National Transportation Safety Board
Aviation Accident Final Report

Location:	Baltimore, MD	**Accident Number:**	IAD01FA089
Date & Time:	08/01/2001, 1300 EDT	**Registration:**	N89FB
Aircraft:	Bell 206B	**Aircraft Damage:**	Destroyed
Defining Event:		**Injuries:**	2 Fatal
Flight Conducted Under:	Part 91: General Aviation - Aerial Observation		

Analysis

The purpose of the helicopter flight was to take aerial photographs of a large airport expansion construction project. The helicopter approached the construction site in an out-of-ground-effect hover taxi, with a quartering left tailwind. The helicopter turned to the right, and slowed to a stationary hover about 250 feet above the ground with a direct tailwind. Once in a hover, the helicopter made a right, rapid 180-degree pedal turn around the mast, stopped momentarily, then initiated another rapid pedal turn to the right. The helicopter turned at a faster rate than the initial turn, and continued into a spinning, vertical descent to the ground. Examination of the helicopter revealed no mechanical anomalies. The collective was in the full up position, and the main rotor blades exhibited signatures consistent with low rotor rpm at ground contact. A review of the pilot's company flight records revealed he had 531 hours of total flight experience, 60 hours of which were in airplanes. The pilot had 87 hours of experience in make and model. A relative wind chart published by the manufacturer depicts a helicopter facing 360 degrees over a compass rose. One shaded area of the chart depicts winds from between 120 degrees and 240 degrees, at wind speeds above 5 knots and up to 17 knots. According to a note on the chart an unanticipated right yaw may occur when operating in the shaded areas of the chart. According to FAA Advisory Circular (AC) 90-95, "Any maneuver which requires the pilot to operate in a high power, low airspeed environment with a left crosswind or tailwind creates an environment where unanticipated right yaw may occur." The AC also advised of greater susceptibility for loss of tailrotor effectiveness in right turns and the phenomena may occur in varying degrees in all single main rotor helicopters at airspeeds less than 30 knots.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The pilot's improper decision to maneuver in an environment conducive to a loss of tail rotor effectiveness, and his inadequate recovery from the resultant unanticipated right yaw.

Findings

Occurrence #1: LOSS OF CONTROL - IN FLIGHT
Phase of Operation: HOVER - OUT OF GROUND EFFECT

Findings
1. (F) WEATHER CONDITION - TAILWIND
2. (C) IN-FLIGHT PLANNING/DECISION - IMPROPER - PILOT IN COMMAND
3. (C) LOSS OF TAIL ROTOR EFFECTIVENESS - ENCOUNTERED - PILOT IN COMMAND

Occurrence #2: IN FLIGHT COLLISION WITH TERRAIN/WATER
Phase of Operation: DESCENT - UNCONTROLLED

Findings
4. (C) REMEDIAL ACTION - INADEQUATE - PILOT IN COMMAND

Factual Information

HISTORY OF FLIGHT

On August 1, 2001, at 1300 eastern daylight time, a Bell 206B helicopter, N89FB, operated by Helicopter Transport Services, was destroyed during collision with terrain at the Baltimore-Washington International Airport (BWI), Baltimore, Maryland. The helicopter came to rest on the Alpha taxiway abeam runway 15 Right. The certificated commercial pilot and photographer/passenger were fatally injured. Visual meteorological conditions prevailed for the aerial photography flight that originated at the Martin State Airport (MTN), Baltimore, Maryland, at 1232. No flight plan was filed for the flight conducted under 14 CFR Part 91.

According to the operator, the purpose of the flight was to take aerial photographs of a large airport expansion construction project at BWI.

During an interview, one witness said he was facing in a northwesterly direction as he observed the helicopter flying overhead. He said the helicopter did a succession of 180-degree turns that increased in rate of rotation.

According to the witness, the helicopter approached from the east at hover-taxi speed. He said the helicopter hovered over his head and turned to the north, which oriented the tail of the helicopter into the wind. The witness said the helicopter came to a stationary hover, about 400 feet above the ground, with a direct tailwind.

Once at a hover, the helicopter did a rapid 180-degree pedal turn around the mast, stopped momentarily, then initiated another rapid pedal turn to the right. According to the witness, the helicopter turned at a faster rate than the initial turn, and continued into a descending turn "spinning clockwise, to the right."

With a model of a helicopter in his hand, the witness demonstrated the nose of the helicopter initiating a turn to the right and then continuing a slow spiraling descent to the right. When questioned about the helicopter's engine noise, the witness said:

"I didn't hear anything that was abnormal or out of the ordinary. It sounded like he wasn't having any trouble. There was nothing out of the ordinary. I didn't see any smoke, or parts, or debris."

A second witness said he was standing inside the construction site, and viewed the helicopter as he faced the northwest. According to the witness, the helicopter flew slowly around the construction site. He said his attention was drawn to the helicopter because he felt it was unusual for the helicopter to be at a hover less than 500 feet above the ground.

With a model of a helicopter in his hand, the witness described what he saw and maneuvered the model at the same time. He showed the nose of the helicopter pointed to the north, and said the helicopter was at a stationary hover. The witness demonstrated a jerking of the nose to the right, turns around the mast, and then a spiraling descent.

The witness said the helicopter was running "fine", and said the pilot made rapid hand and arm movements inside the cockpit during the descent.

A third witness was interviewed at the Martin State Airport on the day after the accident. The witness said he was flying a Bell 206B helicopter in the vicinity of BWI Airport at the time of the accident, and then over the airport immediately following to film for a local news station.

The witness went on to describe his flight over the airport, and the winds he encountered aloft. He said the winds were out of the south-southeast and that they were very unstable. The witness said his helicopter would experience an updraft, a good strong downdraft, no wind, and then a strong wind. While in a stationary out-of-ground-effect hover at 1,000 feet, the airspeed indicator showed 20 knots. He said the airspeed indicator would drop to zero and the helicopter would descend and shake violently. According to the witness:

"One minute the winds were from 150 to 180 degrees and then from 240 degrees. If you were in a position where you were flying downwind, it was an ideal situation for LTE (loss of tail rotor effectiveness)."

The accident occurred during the hours of daylight approximately 39 degrees, 10 minutes north latitude, and 076 degrees, 40 minutes west longitude.

PILOT INFORMATION

The pilot held a commercial pilot certificate with a rating for rotorcraft/helicopter. He also held a private pilot certificate with a rating for airplane single engine land. The pilot did not posses an instrument rating.

The pilot's logbook was not recovered. A review of the pilot's company flight records revealed he had 531 hours of total flight experience, 60 hours of which were in airplanes. The pilot had 87.2 hours of experience in the Bell 206B, and 72 hours in the Bell 206L.

The pilot's most recent biennial flight review was completed in conjunction with a Part 135 evaluation on July 11, 2001. The purpose of the evaluation was so that he could perform Part 135 operations for his employer.

Further review of the pilot's flight records revealed that he completed the "Bell Helicopter OH-58 Ground and Flight Procedures Training Course" on August 16, 1996. The course included 3.9 hours of flight time. The pilot received a total of 3.7 hours of instruction in the Bell 206 from the operator's chief pilot. The most recent training flight was completed June 28, 2001, and was 2 hours in duration.

The pilot's most recent Federal Aviation Administration (FAA) second-class medical certificate was issued on June 19, 2001.

AIRCRAFT INFORMATION

Examination of the maintenance records revealed the helicopter was on an annual inspection program. The most recent inspection was a 100-hour inspection that was completed October 23, 2000, at 10,883 aircraft hours. The helicopter had accrued 66.4 hours since that date.

METEOROLOGICAL INFORMATION

At 1254, the weather reported at the Baltimore-Washington International Airport included few clouds at 5,000 feet with variable winds at 6 knots. At 1249:54, air traffic control (ATC) advised landing traffic that the winds were from 130 degrees at 6 knots. At 1253, ATC advised landing traffic that the winds were from 140 degrees at 8 knots.

WRECKAGE INFORMATION

The helicopter was examined at the site on August 1, 2001, and all major components were accounted for at the scene. The helicopter came to rest upright on taxiway Alpha, north of runway 15 Right. The helicopter came to rest at the initial point of ground contact oriented 150

degrees magnetic.

The skid tubes were fractured into three pieces each, and scattered beyond the nose of the helicopter. The cross tubes collapsed forward, and were pinned beneath the wreckage. The fuselage was crushed upwards in compression.

Examination of the cockpit area revealed the pilot's cyclic control stick was broken off about 6 inches below the cyclic grip. The collective stick was intact, but separated from the collective jackshaft. The pilot's tail rotor pedals were intact, but the interconnect push/pull tube was fractured 2 inches from the mixing unit bearing clevis.

Rescue personnel cut the pilot's windshield post. The pilot's side doorpost was fractured in compression.

The flight control "broom closet", situated vertically between the pilot and copilot seats, was crushed upwards, and the cyclic and collective mixing units were exposed.

The floor of the helicopter was crushed upwards and displaced slightly to the left. The empennage was crushed upwards and wrinkled back to the tailboom. The engine deck was wrinkled and deformed. The isolation mount plate, directly beneath the main drive shaft transmission input coupling, displayed a concave dent the approximate size of the coupling. There was rotational smearing across the entire radius of the dent.

Examination of the fuel control quadrant revealed the quadrant pointer was at the 90-degree full-open position.

The aluminum particle separator baffling above the main drive shaft transmission input coupling was punctured and the aluminum was torn and displayed rotational smearing. The puncture was approximately the same width as the input coupling and directly forward of the engine air inlet.

The main drive shaft was still attached at both the engine and transmission. The shaft was displaced upward in the transmission input coupling, and coupling grease was ejected around the transmission pylon area.

The #1 tail rotor drive shaft was fractured 18 inches aft of the tail rotor drive shaft output quill of the engine accessory case. The fracture was directly below a puncture in the engine combustor. The fracture surfaces appeared torn, and the torn metal was wrapped circumferentially. At a point aft of the break, the tail rotor drive shaft was rotated by hand. The tail rotor rotated freely, with no binding noted in the hanger bearings or the 90-degree gearbox.

The tailboom was intact from the empennage back to the vertical fin attach points. Both horizontal stabilizers were intact. The lower half of the vertical stabilizer was crushed upwards about 18 inches.

The tailrotor blades were marked "target" and "blank", respectively. Both blades displayed impact damage and chordwise scratching at the tips. Both blades were wrinkled at mid span. The blank blade was bent over about 90 degrees at a point approximately 6 inches from the hub and rested on the ground.

Both main rotor blades displayed chordwise scratching and upward bending on the trailing edge. Both blades displayed chordwise scoring through the blade skin, at a point approximately 4.5 feet from the blade grip. Rotation of the main rotor blades revealed the

score marks were aligned approximately over top of the upper Wire Strike Protection System (WSPS) cutter. The cutter was bent and displaced to the left.

Rotation of the main rotor blades also established continuity through the transmission to the main drive shaft input coupling with no binding.

Collective, cyclic, and tail rotor control continuity could not be established at the scene.

The helicopter was removed from the scene on the evening of the accident, and examination of the helicopter was completed at the Martin State Airport on August 2 and 3, 2001.

Tail rotor pitch control continuity was established from the tail rotor to the top of the broom closet where the upper clevis of the push/pull tube was fractured. Continuity was established from the break forward to the copilot's tail rotor pedals and the break in the interconnect push/pull tube.

Cyclic control continuity was established from the pilot's cyclic to the top of the broom closet, where the vertical push/pull tube was fractured. The lower 6 inches of the red pitch change link was separated from both the link and the swashplate attach point. The breaks at both ends displayed 45-degree fracture surfaces.

Collective control continuity was established from the collective jackshaft to the top of the broom closet. Crushing of the fuselage pinned the jackshaft in the 'full up' position. Examination of the collective sleeve on the main rotor mast revealed that it was in the 'full up' position. An undamaged collective stick was attached to the jackshaft on the pilot's side. Throttle control continuity was observed through the full range back to the engine.

Examination of the engine air inlet revealed damaged compressor blades and a shredded piece of aluminum wedged in the second stage wheel. Main drive shaft coupling grease was found back to the fifth stage of the compressor.

Disassembly of the compressor revealed rotational scoring across 180 degrees of the centrifugal impeller shroud. The vanes on the centrifugal impeller were bent opposite the direction of rotation.

Examination of the aluminum fragment removed from the inlet revealed that it was similar in gauge and color to the aluminum baffling around the particle separator. After the fragment was removed, the compressor was rotated by hand, and continuity was established through the engine and the accessory section.

Examination of the combustion section revealed melted aluminized deposits scattered throughout.

Disassembly of the main drive shaft revealed the inside of the main input drive shaft couplings displayed radial impact damage.

MEDICAL AND PATHOLOGICAL INFORMATION

The Office of the Chief Medical Examiner, Baltimore, Maryland, performed an autopsy on August 2, 2001.

Toxicological testing was completed at the FAA Toxicology Accident Research Laboratory, Oklahoma City, Oklahoma, on September 11, 2001.

TESTS AND RESEARCH

The #1 tail rotor drive shaft was removed and examined at the Safety Board Materials Laboratory in Washington, DC. Examination of both halves of the drive shaft revealed that the drive shaft failed in overload.

ADDITIONAL INFORMATION

A review of radar data revealed the helicopter hovered around the construction site about 250 feet above ground level. Further examination revealed that traffic neither landed nor departed BWI in the vicinity of the accident helicopter prior to or at the time of the accident.

On October 31, 1983, Bell Helicopter published an Operations Safety Notice regarding loss of tail rotor effectiveness in the Model 206B and similar airframes. Bell Helicopter describes the phenomenon of loss of tail rotor effectiveness as "Unanticipated Right Yaw". According to the Safety Notice:

"When maneuvering between hover and 30 mph:

Be aware that a tail wind will reduce relative wind speed if a down wind translation occurs. If loss of translational lift occurs it can result in a high power demand and an additional anti-torque requirement.

Be alert during hover (especially OGE) and high power demand situations.

Be alert during hover in winds of about 8-12 knots (especially OGE) since there are no strong indications to the pilot, to the possibility of a reduction of translational lift. This reduction results in an unexpected high power demand and increased anti-torque requirements.

Be aware that if a considerable amount of left pedal is being maintained, that a sufficient amount of left pedal may not be available to counteract an unanticipated right yaw.

Be alert to changing aircraft flight and wind conditions such as experienced when flying along ridgelines and around buildings.

Observe the relative wind conditions set out in the attached chart."

The chart depicts a helicopter facing 360 degrees over a compass rose. One shaded area of the chart depicts winds from between 120 degrees and 240 degrees, at wind speeds above 5 knots and up to 17 knots. According to a note on the chart:

"An unanticipated right yaw may occur when operating in the shaded areas of the chart."

According to FAA Advisory Circular (AC) 90-95, "Any maneuver which requires the pilot to operate in a high power, low airspeed environment with a left crosswind or tailwind creates an environment where unanticipated right yaw may occur."

The AC also advised of greater susceptibility for loss of tailrotor effectiveness (LTE) in right turns and the phenomena may occur in varying degrees in all single main rotor helicopters at airspeeds less than 30 knots.

According to the manufacturer, if a sudden unanticipated right yaw occurs, the following recovery technique should be performed.

1. Pedal - Full left; simultaneously, cyclic - forward to increase speed.
2. As recovery is effected, adjust controls for normal forward flight.

CAUTION

Collective pitch reduction will aid in arresting the yaw rate, but may cause an excessive rate of descent. The subsequent large rapid increase in collective to prevent ground contact, may further increase the yaw rate and decrease rotor rpm.

The decision to reduce collective must be based on the pilot's assessment of the altitude available for recovery.

3. If the spin cannot be stopped and ground contact is imminent, an autorotation may be the best course of action. Maintain full left pedal until the spin stops, then adjust to maintain heading.

The helicopter wreckage was released to Helicopter Transport Services on August 3, 2001.

Pilot Information

Certificate:	Commercial; Private	**Age:**	37, Male
Airplane Rating(s):	Single-engine Land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):	None	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 Valid Medical--no waivers/lim.	**Last FAA Medical Exam:**	06/19/2001
Occupational Pilot:		**Last Flight Review or Equivalent:**	07/11/2001
Flight Time:	531 hours (Total, all aircraft), 87 hours (Total, this make and model)		

Aircraft and Owner/Operator Information

Aircraft Make:	Bell	**Registration:**	N89FB
Model/Series:	206B	**Aircraft Category:**	Helicopter
Year of Manufacture:		**Amateur Built:**	No
Airworthiness Certificate:	Normal	**Serial Number:**	1980
Landing Gear Type:	Skid	**Seats:**	4
Date/Type of Last Inspection:	10/23/2000, 100 Hour	**Certified Max Gross Wt.:**	3200 lbs
Time Since Last Inspection:	66 Hours	**Engines:**	1 Turbo Shaft
Airframe Total Time:	10949 Hours at time of accident	**Engine Manufacturer:**	Allison
ELT:	Installed, activated, did not aid in locating accident	**Engine Model/Series:**	250-C20
Registered Owner:	US Lease Co Inc	**Rated Power:**	400 hp
Operator:	Helicopter Transport Services	**Operating Certificate(s) Held:**	On-demand Air Taxi (135)

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual Conditions	**Condition of Light:**	Day
Observation Facility, Elevation:	BWI, 146 ft msl	**Distance from Accident Site:**	
Observation Time:	1254 EDT	**Direction from Accident Site:**	
Lowest Cloud Condition:	Few / 5000 ft agl	**Visibility**	10 Miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	6 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	Variable	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.36 inches Hg	**Temperature/Dew Point:**	27°C / 16°C
Precipitation and Obscuration:			
Departure Point:	Baltimore, MD (MTN)	**Type of Flight Plan Filed:**	None
Destination:	Baltimore, MD (BWI)	**Type of Clearance:**	VFR
Departure Time:	1232 EDT	**Type of Airspace:**	Class B

Airport Information

Airport:	BALTIMORE-WASHINGTON INTL (BWI)	**Runway Surface Type:**	Asphalt
Airport Elevation:	146 ft	**Runway Surface Condition:**	Dry
Runway Used:	15R	**IFR Approach:**	None
Runway Length/Width:	9519 ft / 150 ft	**VFR Approach/Landing:**	None

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:	1 Fatal	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	2 Fatal	**Latitude, Longitude:**	39.184722, -76.677500

Administrative Information

Investigator In Charge (IIC):	Brian C Rayner	**Report Date:**	04/15/2003
Additional Participating Persons:	Bob Henley; FAA; Washington, DC Matthew Rigsby; Bell Helicopter Textron; Fort Worth, TX Scott Scheurich; Rolls-Royce Allison; Indianapolis, IN		
Publish Date:			
Investigation Docket:	NTSB accident and incident dockets serve as permanent archival information for the NTSB's investigations. Dockets released prior to June 1, 2009 are publicly available from the NTSB's Record Management Division at pubinq@ntsb.gov, or at 800-877-6799. Dockets released after this date are available at http://dms.ntsb.gov/pubdms/.		

The National Transportation Safety Board (NTSB), established in 1967, is an independent federal agency mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The NTSB makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

The Independent Safety Board Act, as codified at 49 U.S.C. Section 1154(b), precludes the admission into evidence or use of any part of an NTSB report related to an incident or accident in a civil action for damages resulting from a matter mentioned in the report. A factual report that may be admissible under 49 U.S.C. § 1154(b) is available here.