ACCIDENT INVESTIGATION

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National Transportation Safety Board

The National Transportation Safety Board (NTSB) was created by the Department of Transportation Act of 1966, which simultaneously established the Department of Transportation. However, it was the Independent Safety Board Act of 1974 which established the Safety Board as an entirely independent Federal agency and broadened the responsibilities of the Board in the investigation and prevention of transportation accidents. Among other things, the Board is charged with:

- Investigating certain aviation, highway, railroad, pipeline, and marine accidents.
- Reporting publicly on the facts, conditions and circumstances and the cause(s) or probable cause(s) of such accidents.
- Issuing periodic reports to the Congress and to federal, state, and local transportation safety agencies and others recommending measures to reduce the likelihood of transportation accidents.
- Initiating and conducting special transportation safety studies and investigations.

Inasmuch as this workshop deals with aviation systems and the meteorological and environmental inputs to such systems, this overview will deal only with aviation accident investigation and particularly with those cases in which there was a weather involvement. A weather-involved accident will be defined as one in which the Board has determined that weather was a cause or a contributing factor.

Before discussing some specifics of weather-involved accidents it might be appropriate to provide a brief summary of the manner in which the Board conducts its investigations, for the benefit of those attendees fortunate enough not to have been active participants in such investigations. The Board's headquarters are located at 800 Independence Avenue Southwest in Washington, DC,--the same building that houses the Federal Aviation Administration (FAA) headquarters. There are 12 field offices spread out from Miami, Florida, to Anchorage, Alaska. Eleven of those 12 are designated as Aviation Field Offices. Eight of the 12 are also Railroad Offices, four are also Highway Offices and three are also Pipeline Offices, since the Board's work is intermodal. Under normal circumstances, the field offices conduct investigations of general aviation type accidents. The investigation

is usually conducted by one investigator from a field office assisted generally by an FAA man and on occasion by a manufacturer's representative, i.e., the manufacturer of the aircraft, powerplant or on-board systems. The field offices are provided with any required technical backup from appropriate professional experts in Washington. For example, the case may require the services of our metallurgical laboratory, or investigative assistance from an air traffic control specialist, a meteorologist or others. Field office personnel are also called upon to "stake down" the scene of an air carrier accident until an investigative team arrives from Washington, assist in the investigation and also provide logistical support.

Air carrier accident investigations, on the other hand, are conducted differently. In Washington, there is always a so-called "Go-Team" on standby. The Go-Team is made up of about 10 investigators. There is an Investigator-in-Charge and experts in the various technical areas such as operations, air traffic control, weather, powerplants, etc. The team is normally accompanied to the accident scene by a Board Member and a representative from our Office of Public Affairs. In order to develop a complete factual record, the Board will, at an organization meeting, designate Parties to the Investigation to assist the Board in its work. The Parties consist of such agencies as: the FAA, National Weather Service (NWS), local governmental organizations and others. Also included as Parties will be such organizations as: the air carrier involved, airframe, powerplant and systems manufacturers, the Air Line Pilots Association (ALPA), Professional Air Traffic Controllers Organization (PATCO), and various other trade unions and organizations as may be appropriate.

Under the overall direction of the NTSB Investigator-in-Charge the investigation is conducted by the various groups in their own areas of expertise under the chairmanship of an NTSB investigator. Information is exchanged between participants and coordination is effected at periodic Progress Meetings convened by the fnvestigator-in-Charge. Under the direction of each NTSB Group Chairman, one set of group notes is maintained from which there eventually will be drafted a Group Chairman's Factual Report.

Should circumstances dictate that after the field phase of the investigation is complete a public hearing be held, all Parties are notified and Parties to the Hearing will be designated, normally from among those agencies and organizations which have already participated in the field phase. At the Public Hearing, testimony is taken under oath from appropriate witnesses with questions first from the Board's Technical Panel, normally made up of NTSB Group Chairmen. Questions are also allowed from spokesmen from each of the designated Parties as well as from members of the NTSB Board of Inquiry which conducts the hearing. Subsequently, a formal Board report will be prepared for public release and will contain pertinent findings and the cause or probable cause. At any time after the accident, the Board could issue Safety Recommendations pertinent to the case involved, directed to

appropriate agencies and organizations with an indication of the priority status of each recommendation. Also, as you know, the Board does periodically publish reports on special studies it has developed on various subjects. We are aware that previous workshops discussed at some length the results of the Board's Special Study on Fatal Weather-Involved General Aviation Accidents.

Most of the remainder of this overview paper will be divided into two categories, i.e., information concerning air carrier accidents and information relating to general aviation accidents.

General Aviation Accidents

Table 1 has been developed to provide an overview of all general aviation accidents over a recent 5-year period as well as a comparison between all accidents and the weather-involved accidents. The NTSB continues to be concerned not only with the overall accident picture, but with the continuing large number of weather involvements. Weather continues to be one of the most, if not the most frequently cited causal factor in fatal, general aviation accidents. Table 1 shows that 16.5% of all accidents are fatal, that 22.4% of all accidents are weather-involved, and that 38.6% of the fatal accidents are weather-involved accidents. Looking at just the weather-involved accidents, more than 28% of those are fatal, and, on the average, two or more people are killed in each one.

Table 1

U.S. GENERAL AVIATION ACCIDENTS

	All Accidents			Weather-Involved Accidents		
	Total	Total Fatal	Fatalities	Total	Total Fatal	Fatalities
1973	4,255	723	1,412	963	273	618
1974	4,425	729	1,438	1,009	300	702
1975	4,237	675	1,345	985	278	644
1976	4,193	695	1,320	897	255	606
1977	4,286	702	1,436	946	254	615
Total	21,396	3,524	6,951	4,800	1,360	3,185

Those of you who are familiar with or who have copies of the Board's 1974 Special Study of Fatal, Weather-Involved General Aviation Accidents (which covered a 9-year period) will recognize that the percentages just quoted are not significantly different from those given in 1974.

It is not the intent of this paper to update completely the aforementioned Special Study, but it was considered of interest to provide another look at some of the statistical data available.

For example, what kinds of pilot ratings were held by those involved in the weather accidents delineated in Table 1? The Board lists more than 20 kinds of pilot ratings and also the category of "No Rating." Human nature being what it is, we have found that almost 1.5% of the pilots in weather-involved accidents had no ratings of any kind. On the other hand 55.7% of them had airplane-single-engine-land ratings, 19% had airplane-single/multi-engine-land ratings and about 30% had an instrument rating of some kind. The figures also show that 36% of the pilots with instrument ratings were involved in fatal accidents. One must conclude, therefore, that while an instrument rating is nice to have, it is no guarantee for protection against being involved in a weather accident.

The NTSB categorizes about 65 phases of operation. In an attempt to separate the phases of operations during which most accidents occurred, it was found that the percentages in weather-involved accidents were much the same as the overall general aviation accident picture and that the highest percentage of accidents (35.4%) occurred during the landing phase. This is divided as follows: Level-off/touchdown 15.2%, Roll (fixed-wing) 13.3%, and Final approach 6.9%. Takeoff was next in line with 12.1% and Inflight was next with 11.6%. In all the remaining approximately 60 categories, the percentages were less than 3% in each.

Table 2 was developed to provide some information about the filing of flight plans. There are many more categories than shown, but the table merely highlights the most prevalent citations. Obviously, most pilots do not file flight plans and about three times as many pilots who do not file flight plans are involved in weather accidents as compared with those who do file.

Table 2

U.S. GENERAL AVIATION ACCIDENTS
1973-1977

FLIGHT PLANS

	All Accidents	Weather-Involved Accidents
None	82.7%	73.8%
VRF	10.6%	13.8%
IFR	5.2%	10.5%

The matter of weather briefing is always of interest, particularly those provided prior to an accident which falls in the weather-involved category. Table 3 was developed to show the major sources of weather briefings and as would be expected, briefings by Flight Service Station (FSS) personnel head the list with more than 33% of the briefings having been provided to pilots in all accidents and almost 40% provided to those who had weather type accidents. As you can see, NWS personnel provided less than 3% of the briefings in both cases. It should be noted that in relation to both, all accidents as well as the weather-involved cases, there are large percentages in which there is no record of a briefing having been provided. There is not the implication that the pilots received no briefing (in accordance with the Federal Aviation Regulations for many flights), but that the air safety investigator could not locate such a record, even if there was one. We are well aware that there are many ways to receive a weather briefing and that no record may exist.

Table 3

U.S. GENERAL AVIATION ACCIDENTS
1973-1977

WEATHER BRIEFING

	All Accidents	Weather-Involved Accidents
FSS by phone	21.9%	25.8%
FSS in person	5.2%	5.7%
FSS by radio	6.4%	7.5%
Total	33.5%	39.0%
NWS by phone	1.6%	.7&
NWS in person	1.1%	¹.2%
Total	2.7%	2.9%
No record of briefing	41.2%	35.4%
Unknown/not reported	14.0%	13.4%

In connection with the weather-involved accidents, more than 51% of the pilots did get a weather briefing of some kind (when we had evidence of a briefing). Overall, 45% of the pilots received a weather briefing.

The accuracy of weather forecasts is always a concern, but unfortunately, in the cases covering the 5-year period being discussed, more often than not, it was not possible to make such an assessment. It can only be said at this time that in about 45% of the cases, the forecasts were considered to have been substantially correct or the weather was slightly better than forecast. It can also be said that in only about 5% of the cases, the weather was worse than forecast. However, one must note that in more than 50% of the cases our data bank shows only that forecast information was "Unknown/Not Reported."

We are frequently asked to provide information concerning the types of weather phenomena most often associated with accidents. It appears that over the years the list is almost invariably the same in fatal accidents (Table 4-a) and in the non-fatal accidents (Table 4-b). As is quite evident in Table 4, low ceiling, fog and rain top the list as they did in our 1974 study of the fatal accidents; and unfavorable wind conditions, updraft/downdraft and low ceiling are among the top three just as they were in our 1976 study of the non-fatal accidents. The Board uses more than 20 categories of which Table 4 is just an abstract. It should be noted that a category which has been added is wind shear, which has been cited more than 30 times as a cause or factor over the 5-year period covered by this paper.

Table 4-a

U.S. GENERAL AVIATION ACCIDENTS
1973-1977

CAUSE/FACTOR TABLE: WEATHER PHENOMENA

Fatal Accidents

	Cause	Factor	Total
Low ceiling	7	795	802
Fog	6	544	550
Rain	-	298	298
Snow	1	151	152
Thunderstorm activity	6	133	139
Icing conditions	8	107	115

Table 4-b

Non-Fatal Accidents

	Cause	Factor	Total
Unfavorable wind conditions	306	1,258	1,564
Up/down draft	86	249	335
Low ceiling	5	308	313
Fog	5	290	295
Conditions conducive to carburetor icing	10	282	292
Rain	-	160	160

It is common knowledge that most general aviation flying is in the flying-for-pleasure category. It would be anticipated, therefore, that most of the accidents would occur during pleasure flying, and that is quite correct. The Board lists more than 50 categories of flying, and Table 5 lists some of the top categories where accidents are involved.

Table 5

U.S. GENERAL AVIATION ACCIDENTS
1973-1977

KIND OF FLYING

	All G/A Accidents	Weather-Involved Accidents
Pleasure	50.6%	58.8%
Business	7.2%	9.5%
Aerial application	5.8%	-
Instructional/dual	5.3%	-
Instructional/solo	4.3%	-
Air taxi-passenger operations	-	4.2%

As you are well aware, the pilot involvement as a cause or factor in weather type accidents is quite high. Table 6 has been developed to highlight the major types of pilot involvement (of the more than 60 listed by the Board) which occurred in weather-involved accidents during the 1973-1977 period. Four of these top five are the same citations outlined in the 1974 study previously mentioned.

Table 6

U.S. GENERAL AVIATION ACCIDENTS
1973-1977

CAUSE/FACTOR TABLE: PILOT INVOLVEMENT

Fatal Accidents

Pilot-in-command	Cause	Factor	Total
Continued flight in adverse weather	641	12	653
Spatial disorientation	458	1	459
Inadequate preflight preparation or planning	145	157	302
Improper inflight decision or planning	243	51	294
Failed to obtain/maintain flying speed	195	-	195

Air Carrier Accidents

Table 7 is a table for air carrier accidents parallel to Table 1 for the general aviation segment of the industry. While the numbers are not nearly so large, except for the fatalities resulting from the Tenerife ground collision in 1977, the percentage of weather-involved accidents is disturbing. It is perfectly obvious that of the fatal accidents 50% were weather-involved and that compared to the total air carrier accidents, almost 50% were weather-involved. Looking at all accidents, 15.9% were fatal accidents, which is about the same as in general aviation. Ignoring the Tenerife accident as an unusual and hopefully a non-recurring event, there were, on the average, 41 persons killed in each air carrier accident.

Table 7

U.S. AIR CARRIER ACCIDENTS
1973-1977

	All Accidents			Weather-Involved Accidents		
	Total	Total Fatal	Fatalities	Total	Total Fatal	Fatalities
1973	43	9	227	22	4	143
1974	47	9	467	25	4	195
1975	45	3	124	21	2	122
1976	28	4	45	12	3	45
1977	26	5	655	13	2	644
Total	189	30	1,518	93	15	1,149

In discussing air carrier accidents, it was decided not to deal with such matters as pilot ratings, flight plans, weather briefings, and weather forecasts. It was also unnecessary to discuss kinds of flying.

Table 8 lists the weather phenomena, both fatal (Table 8-a) and non-fatal (Table 8-b), most frequently cited by the Board in air carrier accidents from 1973-1977:

Table 8-a

U.S. AIR CARRIER ACCIDENTS
1973-1977

CAUSE/FACTOR TABLE: WEATHER PHENOMENA

Fatal Accidents

	Cause	Factor	Total
Thunderstorm activity	3	2	5
Low ceiling	-	4	4
Rain	-	4	4

Table 8-b

Non-Fatal Accidents

	Cause	Factor	Total
Turbulence associated with clouds and/or thunderstorms	32	1	33
Clear air turbulence	21	1	22
Thunderstorm activity	2	6	8

As in the general aviation area, it was considered of interest to review the pilot involvement as a cause or factor. In the air carrier accidents, the citations were well scattered over more than 35 different types. Table 9 deals with the top citations involved in both fatal (Table 9-a) and non-fatal (Table 9-b) accidents.

Table 9-a

U.S. AIR CARRIER ACCIDENTS
1973-1977

CAUSE/FACTOR TABLE: PILOT INVOLVEMENT

Fatal Accidents

	Cause	Factor	Total
Failed to follow approved procedures, directives, etc.	6	1	7
Improper inflight decisions or planning	3	4	7
Improper IFR operation	4	-	4

Table 9-b

Non-Fatal Accidents

	Cause	Factor	Total
Failed to follow approved procedures, directives, etc.	11	1	12
Failed to initiate go-around	6	-	6
Improper inflight decision or planning	4	1	5
Failed to maintain directional control	5	-	5

As this paper was being completed, some additional information became available which was considered to be of interest to this meeting. The information concerns a 10-year look at some of the air carrier data. For example, for the 10-year period 1968 through 1977, weather was the most frequently cited factor in the United States certificated route air carrier accidents--48.3% in all accidents and 45.3% in fatal accidents. Turbulence was cited as the most frequent causal citation when listing types of accidents--32% of the total. Experience has shown that there are fewer CAT citations than citations of turbulence associated with thunderstorms. The ratio of convective type versus CAT is generally somewhat less than two to one.

General

As most of the attendees know, the Safety Board is not a regulatory agency. One of the most important end products is the safety recommendation addressed to other agencies and organizations. Of course the recommendations are designed to reduce the likelihood of transportation accidents. They do not have the force of law, however, they are made public by many means including publication in the Federal Register. Despite the fact that the recommendations are not mandatory, you may be certain that they carry considerable weight with the recipients. We are aware that they are also of considerable interest to the Congress. As stated previously, each recommendation carries with it an indication of the priority it should be given.

Since the Board became operational in 1967, it has issued 82 recommendations related to weather, most of which have gone to the FAA and/or NOAA/NWS. A review of the status of those recommendations indicates that only 10 of them have been closed with the notation of "unacceptable action." As a "batting average," that's not bad, but the batting average, or acceptance rate, is not as important as the improvements made to facilities, services and procedures leading to an increase in aviation

safety. Obviously, the Board cannot take full credit for all of the changes, but certainly the impetus of many of them has come from the Board and can be attested to be representatives from the FAA and NOAA/NWS.

The statistics provided make it obvious that there continues to be a requirement for a decending trend in weather-involved accidents in U.S. aviation. What are the major problems standing in the way of such a downward trend? Based only on the statistics in this overview, it would appear that pilot training, particularly in the general aviation area, is one of them. Why do so many pilots continue flight in adverse weather? It could be, as the Board has said many times before, that it may well be because of the pilots' mistaken idea of their ability to cope with certain weather situations. Is it because of the lack of continued training after a pilot obtains his initial certificate? Is it the overall quality of the training? Why is he cited so often for inadequate preflight preparation or planning? Is that because of the problems associated with obtaining preflight information? Why are there so many cases in which no record of a weather briefing? Why does weather continue to be so dominant a factor in air carrier accidents? Why, despite airborne weather radar, do there continue to be so many accidents involving thunderstorms? Why so many CAT accidents?

These and many other questions will be discussed over the next three-day period in accordance with the overall objectives of the workshop. I trust that there will be agreement on some solutions to the problems raised and that the workshop will be successful in recommending prioritization and implementation of these solutions.