Aviation Investigation Final Report

Location:	Fallon, Nevada	**Accident Number:**	WPR14GA281
Date & Time:	July 3, 2014, 17:15 Local	**Registration:**	N832PA
Aircraft:	AMERICAN EUROCOPTER CORP AS350B3	**Aircraft Damage:**	Substantial
Defining Event:	Loss of tail rotor effectiveness	**Injuries:**	1 Minor
Flight Conducted Under:	Part 133: Rotorcraft ext. load		

Analysis

The pilot was positioning the helicopter with an external load into a mountain supply drop zone located along a barren ridge at an elevation of about 8,600 feet mean sea level (msl). The helicopter had completed numerous drops that day; however, the accident drop was the first since the drop zone had been moved about 100 yards downslope, on the leeward side of the ridge. The helicopter was using a 100-foot long line with a 972-pound external load. According to the pilot, as the helicopter approached the drop zone and the load was about 10 ft above the ground, the helicopter started swaying left and right, suddenly dropped in altitude, and began rotating counterclockwise. The pilot attempted to stop the uncommanded left yaw with right pedal input; he also increased collective to stop the sudden loss of altitude. The pilot set the load down and attempted to release it; however, the long line did not completely release from the hook assembly, most likely due to the helicopter's rotation. The helicopter continued to rotate to the left and descend, despite the pilot's continued application of right pedal and collective. It landed hard and rolled over onto its right side, resulting in substantial damage. The engine could be heard winding down, and a small fire erupted out of the engine compartment. Ground personnel assisted the pilot's egress, and the fire extinguished itself. No preaccident malfunctions or anomalies were identified with the helicopter, and the engine had been operating at maximum power during the accident sequence.

Wind observations taken by the ground crew on scene showed surface wind speeds between 5 and 15 knots from the southwest to west at the time of the accident. The wind just above the surface, however, was likely gusting between 5 and 25 knots as a result of an unstable atmospheric layer between the surface and 25,000 feet msl. As the wind flowed down the leeward side of the ridge, the air followed the contour of the terrain and became increasingly turbulent, resulting in downward pressure and reverse wind flow (eddy). The irregular wind conditions, high operating altitude, and the high-power, low airspeed state of the helicopter, were conducive to the development of a loss of tail rotor effectiveness, which subsequently resulted in a loss of directional control.

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, which resulted in an uncontrolled rotation and descent into terrain. Contributing to the accident was a sudden shift in wind conditions and the helicopter's high power demand condition due to its load weight and operating altitude.

Findings

Aircraft	Yaw control - Attain/maintain not possible
Aircraft	Descent rate - Attain/maintain not possible
Environmental issues	High elevation - Effect on operation
Environmental issues	Sudden wind shift - Effect on operation
Aircraft	Maximum weight - Related operating info

Factual Information

History of Flight

Maneuvering-hover	External load event (Rotorcraft)
Maneuvering-hover	Loss of control in flight
Maneuvering-hover	Loss of tail rotor effectiveness (Defining event)

On July 3, 2014, at 1715 Pacific daylight time, an American Eurocopter Corp. helicopter, AS350B3, N832PA, landed hard and rolled over on a mountain ridge 54 miles east of Fallon, Nevada. The pilot received minor injuries, and the helicopter was substantially damaged. The helicopter was registered to Zuni LLC, and operated by Papillon Grand Canyon Helicopters as a public-use aircraft under an exclusive contract to the Bureau of Land Management. Visual meteorological conditions prevailed at the time of the accident, and a local flight plan had been filed.

The pilot reported that he was positioning the helicopter with an external load into a mountain supply drop zone located along a mountain ridge at an elevation of 8,600 feet mean sea level (msl). As the helicopter approached the drop zone, and the load was about 10 feet above the ground, the helicopter's nose yawed left and descended. The pilot set the load down, but the helicopter continued to rotate to the left. While rotating to the left, the helicopter descended, landed hard, and rolled over.

Witnesses stated that the helicopter was about 200 feet above ground level (agl) with an external load attached to a 100 foot long line as it made its approach to the drop area. When the load was about 50 feet above the ground the helicopter started swaying left and right, suddenly dropped vertically about 20 feet, and then began to rotate clockwise (as viewed from the ground). When the load touched the ground the rotation accelerated, the helicopter landed hard, rotor blades impacted the ground and fragmented, and the helicopter rolled over on its right side. The engine could be heard winding down, and a small fire erupted out of the engine compartment. The ground personnel assisted the pilot's egress out of the cockpit. The fire extinguished its self.

The pilot had made seven external load drops at a location along the ridge line that had been designated as H1. The drop location was moved about 100 yards down slope on the leeward side of the ridge for the final loads. The accident occurred during the first drop at the revised location.

Pilot Information

Certificate:	Commercial; Flight instructor	**Age:**	51,Male
Airplane Rating(s):	None	**Seat Occupied:**	Left
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	3-point
Instrument Rating(s):	None	**Second Pilot Present:**	No
Instructor Rating(s):	Helicopter	**Toxicology Performed:**	No
Medical Certification:	Class 2 With waivers/limitations	**Last FAA Medical Exam:**	January 7, 2014
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	April 17, 2014
Flight Time:	9565 hours (Total, all aircraft), 319 hours (Total, this make and model), 9473 hours (Pilot In Command, all aircraft), 125 hours (Last 90 days, all aircraft), 26 hours (Last 30 days, all aircraft), 5 hours (Last 24 hours, all aircraft)		

The pilot, age 51, held a commercial pilot certificate with a rotorcraft-helicopter rating issued March 30, 2004, and a flight instructor certificate with a helicopter rating issued on December 3, 2009. He held a second-class medical certificate issued January 7, 2014, with the limitation that he wear corrective lenses. The pilot reported on the NTSB Pilot/Operator Accident Report that he had 9,585 hours of flight time, 319 hours in the accident helicopter make and model, and had accumulated 20 hours with in the previous 30 days. Pilot training records provided by the operator document that the pilot's most recent FAR part 135 flight check was conducted on April 17, 2014, flown in an AS350B3e.

Aircraft and Owner/Operator Information

Aircraft Make:	AMERICAN EUROCOPTER CORP	**Registration:**	N832PA
Model/Series:	AS350B3 B2	**Aircraft Category:**	Helicopter
Year of Manufacture:	2012	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	7307
Landing Gear Type:	Skid	**Seats:**	6
Date/Type of Last Inspection:	April 27, 2014 100 hour	**Certified Max Gross Wt.:**	5225 lbs
Time Since Last Inspection:		**Engines:**	1 Turbo shaft
Airframe Total Time:	874.9 Hrs at time of accident	**Engine Manufacturer:**	Turbomeca
ELT:	C126 installed, activated, did not aid in locating accident	**Engine Model/Series:**	Arriel 2D
Registered Owner:	ZUNI LLC	**Rated Power:**	950 Horsepower
Operator:	Papillon Grand Canyon Helicopters	**Operating Certificate(s) Held:**	Rotorcraft external load (133), Commuter air carrier (135), On-demand air taxi (135), Commercial air tour (136), Agricultural aircraft (137)

The six-seat, single engine, conventionally configured helicopter, serial number 7307, was equipped with skid type landing gear and was manufactured in 2012. It was powered by a Turbomeca Arriel 2D, 950-hp engine, serial number 50051. It was equipped with a digital external load scale mounted on the flight deck below the left collective control. The pilot did not recall the load scale reading for the accident load. A review of the maintenance records showed that a 300 hour inspection was completed on April 27, 2014, at 795.5 hours total time. The most recent maintenance was a daily inspection performed on June 30, 2014. The airframe's total time was 874 hours at the time of the accident.

The pilot's own load calculation, performed at 0700 on the day of the accident, utilized the equipped weight of the helicopter of 3,148 lbs, 500 lbs of fuel, pilot weight of 200 lbs, operating at 9,000 feet msl, and OAT of 26 C, was 852 lbs maximum allowable external payload while in an out of ground effect hover (HOGE).

Technical representatives from Airbus Helicopters provided an external load capability calculation. Using an equipped weight of 3,148 lbs for the helicopter, 250 lbs of fuel, pilot weight of 200 lbs, operating at 8,600 feet mean sea level (msl) and 30 degrees C outside air temperature (OAT), the calculated maximum external load while hovering out of ground effect (HOGE) was 1,022 lbs.

The external load was broken down on-scene and each component weighed. The load was configured in a two bundle daisy chain. The total weight of the external load including the 100 foot long line and external hook was 942 lbs.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	KNFL,3934 ft msl	**Distance from Accident Site:**	54 Nautical Miles
Observation Time:	16:56 Local	**Direction from Accident Site:**	270°
Lowest Cloud Condition:	Few / 60 ft AGL	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	9 knots / 14 knots	**Turbulence Type Forecast/Actual:**	/ Unknown
Wind Direction:	300°	**Turbulence Severity Forecast/Actual:**	/ Unknown
Altimeter Setting:	29.92 inches Hg	**Temperature/Dew Point:**	37°C / -9°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Fallon, NV	**Type of Flight Plan Filed:**	Company VFR
Destination:	Fallon, NV	**Type of Clearance:**	None
Departure Time:	16:25 Local	**Type of Airspace:**	Class G

Hourly weather surface observations were recorded by the firefighting crew located at the cargo drop zone.

Weather observation at 1400 PDT; dry bulb 84 degrees F, wet bulb 53 degrees F, relative humidity (RH) 12%, wind from the south/southwest at 10 mph, 15-20 mph gusts.

Weather observation at 1500 PDT; dry bulb 84 degrees F, wet bulb 51 degrees F, RH less than 10%, wind from the south at 10 mph gusts to 20 mph.

Weather observation at 1600 PDT; dry bulb 79 degrees F, wet bulb 53 degrees F, RH 12%, wind from the southwest 10-25 mph.

Weather observation at 1700 PDT; dry bulb 80 degrees F, wet bulb 54 degrees F, RH 13%, wind from the south-southwest 3-5 mph with 10 mph gusts.

The closest official weather surface station was at Fallon, NV (KNFL), about 54 miles west of the accident site.

Fallon weather observation at 1756 PDT; wind from 310 degrees at 7 knots, 10 miles visibility, few clouds at 6,000 feet agl, temperature 37 degrees Celsius, dew point temperature -8 degrees Celsius, altimeter 29.91 inHg. Remarks, sea level pressure 1010.2 hPa, temperature 36.7 degrees Celsius, dew point temperature -7.8 degrees Celsius.

Fallon weather observation at 1656 PDT; wind from 300 degrees at 9 knots with gusts to 14 knots, 10 miles visibility, few clouds at 6,000 feet agl, temperature 37 degrees Celsius, dew point temperature -9 degrees Celsius, altimeter 29.92 inHg. Remarks, sea level pressure 1010.7 hPa, temperature 36.7 degrees Celsius, dew point temperature -8.9 degrees Celsius, 6-hourly maximum temperature of 37.2 degrees

Celsius, 6-hourly minimum temperature of 31.1 degrees Celsius, 3-hourly pressure decrease of 1.7 hPa.

An upper air sounding was taken from a weather computer model for the accident site at 1700 PDT. The upper air sounding showed an unstable or conditionally unstable environment from the surface through 25,000 feet msl. These conditions in the vertical would allow for gusty winds at the accident flight level just above the ridge line and around any mountainous terrain. The wind was mainly from the west to southwest perpendicular or nearly perpendicular to the terrain, creating conditions conductive for mountain wave formation and mountain wave turbulence. The 1700 PDT weather computer weather model generated sounding, indicated that mountain wave conditions of +/- 1500 feet per minute downdrafts and updrafts, that would have been likely near the ridgeline or leeward of the ridgeline at 10,000 feet msl.

WRECKAGE & IMPACT INFORMATION

The main wreckage was positioned on a barren hill top and examined by personnel from the Bureau of Land Management (BLM) and US Department of Interior Office of Aviation Services. The helicopter was positioned on its right side. The right main landing skid had bent and separated from the right side at the upper cross tube. The right horizontal stabilizer was bent in an "L" shape against the ground. The tail boom had separated about 12 inches forward of the tail rotor gear box. Both tail rotor blades had separated from the tail rotor hub, and both pitch links remained attached to the hub. The tail rotor blades were located about 300 feet from the helicopter, and both blades exhibited damage consistent with ground impact. The 3 main rotor blades remained attached to the rotor hub and all displayed ground impact damage. The tail boom was creased where it attaches to the airframe. The area of the airframe below the engine deck and the engine cowling were discolored black consistent with soot production. The cargo long line had been released by the external cargo hook. The helicopter wreckage was recovered and transported to a facility in Phoenix, AZ.

A full airframe and engine examination was performed on July 24, 2014, by the NTSB Investigator-in-Charge (IIC), and technical representatives from Airbus Helicopters, Turbomeca, Papillon Grand Canyon Helicopters, BLM, and DOI. The aircraft was configured for single pilot controls (left side) only. The seat had an attached company made extended arm rest, extending out from the left side. The aircraft also had cargo mirrors. The entire cabin area structure was mostly intact. The left forward door was removed for the flight operation and left sliding door was locked open. The right hand skid was broken and separated from the cross tubes; the left skid remained attached. The aircraft was equipped with an Onboard Systems Cargo Hook sling external load STC (supplemental type certificate). Fuel cut off handle was in the OFF pulled positing. The hydraulic isolation switch (on the collative) was in the on (forward) position. The start switch was ON, and the EBCAU (engine backup control ancillary unit) switch remained guarded. The ACCU TEST was OFF (out) and guarded. The pilot's seat (forward left) did not exhibit any energy stroke attenuation. All the seats appeared to have a 4-point harness system.

The instrument panel was intact and no electrical power was applied to the helicopter during the examination. A Spot tracking device and Garmin 496 were located in the cockpit. The VEMD (vehicle engine management display) and Vision 1000 flight data recorder were removed on site and retained by the NTSB for further investigation. The Vision 1000 electrical continuity was confirmed by the investigative team from the circuit breakers panel to the power plug of the vision 1000 unit, using a multi-meter.

Flight control continuity was confirmed from the cockpit input device to the flight control systems at the main rotor servos and tail rotor servos. The anti-torque control pedals were positioned with the right pedal forward, and could not be moved. Pressure in the tail rotor servo accumulator was released by the investigative team, which freed the tail rotor pedals to move. Both ends of the tail rotor control flex ball cable remained attached to their bell cranks. The collective was loose and free to move partially jammed from the broken controls at the main rotor's servo push pull rods. The cyclic was loose and free to move partially jammed from the broken controls at the main rotor's servo push pull rods.

Both hydraulic pumps remained attached to the transmission and operated normally when turned through by hand. Both Hydraulic regulator valve unit's clogging indicators were extended. The filters were removed and clean red hydraulic fluid was observed; with a small amount of light gray residue on the top of the right hand regulator valve's filter head. Continuity through the transmission was observed as the main rotor was turned through by hand. All three main rotor blades were broken with signatures of power to the outboard sections; and all three star-flex arms were broken. The transmission was separated from the airframe and sat on top of the transmission deck partial attached by control rods. The transmission to engine drive shaft was separated at the flex coupling on the transmission side and remained attached to the engine spline/free wheel shaft.

The tail section was separated just forward of the tail rotor gear box and partially attached by the tail rotor push pull rod and tail rotor drive shaft which had been cut by the retrieval team. The chip detector was clean from any debris. Both tail rotor blades were separated from the hub, and exhibited power on impact damage. The tail rotor blades were not present at the wreckage examination, however they were observed by the initial responding investigative personal. The tail rotor drive shaft was separated at the spline coupling on the aft side of the forward steel "short" shaft.

The Arriel 2D engine and cowling had sustained thermal damage resulting from a post crash fire on the left side. The engine cowling was removed. The air intake bell mouth had been broken away from the axial compressor casing bolts but was still in the general location. The free turbine blades were shed and the bolts between the gas generator and free turbine had sheared as a result. The containment shield was deformed and there were some small punctures in the exhaust pipe but all the shed blades had been contained. Proper freewheel operation was confirmed. The flector group between the transmission shaft and transmission was broken consistent with a main rotor strike with power. The reduction gearbox (module 5) was removed to examine the input pinion alignment mark. The mark was found misaligned in the tightening direction approximately 2mm consentient with the engine providing power at the time of a main rotor strike. All magnetic plugs were checked with no significant findings. The gas generator could not be turned by hand. The axial compressor showed signs of FOD and forward curling of the blades consistent with gas generator operation during and after the impact. The reduction gearbox could not be turned by hand. The engine data recorder (EDR) was removed, sealed in a box, and shipped to Turbomeca USA for further examination.

Wreckage and Impact Information

Crew Injuries:	1 Minor	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Minor	**Latitude, Longitude:**	39.374443,-117.780281

Tests and Research

On August 28, 2014, under the oversight of the NTSB IIC, the EDR was removed from the sealed box, and the engine data downloaded. The EDR contained the continuous recording of the last 50 hours of engine parameters recorded at 1 hertz. The data revealed that the engine power check (EPC) performed the previous flight was with in normal parameters. The power-on time indicated that the accident flight was 91 minutes long. At 16 seconds from the end of recorded data, a steady rise of the collective over a 7 second period was observed, accompanied by the right antitorque pedal moving beyond 70 percent, N1 (gas generator turbine) accelerated to 102.5 percent, fuel flow increased to 222 liters per hour (LPh), and the N2 (main rotor rpm) begins to droop. At 11 seconds before the end of recorded data the main rotor rpm was at its lowest value, 378 rpm. One second before the end of recorded data a fault is detected that is consistent with the main rotor striking the ground.

Additional Information

Wind Conditions in Mountainous Terrain

Chapter 11 of the FAA Pilot's Handbook of Aeronautical Knowledge describes the effects of obstructions on wind. "While the wind flows smoothly up the windward side of the mountain and the upward currents help to carry an aircraft over the peak of the mountain, the wind on the leeward side does not act in a similar manner. As the air flows down the leeward side of the mountain, the air follows the contour of the terrain and is increasingly turbulent. This tends to push an aircraft into the side of a mountain. The stronger the wind, the greater the downward pressure and turbulence become. Due to the effect terrain has on the wind in valleys or canyons, downdrafts can be severe."

Loss of Tail Rotor Effectiveness (LTE)

Chapter 11 of the FAA Rotorcraft Flying Handbook discusses the loss of tail rotor effectiveness phenomena. "The required tail rotor thrust is modified by the effects of the 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 has 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."

"At higher altitudes, where the air is thinner, tail rotor thrust and efficiency is reduced. When operating at high altitudes and high gross weights, especially while hovering, the tail rotor thrust may not be sufficient to maintain directional control and LTE can occur. In this case, the hovering ceiling is limited by tail rotor thrust and not necessarily power available. In these conditions gross weights need to be reduced and/or operations need to be limited to lower density altitudes."

"This alteration of tail rotor thrust can be affected by numerous external factors. The main factors contributing to LTE are:

1. Airflow and downdraft generated by the main rotor blades interfering with the airflow entering the tail rotor assembly.
2. Main rotor blade vortices developed at the main blade tips entering the tail rotor.
3. Turbulence and other natural phenomena affecting the airflow surrounding the tail rotor.
4. A high power setting, hence large main rotor pitch angle, induces considerable main rotor blade downwash and hence more turbulence than when the helicopter is in a low power condition.
5. A slow forward airspeed, typically at speeds where translational lift and translational thrust are in the process of change and airflow around the tail rotor will vary in direction and speed.
6. The airflow relative to the helicopter;
a. Worst case – relative wind within ± 15° of the 2 o'clock position (for clockwise turning main rotor), generating vortices that can blow directly into the tail rotor. This is dictated by the characteristics of helicopters aerodynamics of tailboom position, tail rotor size and position relative to the main rotor and vertical stabilizer, size and shape.
b. Weathercock stability – tailwinds from 120° to 240°
c. Tail rotor vortex ring state (030° to 150° for clockwise rotating main rotors with the tail rotor on the right side of the helicopter). Winds within this region result in the development of vortex ring state of the tail rotor."

Administrative Information

Investigator In Charge (IIC):	McKenny, Van
Additional Participating Persons:	Donald F Morgan; FAA; Reno, NV Federic Aime; BEA John E Becker; Papillion Airways; Las Vegas, NV John Waddell; US Dept of Interior; Boise, ID Bryan Bitting; Bureau of Land Management; Boise, ID Krik Rothwell; Bureau of Land Management; Boise , ID
Original Publish Date:	September 12, 2016
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=89605