

National Transportation Safety Board

Office of Research and Engineering

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AIRPLANE ON-BOARD DATA PERFORMANCE AND BALLISTICS STUDY

Airplane Performance Study

By

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A. ACCIDENT

Location: Raeford, North Carolina
Date: 29 July 2022
Time: 14:04 eastern daylight time
18:04 UTC
Airplane: Casa 212-200, N497CA

B. SUMMARY

On July 29, 2022, about 14:04 eastern daylight time, a Casa 212-200, N497CA, was substantially damaged when it was involved in an accident near Raeford, North Carolina. The pilot-in-command (PIC) was not injured, and the second-in-command (SIC) sustained fatal injuries during the subsequent diversion to the Raleigh-Durham International Airport (RDU), Durham, North Carolina. The airplane was operated as a Title 14 *Code of Federal Regulations* Part 91 skydiving flight.

C. PERFORMANCE STUDY

1.0 Aircraft

The airplane is a CASA C-212 Aviocar, a turboprop short take-off and landing (STOL) medium sized cargo plane. Its rear ramp can be lowered in flight and the main landing gear do not retract.



Figure 1. The airplane, N497CA, with the ramp lowered.

2.0 Available Data

This airplane was equipped with an Appareo Stratus 3 which recorded global positioning system (GPS) location data and attitude and heading reference system (AHRS) data. This device recorded latitude, longitude, and altitude; roll, pitch, heading; and x, y, and z accelerations at 5 Hz.

To confirm the reliability of the AHRS attitude and acceleration data, the GPS location information was used with a simplified aerodynamic model of the airplane to estimate the airplane's angles and aerodynamics. While the vertical load factor (N_z) showed good agreement between the calculated and AHRS data, the initial portion of the flight recorded unrealistic roll data. Figure 2 shows how the AHRS roll angle was 10° (or more) left wing down for the first 15 minutes of flight. During this time the airplane was only making left turns or flying straight (Figure 3). Not until the airplane made a right turn after 13:56 did the roll parameter start to record positive values. By 14:10, after a series of right and left turns, the roll angle reflected being wings level on straight flight and showed good agreement with the calculated values.

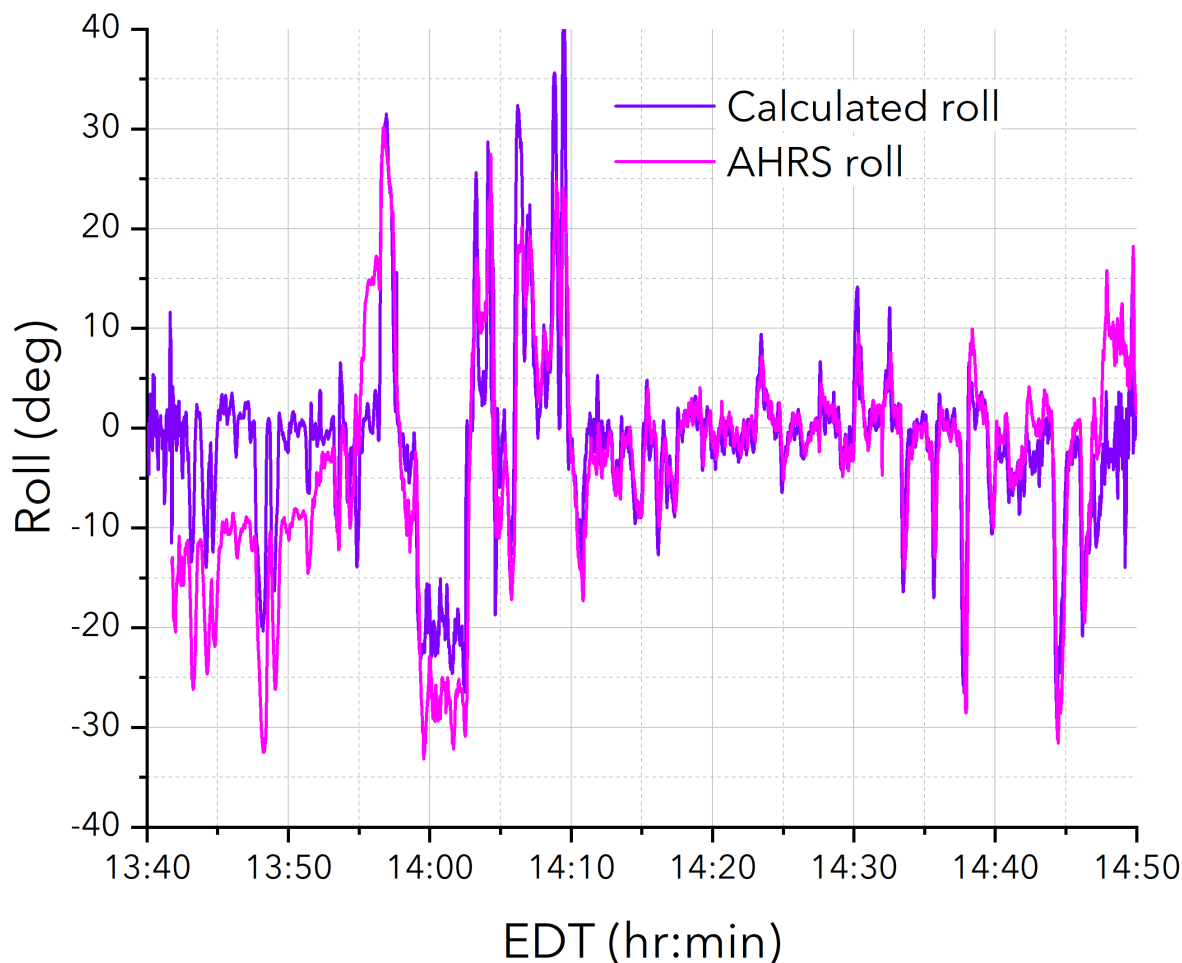


Figure 2. Calculated and recorded roll angles for the accident flight.

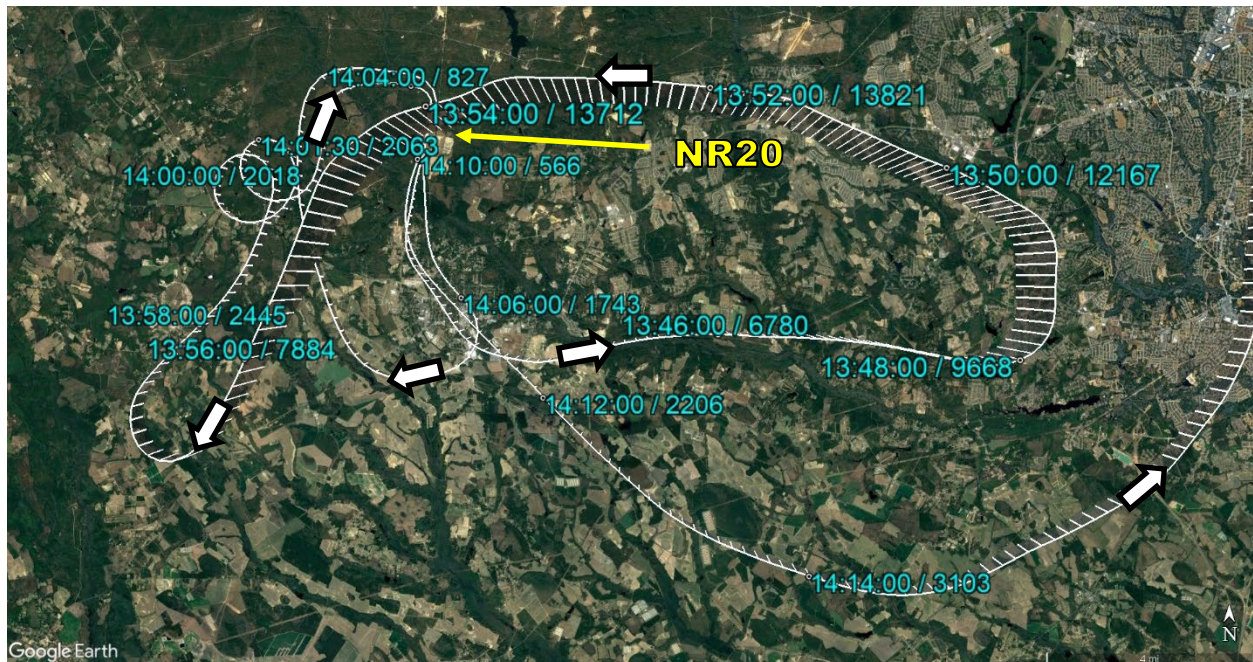


Figure 3. The initial flight path with selected times and altitudes (msl) shown. Flight direction is shown with white arrows. The approximate location of NR20 is highlighted with a yellow arrow.

The recorded pitch angle (Figure 4) was near zero for the initial climb and descent before 13:58 rather than nose up and nose down as seen in the calculated pitch angle. After 14:20, the recorded pitch angle does somewhat begin to match the calculated pitch in trend, but the recorded data shows larger pitch changes and other variations. Pitch appeared to be a less-reliable recorded parameter compared to the roll parameter after 14:10. For this report, AHRS pitch and roll data will not be considered until after 14:20.

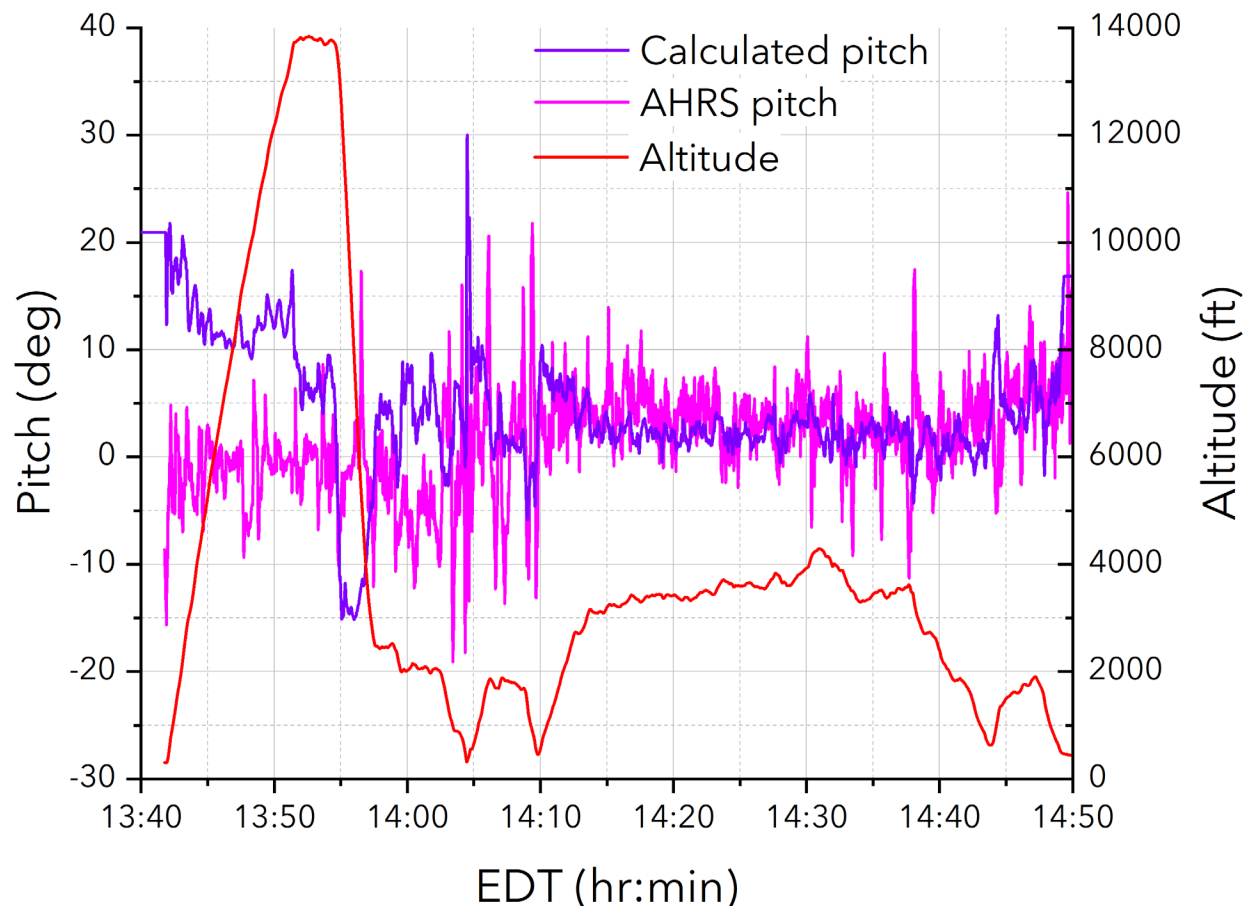


Figure 4. Calculated and recorded pitch angles for the accident flight.

Also included in this report are crew communications with air traffic control (ATC) as transcribed by the Federal Aviation Administration (FAA). The transcript rounded all times to the nearest minute.

3.0 Weather

Weather was recorded for 13:56 at Mackall Army Airfield (KHFF), 13 NM west of Raeford. The temperature was reported as 91°F (33°C), the dew point was 77°F (25°C), and the barometric setting was 29.98 inHg. Winds were 7 kts from 330°. Scattered clouds were reported at 4,200 ft above ground level (AGL) and a broken cloud layer was reported at 6,000 ft AGL. Visibility was ten statute miles.

4.0 Flight Path

The airplane was on the second skydiving flight of the day out of Raeford West Airport (NR20), a private grass airfield. The airplane would take-off, climb to between 13,000 and 14,000 ft above mean sea level (msl), the skydivers would depart the

airplane, then the airplane would descend, land, and take aboard another group of skydivers.

The accident flight took off at 13:41 and climbed above 13,000 ft msl by 13:51. The airplane passed over the airfield, unloaded skydivers, and then began descending after 13:54. While at 2,000 ft msl, the airplane completed two 360° left turns before the runway approach. According to the pilot in command (PIC), when the approach became unstabilized the crew attempted to go around, but the airplane struck the runway (14:04:28), damaging the right main landing gear. The crew circled and flew low over the airfield again and ground personnel verified the damage.

Figure 5 shows the recorded altitude, vertical load factor, and groundspeed for the ground strike. At 14:04:28 the Nz parameter spiked to 3.36 as the airplane contacted the ground.

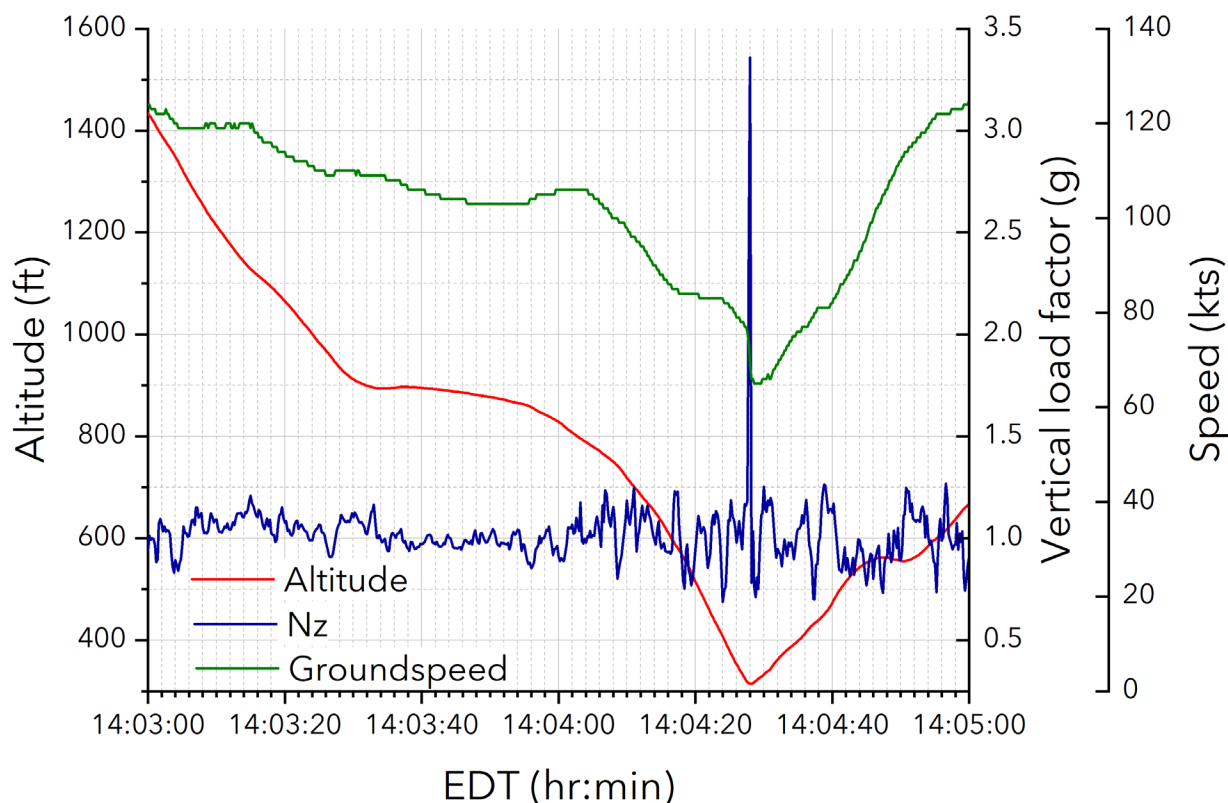


Figure 5. Airplane recorded altitude, Nz, and groundspeed for ground strike that damaged landing gear.

At 14:11, the crew contacted Fayetteville ATC and declared an emergency, reported the loss of the right wheel, and requested to go to Raleigh Durham Airport (RDU). The airplane climbed to between 3,000 and 4,000 ft and headed north towards Raleigh, and the crew planned the eventual landing with ATC.

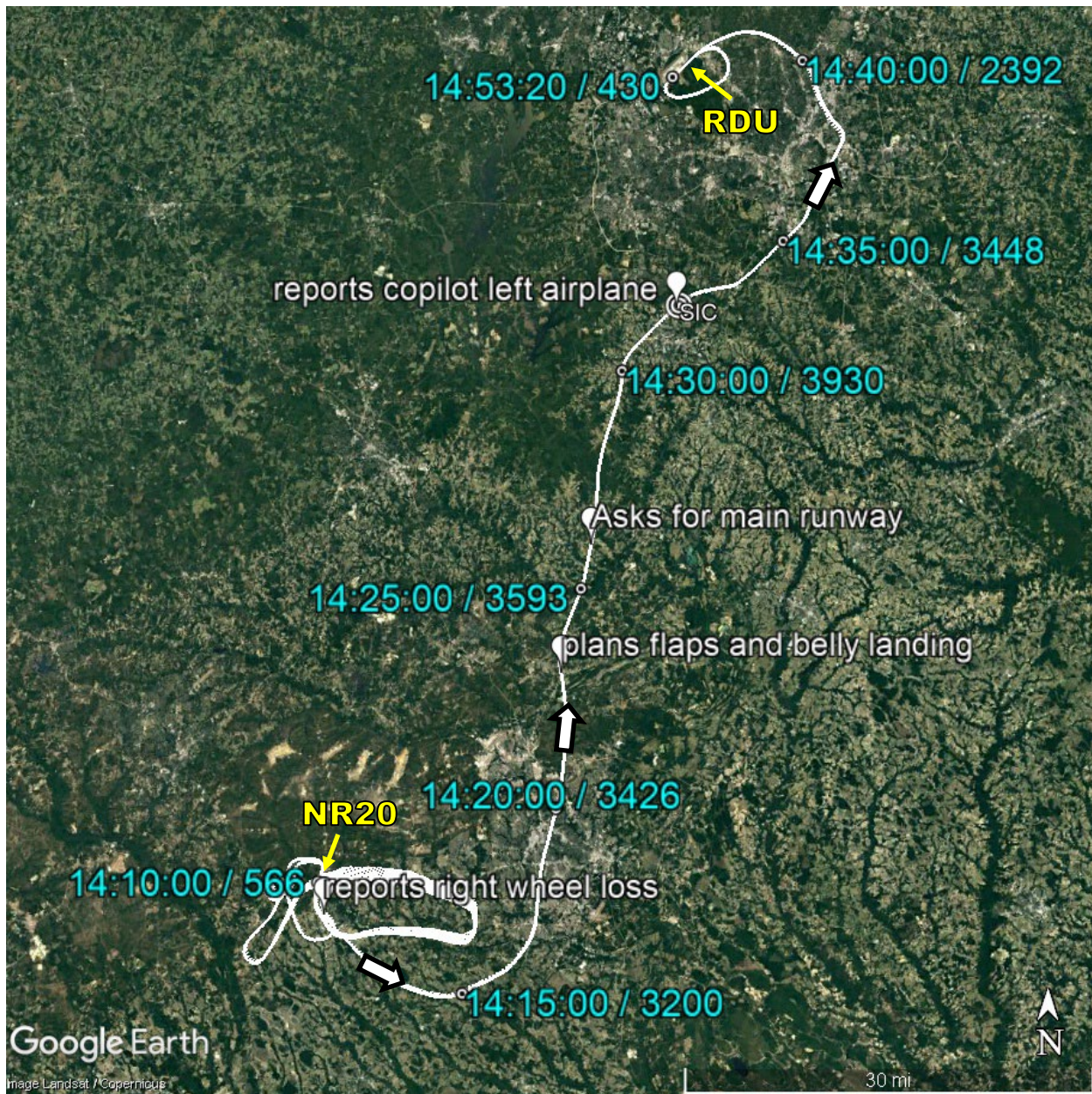


Figure 6. The flight path with selected times and altitudes (msl) shown. Selected ATC communications are also shown. Flight direction is shown with white arrows. The approximate locations of NR20 and RDU are highlighted with yellow arrows.

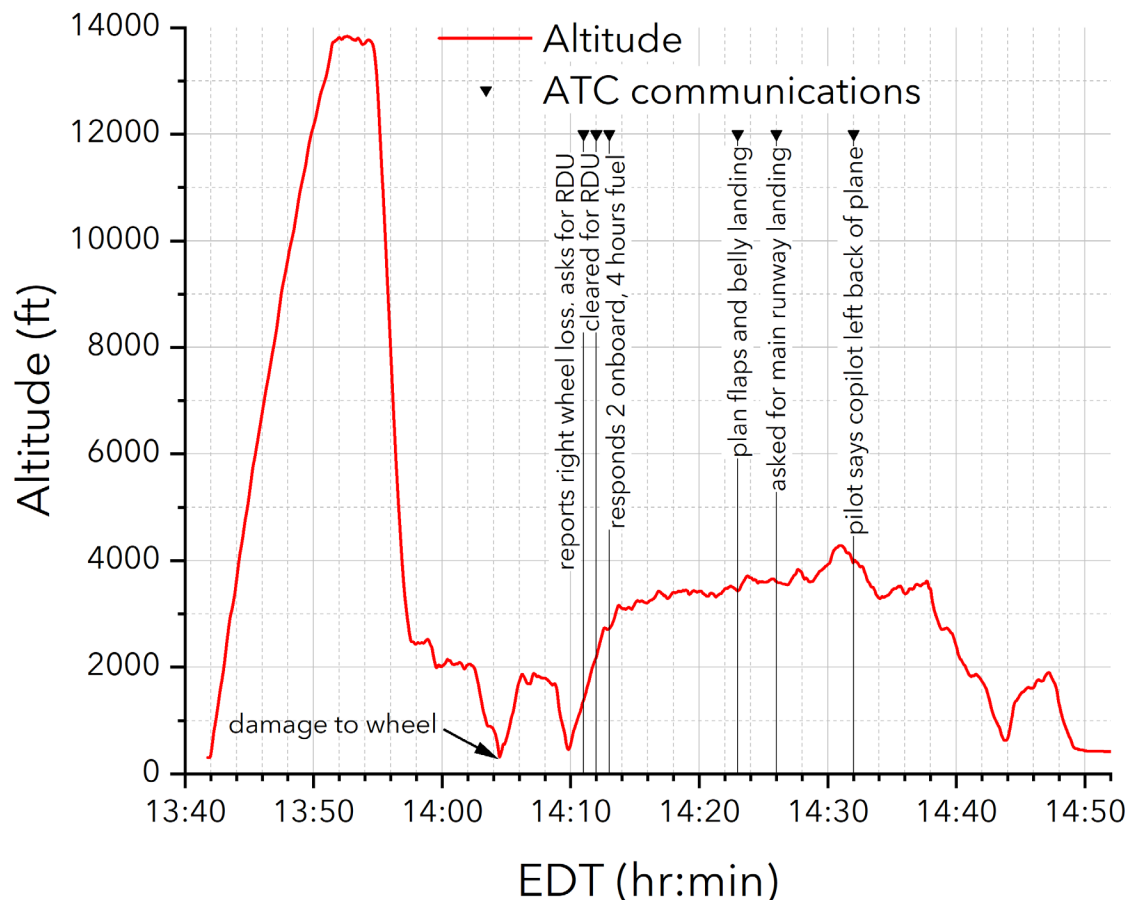


Figure 7. Recorded altitude with some ATC communications shown.

In an interview, the PIC reported that the SIC stated he was feeling sick and needed air. The SIC first opened the cockpit window before lowering the ramp at the back of the airplane. The PIC stated that the SIC then got up from his seat, removed his headset, apologized, and departed the airplane via the aft ramp door.

At 14:32 the pilot informed RDU ATC that the SIC had left the airplane. This occurred enroute to RDU while the airplane was near 4,000 ft. The airplane continued to RDU, passed once low over the runway, before landing just before 14:50.

D. TIME OF SIC DEPARTURE

Of interest was determining the time when the SIC left the airplane. A software tool was used that calculates how an object will fall from an initial starting point through defined atmospheric conditions. The ballistic coefficient was estimated based on the object's size, weight, and drag coefficient, which depends on orientation. Two ballistic coefficients were considered using drag information [1]. One modeled a horizontal body orientation and the other a vertical, head or feet down orientation.

The calculation starts with the initial condition – the airplane’s altitude, speed, and attitude. Two sets of atmospheric conditions were used. The first (Figure 8) used the surface winds reported at KHFF for the whole airmass. For the second (Figure 9), a winds aloft estimate made using a NOAA generated model¹ provided winds at different altitudes in the area.

Figure 8 shows the results for four different initial conditions. The squares represent the airplane location compared to the final known location of the SIC. If an object left the airplane at each time, it would have landed at the location marked by a circle of the same color for the horizontal orientation or a triangle for the vertical orientation. If the surface winds were best representative of actual winds that day, the SIC could have left the airplane between 14:31:55 (best vertical orientation fit to final location) and 14:32:01 (best horizontal orientation final location).

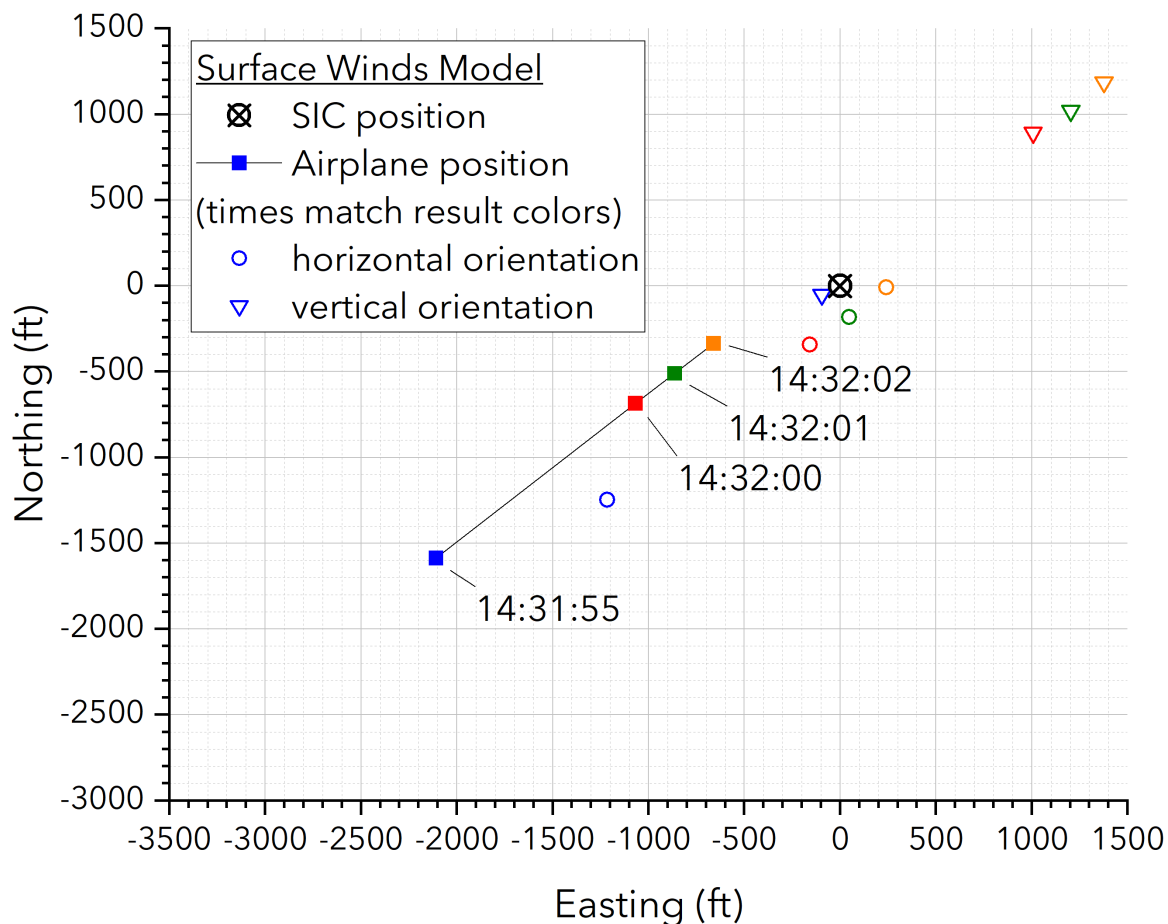


Figure 8. Ballistic analysis for surface winds.

¹ <https://www.ready.noaa.gov/READYamet.php>

Figure 9 each uses the same symbols to show the results of the ballistic calculations using the winds aloft data. If the winds aloft were more representative, the SIC could have left the airplane between 14:31:53 (best fit vertical orientation) and 14:31:58 (best fit horizontal orientation).

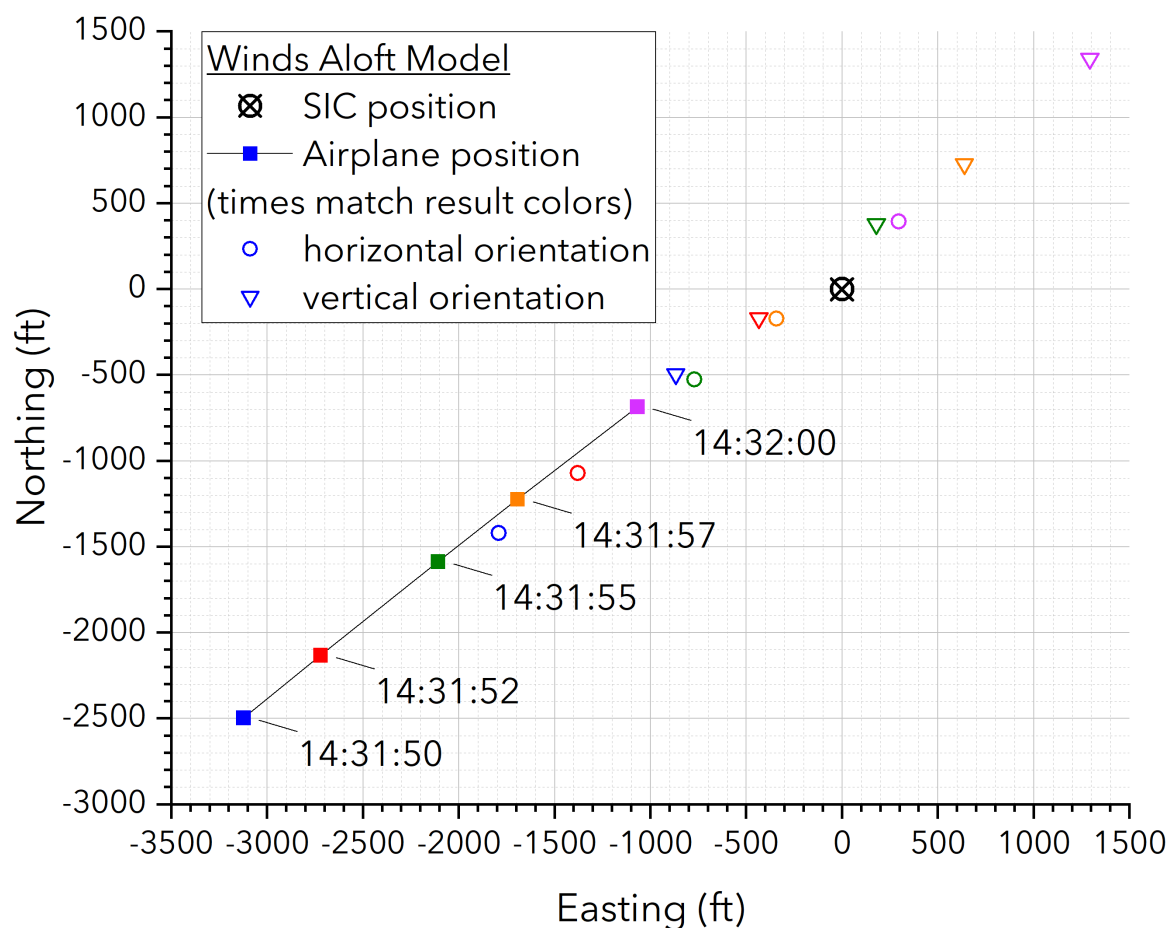


Figure 9. Ballistic analysis for winds aloft data.

The ATC timing was rounded to the nearest minute, but the PIC informed RDU about the SIC leaving the airplane at about 14:32. The ballistic calculations indicate the SIC could have left the airplane between 14:31:53 and 14:32:01 to arrive at the final location.

Figure 10 shows the flight parameters around the time that the SIC departed the airplane. Prior to 14:32 the airplane was descending at a rate of about 750 fpm. During the window of departure, the pitch varied between 1.2 and 2.8°, but the airplane rolled quickly to 5° left wing down. The airplane executed a short climb and the vertical load factor jumped 0.5 gs. As discussed in the Available Data section, the accuracy of the roll and pitch parameters is not known, but the trends are likely reflective of the flight.

Additionally, it cannot be known if the motions were commanded or due to outside forces such as winds. If commanded, they could have been before the SIC departed the airplane, or later in response to the departure.

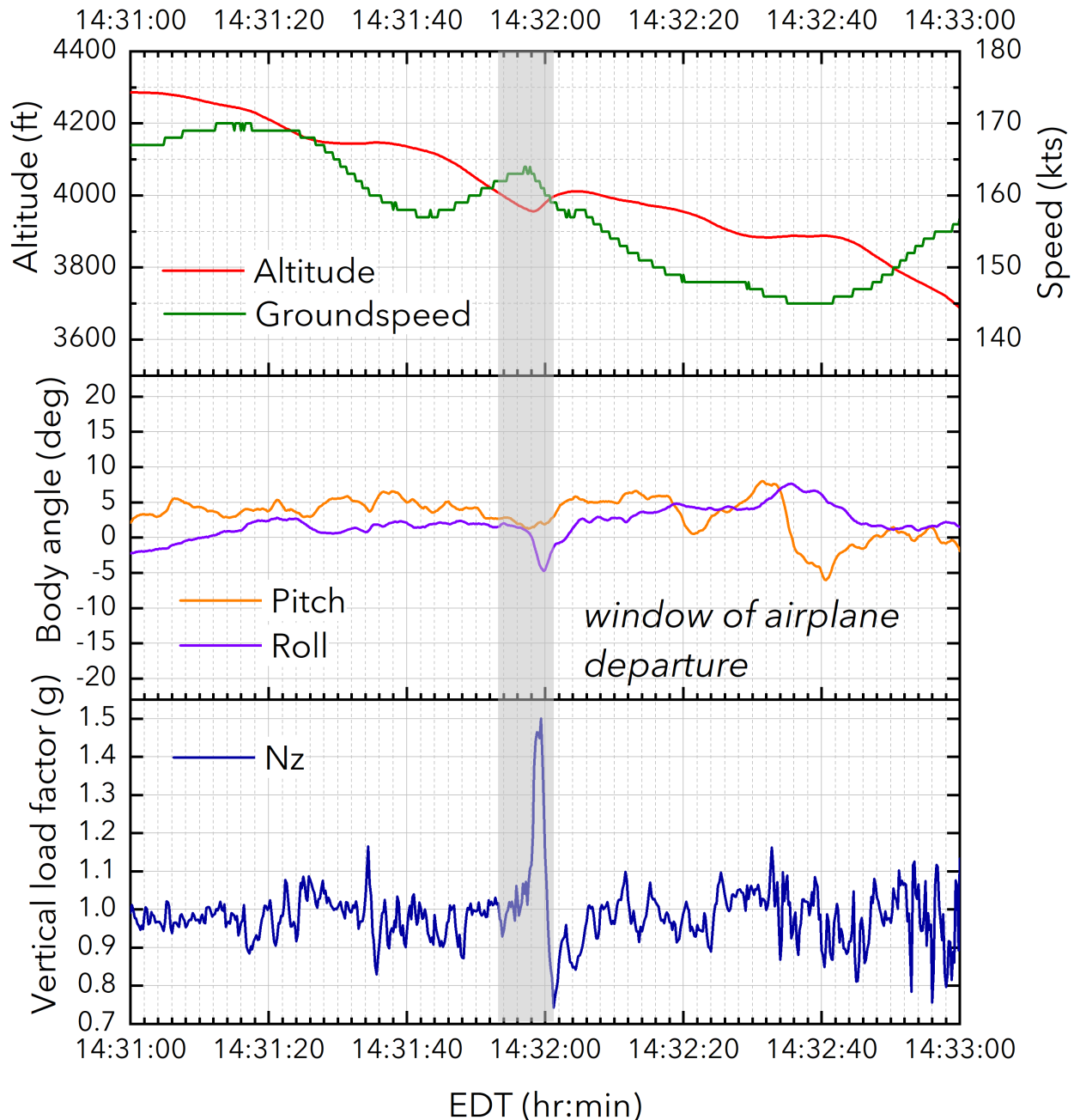


Figure 10. Recorded altitude, speed, pitch, roll, and vertical load factor around time of departure from airplane.

For context, Figure 11 shows the 7 minutes prior to and 3 minutes after the event. The roll transient was sharper and shorter than other rolls and the spike in N_z

was an outlier. Heading is also included in this plot to show that other changes in roll angle accompanied changes in heading.

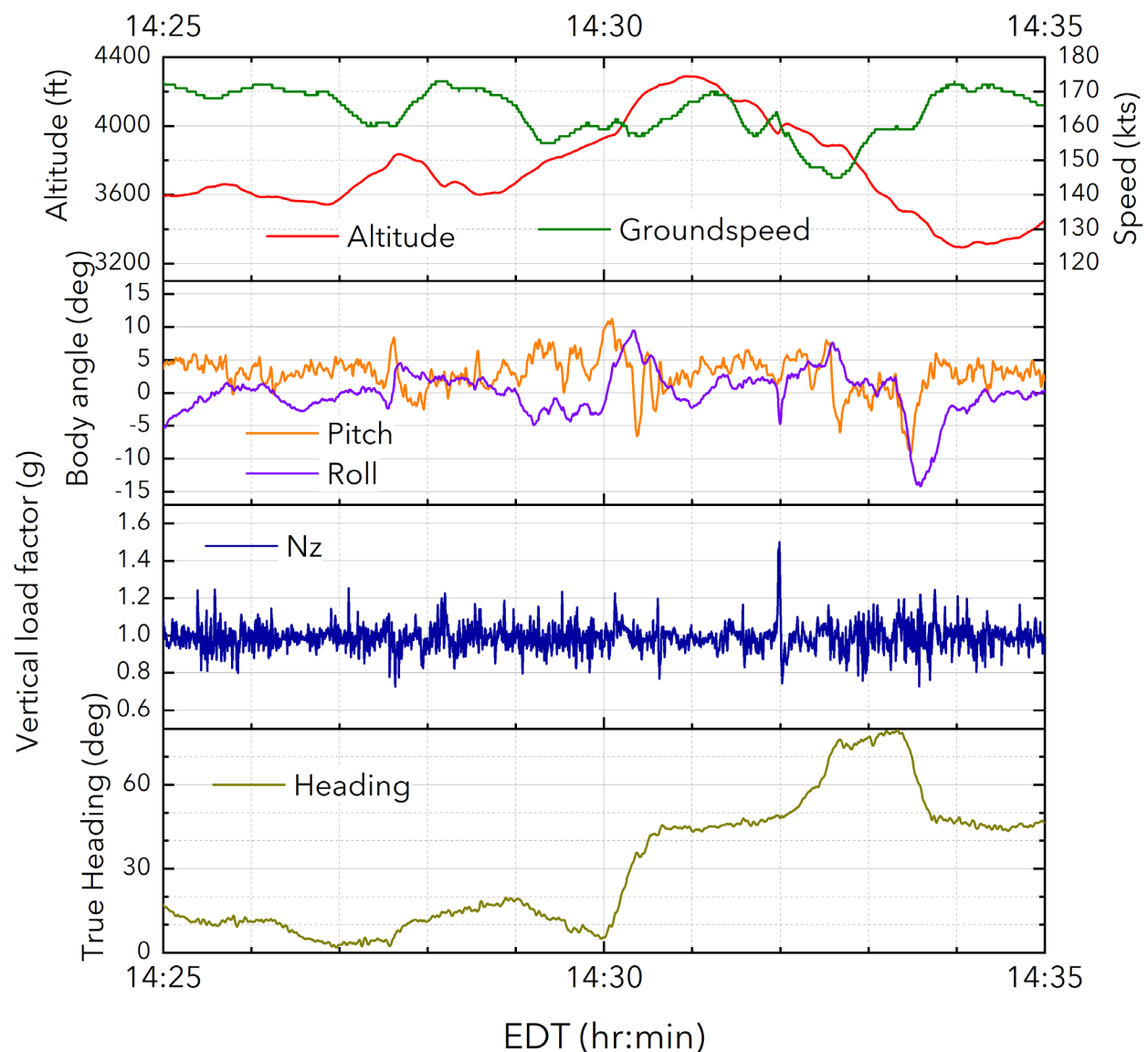


Figure 11. Altitude, speed, pitch, roll, N_z , and heading around time of departure from airplane.

During the time when the skydivers likely left the airplane (between 13:51 and 13:54) the pitch and roll parameters were not considered to be accurately recording the airplane's motion. However, no spikes in N_z similar to the one at 14:32 were seen. This indicated that the 0.5 g increase in N_z was not a result of the copilot leaving the airplane.

E. COMPARISON TO EARLIER FLIGHT

The airplane left Rocky Mountain-Wilson Regional Airport (KRWI) at 1150 and arrived at Raeford West Airport at 1235. Figure 12 shows 20 minutes of cross-country flight for both flights. The mostly level flight portions of these were at different altitudes: 6,700 ft msl for the morning flight and slowly climbing from 3,400 ft to 4,200 ft msl for the accident flight. The earlier flight's roll angle was slightly biased right wing down, but that might be due to the same issues discussed in the Available Data section. Here the characteristics of the parameter are compared rather than their absolute values.

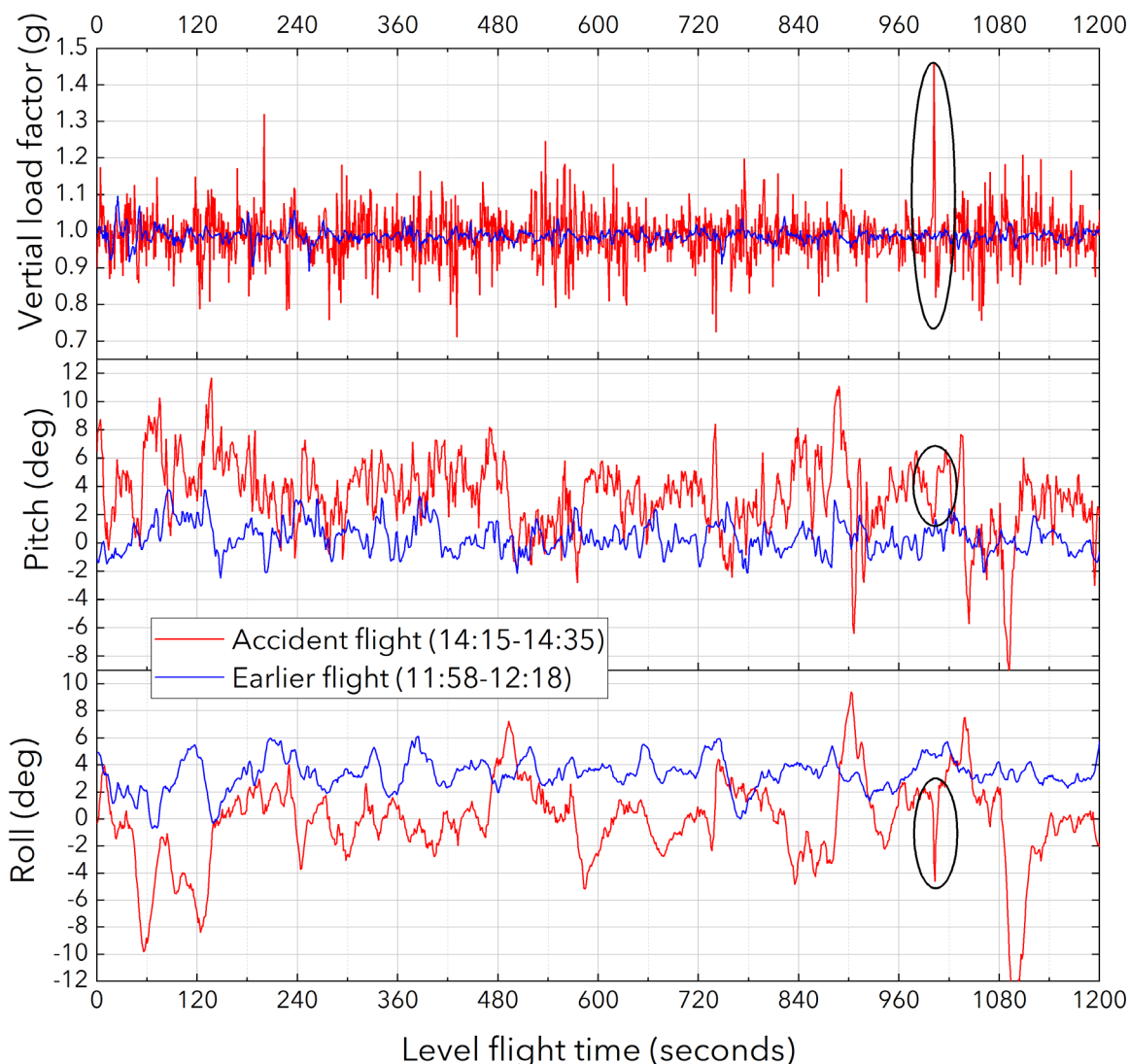


Figure 12. Comparison of vertical load factor, pitch, and roll from portion of accident flight and the earlier flight. The area of SIC departure is circled in black on each parameter.

The accident flight's vertical load factor had higher peaks than the earlier flight that day. The airplane also recorded larger changes in pitch and roll. This was consistent with the pilot's report that there was some turbulence or "chop" during the accident flight.

F. SUMMARY

According to ballistic calculations, the SIC left the airplane between 14:31:53 and 14:32:01. During this time, a roll transient and spike in vertical load factor occurred that was an outlier compared to the earlier seven minutes and following three minutes of flight. This event could have been before, during, or after the SIC departed the airplane. Additionally, it cannot be known if this transient was commanded or a result of external forces on the airplane, as control inputs were not recorded. However, based on recorded vertical load factor, the portion of the flight from the Raeford area to Raleigh likely experienced some turbulence.

G. REFERENCES

1. Davis, Lawrence, (2018). Body Physics: Motion to Metabolism. Open Oregon Educational Resources.