

Title: Research-based insights through accident investigations: the importance of lightweight flight recording systems for accident investigations

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BIOGRAPHY - Beverley Harvey has 40 years of civil aviation experience. She joined the TSB in 2008 as an investigator/operations specialist. Prior to joining the TSB, she was an inspector at Transport Canada, an instructor, and a pilot with a commuter airline. During that time, she flew different aircraft types, from small aircraft to larger commuter aircraft. Since joining the TSB, Bev has participated in several TSB investigations, and she has been an accredited representative in numerous foreign investigations.

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The question for this year's ISASI participants is whether the past has become irrelevant. Certainly, some issues have become irrelevant; investigators have come a long way with access to more modern investigation techniques because of knowledge gleaned from the past. With modern technology, investigators can rely solidly on rapid communications and assistance from first responders, coroners, and manufacturers whose expertise are instantly available for all phases of the investigation. For example, technology regarding photography has improved so much that, instead of having to wait for good weather and a helicopter to film the wreckage site, excellent drone photography is instantly available. This enables investigators to concentrate on their job of combing through the wreckage site, photographing components, interviewing witnesses, and then taking the accident from the outdoors to their computers.

However, there is one challenge in Canada that still needs to be solved. This stems around the absence of regulations for the implementation of lightweight flight recording systems for privately operated aircraft (the private operation of any aircraft type listed in section 604.3 of the *Canadian Aviation Regulations* (CARS) and engaged in non-commercial flight operations must abide by specific regulations set out in CARS Subpart 604), and other commercial aircraft

not currently required to carry crash protected flight recorders. Advanced technology in this field has resulted in recorders that are very sophisticated, light in weight, and much less costly than earlier models. In the past, recorders on large commercial aircraft were not regarded as being essential, but once the benefits were demonstrated in accident investigations, recorders became mandatory.

So it is today – the emergence of lightweight flight recording systems is starting to show the benefits in accident investigations, and normal day-to-day data collection. Canada still has sectors of aviation where recorders are not mandatory for some commercial operators and privately operated aircraft. Our challenge is to demonstrate how effective lightweight flight recording systems are in accident investigations, and continue to recommend that the government address this issue in a timely fashion.

This paper will discuss two high-profile accidents investigated by the TSB. Both involved privately operated aircraft and these accidents occurred in 2016 within months of each other. There are similarities between the two; however, the findings are quite different because one aircraft had a lightweight flight recording system on board and the other aircraft did not.

The first accident that this paper will examine is from the TSB's aviation investigation report **A16A0032: Collision with terrain /Mitsubishi MU-2B-60, N246W/Îles-de-la-Madeleine Airport/ Quebec, 29 March 2016**

Summary

On 29 March 2016, a privately operated Mitsubishi MU-2B-60 aircraft (registration N246W, serial number 1552S.A.) departed Montréal/Saint-Hubert Airport, Quebec, on an instrument flight rules flight to Îles-de-la-Madeleine Airport, Quebec. The pilot, a passenger-pilot, and five passengers were on board. During the final approach to Runway 07, when the aircraft was 1.4 nautical miles west-southwest of the airport, it deviated south of the approach path. At approximately 1230 Atlantic Daylight Time, aircraft control was lost, resulting in the aircraft striking the ground in a near-level attitude. The aircraft was destroyed, and all occupants were fatally injured. There was no post-impact fire.

A lightweight flight recording system was on board the occurrence aircraft, although it was not required by regulation. This device was a cell phone that had GPS, voice recording and accelerometer capabilities; it was attached to the aircraft's radio. Although it was not a crash-survivable recorder, TSB investigators recovered the recorder from the wreckage, and the TSB Engineering Laboratory was able to extract and analyze its data. The resulting information was critical to understanding the sequence of events that led to the aircraft's departure from controlled flight; without recorders, crucial information to understand these events would not have been available.

Data retrieval and analysis

The investigation successfully recovered data from the terrain awareness and warning system and the Wi-Flight recording device. These data were used to reconstruct the flight profile during all stages of flight, enhancing the investigators' ability to understand and analyze the

final moments before impact. The audio retrieved from the Wi-Flight was complete and instrumental to the understanding of the events leading to the accident.

Although not required by regulation, the installation and use of a lightweight flight recording system during the occurrence flight, as well as the successful retrieval of its data during the investigation, permitted a greater understanding of this accident.

The final report found that the cause of the aircraft's upset and subsequent impact was due to a loss of control that occurred when the pilot rapidly added full power at a low airspeed while at a low altitude, causing a power-induced upset. This resulted in the aircraft rolling sharply to the right and descending rapidly. It was the analysis of the recordings that allowed the determination of the rapid throttle advance by the pilot.

The second accident that this paper will examine is from the TSB's aviation investigation report **A16P0186: Loss of control and collision with terrain / Cessna Citation 500, C-GTNG/Kelowna Airport, British Columbia, 4.5 nm NE/13 October 2016.**

Summary

On 13 October 2016, a privately operated Cessna Citation 500 (registration C-GTNG, serial number 500-0169), departed Kelowna Airport (CYLW), British Columbia, on an instrument flight rules night flight to Calgary/Springbank Airport (CYBW), Alberta. The pilot and three passengers were on board. Shortly after departure, at about 2135 Pacific Daylight Time, the aircraft made a tight right turn as it was climbing through 8600 feet above sea level, and then entered a steep descending turn to the right until it struck the ground. All of the occupants were fatally injured. Impact forces and a post-impact fire destroyed the aircraft.

The high-energy impact resulted in a crater approximately 2 feet deep. Fragmented aircraft debris was projected into trees and scattered around a small area. The post-impact fire destroyed the majority of the aircraft structure.

Investigators were able to determine that the engines were producing power at the time of impact, and that there was no in-flight breakup or separation of the wings. As well, weather conditions at the time of the accident did not appear to be conducive to significant icing. There were no difficulties with radio communications, and none of the communications between the pilot and air traffic control revealed any sense of urgency or any anomalies with the aircraft. As well, there was no evidence that pilot fatigue was a factor.

In contrast to the first accident, the information normally contained in flight-data recording systems was not available to this investigation. The aircraft was not equipped with a flight data recorder (FDR), a cockpit voice recorder (CVR), or any other lightweight flight recording system, nor were any required by regulation. Consequently, it was a challenge to establish a detailed sequence of actions in the cockpit and, as a result, it could not be determined if there was an abnormal event before the aircraft's rapid descent.

Although there were no recordings on board, the TSB Engineering Laboratory was able to work with the raw radar data that was available from two radar sites in the vicinity of the accident site. The goal was to determine the aircraft's flight path (ground track and altitude), as well as

to calculate vertical velocity, ground speed, and deviation from the published standard instrument departure (SID) routing. This information was then used to document the flight, synchronized in time with the air traffic control (ATC) recording.

This raw radar data consisted of multilateration (MLAT) surveillance data provided by NAV CANADA. The MLAT data were inaccurate for the takeoff because there was significant scatter in the radar targets. For the latter part of the flight, when the aircraft transitioned into a steep descending turn, accurate MLAT data were also not available.

The climb-out segment of the ground track was generally smooth and consistent. Several radar targets were obviously false targets (off track) in the MLAT data. Since the aircraft was only equipped with a single bottom-mounted transponder antenna, depending on the aircraft's position and attitude, the antenna may have been shielded from a significant number of the radar sensors. Position inaccuracies could have occurred because some of the blocked sensors may have detected reflections off nearby terrain, rather than transponder replies directly from the aircraft.

What exactly happened during the final part of the flight is unknown because there was a lack of data to be able to determine the precise tracking of the aircraft during the steep descending turn. However, it is very likely that there was a tightening turn to the right given the trend suggested in the data.

Investigators were unable to identify and fully understand the underlying causal and contributory factors. The investigation's sole finding as to cause and contributing factors was that the aircraft departed controlled flight, for reasons that could not be determined, and collided with terrain.

The relevant finding in the TSB accident report as to risk was that, if flight data, voice, and video recordings are not available to an investigation, the identification and communication of safety deficiencies to advance transportation safety may be precluded.

For several decades now, FDRs and CVRs have been conceived, designed, and installed in order to record flight and cockpit data for accident investigation purposes. FDRs record a number of aircraft parameters – such as altitude, airspeed, and heading – many times per second. CVRs record radio transmissions and ambient cockpit sounds, including pilot voices, alarms, and engine noises. Image/video recorders capture and provide video of the crew immediately before, during, and after an event.

Currently, FDRs and CVRs are considered the most comprehensive methods of capturing large amounts of flight data for accident investigations. Investigations can also obtain data from other sources, such as iPads, tablets, smartphones, GPS units, engine monitors, and other non-volatile memory sources that are not crash protected. Investigators who have access to data from FDRs and CVRs, as well as from these other types of lightweight recording systems, are more likely to identify safety deficiencies than investigations who do not benefit from FDR and CVR data.

In 2016, the International Civil Aviation Organization (ICAO) amended Annex 6 of its Standards and Recommended Practices to recommend that certain categories of aircraft and

helicopters flown by commercial operators carry lightweight flight recorders. The European Organisation for Civil Aviation Equipment (EUROCAE) established the Minimum Operational Performance Specification for Lightweight Flight Recording Systems, ED-155, and ICAO references this document. As well, ICAO Annex 6 outlines the minimum specifications for such systems. To comply with recent amendments to ICAO Annex 6 and to address 12 safety recommendations issued by 7 different investigation bodies in Europe, the European Aviation Safety Agency (EASA) published a Notice of Proposed Amendment (NPA) in 2017, under which new regulations would prescribe lightweight flight recorders for some categories of commercially operated aircraft and helicopters.

In Canada, FDR and CVR regulations are currently specified in section 605.33 of the CARs, Flight Data Recorder and Cockpit Voice Recorder. Under this provision, the requirements for CVR and FDR equipment in aircraft are based primarily on the number and type of engines, number of passenger seats, and type of operation. Given the design characteristics and configurations, many aircraft flown by private operators, including both aircraft that were involved in the accidents discussed in this paper, are not required by regulation to be equipped with either an FDR or a CVR.

EUROCAE's Minimum Operational Performance Specification for Lightweight Flight Recording Systems defines the minimum specifications for lightweight flight-data recording systems; Transport Canada (TC) does not currently have any regulatory requirements or specifications at this time.

To provide an accessible and feasible means of recording valuable flight data information, regardless of the type of aircraft and operation flown, several lightweight flight recording systems currently manufactured can record combined cockpit image, cockpit audio, aircraft parametric data, and/or data-link messages. Although there are currently no regulations in Canada requiring any aircraft to be equipped with lightweight flight recording systems, these devices provide a potential cost-effective alternative for some sectors of the civil aviation industry.

In 2013, following its investigation into a fatal in-flight breakup occurrence in March 2011 northeast of Mayo, Yukon, the TSB concluded there was a compelling case for implementing lightweight flight recording systems for all commercial operators. The TSB recommended that the Department of Transport (TC) work with industry to remove obstacles to and develop recommended practices for the implementation of flight data monitoring and the installation of lightweight flight recording systems by commercial operators not currently required to carry these systems. (TSB Recommendation A13-01).

TC has acknowledged that flight data monitoring programs would enhance safety and has taken the following actions to address the safety deficiency identified in Recommendation A13-01:

- In 2013, after conducting a risk assessment to evaluate alternative approaches to flight-data monitoring (FDM), TC informed the TSB that it supported

Recommendation A13-01. In 2015, TC informed the TSB that it intended to revisit this risk assessment.

- In 2013, TC informed the TSB that it would develop an Advisory Circular outlining recommended practices for FDM programs.
- In 2013, TC informed the TSB that it would incorporate its analysis and review of Recommendation A13-01 into its planned assessment for FDRs and CVRs, which was scheduled to begin in 2014–2015.
- In 2014, TC informed the TSB that it would consider adding FDM principles in future regulatory initiatives and amendments.
- In 2015, TC informed the TSB that it would prepare an issue paper on the use of FDM, providing information on FDM, including its benefits, costs, and challenges.

Due to other ministerial commitments, TC has not initiated its work for any of these undertakings.

In February 2018, TC conducted a focus group with industry stakeholders to evaluate the challenges and benefits of installing lightweight flight recording systems on aircraft that are not currently required to carry these systems. However, until the focus group reaches conclusions concerning these challenges and benefits in small aircraft, and TC provides the TSB with its plan of action following those conclusions, it is unclear when or how the safety deficiency identified in Recommendation A13-01 will be addressed.

Although Recommendation A13-01 targeted commercial operators, the contrast in available evidence demonstrated between the Îles-de-la-Madeleine and the Kelowna aircraft accidents discussed in this paper highlights the value of installing lightweight flight recording systems on privately operated aircraft as well. Investigators are at a disadvantage in determining the causes of an occurrence when there is no flight data available, regardless of whether the investigation involves an aircraft operated commercially or a business aircraft operated privately.

From past TSB investigation reports, it has been demonstrated that investigators have been unable to determine the reasons for an accident because of the lack of on-board recording devices. The benefits of recorded flight data in aircraft accident investigations are well known and documented. Because of the compelling evidence that the lack of recording devices on board commercial aircraft and private aircraft continues to impede the TSB's ability to advance transportation safety, the TSB Board recommended that the Department of Transport require the mandatory installation of lightweight flight recording systems by commercial operators and private operators not currently required to carry these systems. (TSB Recommendation A18-01 that replaced TSB Recommendation A13-01)

In the first accident discussed in this paper at Îles-de-la-Madeleine Airport, there was a lightweight flight recording system on board although it was not required by regulation. By recovering the recorder and extracting its data for analysis, investigators were able to have an accurate understanding of the sequence of events that led to the aircraft's departure from controlled flight. Had a recording system not been on board, crucial information to understand the circumstances and events leading up to this occurrence would not have been available to the investigation.

In contrast, the information normally recorded by FDR or CVR systems was not available to the second accident discussed in this paper. Investigators could not positively determine why the aircraft departed controlled flight and collided with terrain. Because this aircraft was not equipped with any type of lightweight flight recording system, investigators were precluded from fully identifying and understanding the sequence of events and the accident's underlying causes and contributing factors.

When investigators have access to recorded data on board an aircraft, they can quickly figure out what happened, and then it is possible to spend precious time and resources concentrating on the issues as to why the accident happened. Otherwise, time is needlessly spent testing and discounting hypotheses, and other issues that are deemed irrelevant to the investigation.