

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



DCA22LA133

FLIGHT DATA RECORDER

Specialist's Factual Report

February 1, 2023

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A. INCIDENT

Location: Pittsburgh, Pennsylvania
Date: June 21, 2022
Time: 0944 eastern daylight time (EDT)
Airplane: Boeing 737-9 MAX, UAL2627, N37513

B. FLIGHT DATA RECORDER SPECIALIST

Specialist Charles Cates
Mechanical Engineer/Recorder Specialist
National Transportation Safety Board (NTSB)

C. FEDERAL CARRIAGE REQUIREMENTS

The event aircraft, N37513, was operating as Title 14 *Code of Federal Regulations* (CFR) Part 121. The event aircraft was manufactured in 2019 and was operating such that it was required to be equipped with a flight data recorder (FDR) that recorded, at a minimum, 88 parameters, as cited in 14 CFR Part 121.344.

D. DETAILS OF THE INVESTIGATION

An FDR group was not convened. The NTSB Vehicle Recorder Division received the following FDR:

Recorder Manufacturer/Model: Honeywell HFR5-D
Part Number: HFR5-D 4750
Recorder Serial Number: FDR-07790

1.0 Honeywell HFR5-D Description

The Honeywell HFR5-D records airplane flight information in a digital format using solid-state flash memory as the recording medium. The HFR5-D can receive data in the ARINC 573/717/747 configurations and can record a minimum of 25 hours of flight data. It is configured to record 1024 12-bit words of digital information every second. Each grouping of 1024 words (each second) is called a subframe. Each subframe has a unique 12-bit synchronization (sync) word identifying it as subframe 1, 2, 3, or 4. The sync word is the first word in each subframe. The data stream is "in sync" when successive sync words appear at proper 1024-word intervals. Each data parameter (for example, altitude, heading, and airspeed) has a specifically assigned word number within the subframe. The HFR5-D is designed to meet the crash-survivability requirements of TSO-C124b.

1.1 Recorder Condition

The recorder was in good condition and the data were extracted normally from the recorder.

1.2 Recording Description

The FDR recording contained approximately 26.8 hours of data. Timing of the FDR data is measured in subframe reference number (SRN), where each SRN equals one elapsed second. The event flight was not the last flight of the recording, as the aircraft continued for 3 more flights before the recorder was removed. The event flight duration was approximately 1 hour. The parameters evaluated for the purpose of this report appeared to be in accordance with federal FDR carriage requirements.

1.3 Engineering Unit Conversions

The engineering unit conversions used for the data contained in this report are based on documentation from the aircraft manufacturer. Where applicable, the conversions have been changed to ensure that the parameters conform to the NTSB's standard sign convention that climbing right turns are positive (CRT=+).¹

Table 1 lists the FDR parameters verified and provided in this report. Additionally, table 2 describes the unit and discrete state abbreviations used in this report.

1.4 Time Correlation

Correlation of the FDR data from SRN to the event local time, eastern daylight time, was established by using the recorded coordinated universal time (UTC) Hours, UTC Minutes, and UTC Seconds and then applying an additional 4 hours offset to change UTC to EDT.

Accordingly, the time offset for the event flight data from SRN to local EDT is the following: $EDT = SRN - 19089.375$. Therefore, for the rest of this report, all times are referenced as EDT, not SRN.

¹ 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 = +, Right Rudder = +.

E. FIGURES AND TABULAR DATA

Figures 1 to 5 contain FDR data recorded during the event on June 21, 2022. All the parameters listed in table 1 are plotted except UTC Hours, UTC Minutes, UTC Seconds, Latitude, and Longitude.

Figure 1 is an overview of relevant basic parameters from the entire incident flight from 0840:00 to 0946:00 EDT. Figure 2 is an overview of select autoflight parameters from the same time frame. Figure 3 is FMC parameters from 0939:40 to 0941:30 EDT, the time around the FMC blanking incident. Figures 4 and 5 are map overlays in Google Earth covering the entire incident flight and the approach portion of the incident flight, respectively. Note that weather and lighting conditions in Google Earth may not be representative of the weather and lighting conditions at the time of the incident.

These figures are configured such that right turns are indicated by the trace moving toward the bottom of the page and left turns toward the top of the page.

In summary, the data show that the flight departed Chicago at about 0845:00 EDT. The autopilot was engaged at 0850:47 EDT and the aircraft climbed to 33,000 feet (FL330), and cruised at altitude for about 13 minutes. Initial descent into Pittsburgh began at about 0918:50 EDT. Autopilot was in use for the remainder of the flight until it was turned off during the final portion of the descent into Pittsburgh.

The Flight Management Computer (FMC) valid parameter was in the VALID state for the full duration of the flight. At about 0940:17, while on descent into Pittsburgh at an altitude of about 3,950 ft, parameters sourced from the FMC began to show an error pattern consistent with the recorder not receiving data from their FMC ARINC data bus words. FMC-sourced parameters include latitude and longitude, track and drift angles, wind speed and direction, groundspeed, and FMC select parameters. According to the manufacturer, the fault condition must be present for at least four successive data points before it will be annunciated in the output data frame. Based on the sampling rate of the affected parameters, this means the data loss condition likely began at 0940:13.

The error pattern continued in the FMC-sourced data for about 13 seconds, at which time it transitioned to a No Computed Data (NCD) error pattern. NCD is consistent with the system transmitting data on its ARINC label which is not reliable. The NCD pattern continued for about 6 seconds before valid data was again received by the FDR at 0940:36. The location of the FMC loss of data can be seen in Figure 5. The line between the two markers is the FMC data gap, and is interpolated between the dropout and return of data.

The flight continued and the autopilot was disconnected at 0942:07 EDT at about 2,650 ft. The aircraft was turning onto its final approach course at the time, and

it ultimately aligned with runway 28L. The aircraft touched down on 28L at 0944:42 EDT.

The corresponding tabular data used to create figures 1 to 5, including UTC Hours, UTC Minutes, UTC Seconds, Latitude, and Longitude, are provided in electronic comma-separated value (CSV) format as attachment 1 to this report.

Submitted by:

Charles Cates
Mechanical Engineer/Recorder Specialist

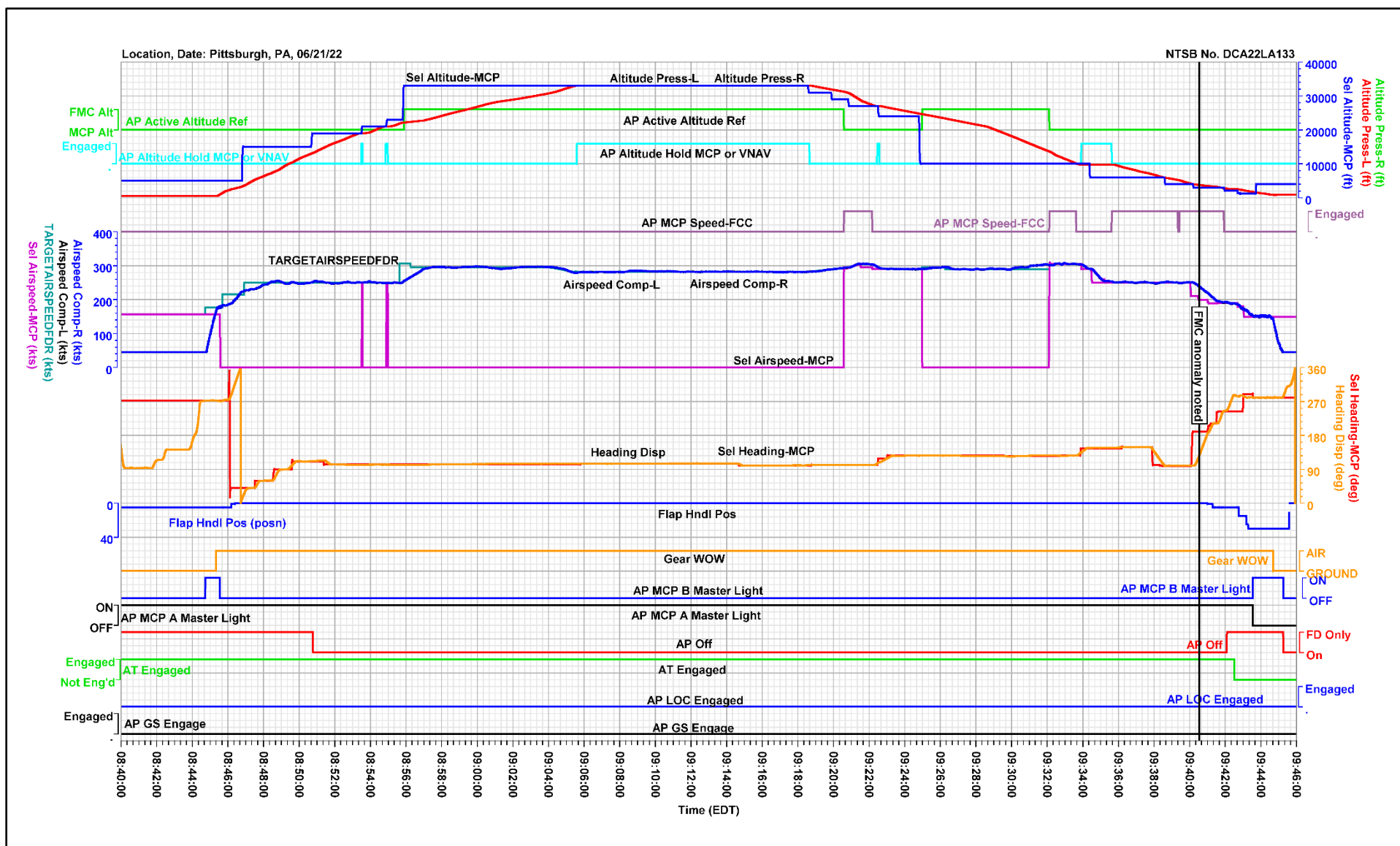


Figure 1. Plot of selected basic and autoflight parameters from the full incident flight

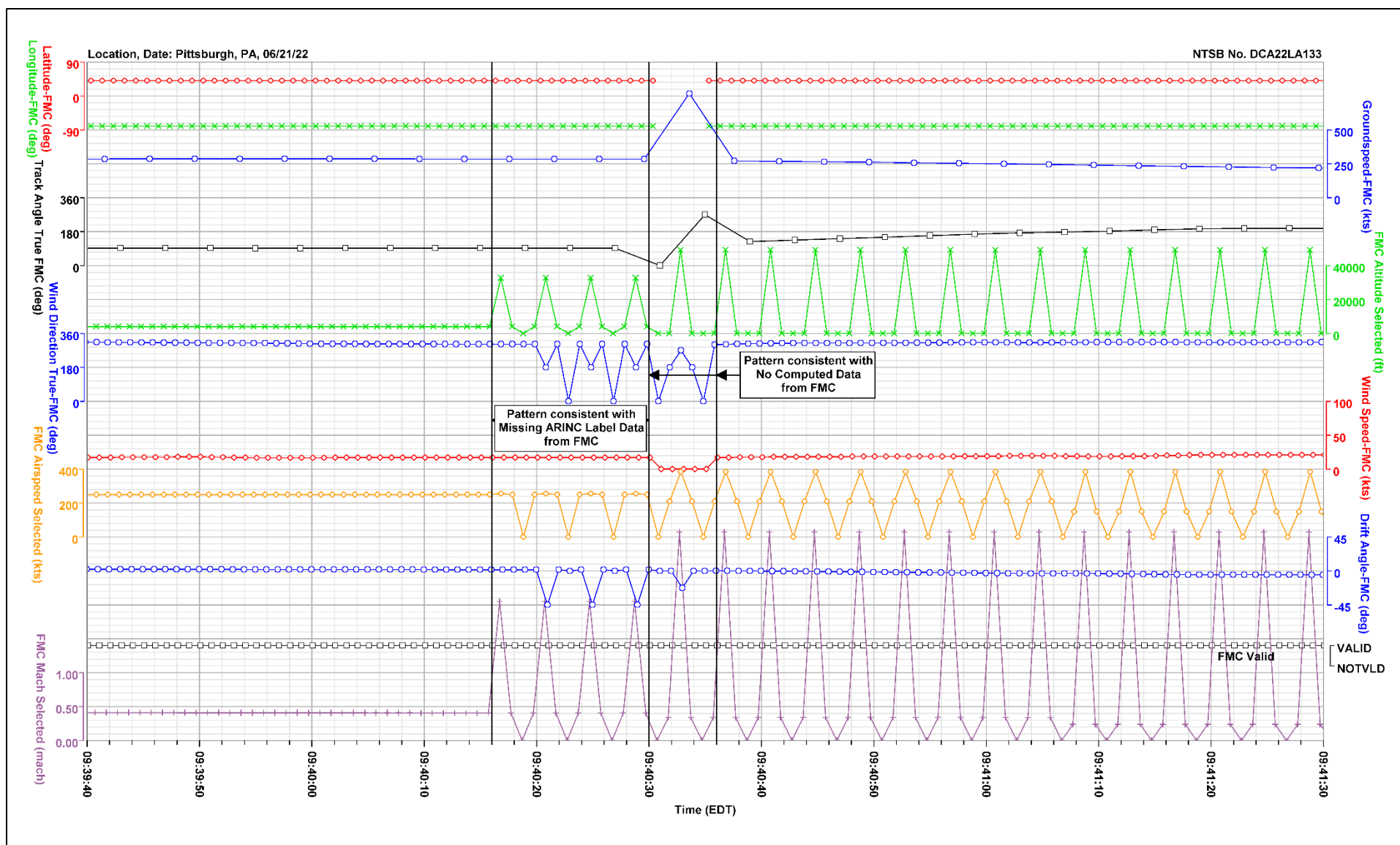


Figure 3. Plot of FMC data pointing to anomaly in FMC system.

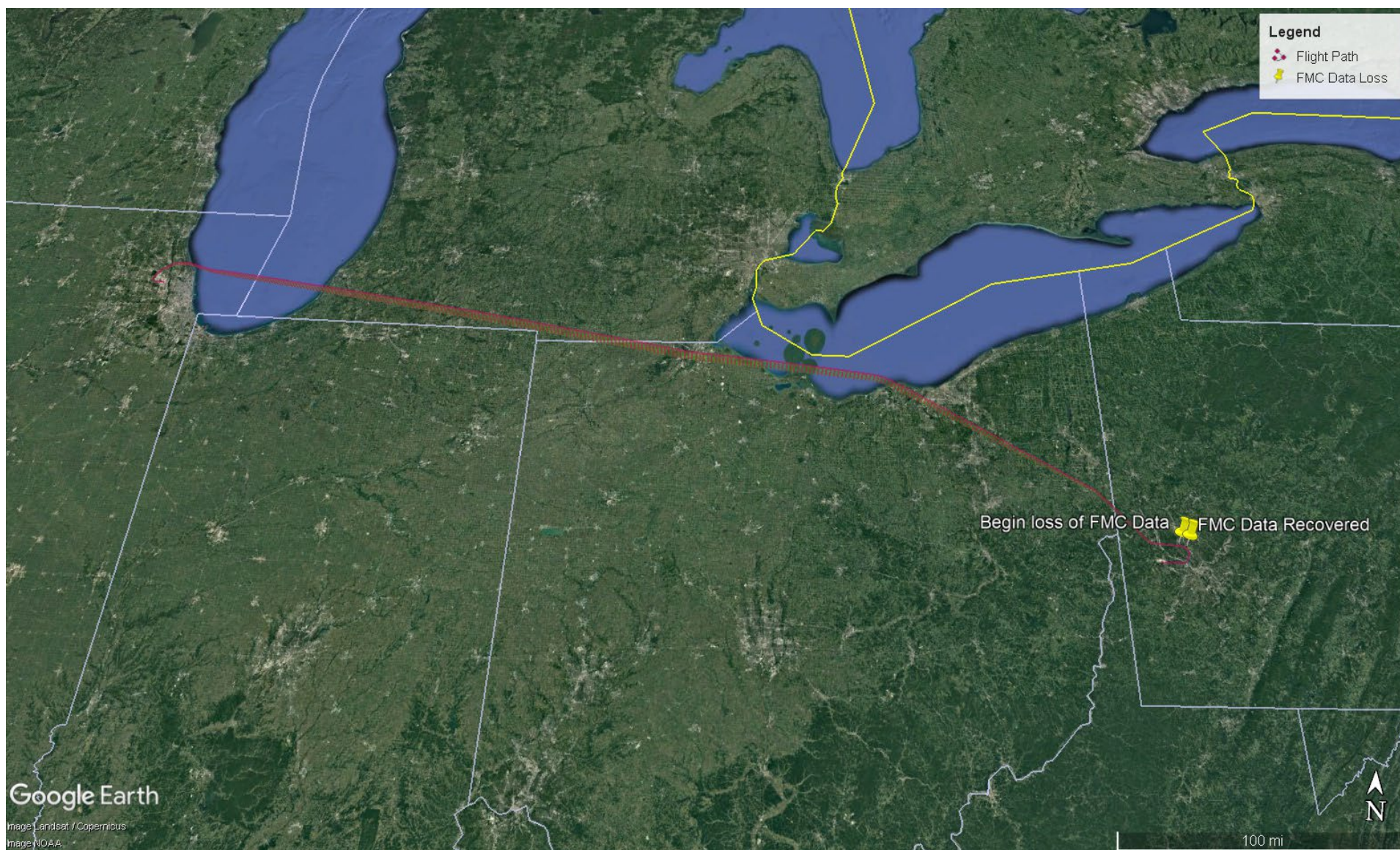


Figure 4. Map overlay showing path of incident flight and FMC anomaly.

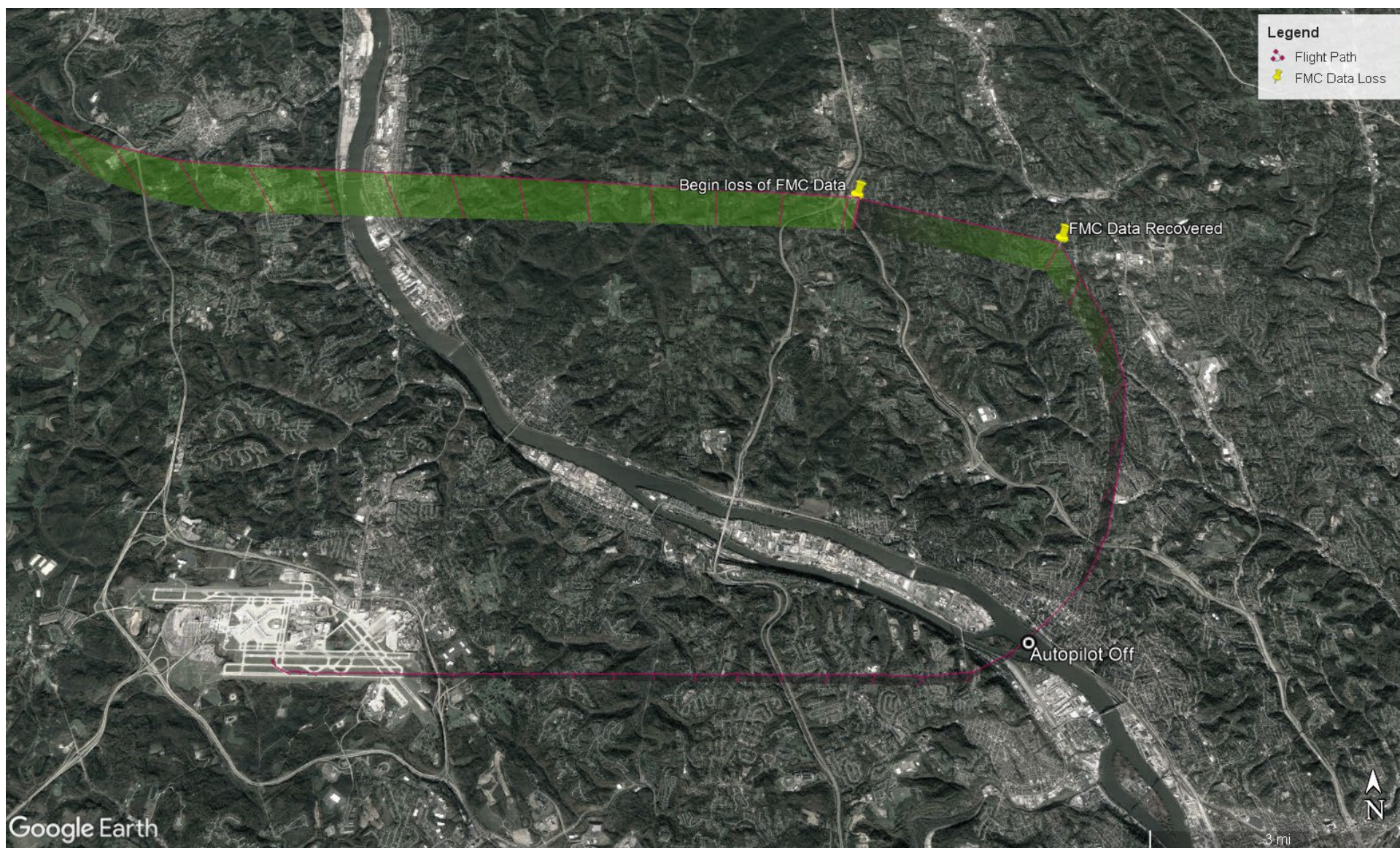


Figure 5. Map overlay showing locations of FMC anomaly and Autopilot off.

APPENDIX A. VERIFIED AND PROVIDED PARAMETERS

This appendix describes the parameters provided and verified in this report. Table 1 lists the plot/table labels, parameter names, and units. Additionally, table 2 describes the unit and discrete state abbreviations used in this report.

Table 1. Verified and provided FDR parameters

Plot/Table Label	Parameter Name/Description	Units
1. Airspeed Comp-L	Computed Airspeed from Left ADIRU	kts
2. Airspeed Comp-R	Computed Airspeed from Right ADIRU	kts
3. Altitude Press-L	Pressure Altitude from Left ADIRU	ft
4. Altitude Press-R	Pressure Altitude from Right ADIRU	ft
5. AP Active Altitude Ref	Autopilot Altitude Reference Source	
6. AP Altitude Hold MCP or VNAV	Autopilot Altitude Hold Mode	
7. AP CMD A	Autopilot A in Command	
8. AP CWS Pitch	Autopilot Control Wheel Steering Pitch	
9. AP FD A On	Flight Director A On	
10. AP FD B On	Flight Director B On	
11. AP GS Engage	Autopilot Glideslope Engaged	
12. AP Heading Sel	Autopilot Heading Select Mode	
13. AP LNAV Engage	Autopilot Lateral Navigation Mode Engaged	
14. AP LOC Engaged	Autopilot Localizer Engaged	
15. AP MCP A Master Light	Mode Control Panel A Master Light On	
16. AP MCP Alt Hold PB Lite	Mode Control Panel Alt Hold Pushbutton Light On	
17. AP MCP B Master Light	Mode Control Panel B Master Light On	
18. AP MCP CWS Warn	Mode Control Panel Control Wheel Steering Warning	
19. AP MCP Hdg Sel PB Lite	Mode Control Panel Hdg Sel Pushbutton Light On	
20. AP MCP IAS Display	Mode Control Panel displaying IAS or Mach	
21. AP MCP LNAV PB Lite	Mode Control Panel LNAV Pushbutton Light On	
22. AP MCP Lvl Chg PB Lite	Mode Control Panel Lvl Chg Pushbutton Light On	
23. AP MCP Spd PB Lite	Mode Control Panel Spd Pushbutton Light On	
24. AP MCP Speed-FCC	Mode Control Panel Speed from FCC Engaged	
25. AP MCP V/S PB Lite	Mode Control Panel V/S Pushbutton Light On	
26. AP MCP VNAV PB Lite	Mode Control Panel VNAV Pushbutton Light On	
27. AP Off	Autopilot Off	
28. AP VS Arm	Autopilot Vertical Speed Mode Armed	
29. AP Warn Capt	Autopilot Warning - Captain Side	
30. AP Warn FO	Autopilot Warning - First Officer Side	
31. AT Engaged	Autothrottle Engaged	
32. Drift Angle-FMC	Flight Path Drift Angle	deg
33. Flap Hndl Pos	Flap Handle Position	posn
34. FMC Airspeed Selected	Flight Management Computer Airspeed Selected	kts
35. FMC Altitude Selected	Flight Management Computer Altitude Selected	ft
36. FMC Mach Selected	Flight Management Computer Mach Selected	Mach
37. FMC Valid	Flight Management Computer Valid	
38. Gear WOW	Landing Gear Weight on Wheels	
39. Groundspeed-FMC	Ground Speed	kts

Plot/Table Label	Parameter Name/Description	Units
40. Heading Disp	Displayed Heading	deg
41. Sel Airspeed-MCP	Mode Control Panel Selected Airspeed	kts
42. Sel Altitude-MCP	Mode Control Panel Selected Altitude	ft
43. Sel Heading-MCP	Mode Control Panel Selected Heading	deg
44. TARGETAIRSPEEDFDR	Target Airspeed	kts
45. Wind Direction-FMC	Wind Direction	deg
46. Wind Speed-FMC	Wind Speed	kts

Note: This FDR records pressure altitude, which is based on a standard altimeter setting of 29.92 inches of mercury (in Hg). The pressure altitude information presented in the FDR plots and in the electronic data has not been corrected for the local altimeter setting at the time of the event.

Note: Parameters with a blank unit description in table 1 are discretes. A discrete is typically a 1-bit parameter that is either a 0 state or a 1 state where each state is uniquely defined for each parameter.

Table 2. Unit and discrete state abbreviations

Unit and Discrete State Abbreviation	Description
ADIRU	Air Data Inertial Reference Unit
AP	Autopilot
AT	Autothrottle
CMD	Command
CWS	Control Wheel Steering
deg	degrees
FD	Flight Director
FMC	Flight Management Computer
ft	feet
Hdg	Heading
IAS	Indicated Airspeed
kts	knots
LNAV	Lateral Navigation
Lvl Chg	Level Change
MCP	Mode Control Panel
posn	Position
Sel	Select
Spd	Speed
VNAV	Vertical Navigation
VS	Vertical Speed
WOW	Weight on Wheels