Aviation Investigation Final Report

Location:	Norfolk, Nebraska	**Accident Number:**	CHI02FA174
Date & Time:	June 21, 2002, 12:07 Local	**Registration:**	N852HW
Aircraft:	Eurocopter France AS-350-B2	**Aircraft Damage:**	Substantial
Defining Event:		**Injuries:**	3 Fatal
Flight Conducted Under:	Part 91: General aviation - Positioning		

Analysis

The helicopter impacted the terrain following a loss of control. Shortly after departing the hospital on a medivac flight, the pilot requested that company dispatch have the company mechanic meet him at a nearby airport because he was experiencing "binding in the right pedal." An airport employee stated that just prior to the accident, she saw the helicopter hovering over the ramp and thought it was going to land. Four other witnesses reported seeing the helicopter climbing and thought it was taking off. Witnesses also reported seeing the helicopter spinning (directions vary) prior to it descending to impact. One witness reported the nose of the helicopter was stationary on an east heading and the tail of the helicopter was swinging back and forth. He stated the helicopter then veered to the left and he lost sight of it when he traveled behind some buildings. Another witness reported seeing the helicopter rocking nose to tail and going in a circle, but not spinning, prior to impact. Inspection of the helicopter revealed one of the scuff sleeves on the tail rotor pitch change rod was moved approximately 3 inches aft of the bearing bracket. The top of the sleeve was gouged and scuffed. Both the forward and aft ends of the sleeve were slightly curled away from the rod. The forward edge of the sleeve was torn. No other mechanical failure or malfunction of the engine, airframe, or systems were identified that would have resulted in the accident. The guarded hydraulic cut off switch was found in the off position. Records show the pilot had approximately 2,500 hours of helicopter time with a total of 43.8 hours of flight time in this make and model of helicopter. Winds at the time of the accident were from 200 degrees at 16 knots, gusting to 21 knots. The Federal Aviation Administration Rotorcraft Flying Handbook states that a loss of tail rotor effectiveness "may occur in all single-rotor helicopters at airspeeds less then 30 knots. It is the result of the tail rotor not proving adequate thrust to maintain directional control, and is usually caused be either certain wind azimuths (directions) while hovering, or by an insufficient tail rotor thrust for a given power setting at high altitudes."

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: A loss of tail rotor effectiveness and the pilot's failure to maintain control of the helicopter. Factors associated with the accident were the binding of the tail rotor pitch changed rod, the gusty wind conditions, and the pilot's lack of total experience in this make and model of helicopter.

Findings

Occurrence #1: AIRFRAME/COMPONENT/SYSTEM FAILURE/MALFUNCTION
Phase of Operation: CRUISE - NORMAL

Findings
1. (F) ROTOR SYSTEM,TAIL ROTOR HUB PITCH ACTUATING SHAFT - BINDING(MECHANICAL)

Occurrence #2: LOSS OF CONTROL - IN FLIGHT
Phase of Operation: HOVER - OUT OF GROUND EFFECT

Findings
2. (F) WEATHER CONDITION - GUSTS
3. (C) LOSS OF TAIL ROTOR EFFECTIVENESS - PILOT IN COMMAND
4. (C) AIRCRAFT CONTROL - NOT MAINTAINED - PILOT IN COMMAND
5. (F) LACK OF TOTAL EXPERIENCE IN TYPE OF AIRCRAFT - PILOT IN COMMAND

Occurrence #3: IN FLIGHT COLLISION WITH TERRAIN/WATER
Phase of Operation: DESCENT - UNCONTROLLED

Findings
6. TERRAIN CONDITION - GROUND

Factual Information

HISTORY OF FLIGHT

On June 21, 2002, at 1207 central daylight time, a Eurocopter AS-350-B2, N852HW, operated by Rocky Mountain Holdings LLC (RMH), as LifeNet flight 12, experienced a loss of control and collision with the terrain at the Karl Stefan Memorial Airport (OFK), Norfolk, Nebraska. The commercial rated pilot, paramedic, and flight nurse were all fatally injured. The Title 14 CFR Part 91 flight was operating in visual meteorological conditions on a company flight plan. The flight originated from the helipad at the Faith Regional West Hospital (NE68), in Norfolk, Nebraska, at 1200.

N852HW was based at the Faith Regional Health Services West Campus Heliport (NE68) in Norfolk, Nebraska. NE68 is located approximately 2.5 miles north-northwest from OFK.

The purpose of the flight was to fly to St. Anthony's Hospital in O'Neill, Nebraska, to pick up a patient. The patient was then going to be transported to the Mercy Medical Center in Sioux City, Iowa. At 1152:46, the pilot was informed of the mission by LifeCom dispatch. At 1201:20, the pilot radioed the LifeCom dispatcher and reported that he had departed. At 1203:25, the pilot reported to dispatch that he was going to land at OFK, and he asked the dispatcher to contact their mechanic and have him meet the aircraft. He reported "we're gonna have to land and get something checked out with maintenance before we can take this mission." The dispatcher began the process of locating the mechanic. At 1205:10, the pilot informed the dispatcher that they were experiencing "binding in the right pedal." This was the last transmission between the helicopter and dispatch.

Several witnesses reported seeing the helicopter just prior to the accident.

The person monitoring the Unicom radio at the Karl Stefan Airport reported that the pilot of N852HW made a radio call saying he was inbound for landing. She stated she responded to the call and asked if they were going to need fuel. There was no response to her inquiry. She stated she then saw the helicopter hovering over the ramp, about 10 feet off the ground, and thought he was gong to land. She stated she answered the telephone and seconds later when she looked back out the window she noticed the helicopter had crashed.

The pilot of an airplane that was landing at OFK reported that he was entering the traffic pattern for runway 19 when he heard the helicopter report being north of the city, landing to the south. He stated that he asked the helicopter three times for a position report, but he did not get a response. He stated that when he was on a one mile final, he saw the helicopter "high right [the witnesses right], descending across to low left [the witnesses left] view (at a high rate of descent)." The helicopter passed between his aircraft and the runway threshold. He stated

he aborted his landing to avoid the helicopter. When he was turning crosswind, he saw the helicopter descend toward the north end of the ramp and he thought it was landing. He turned his attention to flying his airplane and when he looked back toward the helicopter he saw it "crashing on its side and coming to rest."

A witness who was traveling south on Highway 81 reported seeing the helicopter hovering over the northern quadrant of the airport. He lost sight of the helicopter, and then saw it climb to a height of about 100 to 200 feet where it leveled off and hovered. He reported, "it suddenly began to spin (I believe counter-clockwise, but upon reflection, I'm not positive) with its nose angled down, and a moment later it started to descend rapidly, still spinning, apparently out of control. After several complete revolutions, the helicopter dove to the ground, coming to rest on its right side." This witness went to the helicopter to help. He reported hearing an "occasional release of pressure from what I believed to be the hydraulic systems, and from time to time there would be a brief puff of smoke from the exhaust."

Another witness who was located approximately a quarter-mile northwest of the accident site reported that the helicopter stopped for a short time and hovered over his location. He reported that as the helicopter proceeded to the airport "it pitched side ways and the pilot hit the power and got the helicopter back up in the air." He reported the helicopter then began to spin clockwise (looking down from the top). He stated the spin slowed as the helicopter gained altitude then it "dove forward and down into the ground."

Another witness who was at the intersection of Highway 81 and Sherwood Road reported seeing the helicopter about 70 feet southwest of the 2 north buildings at the airport at an altitude of about 30 feet above the ground with its nose pointed to the east. The nose of the helicopter was at an angle, which was about 30 degrees lower than the tail. The witness stated the tail swung about 3 times from the northwest to the southwest and the nose of the helicopter remained in the same position. The helicopter then veered to the left. Buildings blocked his view and the next thing he saw was a cloud of dust.

Another witness reported seeing the helicopter prior to it reaching the airport. She stated that it was "rocking (nose to tail) and going in a circle, it was not spinning when I saw it."

A witness driving south on Highway 81 reported seeing the helicopter climbing out from the airport and thought it was taking off. She stated it reached an altitude about twice the height of the buildings (hangars) at which time it started to spiral. She stated the helicopter then turned and dove nose first into the ground.

A witness traveling north on Highway 81 reported he thought the helicopter was taking off prior to the accident. He reported the helicopter then started to fly "strangely" prior to it impacting the ground.

Another witness reported seeing the helicopter in a level attitude and traveling very slow as it approached the airport. She stated the helicopter banked a little when it got close to the

hangars. It started spinning counterclockwise then it began to spin in a clockwise direction. She stated the helicopter descended and climbed back up at which time she was distracted. She then saw the helicopter dive into the ground. She stated the helicopter was about twice the height of the buildings when it started spinning.

PERSONNEL INFORMATION

The pilot, age 43, received a commercial pilot certificate with rotorcraft-helicopter and instrument-helicopter ratings on November 8, 1985. This certificate was issued based on the pilot's previous military experience. On December 31, 1989, an airplane-single engine land rating was added. On January 26, 2002, a multi-engine land rating was added. On the application for this certificate, the pilot reported having 161.1 hours of airplane flight time and 2,418.5 hours of rotorcraft flight time. On February 5, 2002, a multi-engine instrument rating was added to the pilot's commercial pilot certificate. On the application for this certificate, the pilot reported having 180.6 hours of airplane flight time and 2,399.7 hours of rotorcraft flight time.

The pilot's last Federal Aviation Administration medical certificate was issued on November 15, 2001. On that date, the pilot was issued a second-class medical certificate with no limitations.

The pilot was a member of the Nebraska Army National Guard in Lincoln, Nebraska. According to information supplied by his National Guard Unit, the pilot had approximately 2,550 hours of total flight time. They reported he had about 680 hours of flight time in UH-60 Blackhawk helicopters. The National Guard reported that between November 1, 2001, and May 1, 2002, there was a void in the pilot's flight hours. He had fixed wing aircraft training in May 2002, and he had flown 3 hours in June 2002.

The pilot submitted an Application for Employment to RMH, dated November 21, 2001. On this application the pilot listed having 2,551.6 hours of helicopter flight time. He listed experience in UH-60A Blackhawk, UH-1 Huey, CH-46 Boeing Vetol, TH-57 (Bell 206), and Bell 47 helicopters.

The pilot began his employment with RMH on May 6, 2002. According to information and records provided by RMH, the pilot traveled to Provo, Utah, on May 6, 2002, and began his training on May 7, 2002. Records indicate that he completed Initial Ground and Initial General Emergency training on May 8, 2002. His Initial Aircraft Ground training was completed on May 10, 2002. RMH reported the pilot traveled to Norfolk, Nebraska, on May 10, 2002, to begin his flight training. Records indicate the pilot completed his Initial Flight training on May 12, 2002. This training consisted of 3.2 hours of flight time. All the training was recorded as having been satisfactorily completed. The pilot passed a 14CFR Part 135 Airman Competency/Proficiency Check on May 12, 2002. This checkride was logged as having lasted 1 hour. Company records show the pilot flew 7.1 hours on May 14, 2002, and 6.1 hours on May 15, 2002. Both of these flights were logged as Part 91-Ferry. Records indicate the pilot had four additional

flights between May 23, 2002, and June 9, 2002, which were listed as Part 91-Training. These flights totaled 6.8 hours of flight time. In addition, between May 25, 2002, and June 19, 2002, the pilot's Flight and Duty Time Record show the pilot flew 20.8 hours. The records for these flights did not contain any remarks indicating that they were training flights. Not counting the accident flight, the pilot had accumulated a total flight time in the AS350 of 45 hours while employed by RMH, 10 hours of which were listed as training.

According to the RMH Pilot Training Program syllabus, the rotor system, flight controls, and hydraulic system are addressed under the Aircraft Ground Training Curriculum. The Flight Training Curriculum states, "Pilots will be training on all maneuvers listed in the following flight training module." Item 8 in the Flight Training module lists landing with hydraulic off and Item 12 lists hydraulic system malfunction and anti-torque system failure. According to the pilot's instructor, these items were accomplished.

The training program syllabus contains RMH Approved Maneuvers. The procedures and cautions to be used while practicing hydraulics off landings are listed under this section. Two of the cautions listed for this maneuver state: "Maintain entry airspeed until apparent ground speed and rate of closure appear to be increasing. Continue forward movement to arrive 3 feet above the surface and above ETL [effective transational lift]. Note: Do not terminate to a hover."and" Due to heavy control forces encountered in this maneuver, the instructor must be immediately ready to assist in control of the aircraft." This section also contains the procedures and cautions to be used during flight training for simulation fixed position [jammed] tail rotor failure. A "Loss Of Tail Rotor Drive" and a "Loss Of Tail Rotor Effectiveness" are listed as a "Discussion Only" items.

The paperwork for the pilot's 14 CFR Part 135 Airman Competency/Proficiency Check indicated the pilot received a satisfactory grade during his oral examination on the topics of tail rotor failures, settling with power, dynamic rollover, and loss of tail rotor effectiveness. According to the paperwork, the emergency procedures that the pilot was actually flight checked were simulated engine failures, inadvertent IMC procedures, unusual attitude recovery, and partial panel procedures.

The pilots normally work a 24-hour shift beginning at 0700. Records indicate the pilot was off duty the day before the accident and he reported for duty at 0700 on the morning of the accident.

AIRCRAFT INFORMATION

The helicopter was a single engine multipurpose Eurocopter AS350B2, s/n 2630. The main rotor blades turn clockwise as viewed from the top. Therefore, the right tail rotor control pedal is used to over come the effects of torque generated by the main rotor blades. The main rotor blades on most United States manufactured helicopters rotate counter-clockwise as viewed from the top.

N852HW was issued an airworthiness certificate on July 27, 1992. In October 1992, the helicopter was operated by Memphis Medical AirAmbulance Service, Inc., from 1992 until September 1999, at which time it was returned to American Eurocopter. RMH purchased the helicopter in March 3, 2000, when it had a total time of 4,280 hours.

N852HW was being maintained in accordance with an Approved Aircraft Inspection Program (AAIP). According to the logbooks, an "A" check was performed on the airframe on June 15, 2002, at a total airframe time of 5,543.2 hours.

The engine, a Turbomeca Arriel 1, s/n 9221, was manufactured on January 30, 1992. The engine was installed in 3 other helicopters prior to being installed in N852HW, on April 28, 1998. The engine had a total time of 3,460.8 hours when it was installed in N852HW. The airframe total time at engine installation was 2,998.36 hours. On June 15, 2002, "W" and "X" checks were performed at a total engine time of 6,004.7 hours.

According to maintenance records, on June 21, 2002, the Hobbs time was recorded as 4,391.7 hours, aircraft total time was recorded as 5,562 hours, and the engine total time was 6,023.5 hours.

The mechanic assigned to N852HW stated that on June 19, 2002, he and the accident pilot flew the helicopter from Norfolk to Lincoln, Nebraska, to have some avionics work done. Shortly after they took off on their return flight, smoke filled the cabin. They returned to Lincoln and discovered the air conditioner compressor had locked up and the belt was burned. The mechanic changed the belt and when he was closing the cowling the hydraulic pump belt snapped. The mechanic stated the belt snapped because it was located near the locked up compressor and it had been heated. The mechanic changed the hydraulic pump belt and they flew the helicopter back to Norfolk without incident.

Upon landing at Norfolk, the helicopter was refueled with 25 gallons of Jet A fuel. The helicopter was then flown to NE68 where it remained until departing on the accident flight.

The mechanic stated that on the morning of the accident, he went to the hospital and performed his daily inspection/preflight of the helicopter. He then met with the pilot as he was beginning his shift. They discussed the status of the helicopter and the pilot conducted his own preflight inspection. The mechanic reported that there were no outstanding maintenance issues with the helicopter.

The pilot completed weight and balance calculations prior to the flight. The total weight was calculated to be 4,658.8 pounds with a center of gravity (cg) of 128.7 inches. The maximum gross weight for the helicopter was 4,961 pounds with forward and aft cg limits of 124.8 inches and 137.8 inches respectively.

METEOROLOGICAL INFORMATION

A weather observation station, located at OFK, recorded the weather as:

Observation Time: 1154 cdt
Wind: 200 degrees at 16 knots, gusts to 21 knots
Visibility: 10 Statute Miles
Sky Condition: Clear
Temperature: 29 degrees Celsius
Dew Point: 22 degrees Celsius
Pressure: 30.13 inches of mercury

WRECKAGE AND IMPACT INFORMATION

The National Transportation Safety Board's (NTSB) on-scene investigation began on June 22, 2002.

The main wreckage was located at the edge of taxiway "A", just south of the run up pad near the approach end of runway 19. The helicopter came to rest on its right side with the tail rotor on the taxiway and the nose of the helicopter on the grass. The nose of the helicopter was pointing to a magnetic heading of 215 degrees.

The first impact mark along the wreckage path was at the edge of the taxiway approximately 40 feet southeast of the main wreckage. The forward portion of the left skid was found at this impact point.

Approximately 25 feet after the first impact, two slash marks and a gouge were located on the taxiway. The total distance between the first slash, second slash, and the gouge was 3 feet 7 inches. These marks lined up along the wreckage path with the final resting position of the tail rotor. The marks contained turquoise colored paint transfers which matched the paint color on the tail rotor balance weights.

The slash marks were found in the sandy terrain near the nose section of the helicopter. These slash marks were in line with the final resting position of the main rotor blades. The slash marks were spaced approximately 2 feet apart. The first mark was approximately 7 inches deep and 68 inches long; the second mark was approximately 7 inches deep and 44 inches long; and the third mark was approximately 6 inches deep and 64 inches long.

Both windscreens and the nose canopy were separated from the helicopter. The right door along with a section of the doorpost was separated from the helicopter. The left front door was separated and the upper aft edge of the door was bent outboard. The left sliding door was separated. The lower portion of the sliding door was bent inward and the upper aft edge was bent outward. The pilot's seat was separated from the lower rails.

The cockpit floor was crushed upward, jamming the tail rotor pedals and the cyclic. The tail rotor pedals were jammed forward in the neutral position. The collective was at the bottom of

its travel limit. The guarded hydraulic cut off switch on the collective was in the "off" position. The guard was intact and in place. The center control console was separated from its mounting. None of the control pushbuttons were pushed in. There were four pushbuttons found that were not in their mountings. Those included the INVERT, W/LT TEST, and two others that were not marked. The light bulbs from the control console buttons were removed and examined. The rotor brake and the fuel shut-off control were in the flight position. The fuel flow control lever was found out of the flight detent and positioned slightly toward the retarded position.

The left skid toe separated forward of the forward cross tube. This portion of the skid was found at the initial impact point. The right skid tube was bent upward between the front and rear cross tubes. The right skid was separated just forward of the forward cross tube. The separated portion of the skid was located with the main wreckage. The fractured end of the skid, just forward of the cross tube, was impacted with dirt. The skid was also fractured, but not completely separated, just forward of the rear cross tube.

The longitudinal structural beams were buckled to the right midspan along the fuel tank. Both the forward and aft fuel tank supports were separated from the longitudinal beams. The main rotor gearbox crossbeam supports separated from the transmission deck. The left aft and left forward support bars were separated near the middle.

Rotational continuity was confirmed between the main rotor head, main rotor shaft, swashplate, main rotor gearbox, drive shaft, and the engine. The upper and lower blade sleeves for both the red and blue main rotor blades were dislocated, opposite the direction of rotation. Both the red and blue starflex arms were separated. The pitch control rod for the blue blade was bent. The yellow starflex arm was intact. The nitrogen charge in the main rotor hydraulic servo accumulators was checked. The right servo had 100 PSI, the left rear servo had 175 PSI, and the left front servo had 60 PSI. Fully charged operating pressure of the accumulators is 215 PSI.

All three main rotor blade sleeves remained attached to the main rotor hub. The blue blade was lying on the ground pointing toward the rear of the helicopter. The outboard 4 feet 3 inches of this blade was completely separated from the inboard section of the blade. The separated portion of the blade was located approximately 80 feet behind the main wreckage. In addition, the blue blade also contained another break that was 3 feet 7 inches inboard of the separated edge. This break was from the trailing edge of the blade up to the leading edge. The yellow blade was found pointing in the air at an approximate 45-degree angle from the ground. The upper surface of the yellow blade was severed and the blade was bent in half at a point that was approximately 6 feet 3 inches from the tip. The red blade was lying on the ground pointed toward the nose of the helicopter. The red blade was buckled chordwise at a point that was approximately 5 feet 3 inches from the tip. All of the blades contained trailing edge separation.

The tailboom was separated from the fuselage at the attach flange. The tailboom came to

rest in a near inverted position. The lower portion of the tailboom was buckled at the attach point. As viewed from the tail of the helicopter looking forward, the tailboom was bent to the right just forward of the horizontal stabilizer. The rivets on the left side of the tailboom, just forward of the horizontal stabilizer were sheared. The outboard end of the right horizontal stabilizer was bent. The lower vertical stabilizer was buckled to the left.

The forward flex coupling on the tail rotor forward (short) shaft was separated at the drive flange at the rear of the reduction gear case. The three corners of the drive flange coupling were bent rearward. One of the ears on the short shaft forward coupling separated and remained with the drive flange coupling. The rear flex coupling on the short shaft was intact as was the splined gear adapter to the rear (long) drive shaft. The short drive shaft cowling exhibited rotational scoring with an exit hole at the forward section of the cowling. The rear flex coupling on the long drive shaft was intact. The long drive shaft is bent in the same direction and location as the tailboom. The long drive shaft, the tail rotor gearbox, and the pitch change spider all rotated freely by hand with no binding noted. The tail rotor pitch change links were intact. The tail rotor gearbox chip detector was clean. One tail rotor blade was fractured, but not separated, just inboard of the trim tab. The fracture ran from the trailing edge of the blade to near the leading edge. This blade contained chordwise scratches outboard of the fracture. The other blade contained pitting on the outboard half of the blade near the leading edge. The balance weight for this blade contained an abrasion mark on its outboard tip.

The tail rotor pitch change rod was intact from the load compensator to the actuating bellcrank. This rod travels through five drive shaft bearing brackets between the load compensator and the bellcrank. A Teflon guide is mounted on the aft side of each bracket and the rod runs through the Teflon guide. The rod is covered with a 4.75-inch long scuff sleeve where it passes through each guide. The sleeve is a heat shrink material. ProSeal was applied to both the forward and aft ends of the sleeve. All of the sleeves were in place with the exception of the one for the fourth bracket aft of the load compensator. This sleeve remained around the rod, but it had been moved to a position approximately 3 inches aft of the bracket. The top of the sleeve was gouged and scuffed. Both the forward and aft ends of the sleeve were slightly curled away from the rod. The forward end of the sleeve contained a small tear. According to the RMH maintenance program, the sleeves are inspected at 100 hour intervals during the "B" check. The last "B" check was on May 23, 2002, at an airframe time of 5498.4 hours.

The tail rotor control cable was separated at the swage fitting where the aft threaded portion of the cable attaches to the servo input rod. The cable was bent under the main fuselage. The internal ribbon was removed from the housing cable and no damage, rust, or fraying was noted except for the bend that corresponded to that of the housing cable.

The tailboom was disconnected from the fuselage for further examination. The tail rotor servo was removed and the control rod was free to move fore and aft. The tail rotor load compensator eccentric lever was jammed in an over center full right pedal position. According

to Eurocopter, this position is not uncommon when the tailboom is pulled away from the fuselage. The load compensator accumulator was checked for nitrogen pressure and hydraulic fluid bled from the nitrogen side of the accumulator. No nitrogen pressure was noted. The compensator eccentric lever was free to move from the left to right pedal positions once the hydraulic fluid was released. A nitrogen charge was then placed on the accumulator and once again the lever could not be moved by hand. The load compensator was retained for further testing. (See Tests and Research) The tail rotor pitch change links were disconnected and the tail rotor pitch change spider was free to move. The servo was free to move fore and aft with actuation of the input valve.

The hydraulic pump belt was secure and no damage was noted. The pump was removed from the helicopter. The pump splines were intact and the pump moved freely. The hydraulic pump was retained for testing. (See Tests and Research).

The front support mount on the engine was secure and the engine had shifted forward. The two engine retaining clamps on the rear support mount were broken and the link tube was off the mount. The air inlet duct was clear with a small amount of dirt at the base of the inlet. The bleed valve gate was open. The axial compressor, centrifugal impeller, the T1 and T2 turbines, and the free turbine were free to rotate. Rotation and free wheeling operation of the free wheel assembly was confirmed.

The throttle linkage on the fuel control unit was set at 42 degrees on a scale of -10 to 90, and the anticipator was at 101 degrees on a scale of 0 to 110. Fuel was present inside the unit. Fuel samples examined from the fuel control unit, the airframe, and the fuel filters were clean. The fuel control unit was retained for testing.

The helicopters and engine filters and magnetic plugs were inspected. No significant chip debris was found on any of the magnetic plugs and the fuel and oil filters were clean. The hydraulic filter was slightly dirty. Hydraulic fluid was present on the pavement when the helicopter was removed from the accident site.

MEDICAL AND PATHOLOGICAL INFORMATION

An autopsy was performed on the pilot at the Douglas County Morgue, Omaha, Nebraska, on June 22, 2002.

A Forensic Toxicology Fatal Accident Report was prepared by the FAA Civil Aeromedical Institute, Oklahoma City, Oklahoma, for the pilot. The toxicology results for the pilot were negative for all tests performed.

TESTS AND RESEARCH

The hydraulic pump, the tail rotor load compensator, the fuel control unit, the tail rotor hydraulic servo, the failure warning panel, and the systems control console were retained for

further investigation.

The tail rotor hydraulic servo, Dunlop part number AAC67032, serial number QJ272, was inspected and tested at the Hawker Pacific Aerospace facility in Sun Valley, California, under the supervision of the Safety Board. The pressure/return manifold was removed so that the servo could be mounted on a test bench. A minor amount of debris was found inside the manifold and its orifices. The debris was not large enough to have blocked any of the orifices. The servo was placed on a test bench. The test revealed the servo performed within specifications with the exception of the Permanent Flow Test, which resulted in excessive flow in the mid-stroke, the fully extended, and the fully retracted positions. A bypass shuttle valve inside the servo is there to limit the fluid flow to 100cc/min. The flow test exceeded this flow rate by 50 to 75 cc/min. According to Hawker Pacific and the RMH representative, this excessive flow would not have any adverse effects on the operation of the unit nor on the hydraulic system as another interchangeable servo allows a bypass flow of 300cc/min. See attached report.

The fuel control unit, Turbomeca part number 0164248850, serial number C317B, was tested at the Turbomeca Facility in Grand Prairie, Texas, under the supervision of the Safety Board. The specifications used were for new or overhauled fuel control units. The unit performed within the specifications with the exception of the acceleration test where 1 point out of 10 tested was above the limitation and the static droop test where all points tested were at or slightly above the high side limit. See attached report.

The hydraulic pump and the tail rotor load compensator were inspected and tested at Eurocopter in France under the supervision of an investigator from the Ministere des Transport, BEA. The hydraulic pump, Eurocopter part number 704A34310006, serial number 10764665, tested within specifications.

The tail rotor load compensator was Eurocopter part number 355A 75 170 03. The Laboratory Investigative Report provided by Eurocopter stated, "Tests have evidenced lack of sealing on the diaphragm between the nitrogen chamber and the oil. But it is important to note that the tail rotor load compensator system itself was able to keep oil pressure." The report continued, "Fed electrovalve with electric current. The flow has to appear through return opening and the accumulator pressure has to go down up to the accumulator inflating pressure ---the pressure drop immediately to 0 bars; by feeding with nitrogen the inflating valve confirming the absence of sealing of the nitrogen chamber."

The load compensator was pressurized with 40 bars (580 psi) of oil pressure and no leaks were noted. The electrovalve was tested and an absence of sealing of the nitrogen chamber was noted. The compensator was then pressurized with nitrogen and after 12 hours, no leaks were noted.

According to Eurocopter, the lack of a nitrogen charge in the compensator accumulator would not effect the operation of the tail rotor as long as there is hydraulic pressure in the system.

HYDRAULIC SYSTEM

The AS-350-B2 is equipped with four servo actuators, one for each main rotor blade and one for the tailrotor. The Eurocopter AS350 Instruction Manual states:

> The helicopter can be controlled without servo actuators but this requires the pilot to apply non-negligible forces that are difficult to gauge. These control loads are absorbed by hydraulic servo actuators so that the pilot can fly the helicopter PRECISELY and EFFORTLESSLY.
>
> In case of loss of hydraulic pressure, accumulators in the main rotor servo actuators provide a small energy reserve, giving the pilot time to reconfigure in the safety configuration. The B1 and B2 versions are fitted with a yaw load compensator.
>
> YAW LOAD COMPENSATOR ON VERSIONS B1 & B2
>
> Without any hydraulic pressure, the pedal operating force is very high on the B and B2 versions. This is why a hydraulic device or "load compensator" has been mounted in parallel with the tail rotor servo actuator.
>
> In flight the helicopter's hydraulic system charges an accumulator and an actuator.
>
> In case of hydraulic failure (pump inoperative, leakage, etc.) ,the accumulator is kept charged by
> -non-return valve in the pressure circuit
> -pressure relief valve set at 55 bar (N.B. The system's operating pressure is 40 bar) [1 bar equals 14.7 PSI]
> -solenoid valve always closed and opened by the pilot

The AS-350-B2 Flight Manual states:

> A tail rotor servo-control mounted on the tail boom actuates a rod which controls the tail
> rotor spider bellcrank. In the event of a hydraulic system failure, a load compensating servo in the tail rotor linkage limits the yaw pedal operating load. The hydraulic accumulator that supplies the compensation system may be depressurized by means of a HYD. TEST pushbutton.
>
> The pilot is informed of hydraulic system fault conditions by a red "HYD" low-pressure warning light on the Warning-Caution-Advisory Panel, and by an aural alarm, both of which are actuated by the pressure switch on the regulator unit
>
> The horn sounds to warn of:

-Rotor speed (NR) between approx. 250 and 360 r.p.m. (continuous sound).
-Rotor speed above 410 r.p.m. (intermittent sound).
-Hydraulic pressure drop (below 30 bars).

It is operative only if the"HORN"push-button is pushed in. When this push-button is out, at nominal rotor speed, the HORN light of the warning-caution-advisory panel is on.

Alarm procedure (if HORN sounds):
-If the HYD warning light is on:
The malfunction is in the hydraulic system.

The switch on the collective pitch lever can be used to cut off all hydraulic power by opening the three solenoid valves on the main rotor servo-controls to depressurize the system.

A push-button [HYDR TEST] on the control console is used:
-to test the hydraulic accumulators by opening the regulator unit solenoid valve
-to depressurize the tail rotor load compensating servo.

The Flight Manual lists the Hydraulic Failure and Tail Rotor emergency procedures as:

Hydraulic System Failures

Yaw Servo-control Slide-valve Seizure
-In hover: If no movement about the yaw axis, land normally: If rotation about the yaw axis, cut off hydraulic pressure by actuating the switch situated on the collective pitch control lever.

-In cruise flight: Reduce speed, entering into a side slip if necessary, then cut off hydraulic pressure by actuating the switch situated on the collective pitch control lever.

Tail Rotor Drive Failure

Loss of tail rotor in power on flight results in a yaw moment to the left: the extent of such
rotation will depend on the power and speed configuration at the time the failure occurs.

Failure of the Tail Rotor in Hover or at Low Speed

-I.G.E. (In Ground Effect): bring the aircraft to the ground by reducing collective pitch before yaw rate is too high.

-O.G.E. (Out of Ground Effect): reduce collective pitch moderately, to reduce yaw

torque, and simultaneously start to pick up speed.

Failure in Forward Flight
-In forward flight reduce the power as much as possible and maintain forward speed (weathercock effect), select a suitable landing area for a steep approach at a hover enabling a reasonable coordinated flight.
-On final approach, shut down the engine and make an autorotative landing at the lowest possible speed.

Tail Rotor Control Failure
-Set I.A.S 70 knows (130 km/hr), in level flight.
-Press the hyd accumulator test push button (this cuts off hydraulic power to the yaw servo control and depressurizes the load-compensating servo accumulator). After 5 seconds, reset the test button to the normal position.
-Make a shallow approach to a clear landing area with a slight side slip to the left. Perform a run-on landing: the side slip will be reduced progressively as power is applied.

Hydraulic system checks in the Normal Procedures section in the Flight Manual states in part:

BEFORE STARTING ENGINE

Press the HYD TEST pushbutton for approx. 2 seconds to depressurize the yaw hydraulic accumulator in order to center the yaw pedals.

Test Warning-Caution-Advisory Panel lamps - W/LT TEST
Hydraulic pressure - ON
(if isolated the HORN will come on)

STARTING

Gradually increase the fuel flow, maintaining a constant rate of rotor acceleration
-Check that the following Warning-Caution-Advisory Panel lights go out:
HYD, with simultaneous illumination of the KLAXON (HORN) light

Check all warning lights off

Carry out a hydraulic accumulator test:
-Check collective pitch - locked
-Cut off hydraulic pressure by actuating the test push-button On console
-Check that the HYD light illuminates and HORN sounds
-Move the cyclic stick 2 or 3 times along both axes separately on 10% of total travel, check for hydraulic assistance by absence of control load

-Press the test pushbutton to restore hydraulic pressure. On console
-Check that the HORN is cancelled and HYD light goes out

Carry out a hydraulic pressure isolation check:
-Isolate hydraulic pressure by actuating the switch on the collective pitch lever: the HYD light illuminates and control load is felt immediately, except on yaw pedal, where control load should remain low because of load-compensating servo.
-Restore hydraulic pressure using the switch: the HORN sounds until the HYD light goes out (2-3 sec.).

The Performance Section in the Flight Manual states:

Hovering with wind from any direction has been substantiated over the entire flight envelope up to winds of 17 kts, although this is not to be taken as a limit. For example hover at sea level at maximum weight, for all c.g. locations, has been substantiated at 30 knots.

Unanticipated Yaw/Loss of Tail Rotor Effectiveness (LTE)

The Federal Aviation Administration Rotorcraft Flying Handbook states:

Unanticipated yaw is the occurrence of an uncommanded yaw rate that does not subside of its own accord and, which, if not corrected, can result in the loss of helicopter control. This uncommanded yaw rate is referred to as loss of tail rotor effectiveness (LTE) and occurs to the right in helicopters with a counter-clockwise rotating main rotor and to the left in helicopters with a clockwise main rotor rotation. Again, this discussion covers a helicopter with a counter-clockwise rotor system and an antitorque rotor.

LTE is not related to an equipment or maintenance malfunction and may occur in all single-rotor helicopters at airspeed less than 30 knots. It is the result of the tail rotor not providing adequate thrust to maintain directional control, and is usually caused by either certain wind azimuths(directions) while hovering, or by an insufficient tail rotor thrust for a given power setting at higher altitudes.

For any given main rotor torque setting in perfectly steady air, there is an exact amount of tail rotor thrust required to prevent the helicopter from yawing either left or right. This is known as tail rotor trim thrust. In order to maintain a constant heading while hovering, you should maintain tail rotor thrust equal to trim thrust.

The required tail rotor thrust is modified by the effects of wind. The wind can cause an

> uncommanded yaw by changing tail rotor effective thrust. Certain relative wind directions are more likely to cause tail rotor thrust variations than others. Flight and wind tunnel tests have identified three relative wind azimuth regions that can either singularly, or in combination, create an LTE conducive environment. These regions can overlap, and thrust variations may be more pronounced. Also, flight testing had determined that the tail rotor does not actually stall during the period. When operating in these areas at less than 30 knots, pilot workload increases dramatically.

The Federal Aviation Administration Rotorcraft Flying Handbook also states:

> In addition, at higher gross weights, the increased power required to hover produces more torque, which means more antitorque thrust is required. In some helicopters, during high altitude operations, the maximum antitorque produced by the tail rotor during a hover may not be sufficient to overcome torque even if the gross weight is within limits.

ADDITIONAL INFORMATION

Parties to the NTSB investigation included the FAA, Turbomeca Engine Corporation, Rocky Mountain Holdings, and the American Eurocopter Corporation.

Arrangements for the return of the fuel control unit were made between representatives from RMH and Turbomeca following the testing on August 14, 2002. The tail rotor hydraulic servo and the fuel control unit were returned to RMH on November 7, 2002. The load compensator and the hydraulic pump were returned to RMH on May 7, 2003. A RMH representative was present when the fuel control unit was tested at Turbomeca on August 14, 2002. This representative coordinated the return of the fuel control unit with Turbomeca and at the completion of the testing. The failure warning panel and the systems control console lights were returned to a representative of RMH's insurance company on January 12, 2004. The main wreckage was released to a representative of RMH's insurance company on January 26, 2004.

Pilot Information

Certificate:	Commercial	**Age:**	43,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	
Instrument Rating(s):	Airplane; Helicopter	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 Valid Medical--no waivers/lim.	**Last FAA Medical Exam:**	November 15, 2001
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:	2580 hours (Total, all aircraft), 44 hours (Total, this make and model)		

Aircraft and Owner/Operator Information

Aircraft Make:	Eurocopter France	**Registration:**	N852HW
Model/Series:	AS-350-B2	**Aircraft Category:**	Helicopter
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	2630
Landing Gear Type:	Skid	**Seats:**	3
Date/Type of Last Inspection:	June 15, 2002 AAIP	**Certified Max Gross Wt.:**	4961 lbs
Time Since Last Inspection:	19 Hrs	**Engines:**	1 Turbo shaft
Airframe Total Time:	5562 Hrs	**Engine Manufacturer:**	Turbomeca
ELT:	Not installed	**Engine Model/Series:**	Arriel 1
Registered Owner:	CIT Group/Equipment Financing	**Rated Power:**	640 Horsepower
Operator:	Rocky Mountain Helicopters	**Operating Certificate(s) Held:**	On-demand air taxi (135)
Operator Does Business As:	Life Net	**Operator Designator Code:**	

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	OFK,1573 ft msl	**Distance from Accident Site:**	0 Nautical Miles
Observation Time:	11:54 Local	**Direction from Accident Site:**	0°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	16 knots / 21 knots	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	200°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.12 inches Hg	**Temperature/Dew Point:**	29°C / 22°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Norfolk, NE (NE68)	**Type of Flight Plan Filed:**	None
Destination:	Norfolk, NE (OFK)	**Type of Clearance:**	None
Departure Time:	12:00 Local	**Type of Airspace:**	Class E

Airport Information

Airport:	Stefan Memorial Airport OFK	**Runway Surface Type:**	
Airport Elevation:	1573 ft msl	**Runway Surface Condition:**	Unknown
Runway Used:		**IFR Approach:**	None
Runway Length/Width:		**VFR Approach/Landing:**	Precautionary landing

Wreckage and Impact Information

Crew Injuries:	3 Fatal	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	3 Fatal	**Latitude, Longitude:**	41.985279,-97.434997

Administrative Information

Investigator In Charge (IIC):	SULLIVAN, PAM
Additional Participating Persons:	Robert Johnson; FAA; Lincoln, NE Rick Johnson; FAA; Lincoln, NE Kenneth Arnold; American Eurocopter Corp.; Grand Prairie, TX Joe Syslo; American Eurocopter Corp.; Grand Prairie, TX Archie Whitten; Turbomeca; Grand Prairie, TX Dan Woods; Rocky Mountain Holdings; Provo, UT Larry Adams; Rocky Mountain Holdings; Provo, UT
Original Publish Date:	June 2, 2004
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=55007

The National Transportation Safety Board (NTSB) is an independent federal agency charged by Congress with investigating every civil aviation accident in the United States and significant events in other modes of transportation—railroad, transit, highway, marine, pipeline, and commercial space. We determine the probable causes of the accidents and events we investigate, and issue safety recommendations aimed at preventing future occurrences. In addition, we conduct transportation safety research studies and offer information and other assistance to family members and survivors for each accident or event we investigate. We also serve as the appellate authority for enforcement actions involving aviation and mariner certificates issued by the Federal Aviation Administration (FAA) and US Coast Guard, and we adjudicate appeals of civil penalty actions taken by the FAA.

The NTSB does not assign fault or blame for an accident or incident; rather, as specified by NTSB regulation, "accident/incident investigations are fact-finding proceedings with no formal issues and no adverse parties … and are not conducted for the purpose of determining the rights or liabilities of any person" (Title 49 *Code of Federal Regulations* section 831.4). Assignment of fault or legal liability is not relevant to the NTSB's statutory mission to improve transportation safety by investigating accidents and incidents and issuing safety recommendations. In addition, statutory language prohibits the admission into evidence or use of any part of an NTSB report related to an accident in a civil action for damages resulting from a matter mentioned in the report (Title 49 *United States Code* section 1154(b)). A factual report that may be admissible under 49 *United States Code* section 1154(b) is available here.