Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A04C0016

LOSS OF DIRECTIONAL CONTROL AND RUNWAY EXCURSION

BEARSKIN LAKE AIR SERVICE LTD.
FAIRCHILD SA227-AC, C-FYAG
DRYDEN REGIONAL AIRPORT, ONTARIO
15 JANUARY 2004

Canada

Aviation Investigation Report

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Bearskin Lake Air Service Ltd.
Fairchild SA227-AC, C-FYAG
Dryden Regional Airport, Ontario
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Report Number A04C0016

Summary

Bearskin Lake Air Service Flight BLS342, a Fairchild Metro SA227-AC (registration C-FYAG, serial number AC-670B) had departed Kenora, Ontario, and was landing on Runway 11 at Dryden, with two pilots and ten passengers on board. During the landing roll, the aircraft went off the left side of the runway into deep snow. The aircraft was not damaged, except for two blown tires on the left main landing gear. The crew and passengers were not injured. The incident occurred during daylight hours at 1457 central standard time.

Ce rapport est également disponible en français.

Other Factual Information

On the day of the occurrence, the crew flew several uneventful flights in C-FYAG and landed in Kenora at 1412 central standard time.[1] The aircraft was de-iced, and a higher than usual power setting was required to get the aircraft rolling from the de-icing location because one or more brakes had frozen during the de-icing. The brakes were not inspected, but did operate properly during the taxi check. There were snow drifts on the runway during the take-off from Kenora at 1439. The crew followed the guidance in the Bearskin Airlines *Metro SA227 Standard Operating Procedures* (SOP) to reduce the risk of brake freeze-up. They took no action to reduce the risk of loss of directional control on landing, nor were they required to do so by the SOP or the SA227-AC *Airplane Flight Manual* (AFM) produced by the aircraft manufacturer.

The first officer (FO) was the pilot flying for the approach and landing at Dryden. The brakes were checked during the before-landing check, and no abnormalities were detected. The aircraft landed at 1457 on Runway 11, touching down on the runway centerline in the normal touchdown zone, at the correct speed, and in the correct landing configuration. The aircraft yawed to the left immediately at touchdown. The FO applied reverse thrust on the right engine and full right rudder.

The aircraft was equipped with nosewheel steering (NWS) for directional control on the ground. The NWS is armed before landing by selecting a switch on the captain's side panel to ARMED. During a normal landing roll, the pilot flying centres the rudder pedals and calls "SPEEDS LOW," and the NWS is engaged when the pilot not flying selects the engine speed levers to LOW. The NWS may also be engaged by either pilot pressing a switch on the outboard side of either power lever. The NWS will slew the nosewheel to a position corresponding to the rudder pedal position if the pedals are not centred when the NWS is engaged. Although the NWS was armed, it was not engaged for two reasons. First, because the crew was responding to the yaw, they did not select the speed levers to LOW. Second, the first officer did not press the power lever NWS engage switch because he was already applying full right rudder, and the nosewheel would have slewed to a position corresponding to the position of the rudder pedals. Centring the rudder pedals to smoothly engage the NWS would have exacerbated the left yaw.

Because the FO's feet were positioned on the rudder pedals with the heels on the floor, they not be shifted upward to apply the right brake while pressure was being applied to the right rudder pedal. Neutralizing the pedals to permit shifting the feet upward also would have exacerbated the yaw.

The yaw increased uncontrollably before the captain could assist in controlling the aircraft. The aircraft departed the left side of the runway about 2900 feet from the threshold of Runway 11 and travelled about 150 feet through the snow. It came to rest on a heading of 080 degrees, approximately 30 feet from the runway edge. They shut down the engines and feathered the propellers before the aircraft went off the runway.

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[1] All times are central standard time (Coordinated Universal Time minus six hours).

After the aircraft came to a stop, and it was determined that there were no injuries, the passengers were evacuated through the main door.

An airport maintenance equipment operator, in a truck on the terminal apron, saw the aircraft go off the runway and immediately advised Winnipeg Radio. The operator drove to the occurrence site and determined that fire fighting and other emergency response services would not be required.

The passenger evacuation was directed by the FO; however, once the passengers left the aircraft, the FO and airport staff did not have direct control over their movements. Most of the passengers and the FO walked in an extended single file across the runway, along Taxiway A, and across the terminal apron to the terminal building. One passenger accepted the offer of a ride by the equipment operator.

Transportation Safety Board (TSB) investigators authorized the removal of the aircraft from the occurrence site before their arrival. When the operator's maintenance personnel arrived at the scene, the brake units on both main landing gear were frozen and would not rotate until they had been thawed using a portable heater. The left main gear wheel assemblies and damaged tires were replaced at the occurrence site, and, at about 2100, the aircraft was towed to a hangar on the airport where the operator began an abnormal-occurrence inspection.

The aircraft, wheels, and tires were examined in the hangar the following day by TSB investigators. Both tires on the left wheel assembly had large flat spots with holes through the tire tread and cords. The left main gear brake assemblies were serviceable. The aircraft brake system, the parking brake, and the NWS were inspected and found to be serviceable. The tires on the right main gear were undamaged, indicating that they had been rotating normally during the landing roll. Several gear swings were conducted and no anomalies were found. The abnormal-occurrence inspection of the aircraft by company staff revealed no structural damage.

Records show that the flight crew were certified and qualified for the flight in accordance with existing regulations, and that the aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. There were no recorded deferred aircraft maintenance items relevant to the circumstances of the occurrence.

Regulations required that the aircraft be equipped with a cockpit voice recorder (CVR). An L3 Communications Fairchild model FA2100 CVR, serial number 000103578, was installed. A flight data recorder (FDR) was not required by regulation; however, a Fairchild model F800 FDR, serial number 2098, was installed. Both the CVR and FDR were removed from the aircraft and forwarded to the TSB Engineering Branch for analysis.

The weather in Kenora at 1400 was as follows: wind 100 ° True (T) at 11 knots gusting to 17 knots, visibility one statute mile (sm) in light snow and drifting snow, sky condition vertical visibility 2000 feet, temperature -15°C, dew point -19°C, altimeter setting 29.97. A special observation taken at 1433 reported the Kenora weather as follows: wind 100° T at 10 knots gusting to 15 knots, visibility two sm in light snow and drifting snow, sky condition overcast at 4000 feet above ground level (agl).

The runway at Kenora was inspected at 1314; the runway surface condition (RSC) was reported as 30% bare and dry, 30% compacted snow, 40% scattered snow patches ¾-inch depth, Canadian runway friction index (CRFI) .42, temperature -16°C. The crew received and acknowledged this RSC and CRFI during the approach to Kenora. Taxiway and apron surface conditions were similar to the runway conditions.

The weather in Dryden at 1433 was as follows: wind 080° T at 10 knots, visibility two sm in light snow, sky condition overcast at 1100 feet agl, temperature -18°C, dew point -22°C, altimeter setting 30.04. The crew received and acknowledged this weather report during the approach. Following the occurrence, a special observation taken at 1458 reported the Dryden weather as follows: wind 080° T at nine knots, visibility two sm in light snow, sky condition vertical visibility 1000 feet, temperature -18°C, dew point -22°C, altimeter setting 30.05.

The runway at Dryden was inspected at 1035. The RSC was recorded as 150-foot width 20% bare and dry, 80% loose snow ¼-inch depth; the CRFI was recorded as .38 at 1030. The crew received and acknowledged this RSC and CRFI during the approach. Airport snow removal operations had been underway throughout the day, and equipment operators vacated the runway shortly before BLS342 landed. At 1500, a post-occurrence runway inspection confirmed that the runway was debris-free; the RSC was recorded as 150-foot width 60% bare and dry, 40% loose snow ¼-inch depth.

Runway 11 at Dryden is 6000 feet long, 150 feet wide, and has an asphalt surface. Runway strips are described in Transport Canada manual TP312E *Aerodrome Standards and Recommended Practices* as a defined area, including the runway, intended to reduce the risk of damage to aircraft running off a runway. The runway strip for Runway 11 includes a graded, gravel-covered area extending about 200 feet outward along both sides of the runway. The aircraft came to rest 105 feet from the runway centre line in Zone 1 of the runway strip, the area within 75 feet of the runway edge. For the landing of BLS342, the graded runway strip fulfilled its intended purpose of reducing the risk of damage to aircraft running off the runway. Airport staff and TBS investigators examined the runway and found no tire skid marks on the runway surface.

Air traffic control service is not available at Dryden; however, remote aerodrome advisory service is provided by the NAV CANADA Winnipeg Flight Information Centre, using the call sign Winnipeg Radio.

Operations at Dryden Airport are governed by the *Dryden Airport Operations Manual* (AOM). The AOM, Section 1.3.2, requires that immediate notice be given of any obstruction affecting aviation safety at the airport; airport staff immediately notified Winnipeg Radio of the location of the disabled aircraft. The AOM, Section 1.3.4, requires that any obstruction on the surface of the airport that is likely to be a hazard shall be removed; within 30 minutes of the occurrence, the airport staff made contact with the operator and the TSB to arrange for removal of the disabled aircraft.

The AOM states that the airport shall be operated in compliance with the standards in TP312E, and that a decision to close the runway is the responsibility of the airport manager or the manager's designate and requires the issuance of a notice to airmen (NOTAM). The standard in section 3.1.6.8 of TP 312E required that no mobile object be permitted within 196 feet of the

Dryden runway 11 centre line during the use of the runway for landing or take-off. Although the standard does not clearly say so, the effect is that landings and take-offs are not permitted when mobile objects, such as vehicles, are within 196 feet of the runway centre line. Attachment A to TP312E (Guidance Material Supplementary to TP312E) provides guidance to airport operators, but has no regulatory force. Section 5.3.2 provides guidance regarding temporary hazards in Zone 1 of runway strips, and states that "an aircraft immobilized in this zone would automatically require the closure of the runway."

The airport manager was on duty at the time of the occurrence and was on the scene within minutes of the occurrence. Because Dryden has only one runway, the airport staff decided to keep the runway open to permit continued operations. The runway remained open and operating during the time the aircraft was disabled beside the runway. During the 30 minutes after the occurrence, Winnipeg Radio asked the airport staff on two occasions to confirm whether the runway would be closed; both times the response was negative. No NOTAM was issued regarding the runway status.

Vehicle operators are required to obtain permission from the appropriate flight service station before driving on the movement area of an airport; every vehicle going to the occurrence site needed to cross Runway 11/29. Standard communication procedures between airport staff and Winnipeg Radio were used to control the extensive vehicle movements on the airport while the runway remained open with the aircraft disabled in Zone 1. However, analysis of communications recordings revealed that some vehicle movements were not communicated to Winnipeg Radio.

Several aircraft movements took place while vehicles and the disabled aircraft were within Zone 1. Winnipeg Radio advised the flight crews of the position of the disabled aircraft and positions of vehicles known to be at the occurrence site before each aircraft movement. However, because some vehicle movements were not communicated to Winnipeg Radio, there was a risk that an aircraft movement could occur while a vehicle was on the runway. None of these aircraft experienced directional control problems during take-off or landing; however, the continued operation of the runway with a disabled aircraft and vehicles within Zone 1 of the runway strip increased the risk to aircraft using the runway. The risk of missed communications between vehicles and Winnipeg Radio, the associated risk of simultaneous aircraft and vehicle movements, and the risk of damage to aircraft running off the runway would all have been eliminated by closing the runway.

The aircraft was equipped with model 5011640-1, hydraulic-operated, multi-disk wheel brakes manufactured by Aircraft Braking Systems Corporation. The brake assemblies are located between the dual wheels on the main landing gear; one brake assembly for each wheel. There was no shielding to prevent snow from entering the brake disk area. The brake system is not power assisted and is not equipped with an antiskid system. Some aircraft brake systems include protection against brake application before touchdown. The brake systems on the SA227-AC and most other aircraft types used in commuter and air taxi operations do not provide this protection. Use of the brakes during taxi, take-off, and landing causes a heat buildup within the brake assemblies, and snow entering the warm brake assembly melts. With temperatures below freezing, the water then freezes, preventing the wheels from rotating. The aircraft was operating in below freezing temperatures, with snow and drifting snow at the departure airport. There

was no shielding to prevent blowing snow from entering the brake assemblies, and it is likely that snow blown onto the brake assemblies during the departure from Kenora melted and then froze en route to Dryden.

The brakes are operated by applying pressure to the top of the rudder pedals. The brakes can be operated from either the left or the right pilot seat through the dual rudder pedal system. Examination of the rudder pedals by TSB investigators determined that, with the feet placed with the heels on the floor, very little pressure could be applied to the tops of the pedals to operate the brakes. It was possible to position the feet higher on the pedals so that the rudders could be operated without exerting pressure on the brakes, while also permitting the brakes to be operated simultaneously with deflection of the rudder pedals.

The pressure exerted by the FO's foot against the right rudder pedal prevented repositioning the foot higher on the pedal to operate the brake. The FO was unable to operate the brake for directional control because he was unable to release the pressure on the rudder pedal without losing the directional control provided by the rudder.

Interviews with Bearskin pilots and management revealed that the company had an undocumented practice whereby pilots would position their feet on the rudder pedals with their heels on the floor and would move their feet higher on the pedals when they needed to operate the brake. This practice is employed on all aircraft types the company operates. The sole exception to this practice was that of one senior company pilot who advocated placing the feet higher on the pedals to be prepared to immediately operate the brakes after touchdown. The heels-on-the-floor position is intended to reduce the risk of unintentional brake application, before or at touchdown, because it can lead to tire damage or failure. Other commuter and air taxi operators employ this practice for the same reason. It is undocumented and is employed on aircraft types used in commuter and air taxi operations, including the SA227-AC.

The Fairchild AFM does not contain any abnormal or emergency operating procedures for frozen brakes. The Bearskin Airlines Metro SOP (pages 4 to 2) contains an abnormal procedure for frozen brakes that reads as follows:

> If you suspect your brakes may be frozen (before you start up), release the parking brake and pry the brake disc apart with the large flat screwdriver which is kept in the nose baggage compartment. Try to avoid using brakes when taxiing through deep snow in cold weather. If you can't avoid taxiing through deep snow in order to take off, use of brakes should be limited. You may want to spray the brakes with glycol as a <u>last</u> resort.

The company SOP provided limited guidance to crews regarding frozen-brake risk management and did not address the risk of loss of directional control on landing.

Other Canadian operators of Fairchild SA227 aircraft were contacted to determine how the risk of frozen brakes is managed. This informal survey indicated that brake freeze-up risk management strategies employed in the industry are mostly undocumented and are inconsistently applied from one operator to another. The frozen-brake risk management strategies employed by operators were as follows:

- placing a cautionary note in the SOP regarding the risk of frozen brakes on landing and the subsequent potential control difficulty;
- doing a risk assessment if snow depth is greater than two inches;
- releasing the parking brake as soon as the chocks are in place to allow the brakes to cool without freezing;
- spraying de-icing fluid on the brakes after shutdown to prevent freezing and again before engine start;
- checking the brakes for freezing before boarding the aircraft;
- before engine start, prying frozen brakes apart using a screwdriver;
- thawing frozen brakes with a portable heater before taxiing rather than trying to free the brakes by using increased engine power;
- spraying de-icing fluid on a frozen brake;
- using minimal braking to keep the brakes from heating up and melting the snow;
- trying to avoid taxiing through deep snow;
- avoiding using the brakes when taxiing through deep snow;
- after taxiing through snow or slush, delaying landing gear retraction after take-off to allow airflow to remove brake contaminants;
- before landing, operating the brakes two to three times after gear extension to break any ice bonding in brake assemblies; and,
- making firm landings to ensure good tire contact on runway and wheel spin-up.

Some of the strategies employed by operators contradict strategies recommended by the brake manufacturer. In particular, the brake manufacturer expressed concerns about the use of de-icing fluid on brakes, as some de-icing chemicals can cause significant deterioration of carbon brakes, and de-icing fluid in brake assemblies can reduce the coefficient of friction, reducing brake effectiveness. The manufacturer recommended the following strategies to reduce the risk of brake freeze-up:

- heat up the brakes by using them during taxi to dry out any moisture present;
- after shutdown, leave the parking brake on to eliminate spaces for moisture to accumulate; and,
- operate the brakes before landing to break any ice bonds in the brake assemblies.

Transport Canada provides guidance material to pilots on some safety issues, including winter operations, in the airmanship section of the *Aeronautical Information Publication*. There is no information in this publication regarding the risks associated with frozen brakes.

A search of the Transport Canada Civil Aviation Daily Occurrence Reporting System database revealed 54 frozen-brake occurrences from November 2000 to April 2004. None of these occurrences resulted in injuries; two occurrences resulted in minor aircraft damage, and in the remainder the aircraft were not damaged. Three occurrences resulted in runway excursions, and 26 occurrences resulted in aircraft disabled on the runway. Five occurrences involved transport category aircraft, 12 involved aircraft types used in commuter operations, and 37 involved aircraft types used in air taxi operations. A previous TSB investigation (A94O0055) determined that a frozen brake on another Fairchild SA227 led to loss of directional control and a runway excursion, resulting in minor damage to the aircraft.

The CVR had four high-quality, 30-minute tracks and two lower-quality, 120-minute tracks. One of the 120-minute channels was of poor quality. It was determined that the connections on the cockpit audio/microphone jacks were reversed, resulting in the interphone outputs being out of phase. The summing of these out of phase signals resulted in attenuation of portions of the recording, making it difficult to discern communications on these portions. Audio/microphone jacks are routinely replaced by operators and any mis-wiring could go undetected during normal operations. CVR function and intelligibility tests are required annually or every 3000 hours. The function and intelligibility test procedure provided by the manufacturer for the model FA2100 CVR did not include a separate test of the 120-minute mixed channel. The effect of the signal attenuation on this investigation was minimal because the 30-minute tracks contained the required information.

The FDR model installed was a six-track tape-based unit that recorded altitude, airspeed, magnetic heading, vertical acceleration, and VHF radio keying. Analysis of the flight data revealed that the accuracy of some of the parameters was suspect. Although installation of an FDR was not required, the company operated with a minimum equipment list containing FDR serviceability provisions and also with an FDR maintenance program. The FDR maintenance program required correlation checks of the FDR system. The last correlation check of the aircraft prior to the occurrence was completed in October 2003, and the operator indicated that no anomalies were found at that time. The operator did not archive the correlation check data. The effect of the data inaccuracies on this investigation was minimal, because other data sources provided correlation of the required parameters.

The potential exists for misidentifying or delaying the identification of safety deficiencies in future investigations as a result of FDR data inaccuracies or similarly undetected CVR signal attenuation from phase discrepancies.

The following TSB Engineering Branch report was completed:

LP 015/2004 – Flight Data Recorder and Cockpit Voice Recorder Analysis

This report is available from the Transportation Safety Board of Canada upon request.

Findings as to Causes and Contributing Factors

1. The aircraft was operating in environmental conditions conducive to snow penetration into the brake assemblies during ground operations at Kenora.

2. The brake assemblies on the left main landing gear froze, preventing the wheels from rotating during the landing roll at Dryden.

3. The first officer's foot position and pressure application on the rudder pedals prevented effective use of differential braking and nosewheel steering to maintain directional control of the aircraft after landing.

Findings as to Risk

1. Although the practice of pilots placing their feet on the rudder pedals with their heels on the floor reduces the risk of tire damage from an unintentional brake application, the practice creates a risk that pilots will not be able to use the brakes to maintain directional control.

2. The aircraft manufacturer's AFM does not provide emergency or abnormal procedures for frozen brakes.

3. The company SOP provides very limited guidance regarding frozen brakes, and the Transport Canada *Aeronautical Information Publication* does not provide any guidance material regarding the risks associated with frozen brakes.

4. Brake freeze-up risk management strategies are, for the most part, undocumented and inconsistently applied by the industry. Industry strategies in some cases contradict the strategies recommended by the brake manufacturer.

5. Some vehicle movements on the Dryden aerodrome were not communicated to Winnipeg Radio, creating a risk that an aircraft movement could occur while a vehicle was on the runway.

6. The continued operation of the runway with a disabled aircraft and vehicles within Zone 1 of the runway strip increased the risk to aircraft using the runway.

7. The passengers walked across active airport manoeuvring surfaces to the terminal building with no direct control over their movements.

8. The potential exists for misidentifying or delaying the identification of safety deficiencies in future investigations as a result of FDR data inaccuracies or undetected CVR signal attenuation from phase discrepancies.

Other Findings

1. The graded runway strip intended to reduce the risk of damage to aircraft running off the runway fulfilled its purpose for the landing of BLS342.

2. The crew's action of shutting down both engines before the runway excursion most likely prevented structural failure of the propeller system and possible subsequent damage to the cabin integrity.

Safety Action Taken

The operator corrected the wiring of the cockpit audio/microphone jacks and confirmed proper operation of the CVR. The operator reported that no further problems existed with the mixed channel.

L3 Communications, the manufacturer of the FA2100 CVR, is in the process of revising the Installation and Operation Manual for the CVR Functional and Intelligibility Test procedures, to ensure that operators check the 120-minute channels for proper operation.

The Transportation Safety Board sent an Aviation Safety Advisory (615-A040037-1) to Transport Canada suggesting that they may wish to consider action to ensure that pilots understand the risks associated with frozen brakes and are adequately prepared to maintain directional control on landing.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 02 March 2005.