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

October 23, 2014

Electronic Devices Factual Report

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

1. EVENT

Location:	Littleton, North Carolina
Date:	June 27, 2014
Aircraft:	Cessna 182Q
Registration:	N182PE
Operator:	Private
NTSB Number:	ERA14FA313

On June 27, 2014, about 0940 eastern daylight time (EDT), a Cessna 182Q, N182PE, was substantially damaged during a forced landing near Littleton, North Carolina. The commercial pilot was fatally injured. Visual meteorological conditions prevailed and an instrument flight rules flight plan was filed for the flight, which departed from Sabot Airport (1VA0), Sabot, Virginia, at 0850, and was destined for Rocky Mount-Wilson Regional Airport (RWI), Rocky Mount, North Carolina. The personal flight was conducted under the provisions of 14 *Code of Federal Regulations* Part 91.

2. DETAILS OF DEVICE INVESTIGATION

The Safety Board's Vehicle Recorder Division received the following devices:

Device 1:	Olympus Digital Voice Recorder Model DS-2500
Device 1 Serial Number:	Unknown
Device 2:	Apple iPad (Model A1397)
Device 2 Serial Number:	DLXGP0Z5DJHH
Device 3:	JPI Engine Monitor EDM-700
Device 3 Serial Number:	30150
Device 4:	Garmin GPSMAP 496
Device 4 Serial Number:	19717372

2.1. Olympus Digital Voice Recorder Model DS-2500 Device Description

The Olympus Digital Voice Recorder Model DS-2500 is a personal digital audio recorder. The device records audio to a removable SD card.

2.1.1. Olympus Digital Voice Recorder Model DS-2500 Data Recovery

Upon arrival at the Vehicle Recorder Laboratory, an exterior examination revealed the unit had not sustained any damage, as shown in figure 1. Audio content on the device was examined using the recorder's built-in playback functionality.

Figure 1. Olympus Digital Voice Recorder Model DS-2500.

2.1.2. Olympus Digital Voice Recorder Model DS-2500 Data Description

None of the information on the recorder was pertinent to the investigation.

2.2. Apple iPad Device Description

The Apple iPad is a tablet computer with a high-resolution color touch-screen interface. All iPad devices support WiFi and Bluetooth connectivity, and use either 16, 32, or 64 GB of non-volatile memory for storage (depending on model). Some devices also support data connectivity via existing cell-phone networks. The iPad also includes front and back cameras. The iPad implements its functionality by running programs called "Apps" capable of supporting web-browsing, email, audio/video playback, contact and calendar management, and numerous other specialized functions. User-installed Apps can be used to support functionality for electronic flight bags, flight planning and filing, aviation weather depiction, and electronic flight charts. Application data is stored in non-volatile memory[1] and may include image, video, and position location information. Specialized application data may be stored in a proprietary file structure using

[1] Non-volatile memory is semiconductor memory that does not require external power for data retention.

numerous proprietary file formats. The amount and type of data stored varies based on the software version and configuration of the specific device.

2.2.1. Apple iPad Data Recovery

Upon arrival at the Vehicle Recorder Laboratory, an exterior examination revealed the unit had not sustained any damage. Applications and content were examined using the iPad's user interface.

2.2.2. Apple iPad Data Description

The iPad contained a number of personal, weather, and aviation applications. The data pertinent to this investigation was contained in the ForeFlight aviation application.

When ForeFlight's "Airports" page was selected, the RWI airport page was displayed. Foreflight's "Maps" page revealed the route shown in figure 2 (see Section 2.3 of this report for the Garmin 496 overlay of the latitude/longitude point in the route). Figure 3 shows ForeFlight's profile view of the route, along with the search box annotated with "A" in the upper right hand corner. The search box contained the following characters, "37.128N/77.699W KRWI 135 kts 14gph N182PE 4000ft." According to the ForeFlight Pilot Guide Version 6.2, the search box syntax used in this instance can be used to enter a route; specifically, the "37.128N/77.699W" was likely a replacement for the aircraft's current position when the pilot entered a "D" into the search box.

Figure 2. Route in ForeFlight application.

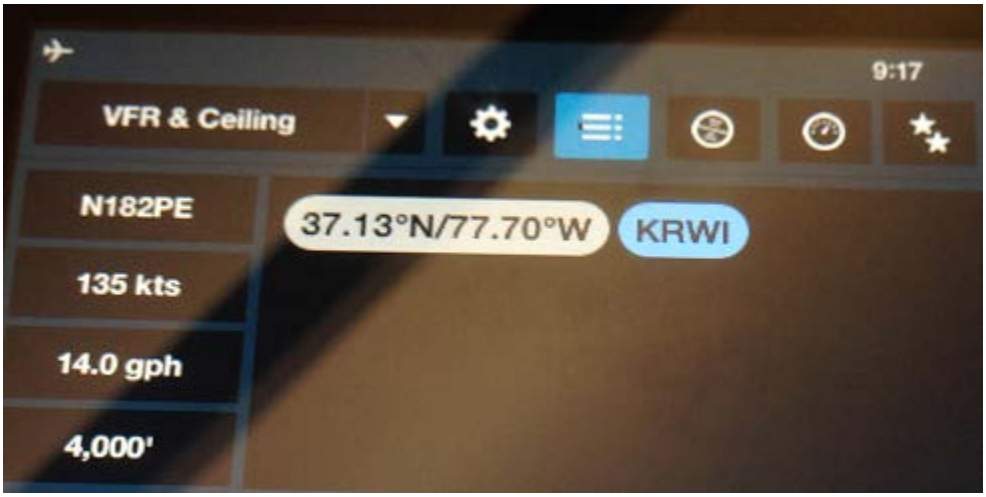
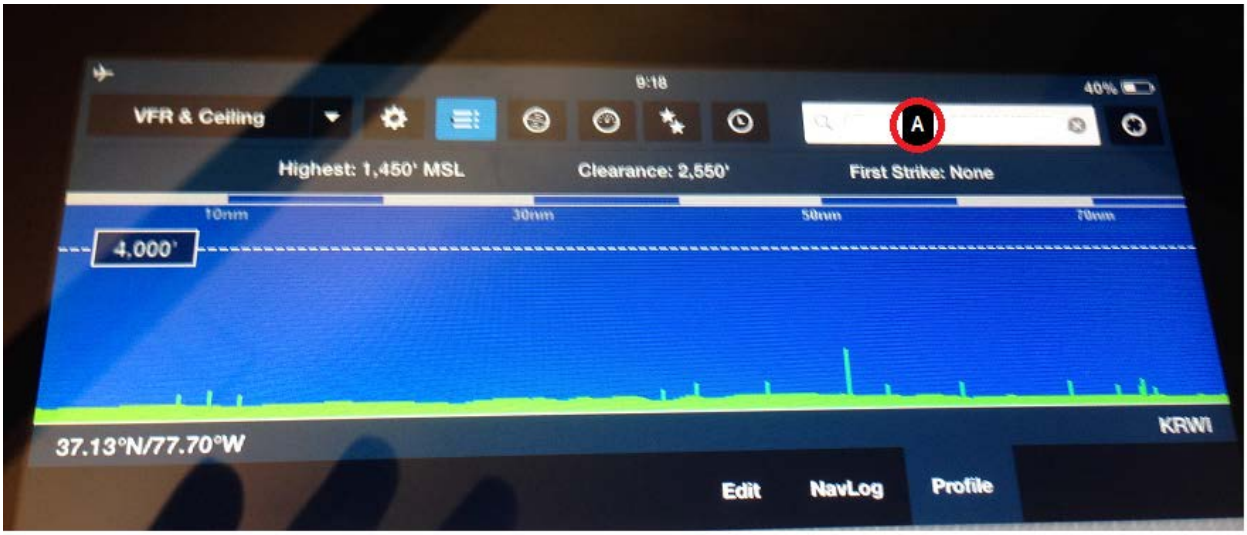


Figure 3. ForeFlight profile view and search box.



2.3. Garmin GPSMAP 496 Device Description

The Garmin GPSMAP 496 is a battery-powered portable 12-channel GPS receiver with a 256-color TFT LCD display screen. The unit includes a built-in Jeppesen database and is capable of receiving XM satellite radio for flight information including NEXRAD radar, lightning, METARs, TAFs, and TFRs. The unit stores date, route-of-flight, and flight-time information for up to 50 flights. A flight record is triggered when groundspeed exceeds 30 knots and altitude exceeds 500 feet, and ends when groundspeed drops below 30 knots for 10 minutes or more. A detailed tracklog – including latitude, longitude, date, time, and GPS altitude information for an unspecified number of points – is stored within the unit whenever the receiver has a lock on the GPS navigation signal. Position is updated within the tracklog as a function of time or distance moved, depending on how the unit has been configured. Once the current tracklog memory becomes full, new information either overwrites the oldest information or the recording stops, depending on how the unit is configured. The current tracklog can be saved to long-term memory and 15 saved tracklogs can be maintained in addition to the current tracklog. Tracklog storage may be activated or de-activated at user discretion. All recorded data is stored in non-volatile memory. The unit contains hardware and software permitting the download of recorded waypoint, route, and tracklog information to a PC via a built-in serial port using the NMEA 0183 version 2.0 protocol. The unit can also communicate with external devices such as a computer using a built in USB port. An internal button-battery is used to back-up power to the internal memory and real-time clock during those periods when main power is removed.

2.3.1. Garmin GPSMAP 496 Data Recovery

Upon arrival at the Vehicle Recorder Laboratory, an exterior examination revealed the device had not sustained any damage. Power was applied to the device and information was downloaded normally, without difficulty.

2.3.2. Garmin GPSMAP 496 Data Description

The data extracted included 32 sessions (10,001 data points) from April 26, 2014 through June 27, 2014. The accident flight was the last flight recorded, starting at 20:36:33 EDT and ending at 9:41:33 EDT on June 27, 2014[2].

2.3.3. Garmin GPSMAP 496 Parameters Provided

Table 1 describes data parameters provided by the GPS device. Date, Time, Latitude, Longitude, and GPS Altitude are recorded by the device. Groundspeed and Track are derived from the recorded parameters. Date and Time were recorded as UTC by the device; 4 hours was subtracted from all UTC values to convert to EDT for this report.

Table 1: GPS Data Parameters

Parameter Name	Parameter Description
Date	Date for recorded data point (MM/DD/YYYY)
Time	Time (EDT) for recorded data point (HH:MM:SS)
Latitude	Recorded Latitude (degrees)
Longitude	Recorded Longitude (degrees)
GPS Alt	Recorded GPS Altitude (feet, MSL[3])
Groundspeed	Average groundspeed between current and previous data point (knots)
Track	Average true course between current and previous data point (degrees)

2.3.4. Garmin GPSMAP 496 Overlays and Corresponding Tabular Data

Figures 4 through 8 were generated using data extracted from the Garmin GPSMAP 496 and overlaid using Google Earth. The weather depicted in Google Earth is not necessarily representative of the weather conditions experienced by the accident flight.

Figure 4 shows an overview of the accident flight. The recording began at 8:36:33 EDT and ended at 9:41:33 EDT. The latitude and longitude from the ForeFlight "maps" page (as discussed in section 2.2 of this report) is shown on the overlay. After take-off, the aircraft proceeded south towards RWI until it was about 12 nautical miles (nm) north of the airport. At about 9:30 EDT, the aircraft turned about 180 degrees towards the north. At the time of this turn, the aircraft was about 19 nm from the IXA airport and 16 nm from the ultimate off-airport landing site.

Figure 5 shows the start of the recording at 1VA0. The aircraft began its take-off at about 8:46:19 EDT, about 10 minutes after the start of the recording. Figure 6 shows the aircraft's top-of-climb at about 8:51:41 EDT at a groundspeed of about 107 knots.

[2] The GPS recorded these times in UTC and they were converted to EDT for this report.
[3] MSL means altitude above mean sea level

By 8:52:45 EDT, the aircraft had accelerated to 140 knots at an altitude of about 4,000 feet.

Figures 7 and 8 focus on the end of the recording. Between 9:28:07 EDT and 9:30:19 EDT, the aircraft decelerated from about 140 knots to 100 knots and climbed from 4,065 feet to about 4,285 feet. At about 9:30:19 EDT, the aircraft began to alter course from south to north. At about 9:35:00 EDT, the aircraft began to turn towards the northeast and descend. The aircraft continued to descend at a groundspeed between 100 knots and 75 knots. The recording ended at 9:41:33 EDT at 253 feet.

Tabular data used to generate figures 4 through 8 are included as Attachment 1 in electronic comma-delimited (.CSV) format.

Figure 4. Accident flight as recorded by Garmin 496.

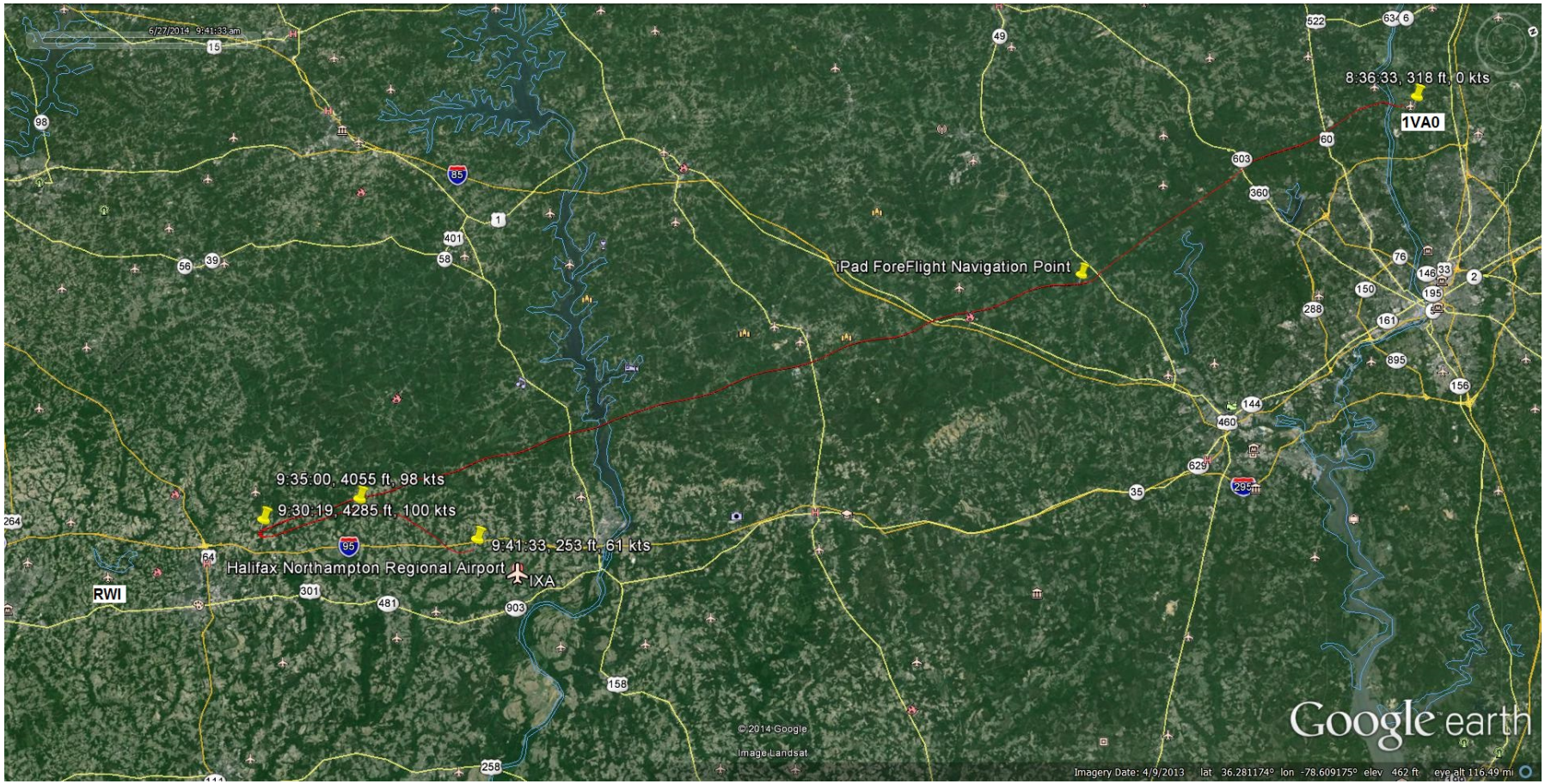


Figure 5. Accident flight start of recording as recorded by Garmin 496.

Figure 6. Accident flight level-off at 4,000 feet as recorded by Garmin 496.

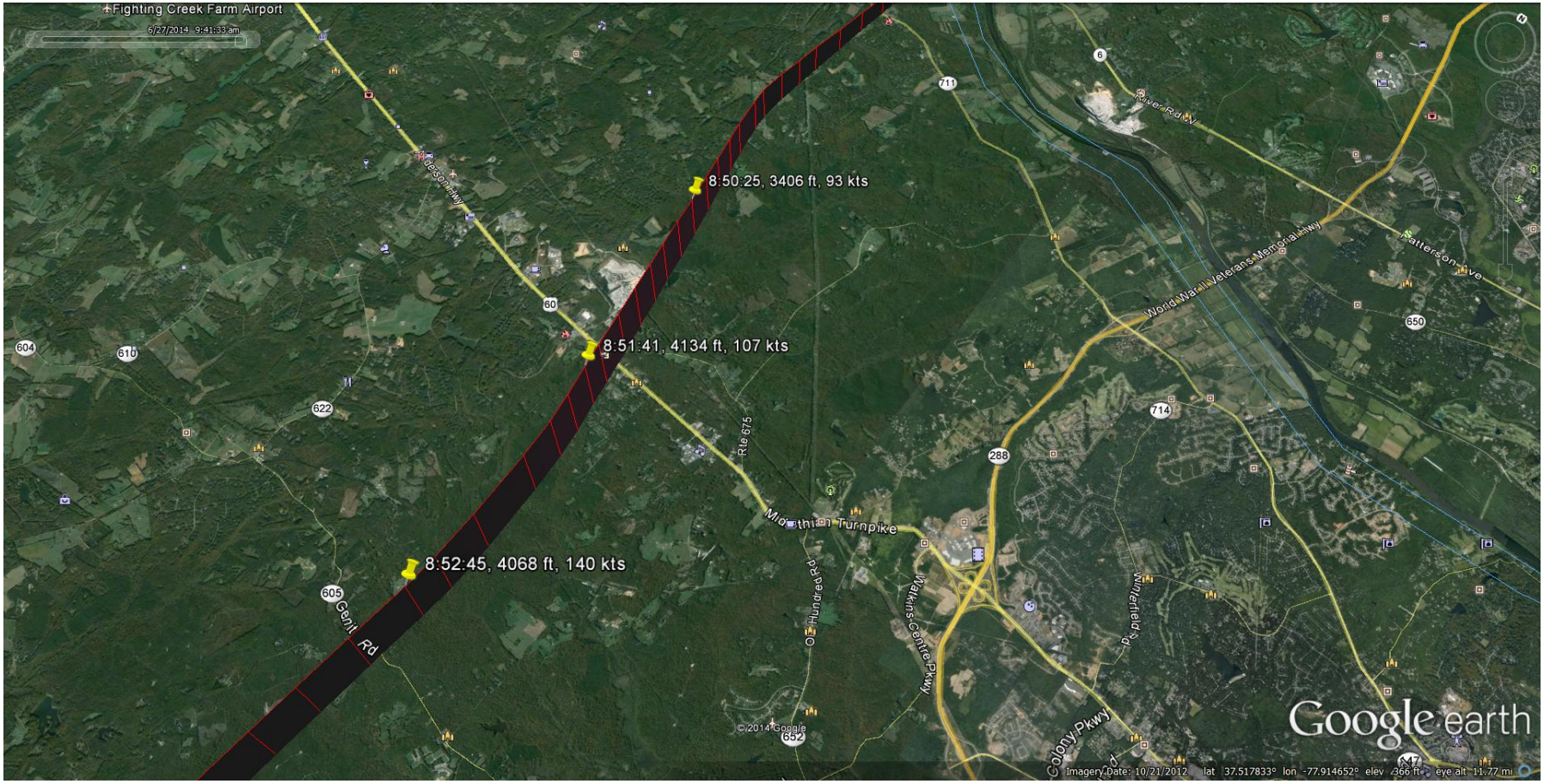


Figure 7. Accident flight change in groundspeed before course reversal as recorded by Garmin 496.

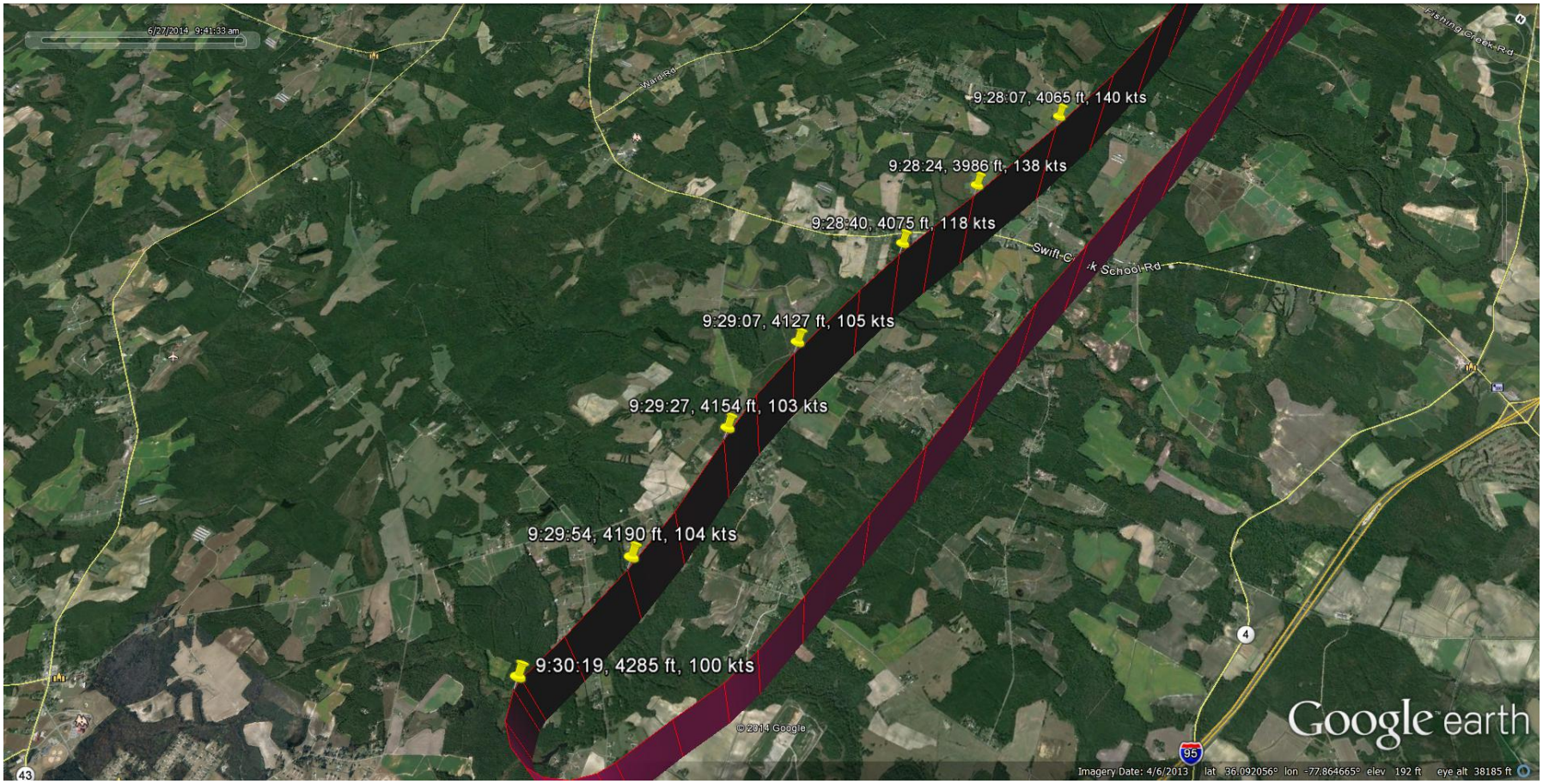
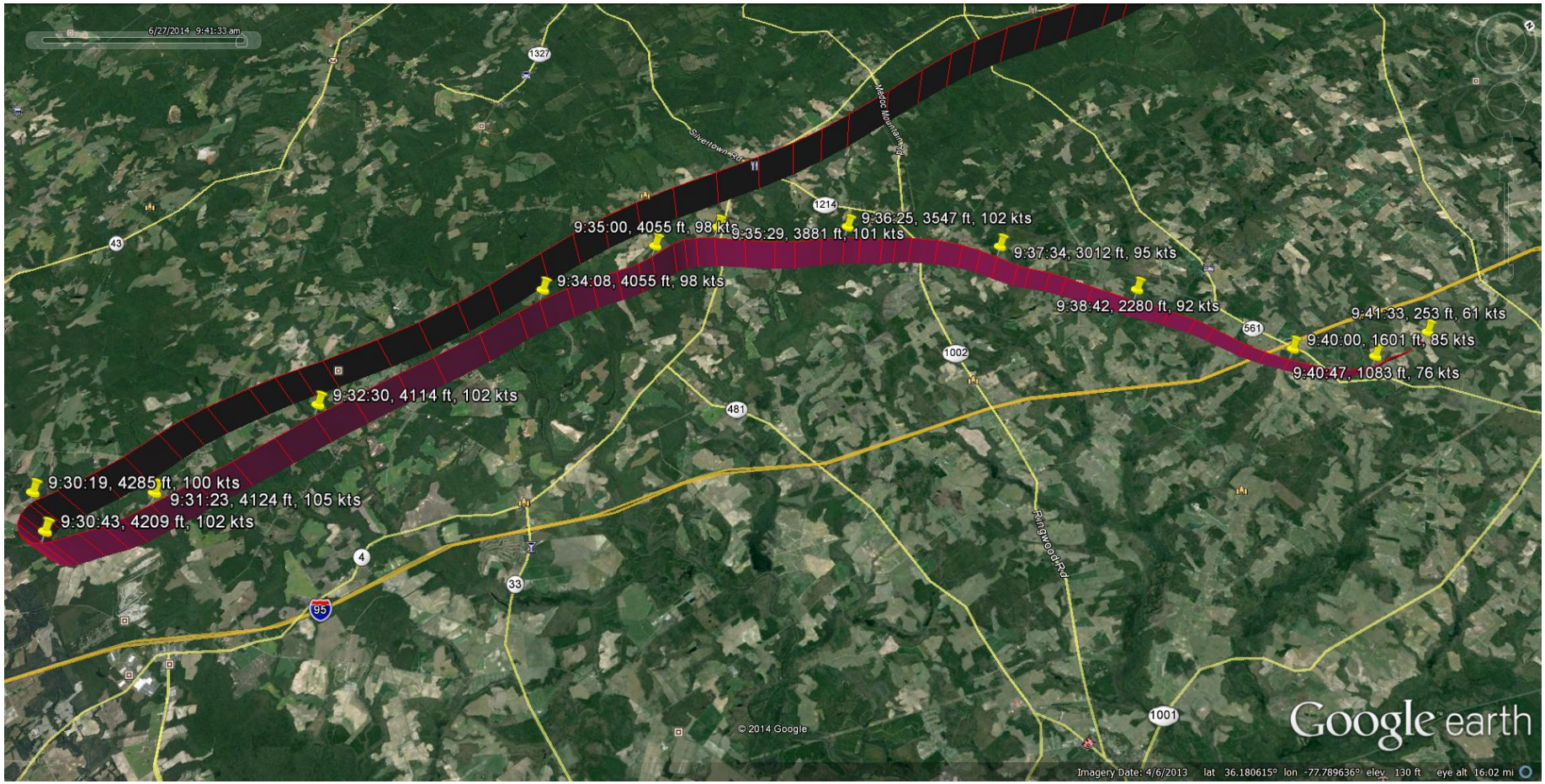


Figure 8. End of accident flight as recorded by Garmin 496.



2.4. JPI EDM-700 Device Description

The J.P. Instruments (JPI) EDM-700 is a panel mounted instrument enabling the operator to monitor and record up to 24 parameters related to engine operations. Depending on the installation, engine parameters monitored can include: exhaust gas temperature (EGT), cylinder head temperature (CHT), oil pressure and temperature, manifold pressure, outside air temperature, turbine inlet temperature (TIT), engine revolutions per minute, compressor discharge temperature, fuel flow, carburetor temperature, and battery voltage.

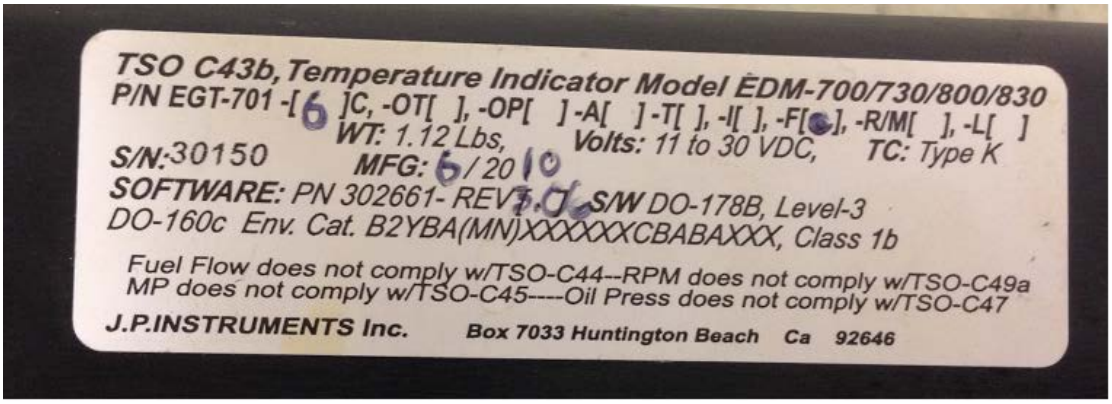
The unit can also calculate, in real-time, horsepower, fuel used, shock cooling rate, and EGT differentials between the highest and lowest cylinder temperatures. The calculations are also based on the aircraft installation.

The unit contains non-volatile memory for data storage of the parameters recorded and calculated. The rate at which the data is stored is selectable by the operator from 2 to 500 seconds per sample. The memory can store up to 20 hours of data at a 6 second sample rate. The data can then be downloaded by the operator using the J.P. Instruments software.

2.4.1. JPI EDM-700 Data Recovery

The device was in good condition and the data were extracted normally. Figure 9 shows a picture of the unit data plate, indicating the firmware revision of 3.06, the number “6” inscribed next to the letter “C,” and a dot next to the letter “F.” There were no entries on the data plate adjacent to the letters “O,” “A,” “T”, “I,” or “R/M.” The number inscribed adjacent to “MFG” was “6/2010”.

Figure 9. JPI EDM-700 dataplate.



2.4.2. JPI EDM-700 Data Description

The unit contained recorded data over 7 power cycles recorded at a sample rate of once every 6 seconds. The recorded data included dates between June 2, 2014,

through the accident flight on June 27, 2014, as recorded by the unit's internal clock. The parameters recorded were EGT, CHT, voltage, and fuel flow. Additionally, the calculated shock cooling rate and maximum difference between EGT sensors was also recorded. No other parameters were recorded by the unit.

This report examined the last flight on the recording on June 27, 2014.

2.4.3. JPI EDM-700 Parameters Provided

The engineering units conversions used for the data contained in this report are based on documentation from the manufacturer of the EDM-700, JPI.

Table 2 describes data parameters provided by the EDM-700. Time is set by the operator and is maintained by an internal clock. When the unit was powered on at the NTSB's Vehicle Recorder Laboratory, the EDM-700 time displayed July 28, 2014 at 11:13. This time corresponded to July 28, 2014 at 06:49 EDT. As a result, 4 hours and 24 seconds was subtracted from EDM-700 time to convert to EDT. Given tolerances of the EDM-700 internal clock and the limitation of only displaying time to the minute on the display, time in this report relative to GPS time may be off by up to 2 minutes.

Table 2: JPI EDM-700 Data Parameters

Parameter Name	Parameter Description
1. BAT (Volts)	Bus Voltage
2. C-1 (degF)	Cylinder Head Temperature Cylinder 1
3. C-2 (degF)	Cylinder Head Temperature Cylinder 2
4. C-3 (degF)	Cylinder Head Temperature Cylinder 3
5. C-4 (degF)	Cylinder Head Temperature Cylinder 4
6. C-5 (degF)	Cylinder Head Temperature Cylinder 5
7. C-6 (degF)	Cylinder Head Temperature Cylinder 6
8. E-1 (degF)	Exhaust Gas Temperature Cylinder 1
9. E-2 (degF)	Exhaust Gas Temperature Cylinder 2
10. E-3 (degF)	Exhaust Gas Temperature Cylinder 3
11. E-4 (degF)	Exhaust Gas Temperature Cylinder 4
12. E-5 (degF)	Exhaust Gas Temperature Cylinder 5
13. E-6 (degF)	Exhaust Gas Temperature Cylinder 6
14. FF (gph)	Fuel Flow
15. Time (hh:mm:ss)	Time of Data Sample
16. USD (gals)	Fuel Used

Note: degF is degrees Fahrenheit; gph is gallons per hour; gals is gallons.

2.4.4. JPI EDM-700 Plots and Corresponding Tabular Data

Some of the plotted EDM-700 data is compared to the Garmin GPSMAP 496 data. For brevity, Garmin GPSMAP 496 data is referred to as "GPS recording" in this narrative.

Figure 10 shows the entire accident flight recording. The EDM-700 recording began at 08:43:22 EDT, about 7 minutes after the GPS recording began. The EDM-700 recording ended at 9:33:14 EDT, about 8 minutes before the GPS recording ended. At about 8:53 EDT, the EGTs rose and stabilized; this was shortly after the aircraft levelled off at 4,000 feet according to the GPS recording.

At 9:27:38 EDT, all the EGTs spiked and then gradually increased as did the CHTs. About 3 minutes after this spike, the aircraft reversed course to the north according to the GPS recording. At 9:31:32 EDT, the voltage dropped from a steady value of 13 Volts to 11 Volts. At about 9:32:32 EDT, the EGTs spiked again and the EDM-700 recording ended shortly thereafter at 9:33:14 EDT. According the GPS recording, the aircraft turned towards the northeast and began to descend shortly thereafter, at about 9:35:29 EDT.

Figure 11 shows a change in EGTs during cruise flight. At about 9:03:04 EDT, all the EGTs decreased by about 70 degF and then increased about 20 degF about 1 minute later.

Figure 12 shows the start of the EDM-700 recording compared to the start of the GPS recording. The plot compares the EDM-700 data to the take-off roll from the GPS recording.

Figure 13 shows the end of the EDM-700 recording. Shortly after the voltage drop, the EDM-700 missed two data samples between 9:31:44 EDT and 9:32:02 EDT. The recording ended as CHT-1 and CHT-3 were increasing and the EGTs had decreased.

Tabular data used to generate figures 10 through 13 are included as Attachment 2 in CSV format.

Figure 10. JPI EDM-700 plot of entire accident recording.

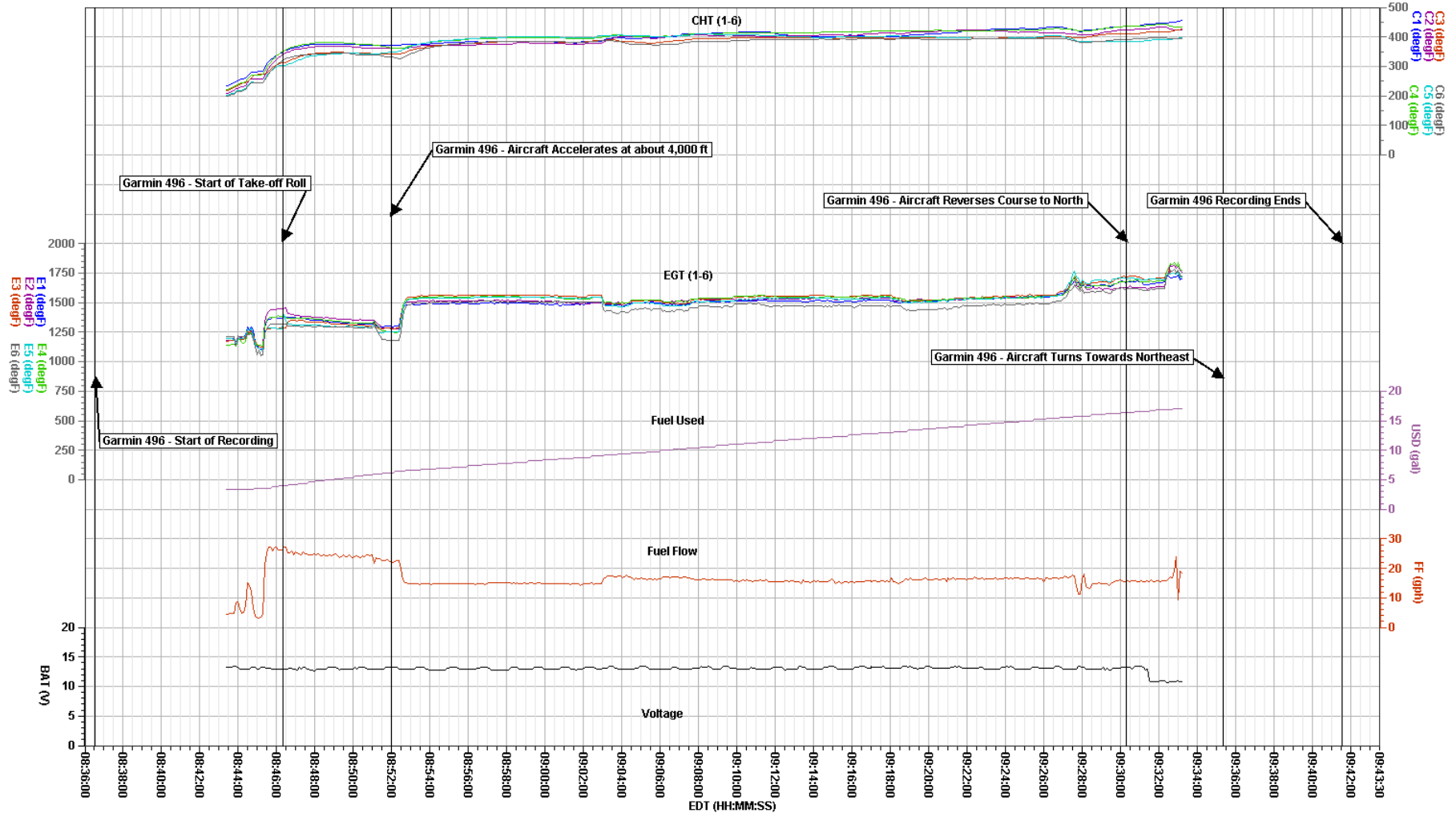


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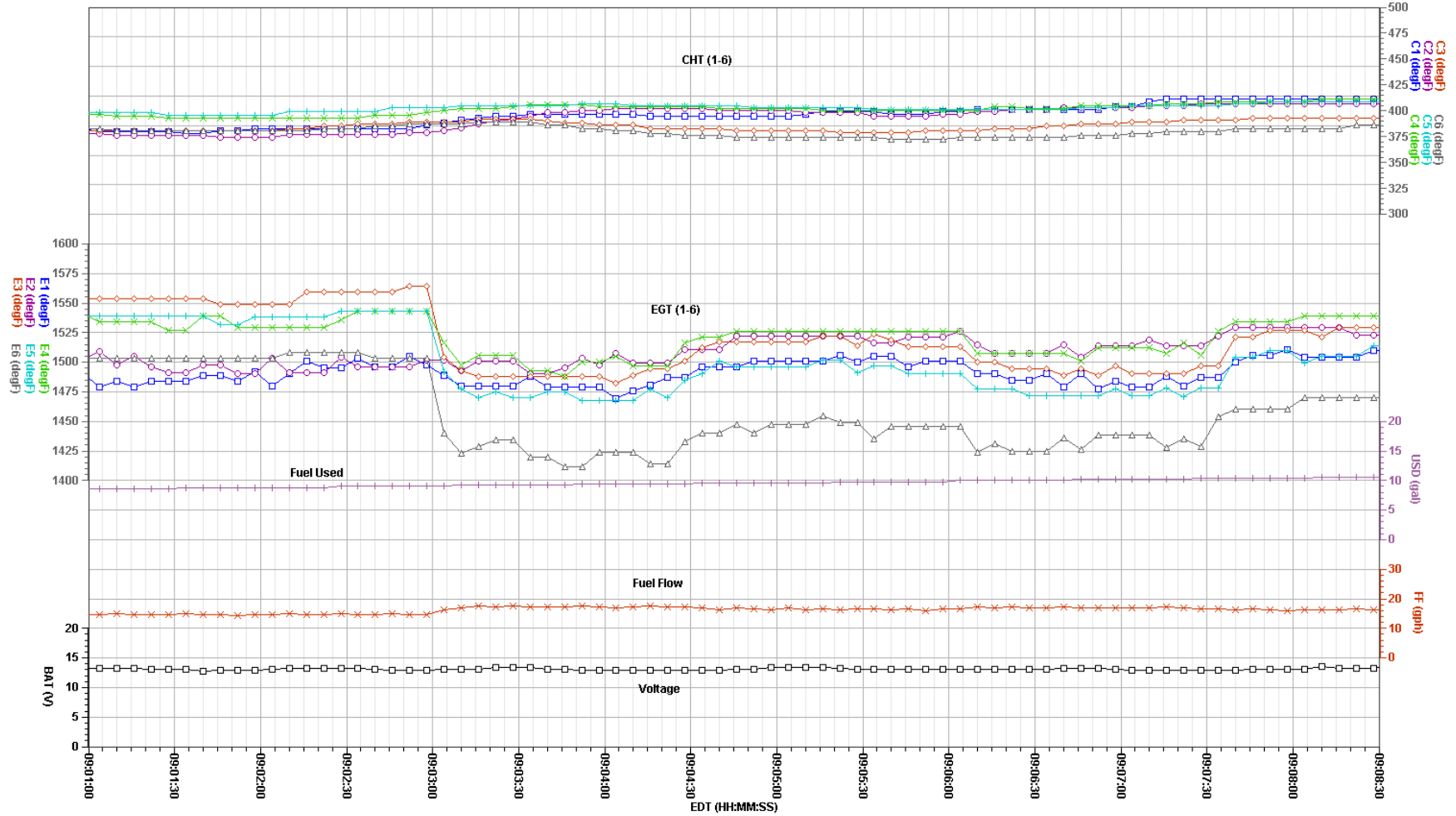
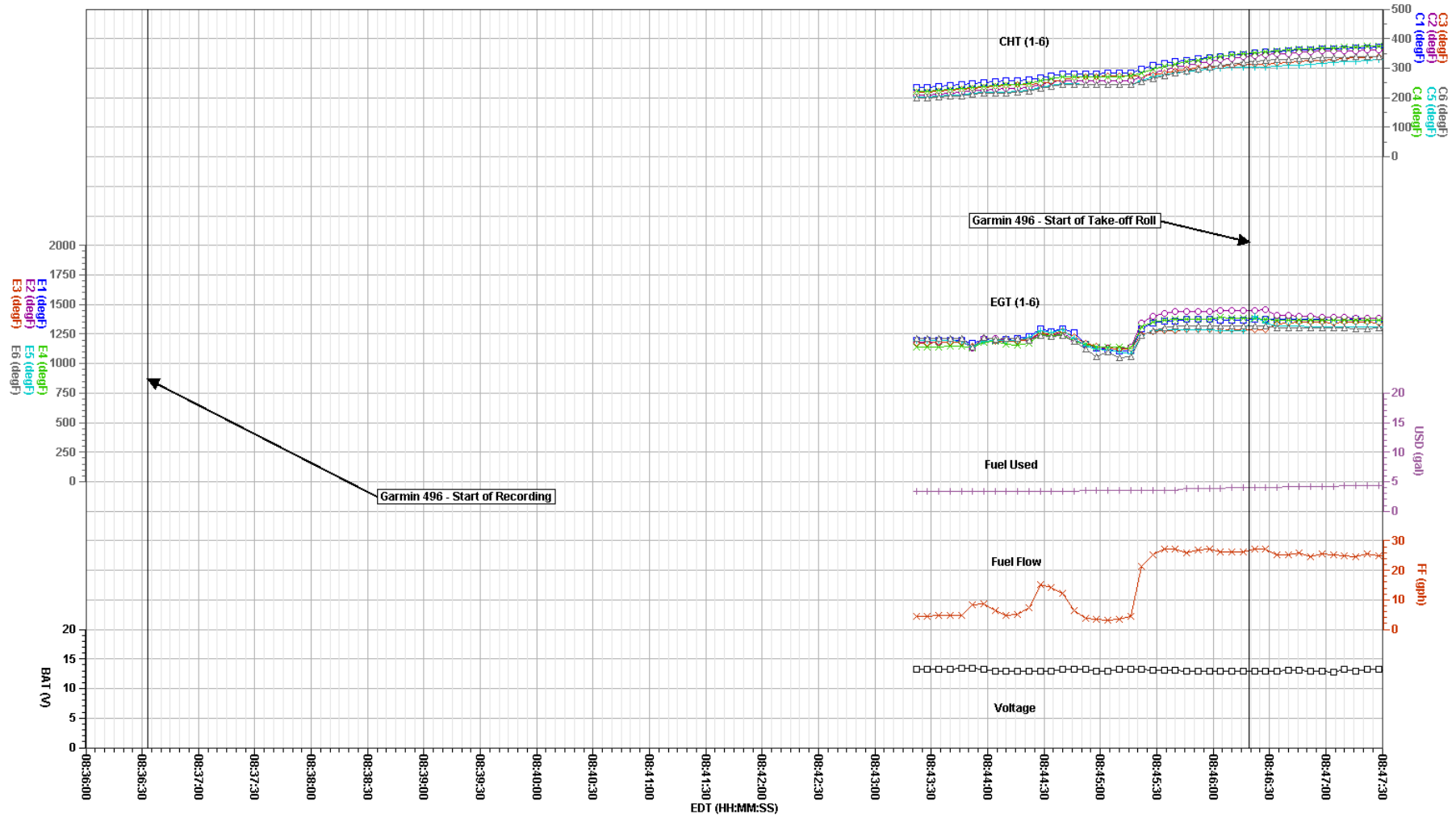
Figure 11. JPI EDM-700 plot of first EGT change in level flight.



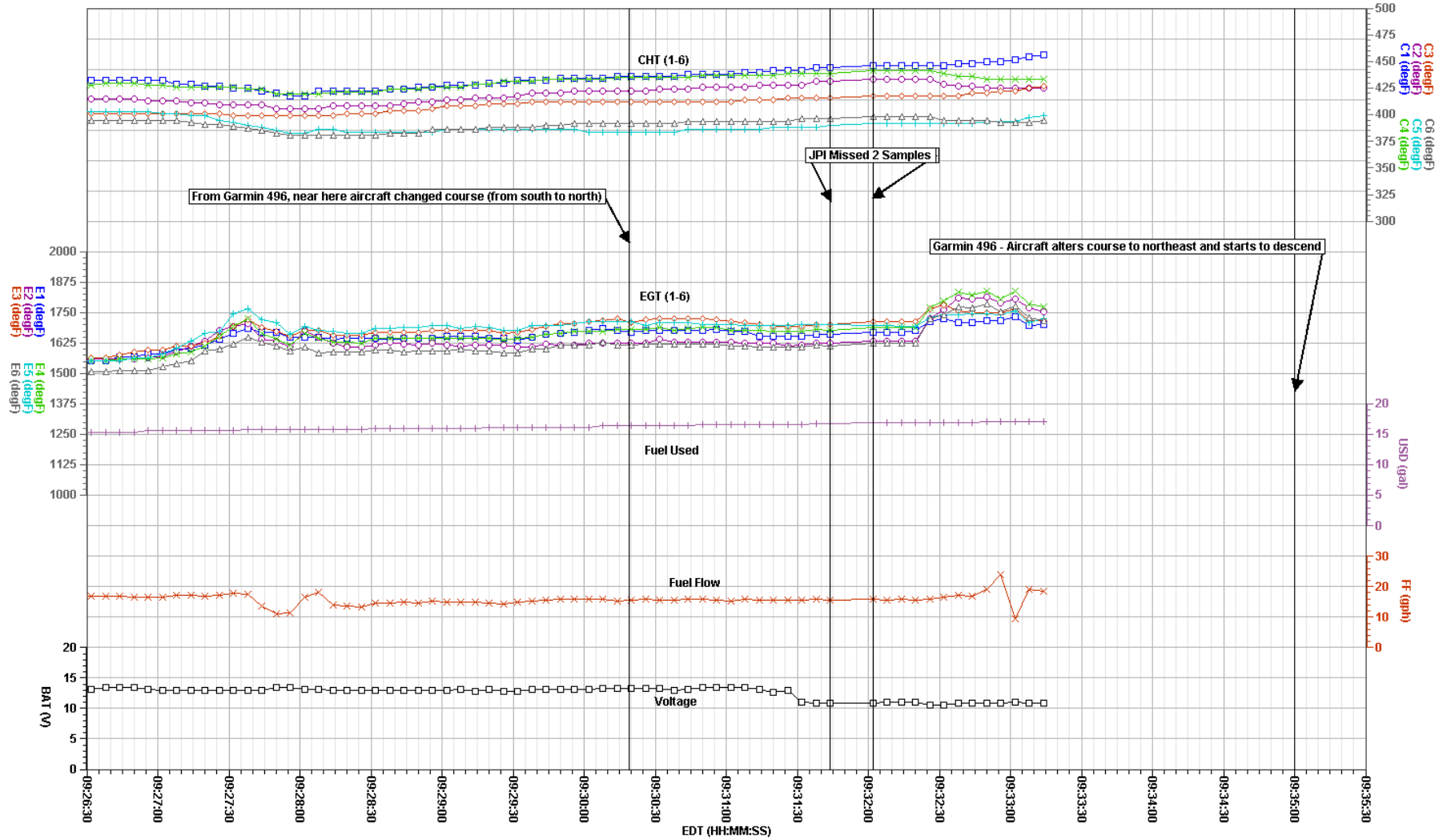
Revised: 28 July 2014 Accident Flight - Around EGT Changes National Transportation Safety Board

Figure 12. JPI EDM-700 plot of start of recording.



Revised: 28 July 2014 Accident Flight - Start of Recording National Transportation Safety Board

Figure 13. JPI EDM-700 plot of end of recording.



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