

National Transportation Safety Board

Office of Research and Engineering

Washington, D.C. 20594

Performance Study

Specialist Report

Marie Moler

A. ACCIDENT

Location:	Calabasas, California
Date:	January 26, 2020
Time:	09:45 Pacific Standard Time (PST)
Aircraft:	Sikorsky S-76B, N72EX
NTSB Number:	DCA20MA059

B. GROUP

No vehicle performance group was formed.

C. SUMMARY

On January 26, 2020, about 09:45 PST, a Sikorsky S76-B helicopter, N72EX, was destroyed when it was involved in an accident near Calabasas, California. The pilot and eight passengers were fatally injured. The helicopter was operated as a Title 14 *Code of Federal Regulations* Part 135 charter flight.

D. PERFORMANCE STUDY

The helicopter was equipped with ADS-B (automatic dependent surveillance – broadcast), by which system the Federal Aviation Administration (FAA) recorded the time, the helicopter's latitude and longitude, pressure and geometric altitude, and inertial speeds. ADS-B data began at 09:06 PST and continued until 09:45:36 PST. The last ADS-B location was about 500 ft away from the wreckage location.

Communications between the accident helicopter (N72EX) and the Burbank airport air traffic control tower (ATCT), the Van Nuys airport ATCT, and the Southern California Terminal Radar Approach Control (Southern California TRACON, SCT, or SoCal) are also included in this report [1].

Performance Study DCA20MA059, Sikorsky S-76B, N72EX

Aircraft Flightpath

The helicopter departed John Wayne Airport at 09:07, after receiving a special visual flight rules (SVFR) departure from Long Beach Airport air traffic control tower (ATCT) (Figure 1). Its destination was Camarillo Airport which is shown west of the final ADS-B point. The helicopter flew northwest towards Glendale, where it held for 12 minutes, awaiting clearance from Burbank ATCT to continue. It then continued north along I-5 and around the Burbank and Van Nuys airports before turning south. At 09:42:45 the helicopter joined US 101 heading west towards Camarillo¹. ADS-B data ended about three minutes later and the helicopter impacted terrain near Calabasas.

The weather at John Wayne Airport at 08:53, 14 minutes before take-off, was reported as 57°F, dew point 50°F, winds from the northeast at 5 kts, barometric pressure of 30.10 inHg, and cloudy. Weather reported from Van Nuys Airport at 09:53 was 52°F, dew point 46°F, winds from the north-northwest at 5 kts, barometric pressure of 29.33 inHg, and haze. Weather and visibility was critical to the accident and is discussed in much greater detail in the Weather Study [2].

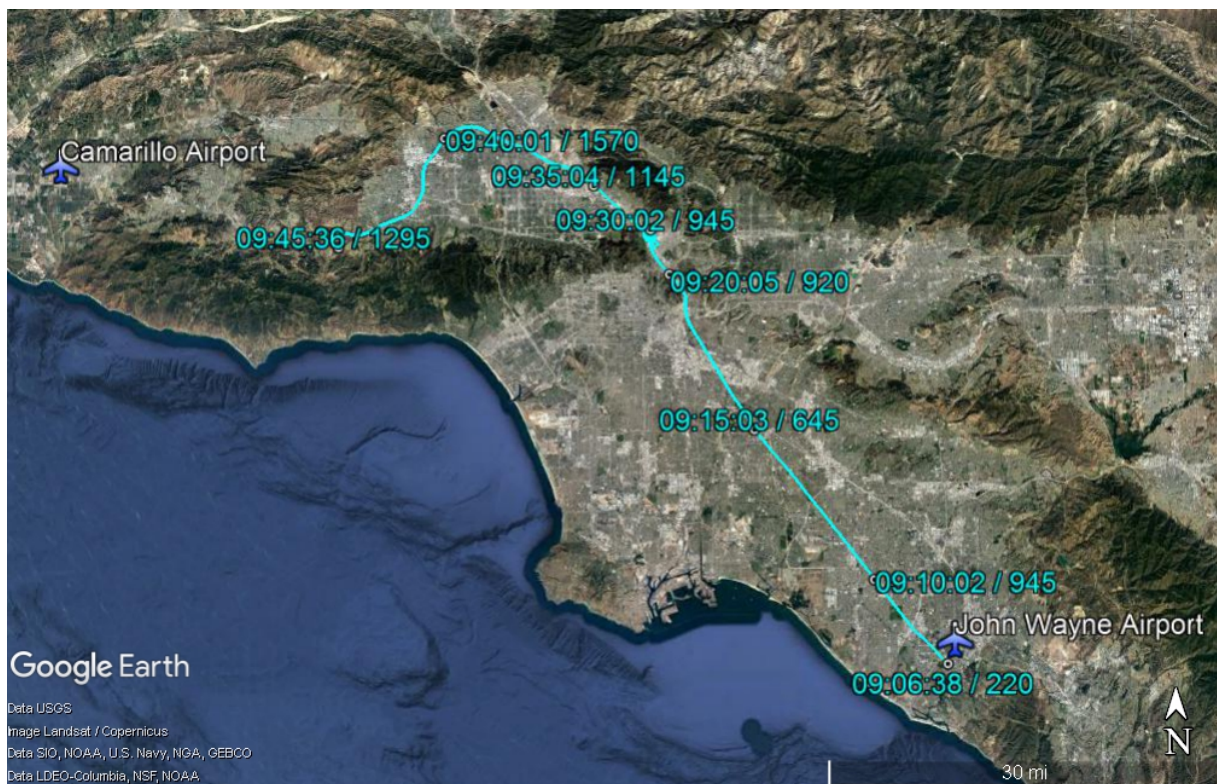


Figure 1. Accident flight path.

Figure 2 shows the corrected altitude, groundspeed, and terrain elevation. After departure, the helicopter headed northwest at about 150 kts. It climbed to 1,000 ft msl (mean sea level) before descending to 600 ft at about 09:13. From there, the helicopter stayed between 400 and 600 ft

¹ Camarillo Airport, the intended destination, is along US 101.

Performance Study
DCA20MA059, Sikorsky S-76B, N72EX

above the terrain which was increasing in elevation. Just after 09:20, the helicopter slowed to between 40 and 60 kts as the pilot requested to transition to the area along US 101. The helicopter was asked by ATC to hold outside Burbank Class C airspace due to traffic.

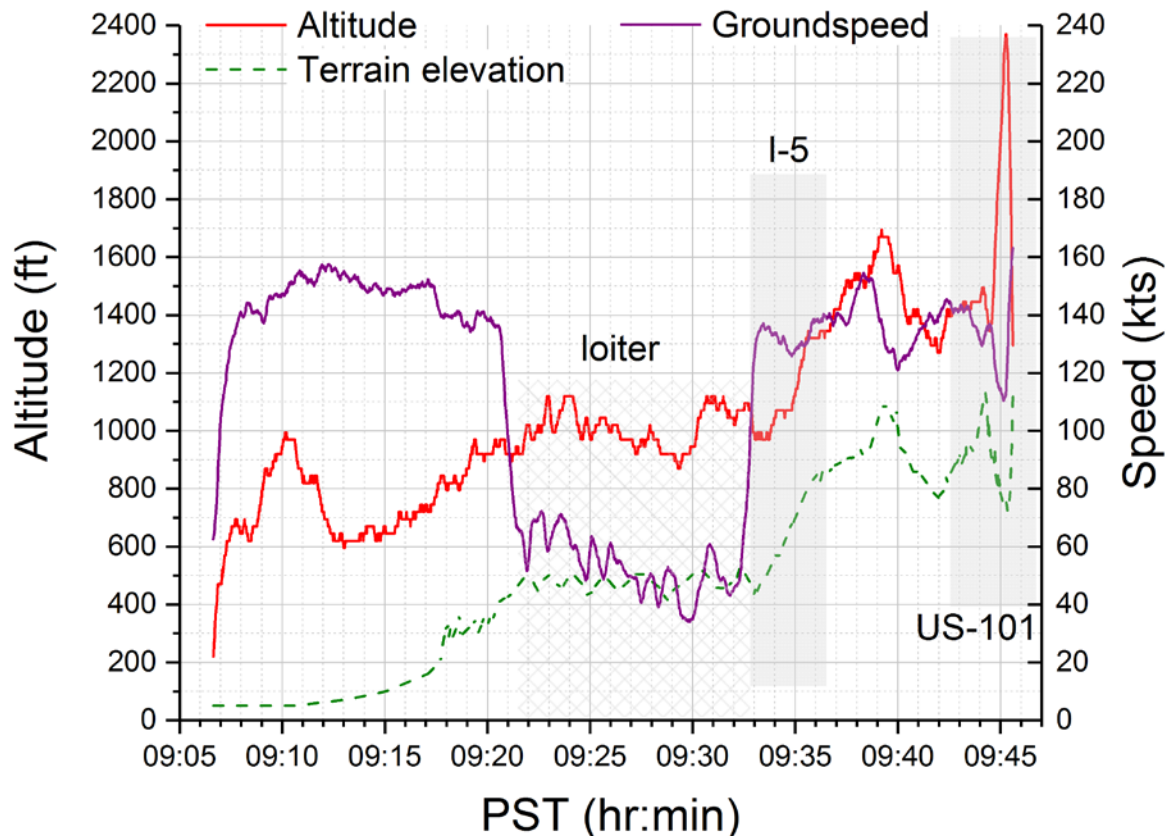


Figure 2. Accident altitude, groundspeed, and terrain elevation.

The Burbank weather observation current at the time of the pilot's request reported instrument flight rules (IFR) conditions, and the air traffic controller advised that cloud tops were reported at 2,400 ft msl. The helicopter loitered, circling, until 09:32 when it was given clearance to follow the I-5 freeway to SR 118, and then south to US 101, staying out of the Class C airspace and under special visual flight rules (SVFR) at or below 2,500 ft. At 09:33, Burbank ATCT reported 2.5 miles of visibility with a haze ceiling at 1,100 ft and stated Van Nuys weather was "almost identical". At 09:36, Van Nuys ATCT asked the pilot to advise when "you are in v-f-r conditions or when you're clear of the van nuys class delta transition." At 09:39:45, the helicopter had turned south, and the pilot reported they were transitioning to SCT while in visual flight rules (VFR) conditions. At 09:40, SCT asked if "you just gonna stay down low at that for all the way to Camarillo" and the pilot responded affirmatively. At 09:43, a new controller took over at SCT. The helicopter maintained an altitude of 400 to 600 ft above ground level but remained below 1,700 ft msl.

Performance Study

DCA20MA059, Sikorsky S-76B, N72EX

The helicopter joined US 101 at 09:42:45 at which point it was about 29 miles from its destination. Figure 3 shows the helicopter's altitude, groundspeed, and rate of climb at the end of flight. Figure 4 shows the flight path over a terrain map, Figure 5 shows the end of flightpath from an oblique angle, and Figure 6 from overhead. Just before 09:44, the helicopter entered more hilly terrain as US 101 followed a pass through local mountains (Figure 4). Visibility within this pass was limited and is discussed further in the Video-Based Visibility Study [3]. Just after 09:44:30, the helicopter started climbing at a rate of about 1,500 ft/min. About 09:45:10, the helicopter started a left turn away from US 101. The helicopter reached a maximum altitude just below 2,400 ft msl at 09:45:15, about 1,600 ft above the terrain below, when it began to descend rapidly while in a left turn.

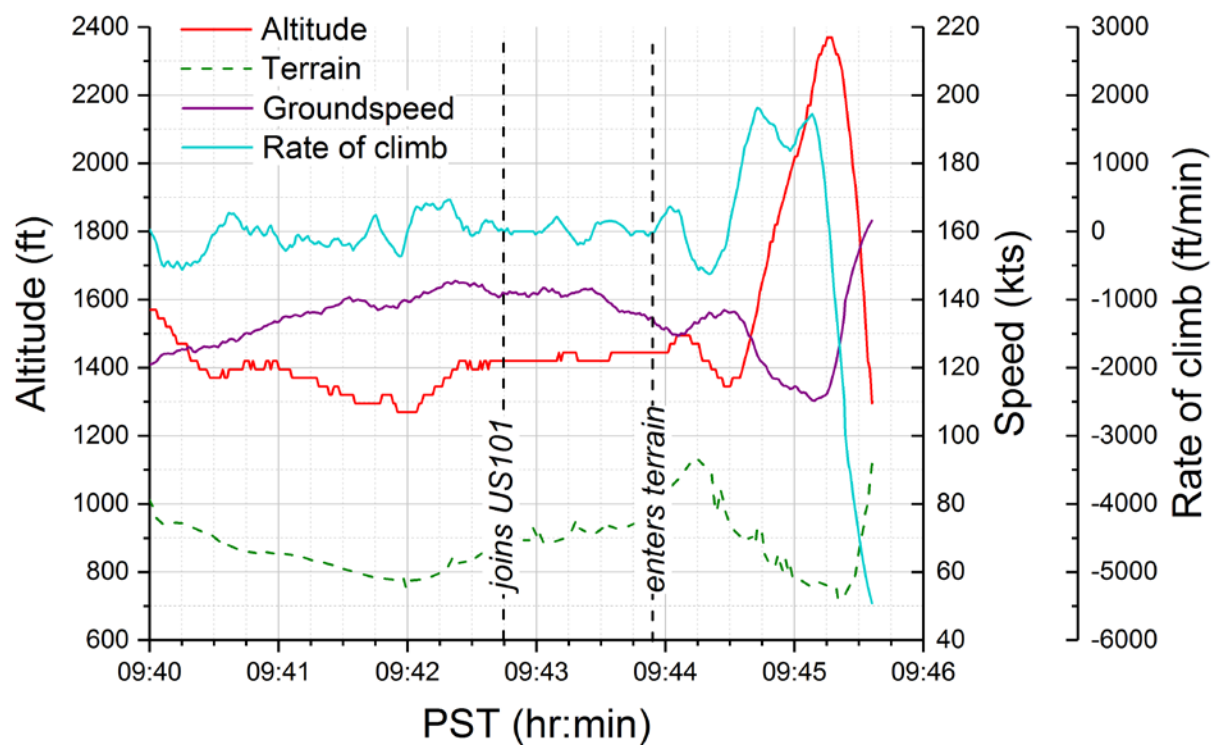


Figure 3. Accident altitude and terrain elevation, groundspeed, and rate of climb and the end of flight.

Performance Study
DCA20MA059, Sikorsky S-76B, N72EX

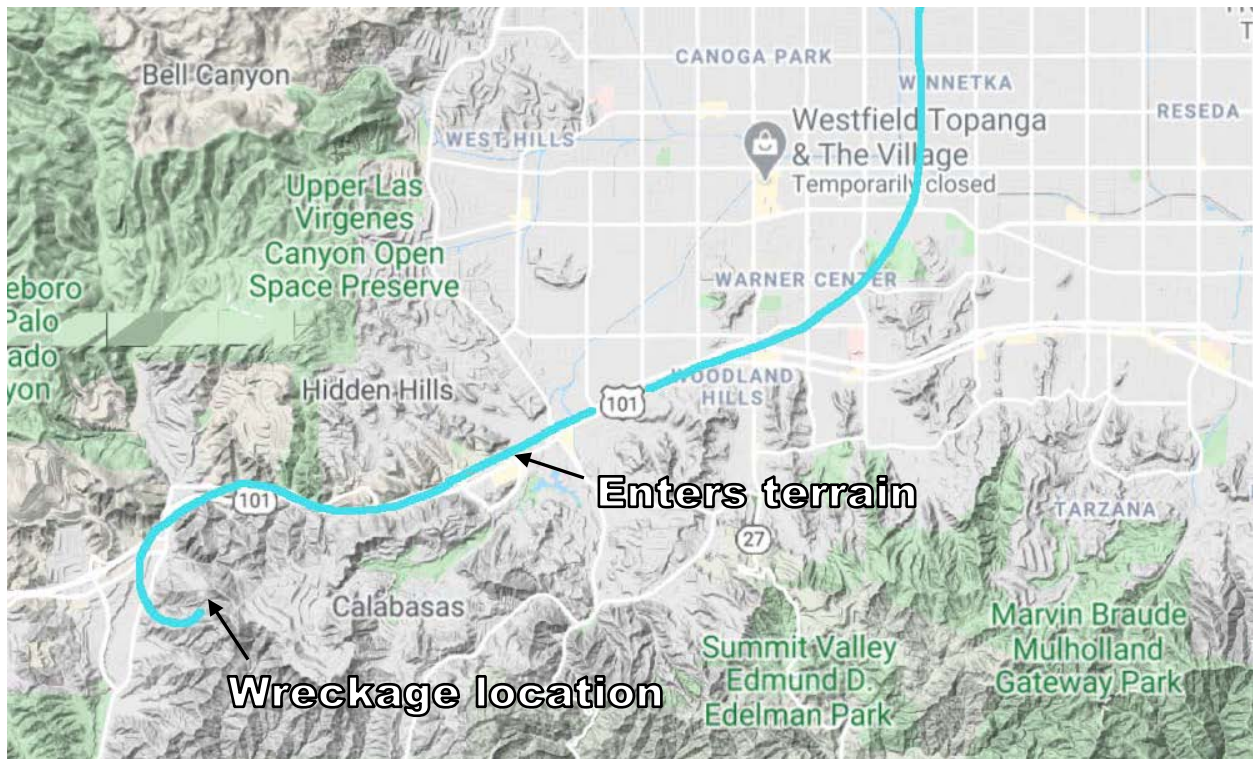


Figure 4. Accident flight path over terrain map.



Figure 5. End of accident flight with time and altitudes noted.



Figure 6. End of accident flight with time and altitudes noted.

The helicopter attitude was not recorded, but bank angles were estimated by the equation below, where θ is the bank angle to complete a level turn of radius R at constant groundspeed V , neglecting winds (g is the gravitational constant, 32.2 ft/s^2),

$$\theta = \tan^{-1} \left(\frac{V^2}{gR} \right)$$

The radii of the turns were determined from the flight path. Figure 7 shows the resultant bank angle calculations from the method described above. A left-hand turn resulted in a negative bank angle. These calculations are estimates but are illustrative of trends in the data.

Performance Study
DCA20MA059, Sikorsky S-76B, N72EX

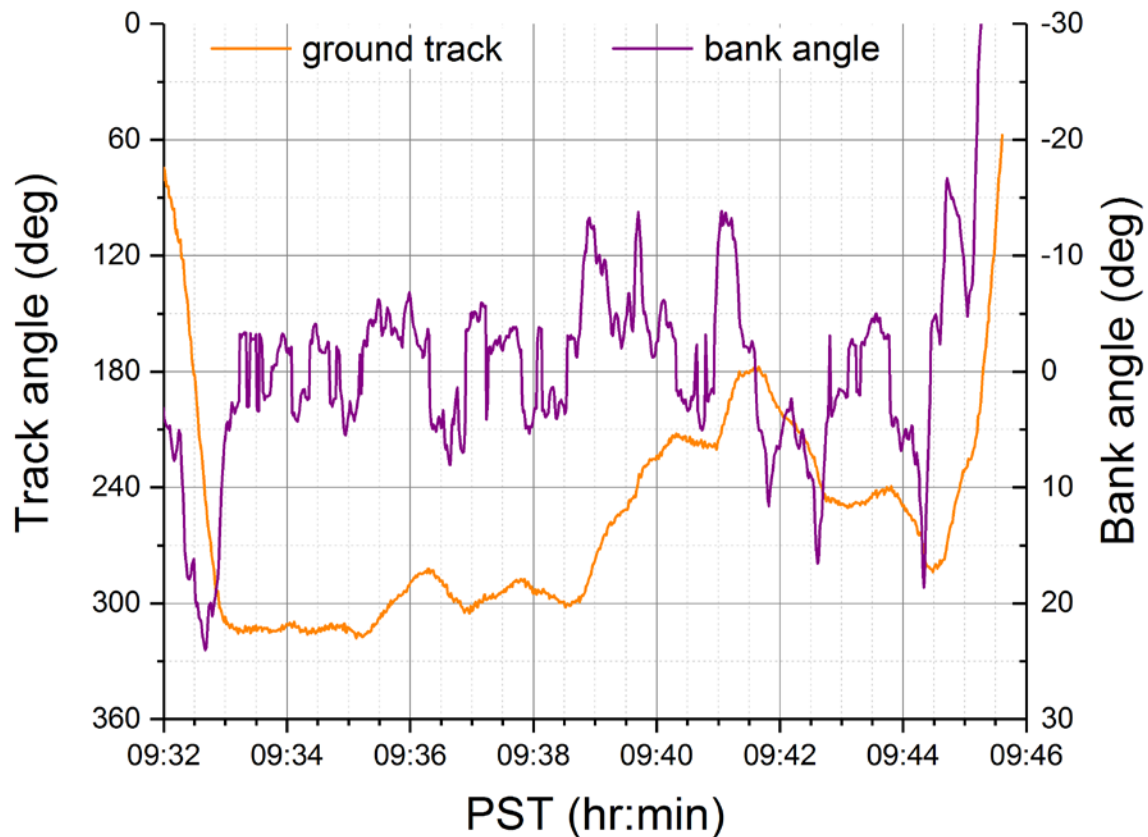


Figure 7. Accident track angle from ADS-B data and calculated bank angle. Negative bank angle indicates a left turn. The whole flight is not shown for clarity.

Figure 8 shows the altitude and bank angle of the last minute of flight overlaid with ATC communications. The pilot informed SCT at 09:44:34 that they were going to “start our climb to go above the ... layers” immediately after which the final climb began. The new controller at SCT asked where the accident helicopter was and discussed the helicopter’s transponder code. The helicopter’s left bank angle increased about 09:45:10 and as the helicopter reached its maximum altitude right as SCT asked for the pilot’s intentions. The pilot responded, “climbing to four thousand,” but the helicopter was descending, 17 seconds before the end of data. SCT asked for his intentions, but the pilot never responded.

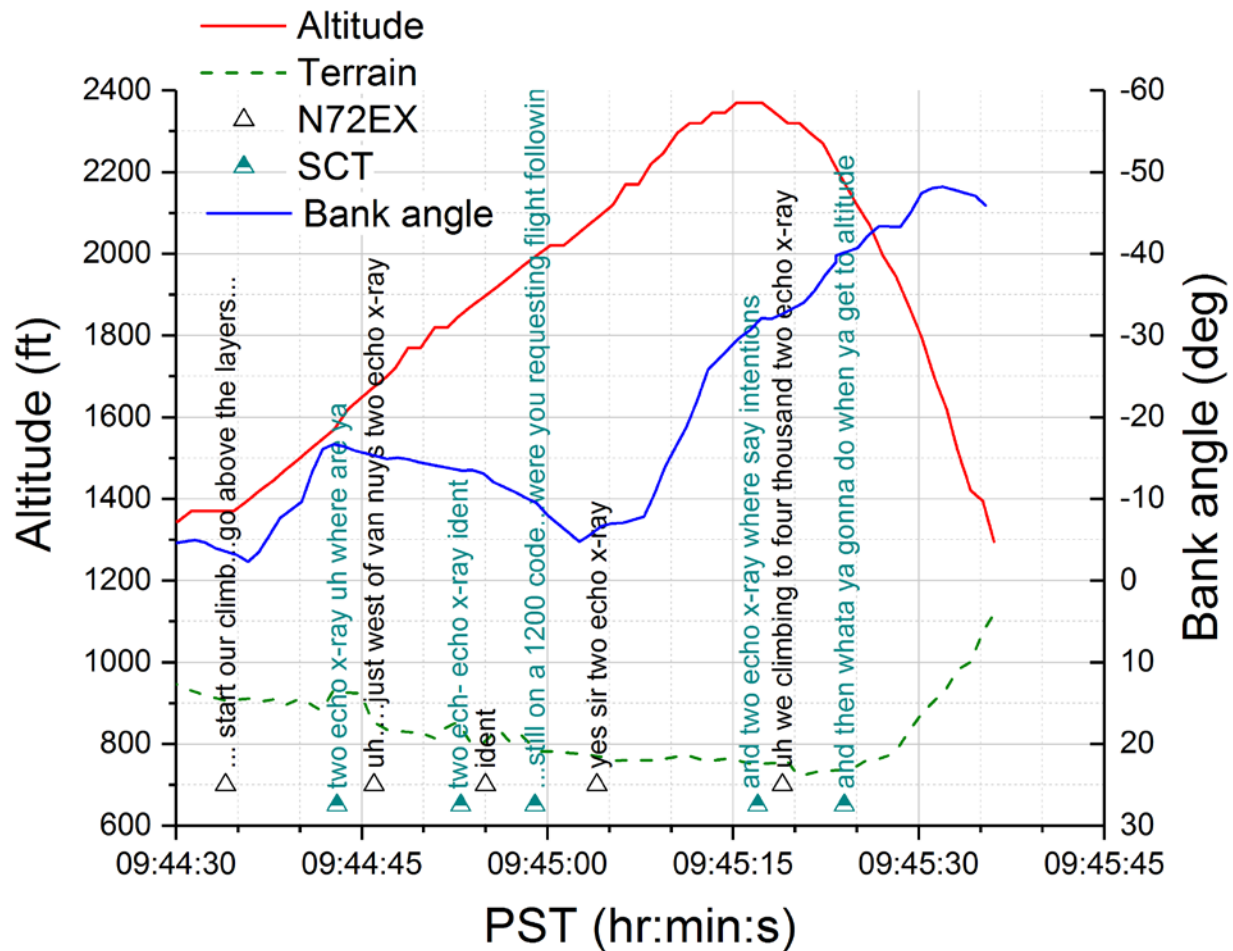


Figure 8. End of flight altitude, terrain, and calculated bank angle. ATC communications between the accident helicopter (N72EX) and SCT are also show.

Apparent Angles and Spatial Disorientation

The vestibular system of the inner ear allows a person to have a sense of balance and spatial orientation. However, like all accelerometers, the vestibular system cannot distinguish between load factors due to motion versus load factors due to gravity. Simply put, on its own, the inner ear cannot differentiate between accelerations and tilt. Additional sensory inputs, such as visual cues, are needed to correctly perceive attitude and acceleration. When a pilot misperceives attitude and acceleration it is known as the “somatogravic illusion” and can cause spatial disorientation. Further information is available in the Human Performance Report [4].

Figure 9 shows the orientation of the resultant load factor vector $\vec{n}$ for two cases. In the left image, the aircraft is unaccelerated, and $\vec{n}$ is aligned with the gravity vector $\vec{g}$, along the earth’s vertical axis (z_e). In the right image, the aircraft is in accelerated flight, and $\vec{n}$ has a component along the x_b axis (n_x). In both cases, the angle of the vector $\vec{n}$ relative to the aircraft’s vertical axis (z_b) is the

Performance Study
DCA20MA059, Sikorsky S-76B, N72EX

same: θ_{APP} , or the “apparent” pitch angle. While in the left image, θ_{APP} is the actual pitch angle of the aircraft ($\theta_{APP} = \theta$), in the right image the actual pitch angle is less than θ_{APP} . However, in both cases the pilot’s vestibular/kinematic system alone would perceive the pitch angle as θ_{APP} .

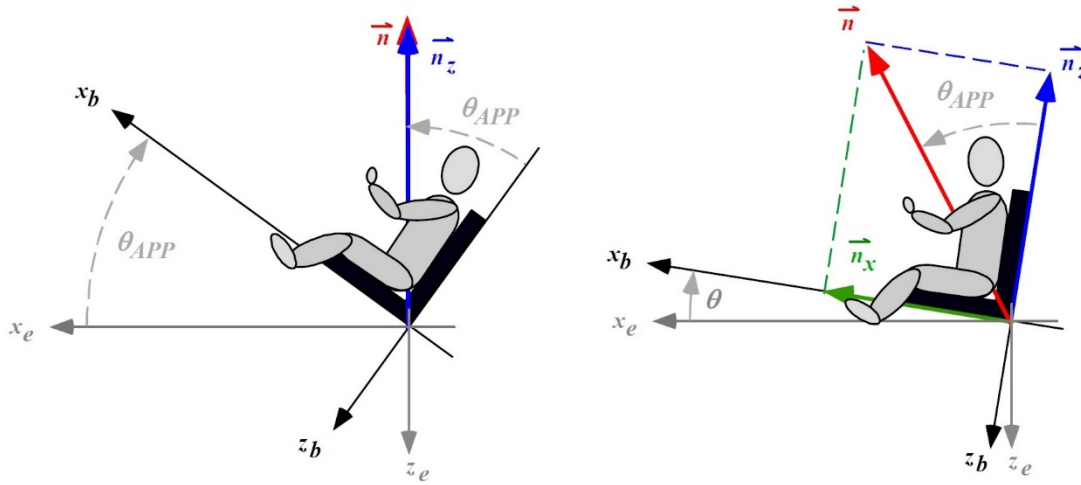


Figure 9. Apparent angles in an unaccelerated (left) and accelerated (right) reference frame.

The following equations represent the apparent pitch and roll angles for a worst-case scenario where acceleration is wholly mis-equated for gravity, but the actual pilot perception could range between an accurate attitude to one where the aircraft attitude is wholly mis-equated. The pitch and roll angles in an unaccelerated axis system that will produce a vector $\vec{n}$ parallel (in aircraft body axes) to the vector $\vec{n}$ in the accelerated system are needed to compute θ_{APP} and ϕ_{APP} . In the unaccelerated system, $\vec{n}$ has Earth-axis components $\{0, 0, -g\}$, or equivalently

$$\vec{n} = \begin{pmatrix} 0 \\ 0 \\ -|\vec{n}| \end{pmatrix}_{EARTH}$$

Where

$$|\vec{n}| = \sqrt{(n_x)^2 + (n_y)^2 + (n_z)^2} = g$$

Transforming these components into aircraft body axis for the unaccelerated system gives

Performance Study
DCA20MA059, Sikorsky S-76B, N72EX

$$\vec{n} = -|\vec{n}| \begin{pmatrix} -\sin \theta \\ \sin \phi \cos \theta \\ \cos \phi \cos \theta \end{pmatrix}_{BODY}$$

For the accelerated system, θ_{APP} and ϕ_{APP} are such that when the aircraft body axis is aligned with these angles in an unaccelerated system, the resulting body-axis components of $\vec{n}$ will match the load factors n_x , n_y , and n_z from the accelerated case. So, the last equation is set as

$$|\vec{n}| \begin{pmatrix} -\sin \theta_{APP} \\ \sin \phi_{APP} \cos \theta_{APP} \\ \cos \phi_{APP} \cos \theta_{APP} \end{pmatrix}_{BODY} = \begin{pmatrix} n_x \\ n_y \\ n_z \end{pmatrix}$$

And θ_{APP} and ϕ_{APP} can be calculated as

$$\theta_{APP} = \sin^{-1} \left(\frac{n_x}{|\vec{n}|} \right)$$

$$\phi_{APP} = \sin^{-1} \left(\frac{-n_y}{|\vec{n}| \cos \theta_{APP}} \right)$$

Since it did not have a data recorder, the helicopter's accelerations, which could be measured by onboard accelerometers, were not recorded. Therefore, ADS-B position data was twice differentiated to determine load factors. However, these calculations are not as accurate as measurements would be and required extensive smoothing of the data. Once n_x , n_y , and n_z were determined, θ_{APP} and ϕ_{APP} were calculated and are shown below in Figure 10. Without outside references or attention to the helicopter's attitude display, the actual pitch and bank angles have the potential to be misperceived. The apparent angles were compared to the calculated bank angles discussed earlier and the helicopter's flight path angle, since pitch was not recorded.

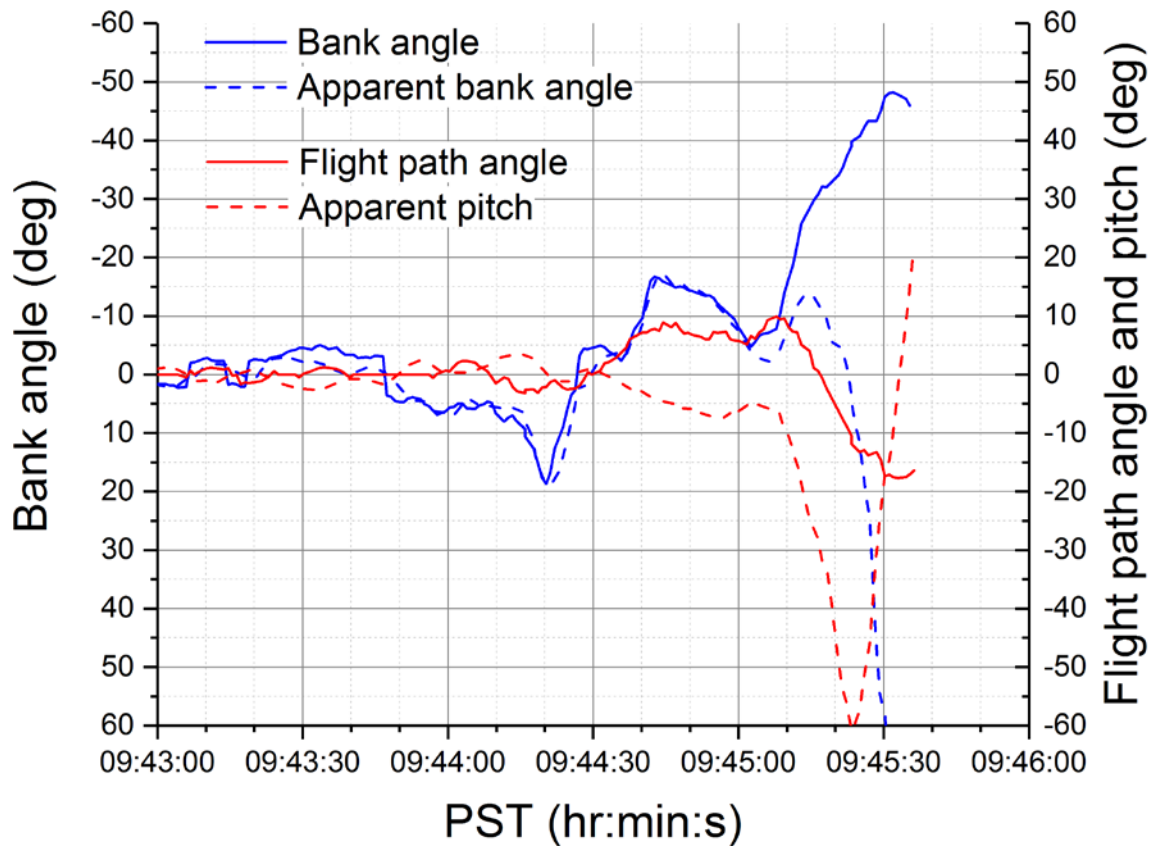


Figure 10. Apparent bank and pitch angles as compared to calculated bank and flight path angles.

The helicopter's forward speed slowed beginning at 09:44:30 (refer to Figure 3), contributing to a negative apparent pitch angle despite the rapid climb to near 2,400 ft, followed by an increasing apparent pitch as the helicopter gained speed while descending. While the apparent and actual bank angles initially track each other, the apparent bank is to the right as the left turn tightens. Figure 11 overlays the final ATC communications with the helicopter attitude and apparent angles and shows that the pilot was communicating with ATC during the deviation of actual and apparent roll angles.

Performance Study
DCA20MA059, Sikorsky S-76B, N72EX

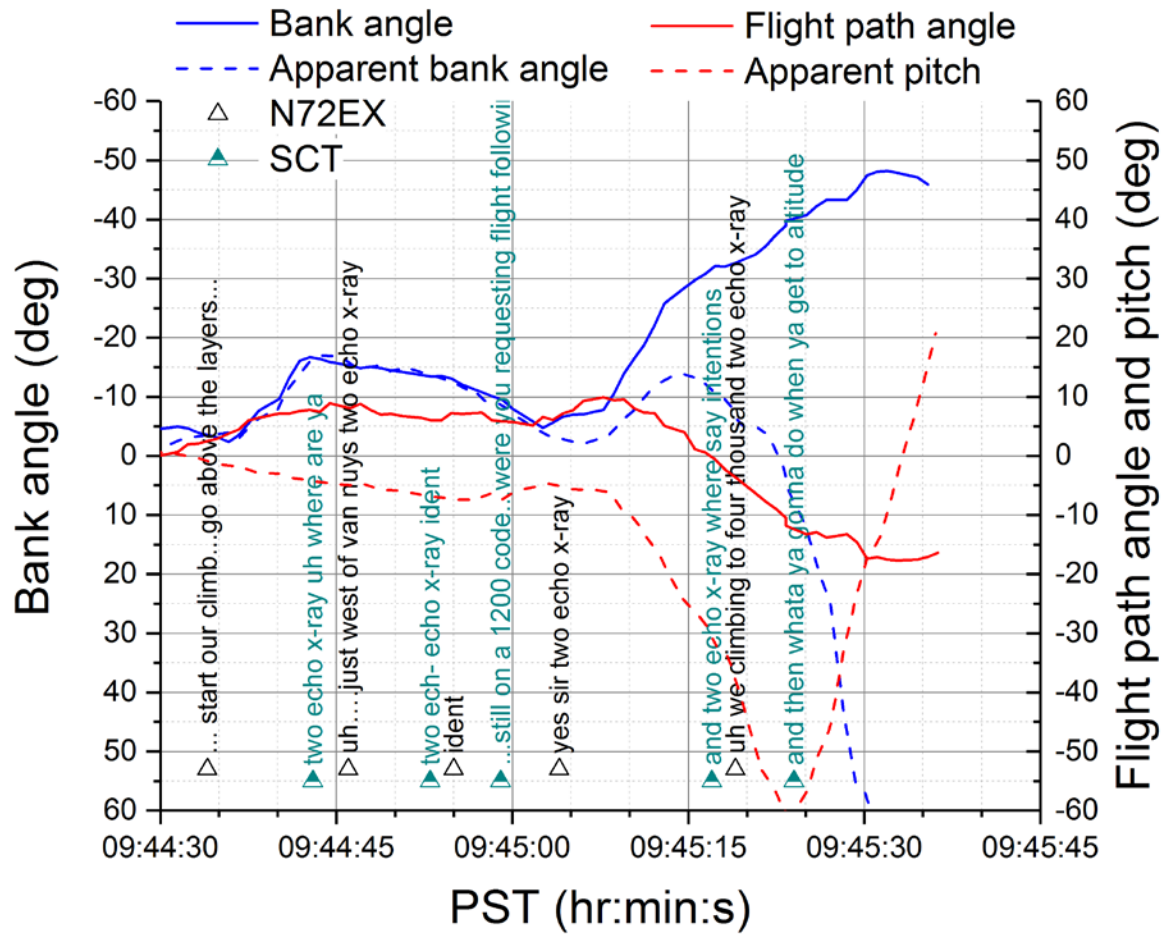


Figure 11. Apparent bank and pitch angles as compared to calculated bank and flight path angles with ATC communications overlaid.

Performance Study
DCA20MA059, Sikorsky S-76B, N72EX

E. CONCLUSIONS

The helicopter took off from John Wayne Airport at about 09:06 PST and flew northwest at 150 kts of groundspeed until nearing the Burbank Class C airspace. There it slowed and loitered from 09:20 until 09:32 when clearance was given to follow I-5 north around the Burbank and Van Nuys Airports. The helicopter flew at groundspeed between 130-150 kts, 400 to 600 ft agl, as it circled around the airspace and turned south. It did not exceed 1,700 ft msl. The helicopter joined US 101 at 09:42:45. At 09:44:34, the pilot informed SCT that they were going to “start our climb to go above the ... layers” and immediately began climbing. Just after 09:45:10, while communicating with ATC, the helicopter began to bank left, leaving US 101. Calculated apparent angles at this time show that the pilot could have misperceived both pitch and roll angles. By 09:45:15 the helicopter reached its maximum altitude and began descending. During the final descent the pilot, responding to ATC, stated that they were “climbing to four thousand”.

Marie Moler
Specialist – Aircraft Performance
National Transportation Safety Board

F. REFERENCES

1. Air Traffic Control Partial Transcript, DCA20MA059, National Transportation Safety Board, 2020.
2. Weather Study, DCA20MA059, National Transportation Safety Board, 2020.
3. Video-Based Visibility Study, DCA20MA059, National Transportation Safety Board, 2020.
4. Human Performance Report, DCA20MA059, National Transportation Safety Board, 2020.