NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, D.C. 20594

March 18, 2015

Electronic Devices

Specialist's Factual Report
By Bill Tuccio, Ph.D.

1. EVENT SUMMARY

Location: Duluth, Minnesota
Date: June 7, 2014
Aircraft: Lancair IV
Registration: N86NW
Operator: Private
NTSB Number: CEN14FA278

On June 7, 2014, about 1123 central daylight time (CDT), an experimental, amateur-built Lancair IV, N86NW, was destroyed when it impacted Lake Superior after departing from the Duluth International Airport (KDLH), Duluth, Minnesota. The pilot was the sole occupant and received fatal injuries. The airplane was registered to A.O. Engineering Inc. and operated by the pilot under the 14 *Code of Federal Regulations* Part 91 as a personal flight. Marginal visual meteorological conditions prevailed at the time of the accident, and an instrument flight rules (IFR) flight plan was filed. The airplane departed KDLH about 1115 and was en route to Goose Bay (CYYR), Newfoundland, Canada.

2. DETAILS OF INVESTIGATION

The devices in this report were recovered from Lake Superior at a depth of about 137 feet (ft). The devices were recovered on or about June 23, 2014, having been submerged for about 16 days. All the devices had a distinct odor similar to jet fuel. The Safety Board's Vehicle Recorder Division received the following electronic devices:

DEVICES WITH NO DATA RECOVERED

Recorder Manufacturer/Model: **Nokia C5 Cell Phone**
IMEI Number: **354115/05/754249/8**

Recorder Manufacturer/Model: **Avidyne FlightMax Entegra Part No. 700-00004-104**
Recorder Serial Number: **E0018**

DEVICES WITH DATA RECOVERED

Recorder Manufacturer/Model: **Chelton Integrated Display Unit Part No. IUA1A.1/P-S1**
Recorder Serial Number: **291**

Recorder Manufacturer/Model: **Chelton Integrated Display Unit Part No. IUA0A.1/P-S1**
Recorder Serial Number: **292**

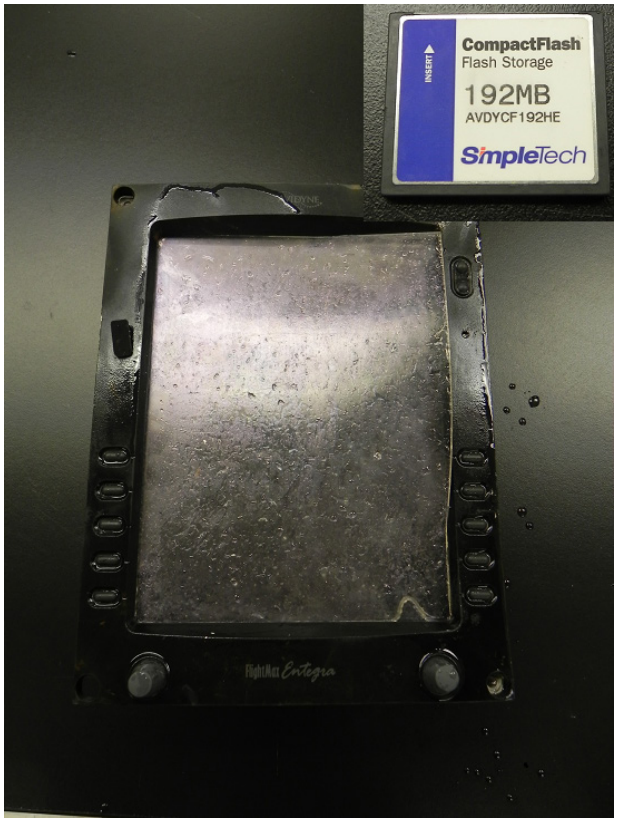
2.1. Descriptions of Devices with No Data Recovered

The Nokia C5 cell phone and Avidyne FlightMax Entegra are shown in figures 1 and 2, respectively. The Nokia cell phone turned on, but the screen was damaged. In agreement with the Investigator-in-Charge, no further recovery attempts were attempted.

The Avidyne FlightMax Entegra is a multifunction display (MFD). Depending on the version and installation, the unit may record information to a removable compact flash (CF) card. While the CF card was successfully read, it did not contain any recorded information. Avidyne confirmed that the Entegra does not record any information when installed on an experimental, turbine aircraft.

Figure 1. Nokia C5 cell phone.

Figure 2. Avidyne FlightMax Entegra with compact flash (CF) card.



2.2. Descriptions of Devices with Data Recovered

2.2.1. Chelton Integrated Display Unit

The Chelton Integrated Display Unit (IDU) (Chelton Flight Systems part numbers IUAOAI/P-SI and IUA1AI/P-SI) is an Electronic Flight Information System (EFIS). The unit has a 5" wide by 4" tall display with four buttons on each side and a knob at each lower corner. The instrument integrates multiple primary flight instruments including airspeed, altitude, electronic compass, turn rate, bank angle, pitch angle, vertical speed, and an optional slip/skid ball. The unit can also function as a navigation and engine display. The unit may integrate with external components, including a GPS/Air Data/Attitude Heading Reference System (AHRS). Units are typically installed in pairs, providing primary flight display (PFD) and multifunction flight display (MFD) capabilities.

The unit is capable of recording a log of aircraft parameters at a rate of 1 sample per second to an internal PCMCIA card. The parameters recorded depend upon installation and include primary flight instrument data, GPS position data, AHRS data, and engine data. The PCMCIA card is formatted in MSDOS[1] file system format, and parameters are recorded in engineering units as plain text to sequential log files.

Additionally, a screen capture of the display is stored each time the pilot pushes the FPL (flight plan) key at the upper left of the display. This feature is a diagnostic tool to assist in troubleshooting avionics issues.

[1] MSDOS means Microsoft Disk Operating System.

Chelton Flight Systems acquired Sierra Flight Systems; Chelton was subsequently acquired by Cobham plc, which was subsequently acquired by Genesys Aerosystems.

2.2.1.1. Device Condition

Two Chelton Flight Systems IDUs were recovered from the accident aircraft. The units sustained minor impact and water damage. Figure 3 shows the units with serial number 291 on the left and serial number 292 on the right. Figure 3 also shows the internal PCMCIA cards that were removed from each unit.

The cards were heated to 40º Celsius and a half atmosphere for 12 hours to dry; however, afterwards each card was opened and residual liquid was still observed. The cards were cleaned with deionized water and ethanol and then dried with compressed air. Each PCMCIA card was reassembled and read with a Windows-based computer and the data log and screen capture files were retrieved.

Figure 3. Damaged exterior of Chelton Flight Systems IDUs.

2.2.1.2. Recording Description

The current log file “LOG00.DAT,” was retrieved from the download of each Chelton Flight Systems IDU unit. The “LOG00.DAT” file from the unit with serial number 292 contained recorded data on June 7, 2014 between 16:00:16 UTC and 16:20:53 UTC. The file

recorded primary flight instrument data, GPS position data, AHRS data, and engine data. There were about 20 additional log files of prior flights, four of which were recorded on June 6, 2014. The remaining 16 log files were from the year 2002. According to the manufacturer, with IDU software version 6.0B, only the last five log files are retained by the IDU; log files recorded prior to the version 6.0B upgrade would be expected to remain on the PCMCIA card unless specifically deleted by a user.

The "LOG00.DAT" file from the unit with serial number 291 was compared to the data from the serial number 292 unit. The data from both units were similar. Since the data were similar, the serial number 291 unit data is not used in this report.

The data in this report is from the serial number 292 unit and contains the accident flight recording and prior flight recordings on June 6, 2014.

2.2.1.3. Engineering Units Conversions

The logged data is recorded by the Chelton Flight Systems IDU in engineering units. In experimental aircraft installations, the builder may configure the Chelton based on individual preferences. For this aircraft, observed values support that N2 was configured to measure propeller RPM.

Where applicable, changes to the conversions have been made to ensure the parameters conform to the Safety Board's standard sign convention that climbing right turns are positive (CRT=+).[2]

APPENDIX A lists the Chelton Flight Systems IDU parameters verified and provided in this report from the Chelton Flight Systems IDU, serial number 292.

2.2.2. Time Correlation

The Chelton Flight Systems IDU has an internal clock that is automatically set to GPS time when a valid GPS time signal is first received. After the internal clock is set to GPS time, it then increments time until power is removed from the IDU.

The times in this report use the time as recorded by the Chelton Flight Systems IDU, serial number 292. For the accident flight, 5 hours were subtracted from UTC to convert to CDT. For the prior flights on June 6, 2014, no adjustments were made and times are reported as "unknown time zone."

2.2.3. Overlays, Plots, and Corresponding Tabular Data

Figures 4 through 10 contain data recorded during the June 7, 2014 accident flight. All times are CDT and all altitudes are pressure altitude. Figures 4 through 6 are Google Earth overlays of the accident flight. Figures 7 through 10 are plots of the accident flight data. Figures 11 through 19 show data from prior flights on June 6 2014. The weather and

[2] CRT=+ means that for any parameter recorded that indicates a climb or a right turn, the sign for that value is positive. Also, for any parameter recorded that indicates an action or deflection, if it induces a climb or right turn, the value is positive. Examples: Right Roll = +, Left Aileron Trailing Edge Down = -, Right Aileron Trailing Edge Up = +, Pitch Up = +, Elevator Trailing Edge Up = +.

lighting conditions in the Google Earth imagery are not necessarily representative of the conditions at the time of the accident.

The Google Earth overlays and plots in this report show the aircraft departed from KDLH, climbed towards Lake Superior with intermediate level offs, exhibited fluctuations in pitch, speed, and roll, and then descended rapidly and crashed into Lake Superior. The narrative that follows provides further details.

Figure 4 is a Google Earth overlay of the accident flight with select points annotated. The recording began at 11:00:16 CDT with the aircraft taking off at about 11:15:06 CDT. Figure 5 shows the start of the recording and ramp movements. At about 11:15:06 CDT, the aircraft climbed on an easterly track and achieved a maximum altitude of 6,607 ft at 11:20:26 CDT. Figure 6 focuses on the end of the recording. The minimum recorded indicated airspeed (IAS) after the initial departure climb was 94 kts at 11:20:26 CDT at the maximum altitude of 6,607 ft. Thereafter, the IAS increased and the aircraft descended, reaching a maximum recorded IAS of 262 kts about 6 seconds before the end of the recording.

Figure 7 is a plot of the entire accident flight recording. The recording began at 11:00:16 CDT, and at 11:07:34 CDT, N2 values were greater than 0%. As shown in figure 5, by 11:08:16 CDT, the aircraft began to move on the ramp. By 11:15:06 CDT, the aircraft began its take-off from KDLH.

Figure 8 is a plot of engine parameters during the flight portion of the accident recording. At about 11:17:33 CDT, the pressure altitude first levelled off since take-off, followed by an IAS increase until 11:17:43 CDT. At 11:17:44 CDT, N1 reduced from the climb value of about 93% to 77%, before increasing to a value of about 90% by 11:17:56 CDT. N1 decreased steadily to 88% by 11:19:32 CDT and remained so until 11:20:06 CDT.

At 11:19:52 CDT, the pressure altitude began to descend from 6,407 ft as the IAS increased. At 11:20:09 CDT, N1 decreased to 73% as the IAS peaked at 160 kts, and then began to decrease as the pressure altitude began to climb by 11:20:13 CDT. By 11:20:18 CDT, N1 reduced to 68%, IAS was decreasing and pressure altitude was descending. For about the next 7 seconds, N1 began to increase as IAS continued to decrease to a minimum value (after the initial take-off climb) of 94 kts as pressure altitude reached a maximum value of 6,607 ft. By 11:20:30 CDT, N1 increased to about 88% for about 6 seconds as pressure altitude decreased and IAS increased. By 11:20:38 CDT, N1 began to decrease through 77% as IAS increased through 179 kts.

Figure 8 also shows the left and right fuel tank measures decreased and then increased during the recording. After the IAS passed through about 55 kts during the take-off roll, N2 stabilized at about 1,960 rpm and remained so, with slight fluctuations, until the IAS passed through 243 kts at 11:20:45 CDT, when N2 reached a minimum value of 1,339 rpm and then increased at the end of the recording.

Figure 9 is a plot of basic parameters during the first part of the accident flight, before the pitch attitude exceeded 20 degrees nose up towards the end of the recording. Between 11:15:03 CDT and 11:15:31 CDT, the aircraft accelerated from 0 kts IAS to 102 kts IAS as

the pressure altitude remained at about 1,427 ft. At 11:15:31 CDT, the pressure altitude began to climb as the IAS continued to increase. By about 11:16:03 CDT, the pressure altitude was climbing through about 1,700 ft as the IAS was about 160 kts. By about 11:17:31 CDT, the pressure altitude levelled off at about 4,800 ft and remained so until about 11:18:20 CDT. At about 11:18:20 CDT, the pressure altitude began to climb, reaching about 6,600 ft by 11:19:22 CDT. The pressure altitude descended to about 6,200 ft by 11:20:15 CDT.

After about 11:16:05 CDT, when the IAS first steadied at about 155 kts, the Chelton calculated wind speed varied between about 50 kts, then decreased to about 6 kts, then increased to about 90 kts by 11:20:15 CDT. The Chelton calculated wind direction also varied during this time period. The magnetic track and heading were generally consistent with each other during this same period.

Figure 9 also shows that recorded vertical acceleration varied during the first portion of the flight. Around the time of the N1 change at 11:17:44 CDT, vertical acceleration varied between +0.7 and +1.6 g. By 11:20:15 CDT, vertical acceleration varied between +0.3 and +2.1 g.

Figure 10 is a plot of the end of the accident flight. After 11:20:47 CDT, the validity of certain values become questionable (e.g., vertical acceleration steady at 1.0 g, pitch of 0 degrees, which are inconsistent with the accident sequence). At 11:20:21 CDT, the pitch attitude began to decrease from a maximum 24 degrees nose up when the airspeed was 108 kts. By 11:20:25 CDT, the pitch attitude decreased through 3 degrees nose up as the airspeed reached a minimum recorded value of 94 kts. From 11:20:33 CDT, the vertical acceleration began to fluctuate between -2.7 and 5.7 g, roll recorded extreme values (greater than +/- 60 degrees), and vertical speed recorded extreme values (greater than +/- 4,000 feet per minute).

Between 11:20:28 and 11:20:47 CDT, IAS increased from 97 kts to a maximum of 262 kts. The recording ended at 11:20:53 CDT with a pressure altitude of 1,387 ft.

Figures 11 and 12 show a Google Earth overlay of four prior recordings, all on June 6, 2014; the 1st recording did not contain a flight. The aircraft made a round trip flight from Bend, Oregon to Redmond, Oregon (2nd and 3rd recordings) and then flew from Bend, Oregon to Duluth, Minnesota (4th recording). Figure 13 is a plot of all parameters for all flights on June 6, 2014.

Figures 14 through 19 show the following details from June 6, 2014:

- Figure 14: 2nd recording overview.
- Figure 15: 3rd recording overview.
- Figure 16: 4th recording takeoff and climb.
- Figure 17: 4th recording en route climb and level off.
- Figure 18: 4th recording portion of en route cruising flight.
- Figure 19: 4th recording cruise descent.

The corresponding tabular data used to create the 16 figures are provided in electronic comma separated value (*.csv) format as attachment 1 to this report.

Figure 4. Google Earth overlay of accident recording.

Figure 5. Google Earth overlay of ramp area.

Figure 6. Google Earth overlay of end of accident recording.

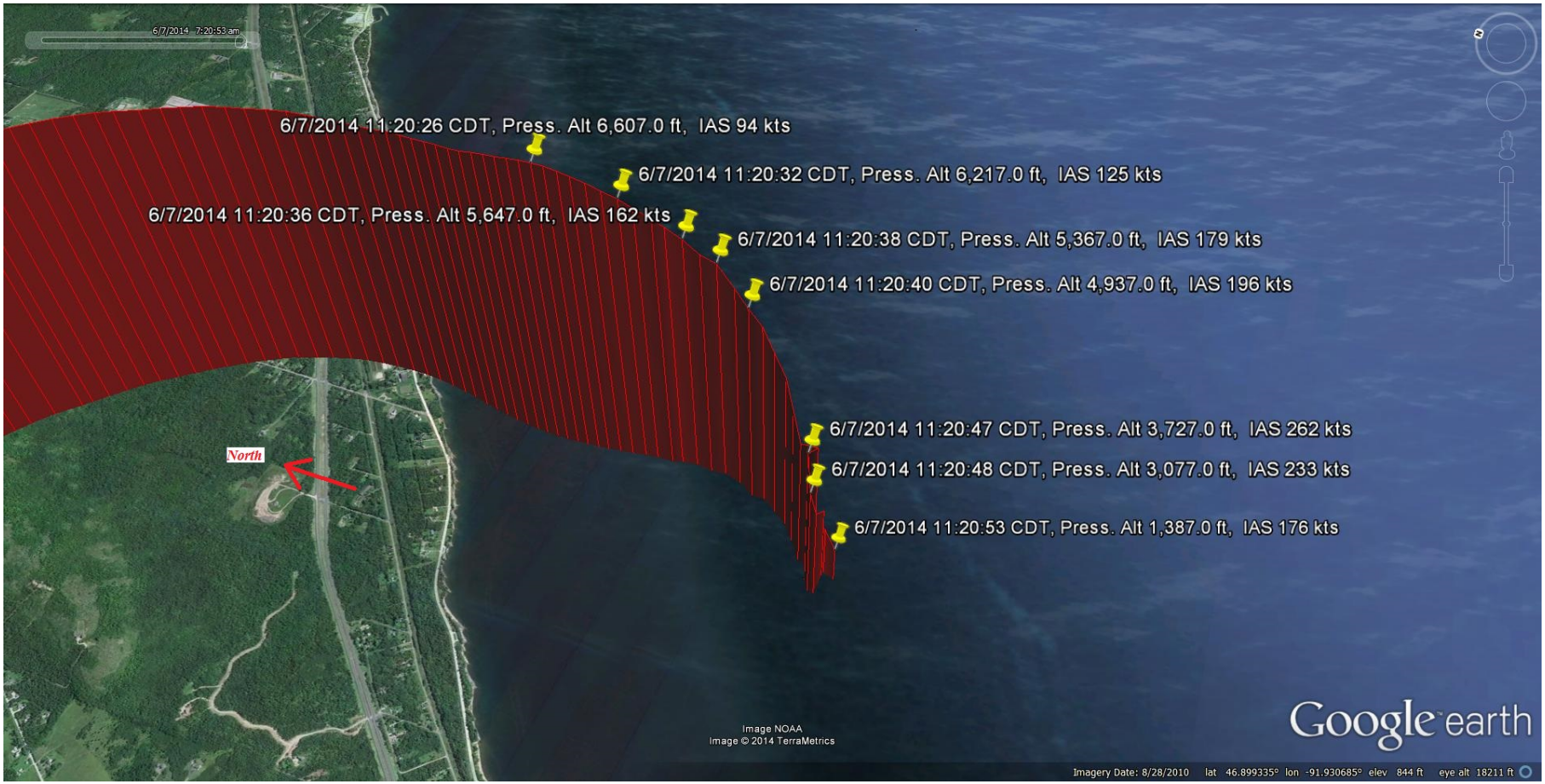
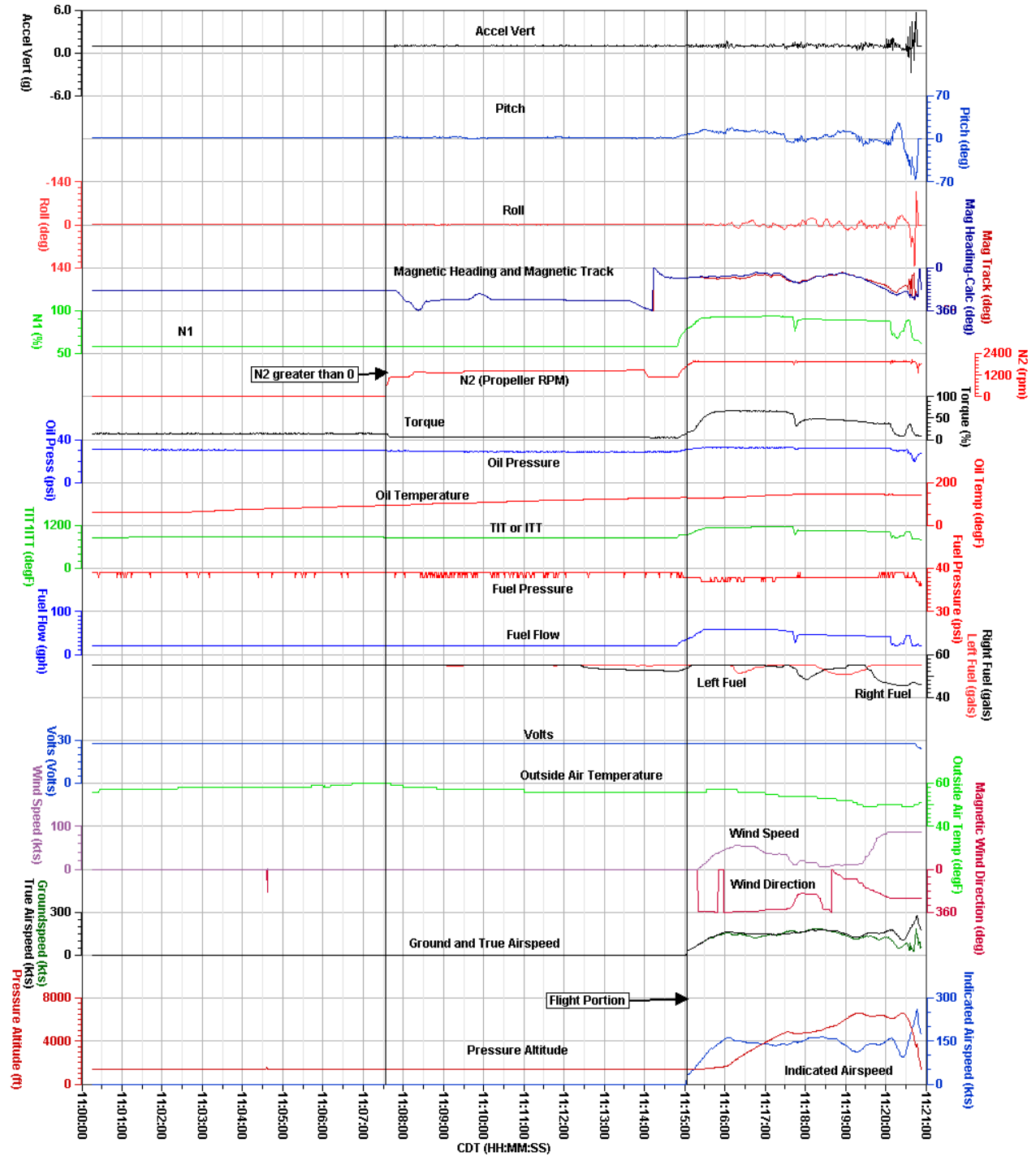
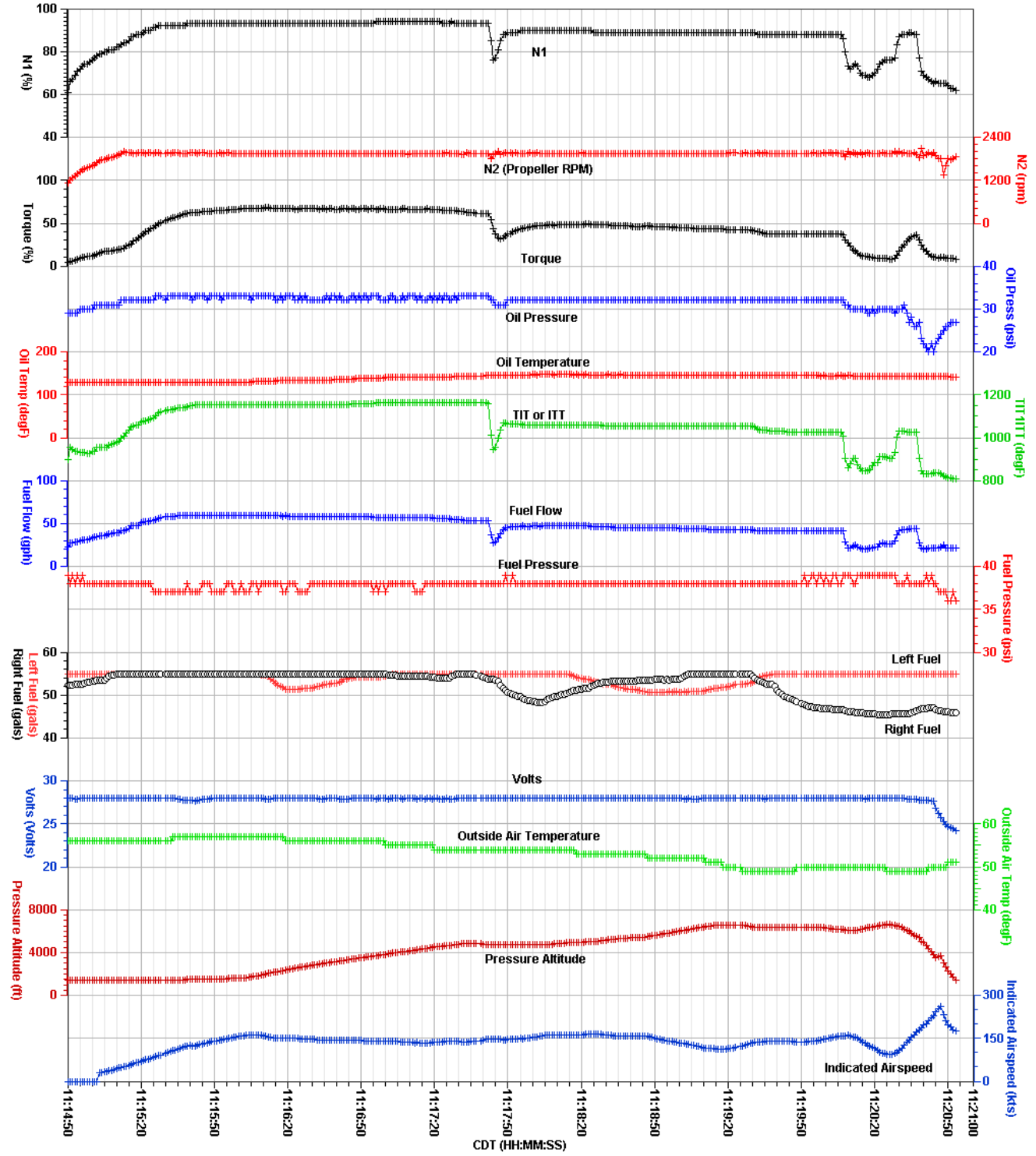


Figure 7. Plot of accident flight recording.



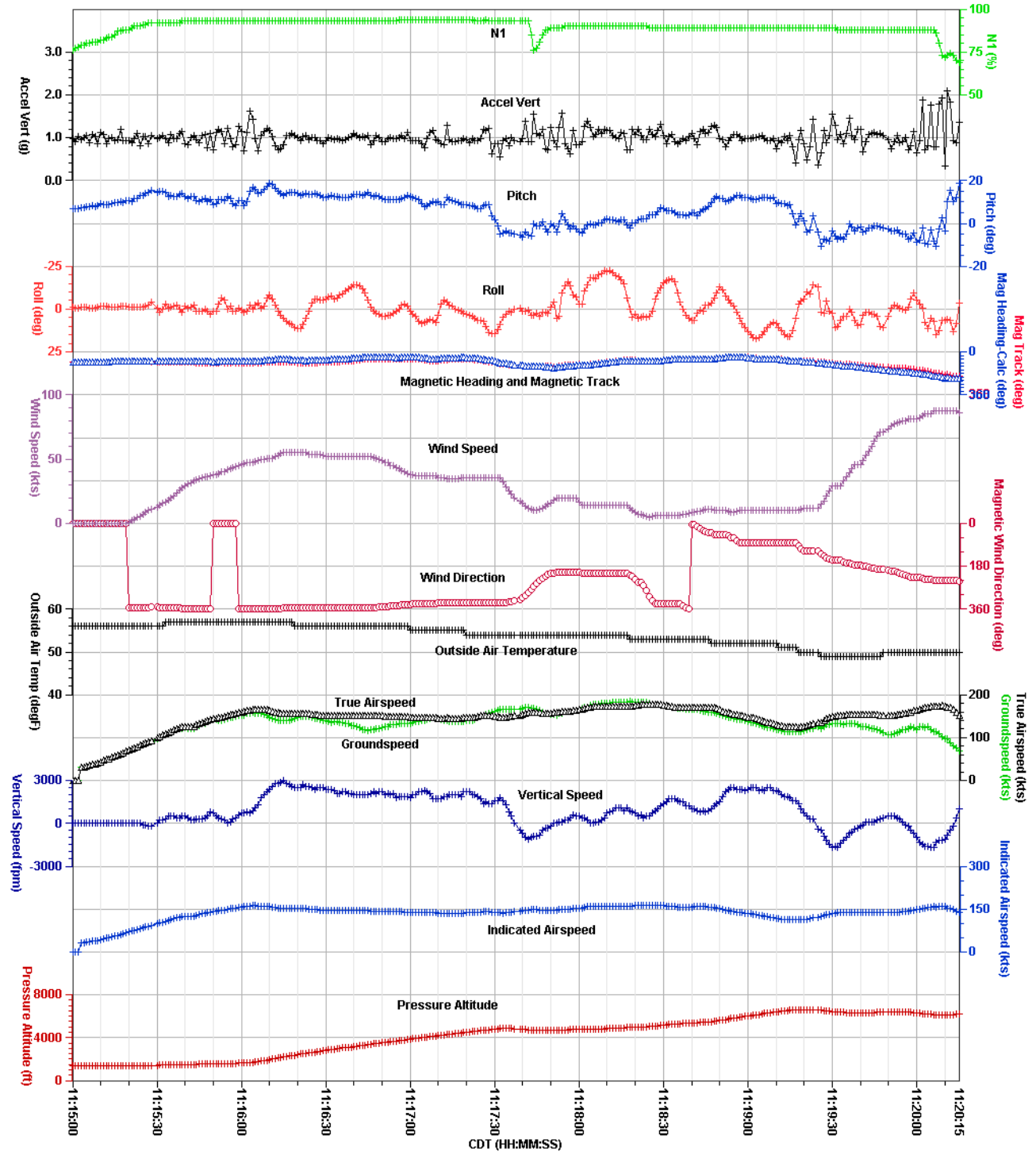
Revised: 11 July 2014 Entire Accident Flight Recording (Chelton S/N 292) National Transportation Safety Board

Figure 8. Plot of engine parameters during the flight portion of the accident recording.



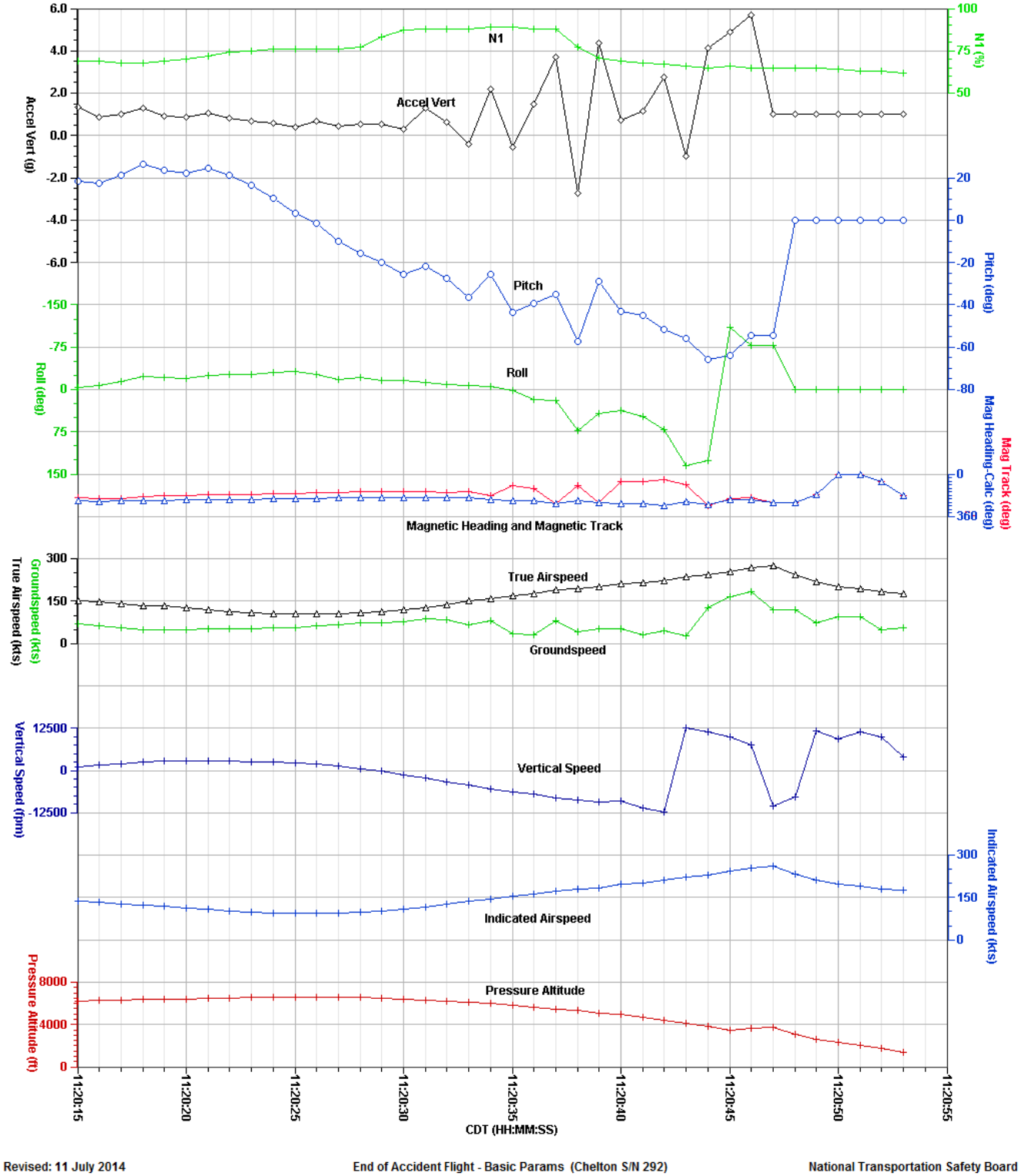
Revised: 11 July 2014 Flight Portion - Engine Parameters (Chelton S/N 292) National Transportation Safety Board

Figure 9. Plot of basic parameters during first part of accident flight.



Revised: 11 July 2014 Start of Accident Flight - Basic Params (Chelton S/N 292) National Transportation Safety Board

Figure 10. Plot of basic parameters during end of accident flight.



Revised: 11 July 2014 End of Accident Flight - Basic Params (Chelton S/N 292) National Transportation Safety Board

Figure 11. Google Earth overlay of prior flight recordings, June 6, 2014.

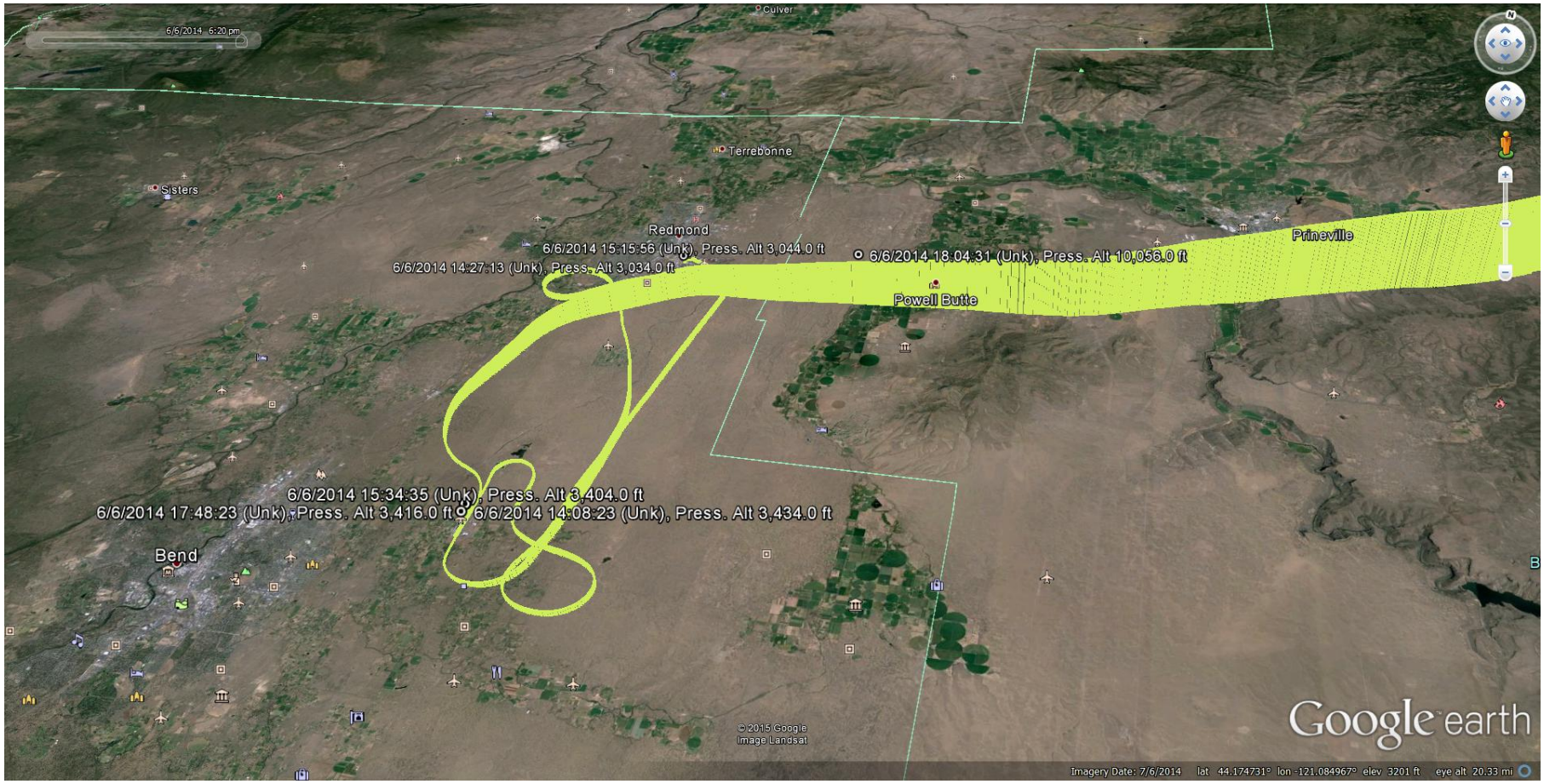


Figure 12. Google Earth overlay of prior cross-country flight recording, June 6, 2014.

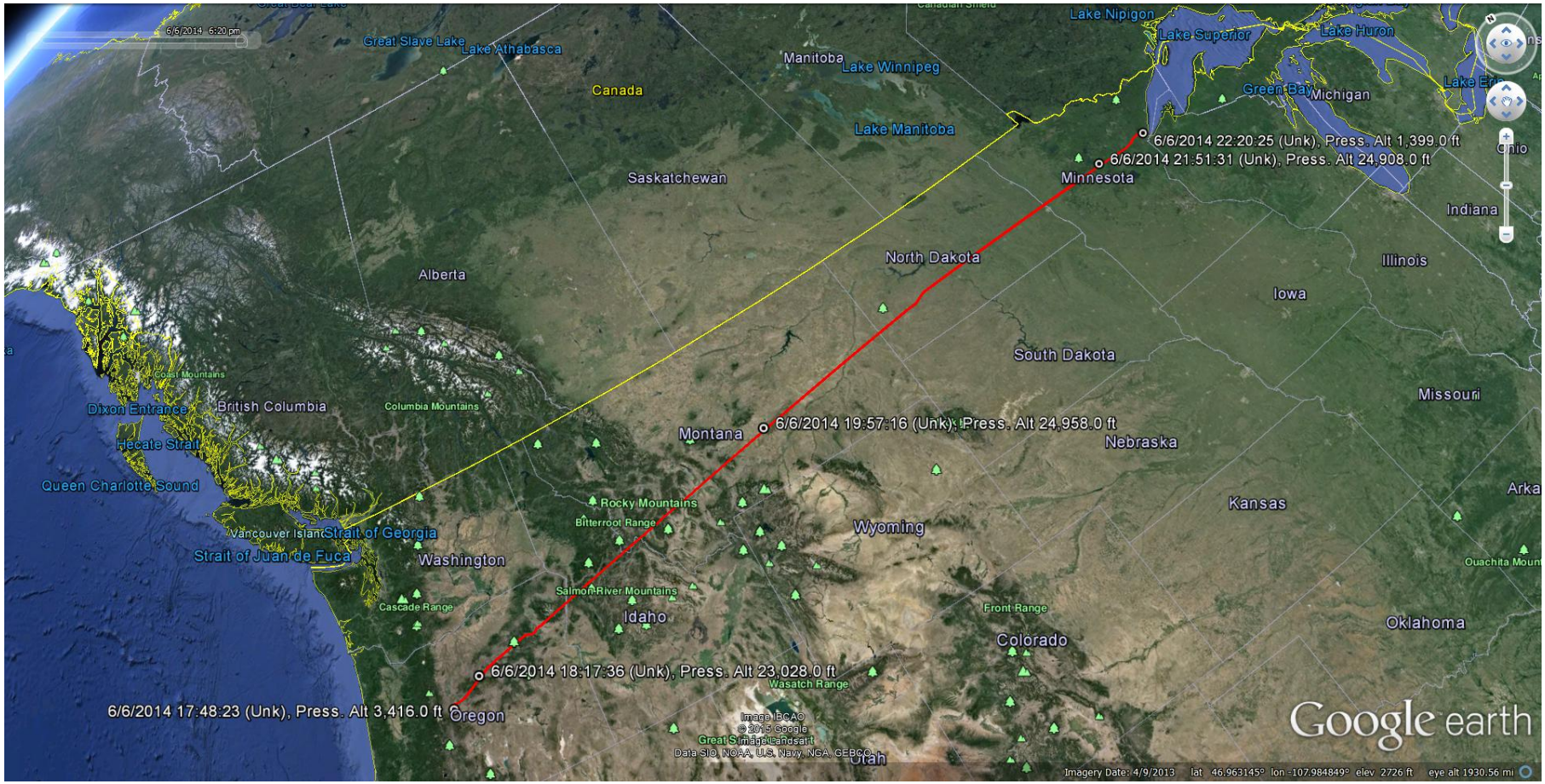


Figure 13. Plot of all flights on June 6, 2014.

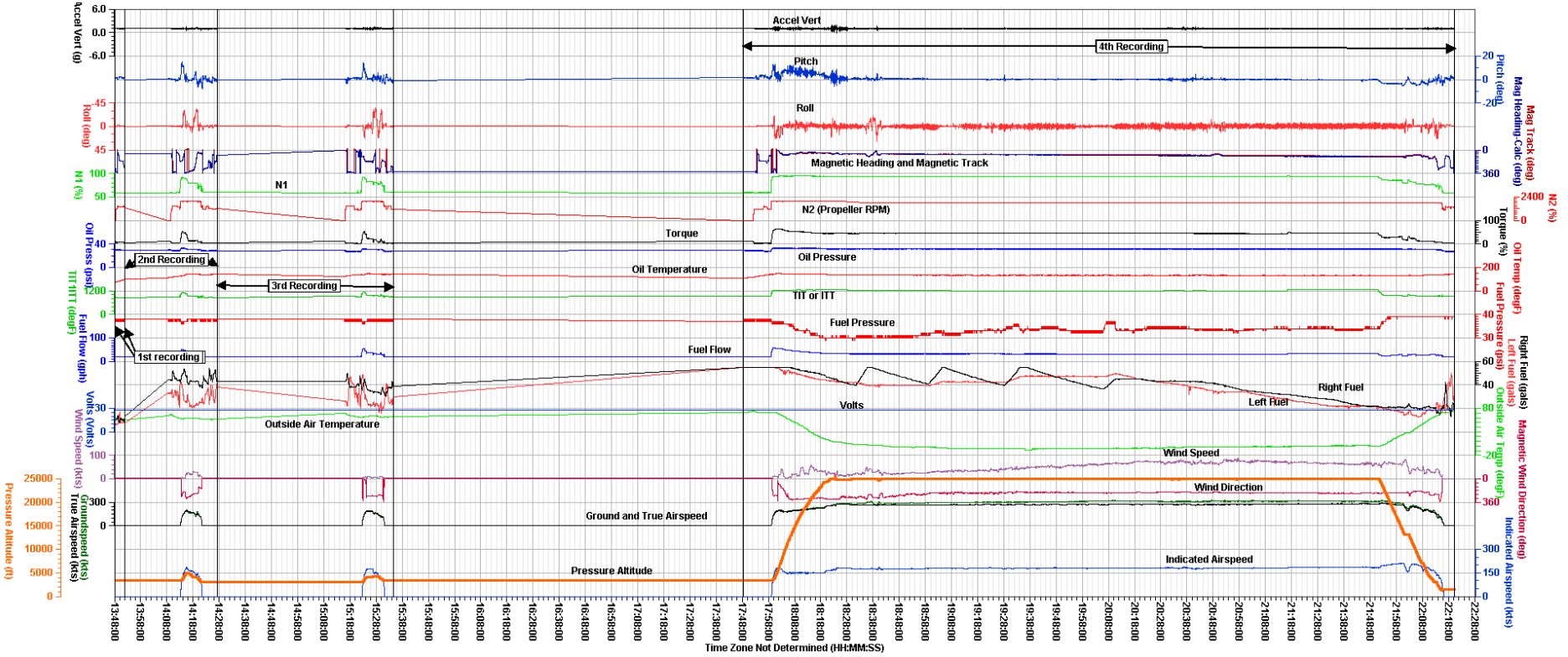


Figure 14. Plot of 2nd recording on June 6, 2014.

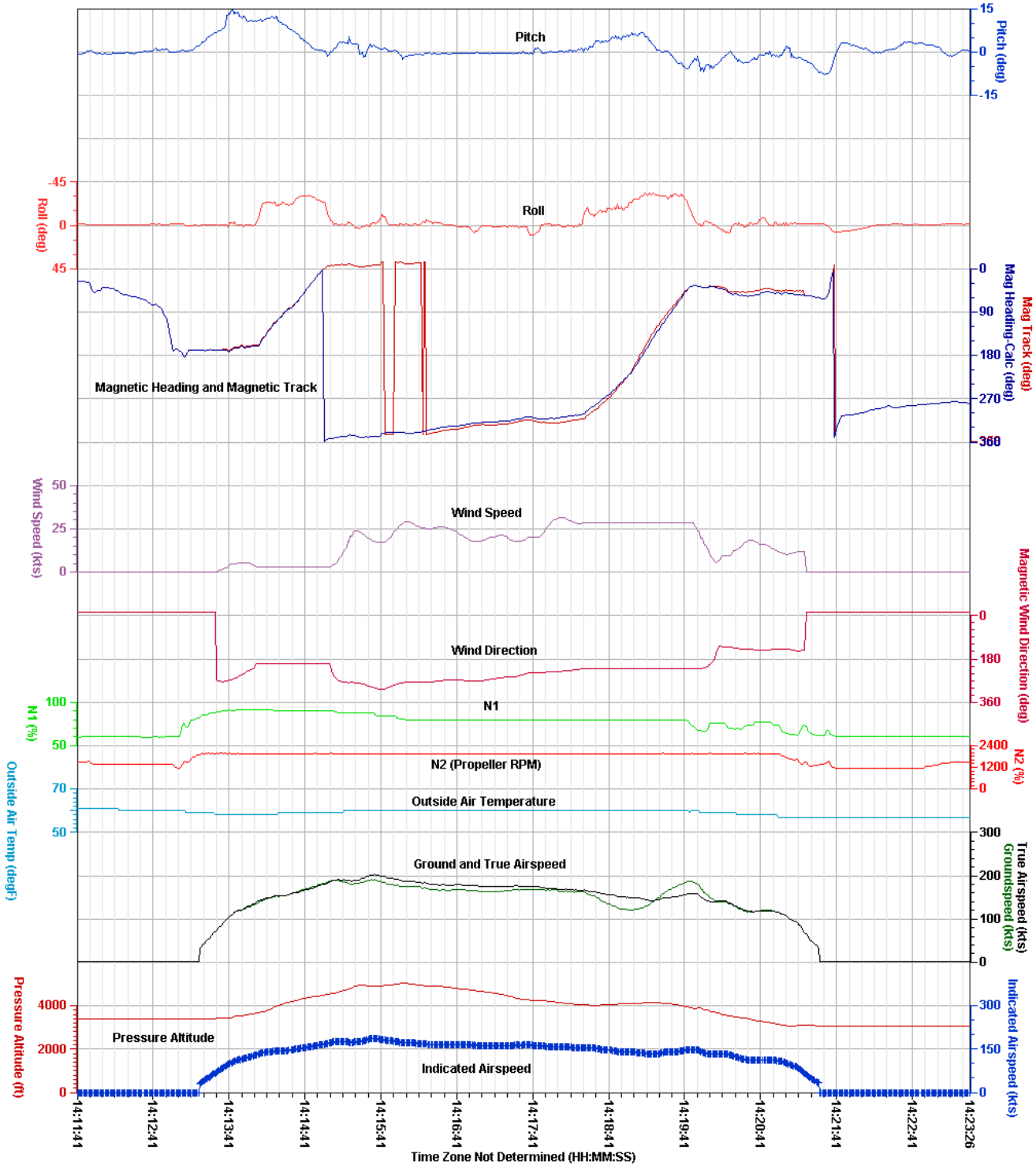


Figure 15. Plot of 3rd recording on June 6, 2014.

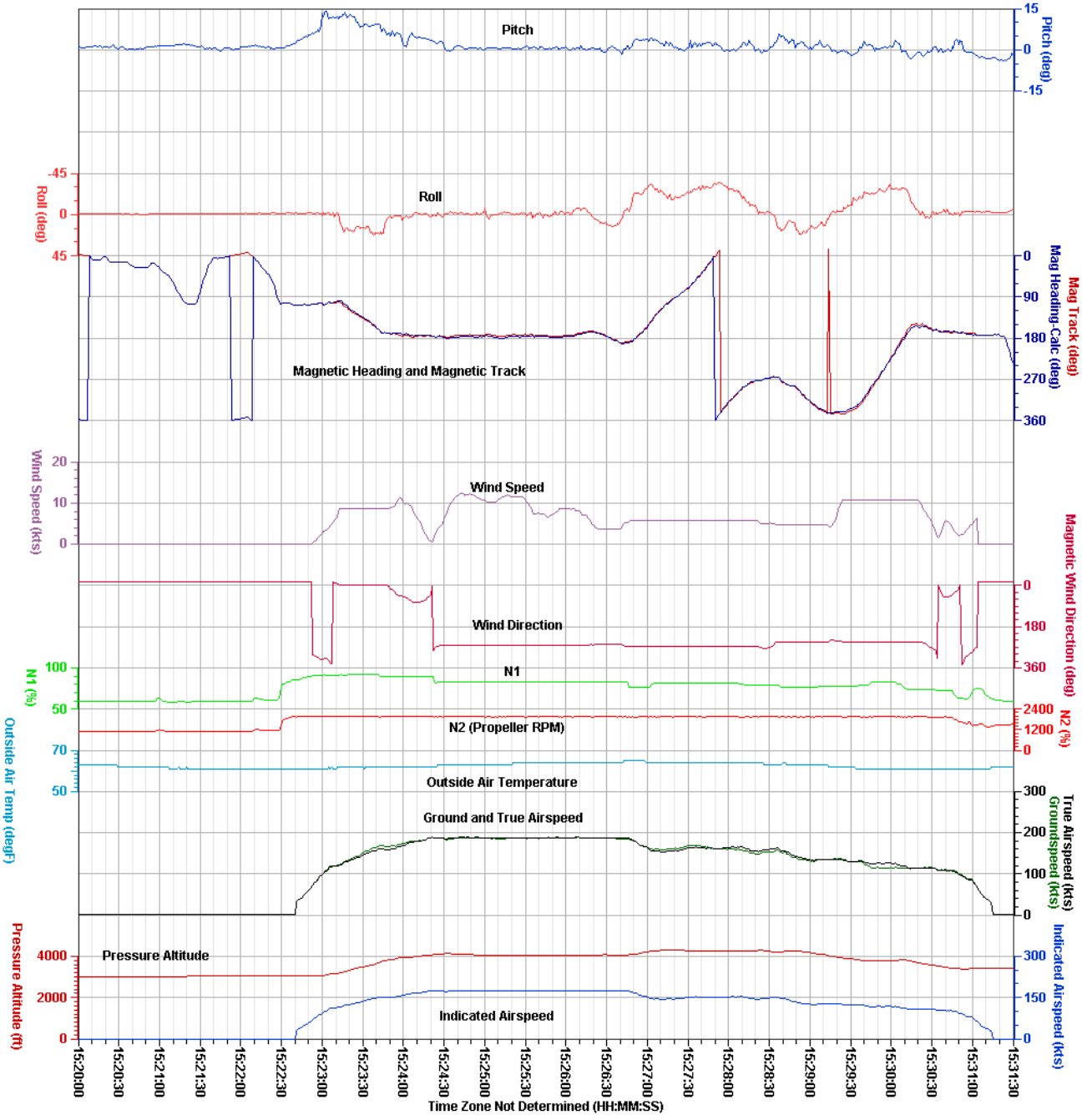


Figure 16. Plot of 4th recording on June 6, 2014 – takeoff and initial climb.

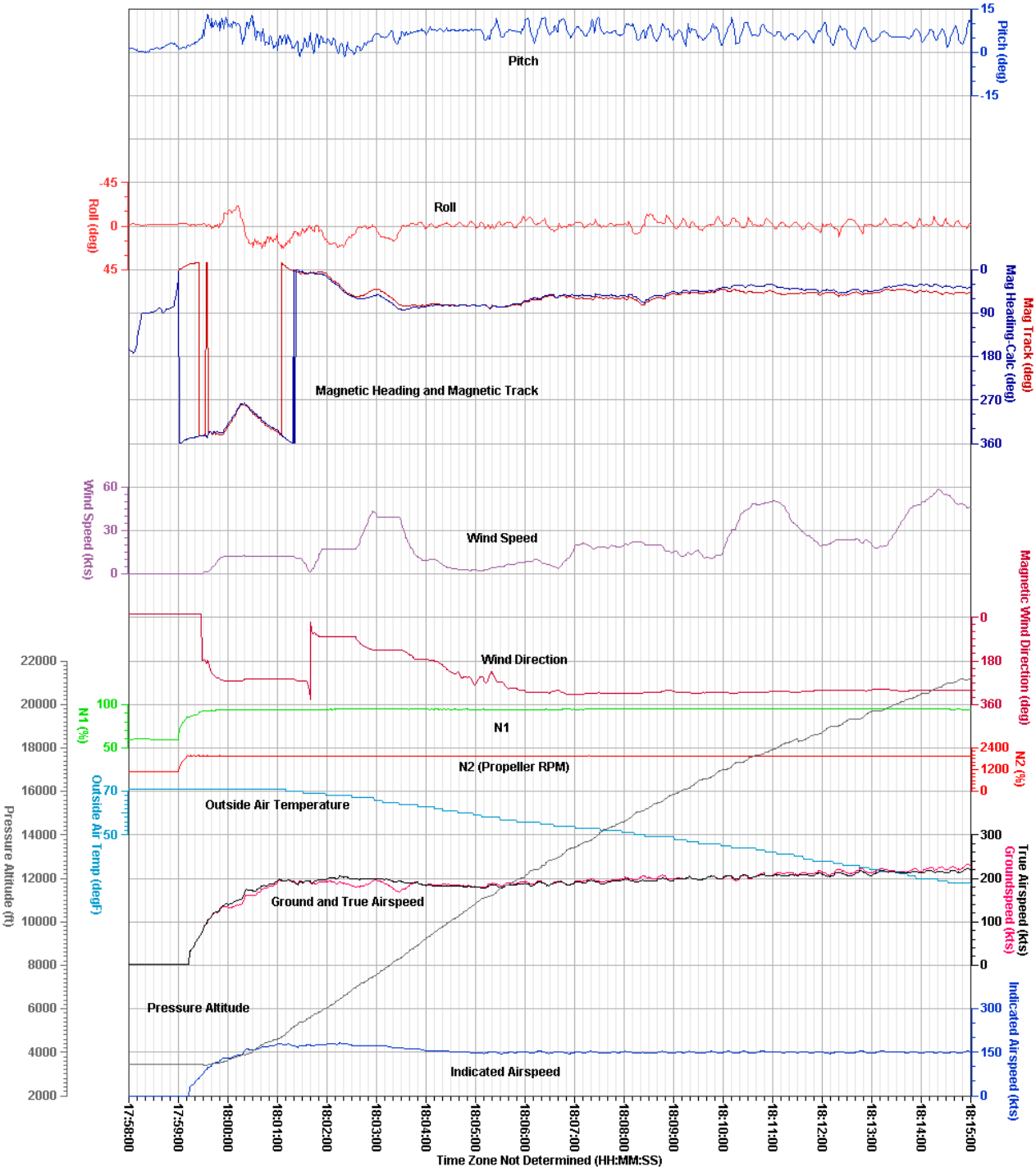


Figure 17. Plot of 4th recording on June 6, 2014 – cruise climb and level off.

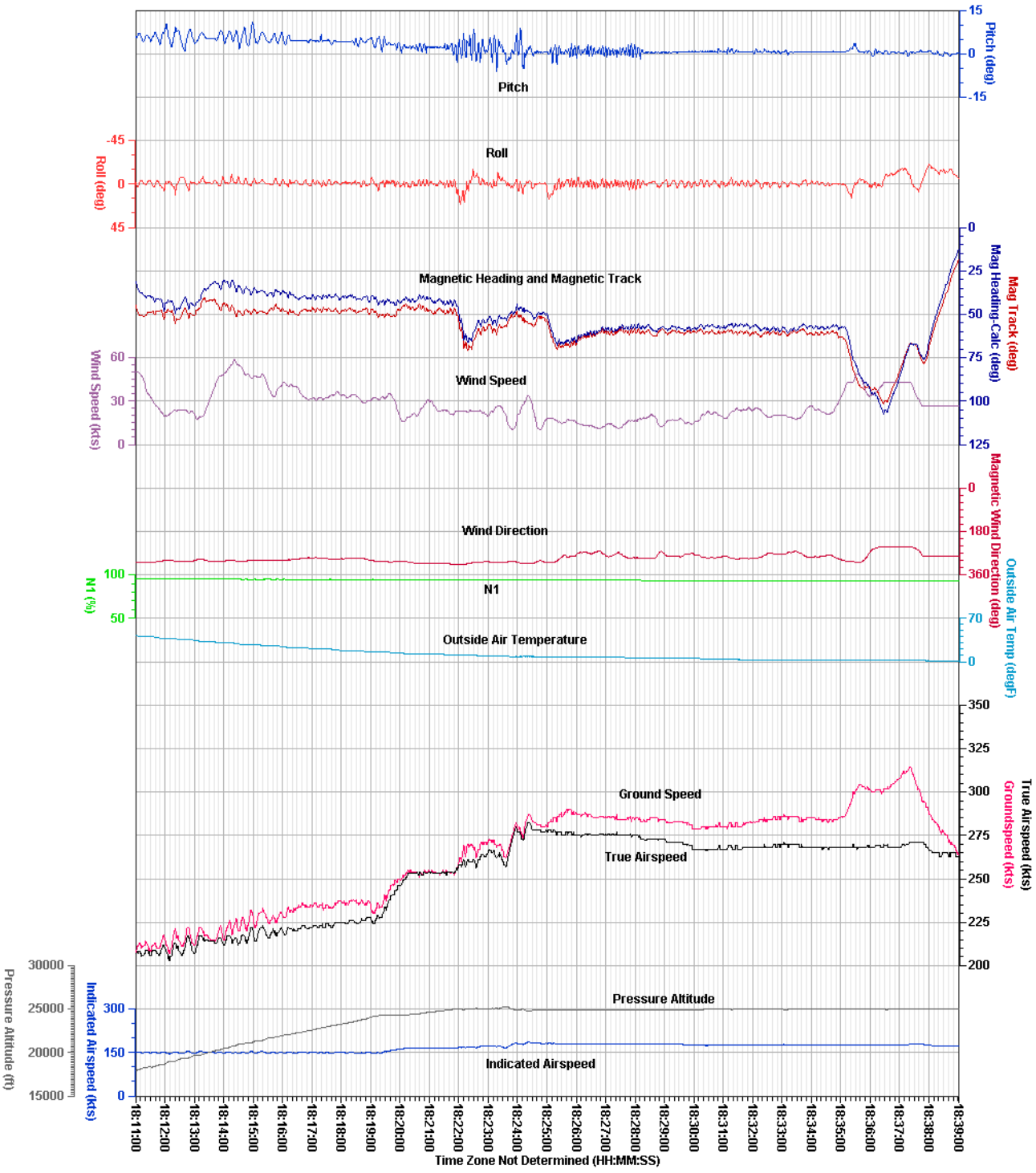


Figure 18. Plot of 4th recording on June 6, 2014 – cruise excerpt.

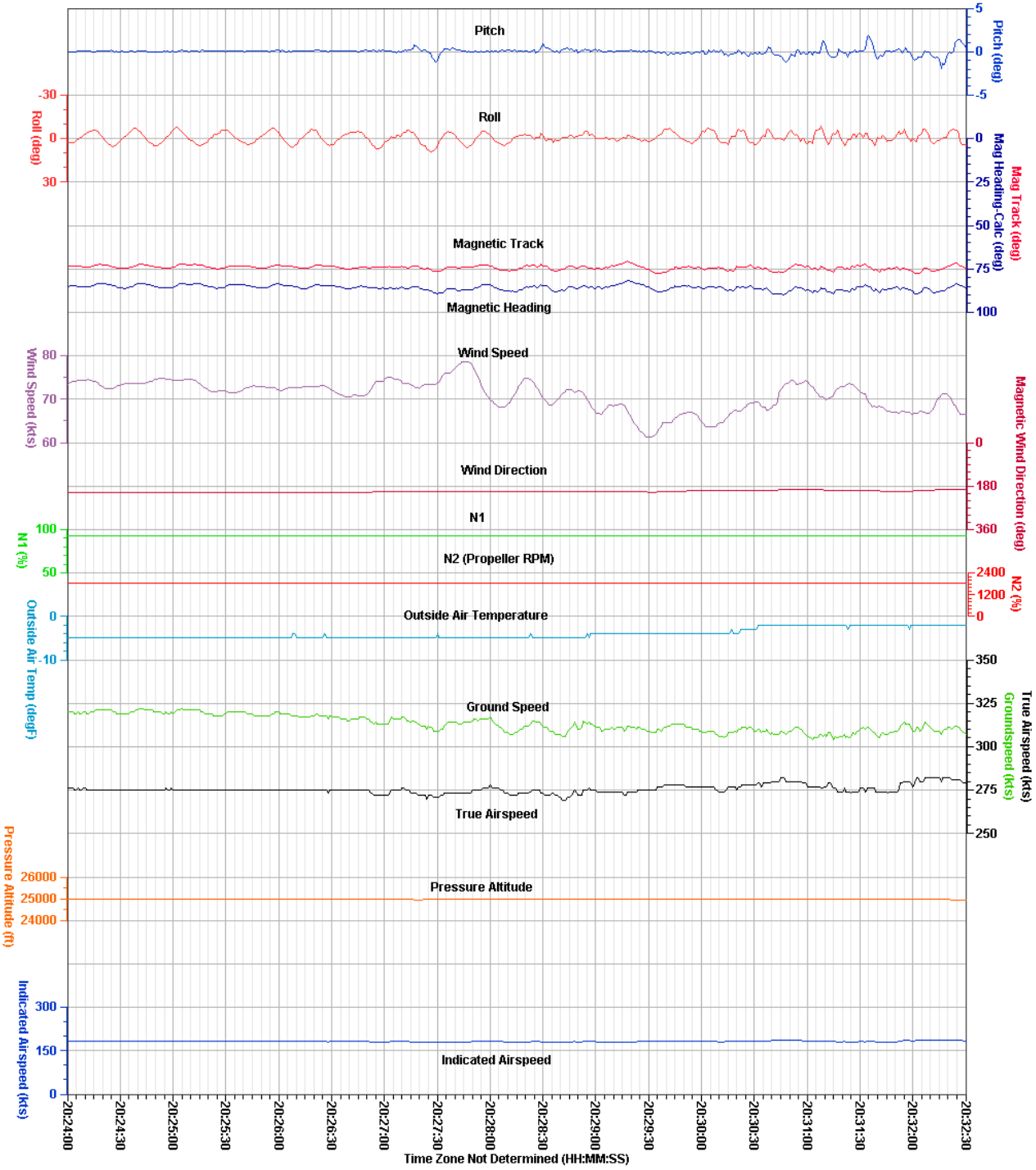
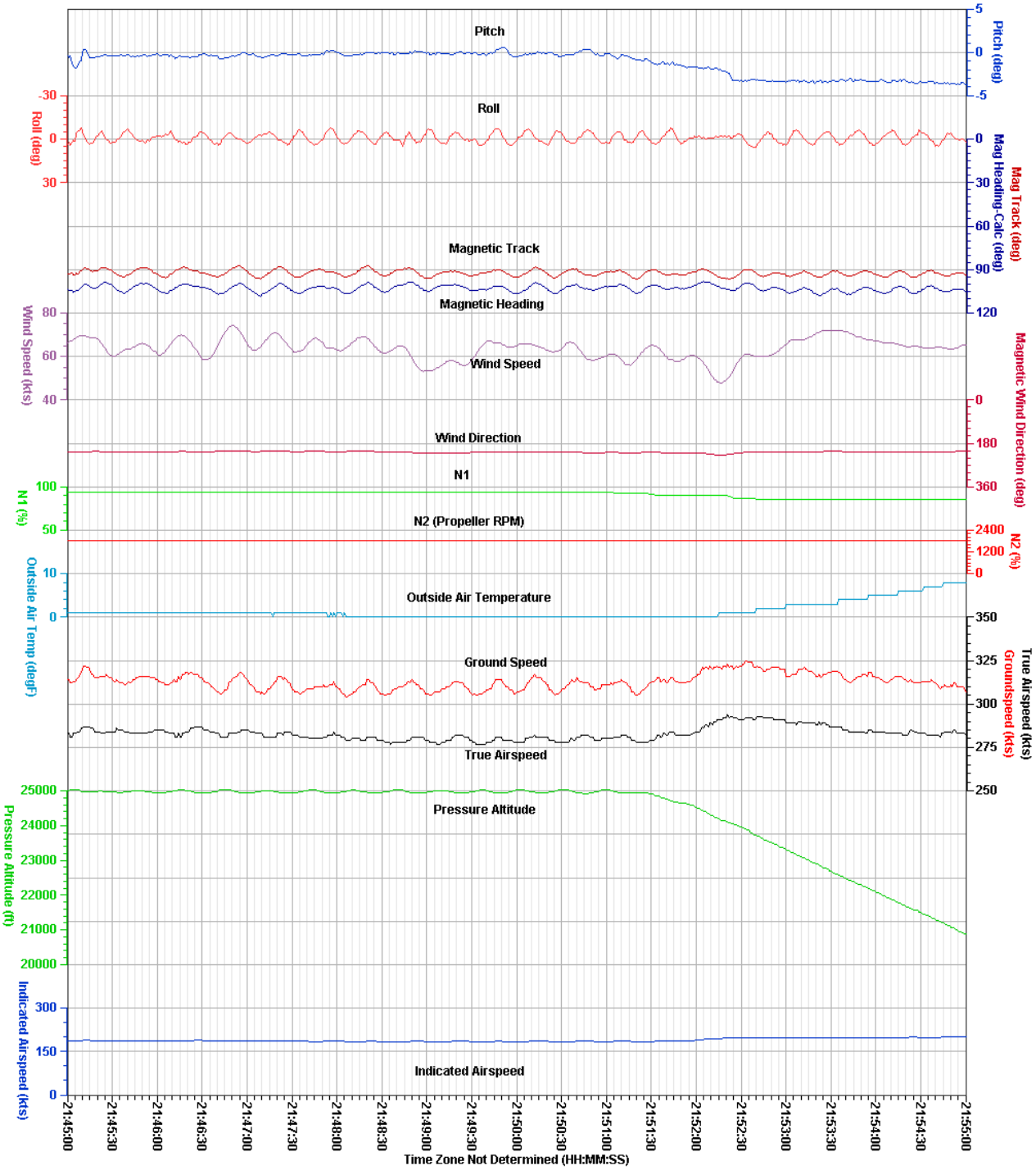


Figure 19. Plot of 4th recording on June 6, 2014 – cruise descent.



APPENDIX A – Chelton Flight Systems Parameters

This appendix describes the parameters provided and verified in this report. Table A-1 lists the parameters and table A-2 describes the unit abbreviations used in this report.

Table A-1 - Verified and provided parameters.

Parameter Name	Parameter Description
1. Accel Vert (g)	Vertical Acceleration
2. Fuel Flow (gph)	Fuel Flow
3. Fuel Pressure (psi)	Fuel Pressure
4. Groundspeed (kts)	Ground Speed
5. Indicated Airspeed (kts)	Indicated Airspeed
6. Latitude (deg)	Latitude
7. Left Fuel (gal)	Left Fuel Level
8. Longitude (deg)	Longitude
9. Mag Heading-Calc (deg)	Magnetic Heading
10. Mag Track (deg)	Magnetic Track
11. Magnetic Wind Direction (deg)	Magnetic Wind Direction
12. N1 (%)	N1
13. N2 (rpm) [3]	Propeller revolutions per minute
14. Oil Press (psi)	Oil Pressure
15. Oil Temp (degF)	Oil Temperature
16. Outside Air Temp (degF)	Outside Air Temperature
17. Pitch (deg)	Pitch
18. Pressure Altitude (ft)	Pressure Altitude
19. Right Fuel (gal)	Right Fuel Level
20. Roll (deg)	Roll
21. Time UTC	Time UTC
22. TIT1ITT (degF)	Turbine Inlet Temperature or Inter Turbine Temperature[4]
23. Torque (%)	Torque
24. True Airspeed (kts)	True Airspeed
25. Vertical Speed (fpm)	Vertical Speed
26. Volts (Volts)	Volts
27. Wind Speed (kts)	Wind Speed

Table A-2 - Unit abbreviations.

Units Abbreviation	Description
%	percent
deg	degrees
degF	degrees Fahrenheit
fpm	feet per minute
ft	feet
g	g

[3] Chelton Flight Systems documentation identifies the parameter as “N2” but does not provide any units; observed values support that N2 was configured to measure propeller RPM.
[4] The value recorded depends on aircraft configuration and could not be determined for this report.

Units Abbreviation	Description
gal	gallons
gph	gallons per hour
kts	knots
psi	pounds per square inch
V	Volts DC