AIRCRAFT ACCIDENT REPORT NUMBER 2011-003

GROUND IMPACT, A CHARTER FLIGHT, ROBINSON HELICOPTER R44 II, REGISTRATION 9XR-SI, GATARE SECTOR, NYAMAGABE DISTRICT, 24 AUGUST 2011

PURPOSE OF THE INVESTIGATION:

In terms of regulation 3 of the Rwanda Civil Aviation (Aircraft Accident and Incident Investigation) Regulations and section 3.1 of Annex 13 to the Chicago Convention this investigation was conducted and report compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and not to apportion blame or establish legal liability.

ORGANIZATION OF THE INVESTIGATION

In accordance with Rwanda Civil Aviation (Aircraft Accident and Incident Investigation) Regulations 2008 (Annex XVII to the Presidential Order N° 60/01 of 20/10/2008) and Annex 13 to the Chicago Convention, the Ministry of Infrastructure on behalf the Republic of Rwanda, the State of Occurrence/ Operator, launched an investigation to establish circumstances surrounding the accident.

EXECUTIVE SUMMARY

On August 24, 2011, about 1230 UTC, a charter flight, Robinson helicopter R44 II, 9XR-SI, registered to and operated by an Rwandan Operator, impacted with rising terrain in the vicinity of Gatare Sector, Nyamagabe District, Rwanda. The pilot and two passengers sustained serious injuries. Aircraft was destroyed.

The aircraft was operated from a take-off site surrounded by rising terrain with limited escape routes and the ambient conditions (temperature and pressure altitude) were high. The aircraft was loaded within its operational performance envelop but close to its upper limits.

The accident may have been caused by pilot ‘s incorrect response (intuitively keeping the collective in order to out-climb obstacles) to low rotor rpm warning and caution light resulting in the rotor blade stall, loss of lift and control leading to the helicopter impacting with the flank of the rising terrain. Given the pilot was also trying to out-climb an obstacle, pushing down on the collective would have been counter-intuitive.

It is recommended that the operator reviews the current operational procedures and training standards with regards to high altitudes & confined area operations. Also, given the general terrain of Rwanda, prevailing weather patterns, the air operator needs to carry out a risk assessment to determine the suitability of operating single engine low blade inertia helicopter in Rwanda.

1. FACTUAL INFORMATION

1.1 History of Flight

On August 24, 2011, about 1230 UTC, a charter flight, Robinson helicopter R44 II, 9XR-SI, registered to and operated by a Rwandan Operator, impacted with rising terrain in the vicinity of Gatare Sector, Nyamagabe District, Rwanda. Visual meteorological conditions prevailed and the weather conditions were calm. The commercial pilot and two passengers sustained serious injuries. The aircraft was destroyed. There was no fire.

The pilot reported that in about a minute into the flight, with a positive rate of climb of 200-300 feet per minute and 50 knots of airspeed, a rotor low rpm aural and light warning came on followed by a rapid loss of altitude at very low altitude above ground level. The pilot turned the helicopter to the right to avoid obstacles and impacted the flank of rising terrain less than a kilometer east of the takeoff site.

The accident occurred during the hours of daylight at latitude of 02° 22' 24" South and longitude 29° 22' 93" East.

The flight had originated from Kigali International Airport with two Robinson R44II helicopters registrations 9XR-SE and 9XR-SI. According to their reports, 9XR-SE pilot had planned to fly from Kigali to Nyungwe Lodge with one stopover in Gatare whilst the 9XR-SI (the accident aircraft) pilot had planned to fly to Nyungwe Lodge with one stopover in Gatare and a refueling stop in Butare.

The flight to Gatare was uneventful. According to pilots and witness reports, the two helicopters first landed on a soccer field surrounded by rising terrain on all sides except the northern side that they used to fly in. 9XR-SE pilot reported experiencing a light tail wind on landing. After noticing changes in wind direction and strength, the two helicopters were relocated to another open area less than a kilometer away, apparently a site the Operator Chief Pilot and 9XR-SE pilot had previously used.

After two hours on ground, the two helicopters were prepared for the next respective flights. 9XR-SE pilot had planned flying to Nyungwe Lodge along the forest edge line. 9XR-SI pilot had planned flying to Butare for refueling and then proceed to Nyungwe Lodge.

According to load sheet data, 9XR-SI had two passengers with a total weight of 200 lbs. The load sheet showed aircraft basic weight of 1593.00 lbs, arm of 107.3 inches, longitudinal moments of 170928.90 in-lbs, and a total takeoff weight of 2278.02lbs at 95.1 inches. The current weight and balance report contained in the approved Robinson Rotor Flight Manual showed aircraft basic weight of 1593.20, arm 107.3 inches, longitudinal moments of 169219 in-lbs and lateral moments of minus(-) 159 in-lbs.

9XR-SE took off first for Nyungwe Lodge initially flying along the forest edge. According to two videos shots taken by ground personnel, 9XR-SI hovered and repositioned to a place where 9XR-SI helicopter had taken off from. It hovered and landed again. According to his report, the pilot noted 22 inches of manifold pressure and one hour endurance during hovering. The aircraft lifted off the ground, moved forward and slowly climbed at 200 to 300 feet per minute.

The pilot stated that on approaching top of the rising terrain, a low RPM horn and light came on. The pilot opened the throttle keeping the collective, at the same time trying to overfly the trees and rising hilly terrain. According to the pilot, the helicopter did not respond and there was not much of escape route available to maneuver.

The helicopter impacted with the flank of a hilly terrain less than a kilometer east of the take off site used.

An eye witness reported that two helicopters landed on the soccer pitch around 10 am. After a while, one helicopter took off, circled and landed and then the two helicopters took off and landed on another site. At approximately 1430 hours the two helicopters started engines ready for takeoff. One helicopter took off and flew away. According to this eye witness, the accident helicopter took off, turned left, then right and started descending.

A second witness heard a “bang” and rushed to the scene with another local person. He found one person bleeding and lying next to the wreckage. He assisted him to a safe place, and then helped the other passenger and pilot out. The three injured occupants were taken to a local health centre where they received primary health care and later air lifted to a more adequate hospital.

1.2 Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal	0	0	0	0
Serious	1	2	3	0
Minor	0	0	0	0
None	0	0	0	0
TOTAL	1	2	3	0

1.3 Damage to aircraft

The aircraft was destroyed. Landing skids were damaged due to impact with ground. The bottom of the fuselage sustained serious damage.

1.4 Other damage

No other damage was noted.

1.5 Personnel information

The pilot, aged 33 years held valid Rwandan Commercial Pilot license and first class medical certificate dated 11 February 2011 with no limitations. The pilot also held an FAA license issued on 18 December 2009. The pilot was type rated on the Robinson R44II.

According to pilot interview and RCAA records available, the pilot first began flight training in 2002 in South Africa, acquired his private pilot license in March 2002 and commercial pilot license in January 2007.

The pilot logbook showed he had flown about 953.3 hours total flight time, including about 531 hours in the Robinson R44II. He had flown about 6, 1.8 and 0.8 hours in the previous 30 days, 7 days and 24 hours, respectively, before the accident. His most recent proficiency check and ground training occurred on 5th of August 2011.

1.6 Helicopter Information

The accident helicopter, a Robinson R44II, serial number (S/N) 12965 was acquired by the operator in January 2010. At the time of the accident, the helicopter airframe had accumulated approximately 378 total flight hours.

At the time of the accident, the helicopter was on the second flight of the day. There were no defects recorded in the aircraft technical log (flight folio) before the flight. According to the pilot and other witnesses, the aircraft did not experience any mechanical malfunction during the flight.

Robinson R44 is a four seater, single main rotor, single engine helicopter constructed primarily of metal and equipped with skid type landing gear. The primary fuselage is welded steel tubing and riveted aluminum sheet. The tail cone is a monocoque structure in which aluminum skins carry most primary loads.

1.6.1 Power-plants

The helicopter was equipped with one Lycoming IO-540-AE1A5 six cylinder, horizontally opposed overhead-valve, air-cooled, fuel injected, wet-sump engine serial number L-33911-48E, normally rated at 260 horsepower. A direct drive, squirrel cage cooling fan mounted to the engine output shaft supplies cooling air to the cylinders and oil coolers via a fiberglass and aluminum shroud. The engine was installed during manufacture of the aircraft and the engine had accumulated a total of 446.6 hours since new.

The all metal main rotor had two blades serial numbers 6729 and 6732 mounted to the hub by coning hinges. The main rotor was fitted to the helicopter during manufacture.

The tail rotor had two all metal blades and a teetering hub with a fixed coning angle. The blades were constructed with aluminum skins and forged aluminum root fittings.

A V-belt sheave is bolted directly to the engine output shaft. V-belts transmit power to the upper sheave which has an overrunning clutch contained in its hub. The inner shaft of the clutch transmits power forward to the main rotor and aft to the tail rotor. Flexible couplings are located at the main gearbox input and at each end of the long tail drive shaft.

1.6.2 Controls

The collective stick fitted is conventional with a twist grip throttle control. When the collective is raised, the throttle is opened by an interconnecting linkage. According to the flight manual systems description, an electronic governor makes minor throttle adjustments required to maintain RPM.

A twist grip throttle control located on each collective is interconnected and actuates the fuel control butterfly valve through a system of bell-cranks and push pull tubes. The linkage is designed to open throttle as the collective stick is raised. The helicopter is also fitted with a mixture control on the console face.

1.6.3 RPM Governor

A governor maintains engine RPM by sensing changes and applying corrective throttle inputs through a friction clutch which can be easily overridden by the pilot. The governor is only active above 80% engine RPM and can be switched on or off using a toggle switch on the end of the right seat collective. It is designed to assist in controlling RPM under normal conditions and may not prevent over or under speed conditions generated by aggressive flight maneuvers. When operating at high density altitudes, governor response rate may be too slow to prevent overspeed during gusts, pull-ups or when lowering collective.

1.6.4 Warning and Caution Lights

The Rotor flight manual states that caution and warning lights include clutch, main gearbox over temperature, main and tail gearbox chip, engine fire, starter on, low fuel, fuel filter, auxiliary fuel pump, low RPM, alternator, low oil pressure, rotor brake and carbon monoxide. The table below gives a range of caution and warnings and their possible triggers:

Item	Caution and Warning	Possible Trigger
1	Clutch Light	The actuator is tightening the V-belts
2	Low RPM light and horn	**Rotor RPM at 97% or below (Decaying Lift)**
3	Engine Fire light	Actuated by a temperature switch located at the forward end of the horizontal firewall.
4	Low oil pressure and low fuel lights	Actuated by sensors in those systems and are independent of gage indicators.
5	Alternator and auxiliary fuel pump lights	Possible failures of those accessories
6	Fuel filter light	Filter contamination
7	Governor off light	Governor switched off
8	Main and tail gearbox chip	Metal presence due to failing bearing or gear
9	Carbon monoxide	Elevated carbon monoxide levels

1.6.5 Maintenance Records

Maintenance records indicated that the helicopter was being maintained in accordance with a 100 hour inspection program and was complimented with a 50 hour inspection. The helicopter had undergone a 100 hour scheduled routine maintenance on 10 August 2011 at aircraft total flight time of 373.6 hours. The aircraft was subsequently operated on six flight segments for a total of 4.4 hours.

1.7 Meteorological Information

According to interviews of the two pilots and eye witnesses, it was in the afternoon in no sunny condition, calm wind, high and scattered clouds and temperature, 20° C. The pressure altitude was given by the pilots as approximately 8000 feet.

1.8 Aids to Navigation

Not applicable

1.9 Communications

No communication problems were reported.

1.10 Take off Site Information

The take off site was a lower ground surrounded by rising terrain and tall trees. The preferred site had a limited open space (about one (1) km) that quickly terminated into a rising terrain.

Photo 1 showing take off site and available open space (Flight Path)

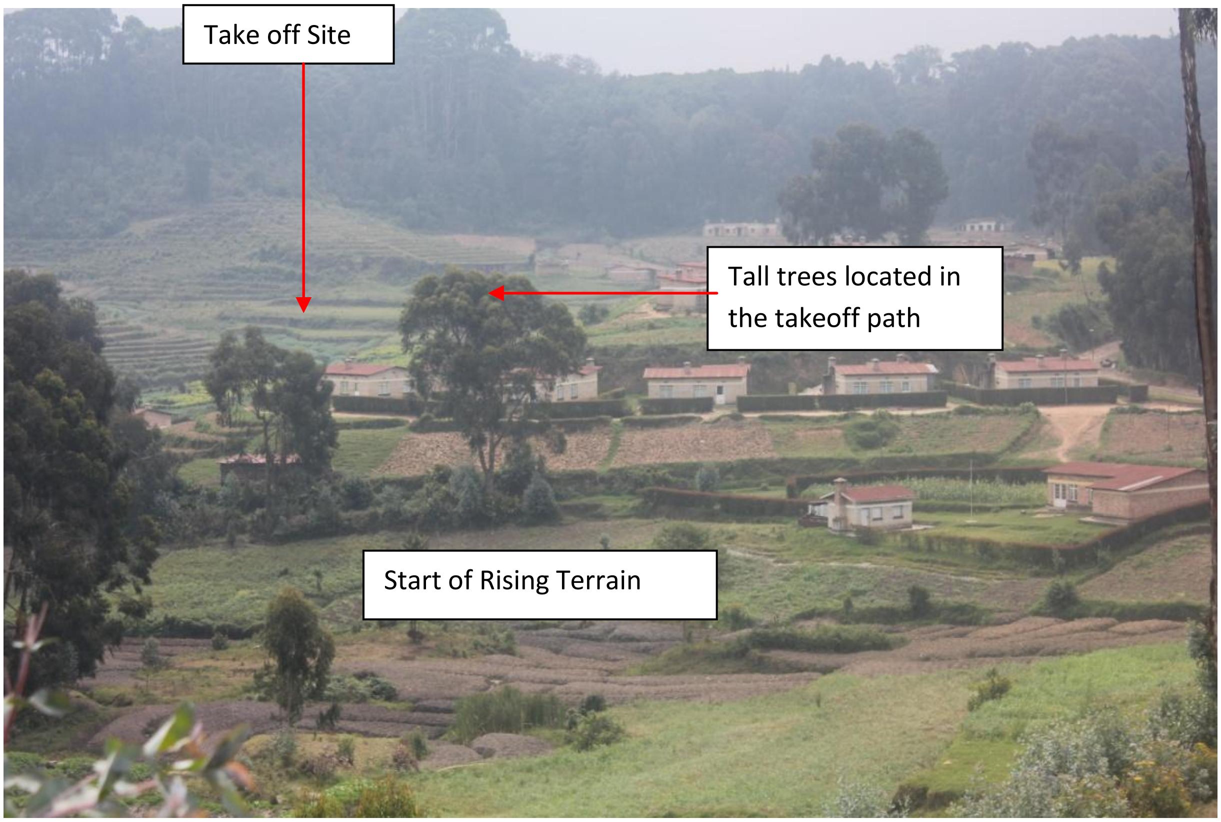


Photo 2: Take off Site

1.11 Flight Recorders

The helicopter was equipped with neither a cockpit voice recorder (CVR) nor flight data recorder (FDR).

1.12 Wreckage and Impact Information

The main wreckage consisting of fuselage, engine, main rotor minus the empennage section, was located midway of the rising terrain flank. The fuselage was positioned with its nose pointing about 095 degrees magnetic.

The helicopter impacted with the rising terrain first with the right landing skid, skidded on its belly up the rising terrain for approximately five meters before resting on its right side (see **Photo 4**). The initial impact point was approximately a third way from the bottom of the rising terrain.

The tail boom, with the ¾ of the tail rotor shaft, vertical and horizontal stabilizers attached, was located approximately 25 meters ahead and 45 degrees right of the main wreckage. See wreckage distribution shown under 1.12.1.1 and 1.12.1.2. Examination of the lower vertical stabilizer exhibited a semi circular indentation, black and yellow paint smug on the leading edge from the root to the tip. The upper vertical stabilizer did not sustain any damage. The horizontal stabilizer sustained ground collision damage. The two tail rotor blades (TRB), which had fractured close to the blade shanks, were located one about five meters north of the main wreckage and the other about 100 meters west of the main wreckage. Examination of both tail rotor blades and tail boom fractured surfaces exhibited some bending and shear forces.

The tail rotor drive shaft was intact from the upper sheave to about 30 cm from the clutch coupling where it fractured twice. A meter long portion of it was located near the wreckage. It exhibited a bend and clockwise twist.

The drive shaft from the upper sheave to the main rotor transmission gear box was intact. The belt tensioning actuator assembly was extended indicating the belts were tightened. The rotor blades remained attached to the rotor head. The muffler was detached from the engine and was found about four meters south of the fuselage.

The engine remained attached to the fuselage frame at its respective attachment points. Engine components including magnetos, carburetor, air box, intake tubes were attached to the engine. On site examination of the engine revealed the mixture control was in full rich position, fuel shut off valve in open position, magnetos in "Both Position" and the RPM governor in off position. Spark plug inspection revealed a clean grey colour.

On site inspection of the main rotor blades indicated that the trailing edge ripped open towards the end and approximately 1.5 meters portion separated from the leading edge along the attachment point exposing the honeycomb structures. The blades were found bending upward (forming a coned shape towards the tip).

The initial impact point showed little ground penetration and slid up the slopes of the terrain for 5 meters before resting on its right side. The skid landing gear, which had had fractured from the attach points, were located around the impact area and along the slide path.

The cabin area was essentially maintained and free of significant intrusions. Examination of seat belts showed very light stretch marks. Judging by the height of trees clipped, the aircraft was flying at an altitude less than 14 feet above ground level (AGL).

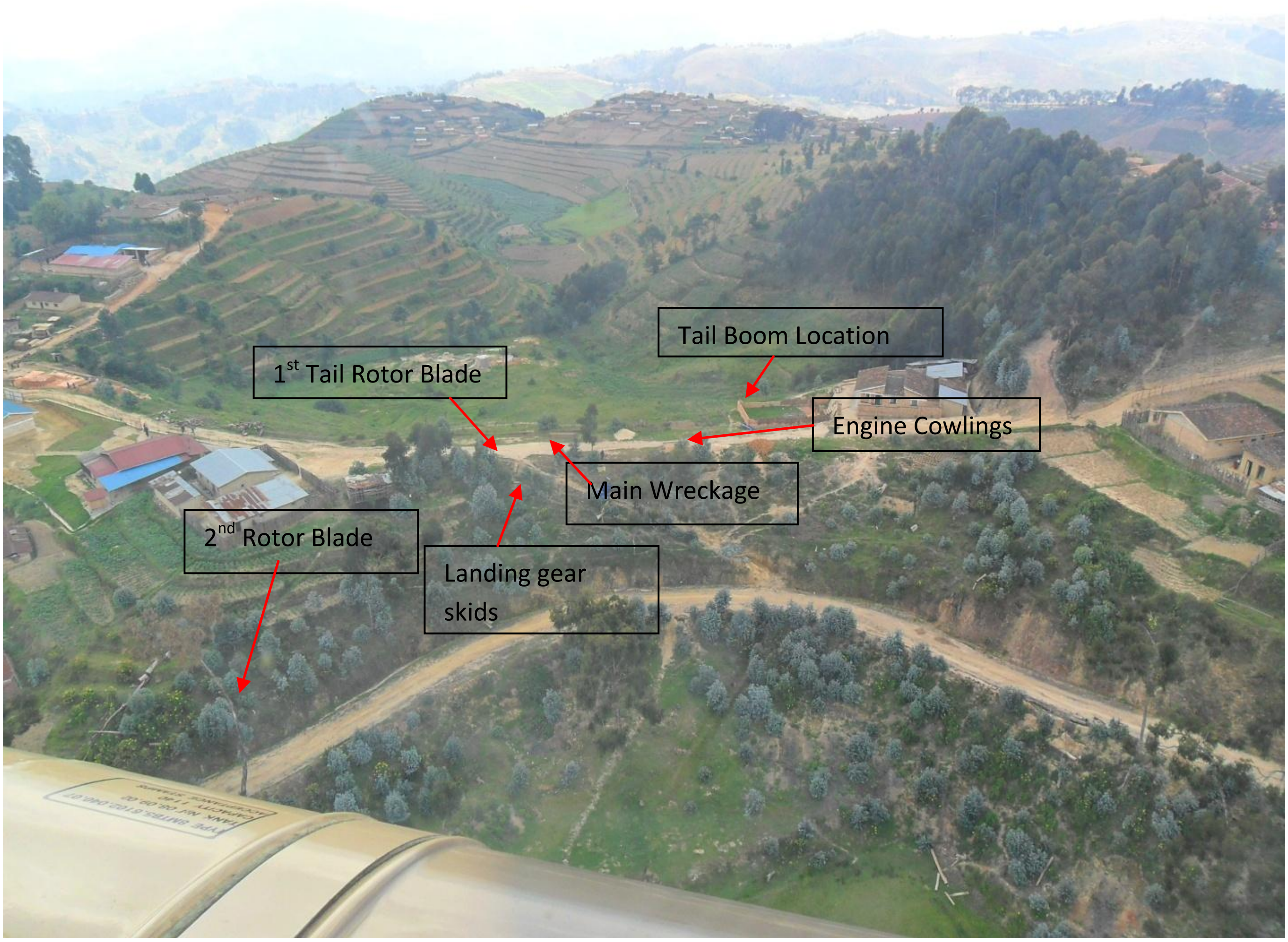
Photo 3. Location of main helicopter wreckage

Photo 4. Initial Impact point and ground skid marks (Above).

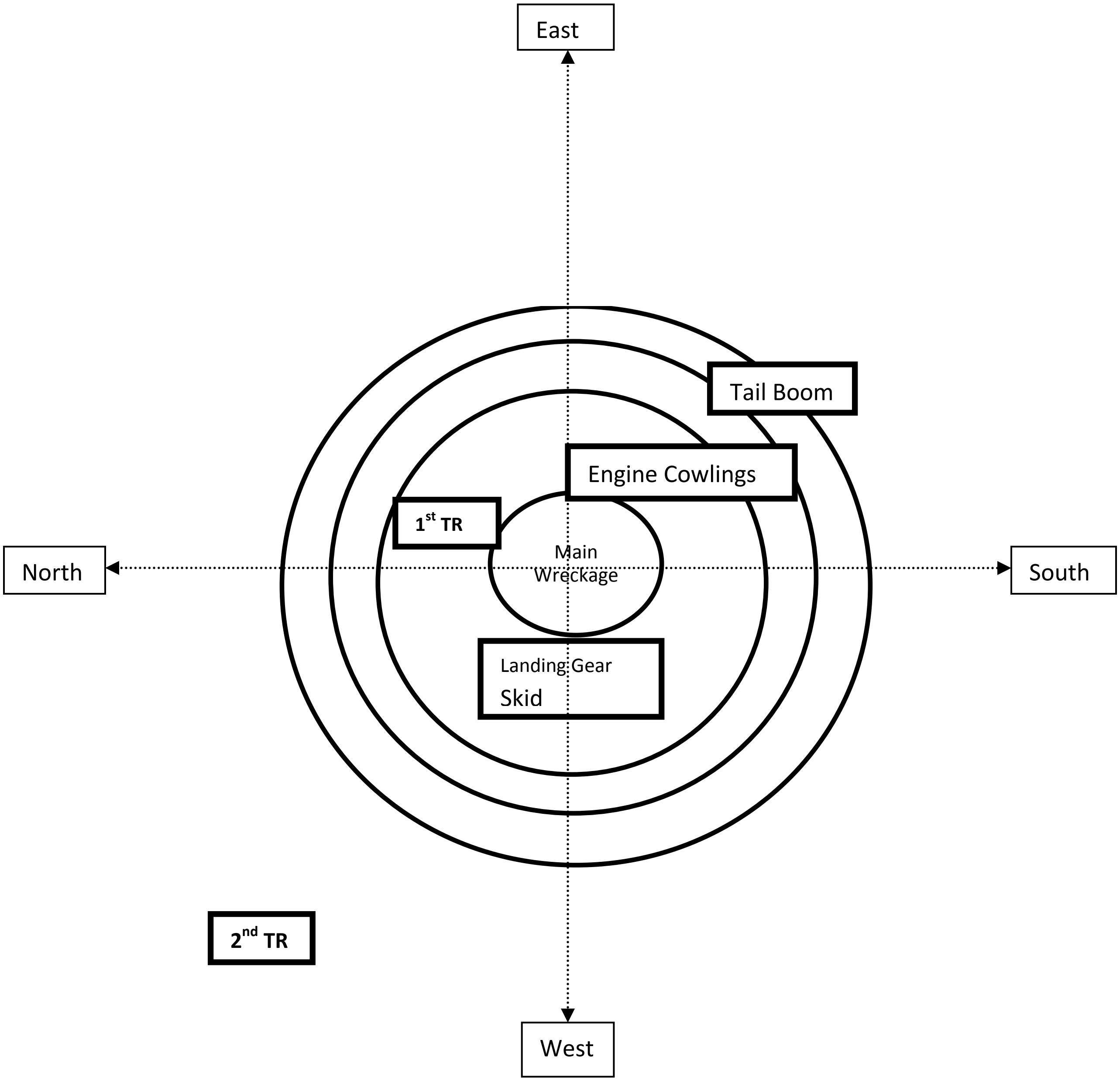
Wreckage Distribution

1.12.1.1 Aerial Photograph

Detached landing gear skids were located within the area of the initial impact point in line with the flight path. An engine cowling was located approximately 4 meters ahead of the main wreckage. The tail boom, together with the tail rotor shaft and hub, was located 25 meters and 45 degrees right of the main wreckage. Most components were still attached to or located near the main wreckage except for TRB that was found about 100 meters west of the wreckage.



1.12.1.2 Scatter Diagram showing relative location of major components


East
Tail Boom
Engine Cowlings
1st TR
Main
Wreckage
North
South
Landing Gear
Skid
2nd TR
West

1.13 Medical and Pathological Information

Toxicological testing of the flight crew was not conducted as it was not considered a factor.

1.14 Fire

There was no post impact fire.

1.15 Survival Aspects

The fuselage occupiable area remained generally intact. Inspection of the seats, seat attachment, and seat restraints did not disclose evidence of malfunction.

Rescuers found one passenger lying outside the wreckage. The passenger who was seated at the rear and the pilot were helped out of the aircraft. Injured persons were treated at nearby local health centre before being air lifted to Kigali.

The pilot remained in his seat during the impact sequence. The instrument panel was slightly displaced into the occupiable space of the front occupant's seats.

1.15.1 Rescue Operations

The first responders to the crash site consisted of the local people, ground team and later on air force personnel. The rescue operations included the recovery of the pilot and the two passengers. They were administered first aid at a local health centre and then airlifted to Kigali.

1.16 Test and Research

The ripped tail boom showed the structure experienced bending forces as a result of impact with the ground. The leading edge of the vertical stabilizer indicated evidence of contact with the main rotor blades.

On site investigation disclosed that the main rotor blades had an upward bending.

1.16.1 Safety Notices and Airworthiness Special Information

The Helicopter Approved Flight Manual emergency procedures section states "A horn and illuminated caution light indicate that rotor RPM maybe below safe limits. To restore RPM, immediately roll throttle on, lower collective and, in forward flight, apply aft cyclic. The horn and caution light are disabled when collective is fully down."

In October 1982 and September 1986, Robinson Helicopter Company issued safety notices, SN-10 (revised February 1989 & June 1994) and SN-24(revised September 1986 & June 1994) respectively advising operators on fatal accidents resulting from low RPM rotor stall. Both safety notices indicate that as RPM of the rotor gets lower, the angle of attack of the rotor blades must be higher to generate the lift required to support the weight of the helicopter. Even if the collective is not raised by the pilot to provide the higher blade angle, the helicopter will start to descend until upward movement of the air to the rotor provides the necessary increase in blade angle of attack. The blade airfoil will stall at a critical angle resulting in a sudden loss of lift and a huge increase in drag. The increased drag on the blades acts like a huge rotor brake causing the rotor RPM to rapidly decrease, further increasing rotor stall. As the helicopter begins to fall, the upward rushing air continues to increase angle of attack on the slowly rotating blades making recovery virtually impossible, even with full down collective.

In July 1994 and January 1995, FAA issued an Airworthiness Special information number No. AWS-94-2 and ASW-95-01 respectively to disseminate safety information to all pilots of the Robinson R-22 and R-44 helicopters of fatal accidents in those aircraft resulting from main rotor contact with the airframe.

According to the information provided in ASW-95-01, data provided by the National Transportation Safety Board and foreign airworthiness authorities; there have a number of fatal accidents in the R-22 and R44 that resulted from main rotor blade/airframe contact. Most of those accidents have been attributed to low rotor RPM stall or mast bumping and pilot lack of experience.

According to data provided by FAA in AWS-95-1, many factors may contribute to main rotor stall and pilots should be familiar with them. Any flight condition that creates excessive angle of attack on the rotor blades can produce a stall. Low rotor RPM, aggressive maneuvering, high collective angle (often the result of high density altitude, over-pitching [exceeding power available] during climb or high forward flight airspeed) and slow response to the low rotor RPM warning horn and light may result in rotor stall. The effect of these conditions can be amplified in turbulence. Rotor stall can ultimately result in contact between the rotor and airframe. Additional information on rotor stall is provided in Robinson Helicopter Company Safety Notices SN-10, SN-15, SN-20, SN-24, SN-27, and SN-29.

1.17 Organizational and Management Information

1.17.1 . Ground School Training

The training syllabus for Akagera Aviation consist of initial, transition, requalification, and recurrence training based on Robinson training program. The recurrence training is conducted at 6 months intervals including ground training which in part covers aircraft systems, abnormal/emergency procedures and confined area operations.

In an interview with the officials of Akagera Aviation, it emerged that at the time of the accident the company was in the process of reviewing its procedures regarding high altitude, confined areas operations, landing site evaluations and training standards.

1.18 Additional Information

1.18.1 Corrective Actions

According to officials of Akagera Aviation, the company is reviewing all its known landing sites in a bid to identify hazards and develop mitigating measures. Crew members are meeting weekly in a pilot forum discussing challenges being encountered during operations in order for the company to maintain safe operations.

Akagera Aviation has also embarked on a comprehensive crew training especially in mountain flying and confined area operations.

1.18.2 Passenger/ Pilot Communication

Just before the flight to Butare, there was a discussion between the pilots and passengers concerning the routing of aircraft 9XR-SI. The passengers wanted to take a routing along the forest edge line while the pilot elected to fly to Butare for refueling and then to Nyungwe lodge.

1.18.3 Weight and Balance

One passenger occupied the front seat and another one the seat directly behind the pilot. With two passengers weighing a total of 200kgs, 9XR-SI became weight limited and therefore the pilot planned to make the refueling stop in Butare and proceed to Nyungwe Lodge.

1.18.4 Flight Briefing

In an interview with the company chief pilot, a similar flight had previously been done by him and the pilot who flew in 9XR-SE on the accident day. The flight was uneventful.

After getting another request to do a similar flight, two pilots were assigned. In preparing the crew for the flight, the chief pilot had the opportunity of briefing the pilots.

2. ANALYSIS

2.1 General

The pilot was properly certificated and there were no medical conditions that prevented him from performing his flight duties.

The aircraft was properly certificated and maintained in a mechanical condition capable to conduct the flight.

Eye witness and pilot reports suggest no pre-impact anomalies were detected with the helicopter or its engine. On site examination of the squirrel cage cooling fan fiberglass and aluminum shroud area showed no evidence of pre-impact anomalies with the engine.

Onsite examination shows the tail rotor had some power resulting in the shattering of the tail rotor blades. Therefore, the tail rotor drive system was intact when the tail boom separation occurred.

According to the load sheet, both lateral and longitudinal moments were within limits.

The skid landing gear sustained ground collision damage. It was observed that the skid landing gear absorbed significant amount of impact force. In the process, the cabin area (occupiable space) was maintained. Crash forces were also determined to be within human tolerance.

Based on pilot reports it was concluded that the governor switch could have been tempered with during rescue operations.

Based on the reconnaissance conducted by the two pilots, the preferred take off site was preferable given the surround rising terrain.

2.2 Organization

At the time of the accident, the Air Operator was undergoing recertification under the new Rwandan requirements.

2.3 Pilot / Passenger Discussion

Based on the fact that the pilot and the passenger had a routing disagreement just before take off for Butare, pilot concentration may have been impaired.

2.4 Helicopter Performance at Higher Altitudes

Robinson R44II aircraft is sensitive to altitude, temperature variations and takeoff weights. At high altitude, engine maximum power output is limited due to decreasing engine manifold pressure (decreasing air density). On this flight, with temperature of 20 degrees C, pressure altitude of 8000 feet and total take of weight of 2278 lbs, the Out of Ground Effect (OGE) hover ceiling was 6500 feet Pressure Altitude and the In Ground Effect (IGE) hover ceiling was 10,300 feet Pressure Altitude, according to the R44 performance charts.

The pilot commented that the OGE performance limit did not apply to this flight because he had an open area he could use during his take-off to accelerate and that he also had in excess of 2 inches of manifold pressure power reserve, hence he thought he was safe to operate between the OGE & IGE limits.

2.5 The tail rotor Blades

The tail rotor blades were fractured close to the hub centre. The deformation of the blades adjacent to the fractures was consistent with the tip piece rotation relative to the root piece. Miscellaneous skin pieces displayed features consistent with over stress fracture.

2.6 Rotor blades

The coned shape formed by the rotor blades suggest a high demand for lift to counteract low rpm or increased weight at high density altitude. According to flight Training Magazine of March 1998; “The coning angle depends on the balance between lift and centrifugal force, and it varies as either of these two forces changes in relation to the other. If rotor rpm increases, the coning angle decreases. Reducing rotor rpm causes the coning angle to increase. Increasing the helicopter's weight (or, in a turn, its apparent weight), has the same effect”.

The increased coning angle effectively reduced disc area. Technically, as the blade tips cone upwards because of the reduction in rotor rpm, the apparent area of the rotor disc, as seen from above, decreases. With less area, the rotor disc produces less lift, and the helicopter descends. If the pilot reacts to the loss of lift by raising the collective, the extra drag on the rotor blades slows them down even more. Apart from the fact that the main rotor disc is getting smaller, the tail rotor is also losing effectiveness at the ratio of 5:1. This reduction in tail rotor rpm can soon lead to pilot losing directional control.

According to the aforesaid Training Magazine, Helicopters with low-inertia rotor systems are extremely unforgiving of low-rotor rpm; low-inertia system loses rpm faster, which requires the pilot to react quicker to prevent low-rotor rpm from reaching the critical stage.

The FAA Rotorcraft Flying Handbook states that the danger of low rotor r.p.m. and blade stall is greatest in small helicopters with low blade inertia. It can occur in a number of ways, such as simply rolling the throttle the wrong way, pulling more collective pitch than power available, or when operating at a high density altitude. When the rotor r.p.m. drops, the blades try to maintain the same amount of lift by increasing pitch. As the pitch increases, drag increases, which requires more power to keep the blades turning at the proper r.p.m. When power is no longer available to maintain r.p.m., and therefore lift, the helicopter begins to descend. This changes the relative wind and further increases the angle of attack. At some point the blades will stall unless r.p.m. is restored. If all blades stall, it is almost impossible to get smooth air flowing across the blades.

2.7 Tail boom Separation

In general, rotor blade contact with the tail boom is typically associated with low rotor rpm and/or abrupt movement of the cyclic control. A low rotor rpm will allow the blade to flex or bend down from its plane of rotation and strike the tail boom. Likewise excessive movement of the cyclic control causes a similar outcome. Also, a hard landing can result in the tail boom flexing into main rotor blade path.

Based on the damage on the landing skids and fuselage bottom, the helicopter struck the ground with the left landing gear. The tail boom fractured and twisted exposing the lower vertical stabilizer to the rotating main rotor blades. The rotating blade struck the lower vertical stabilizer at the root, propelled and deposited it 25 meters ahead and 45 degrees right of the main wreckage.

2.8 Crew Actions

According to the Helicopter Flight Manual, at elevation of 8000 feet, 20 degrees Celsius, the maximum limit manifold pressure was given as 20.9 inches of mercury with an additional of 2.8 inches of mercury required for maximum (limited for 5 minutes) take off power.

At hover, the pilot noted manifold pressure of 22inches of mercury leaving him with some power for takeoff.

Based on the pilot report, the helicopter was operated on the margin of its performance capability. The pilot may have attempted to increase collective after getting the low rotor rpm warning leading to further decay of the rotor rpm. The corrective action would have been to decrease the collective control (push down) to restore the proper rotor rpm and thus regain lift. As the helicopter was close to a surface not suitable for landing, the pilot could have opted to recover lost rotor rpm by "milking" the collective. The skill requires the pilot to maintain full throttle and repeatedly lowers the collective using small movements. This reduces the angle of attack of the rotor blades while preventing the helicopter from hitting the surface until rotor rpm returns to the green arc.

However, given the pilot was also trying to out-climb an obstacle, pushing down on the collective would have been counter-intuitive.

3. CONCLUSIONS

3.1 Findings

1. The pilot was certificated, qualified, and experienced in accordance with applicable air regulations.

2. The aircraft was certificated and maintained in accordance with applicable regulations.

3. The weather was not a factor.

4. The take off site had many challenges such as high pressure altitude, rising terrain, high temperatures and limited escape routes. Considering the prevailing condition on that day, the preferred take off site was ideal.

5. Operating a single piston engine small helicopter with low blade inertial in mountainous terrain and high altitude like Rwanda is a challenge.

6. The pilot was not in a relaxed state following some routing disagreement with the passengers.

7. The pilot may not have complied with standard operating procedures by not applying the appropriate low rotor rpm recovery technique but instead intuitively continued to lift the collective to out-climb the rising terrain.

8. The helicopter was loaded for marginal performance.

9. Akagera Aviation implemented corrective actions following the accident.

10. Rotor blades stalled due to low rotor rpm.

11. The tail rotor drive system was intact and had power prior to impact and the tail boom separation.

12. The helicopter impacted with the ground, tail boom fractured and twisted putting the lower vertical stabilizer in the path of the rotating MRB which struck and propelled it.

3.2 Immediate Probable Cause

The pilot ‘s incorrect response to low rotor rpm warning and caution light resulted in the rotor blade stall at low height above ground level, loss of aircraft control leading to the helicopter impacting with the flank of the sloping terrain. Also contributory to the accident was the operation of the helicopter at its marginal performance.

4. RECOMMENDATIONS

4.1 Operator to review operational procedures with regards to high altitudes, confined areas operations and raise training standards.

4.2 Given the general terrain of Rwanda, prevailing weather patterns, the air operator needs to carry out a risk assessment to determine the suitability of operating single engine low blade inertia helicopter in Rwanda.