

National Transportation Safety Board

Office of Research and Engineering

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VEHICLE PERFORMANCE

Specialist's Study

July 20, 2026

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A ACCIDENT

Location: Philadelphia, Pennsylvania
Date: January 31, 2025
Time: 18:07 Eastern Standard Time (EST)
23:07 UTC
Airplane: Learjet 55, XA-UCI

B VEHICLE PERFORMANCE SPECIALIST

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C SUMMARY

On January 31, 2025, at 18:07 eastern standard time, a Learjet 55 airplane, Mexican registration XA-UCI (call sign MTS056), was destroyed when it was involved in an accident in Philadelphia, Pennsylvania. The two pilots, two medical crewmembers, and two passengers were fatally injured. One person on the ground was fatally injured, 4 people were seriously injured, and 20 people incurred minor injuries. The airplane was operated as a Title 14 *Code of Federal Regulations* Part 129 air ambulance flight.

The flight departed from runway 24 at Northeast Philadelphia Airport (PNE), Philadelphia, Pennsylvania, about 18:06, with the intended destination of Springfield-Branson National Airport (SGF), Springfield, Missouri. Night instrument meteorological conditions prevailed at PNE at the time of the accident, with an overcast ceiling at 400 ft above ground level (AGL), wind from 220° at 9 knots, and 6 statute miles visibility.

D DETAILS OF THE INVESTIGATION

1.0 Airplane

The airplane was a Bombardier Learjet 55, a two-engine, low-wing business jet with a T tail, manufactured in 1982. A picture of the airplane is shown in Figure 1. Weight and balance calculations for the accident flight show the takeoff weight was 20,830 lbs, with a center of gravity (CG) at 16.85 % of the mean aerodynamic chord, or about 2 inches aft of the forward CG limit at that weight. Maximum takeoff weight is shown as 21,500 lbs. Bombardier provided lift and drag data for the airplane.

2.0 Weather

Weather was recorded at PNE at 17:54 EST, about 13 minutes before the accident. Night instrument meteorological conditions prevailed, with overcast skies at 400 ft AGL. Winds were 9 kt from 220°, temperature 9 °C (48 °F), dew point 9 °C (48 °F), and barometric setting of 29.71 inHg. Visibility was 6 statute miles.

3.0 Data

The Federal Aviation Administration (FAA) provided Automatic Dependent Surveillance-Broadcast (ADS-B) data, which broadcasts an aircraft's Global Navigation Satellite System (GNSS) position and other data to ground stations, where it is recorded approximately once per second. The GNSS position data is expected to have an uncertainty of approximately 20 m (65 ft) in horizontal and vertical dimensions. The ADS-B data extended from 18:06:25 to 18:07:03 EST. The GNSS-based altitude above the reference ellipsoid was corrected to the mean sea level (MSL) altitude above the geoid by adding 112.0 ft.

Winds aloft, temperature, and pressure as functions of MSL altitude were taken from a High-Resolution Rapid Refresh (HRRR) model sounding from the National Oceanic and Atmospheric Administration¹. The data were downloaded for coordinates 40.05° North, 75.06° West, at 18:00 EST. The data are shown in Table 1.

Table 1. Winds aloft, temperature and pressure from the HRRR model sounding.					
MSL altitude (ft)	Wind speed (kt)	Wind direction (degrees)	Temperature (°C)	Dew point (°C)	Pressure (hPa)
105	4.5	239.3	6.6	6.1	1002
131	4.1	241.6	6.9	6.7	1001
213	7.8	233.5	6.9	6.4	998
364	11.1	225.9	6.9	6.8	992
620	17.1	219.9	7.1	7.1	983
1506	36.5	227.0	7.9	7.8	952
2116	44.7	231.2	11.0	10.9	931

¹ [READY Archived Meteorology](#)

4.0 Flight Path

An overview of the flight path on a Google Earth background is shown in Figure 2. The first ADS-B data point was recorded at 18:06:25 EST, when the airplane was about 2800 ft past the departure end of runway 24 and about 400 ft AGL. The ADS-B data only extended for about 38 s, with the last ADS-B data point recorded at 18:07:03 EST. The maximum altitude reached was about 1445 ft MSL, or 1325 ft AGL. At the last ADS-B data point, the airplane was about 900 ft AGL and descending rapidly. The crash site was located at 40.04646° North, 75.05758° West.

An overhead plot of the flight path defined by the ADS-B data is shown in Figure 3, with the origin of the north and east axes at the threshold of runway 24. The crash site was about 2.6 NM south and 2.6 NM west of the threshold of runway 24.

Figure 4 shows the pressure altitude and the GNSS-based altitude as functions of time. Dashed lines show smooth polynomial fits to the altitude data. Solid lines show the pressure altitude corrected to MSL using the local atmospheric conditions and the GNSS-based altitude corrected to MSL by adding 112.0 ft, which is the height of the ellipsoid above the geoid. The field elevation of 119.8 ft and the cloud base at 400 ft AGL (519.8 ft MSL) are also shown. Figure 5 shows the pressure altitude and the pressure altitude corrected to MSL altitude, along with the rate of climb recorded in the ADS-B data, which is derived from the pressure altitude. The initial rate of climb began to decrease about 18:06:41, and the airplane began to descend about 18:06:56. At the end of the flight, the airplane was descending at nearly 10,000 ft/min.

The polynomial fit to the pressure altitude and similar polynomial curves fit to the north and east position data were used in a trajectory analysis of the flight path. In the analysis, it is assumed that the airplane flies with zero sideslip, so that a change in direction is a result of a change in orientation of the lift vector by pitching or rolling the airplane. The curves fit to the position data provide smooth inputs for the calculations, and the data was further smoothed by interpolating to a consistent time basis of 0.8 s between points. True airspeed and calibrated airspeed are calculated from the ground speed using the winds aloft and atmospheric conditions in the HRRR sounding model; a pressure-based MSL altitude can also be calculated by interpolating the pressure altitude using the pressure as a function of MSL altitude from the HRRR sounding model. Airplane parameters are also input. The calculations are used to determine airplane orientations and load factors.

Figure 6 shows the groundspeed, true airspeed and calibrated airspeed as functions of time, along with the pressure-based MSL altitude. The groundspeed is calculated from the smooth curves fit to the ADS-B position data. Figure 7 shows the calculated Mach number during the flight. The speed of the airplane was increasing throughout the flight, and the airplane exceeded 250 kt calibrated airspeed about

18:06:53. The speed increased at a higher rate after 18:06:58, when the airplane began its steep descent. At the final ADS-B data point, the airplane was traveling at 300 kt calibrated airspeed.

Figure 8 shows the calculated pitch and roll angles. The calculated pitch angle passed through zero about 18:06:57, when the airplane began to descend. The roll angle was steadily decreasing during the flight, from an initial roll to the right becoming a large roll to the left. During the descent, the calculated roll angle exceeded 90° left wing down. (The start and stop of the data are discontinuities that affect the calculation of rates of change that drive the calculation of the Euler angles, leading to some fluctuations in the Euler angles at the beginning and end of the data.)

Figure 9 shows the calculated roll rate. Between 18:06:28 and 18:06:49, the airplane rolled left at about -2 degrees/s. The magnitude of the roll rate began to increase about 18:06:50, about 6 s before the airplane began to descend. Figure 10 shows the calculated roll angle, roll rate and roll acceleration. Between 18:06:29 and 18:06:59, the magnitude of the roll acceleration was less than 2 degrees/s².

Sustained forward acceleration can lead to a form of spatial disorientation known as somatogravic illusion, because the vestibular system cannot distinguish the acceleration of translational motion from the acceleration of gravity. Figure 11 shows two images of a seated person. In the left image, the seat is pitched back at an angle of θ , but there is no translational acceleration. The load factor vector $\vec{n}$ is only due to gravity. Resolved along the body x_b and z_b axes, the longitudinal and normal load factor magnitudes are $|\vec{n}_x| = |\vec{n}| \sin \theta$ and $|\vec{n}_z| = |\vec{n}| \cos \theta$. (The trajectory analysis uses an assumption that there is no sideslip, so $|\vec{n}_y| \equiv 0$, meaning $|\vec{n}|^2 = |\vec{n}_x|^2 + |\vec{n}_z|^2$.) In the right image, there is an added forward acceleration along the body x_b axis, increasing the magnitude of $\vec{n}_x$, and the load factor vector $\vec{n}$ is a result of both gravity and inertial force ($\vec{n}$ is also called the gravito-inertial force vector or GIF vector). The apparent pitch angle is the angle between the GIF vector and the body z_b axis. The trajectory analysis calculates $|\vec{n}_x|$ and $|\vec{n}_z|$ directly, and the apparent pitch arising from the GIF vector can be calculated as

$$\theta_{APP} = \sin^{-1} \frac{|\vec{n}_x|}{\sqrt{|\vec{n}_x|^2 + |\vec{n}_z|^2}}$$

or

$$\theta_{APP} = \cos^{-1} \frac{|\vec{n}_z|}{\sqrt{|\vec{n}_x|^2 + |\vec{n}_z|^2}}$$

In Figure 11, the increased forward acceleration results in an apparent pitch θ_{APP} that is larger than the actual pitch θ .

Figure 12 shows the calculated longitudinal and normal load factor magnitudes calculated in the trajectory analysis; the longitudinal load factor is greater

than 0, consistent with the increasing speed of the airplane during the flight. Figure 13 compares the apparent (GIF) pitch angle θ_{APP} with the actual pitch angle of the airplane, θ . The apparent (GIF) pitch is positive and greater than the actual pitch for the entire flight. Even as the airplane began its steep descent, the apparent pitch increased while the actual pitch dropped below 0, owing to the increased acceleration along the body x_b axis.

Figure 14 shows the potential energy, kinetic energy and total energy (potential plus kinetic) calculated for the flight. The nearly linear increase in total energy indicates there was no decrease in engine power during the flight.

E DISCUSSION

The first ADS-B data point was recorded at 18:06:25, about the time the airplane entered the overcast cloud layer at 400 ft AGL. At that time, the airplane was climbing at 2300 ft/min at a calibrated airspeed of 191 kt. About 18:06:41, the rate of climb began to decrease to 400 ft/min, and about 18:06:56, the airplane began to descend, with the rate of descent reaching -10,000 ft/min at the last ADS-B data point at 18:07:03. The data lasted for about 38 s.

The airplane's calibrated airspeed increased throughout the flight, exceeding 250 kt about 18:06:53. As the airplane began to descend, the calibrated airspeed increased at a higher rate, reaching 300 kt at the end of the ADS-B data.

The airplane was rolling left at a rate of -2 degrees/s for about 25 s, but the magnitude of the roll rate began to increase about 18:06:50, about 6 s before the airplane began to descend. The calculated roll angle exceeded 90° left wing down about 18:07:00. Between 18:06:29 and 18:06:59, the magnitude of the roll acceleration was less than 2 degrees/s².

The calculated pitch angle was initially near 12°, but it began to decrease about 18:06:38, and it passed through zero about 18:06:57, when the airplane began to descend.

The increasing speed throughout the flight was reflected in a positive longitudinal load factor, which rotated the gravito-inertial force (GIF) vector forward, leading to an apparent GIF pitch that was positive throughout the flight. At 18:07:01, the actual pitch angle was calculated to be -18.6°, but the apparent GIF pitch was calculated to be 23.7°.

The total energy calculated as the sum of the potential and kinetic energies increased nearly linearly throughout the flight, indicating no decrease in engine power.

Submitted by:

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REFERENCES

1. FAA Approved Airplane Flight Manual for Gates Learjet 55, Bombardier Learjet, 1981.

FIGURES



Figure 1. A photograph of the accident airplane, XA-UCI. Source: FlightAware.



Figure 2. View of the flight path on a Google Earth background, with selected points annotated. Annotations indicate EST time, MSL altitude in ft and calibrated airspeed in kt. The airport is at upper right, and the crash site is marked with a red circle.

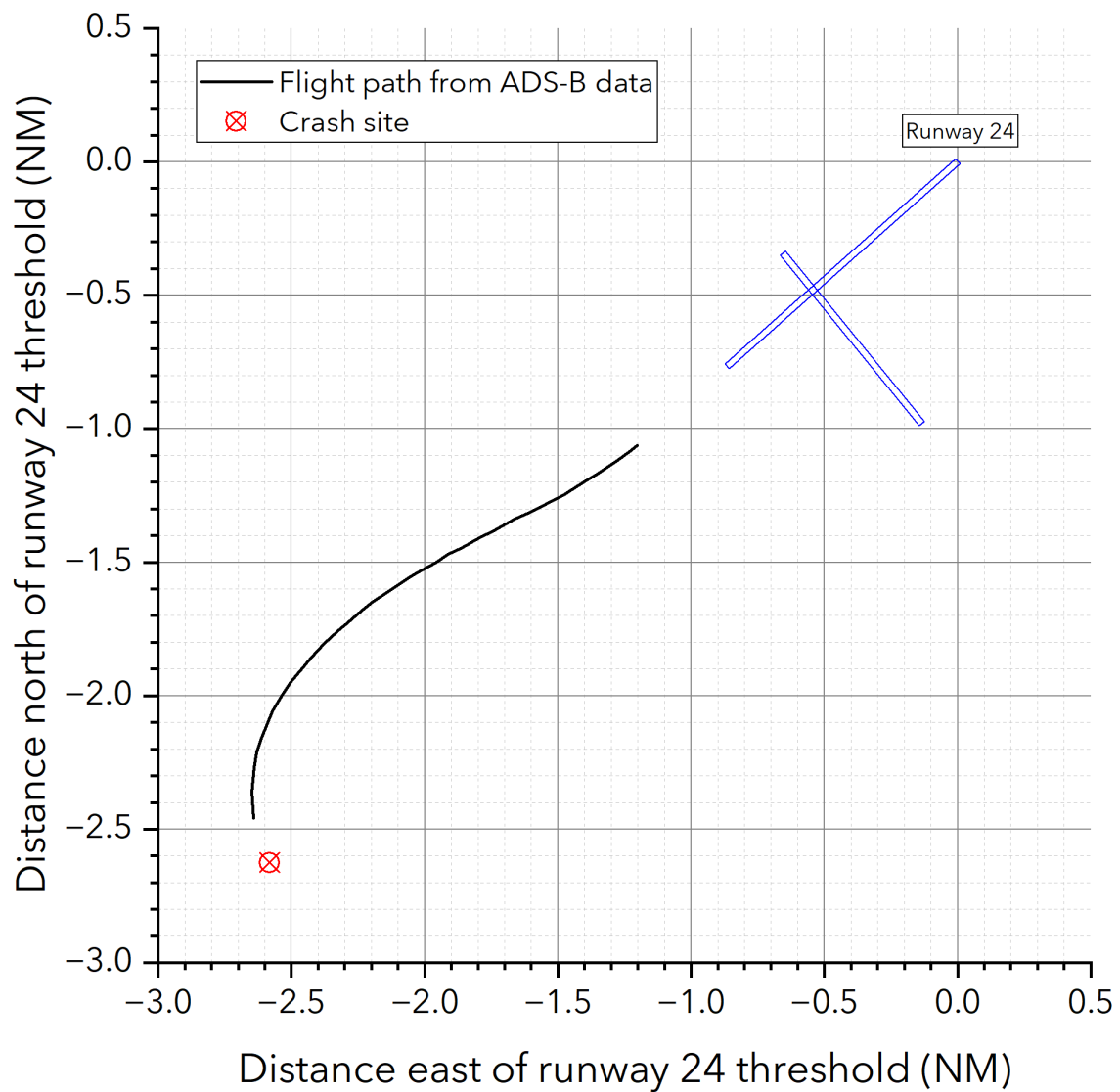


Figure 3. Overhead view of the flight path. Coordinate origin is at the threshold of runway 24 at PNE.

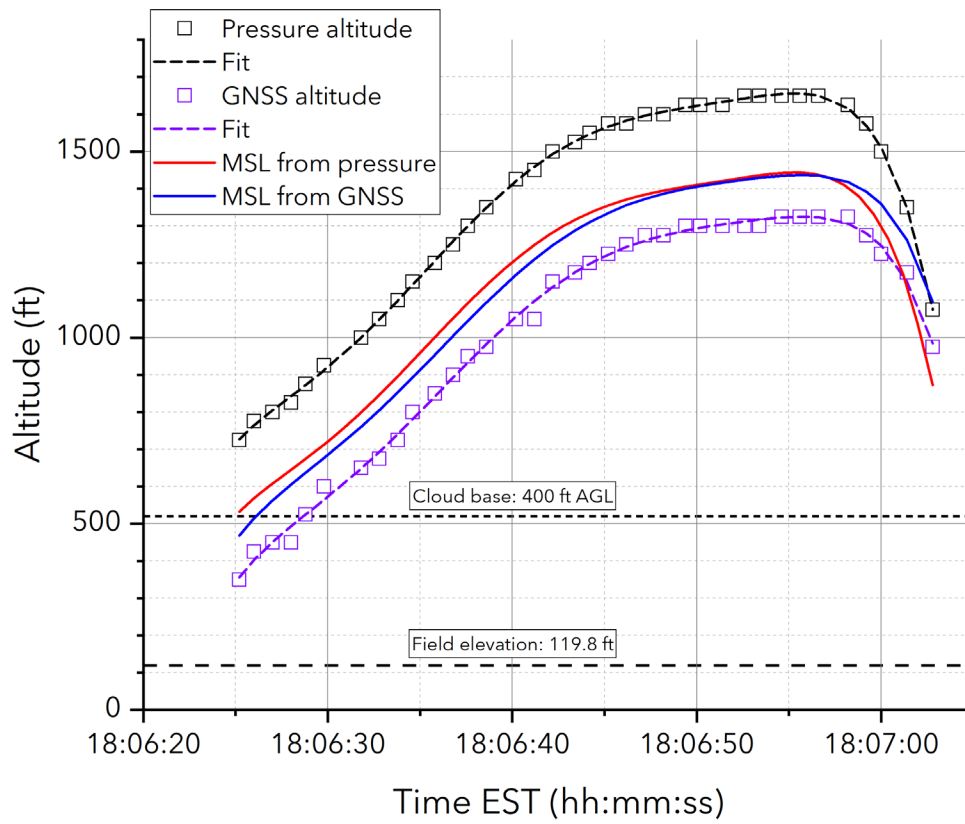


Figure 4. Recorded pressure altitude and GNSS altitude, with polynomials fit through the data, along with the pressure altitude corrected to MSL using the local atmospheric conditions and the GNSS altitude corrected to MSL using the offset between the geoid and the ellipsoid. Horizontal lines indicate the field elevation and the cloud base at 400 ft AGL.

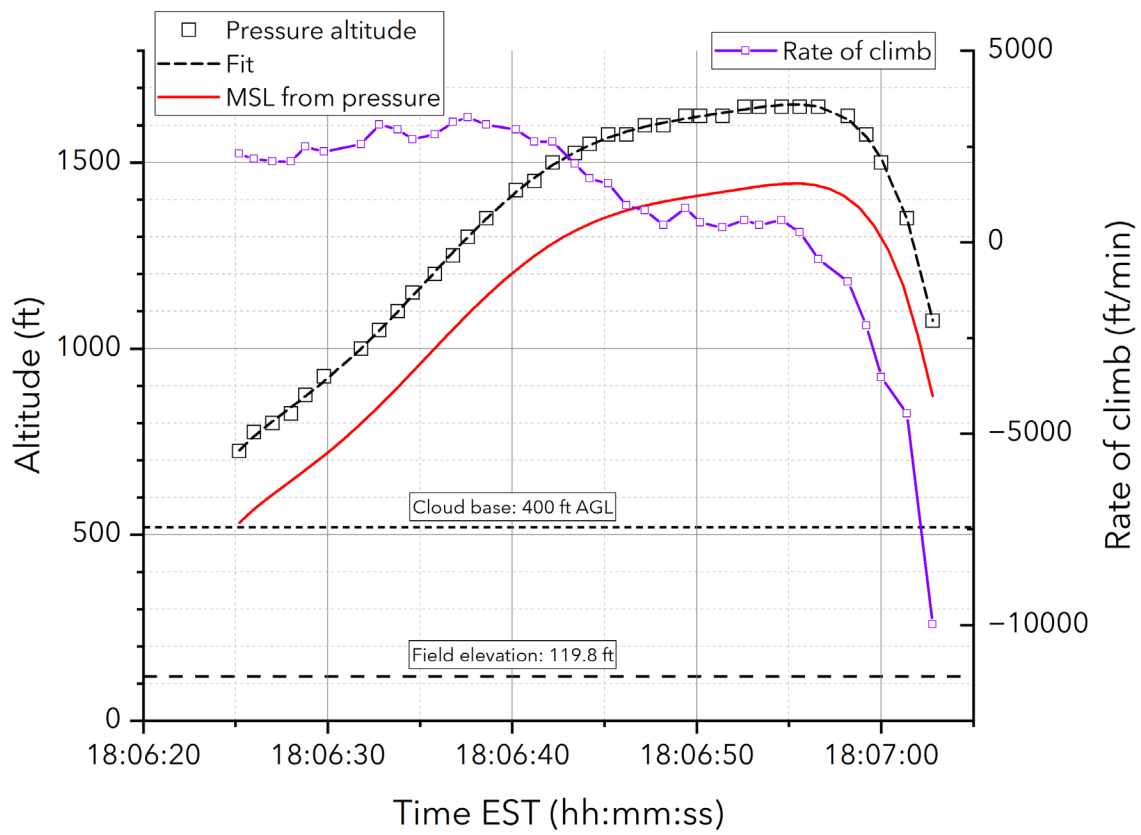


Figure 5. Recorded pressure altitude with polynomial fit, along with the pressure altitude corrected to MSL using the local atmospheric conditions. Horizontal lines indicate the field elevation and the cloud base at 400 ft AGL. Also shown is the recorded rate of climb.

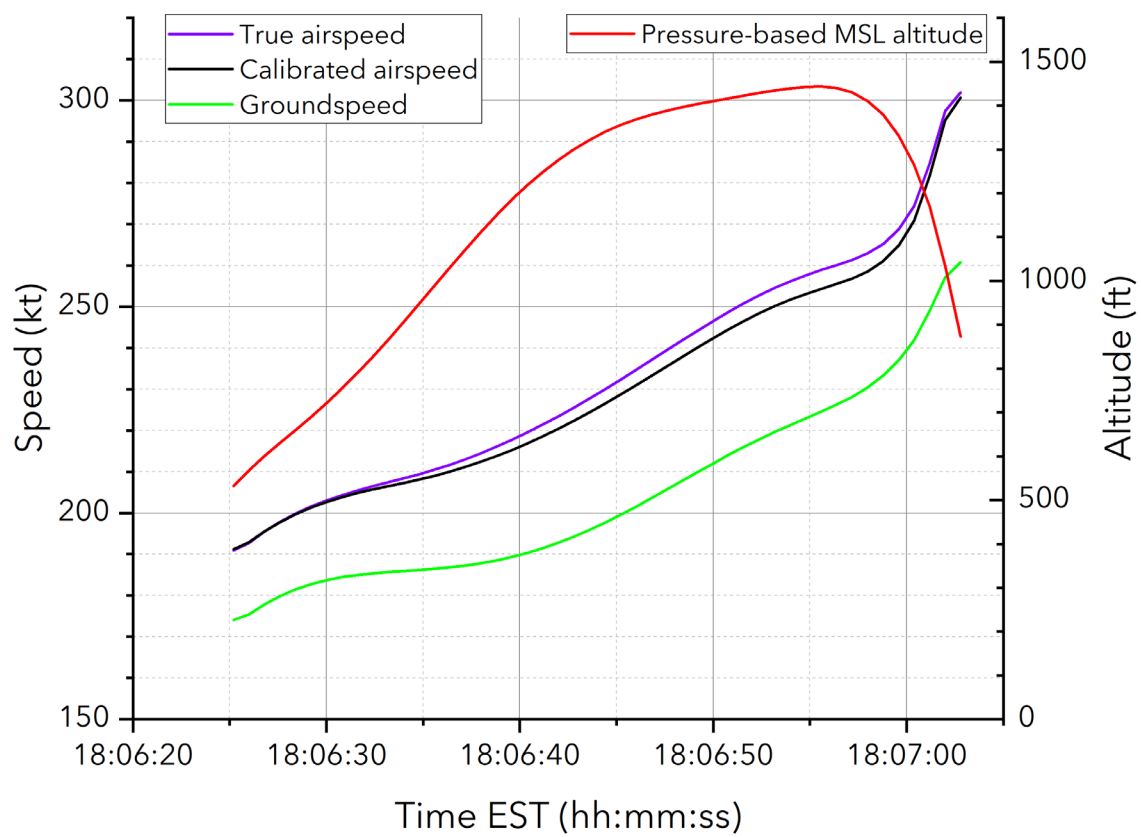


Figure 6. Groundspeed, true airspeed and calibrated airspeed for the flight, along with the pressure-based MSL altitude.

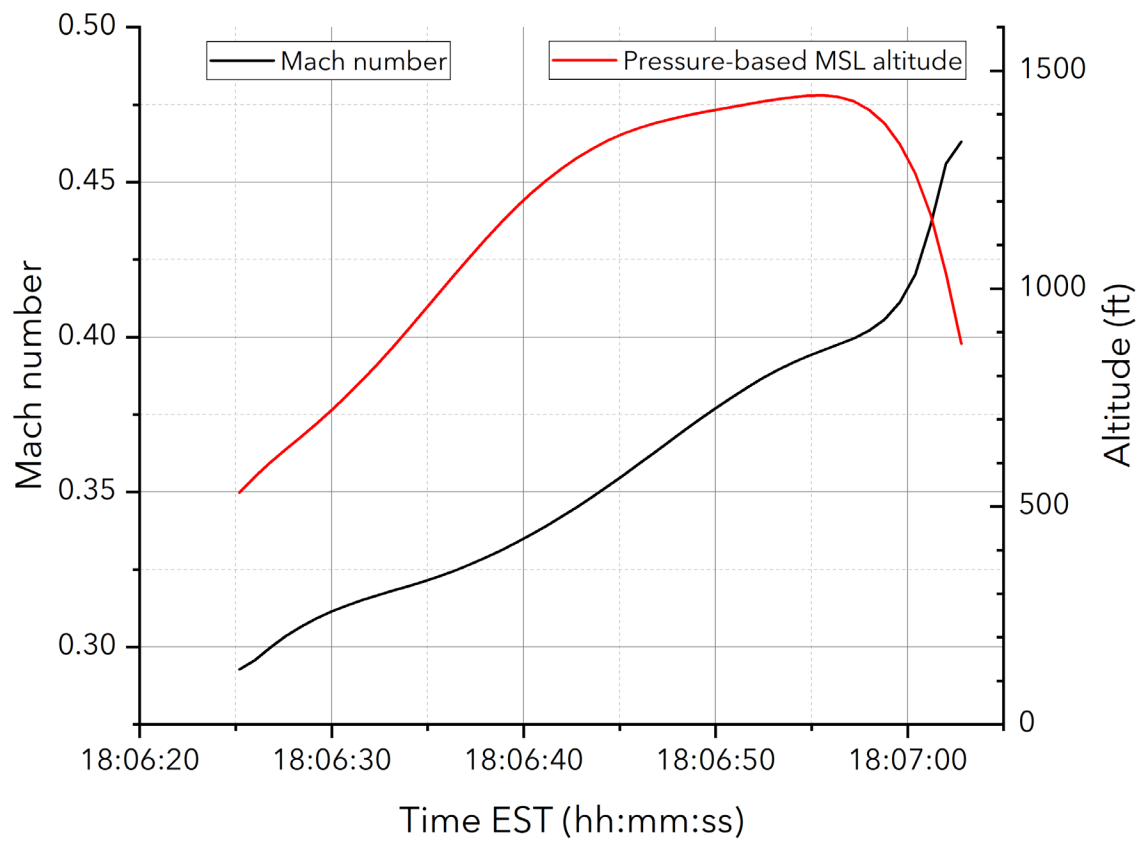


Figure 7. Mach number along with the pressure-based MSL altitude.

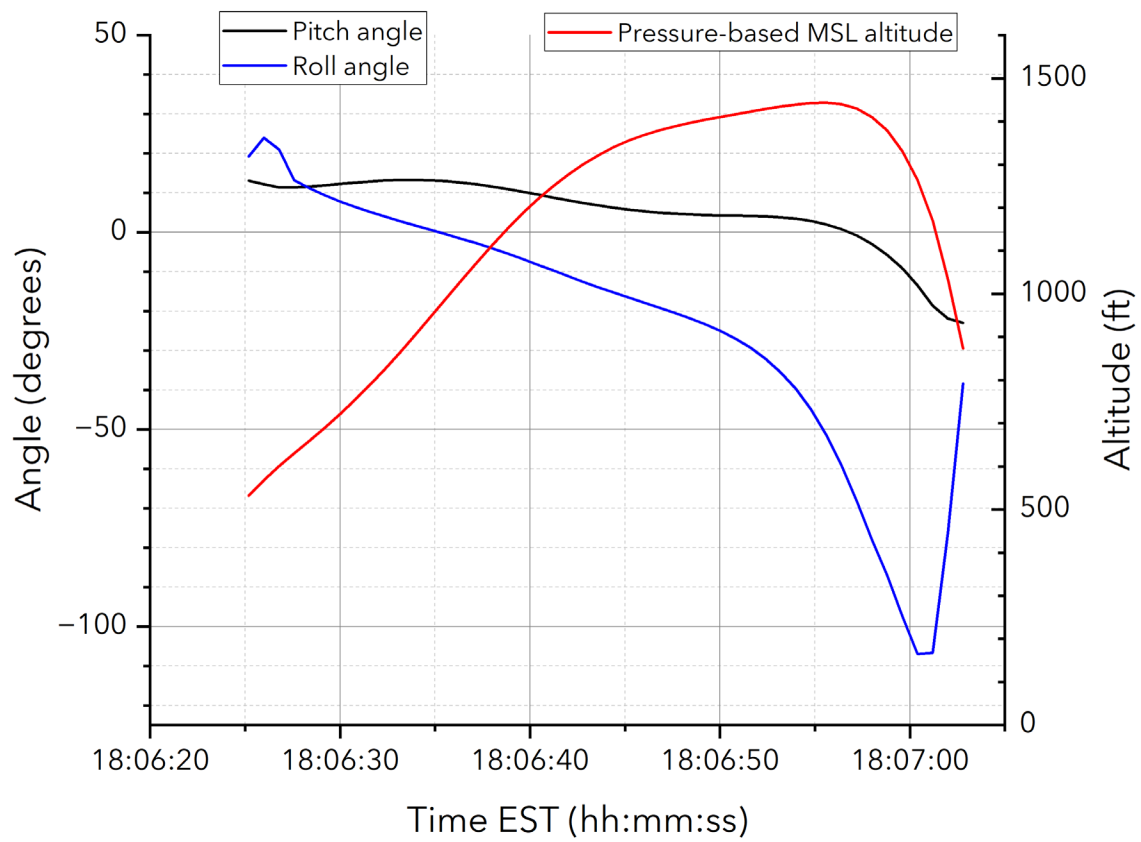


Figure 8. Pitch angle and roll angle, along with the pressure-based MSL altitude.

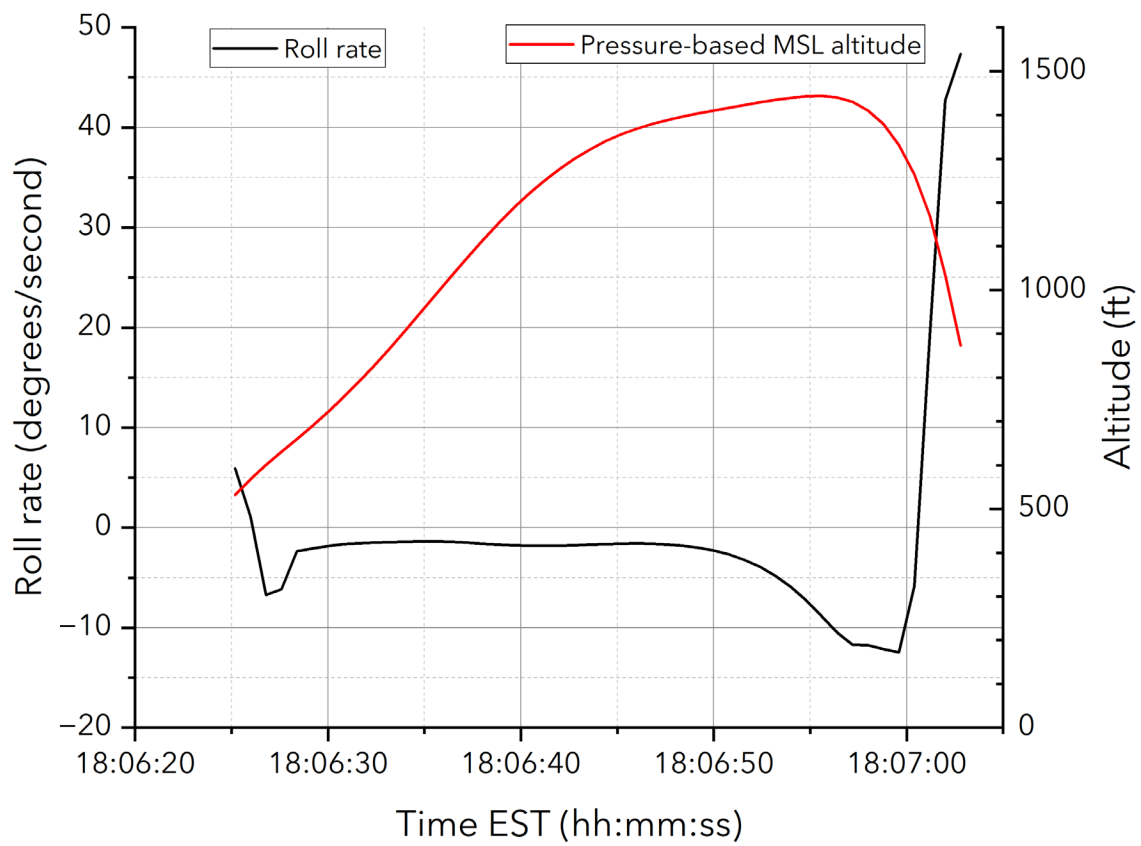


Figure 9. Calculated roll rate along with the pressure-based MSL altitude.

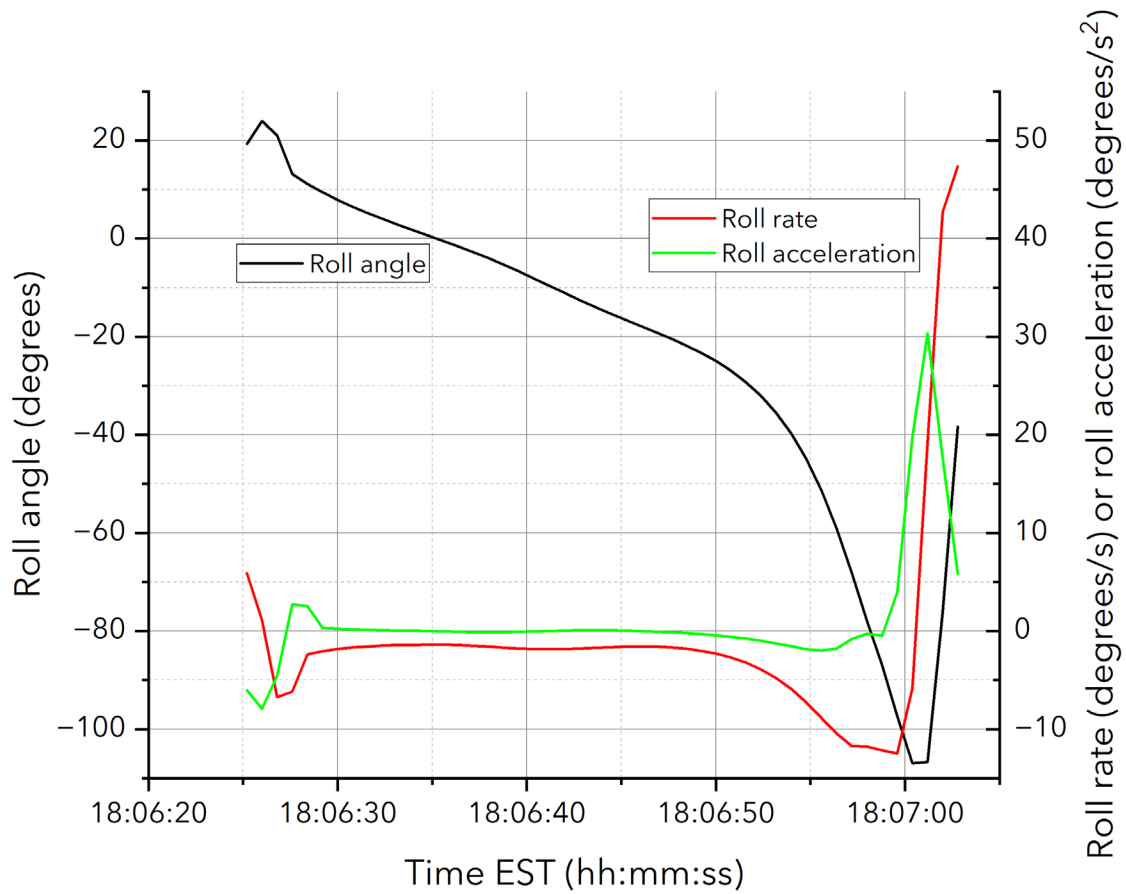


Figure 10. Roll angle, roll rate and roll acceleration.

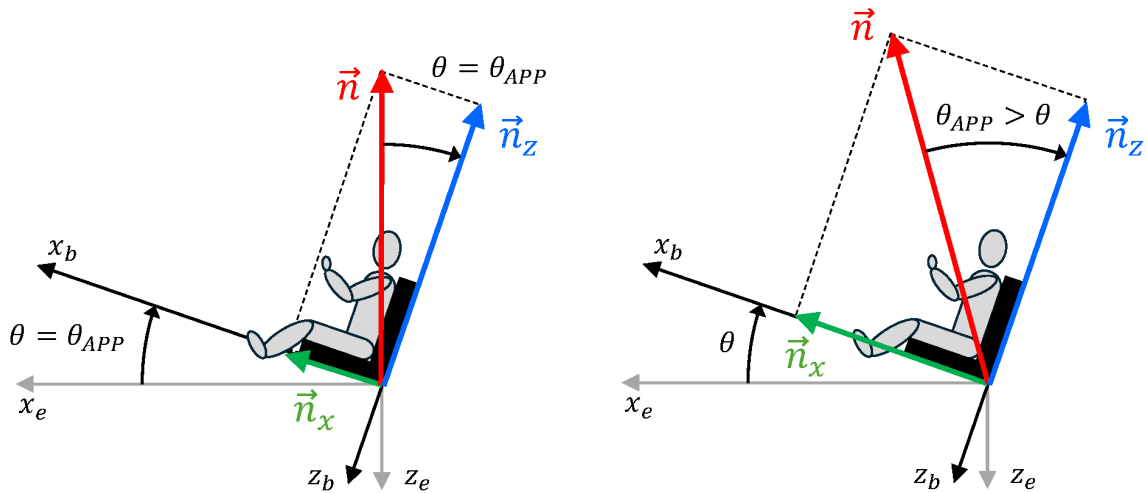


Figure 11. In the left image, the seat is pitched back at an angle of θ , but there is no translational acceleration, so the load factor vector $\vec{n}$ is only due to gravity. In the right image, there is an added forward acceleration along the body x_b axis, increasing the magnitude of $\vec{n}_x$, and reorienting the GIF vector $\vec{n}$. The apparent pitch angle is the angle between the GIF vector and the body z_b axis, and the apparent pitch angle θ_{APP} is larger than the actual pitch angle θ .

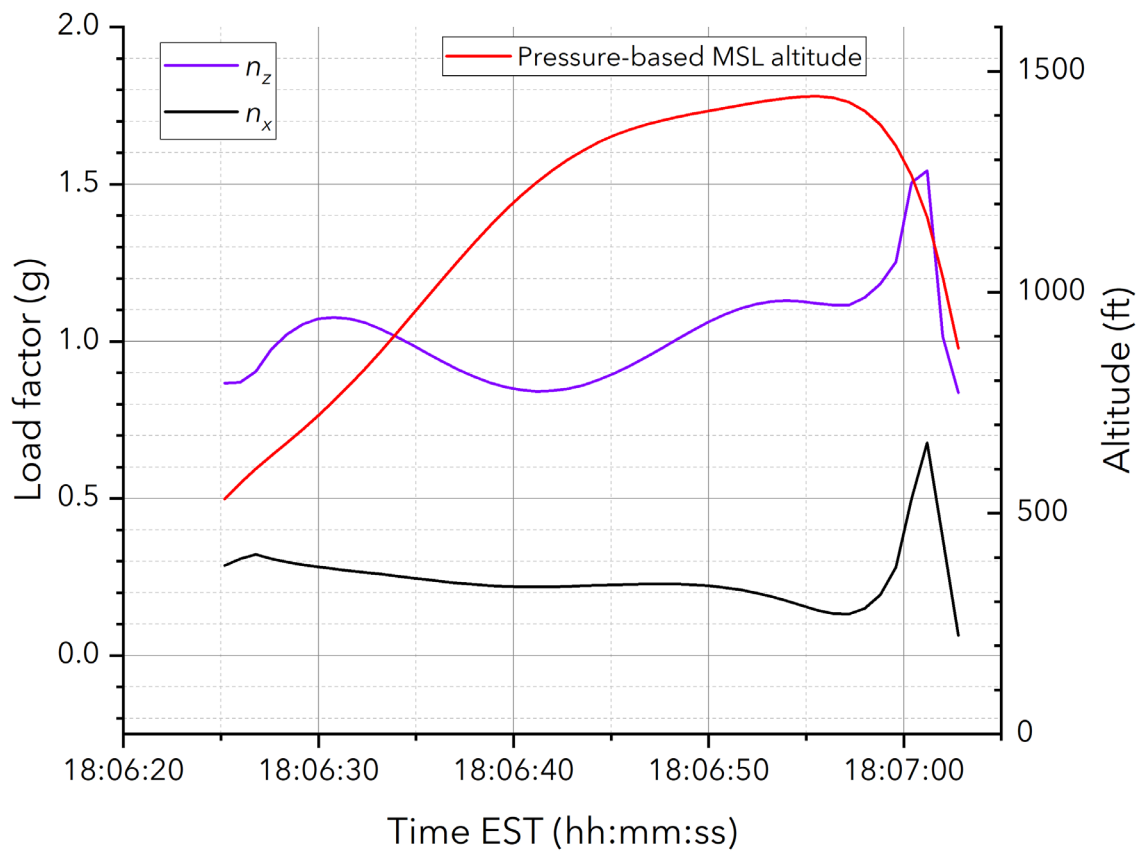


Figure 12. Longitudinal load factor n_x and normal load factor n_z , along with the pressure-based MSL altitude.

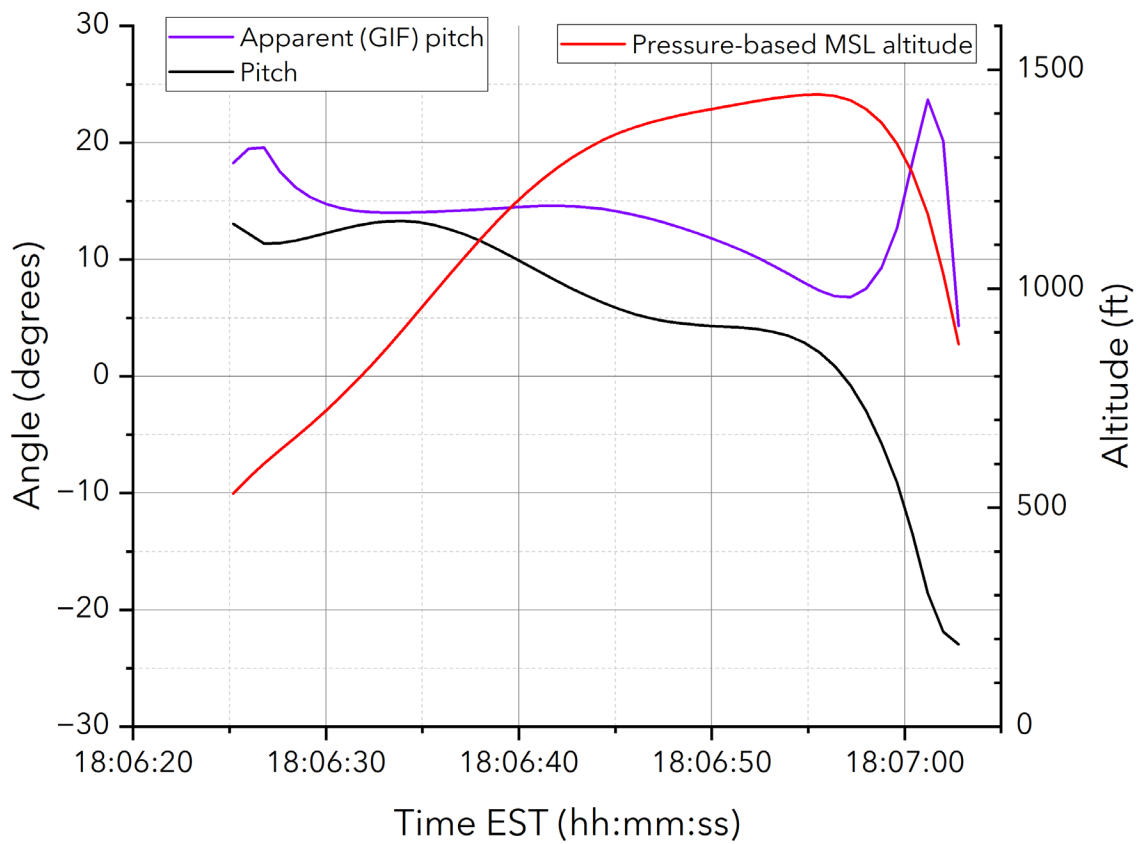


Figure 13. The apparent (GIF) pitch angle and the actual pitch angle, along with the pressure-based MSL altitude.

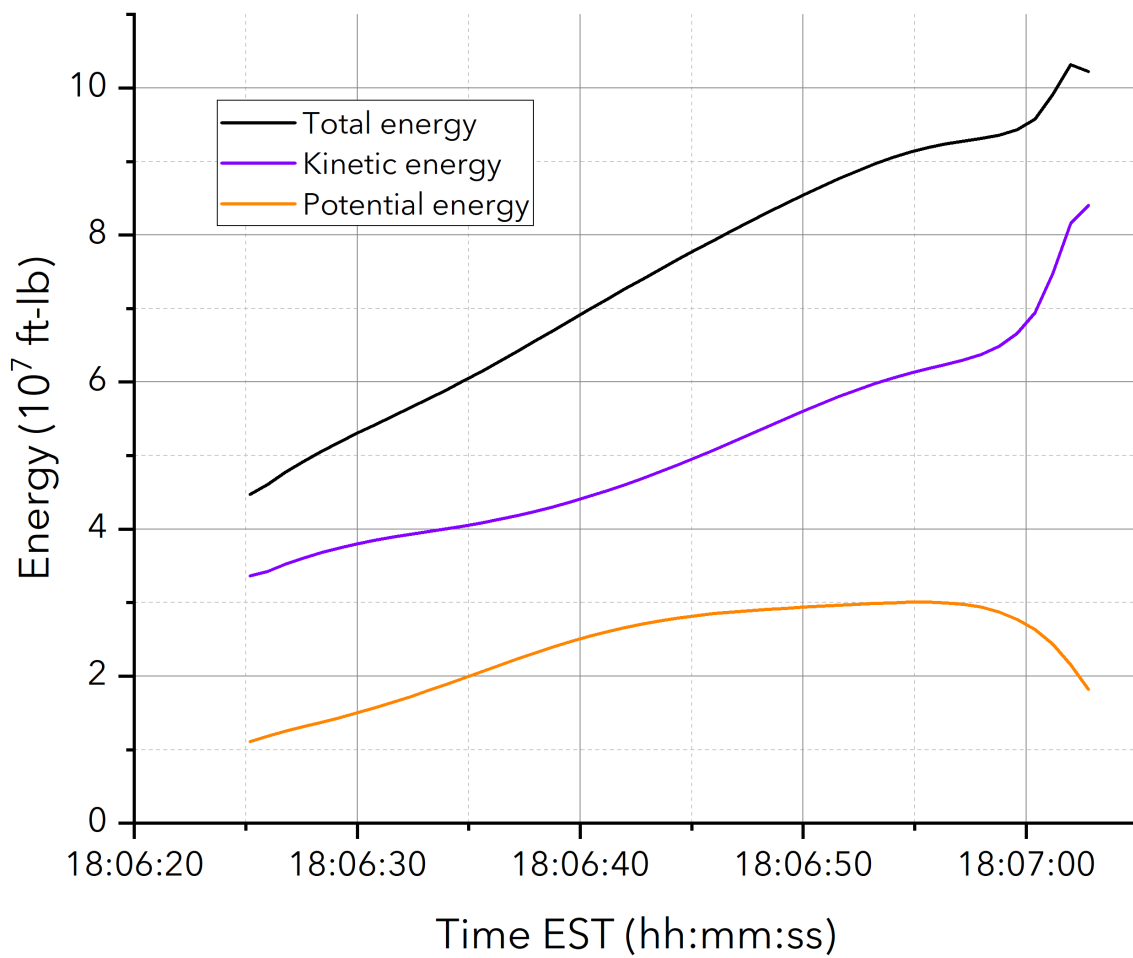


Figure 14. Potential energy, kinetic energy and total energy (the sum of potential and kinetic) during the flight.