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THE ANALYSIS OF NATIONAL TRANSPORTATION SAFETY BOARD SMALL MULT--ETC(U)
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THE ANALYSIS OF NATIONAL TRANSPORTATION SAFETY BOARD SMALL MULTIENGINE FIXED-WING AIRCRAFT ACCIDENT/INCIDENT REPORTS FOR THE POTENTIAL PRESENCE OF LOW-LEVEL WIND SHEAR

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JUNE 1978
FINAL REPORT

Prepared for

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16. Abstract

The National Transportation Safety Board aircraft accident/incident data base covering the years 1964 through 1975 was screened to select those accidents involving multiengine aircraft of less than 12,500 pounds gross weight in which the potential of low-level wind shear as a factor could not be discounted. The successive filtering techniques employed eliminated all but 27 small multiengine fixed-wing aircraft accidents/incidents which were approximately similar to the results obtained for the large multiengine aircraft. The presence of a low-level wind shear was a distinct possibility in these 27 takeoff, approach, or landing accidents/incidents. The historical accident information indicates that orographic or local topographic induced wind shears are a more serious problem for this class aircraft than those shears related to thunderstorm and gust front activities.

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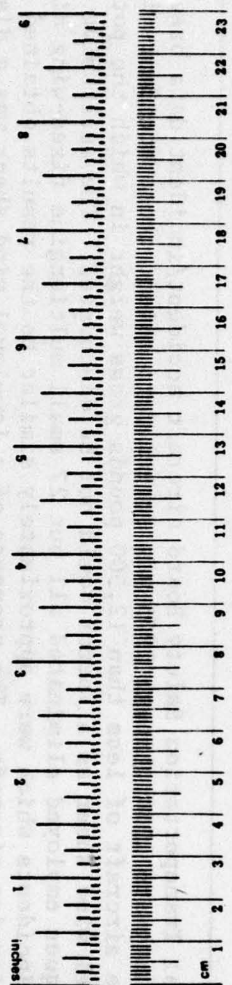
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

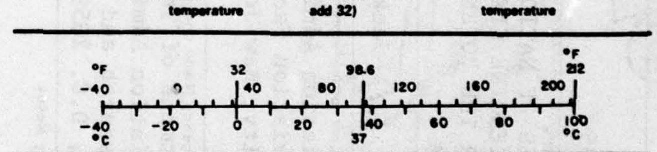


TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

ABBREVIATIONS AND SYMBOLS

⦶ = Scattered Clouds

⦷ = Broken Clouds

⊕ = Overcast

+ = Increase/heavy

- = Decrease/light

BS = Blowing snow

C_L = Lift coefficient

E = Sleet

F = Fog

F_L = Lift

G = Estimated

H = Haze

K = Smoke

L = Drizzle

LCS = Local controller specialist

M = Measured

PRESRR = Rapid pressure rise

PRESFR = Rapid pressure fall

R = Rain

RW = Rainshowers

S = Snow

S = Wing area

SW = Snowshowers

T = Thunderstorm

ABBREVIATIONS AND SYMBOLS (Cont'd)

u = Windspeed along X plane

v = Windspeed along Y plane

V = Velocity (aircraft related data)

w = Windspeed along Z plane

X = Longitudinal plane parallel to earth surface

X = Obscuration (meteorological definition)

-X = Partial obscuration

Y = Lateral plane parallel to earth surface

Z = Vertical plane perpendicular to earth surface

ZL = Freezing drizzle

ρ = Air density

α = Angle-of-attack

INTRODUCTION

BACKGROUND.

The Federal Aviation Administration (FAA) has programs specifically dedicated to identifying and, where possible, reducing hazards encountered in normal aircraft operations. One of these hazards is low-level (surface to 1,500 feet) wind shear. Wind shear is defined in (reference 1) as any change in windspeed and/or wind direction through any thin layer of the atmosphere. Thus, updrafts and downdrafts, wind gusts, turbulence, and mountain waves are examples of different forms of wind shear, as well as the wind shears associated with thunderstorms, rapidly moving frontal activity, and temperature inversions. In such an encounter, the airspeed of the aircraft changes, and the flightpath of the aircraft is altered.

The definition of wind shear can vary depending upon the point of view of the observer and the reference frame used. Appendix A discusses wind shear definition at some length. Examples of horizontal wind shear as defined in this report are (1) encountering a downdraft associated with a rainshower, thunderstorm, or the lee side of a mountain, (2) encountering wind shift caused by a variation in surrounding terrain, or (3) encountering a thunderstorm-induced sudden wind shift during the takeoff or landing roll.

Examples of vertical wind shear are (1) shear associated with a descent through a gust front which is preceding a thunderstorm, (2) a descent below treeline surrounding a small airport, or (3) the change in wind direction associated with a nocturnal temperature inversion.

What would constitute a "significant" vertical or horizontal wind shear encounter would be a function of the aircraft's performance and design. During a thunderstorm or a rainshower of 2.0 inches per hour, the rain area may have associated with it a downdraft (horizontal wind shear) in excess of 20 feet per second (reference 2). This could seriously compromise certain aircraft performance at a critical point on approach. Encountering a low-level vertical shear in excess of 9 feet per second per 100 feet (approximately 5 knots per 100 feet) has been defined as "significant" (reference 3), by FAA personnel currently engaged in some of the wind shear programs.

During the approach, landing, takeoff, and initial climb phases of flight, the aircraft is operating at a low margin of excess airspeed, (1.2 to 1.4 V reference) with respect to a stall speed. The pilot has a minimum altitude which can be exchanged for airspeed. In addition, the engine thrust is either limited by the groundspeed requirements (for flightpath control), noise abatement procedures, or may be the maximum thrust available at the time. Thus, if a low-level wind shear is encountered, large deviations from the intended flightpath could occur due to the change in both airspeed and lift when the pilot has a minimum of corrective actions available.

As was previously noted, the results of a low-level wind shear encounter could be an accident or incident such as landing short (undershoot), ballooning with a resultant overrun (overshoot), drifting off to the side of the runway, stall, hard landing, etc. However, these types of accidents and incidents can also be due to factors totally unrelated to wind shear.

Until recently, investigators were not as aware of the low-level wind shear hazard as they are today, especially following the analysis of pertinent accidents by the National Transportation Safety Board (NTSB) and the FAA's wind shear research and development program, documented in FAA report ED-15-2A (reference 3). It is possible that this hazard could have been present and was an undefined factor in early aircraft accidents and therefore omitted as a contributing weather factor. Thus, the magnitude of the low-level wind shear hazard to both the large and small aircraft may not have been fully known, recognized, or understood by all segments of the aviation community.

PURPOSE.

One of the subjects identified in the FAA's R&D program (reference 3) was a study to summarize the available information concerning both wind shear hazard and its detection. The results of this effort are contained in the FAA report FAA-RD-76-114 (reference 1). With the aid of this information, a further study was undertaken to determine the magnitude of the wind shear hazard using available historical accident data. The data base employed was the NTSB aircraft accident information file covering the years from 1964 through 1975.

The specific objectives of this project were to:

1. Develop a technique to evaluate the historical accident information for cause and effect as it relates to low-level wind shear. (This should not be construed to mean the probable cause of an accident or incident. Probable cause of an accident is determined by the NTSB.)

2. Identify significant meteorological, aircraft, pilot, and operational factors that suggest a common denominator with respect to the wind shear problem in the terminal area.

It was originally planned to separate the project into two segments, one dealing with aircraft of 12,500 pounds (lbs) gross weight or greater, and the other covering aircraft under 12,500 lbs gross weight. However, due to the significantly larger number of aircraft accidents in the lower gross weight category, this group was subdivided into multiengine and single engine categories. Much of the methodology and analysis is applicable to all three groups. The larger weight class aircraft accidents are covered in the FAA report FAA-RD-77-169, reference 4.

This report covers only multiengine aircraft accidents in the lower weight class. An analysis of the lower gross weight single engine aircraft will be the subject of a separate report.

EXPERIMENTAL DESIGN

GENERAL.

It was recognized at the beginning of the project that many segments of the aviation community have an interest in this effort and could make a significant contribution. This contribution could include criteria and techniques which could be used to screen and/or evaluate aircraft accident data for the potential presence of a low-level hazardous wind shear. Accordingly, at the onset of this project, the letter shown in appendix B was sent to the potentially interested organizations listed below, soliciting suggestions and recommendations for selectively screening and evaluating aircraft accident data.

1. Air Line Pilots Associations (ALPA),
2. Aircraft Owners and Pilots Association (AOPA),
3. Airline Transport Association (ATA),
4. Department of Defense Safety Centers (DOD) (Army, Navy, Air Force),
5. General Aviation Manufacturers Association (GAMA),
6. National Business Aircraft Association (NBAA),
7. National Aeronautic and Space Administration (NASA),
8. National Oceanographic and Atmospheric Administration (NOAA),
9. National Transportation Safety Board (NTSB), and
10. Transportation Systems Center (TSC).

Coordination was also accomplished with various segments within FAA including the Air Traffic Service, Flight Standards Service, Office of Systems Engineering Management, and Systems Research and Development Service.

The NTSB provided a copy of its in-house safety analyst's coding guide which is used in encoding accident data for storage and retrieval. NTSB were also helpful in suggesting the encoded types of accidents, phase of operations, and weather factors which would be helpful in a machine search of the approximately 59,000 accident files.

ALPA provided a list of accidents which it had evaluated for a potential wind shear hazard contribution. ALPA also provided some of the criteria upon which it based its evaluation and made available several ALPA studies on the subject. These studies were prepared by ALPA members which included such recognized experts as Dr. Kenneth Hardy and Captain William Melvin. These documents were among those which have been reviewed and are contained in reference 1.

NOAA provided suggested guidelines for selecting those reported meteorological factors which might be indicative of the presence of wind shear. Many of the recommended surface weather observation filtering criteria are contained in the Federal Meteorological Handbook No. 1 (reference 5).

FILTERING PROCEDURES.

The flow chart for the total Wind Shear Accident/Incident Analysis Program is shown in figure 1. In each of the filtering procedures, the criteria for selecting the specific arguments were, in part, selected based on inputs requested and received from the sources noted in figure 1. Most of the software screening criteria were based on recommendations received from NTSB. ALPA provided significant guidance in the selection of the filtering techniques used in reviewing the briefs, and the NOAA recommended the meteorological criteria used in the docket examinations.

The flow diagram for the software to screen the NTSB data base is shown in figure 2, using the NTSB coding defined in reference 6. An expansion of the software-controlled filtering is shown in table 1. Incorporated into the program was a subroutine to generate an output summary for each filter control. A separate program was prepared to print out the coded information in plain language for each accident that met the software filtration criteria.

The briefs were reviewed using the factors noted in table 2. This eliminated those accidents in which the presence of a low-level wind shear, as a significant factor, was not likely or the accident was not applicable to the terminal area phase of flight operations of interest in this study.

The final filtering of those accidents which met both the software and briefing criteria was an examination of the accident files (dockets) maintained by NTSB. All the records relating to an aircraft accident are retained and stored either within the NTSB public docket files (most current 2 years) or, under NTSB control, at the National Archives in Washington, D.C. The filtering factors used in this final phase are shown in table 3.

The following portions of the dockets were examined to obtain pertinent information relating to the filtering criteria.

Factor	Docket Section
Thunderstorm/Squall Line	Surface Weather Observations, Weather Radar Reports, Radar Controller, Pilot Reports, Witness Statements, Crew Statements
Barometric Pressure	Surface Weather Observations, Barograph, LCS, Reported Altimeter Setting
Precipitation at Surface	Surface Weather Observations, Pilot Reports, LCS, Witness Statements

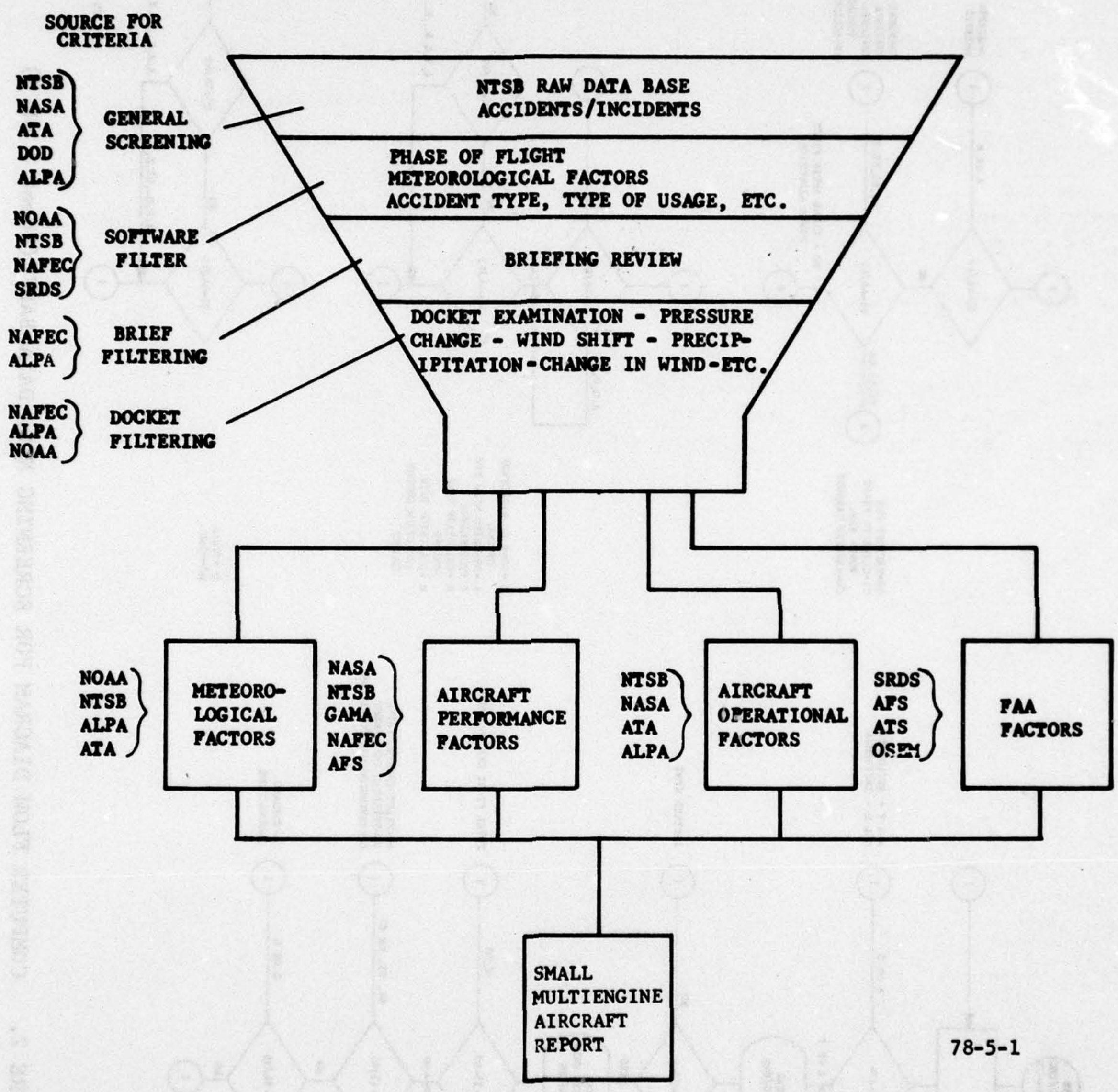


FIGURE 1. WIND SHEAR ACCIDENT/INCIDENT ANALYSIS FLOW CHART

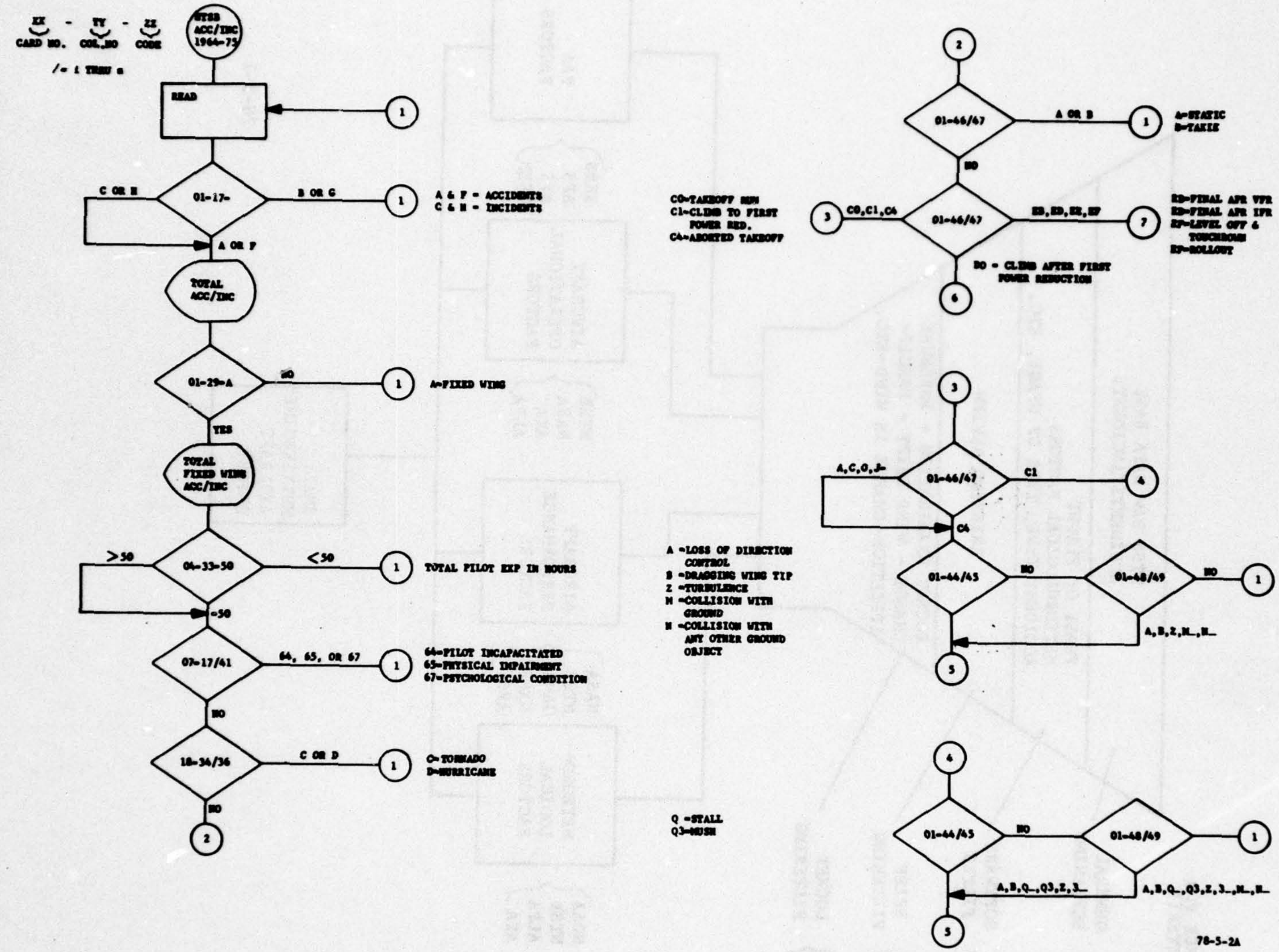


FIGURE 2. COMPUTER FLOW DIAGRAM FOR SCREENING NTSB DATA BASE (Sheet 1 of 2)

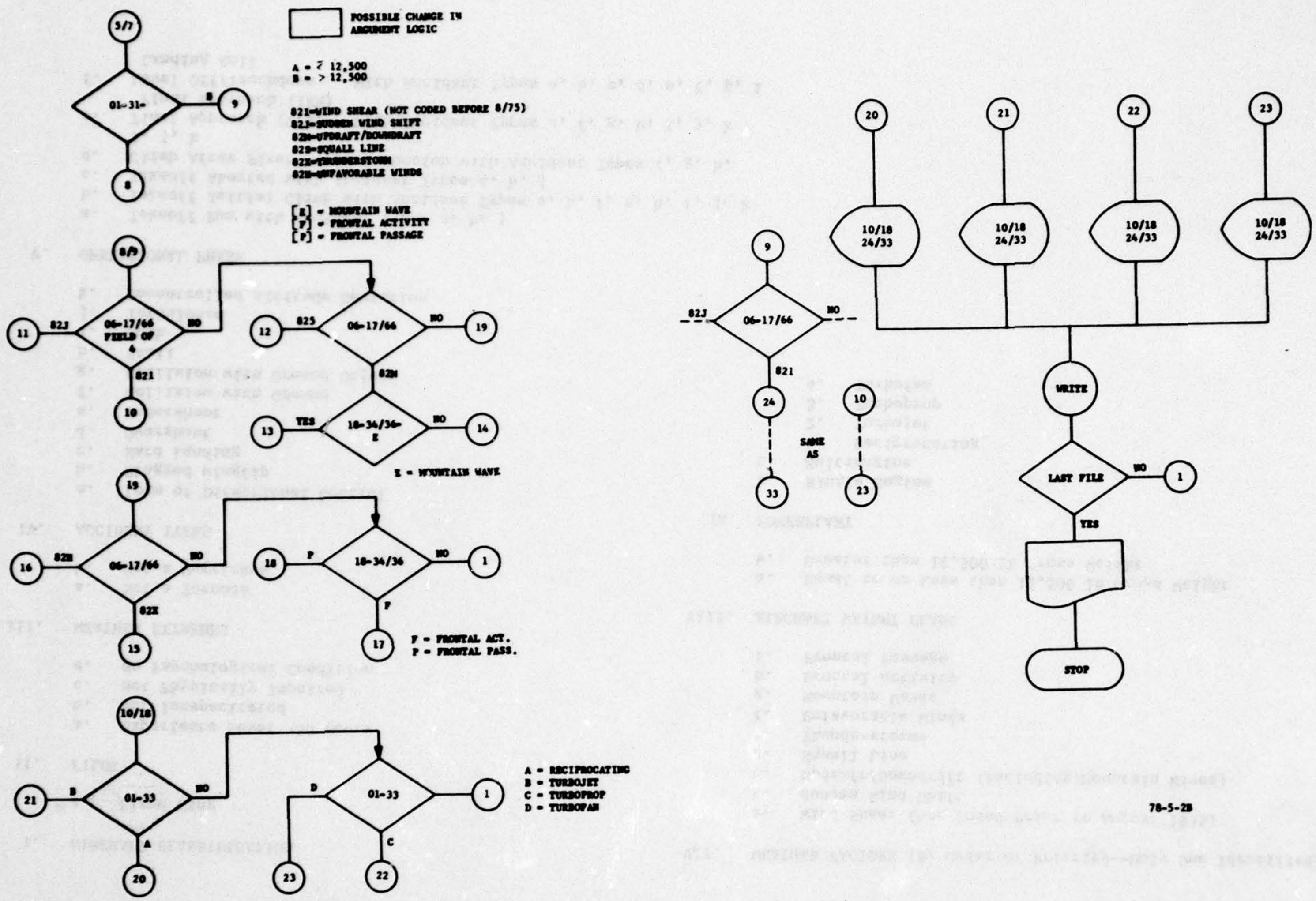


FIGURE 2. COMPUTER FLOW DIAGRAM FOR SCREENING NTSB DATA BASE (Sheet 2 of 2)

TABLE 1. FILTERING CRITERIA FOR NTSB ACCIDENT/INCIDENT DATA BASE

I. AIRCRAFT CLASSIFICATION

a. Fixed Wing

II. PILOT

a. Experience Level >50 Hours
b. Not Incapacitated
c. Not Physically Impaired
d. No Psychological Condition

III. WEATHER EXTREMES

a. Not a Tornado
b. Not a Hurricane

IV. ACCIDENT TYPES

a. Loss of Directional Control
b. Dragged wingtip
c. Hard Landing
d. Overshoot
e. Undershoot
f. Collision with Ground
g. Collision with Ground Object
h. Stall
i. Mush
j. Turbulence
k. Uncontrolled Altitude Deviation

V. OPERATIONAL PHASE

a. Takeoff Run with Accident Types a, b, j
b. Takeoff Initial Climb with Accident Types a, b, f, g, h, i, j, k
c. Takeoff Aborted with Accident Types a, b, j
d. Climb After First Power Reduction with Accident Types f, g, h, i, j, k
e. Final Approach (VFR) Final Approach (IFR) With Accident Types a, f, g, h, i, j, k
f. Level Off/Touchdown Landing Roll With Accident Types a, b, c, d, e, f, g, i

VII. WEATHER FACTORS (By Order of Priority--Only One Identified)

a. Wind Shear (Not Coded Prior to August 1975)
b. Sudden Wind Shift
c. Updraft/Downdraft (Excluding Mountain Waves)
d. Squall Line
e. Thunderstorms
f. Unfavorable Winds
g. Mountain Waves
h. Frontal Activity
i. Frontal Passage

VIII. AIRCRAFT WEIGHT CLASS

a. Equal to or Less than 12,500 lb Gross Weight
b. Greater than 12,500 lb Gross Weight

IX. POWERPLANT

a. Single Engine
b. Multiengine
   1. Reciprocating
   2. Turbojet
   3. Turboprop
   4. Turbofan

Factor	Docket Section
Surface Winds	Surface Weather Observations, LCS, Witness Statements
Wind Shear, Updrafts/Downdrafts	Pilot Reports, Winds Aloft Observations, Meteorological Analysis, Flight Data Recorder, NTSB Analysis, Witness Statements
Temperature	Surface Weather Observations

TABLE 2. FILTERING CRITERIA FOR REVIEW OF ACCIDENT BRIEFS

Area Evaluated	Factors
Accident Statistics	Date, File Number, Aircraft Type, Registration Number, Location
Type of Approach	NAVAID Horizontal Guidance, NAVAID Vertical Guidance, Visual Horizontal Guidance, Visual Vertical Guidance
Weather at Time of Accident	Expected by Flight Crew, Unexpected by Flight Crew, Visibility
Type of Accident	Could be Triggered by a Shear Encounter, Unrelated
Weather Factors	Frontal Activity, Precipitation, Shifting Winds, Wind Direction with Respect to Runway, General Weather
Airplane Factors	Navigation Equipment Available, Usage, Autopilot Information
Location of Accident	Distance from Runway in Use, Airport Elevation, Altitude of Occurrence

It is most important to note that this study does not, nor is it intended to, redefine the "PROBABLE CAUSE" of any accident. The filtering criteria used at each level (software, review of accident briefs, and docket examination) did not consider the NTSB-defined probable cause of the accident.

TABLE 3. FILTERING CRITERIA FOR DOCKET EXAMINATION

Factor		Criteria
Thunderstorm/Squall Line	(1)	Along the aircraft's flightpath, within 5 nmi of approach and moving in the direction of the aircraft's flightpath
Barometric Pressure Jump (rate of change)	(2)	* 0.0005 inHg/minute (0.017 millibar/minute) (pressure jump)
	(2)	** 0.06 inHg/hour (2 millibars/hour (pressure rise or fall))
Precipitation at Surface	(1)	0.03 inches/minute (approximately 2 inches/hour)
Surface Wind Direction (Shift of)	(1)	* 30° or greater
Surface Windspeed Change	(2)	15 knots or doubles its value (above 10 knots) between successive surface weather observations
Peak Surface Windspeed	(1)	$\geq$ 25 knots
Horizontal Wind Shear Gradient	(1)	1 knot/100 feet or greater
Vertical Wind Shear Gradient	(1)	5 knots/100 feet or greater
Difference between the In-Flight and Airport Surface Windspeeds	(1)	10 knots
Pilot NWS/ATS Reports	(1)	Wind shear/updrafts/downdrafts
NTSB Analysis	(1)	Wind shear, updrafts/downdrafts, mountain waves, or sudden wind shift noted as a factor
Others	(1)	Moderate or heavy shower along aircraft's flightpath
	(1)	Frontal system movements of 10 knots, temperature across front $\geq$ 10° F
	(1)	Terrain (orographic and local topography)

* Changes occurring within ±15 minutes of accident
**Changes occurring within ±60 minutes of accident

(1) Selected by and/or recommended to author. (2) Extract from reference 6.

RESULTS

The NTSB data base contained 59,465 accidents or incidents. Within the terminal area, 5,277 were during the takeoff phase of flight and 14,055 during approach and landing. The number of aircraft whose gross weight was less than 12,500 lbs, and which meet the software filtering criteria was 2,625, of these, 156 were multiengine. Table 4 is a listing of location of those 156 accidents which met the software filtering criteria shown in table 3.

This report does not take into account such pertinent factors as the number of operations at a given location, the average number of operations as a function of a given weather state, etc. Therefore, it is not possible to assign any particular significance to the number of accidents at any given location shown in table 4, nor is any implied. Similar limitations apply with respect to evaluating the number of accidents by aircraft type, aircraft operator, etc.

Some of the files requested were not readily available for docket review. Among those factors limiting their accessibility were (1) under review or reexamination by NTSB, (2) some or all of the dockets were involved in litigation, (3) the docket was in use by others, and (4) their present location could not be ascertained in time to meet the requirements of this study. In the opinion of the author, the findings of this study have not been adversely affected by the limited nonavailability of those documents and files. The information gleaned from the review of the dockets is contained in appendix C.

Prior to discussing the specifics of the docket examinations, there are several general points which a review of the dockets brought out.

1. There is very limited information in the dockets concerning documented weather conditions prior to, at the time of, and following the accident. Yet all of the accidents evaluated occurred in close proximity to an approved airport. Many of these airports were classified as municipal airports, yet the meteorological information relative to the accident was not included in the docket. It is therefore assumed that such information was apparently not available at a majority of airports.

2. The extent to which the accident/incident was investigated was, in most cases, of a much lower magnitude than that which was accomplished for the larger gross weight aircraft accidents (reference 4).

3. The official accident reports were usually filled out by the pilot and lacked much of the specifics which would have been helpful in the analysis of the accident.

4. According to the information contained in the applicable dockets, a number of airports were known to have orographic or local topographically induced wind anomalies but this information was not readily available to the nonlocal pilot.

The decoded briefs for the 156 accidents meeting the software filtering criteria were printed out in plain language and reviewed. As a result of this review, 53 accidents were identified which met the criteria noted in table 2. This is

TABLE 4. MULTIENGINE SMALL AIRCRAFT ACCIDENTS MEETING SOFTWARE FILTERING CRITERIA

NTSB File No.	Date	Location	State	Aircraft Type	NTSB File No.	Date	Location	State	Aircraft Type
3-0105	3/18/71	Birmingham	AL	BED95A	3-2602	7/29/67	Lahaina	HI	DH104
3-4343	12/5/70	Monroeville	AL	PA-30	3-3970	4/26/66	Albion	IL	PA30
3-1226	3/22/72	Scottsboro	AL	PA-39	3-2882	9/20/75	Chicago	IL	C414
3-0194	1/19/75	Talladega	AL	PA30	3-3705	12/27/73	Chicago	IL	BE18S
3-4279	8/1/66	Anchorage	AK	G44	3-3276	7/27/73	Chicago	IL	PA23
3-2043	1/27/72	Yukon	AK	BE VOLPAR	3-4445	12/13/68	Chicago	IL	BEA65
3-1349	5/20/64	Kenai	AK	G21	3-2884	9/03/68	Chicago	IL	C337B
1-0024	8/23/73	Togiak	AK	G21A	3-4380	12/11/68	Chicago	IL	BEC45G
1-0048	11/26/70	Wrangell	AK	G21A	3-0497	3/16/73	Kewanee	IL	BEC18S
3-0878	4/7/73	Casa Grande	AZ	PA30	3-3987	10/27/68	O'Hare Airport	IL	BEH18
3-1122	3/25/71	Douglas	AZ	BED18S	3-0595	3/26/73	Savoy	IL	DHC6
2-0504	8/21/65	Grand Canyon	AZ	NAVION D-16	3-0435	4/29/72	Spring Grove	IL	PA23
		National Park			3-1493	4/12/72	Urbana	IL	PA30
3-1439	6/15/65	Sedona	AZ	AC680	3-4479	12/26/68	Elkhart	IN	C421
3-0480	3/24/75	Hot Springs	AZ	C310B	3-0901	1/03/66	Arkansas City	KS	C337
3-0476	4/24/75	Tin City	AR	BN2A	3-1010	5/4/75	Beaumont	KS	BE95-B55
3-0514	4/5/73	North Avalon	CA	G21A	2-0122	4/22/64	Colby	KS	BE95
3-1772	4/24/72	Bermuda Dunes	CA	PA30	3-4141	12/28/66	Olathe	KS	C310D
3-0576	2/28/65	Lodi	CA	BE55	3-1690	5/25/67	Wichita	KS	C421
3-0602	3/12/68	Mariposa	CA	PA23	3-1349	5/22/73	Richmond	KY	Pine Air SV
3-0578	3/4/65	Palo Alto	CA	C310C	3-2161	8/16/75	Alexandria	LA	PA23
3-0446	2/25/69	Plaster City	CA	PA23	3-1241	4/17/67	Gaithersburg	MD	BE95-B55
3-1672	5/6/70	San Francisco	CA	BETC45J	5-0028	10/16/74	Ocean City	MD	PA34
3-0842	4/29/73	Thfee Rivers	CA	PA30	3-1287	2/20/72	Boston	MA	BEG18S
3-0764	5/13/72	Van Nuys	CA	BE3TM	3-0185	1/31/73	Detroit	MI	MU2
3-2062	7/13/63	Aspen	CO	C310	3-4372	12/29/66	Detroit	MI	BEC45G
3-0916	4/16/65	Avon	CO	BED18S	3-0756	2/03/68	Gaylord	MI	L12A
3-4299	11/16/66	Denver	CO	C310	3-0016	11/27/65	Houghton Lake	MI	PA23
3-3756	12/12/74	Denver	CO	BE18	3-1350	4/3/74	Menominee	MI	C500
2-0027	1/4/67	Leadville	CO	C310J	3-0736	3/31/73	Niles	MI	PA31
3-1606	6/3/68	Hartford	CT	BEC45H	3-4304	1/26/74	Romulus	MI	BE55
3-0844	2/11/70	Middletown	DE	C310L	3-0533	2/18/74	St. Ignace	MI	C402
3-0833	4/4/73	Wilmington	DE	BEA90	3-0363	1/13/73	Traverse City	MI	PA34
3-1448	3/10/72	Indiantown	FL	C336	3-2676	8/2/74	Austin	MN	C310J
3-1475	4/5/70	Lake Placid	FL	PA23	3-2950	8/14/74	Glenwood	MN	PA30
3-1005	2/20/75	Opa Locka	FL	BE95	3-0047	1/7/67	Minneapolis	MN	BE18S
3-2309	7/3/74	Panama City	FL	BE18S	3-0907	3/11/73	Willmar	MN	BEG18S
3-1946	4/27/72	Tallahassee	FL	BE18S	3-1858	12/16/70	Kansas City	MO	BE18S
3-0177	1/9/74	Williston	FL	BE18S	5-0005	3/25/75	Kirksville	MO	BE18
3-0588	3/15/66	Kaanapali	HI	BEC45G	3-3117	7/23/68	Omaha	NE	C310C
3-2849	11/3/69	Kalaupapa	HI	DH104-6A					

TABLE 4. MULTIENGEINE SMALL AIRCRAFT ACCIDENTS MEETING SOFTWARE FILTERING CRITERIA (Continued)

NTSB File No.	Date	Location	State	Aircraft Type	NTSB File No.	Date	Location	State	Aircraft Type
3-3829	7/24/66	Gardnerville	NV	C337	3-2957	8/18/67	Block Island	RI	PA30
3-3708	8/4/74	Bedminster	NJ	BEA55	3-3334	7/30/70	Charleston	SC	PA23
3-0198	1/23/65	Red Bank	NJ	PA23	3-4017	10/16/72	Union	SC	C310G
3-4370	10/28/71	Conchas Dam	NM	BED18S	3-1564	3/17/68	Rapid City	DS	BE18S
3-2037	6/23/71	Deming	NM	CT337E	3-4058	11/6/72	Memphis	TN	PA30
3-2742	6/20/72	Dulce	NM	PA30	3-2897	10/17/65	Andrews	TX	C320B
3-3011	10/31/66	Las Vegas	NM	C310	3-0648	3/31/73	Austin	TX	C414
3-2149	5/8/70	Ruidoso	NM	PA30	3-0221	1/21/73	Austin	TX	PA30
3-0918	4/13/64	Springer	NM	C310G	3-0874	4/24/69	Big Spring	TX	BE18S
3-2488	7/11/71	Torreon	NM	C337B	3-2535	7/23/74	Canyon	TX	AC681
3-3525	12/21/73	Endicott	NY	C411	3-0443	2/7/72	Corpus Christi	TX	L10A
3-2490	8/10/73	Farmingdale	NY	BE55	3-1476	6/8/74	North D'Hanis	TX	PA31
3-3141	10/10/66	Gardenville	NY	BE95-55	3-1615	6/25/66	El Paso	TX	PA30
3-1017	3/20/70	Hammondsport	NY	BED18S	5-0048	2/22/71	Fort Worth	TX	BE95-B55
3-2832	7/3/70	Lockport	NY	BE95-B55	3-0908	2/21/71	Fort Worth	TX	BE95-B55
3-3275	11/14/75	Norwich	NY	BED50E	3-0463	3/1/69	Lowake	TX	C337C
3-0327	1/10/70	Stormville	NY	BED18S	3-1230	6/9/66	Lubbock	TX	PA23
3-3904	12/22/73	Syracuse	NY	BE18S	3-1774	6/11/69	Ranger	TX	C320D
3-0082	12/05/73	White Plains	NY	AC680W	3-4309	10/27/69	San Antonio	TX	BE90
3-4424	12/3/71	Charlotte	NC	C421A	3-3394	9/8/72	Zapata	TX	PA34
3-0452	1/14/52	Fort Bragg	NC	PA34	3-0238	2/2/71	Tooele	UT	C320
3-0661	4/13/65	Franklin	NC	C310D	3-0410	2/11/67	Bennington	VT	C310
3-0100	1/24/68	Greensboro	NC	C310L	3-0805	4/12/75	Morrisville	VT	BD24R
3-4449	12/17/70	Lincolnton	NC	C337C	3-0200	2/9/74	Wilmington	VT	PA31
3-0795	4/18/73	Lumberton	NC	C310H	3-1280	5/8/66	Herndon	VA	BE95-55
3-0617	4/2/70	Morrisville	NC	C401A	3-0200	1/30/66	Newport News	VA	BDH18
3-0263	1/8/70	Raleigh	NC	C310N	3-4311	12/16/68	Sandston	VA	CT337B
5-0033	11/02/71	Cleveland	OH	Ted Smith 601	3-1219	4/9/71	Delavan	WI	C337A
3-3625	12/24/65	Oaklahoma City	OK	BE55	3-1209	5/7/68	Genoa City	WI	C337B
2-0323	5/31/65	McKenzie Bridge	OR	PA30	3-3352	7/31/69	Iola	WI	PA23
3-0456	3/19/75	Ambler	PA	C421B	3-3550	12/15/72	Lake Geneva	WI	C310
3-3457	12/29/72	Bedford	PA	C310N	3-0302	1/31/67	Marshfield	WI	BE95
3-2872	7/8/70	Coraopolis	PA	HP137	3-1347	4/22/68	Cheyenne	WY	BE18S
3-0642	1/23/71	Hershey	PA	PA30	3-0841	4/12/74	Cheyenne	WY	BE18S
3-0216	2/9/71	Johnstown	PA	SW26T	3-0043	1/13/66	Green River	WY	C320
3-0001	1/6/74	Johnstown	PA	BE99A	3-3914	11/2/71	Culebra Town	PR	PA23
3-0464	3/1/69	Kutztown	PA	C310D	3-0167	2/10/70	San Juan	PR	BE18S
3-3460	12/03/74	Meadville	PA	C402B	2-0679	7/15/65	St. Thomas	VI	DH104

approximately one-third of those selected by the software program. These results were not unexpected, since it was the intent of the experimental design to minimize the rejection of those accidents which should be examined at least at the "brief" level. Table 5 is a listing of 53 aircraft accidents which were selected for docket examination following a review of the briefs.

Table 6 is a listing of the multiengine small-aircraft accidents or incidents in which there is a possibility that a low-level wind shear could have been present in the terminal area along the aircraft's flightpath at the time of the accident. The basis for the selections in the list was the docket examinations. The 27 accidents listed are those in which a low-level wind shear could have been a contributing weather factor.

The matrix table of low-level wind shear factors was structured to examine these accidents in greater detail. These factors were:

1. A change in reported surface wind direction in excess of 30° within 15 minutes of the accident.

2. A change in reported average surface windspeed in excess of 10 knots.

3. Reported surface wind gusts of 10 knots or more above average windspeed or double average windspeed.

4. Reported barometric pressure jump of 0.0005 inches of mercury (inHg)/minute or more.

5. A continuous change in barometric pressure in one direction of 0.06 inHg/hr.

6. Reported change in surface temperature of 10° F between two successive hourly observations and/or special observations.

7. Reported moderate or heavy showers along the aircraft's flightpath.

8. Reported precipitation (rain, snow or fog).

9. Reported thunderstorms, squalls, or heavy precipitation within 5 nautical miles (nmi) of runway and along the aircraft's flightpath.

10. Terrain induced wind anomalies (orographic or local topographic low-level wind shears).

11. Measured, or observed low-level wind shear, significant wind shift, or downdraft which were recorded or reported prior to the accident.

The basis for the difference between the 11 factors identified above and the 15 noted in table 3 was the type of information available in the dockets.

Table 7 indicates that a change in wind direction of 30° or more (selection criterion 1) occurred in 10 of the 27 accidents. Over half (6) of the changes

TABLE 5. SMALL MULTIENGINE AIRCRAFT ACCIDENT DOCKETS REQUESTED FOR EXAMINATION

No.	Date	File No.	Tail No.	Location	State	Aircraft	
1	4/22/64	2-0122	N9979R	Colby	KS	BE95	
2	3/4/65	3-0578	N608G	Palo Alto	CA	C310C	
3	4/13/65	3-0661	N6868T	Franklin	NC	C310D	
4	6/15/65	3-1439	N414N	Sedona	AZ	AC680FL	
5	8/21/65	2-0504	N88W	Nat. Park Grand Canyon	AZ	NAVION D-16	*
6	10/17/65	3-2897	N9849L	Andrews	TX	C320B	
7	12/24/65	3-3625	N1452E	Oaklahoma City	OK	B95-B55	
8	4/26/66	3-3970	N7966Y	Albion	IL	PA-30	
9	5/8/66	3-1280	N8829M	Herndon	VA	B95	
10	6/9/66	3-1230	N5951Y	Lubbock	TX	PA23	*
11	10/31/66	3-3011	N3034D	Las Vegas	NM	C310	*
12	4/17/67	3-1241	N4314Y	Gaithersburg	MD	B95-B55	*
13	5/25/67	3-1690	N3758C	Wichita	KS	C421	
14	7/29/67	3-26C2	N668R	Hilo	HI	DH104	
15	1/24/68	3-0100	N2284F	Greensboro	NC	C310L	
16	3/12/68	3-0602	N1388P	Moriposa	CA	PA23	
17	5/7/68	3-1209	N54385	Genoa City	WI	C337B	*
18	6/3/68	3-1606	N4000Y	Hartford	CO	BC454	
19	7/23/68	3-3117	N6699B	Omaha	NE	C310C	*
20	12/13/68	3-4445	N941V	Chicago	IL	BEA65	
21	12/26/68	3-4479	N3160K	Elkhart	IN	C421	
22	3/1/69	3-0464	N6781T	Kutztown	PA	C310D	
23	4/27/69	3-1412	N3561X	Bridgeport	NJ	MU2B	
24	10/27/69	3-4309	N861K	San Antonio	TX	BE90	*
25	11/3/69	3-2849	N669R	Lalaupapa	HI	DH104-6A	
26	3/20/70	3-1017	N302F	Hammondsport	NY	BE D185	
27	4/2/65	3-3265	N1452E	Oaklahoma City	OK	BE95-B55	*
28	7/3/70	3-2832	N7979R	Lockport	NY	BE95-B55	
29	1/23/71	3-0642	N8685Y	Hershey	PA	PA30	
30	6/23/71	3-2037	N1258M	Deming	NM	C T337E	
31	1/27/72	3-2043	N4847	Fort Yukon	AK	B VOLPAR	*
32	4/29/72	3-0435	N2173P	Spring Grove	IL	PA23	
33	9/8/72	3-3394	N1035U	Zapata	TX	PA34	*
34	11/6/72	3-4058	N7684Y	Memphis	TN	PA30	
35	12/29/72	3-3457	N4101Q	Bedford	PA	C310N	
36	3/31/73	3-0736	N300X	Niles	MI	PA31	
37	7/27/73	3-3276	N1483P	Chicago	IL	PA23	*
38	1/26/74	3-4304	N1164A	Romulus	MI	BE55	
39	2/9/74	3-0200	N510BB	Wilmington	VT	PA31	
40	4/3/74	3-1350	N11A	Menaminee	MI	C500	
41	6/8/74	3-1476	N110BC	D'Hanis	TX	PA31	
42	7/23/74	3-2535	N9091N	Canyon	TX	AC681	*
43	8/2/74	3-2676	N3199L	Austin	MN	C310J	
44	8/4/74	3-3708	N8510M	Bedminister	NJ	BEA55	
45	10/16/74	5-0028	N15686	Ocean City	MD	BE95-B55	
46	1/14/75	3-0452	N1050U	Fort Bragg	NC	PA34	
47	1/19/75	3-0194	N8541Y	Talladega	AL	PA30	*
48	2/20/75	3-1005	N1823W	Opa Locka	FL	BE95	
49	3/25/75	5-0005	N333EH	Kirksville	MO	BE18	*
50	4/24/75	3-0476	N591JA	Tin City	AK	BN2A	
51	5/4/75	3-1010	N8975M	Beaumont	KS	BE95-B55	
52	8/16/75	3-2161	N54166	Alexandria	LA	PA23	
53	11/14/75	3-3275	N9682Y	Norwich	NY	BED50E	

* Indicates these dockets which were not available for examination at the time of this report.

TOTAL = 53
* = 14

TABLE 6. MULTIENGINE SMALL-AIRCRAFT ACCIDENTS IN WHICH LOW-LEVEL WIND SHEAR COULD HAVE BEEN A FACTOR

	NTSB File No.	Date	Location	State	Aircraft Type
1	2-0122	4/22/64	Colby	KS	BEB95
2	3-1439	6/15/65	Sedona	AZ	AC680FL
3	2-0504	8/21/65	Grand Canyon	AZ	ND16
4	3-2897	10/17/65	Andrews	TX	C320D
5	3-3625	12/24/65	Oklahoma City	OK	BEB55
6	3-1280	5/8/66	Herndon	VA	BEB95
7	3-1690	5/25/67	Wichita	KS	C421
8	3-2602	7/29/67	Hilo	HI	DH104
9	3-0100	1/24/68	Greensboro	NC	C310
10	3-0602	3/12/68	Mariposa	CA	PA23
11	3-1606	6/3/68	Hartford	CT	BEC45H
12	3-4445	12/13/68	Chicago	IL	BEA65
13	3-2849	11/3/69	Molokai	HI	DH104
14	3-1017	3/20/70	Hammondsport	NY	BED18S
15	3-0617	4/2/70	Morrisville	NC	C401A
16	3-0642	1/23/71	Hershey	PA	PA30
17	3-0435	4/29/72	Spring Grove	IL	PA23
18	3-4058	11/26/72	Memphis	TN	PA30
19	3-3457	12/29/72	Bedford	PA	C310N
20	3-0736	3/31/73	Niles	MI	PA31
21	3-0200	2/9/74	Wilmington	VT	PA31
22	3-1476	6/8/74	North D'Hanis	TX	PA31
23	3-3708	8/4/74	Bedminster	NJ	BEA55
24	5-0028	10/16/74	Ocean City	MD	PA34
25	3-1005	2/20/75	Opa Locka	FL	BE95-55
26	3-0476	4/24/75	Tin City	AK	BN2A
27	3-2161	8/16/75	Alexandria	LA	PA23

The change in wind speed (selection criterion 2) occurred once and that was associated with both a change in wind direction and thunderstorm activity. Gusts in excess of 10 knots (selection criterion 3) were reported in nine cases. As previously noted, four cases were associated with changes in wind direction only. In two of the cases, the gusts were associated with thunderstorm activities.

As it was noted earlier, the dockets contained very little atmospheric pressure information. This is reflected in table 7, wherein there were 17 cases in which neither pressure criteria (selection criteria 4 and 5) could be established as either "Yes" or "No." Thunderstorms were associated with three of the five affirmative responses for criterion 4 and three of the four affirmative responses for criterion 5.

TABLE 7. MULTIENGINE SMALL AIRCRAFT ACCIDENTS VERSUS LOW-LEVEL WIND-SHEAR FACTOR

No.	Date	1	2	3	4	5	6	7	8	9	10	11
1	4/22/64	Y	U	Y	U	U	N	N	N	N	N	N
2	6/15/65	N	N	N	U	U	N	N	N	N	Y	Y
3	8/21/65	N	N	N	U	U	U	N	N	N	Y	Y
4	10/17/65	Y	N	N	U	U	U	N	N	Y	N	Y
5	12/24/65	Y	N	Y	Y	N	N	Y	Y	N	N	Y
6	5/8/66	Y	N	U	U	U	U	Y	Y	Y	N	Y
7	5/25/67	N	N	N	U	U	U	N	N	N	Y	Y
8	7/29/67	N	N	N	U	U	U	N	N	N	Y	Y
9	1/24/68	N	N	N	U	U	U	N	N	N	Y	Y
10	3/12/68	Y	N	Y	U	U	U	N	N	N	Y	Y
11	6/3/68	Y	Y	N	Y	Y	Y	Y	Y	Y	N	Y
12	12/13/68	N	N	Y	U	U	U	N	N	N	N	N
13	11/3/69	N	N	N	N	N	N	N	N	N	Y	Y
14	3/30/70	N	N	N	N	N	N	N	N	N	Y	Y
15	4/2/70	N	N	N	U	U	U	Y	Y	N	N	Y
16	1/23/71	N	N	Y	N	N	N	N	N	N	Y	N
17	4/29/72	N	N	N	N	N	N	N	N	N	Y	Y
18	11/20/72	Y	N	N	Y	Y	Y	Y	Y	Y	N	Y
19	12/29/72	N	N	N	U	U	N	N	N	N	U	U
20	3/31/73	Y	N	N	Y	Y	N	Y	Y	Y	N	Y
21	2/9/74	N	N	N	U	U	U	N	N	N	Y	Y
22	6/8/74	N	N	Y	U	U	U	U	U	U	U	Y
23	8/4/74	Y	N	Y	U	U	U	N	N	Y	N	Y
24	10/16/74	Y	N	Y	Y	Y	U	Y	Y	N	N	Y
25	2/20/75	U	U	U	U	U	U	Y	Y	Y	N	Y
26	4/2/75	N	N	Y	N	N	N	N	Y	Y	Y	Y
27	8/16/75	N	N	N	U	U	N	Y	Y	Y	N	Y
<u>TOTALS</u>												
Y		10	1	9	5	4	2	9	10	9	12	23
N		16	24	16	5	6	11	17	16	17	13	3
U		1	2	2	17	17	14	1	1	1	2	1

LEGEND

1 - Change in surface wind direction within ±15 minutes 30°
2 - Change in speed >10 knots
3 - Gusts >10 knots or double (2)
4 - Press jump 0.0005 inHg/minutes (0.0169 mil/minute)
5 - Barometric change of 0.06 inHg/60 minutes (2.0314 mil/60 minutes)
6 - Temperature jump 10° F between successive observations
7 - Moderate or heavy rainshowers
8 - Precipitation
9 - Thunderstorm/squall within 5 nmi of runway and along aircraft flightpath
10 - Orographic or Topographic Shear
11 - Conditions of wind shear, wind shift, or downdraft recorded or reported

Y = Yes U = Unknown N = No

There were only two cases which met the temperature requirement (selection criterion 6) and these were both thunderstorm related. Here too, the dockets did not indicate information relating to temperature as denoted by the 14 unknowns shown in table 7.

Nine of the accidents had rain showers in progress at the time of the accident. There were six that were related to thunderstorm activity.

Nine of the 26 accidents reported thunderstorm activities. This was a lower percentage than the 13 of the 25 reported in reference 4 for the larger aircraft. This suggests that smaller aircraft operators may tend to be more restrictive and limit their activity during reported thunderstorm activities.

One of the more interesting statistics is shown by selection criterion 10. There were 12 of 25 accidents in which orographic or local topographic wind shear conditions may have been, or were, present. This compares to only two of 25 for the larger aircraft. The statistics are not unexpected, since smaller aircraft operate in and out of airports which are located in rough terrain with shorter and a more limited number of runways. In most of these cases, the pilot has very little local weather information and equally limited sources of such information. This is particularly true for the transient pilot who may be operating into the airport for the first time. The results of selection criterion 11 expand on this point.

In 23 of the 27 accidents, the conditions conducive to a low-level wind shear hazard were known prior to the accident. However, in 11 of those cases, there is no information in the docket which suggests that the pilot should have been aware of this type of potential hazard.

Most of the accidents shown in tables 4, 5, and 6 have occurred at airports which have little more than a single wind sock for total weather information. The airports are frequently located in areas which are conducive to an orographic or local topographic low-level wind-shear hazard. In addition, this type of airport normally has little or no visual or radio navigational aids to assist the single piloted aircraft in detecting and negotiating wind-shear encounters.

Perhaps one of the more interesting statistics is the number of small multiengine aircraft which were identified as having a potential wind-shear problem as compared to the larger aircraft noted in reference 4. There are considerably more multiengine small aircraft than large aircraft. The number of small multiengine aircraft accidents in the terminal area is at least an order of magnitude larger than the number of large aircraft accidents. However, the number of potential wind shear related accidents was approximately equal (27 versus 25).

SUMMARY

1. Findings revealed that there were 27 multiengine small aircraft accidents/incidents between 1964 and 1975 in which the presence of low-level wind shear was possible.

2. Thunderstorms were reported in 9 of the 27 cases examined. The storm activity was located very close to the aircraft's flightpath and may have resulted in low-level wind shear.

3. A change in wind direction was recorded in 10 of the dockets. Six of the changes were associated with thunderstorm activity, while the remaining four cases reported strong wind gusts.

4. Wind gusting in excess of the 10-knot criteria was noted in nine of the cases, two of which were associated with thunderstorms.

5. Very little information on atmospheric pressure changes was contained in the dockets. However, those six cases which included barometric pressure change information were responding to variations which were associated with area thunderstorms.

6. There was precipitation present in 10 of the 27 accidents/incidents studied. Nine of the cases reported rainshowers in progress at the time of the accident. This condition may have associated horizontal wind shear in the form of downdrafts.

7. It is likely that in 12 cases there was orographic or local topographic wind shear present at the time of the accident.

8. In 23 of the accidents, the conditions conducive to low-level wind shear were known prior to the accident. However, 11 of the dockets contained no information which indicated that the pilot was aware of these conditions.

CONCLUSIONS

It is concluded that:

1. Wind shear may be involved in more accidents than previously identified.

2. Operating an aircraft in close proximity to a thunderstorm can result in a hazardous low-level wind-shear encounter.

3. Although thunderstorms and their related gust fronts are a hazard to all aircraft, the low number of thunderstorm-related accidents suggests that the smaller aircraft tend to avoid such adverse weather systems.

4. Orographic and/or local topographic induced wind shears are as much or more of a hazard to the smaller aircraft as are those shears related to thunderstorm and gust front activities.

5. Conditions conducive to wind shear (orographic, topographic, thunderstorm, etc.) may have been known prior to the accident but may not have been known to the pilot involved in the accident.

6. There was a lack of surface weather information, including local wind anomolies available to the pilots involved in the accidents which were reviewed.

REFERENCES

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4. Shrager, J., The Analysis of NTSB Large Fixed-Wing Aircraft Accident/Incident Reports for the Potential Presence of Low-Level Wind Shear, FAA-RD-77-169, DOT, Atlantic City, New Jersey, November 1977.

5. Anonymous, Manual of Code Classifications, Aircraft Accidents and Incident, NTSB, Washington, D.C., June 1970.

6. Anonymous, Federal Meteorological Handbook No. 1 Surface Observation, U.S. Dept. of Commerce, Washington. D.C., July 1, 1975.

APPENDIX A

WIND SHEAR DEFINITION

What constitutes wind shear and whether it is a vertical or horizontal wind shear depends upon the point of view of the observer or the reference used in describing the wind shear.

In the Boeing Airliner magazine of January 1977, wind shear is defined as "a change in wind speed and/or wind direction over a short distance along the flightpath". This article further clarifies this definition by limiting wind shear to changes with respect to tailwind or headwind components and places updrafts and downdrafts in a separate category. Figure A-1 shows examples of this definition of wind shear.

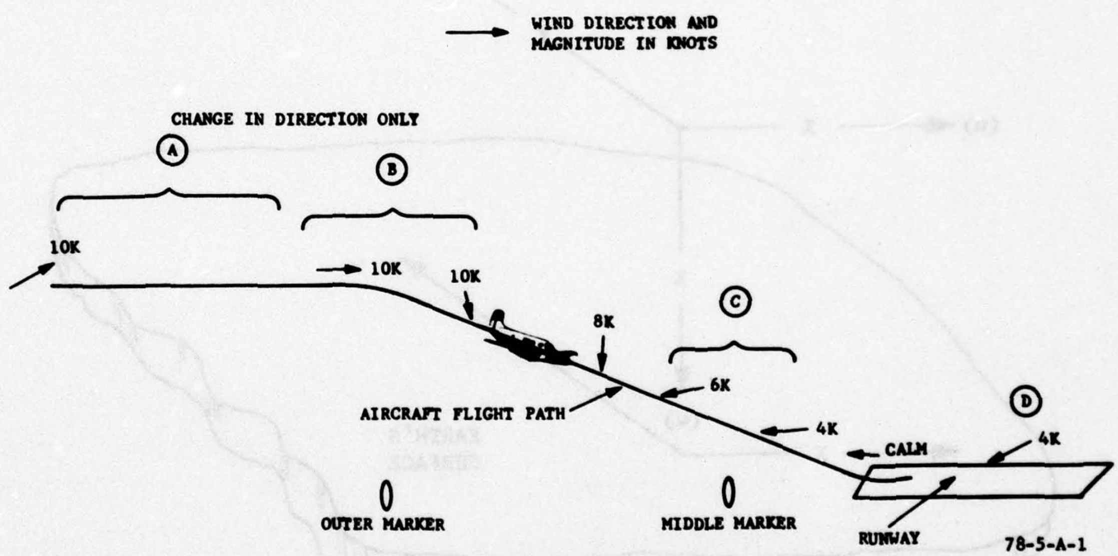

FIGURE A-1. WIND SHEAR DEFINITION WITH RESPECT TO FLIGHTPATH

In the hypothetical example shown in figure A-1, the aircraft encounters a horizontal wind shear due to change in wind direction only as it approaches the outer marker while flying at a constant altitude, (A). It experiences next a vertical wind shear due to a variation in wind direction only, (B). As it continues its descent, the aircraft encounters a wind shear which is due to both windspeed and direction, (C) and (D). Updrafts and downdrafts associated with thunderstorms, which are defined in the Boeing article as "intense vertical activity," would be superimposed on the examples shown in figure A-1.

Another definition of wind shear is that used in the FAA Report FAA-RD-76-114, dated February 1977. In this report, wind shear is any change in windspeed and/or wind direction over a short distance or time frame with respect to an earth reference. Using such a reference, horizontal wind shear is defined as a change in wind direction or velocity in a plane parallel to the earth's surface (du/dX, dv/dX, dw/dX), as shown in figure A-2. Vertical wind shear is defined as a change in wind direction or velocity in a plane perpendicular to the earth's surface (du/dZ, dv/dZ, dw/dZ).

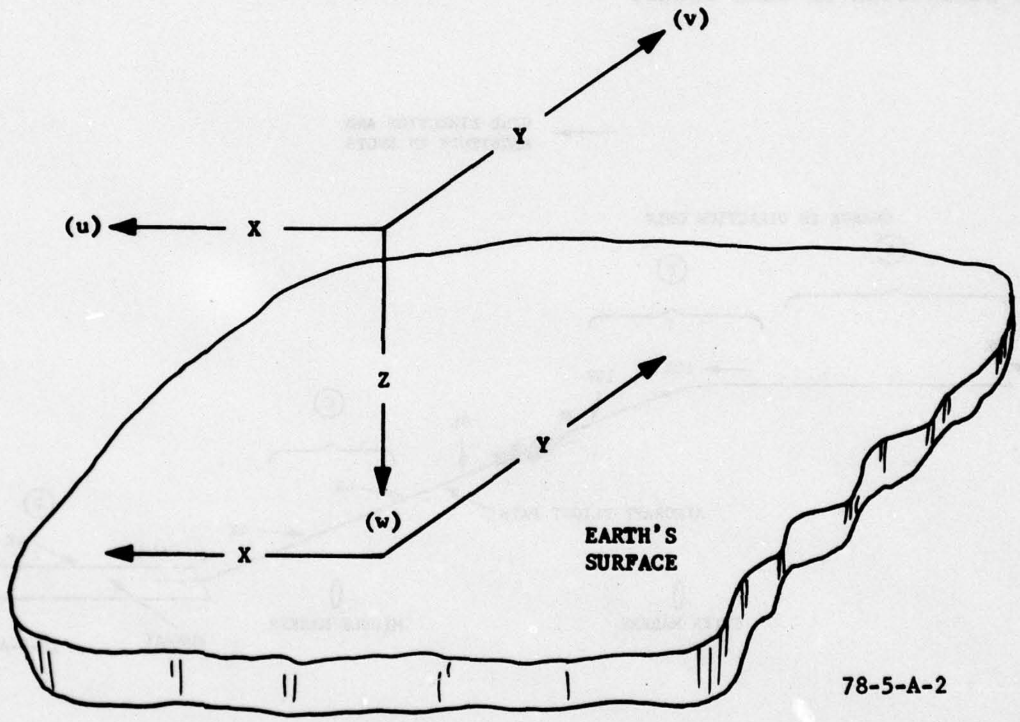

FIGURE A-2. RIGHT-HAND ORTHOGONAL COORDINATE SYSTEM

This definition would include as wind shears, those noted in the Boeing article, plus (1) updrafts and downdrafts, (2) mountain waves (topographic), and (3) shifts in windspeed and or direction due to surface characteristics and surrounding structures (orographic). Figure A-3 shows examples of this definition of wind shear.

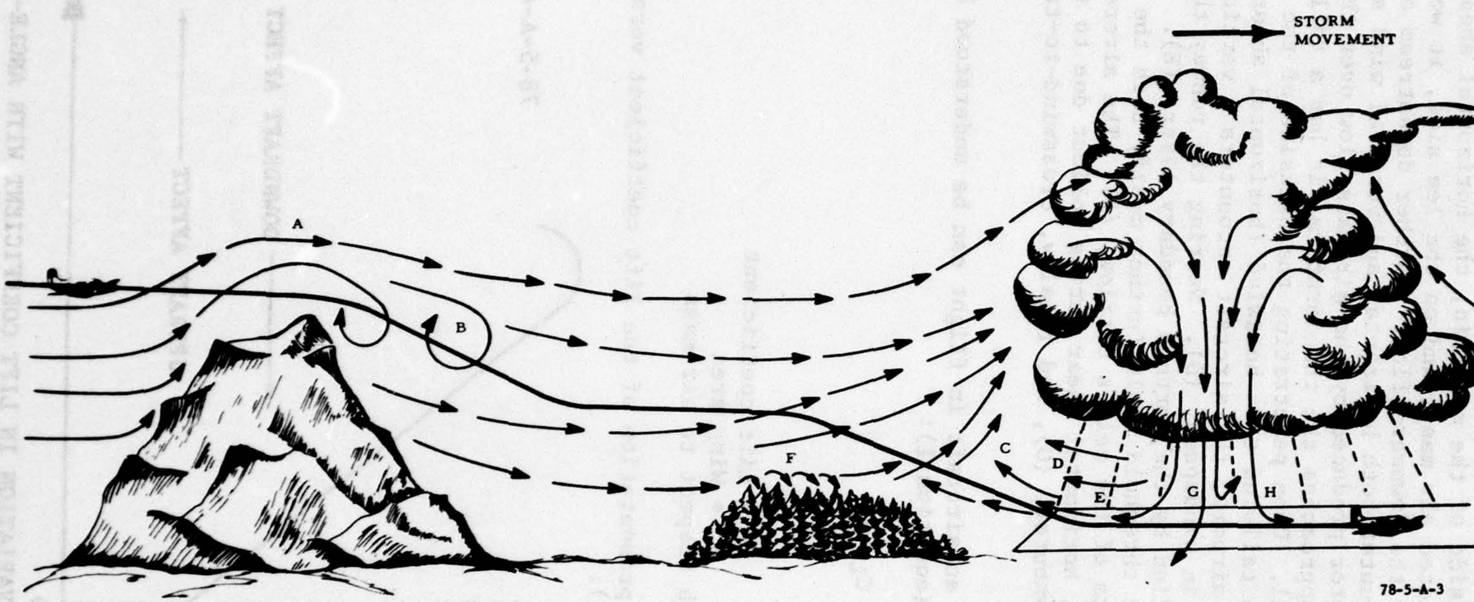

FIGURE A-3. WIND SHEAR DEFINITION WITH RESPECT TO EARTH REFERENCE

The aircraft encounters a horizontal shear as it encounters the mountain wave at (A) on the windward side of the mountain, the horizontal shear would be due to the upward deflected air mass, and on the lee side, it would encounter horizontal shear due to the downward flow. Further downstream of the mountain, the aircraft could encounter both horizontal and vertical wind shear as it descends through the rotor produced by the air mass flow over the mountain, (B). As the aircraft approaches the thunderstorm, it has a tailwind due to the air flow toward the cell. Upon penetrating the backside of the storm system, the wind changes from a tailwind to a headwind (horizontal shear), (C). During its descent toward the airport, the aircraft encounters a vertical shear due solely to the increase in windspeed, (D). Nearing the runway threshold, the vertical shear is modified by the earth's boundary layer, (E). In addition, the topography near the threshold could further modify both the vertical and horizontal shear effects of the cell's outflow, (F). The aircraft finally encounters a crosswind, horizontal shear during rollout due to the outflow associated with the downburst, (G), and finally, crosswind-to-tailwind horizontal shear, (H).

How wind shears affect an aircraft in flight can be understood by examining the equation for lift (equation 1):

$$F_L = 1/2\ \rho V^2\ C_L\ S$$

where

F_L = Lift $\qquad$ C_L = Lift coefficient
ρ = Air density $\qquad$ S = Wing area
V = Velocity with respect to air mass

and a typical graphic presentation of the lift coefficient versus angle of attack (α) (figure A-4).

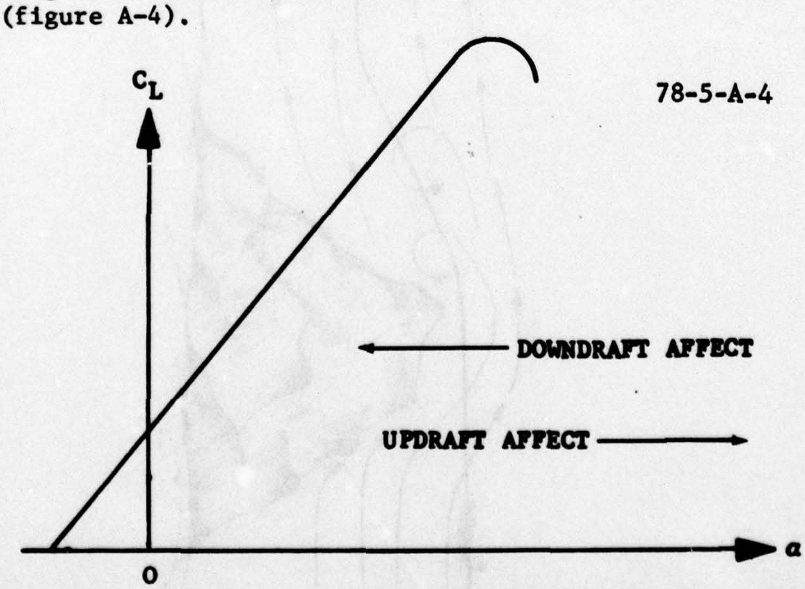

FIGURE A-4. VARIATION IN LIFT COEFFICIENT WITH ANGLE-OF-ATTACK

The wing angle-of-attack is the vector summation of the aircraft's pitch attitude, corrected for the wing's angle-of-incidence and the direction of the prevailing wind. Thus, an encounter with an updraft or downdraft when an aircraft is moving toward the runway during an approach (horizontal wind shear) would change this vector. The result would be a change in angle-of-attack which would affect the "C_L" term in the lift equation (equation 1). This could cause the aircraft to either "balloon" or result in a hard landing. If the change in angle-of-attack is severe enough, it can result in an overshoot or undershoot depending upon whether it is an updraft or downdraft.

Encountering any wind influences the velocity term (V) of the lift equation, (equation 1). This term is a squared quantity, and therefore, small changes in "u" would make large changes in lift (F_L). In addition, changes in "u" also affect path and this in turn would influence groundspeed and/or vertical speed. Thus, a vertical wind shear encounter would alter both the vertical and horizontal components of the aircraft's flight profile during an ILS approach.

APPENDIX B

LETTER TO AVIATION COMMUNITY SOLICITING SUGGESTIONS FOR ACCIDENT/INCIDENT ANALYSIS RELATING TO LOW-LEVEL WIND SHEAR HAZARD

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER
ATLANTIC CITY, NEW JERSEY 08405

DATE:

IN REPLY REFER TO: ANA-430

SUBJECT: Wind Shear Accident Analysis, Project 154-451-000

FROM: Acting Chief, Aircraft & Airports Safety Division, ANA-400

TO:

The National Aviation Facilities Experimental Center (NAFEC) has recently undertaken a project whose stated technical objective is:

> "Investigate the factors involved in wind shear accidents/incidents and their relationship to the severity of the hazard and evaluate procedures designed to increase operational tolerance to wind shear."

The approach to this study will be to develop the meteorological factors and accident data factors which can be used in a computer program to select and evaluate accident/incident data which may be available from NTSB, FAA, and DOD safety centers, covering the period from 1964-1974. This information and related meteorological data will be evaluated to develop a hazard profile definition.

The criteria used in the development of the computer program will be based on discussions and/or recommendations of the various interested segments of the aviation community, including:

1. Aircraft manufacturers (GAMA and commercial aircraft).
2. Aircraft users' and operators (ATA, airlines, air taxi).
3. Pilot organizations (ALPA, NPA, AOPA).
4. Government laboratories and agencies (NOAA, NASA, FAA, NTSB, DOD).
5. Aviation safety foundations and laboratories (FSF, University of Illinois, etc.).

The results of this analysis will be used to identify an updated model of the operational wind shear hazard which could be used to assess the efficacy of proposed technological and procedural countermeasures to the wind shear problem.

Your gratuitous suggestions and recommendations in developing the meteorological and accident/incident factors for initial automatically screening of existing pertinent digitally-stored data and approach in evaluating the available data would be greatly appreciated.

The NAFEC project manager assigned to this program is Jack J. Shrager, ANA-430. He may be reached by phone as follows:

Commercial:	609-641-8200, Extension 2665/2644	
FTS	:	346-2665/2644
Autovon	:	234-1596

We would appreciate your response in our effort to achieve a meaningful aviation safety-oriented analysis of historical data which would produce cost-effective results with respect to the low-altitude wind shear problem.

GEORGE P. BATES, JR.

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APPENDIX C

EXTRACT FROM AVAILABLE DOCKET EXAMINATION OF ACCIDENTS/INCIDENTS LISTED IN TABLE 5

DOCKET NO. 2-0122

The Beechcraft B-95 accident at Colby, Kansas on April 22, 1964, occurred at approximately 14:15 Central Standard Time (CST), 20:15 Greenwich Mean Time (GMT), during reported unstable wind conditions. The flight was a VFR business flight for which no flight plan had been filed. The fatal accident occurred during an approach to runway 18 of the municipal airport at Colby, Kansas.

The following weather information is documented in the accident docket.

Time (local)	Source	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Altimeter Setting (inHg)	Remarks
14:00	*Goodland	70 ⦶	15+	66	24	8	-	964	Virga line West
14:06	Goodland Radio	-	-	-	27	15	-	-	
14:08	Airport Wind Sock	-	-	-	11	-	-	-	
14:15	Airport Manager	Unlimited	15+	62	SSE (17)	14			Turbulent
Approx. 14:30	Airport	-	-	-	NW (31)	?	30	-	

*30 miles west of accident site.

According to witness statements, an aircraft which had landed about 2 minutes prior to the accident, had to go to full power on final to maintain altitude, then after getting through this meteorological phenomenon almost overshoot the 2,600 foot runway. Within 30 minutes after the accident, the observed wind at the airport shifted from the south to the northwest with gusts up to 30 knots.

The subject aircraft's altimeter indicated 5,600 feet with an altimeter setting of 29.64, and an airspeed of 138 mph. The runway elevation is 3,176 feet. The aircraft was observed to descend almost straight down and strike the ground in a more or less flat attitude. According to an analysis of the main impact ground scars, in conjunction with the condition and location of the main wreckage, it was determined that there was little, if any, forward speed when the aircraft struck the ground. There was no evidence of any engine malfunction or power interruption.

The conditions described in the docket would be similar to that which could occur due to a strong wind shear associated with a Virga (similar to the B727 accident at Denver, Colorado in August 1975). Accordingly, the potential presence of a low-level wind shear can not be eliminated.

DOCKET NO. 3-0578

The Cessna 310C accident at Palo Alto, California on March 4, 1965, occurred at 18:00 Pacific Standard Time (PST), 02:00 GMT, during reported gusty wind conditions. The nonfatal aircraft accident occurred during a VFR landing on runway 12 of the Airport of Santa Clara.

The very limited information in the docket reported the weather conditions to be:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Wind Direction (x 10°)	Windspeed (knots)	Gust (knots)	Remarks
100	5 +	18	20	?	Gusty

There is insufficient information in the docket to determine if the hard landing could have been due to the presence of a low-level wind shear.

DOCKET NO. 3-0661

The Cessna 310D accident at Franklin, North Carolina on April 13, 1965, occurred at approximately 13:45 Eastern Standard Time (EST), 18:45 GMT, during reported moderate to severe turbulence. The flight was on a VFR flight plan from Watertown, New York to Franklin, North Carolina. The nonfatal accident occurred during an approach to runway 36 which had a manmade sod dike at the 36 end and resulted in an undershoot.

The estimated weather conditions at the time of the accident were:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
Clear	15 +	65	34	15	20	

According to the accident report, the requirement for making this approach was low and slow because it was 400 feet shorter than its published length (2,286 feet versus 2,700 feet). Such an approach would have made the aircraft sensitive to any change in wind speed or direction due to the orographic wind affects which may have been caused by the sod dike.

The information contained in the docket is very limited; therefore, the determination of the potential presence of a low-level orographic wind shear is not possible.

DOCKET NO. 3-1439

The Aero Commander 680F6 accident at Sedona, Arizona on June 15, 1965, occurred at approximately 12:40 Mountain Standard Time (MST), 18:40 GMT, during observed variable, gust, and turbulent wind conditions. The flight was a VFR executive flight for which no flight plan had been filed. The nonfatal accident occurred during an approach to runway 34 of the Oak Creek Canyon Airport that resulted in a hard landing.

The estimated weather information contained in the docket shows that the weather at the time of the accident was:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
Clear	25 +	80	20	15	20	Turbulent, Downdrafts

Witness statements, including the two pilots, indicated that the approach was normal until just prior to touchdown at which time the aircraft developed a high sink rate that resulted in a hard landing with the initial touchdown point approximately 85 feet short of the runway threshold.

The airport is located on a 500 foot high mesa with the end of the runway used located about 150 feet from the edge of the mesa. There is almost always wind at the airport and at times very turbulent.

The limited information in the docket suggests that the conditions did exist which may have produced a low-level orographic wind shear.

DOCKET NO. 2-0504

The Navion D-16 accident near Grand Canyon National Park, Arizona occurred on August 21, 1965, at approximately 15:00 MST, 22:00 GMT, during reported gusty wind conditions with associated mountain waves. The aircraft accident, which resulted in serious injuries to all three occupants, occurred during the initial climb following a departure from runway 21 of the Grand Canyon Airport. The descent into the ground within 2 miles of the airport was reportedly due, in part, to a mountain wave.

The accident brief reports the weather at the time of the accident to be:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
10	5 +	70	20	25	-	Downdraft

The docket for this accident was not available for review at the time of this report.

DOCKET NO. 3-2897

The Cessna 32D accident at Andrews, Texas on October 17, 1965, occurred at approximately 14:00 Central Daylight Time (CDT), 19:00 GMT, during reported severe frontal activity. The flight was a VFR business/pleasure flight for which no flight plan had been filed. The nonfatal accident occurred during a precautionary approach and landing to runway 15 of the Andrew County Airport which resulted in an overshoot, apparently due, in part, to a sudden wind shift associated with frontal activity.

The estimated weather conditions at the time of the accident was:

Source	Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
Pilot	E80⊕	15 T	65	32	40		Gusty
Witness	-	-	-	SSW/NNW (22)/(32)	35/40		Sudden Wind Shift

The pilot had received a weather briefing prior to departure of a severe weather alert associated with a Pacific cold front.

The information in the docket is consistent with a low-level wind shear which would be associated with strong frontal activity.

DOCKET NO. 3-3625

The Beechcraft B-55 accident at Oklahoma City, Oklahoma on December 24, 1965, occurred at 01:00 CST, 07:00 GMT, during a reported and observed heavy rainfall. The nonfatal aircraft accident occurred during a radar approach to runway 35 at the Will Rogers International Airport which resulted in a hard landing.

The recorded surface weather observations for Will Rogers Airport were:

Type of Observation	Time (GMT)	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Sea Level Pressure (mbar)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Altimeter Setting (inHg)	Remarks
R	06:00	E10⊕	5 R+	046	57	290	5	-	967	
S	06:30	E10⊕	1 R+	-	-	330	7			Wind Shift
L	06:45	E10⊕	1 R+	-	-	-	-	-	-	
R	07:00	6◑E10⊕	1 R+F	046	56	320	20	30	967	Pressure Unsteady
S	07:15	6◑E10⊕	1 R+F -	-	-	350	18	296	967	Accident

Other weather information in the docket included:

	Sky and Ceiling	Visibility	Temperature	Wind Direction	Windspeed	Gusts	Remarks
Accident Report	E12⊕	5 R	50	300	20	30	Turbulent
Official Report	E10⊕	1 R+F	56	360	20	30	

The aircraft encountered a heavy rain at the time of flare with an accompanying wind shift resulting in a very hard landing on the runway surface.

DOCKET NO. 3-3970

The Piper PA-30 accident at Albion, Illinois on April 26, 1966, occurred at approximately 16:30 CDT, 22:30 GMT, during observed approaching thunderstorms and encountered rain conditions. The VFR nonfatal accident happened during a precautionary landing in a sod field which resulted in a hard landing sufficient to induce gear collapse.

The recorded surface weather conditions at Evansville, Indiana (40 miles from the accident site) were:

Type	Time	Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature °F	Wind Direction (x10°)	Speed (knots)	Setting (inHg)
S		7⊕	1 1/2 TRWF	58	12	13	981
R	16:55	M7⊕	1 1/2 RF	58	12	13	981

The accident report shows the weather at the accident site to be:

Accident Report		40⊕	10 TRW		SSE	10 +	

The information in the docket was very limited and although the report does show that thunderstorms were reported in the area forecasts, their proximity to the landing site at the time of the accident can not be established.

DOCKET NO. 3-1280

The Beechcraft B-95 accident at Herndon, Virginia on May 8, 1966, occurred at 18:00 EST, 23:00 GMT, during observed thunderstorm activity. The nonfatal accident occurred during a VFR landing on runway 01R at the Dulles International Airport which resulted in a hard landing.

The estimated weather conditions at the time of the accident were:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
0⊕	5 + TRW +	-	36	-	-	Winds variable with gusts.

The aircraft encountered severe turbulence and possible wind shifts just at touchdown which was believed to be associated with the approaching thunderstorm.

The information in the docket was limited to pilot and witness statements concerning both the weather conditions and the affects of the wind on the landing aircraft.

DOCKET NO. 3-1230

The Piper PA-23 accident at Lubbock, Texas on June 9, 1966, occurred at 01:22 CST, 07:22 GMT, during reported thunderstorm activity and high wind conditions. The nonfatal aircraft accident occurred during a night VFR landing on runway 26 at the local airport which resulted in an overshoot.

According to the accident brief, the weather at the time of the accident was:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
50⊕	5 +	72	5	44	Variable/ Gusty	Thunder-storm Activity

The docket for this accident was not available for examination at the time of this report. Therefore, the specifics relating to this downwind landing can not be determined. Accordingly, this accident has not been included in those in which a potential low-level wind-shear hazard could have been a factor.

DOCKET NO. 3-3011

The Cessna 310 accident at Las Vegas, New Mexico on October 31, 1966, occurred at 23:15 MST, 06:15 GMT, during reported vertical air mass movement (downdraft, updraft), (horizontal wind shear). The nonfatal accident occurred during a night VFR landing on runway 2 at the Las Vegas Municipal Airport.

The accident brief reports the weather at the time of the accident to be:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
20 ?	5 +	32	7	18	Gusty	Downdrafts/ Updrafts

The docket for this accident was not available for a detailed examination. Therefore, the alleged horizontal wind shear encounter is not included in the listing of those accidents with the potential presence of a low-level wind-shear hazard.

DOCKET NO. 3-1241

The Beechcraft 95-B55 accident at Gaithersburg, Maryland on April 17, 1967, occurred at approximately 12:00 EST, 17:00 GMT, during variable and gusty wind conditions and rain. The nonfatal accident occurred during an IFR approach and landing at the Montgomery County Airpark.

The accident brief reports the weather conditions at the time of the accident to be:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
5Ⓞ	4 R	55	Variable	15	25	Wet Runway

The docket for this accident was not available for detailed examination; therefore, no further evaluation of the accident was possible.

DOCKET NO. 3-1690

The Cessna 421 accident at Wichita, Kansas on May 25, 1967, occurred at approximately 15:45 CST, 21:45 GMT, during gusty wind conditions. The nonfatal accident occurred during a VFR approach for runway 17 at the Cessna Aircraft Airport that resulted in an undershoot.

The pilot and investigator's reports indicate that the estimated weather conditions were:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
Clear	15 +	91	18	23	32	-

Due to the topography of the airport which has a gully at the north end of the runway, a downdraft will be present near the threshold of runway 17 when a south wind is blowing.

The aircraft experienced an unanticipated increase in sink rate just short of the runway threshold which was probably due to an orographic horizontal wind shear (downdraft) encounter.

DOCKET NO. 3-2602

The modified DeHavilland DH-104 (Riley 400) accident at Hilo, Hawaii on July 29, 1967, occurred at approximately 12:45 Hawaiian Standard Time (HST), 22:45 GMT, during observed wind shear conditions. The nonfatal accident occurred during a VFR landing for runway 19 at the Kaanapali Airport and resulted in an overshoot.

The accident report shows the weather conditions to be:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
Clear	15 +	86	18	6	-	Turbulence

The pilot reported that the wind sock at the north end of the runway indicated a north wind (tailwind) while the wind sock at the south end and the tower indicated a south wind (headwind). A definite orographic wind shear line frequently appears in the Kaanapali area due to its location on the leeward side of Mauna Loa and Mauna Kea.

After touchdown in the first quarter of the 2,600 foot long runway, the aircraft again became airborne and settled back onto the runway approximately halfway down the runway. This ballooning could have been due to the sudden shift in wind direction from a tailwind to a headwind near the touchdown zone.

DOCKET NO. 3-0100

The Cessna 310 accident at Greensboro, North Carolina on January 24, 1968, occurred at approximately 15:00 EST, 20:00 GMT, at the Greensboro-High Point Airport. The nonfatal aircraft accident occurred during a VFR approach and landing for runway 5 at the Greensboro-High Point Airport and resulted in an undershoot.

The report weather at the time of the accident was:

Sky & Ceiling (x 100 ft)	Visibility (nmi)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gust (knots)	Altimeter Setting (inHg)
14	3 H	27	3	17	25	981

The pilots and passengers reported that the aircraft encountered a strong downdraft just prior to touchdown, causing the aircraft to touchdown hard just short of the runway.

The FAA investigators report indicated that this accident was similar to a Piper PA-28 accident which had occurred within the past 90 days at this airport. It was the seventh landing gear accident at this airport within the current fiscal year (7 months).

The cause of the apparent wind shear condition could not be identified.

DOCKET NO. 3-0602

The Piper PA-23 accident at Mariposa, California on March 12, 1968, occurred at approximately 17:00 PST, 01:00 GMT, during an observed crosswind from the south. The nonfatal accident occurred during a VFR landing on runway 26 at the Yosemite Airport and, due to a sudden wind shift, resulted in an overshoot.

The information in the docket was very limited. The accident report indicates the weather at the time of the accident to be:

Source	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Remarks
Accident Brief	Clear	5 +	55	18	10	25	Sudden wind shift
Witness	-	-	-	9	15	25	Sudden wind shift

A witness statement indicates the winds to be 090/15-25 shifting to a direct tailwind (180 degrees) at 15 to 20 miles per hour. Two pilots who witnessed the accident reported that the wind switched to a tailwind at touchdown.

There is a drop off to a large valley on the eastern end of runway 8/26. A witnessess statement indicated that this airport is known to have problems with changes in wind direction and velocity. In fact, the witnessess statement describes the airport as one which can be "very tricky and treacherous."

Information in the docket tends to support the possible presence of an orographically induced horizontal wind shear (change in wind direction and velocity along the aircraft flightpath) at level off and touchdown.

DOCKET NO. 3-1209

The Cessna 337B accident at Genoa City, Wisconsin, on May 7, 1968, occurred at approximately 17:30 CST, 23:30 GMT during gusty wind conditions and an alleged sudden wind shift. The nonfatal VFR aircraft accident occurred during a landing on runway 27 at the Vincent Airport which resulted in an overshoot.

The accident brief reports the weather to be:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
Clear	5 +	-	14	15	-	Sudden wind shift and wind gusty

The accident docket was not available for examination at the time of this report. Therefore no further evaluation of this accident for the potential presence of a low-level wind-shear hazard was possible.

DOCKET NO. 3-1606

The Beechcraft C-454 accident of June 3, 1968, at Hartford, Connecticut occurred at 15:15 EST, 20:15 GMT, during observed and reported thunderstorm activity. The nonfatal aircraft accident occurred during a landing on runway 20 of Brainard Field.

The recorded surface weather observations for Bradley International Airport (approximately 16 miles north northeast of Brainard) was:

Type of Obser-vation	Time (GMT)	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Sea Level Pressure (mbar)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Altimeter Setting (inHg)	Remarks
R	13:55	-XE18⦶/⦶	2 H	059	73	17	10	-	970	
L	14:12	-XE18⦶/●	2 H	-	-	-	-	-	-	
S	14:18	-XM25●	2 H	-	-	16	10	-	-	
L	14:28	-XM25⦶/●	2 H	-	73	15	8	-	-	
L	14:40	-XE25⦶/●	2H	-	-	-	-	-	-	
R	14:55	-XE33⦶100●	2 H	068	72	18	8	-	972	
S	15:01	-XM33⦶/100●	2 1/2 RW-H	-	-	28	18	-	-	PRESSR
S	15:07	M33 ⦶ 90⊕	2 1/2 TRW-H	-	-	27	20	-	-	TW moving E
S	15:17	M28 ⦶ 90⊕	2 TRW-H	-	-	24	21	-	-	T WSW voving E
S	15:22	15⦶22⦶M28⊕	2 TRW+H	-	-	24	19	-	-	T WSW moving overhead
S	15:26	10⦶E20⊕	1 1/2 TRW+H	-	-	25	13	-	-	T overhead moving E
S	15:34	6⦶10⦶E20⊕	1 1/2 TRW+H	-	-	26	11	-	-	T overhead moving E
S	15:40	6⦶10⦶E20⊕	1 1/2 TRW+H		-	28	8	-	-	T E moving E
R	15:55	6⦶10⦶E20⊕	1 1/2 TRW+H	087	60	25	3	-	978	T E moving E
L	16:01	E20⦶50⦶110⊕	5 TRW-	-	-	33	4	-	-	T E moving E
L	16:09	20⦶E50⦶110⦶	7 RW-	-	-	03	4	-	-	

The recorded surface weather information at Rentschler (East Hartford) (approximately 4 miles east of Brainard) was:

Type of Obser-vation	Time (GMT)	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Sea Level Pressure (mbar)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Altimeter Setting (inHg)	Remarks
R	14:00	-XE15⦶100⊕	3 H	-	75	18	12	-	971E	
R	15:00	15⦶U⊕	5 H	-	72	24	7	-	972E	
S	15:10	-XE15⦶30⊕	5 H	-	64	24	12	-	974E	
S	15:25	E10⦶35⊕	4TRWF	-	64	30	25	35	976E	T W moving E
S	16:00	10⦶E20⊕	6TRW-	-	60	30	10	25	976E	T overhead moving E
S	16:20	E35⦶U⊕	10	-	60	00	00	-	977E	T moving E
R	17:00	E50⦶/-●	10	-	62	00	00	-	977E	

The pilot had established radio communications with Bradley Tower ATC at 15:05 EST for the purpose of filing a special IFR flight plan. ATC advised the pilot that, due to a large thunderstorm which was right over the airport, they were unable to accept a special VFR into Bradley. The pilot acknowledged and indicated the aircraft was going back to Hartford.

The pilot stated that when turning final at Brainard, Rentschler Tower reported winds 240 at 15 gusts to 18. Rentschler Tower reports no record of this contact. The accident report indicates that the weather at the time of the accident was cloudy, ceiling 3,000, visibility 4 to 6 miles with thunderstorms, rain showers, and haze, temperature 60°, altimeter setting 29.76 and winds 300°, 10 knots with gusts to 25 (see Rentschler regular 16:00 weather observations).

The Rentschler surface wind observations 5 minutes prior to the accident (15:10) show the wind to be 240 at 12 and 10 minutes after the accident (15:25), to be 300 at 25, gusts to 35, and thunderstorm conditions with moderate rain showers. This is consistent with the winds reported by the pilot prior to touchdown and the wind conditions reported by a witness statement just at touchdown.

The Bradley International Airport's observations also show a shift in the wind from 250 at 3 knots to 330 at 4 knots which is associated with thunderstorm activities.

These reported wind shifts are typical of the outflow patterns which may be expected when a thunderstorm passes over, or is close to, an airport.

DOCKET NO. 3-3117

The Cessna 310C accident at Omaha, Nebraska on July 23, 1968, occurred at approximately 15:00 CST, 21:00 GMT, during reported gusty wind conditions. The nonfatal VFR aircraft accident occurred when landing on runway 14 at the Omaha Eppley Airport.

The accident brief reports the weather at the time of the accident to be:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
300	5 +	-	14	14	20	-

The accident docket was not available for a detailed examination at the time of this report. Therefore, no further analysis of this accident was possible at this time.

DOCKET NO. 3-4445

The Beechcraft A65 accident in Chicago, Illinois on December 13, 1968, occurred at 08:25 EST, 14:25 GMT, during reported strong wind gusts. The nonfatal VFR aircraft accident occurred during the approach for runway 18 at Meigs Field, which resulted in an undershoot.

The reported surface weather conditions at the time of the accident were:

Source	Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)
Accident Brief	300	5 +	-	23	15	40
Tower	250	10	30	24/25	10	40

The aircraft's reported approach looked good until it apparently stalled when the windspeed dropped off sharply. The magnitude of the reported gusts were approximately 50 percent of the aircraft's stall speed and would have resulted in the aircraft stalling if the pilot were making a normal approach at 1.3 V_{SO}. The pilot had been advised of a measured gust of 40 knots when the aircraft was on final.

Due to the strong gusts, it is not possible to preclude the presence of a low-level horizontal (change in windspeed along the aircraft's flightpath) wind-shear hazard.

DOCKET NO. 3-4479

The Cessna 421 accident at Elkhart, Indiana, on December 26, 1968, occurred at 09:42 CST, 15:42 GMT, during reported gusty wind conditions. The nonfatal VFR aircraft accident occurred during a landing on runway 9 at the Elkhart Municipal Airport and resulted in a hard landing.

The reported surface weather conditions at the time of the accident were:

Source	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Altimeter Setting (inHg)
Accident Brief	35	5 +	-	9	13	21	-
Accident Report	35	15	15	9	15	23	012

There was insufficient information in the docket to allow further analysis of this accident.

DOCKET NO. 3-1412

The Mitsubishi MU-2B accident at Bridgeport, New Jersey on April 27, 1969, occurred at approximately 14:45 Eastern Standard Time (EST), 19:45 GMT, during reported gusty wind conditions. The nonfatal VFR aircraft accident occurred during an approach for runway 4 at the Bridgeport Airport.

The reported surface weather conditions at the time of the accident were:

Source	Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Remarks
Aircraft Brief	Clear	Unlimited	60	Winds gusty and Downdrafts/Updrafts

The information in the accident docket was insufficient to permit further analysis of this accident.

DOCKET NO. 3-0464

The Cessna 310D accident at Kutztown, Pennsylvania on March 1, 1969, occurred at approximately 15:00 EST, 20:00 GMT, during reported gusty wind conditions. The nonfatal VFR aircraft accident occurred during an approach for runway 35 at the Kutztown Airpark which resulted in a hard landing. (The Airman's Information Manual (AIM) Part 2 of Spring-Summer 1977, shows a 09/27 runway that is 2,065 feet long.)

The surface weather conditions at the time of the accident as reported in the accident brief were:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
30	4	-	27	20	28	-

The accident brief reports that the landing was made with a left crosswind component by a pilot with over 300 hours in this type aircraft.

The accident docket was not available for examination at the time of this report. Therefore, it was not possible to determine if runway 9/27 was in existence at the time of the accident and available for use.

Based on the limited information in the accident brief, no further analysis of this accident was possible.

DOCKET NO. 3-4309

The Beechcraft B90 accident in San Antonio, Texas on October 27, 1969, occurred at 11:04 CST, 17:04 GMT, during reported gusty wind conditions. The nonfatal VFR aircraft accident occurred during an approach for runway 3 at the San Antonio International Airport. (The AIMS, Part II, dated Spring-Summer 1977 shows a 17/35 runway which is 2,400 feet long.)

The reported surface weather conditions contained in the accident brief were:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)
25	5 + H	58	36	12	24

The docket was not available for examination; therefore, no further determination could be made concerning this accident.

DOCKET NO. 3-2849

The Dehavilland DH 104 accident at Molokai, Hawaii on November 3, 1969, occurred at 15:27 HST, 01:27 GMT, during reportedly expected orographic downdraft and turbulent conditons. The flight was a VFR air taxi operation for which no flight plan had been filed. This accident, which resulted in serious injury to some of the passengers, occurred during the approach for runway 5 of the Kalaupopo Airport.

The reported surface weather observation for Molokai Airport (8 miles south of Kalaupapa Airport) were:

Time (GMT)	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Sea Level Pressure (mbar)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Altimeter Setting (inHg)	Remarks
15:00	20Ⓑ	15+	145	80	4	15	-	997	
16:00	25Ⓑ	15+	145	79	4	18	-	997	

Observed conditions by an airline pilot who landed at Kalupapa Airport prior to the accident was:

15:10/ 15:15	20Ⓑ	15+	-	-	5	7-10	-	-	

A PIREP report of the estimated weather at Kalaupapa Airport at the time of the accident was:

15:27	20Ⓑ	15	-	80	8.5/9.5	15	20	999	

There have been previously reported accidents at this airport due to downdrafts which are caused by a rocky drop-off between the beach and the runway threshold. There has been repeated recommendations to level this area to eliminate these conditions.

Based on the information in the docket, the presence of a low-level orographic wind-shear condition can not be eliminated.

DOCKET NO. 3-1017

The Beechcraft D185 accident in Hammondsport, New York, March 20, 1970, occurred at approximately 13:30 EST, 18:30 GMT, during reported gusty winds and conditions conducive to downdrafts. The VFR aircraft accident, which resulted in minor injuries to the occupants, occurred during an approach for runway 10 at the Taylor Van Gelder Airport and resulted in an undershoot.

The reported surface weather conditions at the time of the accident were:

Source	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Altimeter Setting (inHg)	Remarks
Airport Report	33⊕V⊕	10	39	16/17	10	15	001	Light Turbulence
Elmira Radio	55	10	39	16/17	-	-	001	Gusty

The accident report indicates that the wind conditions and terrain were conducive to a downdraft (horizontal wind shear) on final approach.

DOCKET NO. 3-0617

The Cessna 401A accident at Morrisville, North Carolina on April 2, 1970, occurred at 00:01 EST, 05:01 GMT, during rain and a reported strong wind shift (wind shear) at approximately 400 feet altitude. The fatal aircraft accident occurred during an instrument approach for runway 5 at the Raleigh Durham Airport.

According to the accident brief, the surface weather conditions at the time of the accident were:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Remarks
3⊕	1 RF	54	15	11	Strong wind shift at approximately 400 feet altitude on final.

Although the docket was not available for examination, the information in the accident brief is sufficient to include this accident as having a low-level wind-shear hazard present along the aircraft's flightpath.

DOCKET NO. 3-2832

The Beechcraft 95-B55 accident at Lockport, New York on July 3, 1970, occurred at approximately 12:30 EST, 17:30 GMT, during reported gusty wind conditions. The nonfatal VFR accident occurred during an approach and landing at Transit Airpark that resulted in a hard landing.

Source	Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Remarks
Accident Brief	Clear	5 +	83	25	15	Left quartering head wind

The limited information contained in the docket does not indicate the possible presence of a low-level wind shear.

DOCKET NO. 0642

The Piper PA-30 accident in Hershey, Pennsylvania on January 23, 1971, occurred at approximately 16:00 EST, 21:00 GMT, during reported gusty wind conditions. The nonfatal VFR accident occurred during an approach and landing on runway 26 at the Hershey Airpark.

The reported surface weather conditions at the time of the accident were:

Source	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Altimeter Setting (inHg)	Remarks
*Harrisburg	Clear	35+	39	29	19	27	995	*(Apprx. 20 miles away)
Accident Report	Clear	15	-	NW	20	30	-	
Accident Brief	Clear	5+	-	27	19	27	-	Downdrafts/Updrafts

The analysis of the limited information in the docket suggests that the accident was influenced by the right quartering gusty head wind encountered by the aircraft at level off and touchdown.

DOCKET NO. 3-2037

The Cessna T337E accident at Deming, New Mexico on June 23, 1971, occurred at approximately 19:30 MST, 02:30 GMT, during reported gusty wind conditions. The nonfatal VFR aircraft accident occurred during an approach and landing in the ramp area of the Deming Municipal Airport. The ramp area landing was authorized at the pilot's option due to the high prevailing winds which did not favor any of the existing runways.

The reported surface observations at the time of the accident were:

Source	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Altimeter Setting (inHg)	Remarks
FSS	220⦶	25+	85	32	17	28	998	Rainshowers, N NW, and NNE

There were known thunderstorms north of the airport environment and the possibility of local whirlwinds. However, there was insufficient information in the docket to do any further analysis.

DOCKET NO. 3-2043

The Beechcraft Volpar accident north of Fort Yukon, Alaska on January 27, 1972, occurred at 15:05 Local Standard Time (LST), 01:05 GMT, during reported stormy wind gusts. The nonfatal aircraft accident occurred following an IFR landing at the Fin Creek Airport.

The accident brief reports the surface weather conditions at the time of the accident to be:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
E10/U	1 BS	18	28	20	35	Right Quartering head-wind.

The accident brief indicates that there were snow banks near the runway. These snow banks coupled with the strong gusty wind conditions could have produced variable winds along the landing roll. However, the docket was not available for a more detailed analysis. Therefore, no conclusions can be drawn regarding the potential presence of a low-level topographic wind shear.

DOCKET NO. 3-0435

The Piper PA-23 accident at Spring Grove, Illinois on April 29, 1972, occurred at approximately 14:30 CST, 20:30 GMT, during reported downdraft. The nonfatal accident occurred during a low approach for runway 18 at the Sheldon Restricted Landing Area (RLA) resulting in an undershoot.

The Glenview Naval Air Station (27 miles southeast of the Sheldon RLA) reported the surface weather observations to be:

Sky and Ceiling (x 100 ft)	Visibility (nmi)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts)knots)	Altimeter Setting (inHg)	Remarks
70 ⊕	18 H	45	15	12	15	006	Light turbulence

The pilot and the operator of Sheldon RLA reported the observed weather conditions to be similar to that of the Glenview Naval Air Station. The operator further indicated that there were normally downdrafts on the final approach when the winds were from the south, due to the valley that was 50 to 100 feet lower than the threshold of runway 18. The pilot was not familiar with this airport nor the potential presence of the orographic low-level wind shears with southerly winds.

DOCKET NO. 3-3394

The Piper PA-34 accident at Zapata, Texas on September 8, 1972, occurred at approximately 15:00 CST, 21:00 GMT, during reported rain. The nonfatal VFR aircraft accident occurred during a landing at the Lakeford Lodge Airport which has a single 14/32 2,900 foot hard surface runway.

The accident brief shows the weather at the time of the accident to be:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)
20 -X	5 + R	65	5	20	-

The docket was not available for a detailed analysis of this accident. However, the accident brief indicates that the aircraft attempted to land with a 20 knot 90° crosswind.

DOCKET NO. 3-4058

The Piper PA-30 accident at Memphis, Tennessee on November 26, 1972, occurred at approximately 17:15 CST, 22:15 GMT, during a reported thunderstorm with associated rain showers. The aircraft accident, which resulted in a serious injury to the sole occupant, occurred during an ILS approach to runway 35R at the Memphis International Airport.

The official reported surface weather observation for the Memphis International Airport were:

Type of Observation	Time (local)	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Sea Level Pressure (mbar)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Altimeter Setting (inHg)	Remarks
S	15:38	M5⊕15⊕	1 1/2 RWF	-	-	35	12	-	009	
R	15:55	M5●	1 RWF	181	55	4	9	-	009	
S	16:15	M3⊕15⊕	1/2 TRW-F	-	-	10	7	-	009	
R	16:54	M3⊕15⊕	1/2 TRW-F	-	56	10	9	-	008	T overhead
S	17:14	M3⊕	1 TRWF	-	-	10	10	-	007	pressure unsteady T overhead
S	17:18	M3●	1 TRWF	-	56	10	11	-	007	pressure unsteady T overhead

Other reported weather information include:

Source	Time (local)	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Altimeter Setting (inHg)	Remarks
A ATIS	-	M3⊕15●	1/2 TRW-F	68	10	7	-	009	
ATC	16:56	M3⊕15●	1/2 TRW-F	-	8	7	-	009	Acknowledged by pilot
ATC	17:13	-	-	-	0	8	-	-	

The instrument rated pilot/owner of the aircraft had over 1300 hours experience in this type of aircraft, including 63 hours (10 hours actual instrument experience) in the last 90 days. The pilot reported that he had experienced difficulties in being able to maintain the glide slope. The reasons for his experiencing this difficulty cannot be ascertained from the information in the docket.

DOCKET NO. 3-3457

The Cessna 310N accident at Bedford, Pennsylvania on December 29, 1972, occurred at 12:12 EST, 17:12 GMT, during reported gusty wind conditions with associated downdrafts. The VFR aircraft accident, which resulted in critical injuries to the sole occupant, occurred during an approach and landing on runway 21 at the Bedford Airport.

The reported or observed weather at the time of the accident was:

Source	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Remarks
Accident Brief	Clear	5+	-	11	5	-	Downdrafts/Updrafts
Pilot	Cloudy	7	57	ESE	5	-	Gusty
FAA Investigator	-	7	-	ESE	5	15	

This undershoot accident appears to have occurred under conditions which would normally result in touching down further down the runway than normal (tailwind).

There is very limited information in the accident docket; however, the investigator does report that gust winds and downdrafts were a contributing factor. The cause of these downdrafts (horizontal wind shear) is not indicated in the report.

DOCKET NO. 3-0736

The Piper PA-31 accident at Niles, Michigan on March 31, 1973, occurred at 20:53 EST, 1:52 GMT, during reported thunderstorm conditions with associated heavy rain showers. The fatal aircraft accident occurred during an approach and landing on runway 3 at the Jerry Tyler Memorial Airport.

The official surface weather observations for South Bend, Indiana (approximately 14 miles from Niles) was:

Type of Observation	Time (local)	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Sea Level Pressure (mbar)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Altimeter Setting (inHg)	Remarks
R	19:56	M3●	2 1/2 F	021	49	8	13	-	959	
S	20:11	M2●	2 TF	-	-	8	13	-	957	T SW N
R	20:58	M2●	2 TRW-F	009	50	9	6	-	956	Peak winds 9/19
S	21:13	M1●	2 TRW-F	-	50	24	6	-	956	
S	21:37	M5●	2 TRW-F	-	-	33	3	-	957	
R	21:56	M6●	2 TRW-F	-	50	2	5	-	957	T all quadrants

The pilot was advised of the thunderstorm activity which was along his flightpath and projected to be at/or near Niles. ATC recommended and the pilot accepted guidance in an effort to avoid flying too close to the large build-up along his flightpath.

During the last communications between the aircraft and ATC, the following weather information was exchanged:

Source	Time (local)	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Altimeter Setting (inHg)	Remarks
ATC	20:49	M2●	1 TF	-	-	-	-	-	Cleared to final approach fix for Niles
Pilot	20:52	-	RW	-	-	-	-	-	Moderate turbulence
ATC	20:52	-	-	-	7	10/15	20	953	You are along lead edge of cell

The 20:52 communications was the last one with the aircraft. Its reported close proximity with a cell after having been cleared for the VOR 3 approach to Niles (at 20:50) would place the aircraft in an environment of hazardous wind shear associated with the gust front and cell activity.

DOCKET NO. 3-3276

The Piper PA-23 accident in Chicago, Illinois on July 27, 1973, occurred at 14:31 CST, 20:31 GMT, during reported gusty cross-wind conditions. The VFR aircraft accident, which resulted in one fatality, occurred during an attempted go-around following a missed approach for runway 18 and the Merrill C. Meigs Airport.

The accident brief indicates that the weather conditions at the time of the accident were:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
50◐	5 +	87	25	15	28	Winds gusty.

The docket was not available; detailed analysis of this accident is not possible.

DOCKET NO. 3-4304

The Beechcraft B55 accident in Romulus, Michigan on January 26, 1974, occurred at approximately 18:00 CST, 24:00 GMT, during reported frontal activity with associated rain. The IFR accident, which resulted in two fatalities, occurred during a straight-in ILS approach for runway 3 at the Metropolitan Wayne County Airport.

The very limited information in the accident docket indicates the weather conditions at the time of the accident were:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
W2	1/4 R-FK	40	9/11	8/10	-	-

The aircraft struck trees approximately 2 miles from the runway threshold during reported frontal activity. While frontal activity can have associated with it a low-level wind shear hazard, there is insufficient information in the docket to allow such an interpretation.

DOCKET NO. 3-0200

The Piper PA-31 accident in Wilmington, Vermont on February 9, 1974, occurred at approximately 11:30 EST, 16:30 GMT, during reported downdrafts at an airport which is located in mountainous terrain. The nonfatal aircraft accident occurred during an approach and landing on runway 1 at the Mt. Snow Airport.

The limited information in the accident docket indicates that the Weather Bureau's report of weather conditions at the time of the accident to be:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Remarks
Clear	15 +	10	36	10	Moderate Turbulence

The pilot reported encountering severe downdrafts just about the time of flare. The aircraft's indicated airspeed was higher than normally required at Flare (100 IAS). Therefore, it is possible that in this mountainous terrain, that the aircraft encountered an orographically induced low-level wind-shear hazard.

DOCKET NO. 3-1350

The Cessna 500 accident in Menominee, Michigan on April 3, 1974, occurred at approximately 17:15 CST, 23:15 GMT, reported moderate turbulence with rain. The nonfatal accident occurred during a landing on runway 36 at the Menominee County Airport that resulted in an overshoot.

The surface weather conditions at the time of the accident were:

Source	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Altimeter Setting (inHg)	Remarks
Accident Brief	12U	5+R+	33	5	27	-	-	Wind Gusty
North Central Airlines	-	7R+	33	5	22	27	946	Moderate Turbulence
Accident Report	-	&R+	34	5	22	-	946	Moderate Turbulence

According to the accident report the computed runway requirement for the aircraft under heavy rain conditions was 55 feet more than the available runway length.

DOCKET NO. 3-1476

The Piper PA-31 accident in North D'Hanis, Texas on June 8, 1974, occurred at approximately 14:30 CST, 20:30 GMT, during reported moderate to severe turbulence. The nonfatal VFR accident occurred during a landing on runway 17 at the G and L Ranch Airport.

The reported surface weather conditions at the time of the accident were:

Source	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts)knots)	Altimeter Setting (inHg)	Remarks
Accident Brief	10+⦶	5+	-	18	15	30	-	Wind Gusty
Accident Report	50⦶	20+	105	18	15	30	-	

The pilot reported that he was carrying 10 percent more airspeed than normal due to the gust wind conditions when the aircraft hit a downdraft just prior to touchdown.

The very limited information in the accident docket precludes the ability to identify the specific cause of this low-level hazardous wind shear.

DOCKET NO. 3-2535

The Aero Commander 681 accident in Canyon, Texas on July 23, 1974, occurred at approximately 13:30 CST, 19:30 GMT, during reported local whirlwind conditions. The nonfatal VFR accident occurred during a takeoff from runway 17 at the Canam Airport.

The surface weather conditions as reported in the accident brief were:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
Clear	5 +	102	10	5	30	Local Whirlwind

The reported runway elevation was 3,600 feet with a reported length of 2,600 feet. The aircraft struck a fence post following take-off but was able to continue to its planned destination of Lubbock, Texas. This airport would be critical in length due to its high density altitude and short length.

The pilot reported that the aircraft encountered a local whirlwind with gusts up to 30 knots during take-off and initial climb.

The docket was not available for a detailed analysis; therefore, it was not possible to establish the presence of a low-level wind-shear hazard.

DOCKET NO. 3-2676

The Cessna 310J accident in Austin, Minnesota on August 2, 1974, occurred at approximately 16:30 CST, 22:30 GMT, during reportedly deteriorating weather conditions. The nonfatal VFR accident occurred during a landing on runway 35 of the Austin Municipal Airport which resulted in a hard landing.

The reported surface weather conditions at the time of the accident were:

Source	Time (local)	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Sea Level Pressure (mbar)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Altimeter Setting (inHg)	Remarks
Accident Report	-	10U	6/8 R-	-	70	27	18	25	001	Moderate Turbulence
Accident Brief		10U	5+R	-	70	27	18	25	-	
NWS Rochester Minn.	15:59	M34⊕70●	15	071	65	25	16	-	974	
NWS Rochester Minn.	16:30	M9●	12 R	-	-	23	13	-	-	
NWS Rochester Minn.	16:58	M21⊕34●	15	068	62	24	17	-	973	
NWS Rochester Minn.	17:21	M12●								
NWS Rochester Minn.	17:39	M9●	12	-	-	23	13	-	972	
NWS Rochester Minn.	17:59	9⊕M28⊕	15	065	60	24	11	-	972	

According to the pilot's statement, the aircraft suddenly dropped while he was correcting for a very strong gusty crosswind.

The information in the docket is insufficient to establish the potential of a low-level wind-shear hazard.

DOCKET NO. 3-3708

The Beechcraft A55 accident in Bedminster, New Jersey on August 4, 1974, occurred at 12:35 EST, 17:35 GMT, during reported thunderstorm conditions in close proximity to the airport. The nonfatal VFR accident occurred during an approach and landing on runway 30 at the Somerset Airport which resulted in an undershoot.

The accident report shows the surface weather conditions at the time of the accident to be:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
25 U	15 +	87	19	15	25	Thunder-storm in vicinity

The pilot reported that initially the wind favored runway 30, but during the approach shifted to favor runway 12 (180° wind shift); however, the approach was continued. Just after crossing the tree line, a severe downdraft was encountered which could not be compensated for with the application of full power.

The accident docket indicates conditions which would be conducive to a low-level wind shear associated with topographic and thunderstorm gust front conditions.

DOCKET NO. 5-0028

The Piper PA-34 accident in Ocean City, Maryland on October 16, 1974, occurred at 09:50 EST, 14:50 GMT, during reported heavy rain showers. The nonfatal VFR accident occurred during a landing on runway 14 at the Ocean City Municipal Airport which resulted in an overshoot.

The reported surface weather conditions at the time of the accident were:

Source	Time (local)	Sky and Ceiling (X 100 ft)	Visibility (nmi)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Altimeter Setting (inHg)	Remarks
Air Executive Inc.	9:50	6⦶12⦶15●	4 R+	17	8	-	984	
Air Executive Inc.	10:10	6⦶E14●	6 F	32	8	-	982	
Flight Crew	-	-	5 RW+	16/17	10	20	-	Light to moderate turbulence

According to the company's weather observer, the wind shifted 150° from the start of the approach until the aircraft had landed and overran the available runway. The exact cause of the sudden windshift (horizontal low-level wind-shear hazard) is not identified in the docket.

DOCKET NO. 3-0452

The Piper PA-34 accident in Fort Bragg, North Carolina on January 14, 1975, occurred at 14:15 EST, 19:15 GMT. The nonfatal VFR accident occurred during an approach and landing on runway 27 at the Simmons Army Air Field which resulted in an undershoot.

The reported surface weather at the time of the accident was:

Sky and Ceiling (x 100 ft)	Visibility (nmi)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gust (knots)	Altitude Setting (inHg)	Remarks
250⦶	20	36	31	10	10	015	Light turbulence

The information in the accident docket was very limited. Nothing in the docket suggested the presence of a low-level wind-shear hazard.

DOCKET NO. 3-0194

The Piper PA-30 accident in Talladega, Alabama on January 19, 1975, occurred at approximately 11:00 EST, 16:00 GMT, during reported shifting, gusty wind conditions. The nonfatal VFR accident occurred during an approach and landing for runway 21 at the Talladega Municipal Airport.

The accident docket was not available for a detailed analysis; however, the accident brief indicates the following surface weather conditions at the time of the accident:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)
E 10⊕	5 +	50	23	15

There was insufficient information in the brief to evaluate this accident with respect to wind shear.

DOCKET NO. 3-1005

The Beechcraft 95-55 accident at Opa Locka, Florida on February 20, 1975, occurred at 13:35 EST, 18:35 GMT, during reported and observed thunderstorm activity with associated rain showers. The nonfatal aircraft accident occurred during the landing roll on runway 9L at the Opa Locka Airport.

The pilot, who was a professional pilot with a current airline transport rating, elected to hold at the VOR when advised by the ATC at 13:00 that the airport was below VFR minimums due to thunderstorm activities and heavy rain. The tower advised the pilot that conditions had improved to VFR minimums at approximately 13:25 EST.

Following the touchdown on the runway, the pilot encountered a severe gust which was associated with the nearby thunderstorm that lifted the aircraft off the runway. Although immediate recovery action, including power application, was initiated, a hard landing resulted in substantial damage to the aircraft.

While there is minimal information in the docket, the accident report describes conditions which are typical of what could occur from the outflow of a thunderstorm in close proximity to an airport. This could produce a hazardous low-level wind shear.

DOCKET NO. 5-0005

The Beechcraft E-18 accident at Kirksville, Missouri on March 25, 1975, occurred at 04:15 CST, 10:15 GMT, during reported sudden wind shift conditions. The accident occurred during a downwind landing on runway 17 at the Clarence Cannon Memorial Airport.

The accident brief shows the surface weather at the time of the accident to be:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind-Direction (x10°)	Windspeed (knots)
30	5 +	-	25	14

The docket was not available for a more detailed analysis with respect to a potential wind-shear hazard.

DOCKET NO. 3-0476

The Britt Norman BN-2A accident in Tin City, Arkansas on April 24, 1975, occurred at 12:20 CST, 18:20 GMT. The nonfatal IFR accident occurred during an attempted landing on runway 34 at the Tin City Airport.

The official weather observation for Tin City were:

Time	Sky and Ceiling (x 100 ft)	Visibility (nmi)	Temperature (F°)	Wind Direction (x 10°)	Windspeed (knots)	Gusts (knots)	Altimeter Setting (inHg)	Remarks
11:00	Clear	1/4 BS	2	1	22	33	953	
12:27	Clear	1/4 BS	2	35	24	33	-	

The pilot reported encountering severe downdrafts (1,800 foot per minute descent rate) which he could not arrest with full power. The accident docket indicated that strong downdrafts were not unusual with a northerly wind. This was due to a valley at the approach end of runway 34.

The limited information in the docket indicates that a low-level orographic wind shear hazard could have been present during the approach to runway 34.

DOCKET NO. 3-1010

The Beechcraft 95-B55 accident in Beaumont, Kansas on May 4, 1975, occurred at 14:40 CST, 20:40 GMT, during reported gusty wind conditions. The VFR accident, which resulted in critical injury to the pilot, occurred during a takeoff from runway 18 at the Beaumont Hotel Airport.

The accident brief indicates that the surface weather conditions were:

Sky & Ceiling (100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
Clear	5 +	-	22	20	-	Wind gusty

DOCKET NO. 3-2161

The Piper PA-23 accident in Alexandria, Louisiana on August 16, 1975, occurred at 20:35 CST, 02:35 GMT, during reported thunderstorm activity. The IFR accident, which resulted in minor injuries to the sole occupant, occurred during a precautionary attempted approach and landing to runway 26 at the Ester Field Airport.

The reported surface weather conditions at the time of the accident were:

Source	Time	Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind Direction (x10°)	Windspeed (knots)
NWS	19:58	30 E 120⊕	7 TRW-	77	33	8
NWS		30 E 120⊕	7 TRW-	77	33	8

The pilot reported that he was on an ILS approach and had sighted the outer marker inbound when he encountered a severe downdraft or wind shear due to a severe thunderstorm cell. Ground witnesses also reported the presence of a thunderstorm just east of the airport.

DOCKET NO. 3-3275

The Beechcraft D50E accident in Norwich, New York on November 14, 1975, occurred at approximately 21:30 EST, 02:30 GMT, during reported light rain and gusty winds. The nonfatal VFR accident occurred during an approach and landing for runway 1 at the Lieutenant Warren E. Eaton Airport and resulted in an undershoot.

The reported weather conditions at the time of the accident were:

Sky & Ceiling (x100 ft)	Visibility (nmi)	Temperature (°F)	Wind-Direction (x10°)	Windspeed (knots)	Gusts (knots)	Remarks
30⊕	6 R-	-	32	15	25	Moderate Turbulence

The limited information available in the docket and the pilot's statement concerning possible optical illusion due to city lights preclude consideration of wind shear.