

National Transportation Safety Board

Office of Research and Engineering

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AUTOMATIC DEPENDENT SURVEILLANCE- BROADCAST (ADS-B) STUDY

Aircraft Performance Study

By

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A. ACCIDENT

Location: Weston, Florida
Date: January 23, 2024
Time: 18:44 Eastern standard time (EST)
Airplane: Cessna 172N, N737VC

B. SUMMARY

On January 23, 2024, about 1844 eastern standard time, a Cessna 172N, N737VC, was substantially damaged when it was involved in an accident near Weston, Florida. Both commercial pilots were fatally injured. The airplane was operated as a Title 14 *Code of Federal Regulations* Part 91 personal flight.

C. PERFORMANCE STUDY

1.0 Aircraft

The airplane involved was a Cessna 172N, a single-engine general aviation airplane.



Figure 1. Cessna 172N, N737VC.

2.0 Available Data

The NTSB's Aviation Safety's Operational Factors group provided OpsVue data. OpsVue data uses a multi-sensor system that aggregates and georeferences multiple

FAA data sources. This includes radar data, Automatic Dependent Surveillance-Broadcast (ADS-B) data from the airplane's GPS position, and other information.

3.0 Weather

Weather was recorded for 18:53 at Fort Lauderdale-Hollywood International Airport (FLL), 21 nautical miles east of the wreckage location. The temperature was reported as 75°F (24°C), the dew point was 66°F (19°C), and the barometric setting was 30.24 inHg. Winds were 11 kts from 100°. Visibility was 10 miles. Night visual meteorological conditions prevailed.

4.0 Flight Path

The airplane took off from North Perry Airport (HWO) at 18:30 to the east before turning 180° right onto a westerly heading (Figure 2). The airplane climbed to a maximum altitude of 1,950 ft MSL by 18:34 before beginning to descend (Figure 3). For the remainder of the flight, the airplane's altitude varied between 1,000 ft and 1,600 ft, and its calibrated airspeed varied between 90 and 120 kts. Beginning about 18:37:45, the airplane made a gradual right turn onto a northerly heading out over the Everglades Wildlife Management Area, an undeveloped wetland area with little to no ground lighting.

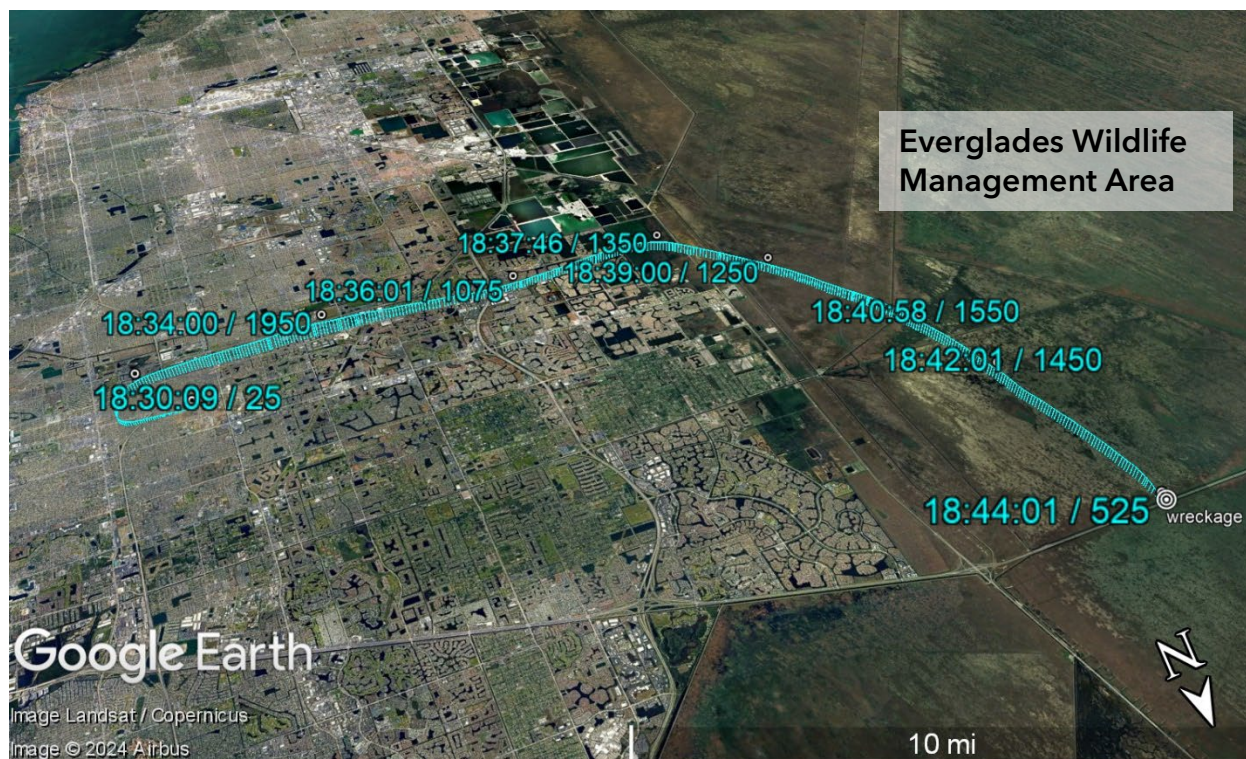


Figure 2. ADS-B flightpath with selected time and altitudes shown.

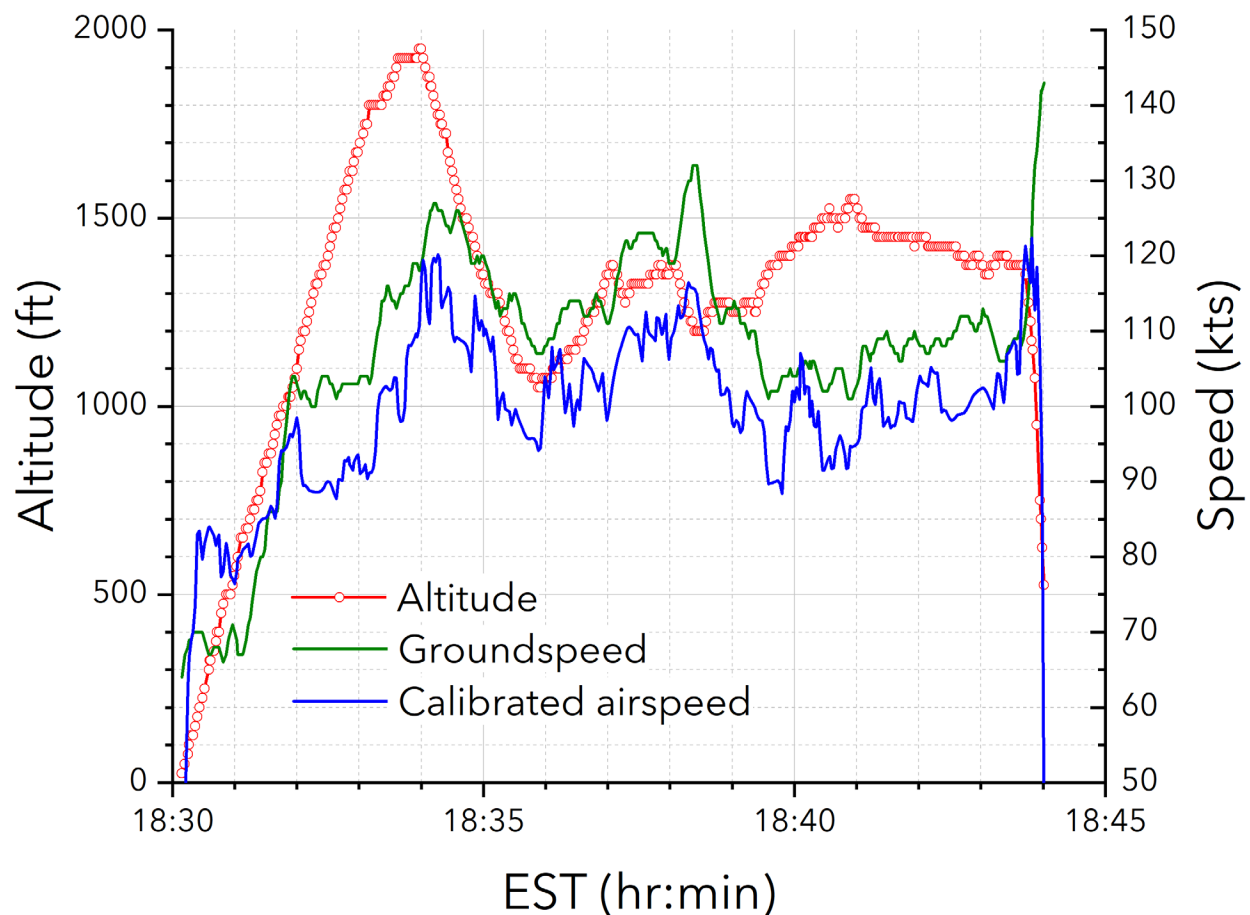


Figure 3. Altitude and groundspeed from ADS-B data. Calibrated airspeed calculated with weather data.

During the final five minutes of flight, the airplane continued to gradually turn onto a more northerly heading (Figure 4). After 18:41 the airplane gained airspeed while descending 100 - 200 ft. At 18:43:43, the airplane began to lose altitude at an initial rate of 1,700 ft/min. After 18:43:50 the descent rate increased to 3,400 ft/min until the end of the ADS-B data at 18:44:01 when the altitude was 525 ft. The airplane wreckage was 1,000 ft farther along the final track from the last ADS-B point at an elevation 10 ft above sea level.

The airplane's speed and attitudes (Figure 5), which were calculated using the ADS-B data, a simplified aerodynamic model of the airplane, and the meteorological information, did not exceed any documented limitations and were well within the airplane's flight envelope.

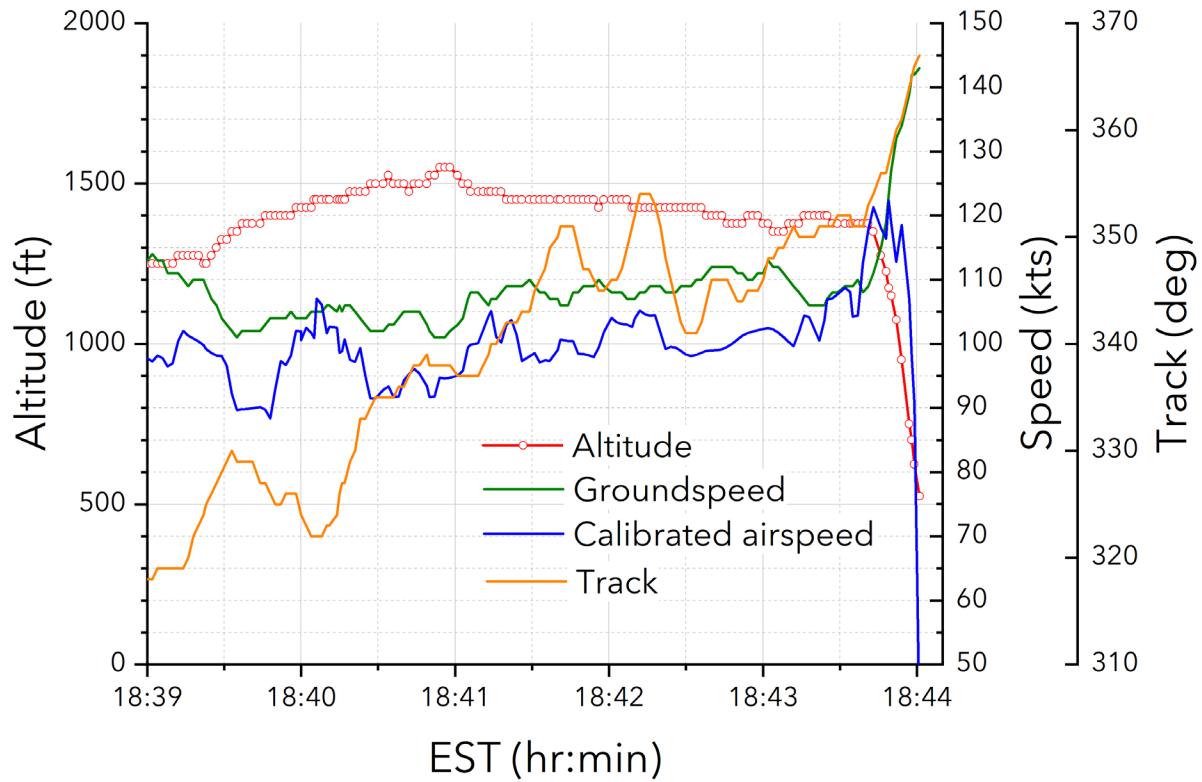


Figure 4. Altitude, groundspeed, and track angle from ADS-B data. Calibrated airspeed calculated with weather data.

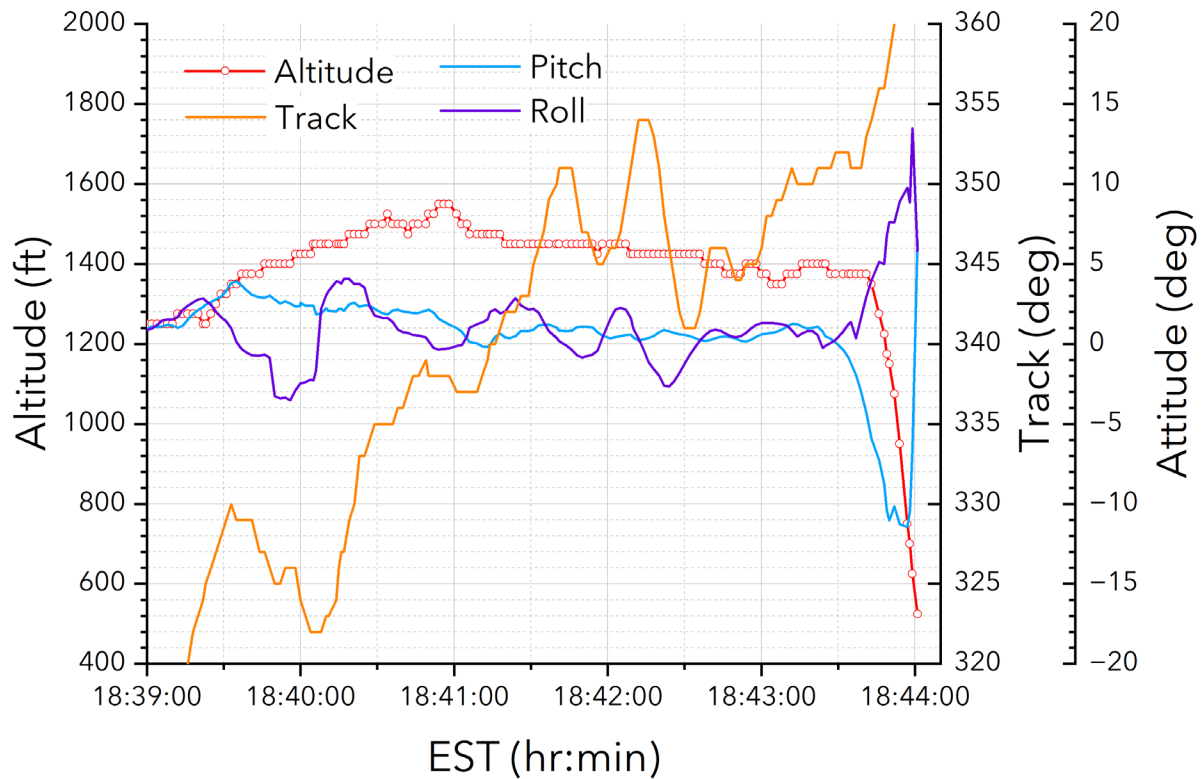


Figure 5. Altitude and track angle from ADS-B data. Calculated pitch and roll angles.

5.0 Spatial Disorientation

Human spatial orientation is complex and relies on the brain's integration of visual, vestibular, and kinesthetic sensory inputs. Vision is the dominant source of sensory inputs used for spatial orientation, but when external visual cues are limited, vestibular inputs become more important. The vestibular system provides reasonably accurate information to the brain when walking on the ground, but it can provide misleading information when subjected to the forces of flight. One of the vestibular system's limitations is a difficulty distinguishing the acceleration of translational motion from the acceleration of gravity. Sustained forward acceleration can lead to a form of spatial disorientation known as somatogravic illusion. In coordinated flight, this illusion is most often experienced as a misperception of pitch.

Figure 6 shows two images of a seated person. In the left image, the person's seat is pitched back at an angle of θ . The gravity vector, $\vec{n}_z$ is the only force acting on the person, in relation to the angle θ . In this case, the pitch angle that is apparent to the person, θ_{APP} , is equal to the seat pitch and can be accurately determined by a person's vestibular system.

In the right picture, the pitched-up seat is now also accelerating forward due to $\vec{n}_x$. The person experiences $\vec{n}_z$ and $\vec{n}_x$ together as $\vec{n}$ which is called the gravito-inertial force (GIF) due to it being a combination of gravity acting on the person and the inertial movement of the vehicle. Now, the angle that is apparent to the vestibular system is the angle between the person's upright orientation and the gravito-inertial force. This angle is referred to as the GIF angle and may not be equal to the actual pitch of the seat.

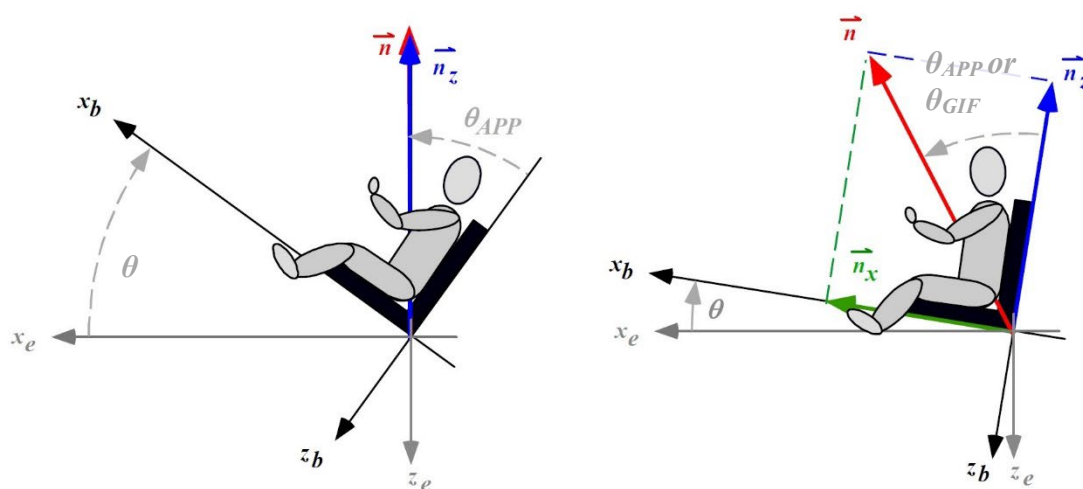


Figure 6. GIF/Apparent angles in an unaccelerated (left) and accelerated (right) reference frame.

To determine the GIF/apparent angles, first the total acceleration is determined as

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

Then, the apparent pitch and roll a pilot could experience can be calculated as

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

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

Since the airplane did not have a data recorder, its accelerations, which could be measured by onboard accelerometers, were not recorded. A simplified aerodynamic model of a Cessna 172 was “flown” through the ADS-B flight path data using a mathematical simulator to estimate the airplane’s load factors for the final two minutes of flight. However, these calculations are not as accurate as measurements would be. Once n_x , n_y , and n_z were determined, θ_{GIF} and ϕ_{GIF} were calculated. ϕ_{GIF} showed little change compared to the roll angle ϕ plotted in Figure 5, so only θ_{GIF} is compared to the calculated airplane pitch θ in Figure 7.

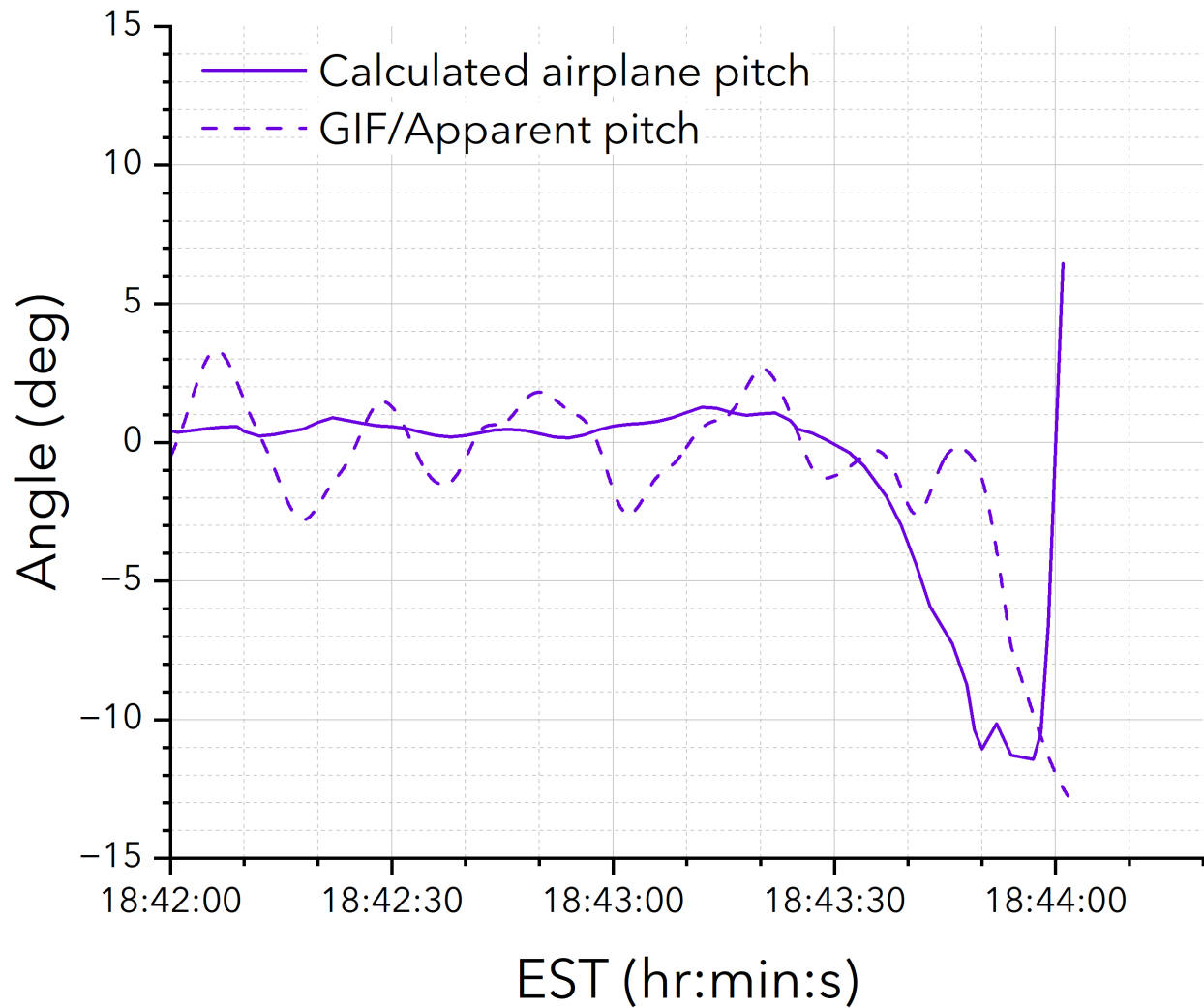


Figure 7. Calculated pitch and apparent pitch for final two minutes of flight.

The GIF/apparent pitch angle lagged the actual end of flight pitch down by nearly 20 seconds and began trending down after 18:43:50, when the airplane's descent rate doubled from 1,700 ft/min to 3,400 ft/min.

D. SUMMARY

The accident flight was approximately 14 minutes long, during which the airplane did not exceed any documented aerodynamic limitations. However, the GIF/apparent pitch angle remained nearly nose level during the initial 20 second portion of the final descent.