National Transportation Safety Board

Office of Research and Engineering

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AUTOMATIC DEPENDENT SURVEILLANCE-BROADCAST (ADS-B) STUDY

Airplane Performance Study

By

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A. ACCIDENT

Location: Victoria, Minnesota
Date: August 7, 2021
Time: 17:40 central daylight time (CDT)
22:40 UTC
Aircraft: Mooney M20M, N9156Z

B. SUMMARY

On August 7, 2021, about 1740 central daylight time, a Mooney M20M, N9156Z, was destroyed when it was involved in an accident near Victoria, Minnesota. The private pilot and two passengers sustained fatal injuries. The airplane was operated as a Title 14 *Code of Federal Regulations* Part 91 personal flight.

C. PERFORMANCE STUDY

1.0 Available Data

This performance study is based on Automatic Dependent Surveillance-Broadcast (ADS-B) data provided by the Federal Aviation Administration (FAA). ADS-B broadcasts an airplane'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 dimensions.

2.0 Weather

Weather was recorded at Flying Cloud Airport (KFCM), approximately 8 NM from the accident site. The temperature was reported as 71°F (22°C), the dew point was 68°F (20°C), and the barometric setting was 29.77 inHg. Winds were 10 kts from 80° and overcast clouds at 1,100 ft above ground level (agl) were reported. Instrument meteorological conditions (IMC) prevailed.

3.0 Flight Path

The airplane departed Chandler Field Airport (AXN), Alexandra, Minnesota, at 16:54 on an instrument flight rules (IFR) flight plan to Flying Cloud Airport, Minneapolis, Minnesota. The pilot was cleared by air traffic control to fly the instrument landing system (ILS) approach to Runway 10R at FCM. The airplane approached from the northwest (Figure 1), descending from 5,200 ft mean sea level (msl) and slowing from 160 kts of airspeed (Figure 2). Just after 17:36:30, the airplane aligned with the heading for runway 10 at Flying Cloud. At this point it was approximately 14 NM from the airport.

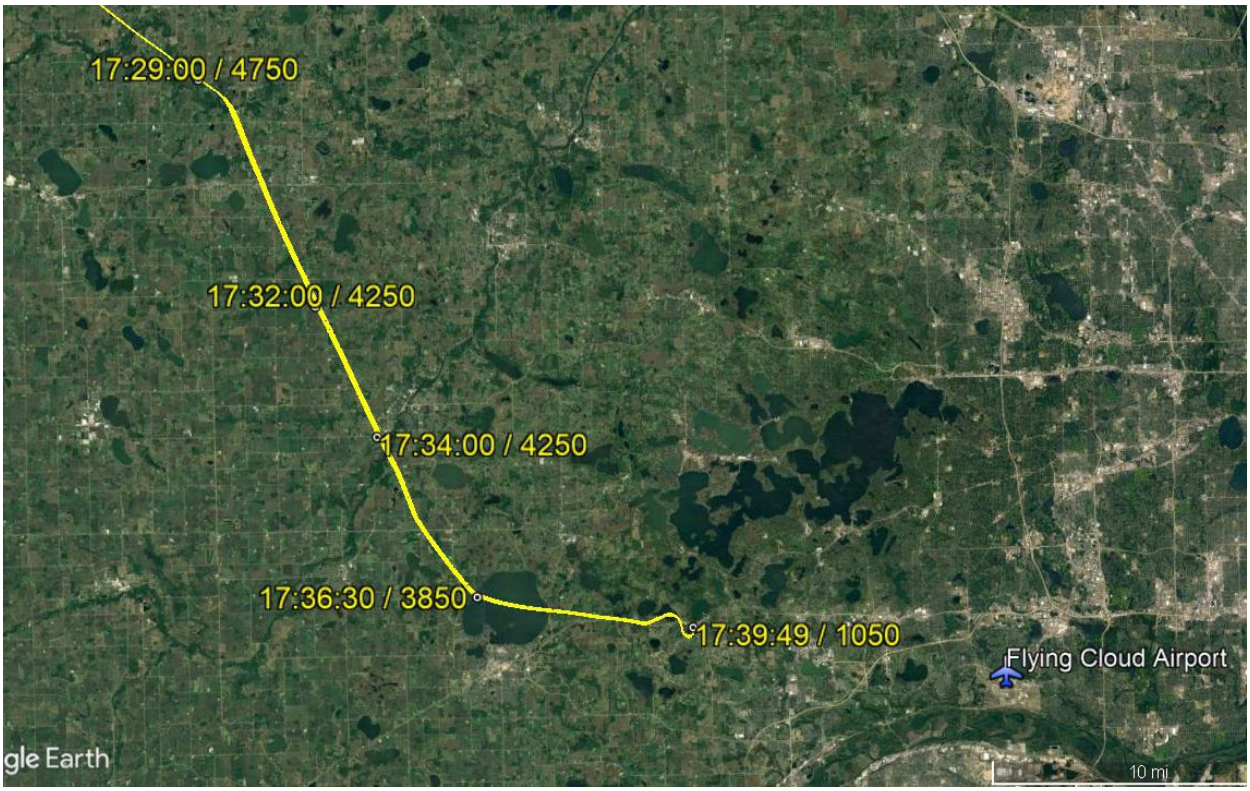

Figure 1. Accident flight in yellow with select times and altitudes (msl) annotated in yellow.

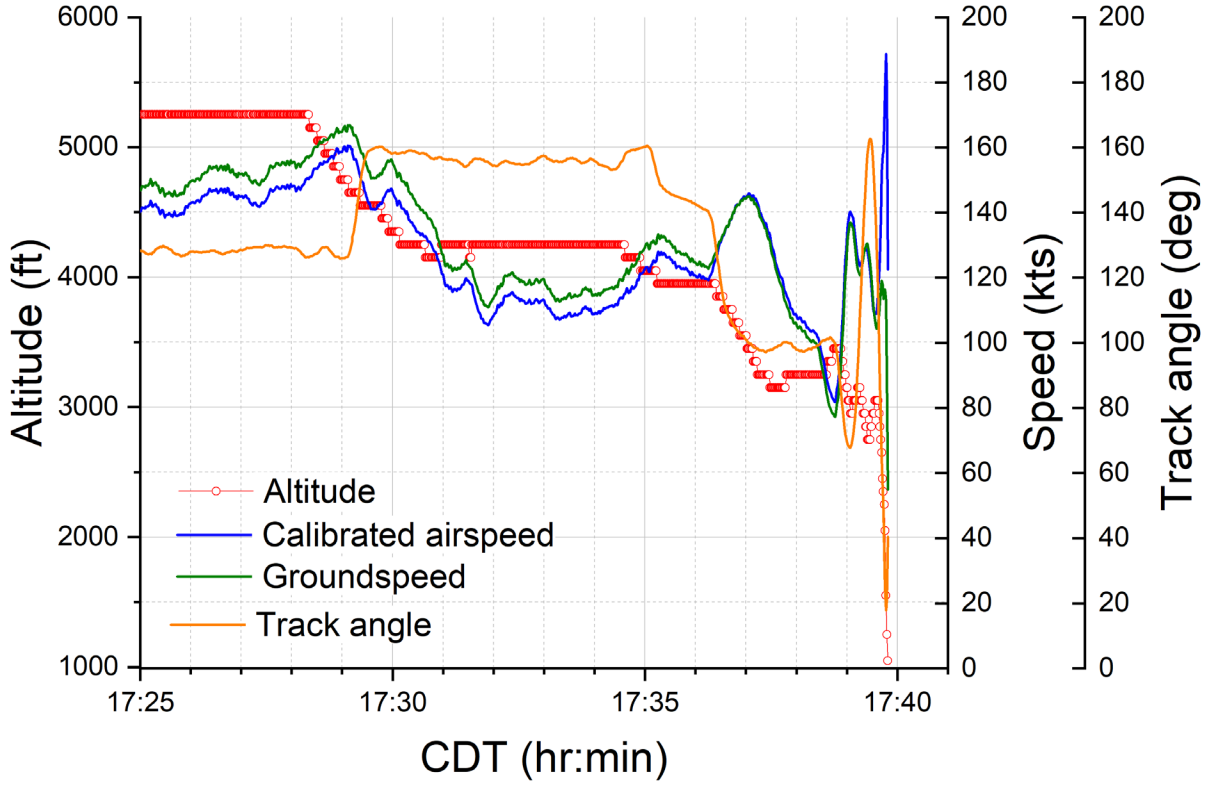

Figure 2. Recorded altitude (msl) and calculated airspeed, groundspeed, and track angle.

While on the runway heading, the airplane slowed to 80 kts and descended to about 3,200 ft (Figure 3). Then, at about 17:38:45, the airplane's airspeed increased to 140 kts and shortly after the track diverged to the left (Figure 4) and the airplane descended about 200 ft. The airplane turned right and then left again in a tightening series of turns while speed increased to over 180 kts and altitude fluctuated. After 15:38:38 the airplane descent increased to 6,000 fpm for the final 12 seconds of data. The airplane was above the reported overcast cloud base for all but the last few seconds of the flight path.

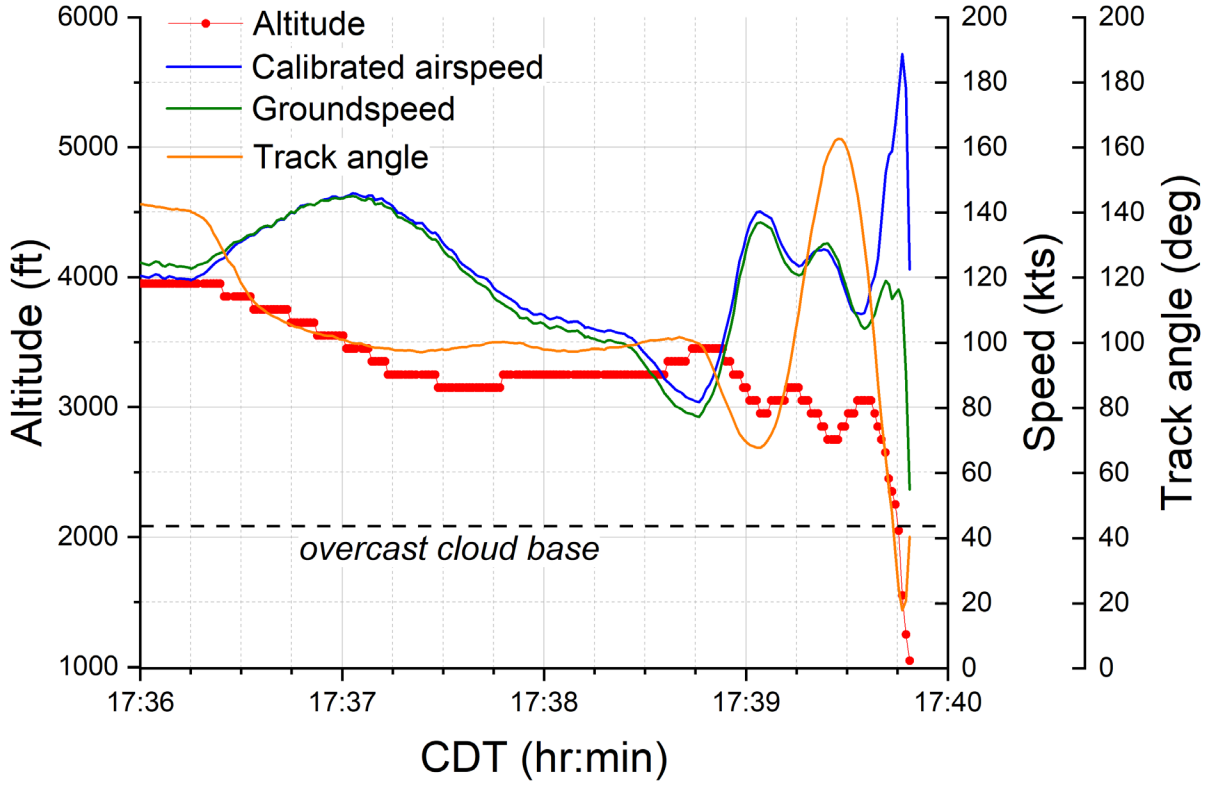

Figure 3. Recorded altitude (msl) and calculated airspeed and groundspeed for the end of flight.

The airplane's maximum maneuvering speed, V_A, (the speed at which full deflection of any flight control should not be attempted because of the risk of damage to the aircraft structure) is listed as between 111 kts (light) and 126 kts (heavy) calibrated airspeed [1]. Figure 3 and Figure 4 show that after 17:39 the airplane made increasingly tight turns at speeds above V_A. Also, in the Limitations section of the Pilot Operating Handbook, the manufacturer lists the maximum positive load factor with flaps up as 3.8 g [1].

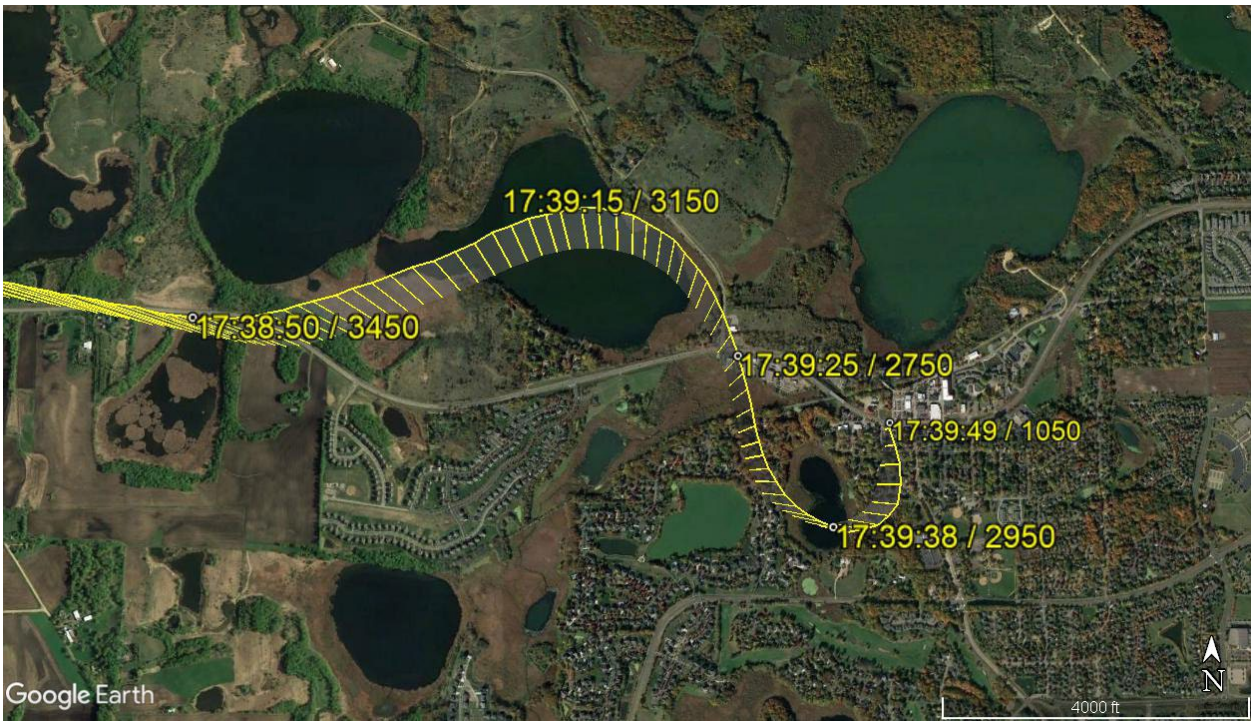

Figure 4. End of flight path in yellow with select times and altitudes (msl) annotated in yellow.

After 17:39:39 the flight path changed. The turn, which had been on a radius of about 1,100 ft since 17:39:31, tightened markedly and the airplane began to rapidly descend at more than 7,000 fpm. Airspeed and groundspeed began rapidly increasing. As stated in the Weather section, IMC prevailed and an overcast ceiling at 1,100 ft agl was reported at the airport. In the area of the accident, 1,100 ft agl would have been 2,100 ft msl, which the airplane passed below between 17:39:44 and 17:39:45. However, actual height of the overcast cloud ceiling in the area may have been higher or lower than what was reported 8 NM away.

Figure 5 shows the final portion of the ADS-B data. The load factor, *N*, on the airplane can be estimated using the airplane's true airspeed, *V*,[1] and the radius of the turn, *r*, according to

$$N = \frac{1}{\cos(\varphi)} = \frac{1}{cos\left(atan\left(\frac{V^2}{rg}\right)\right)}$$

where φ is the bank angle and *g* the acceleration due to gravity. Table 1 shows the resultant calculations using the true airspeed at 17:39:38, 17:39:41, 17:39:43, and 17:39:44. Each point was on an increasingly smaller red circle (shown in Figure 5), reflecting the tightening radius of the final left turn. As the turn tightened and the speed increased, the resulting bank angle and load factor increased. By 17:39:43, the

[1] For these conditions, the true airspeed was about 8 kts faster than calibrated airspeed.

estimated load factor of 4.8 g exceeded the manufacturer's listed maximum positive load factor of the airplane. One second later, the increased speed and tighter turn resulted in a load factor over 8 gs.

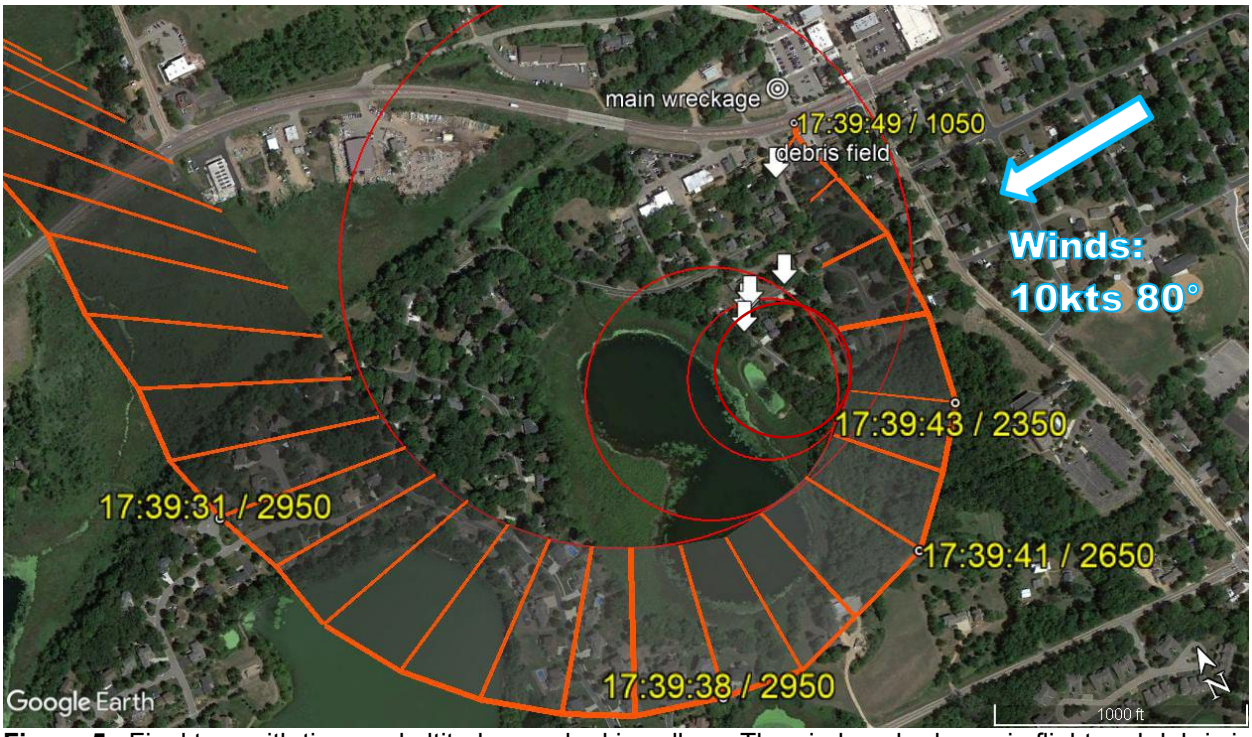

Figure 5. Final turn with time and altitudes marked in yellow. The airplane broke up in flight and debris is marked with white arrows. The main fuselage wreckage is shown with a white circle. The red circles show the radius of the turn at four different points.

Table 1. Calculated bank angle and load factors for three turns highlighted in Figure 5.

Time	Radius, ft	True airspeed, kts	Bank angle, deg	N, load factor
17:39:38	1,100	127	52	1.6
17:39:41	850	160	69	2.8
17:39:43	510	168	78	4.8
17:39:44	400	195	83	8.5

The final left turn would have required larger and larger control surface deflections while at speeds greater than V_A. By 17:39:43 the airplane exceeded the manufacturer's listed maximum positive load factor and forces continued to increase. The debris field and wind direction are consistent with a breakup near this portion of the flight path as the pieces would have continued forward but carried to the left of the flight path by the reported winds.

D. CONCLUSION

The airplane's flight path to runway 10 at Flying Cloud Airport was typical until 17:38:45 when the airplane quickly gained 60 kts of airspeed while descending and turning left away from the runway heading. The airplane turned right while its altitude fluctuated, passed the runway heading, and began to turn back left. The left turn tightened as the airplane accelerated and descended. During this time the airplane likely passed below the overcast ceiling.

The tightening right and left turns were at speeds exceeding all listed maneuvering speeds. As the final left turn tightened, it exceeded the manufacturer's listed maximum positive load factor. The airplane subsequently suffered an in-flight breakup.

REFERENCES

1. Mooney M20M Pilot Operating Handbook, Mooney Aircraft Corporation, Revision H 5-05.