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A REVIEW OF IN-FLIGHT EMERGENCIES IN THE ASRS DATA BASE

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FINAL REPORT

on

A REVIEW OF IN-FLIGHT EMERGENCIES IN THE ASRS DATA BASE

by

Richard F. Porter

SUMMARY

This report describes a series of 154 in-flight emergencies as reported to the Aviation Safety Reporting System. The various types of emergencies are examined and an attempt is made to determine the human errors and other factors associated with each incident, as well as the measures taken to resolve the emergency. It is concluded that nearly one half of those emergencies reported were related to failure or malfunction of aircraft subsystems. Of all the emergencies, nearly one quarter were associated with power-plant failure. Other frequently-encountered emergency types are associated with operation in Instrument Meteorological Conditions without appropriate clearance or qualification, and with low fuel-state situations. Human error is prominently featured in many of the incidents, appearing in the actions of pilots and air traffic controllers.

INTRODUCTION

An analysis of information transfer problems in emergency air-ground communications has recently been completed, based upon the reports in the ASRS files. A prerequisite to that analysis was the extraction of ASRS reports which describe an in-flight emergency. Approximately one-third of the emergency occurrences were usable in that they contained an identifiable post-emergency problem related to a communication dysfunction.

This report presents the results of a broader examination of the complete set of previously extracted in-flight emergency reports. Attention has been given to an exposition of the factors significant to the emergencies themselves, without being limited to those associated with a communication problem.

OBJECTIVE

The objectives of this study were: (1) to describe the types of in-flight emergency occurrences appearing in the reports in the ASRS files; (2) to define the system factors, human errors, and associated causes of these emergencies; and (3) to define the manner in which they were resolved, as appropriate for each case.

SCOPE

This study is confined to the group of reports extracted from the ASRS files for a previous analysis entitled "Information Transfer Problems in Emergency Air-Ground Communications." The reports were extracted from over 14,000 reports submitted between May 1978 and September 1980. The search strategy employed in that study is described in the following section; but, in essence, it sought to extract those reports which describe a distressful situation which either led to a declared emergency, or was similar in circumstances to other incidents in which an emergency was declared.

The Air Traffic Control Handbook (FAA, 7110.65A 1550) describes an emergency as "... any situation which places an aircraft in danger; i.e., uncertainty, alert, being lost, or in distress." A standard dictionary specifies an unforeseen combination of circumstances that calls for immediate action to avoid disaster. Both of these definitions are broader in scope than that which is implicit in the group of reports used in this study.

None of the incidents used in this study deal with the types of sudden crisis situations in which recovery is immediately achieved by a more or less reflex action on the part of the flight crew. Examples of the excluded situations are near mid-air collisions, wake vortex encounters, turbulence upsets, and others in which there is sufficient time for a conscious choice of optional courses of action.

The incidents used in this study are restricted to those in which a declaration of emergency was appropriate, whether or not such a declaration was actually made. They are characterized by a relatively prolonged period of distress and a demand for air crew procedures or ATC handling beyond the ordinary.

APPROACH

As mentioned previously, the data base for this study was the group of reports extracted from the ASRS files for a recently completed analysis of information transfer problems in emergency communications. Although no additional search was conducted for the current study, the search strategy for the earlier analysis is outlined below.

The initial screening consisted of a search for all reports which contained the word "emergency" in any phrase in any of the five fields (Enabling Factors, Associated Factors, Recovery Factors, Supplementary Factors, and Descriptors) utilized in the ASRS system. Following an examination for duplicate reports of the same incident or for others which were deemed unsuitable, the initial screening yielded 131 discrete emergency situations.

The next step was to expand the sample by examining the 131 reports to identify other descriptive phrases with a relatively high frequency of occurrence or which, intuitively, might be useful in finding other pertinent study cases even though the word "emergency" did not occur in a descriptor.

Table 1 lists the key descriptors that were selected, other than those explicitly containing the word "emergency".

Excluding the reports previously examined, it was found that at least one of the descriptors in Table 1 appeared in 850 reports in the data base.

TABLE 1. DESCRIPTORS USED IN REPORT SELECTION

Situation	Descriptor
Low Fuel	Fuel Remaining
Engine	Inflight Engine Shutdown
	Engine Problem
	Aircraft Engine-Out Performance
	Aircraft Equipment Problem/Engine
	Power Plant Problem
	Engine Control Problem
	Aircraft Equipment Operating Problem/Engine
	Inflight Fire
Weather	IMC in VFR Flight
	Weather in Terminal Area
	Weather Forecast
	Weather Report
	Weather Avoidance
	VFR on Top
	Enroute Weather
Landing	Precautionary Landing
	Return/Land
	Off Airport Landing
Pressurization	Aircraft Equipment Problem/ Pressurization
Command Authority	Command Authority
Disorientation	Disorientation
	Spatial Disorientation
Miscellaneous	Blind Broadcast
	Sensory Illusion
	Loss of Aircraft Control

From these, 37 were judged to qualify as emergency situations.

Combining the 131 cases from the first search with the 37 additional cases produced a total of 168 emergency incidents which formed the basic data set for the study of related information transfer problems.

For the current study, with emphasis on the emergency situations themselves, the data set was further reduced to 154 discrete incidents by eliminating those which did not contain sufficient information to classify the nature of the emergency.

The analysis consisted of an initial classification of each emergency by type, followed by a careful review of the report narratives in an attempt to: (1) identify the basic reason that the emergency developed, and (2) to take note of the manner in which the difficulties were resolved.

RESULTS

The 154 cases can be segregated into two basic types: (1) those related to a physical failure of an aircraft subsystem, and (2) those that are not.

Table 2 lists the 154 emergency cases by type.

Each of the emergencies was examined with regard to the causal factors and noteworthy recovery factors. These are described in the following paragraphs.

Aircraft Systems Emergencies

The broad nature of the enabling, or causative, factors for each of the 74 aircraft systems emergencies is given in Table 3.

Almost half of the emergencies in Table 3 were caused by a failure of the aircraft's propulsion system. Eighteen of the 34 incidents occurred with multi-engine aircraft and were resolved largely by priority treatment from ATC. The remaining 16 failures occurred on single-engine aircraft, and six

TABLE 2. TOTAL POPULATION OF EMERGENCY SITUATIONS

Type	No. of Cases	Percent Total Emergencies
Aircraft Systems Emergencies		
Propulsion	34	22.08
Pressurization	12	7.79
Electrical	7	4.55
Landing Gear/Tires	6	3.90
Hydraulic	5	3.25
Flight Control	4	2.60
Airframe	3	1.95
Fire Warning	2	1.30
Smoke/Fumes, Unspecified Cause	1	0.65
Subtotal	74	48.05
Emergencies Not Involving Aircraft Systems		
VFR Pilot in IMC	32	20.78
Low Fuel State	27	17.53
Severe Weather Avoidance	8	5.19
Lost	6	3.90
Illness on Board	2	1.30
Miscellaneous	5	3.25
Subtotal	80	51.95
Grand Total	154	100.00

TABLE 3. NATURE OF ENABLING FACTORS FOR AIRCRAFT SYSTEMS EMERGENCIES

Type	Number of Cases		
	Mechanical Failure	Human Error	Both
Propulsion	30	3	1
Pressurization	12	0	0
Electrical	7	0	0
Landing Gear/Tires	5	1	0
Hydraulic	5	0	0
Flight Control	3	1	0
Airframe	3	0	0
Fire Warning	2	0	0
Smoke/Fumes	1	0	0
Totals	68	5	1

of these consisted of a total loss of power. Oddly enough, only two culminated in an off-airport landing; the remaining four were within gliding distance of an airport.

Next in frequency were failures in the cabin pressurization system, requiring a rapid loss of altitude, often initiated prior to an appropriate clearance.

Electrical problems created seven emergencies. Five of these were resolved by landings with no radio contact with ATC, one of which required a small twin to execute a low-altitude visual approach in instrument meteorological conditions. Other electrical failures caused the emergency landing of a three-engine wide-body transport after loss of instrumentation, and the emergency evacuation of an air taxi aircraft after landing roll-out because of smoke in the cabin.

Landing gear and tire failures contributed six incidents. Two cases of tire failure on takeoff were reported for air carrier aircraft. In one, the takeoff was aborted, the passengers evacuated, and a small fire extinguished by the fire crew. In the second, extensive landing gear damage to a four-engine heavy transport was caused by blown tires on takeoff, requiring an emergency landing on a foamed runway. Minor landing damage was also suffered by a small aircraft whose right main gear would not fully extend, by an air carrier aircraft whose right main gear would not fully extend, and by an air carrier aircraft with a hanging landing gear door. In the remaining two cases, the aircraft landed without further incident.

Hydraulic system failures resulted in emergency landings for four aircraft: two air carrier aircraft and two military. In the remaining case of hydraulic problems, leaking hydraulic fluid dripped on hot engine parts of an air carrier aircraft after landing, creating heavy smoke and causing an emergency evacuation of the airplane.

Problems with the flight control system accounted for four emergencies. In one, a military fighter was given an emergency clearance to return to base after unspecified trouble with the control system. Two cases, involving an air taxi light twin and a three-engine air carrier aircraft were particularly dramatic and are discussed later. In the remaining incident, an aileron boost malfunction restricted the right aileron control movement on a three-engine air carrier aircraft after takeoff. The crew was able to execute a left-turn pattern to return to the runway for landing.

Failures of the airframe itself were only three in number. A cracked window panel on a corporate jet at 41,000 feet required an emergency descent, but no depressurization was experienced. The aft stair partially lowered in flight on a three-engine air carrier airplane, while a military trainer experienced airframe vibration of an unspecified nature; both required expedited landings.

Fire warning lights initiated emergencies with two military aircraft, one a four-engine transport and the other a fighter. Both executed emergency landings.

The remaining aircraft system emergency concerned a precautionary off-airport landing of a military helicopter because of smoke and fumes of an unspecified origin.

The immediate cause of all 74 incidents in the aircraft systems emergency group was, by definition, a failure of some component of the aircraft or its subsystems to perform as expected. In most cases, the root cause of the failure cannot be determined from a reading of the submitted report. In general, it is not possible to determine whether a design defect, a material failure, improper operation, or faulty maintenance precipitated the failure.

There are exceptions, in which a human error clearly caused or combined with a system failure to create an emergency situation. These cases are discussed in the following paragraphs.

In three cases, a propulsion system failure can be clearly attributed to the inexperience of the pilot. One of those cases combined inadequate training on the part of a student with commendable perception and competence on the part of a controller:

> "...After crossing Diablo Range mountains and reducing RPM's to achieve a 200 ft/min descent, I noticed the engine started running roughly. Applying full power to level off, the engine RPM dropped from 2000 RPM t 500 then back to about 1500 and the engine almost died. I decided to get help and tuned in 121.5, ... Whoever answered my call verified contact and then told me to pull carb heat on. I did and the RPM gained to almost normal and the engine ran smoother. ... The engine began to run smoothly and normally and all gauges were in green."

The second pilot-induced engine failure is apparently related to a student's lack of familiarity with his aircraft:

> "A small aircraft was on downwind turning base, when he said 'I have a real problem'. He would not answer any further transmissions. He made an emergency landing on Taxiway C. ... He said he meant to turn off (sic) the carburetor heat, but pulled the throttle instead. He then pushed the throttle back in and the engine apparently flooded out."

The third pilot-induced engine problem was created by a more experienced (364 hours) pilot of a small single-engine aircraft:

> "Turned off engine as scanning caught oil pressure dropping below 2 lbs. Oil temp on pin. Declared emergency after setting up glide from 8200 ft., restarted engine at 2300 - all appeared normal. ... Believe cause to be long climb at 80 mph and too lean."

In one case, a mechanical problem combined with pilot error to create a propulsion system emergency. In this case, the pilot (420 hours) continued takeoff despite abnormal engine operation which was later attributed to contamination in a fuel line:

> "Take off run started...engine became rough...adjusted mixture 1/2 runway. Normal climb to approximately 100 feet...end of runway plane began to settle...engine became rough again...Decided to abort. No runway left...Normal landing on sand access road near end of runway area."

The single case of a human-error induced landing gear emergency occurred after takeoff of an air carrier aircraft when the Gear-Unsafe and Gear-Door-Open lights illuminated as a result of the crew's failure to remove the right main landing gear pin during preflight.

The remaining example of a clear human-error causal factor in an aircraft systems emergency concerns the flight control system of a three-engine air-carrier aircraft on a scheduled passenger flight:

> "The aircraft was towed from the hangar to the gate by maintenance personnel. It had been worked on to comply with a bulletin. Since hydraulics had been involved (disconnected to allow work) items powered by hydraulics were not all in normal configuration (gear door-leading edge devices, etc.) but not unusual, for having depressurized hydraulics and not yet pressurizing 'A' system. All check lists were accomplished... Takeoff roll and lift-off seemed normal. Immediately after liftoff a lateral control problem appeared (roll to right) requiring about 15 to 20 degrees aileron and left rudder... At 1600 ft going from flaps 5 to 2 degrees, a number of compressor stalls occurred on number three engine. Power immediately retarded to idle. Emergency declared to Bay departure. Emergency check lists completed. Fuel dumped

> (3000 pounds) (over water-bay) to reduce weight to landing weight...30 degree flaps landing made without further incident. However, after reducing power to idle on number 3 engine, lateral control became difficult, aircraft rolling right. (About 90-95 percent aileron and about 75-80 percent rudder required for level flight.) After arriving at gate it was found that the right ground spoilers were deployed (up). A check by maintenance found the hydraulic lines (left wheel well) to right inboard ground spoilers had been reconnected in reverse position, causing ground spoilers to deploy, with speed brake handle selected to down position."

The exemplary airmanship evident in the preceding narrative obviously averted a major disaster. An examination of the recovery factors in the Aircraft Systems Emergencies group reveals other Homeric recoveries by air crews. Consider the case of the pilot of a twin-engine air taxi whose control column became disconnected from the elevator surfaces:

> "... Passenger questioned me as to what the trim was for and I told him to hold the controls while I put one full turn up-trim as a demonstration. A loud pop was heard and the aircraft pitched up. I tried to lower the nose with elevator control but found that the control column was no longer connected to the control surface. The aircraft was just about to stall and as a last ditch effort I pulled the power off and tried the trim. I was able to regain a safe attitude by jockeying the power and trim. At this time I felt it prudent to declare an emergency. ... I carefully tried the controls and found all to be working normally except the elevator. The only up-down control I had was power and trim. ... I was able to land the aircraft at DFW using power, trim, and rudder only. I was hesitant to use the aileron or otherwise fiddle with a relatively controlled situation. Upon touchdown I shut the engines and electrical system down so as to eliminate as many sources of ignition as possible. There was no damage to the aircraft and no person was injured..."

Other noteworthy recoveries are evident. The crew of a four-engine wide-body transport executed a successful straight-in approach with three engines stuck at idle thrust following a new fuel-saving slow descent from cruise altitude. In another display of skill, the crew of a twin-engine air carrier aircraft landed successfully with no pressure in either hydraulic system; leaving them with limited control power, only 15 degrees of flap, no spoilers, no nose-wheel steering, free-fall lowering of the landing gear, and a one-shot braking ability.

Emergencies Not Involving Aircraft Systems Failure

The 80 cases in this second major grouping are incidents in which all aircraft subsystems were functioning normally. An element of human error in forecasting, planning, or execution is present in the majority of these; but some are created by the pilot's perception that he cannot safely follow standard ATC procedures or controller directive.

In Table 4, this group is segregated into two distinct subsets: (1) those in which the aircraft was truly in distress; and (2) those in which the declaration of an emergency was needed, in the pilot's opinion, to avoid a potentially dangerous situation by disregarding controller instructions or by seeking priority handling.

TABLE 4. CLASSIFICATION OF EMERGENCIES NOT INVOLVING AIRCRAFT SUBSYSTEM FAILURES

	Number of Cases	
Type of Emergency	Aircraft Actually in Distress	Declaration For Deviation From ATC Procedures
VFR in IMC	29	3
Low Fuel State	19	8
Severe Weather Avoidance	0	8
Lost	6	0
Illness on Board	0	2
Miscellaneous	4	1
Totals	58	22

Each type of emergency in Table 4 is treated separately in the following paragraphs.

VFR in IMC

With regard to the VFR in IMC emergencies, the 29 cases in the first column of Table 4 all involve non-instrument-rated pilots who were in instrument meteorological conditions or were in imminent danger of being forced into such conditions.

Five of the 29 arrived at their destination "VFR on top." In two of these, the narratives contain an implication that the subsequent let-down on instruments could have been avoided. It may be conjectured that these two incidents, at least, were not entirely inadvertent.

In the first of these, a 230 hour pilot arrived at his destination at 9500 feet, VFR on top of a solid overcast:

> "... Center informed me that he had just finished (45 minutes ago) giving another VFR pilot vectors to find a hole... I informed him that I had 40 hours of instrument time and could easily descend through the overcast...so then I declared emergency and he gave me clearance to descend below the overcast. Less than five minutes later I was flying under blue sky. A break in the overcast...five miles in diameter or more. ... At the time of the incident I had 2.5 hours of fuel on board..."

In the other case, a pilot with a degree in meteorology ignored a two-degree spread between temperature and dew point at his destination:

> "... Upon arrival at Wenatchee the stratus had become overcast with only a few thin spots. I felt it would have been too dangerous to attempt penetration. I called Wenatchee FSS and...refiled for a return to Felts field. ... Wenatchee FSS called and reported that both Felt and Spokane International had gone IFR. ... I advised them that I was VFR rated pilot with 10 hours of logged IFR instruction and 20 hours of total instrument and simulator time ... I stated I felt comfortable staying in the Wenatchee area and making an approach through the 100 feet thick layer. FSS acquired a VOR approach clearance for me. I made a complete and successful approach break-

ing out at 2500 feet, or 1200 AGL. ... The emergency was not absolutely necessary nor the IFR approach. I could have landed on farm road on the Badger Mountain Plateau north of Wenatchee. These are often used as emergency landing practice runways...and were above the stratus layer."

Since all unintentional flight into IMC by non-instrument pilots involves an error in judgement at some point, an effort was made to classify these incidents in some manner which would reveal the root cause of these emergencies. This effort was not entirely successful because of the fact that each reporter related only the facts that he chose. Ten reporters cite inaccurate terminal or enroute weather forecasts, but many mention no weather briefing at all. In the latter case, it cannot be assumed that none was received.

Some general types of errors are apparent. In some, the reporter received a terminal area forecast but neglected to inquire about the enroute conditions. Typical of these was an 87 hour pilot on a flight from Kansas City to Indianapolis:

"... received weather from St. Louis FSS ... Indianapolis 4000 scattered to broken, 4 miles in haze. I failed to ask for Terre Haute (enroute) weather... At approximately Mattoon, Illinois (40 miles west of Terre Haute) visibility and ceilings began to lower. Dropped down to 2500 MSL and attempted to call Mattoon Unicom - No answer ... lost VLA VOR about the same time as HUF VOR became usable. As I continued the flight (I should have made the 180 degree turn at this point - but didn't) the visibility and ceilings became lower until I found myself trapped at 1000 feet MSL..."

Another type of mistake evident in the reports is to receive a complete briefing at departure but fail to keep current on enroute weather, even when observation doesn't agree with the briefing. As an example, (from a 1000 hour pilot):

"... As the cloud cover increased in density, the pilot stayed on top thinking the condition was a local area condition therefore not reported in the weather briefing. The pilot did not call Chicago to verify the area condition. The pilot flew for an additional 65 nautical

> miles. When the cloud cover did not clear and his fuel supply was what he thought to be low, he called South Bend Approach Control and requested radar vectors to Goshen Airport. The pilot was told that Goshen Airport was 300 feet..."

If there is a common thread which binds many of these VFR pilot/weather incidents together, it is evident in the narrative above. An optimism, often unfounded, seems to prevail that an observed area of IMC is local and that conditions will improve. This often erroneous assumption is particularly tempting when supported by a weather forecast. In ten of these incidents, the reporter complained of an inaccurate enroute or terminal forecast. Despite observations at variance with the forecast weather, each continued to a point where he could no longer remain in VMC with the fuel remaining.

The three VFR/weather incidents in the second column of Table 4 differ from the 29 in the first column in that the aircraft was never actually in distress. In one, an instrument rated pilot initiated an emergency climb to VMC conditions after unforecast IMC was encountered at 1000 feet, but before an IFR clearance could be obtained. Another pilot, encountering 1-3/4 miles visibility (not forecast) in the control zone of a non-tower airport, and unable to get a radio response from the FSS, exercised his emergency authority to enter the control zone and landed without difficulty. In a somewhat similar incident, the reporter's aircraft was on base leg in rapidly deteriorating weather when the airport went below legal VFR minimums.

Low Fuel State Emergencies

The 27 low fuel state emergencies are categorized in Table 5. It may be noted that one of those involved a faulty fuel gauge and therefore might have been categorized as an aircraft systems failure.

As listed previously in Table 4, eight of these were judged to be declarations of emergency to prevent a distressful situation rather than to recover from an existing condition. However, since this interpretation is a matter of judgement, all low-fuel emergencies are listed in Table 5.

TABLE 5. CIRCUMSTANCES IN LOW-FUEL EMERGENCIES

Events	Number of Cases			Total
	Air Carrier	Gen. Av.	Mil.	
Held Until Fuel Critical	5	2	0	7
Total Fuel Exhaustion	0	6	0	6
Held-Field Closed-Diverted	3	0	1	4
Arrived With Min. Fuel, Could Not Hold	0	0	3	3
Critical Fuel After Missed Approaches	0	1	1	2
Insufficient Fuel For Destination	0	1	0	1
Inaccurate Fuel Gauge False Alarm	0	1	0	1
Negligent Handling by ATC	0	0	1	1
Low Fuel, Uncertain of Position	0	1	0	1
Unspecified Fuel Problem	0	1	0	1
Totals	8	13	6	27

The most common problem is simply an excessive holding time at busy terminals, which gave rise to seven incidents. More insidious, apparently, from an actual hazard standpoint, are the four cases in which the aircraft held to a low fuel state only to have the field go below minimums, requiring diversion to an alternate. An example is an incident involving a four-engine heavy transport, described in the following narrative excerpt:

> "... I elected to depart with an estimate of 16,600 lbs for landing at ORD... We were given a hold at Capital FL200 with an acceptable EFC. Reason for hold was ORD was down to one runway, which was 14R and many C/B's North, East and South. Nineteen thousand lbs of fuel remained at this point. We were stepped down and brought into Vains intersection 25 DME from ORD at 6,000 feet. Weather at ORD and MKE worsened rapidly with heavy TRW's reported all directions but west. Then a large C/B moved in directly over O'Hare and the field closed. One half turn more in the hold put us down to 13,000 lbs and I

requested an immediate radar vector to Rockford. RFD ATIS was 1900 overcast, 1 mile, gusts 20, 75 degrees, 29.71. I made a localizer back course ILS to 18 in rapidly deteriorating weather and heavy rain. A cell moved in between the runway and the final approach fix. I continued the approach at MDA, penetrated the cell and eventually missed the approach, never seeing any form of airport environment. I immediately declared an emergency and asked for radar vectors to 36 ILS... We were fuel critical now. At or above 1000 feet we became contact, and I elected to continue the approach manually, one dot low. Circling was out of the question due to a black cell off the north of the runway. I estimate the wind over the fence at 10 to 20 knots with gusts to 30 on the tail. Runway wet. Spoilers did not deploy on rear wheel spinup and were extended manually with maximum braking from touchdown and maximum rev all four. Braking action was poor and we hydroplaned the entire length, stopping 50 to 100 feet from the end...6,000 lbs were remaining."

While all eight of the air carrier incidents involved holding at the destination, half of the six military incidents occurred because the aircraft arrived at the terminal area with insufficient fuel for any holding time.

With regard to General Aviation, 6 of the 13 low-fuel emergencies involved total fuel exhaustion, resulting in five off-airport emergency landings. These were all cases of human error, ranging from miscalculated fuel consumption to simple inattention to the fuel state. One, from a non-instrument-rated pilot, combined poor fuel planning with an apparent disregard for operating in IMC without an appropriate rating:

"This flight was to be a round trip from Dayton, Ohio to Detroit. The weather forecast was for ceilings below 4000 feet and visibilities 3 to 5 miles, deteriorating as a warm front came in from the south. ... The temperatures were below freezing at Dayton, forecast to reach low 40's with drizzle by the P.M. ... The first leg was uneventful..., landing in 1 miles visibility during light snow. We declined to refuel...expecting at least 0.9 hour reserve. Prior to departing Detroit we made several attempts to contact FSS, by phone, but were unable to find an open line... Except for traces of rime ice we picked up south of Salem VOR enroute to Toledo, all was typical of a "scud run." Somewhere between Findlay and Rosewood, the cloud cover became more obscured and the visibility progressively deteriorated. Incredibly, we did not contact FSS at Findlay (or for that matter, any ground stations)... Quite rapidly thereafter the ground visibility dropped below VFR minimums (1 mile), we entered moderate fog and built up nearly 1/4 inch of crusty rime ice... I opted to continue south and up - and enlisted the aid of Dayton Approach. Running full throttle gave 2500 to 2550 RPM, 95 MPH and slowly resulted in positive climb...we were given vectors toward the ILS 24L at Dayton... We were vectored to intercept the localizer, cleared for the approach and cleared to land. Just prior to crossing the OM at 2800 MSL we lost all power... V, broke out and made a clean, full flap off-airport landing in 10 inches of snow..."

Severe Weather Avoidance

All eight of the incidents in this category were an exercise of command authority by the pilot to deviate from the clearances given by air traffic control. Seven of these were air carrier aircraft while one was a commuter aircraft. Six declared an emergency to avoid thunderstorms on their assigned heading while two deviated from their assigned altitude, without clearance, to escape severe turbulence.

Lost

Four of the six lost pilots were identified as student pilots. Three were also handicapped by a language problem, and one was not within direct range of any ground radio facility. Two of these emergencies resulted in off-airport landings.

Illness on Board

Two incidents are reported in which emergency descents and landings were executed by air carrier pilots because of suspected coronary attacks suffered by passengers.

Miscellaneous Emergencies

Five incidents are classified as miscellaneous because they are unique for their type.

Somewhat surprisingly, only one incident contains airframe icing as the primary cause of an emergency. Following a missed approach in IMC, a small single-engine aircraft was unable to climb above 1000 feet over terrain, lost its gyro vacuum system and airspeed indicator, and was vectored to an alternate.

One of the strangest incidents involved the pilot of a small single-engine aircraft who filed an IFR flight plan, by telephone, from an uncontrolled airport at night. Once airborne, he realized he had forgotten to bring along either a microphone or a flashlight. Squawking 7700 on his transponder, he attempted to return only to find that his landing gear would not extend. Unable to find the circuit breakers with no flashlight, he executed a wheels-up landing.

One incident was caused by the disorientation of an inexperienced instrument rated pilot at night in low visibility, attempting an instrument approach. He was observed, far off the localizer, by the local controller who directed him to the runway.

In another incident, an air taxi pilot suffered vertigo on a 2-mile final with a 500 foot ceiling. After breaking off the approach he was vectored back for another attempt and landed after some difficulty in flying the ILS.

The final incident in this category might have been included in the "Severe Weather Avoidance" group because it contains the same element of conflict between the pilot's perception of an unsafe operation and the inflexibility of a controller:

> "... Noted approaching dark clouds to the east of the airport. After contacting tower received wind report of 100 degrees 25 knots, gusts to 32... Attempted crosswind landing. Used full left rudder to the stop with airspeed at 80 mph. Was able to contact ground with right main but unable to reduce speed without loss of control. Made go around and requested permission to land on center taxiway straight into wind 2000 feet long. Tower said they 'were unable to approve landing without contacting airport manger.' Nearest other airports were east toward bad weather... Declared emergency...made approach 75

degrees off runway heading, landed across runway and rolled out on taxiway... After I declared the emergency and was on approach, tower would not answer radio calls and volunteered no wind reports or assistance..."

DISCUSSION

Causal Factors

The most useful produce of this study would be a definitive assessment of the underlying causes of each of the emergency incidents, with particular emphasis on human shortcomings and system deficiencies. Unfortunately for our purposes, such information is usually contained in the ASRS reports only by implication, if at all. For example, out of the 74 incident involving a failure of an aircraft system, only one can clearly be traced to a maintenance error; while five can definitely be ascribed to air crew deficiencies. There is no hint as to the root cause of the remaining 68 systems emergencies.

In the 80 incidents which did not involve a failure of an aircraft system, the underlying reason for the emergency also remains a matter of conjecture in most cases.

In 29 of the cases involving a non-instrument pilot in IMC, the pilot must assume the ultimate responsibility, although it is evident that more reliable weather information might have precluded many of these incidents. In a very few cases (2 or 3) there is a hint that the pilot deliberately decided to exercise his limited instrument training. In the bulk of the incidents, however, the trap was sprung by a combination of inadequate (no enroute weather) or inaccurate weather data together with an innate optimism that the VMC forecast will turn out to be correct, even though the pilots first-hand observations indicate otherwise.

The low-fuel-state emergency causal factors are not as easily deduced, in many cases. In the 11 incidents which included extensive holding at the destination, it appears that the fundamental problem was traffic saturation at the intended destination. When such congestion is aggravated by deteriorating weather, the need to divert after an extensive hold can create a truly hazardous situation.

Other low-fuel emergencies were clearly caused by pilot deficiencies--usually by poor flight planning--but sometimes they must be attributed to simple inattention to the fuel remaining. Perhaps eight incidents can be placed in this group.

The eight emergencies related to severe weather avoidance were all created by a combination of dangerous meteorological conditions, as perceived by the pilot, and a reluctance on the part of a controller to permit a prompt course or altitude change. In no case is it clear why the controller appeared inflexible, although usually it may be surmised that traffic congestion and controller workload were contributing factors.

All six of the emergencies created by lost pilots can be attributed to pilot inexperience, while the two cases of illness on board the aircraft can only be considered acts of God.

Recovery Factors

In most cases, the recovery from the emergency, once declared, is relatively straight-forward. On the other hand, several of the recoveries were effected only through truly impressive feats of airmanship, particularly in those incidents involving an aircraft systems failure. Some examples were cited in the previous section.

It may be significant that in none of the reported incidents involving a non-instrument pilot in IMC is there any mention of difficulty in maintaining control of the aircraft. While some of those reporters mention specific training experience towards an instrument rating, the ASRS reports suggest that the basic instument training required for the Private Pilot certificate has literally been a life-saver.

CONCLUSIONS

A total of 154 reports, describing emergency incidents, were reviewed in detail during the course of this study. Although a numerical break-down of pertinent factors may not have rigorous statistical significance because of the relatively small number of cases in some subgroupings, the following conclusions are drawn:

1. Almost half of the emergencies involved a failure of the aircraft subsystems, with the preponderance of failures related to the aircraft's propulsion system. Propulsion system failures account for over 22 percent of all the emergency cases.

2. Other types of emergencies which appear with relatively high frequency are caused by operation in instrument meteorological conditions without an appropriate rating or clearance (21 percent) and a low fuel state (18 percent). No other type of emergency was numerically more than 8 percent of the total.

3. Considering all types of emergencies, at least one-third can clearly be attributed to human error in flight planning or execution. Most of these are related to operation in IMC by non-instrument pilots and the low-fuel emergencies reported in the General Aviation category.

4. A failure of the Air Traffic Control system to provide expeditious and safe clearances is implied in 24 cases (about 16 percent of all emergencies). Most of these failures created critical fuel situations. The implied cause of the ATC deficiency is traffic congestion, often coupled with inclement weather,

5. The basic instrument training required for the Private Pilot certificate may have been a crucial aid in recovery for non-instrument pilots in IMC. None of the narratives indicated a basic difficulty with aircraft control in these emergencies.