National Transportation Safety Board
Office of Research and Engineering
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WPR22FA101

AUTOMATIC DEPENDENT SURVEILLANCE-BROADCAST (ADS-B) STUDY

Aircraft Performance Study

By

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A. ACCIDENT

Location: Newport Beach, California
Date: February 19, 2022
Time: 18:34 Pacific standard time (PST)
02:34 UTC (February 20, 2022)
Aircraft: McDonnell Douglas 500N, N521HB

B. SUMMARY

On February 19, 2022, about 18:34 Pacific standard time, a McDonnell Douglas 500N, N521HB, was substantially damaged when it was involved in an accident in Newport Beach, California. The pilot sustained minor injuries, and the tactical flight officer (TFO) was fatally injured. The helicopter was operated as a public aircraft flight by the Huntington Beach Police Department.

C. PERFORMANCE STUDY

1.0 Aircraft

The McDonnel Douglas 500N (marketed as the 520N) is a light utility helicopter. The five main rotor blades rotate in a counter-clockwise direction viewed from above. The MD 500N has a NOTAR system instead of conventional tail rotor. Air from a fan inside the tail boom is directed through horizontal slots in the tail boom and combined with downwash from the main rotor blade to create force to one side of the tail[1] which provides anti-torque to stabilize the helicopter's yaw. The yaw pedals in the helicopter control the pitch of the fan blades and the direction of a direct jet thruster at the end of the tail boom (also powered by the air from the fan). Additionally, the angle of attack of the left vertical stabilizer (the right vertical stabilizer is fixed) can add additional yaw-control at the command of the Yaw Stability Augmentation System (YSAS). In Figure 1, the accident helicopter is shown with left pedal input. The left vertical stabilizer is trailing edge left and the direct jet thruster is open to the left. These inputs would impart a left yawing moment to oppose the main rotor blades.

[1] Airflow through the horizontal slots will stay attached to the convex surface of the tailboom creating a region of low pressure. This is known as the Coandă Effect.

Figure 1. Photograph of accident helicopter.

2.0 Available Data

The flight was recorded by Automatic Dependent Surveillance-Broadcast (ADS-B) data, which was provided by the Federal Aviation Administration (FAA). ADS-B broadcasts an aircraft's Global Positioning System (GPS) position and other data to the ground where it is recorded. The GPS position has an accuracy of approximately 20 meters (65 ft) in both the horizontal and vertical planes.

The helicopter was equipped with an L3Harris WESCAM MX-10 EO/IR camera mounted on a gimbal on the right side of the aircraft. The video was processed by an AeroComputers digital mapping system with superimposed aircraft and camera information on the video image. The Video Study [1] determined the helicopter's heading and yaw rate during the end of flight, which will be used in this study.

3.0 Weather

At 18:53, the nearest weather station, five nautical miles northeast of the accident site, recorded the temperature as 63°F (17°C), the dewpoint as 46°F (8°C), and the barometric pressure as 30.00 inHg. Winds were 3 kts from 210°. Skies were clear and night conditions prevailed.

Additionally, a High-Resolution Rapid Refresh (HRRR) wind and temperature sounding was provided for the area for 18:00 and 19:00 local time. At the end of flight (18:34), the helicopter was at an altitude of about 400 ft above mean seal level (msl).

From the HRRR, winds at that altitude at the time were between 14 kts from 281° (18:00) and 11 kts from 286° (19:00). For the purpose of this Study, the lower 11 kts from 286° will be used for airspeed calculations.

4.0 Flight Path

The helicopter took off from the Huntington Beach Police Department air support unit base at 17:59. For the first 30 minutes of flight, the helicopter was between 500 and 1,100 ft msl and at groundspeeds above 50 kts. Figure 2 shows the ADS-B flight path on a map and Figure 3 shows the helicopter's altitude and calculated groundspeed.

Figure 2. Helicopter's flight path with selected times and altitudes (msl) noted.

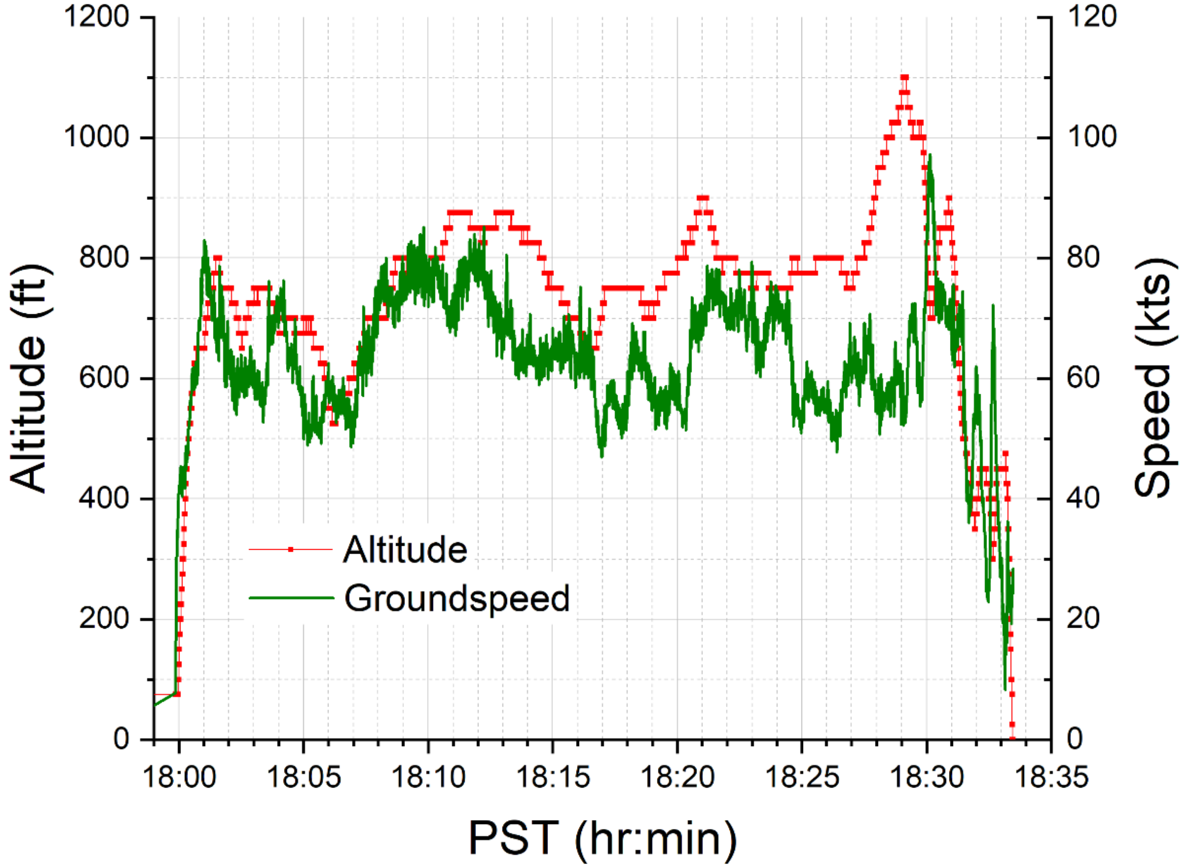

Figure 3. ADS-B altitude (msl) and calculated groundspeed for full flight.

After 18:30 the helicopter approached the area in Newport Beach where it was to orbit an area of interest and film (Figure 4). The helicopter proceeded to make a series of right turns over the area.

Figure 4. Final three minutes of flight with selected times and altitudes noted. The yellow arrow marks the location being filmed by the onboard camera.

The Video Study used the video filmed onboard to determine the helicopter's heading from time 18:33:02 until 18:33:11. The study found that after 18:33:11 (shown in Figure 5) the helicopter's right yaw rate rapidly increased and that the helicopter was spinning. The yaw rate increased to a yaw rate greater than 130°/s in less than three seconds. This corresponded with the loss of altitude at the end of the flight as seen in Figure 5.

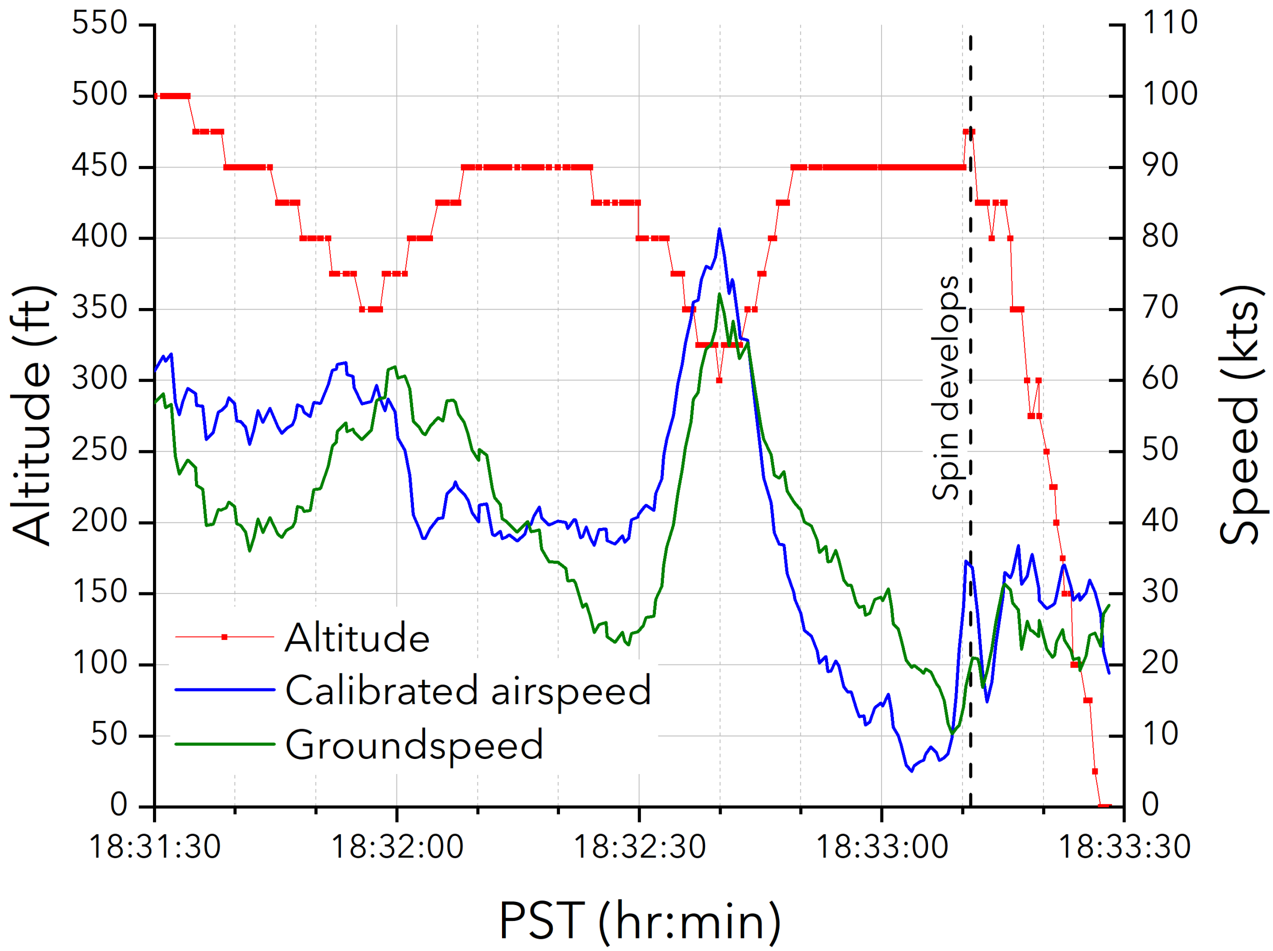

Figure 5. Altitude (msl), calibrated airspeed, and groundspeed of the end of flight.

Figure 6 shows the flight path in the area where the spin developed in detail. The four plots are annotated with time, heading from the Video Study, groundspeed, and calibrated airspeed. The ADS-B path shows the helicopter entering from the left, completing a small circle, and then exiting the plot to the top right. The approximate point where the spin began to develop according to the Video Study is shown in all plots. As discussed in section 2.0 Available Data, the resolution on ADS-B position data is 65 ft. The small squares in Figure 6 are 10 ft by 10 ft and the approximate size of the accident helicopter can be seen in the top right plot. The approximately 40 ft by 20 ft circle could reflect a flight path where the helicopter was initially moving to the east before slowing, changing direction, and returning west.

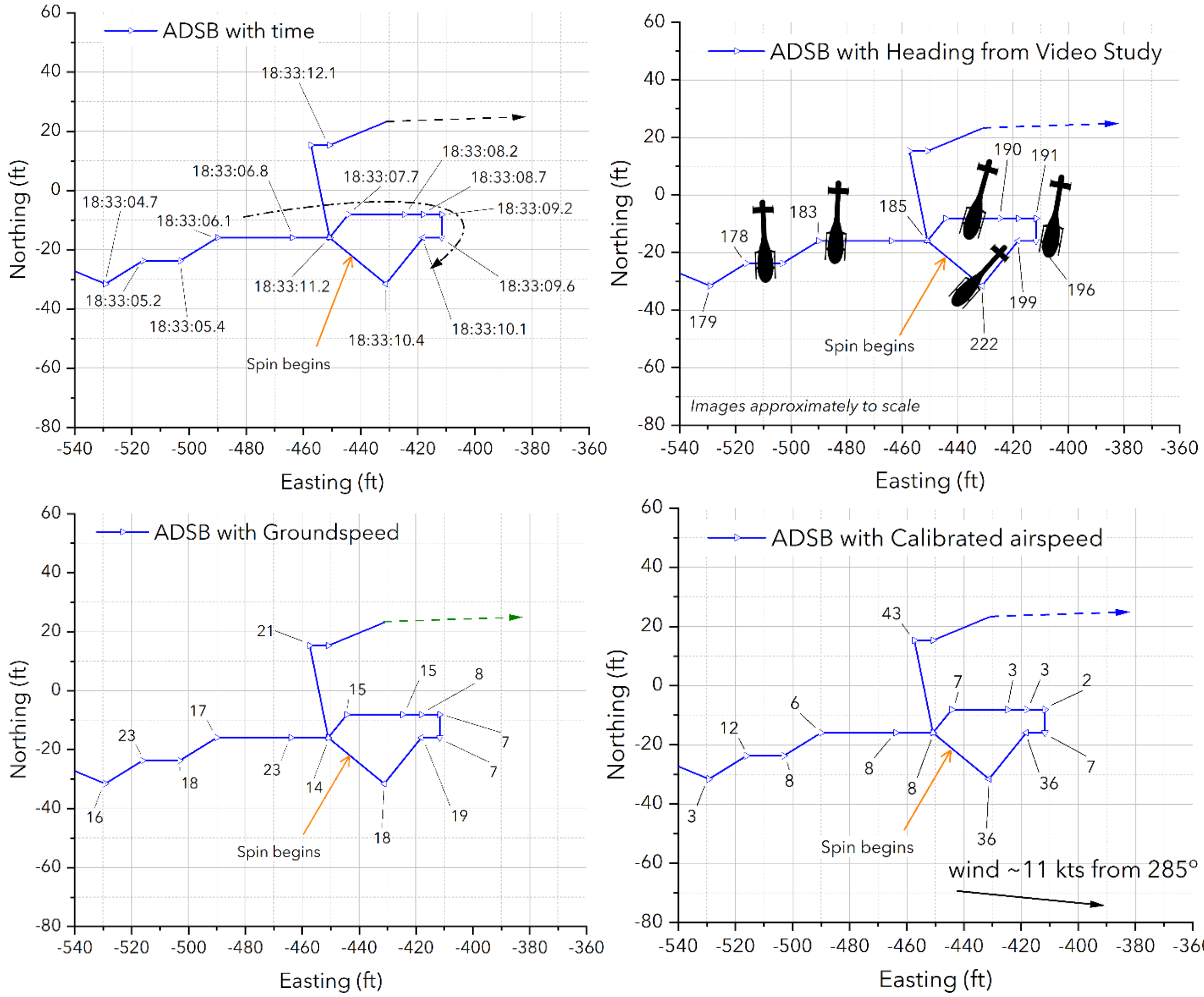

Figure 6. ADS-B flight path in Northing and Easting with time (top left), heading (top right), groundspeed (bottom left) and calibrated airspeed (bottom right) for each point. Wind direction and magnitude is also noted on calibrated airspeed plot.

The helicopter's groundspeed was between 15-23 kts as it moved east. Winds were 11 kts from 286°, so the resulting calibrated airspeeds were between 3-12 kts. During this time, the helicopter was pointed south on a heading between 178° and 185°. Groundspeed slowed markedly after 18:33:08 as did calibrated airspeed. The helicopter's heading came slightly more to the right. As the helicopter moved back on a westerly course, groundspeed increased to near 20 kts and airspeed to more than 30 kts due to the wind. The last heading determined in the video study before the yaw rate increased significantly was 222°. The helicopter impacted the water approximately 17 seconds after the spin began.

In general, helicopter power requirements are greatest at low speeds which subsequently require the greatest amount of anti-torque to control heading [2]. Once a helicopter accelerates beyond 16-24 kts, it gains translation lift as undisturbed air enters the main rotor system and the power required declines. However, as translational lift is gained, gyroscopic precession induces a right rolling motion to the rotor (and fuselage if aligned with the flight path) and the helicopter pitches up [3] necessitating increased anti-torque and forward cyclic for the transition.

Until 18:33:09, the helicopter's flight path was with the wind and its subsequent airspeed was under 10 kts. The helicopter's forward airspeed began to increase after 18:33:10. As the helicopter accelerated, power would have increased as it approached translational lift, increasing the amount of anti-torque required. As it gained translational lift with increased speed, the helicopter would have encountered the induced right rolling motion which would have needed to be countered. However, since the fuselage was not aligned with the flight path, its induced moment would be about a different axis, complicating the maneuver. A right rolling motion to the rotor coupled with the tendency to yaw right could have been responsible for the helicopter's continuing tight right turn after 18:33:11.

The anti-torque requirements during these few seconds would have been complex and changing. If the anti-torque requirements were not managed in a timely manner, the result could have been an uncontrolled right yaw. Compounding the difficulty of arresting the yaw once it began would have been the dark, night-time conditions and the proximity to the ocean, which would have limited the visual cues for the pilot.

D. CONCLUSIONS

The helicopter was traveling at a low airspeed and with its nose nearly 90° right of the flight track before the uncommanded right yaw event. While accelerating and gaining translational lift, the power requirements on the anti-torque system would have changed and needed to be continuously adjusted in a timely manner.

REFERENCES

1. Video Study, WPR22FA101, National Transportation Safety Board, 2022.
2. Unanticipated Right Yaw in Helicopters, Advisory Circular 90-95, Federal Aviation Administration, 1995.
3. Section 2-20, Effective Translational Lift, Helicopter Flying Handbook, FAA-H-8083-21A.