



Transportation
Safety Board
of Canada

Bureau de la sécurité
des transports
du Canada



AIR TRANSPORTATION SAFETY INVESTIGATION REPORT A20C0107

RUNWAY EXCURSION

Calm Air International LP
Avions de Transport Régional ATR 42-300, C-FAFS
Naujaat Airport, Nunavut
26 November 2020

ABOUT THIS INVESTIGATION REPORT

This report is the result of an investigation into a class 3 occurrence. For more information, see the Policy on Occurrence Classification at www.tsb.gc.ca

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

TERMS OF USE

Use in legal, disciplinary or other proceedings

The *Canadian Transportation Accident Investigation and Safety Board Act* states the following:

- 7(3) No finding of the Board shall be construed as assigning fault or determining civil or criminal liability.
- 7(4) The findings of the Board are not binding on the parties to any legal, disciplinary or other proceedings.

Therefore, the TSB's investigations and the resulting reports are not created for use in the context of legal, disciplinary or other proceedings.

Notify the TSB in writing if this investigation report is being used or might be used in such proceedings.

Non-commercial reproduction

Unless otherwise specified, you may reproduce this investigation report in whole or in part for non-commercial purposes, and in any format, without charge or further permission, provided you do the following:

- Exercise due diligence in ensuring the accuracy of the materials reproduced.
- Indicate the complete title of the materials reproduced and name the Transportation Safety Board of Canada as the author.
- Indicate that the reproduction is a copy of the version available at [URL where original document is available].

Commercial reproduction

Unless otherwise specified, you may not reproduce this investigation report, in whole or in part, for the purposes of commercial redistribution without prior written permission from the TSB.

Materials under the copyright of another party

Some of the content in this investigation report (notably images on which a source other than the TSB is named) is subject to the copyright of another party and is protected under the *Copyright Act* and international agreements. For information concerning copyright ownership and restrictions, please contact the TSB.

Citation

Transportation Safety Board of Canada, *Air Transportation Safety Investigation Report A20C0107* (released 01 November 2022).

Transportation Safety Board of Canada
200 Promenade du Portage, 4th floor
Gatineau QC K1A 1K8
819-994-3741; 1-800-387-3557
www.tsb.gc.ca
communications@tsb.gc.ca

© His Majesty the King in Right of Canada, as represented by the Transportation Safety Board of Canada, 2022

Air transportation safety investigation report A20C0107

Cat. No. TU3-10/20-0107E-PDF

ISBN: 978-0-660-45813-7

This report is available on the website of the Transportation Safety Board of Canada at www.tsb.gc.ca

Le présent rapport est également disponible en français.

Table of contents

1.0	Factual information	6
1.1	History of the flight.....	6
1.2	Injuries to persons.....	8
1.3	Damage to aircraft.....	8
1.4	Other damage.....	8
1.5	Personnel information.....	8
1.5.1	Captain	9
1.5.2	First officer	9
1.5.3	Flight attendant	9
1.6	Aircraft information	9
1.6.1	General	9
1.6.2	Propeller system	10
1.6.3	Propeller maintenance.....	12
1.6.4	Cockpit engine and propeller indications	13
1.7	Meteorological information	14
1.7.1	General	14
1.7.2	Departure weather.....	14
1.7.3	Arrival weather	15
1.8	Aids to navigation	15
1.9	Communications.....	15
1.10	Aerodrome information.....	15
1.10.1	General	15
1.10.2	Runway surface conditions.....	16
1.11	Flight recorders	16
1.12	Wreckage and impact information.....	16
1.13	Medical and pathological information.....	17
1.14	Fire.....	17
1.15	Survival aspects.....	18
1.16	Tests and research	18
1.16.1	TSB laboratory reports	18
1.16.2	Propeller pitch analysis	18
1.16.3	Safety belts	20
1.17	Organizational and management information.....	21
1.17.1	General	21
1.17.2	Aircraft flight operations	21
1.17.3	Quick Reference Handbook design features	23
1.18	Additional information.....	24
1.18.1	Arctic flight operations	24
1.18.2	Crew communications.....	25
2.0	Analysis	26
2.1	Propeller control unit failure.....	26
2.2	Crew communications.....	27

2.3	Quick Reference Handbook	27
2.4	Survivability.....	28
3.0	Findings.....	29
3.1	Findings as to causes and contributing factors.....	29
3.2	Findings as to risk.....	29
4.0	Safety action.....	30
4.1	Safety action taken	30
4.1.1	Calm Air International LP	30
5.0	Appendices	31
5.1	Appendix A – Previous ATR 42 pitch-lock accidents.....	31
	Appendix B – Airworthiness Directive: ATR 42 aircraft – Propellers – Pitch change system component (ATA 61).....	33

AIR TRANSPORTATION SAFETY INVESTIGATION REPORT A20C0107

RUNWAY EXCURSION

Calm Air International LP
Avions de Transport Régional ATR 42-300, C-FAFS
Naujaat Airport, Nunavut
26 November 2020

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability. **This report is not created for use in the context of legal, disciplinary or other proceedings.** See the Terms of use on page 2.

Summary

On 26 November 2020, the Calm Air International LP Avions de Transport Régional ATR 42-300 aircraft (registration C-FAFS, serial number 298) was conducting flight CAV464 under instrument flight rules from Rankin Inlet, Nunavut, to Naujaat, Nunavut, with 3 crew members on board. While on descent, the crew observed abnormally low propeller rpm indications on the left engine. At 1326 Central Standard Time, shortly after touchdown on Runway 34 at Naujaat Airport, directional control was lost and the aircraft experienced a runway side excursion on the east side of the runway. The aircraft came to rest approximately 108 feet from the runway edge. The captain received serious injuries. The aircraft sustained substantial damage.

1.0 FACTUAL INFORMATION

1.1 History of the flight

On 26 November 2020, the flight crew reported for duty at Rankin Inlet Airport (CYRT), Nunavut, at 0745.¹ Before departing on the occurrence flight, they conducted a cargo flight to Baker Lake Airport (CYBK), Nunavut, in another Avions de Transport Régional (ATR) 42 aircraft and returned to CYRT.

When the flight crew boarded the ATR 42-300 aircraft (registration C-FAFS, serial number 298) to conduct the occurrence flight, Calm Air International LP (Calm Air) flight CAV464, they noted, as part of their initial interior aircraft checks, that the left and right propeller feather solenoid circuit breakers were out and not collared.² They called the maintenance supervisor, who informed them that the breakers had been pulled as part of a routine maintenance task³ that had been carried out the night before. At the request of the maintenance supervisor, the flight crew then reset the breakers as instructed.

At 1217, the occurrence aircraft departed CYRT destined for Nauyas Airport (CYUT), Nunavut. On board were 2 pilots⁴ and a flight attendant, as well as 3539 pounds of cargo. For this instrument flight rules (IFR) flight, 1272 L of Jet A fuel had been uploaded for a total fuel load of 5150 pounds. The departure, climb-out, and cruise portions of the flight were uneventful.

At approximately 1321, while the aircraft was on descent into CYUT, the flight crew observed that the left propeller was operating at a lower rpm than normal,⁵ while engine parameters remained normal. They briefly discussed the situation and made various attempts to troubleshoot and identify the problem, but did not consult the Quick Reference Handbook (QRH). They were unable to identify a specific malfunction and did not take any further action.

The captain considered his options: returning to CYRT, shutting down the left engine, or both. However, there was a crosswind at CYRT and he did not want to land on a runway with compacted snow in a crosswind or initiate a long return flight to CYRT in arctic

¹ All times are in Central Standard Time (Coordinated Universal Time minus 6 hours).

² A collar is device that blocks a circuit breaker and prevents it from being reset. When a circuit breaker is collared, a corresponding notation will be made in the aircraft journey log informing the flight crew to why the collar was added.

³ The task was a main gear oleo inspection, which requires that the propeller solenoid circuit breakers be pulled to prevent damage to the feathering pumps when the aircraft is on jacks.

⁴ The captain was seated in the left seat and was the pilot flying (PF), and the first officer was seated in the right seat and was the pilot monitoring (PM).

⁵ According to data from the flight data recorder, the rpm of the left propeller was 71% at the time, while the rpm of the right propeller was 86%, which is a normal setting. (Source: Calm Air International LP, *Standard Operating Procedures ATR CAV-2116*, Amendment 06 [01 May 2020], Section 1: Normal Checklists, p. 26.)

conditions, particularly with only 1 engine operating. The captain believed that the propeller indications were related to the maintenance task that had been performed prior to the flight and did not discuss the options with the first officer. The flight crew continued the approach and monitored the situation.

During the approach, the captain advanced the condition levers⁶ to see if he could achieve 100% propeller rpm. This was successful at first, but as engine torque was reduced on descent, the left propeller rpm started to decay. On short final, the left propeller rpm continued to decrease, and the aircraft was becoming noticeably more difficult to control.

During the landing on Runway 34 at CYUT, the aircraft initially touched down 750 feet past the threshold and the pilot flying immediately selected reverse thrust on both power levers; however, only the right propeller went into reverse. Almost simultaneously with the selection of reverse thrust, only the “LO PITCH” light for the No. 2 engine illuminated, which went unnoticed by the flight crew.

At 1326, shortly after touchdown, the aircraft swerved to the right. In an effort to prevent a loss of control, the captain attempted to use asymmetric thrust and nose wheel steering. Although directional control was maintained momentarily for approximately 40 feet, lateral control was lost and the aircraft exited the right side of the runway in a north-easterly direction.

The aircraft travelled about 500 feet through the snow adjacent to the runway before coming to rest. At some point during the runway excursion, the captain’s safety belt released, and his head struck the forward cockpit area. The aircraft came to a stop approximately 108 feet from the edge of the runway, at which time the flight crew shut down the engines with the fire handles because the condition levers were jammed.

Figure 1. Wreckage site (Source: Naujaat Airport)



The captain received serious injuries and the 2 other crew members received minor injuries. The aircraft was substantially damaged (Figure 1). The emergency locator transmitter did not activate.

⁶ The condition levers (CL) “operate feathering control, HP [high pressure] fuel shutoff valves and propellers speed (NP), controlled by PCU [propeller control unit] when in blade angle governing propulsion mode.” (Source: Calm Air International LP, *FCOM Flight Crew Operations Manual ATR CAV-2116*, Revision 10 [July 2020]).

1.2 Injuries to persons

The 3 crew members on board the aircraft were injured (Table 1). The captain was seriously injured. He was examined at the Repulse Bay Health Centre and was later transported to Winnipeg, Manitoba, for further examination. It was determined that he had received serious head injuries. The 2 other crew members sustained 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	1	–	–	1
Minor	2	–	–	2
Total injured	3	–	–	3

1.3 Damage to aircraft

After the aircraft had departed the maintained surface of the runway, it travelled through a windrow of compacted snow, then crossed through a shallow ditch and continued over rough terrain. During the runway excursion, the aircraft sustained damage to the forward fuselage belly area. Additionally, the nose gear collapsed, both main landing gear assemblies were damaged, and the left main landing gear was almost completely severed from its attachment points.

1.4 Other damage

Not applicable.

1.5 Personnel information

Table 2. Personnel information

	Captain	First officer
Pilot licence	Airline transport pilot licence	Airline transport pilot licence
Medical expiry date	31 January 2021	30 April 2021
Total flying hours	21 000	16 500
Flight hours on type	1477	1749
Flight hours in the 7 days before the occurrence	13.4	11.7
Flight hours in the 30 days before the occurrence	13.4	17.4
Flight hours in the 90 days before the occurrence	44.1	51.5
Flight hours on type in the 90 days before the occurrence	44.1	51.5
Hours on duty before the occurrence	7.5	7.5
Hours off duty before the work period	12	12

1.5.1 Captain

The captain had been employed by Calm Air since February 1999. He had previously been a captain and first officer on the Saab 340 for the company and was promoted to captain on the ATR 42 in April 2014. The captain had successfully completed his recurrent ATR 42 simulator training on 04 September 2020 and crew resource management (CRM) training on 04 February 2020. The captain held the appropriate licence and ratings for the flight in accordance with existing regulations.

1.5.2 First officer

The first officer had been employed by Calm Air since June 1998. He had previously been a first officer on the DHC-6 Twin Otter, Saab-340, and Fairchild-Dornier 328 JET, and became a first officer on the ATR 42 in April 2017. The first officer had completed his recurrent ATR 42 simulator training on 25 June 2020 and his CRM training on 14 May 2020. The first officer held the appropriate licence and ratings for the flight in accordance with existing regulations.

1.5.3 Flight attendant

Although there were no passengers on board, the flight carried a flight attendant in the rear passenger cabin. At the time of the occurrence, she was not seated in her normal flight attendant seat; she was seated in a left window seat just aft of the left wing.

1.6 Aircraft information

1.6.1 General

The ATR 42-300 is a pressurized twin-engine turboprop manufactured by Avions de Transport Régional (ATR) and type certified in the transport category.

The occurrence aircraft was manufactured in 1993, and acquired by Calm Air in 2013. It was configured as a cargo/passenger combi aircraft. The forward area of the cabin was a cargo compartment with restraints and was separated from the rear passenger area by a bulkhead. The rear area, aft of the bulkhead, had seats to accommodate 22 passengers plus 2 flight attendants.

Table 3. Aircraft information

Manufacturer	ATR-GIE Avions de Transport Régional (ATR) (formerly Aerospatiale)
Type, model, and registration	ATR 42-300, C-FAFS
Year of manufacture	1993
Serial number	298
Certificate of airworthiness/flight permit issue date	26 July 2013
Total airframe time	44 180 hours
Engine type (number of engines)	Pratt & Whitney Canada PW121 (2)

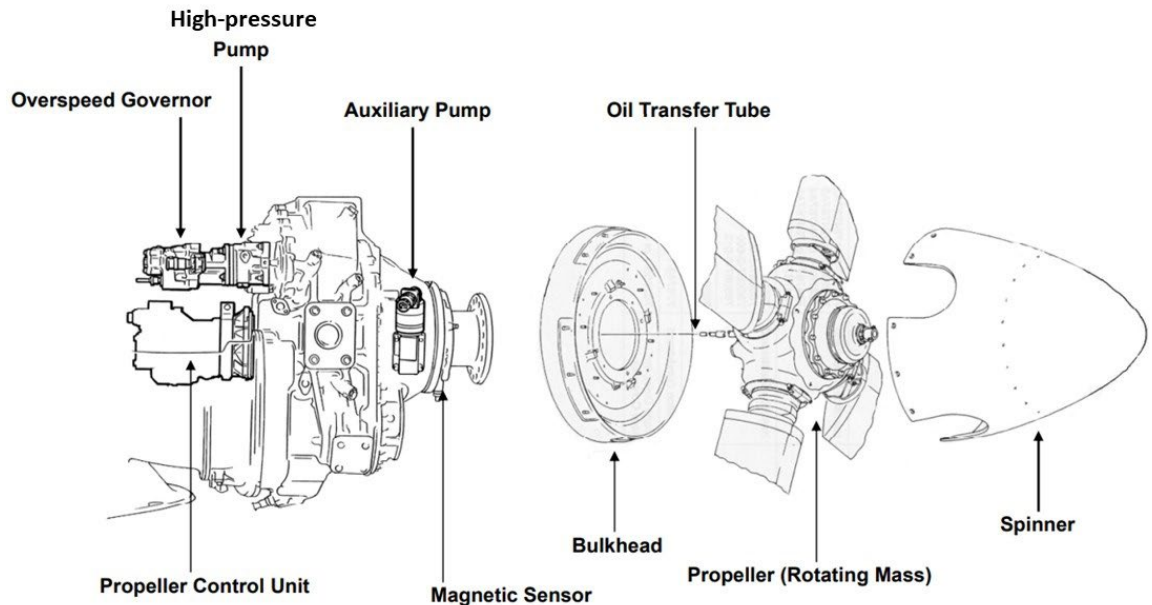
Propeller type (number of propellers)	Collins Aerospace (formerly Hamilton Sundstrand) Model 14SF-5 (2)
Maximum allowable take-off weight	37 258 pounds
Recommended fuel type(s)	Jet A, Jet A1, Jet B
Fuel type used	Jet A

1.6.2 Propeller system

The ATR 42-300 is powered by 2 Pratt & Whitney Canada PW121 turbo prop engines driving 2 Collins Aerospace (formerly Hamilton Sundstrand) Model 14SF-5 propellers. The 14SF propeller is made of metal and composite materials. It is a constant-speed, fully feathering, and reversible propeller.

Propeller rpm (N_p) and engine rpm (N_h) are controlled hydromechanically via power and condition levers in the cockpit. The mechanical movement of the power and condition levers direct the propeller control unit (PCU) (Figure 2) and hydromechanical unit (HMU)⁷ to regulate propeller rpm.

Figure 2. The propeller system, with a propeller control unit, and the pitch change actuator (located within the rotating mass) (Source: Collins Aerospace, with TSB modifications and annotations)



The propeller is controlled by the PCU, which uses high-pressure engine oil to control the blade angle. Engine oil pressure is increased by a high-pressure pump mounted on the propeller reduction gearbox.

There are 3 modes of propeller governing:

- Fuel-governing mode: On the ground and at low aircraft speed, the HMU and electronic engine control maintain the propeller rpm at 70.8% by regulating fuel to the engine.

⁷ The HMU is the hydromechanical component of the fuel control system.

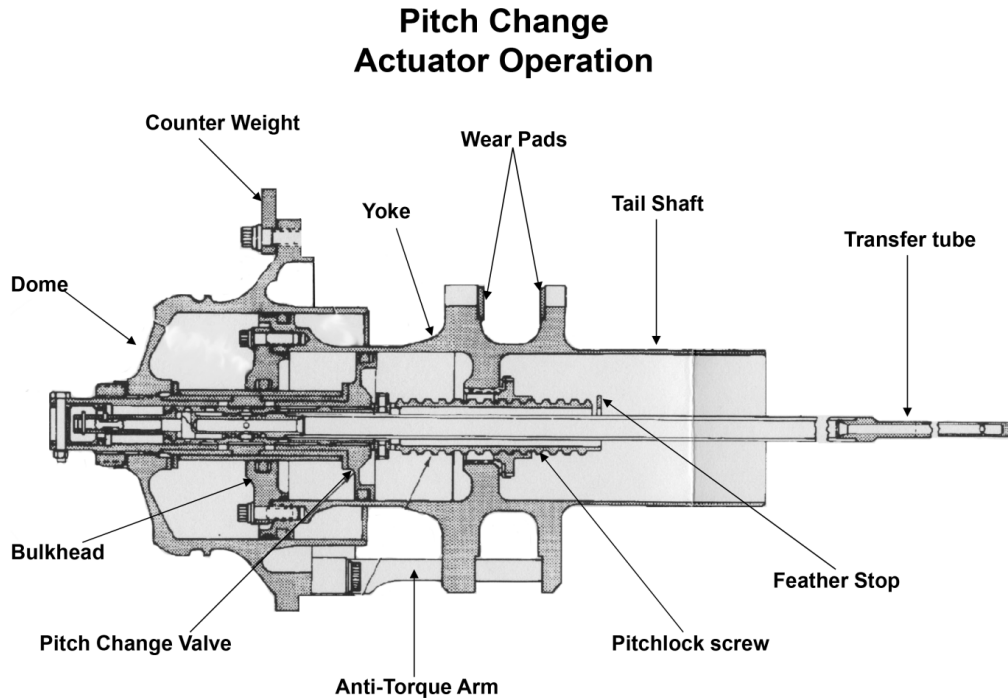
- Transition mode: The propeller rpm (N_p) is within 71% to 77%. Forward movement of the power lever (beyond the flight idle gate⁸) adds more fuel, and the N_p increases to 77%, where the condition lever position can start to control N_p .
- Propeller-governing mode: The N_p is greater than 77% and the power levers are beyond the flight idle gate. Propeller speed is controlled by the PCU and input from the condition lever.

The propeller incorporates several safety devices, one of which is a pitch-lock mechanism. The pitch-lock mechanism is located inside the pitch change actuator. The mechanism locks the blade pitch and prevents propeller overspeed in the event that oil pressure to the PCU is lost. If oil pressure is lost while the propeller is in a positive blade angle, centrifugal and aerodynamic forces will attempt to drive the propeller blades to a flat pitch (approximately 0°). If this were to happen, the propeller would overspeed and produce high drag.

The pitch lock is engaged when the pitch-lock screw makes contact with the pitch-change valve on the bulkhead (Figure 3). The pitch of the pitch-lock screw thread combined with the friction between the pitch-lock screw and pitch-change valve is such that the acme thread of the pitch-lock screw cannot be back driven. This pitch-lock feature limits overspeed to approximately 2% at any positive blade angle as long as the operating condition and engine power do not change. If the pitch-lock is engaged, the flight crew cannot achieve reverse thrust.

⁸ A gate is a mechanical lock in the engine control console that prevents inadvertent movement of the power levers to the beta (fuel-governing) mode during flight operations. In order to retard the power levers and keep them in the beta position for ground operations, the flight crew must remove the lockout "gate" by pulling a T-handle, located aft of the power levers, that mechanically removes the gate, allowing beta and reverse thrust to be obtained.

Figure 3. Pitch-change actuator showing pitch lock (Source: Collins Aerospace)



When the power levers are in the ground-idle range and the aircraft is on the ground, there are “LO PITCH” lights that illuminate when propeller blade angles are lower than the normal flight idle blade angle. These lights will not illuminate if the propellers are in a pitch-lock condition and are in the normal flight blade angle range. Other than subtle cues, there is no caution or warning light in the cockpit to indicate that the pitch lock is engaged; there is no pitch lock warning on the crew alerting panel (CAP) or on the master warning system.

1.6.3 Propeller maintenance

The Collins Aerospace 14SF-5 propellers installed on Calm Air’s ATR 42 aircraft are maintained in accordance with the Airworthiness Limitations section of the Hamilton Sundstrand Maintenance Manual,⁹ which states the major inspection intervals for various parts of the propeller.

The inspection interval for the blade and pin assemblies, as well as the propeller hub (within which the pitch change actuator is mounted) is 10 500 flight hours or 7 years from the date of installation. The inspection interval for the propeller outer and inner bearing races and the actuator assembly is 10 500 flight hours.¹⁰

In addition, a critical part inspection (CPI) is required for the actuator assembly, oil transfer tube and retainer, and PCU. The CPI interval for the actuator assembly is 10 500 flight

⁹ Hamilton Sundstrand Corporation, *Propeller System Maintenance Manual Model Number: 14SF-5*, Revision 11 (07 August 2013).

¹⁰ *Ibid.*, p. AL-1.

hours. The interval for the initial inspection of the oil transfer tube and retainer and the PCU is 6000 flight hours or 3 years. The CPI must be repeated at intervals of 10 500 flight hours.¹¹ These CPIs satisfy the requirements of the U.S. Federal Aviation Administration's Airworthiness Directive (AD) 96-25-20¹² as an alternate method of compliance.

A review of Calm Air's maintenance records indicated that the left propeller's components had been inspected in accordance with AD 96-25-20 on 18 November 2018 and were installed on the occurrence aircraft on 11 November 2019. The CPI had not revealed any defects that may have caused the propeller components to malfunction.

On 23 January 2002, the French Direction générale de l'aviation civile issued AD 2002-070-091(B) related to the pressure relief valve.¹³ The investigation determined that all inspections mentioned in this AD were either complied with or not applicable because of the part number.

There have been 4 other occurrences involving ATR 42 series aircraft in which flight crews did not identify pitch-locked propellers that resulted in control difficulties and runway excursions when reverse thrust was selected (Appendix A). On 15 May 2002, the French Direction générale de l'aviation civile issued Airworthiness Directive 2002-070-090(B) R1 (Appendix B) to address the issue.¹⁴

1.6.4 Cockpit engine and propeller indications

The engine and propeller indications in ATR 42 series aircraft are displayed in both analogue and digital formats. The dials indicate:

- Engine torque in %
- Propeller rpm in % (Figure 4)
- Engine rpm (N_h) in %
- Engine oil pressure in psi (note: not propeller oil pressure)
- Engine oil temperature in °C

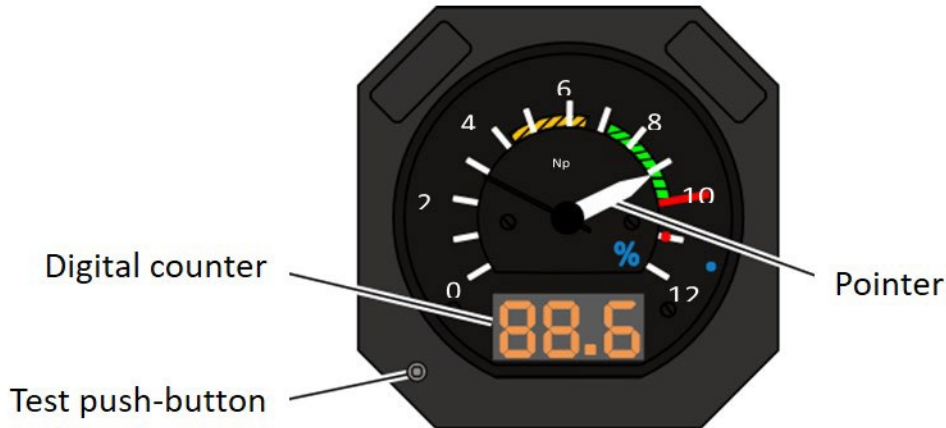
¹¹ Ibid., p. AL-2.

¹² Federal Aviation Administration, Airworthiness Directive (AD) 96-25-20 (effective on 07 February 1997). This AD requires inspections and actions intended to identify failure(s) of critical control components to prevent loss of propeller control.

¹³ The pressure relief valve on the occurrence aircraft had been replaced with model 86210-286.

¹⁴ Airworthiness Directive 2002-70-090(B) R1 requires that internal components of the propeller's PCU be cleaned ultrasonically before the component reaches 10 500 flight hours, when contamination is observed, or when propeller operating anomalies are observed.

Figure 4. Propeller rpm indicator, with digital counter, test push-button, and pointer labelled (Source: Avions de Transport Régional, Calm Air Flight Crew Operations Manual, with TSB annotations)



The normal rpm range (between 70.8% and 100%) is indicated by a green arc on the gauge.

1.7 Meteorological information

1.7.1 General

Both CYUT and CYRT have community aerodrome radio stations, which provide weather information that is contained in aerodrome routine meteorological reports (METARs).

Several types of weather forecasts are available for flight planning and navigation purposes, such as aerodrome forecasts (TAFs) and graphic area forecasts (GFAs). The information contained in these forecasts is based on weather information observed and analyzed by Environment and Climate Change Canada and provided to the aviation industry by NAV CANADA.

1.7.2 Departure weather

Prior to departing CYRT, the flight crew received the following weather information.

The TAF for CYUT issued at 0839 and valid for the period between 0900 and 1700 forecasted the following:

- From 1100:
 - Winds from 360° true (T) at 6 knots
 - Visibility greater than 6 statute miles (SM)
 - Scattered clouds at 2000 feet above ground level (AGL) and broken ceiling at 20 000 feet AGL
- Temporarily from 1100 to 1700:
 - Visibility 3 SM in ice crystals and mist
 - Few clouds at 600 feet AGL and a broken ceiling at 2000 feet AGL
- With a 30% probability from 1100 to 1700:

- Visibility 2 ½ SM in ice crystals and mist

The METAR issued at 1100 for CYUT indicated the following:

- Winds from 030°T at 3 knots
- Visibility 15 SM
- Few clouds at 9400 feet AGL, with a broken ceiling at 22 000 feet AGL
- Temperature –23 °C, dew point –26 °C
- Altimeter setting of 29.66 inches of mercury

The TAF for CYBK, the alternate airport listed on the IFR flight plan, issued at 0541 and valid from 0600 to 1800 forecasted the following:

- From 0600 to 1800:
 - Winds from 010°T at 8 knots, gusting to 28 knots
 - Visibility greater than 6 SM in light snow
 - Overcast ceiling at 3000 feet AGL
- Temporarily from 0600 to 1800:
 - Visibility 4SM in light snow and blowing snow
 - Overcast ceiling at 2000 feet AGL

1.7.3 Arrival weather

The reported weather conditions for CYUT taken at 1334 (approximately 8 minutes after the occurrence) were:

- Winds from 020°T at 6 knots
- Visibility 15 SM
- Scattered clouds at 15 000 feet AGL, broken ceiling at 24 000 feet AGL
- Temperature –23 °C, dew point –26 °C
- Altimeter setting of 29.65 inches of mercury

1.8 Aids to navigation

Not applicable.

1.9 Communications

Not applicable.

1.10 Aerodrome information

1.10.1 General

Naujaat Airport (CYUT) is located approximately ½ km east of the village of Naujaat, Nunavut. It has a single gravel-surface runway, Runway 16/34, that measures 3400 feet long by 100 feet wide. The orientations of runways 16 and 34 are, respectively, 161°T and

341°T. The landing distance available is 3400 feet. Runway 34 has an upslope grade of 1.08%.

CYUT is available for use 24 hours a day, 7 days a week, supporting both day and night, VFR (visual flight rules) and IFR operations. The community aerodrome radio station at CYUT provides local weather, traffic, and other information related to the airport during scheduled hours (Monday to Friday, 0645 to 1715) and is also available after hours on a call-out basis. At the time of the occurrence, the CYUT community aerodrome radio station was operational and had a staff person on duty.

1.10.2 Runway surface conditions

The runway surface conditions for CYUT reported at 1158 on 26 November 2020 described the condition of Runway 16/34 as 100% compacted snow-gravel mixture, with remarks indicating that the conditions of both the taxiway and the airport apron were 100% compacted snow.

For Runway 13/31 at CYRT, the reported runway surface condition at 1151 was 90% frost, 10% compacted snow patches and sand. The Canadian Runway Friction Index value was 0.26 at -11 °C.

1.11 Flight recorders

The aircraft was equipped with a Fairchild F1000 flight data recorder (FDR), which can record over 25 hours of flight data on solid-state memory, and an L3 Harris FA2100 cockpit voice recorder (CVR). The L3 Harris FA2100 CVR can record 2 hours on the standard 4 channels (pilot, co-pilot, spare, and cockpit area microphone). The cockpit area microphone channel is recorded at 16 kHz (high quality), whereas the others are recorded at 8 kHz (standard quality).

Both the FDR and the CVR were recovered from the aircraft and sent to the TSB Engineering Laboratory for further analysis.

1.12 Wreckage and impact information

The aircraft came to rest approximately 2500 feet from the threshold of Runway 34 on the unprepared adjacent area to the east (Figure 5). Its location was approximately 108 feet east of the runway edge.

Figure 5. Location of wreckage (Source: Google Earth, with TSB annotations)



1.13 Medical and pathological information

The captain's safety belt buckle released during the runway excursion. As a result, the captain was thrown forward by deceleration forces and struck his head on the forward upper cockpit area. He sustained serious head injuries. Consequently, his Transport Canada medical certificate was suspended until such time that it can be concluded that he has not suffered permanent injury.

The first officer's safety belt remained secure, and he sustained only minor injuries (bruises) to his legs and torso. It could not be determined whether the flight attendant's lap strap was secure at the time of the runway excursion. She sustained minor injuries.

1.14 Fire

There was no post-impact fire.

1.15 Survival aspects

While the aircraft was traversing the rough terrain adjacent to the runway, some cargo was released from the restraints and partially blocked the access aisle to the cockpit. This unsecured cargo did not prevent the flight crew from exiting the aircraft.

1.16 Tests and research

1.16.1 TSB laboratory reports

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

- LP170/2020 – FDR/QAR Download and Analysis
- LP171/2020 – CVR Download and Analysis
- LP197/2020 – NVM Data Recovery
- LP001/2021 – ATR-42-300 Seat Belt Analysis
- LP002/2021 – Propeller System Examination

1.16.2 Propeller pitch analysis

An analysis of the FDR revealed that the left propeller had entered a pitch-lock condition at the same time the flight crew observed the unstable propeller indication. The propeller pitch had locked at an approximate blade angle of 22.5°.

A tear-down inspection of the left PCU revealed that it did not meet certification criteria and was slow to function at normal operating temperatures. More detailed component testing of the propeller's high-pressure oil pump (Figure 6) revealed that the pump's pressure relief valve had failed and was not allowing adequate oil pressure to build up in the system.

A metal fragment composed of a low-grade iron substance (Figure 7) was discovered stuck to the sealing surface of the pump's pressure relief valve (Figure 8), which prevented the pressure relief valve from sealing. The origin of the metal fragment could not be determined; however, the composition of the metal contaminant was not consistent with any parts tested. Given the size of the metal fragment, it should have been trapped by the engine oil filter.

Figure 6. Overspeed governor and high-pressure pump assembly (Source: TSB)

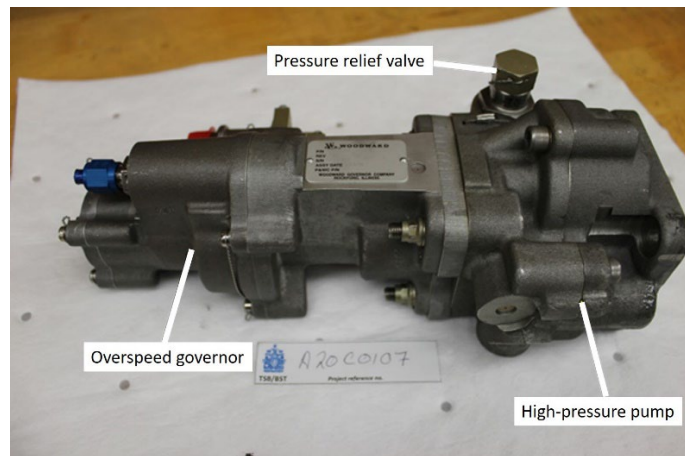


Figure 7. The metal fragment, retrieved from the sealing surface, was composed of a low-grade iron substance not common to the parts tested (Source: AeroControlex Group, Inc, with TSB annotations)

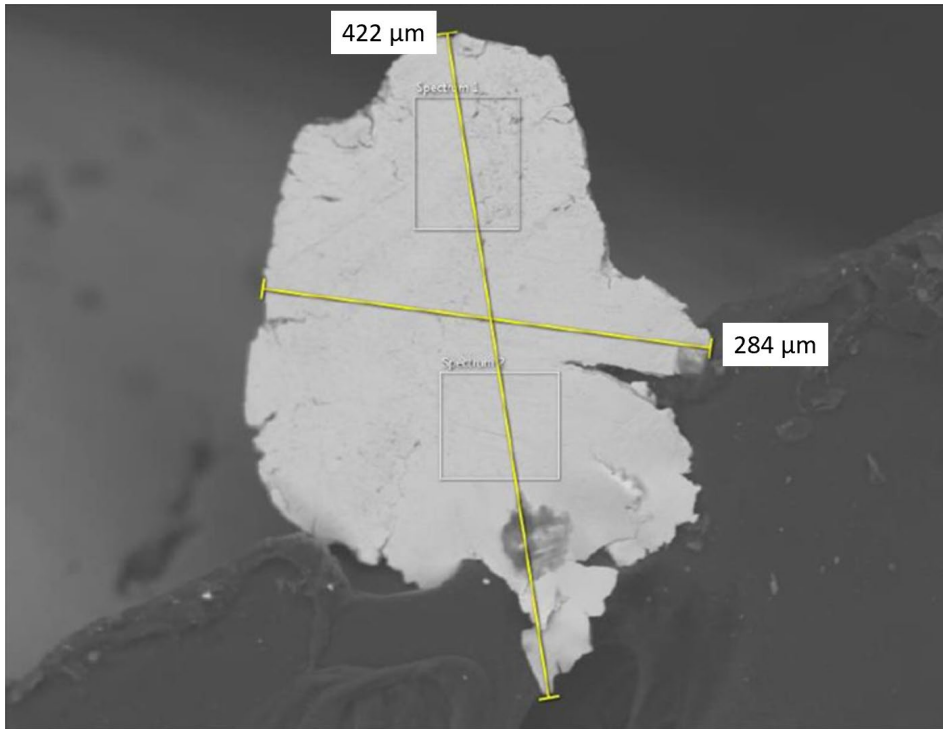
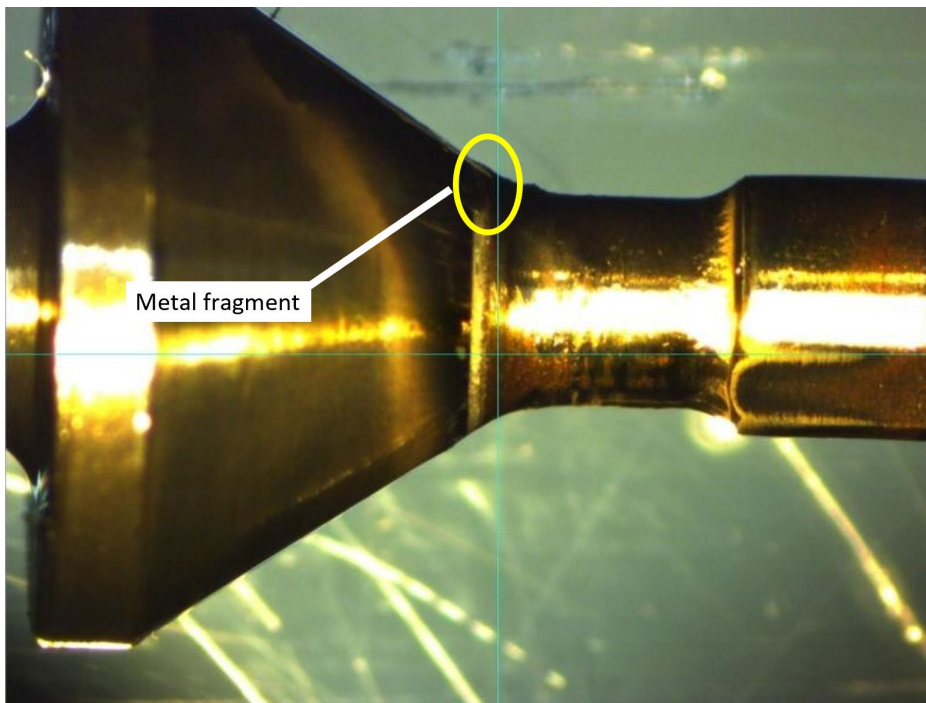


Figure 8. Location of the metal fragment on the sealing surface on the high-pressure valve (Source: AeroControlex Group, Inc, with TSB annotations)



The propeller entered the pitch-lock condition because of the degraded pressure output from the high-pressure pump. The tear-down inspection did not reveal any other pre-

existing defects or anomalies that could have caused the left propeller to enter a pitch locked condition.

1.16.3 Safety belts

The safety belt system for each pilot seat was a 4-point restraint system, consisting of a lap strap, shoulder harness, and a rotary release buckle.

Bruises on the captain's shoulders and abdomen indicate that his lap strap and shoulder harness had initially transferred deceleration forces to his body. However, at some point during the runway excursion, his safety belt system released and his head struck the forward cockpit area.

The TSB laboratory completed a detailed visual inspection of both the captain's and the first officer's safety belt systems and included inspecting the fabric condition of the belts and the general condition of the hardware. The functionality of the rotary release buckles was also inspected. No defects were noted.

Upon completion of the visual and rotary release inspections, the TSB laboratory tested the strength of the webbing and the release latch, and the latching effectiveness of both pilot seat safety belt systems by conducting a tensile test. The captain's 2 lap strap sections and the rotary release mechanism were installed into the tensile tester. The lap strap sections were then pulled to verify conformance with the regulatory specification,¹⁵ which is 3000 pounds force. There was no premature release of the captain's rotary mechanism during tensile testing, but the buckle failed internally and both sections of the lap strap disengaged simultaneously at approximately 2937 pounds force. The testing was halted at this point due to the failure of the buckle.

The regulatory specification refers to the entire 4-point harness system being installed in a test rig as a complete assembly. However, the testing that was performed at the TSB Engineering Laboratory used a single-axis tensile tester using 2 grips; therefore, only 2 legs of the 4-point system could be tested at any given time. Although it appears as though the buckle failed the test, for the purposes of this investigation, it demonstrated that the lap straps could withstand significant force before being released.

The inspection and testing did not identify any pre-existing defects or anomalies that could have contributed to an uncommanded release of the captain's safety belt system during the runway excursion. The cause of the uncommanded safety belt release could not be determined.

¹⁵ Federal Aviation Administration, Technical Standard Order TSO-C22g: Safety Belts (05 March 1993).

1.17 Organizational and management information

1.17.1 General

Calm Air operates in accordance with Subpart 705 (Airline Operations) of the *Canadian Aviation Regulations* (CARs). It has a fleet of ATR 42 and ATR 72 aircraft in northern Manitoba and the central Arctic.

The company operates under a Type B operational control system, which is a Co-Authority Dispatch System.¹⁶ Before each flight, dispatchers review weather, NOTAMS, and aircraft performance from a computer-based application, known as NAVBLUE, which generates the operational flight plan (OFP). The flight crew then review the OFP and confirm that the information is correct and that the flight can be conducted safely and in accordance with the CARs and company procedures.

After the flight departs, the dispatchers then perform flight-watch duties using a very high frequency radio and/or a SKYTRAC satellite phone, email, and text messages.

Because Calm Air operates in accordance with Subpart 705 of the CARs, it is required to have a safety management system (SMS). Calm Air's SMS had recorded 2 previous occurrences involving problems with the propeller; however, neither was related to a pitch-lock condition.

1.17.2 Aircraft flight operations

Instructions and procedures for the operation of company aircraft are contained in Calm Air's Flight Crew Operations Manual (FCOM),¹⁷ ATR 42 Aircraft Flight Manual (AFM),¹⁸ and Standard Operating Procedures (SOPs).¹⁹

In the event of an emergency or abnormal situation, Calm Air's SOPs direct flight crews to "assess the situation as a whole, taking into consideration the failures, when fully identified and the flight constraints imposed."²⁰ The SOPs also state,

Any Master Warning (MW) or Master Caution (MC) illumination and associated Single Chime or Continuous Repetitive Chime shall be acknowledged by the PF [pilot flying] call:

"IDENTIFY AND CANCEL"

¹⁶ In a Co-Authority Dispatch System, the pilot and flight dispatcher share authority "for decisions respecting the operational flight plan prior to acceptance of the operational flight plan by the pilot-in-command." (Source: Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, Standard 725: Airline Operations - Aeroplanes, section 725.20.)

¹⁷ Avions de Transport Régional, *Calm Air FCOM Flight Crew Operations Manual*, Revision 10 (July 2020).

¹⁸ Avions de Transport Régional, *Calm Air AFM Aircraft Flight Manual*, Revision 7.0 (July 2020).

¹⁹ Calm Air International LP, *Standard Operating Procedures ATR CAV-2116*, Amendment 06 (01 May 2020).

²⁰ *Ibid.*, Section 4.1: QRH Checklist Procedures, p. 3.

The PM [pilot monitoring] will then identify the CAP [crew alerting panel] fault and local alert, and then cancel the warning by depressing the associated MW or MC.²¹

The QRH,²² which is carried on board the aircraft,²³ contains an abbreviated version of the FCOM procedures and SOPs. It is a checklist that allows flight crews quick and easy access to critical aircraft information so that they are able to respond appropriately to an emergency or abnormal situation.

1.17.2.1 Low pitch lights procedures

The Normal Procedures section of Calm Air's SOPs requires that the pilot monitoring call "TWO LOW PITCH" if both LO PITCH lights illuminate on touchdown and states that reverse thrust must not be used if only 1 LO PITCH light illuminates.²⁴ In addition, the Abnormal and Procedures Following Failures section of the SOPs states

If both low pitch lights do not illuminate after landing then reverse must not be selected.²⁵

A similar caution is also stated in the ATR 42 AFM.²⁶ There is no standard call in the SOPs or the ATR 42 AFM for the non-illumination of a low pitch light upon touchdown.

The FCOM elaborates further by stating the following:

CAUTION

If a thrust dissymmetry occurs or if one LO PITCH light is not ON, the use of any reverser is prohibited.

In this case the propeller pitch change mechanism is probably locked at a positive blade angle, resulting in a positive thrust for any PL [power lever] position.

Applying any reverser could result in an increased positive thrust and therefore in a difficulty to control lateral asymmetry.²⁷

²¹ Ibid.

²² Avions de Transport Régional, *Calm Air Quick Reference Handbook*, Revision 1.0 (January 2018).

²³ Each aircraft carries a hard copy of the QRH specific to that aircraft's serial number, and an electronic copy is saved on each flight crew member's tablet. The electronic copies of the QRH are generic and not airframe-specific.

²⁴ Calm Air International LP, *Standard Operating Procedures ATR CAV-2116*, Amendment 06 (01 May 2020), Section 3.59.6: Touchdown, p. 99.

²⁵ Ibid., Section 4.7: Flight Idle Gate and Low Pitch Lights, p. 10.

²⁶ Avions de Transport Régional, *Calm Air AFM Aircraft Flight Manual*, Revision 7.0 (July 2020), section 5.01 Normal Procedures: Normal Landing, p. 9.

²⁷ Avions de Transport Régional, *Calm Air FCOM Flight Crew Operations Manual*, Revision 10 (July 2020), Normal Operations: Additional Normal Procedures, section ANOR 1.3: Landing, p. 6.

The normal landing procedures in both the FCOM²⁸ and QRH²⁹ contain a table with calls and reverse actions based on the LO PITCH lights' illumination status on landing (Table 4).

Table 4. Normal landing procedure: LO PITCH CHECK & ANNOUNCE (Source: ATR)

ENG	LO PITCH	ANNOUNCE	REVERSE
2 ENG	2	2 LOW PITCH	NORMAL USE
	1	NO REVERSE	NO REVERSE
	0		
1 ENG	1	1 LOW PITCH	USE WITH CARE

1.17.3 Quick Reference Handbook design features

The QRH contains procedures that may need to be referred to quickly or frequently by a knowledgeable user during aircraft operation, including emergency and abnormal procedures. It also provides strategies to address the prevailing conditions. While the flight crew may refer to information and the expanded abnormal and emergency procedures contained in the AFM, SOPs, or FCOM for possible additional guidance, conditions permitting, the QRH is a stand-alone document.

The way the QRH is designed and developed is critical to ensuring that pilots respond appropriately to various situations. The QRH provides strategies to address specific failures so as to minimize their operational impact on aircraft systems and performance. It aims to ensure that the response to an emergency or abnormal situation is as organized and all-encompassing as possible at a time when the flight crew members' cognitive load can impair their performance. To fulfil this aim, the QRH must use clear and unambiguous layout ergonomics. Content must be able to support pilots in correctly identifying an abnormal or emergency situation as well as the associated preconditions and conditional steps to address the situation while avoiding the omission of an action or the use of irrelevant or inadvertent actions.

1.17.3.1 Quick Reference Handbook

The QRH carried in the cockpit on the occurrence flight was revision 1.0, dated January 2018. The following features of the format and layout were noted:

- The first page of text after the cover page lists the QRH sections in the order they appear: OEB (Operations Engineering Bulletins), GEN (General Information), LIM (Limitations), EMR (Emergency Procedures), ABN (Abnormal Procedures), NOR (Normal Procedures), PER (Performance [Operational] Data).
- A coloured divider identifies 4 of the 7 sections: yellow for Operations Engineering Bulletins, red for Emergency Procedures, orange for Abnormal Procedures, and green for Normal Procedures.

²⁸ Ibid., section NOR 2.2: Landing, p. 52.

²⁹ Avions de Transport Régional, *Calm Air Quick Reference Handbook*, Revision 1.0 (January 2018), Procedure: Normal Operations, section 17: Landing, p. 16.

- At the end of the General Information section, there is a list of the procedures found in the Emergency Procedures and Abnormal Procedures sections. These are organized by following the Air Transport Association (ATA) numbering system as much as practical, not by failure, and no page numbers are listed. This lack of information does not lead to an expeditious finding of a given procedure in the event of an emergency.
- At the beginning of the Emergency Procedures and Abnormal Procedures sections the procedures each section contained are listed, albeit without page numbers. The Abnormal Procedures section is organized sequentially by ATA code, each under a heading of aircraft system (e.g., air conditioning, flight controls, power plant, etc.); the Emergency Procedures section is similarly organized except without aircraft system headings.
- There is no specific section in the QRH pertaining to propeller operation or any related abnormal operation. Under the heading of Power Plant in the Abnormal Procedures section are procedures pertaining to propeller operations.

1.17.3.2 **Abnormal procedures in the Quick Reference Handbook**

There are 3 abnormal-situation checklist items in the QRH that are related to the propeller system in flight: “LO PITCH IN FLIGHT” (code A70.11),³⁰ “ABNORMAL ENG [engine] PARAMETERS IN FLIGHT” (code A70.13),³¹ and “PROP 1(2) OVER LIMIT” (code A70.19).³²

The purpose of these procedures is to help the flight crew isolate the affected engine and then shut it down. These 3 procedures are located in the Abnormal Procedures section, under Following Procedures: Power Plant. There is no specific procedure for a pitch-lock condition, nor is there a separate QRH section for propeller abnormal operations.

All 3 of these abnormal procedures direct the flight crew to shut down the affected engine and apply the “SINGLE ENG [engine] OPERATION” procedure (code A70.12).

1.18 **Additional information**

1.18.1 **Arctic flight operations**

Aircraft engaged in arctic flight operations are subject to particular conditions that can affect flight crew decision making to a greater extent than in flight operations conducted further south. These conditions include the following:

- extreme cold weather

³⁰ Ibid., Following Failures: Power Plant, A70.11: LO PITCH IN FLIGHT, p. 4

³¹ Ibid., A70.13: ABNORMAL ENG PARAMETERS IN FLIGHT, p. 5.

³² Ibid., A70.19: PROP 1(2) OVER LIMIT, p. 8.

- slippery runways³³
- only a single runway at most airports, which may lead to crosswind conditions on takeoff and landing
- limited number of aerodromes, which results in great distances to alternate airports³⁴ and maintenance and repair facilities

1.18.2 Crew communications

Crew resource management (CRM) is “the effective utilization of all resources including crew members, aircraft systems, supporting facilities and persons to achieve safe and efficient operations. The objective of CRM is to enhance communication, interaction, human factors and management skills of the crew members concerned.”³⁵ CRM training required by Transport Canada includes effective crew communications, threat and error management, and human factor issues relating to aviation.³⁶ One particularly important method of gathering information is through effective crew communications. Effective communication is defined as the ability to clearly convey an intended message. Before the approach into CYUT, there was very little communication between the flight crew members about the abnormal propeller rpm indications and possible options.

³³ When operating on compacted snow / slippery runways, it is common practice to select “low pitch” immediately after touchdown. This procedure does not preclude the flight crew from calling out the status of the low pitch lights upon touchdown.

³⁴ Diverting to these alternate airports often requires more fuel.

³⁵ Transport Canada, Advisory Circular (AC) 700-042: Crew Resource Management (CRM), Issue 02 (14 March 2020), section 2.3 Definitions and Abbreviations, at tc.canada.ca/en/aviation/reference-centre/advisory-circulars/advisory-circular-ac-no-700-042 (last accessed on 15 August 2022).

³⁶ Ibid., section 7.6 Training Syllabus.

2.0 ANALYSIS

This analysis will focus on the following:

- The multiple component failures of the propeller control system, one of which resulted in a propeller pitch-lock condition;
- The flight crew's actions and decision making in response to the propeller pitch-lock condition;
- The usability of the Quick Reference Handbook (QRH) checklist; and
- Survivability with respect to the uncommanded release of the captain's safety belt.

2.1 Propeller control unit failure

The tear-down inspection of the left propeller control unit (PCU) revealed that it did not meet certification criteria and was slow to function at normal operating temperatures. Testing of the propeller's high-pressure oil pump revealed that its pressure relief valve was not allowing adequate oil pressure to build up in the system.

Metal contamination from an undetermined source was found in the high-pressure pump's pressure relief valve and was preventing the valve from sealing. The impeded seal decreased the pressure output from the high-pressure pump, and decreased the ability of the PCU to control the propeller pitch.

This decreased pressure output occurred during the cruise portion of the occurrence flight, around the same time the flight crew observed the unstable propeller indication. When the decreased pressure output occurred, in order to prevent the aerodynamic and centrifugal pressure from driving the propeller blades into fine pitch (and cause an overspeed condition), the propeller pitch-lock mechanism activated and locked the propeller blades in approximately 22.5° of pitch. This pitch-lock condition was, however, unknown to the flight crew.

Finding as to causes and contributing factors

A contaminant inside the left propeller's high-pressure pump caused its pressure relief valve to fail. As a result, the propeller entered a pitch-lock condition and remained in that condition until the aircraft landed.

The Calm Air Standard Operating Procedures (SOPs) require the pilot monitoring to make a call if both LO PITCH lights illuminate on touchdown and specify that reverse thrust is not permitted if only 1 light illuminates. There is no requirement for a standard call in the SOPs or the ATR 42 Aircraft Flight Manual (AFM) for the non-illumination of a low pitch light during landing. However, the AFM, the QRH, and the Flight Crew Operations Manual (FCOM) all state that if both LO PITCH lights do not illuminate after landing, reverse thrust must not be selected because the pitch change mechanism is probably locked at a positive blade angle.

On touchdown, 750 feet past the threshold, the pilot flying immediately selected reverse thrust, possibly due to the relatively short runway length; however, only the right propeller

went into reverse. Almost simultaneously with the selection of reverse thrust, only the “LO PITCH” light for the No. 2 engine illuminated. The pilot monitoring did not have the time to identify the status of the LO PITCH lights and to make the “TWO LOW PITCH” callout before reverse was selected. The flight crew was unaware that the left propeller was in a pitch-lock condition and that reverse thrust was unavailable on the left side.

Findings as to causes and contributing factors

Immediately on touchdown, reverse thrust was selected by the pilot flying without confirmation that both LO PITCH lights had illuminated. With the left propeller in a pitch-lock condition, the selection of reverse thrust resulted in the aircraft entering an asymmetric thrust state.

Due to the asymmetric thrust, directional control of the aircraft could not be maintained. As a result the aircraft exited the landing surface of the runway, travelled across rough terrain adjacent to the runway, and was substantially damaged.

2.2 Crew communications

When the flight crew first noticed the abnormal propeller indications, they briefly discussed the situation, but they did not consult the QRH to find a solution to their situation, or take any other procedural action. The captain considered his options (i.e., return to Rankin Inlet Airport, shut down the left engine, or both); however, he did not specifically discuss these options with the first officer. This meant that the flight crew did not fully assess their situation as a team, which may have prevented them from identifying the nature of the malfunction that they were experiencing. This was not in accordance with CRM best practices.

Finding as to risk

If flight crews do not assess abnormal situations as a team, there is a risk that they will not identify the nature of the abnormal situation and determine the most appropriate action to take.

2.3 Quick Reference Handbook

The QRH does not contain a specific abnormal or emergency procedure explaining how flight crews can identify and manage a propeller pitch-lock condition in flight.

The only procedure in the QRH that could be presumed to address a pitch-lock condition is the “ABNORMAL ENG [engine] PARAMETERS IN FLIGHT” (code A70.13), which is found in the Abnormal Procedures section of the QRH. The purpose of this procedure is to help the flight crew isolate the affected engine and then shut it down. In this occurrence, the flight crew briefly discussed the situation and made various attempts to troubleshoot and identify the problem, but they did not consult the QRH.

During the occurrence flight, the propeller rpm fluctuated but remained within limitations and the engine parameters were normal. In fact, the captain believed that the propeller rpm fluctuations were related to a pre-flight maintenance activity. Because there was no clear

indication of a pitch-lock condition, the flight crew were not aware of what the safest course of action was to resolve the issue.

Finding as to causes and contributing factors

Because there is no indication in the cockpit of a pitch-lock condition in flight, the flight crew were not aware that the propeller had entered a pitch-lock condition, and they continued the flight to Nauyas Airport (CYUT), Nunavut, without discussing any options.

Given the layout of the QRH, flight crews need to be familiar with the QRH and type of malfunction in order to quickly locate the applicable procedures. While the abnormal and emergency sections could be identified using the coloured dividers, it would still take time for a flight crew to leaf through sections to locate the procedure. There are no page numbers in the table of contents to assist the flight crew; the codes associated with the procedures take time to identify in the table of contents, and must then be memorized while the flight crew are leafing through the section until the desired code is found. The layout and design of the QRH makes it difficult for a flight crew to quickly and efficiently find the desired procedure in an emergency.

Finding as to risk

If the layout and design of a QRH make it difficult for flight crews to find a procedure to address a malfunction, they may not take the appropriate actions quickly or efficiently, which may lead to an unsafe aircraft state.

2.4 Survivability

The captain's safety belt buckle released without input from the captain at some point during the runway excursion. The cause of the uncommanded safety belt release could not be determined.

Finding as to causes and contributing factors

For undetermined reasons, the captain's safety belt buckle released during the runway excursion and the captain's head struck the forward upper area of the cockpit, resulting in serious head injuries.

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. A contaminant inside the left propeller's high-pressure pump caused its pressure relief valve to fail. As a result, the propeller entered a pitch-lock condition and remained in that condition until the aircraft landed.
2. Because there is no indication in the cockpit of a pitch-lock condition in flight, the flight crew were not aware that the propeller had entered a pitch-lock condition, and they continued the flight to Nauyasat Airport (CYUT), Nunavut, without discussing any options.
3. Immediately on touchdown, reverse thrust was selected by the pilot flying without confirmation that both LO PITCH lights had illuminated. With the left propeller in a pitch-lock condition, the selection of reverse thrust resulted in the aircraft entering an asymmetric thrust state.
4. Due to the asymmetric thrust, directional control of the aircraft could not be maintained. As a result the aircraft exited the landing surface of the runway, travelled across rough terrain adjacent to the runway, and was substantially damaged.
5. For undetermined reasons, the captain's safety belt buckle released during the runway excursion and the captain's head struck the forward upper area of the cockpit, resulting in serious head injuries.

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. If flight crews do not assess abnormal situations as a team, there is a risk that they will not identify the nature of the abnormal situation and determine the most appropriate action to take.
2. If the layout and design of a Quick Reference Handbook make it difficult for flight crews to find a procedure to address a malfunction, they may not take the appropriate actions quickly or efficiently, which may lead to an unsafe aircraft state.

4.0 SAFETY ACTION

4.1 Safety action taken

4.1.1 Calm Air International LP

On 09 December 2020, the operator issued Flight Operations Bulletin 2020-07, which describes a condition known as “pitch lock.” It further describes:

- possible causes for this condition;
- how to identify it; and
- what action to take if this condition is suspected.

In February 2021, the operator introduced to its ATR 42 recurrent simulator training scenarios in which the propeller enters a pitch-lock condition.

This report concludes the Transportation Safety Board of Canada’s investigation into this occurrence. The Board authorized the release of this report on 19 October 2022. It was officially released on 01 November 2022.

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 – Previous ATR 42 pitch-lock accidents

Date	Aircraft model (serial number)	Engine model	Location	Event description	Technical analysis
1999-10-24	ATR 42-320 (284)	PW121	Apartadó/Antonio Roldán Betancur Airport, Colombia	<ul style="list-style-type: none"> • Aircraft exited the runway after landing on the right-hand side • Nose landing gear collapsed due to high loads generated by very soft ground that had been soaked by heavy rain • Right propeller had impact marks from the ground 	<ul style="list-style-type: none"> • Pitch lock confirmed, by flight data recorder (FDR) and by a Hamilton Sundstrand examination, to be the consequence of a high-pressure pump malfunction induced by over-torque of the pressure relief valve • Detailed investigation of the pressure relief valve managed by Woodward, Inc. confirmed findings of the test performed at Pratt & Whitney Canada • Aircraft Flight Manual (AFM) revised to introduce a check of the low pitch light during landing • Incorporation of the AFM revision mandated by Direction générale de l'aviation civile Airworthiness Directive (AD) 2000-436-080(B)
2000-08-01	ATR 42-320 (169)	PW121	Athens International Airport, Greece	<ul style="list-style-type: none"> • After approximately 2000 m, the aircraft left the runway, travelled over hard ground, and stopped safely at an intersection • Pilot reported that steering and braking had been lost without warning 	<ul style="list-style-type: none"> • Data from the digital FDR clearly indicated that the engine was in pitch lock at 80% N_p at about 1000 feet and 145 knots when the condition levers were moved to 100% N_p before landing • No. 2 engine was then automatically controlled at 70.8% N_h through fuel-governing mode • No. 1 engine was operating with normal parameters, and after touchdown, the reverse was applied • Pitch lock attributed to propeller control unit (PCU) ball screw—PCU teardown showed metallic particles inside and revealed a ball screw contamination • Ball screw test bench and teardown performed. Ball screw failed to pass test bench (the data recorded was in excess of the limits allowed by production). Teardown revealed that on the 6 ball tracks, which accept 30 balls each, only 2 (tracks 1 and 4) had balls • Most likely scenario: balls were missing from production. A new quality control has been put in place to check the presence of the balls out of assembly line

					<ul style="list-style-type: none"> • Contamination identified as the main contributing factor in this event • Airworthiness Directive 2002-070-090(B) R1 issued in 2002 to mandate the ultrasonic cleaning of PCU's ball screw
2007-07-16	ATR 42-300 (unknown)	PW120	São Paulo/Congonhas Airport, Brazil	<ul style="list-style-type: none"> • Just after touchdown in severe conditions caused by heavy rain, the aircraft suddenly veered off the runway and travelled through an escape area, hitting a series of obstacles • No fatalities or injuries, but heavy damage to nose landing gear (pushed into fuselage), both main landing gear (which remained in extended position), and other areas, with extensive structural damage to the aircraft • Aircraft came to a stop approximately 500 m from excursion point, after rotating almost 180° • At final stop, aircraft main wheels sank 4 inches into the ground (in an escape area grass field) 	<ul style="list-style-type: none"> • PCU did not pass test as received at Hamilton Sundstrand • PCU failure caused fixed pitch mode operation. However, application of reverse without low pitch light in the cockpit created asymmetric thrust • Operational procedure preventing use of reverse in case of absence of low pitch light already exists
2009-05-30	ATR 72-202 (316)	PW124B	Unknown	<ul style="list-style-type: none"> • Direct current (DC) generator No. 2 fault • Pilot used reverse after aircraft had landed, after the nose wheel had touched down • Aircraft skidded off the runway • Pilot tried to use normal brake but could not do so, then decided to use emergency brake 	<ul style="list-style-type: none"> • Pitch lock was suspected • Recommendations were sent to the operator to replace the PCU and the high-pressure pump

Source of information: Avions de Transport Régional

Appendix B – Airworthiness Directive: ATR 42 aircraft – Propellers – Pitch change system component (ATA 61)

GSAC

AIRWORTHINESS DIRECTIVE

released by DIRECTION GENERALE DE L'AVIATION CIVILE

Inspection and/or modifications described below are mandatory. No person may operate a product to which this Airworthiness Directive applies except in accordance with the requirements of this Airworthiness Directive.

Translation of 'Consigne de Navigabilité' ref. : 2002-070-090(B) R1
In case of any difficulty, reference should be made to the French original issue.

ATR

ATR 42 aircraft

Propellers - Pitch change system component (ATA 61)

1. APPLICABILITY:

ATR 42-200, -300, and -320 model aircraft.

2. REASONS:

During years 1999 and 2000, three cases of propeller pitch lock during final approach, have been experienced on ATR fleet. During two of these events the asymmetric power resulting from the propeller pitch lock was not recognized by the crew during landing and the aircraft veered off the runway after selection of reverse power while the "Low Pitch" condition was not effective for both engines.

On one case, the investigation led on the suspected components of the propeller pitch control system showed significant anomalies on a Pitch Control Unit (PCU) servo ball screw. The hang up and the loss of efficiency noticed on the test bench are due to ball screw contamination. On aging PCU fitted on 14SF5 Hamilton Sundstrand propellers, these anomalies could contribute to a pitch lock condition especially when they combine with another propeller component failure of the pitch control system.

The actions rendered mandatory by this Airworthiness Directive (AD) are intended to clean the ball screw in order to avoid a propeller pitch lock situation and reduced controllability of the aircraft during landing.

Revision 1 of this AD aims at clarifying the paragraph 3.

3. COMPLIANCE:

The following measures are rendered mandatory from the effective date of this AD.

- Before reaching 10,500 FH since new or since last Critical Parts Inspection (CPI),
- or in case of contamination,
- or in case of anomalies noticed during Production Acceptance Tests (PAT),

perform, according to the temporary revision No. 61-6 of the PCU Component Maintenance Manual 61-21-07, the ultrasonic cleaning of PCU servo ball screw installed on HAMILTON SUNDSTRAND 14SF5 propellers.

iH

.../...

May 15, 2002

ATR
ATR 42 aircraft

2002-070-090(B) R1

GSAC	AIRWORTHINESS DIRECTIVE ref. : 2002-070-090(B) R1 Page n° 2
<p data-bbox="358 310 1300 338">Note: The actions mandated by this AD complete the prescriptions of the AD 2002-071-091(B).</p> <hr data-bbox="760 373 989 382"/> <p data-bbox="607 422 1133 449"><u>REF.:</u> HAMILTON SUNDSTRAND CMM 61-21-07.</p> <hr data-bbox="760 485 989 493"/> <p data-bbox="358 533 1130 560"> This Revision 1 replaces original AD 2002-070-090(B) dated January 23, 2002.</p> <hr data-bbox="760 596 989 604"/> <p data-bbox="760 644 984 672"><u>EFFECTIVE DATES :</u></p> <p data-bbox="594 695 1149 722"> <u>Original AD and Revision 1 : FEBRUARY 02, 2002</u></p>	

Source: Direction générale de l'aviation civile, Airworthiness Directive AD 2002-070-090(B) R1: ATR 42 aircraft – Propellers – Pitch change system component (ATA 61) (issued 15 May 2002).