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

AIR TRANSPORTATION SAFETY INVESTIGATION REPORT A23O0046

RUNWAY OVERRUN

Porter Airlines Inc.
De Havilland Aircraft of Canada Ltd. DHC-8-402, C-GLQB
Sault Ste. Marie Airport (CYAM), Ontario
16 April 2023

Canada

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Summary

At approximately 2122 Eastern Daylight Time on 16 April 2023, the Porter Airlines Inc. De Havilland Aircraft of Canada Limited DHC-8-402 aircraft (registration C-GLQB, serial number 4130) departed from Toronto/Billy Bishop Toronto City Airport (CYTZ), Ontario, on an instrument flight rules flight to Sault Ste. Marie Airport (CYAM), Ontario, with 2 flight crew members, 2 cabin crew members, and 52 passengers on board. Upon arrival, the flight crew performed an approach for Runway 12; however, after touchdown, the aircraft overran the end of the runway. The aircraft came to a stop in muddy grass about 350 feet beyond the end of the runway. No one was injured and the aircraft was not damaged.

1.0 FACTUAL INFORMATION

1.1 History of the flight

At approximately 2122[1] on 16 April 2023, the Porter Airlines Inc. (Porter Airlines) De Havilland Aircraft of Canada Limited (De Havilland) DHC-8-402 aircraft departed from Toronto/Billy Bishop Toronto City Airport (CYTZ), Ontario, on instrument flight rules flight POE2691 to Sault Ste. Marie Airport (CYAM), Ontario, with 2 flight crew members, 2 cabin crew members, and 52 passengers on board. The flight was the 2nd of 2 scheduled flights for the flight crew's duty period, which had begun at Boston/General Edward Lawrence Logan International Airport (KBOS), Massachusetts, United States, at 1605. Their 1st flight, from KBOS to CYTZ, had departed at 1801.

The flight to CYAM was a line indoctrination training flight for the first officer (FO). The captain, who was a training captain with the airline, was the pilot monitoring (PM) and in the left seat; the FO, who was the pilot flying (PF), was in the right seat.

The entire flight took place during the hours of darkness and was uneventful until the landing. While in cruise, the flight crew planned for the area navigation global navigation satellite system approach to Runway 12 at CYAM. In preparation for the landing, the flight crew received the latest weather, including wind and barometric information, for landing on Runway 12 at CYAM.

The flight crew also conducted an approach briefing during which they discussed their landing reference speed (V_{ref}), target approach speed, and acceptable target speed range. They also discussed their planned touchdown point being 1000–2000 feet from the runway threshold. The V_{ref} speed for the approach was 119 knots indicated airspeed (KIAS). However, the flight crew chose 130 knots as their target speed, with a bracket between 119 knots and 139 knots. In accordance with the aircraft flight manual (AFM),[2] they planned for a required landing field length of 4000[3] feet based on the 15° flap setting and a wet runway surface.

During the approach, the aircraft met the company's stable approach criteria. The aircraft crossed the threshold of Runway 12 at an altitude of 48 feet above ground level (AGL) with an airspeed of 132 KIAS, a ground speed of 136 knots, and approximately 13% engine torque.

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[1] All times are Eastern Daylight Time (Coordinated Universal Time minus 4 hours), unless otherwise stated.

[2] De Havilland Aircraft of Canada Limited, *DHC-8 Series 400 Model 402 Airplane Flight Manual*, PSM 1-84-1A, Revision 412 (14 April 2023), Subsection 5.11: Landing Distances, figures 5-11-2 and 5-11-5, pp. 5-11-4 and 5-11-10.

[3] The required landing field length is calculated by multiplying the unfactored landing distance by an operational factor. It represents the distance required for the aircraft to come to a complete stop from the point at which it is at 50 feet above ground level and travelling at V_{ref} or V_{ref} +10 knots. (Source: Ibid., Paragraph 5.11.1: Landing Field Length Required).

While the aircraft was pitched nose up to 4.3°, it was approximately 3 feet from the ground with a speed of 129 KIAS and the engine torque reduced to approximately 6% (flight idle). The PM was monitoring the pitch angle while the PF was focused on the surface of the runway.

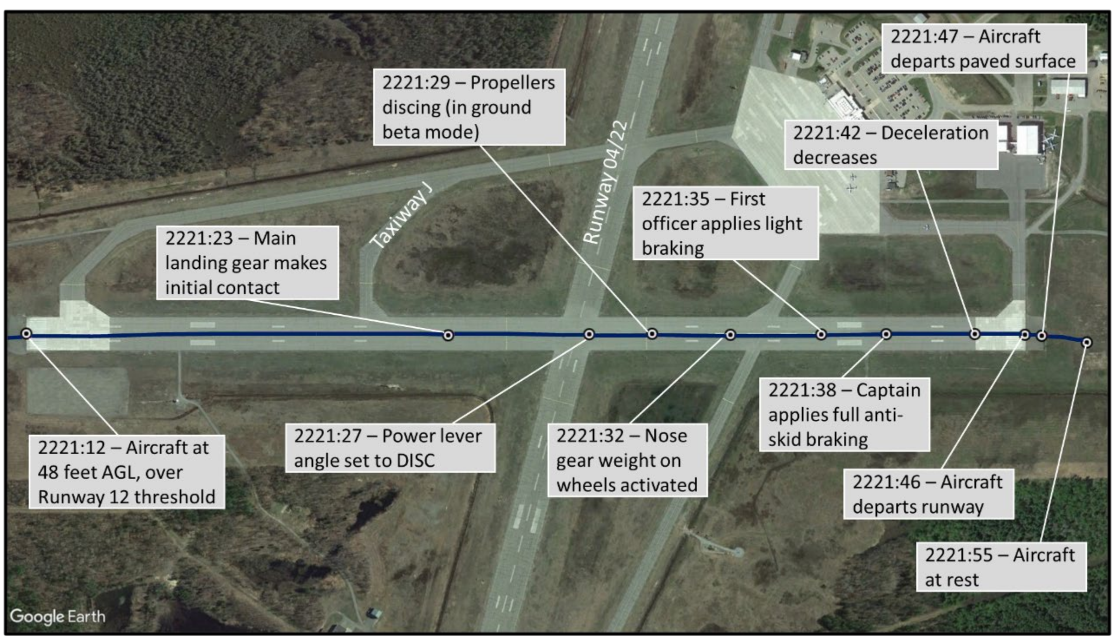
At 2221:23, shortly after the PM called the 5° pitch angle per the standard operating procedures (SOPs), the aircraft's main landing gear (MLG) wheels made light contact with the runway about 2500 feet beyond the threshold, while the aircraft's ground speed was 129 knots. About 2 seconds later, the aircraft's weight compressed the MLG so that the wheels made solid contact with the runway surface, activating the weight-on-wheels signal at about 2850 feet down the runway.

As designed, the spoilers deployed automatically; at this time, the aircraft's ground speed was 127 knots. Two seconds after the weight-on-wheels signal, the power levers were moved from the FLIGHT IDLE setting to the DISC setting. At this time, the aircraft was passing the intersection of Runway 12 with Runway 04/22.

Shortly afterwards, the nose landing gear wheels contacted the runway (9 seconds after the MLG had made initial contact). While the nose wheels were touching down, the captain instructed the FO to correct a minor lateral deviation. At this point, about 2000 feet of runway remained, and the aircraft's ground speed was 105 knots. The weight-on-wheels signal for the nose gear activated shortly after.

The PF then applied the brakes lightly and, moments later, the PM took over and applied full braking. When the brakes were fully applied, the aircraft was travelling at a ground speed of 78 knots, and the remaining distance to the end of the runway was 850 feet (Figure 1).

Figure 1. Landing sequence of the occurrence aircraft on Runway 12, based on data from the cockpit voice recorder and flight data recorder (Source: Google Earth, with TSB annotations)



The brakes did not perform as well as the flight crew had expected they would, and the wet runway felt slippery to the crew during braking. For the following 4 seconds of full anti-skid braking, the average deceleration was about 0.29*g*. Once the aircraft reached the concrete portion of pavement at the end of the runway, its deceleration decreased; for these last 300 feet of the runway, the average deceleration was 0.16*g*.

The aircraft departed the end of the runway at a ground speed of approximately 41 knots. It then passed the end of the paved surface at a speed of 35 knots. The captain steered to the right to avoid the approach lighting system, and the aircraft eventually came to a stop in the muddy grass approximately 350 feet beyond the end of the runway, or 250 feet beyond the end of the additional paved surface (Figure 2). There were no injuries. The aircraft was not damaged.

Figure 2. Occurrence aircraft after the runway overrun, photo taken from the end of the paved surface of Runway 12 (Source: Porter Airlines Inc.)

1.2 Injuries to persons

There were no injuries.

1.3 Damage to aircraft

The aircraft was not damaged. However, an extensive amount of dirt was found around the landing gear system.

1.4 Other damage

There was no other damage.

1.5 Personnel information

Table 1. Personnel information

	Captain	First officer
Pilot licence	Airline transport pilot licence - aeroplane	Commercial pilot licence - aeroplane
Medical expiry date	30 April 2023	30 April 2023
Total flying hours	5700	1648
Flight hours on type	3200	88.5
Flight hours in the 24 hours before the occurrence	2.5	2.5
Flight hours in the 7 days before the occurrence	15	11.5
Flight hours in the 30 days before the occurrence	57	55
Flight hours in the 90 days before the occurrence	107	86
Flight hours on type in the 90 days before the occurrence	107	86
Hours on duty before the occurrence	6.3	6.3
Hours off duty before the work period	20.60	20.60

The FO was in the process of completing his FO line indoctrination training and was preparing for a line check. The captain was a qualified line indoctrination training captain for Porter Airlines. Both flight crew members held the appropriate licences and ratings for the flight in accordance with existing regulations. Based on a review of the captain's and FO's work and rest schedules, there was no indication that their performance had been degraded by fatigue.

1.6 Aircraft information

1.6.1 General

Table 2. Aircraft information

Manufacturer	Bombardier Inc.*
Type, model, and registration	DHC-8-402, C-GLQB
Year of manufacture	2006
Serial number	4130
Certificate of airworthiness issue date	15 August 2006
Total airframe time	34 406 hours
Engine type (number of engines)	Pratt & Whitney Canada PW150A (2)
Propeller type (number of propellers)	Dowty Aerospace R408/6-123-F/17 (2)
Maximum allowable take-off weight	63 930 lb (28 998.7 kg)
Recommended fuel type(s)	Jet A/A1, JP-5, JP-8, JP-8+100, RT, TS-1, Jet B, JP-4.
Fuel type used	Jet A/A1

* The current type certificate holder is De Havilland Aircraft of Canada Ltd.

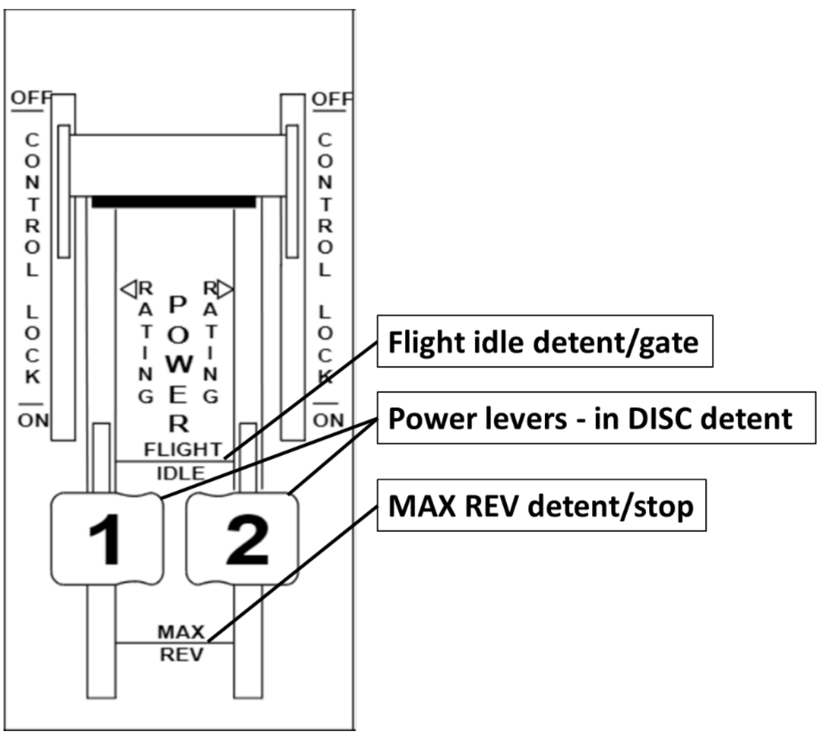
There were no recorded defects outstanding at the time of the occurrence. The aircraft's weight and centre of gravity were within the prescribed limits. The landing gear tire pressure and conditions were checked after the occurrence and found to be within the limits prescribed by the *DHC-8 Series 400 Aircraft Maintenance Manual*.

1.6.2 Aircraft propeller reverse thrust control and beta mode

The propellers have a reverse thrust function, which assists in reducing the aircraft's speed during a landing. Reverse thrust is a part of beta mode, which is used for ground operations and is controlled by the power levers in the cockpit.[4]

During flight, unintentional movement of the power levers below the FLIGHT IDLE setting is prevented by a detent combined with a gate on the power lever quadrant (Figure 3). The pilot must operate the release lever to permit entry of the power lever into the ground regime. There is also a detent at the DISC position, and at the MAX REV (maximum reverse) position where the travel is limited by a stop. The detent is felt by the pilot when reached or passed through. However, it does not require additional action.

Figure 3. DHC-8 Series 400 aircraft's power levers and console (Source: De Havilland Aircraft of Canada Limited, *DHC-8 Series 400 Aeroplane Operating Manual*, Revision 27 [07 March 2021], Figure 6.13-8, p. 6.13-14, with TSB annotations)



In reverse thrust, the blade pitch angle of the propellers has a negative value, up to a blade angle of negative 17°, which is the MAX REV position. At this angle, the propeller blades

4 De Havilland Aircraft of Canada Limited, *DHC-8 Series 400 Aircraft Maintenance Manual*, Revision 76 (05 March 2022), System Description Section 61-00-00-001: Propellers, General, pp. 2-6.

direct the generated airflow forward. In the DISC position, the blade pitch angle is flat, approximately 0°.

The flight crew did not use reverse thrust during the landing and overrun; however, they placed the power levers into the DISC position about 4 seconds after the initial MLG touchdown. According to the manufacturer, an approximate 3 second delay exists between the moment the power levers are placed in the DISC or MAX REV positions and the time the propellers begin to provide deceleration. Flight crews commonly use DISC given the reportedly high efficiency of propeller discing during landings.

1.6.2.1 Use of reverse thrust during normal and abnormal landings

The normal landing procedure in the AFM instructs flight crews to set the power levers to FLIGHT IDLE before touchdown then to DISC after touchdown.[5] There is no mention of reverse thrust usage in the normal landing procedure section.

For abnormal landings (flap setting abnormalities and/or nosewheel steering failure), the AFM provides a note stating: "Reverse thrust may be used, commensurate with directional control, to reduce the calculated abnormal landing distance."[6] In a note, it is stated that the use of maximum reverse thrust for stopping may cause directional deviation.[7] Supplement 7 of the AFM: Operation with an Inoperative Anti-Skid Brake Control System also provides a note in the emergency procedures section stating that "[r]everse thrust may be used, commensurate with directional control."[8]

1.6.3 Aircraft braking and anti-skid system

1.6.3.1 Aircraft braking system

The aircraft braking system includes the MLG brakes that are controlled by the pilot's and co-pilot's[9] brake pedals. The pedals are connected to the brake control valve.

When a pedal is pushed, it operates the applicable lever on the brake control valve resulting in hydraulic pressure supplied to the anti-skid valve. As the aircraft maintenance manual explains,

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5 De Havilland Aircraft of Canada Limited, *DHC-8 Series 400 Model 402 Airplane Flight Manual*, PSM 1-84-1A, Revision 412 (14 April 2023), Subsection 4.4.1: Normal Landing, p. 4-4-1.

6 Ibid., Subsection 5.11.2: Unfactored Landing Distance in Abnormal Configurations, p. 5-11-7.

7 Ibid., Subsection 3.11.1: No Hydraulic Pressure Available from No. 1 and No. 2 Hydraulic Systems, pp. 3-11-1 and 3-11-2.

8 De Havilland Aircraft of Canada Limited, *DHC-8 Series 400 Model 402 Airplane Flight Manual*, Supplement 7: Operation with Inoperative Anti-skid Brake Control System, Issue 1 (19 December 2000), Section 6.7.3: Emergency Procedures, p. 6-7-2.

9 The aircraft maintenance manual system description section 32-42-00 uses the terms *pilot* and *co-pilot* to refer to, respectively, the pilot occupying the left seat (the captain and PM in this occurrence) and the pilot occupying the right seat (the FO and PF in this occurrence).

> [t]he brake control valve will supply hydraulic pressure in proportion to the amount of brake pedal travel. Hydraulic pressure is supplied from the skid control valve through the fuse/shuttle valves to the applicable MLG brake units.[10]

1.6.3.2 Aircraft anti-skid system

The DHC-8-402 (Dash 8 Q400) is equipped with an anti-skid system, which provides maximum braking while minimizing tire wear and optimizing stopping distance. The anti-skid control valves receive hydraulic pressure from the brake control valve, which is modulated by the application of the brake pedals. The anti-skid control valves control hydraulic pressure to the fuse/shuttle valves and the brake units. When a skid condition is detected by the system, it sends a signal to the applicable anti-skid control valve, which then releases the brake pressure through the anti-skid hydraulic return line.

The outboard and inboard MLG wheels are paired for locked wheel protection, which allows affected wheels to recover from skids. A locked wheel condition is when the speed of 1 wheel is below 30% of the reference velocity, which is the fastest of the paired wheels. It is when this condition occurs that a signal is sent from the anti-skid control unit to the skid control valve to release brake pressure to the locked wheel until it recovers from the skid. According to the aircraft maintenance manual, a wheel recovers from a locked wheel condition when its speed is higher than 35% of the reference velocity.[11]

During the occurrence, the anti-skid system, including the locked wheel protection, was activated approximately 2 seconds after the captain took over the control of the aircraft and fully applied the brakes. The system stayed active for approximately 14 seconds until the aircraft came to a stop past the end of the runway.

1.6.3.3 Effect of air in the hydraulic system

During the occurrence landing sequence, the FO initially applied light brake pressure for about 2 seconds until the captain took over and fully pushed the brake pedals. Data from the flight data recorder (FDR) indicated that the maximum braking pressure of 3000 psi was reached shortly after the captain applied full pressure to the right pedal. During the left brake pedal full application, the pressure initially reached a maximum of 2100 psi then varied between 2100 and 1000 psi until the aircraft departed the runway. The variation in brake pressure likely shows differential brake pedal application to maintain directional control. However, the difference in response between left and right brakes was not felt by the captain while pressing the brake pedals. Directional control was maintained using the nose-wheel steering.

The normal braking system on the DHC-8-400 aircraft is supplied with hydraulic pressure by the No. 1 aircraft hydraulic system. During post-occurrence maintenance activities, a

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10 De Havilland Aircraft of Canada Limited, *DHC-8 Series 400 Aircraft Maintenance Manual*, PSM 1-84-2, Revision 76 (05 March 2022), System Description Section 32-42-00-001: Main Landing Gear Brake System, Detailed Description, p. 2.

11 Ibid., System Description Section 32-46-00-001: Anti-Skid System, Detailed Description, p. 3.

high-power engine run was performed. It was noticed that, while 90% power was applied, the aircraft was rolling slowly, and the brakes could not hold the aircraft in position. After troubleshooting was conducted, the fluctuation was determined to be caused by air in the brake system. The investigation determined that the No. 1 hydraulic system had stayed sealed and therefore could not have had air introduced into the system after the occurrence. The air was bled, and full braking capability was restored. There were no fault indications, nor were there any maintenance records related to the braking or anti-skid system.

SAE International[12] Aerospace Information Report AIR5829 states that

> [t]he stiffness of a cylinder with a free or entrained air/oil mixture is degraded compared to a homogenous column of fluid. […] Reduced stiffness affects the dynamic performance of the actuator and the flight control surfaces it may be powering.[13]

The occurrence aircraft's braking performance during the landing was perceived to be less effective than what the flight crew had expected it to be.

1.6.3.4 Braking performance

The TSB laboratory conducted a braking performance analysis using the ESDU's[14] methods.[15] The analysis takes into consideration a fully serviceable aircraft, normal landing procedures, runway macrotexture, and the environmental factors present during the occurrence. The analysis results were used to compare the theoretical landing performance to the actual landing performance (Figure 4). The theoretical landing distance on Runway 12 was calculated to be about 3700 feet from the threshold.

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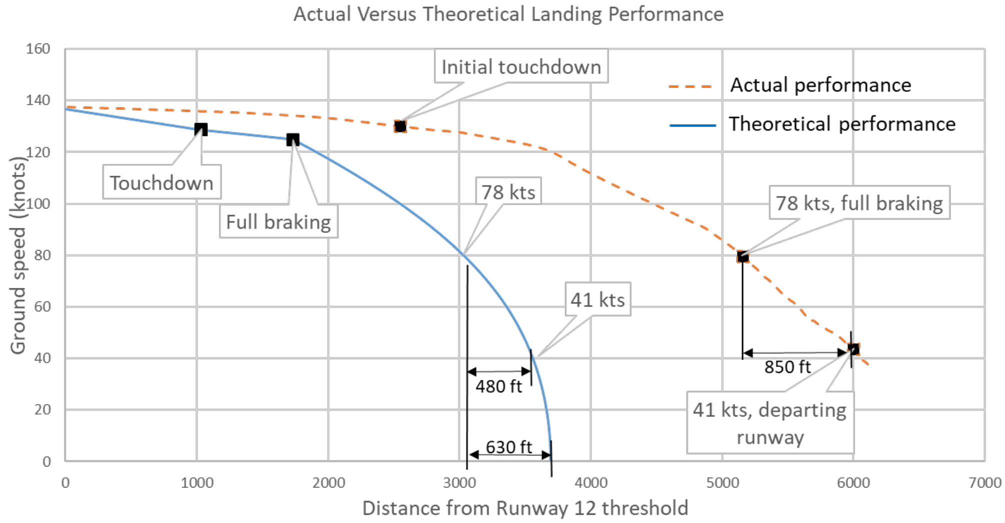
12 Formerly known as the Society of Automotive Engineers.

13 SAE International, *Aerospace Information Report AIR5829: Air in Aircraft Hydraulic Systems* (issued February 2008, reaffirmed January 2018), Section 4.1: Reduced stiffness of actuators, p. 6 of 14.

14 Formerly known as the Engineering Sciences Data Unit.

15 ESDU methods facilitate "better and faster design using validated methods and solutions and reduce costly cycles of research, redesign and testing. ESDU methods and data form an important part of the design process for industry professionals in companies large and small and are a vital resource for scientists and engineers in research establishments and academic institutions throughout the world." (Source: esdu.com)

Figure 4. Graph showing the actual versus the theoretical landing performance (Source: TSB, based on data from the aircraft manufacturer)



The actual landing performance data indicate the occurrence aircraft touched down 2500 feet from the runway threshold, and there was a delay in using the DISC setting and applying the brakes. The data indicate that the aircraft used about 850 feet of runway when decelerating from 78 to 41 knots. In comparison, the theoretical performance indicates that the aircraft should have used only 480 feet of runway and that 630 feet of runway should have been sufficient for the aircraft to fully stop from 78 knots. When the occurrence aircraft's speed was 78 knots, there was 850 feet of runway remaining. Therefore, despite the delays in lowering the nose and applying full braking, there should have been sufficient runway available for a DHC-8-402 with a fully serviceable braking system to stop.

The actual braking performance below ground speeds of 78 knots was also analyzed to assess anti-skid braking. It was determined that there was a significant disparity between the expected and actual braking performance. As ground speed decreases, the braking performance (i.e., rate of deceleration) should normally increase; however, in this case, decreased braking performance was observed. In addition, there was an abrupt decrease in the braking performance through 55 knots, which corresponds to the moment the aircraft was transitioning from the asphalt onto the concrete pavement.

The actual performance also shows a minimal increase in deceleration following a full brake application, inconsistent with predicted theoretical performance.

1.7 Meteorological information

1.7.1 General

The aerodrome routine meteorological report for CYAM issued at 2200 indicated the following:

- Winds 180° true at 4 knots

- Visibility 5 statute miles in light rain showers and mist
- Few clouds at 700 feet AGL, scattered clouds at 1400 feet AGL, and broken ceiling at 4400 feet AGL, and additional broken cloud layers at 5800 feet AGL and 8600 feet AGL
- Temperature 10 °C, dew point 10 °C
- Altimeter setting 29.40 inches of mercury

When the flight crew conducted an approach briefing, the latest weather update indicated winds from 220° magnetic at 4 knots with an altimeter setting of 29.39 inches of mercury. FDR data indicated that the average tailwind component for the duration of the landing was 2 knots. During the final approach, the flight also encountered rain at approximately 500 feet AGL. The investigation estimated, based on a local weather report, that there was approximately 1 mm of water on the runway surface during the occurrence landing.

1.8 Aids to navigation

Not applicable.

1.9 Communications

There were no known communication difficulties.

1.10 Aerodrome information

1.10.1 General

CYAM is located approximately 7 nautical miles west-southwest of Sault Ste. Marie, Ontario, at an elevation of 632 feet above sea level. There are 2 asphalt runways: Runway 04/22, which is 6000 feet long and 148 feet wide, and Runway 12/30, which is 6000 feet long and 200 feet wide. Runway 12 has a negligible longitudinal slope of 0.01%. There is a paved area extending 100 feet beyond the threshold, and a clearway that is 300 m long and 150 m wide, however there is no runway end safety area.[16]

CYAM has an air traffic control tower operated by NAV CANADA between the hours of 0630 and 2230.

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16 A clearway is a "defined rectangular area on the ground or water under the control of the appropriate authority, selected or prepared as a suitable area over which an aeroplane may make a portion of its initial climb to a specified height." A runway end safety area is defined as "[a]n area symmetrical about the extended runway centre line and adjacent to the end of the strip primarily intended to reduce the risk of damage to an aeroplane undershooting or overrunning the runway." (Source: Transport Canada, TP 312, *Aerodrome Standards and Recommended Practices*, 4th Edition [effective March 1993, updated March 2005], 1.1 Definitions, pp. 1-2 and 1-5.)

1.10.2 Runway surface condition monitoring

Airport personnel at CYAM monitored the runway surface condition of Runway 12 in accordance with the procedures outlined in the airport operations manual,[17] which had been approved by Transport Canada (TC). The airport conducts runway pavement surface roughness evaluations as required and coefficient of friction evaluations every 3 years, or more frequently if required.[18]

In accordance with TC's guidelines,[19] Runway 12 at CYAM had periodic surface friction tests conducted with the use of continuous friction measuring equipment to evaluate the surface's frictional characteristics. These tests were last completed in June 2020 and indicated that the runway friction values were well above the recommended maintenance planning level described in TC's *Aerodrome Standards and Recommended Practices* (TP 312).

During the period of winter operations (12 November to 31 March), the airport conducts and issues Canadian Runway Friction Index readings; however, formal surface condition reports are not prepared in the summer months because they are generally not required. During summer operations, a daily visual inspection is carried out from Monday to Friday to identify issues on the manoeuvring area. The inspection notes observations related to ponding, sunken areas, edge erosion, turf growth, slipperiness, contamination (from rubber, oil, or other materials), visual aids, normal and secondary power supplies, and slab settlement.

1.10.3 Runway surface condition

Before the departure of the occurrence flight, the information available to the flight crew indicated a dry surface on Runway 12 at CYAM. However, the latest weather information available shortly before the landing indicated light rain, and the crew therefore planned for

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17 Sault Ste. Marie Airport Development Corporation, Certificate Number 5151-1-147, *Airport Operations Manual: Sault Ste. Marie Airport*, Amendment 42 (07 June 2022, approved 06 March 2023).

18 Ibid., Section 3.1.1: Airside Maintenance Service, Part 3-3.

19 Transport Canada, Advisory Circular (AC) 302-17: Runway Friction Measurement (Issue 03: 30 January 2017), at https://tc.canada.ca/en/aviation/reference-centre/advisory-circulars/advisory-circular-ac-no-302-017 (last accessed 07 August 2024).

a landing on a wet runway surface. The TSB laboratory conducted runway surface macrotexture[20] and microtexture[21] analyses 5 days after the occurrence.

The macrotexture test was conducted in accordance with ASTM International[22] Standard ASTM-E965 (*Standard Test Method for Measuring Pavement Macrotexture Depth Using a Volumetric Technique*)[23] and shows a degradation in macrotexture when the surface transitions from asphalt to concrete (Appendix A, Figure A1). The final 300 feet of Runway 12 is concrete; there is an additional 100 feet of asphalt after the end of the runway. Therefore, 35% of the distance of the occurrence aircraft's friction-limited anti-skid braking was on the concrete surface.

Examination of the microtexture of Runway 12 indicated that there was significant polishing of the asperities on the runway's surface, and their sharpness was imperceptible when touched.

The pavement of Runway 12 was constructed approximately 20 years before the occurrence. Over the lifetime of the runway, it had been subjected to a significant number of winter maintenance activities, which included the removal of ice and snow accumulations using plows and rotary brooms. These activities may have been responsible for the polishing of the aggregate, reducing the microtexture, or sharpness, of the surface. They also eroded the amalgam, which had helped to maintain a moderate amount of macrotexture and drainage.

The TSB's braking performance calculations considered different microtexture values, from a sharpness factor of 0.25 (for nominal, new pavement) to a degraded sharpness factor of 2.0 (Appendix A, Figure A2). The theoretical landing performance presented in Section 1.6.3.4 *Braking performance* used a sharpness factor of 1.25. The investigation determined that even on an asphalt runway surface that has a degraded surface microtexture with a sharpness factor of 2.0, once a DHC-8-402 with a fully serviceable braking system applies full braking, it should be able to stop within the same runway

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20 *Macrotexture* is the average depth/height between the peaks and valleys of surface asperities. In an asphalt surface, the mean macrotexture depth is proportional to the amount of exposed aggregate that protrudes above the pavement's amalgam. Macrotexture plays an important role in providing pathways through which liquid can exit a tire footprint as the tire translates through the liquid. Insufficient macrotexture will significantly degrade braking performance on a runway contaminated by liquid (such as rain). The mean macrotexture depth is measured in accordance with Standard ASTM-E965.

21 *Microtexture* refers to the "sharpness" of the individual asperities that make up the topography of a surface. Microtexture plays an important role in breaking down the viscous surface tension of thin fluid films. There are currently no standardized tests for objectively evaluating microtexture. It can instead be characterized by observing how "polished" the surface is. If the asperities of the exposed aggregate on an asphalt runway are smooth and polished from extended years of use, the microtexture will be characterized as poor or degraded. If this is the case, the surface will have a reduced "sharpness" constant, which will result in degraded braking performance with a higher likelihood of viscous hydroplaning.

22 Formerly known as the American Society for Testing and Materials.

23 ASTM, Standards Document ASTM-E965, *Standard Test Method for Measuring Pavement Macrotexture Depth Using a Volumetric Technique* (last updated 06 December 2019).

distance remaining at the time when the occurrence aircraft fully applied its brakes, which is 850 feet. However, the occurrence aircraft transitioned at 55 knots from asphalt to concrete where the macro- and microtextures were significantly degraded, resulting in reduced deceleration.

1.10.4 Runway lighting

Lighting and marking on Runway 12/30 at CYAM were approved under the requirements outlined in TC's *Aerodrome Standards and Recommended Practices* (TP 312).[24] As this publication states, runway end lights consist of 2 groups of lights, each with 3 lights if the runway measures less than 45 m wide or 4 lights if its width is equal to or greater than 45 m. These 2 groups of lights are arranged perpendicular to the runway axis and as close as possible to the end of the runway. The lights are red and unidirectional, facing the direction of the runway.[25] The intensity of runway end lights is typically around 25% to 50% of the intensity required for runway edge lights.[26]

At CYAM, runway end lights are installed at the end of the paved section of Runway 12. While the occurrence aircraft was approaching the end of the runway during the landing roll, these runway end lights were seen by the captain.

The runway's edge lighting consists of white high-intensity fixed lights on both sides of the runway. At CYAM, the runway edge lights were approved at the time of certification under the requirements included in the 3rd and 4th editions of TP 312. However, the latest edition of the TP 312 (5th edition)[27] requires that runway edge lights be fixed lights showing variable intensity white light except on runways 1200 m or greater in length. For runways greater than 1200 m, the lights in the last 600 m section or the last third of the take-off run available, whichever is less, are required to show yellow toward an aircraft on takeoff.

At CYAM, runway edge lights are white only and do not provide the additional indication of the remaining runway distance to the flight crew.

1.10.5 Runway distance-remaining signage

Runway distance-remaining signs are an example of cues to assist pilots. Although not mandatory, these advisory signs are used at some airports in the United States and at most Canadian military airports and are installed at 1000-foot intervals along the runway indicating the distance remaining to the end of the runway. The runways at CYAM are not equipped with runway distance-remaining signs nor are they required to be by regulation. If an airport operator chooses to provide the signs, the standards that must be followed are included in TC's *Aerodrome Standards and Recommended Practices*.

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24 Transport Canada, TP 312E, *Aerodrome Standards and Recommended Practices*, 4th Edition (effective 01 March 1993, updated March 2005).

25 Ibid., Section 5.3.12 Runway End Lights, p. 5-47 and 5-48.

26 Ibid., Annex B Figure B-9, p. B-9.

27 Ibid., 5th Edition (effective 15 September 2015, updated 28 June 2024), 5.3.12.5 Runway Edge Lights, p. 172.

1.11 Flight recorders

The aircraft was equipped with a solid-state FDR, which contained over 26.8 hours of flight data, covering the occurrence flight and 15 previous flights. The FDR data was successfully downloaded.

The aircraft was also equipped with a cockpit voice recorder, which had a recording capacity of 125 minutes; its recorded data included the occurrence flight. This data was successfully downloaded and contained good-quality audio for the occurrence flight.

1.12 Wreckage and impact information

Not applicable.

1.13 Medical and pathological information

According to information gathered during the investigation, there was no indication that the flight crew's performance was affected by medical or physiological factors.

1.14 Fire

There was no indication of fire either before or after the occurrence.

1.15 Survival aspects

Not applicable.

1.16 Tests and research

1.16.1 TSB laboratory reports

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

- LP063/2023 – CVR Audio Recovery
- LP064/2023 – FDR Download & Analysis

1.17 Organizational and management information

1.17.1 Porter Airlines Inc.

Porter Airlines is a Canadian air operator approved under *Canadian Aviation Regulations* Subpart 705. The company's main base is located at CYTZ. It operates a fleet of 43 aircraft, which consists of 29 De Havilland DHC-8-402 aircraft and 14 Embraer ERJ 190-400 aircraft. Porter Airlines operates in North America, transporting passengers to destinations in Canada and the United States. The company is also the holder of an approved maintenance organization certificate for maintenance work in the Aircraft, Avionics, Components, Instruments, and Structures categories.

1.17.2 Flight crew training

The FO had completed the initial ground training and the simulator portion of the flight training, including the pilot proficiency check, and was in the process of completing the enhanced line indoctrination training portion of the flight training. He was completing his 18th trip and 55th sector[28] of the enhanced line indoctrination training. The enhanced line indoctrination is for FO candidates with less experience and includes more requirements than the regular line indoctrination.[29]

The *Porter Airlines Inc. Training Control Manual*[30] outlines the subjects that must be covered during line indoctrination training. For landing and taxiing, each pilot shall perform, or demonstrate satisfactory knowledge of, "contaminated runway operations; landing in normal and crosswind conditions; proper braking and use of discing/reverse; approach ban; and After Landing checks."[31]

According to the Landing section of the *Porter Airlines Inc. Dash 8-400 Candidate's Line Indoctrination Handbook*, a discussion about avoiding a high-energy overrun must be held in preparation for landing. A captain candidate must be asked how to avoid a runway overrun.

For an FO candidate, there will be a discussion about the importance of a stable approach, landing in the touchdown zone, the proper selection of disc and/or reverse (as needed), being comfortable with using the brakes to slow the aircraft to 60 knots, and executing a balked landing, if needed.[32] In addition, pilots practise the use of reverse in simulator training. However, the FO did not have the opportunity to use reverse in operational conditions in his line indoctrination training before the occurrence, nor was he required to.

The above-mentioned items had been reviewed under the supervision of a training captain. For the FO, the recommendation for a line check would normally come after the satisfactory completion of the enhanced line indoctrination training, which includes a minimum of 60 sectors, instead of 40 sectors for the regular line indoctrination training.

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28 A *sector* refers to "a flight composed of a takeoff, departure, at least a 50 NM en route segment, arrival and landing to a full stop". (Source: Porter Airlines Inc., *Porter Airlines Inc. Training Control Manual*, Revision 8 [25 May 2021], Section 6.3: Hours and Sectors Requirements.)

29 Porter Airlines Inc., *Porter Airlines Inc. Dash 8-400 Candidate's Line Indoctrination Handbook*, Revision 5 (10 January 2022), Line Indoctrination Forms – Section Description, p. 4.

30 Porter Airlines Inc., *Porter Airlines Inc. Training Control Manual*, Revision 8 (25 May 2021).

31 Ibid., Section 6.2: Line Indoctrination Curriculum, p. 5.

32 Porter Airlines Inc., *Porter Airlines Inc. Dash 8-400 Candidate's Line Indoctrination Handbook*, Revision 5 (10 January 2022), Landing, Avoiding High Energy Overrun (Discuss), p. 39.

1.17.3 Porter Airlines Inc. and manufacturer operating procedures

1.17.3.1 Porter Airlines Inc. approach briefing and stabilized approach criteria

The *Porter Airlines Inc. Dash 8-400 Standard Operating Procedures* manual states the following with regard to approach briefings, target speeds, and stabilized approaches:

> 9. Special Considerations and any mitigations, including but not limited to:
>
> a) go-around readiness factors (e.g. "possible windshear on approach") and the consideration that if any stable approach criteria are compromised at or below 100 ft AGL, a go-around shall be commenced;
>
> b) target speed (a single speed); in ideal atmospheric conditions, target speed should match V_{REF}. A higher speed may be chosen when appropriate for the existing conditions. This speed must be deemed safe by both pilots and include consideration for increased landing distance. If a landing with the INCR REF switch ON is planned, target speed must be briefed as V_{REF} + INCR REF speed;
>
> c) target speed tolerance (allowable bracketing above and below the target speed), outside of which a go-around must be called once at or below 100 ft AGL. This tolerance is to account for airspeed fluctuations and must be appropriate to the conditions on the approach. In no case can this tolerance allow a speed of less than V_{REF} - 5 kts;
>
> **Note:** These speeds must be realistic and strictly adhered to, otherwise a go-around must be performed if not stable at 100 ft AGL.[33]

Although not specifically mentioned in Porter Airlines' SOPs, a speed of approximately V_{ref} +10 knots is commonly used for landings with flaps set at 15° on the aircraft type to reduce the pitch attitude and allow for more pitch authority in the landing flare while reducing the risk of an aft fuselage strike.

1.17.3.2 Porter Airlines Inc. normal landing procedures

The Porter Airlines SOPs for normal landing state that

> […] the PF is to, at their discretion, command the landing gear and flap to the required position for the approach and subsequent landing. Once the aircraft is configured for landing, the PF is to call for the "LANDING CHECK" (Read, Challenge and Response).[34]

The procedure also specifically states that "[l]ong landings are *NOT* [emphasis in original] permitted regardless of the runway length available."[35] It adds that, depending on the

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33 Porter Airlines Inc., *Porter Airlines Inc. Dash 8-400 Standard Operating Procedures*, Revision 14 (01 June 2021), Section 2.14.4: Approach Briefing.

34 Ibid., Section 2.16: Landing.

35 Ibid.

circumstances, adding a small amount of power may be necessary because of a late-stage sink rate. However, a go-around must be conducted in the case of unusual power requirements.[36] Below 100 feet AGL, the PM is to state the pitch attitude whenever the pitch is greater than or equal to 5°. The procedure also notes that "[t]o decrease the landing descent rate and not exceed a pitch attitude of 6 degrees, power will be required in the landing flare through the touchdown any time the landing descent rate is higher than desired."[37]

Porter Airlines' After Landing procedures are as follows:

> If runway length permits, brake application should be kept to a minimum. Use disc to slow the aircraft after landing. Sharp and/or abrupt braking should be avoided if the runway can be vacated at an intersection further down the runway. Plan ahead which exit to use. High-speed turn offs should be used if available.
>
> When the Landing Distance Required is close to the Landing Distance Available, after nosewheel touchdown, brakes shall be applied in a positive manner with respect to passenger comfort. The brakes shall not be applied with light continuous pressure. This is particularly important while taxiing to avoid excessive brake wear.
>
> Use of reverse thrust should be kept to a minimum unless required for operational or safety reasons. Caution should be exercised when using reverse thrust in a crosswind. If using reverse thrust, attempt to return to discing above 60 knots to prevent engine FOD damage.
>
> On roll out, if the captain is the PM, they will assume control at approximately 60 knots (above this speed, tiller should not be used).[38]

In this occurrence, the aircraft passed the flight crew's targeted landing zone, which was approximately 1000 to 2000 feet from the runway threshold, while still airborne; the MLG wheels came into contact with the runway approximately 2500 feet from the threshold.

1.17.3.3 Manufacturer's landing information

The Normal Landing section of the *DHC-8 Q400 Aeroplane Operating Manual*[39] provides the following information:

On final approach, the landing gear, flaps, and condition levers should be at the required position for the landing. The minimum airspeed is V_{ref}; pilots are to reduce airspeed to V_{ref}, then fly a stable approach with small corrections to control inputs and power so that the aircraft maintains the runway centreline and glide path. There is a note that explains that the aircraft landing performance assumes that the appropriate V_{ref} is achieved by 50 feet AGL.

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36 Ibid.

37 Ibid., Section 2.16.3: Pitch Awareness and Callouts.

38 Ibid., Section 2.19: After Landing.

39 De Havilland Aircraft of Canada Limited, *DHC-8 Series 400 Aeroplane Operating Manual*, Section 2.7: Normal Landing, p. 2.7-1.

The manual then states the following: "Commence flare and adjust power to achieve positive ground contact with minimum descent rate at the desired point on the runway."[40] The power levers should be set to FLIGHT IDLE before touchdown, then to DISC after touchdown.

The nose wheel should be promptly brought into contact with the ground following the main wheel's contact. Anti-skid braking should be applied as required to allow the aircraft to decelerate within the available distance on the runway.[41]

1.17.3.4 Porter Airlines Inc. Safety Alert

In June 2019, following a hydraulic system failure incident, Porter Airlines Flight Operations Management released a Safety Alert[42] in reference to the use of the propeller reverse. The Safety Alert stated that company pilots may not be familiar with the use of reverse and encouraged them to consider its use in the following situations:

- Flapless landing;
- Anti-skid or normal brakes inoperative;
- Rejected takeoff on short runway;
- Any other situation where stopping distance is critical[43]

The Safety Alert also notes the following best practices associated with the use of reverse thrust:

- Reverse thrust is most effective at high speed; effectiveness degrades as speed decreases;
- To prevent FOD ingestion, reverse should not be used below 60 KIAS unless in an emergency;
- Avoid the use of reverse thrust on icy or slippery runways;
- If reverse thrust is used in a crosswind, be prepared for a possible down-wind drift on slippery runways;
- Use of reverse on contaminated runways may negatively impact visibility[44]

1.18 Additional information

1.18.1 Use of visual cues to build runway situational awareness

During an approach and landing, it is common for a flight crew to use a variety of visual cues to accurately determine their orientation on approach, where they have touched down on the runway, how fast they are going, and how much runway they have left. These cues can

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40 Ibid.

41 Ibid.

42 Porter Airlines Inc., Safety Alert: Use of Reverse (21 June 2019).

43 Ibid.

44 Ibid.

include runway markings, intersecting runways and taxiways, and other physical features around the runway. However, when a flight crew is landing in night conditions and at a smaller airport in a remote area where much of the visual space appears as a featureless black background, there are significantly fewer cues available for the crew to use as a reference. Much of the physical environment is difficult to see, and cues can be limited to lights designating different parts of the manoeuvring surface, such as the runway edge lights, the taxiway lights, the lights of intersecting runways, and the runway end lights. This makes it more difficult to develop and maintain runway situation awareness while landing an aircraft.

Situational awareness has been defined as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future."[45] This definition cites 3 essential levels that are critical for effective performance in dynamic environments: performance that produces a desired result relies on an individual's ability to take in information (perception) and to understand both its meaning (comprehension) and its implications for the future of the operation (projection). Situational awareness is a construct that describes how humans perceive information, understand it, make predictions about it, creating an awareness of the present situation about themselves.

It may be difficult for flight crew members to quickly and accurately determine where they are on the runway and how fast they are travelling when many of the cues they would normally use are unavailable because of the lighting conditions, particularly at night.

1.18.2 TSB Watchlist

The TSB Watchlist identifies the key safety issues that need to be addressed to make Canada's transportation system even safer.

Runway overruns are a Watchlist 2022 issue. As this occurrence demonstrates, when a runway overrun occurs during a landing, it is important that the aircraft have an adequate safety area beyond the end of the runway to reduce adverse consequences.

Despite the millions of successful movements on Canadian runways each year, runway overrun accidents sometimes occur during landings or rejected takeoffs. From 01 January 2005 to 30 November 2023, there were on average 9.1 runway overrun occurrences per year at Canadian aerodromes, of which 6.7 occurred during the landing. The TSB investigated 28 of these occurrences in this period, issuing 6 recommendations. Three recommendations are still active,[46] one is dormant,[47] and two are closed.[48]

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45 M.R. Endsley, "Situation Awareness", *The Handbook of Human Factors and Ergonomics*, 5th ed. (2021), p. 435.

46 TSB recommendations A20-02, A20-01, and A07-05.

47 TSB Recommendation A07-01.

48 TSB recommendations A07-03 and A07-06.

ACTION REQUIRED

Runway overruns will remain on the TSB Watchlist until:

- TC demonstrates that the residual risk at airports with runways that are not required to comply with ICAO's 150 m standard is as low as reasonably practicable; and
- TC requires operators of airports with runways longer than 1800 m that have a runway end safety area shorter than ICAO's recommended length of 300 m to conduct formal runway-specific risk assessments and to take action to mitigate the risks of overruns to the public, property, and the environment.

Despite the actions taken to date, the number of runway overruns in Canada has remained constant since 2005 and demands a concerted effort to be reduced.

2.0 ANALYSIS

In this occurrence, while touching down on Runway 12 at Sault Ste. Marie Airport (CYAM), Ontario, the flight crew were not initially aware of the aircraft's proximity to the end of the runway, and when they did become aware, the actions taken were not able to bring the aircraft to a stop before it reached the end of the runway, resulting in a runway overrun.

The analysis will therefore focus on runway situational awareness; flight crew landing technique, including the use of reverse thrust; as well as degraded braking performance stemming from technical system faults and runway surface conditions.

2.1 Runway situational awareness

The occurrence aircraft's approach into CYAM was conducted during night lighting conditions and in light rain. The crew's plan was to touch down between 1000 and 2000 feet from the beginning of the runway, with Taxiway J (located approximately 2000 feet from the beginning of the runway) marking the end limit of the expected landing zone. The primary visual indicators that were available to assist them in their landing were the runway edge lights, the taxiway lights and signs, the lights of the intersecting runway, and the runway end lights.

While the aircraft was passing Taxiway J during the final approach, the captain was checking the pitch indicator to monitor for a pitch angle greater than or equal to 5°, per company procedures, to avoid the risk of an aft fuselage strike. At that point, the first officer (FO) was focused primarily on the runway surface to ensure the aircraft's proper contact and alignment given the visual challenges associated with conducting a landing at night and in light rain. It is therefore likely that the crew did not either perceive or process Taxiway J as they passed it during this final phase of flight.

Based on where the first weight-on-wheels signal was triggered and on the expectations of the flight crew given their targeted landing zone, they may have mistaken Runway 04/22, which intersects with Runway 12, for Taxiway J, creating an inaccurate mental picture that they touched closer to the threshold than they actually did. This mental picture of their location is supported by the fact that the captain focused on matters less pressing than decelerating the aircraft by instructing the FO to correct a minor lateral deviation while the nose wheels was touching down when the aircraft was approximately 2000 feet from the end of the runway.

When the nose gear touched down completely with 1700 feet of runway remaining, the FO initially applied only light braking in accordance with company After Landing procedures, which was not immediately corrected by the captain, indicating that the crew was still not aware of the aircraft's proximity to the end of the runway.

One of the ways in which a flight crew's situational awareness on a runway can potentially be improved is the use of signage dedicated to indicating remaining runway length. Some other airports throughout the world, and most Canadian military airports have adopted distance-remaining signage. These signs assist flight crews by showing the distance remaining on the runway in increments of 1000 feet.

Situational awareness can also be improved by having yellow runway edge lights in the last portion of the runway indicating to a flight crew that they have reached the last third or the last 600 m of the runway. Although newer runways are approved under these requirements, many airports like CYAM were certified under previous standards and still have white runway edge lights.

Finding as to causes and contributing factors.

Once the aircraft was over the runway, the flight crew's focus briefly shifted to other tasks and, with the limited visual cues available during the night landing, they did not recognize that the aircraft was further down the runway than expected.

2.2 Landing technique

Before landing on Runway 12, the flight crew conducted a stable approach and were aware of the wind and runway surface conditions. According to the aircraft flight manual (AFM), the landing was planned with sufficient runway length for the given aircraft configuration and the wet runway condition. The aircraft's approach speed was higher than the minimum reference speed (V_{ref}); however, this approach speed was briefed by both flight crew members during the approach briefing and was within the requirements of Porter Airlines' standard operating procedures (SOPs).

The aircraft initially made a soft touchdown on the runway. As a result, the wing spoilers did not activate until 2 seconds later, when the main landing gear wheels made solid contact, compressing the main landing gear wheel struts enough to activate the weight-on-wheels signal to the aircraft systems. At this point, the aircraft was already 2850 feet down the runway.

Following this solid contact, propeller DISC mode was selected; however, the nose landing gear contacted the runway about 7 seconds after the weight-on-wheels signal, with approximately 1700 feet of runway remaining.

Following the nose touchdown, the FO initially applied only partial braking. It was not until 6 seconds after the nosewheel touchdown, approximately 850 feet from the runway end, that the captain recognized the runway end lights and the lack of deceleration, given the runway distance remaining, and took over to input full braking action.

At this time, the runway length remaining was close to the limit of the aircraft's theoretical landing performance for the given conditions. As a result, there was no remaining margin for the crew to react to unforeseen circumstances, such as possible degraded braking performance.

Finding as to causes and contributing factors

The wing spoilers deployed 2 seconds after touchdown and the lowering of the nose wheel and application of full braking was delayed because the flight crew were unaware of the aircraft's proximity to the end of the runway. As a result, significant deceleration did not commence until the captain recognized the runway end lights, when the aircraft was 850 feet from the end.

2.3 Use of propeller reverse thrust

Owing to the fact that the *Q400 Airplane Flight Manual* and the *DHC-8 Series 400 Aeroplane Operating Manual* do not provide specific guidance on the circumstances in which propeller reverse should be used, the decision to use this function is based mostly on the pilots' training and familiarity with the aircraft's behaviour when reverse is activated.

Porter Airlines Inc.'s procedures state that the use of reverse should be kept to a minimum and should be used only if required for operational or safety reasons. Cautions for its use are also provided. In 2019, Porter Airlines Inc. acknowledged the limited familiarity among its pilots on the usage of the propeller reverse and issued an internal Safety Alert. The Safety Alert identified circumstances in which the use of reverse should be considered, such as an inoperative anti-skid or normal brake system, or any situation in which the stopping distance is critical.

Training provided to company pilots includes practising the use of reverse in the simulator and having discussions about the use of disc/reverse as part of their line indoctrination training. However, the function is rarely used in normal operations given the reportedly high efficiency of propeller discing during landings.

In this occurrence, the deteriorated braking performance and reduced runway length remaining were only recognized approximately 8 seconds before departing the end of the runway. Considering the additional 3 second system delay that follows a pilot's command of reverse before the propellers actually start providing additional deceleration, the investigation could not establish whether the selection of reverse would have avoided the overrun at that time.

However, the use of reverse thrust early in a landing roll would significantly increase aircraft deceleration, reducing potential for a runway overrun. Reverse was not considered by the flight crew at any stage of the landing roll as a means to provide additional deceleration.

Finding as to risk

If operational procedures and pilot training do not emphasize the circumstances in which propeller reverse must be used and the aircraft's behaviour when it is used, there is a risk that flight crews will not recognize and respond correctly to situations that require the use of this function in time to avoid a runway overrun.

2.4 Air contamination in the hydraulic system

During the aircraft's deceleration, control of the aircraft was transferred from the FO to the captain when they both noticed that the aircraft was not decelerating as expected. The brakes were fully applied with 850 feet of runway remaining and while the aircraft's ground speed was still 78 knots. At this point, the propellers were both in DISC mode and all spoilers had deployed.

The anti-skid system activated immediately; however, the flight data recorder data show a pressure fluctuation between 2100 and 1000 psi for the left brakes and a direct increase to 3000 psi in the right brakes following pedal application until the aircraft departed the runway.

Even considering the operational factors (the delay in lowering the nose, applying the DISC setting, and braking) and the environmental conditions that were present at the time of the occurrence, when full braking was applied, there was theoretically still sufficient runway length available for the aircraft to stop before the clearway.

However, post-occurrence maintenance activities revealed that the brakes could not hold the aircraft in position during high-power engine runs because of the presence of air in the hydraulic system. Although the investigation could not determine how this air, which was subsequently bled from the brake assemblies, had been induced in the hydraulic system, it possibly affected the aircraft's braking performance during this occurrence.

2.5 Runway surface texture

Five days after the occurrence, the TSB laboratory conducted a survey of the surface microtexture and macrotexture of Runway 12 at CYAM. A general degradation in the surface microtexture was observed. The macrotexture survey also showed significantly low measurements on the concrete pavement of the last 300 feet of Runway 12 and on the asphalt pavement of the 100 feet of overrun. The aircraft's deceleration decreased from 0.29 to 0.16*g* when the aircraft moved from the asphalt portion of the runway to the concrete portion, indicating a degradation of the braking performance.

The theoretical landing performance considered different runway surface conditions (from a nominal, new surface to a moderately polished one) and varying "sharpness" factors of the asperities on the paved runway surface. The results indicate that regardless of the runway surface microtexture or macrotexture, the aircraft should have been theoretically able to stop within the runway distance available, even if it came very close to the limit. However, the degraded surface texture of the concrete portion of the runway and the asphalt overrun had an impact on braking performance.

Finding as to causes and contributing factors

When the captain applied full braking with 850 feet of runway remaining, the aircraft should have been theoretically able to stop; however, braking performance was degraded, likely due to the runway surface texture on the last 300 feet of the runway and possible air contamination in the hydraulic system. As a result, the aircraft overran the end of the runway.

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. Once the aircraft was over the runway, the flight crew's focus briefly shifted to other tasks and, with the limited visual cues available during the night landing, they did not recognize that the aircraft was further down the runway than expected.

2. The wing spoilers deployed 2 seconds after touchdown and the lowering of the nose wheel and application of full braking was delayed because the flight crew were unaware of the aircraft's proximity to the end of the runway. As a result, significant deceleration did not commence until the captain recognized the runway end lights, when the aircraft was 850 feet from the end.

3. When the captain applied full braking with 850 feet of runway remaining, the aircraft should have been theoretically able to stop; however, braking performance was degraded, likely due to the runway surface texture on the last 300 feet of the runway and possible air contamination in the hydraulic system. As a result, the aircraft overran the end of the runway.

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 operational procedures and pilot training do not emphasize the circumstances in which propeller reverse must be used and the aircraft's behaviour when it is used, there is a risk that flight crews will not recognize and respond correctly to situations that require the use of this function in time to avoid a runway overrun.

4.0 SAFETY ACTION

4.1 Safety action taken

4.1.1 Porter Airlines Inc.

4.1.1.1 Approach briefing

An internal bulletin was issued to DHC-8-400 pilots to inform them that the approach briefing was changed to include a prescriptive touchdown zone.

4.1.1.2 Training and communication

- The ground school training syllabus was audited to ensure that the course material during initial training includes sufficient instruction related to aircraft performance, the use of reverse thrust, and braking techniques.
- The crew were assigned additional training with a senior training pilot which included discussions and briefings pertaining to touchdown zone awareness, runway length, contaminated runway definition and operations, consideration for flap selection, touchdown point limits, and aircraft performance. The performance of the crew was demonstrated to standard.
- The company released a training memo to highlight the landing procedures described in its aircraft flight manual (AFM).
- A bulletin was issued with information related to the use of reverse thrust SOP updates that were added to the initial DHC-8-400 pilot SOP training course which all new hires are expected to take.
- An internal memo was issued on to all DHC-8-400 pilots reminding them that not all airports provide Global Reporting Format reports for runway surface conditions and reminding them that standing water is a contaminant that may be present in any season.
- An internal memo issued to all DHC-8-400 pilots amended the SOPs to require that the braking plan after touchdown be included in the briefing and that consideration be given to the use of reverse thrust.
- Porter Airlines Inc. (Porter Airlines) introduced a digital records system. Furthermore, pilot candidates must now practice the use of reverse thrust during a line indoctrination flight and be considered proficient before they are recommended for an initial line check.
- Porter Airlines' DHC-8-400 Training Department implemented a thorough briefing on the appropriate use and techniques of reverse thrust.
- The following statements have been removed from Porter Airlines' After Landing SOPs:
    - If runway length permits, brake application should be kept to a minimum.
    - Use of reverse thrust should be kept to a minimum unless required for operational or safety reasons.

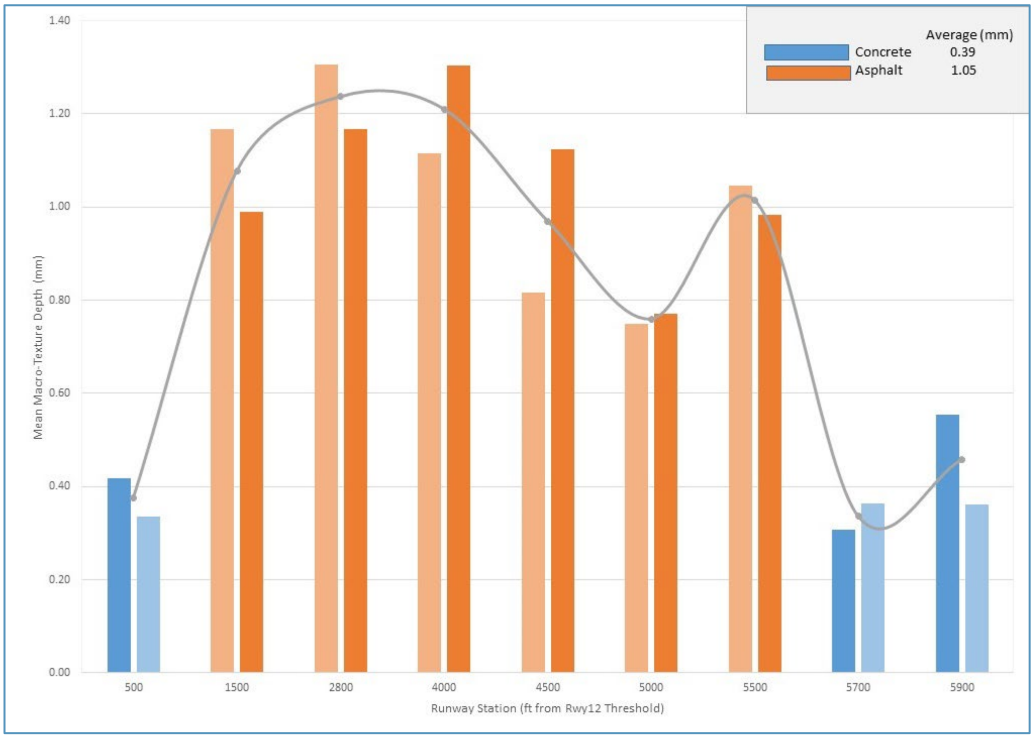
- An internal bulletin issued to all DHC-8-400 pilots amended the Approach Preparation SOPs to require that all normal landings should have the flaps set at 35° when the landing distance available is 6000 feet or less.
- A memo was issued to the Training Department that clarified the Line Indoctrination Captain's seat position, the shadowing of controls, and how to make decisions concerning flap configuration and power settings on approach.

This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 14 November 2024. It was officially released on 20 November 2024.

APPENDICES

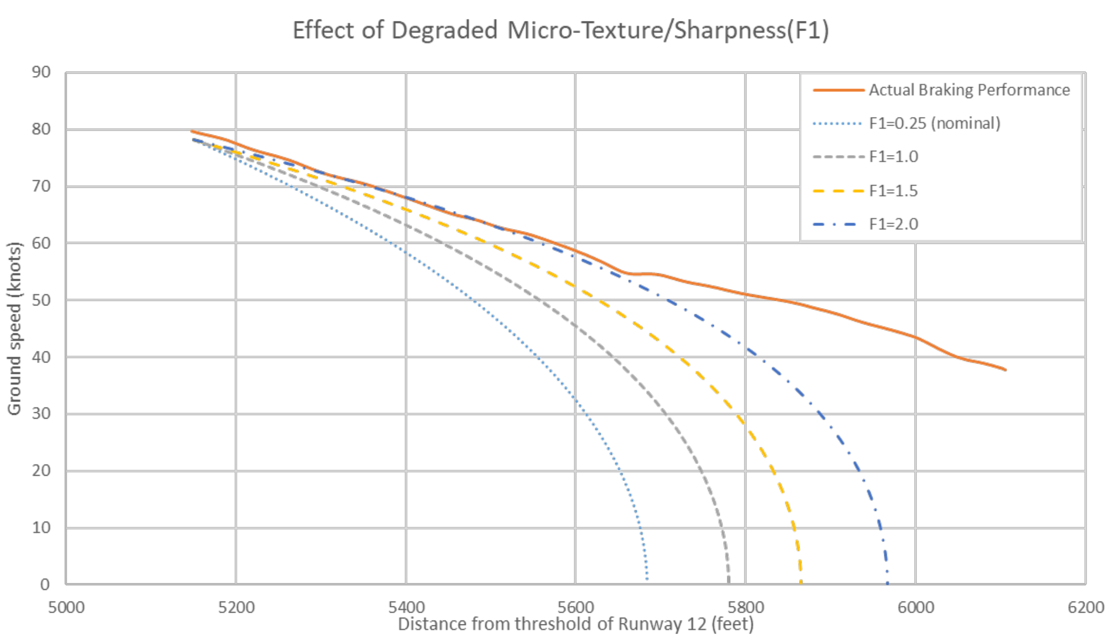
Appendix A – Runway 12 survey

Figure A1. Results of the macrotexture tests using the ASTM-E965 standard test method



Source: TSB

Figure A2. Effect of degraded microtexture on landing performance



Source: TSB