National Transportation Safety Board
Aviation Accident Final Report

Location:	Prospect Heights, IL	**Accident Number:**	CEN10MA088
Date & Time:	01/05/2010, 1327 CST	**Registration:**	N720RA
Aircraft:	GATES LEARJET CORP. 35A	**Aircraft Damage:**	Substantial
Defining Event:	Loss of control in flight	**Injuries:**	2 Fatal
Flight Conducted Under:	Part 91: General Aviation - Positioning		

Analysis

The flight was scheduled to pick up cargo at the destination airport and then deliver it to another location. During the descent and 14 minutes before the accident, the airplane encountered a layer of moderate rime ice. The captain, who was the pilot flying, and the first officer, who was the monitoring pilot, made multiple statements which were consistent with their awareness and presence of airframe icing. After obtaining visual flight rules conditions, the flight crew canceled the instrument flight rules clearance and continued with a right, circling approach to the runway. While turning into the base leg of the traffic pattern, and 45 seconds prior to the accident, the captain called for full flaps and the engine power levers were adjusted several times between 50 and 95 percent. In addition, the captain inquired about the autopilot and fuel balance. In response, the first officer stated that he did not think that the spoilerons were working. Shortly thereafter, the first officer gave the command to add full engine power and the airplane impacted terrain.

There was no evidence of flight crew impairment or fatigue in the final 30 minutes of the flight. The cockpit voice recorder showed multiple instances during the flight in which the airplane was below 10,000 feet mean sea level that the crew was engaged in discussions that were not consistent with a sterile cockpit environment, for example a lengthy discussion about Class B airspeeds, which may have led to a relaxed and casual cockpit atmosphere. In addition, the flight crew appears to have conducted checklists in a generally informal manner. As the flight was conducted by a Part 135 operator, it would be expected that both pilots were versed with the importance of sterile cockpit rules and the importance of adhering to procedures, including demonstrating checklist discipline.

For approximately the last 24 seconds of flight, both pilots were likely focusing their attention on activities to identify and understand the reason for the airplane's roll handling difficulties, as noted by the captain's comment related to the fuel balance. These events, culminating in the first officer's urgent command to add full power, suggested that neither pilot detected the airplane's decaying energy state before it reached a critical level for the conditions it encountered.

Light bulb filament examination revealed that aileron augmentation system and stall warning lights illuminated in the cockpit. No mechanical anomalies were found to substantiate a failure in the aileron augmentation system. No additional mechanical or system anomalies were noted with the airplane. A performance study, limited by available data, could not confirm the airplane's movements relative to an aileron augmentation system or spoileron problem. The level of airframe icing and its possible effect on the airplane at the time of the accident could not be determined.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: A loss of control for undetermined reasons.

Findings

Aircraft	Performance/control parameters - Not specified (Cause)
Not determined	Not determined - Unknown/Not determined (Cause)

Factual Information

HISTORY OF FLIGHT

On January 5, 2010, at 1327 central standard time, a Gates Learjet Corp. 35A, N720RA, operated as Royal Air Freight flight 988 (RAX 988), was destroyed when it impacted water and terrain while maneuvering to final approach to runway 34 at Chicago Executive Airport (PWK), Prospect Heights, Illinois. The captain and first officer sustained fatal injuries. The airplane was owned and operated by Royal Air Freight, Inc., Waterford, Michigan. Visual meteorological conditions prevailed at the time of the accident and an instrument flight rules flight plan was filed for the 14 Code of Federal Regulations Part 91 positioning flight. The flight departed Oakland County International Airport (PTK), Pontiac, Michigan, at 1235.

According to the operator, the accident flight was scheduled to pick up cargo at PWK and then transport the cargo to Georgia. The accident flight was the first flight for the flight crew that day. The flight crew reported for duty about 1200. The airplane departed PTK at 1235, en route to PWK. During the takeoff, climb, and en route portions of the flight, no abnormalities were reported by the crew to air traffic control (ATC) nor were any recorded by the cockpit voice recorder (CVR).

Review of the CVR transcript revealed that the recording began at 1300:03 while the airplane was en route. At 1306:28, the first officer reported to Chicago air route traffic control center (ARTCC) that their altitude was at flight level two zero zero (20,000 feet mean sea level). The controller then instructed the flight crew to be at 4,000 feet, 35 miles northeast of the Northbrook VOR. At 1308:05, the crew obtained the current automatic terminal information service (ATIS) weather information Quebec for PWK. At 1311:00, the captain stated that he had all the airplane anti-ice systems activated, and a discussion took place involving captain's previous experience flying over the "lake." At 1312:34, the captain stated that the "cabin sucks." Digital electronic engine control (DEEC) data indicated that the engines' low pressure spool speed (N1) was approximately 30 to 50 percent from 1312:18 to 1314:18. At 1314:02, the center controller cleared the flight crew direct to the Northbrook VOR and the first officer acknowledged the clearance. At 1314:25, the captain stated, "yeah, there's ice out there." Seven seconds later, the controller cleared the flight crew to descend and maintain 3,000 feet and contact Chicago approach control, and the first officer acknowledged the clearance.

At 1314:58, the first officer stated, "there's ice(ing)," and the captain replied he was glad he had all the airplane anti-ice activated before the descent. The captain stated they were picking up moderate rime ice and the first officer reported the ice conditions to the Chicago approach controller. At 1316:23, the first officer stated, "(look at the) (expletive) tips." Approximately 50 seconds later, the approach controller cleared the flight crew to 2,000 feet and at 1317:37 the first officer reported they broke out of the clouds at 2,600 feet.

At 1318:38, the captain stated that he was turning off the anti-ice system and the first officer stated, "don't need it anymore." Between 1311 and 1318 (the time anti-ice system ON as per CVR comments), engine N1 speeds fluctuated between 30 and 80 percent. For approximately the next two and half minutes, the flight crew had a discussion related to airspeeds within the Class B airspace.

At 1321:06, the captain stated, "we'll go like one twenty eight on the speed." At 1323:03, the approach controller reported PWK was at their 10 o'clock position and 12 miles, and the first

officer reported the airport was in sight. The controller then cleared the flight crew for a visual approach to runway 16 and to contact the PWK air traffic controller tower (ATCT). After contacting ATCT, the flight crew was cleared for a right traffic circling approach to runway 34, and they canceled instrument flight rules (IFR).

At 1324:18, the captain called for flaps at 8 degrees and turned the yaw damper off at 1325:02. The flight crew discussed the winds were reported at 310 degrees at 9 knots. At 1325:49, the flight crew was cleared to land and the first officer acknowledged the transmission. Four seconds later, the captain called for the landing gear to be extended. The crew then briefed portions of the before landing checklist and at 1326:27, the captain called for flaps at 20 degrees.

At 1327:02, the captain called for full flaps (40 degrees) and the first officer responded, "plus twenty." Post-accident performance studies indicated that the airplane's bank angle increased, and the true airspeed decreased. At 1327:10, one of the two crew members stated, "what the # going on up here." The captain stated, "that was # weird." At 1327:18, the first officer stated, "advance the power," and the sound of laughter followed. Post-accident performance studies indicated that the airplane's true airspeed and N1 increased. At 1327:21, the captain inquired whether the autopilot was off and nine seconds later, one of the crew members stated, "I don't like this at all...what the # is going on." At 1327:34, the captain asked the first officer to check the balance on the fuel, and the first officer responded, "looks good. I don't think that spoileron thing is working for some reason." Post-accident performance studies indicated that the airplane's N1 and true airspeed decreased, and bank angle increased to greater than 50 degrees. The sound of 2 "clicks" was then heard at 1327:41.8 and 1327:42.5, respectively. At 1327:42.7, the first officer stated, "add full power, add full power." The CVR recording ended at 1327:48.5.

A witness, who was located at the PWK airport, observed the airplane on a right base leg to runway 34. The witness reported the airplane started to turn to final approach and the bank angle "got very steep, very fast [sic] until the aircraft which seemed to snap roll into a stall and then immediately into a nose dive..."

Another witness (a pilot familiar with PWK) who was riding in a vehicle, reported he first observed the airplane on a right downwind for runway 34. He reported, "The aircraft appeared to make a normal downwind to base turn. However, on the base to final turn, the airplane seemed to be slightly uncoordinated with the right wing down, slightly nose low, and the empennage skidding outside of the turn." He then lost sight of the airplane behind buildings and trees.

PERSONNEL INFORMATION

The director of operations (DO) for Royal Air Freight provided personnel records, training records, and duty and flight time records for the captain and first officer. The information in this section was extracted from that data and Federal Aviation Administration (FAA) records.

Captain

The captain held an airline transport pilot certificate with an airplane multiengine land rating, and type ratings for Learjets and the Cessna Citation 500 series airplanes. The certificate listed commercial pilot privileges for single engine land airplanes. He was hired by the operator in September of 2003 as second in command (SIC) in Learjet airplanes. In June of 2005, he received transition training to act as pilot-in-command (PIC) in EMB-110 airplanes. On July 2,

2009, he completed Part 135 proficiency and line checks to act as PIC in Learjet airplanes.

The captain held a first class airman medical certificate dated April 21, 2009, with no restrictions. On his most recent medical certificate application, the captain listed 7,100 flight hours with 300 hours accumulated within the previous 6 months. Information provided by the operator indicated that the captain had accumulated about 3,000 hours in Learjet airplanes, including 400 hours as PIC. The captain's pilot logbook was not available for review.

According to FAA and operator records, the captain had accumulated the following flight time prior to the accident: 7,100 total flight hours, 3,000 hours in all Learjet model airplanes, 168 hours in Learjet model 35A airplanes in the preceding 4 months, 241 hours in the last 90 days, and 73 hours in the last 30 days.

The accident flight was the PIC's first flight on January 5th. Operator duty time records indicated that the captain had not been on duty since December 23, 2009.

First Officer

The first officer held a commercial pilot certificate with single and multiengine land airplane ratings, and a SIC rating for Learjets. He was hired by the operator in February 2005 as a SIC in EMB-110 airplanes. In May of 2006, he received transition training to act as SIC in Learjet airplanes. On June 29, 2009, he completed a recurrent competency/proficiency check for Part 135 SIC Learjet operations.

The first officer held a first class airman medical certificate dated April 1, 2009. The medical certificate listed the limitation of available eyeglasses for near vision. On his most recent medical certificate application, he listed 6,700 flight hours with 400 hours accumulated within the previous 6 months. Information provided by the operator indicated that the first officer had accumulated about 3,000 hours in Learjet airplanes as SIC. The first officer's pilot logbook was not available for review.

According to FAA and operator records, the first officer had accumulated the following flight time prior to the accident: 7,000 total flight hours, 3,000 hours in all Learjet model airplanes, 126 hours in Learjet model 35A airplanes in the preceding 4 months, 210 hours in the last 90 days, and 62 hours in the last 30 days.

The accident flight was the first officer's first flight on January 5th. Operator duty time records indicated that he had not been on duty since December 23, 2009.

Flight Crew 72-Hour History

Family members for the flight crew reported that both pilots were off over the year-end holiday season and conducted routine tasks around their respective homes. No abnormal routines or health issues were reported.

AIRPLANE INFORMATION

The airplane was a 1977 Gates Learjet Corp., model 35A, serial number 156. It was certified under type certificate A10CE as a transport category airplane and initially issued a standard airworthiness certificate on December 12, 1977. The accident airplane was equipped with two Honeywell (Garrett) TFE731-2C-2B turbofan engines, serial numbers P74675 (left) and P74266 (right).

The operator purchased the accident airplane on September 25, 2009. The airplane's

registration number was subsequently changed from N35WE to N720RA and added to the operator's FAA Part 135 operating certificate. Phase-A / 300-Hour inspections were completed after the change in ownership. In addition, lower cabin structure/fuselage and aft pressure bulkhead inspections were completed. The thrust reversers were deactivated. The airplane was maintained under the manufacturer's prescribed maintenance schedule and current FAA regulations.

At the conclusion of the flights the day prior to the accident, the airframe and engine times were recorded as: 15,827.2 hours total airframe time, 13,384.8 hours left engine total time (12,074 cycles), and 15,172.5 hours right engine total time (13,883 cycles).

Airplane flight records provided by the operator indicated that the accident airplane was flown 2.6 hours the day prior to the accident (January 4th), which included 3 flight legs. The first originated at 1942 from PTK, and proceeded to Mansfield Lahm Regional Airport (MFD), Mansfield, Ohio. The second leg was from MFD to Columbia Regional Airport (COU), Columbia, Missouri. The final leg was from COU to PTK. It landed at PTK about 0003 on January 5th.

There were no discrepancies noted on the daily record sheets within 30 days of the accident.

Weight and Balance

The operator provided the most recent aircraft weight record which was performed on October 30, 2009. Weight and balance calculations performed using a 6,000 pound fuel load and pilot weights as listed on their most recent airman medical certificates placed the airplane takeoff weight and center of gravity at 16,170 pounds and 385.5 inches respectively. According to the flight envelope contained in the FAA approved Airplane Flight Manual (AFM), provided by the airplane manufacturer, these calculated weights were within the takeoff loading limits for the airplane. Assuming a fuel burn of 1,100 pounds per hour, the calculated landing weight and center of gravity for the 53 minute flight were 15,195 pounds and 384.5 inches respectively. These calculated weights were within the required loading limits specified by the landing flight envelope contained in the AFM.

Flap System

According to the Airplane Maintenance Manual (AMM) for the Learjet 35, the flap system is electrically controlled (flap switch on the center pedestal), hydraulically operated, provides lift to the wing when partially extended, and increases drag to reduce speed when fully extended. Maximum flap extension is 40 degrees (plus 5 degrees/ minus 0 degrees) down, and flaps should travel from maximum up to maximum down in 6 seconds or less. When the flaps are extended below 25 degrees, the spoilers (in the augmentation mode) work independently to assist the ailerons.

Spoiler System

The spoilers, located on the upper surface of the wing forward of the flaps, when hydraulically actuated, will hinge up at a specific angle. The spoilers are used either symmetrically as speed brakes or asymmetrically as augmentation to the ailerons for improved lateral control. The spoilers are controlled manually by a switch on the cockpit center pedestal. Spoilers are also controlled automatically through a computer-amplifier during aileron augmentation mode (spoileron mode). The spoilers augment the aileron system when flaps are extended below 25 degrees. During the augmentation mode the spoilers work independently and are controlled by

an aileron monitoring system.

Adjustable switches, adjacent to the limit switches shut down aileron augmentation in the event of failure. Two other switches, adjacent to the limit switches, actuate the spoiler warning light when the spoilers are not down and locked. Two 13 degree limit switches, one adjacent to each flap sector, cause the spoiler warning light to flash when the flaps are extended below 13 degrees with the Spoiler Switch set to EXT (extend).

Whenever the spoiler switch is set to RET (retract), the spoilers will automatically engage to augment the ailerons when the flaps are extended beyond 25 degrees. The spoiler computer-amplifier monitors aileron movement during aileron augmentation. As the ailerons move, the computer-amplifier actuates the spoiler control valve and the spoiler servo valves. As one aileron moves up, the servo valves are actuated to the applicable position and the spoiler on the same wing as the raised aileron extends while the opposite spoiler remains streamlined. The spoiler will rise at a 1 to 1 ratio with the aileron through 14.5 degrees. A limit switch adjacent to each spoiler actuator limits spoiler extension to 16 degrees (plus 1 degree, minus 0 degrees) during aileron augmentation. A monitor circuit automatically disengages the augmentation system, illuminates the amber AUG AIL light on the, and retracts the spoilers if a system malfunction occurs. Depressing the SPOILERON RESET switch will restore system operation if the malfunction has cleared itself. The augmentation mode disengages automatically when flaps are retracted above 25 degrees or is overridden by the spoiler switch. Normal spoiler extension and retraction is accomplished by setting the spoiler switch, on the center pedestal, to EXT or RET.

In aileron augmentation mode, the monitor senses both spoiler positions, and also the aileron position, from the right aileron follow-up. The monitor energizes the engage solenoid only if the positions of the spoilers correspond to the aileron position (within 6 degrees), and neither spoiler is raised above 15 degrees. Any fault which causes the spoilers to exceed 15 degrees, or not to track the ailerons, results in retraction and illumination of the AUG AIL light. According to Learjet "this will result in a noticeable but manageable reduction in roll authority. In other words, it will take greater control wheel displacement and force to achieve a desired roll rate when compared with an operative spoileron system. The result would be a slightly higher workload, particularly in turbulence or crosswind conditions."

The monitor circuit may be reset in flight by actuating a reset/test switch. If the fault has cleared, normal operation is then possible. The monitor circuit is tested prior to flight by turning the control wheel to provide an input to the monitor circuit from the right aileron, and then actuating the reset/test switch. This will result in the monitor tripping and retraction of the raised spoiler. The monitor circuit is bypassed whenever the squat switch is engaged and spoiler extension has been selected. This is done to ensure that ground spoilers can always be obtained even if spoilers are not tracking correctly.

Emergency/Abnormal Procedures

No emergency procedures were listed in the AFM related to a failure of either the aileron augmentation system (AUG AIL), spoiler, or spoileron features of the airplane. The abnormal procedures section of the AFM did contain a reference to an illumination of the AUG AIL indicator light, indicating a malfunction of that system. The procedure listed steps to perform in order to reset the system and restore normal operation if the system malfunction clears. If the AUG AIL light illuminates again after the reset, the procedure listed steps to disable the

system. Disabling the system would result in the spoilers and spoilerons becoming inoperative in flight. The procedure stated that the spoilers would function normally during ground operations.

The emergency procedures section of the AFM provided guidance regarding stall warning activation. The AFM noted that the stall warning system activates if the stall warning computer senses a limit angle of attack. In response to a limit angle of attack being sensed, the red STALL lights will flash, the control column stick shaker will activate, and the angle-of-attack indicators will be in the yellow segment. Recovery procedures are to lower the pitch attitude to reduce the angle of attack, set the thrust levers to takeoff power, level the wings, and accelerate out of the stall condition. The stall recovery procedure was listed in the AFM as a memory item to be accomplished without reference to the AFM. The anti-icing section of the AFM listed a warning that even small accumulations of ice on the wing leading edge could cause an aerodynamic stall prior to activation of either the stick shaker or pusher. The warning also indicated that these ice accumulations could also cause angle-of-attack information to be unreliable.

Airplane Icing Protection/Detection Systems

The Learjet 35A airplane is certified to operate in known icing conditions and is equipped with anti-ice systems to prevent ice accumulation on various exterior areas of the airplane. The airplane was equipped with a wing and horizontal tail anti-ice system. The system used engine bleed air directed through diffusers in the leading edges to heat the wing and horizontal tail to temperatures where ice would not form. The AFM instructed pilots to monitor the wing and stabilizer temperature indicators when the system was activated and to adjust engine power setting to maintain cabin pressurization and wing and stabilizer temperatures within the "green arc". The AFM indicated that temperatures in the green arc indicated that the surfaces were above 35 degrees Fahrenheit and warm enough so that ice will not adhere to the surface.

In addition to the wing and stabilizer temperature indicators, the AFM listed visual methods for ice detection. The AFM stated that icing could be detected visually on the nose of the tip tanks and the lower corners of the windshield as well as on the wing leading edges. Although the airplane was equipped with wing and stabilizer temperature indicators to inform pilots of surface temperatures conducive to icing, the airplane was not equipped with a system to detect the actual presence of ice on the airframe.

Stall Warning System

The accident airplane was equipped with a dual stall warning and pusher control system, which consisted of two angle-of-attack transducers, a stall warning computer-amplifier, two control column shakers, a normal accelerometer, two angle-of-attack indicators, two ON-OFF control switches, two altitude switches, and two power-on warning lights. Below 22,500 feet, the control column shakers produce a low-frequency, high-amplitude buffet transmitted through the control column when the airspeed falls to within 7 percent of stall speed. As the shakers actuate, the angle-of-attack indicator needles enter the yellow arc and the stall warning lights will illuminate and flash. If the pending stall condition continues until the angle-of-attack indicator reaches its red line, the computer will command a nose down attitude (pusher function) to the pitch servo within one knot of stall speed.

According to the Learjet 35A AFM, the accident airplane's stall speed, with no ice on the wings and assuming an airplane weight of about 15,200 pounds and full flaps selected, wings level attitude, should have been about 96 knots. The stall speed, with no ice on the wings, assuming

an airplane weight of about 15,200 pounds, full flaps, and a level coordinated turn of 30 degrees, should have been about 104 knots.

METEOROLOGICAL INFORMATION

Automatic terminal information service information quebec was current at the time of the accident. According to the CVR transcript, the first officer advised the approach controller that the crew had obtained ATIS quebec, which indicated that winds were from 310 degrees at 9 knots, visibility was 10 miles with few clouds at 2,500 feet, ceiling broken at 5,500 feet, the temperature was minus 6 degrees Celsius, the dew point was minus 11 degrees Celsius, and the altimeter setting was 30.19 inches of mercury.

Numerous pilot reports (PIREPs) about icing conditions in the PWK area were received during the day of the accident, including one from the accident flight crew. These PIREPs included reports of trace, light, light-to-moderate, and moderate rime icing from the surface to 6,000 feet in the PWK area. The accident flight crew reported light to moderate rime icing at 3,000 feet with a temperature of minus 5 degrees Celsius.

At 0845, Airmen's Meteorological Information advisory (AIRMET) ZULU, which included the airplane's flight path, was updated for ice and freezing level and valid until 1500. Moderate icing conditions were expected below 12,000 feet, with conditions continuing beyond 1500 to 2100.

At 1341, the PWK automated surface observing system reported the wind from 330 degrees at 9 knots, visibility 10 statute miles, few clouds at 6,000 feet, temperature minus 6 degrees Celsius, dew point minus 11 degrees Celsius, and an altimeter setting of 30.18 inches of Mercury.

AIRPORT INFORMATION

PWK is located about 18 miles northwest of downtown Chicago, Illinois, at an elevation of 647 feet msl. Runway 16/34, which has a grooved asphalt surface, is 5,000 feet long and 150 feet wide. Runway 34 is equipped with a 4-light, 3-degree precision approach path indicator (PAPI) on the left side of the runway.

FLIGHT RECORDER INFORMATION

The airplane was equipped with a Fairchild Model GA-100 cockpit voice recorder (CVR), which recorded 30 minutes of analog audio on a continuous loop tape in a four channel format: one channel for each flight crew and one channel for the cockpit area microphone. On January 7, 2010, the CVR was recovered from the river bottom and sent to the NTSB Vehicle Recorders laboratory for examination and readout. The CVR had sustained some structural damage, which was limited to the exterior components, and all interior contents were undamaged.

Download of the analog audio at the NTSB's laboratory in Washington, D.C. revealed that the CVR captured audio from 4 channels that varied in quality ranking. The recording captured one channel of fair-quality audio information from the cockpit area microphone, and the other channels were poor to unusable. The recording was analyzed and a complete transcript was prepared for the 27 minute 45 second long recording. Time references in the CVR transcript were established utilizing times correlated from the ATC transcript.

The airplane was not equipped with a flight data recorder.

The non-volatile memory (NVM) from the engines' digital electronic engine controls was successfully downloaded, and no faults were recorded.

WRECKAGE AND IMPACT INFORMATION

The accident site was located approximately 1.35 nautical miles south-southeast of the PWK runway 34 threshold. The airplane came to rest in the water along the west bank of the Des Plaines River, within the Lake Avenue Woods forest preserve. The terrain surrounding both the east and west banks of the river was wooded. The river was approximately 100 feet wide in the vicinity of the accident site. There were no obvious tree breaks associated with the airplane's descent and impact. The airplane came to rest oriented on a westerly heading.

The airplane was destroyed during the accident. All of the examined fracture surfaces exhibited signs that were consistent with overload failure; no evidence of any pre-impact failures. Flight control continuity could not be determined because of severe fragmentation and impact damage.

The nose and cockpit had separated from the fuselage. It was inverted and located near the tail (empennage) of the airplane. The cabin area was compromised. It was upright and located about 10 feet from the river bank. The empennage came to rest canted to the left with the outboard portion of the right horizontal stabilizer visible above the water line. The empennage was approximately 20 feet from the river bank adjacent to the nose/cockpit section. The left wing was in position adjacent to the fuselage and visible above the water line. The right wing was in position adjacent to the fuselage and submerged below the water line.

The instrument panel was dislocated from its installed position. Both control wheels remained attached to a section of its respective control column. The forward side of both control wheels exhibited marks consistent with being formed by the upper control column fittings at the time of impact. The orientation of the marks corresponded to an approximate 19-degree left control wheel deflection.

The left flap was separated. The inboard section of the left flap (about a 12-inch section) and two skin fragments were recovered. The actuator arm was intact. The flap attach bracket had separated from the flap and remained attached to the actuator arm. The arm remained attached to the sector assembly (bellcrank) and the sector assembly was secured to the hydraulic actuator. The actuator appeared intact. The outboard actuator attachment fitting was dislocated about 0.100 inches from the wing bracket; otherwise, the flap mechanism appeared intact. A segment of the flap cross cable remained attached to the sector. The cable was continuous to the inboard end of the wing section. The cable end was frayed. The flap actuator was extended to 8.375 inches. The right flap actuator was recovered, and the hydraulic lines remained secured to the actuator. The right flap sector assembly was fractured. The actuator extension was measured at 3.6 inches. The right flap push-pull tube was separated from the sector assembly.

The left spoiler was separated from the wing. The spoiler attachment bracket had separated from the spoiler assembly and remained secured to the linkage. The actuator piston separated near the rod end. The rod end remained attached to the linkage pivot. The hydraulic lines remained secured to the actuator. Actuator extension was 1.05 inches from the cylinder housing to the failed end of the rod end. Approximate extension from the housing to the rod end bolt was 1.70 inches to 1.75 inches - with intact rod end. This dimension was consistent with the spoiler being down. The upper and lower spoiler skins were separated along the

inboard length of the assembly. The skin sections remained attached to each other and to the closure rib at the outboard end. The outboard hinge point remained attached to the spoiler. The right spoiler remained attached to the wing at all three hinge points. However, an approximate 5-foot section of the inboard aft wing spar separated from the remaining outboard spar. The spar was bent about 1-foot from the inboard end, and was buckled about 3 feet from the inboard end near the location of the spoiler center hinge. The spoiler actuator remained attached to the wing former/fuel tank closure rib and the piston remained attached to the spoiler. The spoiler actuator extension was 3.25" from the cylinder to the rod end center (2.60" to the jam nut) at the time of the examination, which was consistent with a 45-degree spoiler deflection.

All three landing gear strut/wheel assemblies separated from the airframe. The nose landing gear actuator was found in the extended position. The right main landing gear actuator housing was fractured exposing the piston. The down and lock ball groove was positioned consistent with the gear being in the down and locked position. The left main landing gear forward trunnion pin remained attached to the wing at the wheel well, and the trunnion appeared intact. The gear actuator remained attached, but no conclusive evidence of the gear's position was found.

Both engine fan compressor blades were found with blades bent in the direction opposite rotation, fractured blades, and leading edge damage. Both engine thrust reverser assemblies were separated and lockout pins were installed.

MEDICAL AND PATHOLOGICAL INFORMATION

Autopsies were performed on the captain and first officer by the County of Cook's Office of the Medical Examiner, Chicago, Illinois. The autopsy reports stated the cause of death for both the captain and first officer was "multiple injuries sustained as a [pilot/co-pilot] involved in an airplane crash." The reports indicated no evidence of pre-accident physical incapacitation or impairment of either flight crewmember.

The FAA's Civil Aeromedical Institute (CAMI) performed toxicology testing on samples from the captain and first officer. The toxicology reports for the captain and the first officer indicated that the samples tested negative for carbon monoxide, cyanide, ethanol, and a wide range of drugs, including major drugs of abuse (marijuana, cocaine, amphetamines, and opiates).

TEST AND RESEARCH

Airplane Performance Study

An aircraft performance study was performed by the National Transportation Safety Board (NTSB) using short-range Airport Surveillance Radar (ASR-9) data from antennas located at Chicago O'Hare International Airport, Chicago, Illinois, manufacturer-provided aerodynamic data, and meteorological information to establish a time history of the airplane's motions, and to estimate the airplane's performance parameters (including ground speed, airspeed, descent rate, and aircraft pitch and roll angles) for the final portion of the flight. Nominal error or uncertainty in the radar and wind data led to variables in the airplane's performance parameters; therefore, the performance parameters should be considered approximations. In addition, the flight crew reported moderate ice on the airplane, and airframe ice data was not included in the performance study.

The NTSB estimated the airplane to be in a 20 degree right base turn when the captain's call for full flaps was requested to the first officer. At this time, airspeed was estimated to be 130 knots, which was the slowest airspeed estimated for the entire approach. Beyond this point, the bank angle appeared to decrease slightly to about 15 degrees right wing down before slowly growing in excess of 70 degrees over the next 30 seconds. The bank angle was estimated to be 75 degrees at the end of the CVR recording. The airplane appeared to be operating at angle-of-attacks below the stall warning system thresholds.

An aircraft performance study was also performed by Learjet using ASR-9 data, manufacturer aerodynamic data, and meteorological information. Learjet estimated the airplane to be in a right base turn of no more than 12 degrees and an airspeed of 148 (Vref plus 20) knots. Learjet's maximum bank angle was calculated to greater than 50 degrees.

Light Bulb Examination

On January 26th to 28th, the cockpit annunciator panel lights were examined at the NTSB Materials Laboratory for evidence of tungsten ductility that is typically associated with heat during impact. Two fire handles were found in the stowed position and none of the bulbs in the ARMED annunciators contained a stretched filament. No stretching was found in the filaments of the bulbs for the autopilot control panel. Gross stretching was noted in the following bulbs: AUG AIL (right bulb), left stall (left and right bulbs), right stall (left and right bulbs), and windshield heat (left and right bulbs). Slight stretching was noted in the following bulbs: AUG AIL (left bulb), and spoiler (right bulb).

Flight Control Component Examination

On February 3 to 4, 2010, the flap actuators, flap position indicator, and spoiler actuators were examined at the NTSB Materials Laboratory.

Right Flap Actuator

The actuator was manufactured by Ronson Hydrolic Unit Corp, part number 48C48609-1, serial number 594. The actuator rod end was still attached to the flap sector. Both the rod end and actuator housing near the attach point were observed to be bent. The distance from the end of the housing to the approximate center of the rod end was measured to be 3.5 inches. The actuator housing was disassembled per AMM 27-50-04/801. Some hydraulic fluid was saved. The housing was cut in half length wise. There were marks on the interior of the housing. The deepest mark was approximately 2.8 inches from the end of the threaded end of the housing. Examination findings corresponded with an estimated flap surface position consistent with 30 degrees. Rigging variations could account for up to plus 3 to minus 0 degrees on the estimate.

Left Flap Actuator

The actuator was manufactured by Ronson Hydrolic Unit Corp, part number 48C48609-1, serial number 591. The distance from the end of the housing to the approximate center of the rod end was measured to be 7.5 inches. The actuator housing was disassembled per AMM 27-50-04/801. Some hydraulic fluid was saved. The housing was cut in half length wise. There were slight marks on the interior of the housing. There were three prominent marks which were between 2.3 and 1.6 inches from the end of the threaded end of the housing. Examination findings corresponded with an estimated flap surface position consistent with 27 degrees. Rigging variations could account for up to plus 3 to minus 0 degrees on the estimate.

Flap Position Indicator

The flap position indicator receives position information from a transmitter installed on the left flap sector. The indicator face was damaged, the glass cover was not present, and there were sediments on it. The indicator needle was present, but bent away from the face. The cover was removed and the internal components were visually examined. The mount for the armature was found loose. A gouge was observed in the face near the down limit mark.

Right Spoiler Actuator

The actuator was manufactured by Gates Learjet, part number 2417015-2, serial number 195. The approximate distance from the center of the attach fitting to the center of the rod end was measured to be 9.7 inches. The head end of the piston assembly was removed from the housing per AMM 27-60-01. Some of the hydraulic fluid was saved. The fluid appeared to be darker than the fluid in the other actuators. The piston was jammed in the actuator housing. The distance from the threaded end of the housing to the end of the piston was 2.6 inches. The actuator housing was cut in an attempt to free the piston, but the piston was still jammed. The piston was removed by applying a force with a hammer on the piston head in the direction of extension. A thumbnail size gouge and small round gouge were noted on the interior of the housing. It was noted that these marks were coincident with two dents in the exterior of the actuator housing. The housing was cut in half length wise and the interior housing was examined. Examination findings corresponded with a spoiler position of down and locked.

Left Spoiler Actuator

The actuator was manufactured by Gates Learjet, part number 2417015-2, serial number 204. The rod end was fractured at the lock nut. The approximate distance from the center of the attach fitting to the center of the rod end was measured to be 8.3 inches. The piston assembly was removed from the housing per AMM 27-60-01. Some of the hydraulic fluid was saved. The piston rod was locked to the head end. No further disassembly was performed. Examination findings corresponded with a spoiler position of down and locked.

N1 Digital Electronic Engine Controls (DEECs)

On January 13, 21, and February 1, 2010, the DEECs were examined at the facilities of Honeywell Aerospace. The DEECs were installed on the two TFE731-2C-2B engines. The DEECs include an incident recorder which collects engine and aircraft operational data and records it into Non-Volatile Memory (NVM) for post accident/incident download and analysis. The recorder collects data into 10 memory buffers for the last 85 minutes, 20 seconds of engine ground and/or flight time. The data set stored in the first memory buffer is recorded once per second for the last 512 seconds (8 minutes, 32 seconds) prior to power down.

According to Honeywell Aerospace, the download of the incident recorder data from both DEECs was completed successfully. Analysis of the data indicated that both engines were rotating, operating, and responding to power lever (PLA) input. Both the left and right engines were operating at a N1 (Low Pressure Spool) RPM of between 90 to 95 percent and N2 (High Pressure Spool) RPM of between 90 to 101-5 percent up until approximately 4 seconds prior to impact when the data indicated that the power levers were moved to settings greater than takeoff. No faults were logged for the previous 12 flights logged on each DEEC.

The engines were operating and responding to PLA movements. The PLAs appear to be constant from 60 seconds until approximately 25 seconds before the end of the data stream (impact) at which time PLAs are increased. Approximately 16 seconds before impact, the PLAs are reduced with corresponding reduction in N1, N2, and interstage turbine temperature (ITT).

Approximately 6 seconds before impact, the PLAs are reduced to the idle setting before being increased to a PLA setting corresponding to greater than takeoff value.

ORGANIZATIONAL AND MANAGEMENT INFORMATION

Royal Air Freight Company Information

At the time of the accident, Royal Air Freight Inc. provided on-demand air freight services in accordance with 14 Code of Federal Regulations Part 135 as authorized by the FAA. The privately owned company also conducted limited on-demand passenger services using various airplanes. The company headquarters and base of operations was located at PTK. The operator did have a flight scheduling office that was responsible for bidding on prospective on-demand flights and for scheduling airplanes and flight crews. If a flight was awarded, the flight crew was responsible for other aspects of the flight such as weather evaluation and weight and balance calculations. The flight scheduling office also conducted flight tracking activities using aircraft positions reported by flight crews.

At the time of the accident, the company operated a fleet of 32 airplanes including the accident airplane. The quantities and airplane makes/models authorized on the operator's certificate were:

6 - Cessna model 310 R

3 - Cessna model 402B

5 - Embraer model EMB 110

3 - Lear Jet model 24

8 - Lear Jet model 25

4 - Lear model 35 - (Including N720RA)

4 - Dassault Falcon model FA20

1 - Raytheon model King Air 100

FAA Oversight

The operator's FAA operating certificate was managed by the Detroit Flight Standards District Office (FSDO) located at the Willow Run Airport, Ypsilanti, Michigan. The FAA assigned a Principal Operations Inspector (POI), Principal Maintenance Inspector (PMI), and Principal Avionics Inspector (PAI) to oversee the carrier. The POI assigned at the time of the accident had been the operator's POI for approximately 3 months. He was assigned to provide oversight for 10 operators: 2 Part 125 operators, 2 Part 125M operators, 3 Part 135 operators, and 3 Part 91 operators.

ADDITIONAL INFORMATION

Learjet Airplane Flight Manual

Approach Checklist

1. Circuit Breakers - Check in.
2. HYDRAULIC PRESSURE and EMERGENCY AIR Pressure - Check.

3. Landing Approach Speed (Vref), Approach Climb Speed (approximately Vref + 7), and N1 for Go-Around - Computed and bugs set. Refer to Section V.

Note: It is recommended that if turbulence is anticipated due to gusty winds, wake turbulence, or wind shear, the approach speed be increased. For gusty wind conditions, an increase in approach speed of one half the gust factor is recommended.

4. Fuel Balance - Check.

5. Avionics:

a. Avionics Equipment - Set for approach.

b. Radio Altimeter - Set to approach minimums.

c. Crew Approach Briefing - Complete.

Before Landing Checklist

1. SPOILER - Check RET.

2. Flaps - As desired (8 degrees/20 degrees)

3. LANDING GEAR switch - DN at Vlo or less. Check for green LOCKED DN indication.

Note: If taxi and/or takeoff were on ice, snow, or slush; ANTI-SKID switch - OFF, pump brakes 6 to 10 times, then ANTI-SKID switch - ON. Brake application will tend to crack any ice between brake discs and between the discs and wheels.

The ENG SYNC light will illuminate whenever the nose gear is down and the ENG SYNC switch is in the SYNC position.

4. LNG LT-TAXI Switches - As required.

Note: The left landing light will not illuminate unless the left main gear is down and locked. The right landing light will not illuminate unless the right main gear is down and locked.

5. ANTI-SKID Switch - On. ANTI-SKID GEN Lights - Out.

6. ENG SYNC Switch - OFF.

7. Flaps - DN.

8. HYDRAULIC PRESSURE Gage - Check, normal.

9. AIR IGN Switches - On.

10. Autopilot - Disengage.

Note: Use control wheel trim switch to disengage autopilot. Control wheel master switch (MSW) will also disengage yaw damper.

11. Yaw Damper - Off during landing flare:

a. Depressing either control wheel master switch will disengage primary or secondary yaw damper.

b. Depressing the PRI or SEC OFF button on the Y/D controller will disengage the PRI or SEC yaw damper.

One or Both Spoilers Up Landing

1. Final Approach Configuration - Gear - DN, Flaps - UP.
2. Final Approach Speed - Vref + 40.
3. Landing Distance - Multiply by 1.50.

Note: Aerodynamic braking at higher speeds will cause the aircraft to become airborne even with the spoilers extended. Use of drag chute or thrust reversers (if installed) is recommended.

Inadvertent Icing Encounter

According to the AFM, if the approach and landing must be made with any amount of ice on the airframe:

a. Do not extend flaps beyond 20 degrees.

b. Use landing procedure for a wing and stabilizer heat failure.

Warning: Even small accumulations of ice on the wing leading edge can cause aerodynamic stall prior to activation of the stick shaker and/or pusher. These ice accumulations can cause angle-of-attack indicator information to be unreliable.

Note: Ice accumulation on the stabilizer may cause deterioration in trim speeds and changes in handling characteristics. Low speed flight should be approached with care so that detection of abnormal flying qualities can be obtained. It may be necessary to land with flaps at 20 degrees as some buffet and/or some nose pitch may be encountered with the flaps full down.

Flight Training

The operator reported that all pilot training was done in-house using the airplanes approved and listed on Royal Air's operations specifications. The Learjet training flights were conducted by the Chief Pilot, and/or the Director of Operations. Learjet flight checks were performed by the Director of Operations who was also the operator's designated check airman.

The FAA approved Royal Air Freight Aircraft Flight Training Manual specified the pilot training be conducted by the operator's pilots. The manual also listed specific training guidelines for various aircraft including the Learjet airplanes. In regard to stall training, the manual listed the procedures to be used for approaches to stalls in the Learjet airplanes. The airplane configurations listed for the approach to stall training included clean (flaps - 0 degrees), approach (gear - down, flaps - approach), and landing (gear - down, flaps - down). Bank angles were not specified, but guidance was given that approaches to stalls were to be practiced with the wings level and from turns. In all cases, the procedures indicated that recovery should be initiated at "first indication". The operator also used the Gates Learjet Flight Training Manual. The stall training series listed in the Gates Learjet manual includes various airplane configurations and flight attitudes. The manual indicated that recoveries from approaches to stalls are normally accomplished at stick shaker/nudger activation. Delayed recoveries beyond stick shaker/nudger activation until stick pusher activation were recommended so that the pilot could develop a feel for the airplane in its extreme slow speed range.

The Royal Air Freight Aircraft Flight Training Manual listed only ground training and an oral examination of pilots with regard to ice and rain protection systems on the airplane. The completion standards stated that the individual would complete an oral examination given by

the instructor to determine adequate knowledge of the aircraft anti-ice/deicing systems. No flight training requirements were found with regard to icing protection systems.

Royal Air Freight Aircraft Flight Training Manual listed training objectives for circling instrument approaches. The procedures listed included performance of circling approaches with both engines operating and with one engine inoperative. The procedures listed in the manual stated that the aircraft must remain in the protected circling area and the airplane must not descend below the published minimum descent altitude until the final descent for landing. The acceptable completion standards were: Airspeed + 5 knots, -0 knots; Altitude + 50 feet, -0 feet at minimums; Bank Angle 30 degrees maximum.

History of Flight

Approach-VFR pattern final	Loss of control in flight (Defining event)
Uncontrolled descent	Collision with terr/obj (non-CFIT)

Pilot Information

Certificate:	Airline Transport	**Age:**	38, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 1 Without Waivers/Limitations	**Last Medical Exam:**	04/21/2009
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	07/02/2009
Flight Time:	7000 hours (Total, all aircraft), 3500 hours (Total, this make and model), 236 hours (Last 90 days, all aircraft), 68 hours (Last 30 days, all aircraft)		

Co-Pilot Information

Certificate:	Commercial	**Age:**	40, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	None	**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	Airplane Multi-engine; Airplane Single-engine; Instrument Airplane	**Toxicology Performed:**	Yes
Medical Certification:	Class 1 With Waivers/Limitations	**Last Medical Exam:**	04/01/2009
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	06/29/2009
Flight Time:	6500 hours (Total, all aircraft), 2400 hours (Total, this make and model), 210 hours (Last 90 days, all aircraft), 62 hours (Last 30 days, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Manufacturer:	GATES LEARJET CORP.	**Registration:**	N720RA
Model/Series:	35A	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	No
Airworthiness Certificate:	Normal	**Serial Number:**	156
Landing Gear Type:	Retractable - Tricycle	**Seats:**	10
Date/Type of Last Inspection:	10/30/2009, Continuous Airworthiness	**Certified Max Gross Wt.:**	18300 lbs
Time Since Last Inspection:		**Engines:**	2 Turbo Fan
Airframe Total Time:	15734 Hours	**Engine Manufacturer:**	GARRETT
ELT:	Installed, activated, did not aid in locating accident	**Engine Model/Series:**	TFE 731 SER
Registered Owner:	ROYAL AIR FREIGHT INC	**Rated Power:**	3500 hp
Operator:	ROYAL AIR FREIGHT INC	**Air Carrier Operating Certificate:**	On-demand Air Taxi (135)

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual Conditions	**Condition of Light:**	Day
Observation Facility, Elevation:	PWK, 660 ft msl	**Observation Time:**	1341 CST
Distance from Accident Site:	2 Nautical Miles	**Direction from Accident Site:**	340°
Lowest Cloud Condition:	Few / 6000 ft agl	**Temperature/Dew Point:**	-6°C / -11°C
Lowest Ceiling:	None	**Visibility**	10 Miles
Wind Speed/Gusts, Direction:	9 knots, 330°	**Visibility (RVR):**	
Altimeter Setting:	30.18 inches Hg	**Visibility (RVV):**	
Precipitation and Obscuration:			
Departure Point:	Pontiac, MI (PTK)	**Type of Flight Plan Filed:**	IFR
Destination:	Prospect Heights, IL	**Type of Clearance:**	IFR
Departure Time:	1335 EST	**Type of Airspace:**	

Wreckage and Impact Information

Crew Injuries:	2 Fatal	**Aircraft Damage:**	Substantial
Passenger Injuries:	N/A	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	2 Fatal	**Latitude, Longitude:**	42.088889, -87.891667 (est)

Administrative Information

Investigator In Charge (IIC):	Aaron M Sauer	**Adopted Date:**	07/18/2011
Additional Participating Persons:	TR Proven; Federal Aviation Administration; Washington, DC Mark Siebert; Learjet; Wichita, KS Dana Metz; Honeywell; Phoenix, AZ Kirt Kostich; Royal Air Freight, Inc.; Waterford, MI		
Publish Date:	07/18/2011		
Investigation Docket:	http://dms.ntsb.gov/pubdms/search/dockList.cfm?mKey=75227		