Aviation Investigation Final Report

Location:	Fountain Hills, Arizona	**Accident Number:**	LAX01FA277
Date & Time:	August 14, 2001, 08:15 Local	**Registration:**	N70457
Aircraft:	MD HELICOPTERS, INC. 600N	**Aircraft Damage:**	Substantial
Defining Event:		**Injuries:**	3 Minor, 1 None
Flight Conducted Under:	Part 91: General aviation		

Analysis

A staff pilot for the manufacturer was providing a sales demonstration flight to a potential customer's pilot when yaw control of the helicopter was lost, it entered a spin, collided with the ground, and rolled over. During the flight the customer's typical aerial application pest control flight profile was to be flown. The customer pilot flew Bell 206's currently in the mission and had no experience in the NOTAR anti-torque system. The maneuver was a simulated aerial application pass followed by a turn around. The manufacturer's pilot said the maneuver was very docile and consisted of a pass down a creek bed at 60 knots and 50 feet. The customer pilot initiated a gentle cyclic pull-up to a 10- to 15-degree nose up attitude while entering a right turn as the helicopter decelerated. At the 90 degree point in the turn, the helicopter was at 40 to 50 knots with a 30-degree or less bank angle to the right. As the nose came around in the turn, the nose tucked down to about 20 degrees below the horizon. The manufacturer's pilot took over the controls and added near full aft cyclic to level the nose; at this point, he received a low rotor warning horn (indicating a rotor droop at 95 percent or lower). Coincident with the low rotor warning, the helicopter began a right yaw rate. He added full left pedal, but the yaw rate continued at what he described as a "slow pedal turn rate," eventually completing 4 to 6 complete revolutions. At this point the helicopter began descending and he added collective. He immediately got a "power" audio warning, indicating that he was exceeding the upper power limit of the engine. The right yaw rate also increased with collective input. The pilot then modulated the collective between the low rotor warning and the excessive power warning in an attempt to both control the yaw and stop the descent. As he lowered the collective and the rotor speed began to build, the yaw would slow, but the helicopter then began descending faster. As he added collective to slow the descent, the yaw rate would increase. As the helicopter neared the ground, the yaw finally stopped; however, the helicopter was translating sideways toward a berm. The helicopter touched down on the right skid against the berm and it rolled over. The manufacturer's pilot said his hands were following on the controls as the customer pilot flew and he did not perceive any unusual control inputs. He further stated that his feet were about 1 inch from the anti-torque pedals and he did not feel any inputs from the customer pilot on the pedals. Based on his extensive flight test experience in this helicopter, the manufacturer's pilot believes that the aft cyclic input to correct the nose down pitching moment induced a rotor droop, and that the droop was the initiating event in the yaw rate onset. He does not know how low the rotor speed went, but the warning is triggered at 95 percent Nr. The lower limit of the Nr green arc is at 90 percent. The NOTAR anti-torque control system uses air from a pedal controlled jet thruster nozzle on the end of the tail boom to provide anti-torque control. Additional yaw control is provided by vertical stabilizers, which are largely effective only above 20 to 30 knots. Air is supplied to the thruster by a fan driven by a power takeoff shaft from the main transmission. There is a direct relationship between the speed of the main rotor and the speed of the fan. The pilot said he believes that the initial yaw onset was because the rotor drooped low enough to slow the fan below the speed which could supply the necessary air volume to the thruster to control the yaw and they were not fast enough for the vertical stabilizers to have any effect. After the occupants had extricated themselves from the wreckage, the customer pilot asked the pilot what had happened. He replied to them that he didn't know what happened and added, "Maybe we should have turned to the left instead." The helicopter's FAA approved Rotorcraft Flight Manual (RFM) contains several warnings about low speed maneuvering. Under the heading "Unanticipated Right Yaw", the RFM section notes that an unanticipated right yaw can occur when operating at low altitude and airspeeds below 60 knots when a pilot's attention is distracted by events outside the helicopter and sufficient control inputs are not made to adjust for changing aerodynamic conditions. The paragraph states, "If no directional or cyclic control inputs are made, a nose down pitch and a right roll may follow the right yaw." The section notes that this is most likely to occur at speeds below 60 knots in uncoordinated right turns, while flying out of trim with too much right pedal, or right turns to a downwind condition. Examination of the helicopter revealed no evidence of a preimpact malfunction or failure of the control system.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: the manufacturer's pilot's failure to maintain yaw control and main rotor speed while recovering from an unusual attitude induced by the customer pilot's inadequate control inputs while maneuvering at low altitude. The manufacturer's pilot's inadequate supervision of the flight is also causal. A factor in the accident was the customer pilot's lack a familiarity with the NOTAR yaw control system.

Findings

Occurrence #1: LOSS OF CONTROL - IN FLIGHT

Phase of Operation: MANEUVERING - AERIAL APPLICATION

Findings
1. (C) ROTORCRAFT FLIGHT CONTROLS - IMPROPER USE OF - COPILOT/SECOND PILOT
2. (F) LACK OF FAMILIARITY WITH AIRCRAFT - COPILOT/SECOND PILOT
3. REMEDIAL ACTION - ATTEMPTED - PILOT IN COMMAND
4. (C) DIRECTIONAL CONTROL - NOT MAINTAINED - PILOT IN COMMAND
5. (C) ROTOR RPM - NOT MAINTAINED - PILOT IN COMMAND
6. (C) SUPERVISION - INADEQUATE - PILOT IN COMMAND

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

Findings
7. TERRAIN CONDITION - BERM

Occurrence #3: ROLL OVER
Phase of Operation: DESCENT - UNCONTROLLED

Findings
8. DYNAMIC ROLLOVER - ENCOUNTERED

Factual Information

1.0 HISTORY OF FLIGHT

On August 14, 2001, at 0815 mountain standard time, a MD Helicopters, Inc., 600N, N70457, collided with the ground and rolled over while maneuvering during a demonstration flight, 6 miles east of Fountain Hills, Arizona. The commercial pilot was not injured, the airline transport pilot customer and two passengers sustained minor injuries, and the helicopter was substantially damaged. Visual meteorological conditions prevailed. The flight was operated by MD Helicopters, Inc., under 14 CFR Part 91 as a sales demonstration flight. A company VFR flight plan was filed for the local area flight that departed at 0745 from Falcon Field in Mesa, Arizona.

1.1 MD Helicopters Company Pilot's Statement

In his written and oral statemens, the MD Helicopters company pilot stated that on the morning of the accident he was assigned to fly a marketing sales demonstration with the Brevard County, Florida, Mosquito Control District. The district's chief pilot was to fly the helicopter with the department director and the department mechanic riding along as passengers. Two specific demonstrations of the district's typical flight missions were to be conducted; personnel transport missions and the typical mosquito abatement aerial application control flight profile. The customer pilot flew Bell 206's currently in the department mission and had little experience with the MD products and none in the NOTAR anti-torque system. The pilot considered the customer pilot an experienced helicopter pilot.

The pilot completed the normal preflight planning operations consisting of the weight and balance computations and the performance capability of the helicopter. The departure gross weight was 4,050 pounds and the anticipated density altitude in the practice area was about 4,000 feet.

During preflight of the helicopter, the exceedance history of the helicopter was checked on the Quad indicator and the fault history verified on the engine instruments that record maintenance information. No exceedances were observed on the Master Caution Panel Lights. He had returned from a series of demonstrations in the helicopter in San Antonio, Texas, the day before, and reported that there were no write-ups on that flight and no open items prior to this departure.

After starting, he hovered the helicopter over to the turf landing area and gave the controls to the customer pilot, who then performed a series of hovering turns and takeoffs and landings to get familiar with the control responses and the NOTAR system. When both of the pilots were comfortable with the customer pilot's performance, they departed for the Sycamore Creek training area. In the training area, the customer pilot conducted a series of approaches to normal landings and some takeoffs. Following this, they performed a pinnacle landing, then a confined area landing. The passengers then deplaned and a fly over was made so the passengers could evaluate the noise signature of the helicopter.

After the passengers had reboarded the helicopter, the customer pilot wanted to evaluate the helicopter in the typical mosquito abatement aerial application flight profile he flies in the Bell 206. Principally the maneuver was a simulated aerial application pass followed by an aerial application type turn around. The pilot had the customer pilot conduct a thorough briefing on the maneuver until he understood exactly what the maneuver consisted of and what to expect. The helicopter gross weight was 3,900 pounds at this point, with the outside air temperature about 85 degrees, and the elevation of the creek bed approximately 1,500 feet msl.

The maneuver was very docile and consisted of a pass down the creek bed at 60 knots and 50 feet. The customer pilot initiated a gentle cyclic pull-up to a 10- to 15-degree nose up attitude while entering a right turn as the helicopter decelerated. At the 90-degree point in the turn, the helicopter was at 40 to 50 knots with a 30-degree or less bank angle to the right. As the nose came around in the turn, the nose tucked down to about 20 degrees below the horizon. The customer pilot did not appear to put any corrective cyclic input into the controls and the pilot took over the controls. He added near full aft cyclic to level the nose; at this point, he received a low rotor warning horn (indicating a rotor droop at 95 percent or lower). Coincident with the low rotor warning, the helicopter began a right yaw rate. He added full left pedal, but the yaw rate continued at what he described as a "slow pedal turn rate," eventually completing 4 to 6 complete revolutions. The pilot said he believes that the left pedal application had an effect on slowing the yaw rate.

At this point the helicopter began descending and he added collective. He immediately got a "power" audio warning, indicating that he was exceeding the upper power limit of the engine. The right yaw rate also increased with collective input. The pilot then modulated the collective between the low rotor warning and the excessive power warning in an attempt to both control the yaw (he still had full left pedal input in) and stop the descent. As he lowered the collective and the rotor speed began to build, the yaw would slow, but the helicopter then began descending faster. As he added collective to slow the descent, the yaw rate would increase. As the helicopter neared the ground, the yaw finally stopped; however, the helicopter was translating sideways toward a berm. The helicopter touched down on the right skid against the berm and it rolled over.

The pilot said his hands were following on the controls as the customer pilot flew, and he did not perceive any unusual control inputs. He further stated that his feet were about 1 inch from the anti-torque pedals and he did not feel any inputs from the customer pilot on the pedals.

Based on his extensive flight test experience in this helicopter, he believes that the aft cyclic input to correct the nose down pitching moment induced a rotor droop, and that the droop was the initiating event in the yaw rate onset. He was too occupied to look at the gages and does not know how low the rotor speed went. The warning is triggered at 95 percent Nr, and this is checked during each run-up before takeoff; it functioned correctly on the run-up at the factory pad before departure. The lower limit of the Nr green arc is at 90 percent.

The NOTAR anti-torque control system uses air from a pedal controlled jet thruster nozzle on the end of the tail boom to provide anti-torque control. Additional yaw control is provided by vertical stabilizers, which are largely effective only above 20 to 30 knots. Air is supplied to the thruster by a fan driven by a power takeoff shaft from the main transmission. There is a direct relationship between the speed of the main rotor and the speed of the fan. The pilot said he believes that the initial yaw onset was because the rotor drooped low enough to slow the fan below the speed which could supply the necessary air volume to the thruster to control the yaw and they were not fast enough to have any aerodynamic effect from the vertical stabilizers. Once again he stated that the left pedal input did have an effect on slowing the yaw rate, but there was just not enough air volume to fully control the yaw.

1.2 Customer Pilot's Statement

The customer pilot stated his concurrence with the MD Helicopters company pilot's statement up to the point where the helicopter began the aerial application turn. The customer pilot said his recollection was that at the 90-degree point, the nose tucked down, and the right yaw rate began immediately. He was certain that the tuck and the right yaw were simultaneous events. He said he put in nearly full aft cyclic and considerable left pedal to counteract both the tuck and the yaw rate onset, but without success in regaining control. The helicopter completed three revolutions at a slow yaw rate he estimated at 5 or 6 seconds per 90 degrees. It was at this point that the company pilot took control of the helicopter and he fully relinquished the flight controls. Near the end of the third revolution, the yaw rate had almost stopped when he saw the company pilot apply collective control. At this time, the helicopter began to spin to the right at a very fast rate that continued to ground impact. The helicopter spun 2 to 4 times. When the company pilot applied the collective, they all heard the female voice warning announce "power," and they also heard a warning horn during the spin. The rate of rotation during this second series of rotations never slowed and the helicopter hit the ground in this spin, and then rolled slowly over.

After the occupants had extricated themselves from the wreckage, the customer pilot asked the pilot what had happened. He replied to them that he didn't know what happened and added, "Maybe we should have turned to the left instead."

2.0 PERSONNEL INFORMATION

2.1 MD Helicopters Company Demonstration Pilot

According to Federal Aviation Administration (FAA) airman and medical certification records, the pilot held a commercial pilot certificate with a category rating for rotorcraft-helicopters and an instrument helicopter rating. His certificate also was endorsed for private privileges in airplanes single engine land. He also held a flight instructor certificate for helicopters. The pilot's most recent second-class medical certificate was issued without limitations on September 28, 2000.

The pilot is a former US Army rotorcraft aviator with 21 years on active duty in various flight assignments. During his time in the Army, the pilot accrued several thousand hours in various helicopter types including the OH-58, the UH-1 series, the AH-64, and the OH-6. According to the pilot and MD Helicopters company records, the pilot had accrued a total time in rotorcraft of 9,100 hours, with about 370 in the model 600N. The pilot's total experience as a flight instructor was given as 5,000 hours, with 100 hours of dual instruction given in the model 600N.

The pilot reported that his duties with the company consisted of customer demonstration flights, production test flights, and some research and development test flights.

2.2 Customer Pilot

The customer pilot was the chief pilot with the Brevard County, Florida, Mosquito Control District. According to FAA airman and medical certification records, the pilot held an airline transport pilot certificate with category ratings for rotorcraft-helicopters and airplanes single and multiengine land. His certificate was endorsed with a type rating in the Bell 206 helicopter. He also held a flight instructor certificate for helicopters and airplanes single and multiengine land, and instruments for both airplanes and helicopters. The pilot's most recent first-class medical certificate was issued on October 9, 2000, with the limitation that correcting lenses be worn while exercising the privileges of his airman certificates.

According to the customer pilot's statement, his total flight experience consists of 5,300 hours, of which 3,000 were accrued in helicopters with 2,500 total hours in agricultural application mission flights. The pilot did not have any prior experience with NOTAR anti-torque control system equipped helicopters.

3.0 AIRCRAFT INFORMATION

The model 600N helicopter, serial number RN057 was owned and operated by MD Helicopters, Inc., under a Special Airworthiness Certificate in the Experimental category for the purposes of research and development, show regulatory compliance, and for market survey flights. A copy of the airworthiness certificate and the accompanying operating limitation letter is contained in the docket for this accident. Review of the helicopter's maintenance logbooks, the maintenance work orders from MD Helicopters, and, the flight department engineering flight test record sheets disclosed that it had accrued a total time in service of 361 hours. The most recent 100-hour/annual inspection was completed on April 13, 2001, 47 hours prior to the accident. At the time of departure on the accident flight, there were no unresolved maintenance discrepancies.

3.2 DESCRIPTION OF THE 500N HELICOPTER AND THE NOTAR SYSTEM

3.2.1 General

The MD Helicopters, Inc., 520N helicopter is a single piloted, five place, turbine powered, skid configured, rotary-wing aircraft constructed primarily of aluminum alloy, while the tailboom and thruster are primarily constructed of graphite composite. The main rotor is a fully articulated, five-bladed system, with antitorque and directional control provided by the NOTAR system. The NOTAR system is a design in which helicopter anti-torque and directional control is markedly different than conventionally designed tail rotor configured helicopters.

The NOTAR system comprises the following subsystems: a NOTAR fan assembly; a circulation control tailboom; a direct-jet variable thruster assembly at the end of the tailboom; and two vertical stabilizers affixed to a horizontal stabilizer in an H-tail configuration.

Power from the Allison Model 250-C20R turbine engine is transmitted through the main drive shaft to the main rotor transmission, through an intermediate drive shaft to the NOTAR fan transmission, and through a NOTAR fan drive shaft to the NOTAR fan assembly. The NOTAR fan drive system also includes the fan support shaft and the fan support bearing. The NOTAR fan transmission increases the input shaft speed to a constant operating speed of 5,388 revolutions per minute (rpm) to drive the NOTAR fan assembly.

The NOTAR fan assembly provides for an air circulation control system within the tail boom that is designed to function as an anti-torque device. The high volume, high pressure air is directed tangentially downward through two rows of four horizontal slots along the right side of the tail boom and mixes with main rotor downwash, accelerating the resulting attached boundary layer flow over the curved contour of the tailboom (referred to as the Coanda effect). The accelerated flow creates a low-pressure region that results in right, lateral lift to provide some anti-torque moment, the remainder of which is provided by the direct-jet variable thruster.

The direct-jet variable thruster assembly and the vertical stabilizers provide additional anti-torque moment, and directional control of the helicopter. The direct-jet variable thruster uses NOTAR fan pressurized air, exiting through nozzles on either side of the tail boom, to provide directional control. The direct-jet thruster provides all of the required directional control for hover and low speed flight. The fully moving, left vertical stabilizer provides directional control of the helicopter in forward flight where the control surface can produce lateral lift, unloading the requirement for directional control from the direct-jet variable thruster. The fully moving, right vertical stabilizer is controlled by the Yaw Stability Augmentation System (YSAS), which is designed to enhance the flying qualities of the helicopter in forward flight. The aircraft is capable of controlled flight with the YSAS disabled.

According to MDHI, the effective translational lift speed is 17 knots.

3.2.2 Mechanical Control of the NOTAR System

Conventional directional control pedals at the pilot and copilot stations work through a bellcrank splitter assembly to simultaneously control the collective blade angles of the NOTAR fan assembly, the direct-jet variable thruster, and the left vertical stabilizer. Push-pull tubes transmit directional pedal control displacement from the splitter assembly to the NOTAR fan blade pitch change mechanism. The pitch change mechanism ensures all of the thirteen NOTAR fan blades collectively change by the same amount of commanded pitch.

The longest push-pull tube, the aft tube assembly, is installed through the center of the rotating NOTAR fan drive system. The aft tube assembly does not rotate, and it is restrained at both ends. The forward end of the aft tube assembly is fitted with a 2.0 in. splined shaft that is free to slide axially through a splined tube support installed on the front housing of the NOTAR fan transmission assembly. To connect the aft tube assembly to the directional control system aft of the splitter assembly, a clevis end is screwed into the forward end of the tube once it is installed. The aft end of the aft tube assembly is fitted with a 2.5 in. threaded shaft that is fixed to the NOTAR fan blade pitch change mechanism with a retaining nut. A pitch slider and a pitch plate bearing, installed as part of the NOTAR fan drive system and connecting the NOTAR fan blade pitch change mechanism, is designed to rotationally isolate the aft tube assembly from the NOTAR fan drive system.

Airflow into the tailboom is increased as the directional control pedals are displaced right or left from the neutral position, or minimum commanded airflow. This increased tailboom airflow exits from the direct-jet variable thruster assembly. The splitter assembly also transmits the directional pedal control inputs to the direct-jet variable thruster and the left vertical stabilizer by a three-part cable.

3.3 Warning system operation

The engine and rotor are protected by warning lights and audible horn tones and computer voice enunciations at both the upper and lower limits of normal operation.

The Nr (rotor speed) gage green arc lower limit is at 90 percent and the upper limit is 106.4 percent. When the rotor speed decreases to 95 percent, the engine out light illuminates and an audible horn warning sounds; these warnings will continue until the rotor speed increases above 95 percent.

The engine torque gage is marked with a green arc over a range from zero to 530, with a yellow arc from 530 to 600. A red triangle denotes the maximum transient high limit of 660. A warning light will be triggered on at 600 and a computer generated female voice will announce "POWER".

Normal engine speed (N1) is defined between the low arc point of 55 percent and the high point of 105 percent. A warning light and horn are triggered when the speed values fall below

55 percent, while values above 105 percent cause a warning light to illuminate.

3.4 Nr Speed versus Yaw Authority

Since the NOTAR fan is driven by the main rotor system transmission, Safety Board investigators requested information from MD Helicopters concerning the point in the rotor speed envelope where the fan speed would fall below the value necessary to maintain an adequate airflow in the tailboom to maintain full yaw authority. Engineering personnel from the company reported in a letter dated April 30, 2002, that a thorough search of the available engineering and certification flight test data revealed that specific test data to answer this request did not exist. The letter noted that all the available engineering and flight test data was for the powered flight condition between 99 and 100 percent Nr, which is considered the "safe operating envelope of the aircraft." Investigators then pointed out that the Nr gage green arc is marked from 90 to 106.5 percent and inquired about this apparent discrepancy between what MD Helicopters considered the "safe operating envelope" and the gage marking. The company could offer no explanation. The letter notes that in addition to the powered condition "safe envelope" (99 to 100 percent Nr), there is a range of 106.5 to 86 percent "that covers controllability of the aircraft to allow the pilot to recover to the 99 to 100 percent range." The letter states that this "...indicate[s] that the aircraft systems are not compromised and control of the aircraft is possible [down to 86 percent Nr]." It further states that, "It must be emphasized that the 'control' in this range is not for continued flight, but only for recovery or autorotation." As an added note, the letter points out that during high altitude development testing, rotor speeds below the lower limit (86 percent) were experienced during some maneuvers and, "although sluggish, the aircraft was controllable and recovery was performed without incident."

Review of certification flight test reports and interviews with the FAA pilot who flew some of the certification flights revealed that yaw authority was demonstrated in certification flight tests in sideward flight to 17 knots, with demonstrations to as high as 50 knots with some yaw authority maintained.

3.5 Rotorcraft Flight Manual Cautionary Notes

Page 4-24 of the FAA approved Rotorcraft Flight Manual (RFM) contains several warnings about low speed maneuvering, and begins with, "Avoid extreme aircraft attitudes and maneuvers at low speeds."

Under the heading "Unanticipated Right Yaw", the RFM section notes that an unanticipated right yaw can occur when operating at low altitude and airspeeds below 60 knots when a pilot's attention is distracted by events outside the helicopter and sufficient control inputs are not made to adjust for changing aerodynamic conditions. The paragraph states, "If no directional or cyclic control inputs are made, a nose down pitch and a right roll may follow the right yaw." The section notes that this is most likely to occur at speeds below 60 knots in uncoordinated right turns, while flying out of trim with too much right pedal, or right turns to a downwind condition.

4.0 METEOROLOGICAL INFORMATION

The pilot reported that the sky was clear and the winds calm during the flight. At the practice area, he noted that the outside outside air temperature was about 85 degrees, which was the number used during the preflight performance calculations. He estimated that the resultant approximate density altitude was 3,600 feet.

5.0 WRECKAGE AND IMPACT

With the Safety Board's concurrence, MD Helicopters, Inc., recovered the wreckage from the accident site and stored the helicopter at their Mesa, Arizona, factory facility pending examination by investigators. Detailed photographs were taken of the wreckage and all critical control system positions prior to movement. Selected photographs are contained in the docket for this accident.

6.0 TESTS AND RESEARCH

6.1 Wreckage Examination

Safety Board investigators examined the wreckage on October 16, 2001, at the MD Helicopters facility in Mesa. Comparison of the site photographs with the wreckage prior to examination revealed no changes.

Examination of the control system revealed that the anti-torque system's intermediate control tube was fractured and separated at the FS 95 bell crank; the fracture was on the forward end of the tube at the end of the threaded rod end. Bend deformation was evident to the tube on either side of the fracture. The fracture face was characterized by 45-degree shear lips and a granular appearance. The aft end of the tube remained connected to the FS 113 splitter assembly. Binding was noted in the movement of the tube from the splitter to the fan blade pitch control rod bell crank and clevis at FS 127. The bulkhead on which the bell crank and clevis were mounted was visually deformed. When fan blade pitch change rod end was disconnected from the bell crank, the upper rod exhibited free movement and the blade pitch change rod also moved without binding.

Anti-torque system continuity was established from the FS 113 splitter to the FS 168.2 quick disconnect between the forward cable and the center cable. Some binding was noted in the cable movement; however, when a distorted cover tube was removed, the cable and the FS 113 splitter moved freely.

The tail boom was separated from the fuselage and fractured into three major sections. The center cable could not be moved in it's sleeve; however, it was observed that the cable housing was trapped and pinched in a fracture of the composite tail boom. Once the sleeve was freed from the fracture, the inner cable moved freely from the FS 168.2 quick disconnect fitting to the FS 273 bell crank. The composite mounting structure for the rear telescoping sleeve was broken from the inner boom mounting point. The FS 273 bell crank moved freely and moved the rods and the sector control pulley for the rear cable. The rotating jet thruster nozzle could not be moved; however, the entire area was longitudinally compressed and distorted. The nozzle was removed to expose the underlying pulleys and the rear cable. The rear cable was routed around the pulleys and was free to move. The rods and bell cranks between the sector control and the FS 273 bell crank were intact and functional.

The cyclic controls were examined from the cockpit control sticks to the swash plate, with continuity established. The controls moved freely throughout their range of motion. Several pitch change links between the rotating swash plate and the blade pitch horns were noted to be fractured, with bend deformation evident to the rods. In each case, the rod fractures were at the rod ends in the threaded area. The fracture faces exhibited 45-degree shear lips and a granular appearance.

NOTAR fan blades were found at a 31 degree pitch setting.

6.2 Data Recovery From Electronic Engine Monitoring Unit

The airplane was equipped with a module which records exceedances of normal values in several systems for maintenance tracking purposes. The unit was found to have retained data, which was subsequently downloaded. The unit does not time or date stamp the data recorded, with no way to determine the interaction of the recorded parameters during the exceedances.

The unit recorded a torque exceedance above 108 percent that lasted 2.2 seconds. The maximum torque value recorded was 144 percent.

The data for engine MGT temperature showed a 19.78-second exceedance above the transient limit of 906 degrees C, with a peak value recorded at 1,026.8 degrees C. A 22.94-second exceedance above the running limit of 779 degrees C was recorded, with a peak value reached of 1,25.8 degrees C.

7.0 ADDITIONAL INFORMATION

The wreckage was released to the owner at the conclusion of the examinations on October 16, 2001. No components were retained.

Flight instructor Information

Certificate:	Commercial; Flight instructor	**Age:**	40,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	
Instrument Rating(s):	Helicopter	**Second Pilot Present:**	Yes
Instructor Rating(s):	Helicopter	**Toxicology Performed:**	No
Medical Certification:	Class 2 Valid Medical--no waivers/lim.	**Last FAA Medical Exam:**	September 28, 2000
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	February 18, 2000
Flight Time:	9100 hours (Total, all aircraft), 369 hours (Total, this make and model), 8800 hours (Pilot In Command, all aircraft), 137 hours (Last 90 days, all aircraft), 47 hours (Last 30 days, all aircraft), 1 hours (Last 24 hours, all aircraft)		

Pilot Information

Certificate:	Airline transport; Flight instructor	**Age:**	33,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:**	Yes
Instructor Rating(s):	Airplane multi-engine; Airplane single-engine; Instrument helicopter	**Toxicology Performed:**	No
Medical Certification:	Class 1 Valid Medical--w/ waivers/lim	**Last FAA Medical Exam:**	October 1, 2000
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	March 1, 2001
Flight Time:	5300 hours (Total, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	MD HELICOPTERS, INC.	**Registration:**	N70457
Model/Series:	600N	**Aircraft Category:**	Helicopter
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Experimental (Special)	**Serial Number:**	RN057
Landing Gear Type:	Skid	**Seats:**	6
Date/Type of Last Inspection:	April 13, 2001 Annual	**Certified Max Gross Wt.:**	4100 lbs
Time Since Last Inspection:	47 Hrs	**Engines:**	1 Turbo shaft
Airframe Total Time:	361.2 Hrs at time of accident	**Engine Manufacturer:**	Rolls-Royce
ELT:	Not installed	**Engine Model/Series:**	250-C47M
Registered Owner:		**Rated Power:**	800 Horsepower
Operator:		**Operating Certificate(s) Held:**	None

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	FFZ,1394 ft msl	**Distance from Accident Site:**	10 Nautical Miles
Observation Time:	07:47 Local	**Direction from Accident Site:**	210°
Lowest Cloud Condition:	Clear	**Visibility**	50 miles
Lowest Ceiling:	Broken / 10000 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.01 inches Hg	**Temperature/Dew Point:**	
Precipitation and Obscuration:			
Departure Point:	Falcon Field, AZ (FFZ)	**Type of Flight Plan Filed:**	Company VFR
Destination:		**Type of Clearance:**	None
Departure Time:	07:45 Local	**Type of Airspace:**	Class G

Airport Information

Airport:	Falcon Field FFZ	**Runway Surface Type:**	
Airport Elevation:	1394 ft msl	**Runway Surface Condition:**	Unknown
Runway Used:		**IFR Approach:**	None
Runway Length/Width:		**VFR Approach/Landing:**	None

Wreckage and Impact Information

Crew Injuries:	1 Minor, 1 None	**Aircraft Damage:**	Substantial
Passenger Injuries:	2 Minor	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	3 Minor, 1 None	**Latitude, Longitude:**	33.583332,-111.666664

Administrative Information

Investigator In Charge (IIC):	Rich, Jefferey
Additional Participating Persons:	Dean Hennies; Federal Aviation Administration; Scottsdale, AZ John Hobby; MD Helicopters, Inc.; Mesa, AZ
Original Publish Date:	February 5, 2004
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=53038