Aviation Investigation Final Report

Location:	Addison, Texas	**Accident Number:**	CEN19MA190
Date & Time:	June 30, 2019, 09:11 Local	**Registration:**	N534FF
Aircraft:	Textron Aviation B-300	**Aircraft Damage:**	Destroyed
Defining Event:	Loss of control in flight	**Injuries:**	10 Fatal
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

The pilot, co-pilot, and eight passengers departed on a cross-country flight in the twin-engine airplane. One witness located on the ramp at the airport reported that the airplane sounded underpowered immediately after takeoff "like it was at a reduced power setting." Another witness stated that the airplane sounded like it did not have sufficient power to takeoff. A third witness described the rotation as "steep," and other witnesses reported thinking that the airplane was performing aerobatics.

Digital video from multiple cameras both on and off the airport showed the airplane roll to its left before reaching a maximum altitude of 100 ft above ground level; it then descended and impacted an airport hangar in an inverted attitude about 17 seconds after takeoff and an explosion immediately followed. After breaching a closed roll-up garage door, the airplane came to rest on its right side outside of the hangar and was immediately involved in a postimpact fire.

Sound spectrum analysis of data from the airplane's cockpit voice recorder (CVR) estimated that the propeller speeds were at takeoff power (1,714 to 1,728 rpm) at liftoff. About 7 seconds later, the propeller speeds diverged, with the left propeller speed decreasing to about 1,688 rpm and the right propeller speed decreasing to 1,707 rpm.

Based on the airplane's estimated calibrated airspeed of about 110 knots and the propeller rpm when the speeds diverged, the estimated thrust in the left engine decreased to near 0 while the right engine continued operating at slightly less than maximum takeoff power. Analysis of available data estimated that, 2 seconds after the propeller speed deviation, the airplane's sideslip angle was nearly 20°. During the first 5 seconds after the propeller speed deviation, the airplane's roll rate was about 5° per second to the left; its roll rate then rapidly increased to more than 60° per second before the airplane rolled inverted.

Witness marks on the left engine and propeller, the reduction in propeller speed, and the airplane's roll to the left suggest that the airplane most likely experienced a loss of thrust in the left engine shortly after takeoff. The airplane manufacturer's engine-out procedure during takeoff instructed that the landing gear should be retracted once a positive rate of climb is established, and the propeller of the inoperative engine should be feathered. Right rudder should also be applied to balance the yawing moment imparted by a thrust reduction in the left engine. Examination of the wreckage found both main landing gear in a position consistent with being extended and the left propeller was unfeathered. The condition of the wreckage precluded determining whether the autofeather system was armed or activated during the accident flight. Thus, the pilot failed to properly configure the airplane once the left engine thrust was reduced.

Calculations based on the airplane's sideslip angle shortly after the propeller speed deviation determined that the thrust asymmetry alone was insufficient to produce the sideslip angle. Based on an evaluation of thrust estimates provided by the propeller manufacturer and performance data provided by the airplane manufacturer, it is likely that the pilot applied left rudder, the opposite input needed to maintain lateral control, before applying right rudder seconds later. However, by then, the airplane's roll rate was increasing too rapidly, and its altitude was too low to recover.

The data support that it would have been possible to maintain directional and lateral control of the airplane after the thrust reduction in the left engine if the pilot had commanded right rudder initially rather than left rudder. The pilot's confused reaction to the airplane's performance shortly after takeoff supports the possibility that he was startled by the stall warning that followed the propeller speed divergence, which may have prompted his initial, improper rudder input.

In addition, the NTSB's investigation estimated that rotation occurred before the airplane had attained Vr (rotation speed), which decreased the margin to the minimum controllable airspeed and likely lessened the amount of time available for the pilot to properly react to the reduction in thrust and maintain airplane control. Although the airplane was slightly over its maximum takeoff weight at departure, its rate of climb was near what would be expected at maximum weight in the weather conditions on the day of the accident (even with the extended landing gear adding drag); therefore, the weight exceedance likely was not a factor in the accident.

Engine and propeller examinations and functional evaluations of the engine and propeller controls found no condition that would have prevented normal operation; evidence of operation in both engines at impact was found. Absent evidence of an engine malfunction, the investigation considered whether the left engine's thrust reduction was caused by other means, such as uncommanded throttle movement due to an insufficient friction setting of the airplane's power lever friction locks.

Given the lack of callouts for checklists on the CVR and the pilot's consistently reported history of not using checklists, it is possible that he did not check or adjust the setting of the power lever friction locks before the accident flight, which led to uncommanded movement of the throttle. Although the co-pilot reportedly had flown with the pilot many times previously and was familiar with the B-300, he was not type rated in the airplane and was not allowed by the pilot to operate the flight controls when passengers were on board. Therefore, the co-pilot may not have checked or adjusted the friction setting before the flight's departure.

Although the investigation considered inadequate friction setting the most likely cause of the thrust reduction in the left engine, other circumstances, such as a malfunction within the throttle control system, could also result in loss of engine thrust. However, heavy fire and impact damage to the throttle control system components, including the power quadrant and cockpit control lever friction components, precluded determining the position of the throttle levers at the time of the loss of thrust or the friction setting during the accident flight. Thus, the reason for the reduction in thrust could not be determined definitively.

In addition to a lack of callouts for checklists on the CVR, the pilots did not discuss any emergency procedures. As a result, they did not have a shared understanding of how to respond to the emergency of losing thrust in an engine during takeoff. Although the co-pilot verbally identified the loss of the left engine in response to the pilot's confused reaction to the airplane's performance shortly after takeoff, it is likely the co-pilot did not initiate any corrective flight control inputs, possibly due to the pilot's established practice of being the sole operator of flight controls when passengers were on board.

The investigation considered whether fatigue from inadequately treated obstructive sleep apnea contributed to the pilot's response to the emergency; however, the extent of any fatigue could not be determined from the available evidence. In addition, no evidence indicates that the pilot's medical conditions or their treatment were factors in the accident.

In summary, the available evidence indicates that the pilot improperly responded to the loss of thrust in the left engine by initially commanding a left rudder input and did not retract the landing gear or feather the left propeller, which was not consistent with the airplane manufacturer's engine out procedure during takeoff. It would have been possible to maintain directional and lateral control of the airplane after the thrust reduction in the left engine if right rudder had been commanded initially rather than left rudder. It is possible that the pilot's reported habit of not using checklists resulted in his not checking or adjusting the power lever friction locks as specified in the airplane manufacturer's checklists. However, fire and impact damage precluded determining the position of the power levers or friction setting during the flight.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be:

The pilot's failure to maintain airplane control following a reduction of thrust in the left engine during takeoff. The reason for the reduction in thrust could not be determined. Contributing to the accident was the pilot's failure to conduct the airplane manufacturer's emergency procedure following a loss of power in one engine and to follow the manufacturer's checklists during all phases of operation.

Findings

Not determined	(general) - Unknown/Not determined
Personnel issues	Aircraft control - Pilot
Aircraft	(general) - Not attained/maintained
Personnel issues	Lack of action - Pilot

Factual Information

History of Flight

Initial climb	Unknown or undetermined
Initial climb	Loss of control in flight (Defining event)
Post-impact	Fire/smoke (post-impact)
Post-impact	Explosion (post-impact)

On June 30, 2019, about 0911 central daylight time (CDT), a Textron Aviation B-300 (marketed as King Air 350), N534FF, was destroyed when it impacted a hangar shortly after takeoff from runway 15 at Addison Airport (ADS), Addison, Texas. A postimpact fire ensued. The airline transport pilot, the commercial co-pilot, and eight passengers sustained fatal injuries. Visual meteorological conditions prevailed for the flight. The airplane was owned by EE Operation LLC and operated as a Title 14 *Code of Federal Regulations* Part 91 personal flight en route to Albert Whitted Airport (SPG), St. Petersburg, Florida.

During postaccident interviews, personnel from Flyte Aero (an aviation service provider at ADS) reported that they arrived at the owner's hangar between 0700 and 0730 on the morning of the accident to prepare the airplane for the flight; they did not perform any maintenance. According to fueling records, all four of the airplane's tanks were filled with a total of 329 gallons of fuel.

According to Flyte Aero personnel, the pilots and passengers arrived about 90 minutes before the flight. The co-pilot greeted the passengers at the hangar and loaded their bags into the baggage compartment. No scale was present, and none of the bags were weighed. Flyte Aero personnel observed both pilots walk around the airplane before the flight but did not see the airplane taxi out.

The airplane was equipped with a cockpit voice recorder (CVR)—but was not required to be—that recorded the taxi and accident flight (it was not equipped with a flight data recorder nor was it required to be). It was also equipped with automatic dependent surveillance-broadcast (ADS-B) and a terrain awareness and warning system (TAWS). ADS-B recorded the time, the airplane's latitude and longitude, altitude, inertial speed, pressure altitude, geometric altitude, and other parameters, and TAWS recorded radio altitude, latitude, longitude, and airplane roll angle.

The CVR started recording at 0706:54. At 0749:51, an unidentified person began discussing an oil consumption issue concerning the left engine with the pilot and stated that the issue needed to be monitored. The unidentified person concluded by saying the pilots needed to "keep a log" on the issue and "keep notes." Flyte Aero personnel reported during postaccident interviews that they did not have this conversation with the pilot; the identity of the person was not determined.

About 0826, the flight crew obtained local weather information via the automatic terminal information service. At 0830:11, the flight crew received clearance to SPG on the ground control frequency. At 0902:59, the CVR recorded a noise similar to an engine starting. At 0903:15, another sound was recorded similar to the second engine starting. The pilots did not call for the airplane's Before Engine Starting, Engine Starting, Before Taxi, or Before Takeoff (Runup) checklists nor did they discuss any emergency procedures.

According to CVR data, the pilot contacted ground control about 0905 stating he was ready to taxi and was provided taxi instructions to runway 15. At 0909:41, the local controller gave the pilot departure instructions to turn left to heading 050 and cleared the flight for takeoff from runway 15. A sound similar to an increase in propeller rpm was recorded about 0910:11, and the co-pilot called "airspeed's alive" at 0910:25. The National Transportation Safety Board's (NTSB) sound spectrum study of the CVR recording and performance study estimated that rotation occurred about 0910:32 at a groundspeed of about 101 knots (102 knots calibrated airspeed).

A reduction in broadband noise recorded at 0910:34 was consistent with the airplane lifting off from the runway. Using available data, the NTSB's performance study calculated that the airplane fully lifted off the ground about 1,900 ft from the beginning of the takeoff roll at a groundspeed of about 105 knots (106 knots calibrated airspeed). The propeller speeds at the time of liftoff were estimated to be consistent with takeoff power, and the two propellers were operating about the same speed (1,714 to 1,728 rpm).

The pilots did not verbalize any V speeds before or during the takeoff roll. With the reported weather conditions (wind at 6 knots from 100° and temperature at 26°C) and at maximum takeoff weight, the takeoff decision speed (V1) for the flight would have been 106 knots, Vr (rotation speed) would have been 110 knots, V2 (takeoff safety speed) would have been 117 knots, and Vmc (minimum controllable airspeed) would have been 96 knots (with flaps retracted) or 94 knots (with the flaps at the approach setting of about 14°).

Six seconds after liftoff (0910:40.1), the pilot stated, "what in the world?" The CVR recorded the sounds of the engines' propeller rpm diverging about the same time; the airplane's groundspeed was about 109 knots (110 knots calibrated airspeed). The NTSB's sound spectrum study determined that the left engine's propeller speed decreased to about 1,688 rpm, and the right engine's propeller speed decreased to 1,707 rpm about this time. A click sound was also recorded about 0910:41 followed by a sound similar to a stall warning horn less than 1 second later. The stall warning horn ended at 0910:43; the left engine's propeller speed was 1,545 rpm about this time. At 0910:43.6, the co-pilot stated, "you just lost your left engine." The NTSB's performance study determined that the airplane had passed over the left edge of runway 15 at this time and continued to climb while turning left.

At 0910:44, the sound of a chime was recorded followed by the sound of another click. About this time, the left engine's propeller speed increased to 1,632 rpm but began to decrease again. The NTSB's performance study calculated that the airplane began to roll left about 0910:45. At 0910:45.2, the stall warning horn sounded again and continued until the end of the recording.

About 0910:47, the airplane reached a maximum altitude of 100 ft agl. At 0910:48.8, the "bank angle" annunciator sounded; the airplane had rolled to 10.6º left-wing down about this time. At 0910:49.5, an expletive from the co-pilot was recorded along with two more "bank angle" annunciations at 1-second intervals. The airplane's altitude was about 70 ft agl and its groundspeed was about 85 knots about this time.

At 0910:51.1, the sound of the airplane's impact with the hangar was recorded. About this time, the estimated speed of the left engine's propeller was 1,403 rpm, and the estimated speed of the right engine's propeller was above 1,700 rpm. Digital video obtained from multiple cameras both on and off the airport showed that the airplane rolled to its left and impacted the hangar in an inverted attitude and that an explosion immediately followed. The airplane then impacted the hangar floor, breached a closed roll-up garage door, came to rest on its right side outside of the hangar, and was consumed by fire.

Multiple witnesses observed the brief flight. One witness standing on the ramp at the airport reported that the airplane sounded underpowered immediately after takeoff "like it was at a reduced power setting." A second witness standing on the ramp reported that the airplane sounded like it did not have sufficient power to takeoff. A third witness described the rotation as "steep"; the same witness along with two others witnesses reported thinking that the airplane was "showboating" or performing aerobatics.

Pilot Information

Certificate:	Airline transport; Commercial; Flight instructor	**Age:**	71,Male
Airplane Rating(s):	Single-engine land; Single-engine sea; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	Unknown
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 1 With waivers/limitations	**Last FAA Medical Exam:**	December 21, 2018
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	March 23, 2019
Flight Time:	16450 hours (Total, all aircraft), 1100 hours (Total, this make and model), 45 hours (Last 90 days, all aircraft)		

Co-pilot Information

Certificate:	Commercial; Flight instructor	**Age:**	28,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	None	**Restraint Used:**	Unknown
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 1 None	**Last FAA Medical Exam:**	April 3, 2018
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	May 14, 2019
Flight Time:	2357 hours (Total, all aircraft), 189 hours (Last 90 days, all aircraft)		

According to people who knew both pilots, they had flown together many times before the accident flight. Although the B-300 is certificated for single-pilot operation, an acquaintance of the pilot reported that he was not comfortable flying the B-300 as a single pilot and that he always had a co-pilot for his flights.

The Pilot

The accident pilot completed recurrent training in the accident airplane (N534FF) on March 23, 2019, at Rich Aviation Services, Fort Worth, Texas. The training consisted of 2.7 hours in the airplane, including abnormal and emergency procedures, and ground training on the airplane's systems, which included—but was not limited to—engine/propellers, performance, and weight and balance.

During a postaccident interview, the flight instructor for the accident pilot's most recent recurrent training stated that it was the only time he had flown with the pilot. They briefed the entire profile before the flight; it was a good briefing of everything they planned to accomplish on the flight. The accident pilot performed well on the simulated single-engine failure on takeoff. Because they were training in the airplane rather than a simulator, the instructor did not reduce power on one of the engines on the runway for safety reasons. The instructor waited to reduce engine power until the airplane had a positive rate of climb, had reached about 200 to 300 ft agl, and the landing gear were coming up. This maneuver, like all the others, was pre-briefed.

The instructor stated that the accident pilot was "super strong" on knowledge about the airplane and nothing about his performance during the training stood out. If the instructor had to point out an area where the accident pilot was weak, it was on the airplane's avionics. They spent extra time with the external power connected to go over the avionics in the airplane. The accident pilot demonstrated a good attitude during the training and accepted advice and coaching well. The recurrent training also accomplished a flight review and instrument proficiency check. The instructor stated that it was obvious to him that the pilot was a career professional pilot and had gone through professional training before.

Several pilots who knew the accident pilot and flew with him in the past were interviewed. Regarding the accident pilot's takeoff rotation technique, two pilots reported that he used two hands during the rotation. None of the pilots interviewed reported that the accident pilot asked them to back him up on or guard the power levers during the takeoff or rotation. One pilot reported that the accident pilot had an aggressive rotation technique and that he would "pull up abruptly" at rotation.

Another pilot reported that the accident pilot "was not strong on using checklists." Another mutual acquaintance of the accident pilot and co-pilot stated that the accident pilot did not like to use a checklist and "just jumped in the airplane and went." The business partner of the accident pilot reported that he was "bad about using checklists" and that he would not use checklists as much if he was familiar with the airplane. His business partner also reported that the accident pilot generally would not do a weight and balance calculation if he was familiar with the airplane and usually verbalized V speeds.

Information to develop a 72-hour history for the pilot was not available.

The Co-pilot

The co-pilot was not type rated in the B-300. He completed recurrent training in the B-200 simulator on May 14, 2019, at Rich Aviation Services, Fort Worth, Texas. The training consisted of 2 hours in the simulator, including abnormal and emergency procedures, and ground training on airplane systems, which included—but was not limited to—engine/propellers, performance, and weight and balance. The systems training also included Beech F90 and Beech C90/B-200 differences training.

During a postaccident interview, the flight instructor for the copilot's most recent recurrent training recalled that the co-pilot was "low time" but was building experience and did a "fine job." He performed well with radio communications, use of checklists, and understanding procedures. The flight instructor stated that he typically emphasized V1 cuts (that is, simulated engine failure at takeoff) in recurrent training and that this material was emphasized during the co-pilot's simulator training.

The co-pilot was described as "very, very particular" and "by the book" during postaccident interviews with pilots who knew him. A mutual acquaintance of the accident pilot and co-pilot stated that the co-pilot did "a great job in the right seat" and was "like a sponge" with "great flying habits."

According to the co-pilot's wife, the co-pilot flew with the accident pilot most of the time and reportedly enjoyed flying with him. The pilot never allowed the co-pilot to manipulate the flight controls in flight if passengers were on board. The co-pilot's wife stated that he did not express any concerns with the pilot's flying abilities and did not discuss any aircraft systems issues with her.

Aircraft and Owner/Operator Information

Aircraft Make:	Textron Aviation	**Registration:**	N534FF
Model/Series:	B-300	**Aircraft Category:**	Airplane
Year of Manufacture:	2017	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	FL-1091
Landing Gear Type:	Retractable - Tricycle	**Seats:**	11
Date/Type of Last Inspection:	March 22, 2019 Continuous airworthiness	**Certified Max Gross Wt.:**	15000 lbs
Time Since Last Inspection:	67.03 Hrs	**Engines:**	2 Turbo prop
Airframe Total Time:	691.23 Hrs at time of accident	**Engine Manufacturer:**	Pratt & Whitney Canada
ELT:	Installed	**Engine Model/Series:**	PT6A-60A
Registered Owner:	EE Operations LLC	**Rated Power:**	1050 Horsepower
Operator:	S&H Aircraft	**Operating Certificate(s) Held:**	None

EE Operations LLC, a subsidiary of a family-owned business, purchased the accident airplane on March 21, 2019. According to the chief financial officer (CFO) of EE Operations LLC, the airplane was primarily used for family business and personal travel and was exclusively operated under 14 *CFR* Part 91. No evidence was found indicating that the airplane was operated for compensation or hire.

EE Operations LLC had an aircraft management agreement with the accident pilot's company, S&H Aircraft LLC, to manage all maintenance and flight scheduling, maintain the airplane's records, and provide pilot services. According to the CFO of EE Operations LLC, the accident pilot managed the day-to-day operation of the airplane through his company. EE Operations LLC compensated the accident pilot for his management and pilot services, and S&H Aircraft LLC hired and compensated the co-pilots used in the airplane's operation. Since the airplane was operated exclusively under Part 91, oversight by a Federal Aviation Administration principal operations inspector was not required.

Before its sale to EE Operations LLC, the airplane underwent phase 1 through 4 inspections, special inspections, service bulletin and airworthiness directive compliance, and engine and propeller maintenance at Textron Aviation Services in Wichita, Kansas. Maintenance records showed that the work on the airplane was completed on March 22, 2019. The airplane had 624.2 hours and 423 cycles at the time of the sale and accumulated about 67.03 hours and 31 cycles from that time to the day of the accident.

The accident airplane was equipped with two pilot seats and a nine-passenger-seat cabin (including the aft, belted lavatory seat). It had left and right overwing exits at row 2 and an aft overwing exit across from the lavatory seat.

Engines

The accident airplane was powered by two Pratt & Whitney Canada PT6A-60A gas turbine engines driving Hartzell HC-B4MP-3C propellers. The Hartzell HC-B4MP-3C propellers on the airplane were four-bladed, hydraulically operated, steel hub, constant-speed propellers with full feathering and reversing capabilities and a normal in-flight operating range of 1,450 to 1,700 rpm. Oil pressure from a propeller governor was used to move the blades toward low pitch (reduced blade angle). Blade-mounted counterweights and a feathering spring moved the blades toward high pitch/feather in the absence of governor oil pressure. The propeller incorporated a beta mechanism that actuated when blade angles were lower than the flight idle position.

As installed on the B-300, selected propeller positions will result in the following blade angle settings:

Reverse	-14.0° (+/- 0.5°)
Beta actuation/low pitch	15.4° (+/- 0.1°)
Flight idle	12.9° to 11.8°
Ground idle	˜ 2°
Feather	80.0° (+/- 0.5°)

Review of the operator’s airplane service records found that the engines and propellers were original to the airplane and had never been removed. Work performed on the engines during the last maintenance completed on March 22, 2019, included control linkage inspections, engine oil filter and secondary screen checks, hot section borescope inspections of both engines, and general visual inspection of both propellers.

Engine and Propeller Controls

The engine and propeller control levers on the accident airplane model are located between the two cockpit seats. The power quadrant includes two power levers (which controls engine power from idle through takeoff) and two propeller levers (which control propeller speed and feathering) to the right of the power levers. Two engine condition levers are to the right of the propeller levers and have three positions: FUEL CUTOFF, LOW IDLE, and HIGH IDLE; the idle settings limit idle speed at 62% N1 (39,000 gas generator rpm) minimum for low idle and 70% N1 minimum for high idle. The left condition lever controls the left engine, and the right condition lever controls the right engine (see figure 1).

Friction lock control knobs are located on the power quadrant. Each power lever has its own friction lock control knob at the base of the quadrant to adjust the power levers’ tension. One friction knob controls the tension of both propeller levers. Turning the knobs counterclockwise increases tension and turning them clockwise reduces tension (see Additional Information for more information on friction adjustment). The force required to move the power lever or the propeller control lever aft with the friction setting fully disengaged is 0.6 lbs and 2 lbs, respectively.

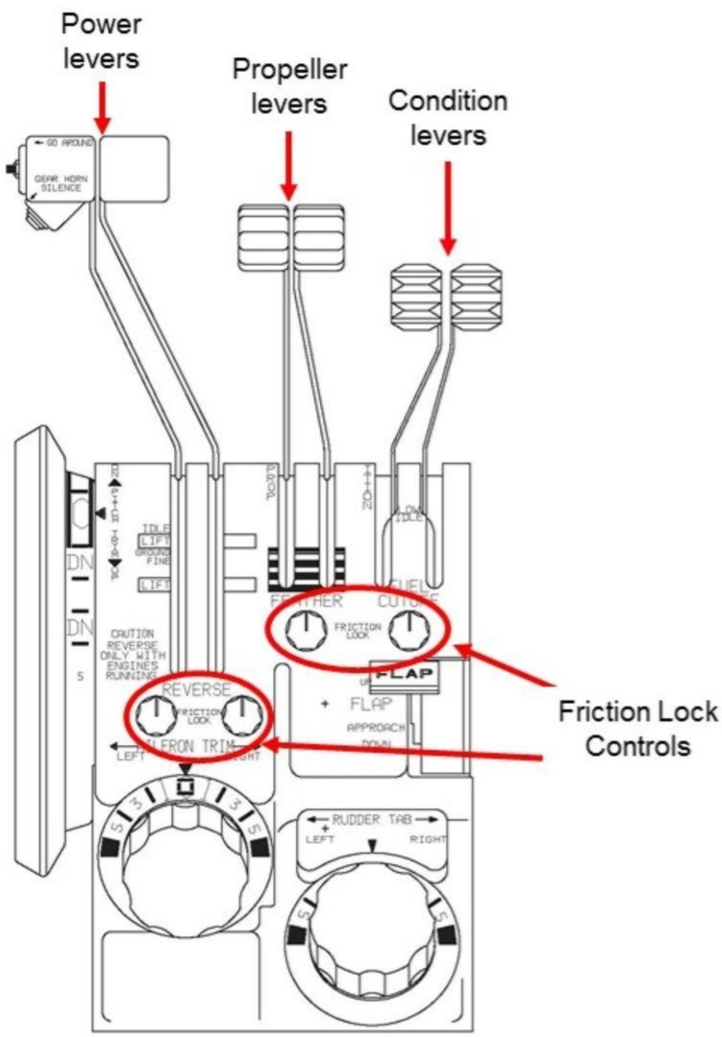

Figure 1. Diagram of B-300 Engine and Propeller Controls

The accident airplane was equipped with an autofeather system that, according to the airplane manufacturer, is intended for use during takeoff and landing if there is a loss of engine power. The system is armed when the autofeather switch is moved to the ARM position, the power levers are advanced to 87% to 89% N1, and both engine torque indications are above 17%. The letters AFX illuminate in green next to the corresponding propeller indication on the multifunction display (MFD). When armed, the system automatically feathers the propeller to reduce drag if the torque on its corresponding engine drops to between 7% to 13%. Aft movement of the power lever for that engine disarms the autofeather system. When the system is not armed, AUTOFEATHER OFF illuminates in amber on the MFD. According to the airplane manufacturer, the AUTOFEATHER OFF caution message would not be inhibited during takeoff.

Rudder Boost System

The accident airplane was equipped with a rudder boost system, which was designed to reduce the required rudder pedal force in the event of an engine failure. Rudder boost is armed by selecting the control switch (mounted on the pedestal) to the RUDDER BOOST position. The system is disarmed by selecting the control switch to the OFF position; the system can also be disarmed by pushing the button on the control wheel that disconnects the trim/autopilot yaw damper (DISC TRIM/AP YD). RUDDER BOOST OFF illuminates in amber on the MFD to indicate that the rudder boost control switch is in a position other than ON. The BEFORE TAKEOFF (RUNUP) checklist in the B-300 pilot operating handbook, Normal Procedures, included procedures for testing the rudder boost system; the system would normally be ON for takeoff. According to the aircraft manufacturer, the RUDDER BOOST OFF caution message is not inhibited during takeoff.

Weight and Balance

The airplane's maximum takeoff and landing weight was 15,000 lbs. Based on the pilots' FAA records, passenger weights provided by family members, baggage and other items recovered from the wreckage, and fuel on board, the airplane's estimated ramp weight before departure was 15,660 lbs. The airplane's computed center of gravity at departure was 206.71 inches aft of datum. The aft limit was 208.0 inches aft of datum.

Airplane Performance

According to the airplane manufacturer, the left engine is the critical engine on the B-300; if it loses power, there will be a greater yaw and rolling moment on the airplane (due to asymmetrical thrust) than if right engine power is lost. The appropriate response to a reduction in left engine thrust is to apply right rudder to balance the imparted yawing moment.

The B-300 engine-out procedure during takeoff (at or above V1) directed a pitch attitude of 10°, retracted landing gear when positive climb is established, takeoff safety speed (V2) to be maintained to 400 ft above ground level (agl), and the propeller of the inoperative engine to be feathered. Once an altitude of 400 ft agl is reached, flaps should be retracted at an airspeed of V2 plus 9 knots then airspeed should be increased to 125 knots. The airplane's performance charts indicated a one-engine-inoperative climb capability of about 700 fpm with landing gear and flaps up, the inoperative engine's propeller feathered and at maximum takeoff weight, and a climb speed of 125 knots.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	KADS,643 ft msl	**Distance from Accident Site:**	0 Nautical Miles
Observation Time:	08:47 Local	**Direction from Accident Site:**	360°
Lowest Cloud Condition:	Scattered / 1400 ft AGL	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	6 knots /	**Turbulence Type Forecast/Actual:**	None / None
Wind Direction:	100°	**Turbulence Severity Forecast/Actual:**	N/A / N/A
Altimeter Setting:	30.06 inches Hg	**Temperature/Dew Point:**	24°C / 20°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Addison, TX (ADS)	**Type of Flight Plan Filed:**	IFR
Destination:	St. Petersburg, FL (KSPG)	**Type of Clearance:**	IFR
Departure Time:	09:05 Local	**Type of Airspace:**	Class D

Airport Information

Airport:	Addison Airport ADS	**Runway Surface Type:**	Asphalt
Airport Elevation:	644 ft msl	**Runway Surface Condition:**	Dry
Runway Used:	15	**IFR Approach:**	None
Runway Length/Width:	7203 ft / 100 ft	**VFR Approach/Landing:**	None

Wreckage and Impact Information

Crew Injuries:	2 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:	8 Fatal	**Aircraft Fire:**	On-ground
Ground Injuries:		**Aircraft Explosion:**	On-ground
Total Injuries:	10 Fatal	**Latitude, Longitude:**	32.96611,-96.832778

Witness marks and wreckage distribution were consistent with the airplane impacting the top of the hangar in a right-wing-low, nose-down, and inverted attitude. The airplane was destroyed by the impact forces and postimpact fire. Fragmented pieces of both wings were located on top and inside of the hangar and immediately to the north of the hangar. The main wreckage, which included the right engine and the fuselage, was located outside of the hangar and came to rest on its right side adjacent to a brick wall. Portions of all the crew and cabin seats were identified, and all showed evidence of various degrees of fire consumption. Some seats exhibited deformation consistent with impact damage. Wreckage examination found no evidence of an in-flight fire before the impact with the hangar.

The left propeller and left engine were found on the hangar floor beneath the roof entry hole. The left engine case and external components were deformed and fractured consistent with impact. There was no evidence of catastrophic mechanical failure. One blade was missing from the left propeller hub. The liberated blade was found on the tarmac in the ramp area outside of the hangar with about 5 inches of its tip missing. There were chordwise white scrape marks on its leading edge. The missing propeller blade tip was found inside the hangar.

Propeller blade strikes (see figures 2 and 3) were observed at the airplane's initial point of impact including a strike to a hangar roof truss, which was coated white. Evidence indicates that the strikes were made by the left propeller. The distances between the propeller blade strikes were measured to determine propeller speed at impact (see figure 3). The left propeller's speed at impact was estimated at 1,259 to 1,300 rpm.

Figure 2. Photograph of an aerial view of the accident site

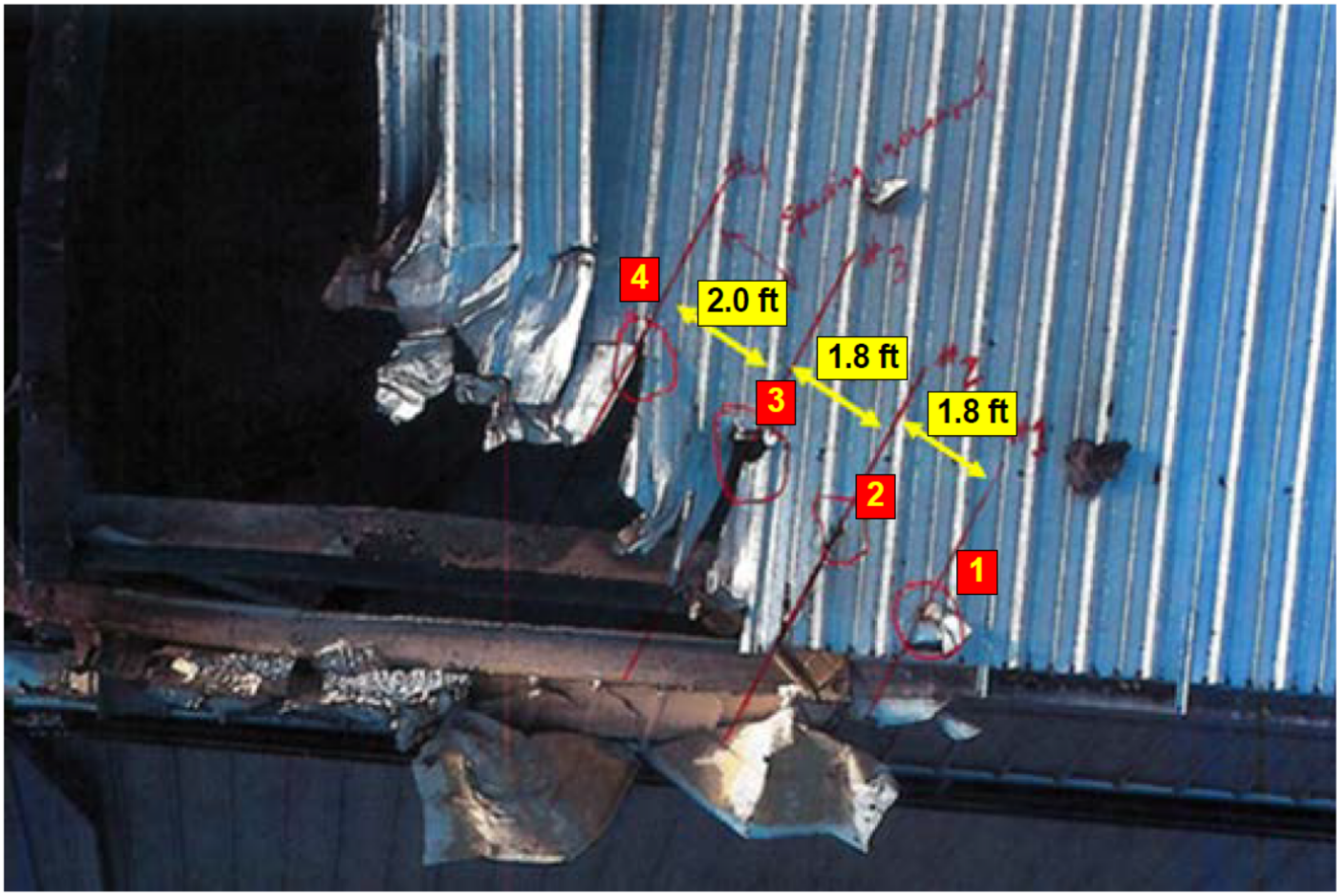

Figure 3. Photograph of propeller blade strikes in hangar roof

The left engine was found about 50 ft southeast of the left propeller. The engine case and external components were deformed and fractured. The first-stage compressor rotor was intact as viewed through the inlet case. The second-stage power-turbine blades were intact as viewed through the exhaust ducts. Both engine rotors were seized. Liberated components, including the compressor discharge pressure filter, propeller governor flyweights, and the fuel heater, were recovered near the engine.

The right propeller was found charred and sooted lying near the east wall of the hangar. The spinner was in place but crushed. Two blades exhibited forward bending and two exhibited aft bending. The front case of the engine reduction gearbox was attached.

The right engine was found in the main wreckage area. Several external components exhibited extensive thermal damage. The forward section of the right engine's reduction gearbox separated at the second stage planet gear carrier web. The second stage planet gear was liberated. The forward section of the reduction gearbox and the planet gear were both found nearby. The first-stage compressor rotor was intact as viewed through the inlet case. The second-stage power-turbine blades were intact as viewed through the exhaust exit ducts. Both engine rotors were seized. The power control and reversing linkage was fractured. The compressor discharge pressure line was damaged but continuous. Liberated components, including the second-stage reduction gearbox planet gear and the propeller governor speed lever, were found nearby.

During teardown examinations, positive evidence of operation at impact was found inside both engines. Among other indicators, rotational scoring noted on the stator structure adjacent to gas generator and power turbine rotating components showed that both engines were operating when impact occurred. In addition, the second-stage planet gear carriers of both engines were separated at their webs and the separated material was plastically deformed in the direction opposite of propeller rotation, indicating that the propellers were being driven when rotation stopped. Detailed engine and propeller disassembly examinations and functional evaluations of engine and propeller controls found no condition that would have prevented normal operation.

Both propeller assemblies displayed internal damage that could provide information about propeller blade position at the time of impact. The estimated preimpact blade angles for the left propeller was 11° to 15°, that is, near low pitch (with a bias toward the low end of the range) and 15° to 24° for the right propeller (with a bias toward the high end of the range).

No evidence was found in the wreckage indicating whether the autofeather system on the airplane was armed or activated during the accident flight.

The horizontal and vertical stabilizers were found attached to each other beneath the initial impact point; the rudder control surface and rudder trim tab were found attached to the vertical stabilizer. Control continuity could not be established due to significant impact and fire damage. The condition of the wreckage precluded determining whether the rudder boost system was active during the accident flight.

Several sections of flaps were found, most with heavy burn damage. The right outboard flap and jackscrew were present. The jackscrew actuator position was about 1 3/4 inches from the actuator housing to the middle of the attachment bolt. The right inboard flap and jackscrew were not present. The jackscrew for the left inboard flap was in the wing, but the flap was not found. The jackscrew actuator position was about 3 3/16 inches from the actuator housing to the middle of the attachment bolt. The left outboard jackscrew was attached to flap structure, but the flap was extensively burned. The jackscrew actuator position was about 1 3/4 inches from the actuator housing to the middle of the attachment bolt. According to the aircraft manufacturer, these flap jackscrew measurements are consistent with a flap position between 0° and 10°.

Both main landing gear were found in a position consistent with being extended. The nose gear upper strut was found in the extended and locked position.

The cockpit area wreckage was extensively burned. The control wheels, power quadrant, rudder pedals, and instrument panel all sustained significant fire damage. All three primary adaptive flight displays were cracked, burned, and sooted. It was possible to determine the following lever-locked switch positions on the fuel system control panel:

- left standby pump switch—ON
- left auxiliary transfer switch—OVERRIDE
- right auxiliary transfer switch—OVERRIDE
- fuel quantity test switch—MAIN
- right standby pump switch—ON

The aileron trim knob was found attached to the power quadrant, and the rudder trim knob and a section of connecting rod were found in the wreckage. No trim position indications could be determined for either knob. Damage to the control lever friction components precluded determining the friction setting during the accident flight.

Flight recorders

The airplane's CVR, model L-3/Fairchild FA2100-1020, recorded (via four channels) 2 hours of high-quality audio, including the accident flight. The outer case of the CVR sustained significant heat and structural damage, but the memory board was undamaged. Excellent quality audio was downloaded from all four channels at the NTSB's recorders laboratory and a transcript was prepared.

Medical and Pathological Information

The two pilots and eight passengers all sustained fatal injuries in the accident. Autopsy reports obtained from the Southwestern Institute of Forensics Sciences at Dallas, Office of the Medical Examiner indicated that all occupants experienced thermal and or smoke inhalation injuries that contributed to their deaths. Six of the 10 occupants also had blunt force traumatic injuries that contributed to their deaths, while 4 occupants died solely from thermal and/or smoke inhalation injuries.

Tests and Research

Video Study

Security cameras located at different points around the airfield recorded portions of the accident flight. The NTSB performed a video study of the flight (from the time the first stall warning sounded about 0910:41 to the airplane's impact with the hangar) to estimate the airplane's groundspeed, altitude, roll angle, pitch angle, angle of attack (AoA), and sideslip angle. The NTSB's video study was primarily based on a video recorded by a camera installed beyond the southern end of the departure runway. Supporting information for the study was obtained from video cameras installed on three buildings near the crash site.

The video study determined that the airplane reached a maximum altitude about 100 ft above the runway. Sideslip was near 20° nose left about 2 seconds after the propeller speed deviation; AoA and pitch were 10° about this time. The airplane's pitch and AoA reached a maximum of 13° before rapidly diverging as the airplane rolled, with AoA increasing to nearly 30° and pitch decreasing to 30° nose-down before impact with the hangar. The study estimated a decrease in the airplane's groundspeed from 114 knots (at the start of the analyzed time) to 85 knots shortly before the airplane crashed into the hangar.

Sound Spectrum Study

A sound spectrum study was completed on a portion of the cockpit area microphone channel of the CVR recording to attempt to determine the airplane's groundspeed and propeller speeds during the takeoff roll and accident sequence, the characteristics of the click sounds recorded shortly after takeoff, and the condition of each engine's operation. Concurrent with the sound of the engines advancing in power, the study identified the presence of a signal in the sound spectrum that was determined to be the blade pass frequency of the propellers. After takeoff, this signal was one tone, consistent with both propellers turning at about the same speed. About 7 seconds later, at 0910:41, about the same time as the sound of a click was recorded, the tone diverged into two tones, consistent with one propeller turning slower than the other.

The CVR recording was also analyzed to identify other data pertinent to the engines' operation. A comparison of the CVR recording with shaft speed and gearbox ratio data provided by the engine manufacturer found that the sound frequencies corresponding to these data were likely masked by other sounds in the cockpit or exceeded the upper frequencies recorded by the CVR. No other engine information could be determined based on this analysis.

Using an exemplar B-300 cockpit, a ground test was conducted (with avionics on and engines not running) to determine if throttle movement (with idle detent contact) and the actuation of an unidentified flight deck switch would produce sounds similar to the two clicks recorded on the CVR (at 0910:41 and 0910:44). After adjusting energy levels in the accident recording (background noise on the accident flight may have masked frequencies of the click sounds), the energy levels from the first recorded click exhibited characteristics similar to the sound recorded during the test when the throttle contacted the idle stop. Similarly, the adjusted energy levels from the second click recorded during the accident flight exhibited characteristics similar to the sound recorded during the test when a flight deck switch was actuated. However, this comparison contains a high degree of uncertainty because of the differences in background noise levels.

Aircraft Performance Study

Based on analysis of the video study and data provided by Textron, the performance study found the airplane's initial sideslip angle (near 20° nose left) is consistent with the opposite rudder input needed to balance the yawing moment imparted by the thrust reduction in the left engine. Based on the airplane's estimated speed and propeller rpm when the propeller speeds diverged, the propeller manufacturer estimated that the thrust produced by the left engine dropped to near 0 while the right engine was likely operating at slightly less than maximum takeoff power.

The performance study calculated that the thrust asymmetry alone was unable to produce the sideslip seen in the video. Yawing calculations estimated the airplane's rudder position to be 11° nose left 2 seconds after the loss of thrust in the left engine then, 2 seconds later, the left rudder decreased to 0°, and the rudder moved to exceed 20° nose right as the airplane's sideslip angle ultimately reached 16° nose right. The airplane's initial roll rate (the first 5 seconds after the propeller speed deviation) was about 5° left per second. Its left roll rate rapidly increased to more than 60° per second before rolling inverted.

The performance study determined that, based on performance data provided by Textron, the airplane was within the tested bounds of controllability during the first 5 seconds after the thrust reduction while the roll rate was still relatively low. The data support that it would have been possible to maintain directional and lateral control of the airplane after the thrust reduction in the left engine if right rudder had been commanded initially rather than left rudder.

Additional Information

Emergency Response

Addison Fire Department Fire Station 1 was located about 600 ft from the accident site. The battalion chief reported that he was inside the station at the time and heard an explosion but did not know what it was. The station was equipped with a direct line ringdown service from the airport control tower (ATCT), which activated almost immediately to report an accident at the airport. The battalion chief and nine other firefighters in the station responded to the accident site in five vehicles. The emergency personnel reported observing heavy smoke as soon as they left the station. The hangar was completely engulfed in fire and smoke upon their arrival. Emergency personnel reported that the fires (one in the hangar and a second outside to the left of the hangar, which was the airplane wreckage) were knocked down within 14 to 15 minutes.

ATCT personnel initially reported to the battalion chief that at least two people were on board, but they were uncertain about the number of occupants. The battalion chief did not learn until several hours later that 10 people were on board; he reported, however, that the information would not have changed his tactics because he did not recognize that the location of the secondary fire was the airplane wreckage. He further stated that he may have concentrated more on the second fire upon arrival had he known that it was the accident airplane but, until the fire was extinguished, there was no way to know that it was an airplane.

Friction Lock Checklist Procedures and Reports of Uncommanded Power Lever Movement

FlightSafety Textron Aviation Training, which emphasizes the risk of an unintended power lever migration and potential loss of control if the friction lock setting is adjusted incorrectly, also provides the manufacturer's checklist procedures. The following procedures are listed as part of the 'BEFORE ENGINE START' checklist:

a. Power Levers................................ IDLE, FRICTION SET

b. Prop Levers................ FULL FORWARD, FRICTION SET

c. Condition Levers............... FUEL CUT OFF, FRICTION SET

In addition, item 7 in the B-300 Before Takeoff (Runup) checklist states that the engine control friction locks should be "set." The Before Engine Starting checklist in the B-300 quick reference handbook also contains an item to check that friction is set on the power, propeller, and condition levers.

According to Textron, the B-300 friction control is the same as that used on all Beechcraft brand twin-engine airplanes since the Queen Air model 88 (introduced in 1965). A search of the Aviation Safety Reporting System found three customer service reports of an insufficient friction setting on the power lever friction locks that led to uncommanded throttle movement in various King Air model aircraft during takeoff.

Administrative Information

Investigator In Charge (IIC):	Rodi, Jennifer
Additional Participating Persons:	Matthew Rigsby; Federal Aviation Administration AVP; Fort Worth, TX Jennifer Barclay; Textron Aviation; Wichita, KS Marc Hamilton; Transportation Safety Board of Canada; Ottawa Les Doud; Hartzell Propeller; Piqua, OH Brandon Johnson; National Air Traffic Controllers Association; Salt Lake City, UT Marc Gratton; Pratt & Whitney Canada; Longueuil
Original Publish Date:	May 18, 2021
Last Revision Date:	
Investigation Class:	Class 2
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=99731