ACCIDENT

Aircraft Type and Registration:	Robinson R44 Clipper I, G-CLIO
No & Type of Engines:	1 Lycoming O-540-F1B5 piston engine
Year of Manufacture:	2000 (Serial no: 742)
Date & Time (UTC):	17 December 2020 at 1530 hrs
Location:	Private landing site, Holmfirth, North Yorkshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - 1 (Minor) Passengers - 2 (Minor)
Nature of Damage:	Tail rotor shaft fractured, tail rotor damaged, damage to skids and belly of the aircraft
Commander's Licence:	Private Pilot's Licence
Commander's Age:	50 years
Commander's Flying Experience:	108 hours (of which 108 were on type) Last 90 days - 2 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

A downwind 'out-of-ground-effect' transition to the hover resulted in overpitching of the main rotor. The subsequent reduction of rotor rpm caused a rapid increase in descent rate and a loss of tail rotor authority. The pilot was unable to react in time to prevent a turning, descending flight path and the helicopter struck the ground causing substantial damage.

Safety Sense Leaflet 17 – '*Helicopter Airmanship',* published by the CAA and Safety Notice SN-42 – '*R44 Pilot's Operating Handbook*', published by the Robinson Helicopter Company contain relevant safety advice to prevent this type of accident. A safety course is also available from the Robinson Helicopter Company for rated pilots.

History of the flight

The pilot had planned to take two passengers to visit his friend at a farm in Holmfirth, where he intended to land in a nearby field. He was aware of obstacles near the field such as trees, power lines and sloping ground, but he intended to make an out-of-ground-effect (OGE) hover to allow him to assess the landing spot visually before landing.

The take off at 1435 hrs and the 20 minute VFR flight to Holmfirth were uneventful. The pilot identified the destination field and completed two overflights to assess his landing point. He observed the overhead domestic power lines running alongside the southern edge of the field and a wind turbine nearby, indicating the wind direction.

He made a steep approach to clear the power lines, but realised he was running out of room to land and raised the collective lever to slow down. He found there was insufficient power to arrest his descent and with about 6 ft of height remaining, the low rpm warning horn sounded and the rpm warning light illuminated. The helicopter yawed through 180° before striking the ground hard in a flat, slightly tail down attitude.

The pilot switched off the fuel valve, disengaged the clutch and turned the master switch off. He applied the rotor brake and he and his passengers vacated the aircraft. There was no fuel leak and no fire.

Accident site

The aircraft had landed in a part of the field where the ground was undulating, sloping and boggy. To the east and west of the field were ridge lines with a wind turbine situated to the south and power lines positioned to the south and south-east (Figure 1).

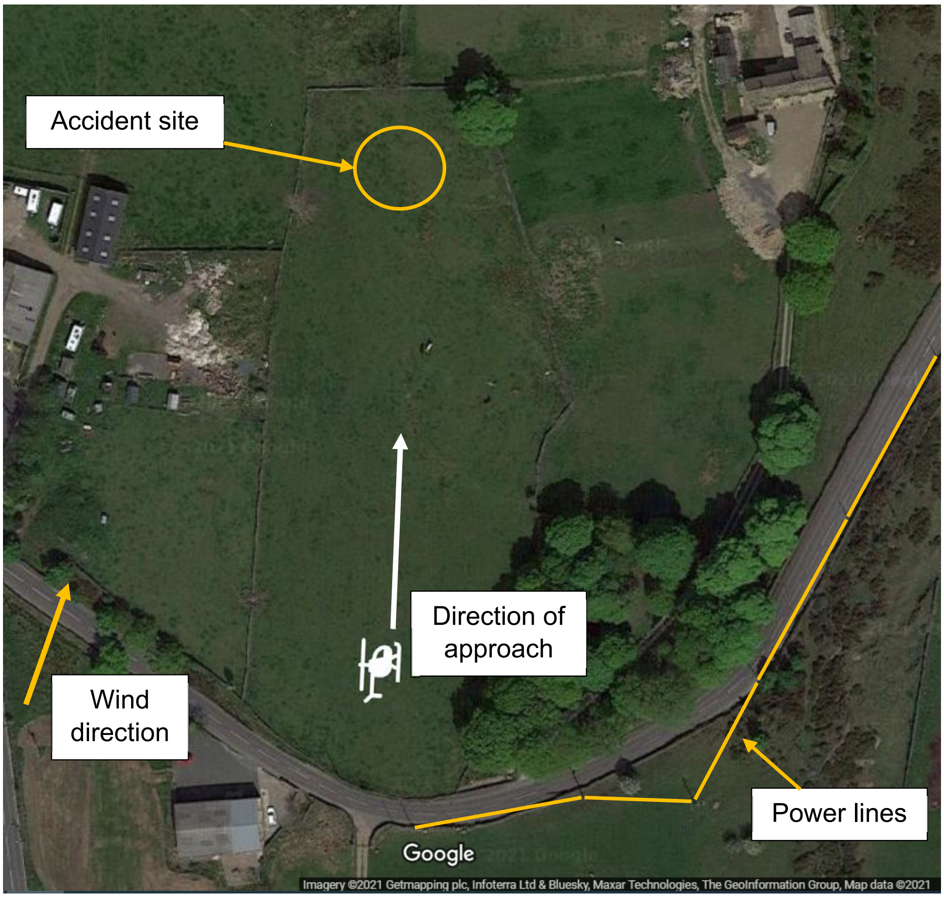

Figure 1

Landing field showing power lines, wind direction and crash site

There were ground impact marks directly below the tail rotor where the blades had hit the soft, grassed surface. The tail rotor blades were bent and twisted and one of them had broken off near the root.

The vertical stabiliser, tail rotor guard and tail skid were damaged and disrupted. A large hole had been made in the left side of the tail boom where the tail rotor had punctured the skin and struck the tail rotor shaft, which had sheared. The landing skids were bent upwards and outwards and were partially disrupted (Figure 2). There was evidence of yielding of the cockpit seat structure and keel panels, and the lower belly of the aircraft was damaged.

In the cockpit, the engine fuel mixture control was found pushed in and guarded, and the carb-heat lever was unlatched and pulled halfway out.

Figure 2

Tail and tail rotor damage, ground impact marks and disrupted landing gear skids

Aircraft information

The Robinson R44 Clipper I[1] (Figure 3) is a four-seat light helicopter powered by a single Lycoming O-540, six-cylinder, carburetted piston engine. The carburettor system features a heat assist function to adjust carburettor heat mechanically as the collective lever is raised or lowered, which is designed to improve safety and reduce pilot workload.

Figure 3

G-CLIO
(Image used with permission)

Footnote

1 The Robinson Helicopter Company also manufacture an R44 Clipper II model.

Aircraft examination

The skid mounting structure was crushed and torn, particularly around the right cross-tube tunnel area, and the lower right side of the fuselage was distorted. The engine's lower carburettor and filter housing was buckled and crushed. The main rotor mast and housing were undamaged and there was no evidence that the main rotor had been in contact with any obstacles or the aircraft structure. The fuel bladder tank was also intact.

Meteorology

The weather at Walton Wood Airfield was dry and bright with no significant cloud and good visibility. The Leeds/Bradford METAR at 1450 showed the wind from 210° at 14 kt, the visibility greater than 10 km, the temperature at 8°C with a dew point of 5°C, and the QNH was 1009 hPa.

Downwind approach

From a video of the approach and landing taken from ground level, smoke from the exhaust can be seen blowing away from the aircraft in a northerly direction after the landing, which shows the pilot had made a downwind approach. This was confirmed by the direction of a nearby wind turbine which showed the prevailing wind was behind the aircraft during the approach.

Pilot's assessment

The pilot knows from the video footage that he misjudged the wind direction and made a downwind approach to the landing site. At the time, he didn't believe the wind direction indicated by the wind turbine because it did not fit with his 'mental picture.' He stated that when he turned final, he increased his speed from 40 mph to 50 mph. He noted his descent rate was 500 fpm and the aircraft felt stable. After clearing the power lines, he realised that he had a high groundspeed and felt forced into slowing the aircraft down sooner and at a greater height than he had planned, therefore, his chosen landing profile would require more power.

His intention had been to raise the collective at approximately 20 to 30 ft agl to flare and transition into a hover, but when he tried there was not enough power available. He stated that this had been a surprise because during the two overflights of the field there seemed to be power to spare.

When he reached 100 ft agl, the wind speed appeared to suddenly reduce, possibly due to the terrain profile of the valley he had flown into. He thinks he might have placed the aircraft into a 'vortex ring state' which caused the aircraft to descend rapidly. The sudden onset of yaw to the right was so rapid he was unable even to attempt any correction before striking the ground.

Overpitching and vortex ring state

Overpitching

'Overpitching' is a dangerous condition in helicopter flight which occurs when rotor blade pitch is increased (from raising the collective lever) without sufficient engine power to compensate for the extra rotor drag produced. The result is a high rate of descent. This is usually because the aircraft is heavy, downwind, at a high density altitude, travelling too fast or too slow, the approach has been misjudged or the pilot has not managed the aircraft to control the rate of descent; or any combination of these factors. In this case the aircraft was flying downwind and the pilot agrees that the approach had been misjudged.

Vortex ring state (VRS)

Although vortices are always present around the outer section of the rotor, under certain airflow conditions, where the helicopter is descending into its own downwash, the vortices will be recirculated and intensified, reducing lift at the blade tips. Coupled with a stall spreading outwards from the root of the rotor blades, the area of the main rotor blades producing lift is substantially decreased. The result is a sudden reduction in vertical rotor thrust and a rapid descent.

As well as a high rate of descent, the symptoms of VRS include random pitching, rolling and yawing which occurs due to the dissymmetry of lift as pressure variations under the main rotor disc cause large and erratic changes to the angle of attack. The controls feel 'mushy' or sluggish and there is usually a marked vibration during the incipient stages. In this instance, the pilot later stated that apart from the rate of descent, none of the other symptoms of VRS appeared to be present.

Survivability

The soft ground, cockpit seats structure and skids absorbed much of the vertical impact with the ground and distorted. However, whilst the occupants walked away from the aircraft without assistance, the pilot later reported that he and his two passengers were suffering from neck and lower back pains.

Analysis

From the video footage of the event, when the helicopter reached the middle of the field the rate of descent and forward speed suddenly increased. This was likely to have been the point the pilot raised the collective lever to slow the aircraft and transition to a hover, but the engine had already reached its power limit. The main rotor speed reduced but torque continued to rise as torque has an inverse relationship with rotor speed. Pulling more collective only reduced rotor speed further, resulting in the rapid loss of lift observed in the video and experienced by the pilot.

As torque was increasing, so was the torque reaction. The R44 has an anti-clockwise rotating main rotor, therefore, the nose of the fuselage rotates to the right with the torque reaction which should be countered by pushing the left yaw pedal. As rotor speed reduces, the tail rotor becomes less effective, requiring more pedal movement to counter the increasing torque reaction. Once the pedal stops are reached, the yaw cannot be prevented.

The pilot's incorrect assessment of wind direction and his downwind approach whilst distracted by the nearby obstacles, resulted in over-pitching of the main rotor and a high rate of descent. The reducing rotor speed and the subsequent increasing torque reaction caused the nose of the aircraft to yaw to the right which the reducing tail rotor authority could not prevent before the hard landing.

Safety messages

Safety Sense Leaflet 17- *'Helicopter Airmanship',* published by the CAA contains a range of advice which is relevant to avoiding this type of accident including:

> *'Awareness of the importance of maintaining rotor rpm, and proficiency at recognising and recovering from low rotor rpm conditions, both with power ON and with power OFF'*
>
> *'The unplanned down-wind approach is particularly hazardous. It can lead to over-pitching, and loss of rotor rpm and lift, resulting in a hard contact with the ground. (Correlators are less effective at high power settings, so maintain rotor rpm by leading with the throttle before applying pitch).'*

Safety Notice SN-42 – *'R44 Pilot's Operating Handbook',* (POH), published by the Robinson Helicopter Company contains the following safety advice:

> *'Note that thrust of any tail rotor decreases significantly as RPM decreases. Low RPM combined with high torque, as occurs when over pitching, may result in an uncontrollable right yaw.'*

The Robinson Helicopter Company also offers a pilot's safety course[2] which is designed to provide specific safety training for rated pilots. The course consists of theoretical and practical training and covers subjects such as aircraft handling procedures, a review of major accidents and how they could be avoided, emergency procedures and critical flight conditions. Although not mandatory in Europe, the course is recommended by the company to improve safety when flying their helicopters.

Conclusion

The helicopter hard landing occurred due to a downwind approach and attempt to flare the aircraft. The main rotor was overpitched when the engine had reached its rpm limit causing a high rate of descent and an uncontrolled yaw to the right before impact with the ground.

The CAA Safety Sense Leaflet 17 and the Robinson R44 POH Safety Notices contain a range of advice on preventing this type of accident.

The Robinson Helicopter Company also offers an optional but recommended safety course for rated pilots which includes safety subjects such as aircraft handling procedures, major accidents and how they could be avoided, emergency procedures and critical flight conditions.

Footnote

2 https://robinsonheli.com/robinson-courses/robinson-pilots-safety-course/ [accessed May 2021]