Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A12P0034

RUNWAY EXCURSION

NORTHERN THUNDERBIRD AIR INC.
BEECHCRAFT 1900C, C-GCMZ
BLUE RIVER, BRITISH COLUMBIA
17 MARCH 2012

Canada

Aviation Investigation Report

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Summary

The Northern Thunderbird Air Inc. Beechcraft 1900C (registration C-GCMZ, serial number UC-61) departed Vancouver International Airport, British Columbia, on a charter flight to Blue River, British Columbia, with 2 crew members and 1 passenger on board. The flight was operated under instrument flight rules to Valemount, British Columbia, where the crew conducted an instrument approach, and then proceeded under visual flight rules to Blue River. Arriving in the Blue River valley, the captain, who was the pilot flying, commenced a straight-in approach to Runway 19. At 1129 Pacific Daylight Time, in daylight conditions, the aircraft touched down on the snow-covered runway. Immediately after touchdown, the left main gear entered an area of deep snow. The aircraft veered into the snow bank, sustaining substantial damage. The crew and the passenger were not injured, and there was no fire. The impact forces were not enough to activate the emergency locator transmitter.

Ce rapport est également disponible en français.

Factual Information

History of the Flight

The occurrence flight was chartered by a travel agency on behalf of a wilderness adventure ski lodge. It was a regularly occurring charter flight that operated weekly during the ski season. The travel agent would make the bookings for the guests and arrange for the appropriate aircraft, depending on the number of guests travelling. The travel agent would also act as the liaison between the ski lodge and Northern Thunderbird Air Inc. (NT Air) flight followers [1] or pilots regarding passenger loads and customer ground transportation at Vancouver and the selected alternate airport if the flight could not land at Blue River, British Columbia. This charter operated on Saturdays, when NT Air's dispatch office was not staffed. A flight follower was available by telephone. It was the flight crew's responsibility to determine the weather and runway conditions at Blue River.

Unofficial Blue River weather and runway information could be obtained through the radio room operator at the ski lodge, who could be reached by telephone before departing Vancouver. This information could also be obtained en route through the very high frequency (VHF) radio on the aerodrome traffic frequency (ATF) for Blue River. The ATF was monitored from the ski lodge, which was not located at the Blue River aerodrome. The radio room operator gathered information from the ski lodge's helicopter contractor pilots, who operated from a hangar at the Blue River aerodrome. The radio room operator would discuss this information by telephone with the travel agent in Vancouver, as it pertained to the likelihood of the flight landing in Blue River or the need to arrange for bus transportation from the alternate airport.

In this occurrence, the travel agent verbally passed the information to the flight crew while the passengers were boarding in Vancouver. The captain understood that the runway had been plowed the previous day, and that the weather had been good that morning in Blue River.

Before departing Vancouver, the flight crew obtained official weather data from regular flight planning sources. This included the 0900 [2] aviation routine weather report (METAR) for Blue River. It was noted that although current conditions at Blue River were good, a weather system was moving northbound, and conditions in the area of Kelowna, Kamloops (CYKA) (the alternate), and Blue River would begin to deteriorate. As the flight progressed, the ski lodge radio room operator overheard the flight crew discussing weather conditions with a local helicopter pilot on the ATF as NT Air overflew Blue River, but the operator did not have any direct contact with the flight. The crew was satisfied with the information received from the helicopter pilot regarding local weather.

The *Canada Flight Supplement* listing for Blue River includes the telephone number of the aerodrome runway maintenance contractor for runway condition reports, as well as a note indicating that runway maintenance is limited during winter. The crew did not make any calls to the maintenance contractor.

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1 Flight followers are able to assist the pilot-in-command with details regarding flights and can act as the responsible person with respect to a flight itinerary. A Northern Thunderbird Air Inc. (NT Air) flight follower is available by phone when NT Air aircraft are in operation.

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

The flight departed Vancouver International Airport (CYVR) at 0930, with CYKA as the instrument flight rules (IFR) alternate airport. Because the Blue River aerodrome (CYCP) does not have a published instrument approach procedure, the intention was to fly over the aerodrome and proceed under visual flight rules (VFR) into the aerodrome. The aircraft had enough fuel to bypass Blue River, make an IFR approach into Valemount (CAH4), fly under VFR back to Blue River, and still have sufficient fuel to continue to CYKA under IFR, if required. The flight progressed as planned until the aircraft passed overhead Blue River at the lowest useable IFR altitude, and the pilot was not able to descend under VFR into Blue River.

The pilot then climbed back up to an enroute IFR altitude and continued to CAH4 under IFR. After conducting the IFR approach into CAH4 and finding the weather suitable for flight under VFR, the aircraft completed the 60-nautical mile (nm) trip back to Blue River visually. The aircraft slowly descended in steps as it flew south towards Blue River at a reduced cruise speed of approximately 175 knots. As the aircraft neared the aerodrome, the pilots descended to altitudes as low as 1100 feet above ground level (agl) to maintain visual contact with the ground in deteriorating weather. Approximately 4 nm from the aerodrome, and 85 seconds before touchdown, control was transferred from the first officer (FO) to the captain, who became the pilot flying (PF).

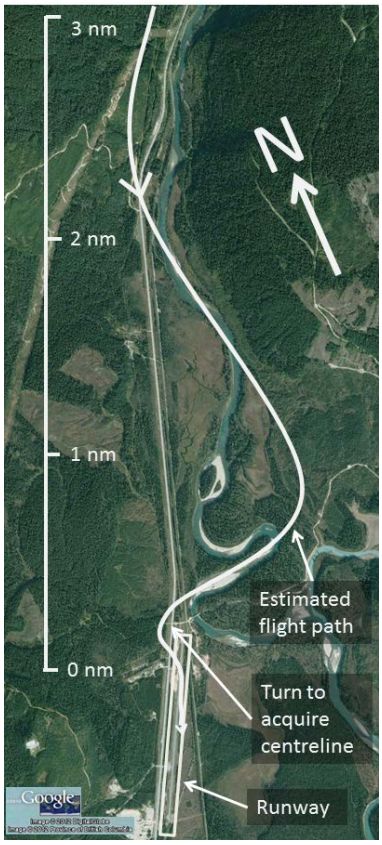

Figure 1. Estimated flight path of C-GCMZ

During the approach, the crew rushed to complete the pre-landing checks, visually acquire the runway, and manoeuvre the aircraft to land. The captain turned slightly to the left, away from the runway centreline (Figure 1). At this point, the FO called visual contact with the runway, and the captain turned right, back towards the runway centreline, and again passed through the runway centreline. The captain did not acknowledge that the runway was in sight.

The aircraft was configured for landing 25 seconds prior to touchdown. As viewed from the pilot's perspective, the aircraft was to the left of centreline. Several seconds later, the aircraft initiated a right turn to line up with the centreline of Runway 19, but actually crossed to the right of the centreline. The aircraft then overflew several buildings on the right of the runway centreline, approximately 75 feet adjacent to the runway threshold. The aircraft then turned sharply to the left as it passed abeam the threshold, then sharply right to aquire the centreline before touching down approximately 2000 feet past the threshold. Immediately after touchdown, the aircraft veered left into the snow bank.

During the last 23 seconds of the flight, the FO broadcast a traffic advisory to indicate that the aircraft was on final, made 3 speed calls, and advised the captain that the runway was to the left. There were no remarks made by the captain since the request for the landing checklist. The FO did not declare an unstable approach, or prompt the captain to execute a missed approach.

Weather in Blue River

When the aircraft was unable to descend into Blue River due to overcast conditions below, the crew made contact with a local helicopter pilot. This pilot informed the crew that weather conditions in Blue River were 4000 to 7000 feet agl overcast, with a visibility of 5 statute miles (sm).

At Blue River, a weather observer under contract with NAV CANADA provides regular hourly and special weather reports during limited daylight hours. This station does not have radio communication capability; all reports produced by this station become available immediately to all flight planning sources, eliminating any advantage of calling this station directly by telephone. This station does not provide any weather briefing, aerodrome advisory or runway condition reporting services.

The weather observer was on duty the day of the accident. The last weather observation prior to the accident was taken 30 minutes earlier (1100), and indicated that visibility was 2 sm, with obscured ceilings at 2500 feet agl in light snow. The wind was from the north at 6 knots, and the temperature was -1°C.

The flight crew could have contacted the radio room at the ski lodge by radio and requested that the operator obtain the official weather through many sources, including the Internet. However, this request was not made. There were several flight service stations and air traffic control (ATC) facilities within radio communication range while the aircraft was en route, and these could also have been used to obtain the current METAR for Blue River. The crew did not obtain the latest METAR for Blue River before commencing the VFR portion of their route to Blue River.

In the hours preceeding the accident, the weather conditions generally corresponded to visual meteorological conditions (VMC) (ceiling at 3000 feet and visibility of 5 sm). As the aircraft got closer to the aerodrome, the conditions deteriorated. The weather observer made a special observation immediately after the accident, reporting the visibility to be 1 ½ sm in light snow, with the ceiling at 1200 feet agl obscured in snow, winds from the north at 5 knots, and temperature -1°C.

Visual Flight Rules Weather Limitations

The VFR route from Valemount to Blue River lies in uncontrolled airspace, where there is no ATC service provided. It is an area where pilots are responsible for their own traffic separation and obstacle clearance. The VFR weather limitation in this area is based on the altitude of the aircraft. If the aircraft is flown above 1000 feet agl, the aircraft must be flown at least 500 feet below the cloud layer and 2000 feet horizontally from cloud. The flight visibility must be at least 1 sm. If the aircraft is flown below 1000 feet agl, the aircraft must be flown clear of cloud, with a visibility no less than 2 sm.

NT Air management did not feel that the *Canadian Aviation Regulations* (CARs) limitations were adequate for flight in VFR conditions in mountainous areas. As a result, NT Air increased the required visibility for VFR flight to 5 sm and incorporated the limitations into the company operations manual (COM).

Damage to Aircraft

The aircraft sustained substantial damage. Both propellers were damaged when the blade tips came in contact with the snow banks. Several of the blade tips separated approximately 10 inches from the end. Both engines were removed for overhaul. The nose gear had partially collapsed when a gear-down linkage broke due to overload. A number of main and nose gear doors were damaged or destroyed. The outboard section of the right wing was damaged. The flaps and nacelles were damaged, but there was no significant damage to the main fuselage (Photo 1 and Photo 2).

Photo 1. Right side of damaged aircraft

Photo 2. Left side of damaged aircraft

Flight Crew Information

Records indicate the crew members were certified and qualified for the flight in accordance with existing regulations. Both pilots were experienced and current on the Beechcraft 1900C (B1900C), and both had flown into Blue River on previous occasions. The captain had previously flown under VFR from Valemount to Blue River. The FO had never flown the route from Valemount to Blue River under VFR.

Table 1. Flight crew information

	Captain	First officer
Pilot licence	Airline transport pilot licence	Commercial pilot licence
Medical expiry date	01 October 2012	01 March 2013
Total flying hours	7600	3002
Hours on type	5238	1268
Hours last 90 days	89	152
Hours on type last 90 days	83	150
Hours on duty prior to occurrence	2.5	2.5
Hours off duty prior to work period	15	15

The captain had worked the previous 4 days and was scheduled to work 20 days in March. Some of the captain's duty days included non-flying duties associated with a management position. The FO was scheduled to work 10 days in March and was scheduled to work on the 3 days prior to the accident. However, there were no flying duties for the FO on these previous 3 days, and the FO was on call at home. This was the first flight of the day for both crew members. There was no indication that fatigue was a factor in this occurrence. Both pilots were on a schedule that provided the required rest and time away from duties.

Crew Pre-flight Duties

Once the aircraft was ready for flight, the captain met with the travel agent and discussed the passenger loads and weather expectations. The travel agent relayed to the captain some unofficial information received from the ski lodge radio operator regarding the weather and runway conditions. The flight crew did not make any calls to the aerodrome runway maintenance contractor listed in the *Canada Flight Supplement* and the NT Air company airport directory, or to the ski lodge to check on the runway or weather conditions on the morning of the flight. The ski lodge radio operator could not obtain more detailed or current official information than the flight crew could have obtained on their own from Vancouver.

Pilot Decision Making and Visual Flight Rules/Instrument Flight Rules

Pilot decision making (PDM) is a critical aspect of flight safety. PDM can be defined as a 4-step process: gathering information, processing information, making a decision based on the possible options, and acting on that decision. For the decision-making process to be successful, however, the pilot must continually re-assess the conditions and determine whether the original plan is still sound, or if a different course of action is required. An accurate and timely interpretation of the information available to the pilot is essential to the success of this process. Failure to understand a changing environment and to act accordingly may have serious consequences.

The decision-making process when flying under VFR is quite different from an IFR flight. An IFR flight must have a planned alternate that is available by a defined route. A VFR flight may have several alernate options, but the plan may be continuously changing based on factors such as ceiling, visibility, and terrain.

Until the aircraft was about 5 nm from the runway, the crew was able to continue the flight in accordance with company limitations. The flight then entered an area where the weather had deteriorated beyond company limitations.

The options available to the crew to abort the approach changed as the flight progressed into deteriorating weather. The crew could remain VFR and turn around to fly back to where the weather was better, or the crew could convert to an IFR flight plan, climb into the clouds and proceed IFR to an alternate destination.

Once the aircraft entered poor weather near the runway, the alternatives became more difficult to conduct. As the aircraft approached Blue River, the valley narrowed, and at the aircraft's altitude, the valley was only 1 nm in width in certain places. At the speed the aircraft was flying, turning the aircraft around using 30° of bank [3] would require about 1.6 nm of horizontal distance. A successful course reversal would require a significant reduction in airspeed, an increase in altitude, a higher angle of bank, or a combination of all 3. A climb procedure would involve climbing in cloud, over an area not assessed for obstacle clearance, with mountains extending 5000 feet above the altitude of the aircraft.

Runway Conditions

The runway was plowed the day before the accident at around 1700. On the morning of the accident, the apron and taxiway were plowed. The runway threshold was also plowed to clear the snowdrifts and windrows left as a result of plowing the taxiway.

The paved runway surface was contaminated with areas of compact snow and ice patches. There had been a small accumulation of snow overnight, which was described as a trace by the weather office. The Blue River aerodrome operator does not provide runway surface condition (RSC) or Canadian Runway Friction Index (CRFI) reports.

Beyond the edges of the runway was a deeper buildup of snow. The windrows left by the snow plow had been driven over by tracked vehicles with the intention of flattening them down. The result was partially-compacted snow of unknown depth and distance from the unmarked runway edge.

The weather conditions at the time of the accident produced a low, dull lighting condition that made features of the runway surface difficult to define. Without runway edge markings, identifying the runway edge becomes more difficult as the aircraft moves down the runway beyond the threshold area. The only thing the pilots can see is a large monochromatic area with no clear definition of the runway edges.

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[3] Although not indicated in the standard operating procedures (SOPs) or company operations manual (COM), 30° of bank is considered by many to be the maximum bank angle to be used in normal passenger operations.

The Transportation Safety Board of Canada (TSB) Watchlist identifies the transportation safety issues that pose the greatest risk to Canadians. One of the items on the TSB's Watchlist is "Landing accidents and runway overruns". One of the solutions to resolve this issue is to ensure pilots receive timely information about runway surface conditions.

Northern Thunderbird Air Evaluation of Winter Operations at Blue River Aerodrome

The aerodrome in Blue River has a single paved runway that is 5000 feet long and 60 feet wide at an elevation of 2240 feet above sea level (asl). The runway has no edge markings or lights. The aerodrome does not have a published instrument approach or any navigation aids. It is a registered aerodrome operated by BC Highways. The area regularly receives annual snowfall accumulations in excess of 20 feet. Limited winter maintenance of the runway is provided under contract by a road contractor that plows the runway in addition to maintaining the local public roads. The contractor usually plows the runway within 24 hours of a snowfall.

NT Air had been operating this charter for the travel agency for at least 2 winter seasons. Prior to accepting the charter, management completed an analysis of the aerodrome with respect to runway length and obstacles. NT Air management had determined that the runway length was sufficient, but was concerned about runway winter maintenance and snow removal. The B1900C has no minimum runway width requirement; however, with a wing span of 58 feet, a 60-foot wide runway is considered narrow for winter operations if snow banks are taken into consideration. NT Air management had decided that the surface would need to be plowed any time there had been a snowfall, and the snow banks would have to be pushed beyond the runway edges by 30 feet, giving the pilots a 120-foot (60 + 30 + 30) swath of cleared area.

NT Air management had expressed this requirement to the travel agency and had spoken to the road contractor. The road contractor would only commit to plowing the runway to the edge of the pavement, as per the contract it had with the aerodrome operator.

It was then decided that the lodge operator would use a Snowcat to push the snow banks back as far as possible and flatten them down if necessary. NT Air management was under the impression that the lodge would provide this service, and through either the lodge or the travel agent, provide a runway report to the pilots before they landed. No training or formalized instructions on reporting runway conditions or preparing the runway surface was provided to anyone outside of NT Air. The travel agent, who is located in Vancouver, is not in a position to provide runway information other than what is verbally given by telephone from the ski lodge radio operator.

NT Air management considered snow removal and runway preparation as basic requirements to operate into Blue River and indicated it would not have authorized the flights had it been aware the runway was not being maintained as required. There was no documentation to support these considerations or agreements, and no risk assessments of the intended operation were documented. NT Air management's minimum expectation concerning the plowing and cleared area was not noted in the airline's airport reference book. The pilots and flight followers were not made aware that this was considered a minimum requirement by management to conduct operations in Blue River.

The road contractor's snow plow operators had been trained to plow highways and roads, and had been given some instructions specific to runway operations. According to the road

contractor, the runway was plowed. There was no restriction in the road contractor's agreement with the aerodrome operator as to the height of the snow banks left on the runway edge. If the snow banks are not pushed back or flattened down, the snow bank can be as tall as or even taller than the height of the wing of a B1900C.

Aircraft Performance on Contaminated Runways

The B1900C flight manual for Canadian operations does not provide performance information for slippery or contaminated runways. This is not uncommon for many smaller aircraft operated under Subparts 703 or 704 [4] of the CARs. There is no requirement in the CARs for a Subpart 703 or 704 company or its pilots to assess landing distance based on contaminated runways unless the aircraft flight manual contains performance charts that allow calculations to be made. The *Canada Flight Supplement* contains information to assist pilots in determining the possible effects of slippery runways; however, there was no CRFI or RSC report available to the crew, and no calculation had been made to account for slippery runway conditions. The stopping distance was not considered a factor in the accident.

Safety Management Systems and Safety Programs

In order to improve safety in Canadian aviation, Transport Canada (TC) has introduced safety management systems (SMS) in the industry. The original goal was to have all Subpart 703, 704, and 705 [5] air carriers operating with their own approved SMS by 2010. To date, only Subpart 705 air carriers are required to have a TC-approved SMS. The original implementation date for Subparts 703 and 704 operators has been postponed.

It should be noted that although not required by the CARs, many aviation companies do have some elements of a safety program. The general term SMS has sometimes been used to describe many of these programs.

This has been recognized by the TSB, and is now an item on the TSB Watchlist, which states in part:

> Transport Canada does not always provide effective oversight of aviation companies transitioning to safety management systems, while some companies are not even required to have one […] Implemented properly, safety management systems (SMS) allow aviation companies on their own to identify hazards, manage risks, and develop and follow effective safety processes.

Implementation of a Safety Management System at Northern Thunderbird Air

Based on the assumption that an SMS would be required in future regulations, as well as having plans to acquire a Subpart 705 operating certificate, NT Air had begun developing and implementing some components of an SMS. The company had TC initially review the program and was prepared to continue with the approval process. However, business plans changed, and NT Air cancelled plans to acquire a Subpart 705 operating certificate. TC also postponed the

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4 Subpart 703 refers to Air Taxi Operations and Subpart 704 refers to Commuter Operations.

5 Subpart 705 refers to Airline Operations.

implementation date of SMS for Subparts 703 and 704 operators until such time as resources would allow the process to be better implemented. These factors contributed to NT Air's decision not to continue the SMS approval process.

Prior Occurrences

Prior to the accident flight, NT Air had been involved in 2 significant occurrences that were relevant to this investigation. Five months before this accident, a Beechcraft King Air 100 suffered a loss of control and crashed on short final to Vancouver International Airport, killing both pilots and injuring 7 passengers. That investigation report, A11P0149, discussed stabilized approaches and identified the following finding as to risk:

> The company's standard operating procedures lacked clear directions for how the aircraft was to be configured for the last 500 feet, or what to do if an approach is still unstable when 500 feet is reached, specifically in an abnormal situation. There is a demonstrated risk of accidents occurring as a result of unstabilized approaches below 500 feet above ground level. [6]

After that accident, the company made changes to its standard operating procedures (SOPs) regarding the approach and landing phases.

In February 2012, NT Air was involved in a similar incident to the current one, also in Blue River, where a B1900C landed slightly off the centreline in similar conditions and almost veered into a snow bank. According to the company SMS investigation, the dull lighting and lack of runway edge definition were determined to be the cause of the incident. In the company SMS report, corrective action was identified, and a company recommendation was made to have markings placed on the runway edges to assist pilots in staying on the centreline. This was discussed with the lodge operator who, not being responsible for the runway, did not take any action. The aircraft operator had not yet established who would be able to mark the runway. Notwithstanding this unsafe condition, operations continued at Blue River. As a result, at the time of this accident, no action had been taken to mark the runway edges.

The intention was to resolve the issue, but no deadlines were established or observed. In the interim, no formal risk assessment was made concerning the continued operation in similar conditions. Thus, there was no change in operational procedures or information provided to crew members about the hazard.

Stabilized Approaches

In recent years, several safety-oriented organizations and airlines have focused on landing accidents. The Flight Safety Foundation [7] (FSF) has been a leader in identifying the issue and promoting mitigation strategies and policies. About 50% of fatal accidents in modern air travel are approach and landing accidents. It has also been determined through research that of these

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6 TSB aviation investigation report A11P0149

7 The Flight Safety Foundation was formed in 1947 to pursue the continuous improvement of global aviation safety. The Foundation meets this objective through research, auditing, education, advocacy and publishing. As an independent, impartial and non-profit international membership organization, the Foundation is in a unique position to identify global safety issues, set priorities and serve as a catalyst to address the issues. (Flight Safety Foundation, http://flightsafety.org)

accidents, 50% were the result of an unstable approach. The issue of approach and landing accidents has received attention from aviation groups and the TSB. [8] A reduction in unstable approaches could dramatically reduce landing accidents. There are telltale signs that an approach is not ideal and, if continued, may lead to an incident or accident. The adoption of unstable approach SOPS helps air crews identify these signs and make timely corrections or conduct a missed approach.

In the majority of unstable approaches that resulted in either an accident or an incident, the captain was the PF. This may be the result of 2 situations: the captain may often fly in poor weather and during difficult approaches, or the captain would likely not allow the FO to deviate as much as the FO may allow the captain to deviate.

The key to reducing unstabilized approaches is to put in place strong SOPs that force the crew to recognize and act on the situation. A set of conditions must be met at designated phases of the approach, such as locations or altitudes. If the conditions are not met, the PF must immediately correct the situation, or the pilot not flying (PNF) must declare an unstable approach and order a missed approach. These criteria may be different for each operator or aircraft type, but it is important to have them and to adhere to them.

One major Canadian airline made these comments to its pilots after conducting a study on unstable approaches within the company.

Following this go-around survey, it was also noted that FOs reported being reluctant to speak up when the captain, as PF, continued an approach in an unstable condition. Captains who had landed after an unstabilized approach indicated that had the FO said something, they would have gone around. It was also noted that in some instances, the FO did say something, but the captain did not understand the significance of the comment. It was evident that an SOP with a standardized call was needed to establish effective crew communications in order to mitigate the unstable approach threat.

The CARs require an air operator to have SOPs for multi-crew operations. The regulations regarding SOPs indicate that certain elements must be present, such as emergency procedures. The SOPs must conform to the aircraft flight manual (AFM); however, the operator has a wide range of discretion on actual content, usage, terminology, and scope. Although the SOP is not an approved document, TC does review the document for content to ensure it meets the AFM and contains the required elements listed in the CARs. There is no requirement in the CARs pertaining to stabilized approaches.

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[8] Sources: 1) International Civil Aviation Organization, Industry Safety Strategy Group, *Implementing the Global Aviation Safety Roadmap* (Montreal: ISSG, 2006). 2) Boeing, *Statistical Summary of Commercial Jet Airplane Accidents, Worldwide Operations, 1959-2005* (Seattle, WA: Boeing Commercial Airplanes, 2006). 3) Boeing, *Statistical Summary of Commercial Jet Airplane Accidents, Worldwide Operations, 1959-2007* (Seattle, WA: Boeing Commercial Airplanes, 2008). 4) International Federation of Air Line Pilots' Associations, *Runway End Safety Areas (RESAs) (08POS01) (Position statement)* (Chertsey, Surrey: IFALPA, 2008). 5) Australian Transport Safety Board, *Aviation Research and Analysis Report AR-2008-018(1) Final* (Canberra, Australia, 2009). 6) Flight Safety Foundation, *Approach-and-Landing Accident Reduction Tool Kit* (Alexandria, VA., USA, 2009).

Northern Thunderbird Air Unstabilized Approach Standard Operating Procedures

The company SOPs contain a recently-amended section (2.13 Approach – General) that describes the actions the crew is required to take during any approach. This section pertains to both instrument and visual approaches, and states that, "For VFR and visual approaches, turns onto final should not be done below 500 feet agl." [9] The section goes on to explain the roles of both the PF and the PNF relating to calling out the relevant airspeeds and monitoring the actions of the PF as the aircraft approaches the runway.

The last paragraph of section 2.13 describes the importance of the PNF's duties in vigilantly monitoring the PF's actions. The PNF is to call any deviations with respect to excessive sink rate, excessive bank, deviations from slope, and deviations from runway centreline. Also, the PNF must confirm that landing checks are complete and assist the PF in ensuring the runway is clear and the required landing clearance or "final" call is made. The SOP states, "The PNF shall vigilantly monitor the PF and heighten readiness to intervene in the case of PF incapacitation or risky deviations." [10]

There are SOP calls the PNF shall make to alert the PF of deviation, but there is no definition of criteria or instructions relating to the importance of identifying the approach as unstable and calling for a go-around.

One of the criteria of a stabilized approach is alignment with the runway centreline. Although the crew thought it had identified the runway, the PF crossed through the centreline twice on short final and executed turns very near or over the runway in an attempt to align the aircraft with a centreline the crew could not identify. The PNF did not call for a missed approach in accordance with the revised SOP regarding stabilized approaches under visual conditions.

The FSF guideline material emphasises the importance of conducting a go-around if the approach is not stabilized below the final stabilization height (usually 500 feet agl in VMC). A list of all criteria used by the FSF to establish whether an approach is stable or unstable is identified in Appendix A.

Cockpit Voice Recorder and Flight Data Recorder

The aircraft was not equipped with a flight data recorder (FDR), nor was it required to by regulation. Although additional data from an FDR would have assisted in the investigation, there was sufficient information available from other sources to determine the circumstances of the accident. The aircraft was fitted with a cockpit voice recorder (CVR) that recorded the last 32 minutes of the flight.

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9 Northern Thunderbird Air Inc., Standard operating procedures, section 2.13.

10 Ibid.

TSB Laboratory Reports

The following TSB Laboratory reports were completed:

- LP058/2012 - CVR Download
- LP053/2012 - GPS Analysis

These reports are available from the TSB upon request.

Analysis

The facts establish several contributing factors, including poor weather, an unstable approach and an unmarked, contaminated runway. The analysis will examine the standard operating procedures (SOPs) that can be used to reduce the number of approach and landing accidents, and examine how the company's safety management system (SMS) may have prevented this accident.

Pilot Decision Making and Visual Flight Rules / Instrument Flight Rules

The accident flight was likely operating with a visibility of 5 miles or more for the majority of the visual flight rules (VFR) portion of the flight, until the aircraft reached the vicinity of the aerodrome. At the time of the accident, the weather was deteriorating rapidly and had gone from marginal VFR to instrument flight rules (IFR) conditions, with ceilings reduced to 1200 feet and visibility 1 ½ miles in snow showers, which was beyond the company operations manual (COM) limits for both ceiling and visibility.

As the aircraft neared its destination, the valley narrowed, and the deteriorating weather limited the aircraft's altitude. Without significant changes to the aircraft's speed, the distance required to safely turn the aircraft around in this situation was greater than the space available, making the option to turn around less and less feasible as the aircraft neared the aerodrome.

As the flight neared its destination, the option of climbing straight out of the valley also became increasingly difficult as the aircraft had descended, and the weather in the valley had deteriorated. For any flight operating under VFR in areas of high terrain, climbing into a cloud layer without an IFR climb procedure that would have been assessed for obstacle clearance can be dangerous as the crew may not be able to determine adequate terrain clearance during the climb. This procedure would also need to be assessed for the possibility of an engine problem with a substantially reduced climb rate.

Had the limitation of the weather been assessed earlier in the flight, the crew may have aborted the approach and proceeded under IFR to Kamloops (British Columbia). The weather in the immediate area around the aerodrome was the worst that the crew had experienced on the flight. By the time the flight entered the area of snow and reduced visibility, the options for aborting the approach would have been difficult to conduct and possibly dangerous. The crew's decision to continue the flight into weather that was beyond the company's standard limitations increased the risk of an accident due to weather-related hazards. The company visibility and ceiling limitations were put in place for this reason.

The difficulty in identifying the runway due to poor visibility and the lack of runway markings or approach aids made it more difficult for the crew to establish the aircraft onto a stable final approach. The resulting unstable approach required additional turns on short final, which reduced the pilot's ability to assess the aircraft's position and establish the aircraft onto the runway centreline.

Standard Operating Procedures and Stabilized Approaches

The pilot entered the valley with the intention to land straight-in on Runway 19. The weather and runway conditions at the time made the identification of the runway difficult. As a result of

this late identification of the runway, the aircraft landing configuration was delayed, and the landing checks were rushed.

When the aircraft descended below 500 feet above ground level (agl), where it should be established on final according to Northern Thunderbird Air (NT Air) SOPs, the aircraft was still manoeuvring, was not fully configured, and was not established on the correct flight path. The unstabilized approach was not identified by either crew member, and the opportunity to conduct a missed approach was lost once the aircraft had settled to the runway.

If company SOPs do not include criteria and procedures for stabilized approaches, or they are not followed, there is an increased risk of landing accidents.

Runway Conditions

Operating on contaminated runways in winter conditions presents challenges to all pilots and aircraft. Without accurate and timely runway reports that are easily available, a pilot may be unprepared or unable to make a safe determination of the conditions prior to landing.

A snow-covered runway, without markings or devices to allow a pilot to easily identify the runway surface, increases the risk of runway excursions. The trace amount of fresh snow would likely not have affected the aircraft's traction, but would have contributed to hiding the features of the surface from the crew. The combination of low overcast and flat lighting conditions in a snow-covered runway environment, as well as the lack of runway edge markings, made it difficult, if not impossible, to identify the runway edges. As a result, the pilot was unable to position the aircraft over the centre of the runway as it settled to land. The left main landing gear entered the deeper snow at the runway edge, causing the aircraft to veer into the snow bank.

Safety Management System

Although NT Air had identified the hazard at Blue River, it did not produce effective mitigation strategies. The recommendation to mark the runway, which came about after an incident 5 weeks earlier, had not been implemented. The delayed action to mark the runway allowed the hazard to persist. If a company's risk mitigation strategy is not implemented in a timely manner, hazards are allowed to persist, increasing the risk of an accident.

As a result of its SMS investigation, NT Air management expected that the runway was being properly serviced. This did not occur, resulting in the hazard continuing to exist, and this information was not communicated to pilots or flight followers. If the identified risks and mitigation strategies are not communicated to the people exposed to the risks, it is possible they will deem the risk as acceptable to management and continue operations.

Findings

Findings as to Causes and Contributing Factors

1. Although the hazardous runway condition had been identified by the company's safety management system, the delay in action to mark the runway allowed this condition to persist.

2. Up-to-date weather and runway condition information was not provided to the crew, nor was it requested by the crew.

3. The pilot continued the approach below the visibility limits specified in the company's standard operating procedures.

4. Deteriorating weather, as well as the lack of approach aids and runway markings, hampered the pilot's ability to establish the aircraft onto a stable final approach prior to crossing the threshold.

5. The company's standard operating procedures for stabilized approaches were not followed, and an unstabilized approach was allowed to continue.

6. The pilot was unable to position the aircraft over the centre of the runway as it settled to land, and the left main landing gear entered the deeper snow at the runway edge, causing the aircraft to veer into the snow bank.

Findings as to Risk

1. If a company's risk mitigation strategy is not implemented in a timely manner, hazards are allowed to persist, increasing the risk of an accident.

2. If company standard operating procedures do not include criteria and procedures for stabilized approaches, or they are not followed, there is an increased risk of landing accidents.

3. Operating on a snow-covered runway that does not have markings or devices to allow a pilot to easily identify the runway surface increases the risk of runway excursions.

4. If the identified risks and mitigation strategies are not communicated to the people exposed to the risks, it is possible they will deem the risk as acceptable to management and continue operations.

Safety Action

Safety Action Taken

Transport Canada

Transport Canada indicated that further prescriptive regulations may not be the appropriate way forward, but rather that the issue of rejected approaches may be better addressed through guidance material on pilot decision making and crew resource management.

This issue will be addressed in the development of the contemporary crew resource management (CRM) and pilot decision making (PDM) training standards for 702, 703, 704, and 705 operations. These standards will include the threat and error management (TEM) model.

The regulatory development of CRM and PDM is part of the 2013/2014priorities.

This report concludes the Transportation Safety Board's investigation into this occurrence. The Board authorized the release of this report on 18 December 2013. It was officially released on 07 Februrary 2014.

Visit the Transportation Safety Board's website (www.bst-tsb.gc.ca) for information about the Transportation Safety Board and its products and services. You will also find the Watchlist, which identifies the transportation safety issues that pose the greatest risk to Canadians. 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 – Flight Safety Foundation Criteria on Determining an Unstable Approach [11]

Recommended Elements of a Stabilized Approach

All flights must be stabilized by 1,000 feet above the airport elevation in instrument meteorological conditions (IMC) and by 500 feet above airport elevation in visual meteorological conditions (VMC).

An approach is stabilized when all of the following criteria are met:

1. The aircraft is on the correct flight path;
2. Only small changes in heading/pitch are required to maintain the correct flight path;
3. The aircraft speed is not more than V_{REF} + 20 knots indicated airspeed and not less than V_{REF}.
4. The aircraft is in the correct landing configuration;
5. Sink rate is no greater than 1000 feet per minute; if an approach requires a sink rate greater than 1,000 feet per minute, a special briefing should be conducted;
6. Power setting is appropriate for the aircraft configuration and is not below the minimum power for approach as defined by the aircraft operating manual;
7. All briefings and checklists have been conducted;
8. Specific types of approaches are stabilized if they also fulfill the following: instrument landing system (ILS) approaches must be flown within one dot the glideslope and localizer; a Category II or Category III ILS approach must be flown within the expanded localizer band; during a circling approach, wings should be level on final when the aircraft reaches 300 feet above airport elevation; and,
9. Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.

   An approach that becomes unstabilized below 1,000 feet above airport elevation in IMC or 500 feet above airport elevation in VMC requires an immediate go-around.

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11 Flight Safety Foundation, *Approach-and-Landing Accident Reduction Tool Kit*, FSF ALAR Briefing Note 7.1, "Stabilized Approach".