

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



ERA23FA340

AUTOMATIC DEPENDENT SURVEILLANCE- BROADCAST (ADS-B) STUDY

Aircraft Performance Study

By

Marie Moler

A. ACCIDENT

Location: Fort Pierce, Florida
Date: August 17, 2023
Time: 12:02 eastern daylight time (EDT)
Airplane: Piper PA-28-161, N9855S

B. SUMMARY

On August 17, 2023, about 1202 eastern daylight time, a Piper PA-28-161 airplane, N9855S, was destroyed when it impacted a building near Ft. Pierce, Florida. One flight instructor was fatally injured, and the other flight instructor sustained serious injuries. The airplane was operated by Aviator College under the provisions of Title 14 *Code of Federal Regulations* (CFR) Part 91 as an instructional flight.

C. PERFORMANCE STUDY

1.0 Aircraft

The airplane was a Piper-28 Warrior, a four seat, light aircraft with a single piston-engine and low-mounted wings.



Figure 1. Piper PA-28, N9855S.

2.0 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.

3.0 Weather

Weather was recorded for 11:53 at Treasure Coast International Airport (FPR) Fort Pierce, Florida. The temperature was reported as 79°F (63°C), the dew point was 75°F (24°C), and the barometric setting was 29.98 inHg. Winds were 3 kts from 220°. Skies were clear and visibility was 10 statute miles.

4.0 Flight Path

The airplane took off from FPR about 11:38 (Figure 2 and Figure 3). The airplane climbed and headed to an area southwest of the airport where it performed a series of maneuvers. Altitude varied between 4,200 ft and 5,500 ft mean sea level (MSL) and calibrated airspeed between 50 kts and 125 kts until the end of flight.

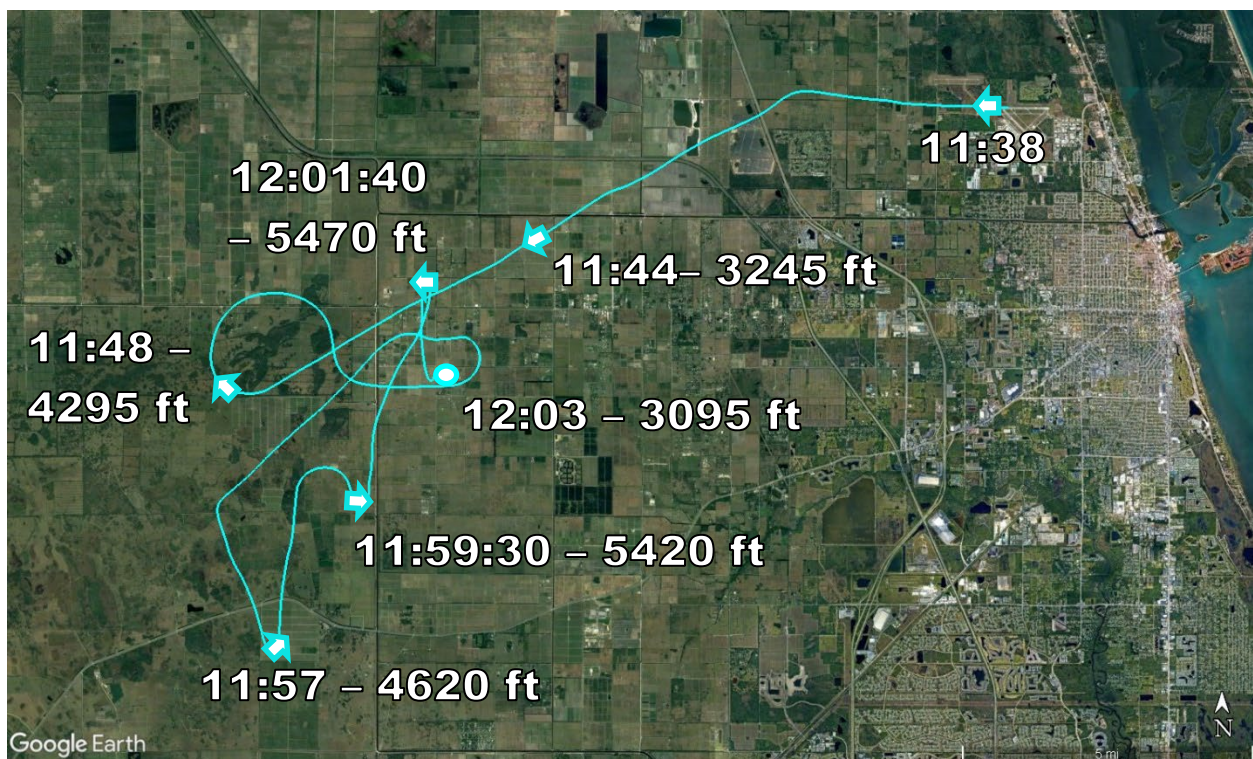


Figure 2. Flight path with selected times and altitudes MSL marked.

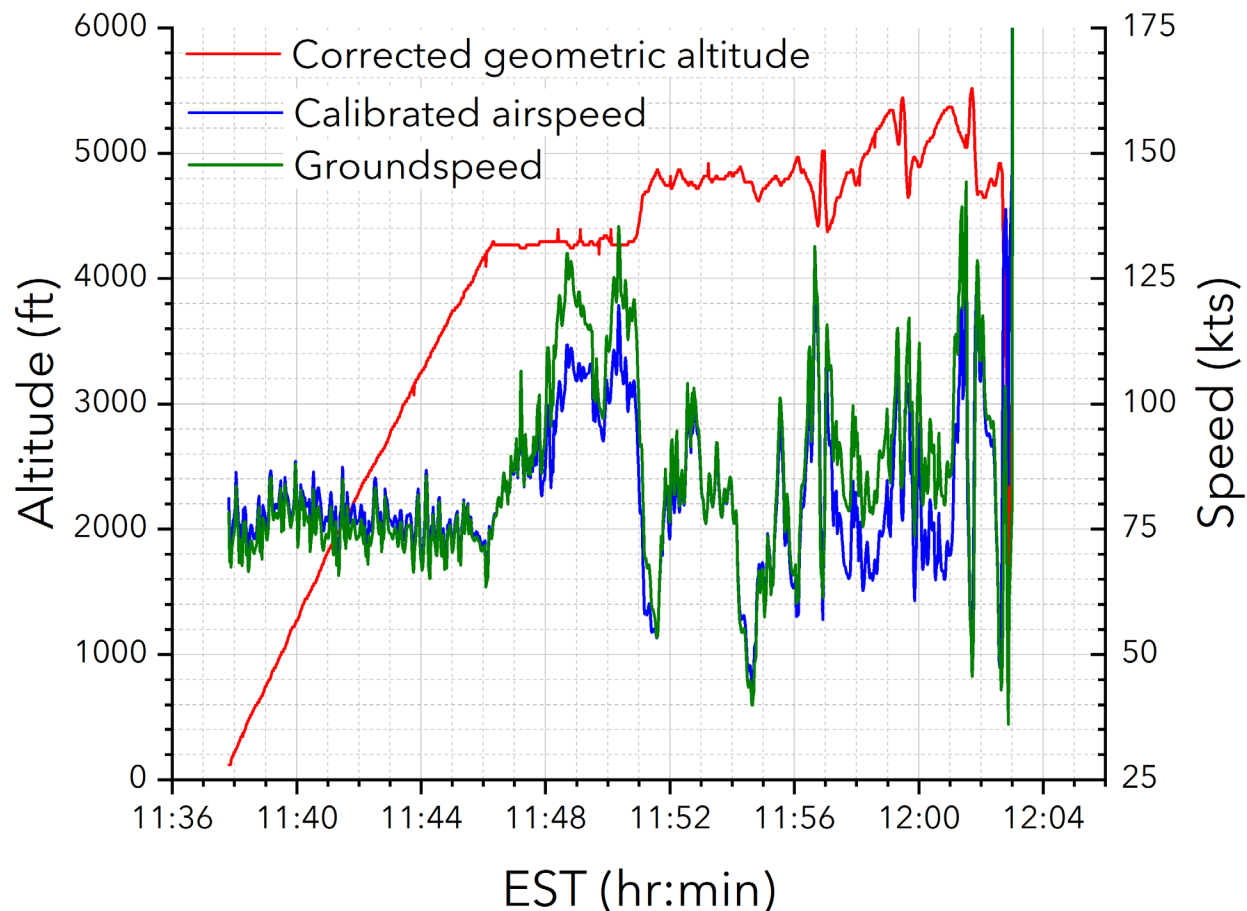


Figure 3. Altitude and calculated ground and airspeed for the flight.

In an interview after the accident, the surviving flight instructor reported that for the majority of the flight, the pilot receiving the evaluation was demonstrating a variety of maneuvers including lazy eights, chandelles, and slow flight; consistent with the flight path shown in Figure 2 and Figure 3. The last maneuver, which the flight instructor said he would demonstrate, was to be a power-off aerodynamic stall and recovery without engine power. The flight instructor reported that he pitched up and entered a full aerodynamic stall with power at idle. After stall, he pitched down to gain glide airspeed (73 kts) to recover, but during the recovery “the right wing came off” and there was an “abrupt banking tendency” to the right. The gross weight, power idle, wings level stall speed for the airplane is 58 kts indicated airspeed [1].

Figure 4 and Figure 5 show the final few minutes of flight. The altitude displayed was integrated from the ADS-B recorded speeds¹ and then corrected. A discussion on the integrated altitude and the recorded geometric and pressure altitudes will follow

¹ ADS-B records VEkts (velocity easting in knots), VNkts (velocity northing in knots), and VzFPM (vertical velocity in ft/min). Integrating these speeds to create a flight path can be used to compare to the recorded latitude, longitude, and altitude to discriminate between real and erroneous data in the directly recorded data.

Figure 5. Starting at 12:01:30, the airplane executed a climbing left turn while slowing below 50 kts calibrated airspeed. The airplane descended 800 ft while accelerating to over 120 kts of airspeed while completing a 180° left turn. This maneuver looked similar to earlier 180° turns, however the minimum speed was lower than the prior maneuvers and below the reported stall speed. The airplane then flew level and straight for about 30 seconds before again beginning a climbing left turn while losing airspeed. The airplane reached a minimum airspeed of 47 kts at 12:02:36 and began descending at 12:02:39. The airplane accelerated as it descended. By 12:02:41, the airspeed was calculated to be 90 kts and the corrected altitude was 4,820 ft.

Just after 12:02:41, the descent rate suddenly increased to over 10,000 ft/min and a second later the track turned to the right.

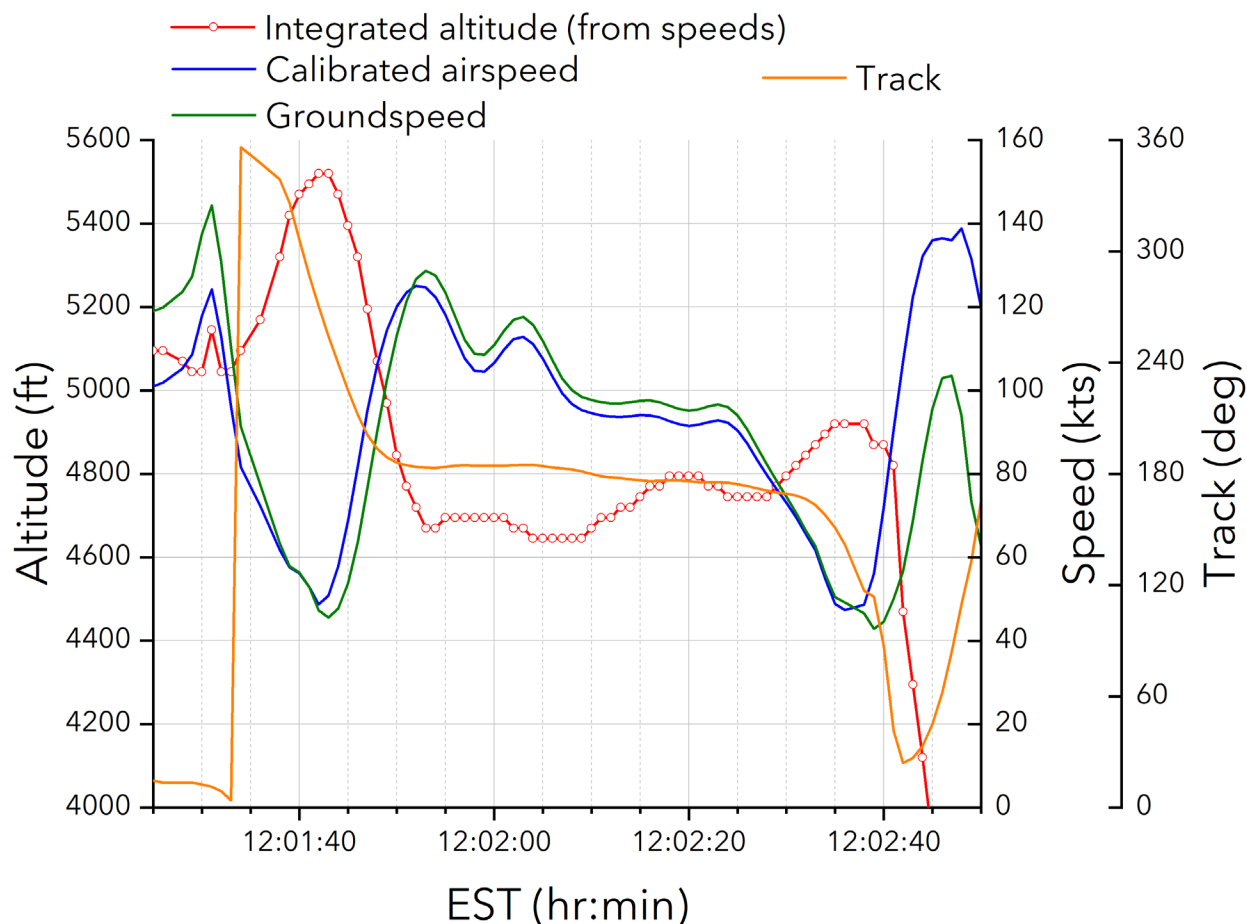


Figure 4. Altitude, calculated ground and airspeed, and track for the final maneuvers.

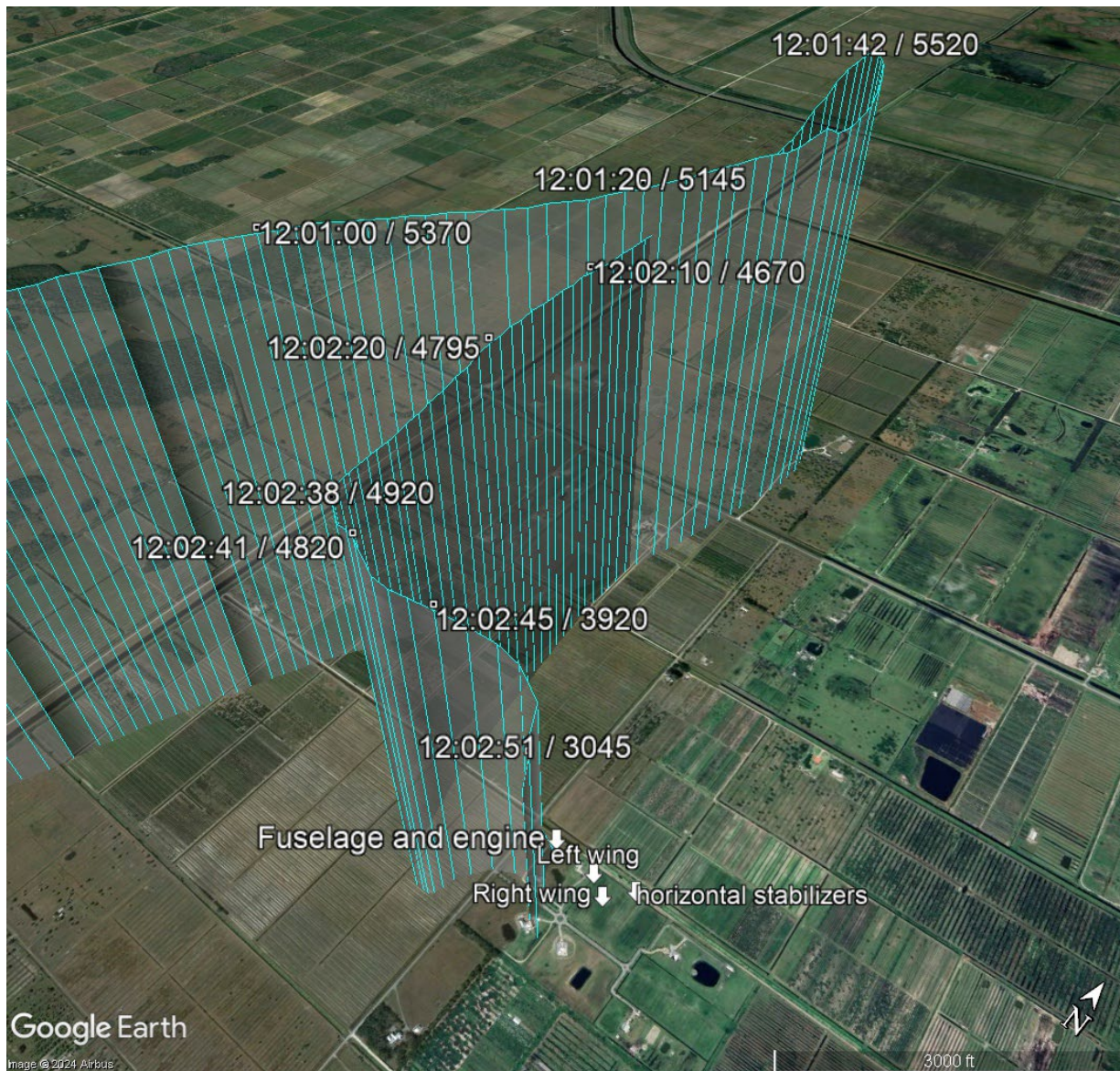


Figure 5. Flight path and altitude for the end of flight. The fuselage and wing final locations are also shown.

During the descent, the ADS-B record of pressure and geometric altitude diverged after 12:02:53 (Figure 6). Pressure altitude increased from 1,800 ft to 3,200 ft in one second before falling to 600 ft by 12:03:00. Geometric altitude continued to decrease from 2,250 ft at 12:02:53 to 1,600 ft before suddenly increasing at 12:03:00 to 3,000 ft. ADS-B also records the airplane's speed in three dimensions and a flight path was integrated from these speeds. The integrated velocity is shown in Figure 6, which did not show an increase in altitude after 12:02:53. The altitude discrepancies are likely due to the inflight breakup of the airplane that occurred.

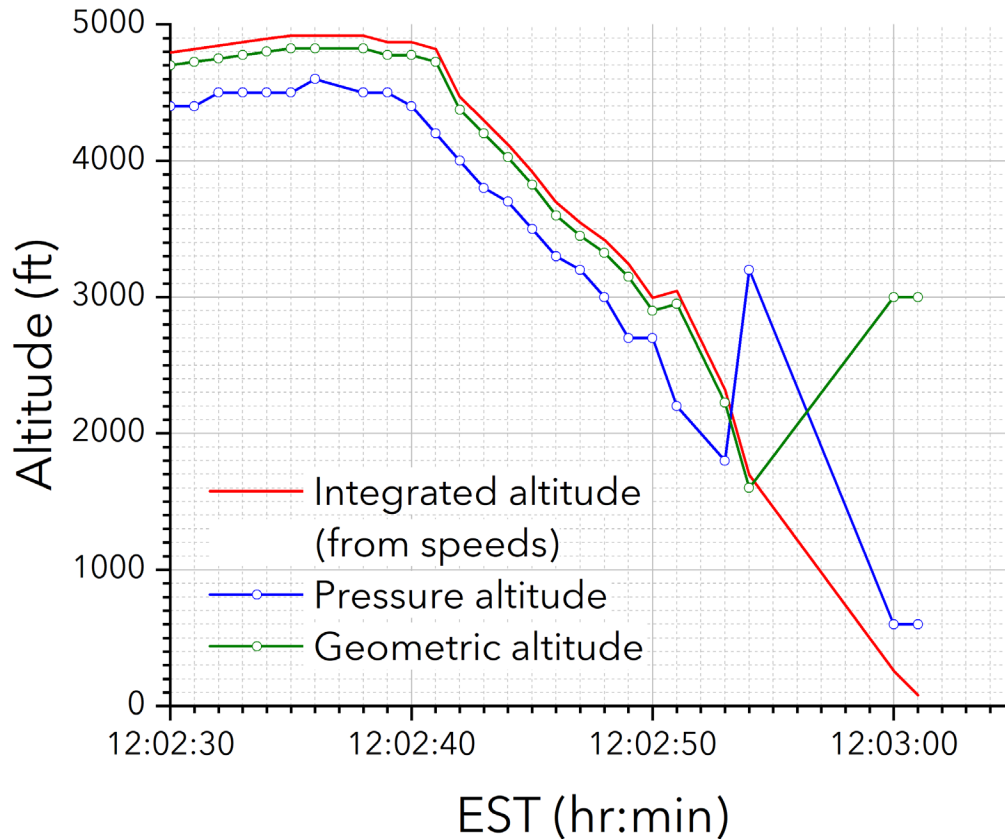


Figure 6. Pressure and geometric altitude from ADS-B and altitude integrated from ADS-B recorded speeds.

The wreckage examination found that the wings came off under large positive g-loading, the right wing being lost first. As discussed earlier, the airplane made several 180° left turns, four of which are shown in Figure 7. The turn at 11:57 had a radius of 500 ft and a low speed of 57 kts. The turn at 11:59:30 had a radius of 660 ft with a low speed of 77 kts. For both turns the airplane began accelerating while still in the turn, increasing bank angle and load factor, n , on the airplane to about 1.4 g according to

$$n = \frac{1}{\cos(\varphi)}$$

Where the bank angle, φ , was determined according to

$$\varphi = \tan^{-1} \left(\frac{v^2}{g * radius} \right)$$

Where v is the true airspeed, g is gravitational acceleration, and $radius$ is the radius of the turn. These equations are derived assuming the airplane is in a level turn, so their use in these circumstances is approximate. The altitude variations during the turns of

interest are relatively small, so their effect is neglected. Atmospheric conditions at the time of the accident made true airspeed higher than the calibrated airspeed by 7-10 kts. Of note, uncertainties inherent to the original data (ADS-B position data and meteorological information) are compounded with each additional calculation. Therefore, the load factors and bank angle calculations best show trends as relatively small changes in airspeed and turn radius can raise and lower these numbers.

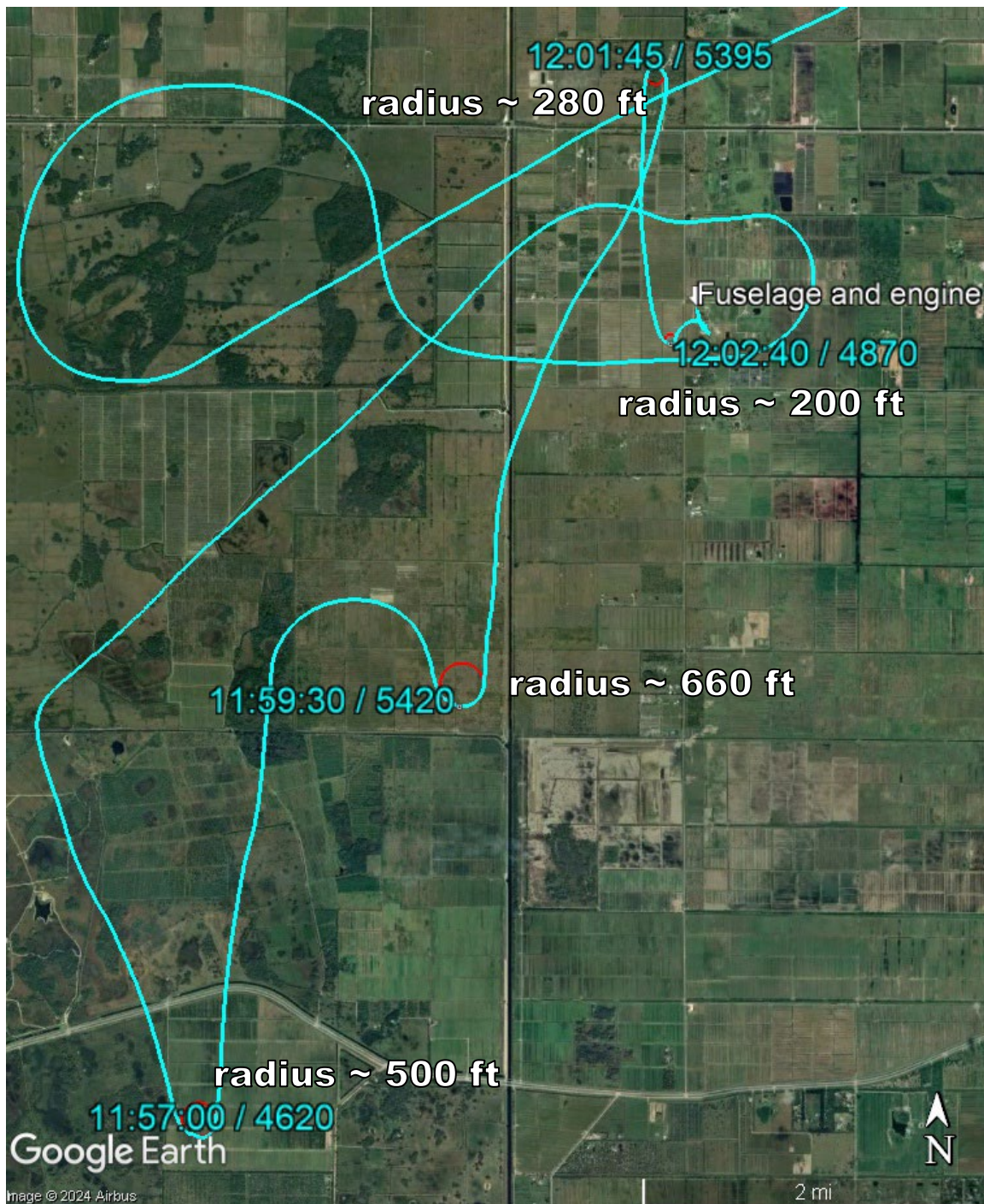


Figure 7. ADS-B flight path with four turns of interest notated.

The final two 180° turns were significantly tighter. The turn at 12:01:45 had a radius of 280 ft and the airplane accelerated to over 100 kts true airspeed while still in the turn, resulting in a calculated bank angle over 70° left wing down and a load factor of 3.6 g, near the 3.8 g limitation of the airplane [1].

The final turn started with a radius of 200 ft which tightened as the airplane accelerated. At 12:02:41, the airplane's true airspeed was 99 kts, which for a 200 ft turn would result in a bank angle over 75° left wing down corresponding to a load factor of 4.5 g, which is above the airplane's limitations. Uncertainties in the ADS-B data mean that this calculation is not an absolute value, but it is consistent with an increasingly tight and fast turn. The pilot reported that the right wing departed the airplane, which would result in a right rolling moment as the left wing continued to provide lift. As discussed earlier, after 12:02:41 the airplane's descent markedly increased and the flight path turned to the right, likely coinciding with the loss of the right wing.

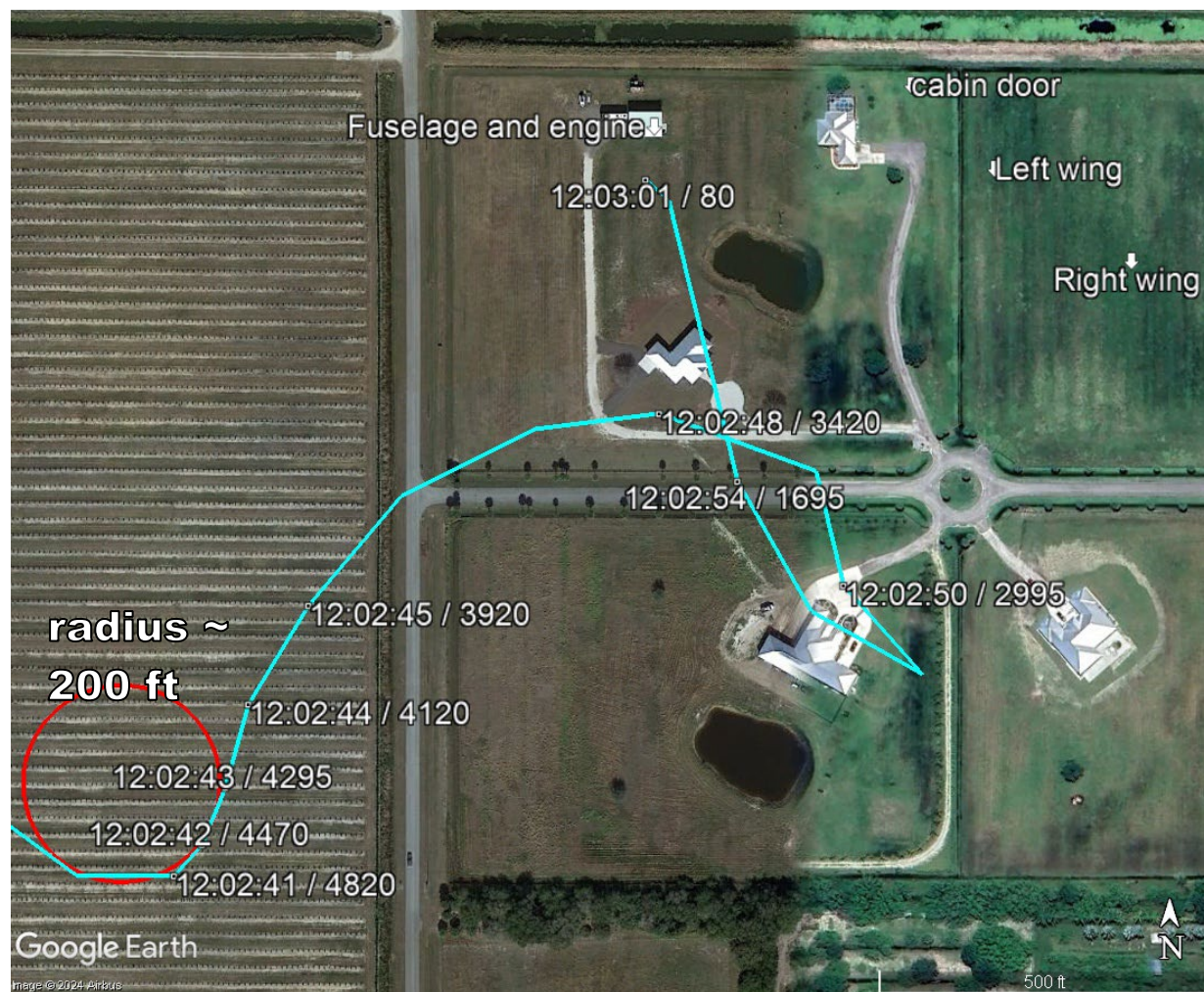


Figure 8. ADS-B flight path for final turn and break up.

D. SUMMARY

The airplane performed a variety of maneuvers during the flight. During the second to last turn, the airplane accelerated while in a small radius turn and nearly reached the airplane's positive load factor limit. The final left turn had a smaller turn radius which resulted in an even steeper bank angle and the airplane exceeded the load factor limit as it accelerated.

E. REFERENCES

1. Warrior II Pilot's Operating Handbook and FAA Approved Airplane Flight Manual, Piper Aircraft Corporation, 1982.