# Gates Learjet 35A N800GP
# Vehicle Performance Study
# CEN11FA144

April 18, 2011

Marie Moler
Dennis Crider

## A. ACCIDENT: CEN11FA144

| | |
|---|---|
| Location: | Springfield, IL |
| Date: | January 6, 2011 |
| Time: | Approximately 17:00 GMT |
| Airplane: | Learjet 35A |

## B. SUMMARY

On January 6, 2011, at approximately 11:00 Central Standard Time (CST), a Learjet 35A, registration N800GP, was substantially damaged during a hard landing and runway excursion on Runway 22 (8,001 feet by 150 feet, concrete) at Abraham Lincoln Capitol Airport (SPI), Springfield, Illinois. The flight was being conducted under 14 Code of Federal Regulations Part 135 on an instrument flight rules (IFR) flight plan. Instrument meteorological conditions were encountered during the instrument landing system (ILS) approach. Visual meteorological conditions prevailed on the airport at the time of the accident. The captain sustained minor injuries. The first officer and all four passengers on-board were not injured. The flight departed Chicago Midway International Airport (MDW), Chicago, Illinois, at 10:34 CST and the intended destination was SPI.

This report details aircraft performance calculations derived from radar data obtained for the accident aircraft. Federal Aviation Administration (FAA) radar data and weather data were used to develop the time history of the accident aircraft motion described in this report. Calculations of performance parameters derived from the radar data for the final minutes of the flight are presented in this report. Pilot and co-pilot comments of interest were incorporated from the Cockpit Voice Recorder (CVR) transcript. Lift curves for the aircraft were provided by Bombardier Aerospace and used to calculate the angle of attack. Composite plots graphically show the location and orientation of the airplane when key events occurred.

## D. RADAR DATA

FAA Airport Surveillance Radars (ASRs) are short range (60 NM) radars used to provide air traffic control services in terminal areas. The ASR antenna at SPI returns radar data about every 5 seconds. The FAA records the data in the Continuous Data Recording (CDR) test format. The secondary radar returns, which contain the altitude of the aircraft in addition to its range and azimuth from the radar, from N800GP were used to analyze the performance of the aircraft.

The ASR returns record the time in Greenwich Mean Time (GMT) in hours, minutes, and seconds. The radar data records the time, azimuth, range, and altitude which were converted into latitude and longitude locations of the aircraft and easting and northing nautical miles with respect to the location of the SPI ASR as shown in Table 1 .

**Table 1. SPI ASR Radar antenna information.**

| | |
|---|---|
| Latitude | N 39º51'17" |
| Longitude | W 89º40'55" |

Uncertainty in the radar positions vary according to altitude, range, and azimuth. The transponder-reported altitude is in hundreds of feet with a resolution of ±50 ft. The slant range of the data is in nautical miles with a resolution of ± 1/16 NM or ± 380 ft. The azimuth relative to magnetic north from the radar antenna to the return is measured in Azimuth Change Pulses (ACP). ACP values range from 0 to 4096, where 0 = 0° and 4096 = 360° magnetic. Thus, the azimuth to the target in degrees would be

$$(\text{Azimuth in degrees}) = (360/4096) \times (\text{Azimuth in ACPs})$$

The nominal accuracy of this data is ± 2 ACP or ± 0.176°.

Figure 1 shows the altitude and ground track of the aircraft on a satellite image of SPI and the surrounding area. Figure 2 shows the northing and easting track in nautical miles from the ASR for the last 23 returns. The uncertainty in positions is also shown in Figure 2. The final resting point of the main aircraft wreckage is noted in both figures.

**Figure 1. Radar ground track and elevation.**

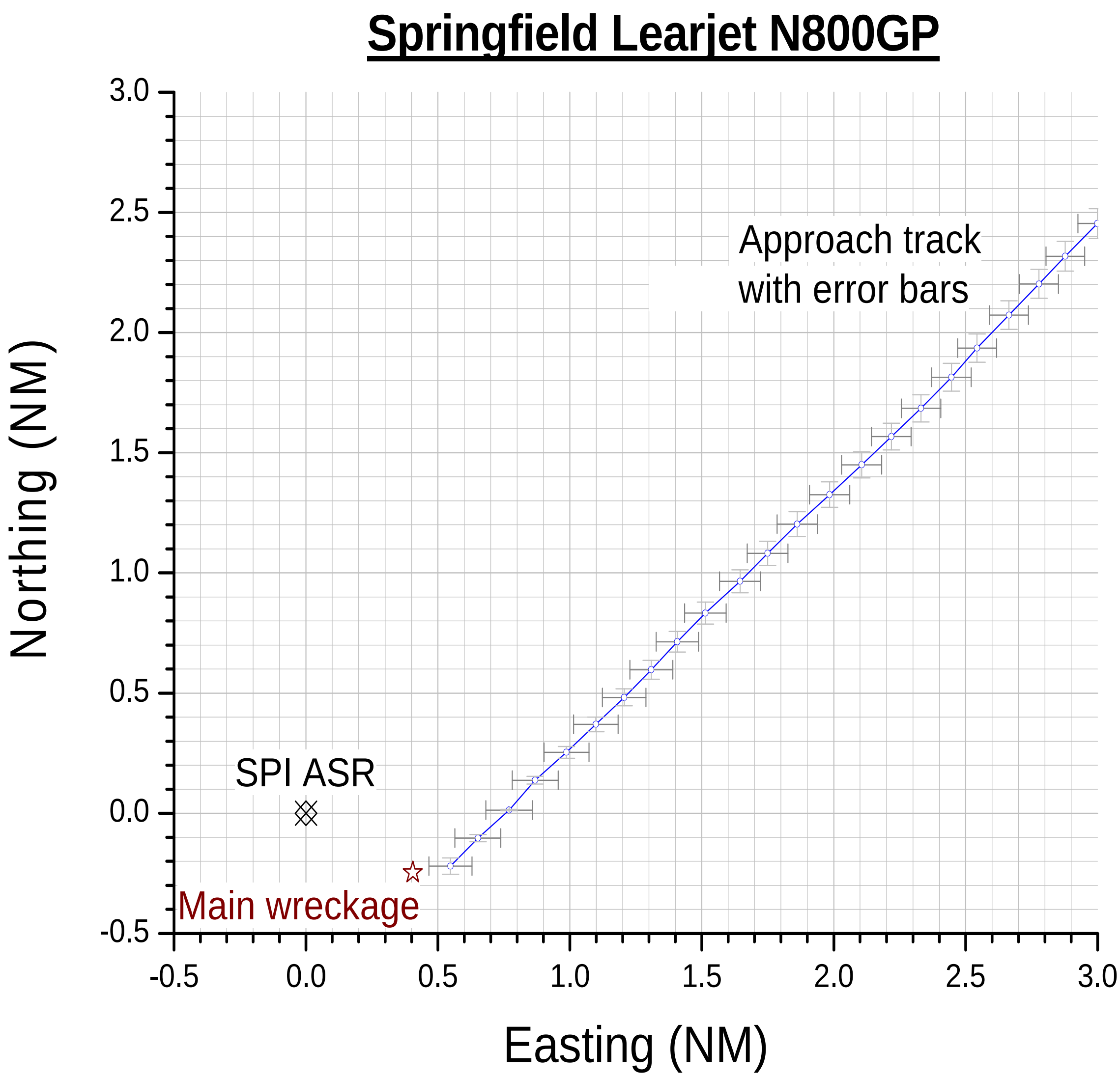


**Figure 2. Ground track with radar uncertainty.**

Figure 3 shows the northing and easting tracks individually for the last six minutes of the flight that was recorded by radar.

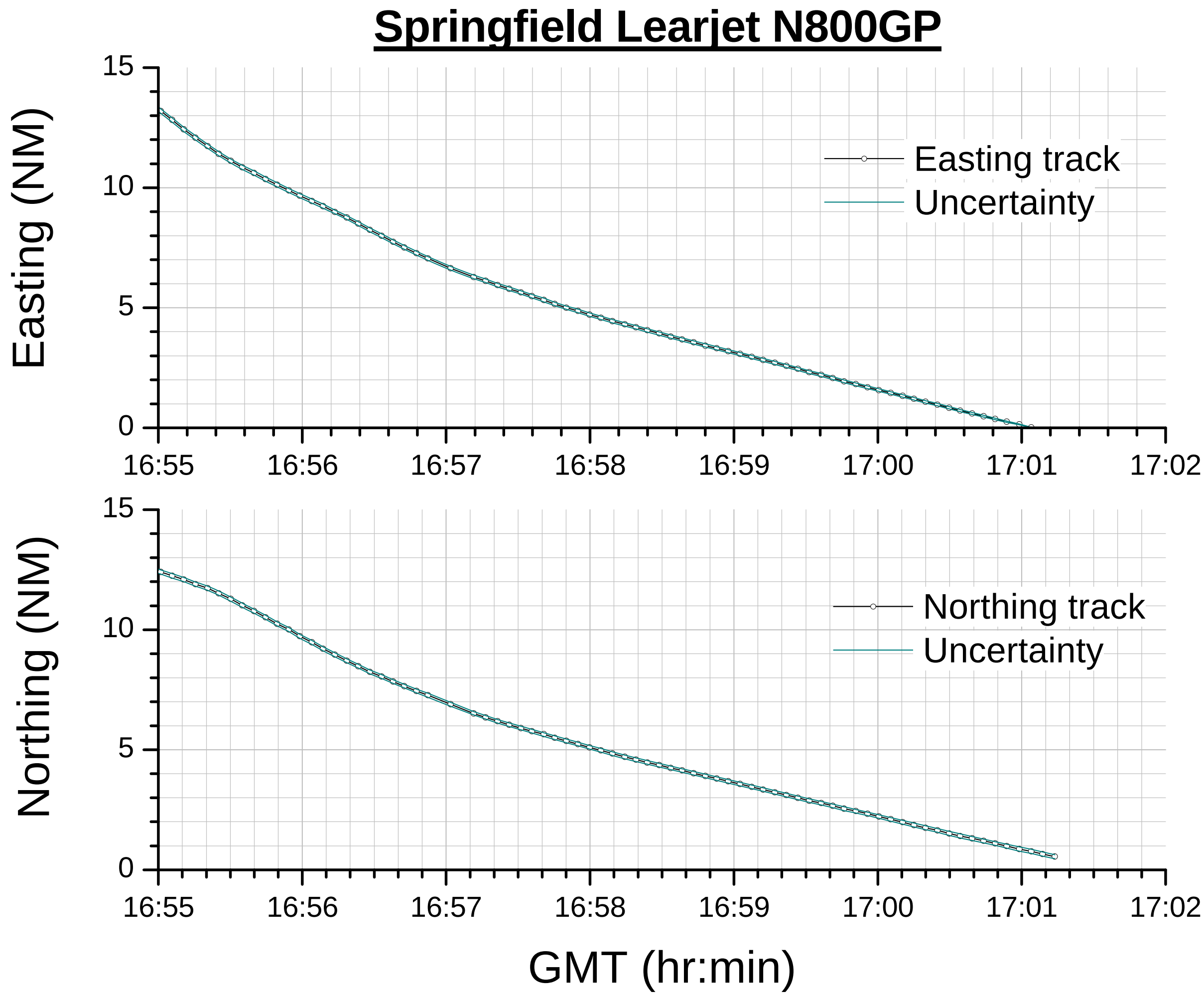


**Figure 3. Easting and northing ground track with uncertainty.**

The aircraft altitude is shown in Figure 4 and Figure 5 with respect to time and distance to runway threshold. During the final 8 NM of the approach, the aircraft's glide slope was 3.3º and its descent rate was 730 ft/min. In the raw radar data, the final return (17:01:13 GMT) shows the aircraft altitude as 100 ft above the runway (the previous return is at the runway elevation). Ground strike data indicate that the aircraft was on the ground at this point and the altitude has been changed from 698 ft to 598 ft (the SPI elevation) to reflect this. The inaccurate altitude is possibly due to an erroneous pressure reading caused by an unusual attitude of the aircraft as it impacted the ground.

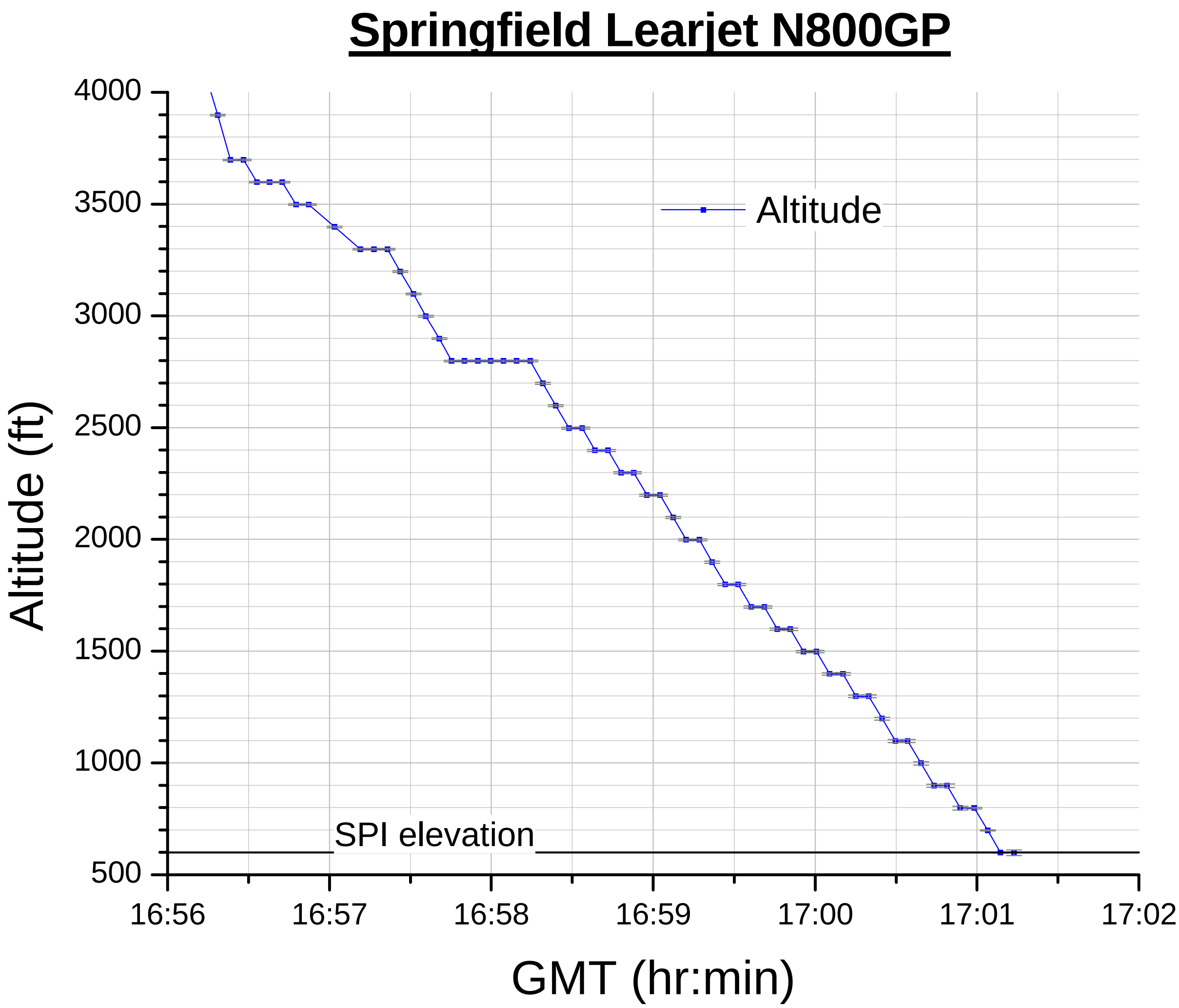


**Figure 4. Altitude versus time.**

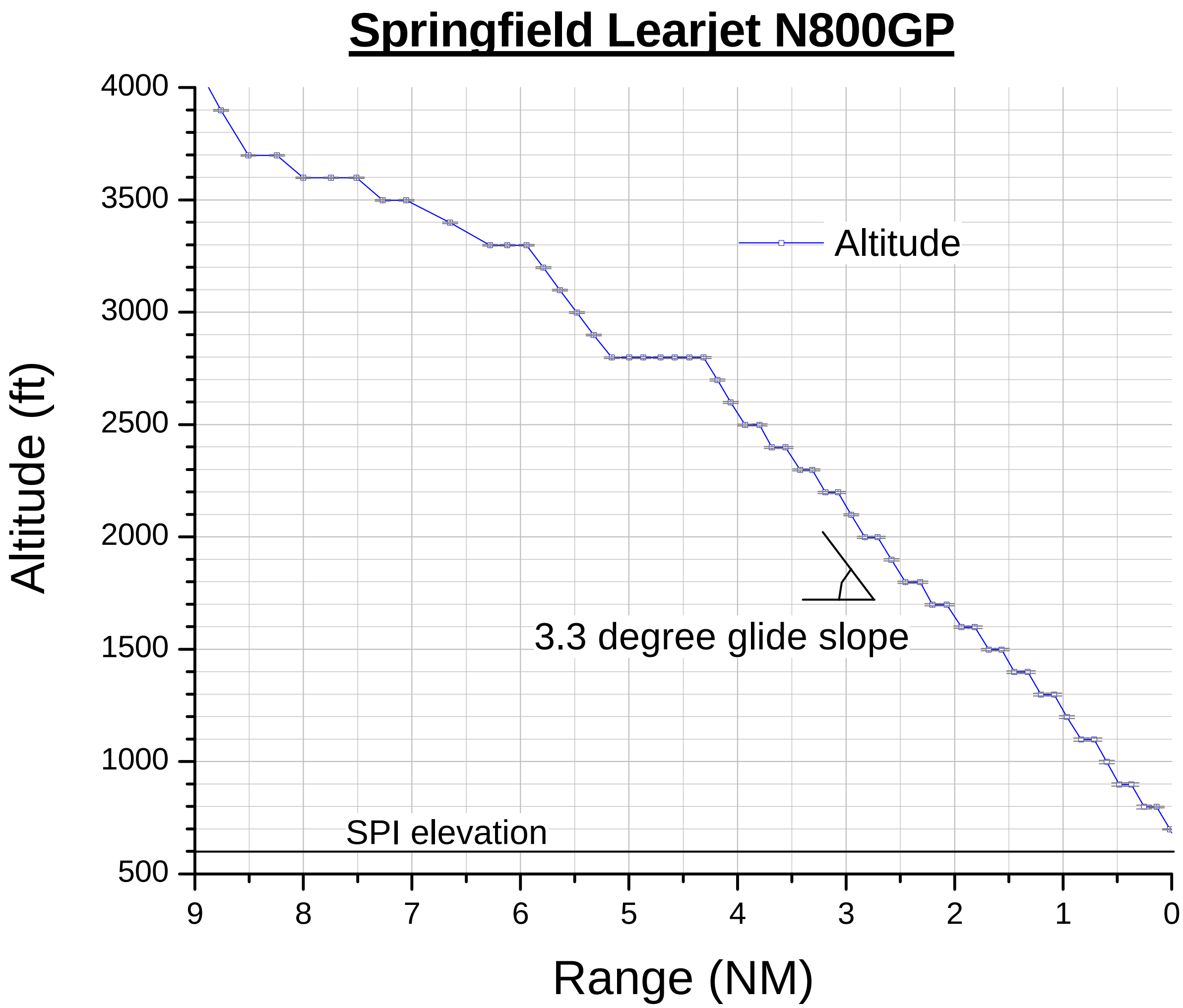


**Figure 5. Altitude and glide slope with respect to distance to runway.**

The aircraft's ground speed was calculated using the ground track and time radar data. Figure 6 shows the speed during the last 6 minutes of flight. The numerical differentiation of the raw radar returns leads to unrealistic noisiness in aircraft performance parameters so the ground speed data is smoothed using a moving average method.

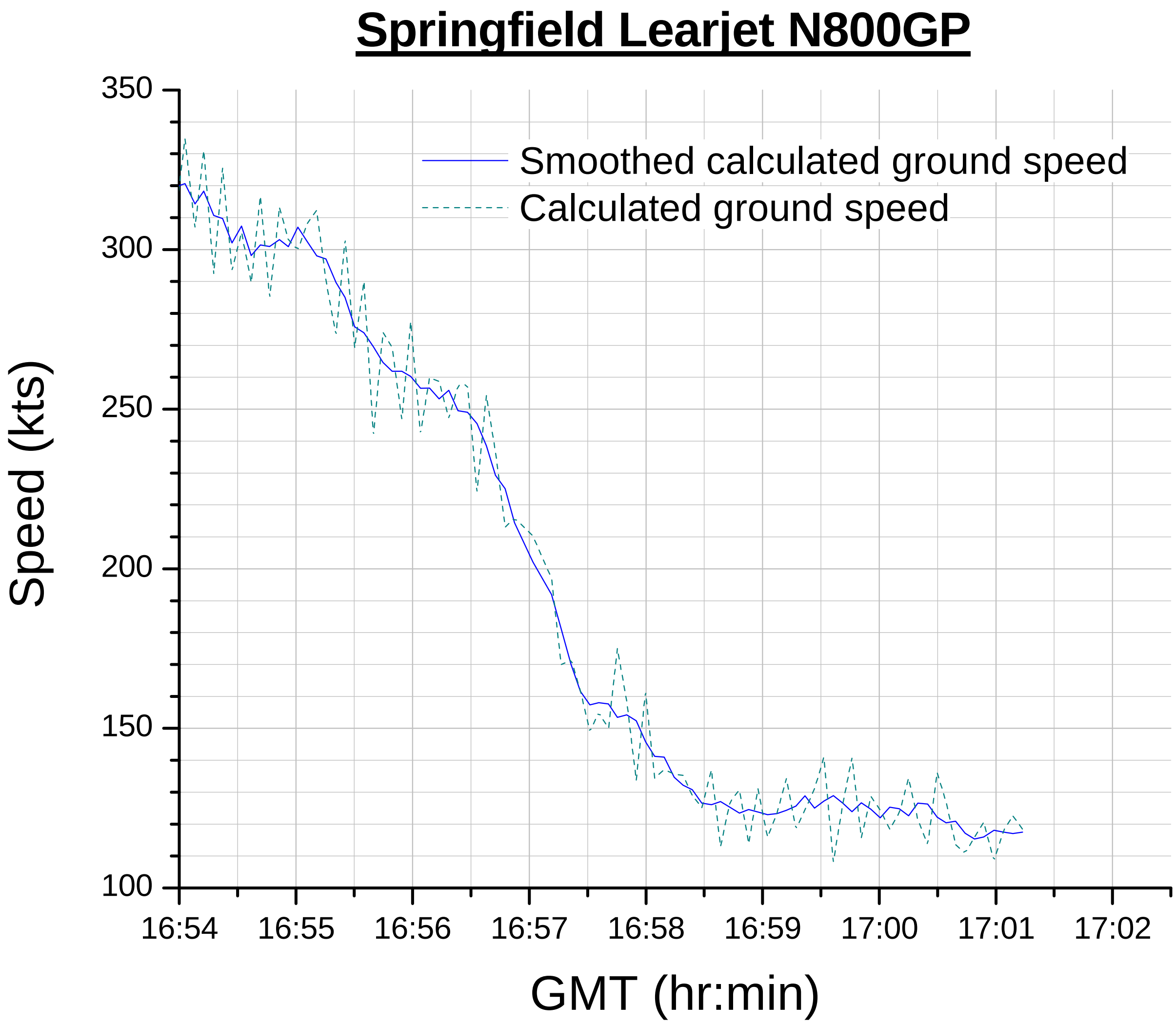


**Figure 6. Calculated approach ground speed.**

The speed for the final 30 seconds of flight was relatively stable with an average speed of approximately 116 knots. The targeted landing speed for the aircraft for the calculated landing weight was 121 knots. The expected stall speed for the aircraft was 93 knots.

## E. Weather Data

Surface winds and weather data were obtained for 17:01 GMT on the day of the accident. The ASOS two-minute average wind was recorded as 12 knots from 289º. The temperature was 29 ºF and the dewpoint was 22 ºF. The barometric pressure was 29.78 inHg. From this data the calibrated, equivalent, and true airspeeds were calculated and plotted in Figure 7.

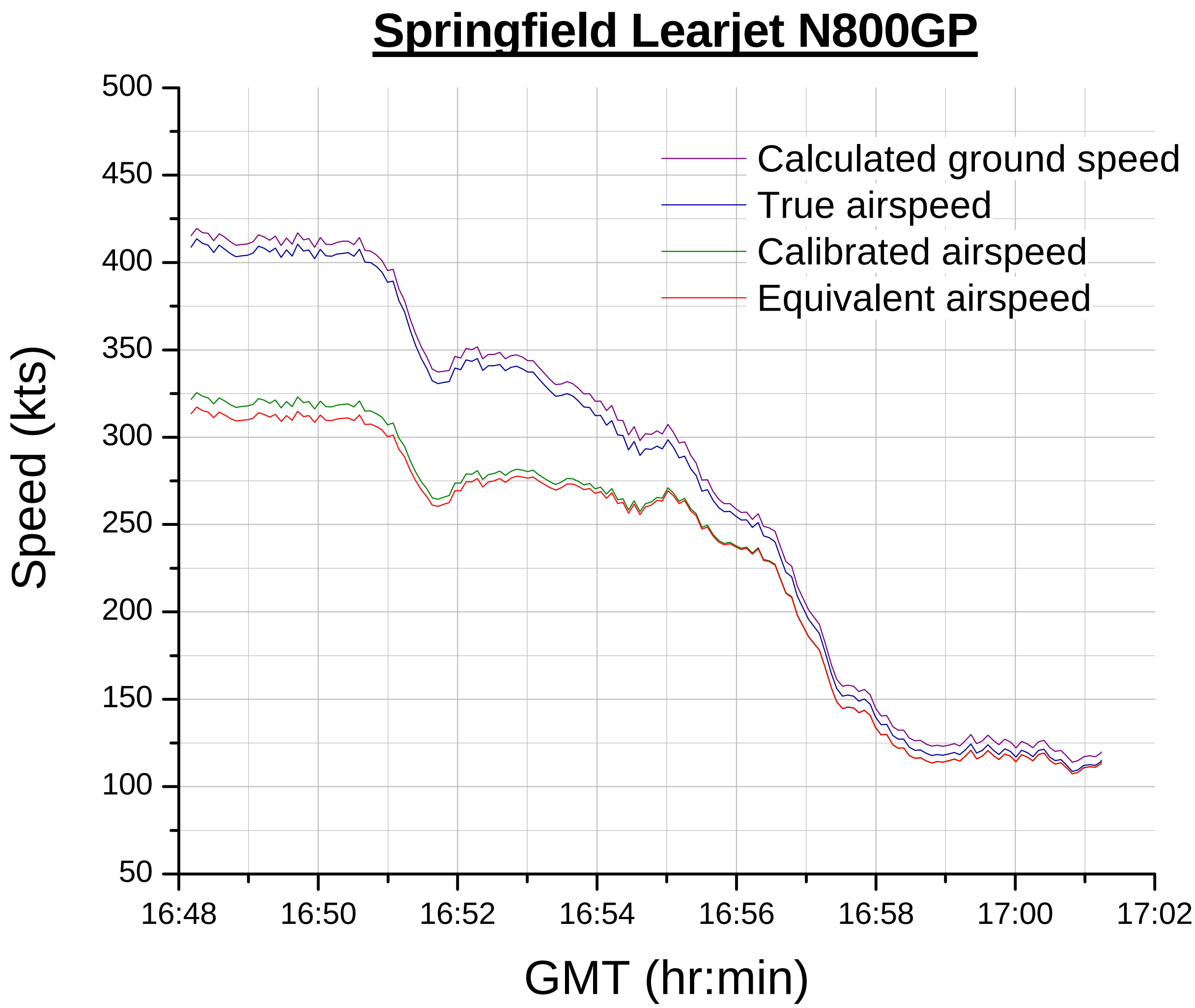


**Figure 7. Calculated air speeds.**

## F. Correlation of Radar Data and CVR Record

The CVR data was time correlated with the radar data. In interviews the crew reported that the de-icing system had been turned on during the flight, but was turned off in preparation for landing [Reference 1] and the CVR indicated that the de-icing system was turned off at 16:53:30 GMT [Reference 2]. At 16:56:48 GMT, about 4 minutes before impact, the pilot mentions a light rime ice. At 17:01:01 GMT there is an exclamation of surprise from the pilot and a series of rapid instructions is given to the co-pilot. At 17:01:05 GMT, there is a rattling noise in the cockpit indicative of the activation of the stick shaker. The final minute of the approach is shown in Figure 8 with the CVR comments. The gasp of surprise, instructions from the pilot, and stick shaker rattle all occur when the airplane was less than 200 ft (± 50 ft) above the ground.


**Figure 8. Approach with CVR recordings.**

## G. Angle of Attack Calculations

The angle of attack (AoA) of the aircraft was calculated using lift curves provided by Bombardier Aerospace for the Learjet M35A with Century III wings in a clean (no ice) configuration and compared to the stick shaker and stick pusher thresholds. When the AoA of the aircraft exceeds the stick shaker threshold, the aircraft's control yoke is noisily shaken to alert the pilot to an imminent stall situation. If the aircraft AoA continues to increase past the stick pusher threshold, the aircraft's control yoke is mechanically pushed to decrease the aircraft AoA and avoid stall. The stick shaker and stick pusher are programmed to be below the actual aircraft stall AoA in free air.

Figure 9 shows the calculated AoA of the aircraft in relation to the angle of attack thresholds for the stick shaker and the stick pusher for each flap setting. The times of changes in flap settings were determined from pilot and co-pilot callouts on the CVR.

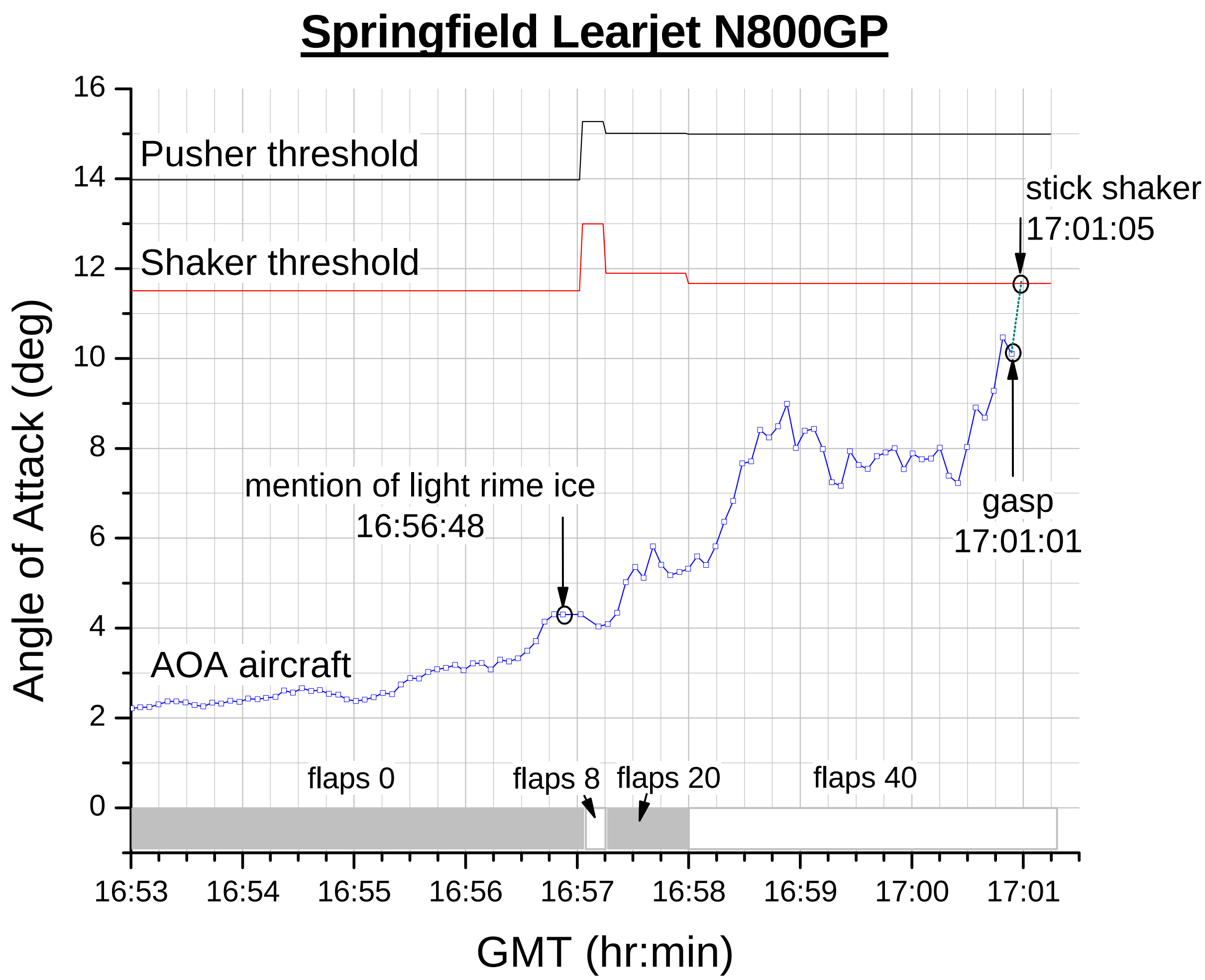


**Figure 9. Aircraft angle of attack (AoA) and shaker and pusher thresholds.**

The AoA of the aircraft increases as it nears the runway, but stays below the shaker and pusher thresholds. At 17:01:01 GMT, the CVR recorded a gasp of surprise and subsequent instructions given to the co-pilot to put the nose down and add power, which are actions consistent with stall recovery procedures. These events occurred before the stick shaker activated at 17:01:05 GMT. The subsequent activation of the stick shaker indicates that the angle of attack continued to climb after the surprised reaction of the pilots began. There is no indication the stick pusher activated.

## H. Summary

The aircraft descent and approach into SPI proceeded normally with expected course, descent rate, glide slope, and approach speed. Four minutes before landing, the development of light rime ice is noted in the CVR transcript. The CVR recorded a gasp of surprise and subsequent instructions given to the co-pilot to push the nose down and add power, which are actions consistent with stall recovery procedures. Angle of attack calculations from radar show that these actions were taken below the stick shaker threshold angle of attack and the stick shaker did activate after the described events. A buildup of ice on the wings will reduce the stall angle of attack so that the aircraft can experience an aerodynamic stall before the stick shaker activates.

Marie C. Moler
Mechanical Engineer
Vehicle Performance Division

## I. References

1. Conversation Record: First Officer, CEN11FA144, National Transportation Safety Board, January 14, 2011.
2. Cockpit Voice Recorder – Factual Report of the Group Chairman, CEN11FA144, National Transportation Safety Board.