Air transportation safety investigation report A21P0001

Loss of control

Privately registered

Mooney M20F, C-GYGN

Vicinity of Upper Kananaskis Lake, Alberta

03 January 2021

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History of the flight

On 03 January 2021, the privately registered Mooney M20F aircraft (registration C-GYGN, serial number 221353) was conducting an instrument flight rules (IFR) flight from Airdrie Aerodrome (CEF4), Alberta, to Nelson Aerodrome (CZNL), British Columbia. The pilot was alone on board. The aircraft departed at 1120 [1] in visual meteorological conditions and initially climbed to 14 000 feet above sea level (ASL). Shortly after levelling off, air traffic control (ATC) asked the pilot if he could maintain an

altitude of 15 000 feet ASL for a portion of the flight. [2] The pilot accepted and climbed the additional 1000 feet, levelling off at 15 000 feet ASL at 1157.

The pilot then requested a minor deviation from the route of flight to avoid entering clouds. However, during this deviation, the clouds could not be avoided, and the aircraft entered instrument meteorological conditions (IMC). Shortly thereafter, the aircraft's attitude direction indicator (ADI) [3] displayed the "AHRS ALIGN" (attitude and heading reference system alignment) message, and indications of attitude (pitch and bank) were lost while indications of airspeed, altitude, and vertical speed were retained (Figure 1).

Figure 1. Garmin GI 275 multi-function instrument configured as an attitude direction indicator. Left image demonstrates a functioning attitude direction indicator (Source: Garmin, *GI 275 Pilot's Guide*, Revision C [2020], p. 175). Right image shows the occurrence aircraft's attitude direction indicator displaying the "AHRS ALIGN" message. (Source: aircraft owner)

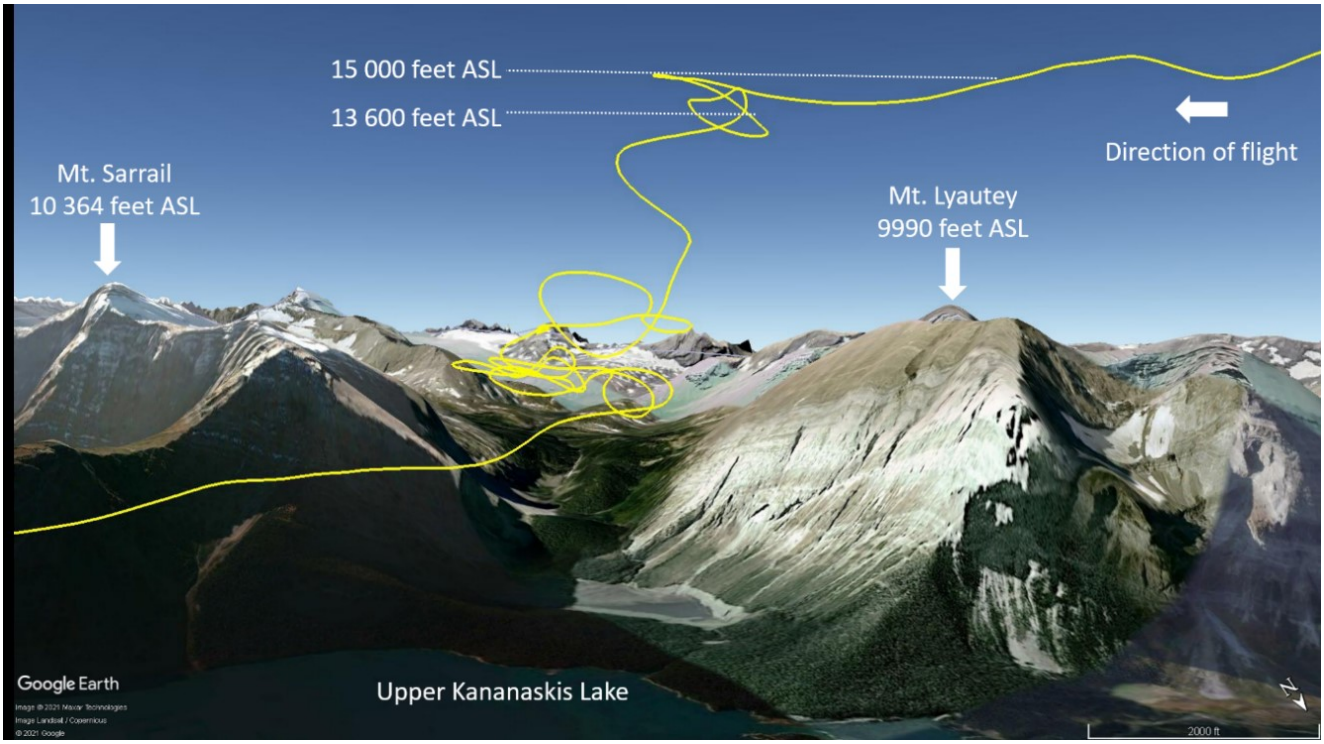
At the same time, the aircraft's horizontal situation indicator (HSI) [4] also indicated a failure, displaying a red X over the HDG (heading) annunciation. The pilot attempted to switch the HSI to the ADI page using the instrument's touch screen function and selector knob, but was unsuccessful.

While the aircraft was still flying in IMC, its altitude began to fluctuate. It then began an unintentional left turn, eventually turning approximately 90° to the left of the assigned track. The pilot informed ATC of the instrument malfunction and requested to return to the Calgary, Alberta, area. At 1206, the pilot declared an emergency, reporting the loss of attitude and heading information from the aircraft's instruments. Thirty seconds later, the pilot informed ATC that the aircraft's HSI was functioning again. The pilot had briefly observed an image on the ADI at that time; however, the flight data recorded by the instrument indicate that AHRS data remained unavailable.

ATC provided the pilot with a heading that would turn the aircraft toward Calgary. During this turn, the pilot experienced spatial disorientation, [5], [6] the aircraft's bank angle progressively increased and the aircraft began to descend. Over the next 5 minutes, control of the aircraft was lost multiple times; the aircraft entered a series of spiral dives, abrupt climbs, and at least 2 aerodynamic stalls. Flight data recovered from the ADI and HSI indicate that during these manoeuvres, the aircraft's climb rate increased to as much as 8500 fpm, and its descent rate increased to as much as 23 000 fpm. In addition, the aircraft's airspeed varied from a low of 43 knots indicated airspeed (KIAS) to a high of 242 KIAS, exceeding the aircraft's never exceed speed by approximately 70 knots. The aircraft descended to as low as 8100 feet ASL (approximately 700 feet above ground level [AGL]) before abruptly climbing again.

The pilot was able to see the terrain below as the aircraft descended through approximately 8500 feet ASL and control of the aircraft was regained at approximately 8100 feet ASL. At the time, the aircraft was in the Kananaskis Valley, where nearby mountain peaks extended up to 10 364 feet ASL (Figure 2). Flight visibility at the time was approximately 1 statute mile (SM), and improved to 2–3 SM as the pilot descended to approximately 7500 feet ASL, while flying toward Upper Kananaskis Lake.

Figure 2. Aircraft's flight path during loss of control event derived from its global positioning system (Source: Google Earth, with TSB annotations)



The pilot maintained a height ranging from approximately 700 to 1000 feet AGL and followed a road to navigate out of the Kananaskis Valley. The aircraft exited the valley at 1238, and the pilot was able to continue the flight directly back to CEF4 under visual flight rules. The aircraft landed at CEF4 at 1302 without further incident.

Communications

Because communications and radar depend on line-of-sight, once the aircraft had descended below 13 600 feet ASL, ATC was unable to communicate directly with the pilot or continue tracking the aircraft on the secondary surveillance radar (using the aircraft's transponder). After recovering from the loss of control event, the pilot was able to relay messages to ATC by communicating on the emergency frequency (121.5 MHz) with aircraft flying at higher altitudes.

Post-occurrence activities

The occurrence pilot entered the avionics defect in the aircraft's journey log and, 1 day after the occurrence, the aircraft owner (who was not the occurrence pilot) flew the aircraft to Red Deer Regional Airport (CYQF), Alberta, to address the defect. Contrary to the regulations, no entry was made in the aircraft's journey log [7] or technical record [8] identifying the exceedance of aircraft limitations. However, the pilot and owner were not aware of the exceedance at this time.

The aircraft continued to be flown, and for an additional 12.3 hours after the occurrence flight, until the flight data retrieved from the Garmin GI 275 multi-function instruments (MFIs) revealed the magnitude of the exceedance. At that time, the aircraft owner also noted fuel weeping from around rivets in several locations and that the landing gear no longer fully retracted. The aircraft was inspected in accordance with Appendix G of *Canadian Aviation Regulations* Standard 625, [9] repaired, and returned to service on 02 March 2021.

Weather information

Before the flight, the pilot received a weather briefing for the route of flight from NAV CANADA. The pilot was informed that there was the potential for very low cloud throughout the mountain valleys, but that it would likely begin to dissipate during the flight.

The graphic area forecast issued on 03 January 2021 at 1026 and valid at 1100, indicated the following for a significant portion of the aircraft's route over the Rocky Mountains:

- broken clouds based at 7000–9000 feet ASL, with tops at 12 000 feet ASL, and visibility greater than 6 SM; and
- occasional altocumulus castellanus clouds up to 18 000 feet ASL, with
    - visibilities ranging from 2 SM to greater than 6 SM in light rain showers or light snow showers and mist; and

- patchy ceilings from 500 feet AGL to 1500 feet AGL.

Aircraft information

The Mooney M20F aircraft is a single-engine, 4-seat, low-wing aircraft equipped with retractable landing gear. The occurrence aircraft was manufactured in 1976. Records indicate it was certified, equipped, and maintained in accordance with existing regulations.

At the time of the occurrence, the aircraft had accumulated approximately 2206.5 total airframe hours.

The aircraft was not equipped with a flight data recorder or a cockpit voice recorder, nor was it required to be by regulation. However, the aircraft's Garmin GI 275 MFIs recorded many flight data parameters pertaining to the occurrence flight.

The aircraft was not equipped with an autopilot.

The aircraft was equipped with a Sky Ox portable oxygen system connected to 4 nasal cannulas. The pilot was using the system during the occurrence flight, and was wearing a portable pulse oximeter. [10]

Garmin GI 275 multi-function instrument

The Garmin GI 275 MFI is an electric, solid state, highly configurable upgrade for many traditional round-gauge instruments, such as ADIs and HSIs, which contain mechanically driven gyros traditionally powered by a vacuum-driven engine pump. It can be configured as either a primary or a standby instrument. [11]

When a standby ADI or HSI detects a fault from a compatible interconnected unit, it will automatically switch to reversionary operation mode, which means it "exclusively behaves as a Primary ADI unit until the fault is resolved." [12] This mode can also be manually selected from a panel-mounted switch. [13]

When a unit is configured as a primary HSI and a fault occurs with an interconnected unit, it will not automatically switch to reversionary operation mode. In addition, the pilot cannot manually select the ADI display page because it is not one of the pages available when the unit is configured as a primary HSI. Pages available for a primary HSI configuration are HSI and HSI Map; pages available for standby ADI and standby HSI include an ADI page.

In July 2020, the occurrence aircraft's directional gyro was removed and a Garmin GI 275 MFI was installed in accordance with U.S. Federal Aviation Administration Supplemental Type Certificate (STC) SA02658SE. [14] This MFI was configured as a primary HSI. In October 2020, the aircraft's attitude indicator was removed and a second Garmin GI 275 MFI was installed in accordance with the same STC, but was configured as a primary ADI. Because both of these instruments were configured as primary units, a reversionary switch was not installed, nor was it required to be.

The aircraft's owner and the occurrence pilot both thought that if a fault was detected in the ADI, the HSI would either automatically enter the reversionary operation mode and display the ADI page, or the pilot would be able to select the ADI page manually. Therefore, their understanding of both the system's automation and the units' reversionary capabilities was incorrect.

The investigation attempted to determine more precisely the source of the initial fault. However, no supplemental information about the instrument, possible reasons it would require realignment while the aircraft was in flight, or analysis of the occurrence aircraft's recorded fault logs were provided to the investigation by Garmin. Therefore, the exact source of the initial fault could not be determined. Nevertheless, based on the information that was available to the investigation, it was determined that the most likely cause of the AHRS ALIGN message on the primary ADI was

either an uncommanded AHRS alignment that took place during the flight or a sensor fault within the AHRS that required the instrument to be realigned once the fault was resolved.

The AHRS can align itself while the aircraft is taxiing or when it is in flight; the realignment takes 1 to 2 minutes. [15] When the AHRS ALIGN message is displayed, control of the aircraft must be maintained within ±10° bank, ±5° pitch, and at a speed of 200 knots or less in order to successfully complete the realignment; exceeding these parameters may delay or prevent the AHRS from realigning. [16] This information is contained in the Garmin *GI 275 Pilot's Guide*, as well as the emergency procedures in the Garmin Airplane Flight Manual Supplement (AFMS). Although the pilot did have access to these documents during the occurrence flight, he did not refer to them as he was focussed on controlling the aircraft. Further, the aircraft's cockpit checklists had not been amended with the additional normal and emergency procedures contained in the AFMS.

Pilot information

The pilot held an airline transport pilot licence – aeroplane, and a valid Category 1 medical certificate. He had accumulated over 6000 hours total flight time, including 21 hours in the 7 days before the occurrence. The pilot had 29.4 hours total flight time on Mooney M20 aircraft. Of those, 2.9 hours were on the occurrence aircraft in the same configuration as on the occurrence flight.

The Garmin AFMS indicates that the Garmin GI 275 MFI "system requires a reasonable degree of familiarity to avoid becoming engrossed at the expense of basic instrument flying in IMC [...]" [17], and "[p]ilot workload will be higher for pilots who are not familiar with the GI 275s or GI 275 system in an IFR environment [...]". [18] The manual recommends that pilots use the Garmin *GI 275 Pilot's Guide* and a tablet trainer app to increase their

familiarity with the instrument. The investigation was unable to find the trainer app and it was not provided to the investigation by Garmin. The occurrence pilot did not know about the app.

In June 2020, the pilot completed recurrent training and successfully completed a pilot proficiency check (PPC) for a business jet, thereby satisfying the requirement to exercise the privileges of an instrument rating. [19] The occurrence pilot's training included recovery from unusual attitudes (often referred to as upset recovery training) and abnormal procedures for avionics systems. However, PPCs do not evaluate a pilot's ability to recognize the onset of, or recover from, unusual attitudes. [20]

By contrast, pilots who complete an instrument proficiency check (IPC) to satisfy the requirements of an instrument rating must demonstrate their ability to recover from unusual attitudes twice:

- once with a full instrument panel; and
- once using a partial instrument panel or standby instruments only, depending on the aircraft configuration (traditional instrument panel vs. technically-advanced). [21]

The occurrence pilot had successfully completed PPCs as required since 2008. All of these PPCs took place on technically-advanced aircraft (i.e. with redundancy in avionic systems, including multiple independent attitude instruments). Before the occurrence flight, the pilot's most recent exposure to conditions of partial panel instrument flight in an aircraft with a traditional instrument panel had been in 2008.

Limited or partial panel flying

The regulations require that flight training programs be conducted in accordance with the applicable flight instructor guide. [22] Some Transport Canada guidance documents do include advice on instrument

training instruction in general, but they do not provide specific advice or guidance with respect to instruction for an instrument rating.

According to the flight test standards, [23] the flight test for the issuance of a commercial pilot licence - aeroplane is the only time during pilot training that students in Canada are required to demonstrate proficiency controlling the aircraft while performing normal manoeuvres with a partial instrument panel. The initial instrument rating flight test does not require pilots to be tested on partial panel flying; however, a flight test examiner may use one of the 3 emergency scenarios required during a flight test to assess the pilot's management of a situation that could lead to partial panel conditions.

The TSB previously investigated a loss of control and in-flight breakup of a Piper PA-46-350P in Wainwright, Alberta, that was initiated by the failure of the attitude indicator and the pilot's attempt to fly the aircraft with a partial panel. [24] The report included a safety concern, which stated in part:

> This pilot had not practiced partial panel flying for a number of years and was not required to do so for his IFR renewal. Indeed, it is likely that he had not been required to demonstrate partial or limited panel skills since either his original commercial pilot test or his initial instrument training. Such skills deteriorate over time if not exercised.

The theme of recent partial panel flying experience was again highlighted in the TSB's investigation into a loss of control and collision with terrain accident involving a Beechcraft King Air 200 near the Whatiì Airport, Northwest Territories. [25] That investigation found that the captain did not have recent experience in partial panel flying. Following the failure of the attitude indicator, the remaining instruments were not used effectively and the aircraft departed controlled flight and entered a spiral dive from which the crew could not recover.

Transport Canada's Advisory Circular (AC) 401-004 outlines the requirement for pilots to be assessed on their ability to recover from unusual attitudes if they are using an IPC to meet the recency requirements of the instrument rating. [26] However, the IPC is only one method of meeting those recency requirements.

As stated in AC 401-004, "**[p]ilots employed by Subpart 4 of Part VI Private Operators or Part VII Air Operators generally meet the recency requirements for their instrument rating by means of a pilot competency check (PCC), line oriented evaluation (LOE), or a pilot proficiency check (PPC), instead of an IPC.**"[emphasis in original] [27] Those types of checks, or IPCs conducted on an airplane or simulator with a technically-advanced cockpit (i.e. with standby instruments), do not require the examiner to evaluate the pilot's ability to recover from an unusual attitude in partial panel conditions. Yet, they also do not exclude those pilots from conducting IFR flights on aircraft with traditional instrument layouts in which partial panel conditions may be encountered.

Safety messages

Regardless of experience level or rating, it is important that pilots acquire and maintain the skill sets and knowledge necessary to safely operate each aircraft they fly. This includes seeking qualified instruction to learn and recognize the features, failure modes, and limitations of aircraft equipment before conducting a flight, particularly when IMC may be encountered.

In the event of an instrument failure in IMC, pilots who do not have recent partial panel flight experience may become spatially disoriented and lose flight control.

This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 30 June 2021. It was officially released on 13 July 2021.

Footnotes

1 All times are Mountain Standard Time (Coordinated Universal Time minus 7 hours).

2 Air traffic control (ATC) made this request to ensure adequate separation with another aircraft that was beginning an approach to Invermere Aerodrome (CAA8), British Columbia.

3 The aircraft was equipped with 2 Garmin GI 275 multi-function instruments (MFIs). The MFI uses an internal digital attitude and heading reference system (AHRS) and air data computer, and can be configured to act as various instruments, including an attitude direction indicator or a horizontal situation indicator.

4 The aircraft's HSI was also a Garmin GI 275 MFI, installed directly below the ADI.

5 Spatial disorientation occurs when a pilot is unable to correctly interpret the aircraft's position, motion, attitude, altitude, or airspeed in relation to points of reference or to the Earth.

6 Several TSB investigation reports have addressed this phenomenon and its consequences. See TSB air transportation safety investigation reports A19Q0153, A19O0178, A19O0026, A19W0015, A18Q0016, A17O029, A16P0186, A15P0217, A15P0081, A15O0188, A15O0031, A14A0067, A13H0001, A13C0073, A13C0014, A12P0079, A12P0070, A11W0152, A11Q0168, A11P0106, A11H0001, A10Q0132, A10P0244, A09O0171, A97P0207, and A94H0001.

7 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, section 605.97, Schedule I, item 6.

8 Ibid., Schedule II, item 3.

9 Ibid., Standard 625 – Aircraft Equipment and Maintenance Standard, Appendix G: Inspection after Abnormal Occurrences.

10 A portable pulse oximeter is a lightweight device, worn on the fingertip, that monitors the percentage of oxygen in the blood and pulse rate of the person wearing the device.

11 Garmin, *GI 275 Pilot's Guide*, Revision C (2020), p. 9.

12 Ibid., p. 10.

13 The supplemental type certificate (STC) installation manual indicates that when a Garmin GI 275 MFI is configured as a standby unit, a panel-mounted reversionary switch is required. (Source: Garmin, *GI 275 Part 23 AML STC Installation Manual*, Revision 7 [December 2020], figures 1-6, 1-24, and 1-26 to 1-28.)

14 U.S. Federal Aviation Administration STC SA02658SE has been validated in Canada by Transport Canada as STCSA20-88.

15 Garmin, *GI 275 Pilot's Guide*, Revision C (2020), p. 13.

16 Garmin, *Airplane Flight Manual Supplement for the Garmin GI 275 Multifunction Instrument*, Revision 4 (approved 23 December 2020), section 3.2.7, p. 33.

17 Ibid., section 1, p. 12.

18 Ibid., section 1, p. 12.

19 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, paragraph 401.05(3)(d).

20 Transport Canada, TP 14727, *Pilot Proficiency Check and Aircraft Type Rating – Flight Test Guide (Aeroplane)*, First Edition (June 2017).

21 Transport Canada, Advisory Circular (AC) 401-004: *Conduct of Instrument Proficiency Checks*, Issue 04 (15 March 2019), paragraph 4.0(2)(a).

22 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, section 405.14.

23 Ibid., Standard 428 – Flight Crew Permits, Licences and Ratings – Conduct of Flight Tests, Schedule 4.

24 TSB Aviation Investigation Report A08W0068.

25 TSB Air Transportation Safety Investigation Report A19W0015.

26 Transport Canada, Advisory Circular (AC) 401-004: *Conduct of Instrument Proficiency Checks*, Issue 04 (15 March 2019), paragraph 6.3(4)(a).

27 Ibid., subsection 1.2(4).