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Pilot Becomes Spatially Disoriented, Aircraft Breaks Apart During Descent

A Raytheon Super King Air 200 was transporting members of a collegiate basketball team in instrument meteorological conditions when the alternating-current electrical system malfunctioned. The report said that the pilot became spatially disoriented. The pilot's control inputs placed a large aerodynamic load on the aircraft and caused it to break apart at low altitude.

FSF Editorial Staff

At 1737 local time Jan. 27, 2001, a Raytheon Super King Air 200 operated by Jet Express Services struck terrain near Strasburg, Colorado, U.S. The aircraft was destroyed by the impact and postaccident fire. All 10 occupants were killed.

The U.S. National Transportation Safety Board (NTSB) said, in its final report, that the probable cause of the accident was "the pilot's spatial disorientation resulting from his failure to maintain positive manual control of the airplane with the available flight instrumentation. Contributing to the cause of the accident was the loss of [alternating-current (AC)] electrical power during instrument meteorological conditions."

The Super King Air 200 was one of three airplanes that were being used to transport members of the Oklahoma State University (OSU) basketball team and team personnel from Broomfield, Colorado, to Stillwater, Oklahoma, which is about 47 nautical miles (87 kilometers) from Broomfield. The OSU team had competed in a basketball game with the University of Colorado team the afternoon of the accident. The other airplanes being used to transport the OSU team members and team personnel were a Learjet 60 and a Cessna Citation 650.

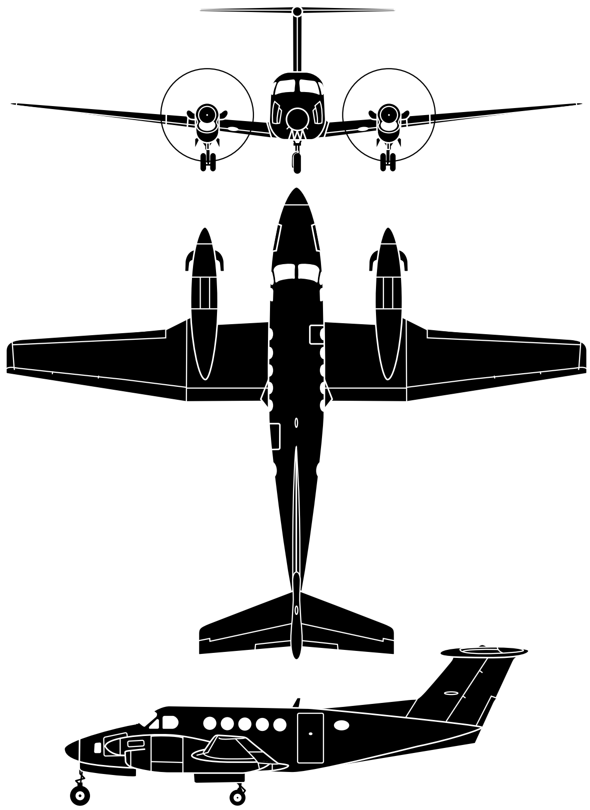
The flight was conducted under U.S. Federal Aviation Regulations (FARs) Part 91, the general operating and flight rules. The Super King Air 200 was certified for single-pilot operation under Part 91.

"The pilot who occupied the left seat in the cockpit was solely responsible for the flight," the report said. "The pilot who occupied the right seat in the cockpit, referred to in this report as the 'second pilot,' was not a required flight crewmember."

The pilot-in-command (PIC), 55, held an airline transport pilot certificate and type ratings for the Cessna Citation 500 and Learjet. He had 5,117 flight hours, including 2,520 flight hours in King Air series airplanes and 767 flight hours in Super King Air 200s. The PIC had received recurrent ground training and simulator training for the Super King Air 200 in April 2000 at the Simcom Training Center in Arizona.

The PIC was the sole proprietor of Jet Express Services, an aircraft-management company in Oklahoma City, Oklahoma. He managed the accident airplane, which was owned by North Bay Charter of Nevada, and another airplane. Between July 1, 2000, and Jan. 25, 2001, the pilot conducted three flights for the OSU athletic department.

On Sept. 11, 1997, the pilot was providing proficiency training in a Super King Air 200 for U.S. Federal Aviation Administration (FAA) safety inspectors when the airplane's nose-gear actuator failed in flight.



Raytheon Super King Air 200

Design of the Raytheon Super King Air 200 business and utility twin-turboprop aircraft began in 1970. The first prototype flew in 1972. The aircraft has the same basic fuselage as the King Air 100 and has increased wingspan, more powerful engines, increased fuel capacity, increased cabin pressurization and a higher gross weight.

The aircraft is certified for single-pilot flight under U.S. Federal Aviation Regulations Part 91. The cockpit has two seats, and the cabin has six seats. Maximum cabin pressure differential is 6.5 pounds per square inch (0.4 bar). The cabin door is in the aft, left side of the fuselage. The aft fuselage accommodates a lavatory and a baggage compartment of 410 pounds (186 kilograms) capacity.

Each of the two Pratt & Whitney PT6A-41 engines produces 850 shaft horsepower (634 kilowatts) and drives a Hartzell three-blade, metal propeller. Maximum fuel capacity is 3,645 pounds (1,653 kilograms).

Maximum takeoff and landing weight is 12,500 pounds (5,670 kilograms). Maximum cruise speed at 25,000 feet and average cruise weight is 289 knots. Maximum rate of climb at sea level is 2,450 feet per minute. Maximum single-engine rate of climb at sea level is 740 feet per minute. Stall speed with flaps up is 99 knots. Stall speed with flaps fully extended is 76 knots.♦

Source: *Jane's All the World's Aircraft*

"The pilot landed the airplane on its two main-landing-gear wheels and the nose," the report said. "No one aboard the airplane was injured, and the airplane received only minor damage to its propellers. The FAA sent the pilot a letter of commendation, dated Sept. 22, 1997, complimenting him for the manner in which he handled the emergency."

On March 24, 1998, the PIC failed a Part 135 check ride administered by an FAA air safety inspector. (Part 135 prescribes requirements for commuter operations and on-demand operations.)

"The purpose of the check ride was to add the pilot to the Part 135 [operating] certificate held by Million Air in Oklahoma City," the report said. "The inspector indicated that one part of the check ride involved a simulated engine failure as the airplane [a Super King Air 200] climbed through 400 feet altitude with the autopilot engaged. According to FAA records, the airplane drifted off its heading by 30 degrees and lost 100 feet of altitude before the air safety inspector intervened and told the pilot to manually fly the airplane. The air safety inspector said that the pilot thought that the autopilot would fly the airplane with the engine failure."

The report said that the pilot received training and passed the check ride the next day.

"In a postaccident interview, the air safety inspector indicated that the pilot 'had a tendency to lock in on a problem and not fly the airplane,'" the report said.

The second pilot, 30, held a commercial pilot certificate and flight instructor ratings. He had 1,828 flight hours, including 1,218 flight hours in multi-engine airplanes. He had flown the accident airplane four times in the 90 days preceding the accident and had logged 10 flight hours as PIC in the Super King Air 200 during the flights. The report did not specify the second pilot's total flight time as PIC in King Airs.

"A pilot who knew the second pilot since May 2000 … indicated that the second pilot flew with the [PIC] once or twice per month," the report said. "The second pilot had not received any formal training on King Air airplanes."

The PIC and second pilot had flown the OSU basketball-team members and team personnel from Stillwater to Broomfield the day before the accident.

About 1100 on the day of the accident, the PIC obtained a weather briefing and filed an instrument flight rules (IFR) flight plan with the Denver (Colorado) Automated Flight Service Station.

"The weather briefing included a general synopsis of the weather situation for the proposed flights [to Stillwater and to Oklahoma City], AIRMETs (airmen's meteorological information) …, forecast airport conditions, winds and temperatures aloft, and notices to airmen [NOTAMs] in effect," the report said.

The AIRMETs advised of occasional moderate rime ice and mixed ice in clouds and precipitation below 22,000 feet, occasional moderate turbulence below 18,000 feet and occasional widespread ceilings below 1,000 feet and visibilities below three statute miles (five kilometers) in precipitation and mist.

The report said that icing was not a factor in the accident: An analysis conducted by the U.S. National Center for Atmospheric Research indicated a "fairly low threat for potential icing and no threat for potential supercooled large droplets [which can cause severe icing] over eastern Colorado, including the area of the accident site." At the time of the accident, there were no pilot reports (PIREPs) of in-flight icing conditions over Colorado.

The airplane, which had been in a hangar overnight, was removed from the hangar between 1115 and 1130. When the pilots arrived at the airport about 1300, the PIC asked ramp-service personnel to move the airplane into a hangar. The pilots then left the airport and attended the first half of the basketball game, which began at 1400.

The pilots and the passengers boarded the airplane about 1700. The airplane then was moved out of the hangar. Ramp-service personnel said that the airplane was dry when it was towed from the hangar onto the apron.

The current automatic terminal information service (ATIS) radio broadcast indicated that the surface wind was variable at three knots, visibility was one statute mile (two kilometers) in light snow, the ceiling was indefinite with bases at 200 feet, temperature was minus four degrees Celsius (25 degrees Fahrenheit) and dew point was minus five degrees Celsius (23 degrees Fahrenheit).

The airplane departed from Runway 29R about 1718. The local controller told the crew to turn right to a heading of 040 degrees and to establish radio communication with the Denver Terminal Radar Approach Control (TRACON) facility.

At 1719, the PIC told the TRACON controller that he was flying the airplane through 6,500 feet to 8,000 feet. The controller told the PIC to fly the airplane to 12,000 feet and to fly a heading of 060 degrees.

At 1722, the controller told the PIC to fly the airplane to the EPKEE intersection and to continue the climb to Flight Level (FL) 230 (approximately 23,000 feet). The controller then observed that the airplane was still tracking 060 degrees and told the PIC to fly a heading of 110 degrees. The controller also told the PIC to establish radio communication with Satellite Radar Two.

At 1726, the PIC told the Satellite Radar Two controller that he was flying the airplane through 16,300 feet to FL 230. The controller told the PIC to fly the airplane to EPKEE.

"About 1726:27, the pilot stated that he was going directly to the EPKEE intersection and that he needed to make about a three-degree left turn," the report said. "The controller did not receive any further transmissions from the pilot."

Recorded air traffic control (ATC) radar data indicated that the airplane reached FL 230 about 1732.

"According to ATC radar data, the airplane's climb through this altitude was normal, and its airspeeds had been steady," the report said. "The last Mode C transponder return [encoded altitude] occurred about 1735:44, when the airplane was at an altitude of 23,200 feet."

An airplane-performance study indicated that after the last Mode C transponder return was received by ATC, the airplane gradually banked 30 degrees right and pitched 15 degrees nose-down; airspeed was about 200 knots.

"Radar data indicated that by 1736:26, the airplane started to deviate from its heading and make a right turn to the south," the report said. "During the next 30 seconds, the airplane's bank angle continued to increase in the right-wing-down direction and its pitch angle remained near 20 degrees airplane-nose-down."

By 1737:02, the airplane had completed a 360-degree turn and was descending through about 17,200 feet at 15,000 feet per minute and about 250 knots.

"By 1737:10, the airplane entered a steep dive," the report said. "At that point, the airplane was descending through 10,000 feet with its pitch angle exceeding 80 degrees airplane-nose-down and its bank angle exceeding 100 degrees right-wing-down."

The report said that the pilot might have observed ground references when the airplane descended below the clouds and that he apparently attempted to arrest the descent by pulling back the control column.

"Calculated performance parameters showed that, about the time of the last Mode A transponder return [identification code] (1737:12), the airplane rolled to the left toward wings-level, its descent rate began to be arrested, and its nose-down pitch decreased," the report said. "During the next five seconds, the airplane's airspeed increased rapidly to more than 350 knots as the descent rate was reduced."

The report said that the pilot's control inputs placed a large aerodynamic load on the airplane.

"The aerodynamic loading caused the airplane to break apart in flight at low altitude (within several hundred feet of the ground) and crash into terrain," the report said.

Parts of the empennage and the outboard section of the right wing separated from the airplane. The airplane then struck rolling terrain at 5,223 feet.

"The airplane initially impacted the ground nose-first and then bounced 125 feet [38 meters] to an inverted position," the report said.

Autopsy reports indicated that the occupants died from multiple massive blunt traumatic injuries. A fuel-fed fire erupted after impact.

Reconstruction of the airplane's flight path during the last two minutes of flight indicates that the pilot became spatially disoriented and flew the airplane into a spiral.

"Spatial disorientation can occur in a banked airplane when it rolls very slowly at a rate that is not detected by the motion-sensing organs of the inner ear," the report said. "The threshold for the detection of roll rate (roll to bank) by humans is about two degrees per second.

"Spatial disorientation can also occur in a banked airplane when a constant-rate turn is maintained and stimulation of the inner-ear organs ceases. A disoriented pilot who falsely perceives a constant-rate turn as a descent may respond with elevator pitch-up controls, which will tighten the turn. As the turn tightens and the airplane's bank continues to increase, the airplane will lose altitude from the resulting loss of vertical lift. A disoriented pilot who still perceives a wings-level flight attitude may respond to the loss of altitude with increased pitch-up controls, resulting in a steep spiral dive (commonly referred to as a 'graveyard spiral')."

The report said that a total loss of AC electrical power occurred when the airplane was at 23,200 feet and transmission of Mode C data by the airplane's transponder ceased. Mode C data are generated by the airplane's air-data computer, which is powered by AC electrical current. Continued transmission of Mode A data by the airplane's transponder indicated that a total loss of electrical power did not occur; the transponder is powered by direct-current (DC) electrical current.

The electrical system in the accident airplane included two 600-volt static inverters. One inverter is selected during aircraft operation to convert DC power to AC power; the other inverter is available as a backup.

"Each inverter provides 800-Hertz (Hz), 115 volts [AC] to the avionics equipment and 400-Hz, 26 volts [AC] to the engine-instrument panel, but only one inverter can be engaged at a time," the report said. "The inverter-select switch [is] located on a panel below the instrument panel and to the left of the control wheel on the pilot's (left) side of the cockpit. … If the selected inverter is inoperative, an inverter annunciator light will illuminate in the cockpit. The other inverter can then be selected."

The "Inverter Inoperative" checklist in the emergency procedures section of the Super King Air 200 pilot's operating handbook has one instruction: "Select the other inverter."

Postaccident tests of a Super King Air 200 with equipment similar to that in the accident airplane showed that a loss of AC electrical power would cause warning flags to appear in the pilot's altimeter, attitude indicator, horizontal situation indicator (HSI), radio altimeter, radio magnetic indicator (RMI) and altitude-preselect unit. A loss of AC electrical power also would cause warning flags to appear in the copilot's RMI and HSI.

"Further, the examination and testing determined that if [AC] power were lost, the working instruments on the pilot's side of the cockpit would be limited to an airspeed indicator and a turn-and-slip indicator," the report said. "The copilot's side of the cockpit would display working airspeed and turn-and-slip indicators but would also display a working altimeter and [a working] attitude indicator. The two pilot-side instruments and the four copilot-side instruments would function because they would receive inputs from the pitot-static or vacuum systems."

Investigators were unable to determine from the factual information gathered during the investigation whether the PIC attempted to restore AC electrical power.

"Despite the loss of AC electrical power, the pilot could have safely flown and landed the airplane from the left seat by referencing the available (non-AC-powered) flight instruments on the right side of the cockpit (the altimeter and the airspeed, attitude and turn-and-slip indicators)," the report said. "Also, the pilot could have asked the second pilot to fly the airplane, because the available flight instruments would be more easily viewed from the right seat."

The accident airplane's maintenance records showed that in October 1990, a pilot reported that both inverters became inoperative during flight and that AC power was restored about five minutes to eight minutes later.

"The cause of the problem was found to be a failed relay rather than inoperative inverters," the report said. "The failed relay was replaced, and no further discrepancies regarding the inverters were reported."

The maintenance records showed that the no. 2 inverter was replaced with a new inverter in October 1994 and that the no. 1 inverter was replaced with an overhauled inverter in May 1996.

"The maintenance records did not indicate any discrepancies regarding either of these inverters," the report said.

Investigators found that 89 service difficulty reports (SDRs) on the Super King Air 200 electrical system were submitted to FAA between Jan. 28, 1986, and Dec. 1, 2000.

"Eight of these reports involved inverters, but none of the reports involved a dual inverter failure," the report said.

Investigators did not determine what caused the loss of AC electrical power aboard the accident aircraft. The report said that the following are possible explanations for the loss of AC electrical power:

- "First, the selected inverter could have failed, and the pilot might not have switched to the other inverter. However, the pilot should have been familiar with this switch because it is always used to supply AC power after engine start and to terminate AC power before engine shutdown;
- "Second, a dual inverter failure could have occurred. However, it is extremely unlikely that both inverters would have failed because of the inverters' history of reliability aboard [Super] King Air 200 airplanes. … The maintenance records for the accident airplane did not indicate a systemic problem with either inverter. In addition, the internal fuses from both inverters were found broken but not melted or burned, which indicated that the inverters had not shorted;
- "Third, the [Super] King Air 200 electrical-system schematic indicates that if at least one of the inverters is operational, [if] no AC power is present at the volt/frequency meter and [if] DC power is available to the inverters, then one of three components — the inverter selector switch, the inverter select relay or the avionics inverter select relay — could produce an AC power electrical system failure. Thus, all three components are potential sources of single-point failures in the electrical system. None of these items was recovered from the wreckage; [and,]
- "Fourth, wiring failures, shorts [short circuits] or opens [open circuits] are possible reasons for the loss of AC power."

In a Jan. 25, 2002, letter to NTSB, FAA said that the accident flight should have been conducted under Part 135, rather than Part 91.

"FAA indicated that the pilot was required to operate the accident airplane pursuant to [Part 135] because he had the primary responsibility for providing the airplane and the pilot services and was receiving compensation for both," the report said.

The report said that the flight operation exceeded Part 135 requirements.

"Even if the flight had been operated under [Part 135], the second pilot would still not have been a required crewmember; the airplane was certified for single-pilot operation under Part 135 in IFR conditions because a three-axis autopilot was installed and operating," the report said. "Because the flight was conducted with two qualified pilots and an operational autopilot and thus exceeded Part 135 requirements, the circumstances of this accident would not have been any different if the pilot had operated the flight under Part 135, rather than Part 91."

The report said that use of the accident airplane was donated by an OSU alumnus who was a friend of the PIC.

"In a postaccident interview, another friend of the pilot said that the donor paid for the airplane's rental fee, fuel and associated expenses," the report said. "This friend also said that the pilot did not bill OSU for his services because he enjoyed being with the basketball team players and coach, and that he mostly flew for OSU as a single pilot because the athletic-department staff wanted to use all of the available seats in the airplane."

The report said that OSU did not provide any significant oversight of the accident flight.

"Even though the university's athletic department knew the accident pilot, the [university's] flight department had no records on file regarding him, the second pilot or the accident airplane, as required [by OSU's team-travel policy]," the report said. "Also, because the accident flight was a donated flight, it was not coordinated with the flight department manager, as were charter flights and flights involving university airplanes."

In April 2002, OSU issued a revised team-travel policy. Among the changes were a requirement for the university to retain a qualified aviation consultant to evaluate the certification and safety records of air-service providers. The policy gives the consultant final authority for approving the use of an air-service provider. The policy also requires two pilots, specific minimum experience levels for the pilots, aircraft with two or more turbine engines and certification for flight into known icing conditions, and aircraft maintenance by FAA-certified repair stations.

"OSU's revised team-travel policy … is a comprehensive travel-management system that promotes safe university-sponsored team travel and provides the necessary oversight to ensure that transportation services are carried out in accordance with the provisions of the revised policy," the report said.

Based on the findings of the investigation, NTSB made the following recommendation to the U.S. National Collegiate Athletic Association, the U.S. National Association of Intercollegiate Athletics and the American Council on Education:

"Review [OSU's] postaccident team-travel policy and develop, either independently or jointly, a model policy for member institutions to use in creating a travel policy or strengthening an existing travel policy."♦

[FSF editorial note: This article, except where specifically noted, is based on U.S. National Transportation Safety Board (NTSB) *Aircraft Accident Report: In-flight Electrical System Failure and Loss of Control; Jet Express Services Raytheon (Beechcraft) Super King Air 200, N81PF, Near Strasburg, Colorado, January 27, 2001* (58 pages with appendixes and illustration) and NTSB *Safety Recommendation A-03-01*, Jan. 21, 2003, (16 pages).]

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