Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

AIR TRANSPORTATION SAFETY INVESTIGATION REPORT A22P0067

LOSS OF ENGINE POWER AND FORCED LANDING

Conair Group Inc.
Air Tractor, Inc. AT-802A, C-FFQS
Cranbrook, British Columbia, 20 NM S
02 August 2022

Canada

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Summary

On 02 August 2022, the Air Tractor, Inc. AT-802A aircraft (registration C-FFQS, serial number 802A-0629), equipped with amphibious floats and operated by Conair Group Inc. as Fireguard 673, was conducting aerial firefighting operations from Cranbrook/Canadian Rockies International Airport (CYXC), British Columbia, with 1 crew member on board. Fireguard 673 was the 4th aircraft working in a group of 4, with 1 additional aircraft acting as a bird dog. After conducting the 8th water drop on the Connell Ridge wildfire, the pilot of Fireguard 673 applied power for the climb-out, but the engine power rolled back to idle. When he then selected the emergency power lever, no more power was produced. The pilot selected a reforested area and completed a forced landing. The pilot sustained minor injuries and was taken by helicopter to receive medical aid. There was no post-impact fire. The aircraft was substantially damaged.

1.0 FACTUAL INFORMATION

1.1 History of the flight

On 02 August 2022, a visual flight rules (VFR) aerial firefighting operation was being conducted by Conair Group Inc. (Conair) approximately 20 nautical miles south of Cranbrook, British Columbia (BC), in the area of Connell Ridge, the site of multiple wildfires. The operation involved a team of 5 aircraft: a Cessna 208 Caravan bird dog[1] and 4 Air Tractor, Inc. (Air Tractor) AT-802A Fire Boss, single-seat, single-engine air tankers (SEATs) equipped with amphibious floats and configured with the Fire Boss system.[2] The occurrence aircraft, one of the Air Tractor AT-802A SEATs, was operating as Fireguard 673. It flew as the 4th aircraft in the group of 4 SEATs. The bird dog crew, which was composed of a pilot and an air attack officer, planned and directed the fire suppression activity.

The 1st flight of the day consisted of 10 scooping runs in which the 4 tankers dropped a total of 40 loads of water onto the same fire. They flew in a circuit-like pattern in formation between the location of the fire and Lake Koocanusa, where they conducted water uploading.

Each trip from Lake Koocanusa to the Connell Ridge fire took approximately 9 minutes, with a climb from the lake elevation of approximately 2500 feet above sea level to a cruise altitude of 7500 feet above sea level. The return flight to the lake took approximately 8 minutes, and for almost the entire duration, the tankers were in descent and at a low power setting.

The group stopped at 1533[3] to refuel and take a lunch break at Cranbrook/Canadian Rockies International Airport (CYXC), BC, and departed at approximately 1716 with full fuel and full foam[4][5] for the 2nd flight of the day. Their plan was to continue the same operation they had conducted in the morning.

At approximately 1919, immediately following the 7th water drop of the 2nd flight, the occurrence pilot advanced the power lever forward to increase engine power, and the aircraft experienced a 2-second reduction of power. The power reduction may not have

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1 A bird dog is an aircraft with a usual crew of a pilot and an air attack officer. The bird dog ensures the air tanker runs are safe and free of obstructions. The crew determines the run locations and drop types to be made, coordinates the aerial action with the ground crews, and controls the airspace around the fire.

2 The Fire Boss is a water scooping system designed for the Air Tractor AT-802A that “combines several airframe modifications, aircraft performance enhancers, and […] amphibious water-scooping floats” for the purpose of aerial firefighting. (Source: Fire Boss LLC, at firebossllc.com/about-fire-boss-llc/ [last accessed on 26 March 2024].)

3 All times are Pacific Daylight Time (Coordinated Universal Time minus 7 hours).

4 Full foam refers to the maximum volume of the foam concentrate tank, which is part of the foam system that allows the pilot to transfer foam concentrate into the hopper for mixing. (Source: Air Tractor, Inc., *FAA Approved Airplane Flight Manual 01-0059 for Air Tractor Model AT-802* [revised 16 April 2021], The Foam System, p. 22O.)

5 The foam is mixed with water before being dropped onto an active fire.

been discernible to the pilot[6]. The engine power returned and the aircraft operated normally. The pilot continued with the firefighting mission.

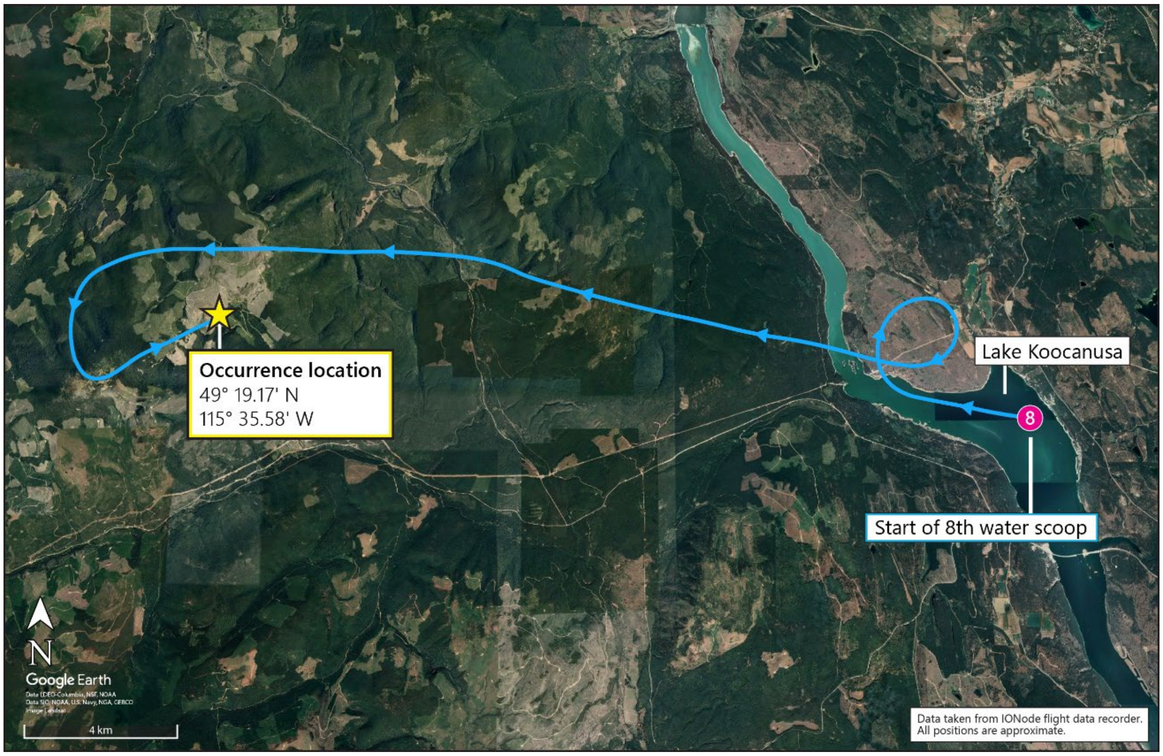
After loading up with water at Lake Koocanusa, Fireguard 673 returned to the Connell Ridge fire for the 8th water drop. Upon completion of this water drop, at approximately 1937, the pilot advanced the power lever, and the engine power initially responded accordingly, but then rolled back in a similar fashion to the earlier power reduction that had occurred after the 7th water drop. This time, however, the engine power did not return. The aircraft was approximately 350 feet above ground level (AGL).

The pilot moved the power lever to the idle position, turned the igniters to the CONTINUOUS position, and advanced the power lever. There was no change in engine power. He next moved the power lever to idle and applied the fuel control unit manual override lever (also known as the emergency power lever [EPL]); however, engine power was not restored.

Unable to determine the cause of the power reduction, the pilot then selected a reforested area and began to perform an emergency landing, managing his descent rate and speed carefully to ensure he would reach the site. During the descent, the engine flamed out, and due to time constraints, the pilot was unable to scan the flight instruments for fuel or fuel flow information. The stall warning horn sounded several times as the pilot gradually brought the aircraft into the trees, which the aircraft struck at approximately 1938 (Figure 1).

6 Flight data collected shows that the fuel flow dropped from 360 L/h to 172 L/h followed by an engine torque drop from 2928 to 1698 pound-foot.

Figure 1. Map showing the aircraft's flight path for the 8th scooping run and the occurrence location (Source: Google Earth, with TSB annotations)



As the aircraft descended into the trees and toward the ground, a small tree was cut, and it penetrated the windscreen, grazing the pilot's helmet. The pilot was covered in shards of glass from the shattered windscreen. The aircraft came to rest approximately 200 m from the edge of the forest fire.

The pilot cleared glass and tree debris from his face and checked himself for injuries. He then used the aircraft radio to call the bird dog aircraft; however, the radio transmission was not received. He next used an FM radio to call the pilot of one of the other SEATs who relayed to the bird dog that the aircraft and pilot were down on the ground. The occurrence pilot then turned off the aircraft battery. The bird dog assisted in arranging for a helicopter to pick up the occurrence pilot, who walked to a nearby logging road. He was then transported to CYXC to receive medical attention for his injuries.

1.2 Injuries to persons

The pilot of the occurrence aircraft received minor injuries.

Table 1. Injuries to persons

Degree of injury	Crew	Passengers	Persons not on board the aircraft	Total by injury
Fatal	0	-	-	0
Serious	0	-	-	0
Minor	1	-	-	1
Total injured	1	-	-	1

1.3 Damage to aircraft

The aircraft was substantially damaged by impact forces.

1.4 Other damage

Approximately 315L of Jet A-1 fuel was released into the forest. The aircraft's foam tank did not rupture, and the remaining foam was recovered.

1.5 Personnel information

Table 2. Personnel information

Pilot licence	Airline transport pilot licence (ATPL)
Medical expiry date	01 May 2023
Total flying hours	11 086.0
Flight hours on type	668.0
Flight hours in the 7 days before the occurrence	4.7
Flight hours in the 30 days before the occurrence	22.3
Flight hours in the 90 days before the occurrence	32.6
Flight hours on type in the 90 days before the occurrence	32.6
Hours on duty before the occurrence	10.5
Hours off duty before the work period	15

The pilot held the appropriate licence and met the recency requirements for the flight in accordance with existing regulations.

The pilot began employment with Conair in March 2017 on a seasonal contract to fly the AT-802. All of his experience on type was obtained conducting flights related to forest firefighting activities. The pilot's last pilot competency check on the AT-802A was completed on 03 April 2022.

Based on a review of the pilot's work and rest schedule, there was no indication that the pilot's performance was degraded by fatigue.

1.6 Aircraft information

The Air Tractor AT-802A is a single-seat, low-wing aircraft with a tail-wheel undercarriage and is intended specifically for agricultural spray applications. Its design was certificated under the United States (U.S.) *Federal Aviation Regulations* in the restricted category. The aircraft operates in Canada under a Special Certificate of Airworthiness—Restricted classification.[7] The hopper, located between the cockpit and the engine, has a capacity of 814 U.S. gallons (3081 L). The fuel tanks are located in the wings and have a maximum capacity of 380 U.S. gallons (1438 L).

Table 3. Aircraft information

Manufacturer	Air Tractor, Inc.
Type, model and registration	AT-802A, C-FFQS
Year of manufacture	2015
Serial number	802A-0629
Certificate of airworthiness/flight permit issue date	20 April 2016
Total airframe time	1055.2 hours
Engine type (number of engines)	Pratt & Whitney PT6A-67F (1)
Propeller (number of propellers)	Hartzell HC-B5MA-3D (1)
Maximum allowable take-off weight	16 000 lb (7257 kg)
Recommended fuel types	Jet A, Jet A-1, Jet B
Fuel type used	Jet A-1

The airplane had no known deficiencies before the occurrence flight. Its weight and centre of gravity were within the prescribed limits, and there was sufficient fuel on board to complete the flight.

1.6.1 Fire Boss conversion

The factory version of the occurrence aircraft had been modified for a firefighting role. The AT-802A was converted to the Fire Boss water scooping system, which incorporated the following changes:

- installation of amphibious floats with hydraulically actuated water scoops
- installation of a fire-retardant delivery system
- installation of a foam system and controls, which incorporate a 30 U.S. gallon foam tank in the right float and an 18 U.S. gallon firewall tank
- modifications to the hopper venting system
- addition of a bilge pumping system and water-in-floats warning system

7 Aircraft operating under this category (*Canadian Aviation Regulations* section 507.03) have been inspected and found safe for flight within Canada's territory. The aircraft does not comply with airworthiness standards under International Civil Aviation Organization Article 31 on the basis of its type design.

Conair developed an independent supplemental type certificate (STC) for the Fire Boss conversion, which increased the engine power from 1350 shaft horsepower to 1600 shaft horsepower (for takeoff) by modifying the equipped engine. The aircraft's maximum take-off weight remained at 16 000 pounds.[8]

1.7 Meteorological information

Flight crews in the area reported moderate turbulence near the fire location throughout the day. There was also some wind shear associated with mechanical turbulence at the ridge crossing. Skies were generally clear, and the temperatures on the water at Lake Koocanusa were observed to be 30 °C.

The nearest weather reporting station, which was CYXC (located about 20 nautical miles north of the occurrence site), issued the following aerodrome routine meteorological report (METAR) at 1700:

- Winds from 280° true (T) at 8 knots, gusting to 17 knots; winds variable from 240°T to 310°T
- Visibility 25 statute miles
- Few clouds at 11 000 feet AGL with broken clouds at 25 000 feet AGL
- Temperature 30 °C
- Altimeter setting 29.87 inches of mercury

The METAR for CYXC issued at 1900 indicated the following:

- Winds from 270°T, at 7 knots; winds variable from 220°T to 300°T
- Visibility 15 statute miles
- Few clouds at 10 000 feet AGL with broken clouds at 23 000 feet AGL
- Temperature 28 °C
- Altimeter setting 29.87 inches of mercury

Weather was not considered to be a factor in this occurrence.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Not applicable.

1.10 Aerodrome information

Not applicable.

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8 Transport Canada, Supplemental Type Certificate P-LSA08-072: Take Off Power Increase to 1600 shp and Maximum Continuous Power Increase to 1440 shp, issued 09 April 2020.

1.11 Flight recorders

The aircraft was not equipped with a cockpit voice recorder, nor was it required by regulation.

The aircraft was equipped with 2 systems that had the capability of recording flight data pertaining to the occurrence flight. These 2 systems are described in the following subsections.

1.11.1 Latitude Technologies flight tracking

A Latitude Technologies IONode flight data recorder unit was installed in the occurrence aircraft in December 2017 in accordance with STC P-LSA15-021/D.[9] The IONode is a small aircraft-mounted system that records multiple flight-data parameters.

The IONode was recovered from the aircraft, and flight data were retrieved from the unit.

1.11.2 Perkins Technologies data logger

The occurrence aircraft was also equipped with a Perkins Technologies Data Acquisition Alarm Monitor (DAAM) System. The DAAM system is an on-board, self-contained aircraft systems monitor. The system is capable of monitoring, displaying, and recording critical aircraft and engine parameters. The system was installed by Air Tractor at the time of manufacturing.

The DAAM data logger was also recovered, and engine data were retrieved from the unit.

1.12 Wreckage and impact information

1.12.1 Accident site

When the pilot was conducting the forced landing, he reduced the approach speed as low as possible, striking the trees just above the aircraft's stall speed of 68 knots calibrated airspeed.

The aircraft struck the trees in a near-level attitude. The floats broke off, separated from the fuselage, and rolled upside down, coming to rest near the trailing edge of the right wing. As the fuselage decelerated, it turned approximately 45° to the right but remained upright (Figure 2). There was significant damage to the leading edges of the wings and the fuselage lower skins. Calculations indicate that, at the time of the forced landing, the aircraft was carrying approximately 315 L of fuel.

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9 Transport Canada, Supplemental Type Certificate P-LSA15-021/D: Operational Data Recorder, issued 26 January 2021.

Figure 2. Accident site (Source: Conair Group Inc., with TSB annotation)

The aircraft came to rest approximately 200 m from the edge of the Connell Ridge wildfire. In that location, the entire aircraft was at risk of being lost to the fire. However, the shifting winds and continued fire suppression operations in the area allowed for a successful recovery a few days later.

1.12.2 Wreckage examination

1.12.2.1 Engine

The occurrence aircraft was equipped with a Pratt & Whitney Canada PT6A-67F turboprop engine with 1055.2 hours total time since new.

After the accident, the engine and engine accessories were shipped to the Pratt & Whitney Canada facility in Saint-Hubert, Quebec, for further evaluation. This evaluation was supervised by the TSB. The engine was inspected for damage externally and internally and found to be relatively undamaged. The engine compressor section was clean and free of debris. The igniters were found in working condition. The chip detectors were found to be free of debris and the pneumatic lines were found to be tight and without leaks.

It was then prepared for a test run in the available test cell, but before the start of this test run, it was discovered that the reduction gearbox had suffered a crack as a result of the impact, causing an oil leak. The engine was therefore unable to be run.

Internally, the engine did not appear to have any pre-impact mechanical anomalies that would have precluded normal engine operation.

The engine air filter was examined and found to be serviceable with no contamination.

The constant speed unit was removed from the engine and shipped to the manufacturer. The unit was tested and disassembled under the supervision of the TSB. No anomalies were found.

1.12.2.2 Fuel control unit

On 10 July 2022, the occurrence aircraft experienced a series of momentary in-flight power reductions, similar to those in the occurrence flight, when the pilot advanced the power lever. At that time, the aircraft had accumulated 1041.6 hours total time. Conair maintenance employees replaced the fuel control unit (FCU).

The removed FCU was shipped to Pratt & Whitney Canada for testing; at the time of the occurrence flight, it had not yet been tested. After the 02 August occurrence, both this FCU and the replacement FCU, which had been on the aircraft at the time of the forced landing, were tested by Pratt & Whitney Canada.

During these tests, which were also supervised by the TSB, no faults were found with either FCU.

1.12.2.3 Fuel pumps

The AT-802 incorporates an engine-driven fuel pump and an electric fuel boost pump. Both pumps are capable of supplying the fuel control pump with sufficient fuel at a minimum pressure of 15 psi.

The engine-driven fuel pump operates at all times when the engine is running. The electric fuel boost pump is used for starting and as a back-up to the engine-driven pump.

The aircraft DAAM data logger revealed a significant dip in fuel flow prior to the reduction of engine power.

The engine-driven fuel pump was forwarded to the TSB Engineering Laboratory in Ottawa, Ontario, for analysis. No anomalies were found during the testing; however, some wear was found on the fuel pump guide vanes during the disassembly examination. The fuel pump was shipped to the pump manufacturer for further examination, supervised by the TSB. The additional examination revealed that the wear observed on the vanes was normal and not significant enough to prevent the pump from operating as designed.

During the occurrence, the electric fuel boost pump was not on during flight, nor had it been selected on by the pilot. The pump was removed from the aircraft and tested by the TSB to ensure it was not restricting fuel flow. No anomalies were found during testing.

1.12.2.4 Aircraft fuel system

Numerous components of the aircraft fuel system were examined by the TSB. These included:

- The fuel filter
- The high-pressure fuel filter
- The fuel lines

- The fuel selector valve
- The fuel strainers
- The fuel flow divider
- The fuel nozzles

All of these components were found in serviceable condition with no contamination or apparent blockages.

The occurrence aircraft was fuelled at CYXC. All of the Conair aircraft operating in the area were also fuelled at the same source before flight. A fuel sample was collected from the wreckage and visually inspected for contamination. No anomalies were found.

1.13 Medical and pathological information

According to information gathered during the investigation, there was no indication that the performance of the pilot was affected by medical or physiological factors.

1.14 Fire

There was no aircraft fire either before or after the occurrence.

1.15 Survival aspects

The pilot was wearing a flight helmet and a fire-resistant flight suit, and was using the available 5-point safety belt at the time of the occurrence. The flight helmet was equipped with a visor; however, it was in the up position during the forced landing. The pilot received minor injuries including small cuts to his face. He was able to egress the aircraft through the left-side cockpit door without difficulty.

1.15.1 Emergency locator transmitter

The Kannad emergency locator transmitter (ELT) on board the occurrence aircraft transmits on both 121.5 MHz and 406 MHz. The ELT activated at impact as designed. However, no signal was received by airborne aircraft in the vicinity of the occurrence or by the Canadian Mission Control Centre in Trenton, Ontario.

The ELT was found inside the aircraft, secured in the mounting bracket and still connected by coax cable to the antenna. The ELT's fibreglass whip rod antenna, which was approximately 13 inches in length, had been broken off during the forced landing.

The coax cable, antenna base, and ELT were removed from the aircraft fuselage and shipped to the TSB Engineering Laboratory for testing.

The coax cable was observed to be functional and in good condition. The broken antenna also functioned, though its signal strength was diminished due to its damaged condition. The ELT battery pack, mode switch, and G-switch were found to be functional.

The investigation determined that the signal strength from the broken antenna was not sufficient to be received outside of the immediate accident location. Therefore, it was not received by other aircraft or the Canadian Mission Control Centre.

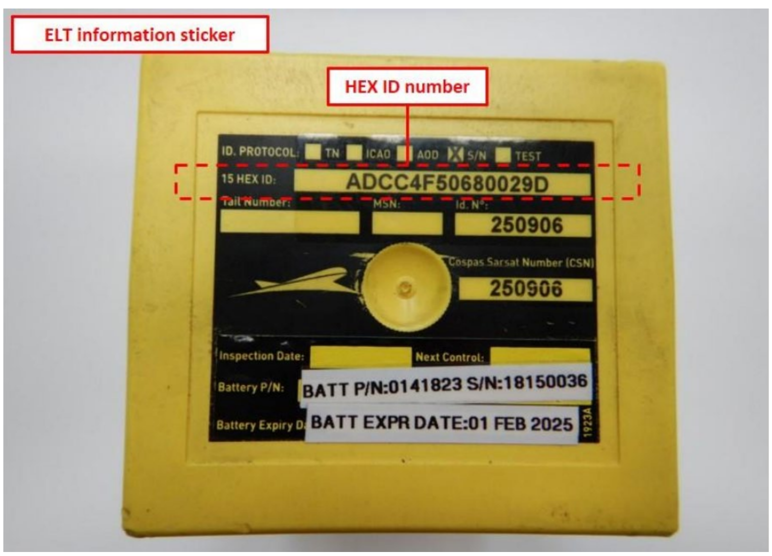
1.15.1.1 ELT identification

According to *Canadian Aviation Regulations* (CARs) subsection 605.38(4),[10] each 406 MHz ELT must be registered with the Canadian Beacon Registry before it is installed on a Canadian-registered aircraft. When the occurrence aircraft was manufactured in the United States, the ELT was installed and registered there.

When the aircraft was brought to Canada, the ELT was required to be recoded with a 15 Hex ID.[11] The Hex ID contains the country code and other identification features that are dependent upon the coding protocol used. The ELT is then required to be registered with the Canadian Beacon Registry. Conair had recoded and registered the ELT as required.

During testing, the 15 Hex ID digital signal received by the testing equipment did not match the external identification sticker at the bottom of the ELT casing. The ELT casing still showed the previous 15 Hex ID from the ELT's original coding for the United States (Figure 3).

Figure 3. Emergency locator transmitter that was removed from the occurrence aircraft (Source: TSB)



There is no requirement to change or update the external identification sticker to reflect the programmed 15 Hex ID.

10 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, subsection 605.38(4).

11 "The Hex ID is a 15 hexadecimal character string (valid range: numbers 0 through 9 and letters A through F), referred to as the beacon 15 Hex Identification, or 15 Hex ID." (Source: International 406 MHZ Beacon Registration Database, at 406registration.com/faq/Lk7I6 [last accessed on 27 March 2024].)

1.15.2 Airbags

The aircraft was equipped with the AmSafe Aviation Inflatable Restraint System. The system was installed in March 2018 in accordance with Federal Aviation Administration STC SA02276AK.[12] In the case of an accident, the airbag will deploy from the shoulder harness.

The airbag system was removed and shipped to the TSB Engineering Laboratory for testing. The tests concluded that the airbag system functioned as designed. The acceleration due to gravity during the forced landing in the occurrence did not reach the 6*g* activation level required for the inflatable restraint system to deploy. The DAAM unit on board the aircraft recorded a maximum of 3.8*g* during the forced landing sequence.

1.15.3 Cockpit windscreen

The Air Tractor AT-802 is designed with a 3-panel windscreen made of tempered glass, to help prevent objects from penetrating the cockpit. The original Air Tractor aircraft were designed with a windscreen ¼ inch in thickness.

In 2008, an accident occurred in Western Cape, South Africa, in which a large bird struck the windscreen of an Air Tractor 502B aircraft, leading to the aircraft's collision with terrain.[13] As a result, Air Tractor issued a service letter[14] that changed the design of the aircraft so that it was equipped with a windscreen that was $^{3}/_{8}$ inch thick. The thicker windscreen provided added impact protection in the event of a collision with a bird or another object. The occurrence aircraft was equipped with a front windscreen that was $^{3}/_{8}$ inch thick.

During the occurrence aircraft's forced landing, the aircraft collided with a small tree, which then penetrated the front and right windscreens. The windows shattered in the immediate area of the impact; however, the majority of the window remained intact (Figure 4). The tree grazed the pilot's helmet. The pilot was showered in glass shards and tree debris, resulting in small cuts to his face.

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12 Transport Canada, Supplemental Type Certificate SA02276AK: *Acceptance of FAA STC SA02276AK*, issued 01 March 2017.

13 South African Civil Aviation Authority (SACAA), Aircraft Accident Report and Executive Summary, reference no. CA 18/2/3/8548, 11 September 2008 (27 January 2009).

14 Snow Engineering Co., Service Letter #276: Installation of Optional 3/8" Thick Windshield (11 June 2009), at airtractor.com/wp-content/uploads/2016/10/SL276.pdf (last accessed on 28 March 2024).

Figure 4. Tree protruding through the front windscreen and into the cockpit of the occurrence aircraft after its collision (Source: Conair Group Inc.)

Finding: Other

The combination of the aircraft's thick windscreen and the pilot's flight helmet minimized the pilot's injuries when the tree penetrated the cockpit.

1.16 Tests and research

1.16.1 TSB laboratory reports

The TSB completed the following laboratory reports in support of this investigation:

- LP068/2022 – Flight Data Analysis
- LP114/2022 – ELT Analysis
- LP104/2022 – AMSAFE Airbag Examination
- LP038/2023 – Constant Speed Unit Examination
- LP037/2023 – Fuel Pump and Py Line Examination

1.17 Organizational and management information

Conair holds an air operator certificate and operates in accordance with Subpart 702 (Aerial Work) and Subpart 703 (Air Taxi) of the CARs. The company also holds an approved maintenance organization certificate. Its maintenance activities are conducted in accordance with Subpart 573 (Approved Maintenance Organizations) of the CARs.

At the time of the occurrence, the Conair fleet consisted of 52 aircraft:

- 7 Aero Commander 690A/B bird dogs
- 5 Cessna 208 Caravan bird dogs
- 8 Air Tractor, Inc. AT-802 land-based air tankers

- 15 Air Tractor, Inc. AT-802 Fire Boss amphibious air tankers
- 3 BAE Systems Avro RJ85 land-based air tankers
- 4 Canadair CL-215T amphibious air tankers
- 4 Convair CV-580 land-based air tankers
- 5 de Havilland DHC-8-402 land-based air tankers
- 1 Cessna 25B (Citation Jet CJ3)

Conair offers the following services:

- aerial forest firefighting
- maintenance and modification of fixed-wing air tankers and bird dog aircraft

Conair had a voluntary safety management system at the time of the occurrence, which is modelled to mirror the CAR 705 requirements for airline operations.

1.18 Additional information

1.18.1 Fuel control unit manual override system

Air Tractor aircraft come equipped with an FCU manual override system[15] installed at the time of aircraft manufacturing. The FCU manual override system allows the pilot to restore power in the event of a fuel control malfunction—for example, the loss of P3 or Py[16] pneumatic pressure or the loss of the unit's ability to meter the fuel.

The FCU manual override is connected through linkage to the override lever on the FCU and governs fuel supply to the engine, should an FCU malfunction occur, by directly actuating the fuel valve within the FCU.

In the cockpit, the FCU manual override lever consists of a red handle mounted on the left side, next to the pilot seat. The handle is equipped with a spring-loaded locking trigger that can be pulled to allow the pilot to push the handle down toward the aircraft floor. The FCU manual override lever is intended for emergency use only.

The FCU manual override system on the occurrence aircraft was ground-tested by maintenance staff when the FCU was changed in July 2022. At that time, the FCU manual override functioned as designed.

During the forced landing sequence, the pilot used the FCU manual override system, but it made no change to the aircraft condition or available power. The investigation could not determine why the FCU manual override was ineffective.

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15 The FCU manual override is referred to as the EPL (emergency power lever) in the emergency checklist. (Source: Conair Group Inc., *Fire Boss Standard Operating Procedures* [01 May 2022], subsection 2.3: Fire Boss Emergency Checklist Card, pp. 20-21.)

16 P3 and Py are related to pneumatic pressure within the engine. P3 is the compressor discharge pressure and is used to operate the FCU. Py is the pressure used to control the fuel metering valve.

1.18.1.1 Fuel control unit manual override system guidance

The *FAA Approved Airplane Flight Manual Supplement: Fuel Control Unit Manual Override System* is attached to the applicable *FAA Approved Airplane Flight Manual 01-0059 for Air Tractor Model AT-802* for aircraft that have been modified by the installation of the Air Tractor FCU manual override system. The manual acquaints the pilot with the features and functions of the system.

Section 2 of the supplement presents the procedures for the use of the FCU manual override system. It offers the following information:

> In the case of an emergency, the power lever control must be in the maximum forward thrust position to enable manual modulating of power via the fuel control manual override lever.[17]

The usage procedure is further explained in section 3, which supplies the following information for an emergency situation in which the power lever is not responsive:

> **POWER LEVER NOT RESPONSIVE:**
> (1) Check engine instruments to ensure that engine is running and is at least running at normal idle rpm.
>
> (2) Power control lever – Advance to maximum forward thrust position.
>
> NOTE: Since the power lever selects the target Ng,[[18]] it is important that the power lever be configured so as to select a high Ng in order to ensure the desired power can be achieved with the manual override. If a low Ng is selected, the Ng governor will act to limit the authority of the manual override and result in reduced power available via the manual override.
>
> (3) Fuel control Manual Override Lever – As Required.[19]

During the investigation, Pratt & Whitney Canada confirmed the above information.

1.18.1.2 Conair Group Inc. standard operating procedures

Conair has developed the *Fire Boss Standard Operating Procedures* (SOPs) for use by flight crews for the operation of each aircraft type. The documented procedures assist in standardizing operations for its Air Tractor fleet using established best practices throughout all phases of flight. The SOPs are to be used in conjunction with the aircraft flight manuals and supplements.

The SOPs for the AT-802 Fire Boss expand the FCU malfunction information for flight crews. Some of the guidance is taken directly from the supplement on FCU manual override.

The SOPs explain that,

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[17] Air Tractor, Inc., *FAA Approved Airplane Flight Manual Supplement: Fuel Control Unit Manual Override System* (21 January 2014), section 2: Normal Procedures, p. 4.

[18] N_g is the indication of the power output of the engine.

[19] Air Tractor, Inc., *FAA Approved Airplane Flight Manual Supplement: Fuel Control Unit Manual Override System* (21 January 2014), section 3: Emergency Procedures, p. 5.

> [i]n the case of an emergency, the power lever control must be in the maximum forward thrust position to enable the manual modulating of power via the fuel control manual override lever.[20]

1.18.1.3 FCU malfunction training and checklist

The investigation revealed that Conair trains its pilots to recognize the signs of an FCU malfunction and take appropriate action. In the simulator, pilots are instructed on and practise the following actions:

- no response to the power lever – move the power lever to idle
- move the FCU manual override lever to the floor
- increase the power lever for additional power as required

The checklist for an FCU malfunction, which can be found in the SOPs, is not a memory item. The checklist makes no mention of the desired position for the power lever before the FCU manual override lever is advanced.

The checklist for an FCU malfunction is as follows:

> **Indications**
>
> 1. Engine at Flight Idle
> 2. Engine does not respond to Power Lever movement
>
> • Advance EPL to max or as required
>
> • Advance Power Lever if more power required
>
> • Monitor engine ITT [interstage turbine temperature] and Torque
>
> • Retardant – Jettison (below 120 kts)
>
> • Monitor engine ITT and Torque[21]

When the pilot applied the FCU manual override during the occurrence flight, the power control lever was in the idle position. In this configuration, the aircraft engine would produce less than maximum power; however, Pratt & Whitney Canada could not determine how much less power would be available.

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20 Conair Group Inc., *Fire Boss Standard Operating Procedures* (01 May 2022), subsection 2.11: FCU Malfunction, p. 31.

21 Ibid., subsection 2.3: Fire Boss Emergency Checklist Card, pp. 20-21, and subsection 2.11: FCU Malfunction, p. 31.

1.18.2 Fuel boost pump

During the occurrence flight, it was unclear to the pilot what was causing the reduction of engine power. The pilot was not sure if he had a complete engine failure or an engine flameout.[22] The aircraft flight manual describes the signs of an engine flameout as similar to those of an engine failure only in regard to a drop in ITT, torque pressure, and N_g.[23] The manual also reminds flight crews of the following:

> Remember that turbine engines seldom fail so long as fuel is being provided. An important procedure in this respect is to know the location of the fuel boost pump switch and the CONTINUOUS position for the ignitor switch. You should have a solid reaction to do two things anytime there is an indication of a power loss:
>
> 1. Put the ignitor on CONTINUOUS
>
> 2. Turn ON the fuel boost pump switch.[24]

During the occurrence flight, the fuel boost pump was not selected on.

1.18.3 Emergency checklists for engine failure and flameout

1.18.3.1 Engine failure in flight

Conair conducted an assessment and, based on the manufacturer's recommendations, developed a SOP that addresses the most critical actions. Conair created a single checklist for pilots to safely execute a forced landing while also attempting to recover from a power loss scenario. The Conair aircraft emergency checklist has a specific memory list for an engine failure in flight:

ENGINE FAILURE IN FLIGHT	
Retardant	Jettison (below 120 kts)
Airspeed	95 KIAS [knots indicated airspeed]
Power Lever	Idle
Ignitors	Continuous
Boost pump	On
Power Lever	Advance
No response…	
EPL	Advance
No response…	
Propeller	Feather
Start Control Lever	Cut Off
Fuel	Off

22 A flameout is a loss of power through the extinction of the flame in the combustion chamber.

23 Air Tractor, Inc., *FAA Approved Airplane Flight Manual 01-0059 for Air Tractor Model AT-802* (revised 16 April 2021), Engine Flame-out, p. 25.

24 Ibid.

Boost Pump	Off
Ignitors	Off
Radio	Advise
Extend Flaps	As Req’d
Gear	As Req’d
Battery Master	Off (prior to landing)[25]

After the engine power reduction, the occurrence pilot began to perform the engine failure checklist from memory; however, the checklist was not completed. The fuel boost pump was not selected on, and the power levers were not advanced prior to the FCU manual override lever being advanced.

1.18.3.2 Engine flameout in flight

The engine flameout in flight checklist is intended for cases of engine flameouts in which the pilot has time to react and attempt a restart.

Conair’s *Fire Boss Standard Operating Procedures* recommend that for any engine failure where the pilot does not have time to react or restart, the engine failure in flight checklist should be used.

In this occurrence, the engine flameout did not occur until the final few moments of the flight (Appendix A). The pilot was unaware of a flameout, and there was not sufficient altitude to attempt a restart.

1.18.4 Pilot self-briefing

Pilots prepare for trips by reviewing the relevant information for the upcoming flight. This preparation may include a review of emergency procedures.

The occurrence pilot was in the habit of completing a daily self-briefing prior to flights. This typically included him sitting in the cockpit, with the engine off, and running through memory checklist items. While running the checklist in preparation of the flight, the pilot was in the habit of verbally completing the checklist without actively touching the switches. He would frequently point at the switch while verbalizing.

During the 40 seconds between the engine power reduction and the forced landing, the pilot attempted to complete the memory checklist for an engine failure in flight. Instead of turning the fuel boost pump switch on, he may have only pointed at it the same way he typically did during his self-briefing.

1.18.5 Pilot decision making and mental models

Pilot decision making (PDM) is a cognitive process to select a course of action between alternatives. The FAA defines aeronautical decision-making as “a systematic approach to the mental process used by pilots to consistently determine the best course of action in

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[25] Conair Group Inc., *Fire Boss Standard Operating Procedures* (01 May 2022), subsection 2.4: Engine Failure in Flight, p. 22.

response to a given set of circumstances. It is what a pilot intends to do based on the latest information he or she has."[26] According to an educational package from Transport Canada,[27] PDM is a function of time, so that before the flight, there is "ample-time decision-making," and while in flight, in a dynamic environment, there can be "time-critical decision-making."[28]

Mental models are critical for effective performance in dynamic, time-critical environments, because they reduce the need for time-consuming evaluations of a given situation and enable quick actions. In operational situations, people use their prior experience and knowledge to rapidly categorize the situation and select an appropriate course of action.[29] Therefore, in highly practised situations, attention and expectations are often driven by the person's existing mental model of the situation, with previous experience dictating what information is important and how the situation will unfold. Time-critical situations require preprogramed training based on the predictability of the situation and must be based on cues to ensure an adequate response within the time available.[30]

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26 Federal Aviation Administration, FAA-H-80803-25C, *Pilot's Handbook of Aeronautical Knowledge* (2016), Chapter 2: Aeronautical Decision-Making, p. 2-1, at www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak (last accessed on 22 March 2024).

27 Transport Canada, TP 13897E, *Pilot Decision Making – PDM*, at tc.gc.ca/eng/civilaviation/publications/tp13897-menu-1889.htm (last accessed on 22 March 2024).

28 Ibid., Module 2: The Decision-making Process.

29 G. Klein, "Naturalistic decision making," Human Factors, Vol. 50, No. 3 (June 2008), pp. 456–460.

30 P. A. Oppenheimer, *Pilot Response in Time Critical Aircraft Upset/Loss of Control Inflight (LOC-I) Events* (2017), at apstraining.com/wp-content/uploads/2017/10/Pilot_Response_in_Time_Critical_LOCI-Events.pdf (last accessed on 15 April 2024.)

2.0 ANALYSIS

2.1 General

In this occurrence, the Air Tractor, Inc. AT-802 aircraft's engine examination included the compressor section, ignitors, chip detectors, pneumatic lines, and the constant speed unit. The fuel control unit (FCU), fuel pumps, and the aircraft fuel system were also examined. No defects were identified that would have affected the normal functioning of the engine.

The investigation was not able to determine the source of the engine power reduction or the reason for the FCU manual override system's ineffectiveness.

During the forced landing, the pilot's use of a helmet, the 5-point safety belt, the aircraft's windscreen, and the slow impact speed all reduced the injuries to the pilot. The pilot's decision making, experience, and recent training assisted in a successful outcome.

This analysis will therefore focus on factors surrounding the forced landing. In particular, it will examine aircraft operations and the usage of standard operating procedures (SOPs) and checklists.

2.2 Aircraft operations

2.2.1 Engine power reduction

In July 2022, the occurrence aircraft's FCU was replaced by maintenance staff after the aircraft had suffered a series of momentary power reductions in flight. The aircraft had accumulated approximately 13.6 flight hours with the replacement FCU when it suffered a significant power reduction and eventual flameout during the occurrence flight, resulting in a forced landing (Appendix A).

At the time of the forced landing, the aircraft had been conducting an aerial firefighting operation in clear skies and areas of moderate turbulence and with sufficient fuel on board for the flight. In addition, the aircraft's maintenance was up to date and the aircraft had no known defects.

Component and airframe examinations conducted as part of the investigation could not determine the cause of the power reduction.

Finding as to causes and contributing factors

During the application of engine power following a low-level water drop, a power reduction followed by a complete power loss occurred. The reason for both could not be determined.

2.2.2 Low-level operations

Firefighting aircraft are required to operate at low levels, which is inherently risky. To fight forest fires effectively, aircraft need to operate close to the fire. Their altitude while dropping water on a fire can be as low as 150 to 200 feet above the ground, leaving little room for error.

At such low levels, recovery from an aircraft malfunction becomes extremely challenging. In such a situation, where a pilot's decision making and reaction time are critical for a successful outcome, the ability to make decisions under time pressure is heavily dependent on mental models and the need for immediate action.

In this occurrence, 40 seconds passed from the time the aircraft suffered the engine power reduction to when it struck the trees. Because of the time constraint, the pilot was unable to consult the cockpit instruments and warning lights, or his checklists. As a result, he was unable to fully determine the origin of the power reduction. His focus was on successfully performing a forced landing and managing the aircraft's rate of descent.

Finding as to causes and contributing factors

The power reduction occurred at approximately 350 feet above ground level, leaving insufficient time for the pilot to complete the checklists, determine the reason for the power rollback, and restore power. As a result, a forced landing was accomplished in a reforested area, resulting in significant aircraft damage.

2.3 Guidance, procedures, and training

The FCU manual override system guidance that is created and controlled by the aircraft manufacturer is contained within the *FAA Approved Airplane Flight Manual Supplement: Fuel Control Unit Manual Override System*. The manufacturer supplies this guidance based on testing and on its understanding of the aircraft engine.

In this case, the guidance dictates that the power control lever must be in the maximum forward thrust position to enable the manual modulation of power via the FCU manual override lever. The note supplied in the guidance explains why the lever needs to be in full forward.

Conair's SOPs are developed to standardize the operation of its Air Tractor, Inc. fleet. They are to be used in conjunction with the aircraft manuals and flight supplements. The *Fire Boss Standard Operating Procedures* (01 May 2022) explain the use of the FCU manual override system in detail and reiterate the manufacturer's guidance that before the FCU manual override is used, the power lever must be in full forward. However, the bullet form procedure that follows the detailed explanation makes no mention of the requirement to advance the power lever to full before applying the manual override lever. This bullet form procedure is replicated in the emergency checklists carried on board the aircraft.

In addition to this disparity, the training Conair delivers to Air Tractor pilots differs from the manufacturer's guidance in that it directs pilots to place the power lever to idle before applying the FCU manual override lever. In keeping with this training, following the power loss on the day of the occurrence, the pilot placed the power lever in idle before applying the override.

Although it likely had no effect on the outcome of this occurrence, with the power lever below the maximum setting, the use of the FCU manual override lever cannot produce maximum engine power, which may be required in an emergency in order to climb away from terrain.

Finding as to risk

When emergency checklists and training do not reflect the guidance provided by aircraft manufacturers, there is a risk that actions taken in the cockpit may not effectively resolve an emergency situation.

2.4 Checklist completion

In an emergency situation, such as an in-flight engine failure, it is important for a pilot to fly the airplane and stay in control. Then, the situation needs to be assessed. Part of this assessment involves the use of an emergency checklist, which may aid in resolving the problem. Critical tasks that are time sensitive, in addition to being listed in the emergency checklists, are normally designated as memory items. The memory items on the occurrence aircraft's engine failure in flight checklist contained all the necessary steps to address the most common scenarios, such as fuel delivery issues, flameouts, or FCU failures.

In the stressful situation created by the engine power reduction, rather than complete all of the memory items on the engine failure in flight checklist, the pilot may have pointed at the fuel boost pump switch without selecting it to the ON position as he had done in his flight preparations during his self-briefing. The FCU manual override lever was quickly applied before advancing the power levers to full, which would have provided the engine with less than maximum power.

The aircraft flight manual reminds pilots that whenever there is an indication of a power loss, the ignitors must be set to CONTINUOUS and the fuel boost pump must be turned on. When the boost pump was not turned on, an important task that may have assisted in correcting a low fuel flow situation was omitted.

Finding as to risk

When flight crews do not complete each item on an emergency checklist, there is a risk that important tasks that may rectify the situation will be omitted.

3.0 FINDINGS

3.1 Findings as to causes and contributing factors

These are conditions, acts or safety deficiencies that were found to have caused or contributed to this occurrence.

1. During the application of engine power following a low-level water drop, a power reduction followed by a complete power loss occurred. The reason for both could not be determined.

2. The power reduction occurred at approximately 350 feet above ground level, leaving insufficient time for the pilot to complete the checklists, determine the reason for the power rollback, and restore power. As a result, a forced landing was accomplished in a reforested area, resulting in significant aircraft damage.

3.2 Findings as to risk

These are conditions, unsafe acts or safety deficiencies that were found not to be a factor in this occurrence but could have adverse consequences in future occurrences.

1. When emergency checklists and training do not reflect the guidance provided by aircraft manufacturers, there is a risk that actions taken in the cockpit may not effectively resolve an emergency situation.

2. When flight crews do not complete each item on an emergency checklist, there is a risk that important tasks that may rectify the situation will be omitted.

3.3 Other findings

These items could enhance safety, resolve an issue of controversy, or provide a data point for future safety studies.

1. The combination of the aircraft's thick windscreen and the pilot's flight helmet minimized the pilot's injuries when the tree penetrated the cockpit.

4.0 SAFETY ACTION

4.1 Safety action taken

4.1.1 Conair Group Inc.

As a result of the accident, Conair Group Inc. took the following actions:

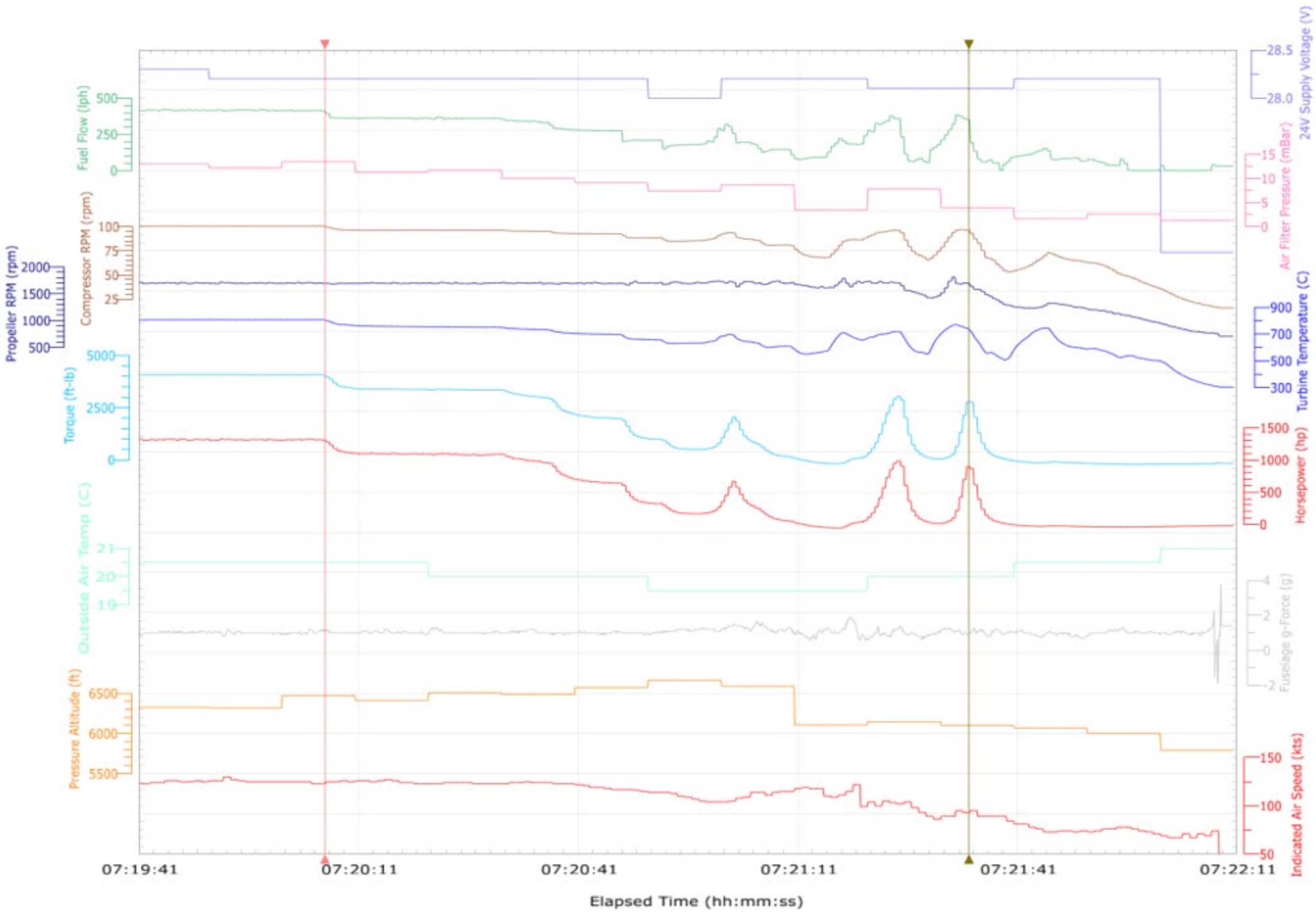
- A flight operations briefing on engine failures in general and the accident specifics was introduced to initial and recurrent pilot training.
- All AT-802 pilots received low-level engine failure training in the AT-802 simulator.
- The AT-802 maintenance team worked with Perkins Technologies to implement a new alarm from the Data Acquisition Alarm Monitor system. Using historical data from previous momentary power fluctuations, an alarm was created that will alert the pilot when the engine N_g value is above 90% with a corresponding fuel flow of 190 L/h or less. The software update was applied to the AT-802 Fireboss fleet first. Once the update is ready, it will also be installed on the AT-802 wheeled fleet.
- A fleet campaign has been implemented to check all fleet emergency locator transmitters for labels with an incorrect Hex Id. Any incorrect Hex Id will be corrected.

This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 20 March 2024. It was officially released on 01 May 2024.

Visit the Transportation Safety Board of Canada's website (www.tsb.gc.ca) for information about the TSB and its products and services. You will also find the Watchlist, which identifies the key safety issues that need to be addressed to make Canada's transportation system even safer. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.

APPENDICES

Appendix A – Time history plot of engine failure event



Source: TSB, based on data from the Perkins Technologies Data Acquisition Alarm Monitor System installed on the aircraft