

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Washington, D.C. 20594

October 20, 2021

Video Study

**NTSB Case Number:
ERA21LA387**

A. ACCIDENT

Location: Miami Executive Airport (KTMB), Miami, Florida
Date: September 28, 2021
Time: 1906 eastern standard time (EST)
Aircraft: Robinson R44 helicopter

B. AUTHOR

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NTSB

C. ACCIDENT SUMMARY

On September 28, 2021, about 1906 eastern standard time (EST), a Robinson R44 helicopter, N212HT, landed on Alpha helipad, then hover taxied on the ramp to get fuel. Pilot reported that he landed and as he was shutting down the helicopter it started to spin out of control. It became airborne for about five seconds and then crashed.

D. DETAILS OF INVESTIGATION

The goal of this investigation was estimating the rotor speed and the yaw rate of the helicopter that crashed based on a video. The video was recorded by a camera installed on the International Flight Center (IFC) building at the airport. The video had 1280x800 resolution and frame rate of 11.07 frames per second (fps). The video duration was 30.8 seconds. The video did not record sound, so the rotor speed could not be estimated through a sound spectrum analysis. The helicopter landed and came to rest at video time 14.3 seconds. It started yawing while still on the ground at video time 22.7 seconds. It became airborne at about time 25.3 seconds and impacted the ground at about time 30.1 seconds. When it impacted the ground, the tail rotor section was already

separated from the tail boom. When the tail rotor separation occurred, the helicopter was not in the field of view of the camera.

The video had incomplete and/or corrupted metadata (Exif information) embedded in it. The frame rate in the metadata was either missing or incorrect which prevented video players from playing the video at the correct frame rate. Examination of the metadata with various tools resulted in frame rates higher than 90 fps, which was incorrect. Therefore, the frame rate was estimated based on the time stamps in the video frames, under the assumption that the time stamps were correct.

The time difference based on the time stamps between video frame No. 5 and video frame No. 337 was 30.00 seconds. Therefore, the estimated video frame rate was $(337-5)/30 = 11.07$ fps.

Estimating Rotor Speed

The Robinson Model R44 Pilot's Operating Handbook specifies the maximum power-on rotor speed as 408 RPM and the minimum speed as 404 RPM. The analysis of the video was based on assuming that the rotor speed was 408 RPM and then testing whether the visual information in the video supported this assumption.

The R44 rotor has two blades, therefore, the assumed blade passage frequency was $2 \times 408 = 816$ blades/minute or $816/60 = 13.6$ blades/second. Since the estimated frame rate was 11.07 fps, the assumed rate of blade passages per video frame was $13.6/11.07 = 1.23$ blades/frame. This rate means that between two adjacent video frames, if a blade is seen in the first frame at a specific angle with respect to the fuselage, in the next video frame, there will be a blade seen at an angle that is $0.23 \times 180 = 41.4^\circ$ more counterclockwise. In the second video frame, it will be the other blade and it will be rotated an additional 23% of the 180° spacing between the two blades. The R44 rotor rotates counterclockwise as viewed from above.

Since the assumed rate of blade passages per video frame is 1.23 blades/frame, in four video frame intervals, the number of passing blades will be $1.23 \times 4 = 4.92$, close to five blades. It means that every four frames, there should be a blade visible at about the same angular position with respect to the fuselage.

Figure 1 shows segments from four video frames that were recorded when the helicopter started yawing counterclockwise while still on the ground at about time 22.7 seconds. These four video frames are all spaced by four frames between them. The rotor is seen at about the same angular position with respect to the helicopter fuselage in all four frames, supporting the assumption that the rotor speed was close to the assumed 408 RPM.



A.
Video Frame: 251
Video Time: 22.6 s
Time Stamp: 19:06:35



B.
Video Frame: 255
Video Time: 23.0 s
Time Stamp: 19:06:35



C.
Video Frame: 259
Video Time: 23.3 s
Time Stamp: 19:06:35



D.
Video Frame: 263
Video Time: 23.7 s
Time Stamp: 19:06:36

Figure 1. Four Video Frames Just before Takeoff



A.
Video Frame: 288
Video Time: 25.9 s
Time Stamp: 19:06:38



B.
Video Frame: 289
Video Time: 26.0 s
Time Stamp: 19:06:38



C.
Video Frame: 291
Video Time: 26.2 s
Time Stamp: 19:06:38



D.
Video Frame: 292
Video Time: 26.3 s
Time Stamp: 19:06:38

Figure 2. Four Video Frames Just after Takeoff



A.
Video Frame: 331
Video Time: 29.8 s
Time Stamp: 19:06:42

B.
Video Frame: 332
Video Time: 29.9 s
Time Stamp: 19:06:42

Figure 3. Two Video Frames Just before Ground Impact

The helicopter landed at the airport at time 14.3 seconds, about 8.4 seconds before it started yawing counterclockwise. Analysis similar to that shown in Figure 1 was performed on five video frames spaced by four frames between time 13.9 seconds and time 15.4 seconds. The analysis showed that when the helicopter landed, the rotor speed was close to the assumed 408 RPM.

Figures 2A and 2B show segments from two adjacent video frames recorded when the helicopter was already airborne and rotating counterclockwise viewed from above. The blade seen in Figure 2B is at an angular position that is close to the predicted 41.4° more counterclockwise than the blade seen in Figure 2A. Figures 2C and 2D also show segments from two adjacent video frames recorded when the helicopter was airborne and rotating counterclockwise. The blade seen in Figure 2D is at an angular position that is close to the predicted 41.4° more counterclockwise than the blade seen in Figure 2C. Therefore, Figure 2 also supports the assumption that the rotor speed was close to the assumed 408 RPM.

Figure 3 shows segments from two adjacent video frames recorded just before the helicopter impacted the ground. In video frame No. 330, the one before the frame shown in Figure 3A, rotor blades are not visible. In video frame No. 333, the one after the frame shown in Figure 3B, the helicopter already impacted the ground. Therefore, only the two video frames shown in Figure 3 are available for analysis.

The blade seen in Figure 3B is at an angular position with respect to the fuselage that is larger counterclockwise than the angle seen in Figure 3A. Since it is difficult to estimate the blade angles accurately because of the helicopter roll and pitch angles, and accounting for the possibility that the rotor speed was reduced due to the impact with the tail rotor section, Figure 3 also supports the assumption that the rotor speed was close to the assumed 408 RPM up to ground impact or, at least, up to the impact of the rotor with the tail rotor section.

Estimating Helicopter Yaw Rate

It was possible to estimate the helicopter yaw orientation with respect to its orientation before it started spinning counterclockwise. The angle was defined as zero when the helicopter started spinning at time 22.7 seconds. It became airborne at about time 25.3 seconds. The angle was estimated as -360° at time 26.2 seconds, when the helicopter was already airborne. Negative yaw angle corresponds to counterclockwise rotation. At time 27.0 seconds, the helicopter exited the field of view of the camera until time 29.3 seconds. Figure 4 shows the plot of the yaw angle vs. time. The yaw rate past time 25 seconds was -142 degrees/second.

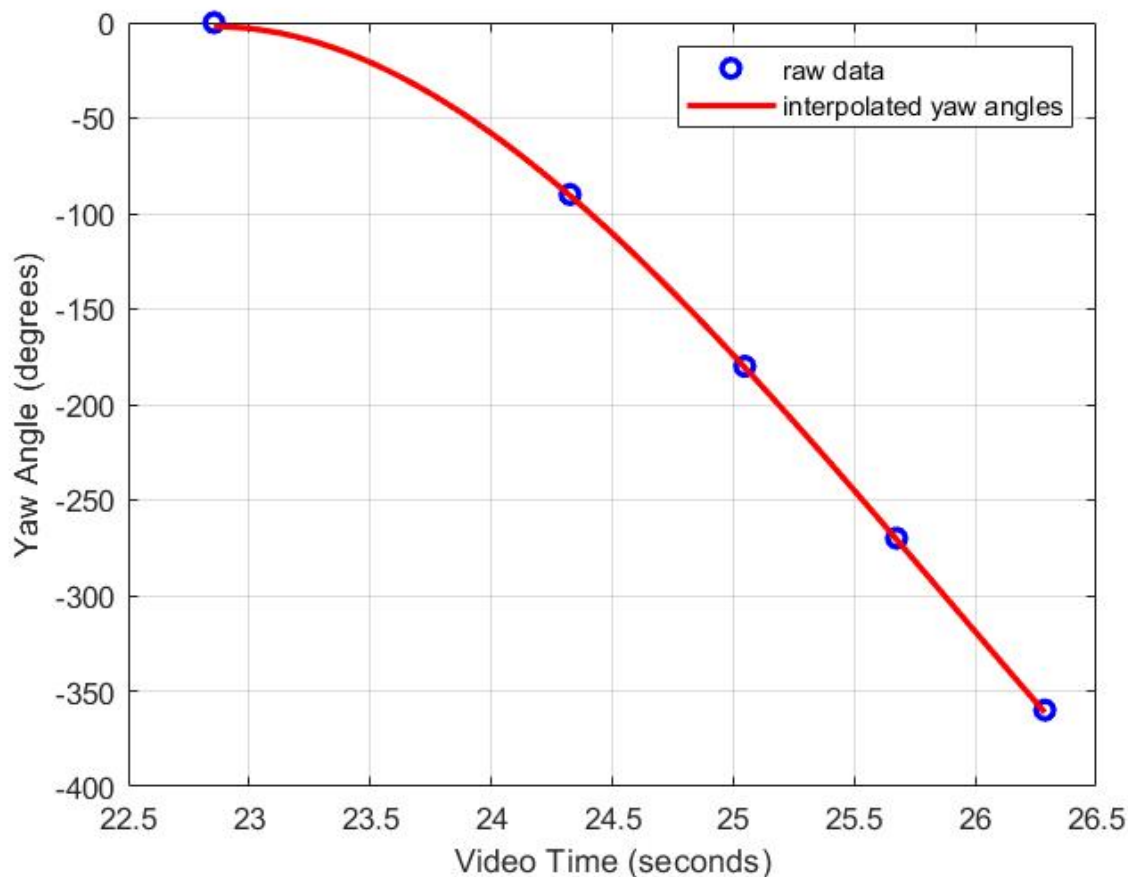


Figure 4. Estimated Helicopter Yaw Angle

E. CONCLUSIONS

The rotor speed of a helicopter that crashed was estimated when it landed, when it started yawing while still on the ground, when it was yawing while airborne, and just before it impacted the ground. The analysis showed that the rotor speed was constant and close to the nominal speed of 408 RPM. The yaw rate of the airborne helicopter was estimated as -142 degrees/second where the negative rate means that the rotation was counterclockwise.