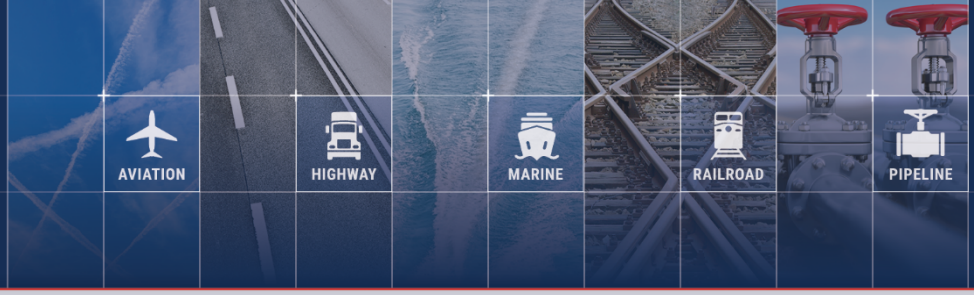

Aviation Investigation Final Report

Location:	San Elizario, Texas	**Accident Number:**	DFW07GA119
Date & Time:	May 22, 2007, 08:38 Local	**Registration:**	N851BP
Aircraft:	Eurocopter AS 350 B3	**Aircraft Damage:**	Destroyed
Defining Event:		**Injuries:**	1 Fatal, 1 Serious
Flight Conducted Under:	Public aircraft		

Analysis

The helicopter was reported to have been maneuvering at a low airspeed at an altitude of approximately 150 feet above the ground while on a patrol flight near an international border. Local authorities reported that the helicopter impacted a parked pickup truck in a nose-low attitude while in a right turn, coming to rest on its right side. Witnesses said that the helicopter "appeared to dip the nose-down and enter a spin to the right nearly straight down. One witness added that the helicopter appeared to have recovered from the spin and initiated a climb before it began to spin to the right again, impacting the ground in a near-vertical attitude. Other witnesses added that the engine appeared to be "screaming." A witness, who reported having experience as a helicopter mechanic, added that the engine was screaming, but that the rotor system sounded as though it was slowing down. One witness stated it sounded like it was sucking or chopping air. The recorded weather near the accident site was reported as winds from 260 degrees at 12 knots, visibility 10 statute miles, clear skies, temperature 23 degrees Celsius, dew point 1 degree Celsius, and a barometric pressure of 29.94 inches of Mercury. Density Altitude was computed to be 5,433 feet MSL, No discrepancies or pre-existing anomalies were found with the helicopter or the engine that could have precluded normal flight. A performance study was conducted to determine the controllability and maneuvering capabilities while operating in the flight environment during the assigned observation mission. The study concluded that at the approximate altitude of 150 feet AGL and an airspeed of 20-30 knots, may not have allowed sufficient time or altitude for the pilot to recover after the helicopter entered a vortex ring state, A fully developed vortex ring state is characterized by an unstable condition where the helicopter experiences uncommanded pitch and roll oscillations, has little or no cyclic authority, and achieves a descent rate which, if allowed to develop, may approach 6000 feet per minute. A vortex ring state may be entered during any maneuver that places the main rotor in a condition of high upflow and low forward airspeed

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The pilot's encounter with a vortex ring state and his inability to maintain control of the helicopter.

Findings

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

Findings
1. (C) VORTEX RING STATE - ENCOUNTERED - PILOT IN COMMAND
2. (C) AIRCRAFT CONTROL - NOT POSSIBLE - PILOT IN COMMAND

Occurrence #2: IN FLIGHT COLLISION WITH OBJECT
Phase of Operation: DESCENT - UNCONTROLLED

Findings
3. OBJECT - VEHICLE

Factual Information

History of Flight

On May 22, 2007 at 0838 mountain daylight time, a single-engine Eurocopter, AS350-B3 turbo-shaft helicopter, N851BP, registered to and operated by the U.S. Customs and Border Protection (CBP) Air Operations, was destroyed when it impacted terrain following a loss of control while maneuvering at approximately 150- above ground level and an airspeed between 20 to 30 knots on a routine border patrol mission near San Elizario, Texas, approximately 15 miles southeast of the El Paso International Airport. The accident occurred 1.8 hours in to the flight. The commercial pilot sustained fatal injuries and his non-rated observer was seriously injured. Visual meteorological conditions prevailed, and a company visual flight rules flight plan was filed for the local flight conducted as a Public Use Flight under 14 Code of Federal Regulations Part 91. The flight departed El Paso International Airport (KELP), near El Paso, Texas, at approximately 0655.

Local authorities reported that the helicopter impacted a parked pickup truck in a nose-low attitude while in a right turn, coming to rest on its right side in a residential area. There were no reported injuries to anyone on the ground. Emergency medical services personnel removed the pilot and observer from the cockpit and transported them to a local hospital.

Following the documentation of the wreckage, the helicopter was recovered to a secured facility at Biggs Army Airfield, near El Paso, Texas, for a detailed examination. The engine, transmission, and flight control hydraulic servos were removed and shipped to laboratory facilities for testing and/or teardown examination along with other drive train components.

Damage to Aircraft

Several witnesses were interviewed during the field portion of the investigation. Most witnesses concluded that the helicopter "appeared to dip the nose-down and enter a spin to the right nearly straight down. One witness stated that the helicopter appeared to have recovered from the spin and initiated a climb before it began to spin to the right again and impacted the ground in a near-vertical attitude. Other witnesses added that the engine appeared to be "screaming." Another witness, who reported having experience as a helicopter mechanic, added that the engine was screaming, but that the rotor system sounded as though it was slowing down. One witness stated it sounded like it was sucking or chopping air.

Injuries to Persons

The air transport rated pilot was killed. The observer sustained critical injuries.

Other Damage

A 1978 GMC pickup truck that was parked at the rear of the residence was destroyed. As the aircraft impacted the vehicle, the right skid of the helicopter struck the cab roof causing the top to collapse across the width of the body. The truck bed showed collision damage on both the forward end of the driver's side and aft end of the passenger's side. The tail gate was cut along its width when the helicopter's main rotor struck the vehicle, and it was found hanging from the vehicle's frame.

Personnel Information

The pilot held an Airline Transport Pilot certificate with single engine airplane, multi-engine airplane, helicopter, and instrument ratings. He joined the U.S. Customs and Border Patrol (CBP) Air and Marine in 1991 where he was assigned to the New York Air Unit and the Puerto Rico Air Operations Branch before transferring to the El Paso Air Branch in the summer of 1996. While at the El Paso Air Branch, the pilot received training in, and was eventually endorsed to fly the AS350-B3 aircraft as Pilot-In-Command. The pilot had accumulated a total of 3919 flight hours, of which 173 hours was in CBP AS350 aircraft.

Initial AS350 training for the pilot was conducted at the University of North Dakota, UND Aerospace, Grand Forks, North Dakota and completed on July 31, 1998. During that year, the pilot logged 19.7 hours of which 1.5 hours were as PIC. From 1999 until late 2003, the pilot accumulated an additional 11.2 hours in the AS350 with 4 hours as PIC. From 2003-2004, no records were discovered indicating the pilot had flown any additional AS350 hours. The next indication of flight time was in 2005 when he logged 22.6 hours as Second-In-Command. From January 01, 2006 to the accident in May 2007, the pilot amassed an additional 121 hours of which 62.7 hours were as PIC. On December 19, 2006, the pilot started AS350-B3 initial transition training at HeliStream located in southern California. On January 5, 2007 in El Paso, the AIA started CBP AS350-B3 transition training and completed said training on February 6, 2007. On February 28, 2007, the pilot was designated as a pilot in command and maintenance test pilot. All training and check rides were completed with satisfactory marks with no derogatory comments. CBP initial training and check ride were completed by the same instructor.

The Border Patrol Agent Observer joined CBP on February 23, 2003 and upon completing his academy training was assigned to the El Paso Sector in August 2003. In 2007, the agent volunteered as an observer with the Air and Marine program and was assigned flight duties as a Qualified Observer in May 2007. The Observer held a private pilot certificate for single engine land airplanes.

Aircraft Information

N851BP, serial number 3588, was purchased by U.S. Customs and Border Protection in April 2003 from American Eurocopter, Grand Prairie, TX. According to records, the aircraft was

maintained in accordance with the manufacturer's recommended procedures. Documentation indicated that the last major maintenance was performed May 18, 2007 by El Paso Aero, Inc., a licensed, FAA-certified repair facility. The maintenance was a 100-hour airframe inspection in accordance with the US CBP Inspection Program and AS350-B3 Master Service Recommendations. Maintenance procedures were completed with no discrepancies noted.

N851BP had a Turbomeca Arriel 2B1 engine producing 848 horsepower that was installed on the aircraft 941.9 hours prior to the accident. The engine had 941.9 total hours and the airframe had 3843.8 hours. Work cards for the aircraft showed that there were no major discrepancies outstanding on the airframe prior to departure and that all major Airworthiness Directives had been complied with.

Weight and balance calculations confirmed that the aircraft was within maximum weight allowances and within center of gravity limits at the time of departure. The aircraft was fueled with approximately 100 gallons of Jet A making the aircraft weight approximately 4357 pounds at time of takeoff. After flying for 1.8 hours, at the estimated time of impact, the aircraft would have weighed 3709.9 pounds and the Center of Gravity would have been 130.7 inches aft of datum.

Meteorological Information

At 0851 MDT, the weather reporting facility at the El Paso International Airport (KELP) reported wind from 260 degrees at 12 knots, visibility 10 statute miles, clear skies, temperature 23 degrees Celsius, dew point 1 degree Celsius, and a barometric pressure of 29.94 inches of Mercury. Density Altitude was computed to be 5433 feet MSL, Pressure Altitude 3941 feet based on these conditions and a terrain level of 3645 feet MSL at the accident site.

Flight Recorders

No flight recorders were installed on this helicopter.

Wreckage and Impact Information

The fuselage came to rest on its right side in the back yard of a residence, adjacent to a parked truck. A large portion of the tailboom had separated and came to rest on the bed of the truck. Rotational damage consistent with the size and dimensions of the tail rotor strike tabs was observed on the left side of the truck.

A detailed examination of the wreckage was conducted at Biggs Army Airfield, El Paso, Texas. Impact damage to cabin and fuselage, deformation of the transmission deck and displacement of the main transmission, as well as deformation of the energy attenuating seats evidenced a right side impact.

The blue and red star arms of the Starflex rotor head were fractured approximately mid-span at

45-degree angles. The yellow star arm was broken inward of the star arm bushing and exhibited broom straw of the composite fibers. All three blade sleeves exhibited impact damage. All three rotor blades exhibited impact damage on the leading edges; trailing edge splitting and chord wise bending was also observed.

The engine to transmission drive shaft separated at the transmission input flex coupling. The main transmission input flex coupling shattered and exhibited splaying.

Two of the three transmission input flange bolts remained attached with portions of the flex coupling still attached. The linking tube exhibited rotational scoring.

The main transmission appeared in good condition, but did not rotate at the recovery site; it was retained for further examination. Three of the four transmission support bars were separated and exhibited angular fracture surfaces.

The rotor brake and fuel cutoff levers were found in the forward/stowed position. The hydraulic cutoff switch was in the on (normal/guarded) position; the upper surface of the guard was broken. The collective(s) was found in a nearly full up position; the cyclic(s) was in a right lateral input position; anti-torque pedals were found with left pedal input (forward). Main rotor control continuity was confirmed; all hardware was found intact.

The hydraulic system pump and pulley assembly with black poly-v belt was intact. The hydraulic reservoir contained fluid. The 3-micron hydraulic filter clogging indicator, which is designed to extend at a delta pressure of 2.7 bars (39.16 psi), was found extended. A hydraulic fluid sample was taken by CBP and sent to the U.S. Army for analysis. Test results revealed the sample contained higher than PPM level of water and possibly hydraulic fluids mixed with MIL-23699. The hydraulic servos were retained for further examination at the manufacturer's facility. The hydraulic pump was disassembled; the spline coupling was amply lubricated and in good condition.

The tail rotor drive shaft output flex coupling was separated and splayed; all three output flange bolts remained attached with portions of flex coupling still attached. The tailboom, pitch change control tube, and tail rotor drive shaft were separated adjacent to the most forward hanger bearing, and exhibited angular fracture surfaces. The tailboom, pitch change control tube, and tail rotor drive shaft were separated again just forward of the horizontal stabilizer, and exhibited angular fracture surfaces.

The right horizontal stabilizer exhibited impact damage in an aft and downward direction (right side impact). The tail cone and vertical fin exhibited compression on the left side (consistent with impact on the right side). The aft portion of the tail rotor drive shaft rotated with corresponding rotation of the tail rotor, confirming rotational tail rotor continuity and continuity of the tail rotor gear box. The aft portion of the pitch change control tube extended and retracted with corresponding movement of the tail rotor pitch links, confirming pitch change control continuity from the separation point aft. Both tail rotor paddles exhibited rotational

impact damage and damage to the strike tabs. One tail rotor paddle was fractured at the root, and both paddles exhibited bending or setting inward (compression on the inboard/left face).

The airframe fuel filter was clean with no debris.

Medical and Pathological Information

An autopsy was performed by the County of El Paso Office of the Medical Examiner and Forensic Laboratory, and issued on May 23, 2007 listing the cause of death was due to blunt force trauma. No abnormalities were found in the blood toxicology report.

Fire

There was no in flight or post crash fire.

Survival Aspects

The right side of the fuselage and cockpit were crushed. The living space of the cockpit was compromised, causing fatal injuries to the pilot and serious injuries to the observer. The lateral impact forces caused both crew seats to tear from their floor mounts along with the shearing of the seat belt retention rings fastened to the seatbelt floor mounting plates.

Search & rescue, evacuations

Tests and Research

The Vehicle & Engine Multifunction Display (VEMD) was removed and sent to France for examination by the Bureau d'Enquêtes et d'Analyses (BEA). Both memories of the VEMD were unsoldered and raw data stored inside were retrieved. No failures or overlimits were recorded during the accident flight. The flight report for the accident flight was not completed.

The main transmission was examined on May 31, 2007, at the American Eurocopter facility, Grand Prairie, Texas. Upon initial examination, it was noted that damage had caused the rotor brake to become engaged and prevented the transmission from turning. Disengagement of the rotor brake allowed the transmission to rotate freely in both clockwise and counterclockwise directions. An external inspection was performed; then the main transmission assembly was disassembled and internal components inspected. No anomalies were noted.

The single channel digital engine control unit (DECU), part number 70BMB01020, serial number 1099, was removed from the wreckage and returned to Turbomeca USA, Grand Prairie, Texas, for downloading and analysis of the stored data. Nine discrepancies occurred, but only eight were recorded. The discrepancies recorded cannot occur together in flight. Since the discrepancies recorded by the DECU could not occur together in flight, they were determined to be the result of the accident itself.

The engine was examined at Turbomeca USA on 12 June 2007. The engine could not be

rotated by hand. The right side of the gas generator case was dented and crushed inward. The pipes and electrical harness on the right side of the engine were crushed. The linking tube was dented at the rear mount. The right side of the exhaust duct was bent and buckled. The Adjusted Pump and Metering Valve Assembly (Hydro-mechanical Metering Unit, HMU) was damaged at the aircraft throttle connection. The power turbine was seized and approximately one quarter of the blades exhibited discoloration. The axial compressor was seized and all axial compressor blades exhibited blade tip rub and discoloration. Eight axial compressor blades exhibited foreign object damage (FOD). Rotational scaring was noted on the engine drive shaft forward nut and lock. The splined shaft exhibited smearing at the forward edges. The magnetic plugs, chip detectors, strainers, and filters were clean. The oil filter clogging indicator was clear, indicating that the oil filter was not in by-pass, the fuel filter clogging indicator was red, indicating that the fuel filter was in by-pass. The engine was disassembled into five modules. Rotation was confirmed for each rotating assembly. The module 5 input pinion gear nut was misaligned by 4mm, indicating an over-torque event had occurred. Rotational scarring was noted on the engine drive shaft, compressors, high pressure turbine, and power turbine.

The Adjusted Pump and Metering Valve Assembly (Hydro-Mechanical Metering Unit - HMU) was tested on the test bench at Turbomeca USA on 12 June 2007. Due to impact damage to the throttle connection body, limited testing of the HMU was conducted. When installed on the test bench, the HMU was found to be in automatic flight mode. The tests performed indicated that the fuel flow was at or slightly below new or overhauled specification. During examination of the HMU, a sleeve in the P3 body assembly appeared to be installed incorrectly according to documentation in the component maintenance manual. It was later learned that the sleeve was installed correctly and that the documentation was incorrect. The HMU was packaged and shipped to the BEA for further testing at Turbomeca France.

The HMU was tested with BEA oversight on the test bench at Turbomeca France on 29 August 2007. The test revealed fuel flow in the automatic mode and no discrepancies that could explain the event. The acceleration limiter test was performed after replacement of the damaged throttle connection. The test revealed no discrepancies.
The hydraulic servos were examined at Hawker Pacific, Burbank, California. No anomalies were found on the right lateral or fore/aft servos. The left lateral main rotor servo exhibited an extruded piston seal and corresponding servo sleeve bulging. The servo assembly was sent to the servo manufacturer in France for further examination and analysis under the supervision of the BEA. It was determined that the anomaly was not pre-existing and was a result of overpressure of the servo during the impact.
Main drive shaft (engine-transmission drive), flex couplings, and drive shaft coupling tube were examined by the materials laboratory at the NTSB. All damage was consistent with impact. No evidence of fatigue or other preexisting damage was observed. Damage to the main drive coupling tube was located only at the upper half of the housing, which is consistent with impact damage.

The wiring harness that connects the collective pitch potentiometer to the DECU was removed,

documented, and sent to Eurocopter France for examination. No anomalies were discovered.

A study was conducted using Regulatory Performance Data, Section 5-6, OGE hovering flight performance in the AS350-B3 Flight Manual, and the Federal Aviation Administration Rotorcraft Flying Handbook, chapter 11 Helicopter Emergencies section 11-4 Height/Velocity Diagram and Section 11-5 Vortex Ring State (Settling With Power), to determine the controllability and maneuvering capabilities while operating in the flight environment conducted during the assigned observation mission. Figure 11-2 (height/velocity diagram) on page 11-5 of the Rotorcraft Flying Handbook depicts that the approximate altitude,150 feet AGL, and airspeed, 20-30 knots, may not have allowed sufficient time or altitude to enter a stabilized autorotative descent. This diagram is consistent with the charts and calculations analyzed in the AS350-B3 Flight manual, Section 5-6. The Rotorcraft Flying Handbook, chapter 11, Section 11-5 states: "…when the helicopter begins to descend vertically, it settles into its own downwash, which greatly enlarges the tip vortices. In this vortex ring state, most of the power developed by the engine is wasted in accelerating the air in a doughnut pattern around the rotor. In addition, the helicopter may descend at a rate that exceeds the normal downward induced-flow rate of the inner blade sections. As a result, the airflow of the inner blade sections is upward relative to the disc. This produces a secondary vortex ring in addition to the normal tip-vortices. The secondary vortex ring is generated about the point on the blade where the airflow changes from up to down. The result is an unsteady turbulent flow over a large area of the disc. Rotor efficiency is lost even though power is still being supplied from the engine. A fully developed vortex ring state is characterized by an unstable condition where the helicopter experiences uncommanded pitch and roll oscillations, has little or no cyclic authority, and achieves a descent rate, which, if allowed to develop, may approach 6,000 feet per minute. It is accompanied by increased levels of vibration. A vortex ring state may be entered during any maneuver that places the main rotor in a condition of high upflow and low forward airspeed. This condition is sometimes seen during quick-stop type maneuvers or during recoveries from autorotations. The following combination of conditions are likely to cause settling in a vortex ring state: 1. A vertical or nearly vertical descent of at least 300 feet per minute. (Actual critical rate depends on the gross weight, rpm, density altitude, and other pertinent factors.) 2. The rotor system must be using some of the available engine power (from 20 to 100 percent). 3. The horizontal velocity must be slower than effective translational lift."

Additional Information

The aircraft was released to US Customs and Border Patrol.

Pilot Information

Certificate:	Airline transport; Commercial	**Age:**	46,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):	Airplane single-engine	**Toxicology Performed:**	No
Medical Certification:	Class 1 Without waivers/limitations	**Last FAA Medical Exam:**	February 28, 2007
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	February 6, 2007
Flight Time:	5526 hours (Total, all aircraft), 173 hours (Total, this make and model), 3947 hours (Pilot In Command, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Eurocopter	**Registration:**	N851BP
Model/Series:	AS 350 B3	**Aircraft Category:**	Helicopter
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	3588
Landing Gear Type:	High skid	**Seats:**	6
Date/Type of Last Inspection:	May 1, 2007 100 hour	**Certified Max Gross Wt.:**	4961 lbs
Time Since Last Inspection:	42 Hrs	**Engines:**	1 Turbo shaft
Airframe Total Time:	3819 Hrs as of last inspection	**Engine Manufacturer:**	TURBOMECA
ELT:	Installed, activated, did not aid in locating accident	**Engine Model/Series:**	ARRIEL 2B1
Registered Owner:	US BORDER PATROL AIR OPERATIONS	**Rated Power:**	747 Horsepower
Operator:	US BORDER PATROL AIR OPERATIONS	**Operating Certificate(s) Held:**	None
Operator Does Business As:	US Border Patrol Air Operations	**Operator Designator Code:**	

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	KELP,3958 ft msl	**Distance from Accident Site:**	15 Nautical Miles
Observation Time:	08:51 Local	**Direction from Accident Site:**	300°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	12 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	260°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.94 inches Hg	**Temperature/Dew Point:**	23°C / 1°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	El Paso, TX (KELP)	**Type of Flight Plan Filed:**	Company VFR
Destination:		**Type of Clearance:**	None
Departure Time:	06:55 Local	**Type of Airspace:**	

Wreckage and Impact Information

Crew Injuries:	1 Fatal, 1 Serious	**Aircraft Damage:**	Destroyed
Passenger Injuries:	N/A	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Fatal, 1 Serious	**Latitude, Longitude:**	31.579166,-106.284446(est)

Administrative Information

Investigator In Charge (IIC):	Gamble, William
Additional Participating Persons:	Bryan Hanson; FAA; Albuquerque „ NM Archie Whitten; Turbomeca; Grand Prairie, TX Lindsay Cunningham; American Eurocopter; Grand Prairie, TX Eric Hausner; CBP Air; Billingham, WA
Original Publish Date:	December 28, 2008
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=65826