National Transportation Safety Board

Office of Research and Engineering
Washington, D.C. 20594

Airplane Performance Study

Specialist Report
Timothy Burtch

A. ACCIDENT

Location:	Duluth, MN
Date:	June 7, 2014
Time:	1121 CDT
Airplane:	Lancair IV, Registration N86NW
NTSB Number:	CEN14FA278

B. GROUP

Chairman: Timothy Burtch
Airplane Performance
National Transportation Safety Board

Member: Robert DuRall
Senior Manager, Product Support
GENESYS Aerosystems

Member: Jose (Tony) Rios
Director of Engineering, Systems
MEMSIC, Inc.

C. SUMMARY

On June 7, 2014, about 1121 central daylight time (CDT), an experimental, amateur-built, Lancair IV, N86NW[1], was destroyed when it impacted Lake Superior after departing from the Duluth International Airport (KDLH), Duluth, Minnesota. The pilot, the sole occupant, received fatal injuries. The airplane was registered to A.O. Engineering Inc. and was being operated by the pilot under 14 Code of Federal Regulations Part 91 as a personal flight. Marginal visual meteorological conditions (VMC) prevailed at the time of the accident, and an instrument flight rules (IFR) flight plan had been filed. The airplane departed KDLH about 1116 CDT, and was en route to Goose Bay (CYYR), Newfoundland, Canada. See Figure 3. (Note that the weather in Figure 3 is not representative of that for the accident.)

The airplane departed KDLH on runway 9 and was cleared direct to Thunder Bay (CYQT) on a northeasterly heading during the initial climb. The airplane climbed to approximately 6,600 feet above mean sea level (msl) and appeared to be turning to the right on a more southeasterly course. Air traffic control (ATC) cleared the flight direct to CYQT two more times. The airplane continued to descend and radar contact was lost about 7 nautical miles (NM) east of KDLH. The airplane impacted Lake Superior about 9 NM east of KDLH. The flight lasted approximately five minutes.

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[1] See Figures 1 and 2 for pictures of the accident airplane. The accident pilot did not build the experimental, amateur-built, airplane but had recently purchased it.

D. PERFORMANCE STUDY

The performance study describes the accident airplane ground track, altitude, and speed, as well as the timing of select radio communication between ATC and N86NW. Estimates of airplane pitch, roll, and heading derived from radar as well as airplane and engine data recovered from the wreckage are presented.

The radar data used in the study are secondary returns (transponder code 2621) from the short-range Airport Surveillance Radar (ASR-8) located at KDLH. The radar data have approximately a 60 NM range and an inherent uncertainty of ±2 Azimuth Change Pulses (ACP) = ± (2 ACP) x (360º/4096 ACP) = ±0.176° in azimuth, ±50 ft in altitude, and ±1/16 NM in range.

The recovered data include various airplane and engine parameters from two Chelton Integrated Display Units (IDU) that sustained minor impact and water damage. The units are typically installed in pairs providing both primary flight display (PFD) and multifunction display (MFD) capabilities.

These particular units (IUA0A.1/P-S1 and IUA1A.1/P-S1) recorded data on internal Personal Computer Memory Card International Association cards (PCMCIA) at the rate of one sample per second.

See the Electronic Devices Specialist's Factual Report for a complete list of recorded parameters on the Chelton IDUs and other recovered devices.

Finally, times in the study are reported in CDT as well as Greenwich Mean Time (GMT or "Z" time): CDT = GMT – 5 hr.

Weather Observation

The Automated Surface Observing System (ASOS) report at KDLH around the time of the accident is as follows:

Accident at 1621Z/1121 CDT

KDLH 071622Z 14009KT 10SM SCT003 BKN010 OVC027 11/10 A3006 RMK AO2 CIG 007V011

KDLH weather on the 7th at 1622 GMT / 1122 CDT (one minute after the accident), the wind is 140˚ at 9 knots (kt); visibility 10 statute miles; scattered clouds at 300 feet (ft) above ground level (agl), a broken ceiling at 1,000 ft agl, overcast at 2,700 ft agl; temperature 11° Celsius (C), dew point 10° C; altimeter setting 30.06 inches of mercury. Remarks: station is automated with a precipitation sensor, and the ceiling is variable between 700 ft and 1,100 ft agl.

In addition, the Meteorological Factual indicates that, given the back wind environment in the area, there was no wind above 20 knots below 15,000 to 20,000 ft msl. Balloon soundings, weather radar velocity data, and pilot reports (PIREPs) in the area at the time of the accident indicate that winds were calm to 4 kt from the northwest at 7,000 feet msl.

The cloud tops were reported at approximately 32,000 ft.

See the Meteorological Factual report for more detailed weather.

Airplane Performance Based on Radar

Figures 4 and 5 highlight the radar ground track for N86NW as the airplane departed Duluth International airport. Each radar point in the figures has an associated GMT time, altitude above mean sea level ± 50 ft, and a calculated calibrated airspeed in knots (in blue)[2]. Figure 6 shows the airport diagram for Duluth International including the departure runway 9.

Figure 7 shows the radar points[3] as well as select radio communications between N86NW and the Duluth control tower and departure control. Duluth departure control repeated N86NW's assigned heading (zero three zero/direct CYQT) twice in the short five minute accident flight. This is consistent with the secondary radar returns in Figure 7 that show the airplane repeatedly turning to the southeast instead of the assigned northeast heading.

Figures 8 through 11 highlight other radar data and flight parameters that were estimated from radar assuming that the airplane was in coordinated flight with little or no sideslip.[4]

Recovered Chelton IDU Parameters

Figures 12 through 14 include engine and wind parameters recovered from the Chelton IDU. Figures 12 and 13 indicate that the engine was operating at or near 90% N1 with torque between 40% and 70% until just before the final descent into Lake Superior. There was a momentary reduction in N1, torque, and fuel flow at about 16:17:46 where the airplane leveled off at approximately 4,600 ft msl before continuing to climb to 6,600 ft msl.

Figure 14 highlights the groundspeed, wind speed, and wind direction recorded in the Chelton log files during the climb. Wind speed on the climb to 6,600 ft msl varied between 5 kt and 88 kt. Wind direction in the log varied counterclockwise from 360˚ to 203˚ and then back (clockwise) to 338˚. It then continued clockwise from 338˚ to 247˚when the data ended. This represents over a 360˚ change in wind direction (i.e., 203˚ clockwise to 247˚) in less than three minutes.

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[2] Airspeed was calculated using the radar-derived groundspeed and the ASOS winds of 140˚ at 9 kt.
[3] The radar "points" are actually red boxes in the figure because of the inherent radar uncertainty mentioned earlier.
[4] Visual "playback" of the Chelton log files indicate that the airplane was flying with a crab angle in excess of 10˚. While crab is not sideslip, they are typically close with little crosswind. This would make the assumption about little or no sideslip invalid. However, the Meteorological Factual report indicates that there were only light winds below 15,000 ft msl at the time of the accident. It is believed that the actual winds were light and that the log winds are incorrect. This will be discussed in more detail later in the study.

Comparison of Radar and Chelton IDU Parameters

Figures 15 through 17 reproduce some of the earlier radar plots but with the recovered Chelton log data overlaid for comparison. Figure 15 shows a relatively good match between the recorded altitude, rate of climb, and airspeed with the equivalent parameters derived from KDLH radar data. However, there are two windows approximately 30 sec in length (the first centered around 16:17:40 and the second at16:19:50, both highlighted in purple in the figure) where the radar-derived airspeed exceeds the airspeed recorded in the log file by 10 kt to 20 kt.

Figures 16 and17 highlight the differences between the radar-derived Euler angles and those recorded in the log file. These figures also include timing of select radio communication between ATC and N86NW. As previously mentioned with Figure 7, Duluth departure control repeatedly reminded N86NW of its assigned heading (030˚) to Thunder Bay.

The two windows described above for airspeed in Figure 15 also apply to bank angle in Figures 16 and 17 and are also highlighted in blue. While the timing is similar, the magnitude of the differences is different. The radar-derived bank angle exceeds the bank recorded in the log file by as much as 25˚ (i.e., more right-wing-down). Figure 17 breaks out bank angle for more clarity.

The other notable difference in the comparison is between the heading derived from radar and that recorded in the log file (shown in orange in Figure 16). For nearly two minutes, early in the flight, the log file heading is 20˚ to 25˚ more airplane-nose-left than that estimated from radar. (This could account for the 30 kt to 50 kt wind from the north recorded in the log file and shown in Figure 14.) From 16:19:20 until the end of the data the log file heading is upwards of 45˚ more airplane-nose-right than that estimated from radar. (This could account for the 88 kt wind from the southwest recorded in the log file and shown in Figure 14.)

Finally, there appears to be an anomaly between the recorded log file bank angle and the recorded heading shown in Figure 16. During the first 30 sec window centered at 16:17:40, the log data show little or no bank while the heading shows the airplane turning to the south/right[5]. The anomaly is highlighted in green in the figure.

E. SUMMARY AND CONCLUSIONS

A comparison between radar-derived and recovered Chelton log file data indicate an apparent discrepancy in airspeed, bank angle, and heading. In addition, the log file wind data computed using magnetometer heading and GPS ground track are not supported by other available data. While the integrity of the magnetometer heading is suspect, the exact source of the discrepancy could not be determined, e.g., bad magnetometer calibration, ferrous payload, etc. The log data are the same data displayed to the pilot on the PFD.

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[5] The discrepancy between bank angle and heading was clear during the log file playback on the GENESYS Aerosystems Chelton desktop PFD simulation.

The discrepancies found in the comparison could explain the circumstances surrounding the accident[6]. The flight lasted approximately five minutes with the airplane impacting Lake Superior about nine nautical miles east of the departure airport. The pilot was apologetic with ATC as he appeared to struggle with his assigned northeasterly heading and repeatedly turned to the southeast. It is possible that the pilot was not seeing accurate information on the PFD that would be necessary to both control and navigate effectively, more so in marginal VMC or IMC like the conditions that existed at the time of the accident.

While the accident pilot had over 2,500 hr total time, he had only about 22 hr in the experimental, amateur-built, Lancair IV pressurized turbine. In addition, the pilot installed a fuel bladder in the back seat to accommodate the long overseas flight. As a result of the extra fuel and other baggage, it is suspected that the airplane maximum gross weight was exceeded by about 500 lb. The center of gravity (CG) was also likely near or even beyond its aft limit[7]. Consequently, this would have reduced N86NW's longitudinal stability beyond the levels documented by the CAFE Foundation for the Lancair IV-P[8].

Timothy Burtch
Specialist – Airplane Performance
National Transportation Safety Board

[6] The Chelton log data and radar data for N86NW appear more like a "controlled" spiral than a stall/spin in the final 30 sec. The estimated angle-of-attack remained less than approximately 9˚ throughout the flight while the airspeed was always greater than approximately 110 kt until just before the final descent into the lake.

[7] The Pilot's Operating Handbook for the Lancair IV states that the allowable CG range is from 8% mean aerodynamic cord (MAC) to 27.5% MAC. It also states that the aft CG limit "must be considered a firm limit" and that "loads which place the CG aft are dangerous and must not be accepted".

[8] The stick force required to change airspeed from a given trim speed is used as a measure of longitudinal static stability. The larger the gradient, the greater the longitudinal stability. A constant gradient without stick force lightening is preferred. A stick reverse reversal is undesirable. Longitudinal static stability for the Lancair IV-P is documented in "CAFE Aircraft Performance Report, Lancair IV-P", EAA Sport Aviation, January 2001, p. 44. The report states that "during the aft center of gravity measurements there was a considerable reduction of the stick force required to maintain level flight, even though only at 84% aft within the allowable limits". The pilot testing the airplane declined to attempt stall tests with an aft center of gravity. Note that the CAFE Foundation is a U.S. non-profit aviation development and flight test organization based in Windsor, California. CAFE is an acronym for "Comparative Aircraft Flight Efficiency."

F. Figures

Figure 1: Accident Airplane N86NW, an Experimental Lancair IV

Figure 2: N86NW, Airworthiness Certificate Issued 12/16/2013

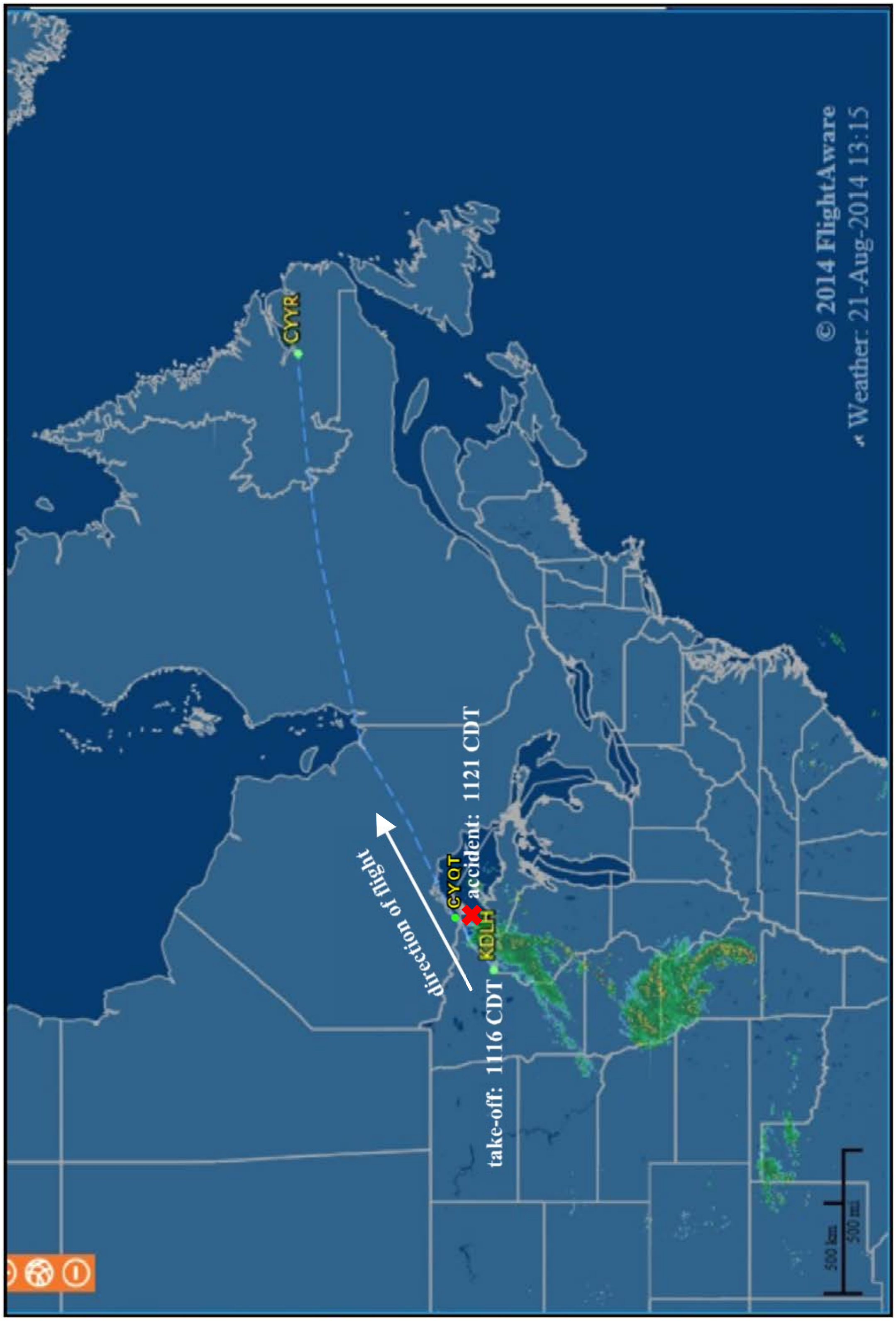

Figure 3: Accident Flight Plan (note: weather not representative of the accident)

Figure 4: Radar Ground Track with hh:mm:ss (GMT) / hmsl (ft) / Vc (kt)

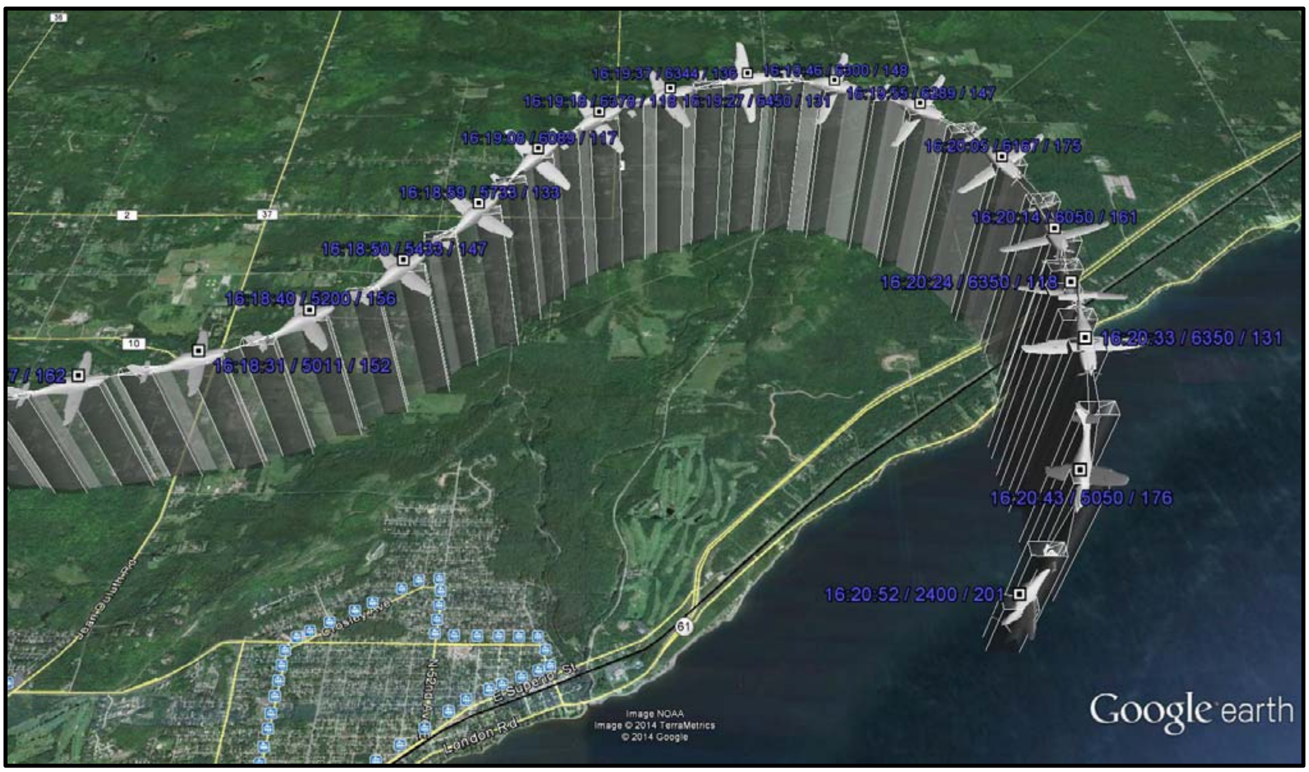

Figure 5: Impact Sequence with hh:mm:ss (GMT) / hmsl (ft) / Vc (kt)

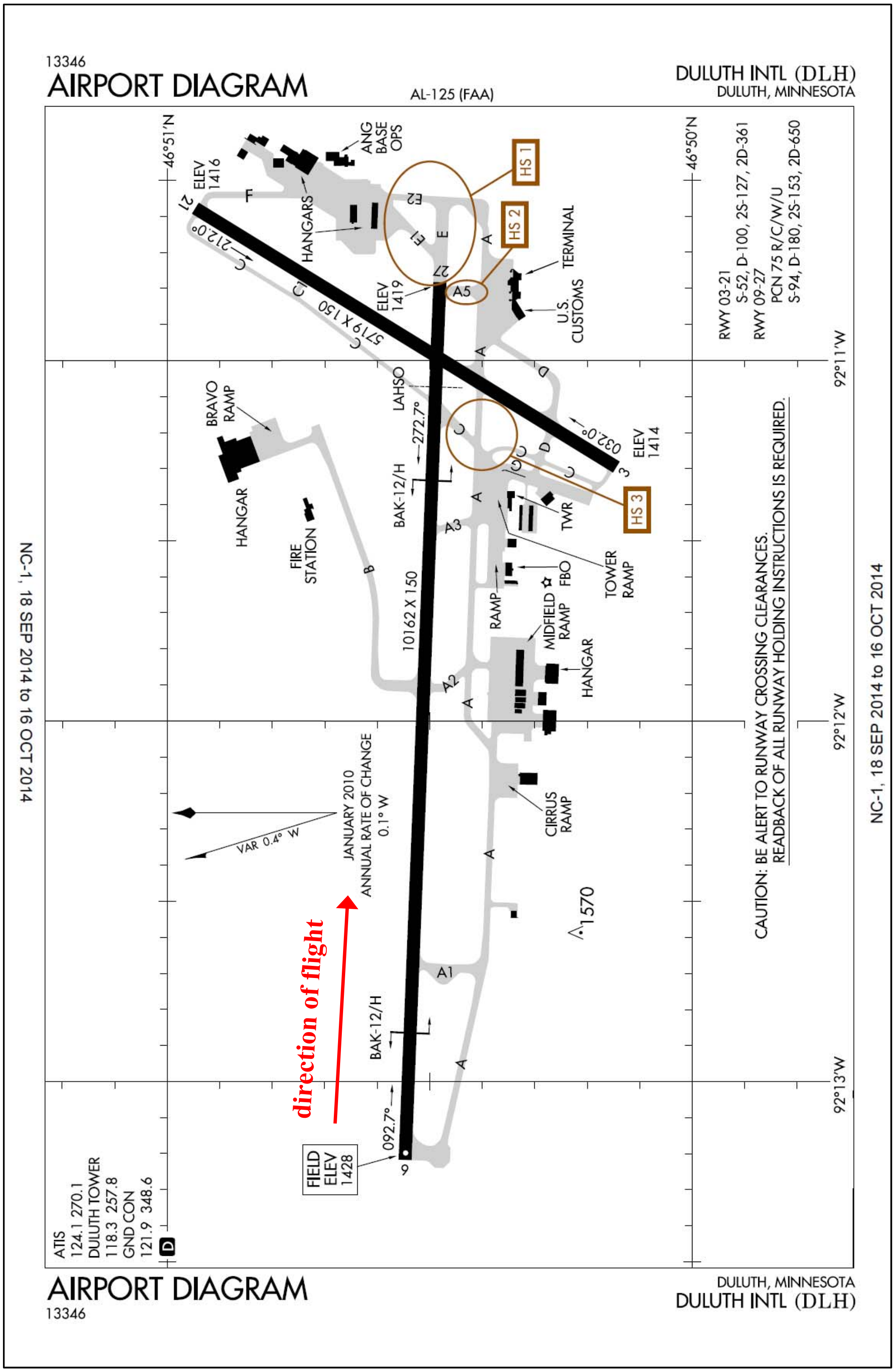

Figure 6: Duluth International Airport Diagram

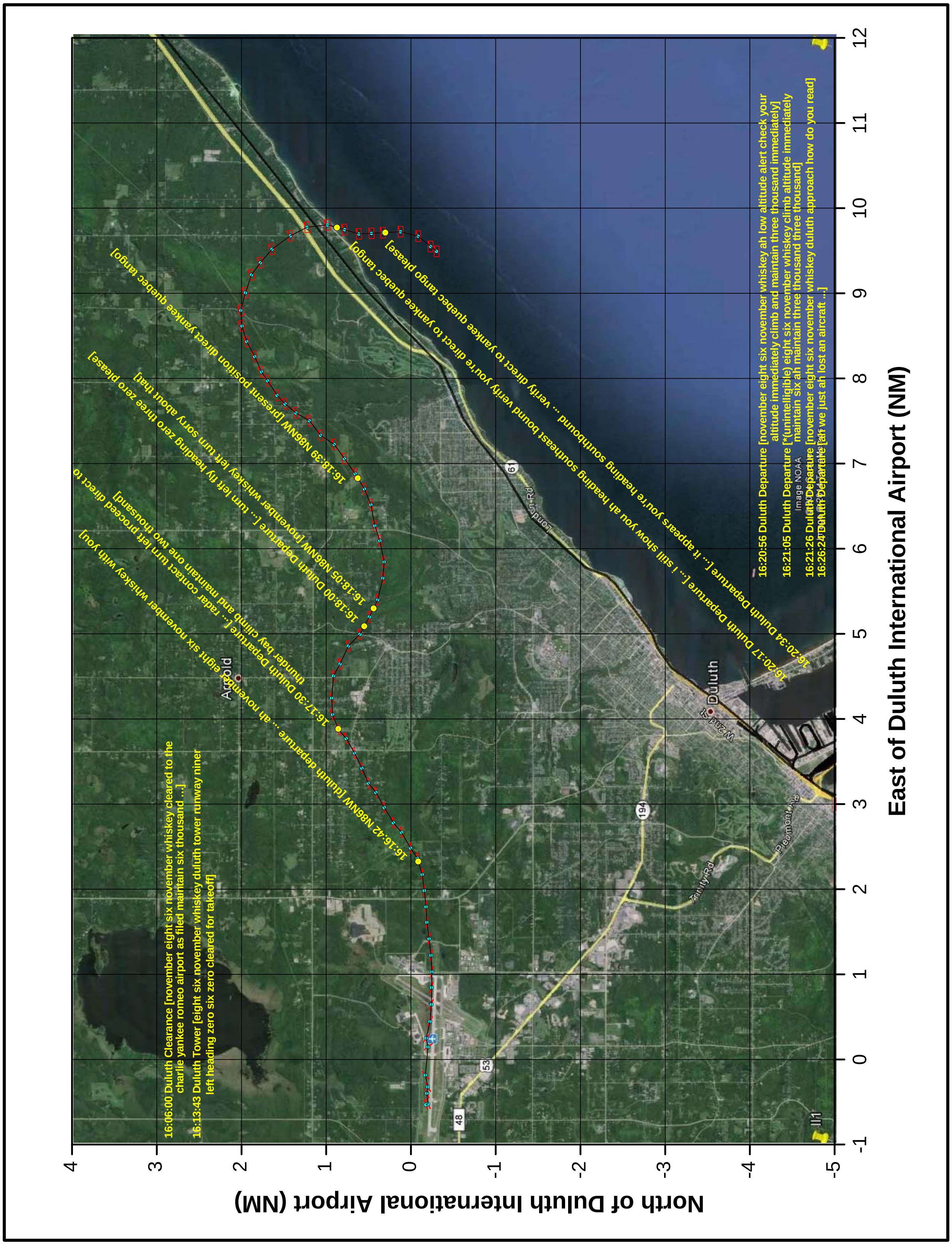

Figure 7: Radar Track from Duluth International Airport (KDLH ASR-8 Radar) with Select ATC Communications

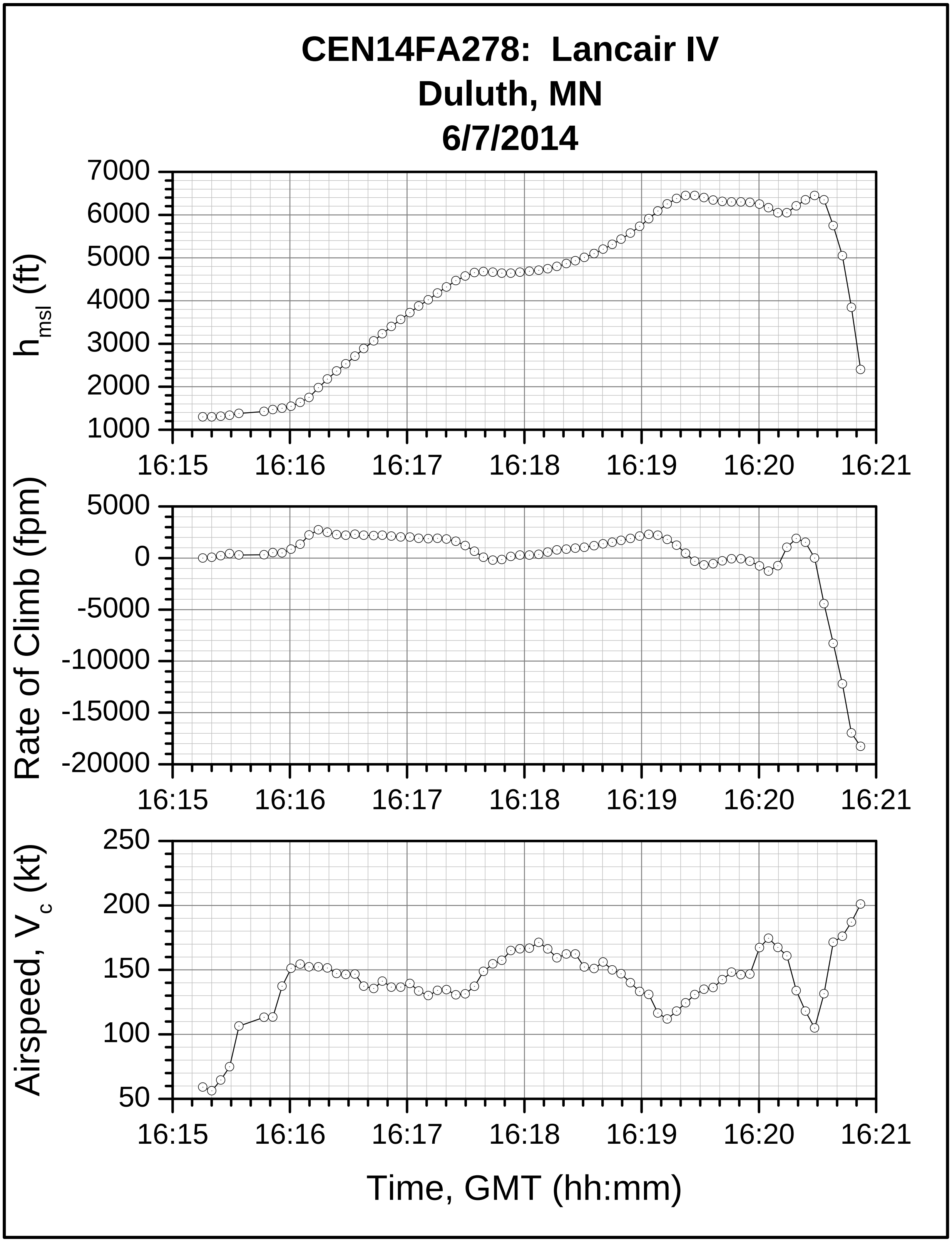

Figure 8: Altitude and Speed Based on Radar

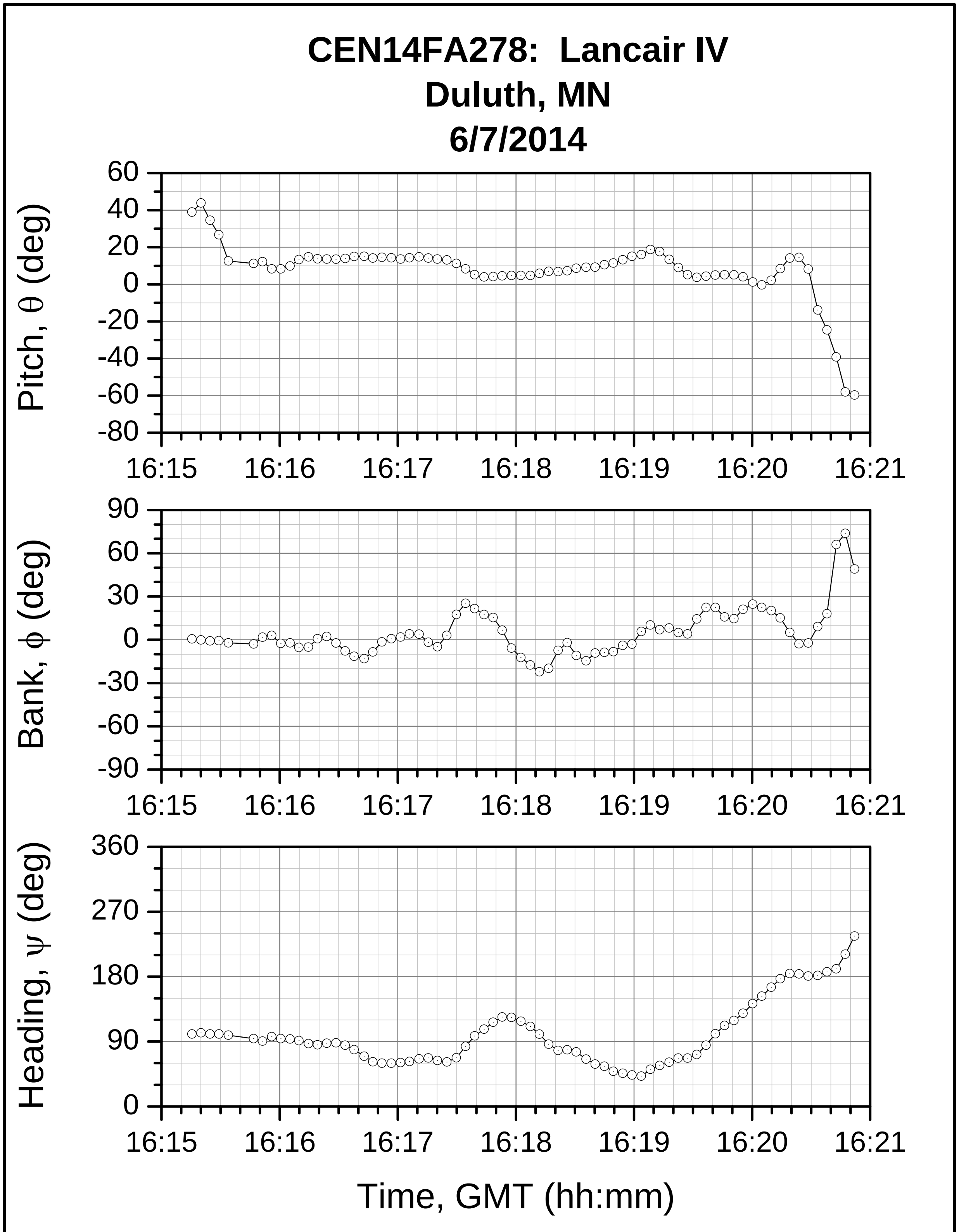

Figure 9: Pitch, Bank, and Heading Based on Radar

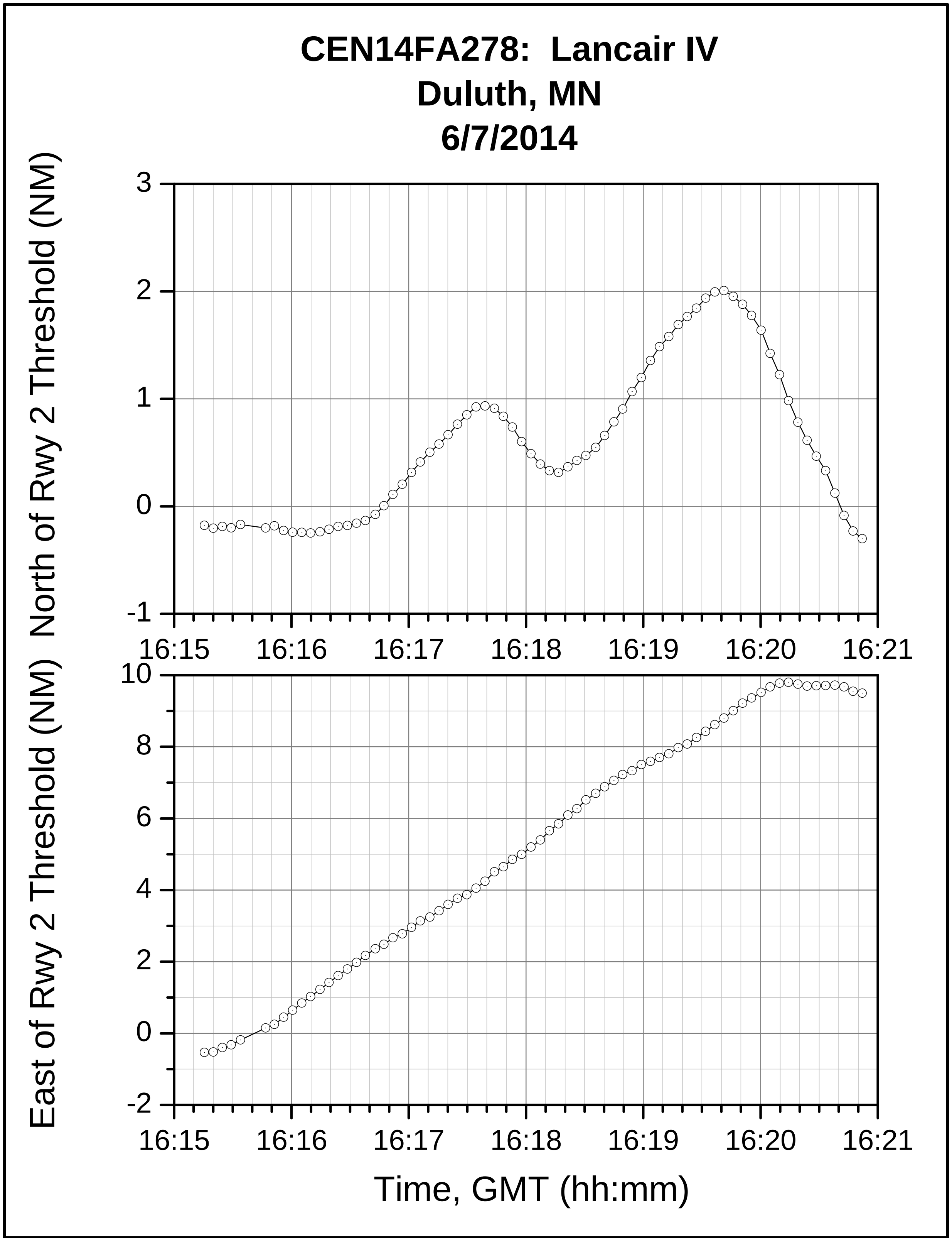

Figure 10: Position North and East of KDLH Based on Radar

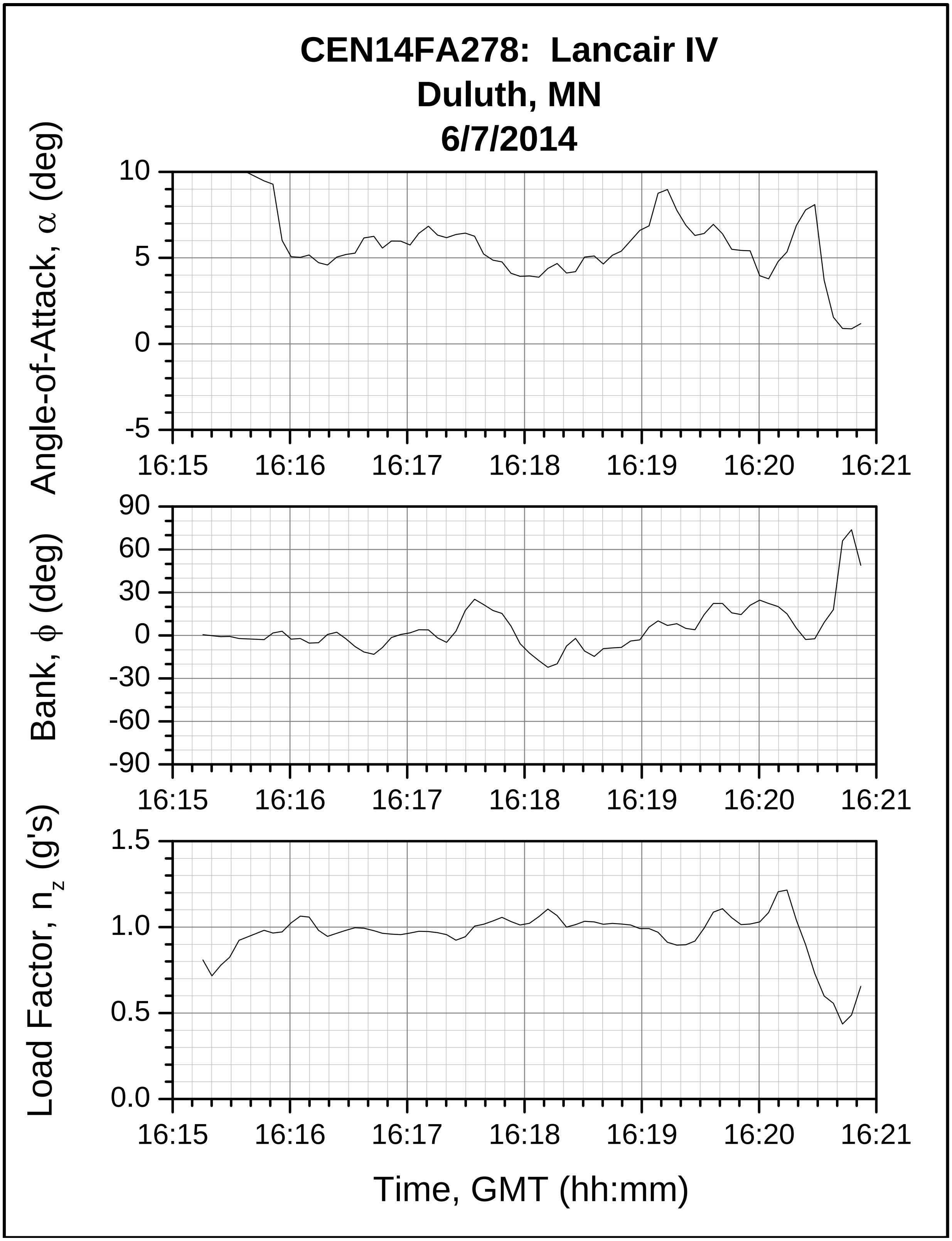

Figure 11: Estimated Angle-of-Attack and Load Factor Based on Radar

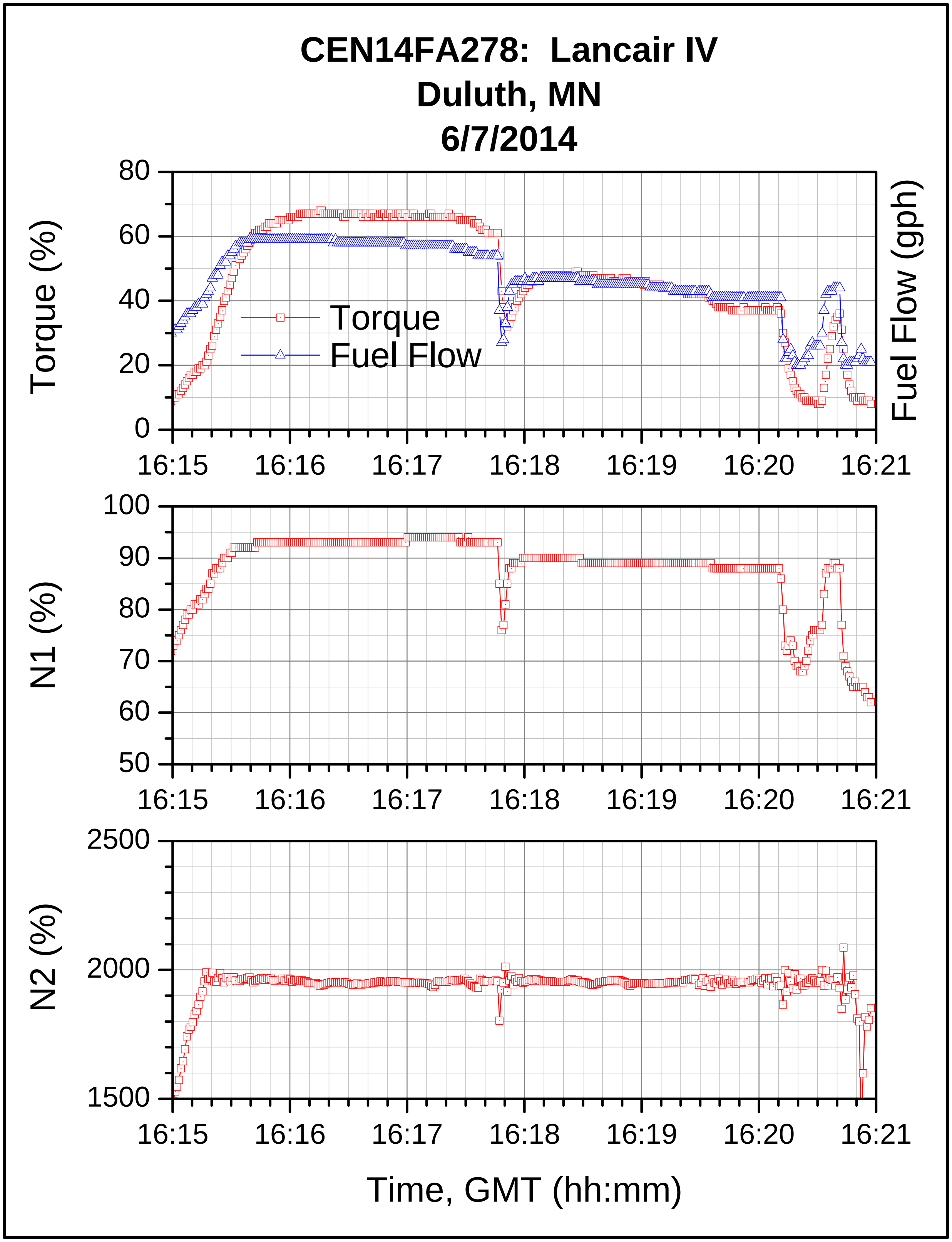

Figure 12: Engine Parameters Based on Chelton IDU

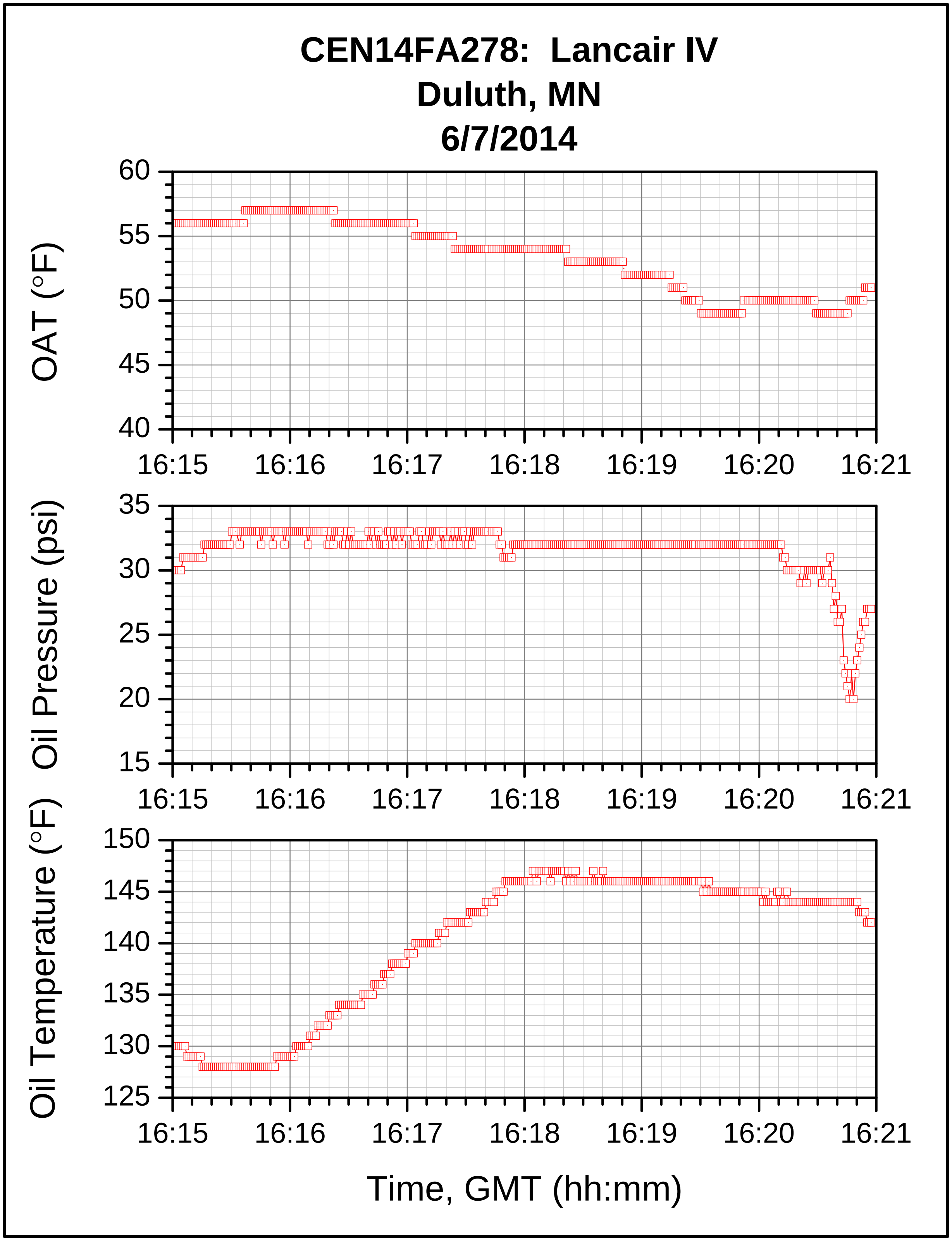

Figure 13: Temperatures and Pressure Based on Chelton IDU

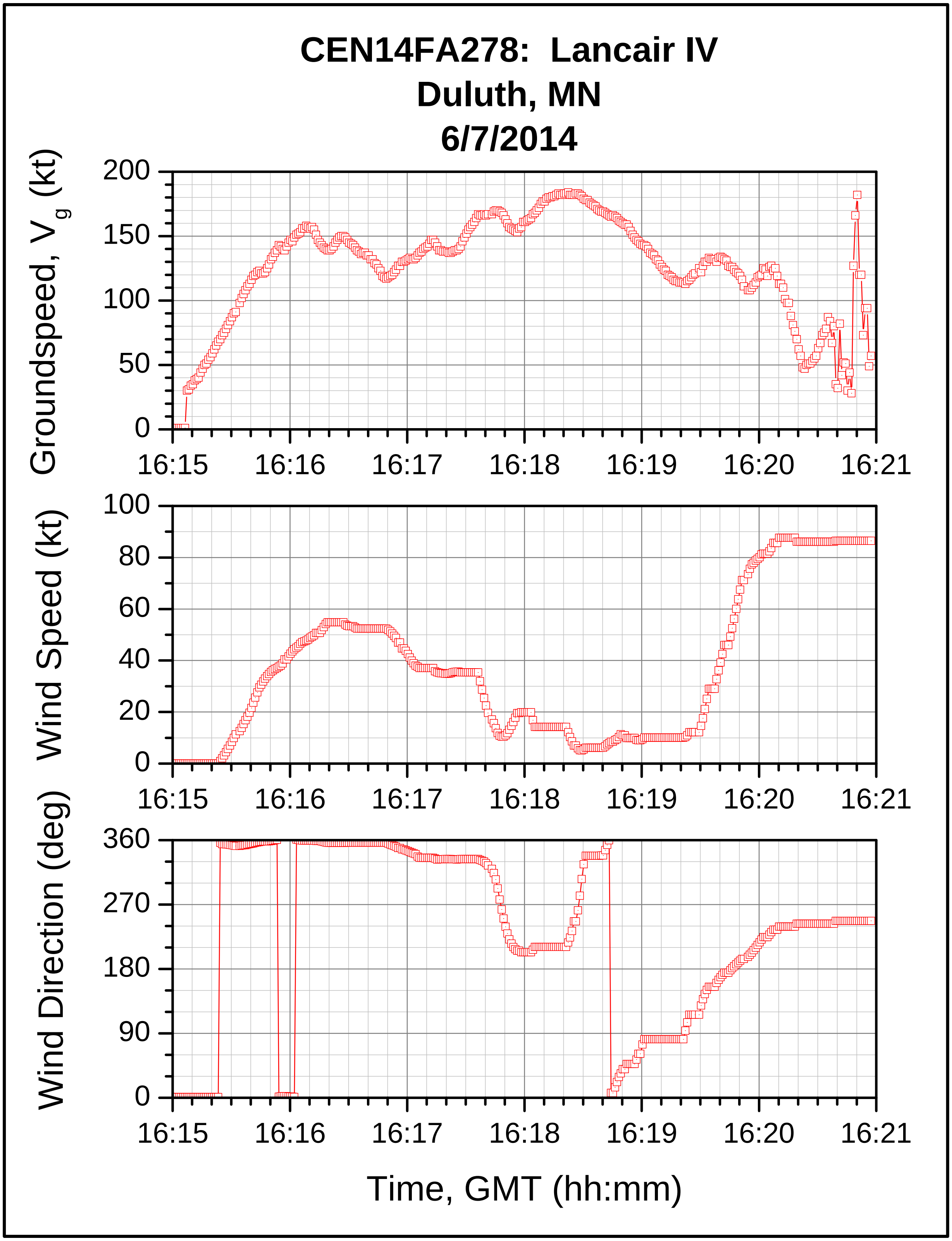

Figure 14: Groundspeed, Wind Speed and Wind Direction Based on Chelton IDU

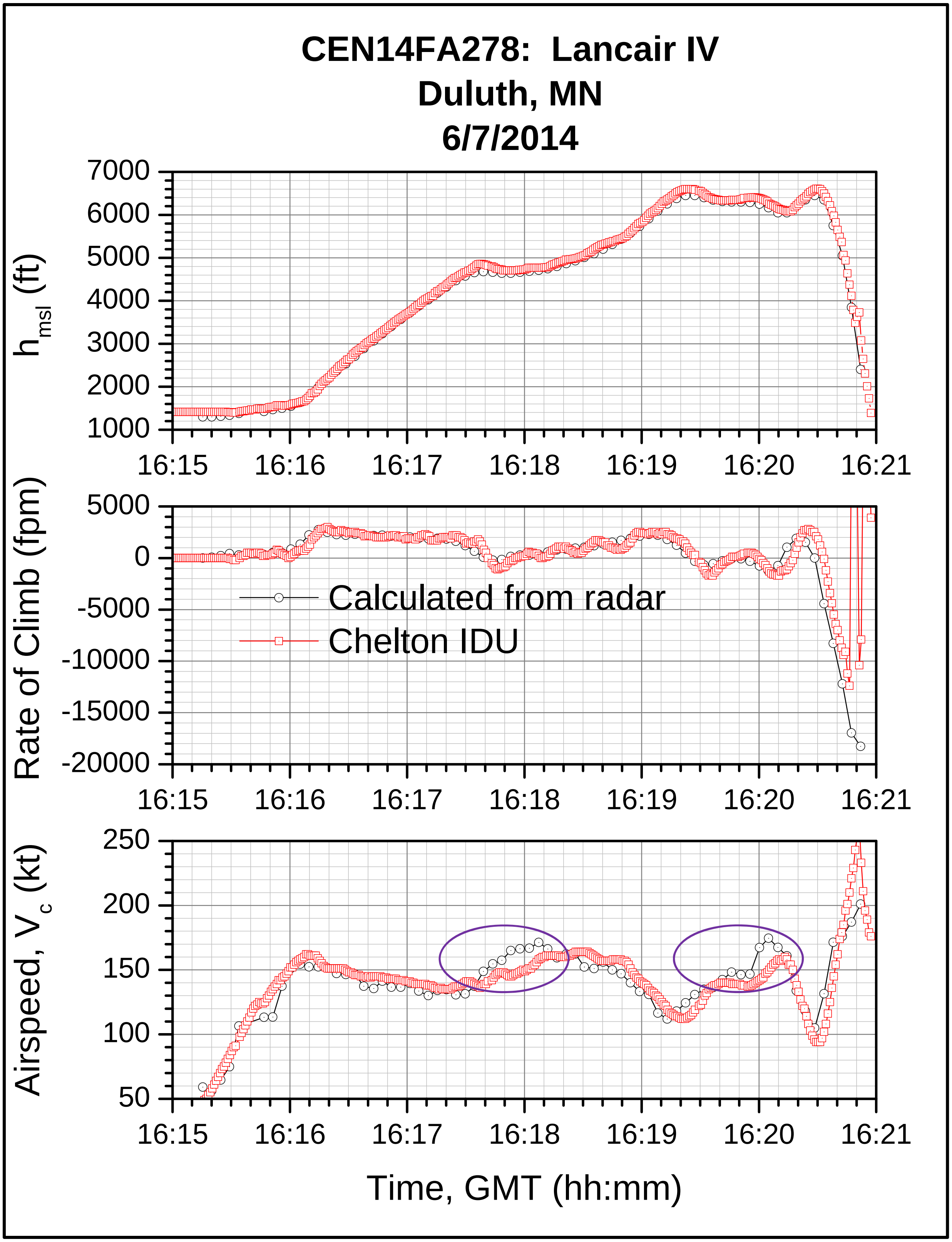

Figure 15: Altitude and Speed Based on Radar with Chelton IDU Overlaid

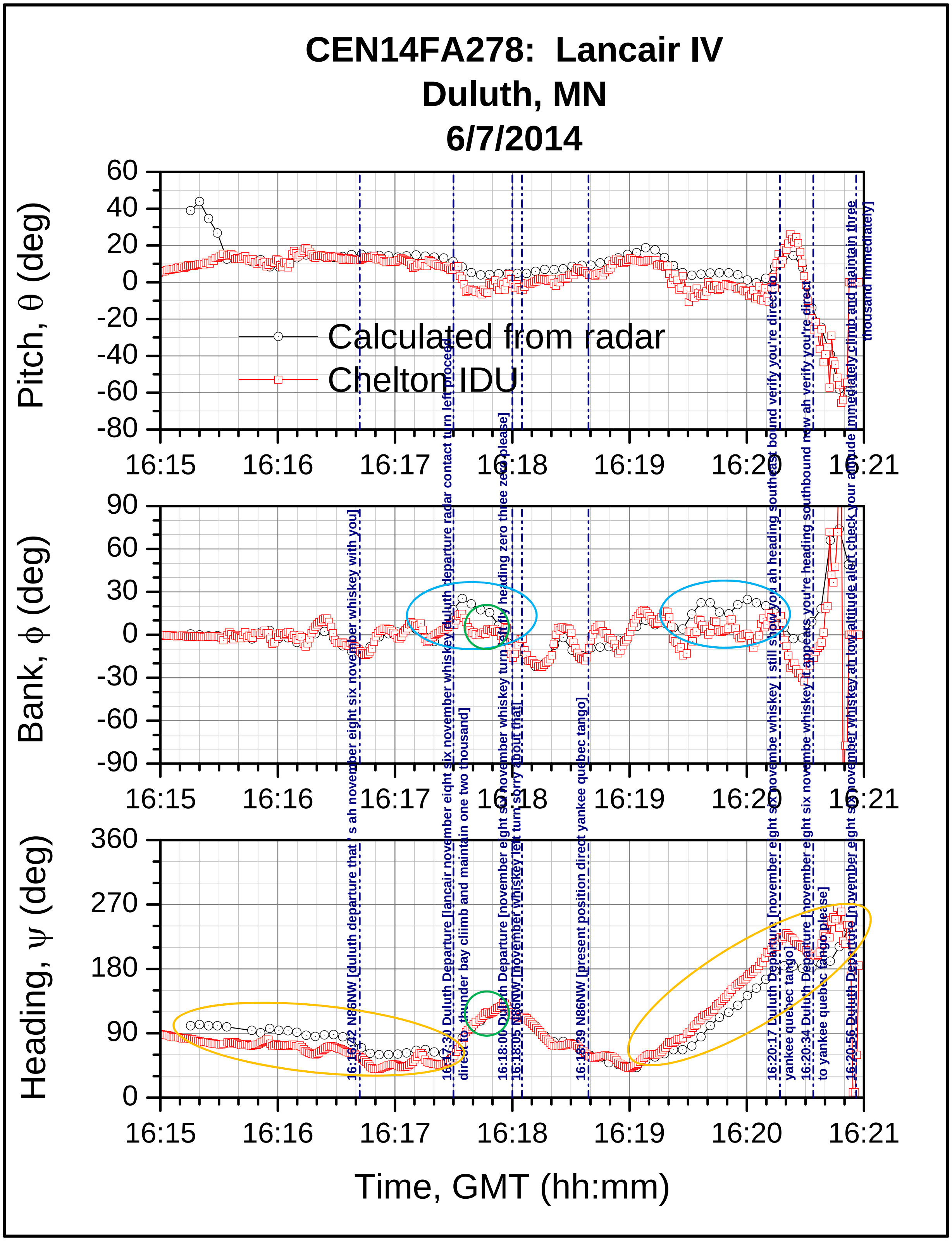

Figure 16: Pitch, Bank, and Heading Based on Radar with Chelton IDU Overlaid

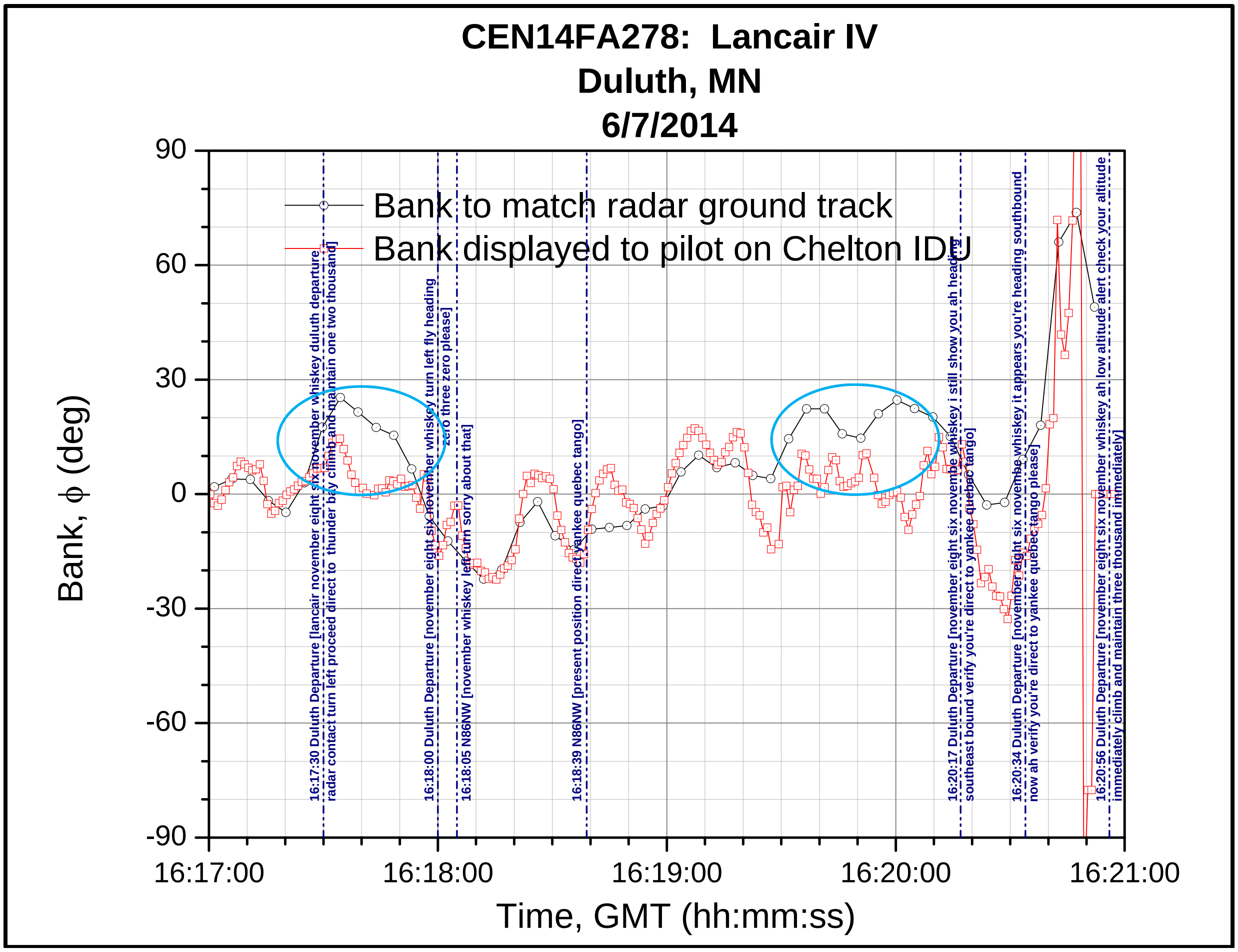

Figure 17: Bank Angle based on Radar with Chelton IDU Overlaid