

Class A Accident
November 23, 2012
Eurocopter AS-350B3 (2B1) Helicopter
N3984A
Newfield, Arizona

Tucson Air Branch



Accident Report
CBP Case Number 20121124ZC0001
NTSB Case Number WPR13GA051



**U.S. Customs and
Border Protection**



U.S. Customs and Border Protection Office of Air and Marine

Aircraft Accident Report

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Acronyms and Abbreviations

AIA	Air Interdiction Agent
AOH	Aviation Operations Handbook
AOR	Area of Responsibility
BPA	Border Patrol Agent
CBP	U.S. Customs and Border Protection
CDO	Command Duty Officer
DAO	Director of Air Operations
DMA	Davis Monthan Air Force Base
DoD	Department of Defense
FAA	Federal Aviation Administration
HFACS	Human Factors Analysis and Classification System
MST	Mountain Standard Time
NATC	National Air Training Center
Nr	Main Rotor Speed (100% = 385±5 rpm on the ground)
OAM	Office of Air and Marine
PIC	Pilot In Command

Executive Summary

On November 23, 2012, a U.S. Customs and Border Protection (CBP) Pilot in Command (PIC) was assigned to conduct a patrol along the Southwest Border aboard an AS-350B32B1, registered as N3984A, and in use by the Tucson Air Branch. Approximately one hour after departure, the PIC was requested to assist Border Patrol agents (BPAs) and a team in the vicinity of the San Miguel gate area close to the law enforcement center. BPAs had discovered suspected contraband and requested assistance to search for additional bundles and potentially three groups of an unknown size for which they were tracking foot-sign. After about 45 minutes without results, the pilot departed the area.

A short time later the pilot decided to take a lunch break and landed in a confined area approximately two miles north of the border along his intended search track. Upon touching down, the pilot performed a stability check with the cyclic and then lowered the collective to the full down position. At this time, with the Nr at 100%, the pilot added cyclic and collective friction (without engaging the collective lock) to prevent the controls from moving inadvertently while he took his lunch from a bag located just aft and to the right of his seat against the door.

The PIC then proceeded to retrieve his lunch bag from behind his seat. He then opened the lunch bag and retrieved the small container of chili to place on the vacant passenger seat beside him. After placing the container on the passenger seat he used two hands to seal the lunch bag and replace it behind the seat while guarding the cyclic with his legs (momentarily losing situational awareness while distracted). While replacing the lunch bag, the PIC felt the nose of the aircraft begin to get light on the skids with a slight pitch upward.

The PIC quickly reacted and placed his hands back on the controls, then added forward cyclic to correct for the nose pitch increase to ensure positive skid contact with the ground. Within seconds, the aircraft began to exhibit vertical dynamic oscillations that continued to resonate and worsen. The PIC then made a positive collective application to lift the aircraft off the ground and regain aircraft stability.

As the aircraft lifted, it lurched forward and downward in an unusually nose-low attitude, resulting in the lower wire strike blade contacting the ground, establishing a pivot point. The PIC reacted with an aggressive aft cyclic movement with a positive collective input to arrest the nose down attitude. This resulted in the tail skid contacting the ground and pushing the vertical fin and tail gearbox upward, severing the tail rotor driveshaft forward of the tail gearbox. The aircraft tail bounced upward from the impact, which momentarily placed the aircraft in a five foot hover followed immediately by an uncommanded left yaw (spin) around the nose for which the PIC experienced no tail rotor

control. The aircraft continued to spin to the left until the PIC made a simultaneous reduction in collective and left cyclic application to arrest the spin. The aircraft landed in a nose up attitude with a slight aft drift compressing the ground resonance straps prior to settling on the skids. Upon landing, the PIC performed an emergency engine shutdown and exited the aircraft through the PIC side door once the rotor blades had stopped. Following his egress, the PIC noticed the aft section of the tail boom was severed and the tail rotor was missing.

The Assistant Commissioner, Office of Air and Marine (OAM) has determined that the most probable cause of this accident was:

- The PIC failed to perform a coordinated vertical ascent to a stabilized hover following his reaction to vertical vibrations he perceived as the onset of ground resonance. The pilot's aggressive over-application of the flight controls caused the tail skid to impact the ground, resulting in the catastrophic failure of the tail rotor drive shaft and subsequent loss of aircraft control.

Contributing Factors:

- The PIC's decision to take a momentary break to have a snack and select a landing zone (confined area) along his route of flight. (contributory)
- The PIC's landing site selection had numerous potholes and cattle hoof prints in dried mud that was hardened like cement. After numerous interviews with the pilot and his description of the vibrations encountered during the accident sequence, it is conceivable that at least one, if not both, ground resonance straps were in a pothole depression and not in contact with the ground at the time the aircraft nose pitched-up and initial cyclic movement took place. This would have exacerbated the pitch change of the aircraft nose. (contributory)
- After landing, the PIC did not bring the aircraft to idle before taking his hands off the controls to reach behind him. (contributory)
- The pilot momentarily lost situational awareness while his attention was diverted inside the cockpit with his hands off of the controls. (contributory)

Recommendations:

1. Conduct thorough post-mishap evaluation of the PIC to include review of Ground Resonance causes/mitigation measures (i.e. securing the aircraft before taking hands off the controls) and landing zone selection.

2. Brief rotary wing pilots and crews on Situational Awareness and the hazards associated with diverting attention to tasks inside the cockpit and aircraft control without properly configuring the aircraft (e.g., control locks applied, throttle - idle).
3. Establish national policy for Appareo Vision 1000 Camera System operation and tampering. (complete)

1 Factual Information

1.1 History of Flight

On November 23, 2012, a CBP pilot was assigned to conduct a patrol along the southwest border aboard an AS-350B32B1, registered as N3984A (Omaha 84A), and in use by the Tucson Air Branch.

At approximately 10:00 a.m. Mountain Standard Time (MST), the pilot arrived at work and conducted the requisite preflight planning for the assigned mission and filed a risk assessment with the command duty officer (CDO) located at the Tucson Air Branch. At approximately 11:30 a.m. (MST) the PIC conducted a preflight inspection of the aircraft.

At approximately 12:08 p.m. (MST), the pilot of N3984A departed on the assigned patrol to the Casa Grande area of responsibility (AOR). Visual flight rules conditions were reported on take-off with gusty winds forecast. At approximately 12:10 p.m. (MST) Omaha 84A was requested to assist BPAs (C483) in the vicinity of one half mile south of Little Church. The grid coordinates to this location were as follows: N31 53.44 W111 46.78. BPA C483 was looking for a group of six that the MSS had on screen 30 minutes prior to the aircraft arriving on scene. BPA C483 and team were on all-terrain vehicles. Once the aircraft arrived on scene, the group hid in the immediate vicinity of the grid coordinates provided. BPA C483 and team apprehended five of the illegal aliens; however, one individual was unaccounted for.

At approximately 1:15 p.m. (MST) Omaha 84A was requested to assist BPA (A161) and team in the vicinity of the San Miguel gate area close to the law enforcement center. BPA (A161) and company had found approximately seven bundles of suspected marijuana and requested assistance searching for additional bundles and potentially three groups of an unknown size for which they were tracking foot-sign. After about 45 minutes without results, the pilot departed the area.

At approximately 2:00 p.m. (MST) the pilot decided to take a lunch break. At approximately 2:10 p.m. (MST) a confined area was chosen. The pilot conducted a high/low recon and, based on strength of the winds (approximately 10 knots from the east), executed an approach to a high hover followed by a vertical landing to the confined area on an approximate magnetic heading of 040 degrees. The selected location had numerous potholes and cattle hoof prints in dried mud that was hardened like cement. The pilot could not recall where the exact point of landing was in relation to the pothole depressions near the initial location of the aircraft in the landing zone.

Upon touchdown, the pilot performed a stability check with the cyclic and then lowered the collective to the full down position. At this time, with the Nr at 100%, the pilot added cyclic and collective friction (without engaging the collective lock) to prevent the controls from moving inadvertently while he gathered his lunch from a bag located just aft and to the right of his seat against the door.

The PIC then used his left hand to guard the cyclic and his right hand to retrieve his lunch bag. He then opened the lunch bag and retrieved the small container of chili to place on the vacant passenger seat beside him. The PIC then placed the container of chili on the passenger seat. He then let go of the cyclic with his left hand and, while guarding the cyclic with his legs, used two hands to seal the lunch bag and replace it behind the seat. It was at this time that he felt the nose of the aircraft begin to get light on the skids with a slight pitch upward. The pilot quickly placed his hands back on the controls and then added forward cyclic to correct for the slight nose pitch increase to ensure positive skid contact with the ground. Within seconds, the aircraft began to exhibit vertical dynamic oscillations that continued to resonate and worsen. The pilot then made a positive collective application to lift the aircraft off the ground and regain aircraft stability.

As the aircraft lifted, it lurched forward and downward in an unusually nose-low attitude resulting in the lower wire strike blade contacting the ground, establishing a pivot point. The pilot made an aggressive aft cyclic movement with a positive collective input to arrest the nose down attitude. This resulted in the tail skid contacting the ground and pushing the vertical fin and tail gearbox upward, severing the tail rotor driveshaft forward of the tail gearbox. The aircraft tail bounced upward from the impact, which momentarily placed the aircraft in a five-foot hover followed immediately by an uncommanded left yaw (spin) around the nose for which the pilot experienced no tail rotor control. The aircraft continued to spin to the left until the pilot made a simultaneous reduction in collective and left cyclic application to arrest the spin. The aircraft landed in a nose up attitude with a slight aft drift compressing the ground resonance straps prior to settling on the skids.

Upon landing the PIC performed an emergency engine shutdown and exited the aircraft through the pilot side door once the rotor blades had stopped. Following his egress, the pilot noticed the aft section of the tail boom was severed and the tail rotor was missing. The pilot then attempted to make cell phone contact with the Tucson Air Branch radio room to inform personnel of what happened but was unsuccessful due to poor cell phone coverage. The pilot then used his portable handheld radio (Motorola) and contacted BP Sector (860) to relay the situation to the Tucson Air Branch. BP Sector (860) made the telephonic notification to the Tucson Air Branch Operations Duty Officer at approximately 2:25 p.m. (MST), advising the branch of the downed aircraft and dispatching BPAs in the vicinity to assist as required. The CDO at the Tucson Air Branch initiated the branch mishap plan and diverted another aircraft on patrol to the accident location.

At approximately 3:00 p.m. (MST) the branch mishap plan execution/notifications were completed.

1.2 Injuries to Persons

The PIC sustained a minor back injury requiring out-patient treatment. The injuries involved back strain/muscular discomfort and did not require hospital stay beyond the initial outpatient treatment. The investigator is not aware of any permanent disability as a result of this accident.

Injuries	Crew	Passengers	Others	Total
Fatal	0	0	0	0
Serious	0	0	0	0
Minor	1	0	0	1
None	0	0	0	0
Total	1	0	0	1

1.3 Damage to Aircraft

On December 5, 2012, a damage assessment team from American Eurocopter, Inc. (AEC) conducted the original damage assessment. The results were as follows:

The AEC team did not find any additional structural damage beyond the items that had previously been photographed. Below is an initial assessment of the damage to the airframe based upon [AEC's] cursory visual inspection (without any disassembly) that was performed on December 4, 2012:

- Tail cone (aft fuselage)- evidence of wrinkles in the skin, tail boom - scrapped,
- Vertical fins- scrapped,
- Tail rotor drive train (entire)- scrapped
- Tail rotor blades and pitch change spider assembly - scrapped
- Right Hand landing gear spring- bent upwards - scrapped,
- Lower wire strike- bent - scrapped
- The engine produces a grinding noise that is heard when the engine is rotated.

It is recommended the entire airframe, main rotor, and main gearbox (MGB) drive train be subjected to a hard landing inspection. AMM 05-50-00,6-5b.

- Optional equipment and components involved in a hard landing. AMM 05-50-00,6-25
- Tail rotor blade impact inspection AMM05-50-00,6-7

This information was preliminary based on a visual inspection. Turbomeca USA will be able to provide further assessment of the engine once it has a chance to examine the engine in detail.

On December 7, 2012, the NTSB Investigator in Charge issued the release of wreckage back to OAM.

On January 2, 2013, the representative from Turbomeca USA responded with an initial estimated repair cost of \$437,756.96 to \$698,313.22 for the overhaul of the engine assembly, bringing the total estimated repair cost (airframe and powerplant) to approximately \$825,000.



Figure 1. Damage to Tail Section (1)



Figure 2. Damage to Tail Section (2)



Figure 3. Marks on T/R Drive Shaft Cover from Gearbox deflection upward



Figure 4. Damage to Tail Rotor (1)



Figure 5. Damage to Tail Rotor (2)

1.4 Other Damage

There was approximately one cup of mineral oil that leaked onto the site from the tail gearbox reservoir post incident. No other damage occurred.

1.5 Personnel Information

1.5.1 Pilot in Command (PIC)

The PIC, age 32, holds a Commercial Pilot Certificate with rotorcraft-helicopter, and instrument helicopter ratings, and a second class medical certificate. His last medical exam was in March 2012.

The PIC's last Annual Proficiency Evaluation was conducted at the Tucson Air Branch. All tasks were completed successfully on May 27, 2012. The Tucson Air Branch Rotary Wing Standardization Flight Evaluator (R/W SFE) conducted this evaluation.

The PIC entered on duty at CBP on September 12, 2008, as an Air Interdiction Agent at the Buffalo Air Branch, where he completed his AS-350 Initial Qualification. The PIC has logged approximately 2,240 hours of total flight time with approximately 687 hours accumulated in the AS-350.

The PIC has an accumulated total flight time of 2,240 hours to date. That time includes:

- 1,900 hours as a Pilot in Command
- 655 hours as a PIC in the AS-350 helicopter
- 430 hours of night/night vision goggles time in the AS-350 helicopter

The PIC's recent flight time is depicted in the matrix below:

	Past 30 Days	Past 60 Days	Past 90 Days
AS-350	40.2	50.3	70.8
UH-60A/L	2.2	6.5	7.5
OH-58C (AZARNG)	16.1	16.1	17.1
Total Flight Time	58.5	72.9	95.4

Prior to reporting for duty on the day of the mishap, the PIC had completed an off duty period of 17 hours.

1.5.2 Second in Command

N/A

1.5.3 Pilot's Recent History

Based on the post-accident interview, the PIC's schedule the day prior to the accident date began at 9:00 a.m. and ended at 5:00 p.m. (MST), flying a total of 3.3 hours, all during daylight with 3 landings. The date of the incident, the pilot began his day at 10:00 a.m. with his shift ending at 6:00 p.m. (MST). The pilot had flown approximately 1.8 hours prior to the accident. The pilot was on the third of week of the day shift at the time. Fatigue was not a factor in the accident.

1.6 Maintenance History

The helicopter's home station is the Tucson Air Branch, located at Davis-Monthan Air Force Base, Tucson, Arizona. The helicopter was maintained in accordance with Federal Aviation Administration (FAA) regulations and CBP policy.

1.7 Aircraft Information

The aircraft was acquired new in 2011 for [REDACTED] and had a current net book value of [REDACTED] at the time of the accident.

The airframe total time at the time of the accident was 1,056 hours.

The aircraft was equipped with a single Turbo Shaft Engine, Turbomeca, Model 2B1, producing 543 SHP.

- Total time: 1,056 hours
- Time since last inspection: 56 hours
- Time since last overhaul: 0 hours

The aircraft was equipped with a forward-looking infrared radar (FLIR) camera that was not installed at the time of the accident.

The gross weight and center of gravity were found within the limits as stated in the Pilots Operating Handbook. The locally produced weight and balance sheet was not located in the green aircraft logbook. This was inconsistent with the other aircraft in the fleet.

1.8 Meteorological Information

Clear skies with gusty winds prevailed from the southeast and were forecast to remain so throughout the day. The temperature was approximately 84 degrees Fahrenheit (29 degrees Celsius) at the location and time of the accident.

1.9 Communications

Communications were not a factor in the mishap.

1.10 Aerodrome Information

The departure airport was Davis-Monthan Air Force Base in Tucson, Arizona. Airport facilities were not a factor in this mishap.

1.11 Airport Stops Enroute

Airport facilities were not a factor in this mishap.

1.12 Wreckage Information

Due to the remote location of the wreckage, the aircraft was relocated to a flatbed trailer via helicopter external load operations (ELO). The ELO was conducted utilizing an organic UH-60L and qualified crew. The ELO aircrew was comprised of the regional helicopter rope suspension technique/ELO Standardization Flight Evaluator (SFE) and the branch Rotary Wing (RW) SFE. In addition to the Directorate of Standardization and Evaluation (DSE)-designated ELO "master," the Tucson Air Branch provided additional (DSE)-designated ELO members on the ground to assist in the operations (additional sets of eyes on rigging, manning tag lines, positive air/ground communications and receiving ground party) at the landing site.

The accident aircraft was rigged in approximately two hours and certified by the ELO Master prior to the lift. The aircraft was then lifted/flown (Figure 6) approximately one half mile to a nearby road where it was lowered without incident to the awaiting flatbed trailer. The aircraft was then driven three hours back to the Tucson Air Branch where it was secured inside the North Hangar.



Figure 6. Aircraft Relocation for transport

On January 3, 2013, the OAM Logistics and Maintenance (L&M) Directorate, through coordination with AEC and Turbomeca USA, determined the total estimated repair cost (airframe and powerplant) at [REDACTED], with an estimated four to five months for return to service. Based on that information and the fiscal climate at the time, it was determined that the aircraft was “Beyond Economical Repair” by the Assistant Commissioner. L&M was given the approval to remove all usable parts from the helicopter for use as spares for the rest of the CBP AS-350 fleet, and to then dispose of the airframe through GSA.

1.13 Medical and Pathological Information

There was one minor injury as a result of this accident. The PIC was sufficiently rested prior to this mishap. There was no evidence the PIC was fatigued, or suffering from any human factor issues that would have adversely affected one’s ability to perform crewmember duties. No evidence of adverse medical histories or chronic or acute ailments was discovered during the course of this investigation.

1.14 Fire

No post-crash fire occurred as a result of this accident.

1.15 Survival Aspects

The aircraft was equipped with a functioning Electronic Locating Transmitter (ELT) (Artex, Model: C406N-HM) at the time of the accident. The ELT did not activate due to the vertical G-load less than the design threshold of the 6-axis switch of +10G. The actual impact forces were not measured during the investigation. The ELT is also equipped with a separate “primary” switch that is set to automatically activate the ELT in the longitudinal axis with a forward impact of +2.3G/45fps. Neither limit was achieved during the crash/landing sequence.

The accident occurred in a confined area surrounded by trees on three sides and a 10 foot berm on the west side of the landing area. The accident was a considerable distance and out of visual contact from the BPAs. Once the PIC exited the aircraft he attempted to contact the air branch via personal cell phone but was unsuccessful due to lack of sufficient cellular service. The pilot was then successful in contacting the U.S. Border Patrol sector for help via his portable Motorola tactical radio and help was dispatched to his location. Interview of the PIC revealed he was not carrying the issued Personal Locator Beacon at the time of the accident. Further interviews with the PIC and the branch Aircraft Safety Officer revealed that this was the practice for most pilots at the Tucson Air Branch since the flights were being tracked via Air and Marine Operations Center radar and the satellite tracking system at the branch.

1.16 Tests and Research

The aircraft Appareo Vision 1000 cockpit camera (Figure 7) was transported to the NTSB lab, Vehicle Recorder Division located at its headquarters in Washington, DC to recover the two non-volatile memory modules, the internal memory component and the removable standard digital card. Those tests returned negative for data associated with this accident. This was due to the camera power cable being disconnected at some point at the end of September (last recording was September 30, 2012).



Figure 7. Appareo Vision 1000 Camera

1.17 Organizational and Management Information

The flight was properly dispatched by the Command Duty Officer (CDO) and a written record was on file with the Tucson Air Branch in accordance with (IAW) the Aviation Operations Handbook (AOH).

1.18 Additional Information

Aircraft Weight and Balance Records

The FLIR ball was previously removed from the aircraft. However, corrected weight and balance data was not logged in the Pilots Operating Manual.

This finding was not contributory to the accident.

Appareo Vision 1000 Camera System

During the course of the investigation it was discovered that the Appareo Vision 1000 camera mounted inside the aircraft at the time of the accident had been unplugged. As a result, the NTSB discovered the last recording came at/near September 22, 2012, (approximately two months prior to the date of the accident). The existing recordings on the internal media card yielded no information associated with the accident flight. Had the camera been in operation, the data would have been critical to the investigation of this accident and would have answered many questions that were left to answer through other investigative methods.

In August 2012, the DDAO for the Tucson Air Branch issued guidance regarding the flight recorder for OM-84A, indicating that deliberately damaging or disabling the video system or any of its components will result in disciplinary action.

2 Analysis

2.1 General

The PIC was trained and qualified in accordance with current FAA and OAM policy and was appropriately designated by the DAO in the AS-350B3/2B1 aircraft.

The PIC was sufficiently rested prior to this mishap. There was no evidence that he was fatigued, or suffering from any human factor issues that would have adversely affected his ability to perform his duties.

The aircraft was certified, equipped, and maintained in accordance with FAA and OAM policies.

The flight was properly dispatched in accordance with the AOH and a written record was on file with the Tucson Air Branch.

The PIC arrived at work and conducted the requisite preflight planning for the assigned mission and filed a risk assessment with the CDO located at the Tucson Air Branch.

The PIC conducted the aircraft preflight on the flight line and noted two minor discrepancies with the aircraft. The first discrepancy was with a chafing oil line and the other a question regarding the tail rotor. After consulting with maintenance, both items were checked and found airworthy. The maintainer asked the PIC to log the chafing oil line discrepancy upon returning from his flight.

The PIC failed to detect that the local aircraft weight and balance sheet was not located in the book (as it usually is with the rest of the aircraft fleet at the branch). Additionally, it was discovered that the PIC failed to calculate the aircraft weight and balance prior to departure.

The PIC departed on his patrol to his assigned area of responsibility (AOR) in support of the U.S. Border Patrol along the Southwest Border Region. Visual Meteorological Conditions (VMC) was reported on take-off with gusty winds forecast throughout the day.

While enroute to his assigned AOR, the PIC was requested to assist a Border Patrol team in the vicinity of the San Miguel gate area close to the law enforcement center.

Upon arrival, the PIC assisted BPAs with sign cutting for approximately 45 minutes without results and departed the area.

At approximately two hours into his patrol, the PIC decided to take a lunch break and selected a landing zone (confined area) along his route of flight.

The PIC conducted a high/low recon and based on strength of the winds (approximately 10 knots from the east) executed an approach to a high hover followed by a vertical landing to the confined landing zone without incident. Although the landing zone that was selected was suitable, during the post-accident interviews the pilot could not recall the exact point of landing was in relation to the location of numerous potholes and cattle hoof prints in the dried mud that was hardened like cement (Figure 8). Based on that information and inspection of the landing zone, the Accident Investigation Team could not discern where the original skid marks were (in particular the ground resonance straps) from the original landing location. There were no discernible skid markings or ground scarring due to the hard surface.



Figure 8. Landing Area Selected with aircraft 115 degrees from landing heading

Upon touchdown, the PIC performed a stability check with the cyclic and then lowered the collective to the full down position. At this time, with the Nr at 100%, the PIC added cyclic and collective friction (without engaging the collective lock) to prevent the

controls from moving inadvertently while he gathered his lunch from his bag located just aft and to the right of his seat against the door.

The PIC then used his left hand to guard the cyclic and his right hand to take the lunch bag. He then opened the lunch bag and retrieved the small container of chili to place on the vacant passenger seat beside him. The PIC then placed the container of chili on the passenger seat. He then let go of the cyclic with his left hand and, while guarding the cyclic with his legs, used two hands to seal the lunch bag and replace it behind the seat (momentarily losing situational awareness while distracted). At that moment, the PIC felt the nose of the aircraft begin to get light on the skids with a slight upward pitch change.

The PIC quickly placed his hands back on the controls and then added forward cyclic to correct for the nose pitch increase to ensure positive skid contact with the ground. During this time the cyclic and collective friction were still applied (collective lock not engaged) as indicated during the post-accident interview with the PIC.

Investigator Note: After numerous interviews with the pilot and his description of the vibrations encountered during the accident sequence, it is conceivable that at least one, if not both, ground resonance straps were in a pothole depression and not in contact with the ground at the time the aircraft nose pitched-up and initial cyclic movement took place. This would have exacerbated the pitch change of the aircraft nose.

Within seconds, the aircraft began to exhibit vertical dynamic oscillations that continued to resonate and worsen. The PIC then made a positive collective application to lift the aircraft off the ground and regain aircraft stability.

As the aircraft lifted, it lurched forward and downward in an unusually nose-low attitude resulting in the lower wire strike blade contacting the ground, establishing a pivot point.

The PIC made an aggressive aft cyclic movement with a positive collective input to arrest the nose down attitude. This resulted in the tail skid contacting the ground and pushed the vertical fin and tail gearbox upward severing the tail rotor driveshaft forward of the tail gearbox.

The aircraft tail bounced upward from the impact which momentarily placed the aircraft in a five-foot hover followed immediately by an uncommanded left yaw (spin) around the nose for which the PIC experienced no tail rotor control.

The aircraft continued to spin to the left until the PIC made a simultaneous reduction in collective and left cyclic application to arrest the spin. The aircraft landed in a nose up attitude with a slight aft drift compressing the ground resonance straps prior to settling on the skids.

Upon landing the PIC performed an emergency engine shutdown and exited the aircraft through the PIC side door once the rotor blades had stopped. Following his exit the PIC noticed the aft section of the tail boom was severed and the tail rotor was missing.

The PIC then attempted to make cell phone contact with the Tucson Air Branch radio room to advise them of what happened but was unsuccessful due to poor cell phone coverage. The PIC then used his portable handheld radio (Motorola) to successfully contact Border Patrol Sector Radio to relay the situation to the Tucson Air Branch for activation of the mishap plan.

Upon notification of the downed aircraft, the CDO at the Tucson Air Branch initiated the branch mishap plan and diverted another aircraft on patrol to the accident location. Upon initial notification, the Border Patrol Sector had also dispatched BPAs in the vicinity to assist as required.

By mid-afternoon, the Tucson Air Branch had completed the execution/notifications for the mishap plan with safety and maintenance dispatched to the scene.

The pilots injuries were diagnosed as minor back strain/muscular strain and were not expected to be permanent as a result of the crash sequence.

2.2 Additional As Required

Ground Resonance Defined

Ground resonance is precipitated by a shock to the aircraft arising from excessive motion of a rotor blade in its plane of rotation thereby moving the rotor center of gravity from the axis of rotation. Inadequate damping allows the rotor center of gravity to spiral away from the rotor axis of rotation, causing the rotor to generate unbalanced rotating moments beyond the compensating ability of the damping system. In addition to damping system malfunctions mentioned above, such blade movement can occur as a result of taxiing over rough ground with the rotor turning at a speed within a susceptible range, or takeoff/landing in which a shock occurs to one side of the landing gear.

Under extreme conditions, the initial shock can cause violent oscillations that quickly build and result in catastrophic damage of the entire airframe. In some cases, complete destruction occurs, e.g. body panels, fuel tanks, and engines are torn away, even at normal rotor speed. Recovery is possible in some cases. If sufficient rotor RPM exists, immediate takeoff can restore rotor balance. If rotor RPM is low, complete shutdown may be sufficient.

3 Conclusions

3.1 Findings

- The PIC was trained and qualified in accordance with current FAA and OAM policy and was appropriately designated by the DAO in the AS-350 aircraft.
- The pilot was sufficiently rested prior to this mishap. There was no evidence that he was fatigued, or suffering from any human factor issues that would have adversely affected his ability to perform his duties.
- The flight was properly dispatched and a written record was on file with the Tucson Air Branch IAW AOH.
- The aircraft was certified, equipped, and maintained in accordance with FAA and OAM policies.
- Visual Meteorological Conditions (VMC) prevailed for the duration of the patrol with gusty winds forecast throughout the day.
- The PIC's preflight inspection was incomplete as he failed to verify the aircraft weight and balance prior to flight. He failed to detect that the local aircraft weight and balance sheet was not located in the book, and the PIC failed to calculate the aircraft weight and balance prior to departure.
- At approximately two hours into his patrol, the PIC decided to take a momentary break for lunch and selected a landing zone (confined area) along his route of flight (contributory).
- The landing zone location had numerous potholes and cattle hoof prints in dried mud that was hardened like cement. After numerous interviews with the pilot, and his description of the vibrations encountered during the accident sequence, it is conceivable that at least one, if not both, ground resonance straps were in a pothole depression and not in contact with the ground at the time the aircraft nose pitched-up and initial cyclic movement took place. This would have exacerbated the pitch change of the aircraft nose. (contributory).
- Upon touchdown, the PIC performed a stability check with the cyclic and then lowered the collective to the full down position. The PIC did not bring the aircraft to idle before taking his hands off the controls to reach behind him. (contributory)
- While the PIC retrieved the small container of chili to place on the vacant passenger seat he let go of the cyclic with his left hand and, while guarding the cyclic with his legs, used two hands to seal the lunch bag and replace it behind the seat.

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- The PIC momentarily lost situational awareness while his attention was diverted inside the cockpit with his hands off of the controls. (contributory)
 - The aircraft nose pitched-up suddenly while retrieving his snack and the PIC quickly reacted by placing his hands back on the controls and adding forward cyclic to correct for the slight nose pitch increase and ensure positive skid contact with the ground. This sudden movement placed the main rotor blades momentarily out of phase, thus inducing the vertical dynamic oscillations felt immediately following the control movement. (causal)
 - The PIC then made a positive collective application to lift the aircraft off the ground and regain aircraft stability. As the aircraft lifted, it lurched forward and downward in an unusually nose-low attitude, resulting in the lower wire strike blade contacting the ground establishing a pivot point (causal).
 - The PIC made an aggressive aft cyclic movement with a positive collective input to arrest the nose down attitude. This resulted in the tail skid contacting the ground and pushing the vertical fin and tail gearbox upward, severing the tail rotor driveshaft forward of the tail gearbox (casual).
 - The aircraft tail bounced upward from the impact, which momentarily placed the aircraft in a five foot hover followed immediately by an uncommanded left yaw (spin) around the nose for which the PIC experienced no tail rotor control.
 - The aircraft continued to spin to the left until the PIC made a simultaneous reduction in collective and left cyclic application to arrest the spin.
 - The aircraft landed in a nose up attitude with a slight aft drift compressing the ground resonance straps prior to settling on the skids.
 - Upon landing, the PIC performed an emergency engine shutdown and exited the aircraft through the PIC side door once the rotor blades had stopped.
 - Following his exit, the PIC then learned of the separation of the aft section of the tail boom and the missing tail rotor blades.
 - The PIC was unsuccessful in his attempt to contact the branch via his personal cellular phone due to poor cell phone coverage.
 - The PIC was successful in using his portable handheld radio (Motorola) to successfully contact Border Patrol Sector Radio to relay the situation to the Tucson Air Branch for activation of the mishap plan.
 - Post-accident analysis of the branch mishap plan procedures revealed that the branch Aviation Safety Officer had recently rehearsed the mishap plan and through lessons learned the execution was exceptional.
 - Post-accident analysis of the pilots egress sequence suggests that although the PIC had conducted a thorough landing zone reconnaissance prior to landing,

his was actually poor due to both the uneven terrain features as well as the inaccessibility of the location. The location had little to no radio reception and nearby ground units could not see the aircraft below the tree line surrounding the landing zone. This complicated the mishap notification process and eliminated the possibility of telephonic notification.

- The pilots injuries were diagnosed as minor back strain/muscular strain and were not expected to be permanent as a result of the crash sequence.
- Post-accident investigation and NTSB lab results revealed the Appareo Vision 1000 Camera had been disconnected for approximately two months prior to the accident despite internal guidance from the DDAO that anyone found tampering with it would face disciplinary action.

3.2 Probable Cause

The Assistant Commissioner, OAM has determined that the most probable cause of this accident was:

- The PIC failed to perform a coordinated vertical ascent to a stabilized hover following his reaction to vertical vibrations he perceived as the onset of ground resonance. The pilot's aggressive over-application of the flight controls caused the tail skid to impact the ground resulting in the catastrophic failure of the tail rotor drive shaft and subsequent loss of aircraft control.

Contributing Factors:

- The PIC's decision to take a lunch break and select a landing zone (confined area) along his route of flight (contributory).
- The PIC's landing site selection had numerous potholes and cattle hoof prints in dried mud that was hardened like cement. After numerous interviews with the PIC and his description of the vibrations encountered during the accident sequence it is conceivable that at least one, if not both, ground resonance straps were in a pothole depression and not in contact with the ground at the time the aircraft nose pitched-up and initial cyclic movement took place. This would have exacerbated the pitch change of the aircraft nose. (contributory).
- Upon touchdown, the PIC failed to properly secure the aircraft before reaching behind him. He left the throttle at 100% and did not lock the collective. (contributory)
- The pilot momentarily lost situational awareness while his attention was diverted inside the cockpit with his hands off of the controls. (contributory)

3.3 Human Factors Analysis and Classification System (HFACS)

Approximately two hours into his patrol, the PIC decided to take a lunch break and selected a landing zone (confined area) along his route of flight. With the aircraft at 100% power, the PIC retrieved a small container of chili to place on the vacant passenger seat, he let go of the cyclic with his left hand and, while guarding the cyclic with his legs, used two hands to seal the lunch bag and replace it behind the seat. The PIC momentarily lost situational awareness while his attention was diverted inside the cockpit with his hands off of the controls. The PIC failed to perform a coordinated vertical ascent to a stabilized hover following his reaction to vertical vibrations he perceived as the onset of ground resonance in accordance with (IAW) Aviation Standardization Manual (ASM), Chapter 4, Pg. 4-13, Task 8 - Hovering Flight, Standards 2, 3 and 4 and the Rotorcraft Flying Handbook (FAA-H-8083-21), Chapter 9, Pg. 9-5. The pilot's aggressive over-application of the flight controls caused the tail skid to impact the ground and pushing the vertical fin and tail gearbox upward, severing the tail rotor driveshaft forward of the tail gearbox. This resulted in the catastrophic failure of the tail rotor drive shaft, subsequent loss of aircraft control and separation of the tail boom assembly aft of the horizontal stabilizer.

- Decision Based Error DE10 (Improperly secured aircraft)
- Decision Based Error DE-1 (Aborted takeoff/landing decision improper)
- DE-8 (Improper inflight planning)
- Perceptual Error PE-2 Failure to identify risk/hazard (e.g. pot holed landing surface vs. placement of resonance straps)

The pilot momentarily lost situational awareness while his attention was diverted inside the cockpit with his hands off of the controls.

- Adverse Mental State AMS-2 (Complacency)
- AMS-10 (Inattention)

The aircraft nose pitched-up suddenly while retrieving his snack and the PIC quickly reacted by placing his hands back on the controls and adding forward cyclic to correct for the slight nose pitch increase and ensure positive skid contact with the ground. This sudden movement is suspected to have placed the main rotor blades momentarily out of phase, thus inducing the vertical dynamic oscillations felt immediately following the control movement. (Causal)

- Skill Based Error SBE-2 (Aircraft control inadequate [e.g., abrupt, excessive, not maintained])
- SBE-22 (Poor coordination or timing of action)

The PIC then made a positive collective application to lift the aircraft off the ground and regain aircraft stability. As the aircraft lifted, it lurched forward and downward in an unusually nose-low attitude, resulting in the lower wire strike blade contacting the ground establishing a pivot point. (Causal)

- Routine Violation RV-11 (ASM , Chapter 4, Pg. 4-13, Task 8 - Hovering Flight, Standards 2, 3 and 4 and the Rotorcraft Flying Handbook (FAA-H-8083-21), Chapter 9, Pg. 9-5 not used or followed)

The PIC made an aggressive aft cyclic movement with a positive collective input to arrest the nose down attitude. This resulted in the tail skid contacting the ground and pushing the vertical fin and tail gearbox upward, severing the tail rotor driveshaft forward of the tail gearbox. (casual)

- Skill Based Error SBE-2 (Aircraft control inadequate (e.g., abrupt, excessive, not maintained))
- SBE-22 (Poor coordination or timing of action)
- SBE-25 (Terrain clearance not maintained)
- SBE-26 (Undesirable aircraft state (airspeed, glide path, configuration))

4 Recommendations

1. Conduct thorough post-mishap evaluation of the PIC to include review of Ground Resonance causes/mitigation measures (i.e. securing the aircraft before taking hands off the controls) and landing zone selection.
2. Brief rotary wing pilots and crews on Situational Awareness and the hazards associated with diverting attention to tasks inside the cockpit and aircraft control without properly configuring the aircraft (e.g., control locks applied, throttle - idle).
3. Establish national policy for Appareo Vision 1000 Camera System operation and tampering.

5 Appendixes

5.1 Appendix A: Definitions

5.1.1 Probable Cause

The probable cause is the action that directly caused the event leading to the accident.

5.1.2 Contributing Factor

A contributing factor is one that did not directly cause a mishap.