National Transportation Safety Board

Office of Research and Engineering

Washington, D.C. 20594

Airplane Performance Study

Specialist's Report of Investigation
Timothy Burtch
12/23/10

A. ACCIDENT

Location: Butte, MT

Date: March 22, 2009

Time: 2030 GMT (2:30 pm MDT)

Airplane: Pilatus PC-12/45, N128CM

NTSB Number: WPR09MA159

B. GROUP

Chairman: Timothy Burtch

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C. SUMMARY

On March 22, 2009, at 1430 mountain daylight time (MDT), a Pilatus PC-12/45, N128CM, impacted the ground near the approach end of runway 33 at the Bert Mooney Airport (BTM), Butte, Montana. The airplane was owned and operated by Eagle Cap Leasing of Enterprise, Oregon, as a personal transportation flight under the provisions of 14 Code of Federal Regulations Part 91. The airplane was destroyed in the collision and post crash fire. All 14 persons onboard the airplane were killed in the accident, and there were no ground injuries. The flight departed the Oroville Municipal Airport (OVE), Oroville, California, at 1210 Pacific daylight time (PDT) on an instrument flight rules (IFR) flight plan with a planned destination of Gallatin Field (BZN), Bozeman, Montana. The airplane was diverting to Butte at the time of the accident. Visual meteorological conditions prevailed at both the Bozeman and Butte airports.

D. PERFORMANCE STUDY

The Central Advisory and Warning System (CAWS) recovered from the accident airplane recorded fuel pump balancing activity on the Redlands, CA, (REI) to Vacaville, CA, (VCB) leg as well as the Oroville, CA, (OVE) to Bozeman, MT, (BZN) leg. (See Figure 1 for an overview of the day's flights.) The investigation identified the fuel pump activity and the resulting asymmetric fuel load as critical in the accident. As a result, the performance study focused on the flight near the Butte airport accident site[1] where the pump activity would have resulted in the largest fuel asymmetry.[2]

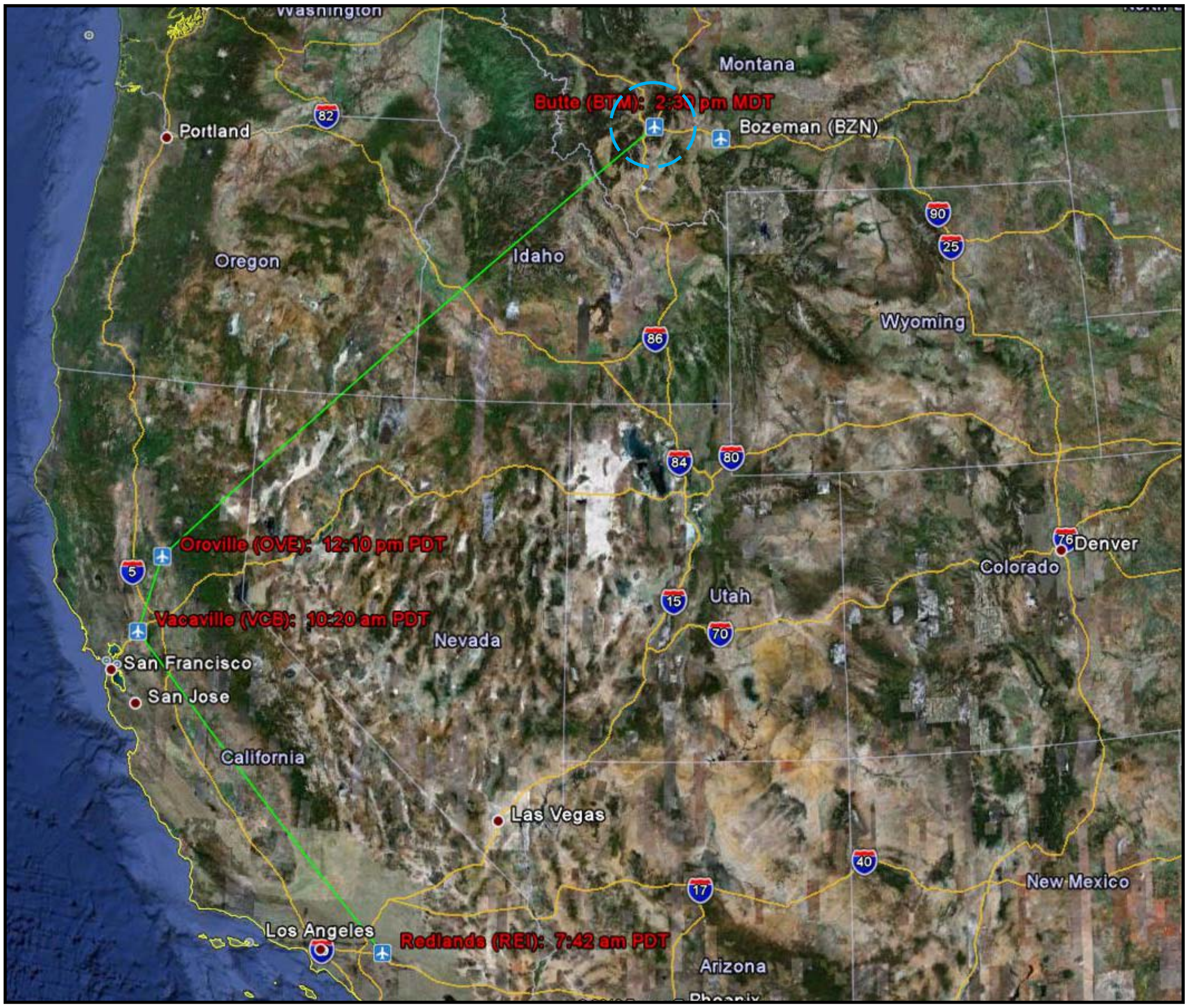

Figure 1: Overview of N128CM's Flights and Departure Times on 3/22/09

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[1] Radar coverage for the flight did not exist within 8 nautical miles of the Butte airport.

[2] The CAWS data indicate that the autopilot was able to carry at least 800 lb of fuel asymmetry before either being manually or automatically disconnected; the CAWS data do not indicate how the autopilot was disconnected.

The airplane wreckage was located the afternoon of 3/22/09 in a cemetery adjacent to the BTM airport, about 2,100 ft west of Runway 33. An initial onsite examination revealed that the airplane had sustained severe fragmentation and deformation as a result of high-energy impact forces, as well as significant thermal damage. Fire damage to the right side of the airplane was less severe than the left side. An on-scene engine tear down that is documented in the Airworthiness Group Chairman's Factual Report indicated that the engine was producing mid to high power at impact. Other wreckage revealed that the aileron trim was in the near full right-wing-down (RWD) position at impact and that the rudder trim was in the near full airplane-nose-left (ANL) position. The flaps were determined to be retracted. Evidence would suggest that that the gear was extended, although this could not be determined conclusively due to the amount of damage. The attitude at impact was reported to be nearly wings-level.

At 1353 MDT, the BTM Automated Weather Observing System (AWOS) reported wind 320° at 10 knots, visibility 10 miles, few clouds at 4,400 feet, overcast clouds at 8,000, temperature 7° Celsius, dew point -3° Celsius, and an altimeter setting of 29.57 inches of Mercury. At 1453, the BTM AWOS reported wind 300° at 8 knots, visibility 10 miles, broken clouds at 6,500 feet, temperature 7° Celsius, dew point -3° Celsius, and an altimeter setting of 29.57 inches of Mercury.

CAWS Data

The extreme trim positions are consistent with the left-wing-heavy fuel asymmetry indicated by the CAWS data. The CAWS data along with radar data and assumptions about the fuel burn put the left tank fuel load at about 1368 lb and the right fuel tank load at 50 lb just prior to the accident. This is also supported by a right fuel tank low CAWS indication that was recorded approximately six minutes before impact. This fuel asymmetry exceeds the limits set in the Airplane Flight Manual (AFM). See the Systems Group Chairman's Factual Report for details on the CAWS fuel pump data.

AFM Limitations

The AFM Limitations Section 2 limits the maximum fuel imbalance for take-off to 100 liters or about 170 lb. This is equivalent to three LCD segments or "bars" on the pilot's display. (Note: one bar is equivalent to approximately 50 lb of fuel asymmetry.) The maximum fuel asymmetry that should develop during normal operations is 40 liters or about 70 lb; the PC-12 is equipped with an automatic fuel balancing system that restricts the fuel imbalance to 40 liters. This represents about 5% of the total fuel capacity of one tank and equates to two bars on the fuel contents gauge graduations displayed to the pilot. In the event that unequal fuel quantities are pumped into the tanks during aircraft refueling, the balancing system will activate the appropriate boost pump for imbalances between 5% and 13% of the total fuel capacity of one tank. The 13% is equivalent to 100 liters or three bars on the pilot's display. (Note: Pilatus has made changes to the asymmetric load section of the AFM since the accident. See the Operations Group Chairman's Factual Report for more details.)

Pilatus Asymmetric Fuel Load Flight Testing

Flight testing to show compliance with CFR 23.23, load distribution limits, for normal flight is documented in Pilatus Engineering Report #ER 12-03-80-002, "Fuel Asymmetry", dated 21 February, 1994. In addition to the required certification testing, Pilatus tested the PC-12 beyond the 100 liter AFM limit for an added margin of safety. This testing is also documented in ER 12-03-80-002.

With the aircraft loaded at the most critical weight and center of gravity, dedicated flight tests were performed to establish the effect of fuel imbalance on the basic handling characteristics of the PC-12. In the most critical condition (i.e., gear down, landing flap, and power on), both wings level and turning flight stalls were performed with a fuel imbalance between 140 liters (240 lb) and 220 liters (380 lb). All tests were flown successfully, and the pilot reported that all maneuvers could be flown without exceptional piloting skill. The first indication of the fuel asymmetry was the need to use increased amounts of aileron trim, and this occurred when the fuel asymmetry reached approximately 10% or 130 lb.

Accident Fuel Loading Calculations and Controllability

The trim positions recorded in the wreckage suggest a steady-heading sideslip to left (i.e., RWD and ANL of the true airspeed velocity vector, V_T), and this is consistent with a left-wing heavy fuel condition. The sideslip to the left is a maneuver that the accident pilot could have used to balance the fuel asymmetry while positioning the airplane for landing in Butte. Pilatus' analysis of the maneuver indicates that a 1318 lb fuel imbalance (1368 lb – 50 lb) is controllable. Pilatus calculated that a steady-heading sideslip at the accident conditions and at speeds close to stall would require just over 50% of the 40° of available aileron (i.e., $\delta a_L - \delta a_R = 8.0° + 14° = 22°$) and that it would produce approximately 20 lb of wheel force[3].

See Figures 2 and 3 for free body diagrams of Pilatus' calculations. See Figures 4 and 5 for Pilatus' estimate of wheel force and aileron deflection as a function of airspeed, respectively.

Note that the Pilatus calculations assume enough rudder exists to balance the yawing moment due to sideslip and that rudder has little effect on airplane rolling moment.

[3] The calculated wheel force of 20 lb is less than both the 50 lb limit prescribed under CFR 23.143, controllability and maneuverability, with two hands and the 25 lb temporary wheel force limit with just one hand

(View Looking Forward: right control wheel and left pedal)

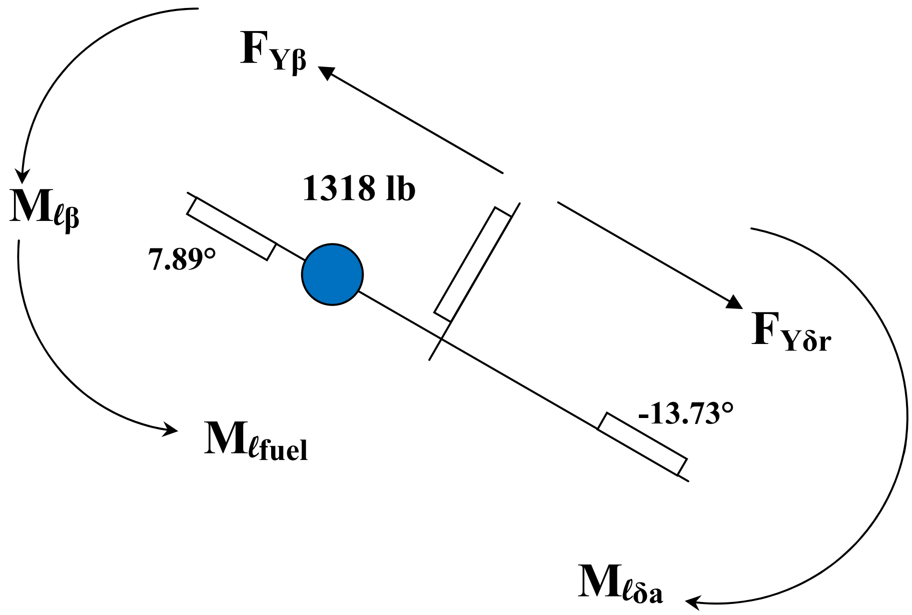

Figure 2: Sideforce and Rolling Moments with a Left-Wing Heavy Fuel Asymmetry

(View Looking Down: right control wheel and left pedal)

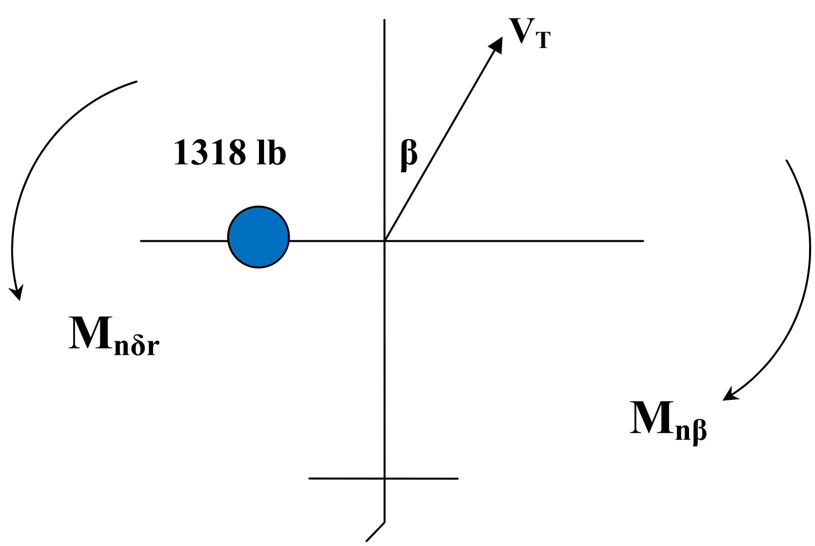

Figure 3: Yawing Moments with a Left-Wing Heavy Fuel Asymmetry

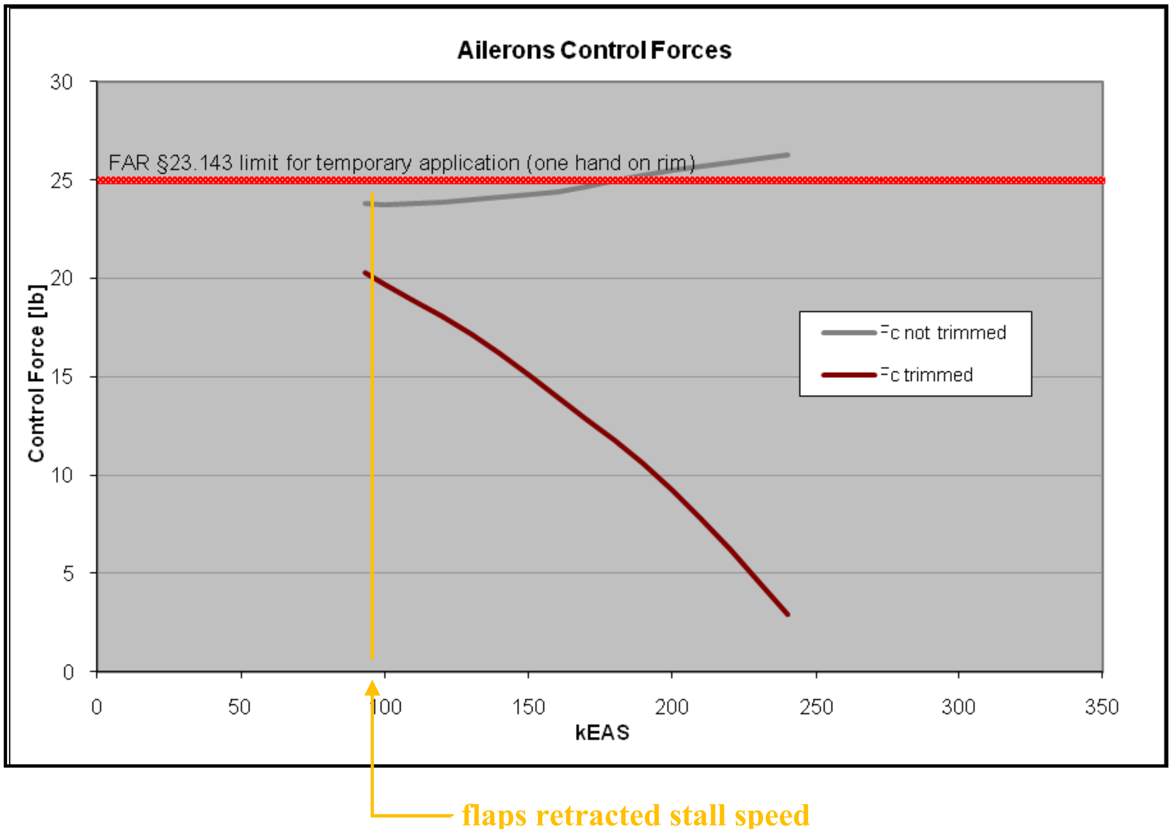

Figure 4: Pilatus' Estimate of Wheel Force as a Function of Speed, 1318 lb Fuel Imbalance

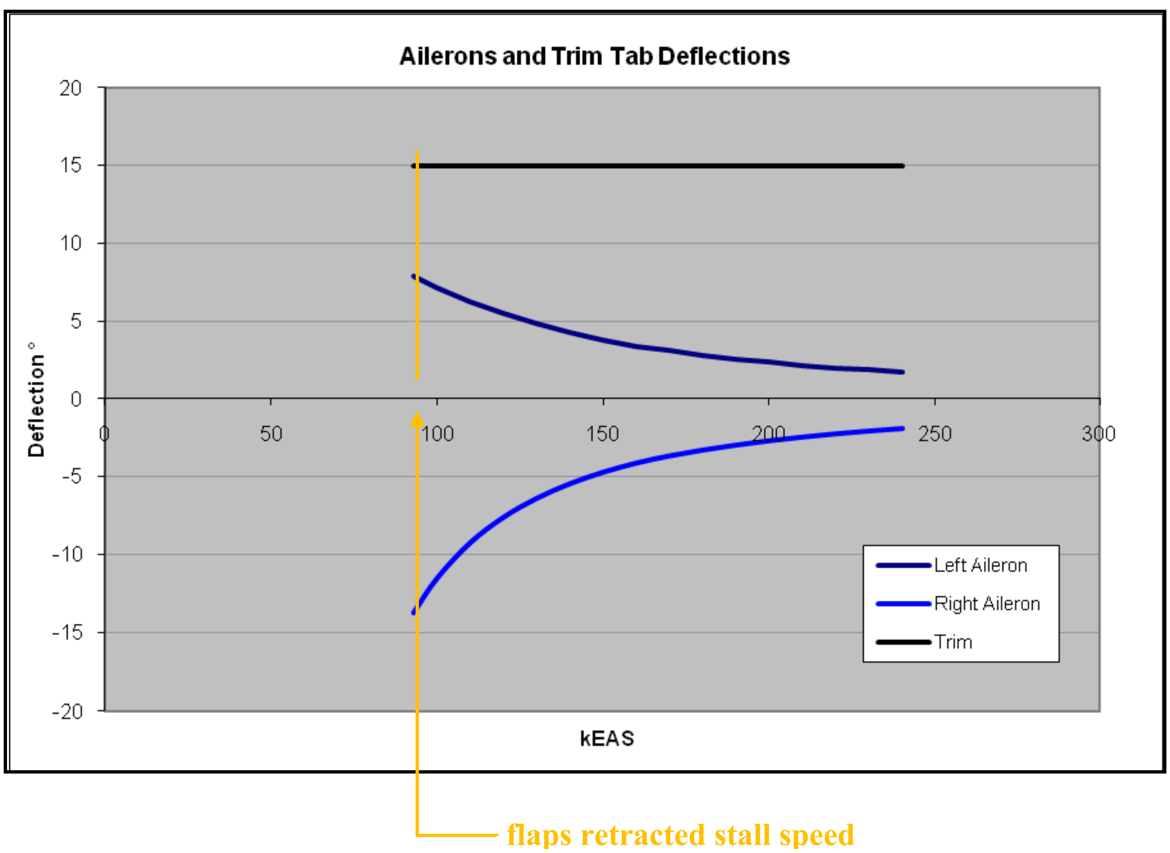

Figure 5: Pilatus' Estimate of Aileron Deflection as a Function of Speed, 1318 lb Fuel Imbalance

Conclusion

Pilatus' post-accident calculations indicate that the fuel asymmetry suspected in this accident was controllable. The calculations also describe how the required control forces and surface deflections increase at lower airspeeds. Pilatus flight tests were performed with a maximum fuel imbalance of 380 lb; however, this is significantly less than the 1318 lb fuel asymmetry calculated for the accident. In addition, the calculations performed by Pilatus assumed static conditions and did not account for airplane dynamics associated with the turning and torque effects typical of high-powered, propeller-driven airplanes. Several witnesses reported seeing the airplane several hundred feet high over the runway threshold and that it appeared the pilot was attempting to circle back around for landing. The larger turning and torque effects associated with low speeds/high angles-of-attack and go-around power, combined with the effects of the fuel imbalance, would make the accident airplane increasingly difficult to control as the pilot maneuvered for landing in Butte.