

NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division
Washington, D.C. 20594

April 18, 2023

Garmin GFC 600 Autopilot

Specialist's Factual Report By David L. Case

1. EVENT SUMMARY

Location: Fairbanks, Alaska
Date: August 16, 2021
Aircraft: Cessna 208B
Registration: N97HA
Operator: Wright Air Service Inc
NTSB Number: ANC21LA073

2. GROUP

A group was not convened.

3. DETAILS OF INVESTIGATION

The National Transportation Safety Board (NTSB) Vehicle Recorder Division received log files downloaded from the following autopilot system:

Device Manufacturer/Model: Garmin GFC 600
Serial Number: Unknown

3.1. Device Description

The Garmin GFC 600 is a standalone panel mount autopilot that includes a built-in solid-state Air Data and Attitude Heading Reference System (ADAHRS). It combines data from pitot/static air data sensors, attitude reference (AHRS), GPS and autopilot servo systems to determine the aircraft's location, heading, airspeed, altitude and attitude. This information is then used to command the autopilot servos to fly the plane when so directed by the pilot. The GFC 600 records data about its internal state once per second to a non-volatile memory.

The autopilot contains hardware and software permitting the download of the stored log data.

3.2. Data Recovery

Because the aircraft was repairable, the data from the autopilot was copied on to a USB memory stick, and then provided to the lab via file transfer.



Figure 1. Photo of the Garmin GFC 600 from the accident aircraft.

3.3. Data Description

The data from the accident flight was given to the lab in the form of 20 comma separated value (CSV) files, and 5 plain ascii log files.

The data in the CSV files was stored at one sample per second starting at a power cycle on the ground before takeoff. The accident flight was recorded and identified.

3.4. Parameters Provided

2583 Parameters were recorded in the collected CSV files. Table 1 is the list of parameters evaluated and plotted in this report, the complete data set is available as attachment 1. The GFC 600 logs its internal data model to non-volatile memory once per second.

The GFC 600 logs both raw and filtered data for pitot/static air data sensors. Data includes airspeed, altitude and vertical speed.

Data from an Attitude & Heading Reference System (AHRS) is also stored, which is presented here as derived pitch/roll/yaw values, and magnetic bearing.

Values are logged for a wide variety of status and mode information. Autopilot modes, stall warning indicators, and many other mode and status flags are recorded.

Units were converted for plotting to board standard units when known. Due to incomplete documentation, some unit conversions could not be performed.

Converted units are changed to conform to the NTSB's standard sign convention that climbing right turns are positive (CRT=+).

Table 1: **Autopilot Data Parameters**

Parameter Name	Parameter Description (Original Units, if Known)	Plotted Name (Converted Units)
Timestamp (sec)	Timestamp in Seconds since start of recording	Time (seconds)
IOP_B_AFCS_GEN_ALG_IO_P1_DBG_1/inputs/alt_arm_ref	Altitude Arm Target / Target Altitude (meters)	Target Altitude (feet)
IOP_B_AFCS_1_PRMTRS_DBG/cndtnd_adahrs/baro_alt/data	Indicated Altitude (meters)	Indicated Altitude (feet)
IOP_A_SVO_1_SYNC_DATA/fd_r_cmd	Commanded Roll	Commanded Roll
IOP_A_AFCS_1_PRMTRS_DBG/mon_adahrs/palt/data	Pressure Altitude (meters)	Pressure Altitude (feet)
IOP_A_AFCS_1_PRMTRS_DBG/mon_adahrs/ias/dat	Indicated Airspeed (meters/second)	Indicated Airspeed (knots)
IOP_A_AFCS_1_PRMTRS_DBG/mon_adahrs/pang/data	Pitch Angle (radians)	Pitch Angle (degrees)
IOP_A_AFCS_1_PRMTRS_DBG/mon_adahrs/rang/data	Roll Angle (radians)	Roll Angle (degrees)
IOP_A_AFCS_1_PRMTRS_DBG/mon_adahrs/vspd/data	Vertical Speed (meters/second)	Vertical Speed (feet per second)
IOP_B_AFCS_GEN_ALG_IO_P1_DBG_1/inputs/vs_ref	Target Vertical Speed (meters/second)	Target V/S (feet per second)
IOP_B_AFCS_1_ANNUNC/afcs_mode_annunc/std_afcs/ap_engage_state	Autopilot Mode (0=off, 1=on, 5=error)	Autopilot Mode
IOP_A_SVO_1_SYNC_DATA/fd_p_cmd	Commanded Pitch	Commanded Pitch
IOP_A_PTCH_SVO_VOLT/data/mon_ctrl_gsa9000/torque	Pitch Servo Torque	Pitch Servo Torque

Parameter Name	Parameter Description (Original Units, if Known)	Plotted Name (Converted Units)
IOP_A_PTCH_SVO_VOLT/data/mon_ctrl_gsa9000/voltage	Pitch Servo Voltage	Pitch Servo Voltage (volts)
IOP_A_PTCH_TRM_SVO_VOLT/data/mon_ctrl_gsa9000/capstan_pos	Pitch Servo Capstan Position	Pitch Servo Capstan Position
IOP_B_AFCS_1_CAS_FLT_MSGS/afcs_cas_pitch_mistrim	Pitch Mistrim	Pitch Mistrim
IOP_A_PTCH_TRM_SVO_VOLT/data/mon_ctrl_gsa9000/torque	Pitch Trim Servo Torque	Pitch Trim Servo Torque
IOP_A_PTCH_TRM_SVO_VOLT/data/mon_ctrl_gsa9000/voltage	Pitch Trim Servo Voltage (volts)	Pitch Trim Servo Voltage (volts)
IOP_A_PTCH_TRM_SVO_VOLT/data/mon_ctrl_gsa9000/capstan_pos	Pitch Trim Servo Capstan Position (radians)	Pitch Servo Trim Capstan Position (degrees)
IOP_A_ROLL_SVO_VOLT/data/mon_ctrl_gsa9000/capstan_pos	Roll Servo Capstan Position (Radians)	Roll Servo Capstan Position (degrees)
IOP_A_ROLL_SVO_VOLT/data/mon_ctrl_gsa9000/torque	Roll Servo Torque	Roll Servo Torque
IOP_A_ROLL_SVO_VOLT/data/mon_ctrl_gsa9000/voltage	Roll Servo Voltage (volts)	Roll Servo Voltage
IOP_B_AFCS_1_PRMTS_DBG/ep/ep_impending_stall_active/data	Impending Stall Warning Flag	Impending Stall
IOP_B_AFCS_1_ANNUNC/afcs_mode_annunc/std_afcs/pitch_coupled_mode	Pitch Coupled Mode	Pitch Coupled Mode

3.5. Time Correlation

Several events in the warning and error log files had date and time recorded for around the time of the accident, but they could not be correlated with events in the flight data with sufficient confidence to determine an elapsed time to local time correlation. Therefore, time shown in plots is seconds since power being applied to the autopilot.

3.6. PLOTS AND CORRESPONDING TABULAR DATA

The incident occurred approximately 1861 seconds (31 minutes) after power was applied to the device. The plane took off from Fairbanks at approximately 2:24pm. The recording starts with power being supplied to the avionics and includes taxiing, takeoff, cruise, the accident and its recovery. The return to the airport and landing were not included in the data.

Figure 1 is an overview of the recorded flight.

Figures 2-4 are a plot of parameters involved with the servos used to manipulate the flight control surfaces near the time of the accident. The time of the event, and the time at which the autopilot disconnected are shown.

Figure 5 is a plot of autopilot modes, the target value for vertical speed, and related values to show the effects of the autopilot disconnecting on the aircraft's attitude, vertical speed, indicated air speed and altitude.

Figure 6 is the accident. Instantaneous vertical speed can be seen following commanded vertical speed until right before the autopilot disengaged where they start to diverge.

Figure 7 is from earlier in the flight, and shows the autopilot warning of an impending stall, and evidence consistent with recovery from that condition.

Tabular data used to generate figures 1 through 7 are included as Attachment 1. This attachment is provided in one large zip file, that contains several comma-separated value files (.CSV)

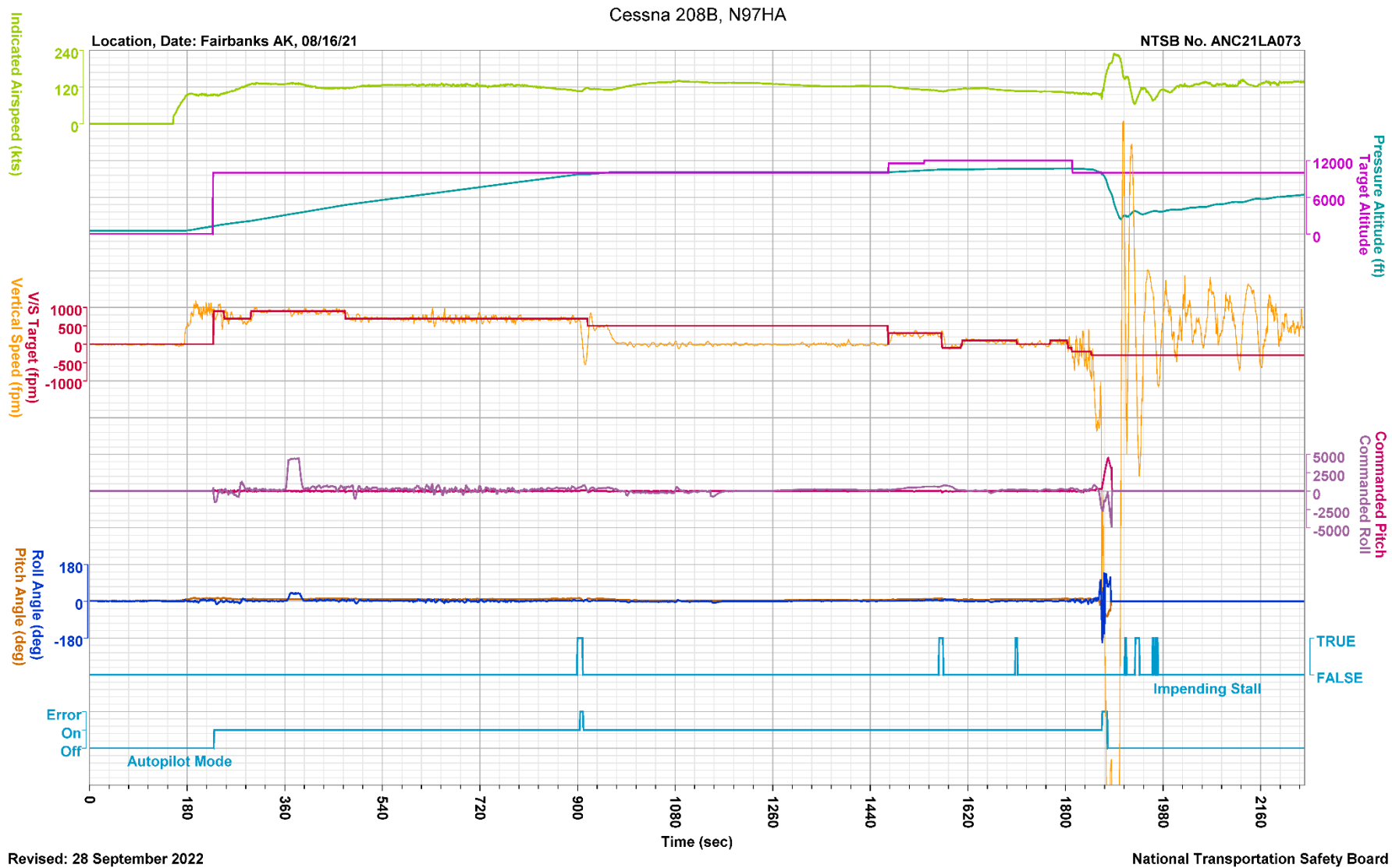
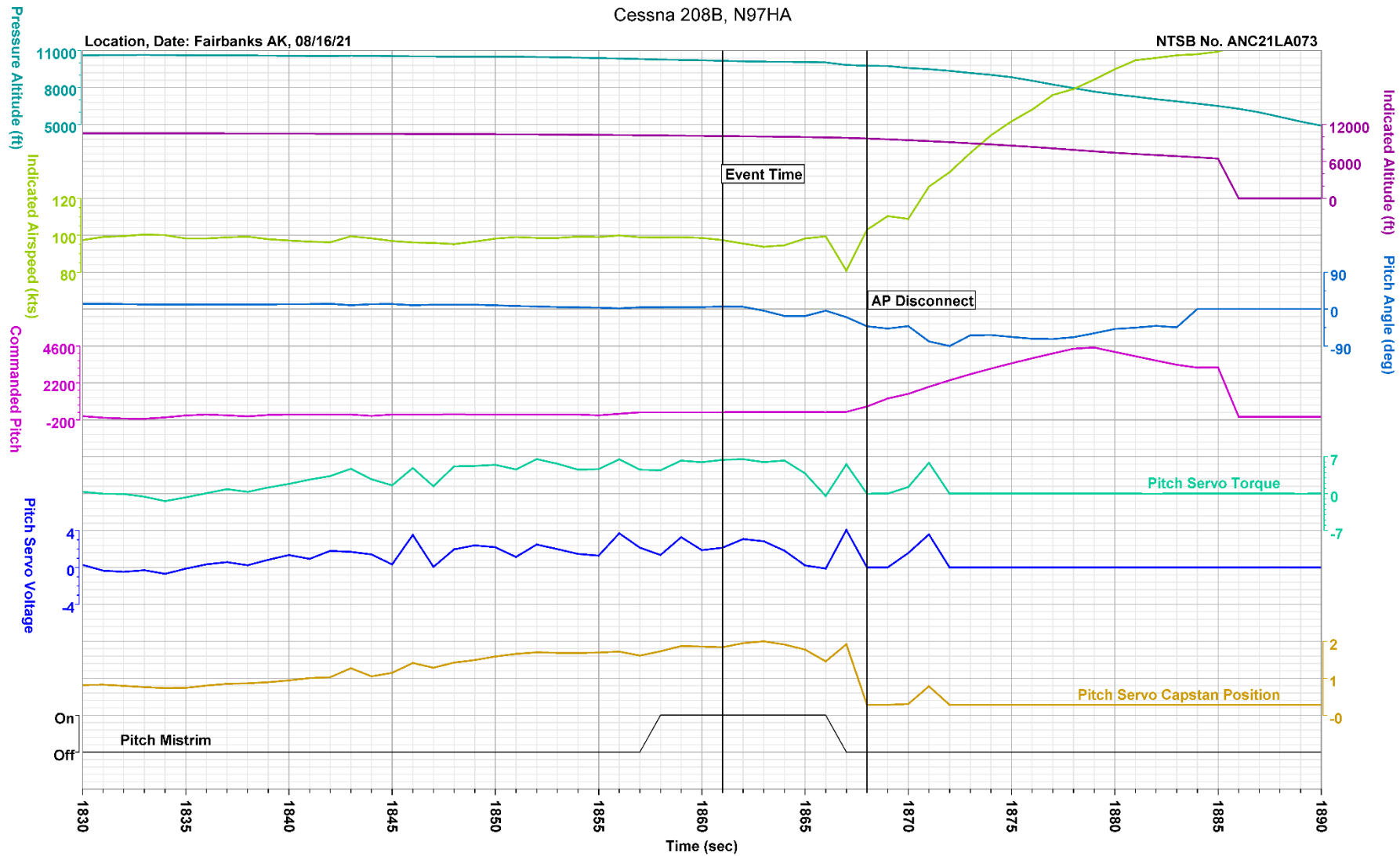


Figure 1. Flight Overview



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Figure 2. Pitch Servo

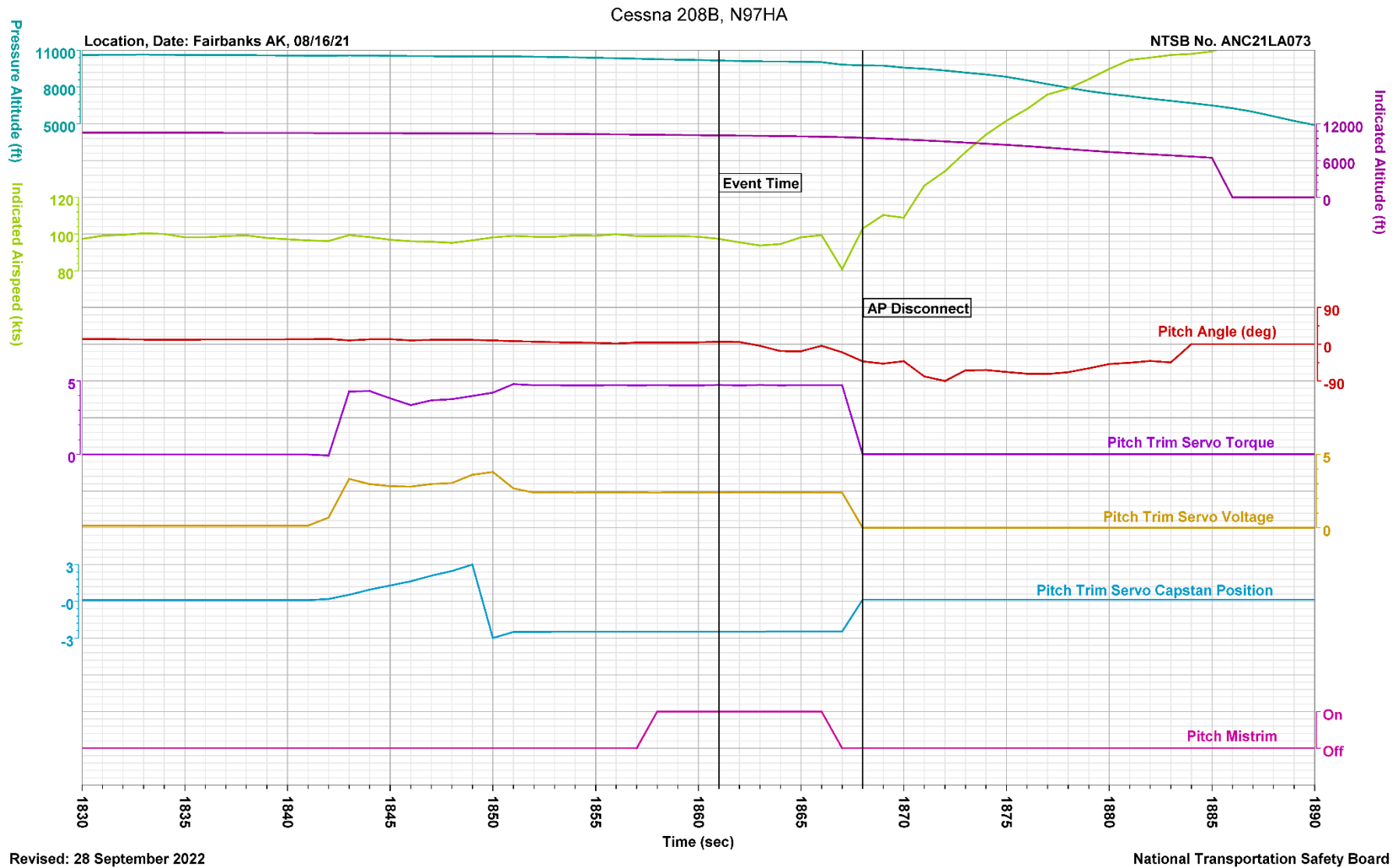


Figure 3. Pitch Trim Servo

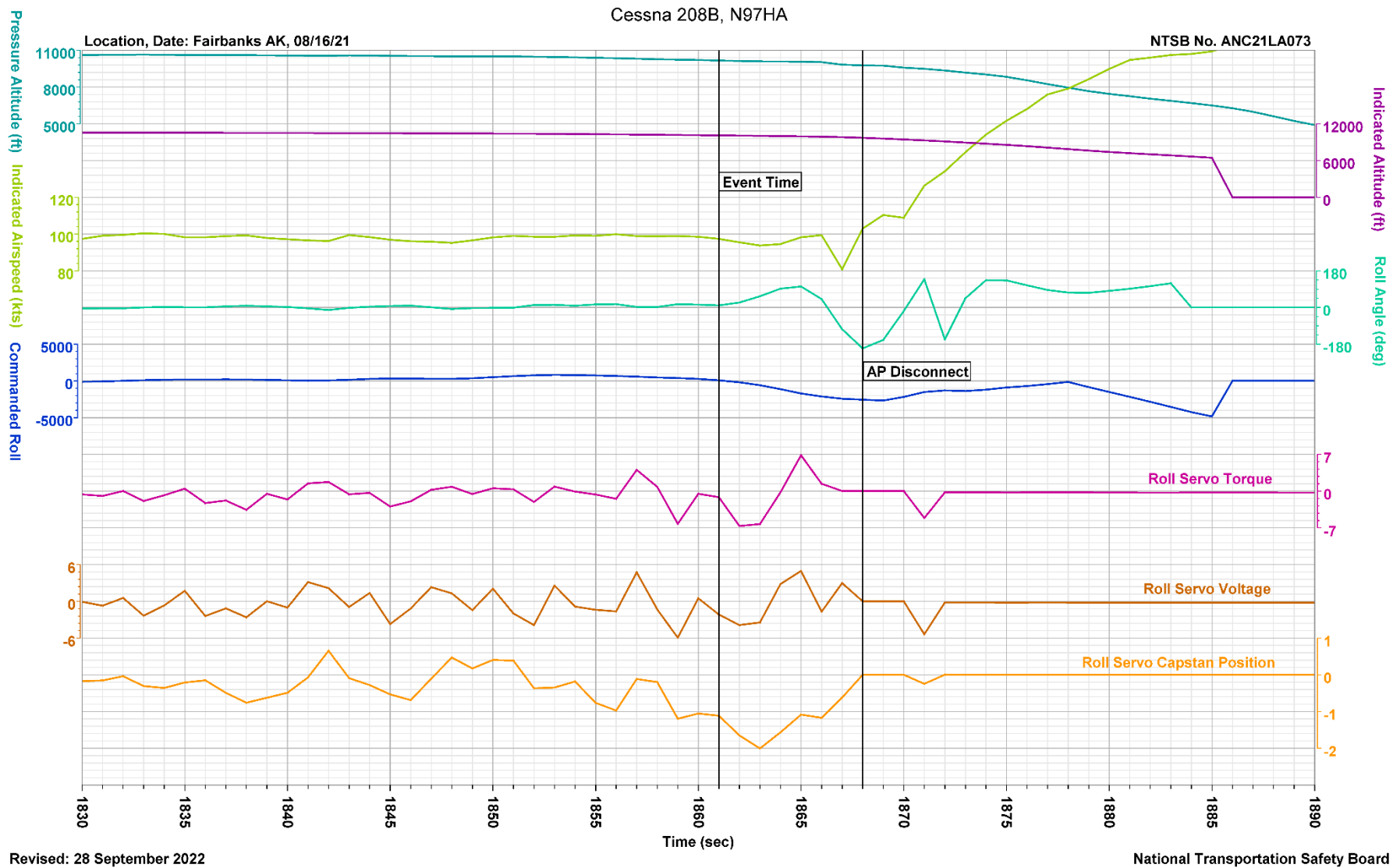


Figure 4. Roll Servo

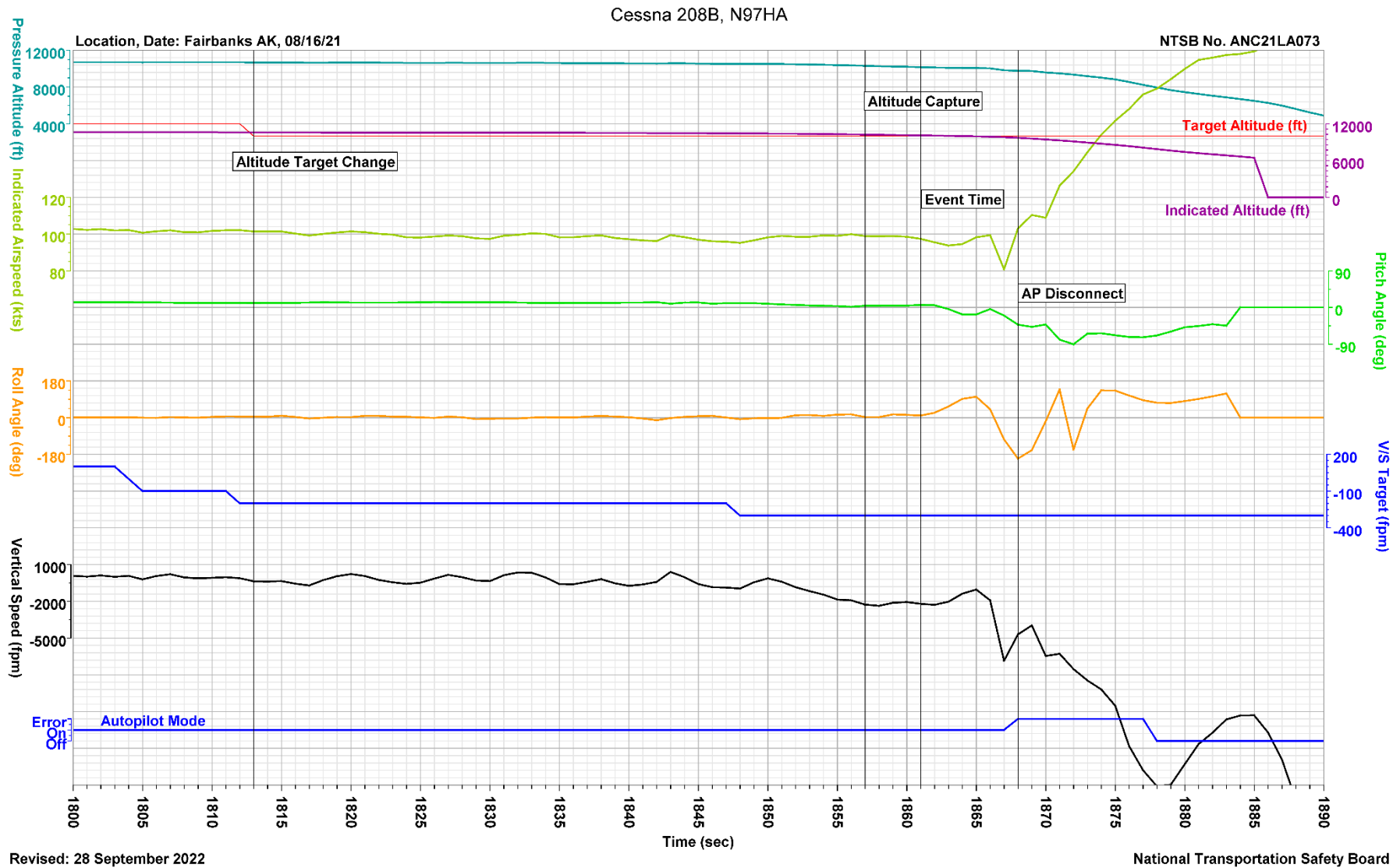
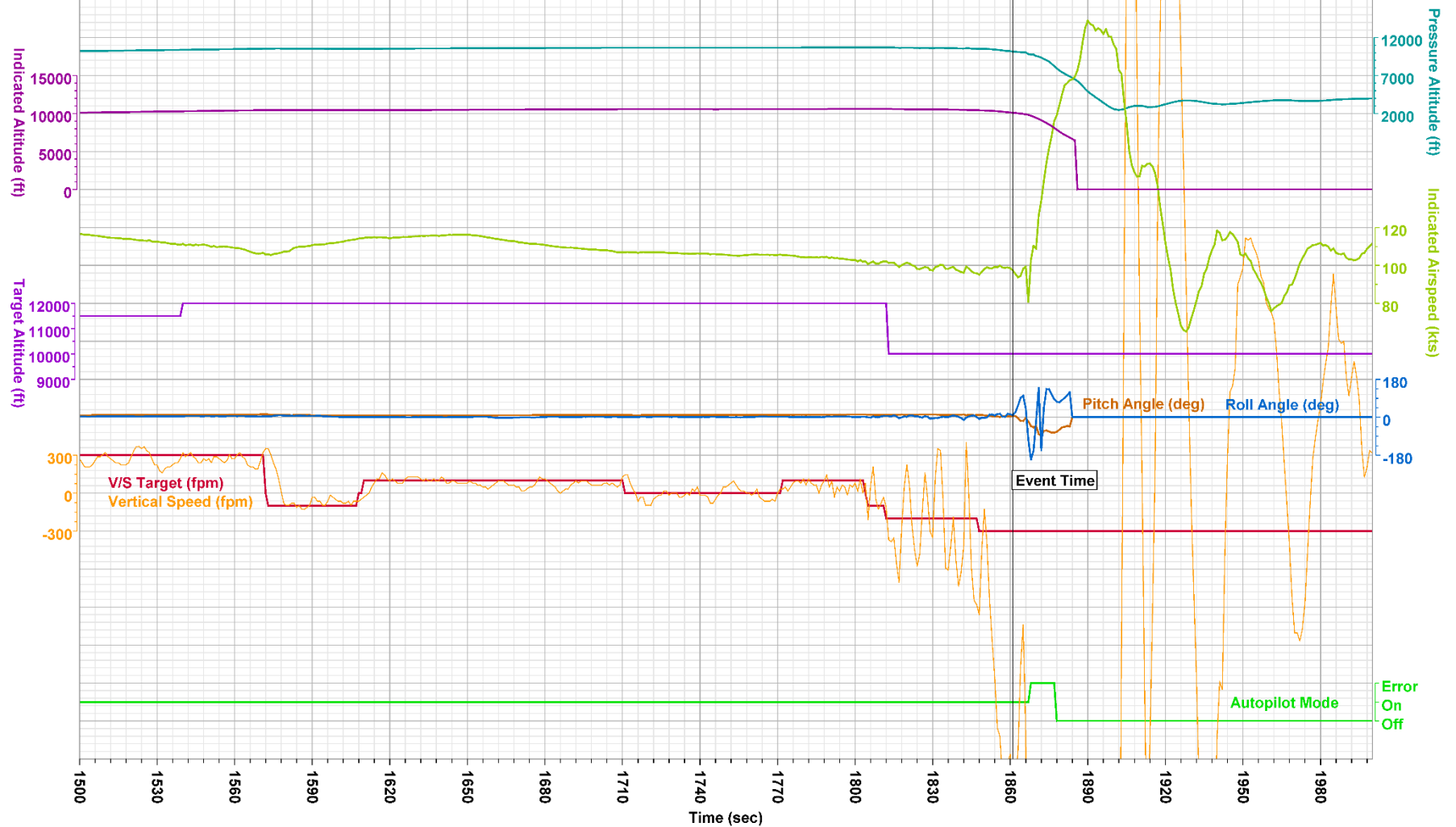


Figure 5. Autopilot Modes

Cessna 208B, N97HA

Location, Date: Fairbanks AK, 08/16/21

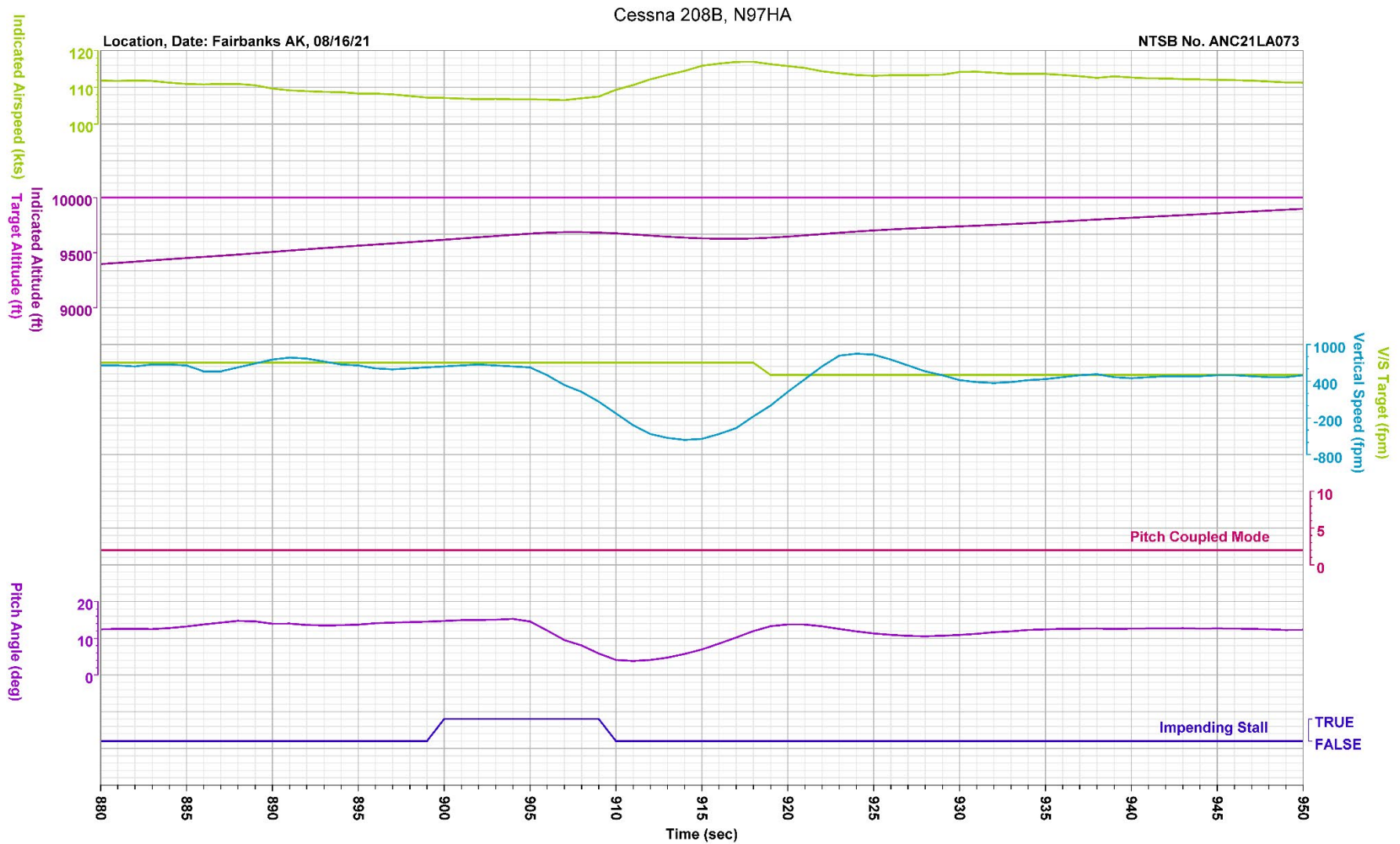
NTSB No. ANC21LA073



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Figure 6. The Accident

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Figure 7. Impending Stall Earlier in Flight