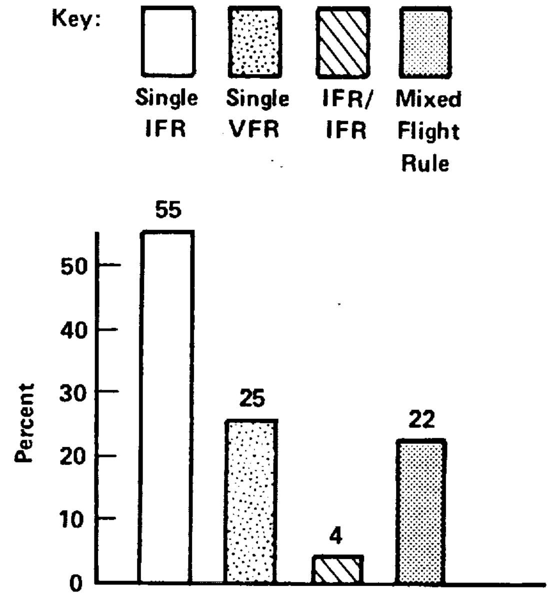


FIGURE 2. PERCENT OCCURRING BELOW 1000 FT A.G.L.

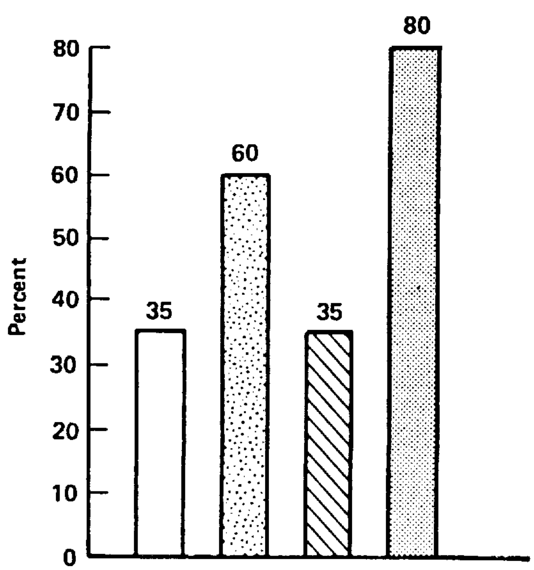


FIGURE 3. PERCENT WHERE FLIGHT CREW WAS ASSIGNED AN ERROR

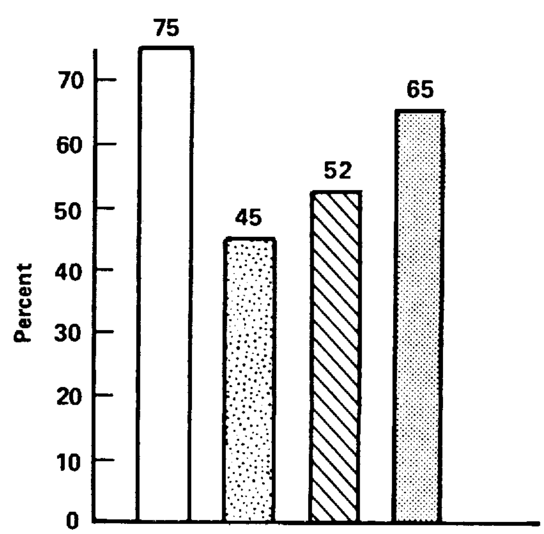


FIGURE 4. FLIGHT WEATHER CONDITIONS PERCENT IMC

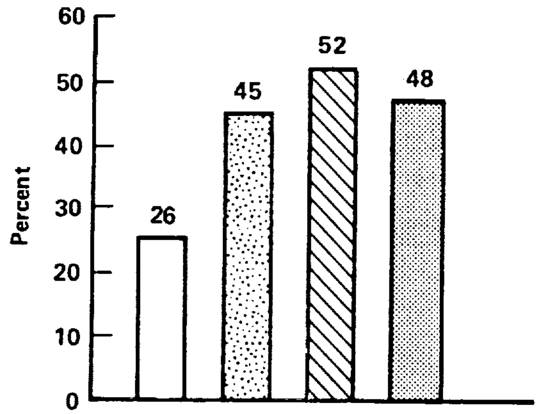


FIGURE 5. PERCENT INCIDENTS OCCURRING DURING JULY, AUGUST, AND SEPTEMBER

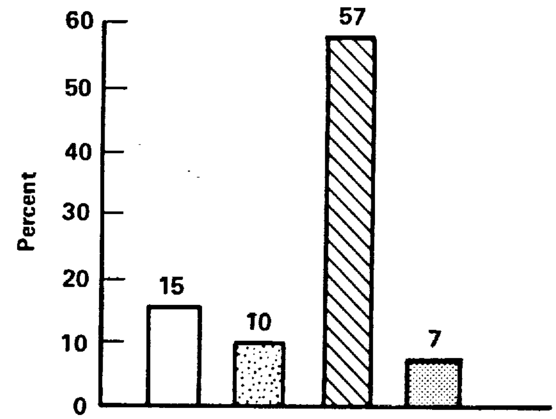
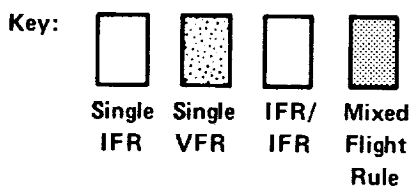


FIGURE 6. PERCENT THUNDERSTORMS AS FLIGHT ENCOUNTERS



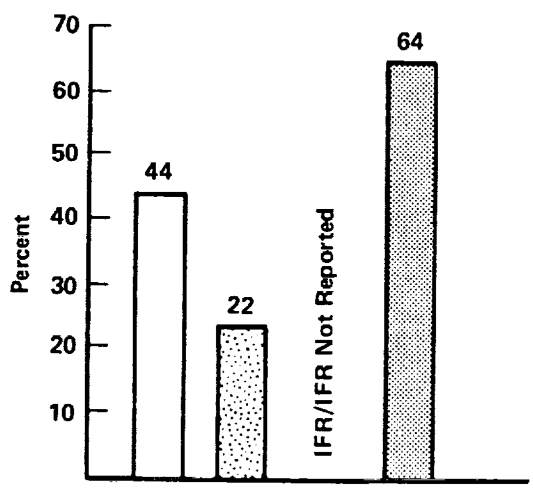


FIGURE 7. PERCENT OF CASES WITH TOTAL FLIGHT TIME ABOVE 1500 HOURS (OF THOSE REPORTED)

differences found in the in-flight weather encounters. More than half of the IFR/IFR incidents reported thunderstorms, while less than 15 percent of the other three categories involved thunderstorms. (Figure 6).

Where the pilot flight time was noted, approximately 75 percent of the single IFR and mixed flight plan pilots had more than 1500 total hours, while this figure drops to 22 percent for the pilots in the single VFR aircraft incidents. (See Figure 7).

With the above pattern differences, it was clear that adding statistics from these categories would have produced erroneous conclusions. Hence, the subsequent analysis treats each of the basic categories independently. Later, in the conclusion section, attempts will be made to draw inferences among these categories.

CHARACTERIZATION OF THE SINGLE IFR AIRCRAFT WEATHER-RELATED INCIDENTS

Twenty-seven of the 163 total weather-related incidents examined involved a single IFR aircraft. Of these incidents, 45 percent were small general aviation aircraft (less than 5000 lbs.). About half of the incidents occurred in the period of Noon to 6:00 P.M.; 75 percent were reported in daytime conditions; 55 percent occurred under 1000 feet (AGL) and were involved with approach, landing, or take-off phases of flight. Unlike other categories of incident reports of GA aircraft in weather, which were over-represented in the summer months, the winter months were over-represented in single IFR incidents. Over 50 percent of all single aircraft IFR incidents were reported in December through March. For these incidents, the weather was usually IMC (75 percent of the cases).

It should be noted that except for four or five cases, the weather should not have been a significant factor in the incidents. IFR flight systems are designed to permit safe and efficient air transport in poor weather, e.g., 200-feet ceilings and 1/2-mile visibility for most ILS approaches. Thus, it might be argued that, in single aircraft IFR operations, weather should not pose a serious problem. The few cases of enroute icing and turbulence are the exceptions in this class of incidents.

Since 55 percent of the incidents involved small transport (SMT) or larger aircraft, it is not surprising that pilot qualifications (in the cases where this was reported) showed that 75 percent of the pilots had more than 1500 hours. The nature of the single IFR aircraft problem is best shown in Table 1. Note that the 27 incidents were widely scattered over 8 problems. Landing below published minimums, severe weather encountered, and failure to accept or receive clearances represent the most reported incidents.

TABLE 1. SINGLE AIRCRAFT IFR INCIDENTS

Landing below published minimums	4
Failure to secure or accept clearance	5
Airport diversions	2
Vectors into severe weather (or failure to receive vectors away from	4
Landing runway incidents	3
Failure to maintain altitude	3
In-flight icing	2
Miscellaneous	4
Total	27

In assessing human errors associated with these incidents (Table 2), it should be noted that in many cases the error is not always certain -- the classic case is landing when the weather is near published minimums. Although the weather may be just below minimums, it can change quickly. In one incident, the pilot argued that the weather was well above minimums rather than below. The errors behind five incidents were caused by pilots breaking instrument flight rules regarding clearances and landing minimums. Most of these incidents involved small transports with very experienced pilots. In one of these incidents a crew acknowledged landing when the weather was below published minimums.

TABLE 2. ERRORS ASSOCIATED WITH SINGLE AIRCRAFT IFR WEATHER-RELATED INCIDENTS

Communication Problems	11
PLT - ATC	6
TWR - CTLR	1
PLT - FSS	1
PLT - Airport	1
ATC - Airport	1
CNTL - FSS	1
Violation of Instrument Flight Rules	5
Inadequate Weather Pre-Flight	5
No Error	2
Miscellaneous	4
Total	27

Communications problems, of the eleven most involved a communication breakdown between pilot and controller (six instances). These included altitude assignment misunderstandings, problems in securing clearances, and weather deviation. Surprisingly, there were many cases of communication problems between combinations of pilots, flight service stations, tower controllers, approach controllers, and enroute controllers, as typified by the following narrative:

> "Myself, a journeyman CTLR, and the FAC chief (working for a CTLR on sick leave) were on duty, day shift, a VFR TWR. WX autowriter was out and FSS agreed to supply RAPCON with current WX. ILS rwy 3 in use. Apch called with SMT A 20 south, ILS 3. I asked if he had the latest WX with 1/4 mile vis. He said no. I gave him the WX, adding that the RVV on 34 was 5/8 and recommended that rwy. RAPCON CTLR responded OK, I'll tell him. Snow removal was in progress on all rwy, I told gnd cntl to clear the plows off 34 and turned the apch lights on. SMT A reported the outer marker, was clrd to land. After ldg, and taxiing is not visible from the TWR, it was resolved SMT A had made the ILS 3 apch and landed on 3 with a large snow sweeper in the center of the rwy. A turned off short of that point and never saw the vehicle. I thought the conditions automatically dictated 34. The apch CTLR merely gave the info to the pilot who continued for 3. There was no further discussion."

Five incidents involved lack of proper information on runway conditions. These resulted in diversions due to closed runways, flareouts in deep slush, landing excursions, and a near-accident with a snow sweeper. There were five cases of poor pre-flight preparation by pilots - two involving decision to fly into known icing conditions.

Table 3 depicts some of the factors behind the observed errors. Weather interpretation, lack of knowledge of the IFR system, lack of airport information, and unprofessional attitude, as inferred by the ASRS analyst, dominate these data.

TABLE 3. CONTRIBUTING FACTORS IN HUMAN ERRORS IN SINGLE AIRCRAFT IFR WEATHER-RELATED INCIDENTS

Weather Interpretation	5
Knowledge of the IFR System and ATC Priorities	3
Inadequate Airport Information	5
Weather Induced Workload	2
Unprofessional Attitude	4
Miscellaneous	5
None	3
Total	27

Generalizations

For the single IFR aircraft, the 27 weather-related incidents could almost be considered substandard performance in the IFR system. Severe weather abnormalities were infrequently involved. Most incidents involved normal IMC. The incidents were less involved with General Aviation small aircraft than with larger General Aviation transports, suggesting that pilot experience and aircraft equipment were probably not key factors in the incidents. If weather, experience, and aircraft capability were not key causes, what were the bases of the incidents? Four major causes appear to be prevalent in the data:

1. Violations of instrument flying rules.
2. Communication breakdowns between FSS specialists or air traffic controllers and pilots.
3. Poor pre-flight planning.
4. Weather interpretations, i.e., the recognition of when conditions have gone from VMC to IMC.

Violations of instrument flight rules include pilots bending the rules or breaking them altogether -- this ranges from landing when the weather was below published minimums to refusing to accept clearances. Reports of communication confusions were expected; such problems are always with us. What was not expected was the lack of transmission of airport and runway information for winter flying. Poor pre-flight planning includes not only failure to secure necessary weather information, but also taking chances with icing in aircraft not equipped to cope with it. Weather interpretation involved take-offs into IMC without IFR clearances.

SINGLE VFR AIRCRAFT IN ADVERSE WEATHER

A total of 52 incidents involving VFR pilots who encountered adverse weather conditions were identified in the ASRS data file. It should be pointed out that these incidents may not be representative of typical general aviation weather encounters. In most of these incidents the pilot was in contact with an ATC facility or flight service station. None resulted in accidents (to be expected; ASRS does not process accident reports) and only one involved an off-airport landing. Thus, the GA pilot who extricates himself from a potentially dangerous situation and does not report to anyone is not represented, nor is the pilot involved in an accident. It is worthwhile, however, to examine the reported incidents to ascertain if patterns exist which might lead to improvements in weather reporting, the ATC system, or pilot training.

The analysis which follows resembles a flight log including pre-flight weather briefings, the flight phase of the weather encounter, the pilot's action in response to the encounter, the nature of assistance requested, if any, the recovery factors, and other contributing factors.

Almost all (49 out of 52) of the incidents in this set involved small aircraft. The other three incidents involved small transports. The majority (43) were reported by pilots. The others were reported by controllers (7) and observers (2). The two observers reporting were flight instructors reporting on situations encountered by their students.

While, as Table 4 shows, incidents occurred in every month of the year, they were most frequent during the summer months. This is probably the result of a higher level of general aviation activity during the summer.

TABLE 4. REPORTED MONTH OF OCCURRENCE

Month	Incidents	Month	Incidents
January	6	July	10
February	5	August	10
March	3	September	4
April	5	October	1
May	1	November	2
June	4	December	1
Total - 52			

Little information concerning pilot ratings was available from the ASRS reports. In 41 of the incidents the pilot's rating was reported as unknown. It may be inferred that these were largely non-instrument rated pilots.

Pilots of all experience levels were involved in these weather incidents. Although the largest group consisted of relatively low time pilots (19 reported less than 500 hours), as Table 5 shows, there were 14 pilots with more than 1000 hours. This raises some questions as to the role of experience in avoiding VFR flight in adverse weather, and whether more experienced pilots are willing to take more chances. Perhaps kinds of experience, attitude, and judgement all interact to contribute to the pilot's involvement. It does not appear that experience alone, as indicated by reported flight hours, is the major contributing factor.

TABLE 5. REPORTED EXPERIENCE OF PILOTS INVOLVED IN VFR FLIGHT IN IMC WEATHER

[Note: One pilot reported 1 year of experience]

Flight Time	Incidents	Flight Time	Incidents
3000 Hours or More	8	200 - 299 Hours	7
1000 - 2999 Hours	6	100 - 199 Hours	6
500 - 999 Hours	6	99 Hours or Less	3
300 - 499 Hours	3	Unknown	13
Total - 52			

Tables 6 and 7 show the weather conditions at the time of the incident as related by the reporter. In most of the incidents the weather was reported as IMC or mixed. Only one incident was reported as VFR and that involved a situation of reduced visibility created by rain showers. Fog and/or rain was present in 16 of the reported incidents, and there was a broken or solid overcast in 26 of the situations. Visibility of less than 3 miles was reported in 15 incidents and in 2 incidents the visibility was less than one mile.

What led these pilots into weather encounters? The obvious initial question relates to their preflight planning. Did they check the current and forecast weather for their departure, destination, and enroute stations?

TABLE 6. REPORTED FLIGHT CONDITIONS AT THE TIME OF THE WEATHER INCIDENT

IMC	32
Mixed IMC and VFR	12
Marginal VFR	5
VFR	1
Unreported	2
Total	52

TABLE 7. REPORTED WEATHER CONDITIONS AT TIME OF INCIDENT

Obscuration		Sky Cover		Visibility	
Fog	8	Overcast	20	7 Miles	1
Rain	8	Broken	6	3 Miles	1
Haze/Smog	4	Obscured	3	2 1/2 Miles	2
Snow	3	Other	2	2 Miles	2
Unknown	29	Scattered	2	1 1/2 Miles	5
		Unknown	19	1 Mile	4
				1/2 Mile or Less	2
				Unknown	35
	52		52		52

Table 8 shows the number of pilots reporting a preflight weather briefing and the forecast they received.

TABLE 8. WHETHER PILOT RECEIVED A PRE-FLIGHT WEATHER BRIEFING, SOURCE, AND FORECAST WEATHER

Pre-Flight Briefing			Forecast Weather	
Yes:	Flight Service	22	VFR	14
Yes:	(Source Unknown)	10	Marginal VFR	6
Yes:	(Military)	1	IMC	4
No		3	Fog	2
Unknown		16	Unknown	26
Total		52		52

Most pilots reported receiving a preflight weather briefing from a flight service station, while others reported receiving preflight weather, but did not mention the source. Probably most of these were also from flight service stations, although some may have used PATWAS, TWEB, TV weather, or other sources. Three pilots reported no weather briefing. Two of these pilots had flown earlier in the day and had experienced favorable VMC at that time. The third pilot took off to practice night landings at the local airport and encountered ground fog.

Most of the pilots who commented reported the forecast weather as VMC. However, it cannot be determined from the reports how much above VFR minimums the weather was forecast to be. Was it barely VMC, e.g., 1200 and 4 with a change to 800 and 2 in rain showers? In such a case, it would not require much weather deterioration for the pilot to find himself in IMC conditions. If the forecast was for clear and unrestricted visibility, the pilot would certainly not expect weather problems. In any case, these pilots initiated their flights either because they expected only weather problems with which they could cope, or they were willing to take the risk of possible deterioration because of "get homeitis" or other factors.

In 6 of the incidents the reported forecast weather was marginal VFR conditions. Not much deterioration was needed for the pilot to find himself in IFR conditions. Of the four pilots who took off in IMC conditions, one requested a special VFR (SVFR) clearance, and three took off VFR in IMC conditions.

It appears that many of the pilots involved in these incidents did check the weather, but were surprised by unforecast weather or decided to take a chance on the weather not deteriorating. Several pilots (12) reported requesting weather updates in flight. No weather updates were indicated by 9 pilots, and in 24 of the incidents, it could not be determined whether or not updated weather was requested. There were also 7 incidents in which weather updates were not practical, since the pilot encountered IMC shortly after take off.

As shown in Table 9 most of the weather encounters (32) occurred while the pilot was enroute. The weather was encountered at the cruise flight level (23) and often involved operating above a cloud deck (VFR on top - 12). Eight encountered IMC conditions immediately after takeoff or climb out. Several others did not encounter the weather problem until they arrived at their destination airport and found that the airport was IMC. There were two incidents in which the IMC were not encountered until the pilot was approaching to land. One of these involved a pilot who cancelled his IFR flight plan and landed at the destination airport without realizing that the field was IMC.

The pilots who reported the weather as underneath or encountered upon descent were involved in situations in which ground fog or haze existed at the destination airport.

The nature of the weather encounter is shown in Table 10. The most frequent encounter was reduced visibility (20 incidents). Rain showers (6 incidents) and ground fog (5 incidents) also resulted in reduced visibility either enroute or when attempting to land.

TABLE 9. FLIGHT PHASE AND LEVEL OF WEATHER ENCOUNTER

Flight Phase at Weather Encounter		Level of Encounter	
Enroute	32	Cruise	23
Takeoff and Climb	8	On Top	12
Destination	10	Climb Out	8
Approach or Landing	2	Underneath	3
		Approach and Landing	3
		Descent	2
		Not Applicable	2
Total	52		52

Several reporters (10) indicated that clouds had closed beneath them and two reported that they were between merging layers. Only 2 pilots reported problems trying to stay below an overcast. There were three incidents involving thunderstorms. One involved a pilot attempting to fly between two cells when they closed; one involved a pilot encountering cells and making a precautionary landing; and the other involved a pilot penetrating a restricted area after becoming unsure of his position while deviating around thunderstorms. Thunderstorms do not appear to constitute a frequent problem factor in weather encounters involving VFR pilots. Thunderstorm activity may appear so threatening to the VFR pilot, (e.g., dark sky and lightning) that he immediately deviates or lands, and consequently avoids this weather condition. Of the five incidents of flight into clouds, two involved pilots who were on SVFR clearances and encountered clouds on climb out, but proceeded to climb through the layer to VFR on top. Two others involved deteriorating weather in which the pilot continued while contacting ATC or FSS. The last

TABLE 10. NATURE OF WEATHER ENCOUNTER INDICATED BY REPORTERS*

Reduced Visibility	20
Broken or Solid Undercast	10
Rain	6
Flew Into Clouds	5
Ground Fog	5
Thunderstorms	3
Merging Cloud Layers	2
Lowering Ceiling	2
Saw or Heard of] Deteriorating Weather Ahead	2
Rising Cloud Tops	1
Strong Cross Winds	1
Unknown But IMC Conditions	2

*Totals over 52 since some pilots encountered more than one condition.

involved a pilot trying to stay underneath a lowering ceiling and, becoming concerned about obstructions, climbed into the clouds before contacting ATC.

The actions taken by the pilots upon encountering the adverse weather conditions are shown in Table 11. During training VFR pilots are frequently advised of the value of a "180 degree turn" when encountering adverse weather. It is apparent that many of them waited too long to execute a 180 degree turn. In some cases, such as ground fog at the departure airport, a return to VMC was not a feasible option. As shown in Table 11, the most frequent actions reported were contacting ATC (11) or landing at an enroute airport (9). Some pilots reported climbing or descending through cloud layers in an attempt to get out of the adverse weather condition.

Incidents where the flight was reported as "continued" represent a variety of situations. They include requesting SVFR at destination airport,

TABLE 11. REPORTED PILOT ACTION UPON WEATHER ENCOUNTER

Contacted ATC	11
Landed Enroute	9
Contacted FSS	5
Continued Flight	5
Made 180 Degree Turn or Returned To Departure Airport	8
Requested SVFR Clearance	4
Landed at Destination in Reported IMC	4
Climbed or Attempted to Climb on Top	4
Climbed Into or Through Cloud Layer	3
Descended to Stay Below Cloud Layer	3
Deviated Around Weather	3
Contacted ATC and Requested IFR Clearance	3
Attempted But Unable to Contact ATC	3
Cancelled IFR and Requested SVFR to Destination Airport	2
Broadcast on 121.5	2
Descended Through Hole in Undercast	2
Other	6

finding VFR on top, descending through a hole in the overcast, and encountering momentary patches of IMC conditions.

In most of the incidents it appears that the pilot waited too long before taking action. When action was taken, the pilot requested help from a ground facility, landed at an enroute airport or, perhaps because of get home-itis or a belief that things would get better, took steps to continue the flight.

Most pilots (44) did not make a precautionary 180 degree turn when encountering adverse weather. Table 12 shows reasons for their decisions.

TABLE 12. REASONS FOR NOT MAKING A RETURN TO VMC

Unknown	10
Option Not Feasible	7
Landed Enroute	6
Requested IFR or SVFR Clearance	5
Deviating Around Weather	3
Made Instrument Approach	2
Other	11

In 10 of the incidents the reason could not be determined. There were several isolated reasons (11), such as lost student pilots, pilots not realizing the airport was below VFR minimums, and breaking into VFR conditions. The most frequent reasons were that the 180 degree turn was not feasible, due to adverse weather closing in or ground fog (7), landing at an enroute airport (6), or requesting IFR or special VFR clearances (5). Apparently in these incidents the failure to make the recommended 180 degree turn was justified by the situation or the pilot's action. Many of the pilots requested assistance from a ground facility when encountering the adverse weather condition. Analysis of the narratives indicated that 33 pilots requested assistance, 16 did not ask for help, and, in 3 incidents, it could not be determined whether they requested assistance. Table 13 shows the type of service requested and provided.

In two-thirds of the requests for assistance, service was provided by the ground facility. The majority of the services consisted of radar vectors to the destination airport, an alternate airport, or VFR weather. In one-third of the requests, however, the pilot was unable to obtain assistance. This was often due to inability to contact the desired facility (4 incidents) or the difficulty of obtaining an IFR or SVFR clearance (4 incidents). This latter situation may have been related to the controller's workload.

The recoveries or outcomes of these incidents are shown in Table 14. The most frequent recoveries were the pilot landing at an enroute airport (10), or receiving vectors to his destination or enroute airport (9). In three incidents the weather was such that the pilot had to be given an ASR or

TABLE 13. WHETHER SERVICE PROVIDED AND TYPE OF SERVICE GIVEN OR DENIED

Service Provided		Reason Service Not Provided	
Vectors to Airport or Landing	12	Could Not Contact ATC or FSS	4
Vectors to VFR Weather or Deviations	4	Request for IFR or SVFR Denied	4
IFR or SVFR Clearance Issued	2	Too Low for Radar Coverage	1
Emergency Climb or Descent Through Clouds	3	Delay in Granting SVFR Clearance	1
Weather Update	1	ATC Would Not Provide Clearance	1
Total	22		11

PAR approach. There were 6 incidents in which flight was continued to the destination airport because the pilot broke out into VMC or continued in the poor weather. The 7 incidents in which no recovery factor was indicated involved such things as pilots entering ATAs without clearance, landing at their destination below VFR minimums, and misunderstanding clearances.

In many of the incidents the situation or the pilot's action resulted in an unsafe condition, as shown in Table 15. The most frequent unsafe condition was the non-instrument rated pilot flying IMC. In some cases the concern was whether the pilot could control the aircraft and follow the controller's instructions. In other incidents, however, the pilot was not in contact with ATC which, in addition to the aforementioned control hazard, posed a threat to IFR traffic. Six incidents involved pilots flying in or through clouds and fog, and not in contact with an ATC facility. Penetration of airport traffic areas, approach corridors, and other controlled airspace without clearance (7 incidents) also produced a threat to other aircraft, especially under conditions of restricted visibility.

TABLE 14. RECOVERY FACTORS OF VFR PILOTS IN IMC CONDITIONS

Landed Enroute Airport	10
Vectored to Airport	9
Continued Flight	6
Landed at Destination	6
ASR or PAR Approach	3
Broke Out on Top	3
Vectored to VFR Weather	2
Other	6

TABLE 15. UNSAFE CONDITIONS CREATED BY VFR FLIGHT IN ADVERSE WEATHER

VFR in IMC (In contact with ATSS)	10
VFR in Clouds or Fog Not in Contact with ATC	6
Penetrated ATA or Other Controlled Airspace Without Clearance	7
ATC Assist Required	4
Landed Without Reporting: Airport IMC	3
Landed Below VFR Minimums	2
Lost, Unsure of Position	2
Non-instrument Rated Pilot Making Instrument Approach	2
Other	5
None	10

In four incidents ATC assists were required for an ASR or PAR approach, or vectors to the runway. While not necessarily a hazard to other aircraft, the safety of the flight in such cases is contingent upon ability of the pilot and the controller. There were several incidents (8) in which no threat to safety was involved. In several of these the pilots saw the deteriorating weather and made a 180 degree turn or landed at an enroute airport when the weather started to deteriorate while the airport was still under VMC. In two of these incidents the pilot heard on the radio frequency he was monitoring that weather ahead was deteriorating and landed before encountering the weather.

Some pilots (10) reported taking off in IMC. Seven of these obtained SVFR clearances. There seems to be some confusion about SVFR clearances among the reporters. Some pilots, finding the weather below VFR minimums, asked for a SVFR to depart and continued to their destination in IMC, or at best, marginal VMC. (See the "Special Issues, Special VFR Incidents" subsection). Three pilots apparently departed under VFR in IMC.

There were only two pilots who reported poor or incomplete weather briefings. In some of the other incidents the briefings may have been incomplete, but this is not apparent from the narratives. There were two incidents in which the pilot did not check the weather. One of these involved a pilot shooting night landings. The other involved a pilot who had flown earlier when the weather was VMC, so he did not check weather for his next flight.

In most of the incidents (31) the pilot was able to get himself out of the situation by returning to VMC, landing at an enroute airport, or finding VMC. In 16 incidents, however, the pilot required assistance from ATC or flight service for landing or finding VMC.

Generalizations

What insights can be gained from this examination of incidents involving VFR pilots in adverse weather? The typical scenario is as follows: the pilot checked the weather with flight service and the forecast was for VFR. He took off and either encountered low visibility conditions or a cloud deck closing in beneath him. He continued in IMC or marginal IMC before electing to execute a return to VMC. He then landed at an enroute airport or received an assist from ATC for vectors to his destination airport or an alternate.

Meteorology is not an exact science. Sometimes weather will be better than forecast and sometimes it will be worse. Some pilots may place too much faith in the forecast and believe that the deteriorating weather is just a local condition and/or that good VFR weather is just down the road. Even when the forecast is for good VFR a pilot should have an alternative course of action in case the weather turns sour.

There is need for pilots to become more familiar with the mechanics of weather observation, and the nature of the forecasts. To prepare for a safe flight, and to be aware of options available in case of an encounter with adverse weather, pilots must understand both the value and the limitations of weather information dissemination systems.

Another problem involves the issue of legal versus practical VFR. A pilot may legally fly in controlled airspace when the reported visibility is as low as three miles, yet he cannot see an airport until he is within the airport traffic area. In such situations the slant visibility may be even less than three miles. At this pont he may become a potential conflict with IFR traffic.

One of the most important issues is the need for more timely weather information to be available to pilots. More PIREPS should be encouraged, even in good weather, and especially for enroute areas where no weather reporting facilities are available. There needs to be better coordination between ATC and FSS for relaying weather information. Many PIREPS are reported to enroute, approach, and departure control facilities that may not be relayed to flight service for dissemination to pilots. Unfortunately, when the weather begins to deteriorate is when the controllers are the busiest but also when such reports are most needed.

Pilots flying under VFR, especially on long cross-country flights, are often uncertain of the frequencies they should monitor in order to be alerted to deteriorating or other weather changes. Should they monitor Center, FSS, or EFAS frequencies? Pilots should be better indoctrinated on the sources of such information.

MULTIPLE AIRCRAFT WEATHER-RELATED ASRS REPORTS

Introduction

One might expect that most reported events involving multiple aircraft would address potential conflicts. This expectation is upheld; 55 out of 65 reported incidents in the non-commercial weather data set being considered are classed as potential conflicts. (Due to multiple reporting, these 65 incidents are described in 77 separate ASRS reports).

A second expectation is that potential conflicts may be closely related to weather problems, due to reduced visibility and heavier pilot workloads. That expectation is not supported by the data. The percentages of potential conflict and near mid-air collision reports contained in the weather-related subset are nearly identical to the percentages in the entire ASRS data base. The weather factor does not appear to raise significantly the frequency of potential conflicts, as noted in Table 16.

TABLE 16. POTENTIAL CONFLICT FREQUENCY

Total File (21,871)		Weather Subset (175)
Potential Conflicts	6977 (32 percent)	67 (38 percent)
Potential Conflicts-SMA	3308 (15 percent)	34 (19 percent)
Near Mid-Air Collisions	1799 (8 percent)	16 (9 percent)
Near Mid-Air Collisions-SMA	1284 (6 percent)	12 (7 percent)

If multiple reports of the same event are deleted, the potential conflict weather subset percentage (34 percent) is even closer to the total data base percentage.

It is also interesting to note in Table 16 that small aircraft (SMA) do not appear to be any more heavily involved in potential conflicts in weather-related reports than they are with all reports of potential conflicts.

Typical scenarios for multiple aircraft events differ significantly between those in which both aircraft are under ATC jurisdication and those in which only one or neither is talking to ATC. When both aircraft are on IFR flight plans, all participants are well identified and the details of the encounter are well documented. Encounters under mixed flight rule operations, on the other hand, often depend upon the observation of a single reporter, who may be accusing others of misbehavior. The reported facts may not be verifiable by a second party and often appear subject to interpretation. For these reasons, the following analyses separate multiple aircraft events into two sets: one, in which all aircraft are on IFR flight plans and a second, in which one or more aircraft may be operating outside the IFR system.

IFR/IFR Incidents

Multiple aircraft events in the set of ASRS reports examined here in which all aircraft are operating under IFR flight plans are reported exclusively by controllers; such events often lead to multiple reports. Among 34 ASRS reports in this category, there are only 23 separate events, all reported by controllers. Because this set of reports is the exclusive contribution of controllers, relatively little is known about pilot qualifications. Of 47 aircraft involved, 10 are assumed to be commanded by an ATP rated pilot and 10 others are commanded by pilots known to hold instrument ratings. The qualifications of the remaining 27 pilots are not reported. Furthermore, no information is reported about any of the 47 pilots' total flying time or recent flight experience.

The aircraft type involved in IFR/IFR incidents is heavily dominated by small transports (SMT) with 23 of 47, or nearly 50 percent, being in that class (SMT-FAR 135 limit, 5000-14,000 lbs.).

Small aircraft (SMA) involvement is minimal with only 2 reported among the 47 (SMA-less than 5000 lbs.). The remaining aircraft are scattered among the heavier classes and are most often air carrier type equipment.

Weather Factors

In spite of the fact that all aircraft involved in this subset of events were on IFR flight plans, only 12 of the 23 events (52 percent) occurred in instrument meteorological conditions (IMC). Six of the 23 events (26 percent) actually occurred in good visibility with the remainder in marginal visual meteorological conditions.

There is no evidence that these events were precipitated by flight crews' inability to deal effectively with weather problems. However, there is evidence that these events may be closely related to failure of the total system to deal effectively with at least one major weather problem, namely thunderstorms. Of the 23 events, 12 involve thunderstorm encounters. Such encounters typically lead to weather diversion maneuvers, (i.e., diversion from flight plan route) which, in turn, culminate in lack of separation through lack of controller communication or coordination.

The domination of thunderstorm activity in these reports is reflected in two other statistics: time of day and month of year. Seventeen of the 23 events (74 percent) occurred between 1200 and 1800, and 15 of the 23 (65 percent) occurred during the summer months of June, July, and August. These patterns differ significantly from the total ASRS data base, but are consistent with the heavy involvement of thunderstorms.

Problem Nature

One report narrative in the IFR/IFR subset is paraphrased as follows:

> "Air Carrier Aircraft A, inbound to the terminal via J60, was deviating right of course for weather. When he could finally return to course, coordination was accomplished with the next sector for a delay vector for sequencing. This put A's projected path in conflict with GA Aircraft B, descending through the altitude of A. B was told to stop above A, but the controller transferred communications to the next sector without listening for a readback from B. B continued to descend and passed through the altitude of A with approximately one mile lateral separation. Traffic was heavy and complex with sequencing of inbound aircraft, which were deviating from course due to weather."

This narrative contains several of the problem elements evident throughout the IFR/IFR subset. Weather deviations, heavy workloads, communication difficulties, controller coordination, and mixed operating phases (cruise by one aircraft and descent by the other in this case) all play a part in this narrative. Not every narrative is so rich in detail, but nearly all have one or more of these same problem-causing elements.

The nature of the problem is potential conflict between two IFR aircraft. Seventeen of 23 events are coded as potential conflicts. Five of the remaining 6 are saved from that designation only because the aircraft involved happened not to violate less-than-standard separation requirements, even though the conditions were such that only by chance (or sometimes by controller vigilance) was it prevented. These intrusions into occupied airspace most often occur during mixed operating phases, e.g., one aircraft cruising, while the second descends or climbs. Seventeen of 23 events occur in such mixed phases. It is also worth noting that only one occurs when both aircraft are in cruise phase and four occur when both are climbing. Although 13 cases (57 percent) occur between 1000 and 10,000 ft. altitude, a significant number 8 (35 percent) take place above 10,000 feet. The events are split nearly equally in terms of the responsible ATC controlling agency. Eleven occur while under the jurisdiction of an air route traffic control center, and 12 while controlled by a TRACON or tower facility.

Problem Causes

The generation of nearly every IFR/IFR event reported begins with some combination of the following three factors:

1. Weather diversions by one or more aircraft (56 percent).
2. Difficulties in coordinating handoffs between controllers (70 percent).
3. Violation of ATC clearances by flight crews (49 percent).

Indeed, as the following paraphrased report indicates, all three factors may be present at once.

> "Aircraft A was climbing to FL280; B was climbing to FL350 out of 290 under control of ZDC. A few minutes later, B was handed off to ZID climbing to 350 on J149. At this point, B was 5 west of EKN VOR and A was over EKN VOR. Aircraft A was cleared to FL350. A rogered and climbed. ZOB then called and said stop A at FL310. Meanwhile, ZID controller turned B to deviate around weather without advising ZDC. Transmissions to stop A at FL310 went unanswered. At a point 20 north of EKN, A called ZDC and was told to descend immediately to FL310. About 20 seconds later A reports level at FL350. These aircraft were together 3 or 4 times before being resolved by ZOB and ZDC."

This report noted ATC as the primary problem code, even though it shows elements of both ATC and FLC (flight crew) shortcomings. It all began when one controller authorized a weather deviation for an aircraft near the boundary of three different sectors without advising the other controllers. The problem was then complicated by communication difficulties, violation of altitude restrictions, and an uncoordinated climb. Weather diversion, controller coordination, and violation of ATC clearances all contributed to this potential conflict.

The three causes are mentioned in the ASRS report narratives with the following frequencies:

Weather Diversions	-	13 (56 percent)
Controller Coordination	-	16 (70 percent)
Clearance Violations	-	11 (49 percent)

However, as noted in the report above, it is often the combination of these enabling factors which leads to a reportable event. In the present set of 13 weather diversion cases, 11 (85 percent) involve controller coordination difficulties. This indicates that ASRS reports are often generated, not so much because of the weather, but rather because of controller coordination problems arising from attempts to accommodate diversions from flight planned routes.

Recovery Factors

The 23 reports under discussion all related to potential disasters. Pure chance appears to have saved at least 9 in which no recovery factor was noted. In 12 of the remaining cases, controller intervention resolved the problem. Pilot vigilance was responsible for recovery in two cases. There was some evidence in the narratives that auxiliary warning systems, which supplement radar tracking, play an important role in recovery. The activation of a conflict alert alarm was mentioned in 6 cases as the means by which controllers became aware that there were potential problems.

Generalizations

The multiple IFR aircraft reports stem from potential conflicts between small transport and larger aircraft. Small aircraft do not play a significant role. Problems are created by weather diversions, complicated controller coordination procedures, and misunderstandings of ATC clearances.

Mixed Flight Rule Events

Although 35 of 42 reports (83 percent) involve one IFR aircraft, multiple aircraft events in which one or more of the participants are not operating under IFR flight plans differ decidedly from the previously discussed IFR/IFR events. The reporter is more likely to be a pilot than a controller (55 percent pilots, 45 percent controllers), whereas in the IFR/IFR case all reporters are controllers. Often, qualifications of only one pilot are reported (27 out of 42 pilots are identified by rating). Of the 22 out of 27 pilots who report flying experience, as well as ratings, 17 (77 percent) claim more more than 1500 hours total flying time, and most of them claim over 30 hours in the last 90 days. We know nothing of the qualifications of the non-reporting, unidentified pilots, who are often the targets of the reports.

The small aircraft types (SMA) tend to dominate mixed flight rule events with 53 (63 percent) of the 84 aircraft reported being SMA. This is markedly different from the IFR/IFR case, in which only 4 percent were SMA. Sixteen small transports (19 percent) are reported, with the remaining aircraft distributed among the heavier classes of equipment.

Weather Factors

A high proportion of the mixed flight rule events were reported to have occurred in instrument meteorological conditions (IMC): 26 out of 42 (62 percent). Since only 3 (7 percent) were reported to be in VMC, the total marginal weather plus IMC reports account for 93 percent of the reported events. This contrasts in an unexpected way with the IFR/IFR events, in which 26 percent were reported to have occurred under visual meteorological conditions (VMC).

Contrary to the predominance of thunderstorm activity in the IFR/IFR case, the mixed flight rule events show no particular in-flight weather encounters beyond clouds and precipitation. Thirty-eight out of 42 (90 percent) of the events list no in-flight encounter, and only 3 (7 percent) are related to thunderstorm activity. The most common obscuration factor is "fog" with 19 reports (45 percent). This classification includes both ground fog and cloud encounters. Rain or snow are reported 8 times (19 percent) and haze is noted 5 times (12 percent). Flight visibility of less than 3 miles is noted in 14 reports (33 percent). Ceiling of less than 1000 feet is noted 8 times (19 percent).

One troublesome aspect of the reported weather statistics is that they often originate with an IFR pilot who has encountered another aircraft while flying in conditions which he, the IFR pilot, judges to be below VFR minimums. In some cases, this is a judgement call, with which the non-reporting pilot might not agree. In marginal weather, it seems possible for two persons of good faith to have honest differences of opinion, with one judging conditions to be IMC while the other calls it VMC. The following paraphrased narrative taken from the ASRS data illustrates the point as reported by the pilot of aircraft A.

> "Aircraft A was northbound on V-23 on an IFR flight plan, flying in snow with a visibility of less than a mile. Aircraft B passed to my right about 1/4 mile away -- not at a VFR altitude, VFR in weather that was definitely IMC -- only chance prevented a midair. The pilot of Aircraft B was obviously at fault."

The reporting pilot (IFR) in this case, had 400 hours total flying time. The non-reporting VFR pilot was also in contact with ATC and was reported to have delayed an expected climb from the altitude in question in order to remain in VMC. Lacking corroborative reports from either the controller or the VFR pilot, there seems to be room to question whether the conditions were as poor or the encounter as close as the relatively inexperienced IFR pilot estimated.

Discounting those events in which an IFR pilot is reporting on other traffic which he judges to be in violation, there is still a group (9 in 42 - 21 percent) of events which seem to point to failure of pilots to deal effectively with a weather problem. For the most part these involve VFR pilots proceeding into weather beyond their capabilities and at some point encountering another aircraft or causing traffic disruption. The following narrative illustrates this point.

> "VFR aircraft in the control zone (IMC) was told to depart to south. Turned northwest and crossed in front of IFR aircraft on localizer. IFR aircraft had to be pulled out of approach. VFR aircraft asked for vectors back to airport. Tower was unable due to no radar. VFR finally landed with VFR controller's assistance. IFR aircraft was delayed.

Problem Nature

The nature of the mixed flight rule events is again that of potential conflict. Thirty-eight of 42 events (90 percent) are so classified. Twenty-nine (69 percent) of the events occur in the vicinity of airports with the remainder (31 percent) occurring during the enroute phase. Thirty-five (83 percent) of the reports involve an encounter between an IFR and other (presumed to be VFR) aircraft. Four more (10 percent) involved special VFR (SVFR) and IFR aircraft encounters for a total of 93 percent of the reported events occurring when at least one aircraft is under direct control of ATC. Ninety-five percent of the reported events occur in daylight hours.

The role of the small aircraft (SMA) in mixed flight encounters is highlighted by Table 17. Note that not only do most of the encounters involve at least one SMA (83 percent), but also that 40 percent of the events involve two SMA's.

TABLE 17. AIRCRAFT TYPES IN MIXED FLIGHT PLAN ENCOUNTERS

	SMA (Percent)	SMT (Percent)	OTHER (Percent)	Total (Percent)
SMA	17 (40)	8 (19)	10 (24)	35 (83)
SMT	-	2 (05)	4 (10)	6 (14)
OTHER	-	-	1 (02)	1 (02)

An analysis of the narratives does not yield an overwhelming majority for the "typical" scenario, as it did in the IFR/IFR case. Rather, mixed flight rule events seem to stem from a variety of problems. If there are common denominators, they must be:

1. Entering control zone without clearance when the weather is below VFR minimums, 17 events (40 percent).

2. VFR flight in (reported) IMC, 23 events (55 percent).

3. Surprise encounters with aircraft popping through holes in clouds, maneuvering around broken clouds, or cruising near cloud decks being penetrated by IFR aircraft, 12 events (29 percent).

A given scenario may involve one or more of these factors.

Again, the statistics on IMC identification and estimation of encounter distances must be tempered by the knowledge that they originate from single, possibly biased, reporters.

As was the case with the IFR/IFR events, the mixed flight rule encounters most often occurred during mixed flight phases; 24 out of 42 events (57 percent). An additional 11 (26 percent) occurred with both aircraft in the traffic pattern or on approach. Only 4 events (10 percent) occurred when both aircraft were in cruise mode.

The mixed flight rule events are primarily low altitude phenomonon, with 10 reported under 1000 feet and 26 between 1000 and 10,000 for a total of 86 percent of all reports. The controlling agency is also reflected in the altitude structure, with ARTCC involvement in only 8 of 42 cases (19 percent). The other communication facilities are spread among TRACON, tower, FSS and UNICOM.

Contributing Factors

An examination of the narratives reveals the presence of one or more of a variety of contributing factors:

1. Weather interpretation - 21 events (50 percent).
2. Controller coordination - 10 events (24 percent).
3. Regulation knowledge and interpretation - 10 events (24 percent).
4. Clearance violations - 9 events (21 percent).
5. Weather encounters beyond a pilot's capabilities - 9 events (21 percent).

As previously suggested, the outcomes of such contributing factors are to cause a pilot to enter a control zone when the weather is below VFR minimums without clearance (40 percent), to cause a second pilot to be surprised by sudden encounters with another aircraft close to clouds (29 percent), or to cause a VFR flight to be operating in IMC (55 percent).

Weather interpretation causes ASRS reports to be filed for the following reasons:

1. A VFR pilot may misjudge visibilities and actually enter IMC.
2. An IFR pilot may misjudge visibilities and report an illegal VFR operation when, in fact, VMC does exist.
3. A VFR pilot may misjudge cloud clearance distances and actually be too close to clouds.
4. An IFR pilot may misjudge cloud clearance distances and report an offending VFR operation which is, in fact, legal.
5. Ground observers and a VFR pilot may disagree on prevailing ceiling and visibility, causing a VFR flight to enter a control zone in reported IMC. For example, the visibility value which is reported is that which prevails over 51 percent of the 360-degree horizon visible from the observing point. Thus, an airport may be below VFR minimums due to low visibility values over 51 percent of the area. A pilot, however, may be approaching the field from a quadrant where the visibility is better, have the airport in sight, and does not realize that the field is IMC. He consequently proceeds to land without concern for "legality".

Unfortunately, the weather interpretation factor is one in which conflicting opinions can only be inferred and, most often, are not available for explicit analysis. The suspicion that conditions may not be exactly as reported is raised when a pilot reports in one narrative, "... I was on solid instruments at that altitude", yet advises radar that he has the traffic. It seems plausible that the pilot of the offending VFR aircraft might have believed conditions were VMC and was following visual separation procedures.

Controller/pilot communication factors may appear when adjacent facilities have different reported weather. A VFR aircraft may be cleared (legally) out of one jurisdiction, only to enter a second which is reporting

IMC and ultimately causes a potential conflict. The following synopsis involving a VFR departure which entered a neighboring control zone reported to be below VFR minimums illustrates such a problem:

> "LAX was VMC, HHR, adjoining airport IMC. Helicopter A departed LAX VFR. Later light aircraft on approach to HHR reported NMAC with A. A was outside TCA and no longer in contact with LAX tower."

Knowledge and interpretation of regulations may be factors in potential conflicts occurring in control zones which are not served by towers. Consider the following excerpts from a narrative, in which the field had a flight service station, but no control tower:

> "Aircraft A broke out on an ILS approach just above minimums and observed aircraft landing on same runway. --He was not in communication with controlling authority in a control zone that was IMC at the time."

The offending VFR pilot was illegally in the control zone, which was below VFR minimums. He did not check with the FSS; either he was not radio equipped or he did not know that a clearance was required when the visibility was less than 3 miles. No communication would have been required if the control zone was in fact above VFR minimums.

A more subtle regulation factor occurs when an IFR approach is made to an uncontrolled airport not in a control zone at which local operations are being conducted below 700 feet in one mile visibility. Since, at many locations, that is uncontrolled airspace, the local VFR flights may be legal, but may be a surprise to the arriving IFR pilot who breaks out at 700 feet to face another aircraft in the pattern as noted in this narrative:

> "With a ceiling of 700 ft. A GA Aircraft B was practicing pattern work at what he said was 500 ft. AGL. I consider it unsafe when we break out right at minimums on the circling approach, switch frequencies from approach to UNICOM and hear B say he will do a 360 on crosswind to avoid the jet. -- We all could have been dead right."

Clearance violations are contributing factors whenever failure to follow instructions causes one aircraft to come in close proximity to another. The most common violation (5 events - 12 percent) seems to be for a VFR pilot to change altitude or direction while in contact with ATC in marginal weather without announcing his intentions.

Weather encounters beyond a pilot's capability include those in which a pilot loses separation from clouds and requires special handling to complete his flight. These become mixed flight rule events only when other flights are delayed or diverted while the problem is resolved.

Recovery Factors

Pure chance, as evidenced by no recovery factor, appears to be the only reason that 17 of the 42 mixed flight rule events (40 percent) did not lead from potential to actual conflict. Pilots initiated recovery actions in 13 (31 percent) cases. These were most often self-initiated evasive maneuvers. In the remaining 12 cases (29 percent), controller vigilance played a part in resolving the mixed flight plan problems.

The majority of the mixed flight rule reports involve small aircraft operations (SMA). The most numerous reports involve VFR flight in reported IMC conditions and are filed by IFR pilots. Entering control zones without proper clearance in IMC conditions and operating VFR in close proximity to clouds, are also frequently mentioned. Weather interpretation, knowledge of regulations, controller coordination and clearance violations are factors which lead to the reported problems. A relatively small number of events occur because of obvious inability of pilots to cope with weather encounters.

The data suggest the problem is more serious in MXD weather and when one aircraft is climbing or descending.

WEATHER INFORMATION SERVICES

There were 14 complaints about weather information services other than inaccurate forecasts where the pilot encountered IMC weather. The inability to reach flight service by telephone was the complaint in 5 of the incidents.

Reporters relate waits as long as 20 to 45 minutes on hold and then being disconnected. This problem appears to be more prevalent in busy terminal areas. Reporters allege that, because of the inability to reach flight service, many pilots in their area depart without preflight weather briefings or take off and contact enroute flight advisory service as illustrated in this narrative:

> "In this area it is practically impossible to obtain a weather briefing by dialing the local phone numbers for the FSS. A phone call to the local FSS at any time of the day, morning or night, and in any kind of weather, good or bad, will produce the same result of receiving a recording which says that all lines are busy and a wait of approximately 20 to 25 minutes. On more than one occasion I have waited 30 to 45 minutes, only to have the equipment disconnect my call, thereby causing me to redial. My experience is also the experience of other people in this area which I believe represents a dangerous hazard to both VFR and IFR flight due to the inability of the pilot to obtain a weather briefing. I have heard pilots inform me that on more than one occasion flights have been planned without a weather briefing because of the inability to obtain a briefing on the ground. More than one pilot has informed me that he will take off and attempt to get flight watch on 122.0 in an attempt to obtain a weather briefing to his destination. Simply passing a law requiring a pilot to obtain a weather briefing prior to flight and then making it impossible for him to obtain a weather briefing does not improve safety of flight and in fact encourages what eventually must be an illegal operation by the pilot and which represents a dangerous condition for all. From my own personal observation the quality of the weather report received from the FSS personnel is spotty and inconsistent with the experienced people giving you an excellent report and the inexperienced people giving you a broad brush that for all practical purposes is valueless. When the weather is good, everyone gives you a good report, but when the weather is bad I have found it is always necessary to talk directly to the weather personnel. I have attended many safety seminars put on by the FAA who are aware of the problem and have suggested submitting these danger reports to NAA for their evaluation.

One pilot reported a systems problem where, after waiting on hold, the line disconnected when the briefer answered. This appeared to be a recurrent problem at this particular FSS. Three pilots complained of pessimistic forecasts issued by flight service. Two of these pilots cancelled flights because of the forecasts when, in fact, the weather turned out to be VMC. The other pilot took off in spite of the pessimistic forecast and completed his flight without incident. In this later case, however, the forecast was substantially correct and the pilot was fortunate enough to find breaks in the overcast to climb to VFR on top and descend at his destination. There were three complaints of incomplete briefings or lack of information. These complaints involved lack of charts and radar summaries at self-briefing desks, automated systems being down, and lack of PIREP information. One pilot suggested that, at terminal areas with approach and departure control, every hour a departing aircraft, either GA or air carrier, be designated as a PIREP aircraft. This aircraft could report cloud bases, tops, freezing level, turbulence, etc. The information could then be relayed to flight service, entered into the computer, and dispersed to FSS throughout the system. This could be effective in poor or rapidly changing weather conditions.

There were also three complaints of poor attitudes on the part of FSS or NWS personnel. One pilot reported that NWS personnel refused to provide weather information and even stood in front of the radar so that the pilot could not see it.

The other complaints involved an inaccurate forecast and lack of weather reporting facilities at the airport.

WEATHER-RELATED INCIDENTS INVOLVING BALLOONS

Five incidents involved hot-air balloons. Four of these occurred because the winds aloft differed from those forecast. One pilot landed to avoid penetrating a TCA; another climbed to altitudes of 16,000-17,500 feet without oxygen and crossed airways to overfly forested areas. The third pilot flew at 100 feet AGL over a housing development to take advantage of surface winds. The last pilot drifted into an airport traffic area and was becalmed over the airport. All pilots and especially balloon pilots should recognize that the winds aloft forecast is a computer generated forecast based on the prevailing and projected pattern of high and low pressure areas and will often be different from actual conditions. While in most cases this does not pose a problem for the pilot of a powered aircraft, who may miss his ETA by a few minutes, it can be a major problem for balloon pilots.

LIMITATIONS TO THE DATA

In the foregoing analysis it should be recognized that there are limitations to the conclusions drawn from the ASRS data. Clearly, there is no evidence on the representativeness of the data. For example: how many mixed VFR/IFR potential conflicts go unreported? Are these unreported conflicts substantially different in terms of inflight weather, mission phase, type of aircraft, etc.?

It is well known that General Aviation pilots are not the usual reporters of incidents. General Aviation pilots comprise more than 90 percent of all pilots in the USA and account for 75 percent of the total hours flown and 44 percent of the instrument approaches; yet they figure in only 29 percent of the reported incidents (where GA operations include pleasure, corporate, training, and personal business). Does this suggest that fewer GA pilots are involved in incidents? The answer is probably that air carrier pilots are motivated and encouraged to take an active role in the ASRS system in the interest of increasing safety, they have ready access to reporting forms, and probably are more likely to "cover" their performance inadequacies by an ASRS report to avoid disciplinary action from the FAA. Incidents where pilots confess to altitude deviations probably belong to this category. The same might be said for air traffic controller reports of LTSS of two IFR aircraft. While this may bias the data, the data still provide the analyst with detailed descriptions of system problems.

Attitudes of pilots toward controllers (and vice versa), of air carrier pilots toward General Aviation pilots (and vice versa), and of IFR pilots toward VFR pilots (and vice versa) can be seen as underlying factors behind some of the incidents reported. Again, this bias is important in understanding the development and consequential effects of incidents. An example of this is the following narrative:

"I was on V233 tracking from the Roberts VOR to Knox at 5000 ft and was with Chicago center. My first indication of any weather was when I saw lightning flash several miles ahead and began hearing airliners asking to divert right or left of course. I was told to climb to 7000 feet and I asked the controller how the weather looked along my line of flight and was told that I would pass to the right of the storm. In a few minutes I saw that my line of flight was taking me into the area of intense lightning. I then asked the man for an update of my position in relation to the storm. He then very sarcastically told me 'I told you the weather was to your left, divert to the right if you want to.' I immediately turned right about 30 degs and was then handed off to another frequency. Explained my situation and asked for assistance. He was very helpful and diverted me farther to the right to miss still another cell. The point of this report is two-fold: No. 1-please weed out sarcasm in ATC. No. 2-please--let's be assured of some help from the ground in weather situations. My flight originated in Fort Worth, TX, where I checked with FSS twice on weather conditions and once in flight with Dacatur, Ill radio thru the VOR. There was no report of any weather, so I didn't knowingly get into the situation."

A basic issue is the relation of exposure frequency to incident frequency. In other words, before one becomes awestruck by a statistic that suggests that icing is a factor in IFR incidents, one must know the number of pilot exposures to icing which were incident free. Thus, in drawing conclusions from these data, one must recognize that, for the most part, there does not exist sufficient exposure data to permit comparison of one incident type to another.

Finally, all the incidents reported herein were selected because the ASRS analyst reported that weather was a significant factor in the incident. Indeed, in the case of the single IFR aircraft incidents, it has been argued that weather should not have been a factor in a large percentage of these cases because it was not unusual, i.e., it was IMC which the IFR system was designed to handle. If the analyst can err on over-emphasizing the importance of weather, he can obviously also under-emphasize. In any event, this source of error was probably trivial in comparison to the "exposure problem" or the "representativeness problem" or to the "bias problem."

Yet, despite the inability to know the true representativeness of the ASRS data, it is evident that valuable insight into pilot-controller problems has been gained.

SPECIAL ISSUES

Role of Increased Workload in General Aviation Weather Incidents

One of the consequences of both deteriorating weather and sudden weather changes is the impact on both pilot and controller workloads. The ASRS analyst codes list excessive workload as a behavior factor which contributes to some incidents. It was anticipated that this factor would be a significant contributor in the reported General Aviation weather-related incidents, yet there were few cases where this was indicated. In only 6 of the 175 reports was workload cited, and half of these involved air traffic controllers. The problem might be the analyst interpretation of workload. One might argue that most VFR pilots (at least low-time pilots) experience increased workload with flight into adverse weather. It is difficult to ascertain how excessive such workloads might be, however. The VFR pilot in IMC usually gets special handling, i.e., altitude and heading instructions from ATC.

To argue workload for the IFR pilot in IMC would seem to contradict the idea of an instrument rating. A "good" pilot is expected to handle navigation, communication and maintain straight and level flight at the same time. Icing, admittedly, could lead to stress which could enhance workload. Neither of the inflight icing incidents suggests any workload factor, however.

The fact that the small general aviation aircraft has, typically, less sophisticated avionics, e.g., auto pilots, may be counteracted by the fact that the pilot does not have the schedule pressures of air taxi, air carrier crews, or corporate operations associated with more sophisticated aircraft.

The more likely case for workload-induced stress resides in the IFR/IFR cases where weather-induced diversions lead to controller workload and coordination problems between controllers. In summary, stress, workload, fatigue, and related concepts are difficult to ascertain after the fact. Pilots and controllers may be reluctant to admit such behavioral factors because they "suggest" an unprofessional pilot or controller. Perhaps no post hoc reporting system can ever probe the degree to which weather-induced stress influences a flight.

Problems With Obtaining Clearances in Flight

The results of this search of General Aviation pilots and weather-related incidents revealed several instances of instrument-rated pilots reporting difficulties in obtaining clearances in the air. This is illustrated by the following narrative:

> "After takeoff, ACFT A was still within the airport boundary. FSS advised that the airport was now below VFR minimums. I asked for a clearance but was told they didn't have the zone, contact AN Center 119.09, center was contacted and advised I was airborne and needed a clearance. Center would not issue a clearance of any kind (depart, hold, land) because there was an IFR Acft B inbound. Again I advised I was airborne and needed to do something so was circling the airport maintaining VFR awaiting a clearance. Several times I asked for a clearance, whereupon ATC Anchorage center gave me an IFR clearance of "get the hell out of there." I continued to circle the airport (at 800 ft with 30 miles visibility) until I was given a proper ATC clearance. Time involved approx 25 min."

Often IFR rated pilots will go up and "take a VFR look" at marginal weather, and assume that they can always get an IFR clearance if it appears that they will need one. They seem surprised that controllers are often too busy to oblige them immediately. This stems from lack of understanding of three considerations:

1. If an airport becomes MVMC or turns IMC there will probably be an increase in IFR traffic.
2. The controller's primary job is to provide separation of IFR traffic.
3. If the controller is already overloaded with separation responsibilities, he may be loathe to accept new responsibilities (at least, immediately).

The upshot of this situation is the case of a frustrated IFR rated pilot trying to maintain VFR flight in rapidly deteriorating weather conditions in controlled airspace. By not being under positive control, he then becomes a potential hazard for other traffic.

One solution would be to file IFR even when weather is still reported VMC -- a policy adopted by many pilots. This practice could, of course, overload the IFR system and, hence, create additional problems. A balanced approach would be to let each pilot decide on the basis of weather and traffic in his area of operation. If he can hold VFR above a cloud deck for an IFR clearance, there is little problem. The problem develops when he is faced with visibility interpretations on arrival or on take off. Here the dilemma of two versus three miles visibility estimation appears. Because of the lack of obvious solutions to this problem, it would appear to be a candidate for systematic research.

Weather Incidents at Night

One of the concerns of aviation safety specialists is the combined effect of weather and night operations, particularly for the VFR pilot. Marginal VFR in daylight is considered by some to be IMC at night where there is a paucity of visual cues for the pilot. Even scattered layers may cause airports to go un-noticed at night. Examination of the 177 ASRS reports reveal that only 12 incidents were under night conditions, and for VFR into IMC only 4 incidents or 8 percent of that type were reported as occurring at night. This does not suggest that the night weather problem does not exist; it may only suggest that such cases are not being reported. Lack of such reports may be due to a combination of factors such as:

a) Night flying, especially VFR, is much less frequent than daytime flying (the exposure issue).

b) Pilots who fly at night may have more experience and more sophisticated aircraft, and are less likely to find themselves in a weather-related incident, or better able to cope with weather.

c) The air traffic control system is less crowded and is better able to accept deviatons without system disruption at night.

d) Pilots, in general, demand better weather for night operation than for daytime operation.

Special VFR Incidents

Eight incidents involved special VFR clearances. In several cases, upon flight continuance, the pilot discovered deteriorating rather than improving weather. Some "specials" were filed to reach satellite airports. The following incident illustrates one kind of problem resulting from SVFR clearances:

> "I received permission to depart Wichita Falls special VFR. During climb out (at approx 500-600') I could see at a distance of one mile in front of me. The ceiling going down--I immediately decided this was not for me and decided upon a 180 deg turn back to the airport. However, due to commercial traffic, I decided that the tower should be notified of my decision. Before initiating the turn, I radioed the tower twice, with no response (radios were set up correctly). Next contact attempt was to departure with the same results. Felt an emergency (lost comm) was necessary and continued a 500' climb into clouds as opposed to 180 deg turn or flying lower. A commercial jet was preparing to depart when I departed. At 3500 MSL I broke on top and 2-3 minutes later Wichita Falls transmitted to me (no apparent problems now). I felt the climb was the safest choice -- also due for IFR checkride on (date). Continued flight to Dallas with no problems."

Pilots need to have a better understanding of SVFR. Perhaps the presence of VOR receivers leads pilots to undertake trips in such weather conditions where pilotage would be impossible.

Whether special VFR's lead VFR pilots into problems excessively cannot be answered with these data without knowledge of successful VFR pilot use of SVFR clearances. For example, how many SVFR clearances are issued each year, and under what conditions -- localized ground fog or general low visibility conditions? How many pilots return to airports immediately after SVFR departures with special assistance from controllers? How many special VFR clearances are denied and for what reasons? Clearly, SVFR clearances can invite some pilots into unsafe conditions. The data suggest that research be done in this area to ascertain the value of SVFR, the percent of time difficulties result, and the comparison between the benefits versus the costs of this procedure to the aviation system.

Weather Involvement and General Aviation Operations in the Vicinity of Airports

Operations conducted in the vicinity of airports provide many opportunities to generate potential conflicts among aircraft. The airports are collection points for arriving aircraft and dispersion points for departing aircraft. This natural opportunity for conflict is increased when IFR and VFR operations are mixed during periods of marginal weather. Three factors contribute to enhanced conflict potential:

1. Operating rules, involving weather minimums and communication requirements, differ among airports.
2. Ceiling and visibility estimates are difficult to make and may differ among observers.
3. The transition from VFR to IFR operation may occur with no time or space buffers.

Table 18 summarizes the airspace types in 27 reports of mixed flight rule events which originate in the vicinity of airports.

Instrument approaches may be available at four different classes of airports. The first class includes the major terminals protected by TCA (Terminal Control Area) airspace. These areas are well charted and the equipment and operating requirements to enter that airspace are widely publicized. ATC authorization is required to operate in a TCA, regardless of weather conditions. Conflicts in these areas are most likely to be caused by clearance violations, intruders, or controller errors.

The second class includes those airports with operating control towers, but no TCA. Again, the airport traffic area (a cylinder of airspace 5 miles in radius and 3000 feet high) should be well understood by all pilots. No one legally approaches the airport served by the control tower without communicating with ATC.

TABLE 18. ASRS REPORTS FOR MIXED FLIGHT RULE TRAFFIC IN THE VICINITY OF AIRPORTS

Location	Number of of Airports	Percent of Total (42 Reports)
Terminal Control Area	3	7
Airport Traffic Area	12	19
Control Zone	7	17
Airport in Uncontrolled Airspace	5	12
Total in Vicinity of Airports	27	64

The third class of airports consists of those lying in control zones, but without operating control towers. This appears to be the group with the most confusing operating rules. The stated weather minima for VFR operations in a control zone are 1000 feet ceiling and 3 miles visibility. The confusion arises because pilots are not required to communicate with ATC to operate at these airports in VFR conditions. This leads the VFR pilot to believe that he is flying in an uncontrolled environment. Unless there is a flight service station on the field and the pilot is participating in the airport advisory program, an arriving VFR aircraft could enter a control zone which is officially below minimums, communicating with no one, in weather he judges to be VMC. At the same time an IFR aircraft on approach may be (falsely) counting on ATC to assure separation from all traffic, since he is in controlled airspace that is officially below VFR minimums. The conflict potential escalates.

The fourth class of airports consists of those with approved instrument approaches, but no control towers or control zones. Controlled airspace at these airports ends at 700 feet above ground level (AGL). Below 700 feet is uncontrolled airspace in which VFR requirements are 1 mile visibility and clear of the clouds. An approaching IFR aircraft flying in IMC moves from separation by ATC from all other legal traffic to no protection, beyond visual separation, as it descends below 700 feet. The potential for conflict, with perfectly legal VFR operations just below the ceiling, is obvious. Marion, Ohio is typical of such airports. Marion has a VOR approach with a minimum descent altitude of 490 feet AGL, yet controlled airspace there ends at 700 feel AGL. There are no time or space buffers between the IFR and VFR worlds at such locations.

Weather interpretation and non-uniform operating rules combine to increase the potential conflict hazard in mixed IFR/VFR operations at airports in classes 3 and 4 to a greater degree than in classes 1 and 2.

Any airport with an operating control tower (classes 1 and 2) has a qualified weather observer who has direct communication with all aircraft legally entering the airspace in the vicinity of the airport. All players should know the ground rules. Current weather is, for example: "800 feet and 2 miles" -- because the tower says it is.

Airports in control zones, but without control towers, may also have qualified weather observers present, but they may not be talking to all the participants. The IFR pilot knows the rules because he is in communication with ATC and has been told that the weather is below 1000 feet and/or 3 miles. The VFR pilot, on the other hand, must either contact the flight service station, if one is on the field, or rely on his own judgement to determine whether or not VFR minimums exist. There is no mandatory communication in VMC weather. Honest differences lead to a violation of "VFR in IMC" and a potential conflict with IFR traffic.

Airports with instrument approaches which lie in uncontrolled airspace (below 700 feet AGL) and lack qualified weather observers rely entirely on the judgement of the participants to establish the operating ground rules. A VFR pilot can legally operate at such airports as long as he estimates the visibility to be greater than 1 mile and he remains clear of the clouds. An arriving IFR flight might disagree with the visibility assessment of his VFR counterpart if both meet on the final approach to landing. The two pilots are operating under different assumed rules because they lack a common information source.

A second weather-related problem, which does not involve conflicting estimates, occurs at airports in uncontrolled airspace. This is the potential conflict between an arriving IFR flight which breaks out of the overcast below 700 feet AGL and a VFR flight operating very close to, but clear of, the clouds. There is no buffer to accommodate the changeover from total reliance on radar separation to a see and be seen doctrine. Perhaps further research is warranted to assess the impact of raising approach minima at such airports, so that the MDA (minimum descent altitude) is always in controlled airspace (e.g., above 700 feet, AGL). That way all participants would be operating under the same rules (VFR) at a well defined altitude. As it is now, an approach with an MDA of 500 feet terminates 200 feet into uncontrolled airspace. At least if ground contact was required before entering uncontrolled airspace, some buffer would be created to accommodate the changeover from an IFR to a VFR environment.

CONCLUSIONS

In general, the analysis of weather-related incidents involving general aviation did not indicate glaring deficiencies in skill or training of the GA pilot. While some pilots may have needed help from a ground-based facility, all but one of the pilots landed safely without damaging the aircraft. There was, also, little indication that the lack of equipment contributed to any of the reported incidents.

The major problems may be ranked as follows:

1. Lack of timely weather information, especially in deteriorating weather.
2. Lack of exact weather interpretation, e.g., visibility reports.
3. Questionable judgement and attitude of pilots in regard to weather flying.
4. Pilot attentiveness.

5. Aircraft equipment.
6. Navaids.
7. ATC System.

In regard to single IFR aircraft, the problem causes appear to be:

1. Violation of rules or lack of precision in IFR flying.
2. Weather interpretation, i.e., the classic issue of when conditions have deteriorated from VMC to IMC.
3. Communications breakdowns between FSS, controllers, and pilots.
4. Poor preflight planning by pilots.

The problem causes for the VFR pilot encountering adverse weather appear to be as follows:

1. Weather turns out to be worse than forecast.
2. Pilots departing VFR in marginal weather conditions.
3. Lack of timely weather information or enroute weather (between stations) e.g., PIREPS.
4. Poor pre-flight planning by pilots.
5. Failure of pilots to initiate 180 degree turns soon enough when the weather is worse than forecast.

In the incidents involving multiple aircraft, the major problems were related to the difficulty of coping with non-routine operations during weather diversions and the hazard created by two or more aircraft operating on mixed flight rules and mixed flight phases in conditions of reduced visibility.

These analyses suggest that improvements in the following areas may aid in reducing future incidents involving GA pilots and adverse weather.

1. Pilots
   a. The need for better weather recognition, especially estimates of visibility.
   b. A more professional approach to IFR flying.
   c. Better pre-flight planning, especially in regard to runway information during winter months and planning alternatives in the event of weather changes.

d. Need for fuller understanding of the mechanics of weather observation and forecasting.

2. ATC

a. Need to improve handling of non-routine events caused by traffic diversions due to weather (sector coordination problems).

b. Need for improved asistance to pilots confronting deteriorating weather.

3. Weather Information Services

a. Need for more timely dissemination of weather information.

b. Need to provide pilots with better access to weather information for flight planning purposes.

4. Pilot - ATC Relations

a. The need to improve communication between pilots and ATC as regards weather-related problems.

b. The need to understand better the attitudes of pilots towards controllers (and vice versa) and how these attitudes contribute to incident causation and associated consequences. For example: if pilots view controllers as policemen as opposed to "helpers", they (the pilots) tend to be easily offended, defensive, non-communicative, and in many cases refuse to confess problems which can affect the safety of others. In turn, controllers may lose their professional composure and ....

The reduction of GA weather-related incidents does not appear to require more experience for the General Aviation pilot, nor better equipment.

Aircraft equipment sophistication endorsed by some aviation safety advocates appears not to be a factor in incident causation. The lessons suggested from the analyses provide additional evidence for curriculum design for training both pilots and controllers and, at least minimally, remind all General Aviation pilots of the potential

The data suggest better utilization of the current resources of the aviation system such as better weather information dissemination, better utilization of the IFR system, and better training of VFR pilots to detect, diagnose, and cope with changing weather patterns.

APPENDIX A.

ACCESSION NUMBERS USED

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The accession numbers on which this report is based are as follows:

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