

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



WPR22LA251

OPERATIONAL FACTORS

Group Chair's Factual Report

April 12, 2023

TABLE OF CONTENTS

A. ACCIDENT	4
B. OPERATIONAL FACTORS	4
C. SUMMARY	4
D. DETAILS OF THE INVESTIGATION	5
E. FACTUAL INFORMATION	5
1.0 HISTORY OF FLIGHT	5
2.0 PILOT INFORMATION	7
2.1 Certifications Records	7
2.2 Certification and Ratings Held at the Time of the Accident	8
2.3 Flight Hours	8
2.4 Training	9
2.4.1 Meteorology Training	9
2.5 Trip Pairing	10
2.6 Duties and Responsibilities	10
3.0 AIRPLANE INFORMATION	11
3.1 Weight and Balance	12
3.2 Cockpit Video Recording	12
4.0 AIRPORT INFORMATION	13
4.1 Security Camera Images	14
5.0 METEOROLOGICAL INFORMATION	16
6.0 OPERATOR	16
6.1 Corporate Air Organizational Structure	16
7.0 MANUAL EXCERPTS	17
7.1 Preflight Actions	17
7.2 Airborne Thunderstorm Detection Equipment Requirements	18
7.3 Ground Operations in High Wind Conditions	18
7.4 Wind Shear	19
7.5 Additional Windshear Guidance	22
7.6 Windshear Recovery	24
8.0 FLIGHTSAFETY TRAINING	26

8.1	FlightSafety International Wind Shear Ground Training.....	26
9.0	FAA GUIDANCE.....	27
9.1	Wind Shear	27
9.2	Advisory Circular (AC) 00-54.....	29
10.0	NASA ASRS REPORTS	30
F.	ATTACHMENTS.....	31

A. ACCIDENT

Location: Salt Lake City, UT
Date: July 13, 2022
Time: 1852 mountain daylight time (MDT)¹
0052 coordinated universal time
Airplane: Cessna 208B, N877FE, CPT7727 (Air Spur 7727)

B. OPERATIONAL FACTORS

Chairman	Shawn Etcher NTSB Washington, D.C.
Member	Kerry Shumway Federal Aviation Administration (FAA) Salt Lake City, UT
Member	David Oylo ² Corporate Air Billings, MT

C. SUMMARY

On July 13, 2022, about 1852 mountain daylight time, a Cessna 208B, N877FE, was substantially damaged when it was involved in an accident at the Salt Lake City International Airport (SLC), Salt Lake City, Utah. The pilot sustained minor injuries. The airplane was operated by Corporate Air as a Title 14 *Code of Federal Regulations (CFR)* Part 135 cargo flight. The flight originated from the Friedman Memorial Airport (SUN), Hailey, Idaho.

The pilot stated that during the flare for landing the airplane encountered a wind shear³, and he was unable to maintain directional control and executed a go-around. The accident flight climbed to about 30 ft above ground level (agl) and then encountered a downdraft that pushed the airplane towards the runway. Subsequently, the airplane impacted terrain, off the right side of the runway, in a left-wing low attitude.

¹ All times in this report will be MDT unless specified.

² Member was unable to attend the crew interviews in August of 2022 nor the airplane examination on August 4, 2022 due to work schedule but did attend pilot interviews virtually.

³ In this report wind shear and windshear are synonymous. Various FAA publications used the two word or one word version. However, to maintain consistency with this report and the NTSB Meteorological Factual report the two-word version will be used, unless it is a direct quote from a publication and was spelled as the one-word version.

D. DETAILS OF THE INVESTIGATION

July 13, 2022 - Following discussion with the Deputy Director of Western Pacific Region, the IIC, Weather, Air Traffic Control Specialist, and Operational Factors investigators was assigned to the event.

July 14, 2022 - Pilot statements, training records, manuals and other information was requested from the point of contact at the operator, Corporate Air.

July 27, 2022 - After reviewing pilot statements and discussion with the IIC, interviewing the pilot and the pilot following the accident flight was determined to be necessary. The interviews would be done in person in Salt Lake City.

July 29, 2022 - The operator, Corporate Air, assigned a group member to the Operational Factors group.

August 3, 2022 - the group met in Salt Lake City or virtually and interviewed the accident pilot. That interview was recorded and was transcribed.

August 4, 2022 - the operational factors inspected the accident airplane and documented the cockpit and flight controls. Additionally, the group interviewed the pilot that was following the accident flight into the airport on the day of the accident.

E. FACTUAL INFORMATION

1.0 History of Flight

The flight departed SUN approximately 1729 and climbed on a southeast course to the filed altitude of 15,000 ft msl⁴. The route of flight was HLE⁵ V101 TCH⁶.

⁴ Mean sea level.

⁵ Hailey NDB/DME (non-directional beacon/distance measuring equipment).

⁶ Wasatch VOR (very high-omnidirectional range).

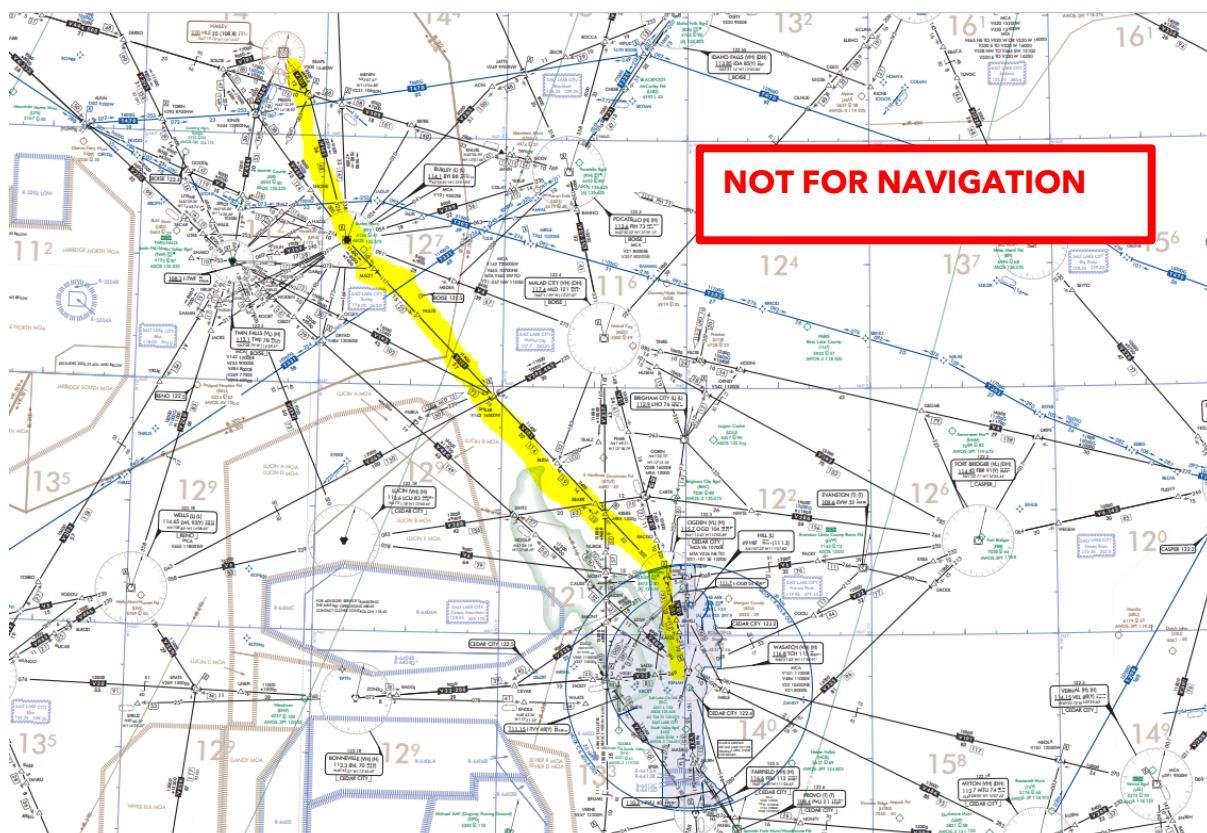


Figure 1: IFR⁷ Enroute Chart [Excerpt] (Source: FAA). The yellow highlighted portion was the route the accident flight operated on.

Approximately 1817 the accident airplane began a descent from 15,000 ft msl to 11,000 ft msl.

The accident flight entered the left downwind leg for runway 34R, turned the base leg, and about 1849 turned left to intercept the final approach course for runway 34R. According to the pilot statement, the flight was cleared for the visual approach from the downwind leg to follow behind a B-757 aircraft. The pilot also reported that the latest weather he had obtained prior to the visual approach and indicated a left quartering headwind.

The pilots of the B-757 reported that they had the airfield about 7 miles away; however, there was *"heavy rain"* for them on final. Additionally, they reported that the crosswind was strong and increased in strength as their flight descended. They further stated that while on final approach the airplane's auto throttles *"had trouble keeping up with the gusts."*⁸

⁷ Instrument Flight Rules.

⁸ Source: Operational Factors - Attachment 3 - Other Airline Pilot Statement Excerpts.

Radar data indicated that at 1851:49 the airplane crossed the threshold of runway 34R. In a written statement, the pilot reported that *"in the flare, the tower reported that the 757 had encountered windshear on landing."*⁹ He further stated he also encountered the Wind Shear. Unable to maintain direction control of the airplane due to wind from the left, he *"elected to go around,"* and informed the air traffic control tower (ATCT) controller.

The pilot further reported that after adding power and initiating the go-around, about 30 feet agl he *"lowered the left wing"* to counteract the drift from the runway centerline. Subsequently, he encountered a *"downdraft pushing"* the airplane towards the ground.

Surveillance video showed, the aircraft impacted the right side of the runway in a left-wing low, nose down attitude. The airplane's tail came up to a near vertical position and then settled back down. The airplane came to a rest on its belly and right main landing gear. The left main and nose landing gear collapsed during the accident sequence.

According to the pilot, after assessing there was no fire visible, he secured the aircraft by turning off the electrical and master power. He then exited the aircraft.

Radar data indicated that following the accident, an aircraft was approaching to land on runway 34L; however, the air traffic control tower issued that flight *"a go-around with no initial reason given"*¹⁰.

2.0 Pilot Information

The pilot, age 60, held an Airline Transport Pilot (ATP) certificate with a rating for airplane multiengine land, with commercial privileges airplane single-engine land. He held a FAA first-class medical certificate, dated March 23, 2022, with limitations of *"must wear corr lenses & possess glasses for near & intrm vision."* At the time of the accident, he was based at SLC.

2.1 Certifications Records

The following information about the accident pilot certificates was provided by the FAA:

Private Pilot – Airplane Single-Engine Land certificate was issued on October 22, 1988.

⁹ Source: Attachment 1 - "Pilot Statement and Transcripts" pg. 94.

¹⁰ Source: Operational Factors - Attachment 3 - Other Airline Pilot Statement Excerpts.

Notice of Disapproval - Instrument Airplane dated April 19, 1995. Unsatisfactory items: Area of Operation VI Task A & B - ATC Procedure - reporting position, non-precision approach timing.

Private Pilot - Airplane Single-Engine Land; Instrument Airplane certificate was issued April 21, 1995.

Commercial Pilot - Airplane Single-Engine Land, Instrument Airplane certificate was issued on April 1, 1996.

Notice of Disapproval - Commercial Pilot Airplane Multiengine Land dated January 28, 1998. Unsatisfactory items: Area of Operation III: Ground Operations, VI: Instrument Flight-Instrument Approach - All Engines Operating, VIII: Emergency Operations - Maneuvering with One Engine Inoperative.

Commercial Pilot - Airplane Single and Multiengine Land, Instrument Airplane certificate was issued on January 29, 1998.

Airline Transport Pilot - Airplane Multiengine Land, Commercial Privileges Airplane Single-Engine Land certificate was issued on January 22, 2001.

2.2 Certification and Ratings Held at the Time of the Accident

AIRLINE TRANSPORT PILOT (Issued January 22, 2001)
Airplane Multiengine Land
Commercial Privileges: Airplane Single-Engine Land

MEDICAL CERTIFICATE FIRST-CLASS (issued March 23, 2022)
Limitations: Must wear corrective lenses and possess glasses for near and interim vision.

2.3 Flight Hours

The following estimated flight hours were provided by the pilot and by the operator:

Previous 24 hours ¹¹	3:09
Last 14 days	28:21
Last 30 days	69:00
Last 90 days	148
Last 12 months	511
Total Hours C208B	6,771

¹¹ Includes accident flight.

Total Flight Experience	10,516
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2.4 Training

Date of Hire	June 25, 2001
Initial Qualification - Cessna 208B	July 12, 2001
Emergency Drills	August 19, 2021
Emergency Situation	August 19, 2021
Autopilot CFR Part 135.297 ¹²	January 26, 2022
Autopilot CFR Part 135.299 ¹³	August 19, 2021
Aircraft Flight Training	August 19, 2021
Aircraft Proficiency Check	January 26, 2022
Aircraft Ground Training	August 19, 2021

2.4.1 Meteorology Training

The Corporate Air, Flight Operations Training Manual provided, in part, the following training topics provided during recurrent ground training:

The Aircraft Recurrent Ground Training will include:

- *General operational subjects including airport ground operational safety, flight crew procedures during taxi operations, Parts 91 and 135 single pilot.*
- *Aircraft Systems*
- *Systems integration*
- *Special operations, such as windshear*

...

Recurrent Flight Training Emphasis Considerations: *The Recurrent Flight Training Curriculum outlines should address all the required training events listed in the flight training maneuvers table. However, during RFT, specific training on every event is unnecessary unless it is needed for maintaining pilot proficiency on particular events. It is national direction and guidance that during periods of RFT, that training emphasis should be on those events or other maneuvers or procedures not normally encountered during routine line operations, such as abnormal or emergency procedure training or windshear*

¹² Pilot in Command: Instrument proficiency check requirements. [eCFR :: 14 CFR 135.297 -- Pilot in command: Instrument proficiency check requirements.](#)

¹³ Pilot in command: Line checks: Routes and Airports. [eCFR :: 14 CFR 135.299 -- Pilot in command: Line checks: Routes and airports.](#)

training. Additionally, training on new or revised maneuvers or procedures, new equipment, or other similar areas is ideally suited for periods of RFT. Time should be allotted to conduct training in maneuvers or procedures the airman wishes to practice, or in certain operational areas in which deficiencies have surfaced during proficiency or line checks, indicating a need for additional training.

2.5 Trip Pairing

The pilot operated flight 8827 from SLC departing at 0741 and arriving at SUN at 0859. He then operated the accident flight which departed SUN at 1729. A review of the pilot's schedule for the month of July indicated that he operated these flights beginning on Monday or Tuesday operating flight 7727 and completing Saturday with flight 8827.

2.6 Duties and Responsibilities

Corporate Air, General Operations Manual, provided, in part, the following responsibilities for the captain:

- a. *The PIC is responsible to the Chief Pilot. This person is the direct employee of the company when assigned duty as PIC by the company. When assigned to a flight, the PIC is in command of the aircraft and crew including any pre-flight and postflight duties. During flight time each PIC of an aircraft is in command of the aircraft and crew and is responsible for the safety of the jumpseat occupant, crewmembers, cargo, and aircraft. Without limitation, the PIC has full control and authority in the operation of the aircraft over other crewmembers and their duties during flight time. In conjunction with or in addition to responsibilities mentioned elsewhere in this manual or in FAR 135, the PIC's specific duties and responsibilities include:*
 1. *Keeping himself knowledgeably current in all respects with regard to the requirements of the appropriate FARs.*
 2. *Exercise command authority and responsibility with emphasis on:*
 - i. *Ensuring the aircraft he commands is operated in a safe manner that will not endanger anyone's life or property, and*
 - ii. *Ensuring all preflight planning and flight operations are conducted in accordance with the regulations, company procedures, and the FAA-issued Operations Specifications for Corporate Air, and the flight(s) can be initiated, conducted, and terminated safely. (Operations Specifications A008)...*

11. *Conducting a proper preflight weather check (reported and forecast weather) for the route(s) about to be flown. If unsatisfactory conditions exist or are forecast, he shall inform Flight Following and advise of an alternate course of action if one is available. If an alternate route is used, the PIC shall be thoroughly familiar with the current and forecast weather on the route to be flown. If alternated routing or delaying the flight is required by the PIC, the flight follower handling the flight will record these actions on the Flight Following turnover log...*
15. *The PIC is responsible for exercising operational control. Operational control is the initiation, continuation, diversion, and termination of a flight. If in the opinion of the PIC, the flight cannot be safely operated as planned, the flight will be diverted or delayed....*

3.0 Airplane Information



Figure 2: Accident Airplane (courtesy of planespotters.com)

The accident airplane was a Cessna 208B Caravan, registration N877FE, serial number 208B0232 with a certification date of October 12, 1990. It was a single engine airplane manufactured in 1990 and the registered owner was Federal Express Corp of Memphis, Tennessee. It was powered by a single Pratt & Whitney PT6A-114A engine.

According to aircraft flight records provided by Corporate Air, the airplane, prior to the accident flight, had 16,281.4 total hours of service and 16,783 airframe landings (cycles)¹⁴.

¹⁴ Aircraft flight records indicated 2 cycles on the day of the accident; however, one of those landing cycles would have been the accident landing and likely that entry was made prior to the flight. Of note: prior to the start of the accident flight day the airplane had total cycles of 16,782.

According to the Corporate Air, Operations Specifications, the CE-208B was authorized to conduct cargo operations in IFR/VFR and day/night.¹⁵

The minimum crew required was one pilot, seated in the left seat.¹⁶

3.1 Weight and Balance

The accident flight's weight and balance was provided by the operator. Additionally, Corporate Air Operations Specifications A096 authorized only actual weights when determining the aircraft weight and balance. The Operations Specifications further utilized the "*Center Load Method and See Gee Calculator*" for the loading schedule. Weights below are in lbs. and limitation weights are in **bold**.

Basic Operating Weight	4,872
Crew and Bag Weight	200
Cargo Weight	709
Zero Fuel Weight	5,781
Fuel Weight	1,200
TKS Weight	200
Ramp Weight	7,181
Maximum Ramp Weight	8,785
Taxi Fuel	35
Takeoff Weight	7,146
Maximum Takeoff Weight	8,750
Fuel Burn (estimated)	500
Estimated Landing Weight	6,646
Maximum Landing Weight	8,500
Center of Gravity (CG)	-11.9
CG limits	-16.2 to - 2.0

3.2 Cockpit Video Recording

The airplane was equipped with an Appareo Vision 1000, which was mounted in the cockpit on the ceiling of the airplane between the two pilot seats.

¹⁵ Source: Corporate Air Operations Specifications A003.

¹⁶ Source: Corporate Air, Flight Operations Manual - Volume 1 Cessna 208, pg. 25.04.08.



Figure 3: Appareo Camera as found in the Airplane.

The unit was removed and sent to the NTSB Recorder's laboratory for download. The removable SD card did not capture the accident flight. For further information reference the Onboard Image, Audio and Data Recorder, Specialist's Factual report associated with this accident.

4.0 Airport Information

Salt Lake City International Airport (SLC) was located about 3 miles west of Salt Lake City, Utah, had a field elevation of 4,231ft msl, and was located at a latitude/longitude of 40°47.30'N/111°58.67W. The airport was owned by the city of Salt Lake City and was serviced by an FAA Air Traffic Control Tower that was in operation 24-hours a day and was operational at the time of the accident. The airport had four paved landing surfaces designated as 16L/34R, 16R/34L, 17/35, and 14/32 and two helipads located on the general aviation ramp. Runway 16L/34R was an asphalt runway and 12,002-foot-long and 150-foot-wide. The accident flight landed on runway 34R.

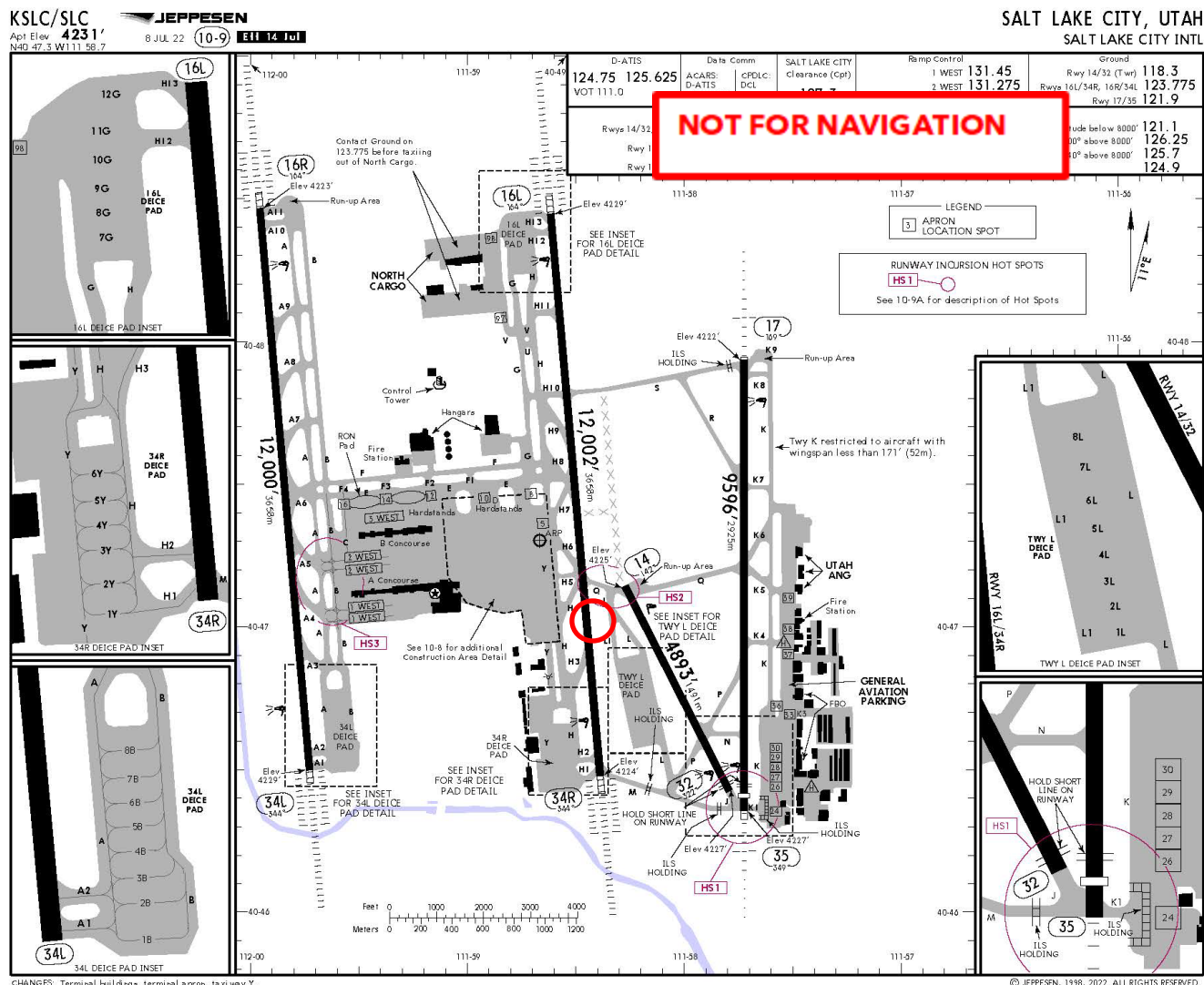


Figure 4: SLC Airport Diagram Chart (Source: Jeppesen). The red circle is the approximate location of where the accident plane came to rest.

4.1 Security Camera Images

The following are still images taken from a video recording from security cameras located at various points around the airport. The images were captured from the recording around the time of the accident. It should be noted that two of the still images indicate a camera time difference of one hour, however, the time difference on the camera was one hour. The local time of the accident was camera time minus one hour. The video recordings are in the docket associated with this accident and are labeled Weather Attachment 15, Weather Attachment 16, and Weather Attachment 17:



Figure 5: Looking Southwest of the Airport from the Air Traffic Control Tower Location (camera time 1851:47)

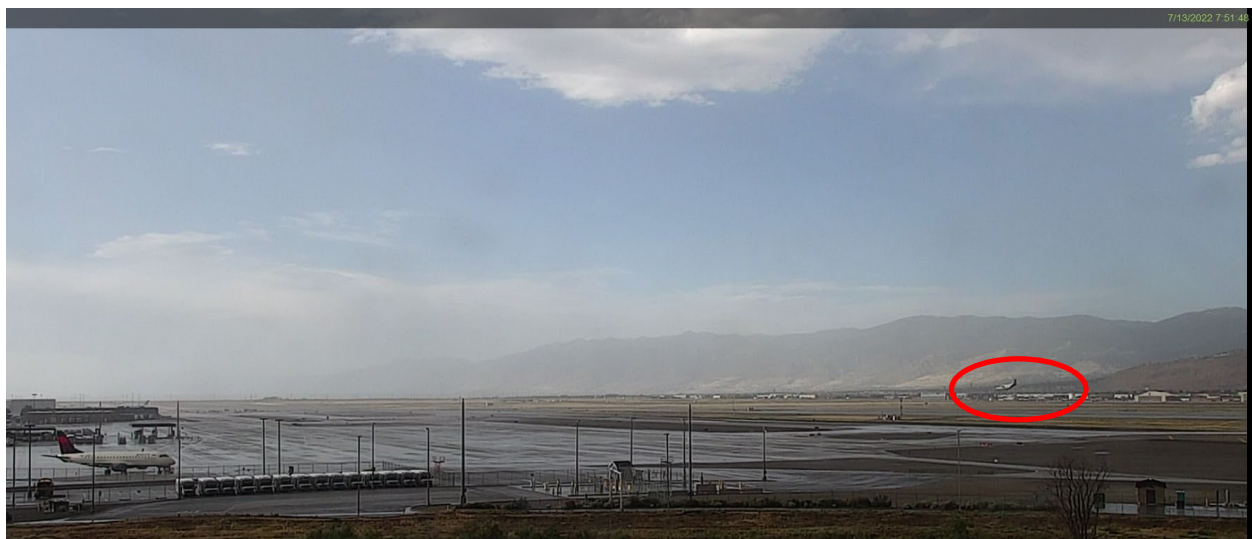


Figure 6: Looking Northeast from the Airport South boundary (Accident airplane in the red circle while on the approach prior to landing, camera time 1951:48, actual time 1851:48)

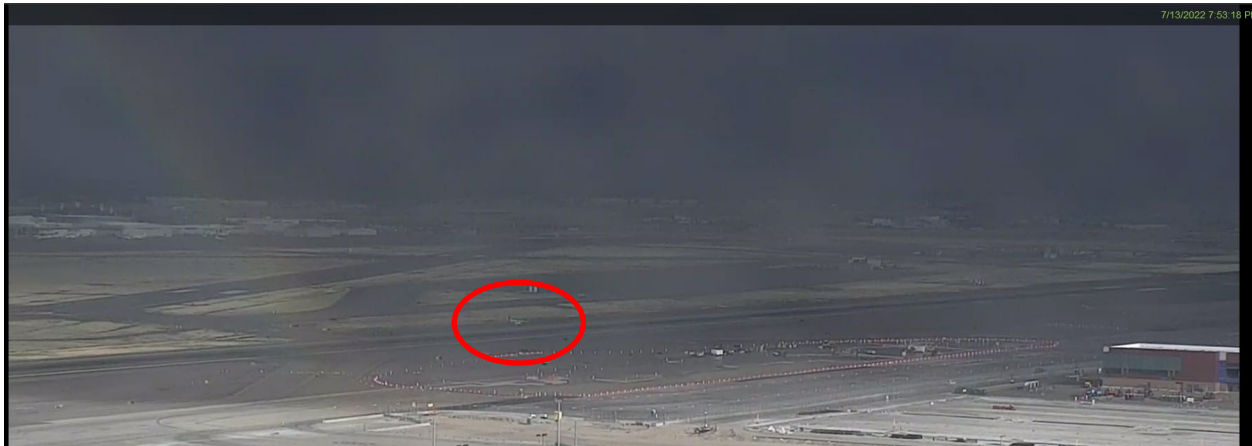


Figure 7: Looking Southeast of the Airport from the Air Traffic Control Tower Location (Postaccident – accident airplane in red circle at camera time 1953:18, actual time 1853:18).

5.0 Meteorological Information

SLC had an ASOS¹⁷ weather system. The following information was recorded about 2 minutes after the accident:

*KSLC 140054Z 30029G48KT 9SM -TSRA FEW018 FEW120 BKN140 BKN240
33/13 A2997 RMK AO2 PK WND 32048/0054 LTG DSNT SW RAB51
TSB27E42B50 SLP081 CB OHD MOV NE P0000 T03280128*

For further meteorological information reference the meteorological report associated with this accident.

6.0 Operator

Corporate Air was founded in 1981 and was headquartered in Billings, Montana. The company owned and operated maintenance facilities and pilot bases in Montana, Wyoming, North Dakota, Utah, and Hawaii. They specialize in air services offering feeder airline cargo service and operated on a regularly scheduled basis. They operated a fleet of Cessna 208 Caravans.

6.1 Corporate Air Organizational Structure

Corporate Air, General Operations Manual provided the following “Organizational Chart Flight Operations”:

¹⁷ Automated Surface Observation System.

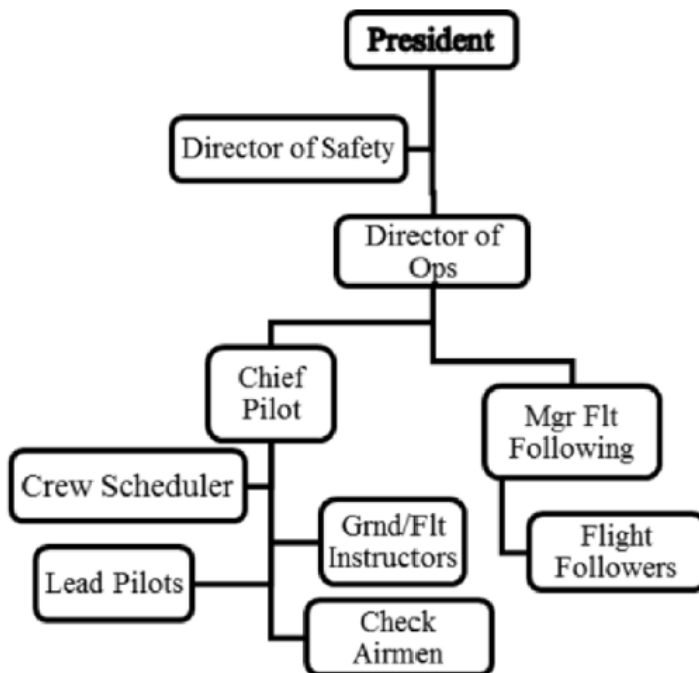


Figure 8: Corporate Air Organizational Chart for Flight Operations

7.0 Manual Excerpts

7.1 Preflight Actions

Corporate Air, General Operations Manual, Section 3.30, provided the following "Preflight Actions":

- a. *The crew shall, after arrival at the airport, have the following tasks complete:*
 1. *An exterior and interior preflight inspection/setup, and ensure the aircraft has the proper amount of fuel for the intended mission, considering weather issues and other known delays.*
 2. *Review the Aircraft Flight Record for open discrepancies and Deferred Maintenance Items.*
 3. *Check all pertinent departure/enroute/destination/alternate NOTAMs*
 4. *Check the departure/enroute/destination/alternate NOTAMs.*
 5. *Call to Flight Following with the in-position report, fuel on board, and alternate airport, if required.*
 6. *Have the Before Start Checklist completed.*
 7. *File VFR or IFR flight plan, if necessary.*

7.2 Airborne Thunderstorm Detection Equipment Requirements

Corporate Air, General Operations Manual, Section 3 "Operations" provide the following about airborne equipment:

a. For the record, in Corporate Air's all-cargo operation, airborne thunderstorm detection equipment is not required by regulation.

1. *However, in the event this equipment becomes inoperative, and thunderstorms or other potentially hazardous weather can be expected along the route of the flight, the following actions will be taken by the crew:*

- i. *Select a route of flight that will avoid the weather in question.*
- ii. *For day operations, select a route of flight to maintain VFR conditions and that allows avoidance of this type of weather visually.*

Note: *VFR operations, except specific routes specified in this manual, require the authorization of the Chief Pilot or the Director of Operations.*

iii. *Delay the flight until such weather conditions no longer exist along the route of flight.*

A. *Advise FF of your intentions.*

iv. *Also, for the record, airborne thunderstorm detection equipment is not required for flight conducted solely within the State of Hawaii.*

7.3 Ground Operations in High Wind Conditions

Corporate Air, General Operations Manual, Section 3.90 "Operations" provide the following about ground operations in high wind conditions:

a. *Ground operations in high wind conditions require extreme caution. Proper wind correction with the flight must be utilized. The weight of the aircraft also figured into the controllability of the aircraft during high wind ground operations. Care should be taken in avoiding sharp 90-degree turns, trying instead to make an arcing turn, if possible. Using a different taxi route also should be considered. All turns should be planned so as to allow ample room for the aircraft to weather vane if it comes to that. Hard braking on the downwind main tire should be avoided, as this will not allow the aircraft to skid or turn into the wind. Also be alert for the effects of buildings and terrain*

on and around the airport, as they may increase wind speed significantly by venturi effect.

- b. The following wind limits will apply to all aircraft:
 - 1. No operation will occur if the wind is in excess of 40 knots.
 - 2. Additionally, for the operation of a C208 with a weight less than 7,000 pounds, no operations will occur if the wind is in excess of 35 knots.
- c. The flight crew has full discretion and the responsibility to reduce these values after taking in account the current ramp/taxiway/runway conditions. Any surface contamination (rain, snow, ice) should be taken into consideration, and extreme caution will be exercised at all times when operating in high wind conditions.
- d. CE208 crew entry door shall be secured in the CLOSED and LATCHED position when winds, sustained or gusts, are in excess of 25 knots.

7.4 Wind Shear

Corporate Air, Flight Operations Manual - Volume 1 "Operating Bulletins", "OB 97-3," provided the following guidance for "Wind Shear:"

The following is background and supporting information for improved understanding of shear and its effect on performance. Although the following uses Shorts 3-60 in a few examples (flap positions, climb rates, etc.), the subject is otherwise fully applicable to all types in the Corporate Air fleet.

General

Wind never blows from a constant direction or speed for more than short periods, even in the most stable conditions. Shear is nothing more than a change in wind component, and since a change in either wind direction or speed changes the component, the airplane is always affected by shear. It's fascinating to observe the continuous display of wind speed and direction on an INS-, IRS-, or GPS-equipped airplane and see the airplane's response to just half a knot change in wind component. This ever-present kind of shear is benign; it's the sudden and large changes in component that cause the mischief.

Shear causes a loss (or gain) of airspeed every time the wind component changes. While shear is often thought of as a horizontal wind effect, vertical wind components are involved as well. Aside from the "downward" effect of a downdraft ("microburst," "downburst"), as it nears the ground, it spreads out horizontally, affecting airspeed, thus lift.

Meteorological Conditions

In a study of 51 shear events, 33% were associated with convective activity (thunderstorms, rain/snow showers), the next most common occurring near fronts. The strength of shear associated with fronts is related to the speed of frontal movement and the temperature difference across the front. A front moving 30 knots or more, or with a temperature difference of 20°F or more, will almost always have strong shear.

The most hazardous shear is associated with the “downburst,” which may have in its core (about a mile in diameter) vertical winds up to 7,000FPM. When the down-flowing air nears the surface, it spreads out horizontally to a diameter of about 2 miles, with the strongest gusts about 100 feet above the ground. A downburst usually lasts from 2 to 5 minutes, although several different downbursts can occur over a relatively short period or distance.

Warm front shear is probable when ceiling and visibility are restricted with some kind of precipitation (rain, drizzle, etc.), and strong gusty winds indicate turbulence in the shear. When surface winds are from an easterly direction (30 through 120°) and pressure is falling rapidly, significant shear is likely.

Cold front shear is probable with northwesterly surface winds (270 through 360°) with pressure rising rapidly.

Gust front shear is common with thunderstorm activity. High base thunderstorms with VIRGA, light surface winds, surface temperatures above 75°, and an OAT/DP spread more than 35° often spawn microbursts in dry climates (as at Denver).

Calm or light surface winds with large drift angles on approach—or an abnormal descent rate on the glide slope—indicate that shear exists between the airplane and the runway. Probably the best “cockpit clue” on approach is a relatively sudden increase in IAS, with the airplane “ballooning” above the glide slope. When this occurs, the temptation to make a large thrust reduction must be resisted; the sudden IAS increase is almost always followed by a sudden decrease. The initial speed increase occurs on entering the outflow as the downdraft nears the ground and flattens out, becoming a sudden headwind component. The opposite effect (sudden airspeed loss) is almost certain to follow as the airplane traverses the “center” of the downflow and moves into the outflow tailwind.

Effects on Performance

There are basically two kinds of shear: “performance-increasing” and “performance decreasing.”

Performance-increasing shear occurs:

- *with a sudden increase in headwind component,*
- *when going from a tailwind to a headwind, or*
- *when going from a calm wind to a headwind.*

The opposite conditions—suddenly increased tailwind, going from headwind to tailwind, or from calm to a tailwind—are “performance-decreasing.”

In many shear encounters, only 5 to 15 seconds are available to recognize a performance decreasing situation and take necessary action. Although most shear accidents occur on approach, that is small comfort when in the grip of a strong downburst after liftoff.

When shear is present at takeoff, acceleration during the ground roll may be very low, and speed may stagnate or even decrease. The result is an increase in liftoff distance, and rotation below VR may be necessary. Shear also may cause a momentary increase in acceleration, but this is almost always followed shortly by the opposite—and unfavorable—effects.

After liftoff, shear may reduce climb performance, or even turn it into a descent. During an approach, shear can turn a normal descent into one well beyond normal limits. Because of this it's important that there is a good understanding of climb performance.

Figure 1 shows climb rate in the “windshear climb” configuration—gear down, flap positions 15 and 30°. Note especially that:

- *Climb capability is much greater with 15° flaps than with 30°. ¹⁸*
- *VREF is essentially the speed for best climb rate with either flap position.*
- *Climb rate drops off more and more sharply at speeds above VREF, especially with flaps at 30°.*

The lowest speeds used in line operations—V2 and VREF—should be considered as “barriers” below which one would not go in normal operation. But there is nothing sacred about either V2 or VREF, and going to lower speeds may be the only thing that will save your bacon in severe shear.

¹⁸ *In any shear having a downflow greater than 1070 FPM—and any shear worthy of the name does—the airplane with 30° flaps, under the conditions of Figure 1, will crash, while the one with 15° will not. This is one of the primary reasons Corporate Air policy requires landing with APPROACH flaps for all fleet types for all normal operations.*

V2 is not necessarily the speed for optimum gradient, optimum rate, or optimum anything; it's simply the speed at which takeoff engine-out gradients were certified. It is usually at or near 120% of stall speed, but can be almost anything at or above 120%, depending on how the airplane was certified. It is 120% on the -R airplane and 122% on the -AR at the higher weights, but will be as high as 125% (-R) to 130% (-AR) in the lower area of the weight envelope.

VREF is simply—and somewhat arbitrarily—130% of the stall speed, and again nothing more than the speed at the 50-foot height used in landing distance certification.

If it becomes necessary to convert a speed at or below V2 or VREF to climb (or a reduced descent rate), it should be handled much like a landing flare. The extra lift should not be taken out all at once, but only as much as needed to stop the descent. There should be no attempt to regain lost speed until terrain contact is no longer a factor, and gear and flap position should not be changed until the descent has been arrested and enough climb achieved to ensure obstacle clearance.

If “caught” in strong shear and still losing altitude even at RTOP power, it may be possible to outclimb the shear with a slow decrease in speed (increase in pitch) below normal limits.¹⁹ [footnote in the original] Though good climb performance is available below V2 and VREF, such speeds should be used only in emergency.

7.5 Additional Windshear Guidance

Corporate Air, Flight Operations Manual provided, in part, the following additional information about windshear and microburst:

Wind shear and microbursts were invented circa 1960, and since then several jet transports have come to grief because of them. It is now known that many more accidents occurred due to these phenomena, with the cause in those not correctly identified.

The above accidents had nearly identical scenarios, all being jet transports trying to penetrate the heavy rain outflow of a thunderstorm below 1,000 feet AGL on takeoff or approach. A dry microburst—no cloud or precip visible—can also be disastrous, and a classic example occurred at Andrews AFB on August 1, 1983. Early afternoon surface winds averaged 10 to 15 knots under a clear sky, but at 1409 EST the surface wind jumped suddenly to 112 knots, returned to 15 knots, jumped suddenly to 83 knots in the second “spike,” then returned to ~15 knots. All this happened over a period of only 6 minutes, after which the wind became

¹⁹ It's comforting to know that even if the shear cannot be outclimbed, the airplane will crash in the most “favorable” manner – under control and at the lowest possible speed.

relatively light and variable again, a perfect example of a SEVERE dry microburst. None more severe have ever been documented...

Be patient, I'll get to the propeller types anon.

There is at least one microburst case where momentary surface winds well above 200 knots have been documented, accompanied by 8-inch steel construction I-beams and a forklift being blown about.

Low-level shear and microbursts are uniquely associated with thunderstorms, and the following should be considered mandatory.

- *Never penetrate the outflow of a thunderstorm when below 1,000 feet AGL.*
- *When approaching in an area of thunderstorms, **NEVER** base a go or no-go decision on the word of the guy in front of you who says he had a "smooth ride." And if the guy ahead of you reports a significant airspeed fluctuation due to shear, expect yours to be at least 3 times as bad.*
- *If you are on the ground awaiting takeoff with TRWs in the immediate area, just set the brakes until there is no doubt, no matter how long it takes.*

Propeller airplanes—piston or turboprop—are not as susceptible to shear "upsets," but one mustn't tease that tiger—Mother Nature in this case. The jet is more susceptible since: 1) there is no propeller airflow over the wings, which is a very powerful lift-increasing factor at high power, and 2) the relatively slow "spool-up" (acceleration) of the jet engine as compared to the near-instantaneous response of the propeller airplane's engine, especially that of the turboprop. One of the most important lessons learned in early jet transport operations—and one could say "just in time"—is that high approach drag is desirable since the power required minimizes engine acceleration time in the event a go-around or shear recovery is necessary. With early jet engines, civil or military, the spool-up time could be 8 to 10 seconds, which felt like an eternity when a lot of thrust was suddenly required as on a missed approach.

There is one well-documented case that might seem to allow a valid comparison where a student in a light airplane landed about one minute ahead of a following Lear 25. The student had a fluctuating airspeed on short final, but "compensated with power and pitch and landed O.K., though firmly." Thirty seconds after he cleared the runway, the Lear on short final ". . . started screaming about wind shear, and I heard the engines powering up, and then he landed with a bang." He told the tower there was ". . . extreme wind shear . . ." and said other

approaching airplanes “should be warned and possibly diverted to another airport.” Surface wind throughout was 25 knots, with some gustiness. Although this may seem to verify the propeller airplane’s reduced sensitivity to shear, one should put little stock in it; the character of a microburst changes in seconds, as you will see in Figure 1. Although the theory of the propeller airplane’s apparent insensitivity to shear upsets is fairly well accepted by many, I would not volunteer to fly comparative tests in severe shear or microbursts attempting to prove it.

There is great significance to the “below 1,000 feet AGL” qualifier, for that’s the layer where the danger of microbursts is greatest. If you find yourself in that stratum under shear/ microburst conditions, you must get above it as quickly as you reasonably can. That and/ or total avoidance are the only places safety lies.

Although it’s mostly of academic interest, the most dangerous microburst/shear phenomena usually occur in the storm’s dying stage, little comfort since you usually will not know a TRW’s relative age from the cockpit.

7.6 Windshear Recovery

Corporate Air, Flight Operations Manual provided the following guidance for Wind Shear Recovery:

Basic TBS²⁰ Rules

The red bug marks stall speed with 10° flaps on takeoff and 20° on approach and landing, the standard flap positions as specified in the TBS numbers tables. Its use is primarily in wind shear recovery and will be covered in detail under The Red Bug subject below.

The Red Bug

The red bug is intended primarily as a reference, so the margin to stall can be visualized when necessary to go below V₂ (or V_{REF}) in recovering from strong shear.

Wind shear was “discovered” about 25 years ago and triggered substantial changes in training procedures. The basic “industry standard” procedure for recovering from severe “altitude-losing” shear is roughly as follows:

- Apply “firewall power” (up against the stop).
- Rotate toward a target attitude of 15°.
- If descent is not arrested at 15°, slowly increase pitch

²⁰ “The Bug System”

- attitude until it is.
- Do not go below (slower than) stall warning speed.

Power Application

Go to “firewall power?” Yes.

Target Pitch Attitude

In the industry-standard recovery procedure, the 15° target was chosen since it is easy to remember and is more or less suitable for most types, including the jet transport. However, at lower weights Caravan shear recovery attitudes can go well above 15° at the lower end of the usable climb speed range.

TBS attitude PE may be used as the initial target (13° at 8,750 pounds, 19° at 6,000 pounds) even though the table PE is for the 10° flap position. This is justified for three reasons: 1) the TBS tables give the pilot the specific attitude for the existing weight, 2) firewall power provides an additional margin, and 3) it is used only as an initial target.

The “Don’t-Go-Below-Stall Warning” Stricture

To preserve adequate margin, under normal conditions one should not go below V2 or VREF. But that won’t make it in severe cases; if you are falling out of the sky, “heroic” action is called for...

... using 20° landing flaps provides a substantially greater margin than 30°, one of the primary reasons Corporate Air requires 20° for all normal landings. In any shear that produces descent rates greater than 530 FPM (at 8,750 pounds) the shear can be outclimbed with 20° but not with 30°. Good climb capability exists below VREF—and stall warning (VSW)—down to several knots above stall speed. The climb capability available below VREF (V2 on takeoff) should be “taken out” only as much and as fast as necessary to arrest the descent, much as in a landing flare. Flaps should remain at the landing position (normally 20°) until the descent is arrested and enough climb achieved to clear obstructions.

If the descent is not arrested at the target attitude, pitch should be increased—slowly, and in small increments, with a pause after each to evaluate the results—until the descent stops. That attitude then should be held, and as soon as a climb adequate to clear obstructions is achieved, attitude should be reduced—again slowly and in small steps—as appropriate. After IAS reaches VREF and is increasing, flaps may be retracted to 10°, power reduced to normal TAKEOFF TP, and flaps retracted to 0° as after a normal takeoff.

Remember, at firewall power actual stall speed will be roughly 10 knots lower than at IDLE, the basic AFM value. However, due to lack of accurate position error data in and near the stall range at low weights, stall speed as defined by the red bug must be considered approximate only.

VS10 Stall speed with 10° flaps (the red bug). Primarily a reference for use in wind shear recovery procedures.

8.0 FlightSafety Training

Corporate Air utilized FlightSafety, Inc. to conduct some of their ground school and simulator training. Part of that training included Wind Shear and microburst training. Wind Shear training was conducted in the simulator with the accident pilot on several occasions²¹ and the most recent being November 10, 2021 with a rating of “T” or “trained procedure only.” The following information was provided to the accident pilot:

WINDSHEAR

*The best windshear procedure is avoidance. Recognize the indications of potential windshear and then: **AVOID***

MICROBURSTS

Microbursts are small scale intense downdrafts that spread outward in all directions from the downdraft center as it nears the surface. This can result in both vertical and horizontal wind shears that can be extremely hazardous, especially at low altitudes. The aircraft may encounter a headwind with increasing performance (climb/increased airspeed), followed by a downdraft and tailwind, which decreases performance (descent and low airspeeds) to the point that terrain impact can occur.

Acceptable Performance Guidelines:

- *Understand that avoidance is primary*
- *Ability to recognize potential windshear situations*
- *Ability to fly the aircraft to obtain optimum performance*

8.1 FlightSafety International Wind Shear Ground Training

A review of FlightSafety’s ground training meteorological sections presentation by a NTSB meteorological investigator revealed that at least four sections within the

²¹ FlightSafety records indicated that Wind Shear training was conducted on June 23, 2018, August 28, 2019, October 3, 2020, and November 10, 2021

presentation were inconsistent with the topic being discussed. Discussion with FlightSafety International's curriculum development group resulted in a review and subsequent corrections of any inconsistent weather sections. FlightSafety reviewed and corrected the inconsistencies. Reference NTSB Safety Accomplishment for further details.

9.0 FAA Guidance

9.1 Wind Shear

FAA publication FAA-P-8740-40²² *"Wind Shear"* defines wind shear as *"Wind shear is a change in wind speed and/or direction over a short distance. It can occur either horizontally or vertically and is most often associated with strong temperature inversions or density gradients. Wind shear can occur at high or low altitude."*

The guidance further described the following, in part, in relation to Wind Shear:

Four common sources of low-level wind shear are—

- 1. Frontal activity.*
- 2. Thunderstorms.*
- 3. Temperature inversions.*
- 4. Surface obstructions.*

Frontal Wind Shear

Not all fronts have associated wind shear. In fact, shear is normally a problem only in those fronts with steep wind gradients. As with so many things associated with weather, there is no absolute rule, but a couple of clues tell you that wind shear may occur:

- The temperature difference across the front at the surface is 10°F (5°C) or more.*
- The front is moving at a speed of at least 30 knots*

Wind Shear From Thunderstorms

Wind shear is just one of the many unpleasant aspect of thunderstorms. The violence of these storms and their winds are well documented. The two worst problems outside actual storm penetration are shear related. These are the "first gust" and the "downburst." The rapid shift and increase in wind just before a thunderstorm hits is the first gust.

²² <https://www.faa.gov/files/gslac/library/documents/2011/aug/56407/faa%20p-8740-40%20windshear%5Bhi-res%5D%20branded.pdf>

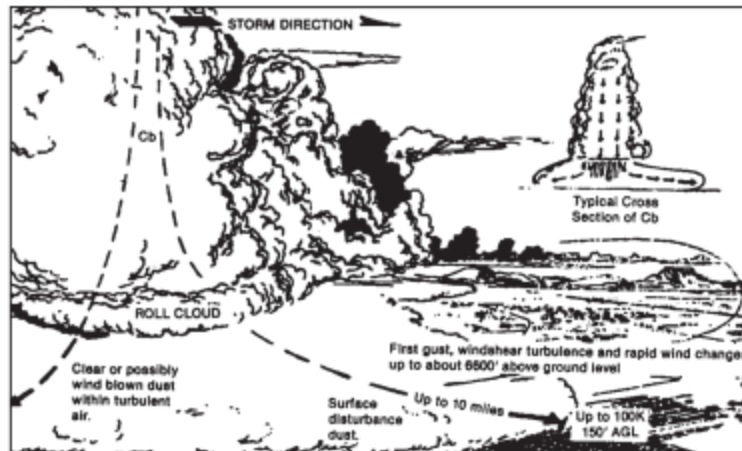


Figure 1. First gust hazards.

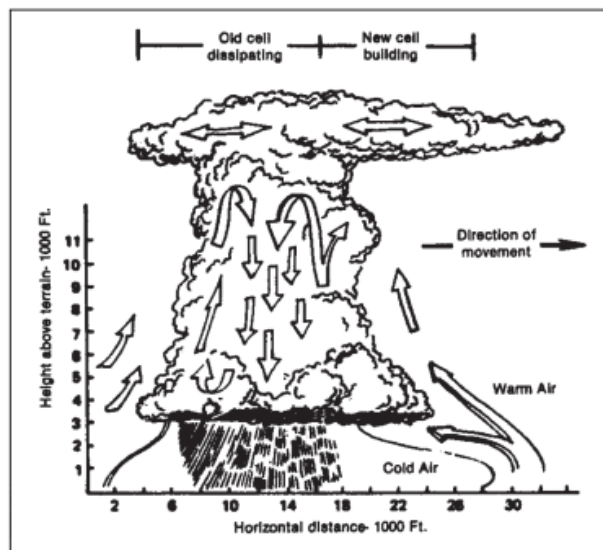


Figure 2. Downdrafts.

Strong downdrafts from a dissipating thunderstorm cell spread horizontally as they approach the ground. This wedge of cold air provides a lifting force on surrounding warm air, which may be sufficient to initiate the formation of new thunderstorm cells.

Gusty winds are associated with mature thunderstorms and are the result of large downdrafts striking the ground and spreading out horizontally. These winds can change direction by as much as 180 degrees and reach velocities of 100 knots as far as 10 miles ahead of the storm. The gust wind speed may increase by as much as 50 percent between the surface and 1,500 feet, with most of the increase occurring in the first 150 feet. The implications for a shear on approach in such a case are obvious.

The other wind problem mentioned previously, the downburst, is also downdraft related. It is an extremely intense, localized downdraft from a thunderstorm. This downdraft exceeds 720-feet-per-minute vertical velocity at 300 feet AGL. The power of the downburst can actually exceed aircraft climb capabilities, not only those of light aircraft, but, as is documented in one case, even a high-performance Air Force jet.

The downburst is usually much closer to the thunderstorm than the first gust, but there is no absolutely reliable way to predict the occurrence. One clue is the presence of dust clouds, roll clouds, or intense rainfall. It would be best to avoid such areas.

For further information on wind shear or microburst reference the NTSB Meteorological Factual report associated with this accident.

9.2 Advisory Circular (AC) 00-54

FAA AC 00-54, "Pilot Windshear Guide," dated November 25, 1988 provided, in part the following information:

Wind variations at low-altitude have long been recognized as a serious hazard to airplanes during takeoff and approach. These wind variations can result from a large variety of meteorological conditions such as: topographical conditions, temperature inversions, sea breezes, frontal systems, strong surface winds, and the most violent forms of wind change--the thunderstorm and rain shower.

Throughout this document several terms are used when discussing low altitude wind variations. These terms are defined as follows:

Windshear - Any rapid direction or velocity. change in wind.

Severe Windshear - A rapid change in wind direction or velocity causing airspeed changes greater than 15 knots or vertical speed changes greater than 500 feet per minute.

Increasing Headwind Shear in which headwind increases causing an airspeed increase. -

Decreasing Headwind Shear - Windshear in which headwind decreases causing an airspeed loss.

Decreasing Tailwind Shear - Windshear in which tailwind decreases causing an airspeed increase.

Increasing Tailwind Shear - Windshear in which tailwind increases causing an airspeed loss...

In order to avoid further windshear encounters, pilots must learn to recognize conditions producing windshear... 2 out of every 3 windshear events were related to convective storms. For this reason, the primary focus of the Pilot Windshear Guide is

directed toward windshear associated with convective weather conditions: thunderstorms, and in particular the most hazardous form of windshear, the microburst...

There are two basic types of thunderstorms: airmass and frontal. Airmass thunderstorms appear to be randomly distributed in unstable air and develop from localized heating at the earth's surface. The heated air rises and cools to form cumulus clouds. As the cumulus stage continues to develop, precipitation forms in higher portions of the cloud and falls. Precipitation signals the beginning of the mature stage and presence of a downdraft. After approximately an hour, the heated updraft creating the thunderstorm is cut off by rainfall. Heat is removed and the thunderstorm dissipates. Many thunderstorms produce an associated cold air gust front as a result of the downflow and outrush of rain-cooled air. These gust fronts are usually very turbulent and can create a serious threat to airplanes during takeoff and approach...

The Microburst as a Windshear Threat: Identification of concentrated, more powerful downdrafts--known as microbursts--has resulted from the investigation of windshear accidents and from meteorological research. Microbursts can occur anywhere convective weather conditions (thunderstorms, rain showers, virga) occur. Observations suggest that approximately five percent of all thunderstorms produce a microburst. Downdrafts associated with microbursts are typically only a few hundred to 3,000 feet across. When the downdraft reaches the ground, it spreads out horizontally and may form one or more horizontal vortex rings around the downdraft (Figure 7). The outflow region is typically 6,000 to 12,000 feet across. The horizontal vortices may extend to over 2,000 feet AGL.

10.0 NASA ASRS REPORTS

In a review of NASA ASRS²³ reported events in the 10 years preceding the accident. There were no windshear events involving a Cessna 208 aircraft during that time. The most recent Cessna 208 windshear reported event was in 2006. During that event, the ATCT instructed the airplane to go around due to windshear after the airplane had landed on the runway. In that event the pilot refused the instruction and remained on the ground.

A search of the database, for the 10 years preceding the accident revealed that there were three reported windshear related events at SLC. One of the reports was from an SLC tower controller who reported that there were two go-arounds due to windshear and at least one created a "potentially dangerous situation."

²³ National Aeronautics and Space Administration Aviation Safety Report System - a voluntary confidential reporting system administered by NASA that serves as a non-punitive means for reporting incidents and safety-related issues. [ASRS - Aviation Safety Reporting System \(nasa.gov\)](https://asrs.nasa.gov/)

Another report stated that while on the downwind to land on runway 34L the airplane encountered windshear and experienced a loss of 2,000 ft.

Another report indicated that while on approach to runway 34L inside the final approach fix the aircraft entered an area of precipitation and the winds *"immediately sheared"* from a tailwind of 40 kts to a crosswind of 38 kts. The aircraft's airspeed subsequently increased by 40 kts which resulted in a flap overspeed.

Neither report by pilots indicated any windshear alert from the air traffic controller.

F. ATTACHMENTS

- 1 - Accident Pilot Transcript and Written Statement
- 2 - Corporate Air Personnel Interviews Transcripts and Statements
- 3- Other Airline Pilot Statements
- 5- Accident Pilot Training Records [Excerpts]
- 6 - Pilot Schedule Previous 90-days
- 7 - Fuel Upload Record
- 8 - Cargo Weight Documentation
- 9 - Corporate Air Airplane Operating Manual [Excerpt]
- 10 - Corporate Air General Operations Manual [Excerpt]
- 11 - NASA ASRS Reports Previous 20 Years
- 12 - Corporate Air Flight Operations Training Manual [Excerpt]

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