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

AIR TRANSPORTATION SAFETY INVESTIGATION REPORT A20C0016

RUNWAY EXCURSION

Perimeter Aviation LP
Fairchild SA227-DC Metro 23, C-GJVB
Dryden Regional Airport (CYHD), Ontario
24 February 2020

Canada

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Summary

On 24 February 2020, the Fairchild SA227-DC Metro 23 aircraft (registration C-GJVB, serial number DC-902B), operated by Perimeter Aviation LP as Bearskin Airlines flight 344, was conducting a visual flight rules flight from Dryden Regional Airport, Ontario, to Sioux Lookout Airport, Ontario, with 2 crew members and 6 passengers on board. At 1610 Central Standard Time, as the aircraft commenced its take-off roll on Runway 12, directional control was lost. The aircraft ran off the right side of the runway approximately 150 m from the runway threshold lights and struck a frozen snowbank. It came to a rest in an upright position approximately 18 m off the side of the runway and in about 46 cm of snow. One passenger sustained serious injuries. The aircraft was substantially damaged. The flight crew and passengers egressed through the main cabin door. The emergency locator transmitter did not activate.

1.0 FACTUAL INFORMATION

1.1 History of the flight

On 24 February 2020, the Perimeter Aviation LP (Perimeter Aviation) Fairchild SA227-DC Metro 23 (registration C-GJVB, serial number DC-902B) was conducting Bearskin Airlines flight 344 (BLS344) between Dryden Regional Airport (CYHD), Ontario, and Sioux Lookout Airport (CYXL), Ontario, with 2 crew members and 6 passengers on board. This was the 6th flight of the day for the flight crew. The first officer (FO), who sat in the right seat, was to be the pilot flying (PF), and the captain, who sat in the left seat, was to be the pilot taxiing and the pilot monitoring (PM) for the flight.

Before the engine start at CYHD, the FO provided a safety briefing to the passengers. The crew then completed the “Engine Start” checklist, followed by the “After Start” checklist and the “Before Taxi” checklist. While conducting the “Before Taxi” checklist, the FO initiated the “Start Locks” task, which has 3 subtasks required to be completed by both the captain and the FO. The captain instructed the FO to stand by, after which the FO then verbalized the correct “Start Locks” subtask response. There was no response from the captain.

Approximately 7 seconds later, the captain began assessing runway conditions and then engaged for a period of time with Sioux Lookout Radio about flight plan and departure details. The captain then called for the “Before Takeoff” checklist, which was completed, and began to taxi the aircraft to Runway 12 for takeoff. Directional control of the aircraft during taxi was accomplished using the nose wheel steering and no differential thrust for turns was required.

After completing the “Line Up” checklist, the captain transferred aircraft control to the FO. At approximately 1610,[1] take-off power was applied and, while the aircraft was accelerating during the take-off roll, directional control was lost. The aircraft ran off the right side of the runway approximately 150 m from the runway threshold lights. The aircraft struck a frozen snowbank and came to a rest in an upright position, about 18 m off the side of the runway and in about 46 cm of snow (Figure 1). The crew then shut down the engines following the “Stopping Engines” checklist.

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

Figure 1. Occurrence aircraft after coming to a stop (Source: Ontario Provincial Police)

The aircraft was substantially damaged. One passenger sustained serious injuries to his hand from splintered wooden propeller blade pieces that penetrated the fuselage. All flight crew and passengers egressed the aircraft through the main cabin door and were met by emergency response. The emergency locator transmitter did not activate due to insufficient impact forces on the aircraft.

1.2 Injuries to persons

Two crew members and 6 passengers were on board the occurrence aircraft. Table 1 presents a summary of injuries.

Table 1. Injuries to persons

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

1.3 Damage to aircraft

The occurrence aircraft sustained substantial damage to the propellers and fuselage. The landing gear was intact, and local airport personnel were able to pull the aircraft out of the snow and tow it to a nearby ramp.

1.4 Other damage

Not applicable.

1.5 Personnel information

Table 2. Personnel information

	Captain	First officer
Pilot licence	Airline transport pilot licence	Commercial pilot licence
Medical expiry date	01 September 2020	01 April 2020
Total flying hours	Approximately 20 000	Approximately 270
Flight hours on type	Approximately 19 000	15
Flight hours in the 7 days before the occurrence	15	8
Flight hours in the 30 days before the occurrence	46	15
Flight hours in the 90 days before the occurrence	128	15
Flight hours on type in the 90 days before the occurrence	128	15
Hours on duty before the occurrence	9	9
Hours off duty before the work period	93	88

The captain joined Perimeter Aviation in April 1998 and completed his initial training on the Fairchild SA227-DC Metro 23 in June 2000. He held a valid Category 1 medical certificate with no restrictions. His last SA-227 pilot proficiency check was successfully completed on 13 March 2019.

The FO joined Perimeter Aviation in January 2020 and completed his initial training and pilot proficiency check on the SA-227 in February 2020. He held a valid Category 1 medical certificate with no restrictions. The FO began his line indoctrination training[2] on the day of the occurrence.

Based on a review of the flight crew members' work and rest schedules, fatigue was not considered a factor in the occurrence.

1.6 Aircraft information

The Fairchild SA227-DC Metro 23 is a pressurized twin turboprop aircraft configured to carry up to 19 passengers and has a retractable landing gear. This aircraft type was first manufactured by Swearingen Aircraft and later by Fairchild Aircraft. Elbit Systems Ltd. currently holds the type certificate for the aircraft. The occurrence aircraft was manufactured by Fairchild Aircraft in 2000 and was equipped with 2 Honeywell TPE331-12UHR-701G turboprop engines.

Records indicate that the occurrence aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures.

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2 Training provided by an air carrier as part of the flight-training program to new flight crew members while under supervision.

Table 3. Aircraft information

Manufacturer	Fairchild Aircraft
Type, model and registration	SA227-DC Metro 23, C-GJVB
Year of manufacture	2000
Serial number	DC-902B
Certificate of airworthiness/flight permit issue date	14 July 2009
Total airframe time	15 460 hours
Engine type (number of engines)	Honeywell TPE331-12UHR-701G (2)
Propeller/Rotor type (number of propellers)	MT-Propeller, model number MTV-27-1-E-C-F-R (G) (2)
Maximum allowable take-off weight	16 500 pounds
Recommended fuel type(s)	Jet A, Jet A-1, Jet B, JP-1, JP-4, JP-5, JP-8
Fuel type used	Jet A

1.6.1 Weight and balance

The aircraft had a gross weight of approximately 13 607 pounds at the time of the occurrence, which is below the maximum certified take-off weight of 16 500 pounds. It was determined that the occurrence aircraft was operated within the allowable weight and centre-of-gravity limitations for the intended flight.

1.6.2 Propeller and propeller start locks

In February 2015, the occurrence aircraft was modified with 2 propellers made by MT-Propeller (model MTV 27-1-E-C-F-R (G)) in accordance with Supplemental Type Certificate (STC) SA03893AT.[3] The propellers were 5-bladed, reversible, hydraulically controlled, variable-pitch, and constant-speed. The propeller blades (hereafter referred to as "composite blades") had a natural composite structure consisting of laminated beech wood covered with epoxy fiberglass and a nickel-cobalt erosion strip bonded to the blade leading edges for protection.

Composite blades, such as those with a combination of wood and epoxy fiberglass, offer lightweight construction with an equivalent strength factor to aluminum propeller blades. However, composite blades have poor ductile qualities, resulting in a shattering failure mode. Conversely, aluminum propeller blades are more ductile and are likely to bend and curl.

During propeller operation, springs and counterweights are always forcing the propeller blades toward a high-angle (or feathered) position, while high engine oil pressure opposes this force to move the propeller blades toward a low-angle (or flight idle) position.

As propeller blade angles increase, the blades take a larger bite of air, resulting in increased propeller thrust and engine torque. Propulsion of the aircraft is controlled by the pilot using

3 Federal Aviation Administration, Supplemental Type Certificate (STC) SA03893AT issued to MT-Propeller USA, Inc. on 24 July 2013.

the engine power levers and speed levers that are mounted in the centre console in the cockpit.

The propeller-control system is designed to operate in either propeller-governing range or beta range. Propeller-governing range[4] is used for flight operations, while beta range[5] is used for ground manoeuvring operations (hereafter referred to as "taxi"). When the engine-power lever is forward of the flight-idle gate, the engine is in the propeller-governing range, and when the engine-power lever is brought aft of the flight-idle gate, the engine is in beta range.

While taxiing, slight fore and aft movements of the power levers are required to control the speed of the aircraft. Pilot manipulation of the engine power levers while in beta during the taxi may not always be in unison, and can result in a staggered demand of the propeller-control systems. Slight or rapid transient movements of the engine power levers between flight idle and beta range can produce varying degrees of propeller blade angles and loading on the start locks.

During engine shutdown, when oil pressure is lost, the feathering springs and counterweights force the propeller blades to a high angle. The propeller hub is equipped with a set of start locks that mechanically lock the propeller blades in place at a low blade angle as the engine winds down.

During engine start-up, the start locks remain engaged to minimize load on the engine starter and electrical power supply by keeping the propeller blades at a low blade angle, thus minimizing the drag of the propeller blades while turning. Once the engine has stabilized, the flight crew must disengage the start locks to allow the propeller blades to increase blade angle and produce thrust. The start locks are listed in the "Before Taxi" checklist and are disengaged by momentarily moving the engine power levers over the flight idle gate, toward reverse.

Following the engine start, the engine power lever typically remain at the flight idle gate. The feathering spring, combined with the pressure exerted by the propeller counterweights, retains the start locks against a collar on the beta tube housing, preventing any change in propeller blade angle and production of thrust. When the engine power lever is moved aft of the flight idle gate into beta range toward reverse, the propeller governor oil pressure now opposes the feathering spring and counterweight force. The opposing oil pressure unloads the start locks and allows centrifugal force to free the start locks from the collar on the beta tube housing, allowing movement of the propeller dome piston to produce the desired propeller blade angle and thrust for takeoff.

An inspection of both propellers hubs did not reveal any pre-occurrence anomalies.

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4 The propeller governor adjusts blade angles to maintain a constant selected propeller rpm.

5 Propeller blade angles are hydraulically selected by the manipulation of the power levers below flight idle.

1.7 Meteorological information

The CYHD hourly meteorological observation for 1600, approximately 10 minutes before the occurrence, was as follows:

- wind 350° true (T) at 7 knots, variable from 320°T to 040°T;
- visibility 9 statute miles;
- sky clear; and
- temperature 1 °C, dew point −10 °C.

Weather was not considered a factor in this occurrence.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Not applicable.

1.10 Aerodrome information

CYHD has 1 asphalt runway (Runway 12/30), which is 5996 feet long and 150 feet wide. The investigation determined that the runway, taxiways, and aprons were bare and dry at the time of the occurrence; runway conditions were not considered a factor.

1.11 Flight recorders

The occurrence aircraft was equipped with a cockpit voice recorder (CVR) capable of recording 205 minutes of audio and a flight data recorder (FDR) that recorded 13 parameters, including engine torque, gas generator speed and propeller speed.

The CVR and FDR were removed from the aircraft and forwarded to the TSB Engineering Laboratory in Ottawa, Ontario, for data download.

The CVR provided the audio recording of the communication between the captain and FO during the occurrence. The recording included all checklist procedures that were conducted from engine start to shortly after the occurrence.

Data obtained from the FDR revealed a steady increase in engine torque on the left engine and no increase in torque on the right engine during power application on the take-off roll.

1.12 Wreckage and impact information

The occurrence aircraft came to a rest facing a southerly direction and was subsequently towed to a nearby hangar for further inspection by TSB investigators. The blades of both propellers were shattered, and the remaining blade roots were found at a low blade angle (Figure 2). Both engine mounts were found fractured and bent and both nacelles sustained substantial distortion. Both inboard upper wing and forward fuselage skins exhibited slight wrinkling.

Figure 2. Shattered propellers (Source: Ontario Provincial Police)

The forward fuselage area revealed complete penetration of both reinforcement panels[6] and skins adjacent to the edge of each propeller disc (Figure 3 and Figure 4). The fuselage also sustained smaller punctures to the belly skin.

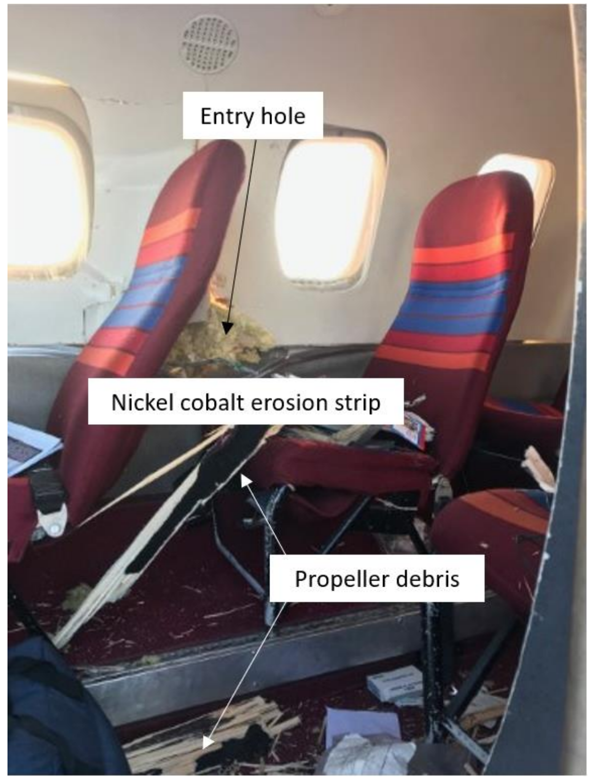
Figure 3. Right-side fuselage penetration (Source: Ontario Provincial Police)

Figure 4. Left-side fuselage penetration (Source: Ontario Provincial Police)

[6] Panels installed over the fuselage skin structure adjacent to the edge of each propeller disc, designed to withstand the impact of ice shed by the propellers.

An inspection of the aircraft cabin area revealed large entry holes by the first seat in the left aisle and the second seat in the right aisle and also revealed large amounts of propeller debris and splinters (Figure 5).

Figure 5. Propeller debris in cabin (Source: Ontario Provincial Police, with TSB annotations)



An inspection of the cockpit revealed that the engine stop-and-feather control was not activated. An inspection of the aircraft systems and engines (including power-lever control rigging) did not reveal any pre-impact anomalies.

1.13 Medical and pathological information

There was nothing to indicate that the performance of the captain or the FO was degraded by any medical, pathological, or physiological factors.

1.14 Fire

Not applicable.

1.15 Survival aspects

The crew were wearing their 4-point safety belts and all the passengers were wearing lap belts, which provided restraint during the occurrence. When the aircraft came to a stop, the crew shut down both engines and the captain made a call to NAV CANADA's Sioux Lookout radio (CYHD's mandatory frequency), informing it of their situation. One passenger sustained serious injury to his hand from the splintered wooden propeller blade pieces that penetrated the fuselage. The FO administered first aid to the injured passenger using the first aid kit on board the aircraft.

After walking around the aircraft to assess for any potential hazards, the flight crew advised the passengers to remain on board until emergency personnel arrived. An ambulance and fire truck arrived at the site 20 to 25 minutes after the occurrence. The injured passenger was transported to a local hospital for treatment.

1.16 Tests and research

1.16.1 TSB Engineering Laboratory reports

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

- LP065/2020 – FDR-CVR Data Analysis

1.17 Organizational and management information

1.17.1 General

In 2017, Bearskin Airlines became a division of Perimeter Aviation, but it was decided to keep the Bearskin brand while operating under Perimeter Aviation's air operator certificate. The regional carrier provides scheduled and charter air services to remote communities in northwestern Ontario and Manitoba, under subparts 703 (Air Taxi Operations) and 704 (Commuter Operations) of the *Canadian Aviation Regulations* (CARs).

Aircraft operated by the Bearskin brand are maintained under Perimeter Aviation's Transport Canada-approved maintenance organization.

1.17.2 Perimeter Aviation standard operating procedures

Standard operating procedures (SOPs) are procedures the flight crew is required to follow in order to safely and effectively carry out flight operations. CARs Subpart 704 air operators are required to "establish and maintain"[7] SOPs and ensure that a copy of the SOPs is "carried on board the aircraft."[8]

An SOP manual[9] was carried on board the occurrence aircraft. It included checklist procedures and indicated that the "Before Taxi" checklist was to be completed using the challenge-and-response method. A challenge-and-response checklist provides standardized communication and understanding between crew members. The generally accepted procedure of a challenge-and-response checklist is that the PF initiates the checklist. The PM challenges the PF by reading aloud the checklist task, which the PF conducts or verifies and then responds back to the PM. If the task cannot be completed, the checklist is paused at that task, the PM announces that the checklist is paused, and it is resumed once the task is completed. The PM waits for confirmation from the PF before moving on to the next checklist task. Once the checklist is complete, the PM will announce that the checklist is complete.

Perimeter Aviation's SA-227 SOPs explain the completion methods for a challenge-and-response checklist; however, they do not mention what to do when a challenge-and-response checklist is interrupted or paused, nor what the PM is to do when the PF's response is not in accordance with the checklist.

1.17.2.1 Checklists

A checklist is a systematic and sequential list of tasks specific to a phase of flight that must be performed by the flight crew. Complex aircraft have a large number of tasks that require

[7] Transport Canada, *Canadian Aviation Regulations* (CARs), SOR/93-433, Subsection 704.124(1).

[8] Transport Canada, *Canadian Aviation Regulations* (CARs), SOR/93-433, Subsection 704.124(2).

[9] Perimeter Aviation, *SA-227 Standard Operating Procedures: Policies and Procedures*, PAL-FO-RA04 (Rev. 10, 24 February 2020).

execution before and during each phase of flight, and checklists contain far more tasks than can be safely committed to memory with total accuracy. The purpose of a checklist is to improve flight safety by ensuring that all necessary tasks are completed.

CARs Subpart 704 air operators are required to establish checklists[10] specific to each type of aircraft and crew members are required to follow them.[11] Checklists for all phases of flight were available to the occurrence aircraft flight crew, and execution of the "Start Locks" task is listed in the "Before Taxi" checklist (Figure 6).

Figure 6. "Before Taxi" checklist (Source: Perimeter Aviation, SA-227 Normal Checklist [Revision 8])

BEFORE TAXI	
Fuel Qty & Balance	SUFFICIENT IN LIMITS
Transponder	AS REQUIRED
TCAS	AS REQUIRED
RADAR	STBY
SAS Clutch	ON
Nose Wheel Steering	ARMED
Parking Brake	RELEASED
Start Locks	CLEAR CLEAN WING CAP ON
Lights	TAXI ON
Brakes	CHECK

1.17.2.2 "Start Locks" task

The "Start Locks" task is one of several tasks listed on the "Before Taxi" checklist within the SOPs and has 3 subtasks (Figure 7).

Figure 7. "Start Locks" task from the "Before Taxi" checklist (Source: Perimeter Aviation, SA-227 Standard Operating Procedures: Policies and Procedures, PAL-FO-RA04 [Rev. 10, 24 February 2020], section 2.5.)

Start Locks ....CLEAR CLEAN WING CAP ON

Each pilot will verify:

- Their prop area clear forward and behind;
- Their wing free of contaminates;
- Their fuel cap in place and secure.

Beginning with the First Officer, each pilot will verbalize, **"Clear, clean wing cap on left/right"** before their propeller is removed from their start locks.

Once the subtasks are completed, the power levers are pulled over the flight idle gate toward reverse to release the start locks to complete the "Start Locks" task; however,

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[10] Transport Canada, *Canadian Aviation Regulations* (CARs), SOR/93-433, Subsection 704.19(1).

[11] Transport Canada, *Canadian Aviation Regulations* (CARs), SOR/93-433, Subsection 704.19(2).

neither the checklist nor the SOPs have a call to confirm that the start locks have been released.

In this occurrence, the captain called for the "Before Taxi" checklist, which the FO then began. In response to the FO's call to conduct the "Start Locks" task, the captain acknowledged it but did not complete his actions, although the FO completed his own. The captain then called for the "Before Takeoff" checklist; however, the remaining 2 tasks on the "Before Taxi" checklist, brakes and lights, and the FO's call that the "Before Taxi" checklist was complete, were not done.

1.17.2.3 Normal take-off procedures

Normal take-off procedures contained in the SOP manual specify that when the FO is conducting the takeoff, the captain is required to advance the power levers through 20% torque. When both engines have passed through 20% torque, the captain is then required to call "positive torque."[12]

In this occurrence, no calls were made during the initial take-off roll to ascertain positive torque.

The SA227 aircraft flight manual (AFM) contains information that applies to that specific aircraft, including limitations, emergency procedures, abnormal procedures, normal procedures, performance data, as well as weight and balance and manufacturer data.

Pilot operating tips contained in the AFM suggest that the engine torque be monitored during initial take-off roll. Failure of the torque to rise above approximately 20% indicates a possibility that the associated propeller start locks are still engaged.[13]

1.18 Additional information

1.18.1 Interruptions

Task interruptions can have a negative effect on performance, leading to increased error frequency and response time. The impact varies with the length of the interruption and the type of task being carried out, where even very short interruptions increase the error rate. When performing sequential tasks, an interruption can impair place-keeping in memory, potentially resulting in errors in the sequence of subtasks. When completing checklists, one's position in the sequence is activated in memory: each task to be performed is

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12 Perimeter Aviation, *SA-227 Standard Operating Procedures: Policies and Procedures*, PAL-FO-RA04 (Rev. 10, 24 February 2020, section 3.14.4).

13 Fairchild Aircraft, *Airplane Flight Manual – Fairchild Aircraft Model SA227-AC-Metro III – ICAO Annex 8 – 16,000 Pounds* (revised 29 June 2015), "Manufacturers data /Pilot operating tips," p. 6-90.

activated one after the other. Once a task is completed, it remains activated for a moment, while the upcoming task is also activated.[14]

When an interruption occurs, a completely different task from the one in progress becomes activated as well, inhibiting the mental processing of the original, primary task.[15] With time, the traces of the primary task in memory fade, and it becomes very difficult to remember where one was in the sequence before the interruption, or even that the sequence was interrupted at all.

1.18.2 Slip of attention

Among the errors most frequently associated with routine, well-practised tasks are slips of attention. This type of error occurs when a check on the progress of a task sequence is mistimed or does not occur because the operator's attention is focused on another aspect of the task or some other preoccupation.

A necessary condition for these errors to occur is the presence of attentional capture, when the operator's attention is focused on another aspect of the task.

1.18.3 Trans-cockpit authority gradient

Optimum trans-cockpit authority gradient means that there is coherence between pilots on the same aircraft. It is well known that a too-strong or too-weak authority gradient between crew members can be a barrier to effective crew resource management.[16] An authority gradient is attributable to differences between the pilots, such as in age, experience, or rank, and the manner in which one or both crew members explicitly or implicitly place emphasis on these differences. A gradient may be too weak, as in the case of 2 pilots with the same ratings and the same degree of experience, or too strong, as in the case of an experienced chief pilot working with an inexperienced FO. In circumstances such as those, there is a risk of lowered coherence between the crew members and reduced crew effectiveness, which increases the risk of an error going undetected and/or uncorrected.

In this case, the authority gradient was strong as the FO had just completed his training and it was his first day flying a scheduled flight for the operator. The captain had approximately 20 years of experience operating the SA-227 with the operator, was a line indoctrination training pilot, and had accumulated approximately 20 000 total flying hours.

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14 E.M. Altmann, J.G. Trafton, and D.Z. Hambrick, "Effects of interruption length on procedural errors," *Journal of Experimental Psychology: Applied*, Vol. 23 Issue 2 (2017).

15 C.K. Foroughi, N.E. Werner, E.T. Nelson, and D.A. Boehm-Davis, "Do interruptions affect the quality of work?" Proceedings of the Human Factors and Ergonomics Society Annual Meeting (September 2013).

16 E. Edwards, *Stress and the Airline Pilot*, document presented to the BALPA Technical Symposium: Aviation Medicine and the Airline Pilot, Department of Human Sciences, University of Technology, Loughborough (October 1975).

1.19 Useful or effective investigation techniques

Not applicable.

2.0 ANALYSIS

2.1 General

There was no indication that an aircraft system malfunction contributed to this occurrence. As a result, the analysis will focus on the operational factors that contributed to the aircraft departing the runway. The analysis will also focus on the penetration of the reinforcement panels and fuselage skins on either side of the fuselage by the shattered/splintered propeller blade debris.

2.2 Standard operating procedures and checklists

The “Start Locks” task is listed as a single item among several others on the “Before Taxi” checklist, and has 3 subtasks. According to the standard operating procedures (SOPs), the subtasks must be completed before the desired action and goal of releasing the start locks from the propellers.

Finding as to causes and contributing factors

While the crew was carrying out the “Before Taxi” checklist, the “Start Locks” task was initiated; however, it was interrupted and not completed.

Finding as to causes and contributing factors

After the captain told the first officer to stand by, the crew’s focus shifted to other tasks. It is likely that this slip of attention resulted in the power levers not being pulled over the flight idle gate to release the start locks.

The SOPs required that the “Before Taxi” checklist be completed using the challenge-and-response method. However, the response required by the checklist following the “start locks” challenge indicated only that the 3 subtasks were complete; it did not include a response to verify that the start locks had been removed.

Finding as to causes and contributing factors

The “Before Taxi” checklist did not contain a task to ensure that the start locks were removed and, as a result, the crew began taxiing unaware that the propellers were still on the locks.

Challenge-and-response checklists tasks are not complete until the proper response and action is completed and communicated between the crew. The Perimeter SOPs did not include specific guidance as to what to do when a challenge-and-response checklist is interrupted, paused, or if the response is not what is expected. In this occurrence, neither the brakes nor the lights tasks in the “Before Taxi” checklist were initiated, nor was a statement made that this checklist was completed. The investigation was not able to determine why the “Before Taxi” checklist was not fully completed.

Finding as to risk

If procedures for challenge-and-response checklists do not include guidance on task interruptions, pauses, or non-standard responses, there is a risk that checklist tasks will be incomplete or omitted, which may result in the aircraft operating in an unsafe or undesirable configuration.

2.3 Accident sequence

When the aircraft taxied for departure, it was well below the maximum take-off weight, and the thrust requirement for taxi was minimal.

Following an engine start and during normal taxi, movement of the engine power levers can range from slightly forward of the flight idle gate, to beta, to full reverse. Movement of the engine power levers while in beta after an engine start or during the taxi by the pilot may not always be in unison, resulting in asymmetrical propeller blade angles, and loading on the start locks when engaged.

Finding as to causes and contributing factors

After the engine was started or while the occurrence aircraft commenced taxiing for departure, it is likely that slight or rapid transient movements of the engine power levers, which were needed to taxi the aircraft, resulted in the release of the left propeller start locks while the right propeller start locks remained engaged.

The SOPs require that when power is advanced for takeoff, and torque has increased through 20%, the captain will verify the torque indication for both engines and call "positive torque." However, once power was applied for takeoff, the call was not made and the crew was still unaware of the status of the start locks.

Data recorded by the flight data recorder suggest that once take-off power was applied, the left-propeller rpm and engine torque began to increase; however, although the right-propeller rpm also began to increase, the right engine torque remained near zero. This difference in torque indicated that the left propeller's start locks were released whereas the right propeller's start locks remained engaged. The aircraft exited the runway to the right and struck a frozen snowbank shortly after the take-off roll began.

Finding as to causes and contributing factors

As the power was advanced through 20%, the "positive torque" call required by SOPs was not made, and the engine torque differential was not noticed by the crew. As a result, power lever advancement continued although the right engine torque/thrust remained near zero.

Finding as to causes and contributing factors

The engaged start locks on the right propeller prevented forward thrust, which resulted in a significant thrust differential. This differential thrust during the take-off roll resulted in a loss of directional control of the aircraft and, ultimately, a lateral runway excursion.

2.4 Cabin wall penetration by propeller debris

Although the reinforcement panels on the sides of the fuselage were designed to withstand ice strikes, they were not designed to prevent penetration of propeller debris.

Finding as to causes and contributing factors

Following the runway excursion, the propellers, which were operating at a high rpm, shattered and splintered when they struck a frozen snowbank.

Finding as to causes and contributing factors

High-energy release of the nickel-cobalt erosion strips and splintered wood core debris from the propeller blades penetrated the reinforcement panel, fuselage skin and cabin wall, and resulted in serious injuries to a passenger sitting next to the penetrated cabin wall.

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. While the crew was carrying out the “Before Taxi” checklist, the “Start Locks” task was initiated; however, it was interrupted and not completed.

2. After the captain told the first officer to stand by, the crew’s focus shifted to other tasks. It is likely that this slip of attention resulted in the power levers not being pulled over the flight idle gate to release the start locks.

3. The “Before Taxi” checklist did not contain a task to ensure that the start locks were removed and, as a result, the crew began taxiing unaware that the propellers were still on the locks.

4. After the engine was started or while the occurrence aircraft commenced taxiing for departure, it is likely that slight or rapid transient movements of the engine power levers, which were needed to taxi the aircraft, resulted in the release of the left propeller start locks while the right propeller start locks remained engaged.

5. As the power was advanced through 20%, the “positive torque” call required by standard operating procedures was not made, and the engine torque differential was not noticed by the crew. As a result, power lever advancement continued although the right engine torque/thrust remained near zero.

6. The engaged start locks on the right propeller prevented forward thrust, which resulted in a significant thrust differential. This differential thrust during the take-off roll resulted in a loss of directional control of the aircraft and, ultimately, a lateral runway excursion.

7. Following the runway excursion, the propellers, which were operating at a high rpm, shattered and splintered when they struck a frozen snowbank.

8. High-energy release of the nickel-cobalt erosion strips and splintered wood core debris from the propeller blades penetrated the reinforcement panel, fuselage skin and cabin wall, and resulted in serious injuries to a passenger sitting next to the penetrated cabin wall.

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 procedures for challenge-and-response checklists do not include guidance on task interruptions, pauses, or non-standard responses, there is a risk that checklist tasks will be incomplete or omitted, which may result in the aircraft operating in an unsafe or undesirable configuration.

4.0 SAFETY ACTION

4.1 Safety action taken

4.1.1 Perimeter Aviation LP

Since the occurrence, Perimeter Aviation has taken the following safety actions:

- The company released a flight operations bulletin entitled "Metro Propeller Lock Release," which describes the procedure to ascertain the positive release of the propeller start locks.
- The company amended the SA-227 standard operating procedures manual to highlight the importance of confirming the start locks are disengaged.
- The company amended the SA-227 "Before Taxi" checklist: removal of start locks is now a stand-alone checklist item and the last checklist item to complete before taxi commences.
- The company implemented scheduled semi-annual simulator training at the 6-month mark for all *Canadian Aviation Regulations* (CARs) subparts 703 and 704 flight crew members who have less than 2 years' experience in the seat they are occupying. This training includes effective directional control techniques during the take-off roll and a review of company policies, procedures, and techniques related to turboprop engine (TPE) 331 propeller lock engagement and disengagement.
- The company issued a bulletin on 09 February 2021 to further increase awareness and understanding of the Metro propeller start lock system.

This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 24 March 2021. It was officially released on 14 April 2021.