AAS 76-2

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-252 203

U.S. GENERAL AVIATION TAKEOFF ACCIDENTS

THE ROLE OF PREFLIGHT PREPARATION

NATIONAL TRANSPORTATION SAFETY BOARD

10 MARCH 1976

PB 252203

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. NTSB-AAS-76-2	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle: Special Study - U.S. General Aviation Takeoff Accidents - The Role of Preflight Preparation		5. Report Date: March 10, 1976
		6. Performing Organization Code
7. Author(s)		8. Performing Organization Report No.
9. Performing Organization Name and Address: Bureau of Aviation Safety, National Transportation Safety Board, Washington, D. C. 20594		10. Work Unit No. 1765
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address: NATIONAL TRANSPORTATION SAFETY BOARD, Washington, D. C. 20594		13. Type of Report and Period Covered: Special Study
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

This report analyzes general aviation takeoff accidents which occurred in 1974, with special emphasis on the involvement of preflight planning. The study discusses the most frequently referenced cause/factors in takeoff accidents in relation to the type certificate held by the pilot, and where possible, analyzes accident files which illustrate preflight preparation involvement. The study also discusses factors to consider during preflight preparation. From these discussions, remedial measures to reduce the number of takeoff accidents were formulated.

17. Key Words: Takeoff Accidents, U.S. General Aviation Preflight Planning.		18. Distribution Statement: This document is available to the public through the National Technical Information Service, Springfield, Virginia 22051	
19. Security Classification (of this report) UNCLASSIFIED	20. Security Classification (of this page) UNCLASSIFIED	21. No. of Pages	22. Price

NTSB Form 1765.2 (Rev. 9/74)

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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

SPECIAL STUDY

Adopted: March 10, 1976

U.S. GENERAL AVIATION TAKEOFF ACCIDENTS: THE ROLE OF PREFLIGHT PREPARATION

INTRODUCTION

The National Transportation Safety Board is concerned about the number of general aviation accidents which occur during takeoff, and the Board is particularly concerned that pilots may not be fulfilling their responsibilies to insure safe takeoff. Traditionally, pilots have emphasized the planning of the en route and approach-landing phases of flight; they study the weather at their distinations, the route to be taken, the en route and terminal facilities, applicable altitudes, the en route weather, and fuel consumption. However, accident data indicate that too little preparation is made for the actual takeoff of the aircraft.

The Safety Board's concern arises from its review of general aviation takeoff accident data for 1970 through 1974 and its in-depth examination of takeoff accidents for 1974. (See Tables 1 through 3.)

These accidents are significant to general aviation pilots -- annually they represent about 19 percent of all general aviation accidents and about 16 percent of all fatalities and serious injuries.

While the number of general aviation accidents has shown a downward trend in recent years, the accident and fatality/serious injury statistics indicate an increase in the percentage of accidents during takeoff. From 1970 through 1974, 822 persons died and 741 were seriously injured in 386 takeoff accidents. These accidents represented 12 percent of all fatal general aviation accidents during the study period. In 1973 and 1974, however, the percentage of fatal takeoff accidents increased to 13 and 15 percent, respectively, even though the total number of fatal accidents remained almost constant.

The most disturbing aspect of the takeoff accident problem is the high ratio of fatal accidents to total accidents. From 1970 through 1974, 10 in every 100 takeoff accidents were fatal. By comparison, only 4.4 in every 100 approach and landing accidents were fatal.

In this study, the Safety Board analyzes the causes of the takeoff accidents it reviewed and recommends action which pilots can take to reduce the rising number of accidents during the takeoff phase of flight.

TABLE 1. -- TOTAL ACCIDENTS
1970 through 1974 1/

Year	Total Accidents	Takeoff	En Route	Approach/Landing
1970	4,084	795	1,141	2,148
1971	4,008	810	1,132	2,066
1972	3,660	676	1,086	1,898
1973	3,634	705	1,122	1,807
1974	3,710	762	1,122	1,826
TOTAL	19,096	3,748	5,603	9,745

1/ Accidents such as crop and fire control related, and agricultural applications have been excluded.

TABLE 2. -- FATAL ACCIDENTS

Year	Total Accidents	Takeoff	En Route	Approach/Landing
1970	565	69	396	100
1971	590	65	430	95
1972	625	68	425	132
1973	653	82	454	117
1974	647	102	452	93
TOTAL	3,080	386	2,157	537

TABLE 3. -- TOTAL FATALITIES(F)/SERIOUS INJURIES(S)

Year	Total		Takeoff		En Route		Approach/Landing	
	F	S	F	S	F	S	F	S
1970	1,252	668	145	148	823	255	221	235
1971	1,357	701	155	133	937	280	218	265
1972	1,385	626	168	144	855	257	276	207
1973	1,360	599	179	135	898	244	238	204
1974	1,368	665	185	181	929	272	197	191
TOTAL	6,722	3,259	822	741	4,472	1,308	1,150	1,120

CAUSES OF TAKEOFF ACCIDENTS

The Safety Board's statistics clearly illustrate that most takeoff accidents are operational. 1/ The primary cause/factor was the pilot, which was cited in 87 percent of all takeoff accidents and in 90 percent of all fatal takeoff accidents. (See Table 4.) While "pilot error" is not new to any phase of flight, it is most distressing in the takeoff phase because the pilots should have had time to analyze the conditions and study the various factors which would affect the takeoff before their aircraft left the ground.

Pilot Data

Most pilots involved in takeoff accidents hold private pilot certificates. This is not surprising, since 42 percent of the pilot population holds private certificates. However, the percentage of student pilot takeoff accidents (9.9) compared to the percentage of student pilots (24 percent) reveals a significantly better safety record for the less experienced group. (Table 5.) The reasons for this lower rate are (1) student pilots operate from adequate airports and (2) since they are still supervised by an instructor pilot, the basics of good preflight discipline are stressed before each flight. Thus, student pilots are less likely to assume unnecessary risks and are less likely to be allowed to take off without considering all factors.

For new private pilots (with 100 hours or less) there is no significant increase in accident rate over student pilots. The figures indicate that a new pilot is still cautious because of his student training. Since these lower accident rates for student pilots and new private pilots are attributed, in part, to adherence to one of the basic principles of flying, the sharp increase in the accident rate (43.7 percent) for the more experienced private pilots is significant.

Pilots with less than 600 hours were involved more frequently in takeoff accidents, especially those pilots with less than 300 but with more than 100 hours. Thereafter, the totals decline significantly, especially for private certificate holders. An explanation for the peak is that by the time the pilot has accumulated more than 100 flight-hours, his confidence in his ability exceeds his actual ability. More importantly, he has not yet developed the experience necessary to evaluate the conditions which affect his aircraft.

1/ For the purpose of this study operational accidents are those where the pilot can exercise a high degree of control over the causal factors. An aircraft factors accident is one where the causal factor results from an malfunction of the aircraft.

TABLE 4. -- TAKEOFF ACCIDENTS (1974) CAUSE/FACTOR *

Cause/Factor

Operational Factors	Fatal Accidents No.	Fatal Accidents Percent	Nonfatal Accidents No.	Nonfatal Accidents Percent	Total No.	Total Percent
Pilot	90	90	555	86	645	87
Personnel	16	16	69	11	85	12
Airport Facilities	7	7	148	23	155	21
Weather	28	28	117	18	145	19
Terrain	25	25	223	34	248	33

Aircraft Factors	Fatal Accidents No.	Fatal Accidents Percent	Nonfatal Accidents No.	Nonfatal Accidents Percent	Total No.	Total Percent
Powerplants	20	20	129	20	149	20
Airframe	2	2	12	2	14	2
Landing gear	0	0	18	3	18	2
Systems	5	5	5	1	10	1
Instruments/equipment/ accessories	2	2	6	1	8	1

TABLE 5. -- INJURY INDEX BY CERTIFICATE TAKEOFF ACCIDENTS - 1974

Certificate	Total Accidents	Fatal	Serious	Minor	None	Percent
Student	76	11	3	13	49	9.90
Private	334	41	50	56	187	43.70
Commercial	178	21	25	29	103	23.30
Commercial w/Flt. Instructor	114	17	12	14	71	14.90
Airline transport	26	3	3	3	17	3.40
Airline Transport w/Flt. Instructor	27	5	2	5	15	3.50
None	9	4	1	0	4	.01
TOTAL	764	102	96	120	446	

* Generally more than one cause and factor are assigned to a single accident. Thus the figures referenced will exceed the total number of 1974 takeoff accidents and the total percent of occurrence will be greater than 100 percent.

However, those pilots holding commercial certificates do not show the marked decrease in takeoff accident frequency beyond the 600-hour point. (See Table 6.) To a degree, this is influenced by the type of operation conducted and the quality of the airstrip used. The majority of takeoff accidents experienced by commercial pilots occurred during noncommercial, pleasure flying operations (Table 7); since there were no commercial or economic reasons to encourage pilots to attempt flights in the face of potential takeoff hazards, pilot judgment, planning, and overconfidence appear to be significant to the cause of the accident.

Pilot Involvement

The Safety Board divides the broad pilot cause/factor category into 51 detailed cause/factors. In the accident files reviewed during this study, "inadequate preflight preparation and/or planning," "failed to maintain/obtain flying speed," "failed to maintain directional control," "failed to abort takeoff," "selected unsuitable terrain and lack of familiarity with aircraft" were cited as cause/factors more than any others, and represented over 50 percent of all fatal takeoff accidents. The fact that "inadequate preflight planning and/or preparation," "selected unsuitable terrain" and "lack of familiarity with aircraft" are a result of a lack of pilot preparation further emphasizes the need for better preflight planning.

An analysis of the accident files which list the pilot as a cause/factor revealed definite patterns regarding the type of accidents which occur during the takeoff phase of flight and the types of pilots involved.

Commercial certificate holders were involved in the highest percentage of fatal takeoff accidents. The type of accident was generally one in which the pilot was aware of the weather, terrain, or aircraft factors pertinent to the particular flight, yet proceeded without attempting to reduce the hazard potential. Takeoff accidents experienced by this group did not stem from a lack of basic skills. For example, few accidents were caused by improper operation of flight controls or failure to maintain directional control. (See Tables 8 through 14.) Commercial pilots were involved in accidents resulting from a loss of directional control of their aircraft in 17.8 percent of this type of accident. Student and private pilots, on the other hand, were involved in 72 percent of these accidents. Although this ratio is expected because of the experience factor, the fact that commercial pilots had 39 percent of the inadequate preflight preparation accidents is not expected. The percentage represents 78 accidents, 9 of which were fatal.

The thoroughness of the preflight preparation is the keynote of the flight. For this reason, the more experienced pilots would be expected to recognize this critical stage and act accordingly.

TABLE 6. -- TOTAL AIRCRAFT ACCIDENTS:

TOTAL PILOT TIME
1974

Time	Student	Private	Commercial	ATP	Commercial w/Flt. Inst.	ATP w/Flt. Inst.	None	Unknown	Total
Hrs.									
Less than 100	64	52	2			2	5	1	126
100-299	9	124	9		2		1		145
300-599	1	62	25	1	15		1		105
600-899		22	14		20				56
900-1,199		16	14		6				36
1,200-1,499	1	7	15		15				38
1,500-1,799		8	17		5				30
1,800-2,099		6	6	1	8			1	22
2,100-2,399	1	4	12	1	1	1			20
2,400-2,699		5	8	1	4				18
2,700-2,999		1	4	1	6	3			15
3,000 Plus	3	27	52	21	32	21			156
Not Reported	3	3	1			2	3	1	13
TOTAL	82	337	179	26	114	29	10	3	

TABLE 7. -- KIND OF FLYING

TABLE 7. -- KIND OF FLYING

Type of Flying	Student	Private	Commercial	Commercial w/Flt. Inst.	Airline Transport	Airline Transport w/ Flt. Inst.	None	Unknown
Instructional								
Dual			5	40		7		
Solo (supervised)	21		1					
Check	1	2	1	1		2		
Training	22	1	2	1	1			
Noncommercial								
Pleasure	20	273	83	42	9	5	5	1
Practice	9	5	5	3	1			
Business (Nonprofessional Pilot)	1	34	17	7	4			
Corporate/Executive (Professional Pilot)			1	1	3	3		
Commercial								
Air Taxi-Passenger			17	8	3	2		
Air Taxi-Cargo			3	3	4	1		
Miscellaneous								
Demonstration		1	3	2		2		
Ferry		5	7	4		1		

TABLE 8. -- PILOT CAUSE/FACTORS
TAKEOFF ACCIDENTS-1974

Detailed Cause/Factor	Fatal Accidents	Nonfatal Accidents	Total
Inadequate preflight preparation and/or planning	26	171	197
Failed to obtain/ maintain flying speed	50	142	192
Failed to maintain directional control	0	84	84
Failed to abort takeoff	5	71	76
Selected unsuitable terrain	2	62	64
Lack of familiarity with aircraft	11	38	49

TABLE 9. -- INADEQUATE PREFLIGHT PREPARATION/PLANNING
TAKEOFF PHASE--1974

Certificate	Fatal	Serious	Minor	None	Accidents	Percent
Student	2		3	3	8	4.1
Private	13	19	19	45	96	48.7
Commercial	5	11	8	26	50	25.4
Commercial w/ Flt. Inst.	4	3	2	19	28	14.2
Airline Transport	2	2	1	6	11	5.6
Airline Transport w/Flt. Inst.				4	4	2.0
Accidents	26	35	33	103	197	
Percent	13.1	17.8	16.9	52.3		

TABLE 10. -- FAILURE TO OBTAIN/MAINTAIN FLYING SPEED
TAKEOFF PHASE--1974

Certificate	Fatal	Serious	Minor	None	Accidents	Percent
Student	9	1	2	5	17	8.8
Private	20	21	20	41	102	53.1
Commercial	11	5	5	18	39	20.3
Commercial w/ Flt. Inst.	7	6	5	7	25	13.0
Airline Transport		1		1	2	1.1
Airline Transport w/Flt. Inst.	1	1		3	5	2.6
None	2				2	1.1
Accidents	20	35	32	75	192	
Percent	26	18.2	16.7	39.1		

TABLE 11. -- FAILURE TO MAINTAIN DIRECTIONAL CONTROL
TAKEOFF PHASE-1974

Certificate	Fatal	Serious	Minor	None	Accidents	Percent
Student		1	4	21	26	30.9
Private		1	3	31	35	41.7
Commercial			1	8	9	10.7
Commercial w/ Flt. Inst.			1	5	6	7.1
Airline Transport				2	2	2.4
Airline Transport w/Flt. Inst.		1	1	2	4	4.8
None				1	1	1.2
Unknown				1	1	1.2
Accidents		3	10	71	84	
Percent		3.6	11.9	84.5		

TABLE 12. -- FAILURE TO ABORT TAKEOFF
TAKEOFF ACCIDENTS-1974

Certificate	Fatal	Serious	Minor	None	Accidents	Percent
Student	1		1	5	7	9.2
Private	1	7	8	24	40	51.3
Commercial	2	1	2	12	17	21.1
Commercial Flt. Inst.	1		4	5	10	13.2
Airline Transport				2	2	2.6
Airline Transport w/Flt. Inst.						
Accidents	5	8	15	48	76	
Percent	6.6	10.5	19.7	63.2		

TABLE 13. -- SELECTION OF UNSUITABLE TERRAIN
TAKEOFF ACCIDENTS-1974

Certificate	Fatal	Serious	Minor	None	Accidents	Percent
Student			1	4	5	7.8
Private	1	3	11	18	33	51.6
Commercial		1	2	13	16	25.0
Commercial w/ Flt. Inst.				7	7	10.9
Airline Transport						
Airline Transport w/Flt. Inst.	1			2	3	4.7
Accidents	2	4	14	44	64	
Percent	3.1	6.3	21.9	86.8		

TABLE 14. -- LACK OF FAMILIARITY WITH AIRCRAFT
TAKEOFF ACCIDENTS-1974

Certificate	Fatal	Serious	Minor	None	Accidents	Percent
Student	2		2	7	11	22.5
Private	3	4	3	8	18	36.7
Commercial	4	1	1	8	14	28.6
Commercial w/ Flt. Inst.				3	3	6.1
Airline Transport	1				1	2.1
Airline Transport w/Flt. Inst.	1				1	2.1
Unknown		1			1	2.1
Accidents	11	6	6	26	49	
Percent	22.4	12.2	12.2	53.1		

The second area in which commercial pilots were involved heavily was the cause/factor "failed to obtain or maintain flying speed." An analysis of accidents reveals that this category was cited as the probable cause of the accident although a condition developed which prevented the aircraft from reaching flying speed. This cause was cited in 64 takeoff accidents in 1974, 18 of which were fatal. The associated factors accompanying a failure "to obtain or maintain flying speed" accident were usually in the area of poor judgment or improper procedures. However, in fatal accidents, these classifications were joined frequently by the lack of familiarity with the aircraft.

The "lack of familiarity with aircraft" cause/factor category was cited in 49 accidents in 1974, which resulted in 11 fatalities. Pilots with commercial certificates were involved in 34 percent of these total accidents and 45 percent of the fatal accidents. By comparison, private pilots accounted for 36 percent and student pilots 22 percent of the lack of familiarity accidents. The willingness of an experienced pilot to attempt a flight in an aircraft with which he is not completely familiar cannot be rationalized. The commercial certificate represents a significant aviation achievement and a demonstrated level of skill. A commercial pilot should objectively evaluate the skills required to operate equipment with which he is not familiar and assure himself that he is qualified in it. At a very minimum, a flight instructor should be utilized to insure proper training. However, there appears to be a trend, in the cases analyzed, for pilots to rely on their past experience as a substitute for a proper transition program.

Generally, takeoff accidents involving pilots with commercial certificates referenced a cause or a factor related to inadequate preflight planning or poor judgment. Often the accidents were characterized by pilots selecting a runway which was too short, according to the operators manual, for the intended operation, an overgrossed aircraft, or a failure to observe approved procedures. One of the most distressing, yet not uncommon, cause/factors was the operation of an aircraft with a known deficiency.

The following case studies illustrate some of the more blatant errors which led to fatal takeoff accidents involving commercial pilots.

Case 1. -- The pilot possessed a commercial certificate, with single-multiengine land and sea, instrument and helicopter ratings. He had 2,400 hours of flying time. After attempting unsuccessfully to start the left engine of the PA-23, the pilot elected to take off on one engine. The left engine was not feathered before takeoff. The runway was 4,000 feet long and had a loose gravel surface. The aircraft struck a tree well beyond the departure end of the runway and crashed.

Case 2. -- The pilot possessed a commercial certificate with an instrument rating. He had 248 total hours. A takeoff was attempted in an American Avco AA-1B from a sod strip 1,443 feet long. The first half of the runway sloped uphill, and the entire runway was covered with 6-inch grass. There was an 8-knot tailwind. The aircraft struck a 50-foot tree, 2,040 feet from the start of the takeoff roll. The owners manual stated that, given the wind conditions present and on a hard surface runway, it would require 1,915 feet to clear a 50-feet obstacle. The aircraft was 11 pounds over the allowable maximum gross takeoff weight.

Case 3. -- This accident involved a Beech-99 commuter and a crew consisting of an Airline Transport Pilot (ATP) with more than 6,300 hours, and a commercial pilot with about 3,400 total flight-hours. The flight was 10 minutes late departing, and the crew appeared to be attempting to make up the lost time. The aircraft was taxied directly to the active runway, and no checklist was accomplished.

According to the captain, who survived the crash, his aircraft pitched up while on initial climbout. He reduced power and called for additional flaps. However, the addition of flaps aggravated the pitched-up condition. This additional pitch, coupled with an installed elevator control lock, caused the aircraft to crash.

Case 4. -- A commercial pilot with a flight instructor's certificate with over 1,000 hours of flight time, unsuccessfully attempted a takeoff in a Cessna 150 from a 800-foot sod strip. The strip was rough and uneven, and there was a 5-knot tailwind. The departure end of the runway was lined with low trees. The Cessna 150 owners manual required a 735-foot takeoff roll on a hard surface runway and no wind in order to clear the referenced obstacles.

Case 5. -- A commercial pilot, with 3,200 flight-hours attempted to take off in a Cessna 182 from a hard-surface road which had a 600-foot portion usable for takeoff. The aircraft was near the maximum allowable gross weight for takeoff. There was a high density altitude.

The aircraft struck 30-foot high power lines located 140-feet beyond the usable end of the road. The operators manual indicated that 1,145 feet was required to take off and clear 30-foot obstacles under the prevailing conditions.

An analysis of fatal takeoff accidents and the data in Tables 8 through 14 revealed that holders of private certificates were involved in the majority of takeoff accidents in each cause/factor category. While "failure to obtain flying speed" and "inadequate preflight preparation" were cited most frequently as probable causes, no other cause was mentioned in significant numbers in 28 fatal accidents analyzed. The causes in the remaining accidents and the accompanying factors did not reveal a pattern of cause/factor relationships. However, this group had a significant number of weather-involved cause/factors. This is related to the fact that, in the 28 fatal accidents, only two pilots were instrument rated. Except for one accident, the pilots involved in weather-related takeoff accidents had more than 200 hours but less than 500 hours of flying time. An explanation for these figures is that the pilots felt confident utilizing minimum VFR experience in actual instrument conditions. Four weather-related accidents involved ceilings of less than 500 feet and visibilities ranging from 1/2 to 2 miles.

The wide range of cause/factors referenced in private pilot-involved takeoff accidents is headed by "inadequate preflight preparation" and "failure to obtain or maintain flying speed." The remaining causes and supporting factors fall into three general categories: (1) Poor judgment, (2) improper procedures, and (3) incorrect decisions. It is significant that the involvement of high obstructions, unsuitable terrain, and powerplant failures for undetermined reasons are minimal in these accidents.

The expected lack of experience on the part of the private pilots involved in the accidents can explain the judgment-and procedure-related accidents. The noticeable lack of high obstructions and unsuitable terrain factors indicates that possibly this group of pilots is not electing to operate from airports or airstrips which are more demanding on the pilot and the aircraft. Possibly, a correlation exists between operations from suitable airports and (1) terrain and obstacle involvement and (2) powerplant failure for undetermined reasons.

A suitable airport affords the pilot the benefit of a normal acceleration and climb out. More importantly, rather than have his attention fixed on a short field takeoff in order to clear obstacles, the pilot is able to concentrate on his pretakeoff checks. This reduces the possibility of incorrect flap settings, and the improper use of carburetor heat or other conditions which could appear to be a powerplant malfunction.

Although pilots holding student certificates represent 24 percent of the total pilot population, with only one exception they were involved in fewer takeoff accidents then any other group. This is a direct result of the controlled environment in which the student pilot operates. The fact that student pilots were involved in only 4 percent of the 197 accidents caused by inadequate preflight planning or preparation emphasizes the value of a disciplined attitude toward this stage of flight.

Except for directional-control accidents and accidents resulting from a lack of familiarity with the aircraft, student pilots generally were not cited to any extent in takeoff accidents. In a study of 75 fatal takeoff accidents, student pilots were involved in 10; 4 of these pilots had accumulated from 150 to 2,300 hours, thus, their experience exceeded that of normal students. All but one assigned probable cause was a "failure to obtain/maintain flying speed." More than half of these cases also cited a premature liftoff as a contributing factor.

Personnel Involvement

Although there were 38 detailed cause/factors in the personnel category, the 3 cause/factors listed in Table 15 were involved in the largest number of total accidents. The personnel cause/factor was mentioned in 107 takeoff accidents. Since this represents less than 7 percent of the accidents in the pilot cause/factor category, it does not represent a significant problem area.

The cause/factor "inadequate maintenance and inspection" appeared in 35 percent of all personnel cause/factor related accidents. An analysis of these cause/factors disclosed that the necessary corrective action was within the perview of maintenance personnel and, for the most part, the accident-producing deficiencies were correctable had proper preflight procedures been employed.

In this area, accidents involving flight instructors were referenced only seven times, and airport supervisory personnel were listed as a cause or a factor only eight times in 1974.

TABLE 15. -- PERSONNEL CAUSE/FACTORS
TAKEOFF ACCIDENTS-1974

Cause/Factor	Fatal Accidents	Nonfatal Accidents	All Accidents
Inadequate maintenance and inspection	6	31	37
Improper maintenance (Maintenance personnel)	3	5	8
Poor inadequate design	1	6	7

Airport Facilities

The most significant detailed cause/factor referenced in airport facility related accidents is "Other" airport conditions. (See Table 16.) This area encompasses any aspect of the airport environment, except the nine cause/factors currently identified, which was involved in the accident. Examples of accidents in this causal area are striking an aircraft which was parked too close to a runway, running into a fence or a tree located in the departure area, or striking cars parked at the end of a runway.

The airport facilities category was mentioned as a factor in 177 takeoff accidents. The most common probable causes cited in these accidents were: (1) Inadequate preflight preparation, (2) failure to maintain directional control, and (3) delayed action in aborting takeoff. The probable causes "premature liftoff" and "failed to obtain/maintain flying speed" also were cited frequently.

A probable cause of inadequate preflight preparation is supported by a factor, such as high vegetation, snow/slush on the runway, or a soft runway. A key to avoiding these accident would have been to consider the runway condition. However, an analysis of these accidents revealed that unsafe airport conditions are significant in accidents where the probable cause involves a failure to maintain directional control or premature liftoff/failure to obtain flying speed. Except for those accidents where unfavorable wind conditions were predominately mentioned, an encounter with high grass, a rough or uneven runway, or a soggy runway surface precipitated the accident. These events, of course, reflect the pilot's failure to consider properly the takeoff requirements for his aircraft.

While student and private pilots with less than 200 total hours were mentioned more frequently in accidents involving a loss of directional control as a result of an airport-facility factor, the other probable causes show no clear pattern with regard to the certificates held. In the accidents reviewed, experience and type of certificate apparently did not cause pilots to be more aware of the hazards referenced in Table 16. However, pilots with more flying experience were able to perform more adequately when it became necessary to take emergency action.

The type of airport was a significant factor in airport-facilities related accidents. Larger airports, with more than one runway and with good obstruction clearance, were not cited frequently. Even smaller airports with a single runway but with a well-planned airport environment were relatively free from this type of accident. A well-planned runway environment would include, in part, a runway oriented into the prevailing wind, properly constructed departure areas which do not require abrupt maneuvers to clear obstacles, the absence of buildings or terrain features which would disrupt an otherwise normal wind pattern, and level, well maintained runways. This type of airport would not make a pilot more careful, but it would eliminate many of the hazards which can lead to accidents which result from inadequacies in airport facilities.

Since more airport-related takeoff accidents occur at airports which require greater pilot skill, a pilot should identify the hazards and take proper actions before takeoff; but a review of these accidents revealed that pilots often do not do so. When pilots stated they had noted an unusual runway condition (high grass, ice/slush, and uneven surface) few were able to state the anticipated effect the condition would have on the takeoff. Even fewer pilots admitted to being cognizant of obstructions in or adjacent to the departure path, or of the effect the existing wind would have on a climbing turn which would be required to avoid the obstacles.

TABLE 16. -- AIRPORT FACILITIES CAUSE/FACTOR
TAKEOFF ACCIDENTS-1974

Cause/factor	Fatal Accidents	Nonfatal Accidents	All Accidents
Other airport conditions	4	77	81
High vegetation	1	20	21
Soft runway	1	17	18
Snow windrows		15	15
Wet runway	1	13	14

Weather

Weather has always played a significant role in aviation and in aviation accidents. Weather was referenced in 19 percent of the takeoff accidents reviewed. The weather cause/factor included 14 detailed cause/factors, representing 145 accidents. (See Table 17.)

"Unfavorable wind conditions" and "high density altitude," were cause/factors in almost 69 percent of the total weather accidents. (See Table 17.) Unfavorable wind conditions include not only high wind conditions and excessive crosswinds, but also the improper evaluation of existing wind. This category includes accidents in which an aircraft strikes an obstacle on initial climb as a result of taking off with a tailwind. Another frequent type of wind-involved accident was the case in which a pilot made a turn shortly after liftoff, but turned downwind. The sudden loss of lift at a low airspeed can cause an aircraft to settle suddenly.

Although pilots can make objective determinations when faced with visible icing conditions, on a sunny, windy day, hazards are not as obvious. As a result, he is more likely to match his skill with the elements. The same logic is often misapplied regarding density altitude.

However, it is suspected that this condition receives less attention than other weather elements because of its nature and lack of visual cues. An encouraging fact concerning weather related takeoff accidents is that there was only one instance in 1974 where an accident resulted from involvement with a thunderstorm.

While weather was associated with 145 takeoff accidents in 1974, it was not listed as the cause of any of the 28 fatal weather-related accidents. Furthermore, weather was a cause in only 7 of the 117 nonfatal takeoff accidents. All nonfatal accidents where weather was a cause reflect unfavorable wind conditions or sudden windshift. The factors most frequently mentioned in fatal accidents were low ceilings, fog, and high density altitude.

In analyzing the accidents where unfavorable wind conditions were involved, it was apparent that the most frequently cited accompanying causes were the failure to obtain/maintain flying speed and improper compensation for wind conditions. The failure to maintain flying speed accidents generally resulted in a collision with obstacles beyond the airport boundary. These accidents were the result of improperly using the wind (i.e. turning in the wrong direction shortly after takeoff) or simply attempting to lift the aircraft off the runway at a point where, under normal wind conditions, the pilot would expect the airplane to fly. In each case, if the pilot had considered the effect of the wind on the aircraft before takeoff he could have prevented the accident. This extra planning would also have caused several pilots not to takeoff in 30- to 50-knot winds.

As would be expected, unfavorable wind conditions presented the greatest hazard to holders of private pilot certificates. In many of the accidents caused by unfavorable wind conditions involving student pilots, the student was allowed by his instructor pilot to attempt a solo flight in excessive wind conditions. Student and private pilots were involved in the greatest percentage of accidents where directional control was lost because of unfavorable wind conditions. Pilots with commercial certificates were normally affected by poor wind conditions only when operating from less than optimum airports. The resultant accidents generally were accompanied by a poor runway condition or high obstructions in the departure area.

TABLE 17. -- WEATHER RELATED TAKEOFF ACCIDENTS-1974

Cause/Factor	Fatal Accidents	Nonfatal Accidents	Total
Unfavorable wind conditions	4	53	57
High density altitude	7	36	43
Fog	9	3	12
Conditions conducive to carburetor induction system icing	2	9	11
Low ceiling	9		9
TOTAL	31	101	132

Terrain

Terrain was referenced as a cause in 66 takeoff accidents and a factor in 182 additional accidents. High obstructions figured as a cause or a factor in more total accidents than any other terrain cause/factor.

Accidents involving unsuitable terrain as a cause or a factor represent a disregard for aviation safety. While it is possible to overlook many aspects of preflight preparations, the fact remains that the pilot must see the runway and taxi onto it before takeoff can begin. He is afforded ample opportunity to note the condition of the runway surface and the threat imposed by surrounding obstructions. However, unsuitable terrain was involved to some degree in 33 percent of all takeoff accidents in 1974. This percentage represents 25 fatal and 223 nonfatal accidents. The most common cause/factor accompanying terrain-involved accidents was the failure to obtain/maintain flying speed. Frequently, one or more factors led to the degradation of the runway surface or departure path, or both, and ultimately contributed to the accident. Each of the accident files reviewed indicated that while the pilots involved knew of the terrain features, they were not sufficiently alarmed to challenge the adequacy of the takeoff requirements.

TABLE 18. -- TERRAIN CAUSE/FACTOR
TAKEOFF ACCIDENTS-1974

Cause/Factor	Fatal Accidents	Nonfatal Accidents	Total Accidents
High obstructions	21	92	113
Rough/uneven terrain		46	46
Soft ground	1	24	25
High vegetation		21	21

Powerplants

The powerplants cause/factor is one aircraft factor which was referenced in a significant number of takeoff accidents. (See Table 19.) The exceedingly low aircraft factors incident rate is directly attributable to the quality of the general aviation aircraft and the level of maintenance existing at most general aviation airports and fixed-base operations. The most referenced cause/factor in the powerplants cause/factor area was powerplant failure for undetermined reasons. This cause/factor was responsible for 63 of the 149 powerplant-related accidents. The subsequent accident investigations did not produce any evidence of malfunctioning components or actual material failure of the powerplants in question. An analysis of the high recurrence rate of this detailed cause/factor would be speculative at best. However, the number of accidents where this detailed cause/factor appears is inconsistent in frequency to any other single aircraft cause/factor.

There are many pilot inputs to powerplant operation which would cause the appearance of a partial powerplant failure, or that the engine was not developing full power. These pilot inputs include operations of throttles, adjustment of the mixture or carburetor heat. Other effects on aircraft performance include a tailwind, high density altitude or high gross weight, and improper flap usage or rotation/climb procedures.

A review of the fatal takeoff accidents involving powerplants failure for undetermined reasons revealed that, in almost every accident, there were additional factors which may have been the cause of the failure.

In one case, the pilot made several successful touch and go takeoffs without utilizing carburetor heat. The accident occurred after a normal takeoff roll and climb to 200 feet, when the engine surged and then stopped. The investigation revealed no preimpact damage. The meteorological conditions favored the formation of carburetor ice with a 4° temperature-dew point spread. Although the temperature was in the 68° to 75° range, the owners manual stated that the temperature in the carburetor mixing chamber can drop 70° below the temperature of the incoming air.

A second accident involved a Cessna 337. Witnesses reported the rear propeller was not turning on the takeoff roll. The aircraft appeared to be pulled off the runway, in spite of the apparent slow speed and lack of acceleration. As the pilot attempted to return to the runway, the aircraft stalled and crashed. The gear was extended and the rear propeller was unfeathered. No preimpact damage was discovered. The owners manual recommends that, on takeoff, the rear engine be advanced to takeoff power and its power output verified before the front engine is advanced to takeoff power.

A third example where "powerplant failure for undetermined reasons" was cited involved a commercial pilot with a flight instructor's rating. Witnesses in the control tower stated that the aircraft appeared to accelerate slowly and exhibited practically no rate of climb. The aircraft passed the airport boundary at less than 100 feet above ground level, settled slightly, and struck high voltage lines 60 feet above the ground. The subsequent investigation revealed no preimpact damage to the engine. However, the aircraft was determined to be 23 pounds over the maximum gross takeoff weight. In addition, the airport elevation was 4,400 feet and the density altitude was reported to be 7,300 feet.

Two distressing aspects of takeoff accidents resulting from undetermined powerplant failures are (1) over 50 percent of the fatal accidents involve an effort by the pilot to turn back to the airport in spite of an average altitude of 100 to 300 feet AGL and (2) the disproportionately high percentage of commercial pilots involved. While there is no logical explanation for these facts, it appears reasonable that a pilot who initiates a takeoff without considering all the factors influencing the flight would most likely be unprepared when an engine failure or an inability to develop takeoff power is experienced.

TABLE 19. -- POWERPLANTS CAUSE/FACTOR
TAKEOFF ACCIDENTS-1974

Detailed Cause/Factor	Fatal Accidents	Nonfatal Accidents	Total
Powerplant failure for undetermined reasons	8	55	63
Fuel system carburetors	1	10	11
Ignition System-sparkplugs	3	5	8
Ignition system-magnetos	3	2	5
Propeller blades	2	4	6
TOTAL	17	76	93

FACTORS TO CONSIDER DURING PREFLIGHT PREPARATION

The importance of a thorough preflight preparation which considers possible hazards to takeoff cannot be overemphasized. However, many pilots continue to skim over many of the important elements of a preflight. The following elements which should be carefully considered continue to emerge as factors in takeoff accidents.

Windshear

Windshear is a change in the direction or the speed of the wind, or both, which occurs in a short distance in the atmosphere. As such, it represents a change in the relative wind acting on the airfoils of an aircraft. If this occurs near the ground, it is described as a low-level windshear and it represents a potential hazard to aircraft which are taking off, or are in the initial climb. During the initial climb phase of flight, most general aviation aircraft are in a high drag configuration with small speed margin and with little additional power available for acceleration and climb. As a result, a pilot must recognize quickly the onset and effect of the windshear and take the proper actions.

Windshear is an insidious hazard since: (1) It currently cannot always be forecast or seen beforehand, (2) it usually is not reported, and (3) an aircraft can be well in its grips before the pilot becomes aware of it. In order to anticipate the existance of a shear, pilots should understand the conditions which can cause it.

Frontal activity may produce more windshear conditions than any other factor; yet unlike the thunderstorm-produced shear, it doesn't provide as many clues. However, if pilots are aware of certain information in relation to a front, they will be better prepared to assess the likelihood of a shear condition. A sharp shear gradient should be anticipated if (1) the front is moving in excess of 30 knots, and (2) the temperatures on either side of the front differ by more than 10°F. If either of these conditions exists, pilots should expect a shear behind a cold front or ahead of a warm front.

Thunderstorms are also major producers of windshear with pronounced vertical currents (updrafts and downdrafts). Thunderstorms may produce shear and vertical currents up to 10 miles from the main cell. This factor should always be considered before trying to out-run or penetrate a storm on takeoff or landing.

Temperature inversions, obstructions such as buildings or hills near departure paths and runways, and thermals must also be considered as potential shear producers during pretakeoff preparations.

A windshear is dangerous to an aircraft when it represents a change of wind velocity which is more than the aircraft can adjust to initially. The most critical type of shear for takeoff is a decreasing headwind or increasing tailwind. These conditions will cause an abrupt decrease in indicated airspeed while the aircraft pitches down. If the aircraft has little additional power to compensate for the unexpected shear, the result may be an inability to obtain or maintain flying speed.

The opposite is, of course, an increasing headwind or decreasing tailwind. These will be evidenced by an increased indicated airspeed; a tendency for a pitchup of the aircraft would result in a stall.

The final question concerning windshear is how to avoid it. The best way is to look for it. Part of your preflight planning should be devoted to searching for indications of a shear. Pilots at the airport and local controllers, if available, should be asked. If you suspect a shear, recheck the required runway length to insure that you can make a faster-than-normal takeoff roll to carry extra climbout airspeed. Review weight and balance and the density altitude figures and be aware of hazards the surrounding terrain may present.

Balance

A pilot must not only determine the takeoff weight of his aircraft, but also he must assure that the load is arranged to fall within the allowable center of gravity (c.g.) for the aircraft.

The c.g. is the balance point for the entire aircraft. The forward limit is usually near the forward portion of the wing root. Each owners manual provides instructions on the proper method to determine if the aircraft loading meets the balance requirements. The pilot should determine routinely the balance of his aircraft, since it is possible to be within the gross weight limits and exceed the c.g. range.

An aircraft which exceeds the forward c.g. limits places heavy loads on the nose wheel, or in a conventional landing gear aircraft, may cause a nose over. Furthermore, performance may be significantly decreased and the stall speed may be much higher.

An aircraft which is loaded in such a manner that the c.g. exceeds the rear-most limit will have decreased static and dynamic longitudinal stability. This condition can produce sudden and violent stall characteristics and can seriously affect recovery from the stall. The aircraft will also be much more susceptible to overstress by its reactions to even light control column forces.

Gross Weight

The gross weight of an aircraft is important because it is a basis for determining the takeoff distance. If gross weight increases, the takeoff speed must be greater to produce the greater lift required for takeoff.

The takeoff distance varies with the square of the gross weight. As an example, for an aircraft with a relatively high thrust-to-weight ratio, a 10-percent increase in takeoff gross weight would cause (1) a 5-percent increase in the speed necessary for takeoff velocity, (2) at least a 9-percent decrease in acceleration, and (3) at least a 21-percent increase in takeoff distance. For aircraft with relatively low thust-to-weight ratios, the figures are slightly higher.

Operations within the proper gross weight limits are outlined in each operators manual. Gross weight and c.g. limits must be considered during preflight preparation. While a small excess of gross weight is not usually a cause of an accident, it can be a contributing factor if coupled with any of a number of factors which adversely affect the ability of an aircraft to take off and climb safely. While these factors range from the elevation of the airport to the condition of the runway, the responsibility for considering these factors before each flight rests with the pilot.

Ice and Frost

Ice or frost can affect the takeoff performance of an aircraft significantly. In fact, pilots should never attempt takeoffs with any accumulation of ice or frost their aircraft.

Most pilots are aware of the hazards of ice on the wings of an aircraft. However, the effects of a hard frost are much more subtle. This is a result of increased roughness of the surface texture of the upper wing, and may cause a 5-to 10-percent increase in the airplane is stall speed. As a result, an airplane with frost on its wings may not be able to become airborne at the takeoff speed specified in the manual because of a lack of necessary lift. If it does become airborne, the aircraft could have an insufficient margin of airspeed above stall such that gusts or even the turning of the aircraft could result in a stall.

Density Altitude

Aircraft instruments are calibrated to be correct under one set of conditions. Standard conditions represent theoretical sea level conditions: 59°F and 29.92 inHg. As higher elevations are reached, both the temperature and the pressure decrease. Thus, density altitude is determined by compensating for pressure altitude and temperature variances from the standard conditions.

A pilot must remember that, as density altitude increases, there is a corresponding decrease in the power delivered by the engine and the propeller. This may cause the required takeoff roll to increase by up to 25 percent for every 1,000 feet of elevation above se level.

The International Civil Aviation Organization (ICAO) recommends that the length of a runway for standard conditions at sea level be increased by 7 percent for every 1,000 feet of elevation above m.s.l. This corrected length should be increased further at a rate of 1 percent for every 1°C that the airport reference temperature exceeds the temperature of the standard atmosphere for that elevation. Thus a 4,000-foot runway at standard conditions would have to be 18 percent longer, or 5,720 feet, at an elevation of 1,000 feet in an area where the airport reference temperature was 70°F.

The most critical conditions of tekeoff performance are the result of a combination of heavy loads, unfavorable runway conditions, winds and high temperatures, high airport elevations, and high humidity.

The following data, taken from a Cessna 172 Owners Manual, illustrate the effect of altitude and temperature increases on the takeoff roll.

TAKEOFF DATA

Gross Weight	Head Wind	At Sea Level + 59°F		At 5,000 Ft. + 41°F		At 7,500 Ft. + 32°F	
		Ground Run	Total to Clear 50 Ft. OBS	Ground Run	Total to Clear 50 Ft. OBS	Ground	Total to Clear 50 Ft. OBS
(lbs.)	(Kn)						
2,300	0	865	1,528	1,255	2,480	1,565	3,855
	10	615	1,170	920	1,955	1,160	3,110
	20	405	850	630	1,480	180	2,425

Note 1. Increase distance 10 percent for each 25°F above standard temperature for particular altitude.

The proper accounting for the pressure altitude (field elevation is a poor substitute) and temperature is mandatory for the accurate prediction of takeoff data. The required information will always be listed in the owners manual and should be consulted before each takeoff, especially if operating at a high density altitude or with a heavily loaded aircraft.

Effect of Wind

The effect of wind on the takeoff distance of an aircraft is well known. Every owners manual gives representative wind data and corresponding ground roll distances. A headwind which is 10 percent of the takeoff airspeed will reduce the no-wind takeoff distance by 19 percent. However, a tailwind which is 10 percent of the takeoff airspeed will increase the no-wind takeoff distance by about 21 percent.

Although this consideration is basic to a successful takeoff, the number of accidents involving the selection of the wrong runway for the existing wind and taking off into unfavorable wind conditions indicates a need for many pilots to reevaluate their preflight planning to insure that the effect of wind is considered fully.

Runway Condition

There are more than 12,000 airports in the United States, each with runways having various surface compositions, slopes, and degrees of roughness. Takeoff acceleration is affected directly by the runway surface conditions and, as a result, it must be a primary consideration during preflight planning.

Most owners manuals list takeoff data for level dry, hard-surfaced runways. However, the runway to be used is not always hard surfaced and level. Consequently, pilots must be aware of the effect of the slope or gradient of the runway, the composition of the runway, and the condition of its surface. Each of these can contribute to a failure to obtain/maintain flying speed, especially if operating a heavily loaded aircraft in a high density altitude.

The effective runway gradient is the maximum difference in the runway centerline elevation divided by the runway length. The FAA recognizes the effect of runway gradient on the takeoff roll of an aircraft and has published limits on the maximum gradients. For general aviation VFR airports, the maximum longitudinal runway grade is 2 percent and the longitudinal runway grade change is 2 percent maximum. Furthermore, the takeoff length for a runway must be increased an additional 20 percent for each 1 percent of change in effective gradient to a maximum allowable effective gradient change of 2 percent.

Since the runway gradient has a direct bearing on the component weight of the aircraft, a runway gradient of 1 percent would provide a force component along the path of the aircraft which is 1 percent of gross weight. In the case of an upslope, the additional drag and rolling friction caused by a 1-percent upslope can result in a 2-percent to 4-percent increase in the takeoff distance and subsequent climb.

Frequently the only runway at an airport has a slope. When determining which direction to use for takeoff, pilots must remember that a direction uphill, but into a headwind, is generally preferred to a downwind takeoff on a downsloping runway.

It is difficult to predict the retarding effect on the takeoff run that water, snow/slush, mud, or long grass on the runway will have. However, these factors can be critical to the success of a takeoff. Since the takeoff data in the owners manual is predicated on a dry, hard surface runway, each pilot must develop his own guidelines for this foreign matter.

The Cessna 172 owners manual states "For operation on a dry, grass runway, increase distances (both 'ground run' and 'total to clear 50 ft. obstacle') by 7 percent of the 'total to clear 50 ft. obstacle figures'." The Pilots Handbook of Aeronautical Knowledge (Advisory Circular 61-23A) states that grass, sand, mud, or deep snow can easily double the takeoff distances. The pilot is responsible for determining this effect in light of existing conditions.

The Safety Board believes that the foregoing elements have such an accident prevention potential that they should be foremost in the minds of pilots planning a flight. This consciousness of preflight planning factors can be instilled by (1) continued training during the student phase and (2) incorporating a review of these elements during biennial flight reviews. Finally, the Federal Aviation Administration should use this subject area as a basis for an accident prevention program which would emphasize and explain the importance of these factors.

CONCLUSIONS

Without question, preflight preparation is the foundation of safe flying. While the Safety Board believes that virtually every pilot accepts this statement as valid, accident statistics of recent years indicate that adequate preflight preparation is lacking. As a result, while the number of general aviation accidents and approach and landing accidents has declined, takeoff accidents have increased. Finally, the continued appearance of inadequate preflight planning or preparation as a cause or a factor in takeoff accidents underscores the individual pilot as the chief offender and, at the same time, the means by which an effective accident-prevention program can be implemented.

The Safety Board does not infer that the majority of takeoff accidents are attributable to negligence and carelessness on the part of general aviation pilots. Rather, this study indicates that takeoff accidents occur because elements of the preflight preparation (1) were not assigned the proper importance, (2) were not incorporated into the preflight routine, or (3) pilots did not anticipate potential takeoff emergencies and the required procedures.

The Safety Board believes that the solution to takeoff accidents is threefold. Pilots must: (1) Form good preflight planning habits and review them continually; (2) be thoroughly knowlegable of the hazards and conditions which would represent potential dangers during takeoff; and (3) must be aware of the capabilities and limitations of his aircraft.

The National Transportation Safety Board urges all pilots to review their preflight routine to insure that it is complete and that it focuses attention on each critical element. The Safety Board further urges that pilots accept a personal challenge to improve their individual knowledge of their aircraft and the factors affecting it during takeoff.

RECOMMENDATIONS

As a result of this special study, the National Transportation Safety Board has recommended that the Federal Aviation Administration:

"1. Through its Accident Prevention Program stress the importance of the elements of good preflight planning and its role in the safety of flight.

2. Amend 14 CFR 141 Appendix A, 14 CFR 61.105 and 14 CFR 61.107 to define the specific elements of preflight operations and to require a separate block of ground and flight training for this subject.

3. Amend 14 CFR 61.57(b) (2) to specify that the person administering a biennial flight review must ascertain that the applicant understands the elements required for a complete preflight preparation.

4. Revise Advisory Circular 61-66, Annual Pilot-in-Command Proficiency Checks, to include an outline of subjects to be included in the preflight planning and preparation phase.

5. Issue an Advisory Circular discussing the elements of thorough preflight preparation and the potential dangers associated with each element.

6. Revise Advisory Circular 61-21, Flight Training Handbook, to provide a comprehensive description of the information which would be included under the subtopic, Preflight Operations."

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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March 10, 1976