

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



ERA22FA141

COCKPIT DISPLAYS

Specialist's Factual Report

January 8, 2024

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A. ACCIDENT

Location: St. Augustine, Florida
Date: March 2, 2022
Time: 1702 eastern standard time (EST)
Airplane: Extra NG, N100NG

B. COCKPIT DISPLAYS SPECIALIST

Specialist David Case
Computer Engineer / Vehicle Recorder Specialist
National Transportation Safety Board (NTSB)

C. DETAILS OF THE INVESTIGATION

A Garmin G3X Displays group was not convened.

The NTSB Vehicle Recorder Division received the following devices:

Recorder Manufacturer/Model: Garmin G3X Touch
Part Number: GDU 460
Recorder Serial Number: 350003137

Recorder Manufacturer/Model: Garmin G3X Touch
Part Number: GDU 450
Recorder Serial Number: 34V000571

1.0 Garmin G3X Display Description

The Garmin G3X series of cockpit displays are touch screen avionics devices designed to serve as primary flight displays (PFD). They are capable of showing air data, attitude, magnetic heading, engine information, global positioning system(GPS)/mapping, radio and autopilot control information (dependent on installed options).

G3X series displays record all log data to an internal non-volatile memory (NVM),¹ which can be copied to a Secure Digital (SD) card inserted into the front of the display. Recorded data is dependent on device configuration, and installed options.

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

In this particular aircraft the G3X displays were configured as a larger (GDU-460) display for the rear seat pilot position, and a smaller display (GDU-450) for the front seat.

1.1 Garmin G3X Display Log Data Recovery

Both Garmin G3X displays were damaged in the event. The extent of the damage is shown in figures 1 through 4.

The accident displays were immersed in brackish water, and corrosion formed (see connectors on figures 2 and 4). Neither display would start up when connected to a bench power supply. The NVM chip was removed from the circuit board on the pilot's display and read with lab equipment. The data on the memory chip appeared valid but was not immediately decodable. The data was copied to a new chip, soldered on to a surrogate Garmin G3X display and was read from the surrogate device using the manufacturer's suggested procedure via an SD Card.



Figure 1. The pilot's G3X (GDU-460) display.



Figure 2. The back of the pilot's G3X (GDU-460) display.



Figure 3. The front seat G3X (GDU-450) display.



Figure 4. The back of the front seat G3X (GDU-450) display.

1.2 Garmin G3X Data Description

The data extracted included several recorded sessions in one Comma Separated Value (CSV) file. The accident flight was found in the data file, saved separately, and read with lab software.

G3X displays record data at varying sample rates dependent on when a recorded value changes. For example, they record separate complete log entries of all recorded parameters when only 1 parameter may have changed.

In the following excerpt from the recorded data of this accident latitude values could be seen to change without a corresponding change in longitude, (table 1). This behavior gives the corresponding graphs and overlays a jagged appearance.

```
2022-03-02, 17:09:17, 1803963, +29.8230753, -82.0666463, 959, 3DDiff
2022-03-02, 17:09:17, 1804013, +29.8241119, -82.0666463, 959, 3DDiff
2022-03-02, 17:09:17, 1804113, +29.8241119, -82.0666463, 959, 3DDiff
2022-03-02, 17:09:17, 1804163, +29.8241119, -82.0666463, 959, 3DDiff
```

The plots produced from this data can appear non-linear when magnified, as shown in figure 5.

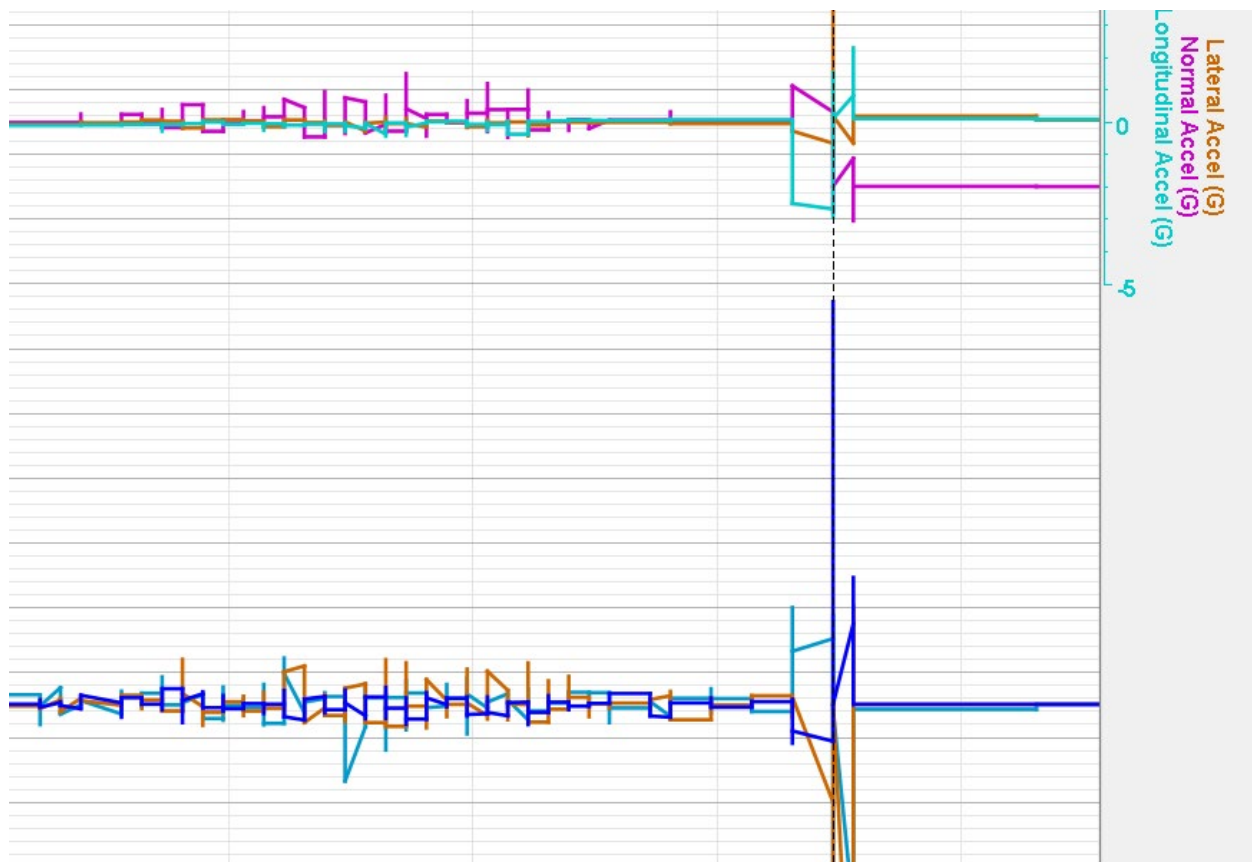


Figure 5. Magnified view of acceleration and rate data collected from the G3X Display.

The Google Earth graphical overlay data was reduced to only show positions after both the latitude and longitude changed. This provided a better visual indication of the underlying data.

The entire flight is recorded in the log, including several minutes after the accident. The data included in this report is provided in CSV format as attachment 1 to this report.

1.2.1 Garmin G3X Engineering Unit Conversions

The flight log data stored in the individual files were converted to engineering units by the surrogate display when it wrote the log to the SD card.

Appendix A lists the parameters verified and provided in this report.

1.3 Garmin G3X Time Correlation

G3X displays record time in Universal Coordinated Time (UTC) which is derived from the built in GPS receiver.

Correlation of the data to the event local time, EST, was established by subtracting 5 hours from the recorded time (UTC). Therefore, for the rest of this report, all times are referenced as EST, not recorded time.

D. FIGURES AND TABULAR DATA

Figures 6 and 7 are Google Earth graphical overlays of GPS position from the pilot's G3X display. Figure 6 provides an overview of the entire flight, and figure 7 is focused on the end of the flight and the accident. The position at which the recorded data indicated an oil pressure loss is noted on the aircraft track. Map imagery taken from Google Earth is not indicative of the actual weather or lighting conditions on the accident day.

Figures 8 and 9 are plots of flight data parameters from the event on March 2, 2022. Figure 8 is a plot of the entire recording, and figure 9 is the accident sequence. Flight data is represented in the board standard 'Climbing Right Turns are Positive' format.

Figures 10 and 11 are plots of engine data parameters. Figure 10 is a plot of the entire recording, and figure 11 is the accident sequence.

The corresponding tabular data used to create figures 6 to 11 are provided in electronic comma-separated value (CSV) format as attachment 1 to this report.

Submitted by:

David L. Case
Computer Engineer / Vehicle Recorder Specialist

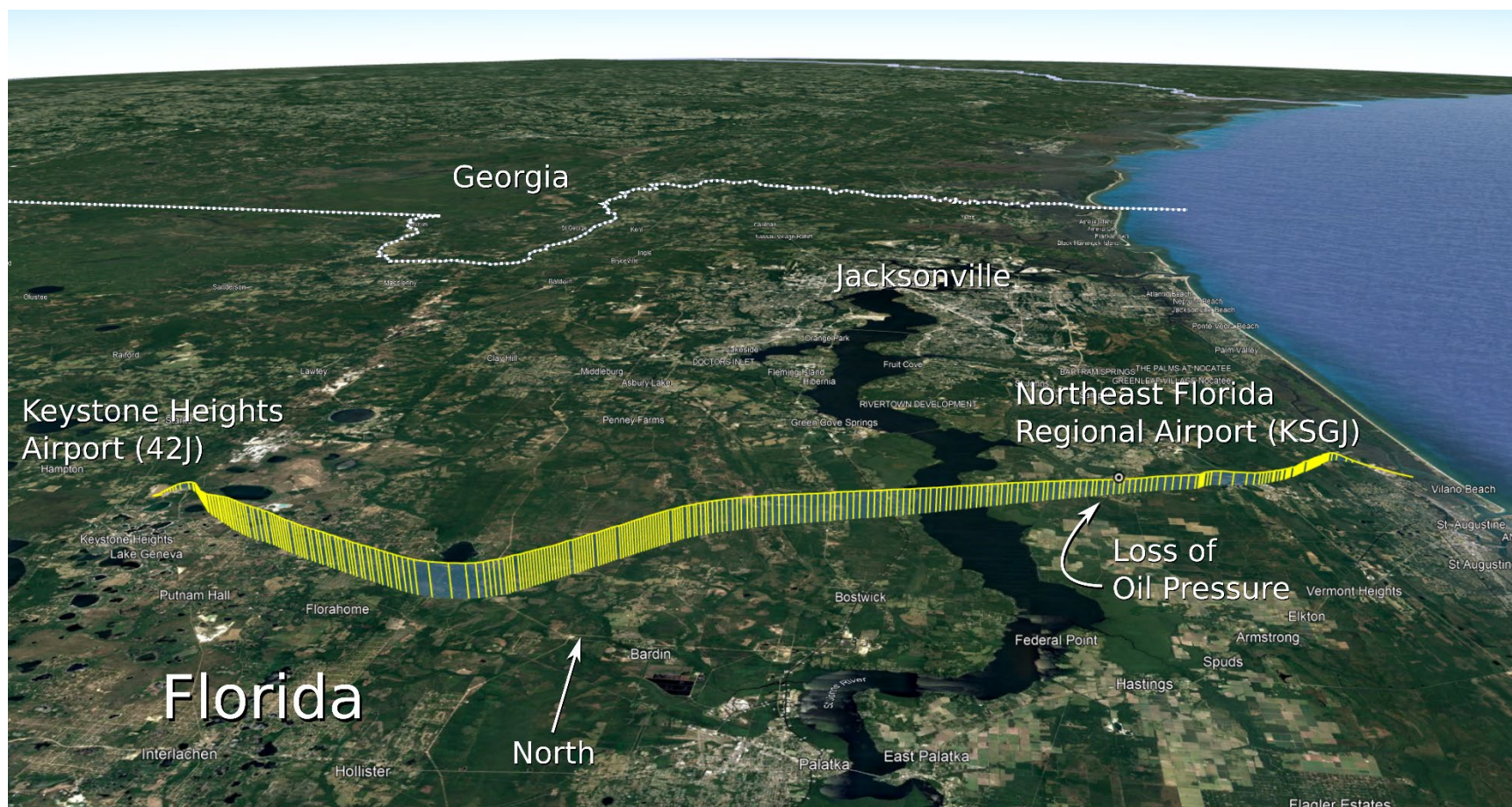


Figure 6. Google Earth overlay of the entire flight.

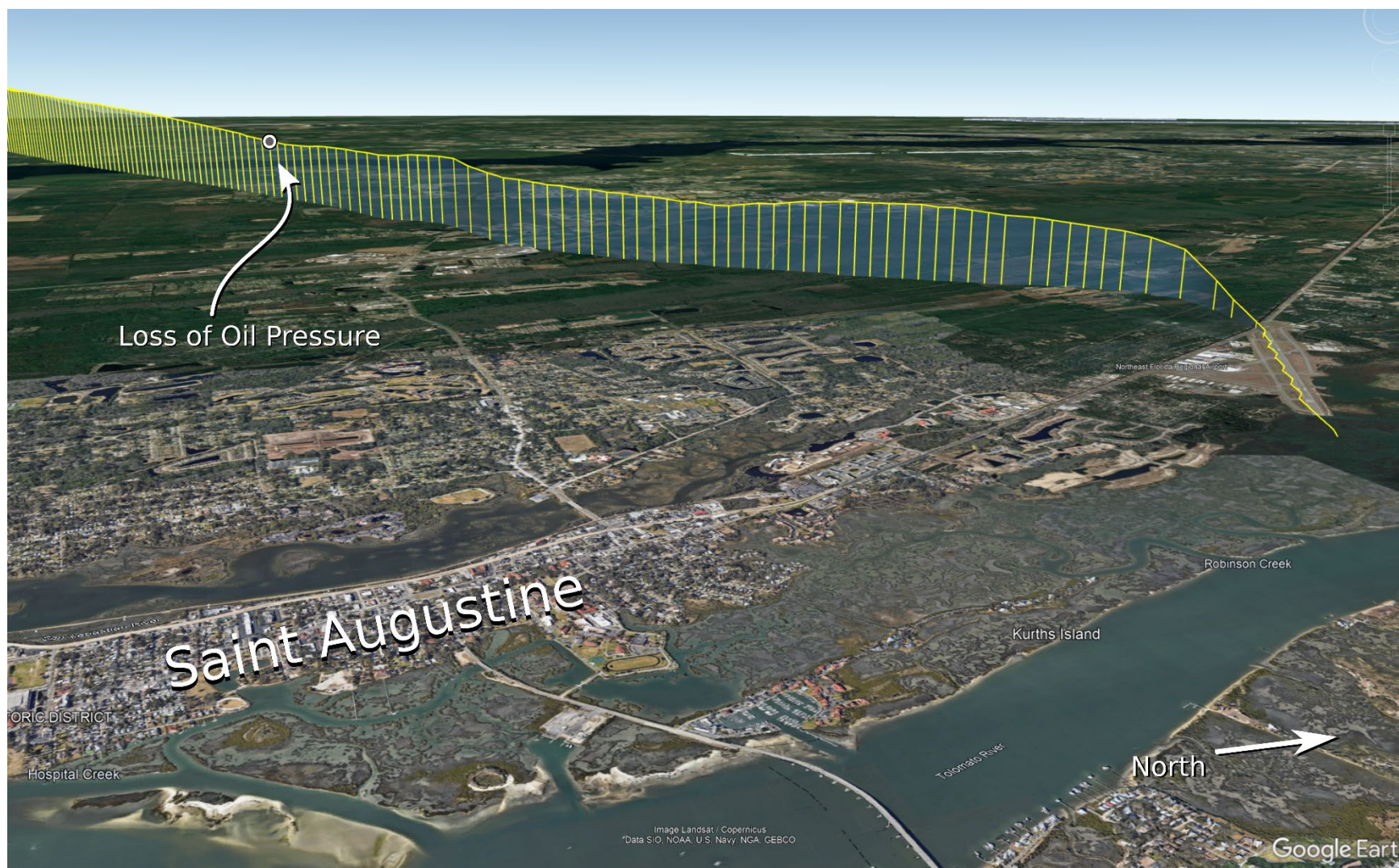


Figure 7. Google Earth overlay of the end of the flight.

Extra NG, N100NG

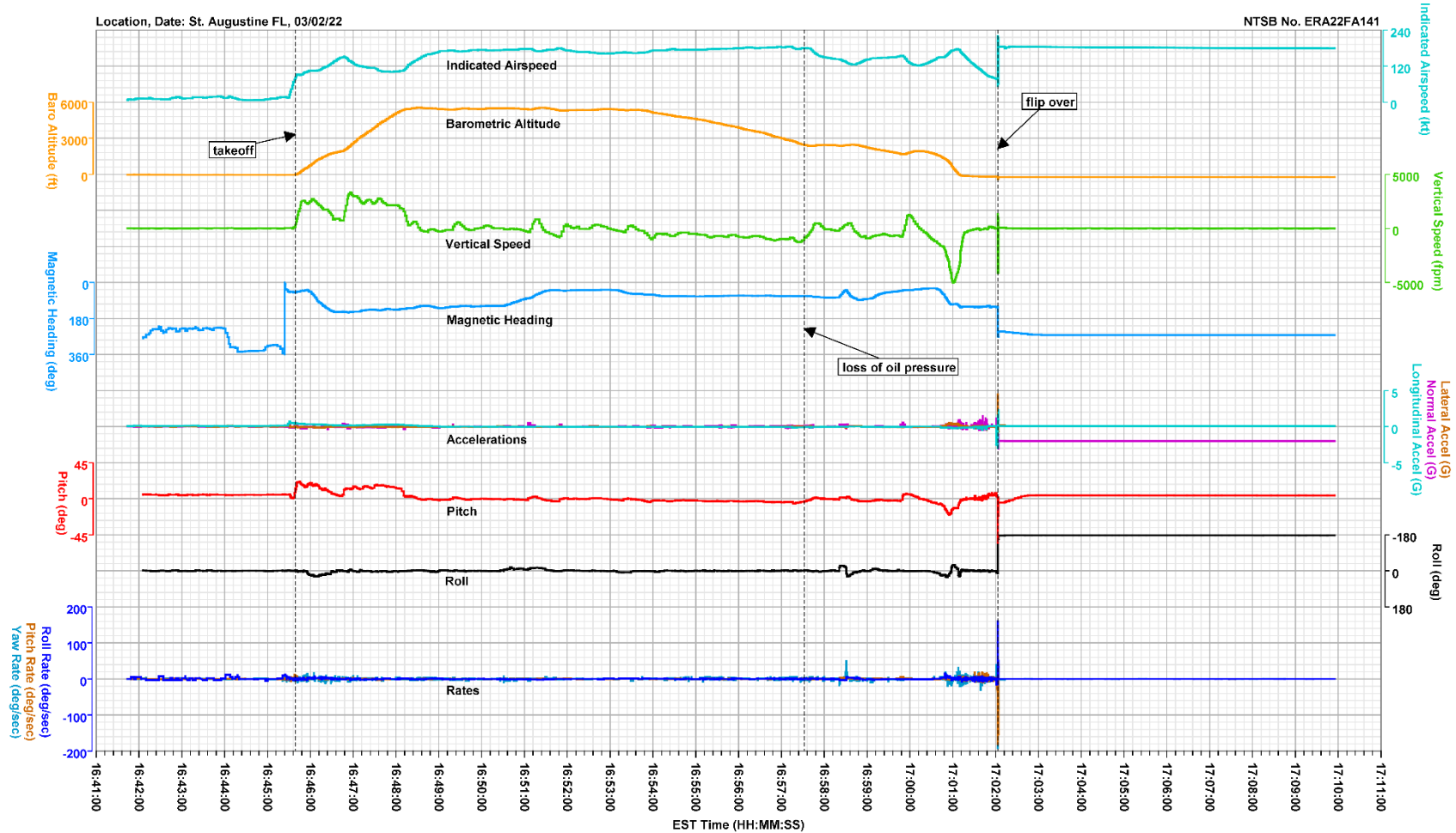


Figure 8. Plot of flight parameters for entire recording.

Extra NG, N100NG

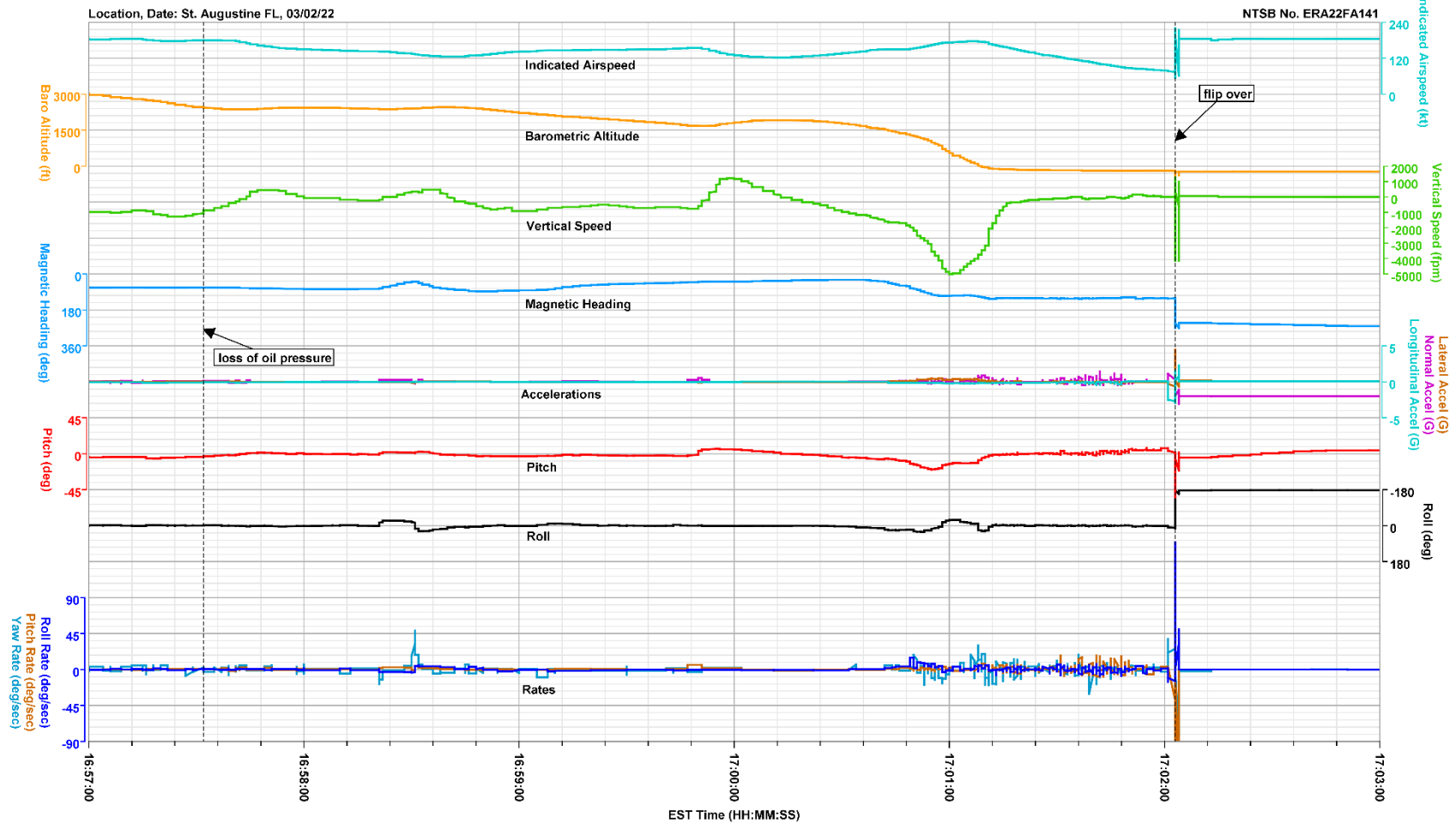


Figure 9. Plot of flight parameters for the accident portion of the flight.

Extra NG,N100NG

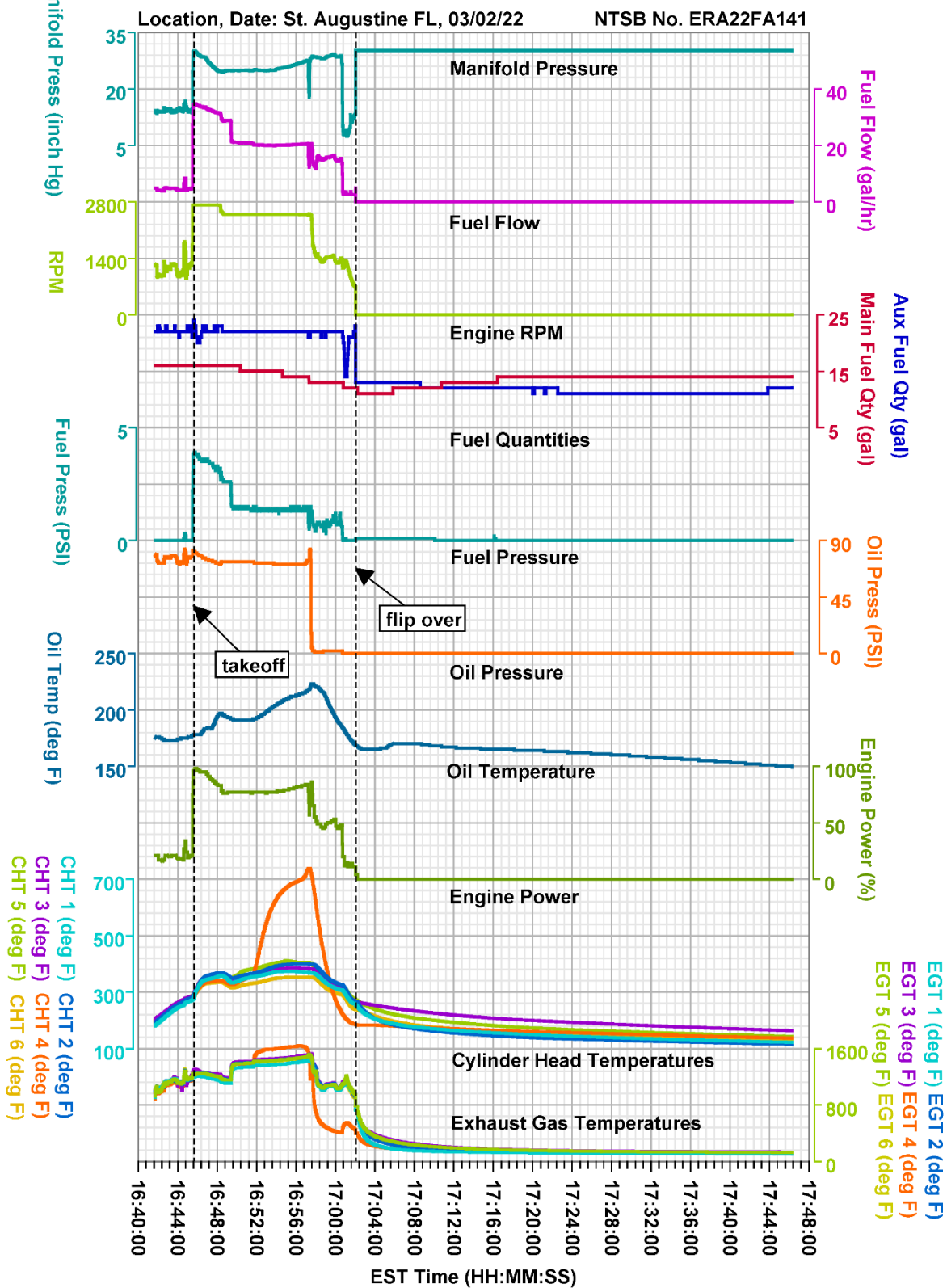


Figure 9. Plot of flight parameters for the accident portion of the flight

Extra NG,N100NG

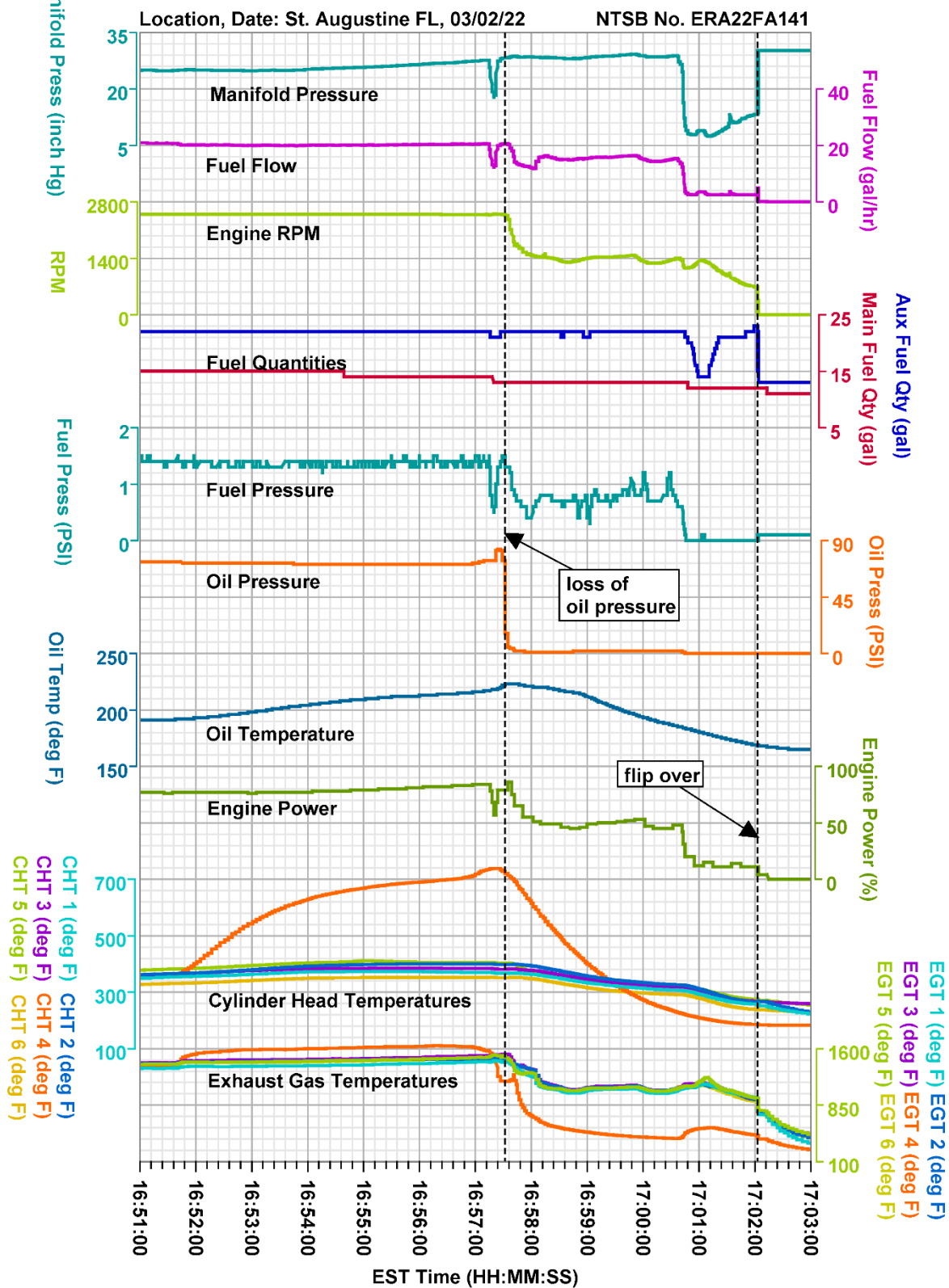


Figure 11. Plot of engine parameters for the accident portion of the flight.

APPENDIX A. VERIFIED AND PROVIDED PARAMETERS FROM THE PILOT'S GARMIN G3X

This appendix describes the parameters provided and verified in this report. Table 2 lists the G3X parameters and table 3 describes the unit abbreviations used in this report.

Table 2. Verified and provided parameters

Parameter Name (units)	Parameter Description
Indicated Airspeed (kt)	Aircraft speed relative to the air around it
Baro Altitude (ft)	Barometric compensated altitude, dependent on pressure value set by pilot.
Vertical Speed (fpm)	Aircraft rate of ascent or descent
Magnetic Heading (deg)	Magnetic Heading
Lateral Accel (g)	Lateral Acceleration (force felt as being pushed from side to side)
Normal Accel (g)	Normal Acceleration (force felt as being pulled up or down)
Longitudinal Accel (g)	Longitudinal Acceleration (force felt as speeding up, or slowing down)
Pitch (deg)	Aircraft angle of pitch
Roll (deg)	Aircraft angle of roll
Pitch Rate (deg/sec)	Rate of change of pitch
Roll Rate (deg/sec)	Rate of change of roll
Yaw Rate (deg/sec)	Rate of change of yaw
Manifold Press (inHg)	Air pressure as measured at the air intake manifold of the engine
Fuel Flow (gal/hr)	Amount of fuel flowing into the engine
RPM	Engine Revolutions Per Minute
Aux Fuel Qty (gal)	Amount of fuel in the auxiliary fuel tank
Main Fuel Qty (gal)	Amount of fuel in the main fuel tank
Fuel Press (psi)	Fuel Pressure
Oil Press (psi)	Oil Pressure
Engine Power (%)	Instantaneous engine power measured as a percentage of total power available
CHT 1-6 (degF)	Temperature for each cylinder head on the engine
EGT 1-6 (degF)	Temperature of the exhaust gasses for each cylinder

Table 3. Unit abbreviations

Unit Abbreviations	Descriptions
kt	Nautical mile, or knot
ft	feet
fpm	feet per minute
deg	directional degrees, 0 being north
g	force per unit mass, expressed as units of the earth's pull at sea level
deg/sec	directional degrees per second
inHG	Atmospheric pressure measured as inches of mercury in a column
gal/hr	gallons per hour
gal	gallons
psi	Pressure, expressed as pounds per square inch
%	Percent of a total
degF	temperature in degrees Fahrenheit