Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT A14O0218

Risk of runway excursion on landing

Sky Regional Airlines
DHC-8-400, C-FSRN
Toronto/Billy Bishop Toronto City Airport, Ontario
03 October 2014

Canada

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

Aviation Investigation Report A14O0218

Cat. No. TU3-5/14-0218E-PDF
ISBN 978-0-660-07164-0

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

Le présent rapport est également disponible en français.

Aviation Investigation Report A14O0218

Risk of runway excursion on landing
Sky Regional Airlines
DHC-8-400, C-FSRN
Toronto/Billy Bishop Toronto City Airport, Ontario
03 October 2014

Summary

On 03 October 2014, the Sky Regional Airlines DHC-8-400 (serial number 4170, registration C-FSRN), operating as flight 7519 (SKV7519), departed Montréal/Pierre Elliott Trudeau International Airport, Quebec, for a regularly scheduled flight to Toronto/Billy Bishop Toronto City Airport, Ontario. The flight was operated under instrument flight rules with 4 crew members and 62 passengers on board. During the landing, at 1649 Eastern Daylight Time, during daylight hours, the flight crew experienced difficulties stopping the aircraft before the end of the runway and steered the aircraft onto a taxiway to prevent an overrun. There was no damage to the aircraft, and there were no injuries to the occupants.

Le présent rapport est également disponible en français.

Factual information

History of the flight

At 1547[1] on 03 October 2014, C-FSRN (the aircraft) departed Montréal/Pierre Elliott Trudeau International Airport (CYUL), Quebec, for a regularly scheduled flight to Toronto/Billy Bishop Toronto City Airport (CYTZ), Ontario. The captain was seated in the left seat, performing the pilot flying (PF) duties; the first officer was seated in the right seat, performing the pilot monitoring (PM) duties. The cruise portion of the flight, flown at flight level 200,[2] was uneventful.

The aircraft was cleared for the Runway 26 instrument landing system / distance measuring equipment (ILS/DME) approach at CYTZ. At 1643, the aircraft turned left to intercept the localizer. At the time, the aircraft was approximately 11 nm from the runway threshold, at an altitude of 3000 feet above sea level (asl), with the flaps set at 5°.

The landing gear was lowered shortly afterward as the aircraft intercepted the localizer, which is offset 3° from the runway heading. The flaps were set to 15°, and at 1644 they were set to 35°, when the aircraft was 6.8 nm from the runway. The aircraft approach speed (V_{APP}) selected for this approach was 120 knots (V_{REF}[3] + 5 knots). The flight crew disconnected the autopilot as the aircraft intercepted the glideslope from below.

At 5.4 nm from the runway, the aircraft was established on the 4.8° glideslope and the final descent was initiated from 3000 feet asl; the airspeed was 117 knots. The ILS was initially tracked without incident and the sink rate was generally between 600 and 1000 feet per minute (fpm).

At 1648:04, when the aircraft was 1.9 nm from the runway and descending through 1200 feet agl, a right turn was initiated to align the aircraft with the extended runway centreline. The aircraft began to descend below the 4.8° glideslope as the flight crew transitioned from the ILS to the 3.3° visual approach, using the heads-up guidance system (HGS).

At 1648:25, the ground proximity warning system (GPWS) generated a glideslope alert. The flight crew cancelled the GPWS warning, as per their training, when transitioning to the 3.3° flight path angle. At 580 feet above ground level (agl),[4] the aircraft was converging on the 3.3° flight path angle from above and the airspeed was 119 knots.

---

1 All times are Eastern Daylight Time (Coordinated Universal Time minus 4 hours).

2 Flight level 200, or 20 000 feet asl at standard pressure.

3 V_{REF} is the "approach speed at a height 50 feet above the runway in the landing configuration."

4 All altitudes are above ground level (agl), unless otherwise specified.

The sink rate was about 1300 fpm, and the distance from the runway threshold was 1.3 nm. During this time, based on the reported weather, the aircraft was in visual meteorological conditions (VMC), with light rain and mist present.

According to the Sky Regional Airlines stabilized approach policy for VMC, the aircraft should be stabilized at 500 feet, and approaches should be flown with stabilized airspeed, stabilized sink rate, and a constant or planned profile. The maximum sink rate is 1000 fpm, unless briefed otherwise for a steeper approach.[5]

At 1648:30, the aircraft descended through 500 feet agl. The aircraft did not meet the stabilized approach criteria because it was not established on a constant or planned profile and the sink rate was decreasing through 1200 fpm. In addition, as the aircraft transitioned to the 3.3° flight path angle, it was no longer on the steeper 4.8° glideslope, and therefore the sink rate was also in excess of the 1000 fpm requirement (Appendix A).

The aircraft was eventually stabilized on the 3.3° flight path angle as it was descending through 250 feet. It remained on this flight path until the landing phase.

At 1648:48 the aircraft was at 180 feet agl, the airspeed was 120 knots, the sink rate was about 700 fpm, and the distance from the runway threshold was 0.5 nm. The aircraft crossed the runway threshold at 1649:04, at approximately 7 feet agl, with an airspeed of 118 knots, and the power lever angle (PLA) at 47° (above the FLIGHT IDLE detent [35°]) (Appendix B).

A momentary main gear weight-on-wheel (WOW) was recorded by the FDR at 1649:08, although the vertical acceleration data indicated that the main gear had contacted the runway up to 0.6 seconds earlier. During the WOW recorded at 1649:08, a vertical load factor of approximately +1.2 *g* was recorded, and the airspeed was 120 knots. The aircraft touched down approximately 770 feet past the runway threshold, with 3218 feet of runway remaining (Appendix C).

During touchdown, the PLA was at 47°, above the FLIGHT IDLE gate—contrary to Sky Regional Airlines standard operating procedures (SOPs), which state that the power levers are to be brought to the FLIGHT IDLE (35°) position just prior to the touchdown.[6]

At 1649:09 (1 second after the initial WOW), a second main-gear WOW was recorded, which remained constant, indicating the main gear was now fully compressed. As per design, the ground spoilers deployed. The airspeed was 120 knots (V_{REF} + 5 knots), the PLA was decreasing through 38° (still above FLIGHT IDLE), and the aircraft was approximately 970 feet past the runway threshold, with 3018 feet of runway remaining.

---

5 Sky Regional Airlines, *Sky Regional Company Operations Manual*, Chapter 3, page 34, Revision 5, 04 October 2013.

6 Sky Regional Airlines, *Skyregional DH8-400 Aircraft Operations Manual*, Volume 1, Chapter 3, page 91, Revision 1, 14 October 2013. The SOP was amended on 01 June 2015.

About 2 seconds after the full main-gear WOW, the PLA was held at 29° (below the FLIGHT IDLE gate, but not in the DISC detent [20°]), engine torques were at 0%, and the aircraft was approximately 1360 feet past the runway threshold, with 2628 feet of runway remaining.

After the main gear touched down, the PF maintained the nose-up pitch inputs (Appendix D). About 3 seconds after the full main-gear WOW, the nose-up pitch inputs were increased to full nose-up and the power levers were retarded. The nose gear WOW indication occurred at 1649:16, indicating that the nosewheel touched down 7.2 seconds after the second main gear WOW. At this point, the airspeed was 90 knots, the heading was 262° magnetic (M), the PLA was at 20° (DISC detent), and the aircraft was approximately 2310 feet past the runway threshold, with 1678 feet of runway remaining.

The nose-up pitch input described above is contrary to Sky Regional Airlines SOPs, which state that "the nose wheel shall be promptly brought into contact with the ground following mainwheel contact."[7] In addition, the power levers are to be brought to the DISC detent after touchdown.[8]

Some initial light braking from the PF was recorded at 1649:18, with the brake pressures reaching approximately 500 pounds per square inch (psi); maximum braking pressure is 3000 psi. The airspeed decreased through 83 knots, the aircraft was on the runway heading of 262°M, the PLA remained at DISC, and the aircraft was approximately 2640 feet past the runway threshold, with 1348 feet of runway remaining.

At 1649:21, as the runway distance remaining decreased to approximately 1040 feet, the PF brake pressures increased to about 1100 psi, the airspeed was 74 knots, the PLA remained at DISC, and engine torques were at 8%.

The power levers were further retarded at 1649:23, through a ground speed of 57 knots. The runway distance remaining was approximately 720 feet, the heading was 262°M, and the PLA was now at 0° (at the MAX REV [maximum reverse] detent).

During the rollout, the PF operated the steering control handle and attempted to steer the aircraft toward Taxiway Alpha, located near the end of Runway 26, and the nose wheel began to caster. The steering control handle is meant to be used during low-speed taxi operations.[9]

At 1649:25, with approximately 560 feet of runway remaining, the PF applied maximum braking (3000 psi) and the aircraft began to deviate off the runway centreline towards the right. The groundspeed was 53 knots and the heading was 264°M. During the deviation to the right, some positive lateral acceleration was recorded (up to +0.26 *g*).

---

7 Ibid.

8 Ibid.

9 Sky Regional Airlines, *Skyregional DH8-400, Aircraft Operations Manual*, Volume 1, Chapter 3, "Normal Procedures," page 61, 14 October 2014.

At 1649:32, the aircraft turned right through 290°M and began exiting the runway at the intersection with Taxiway Alpha, slowing through a ground speed of 21 knots. Two seconds later, both pilots momentarily applied some right braking (1200 psi) as the aircraft continued to turn right through a heading of 302°M with a groundspeed of 15 knots.

The aircraft then taxied along Taxiway Alpha (heading 052°M) at low speed for less than 1 minute before coming to a full stop at 1650:08, in order to re-engage the steering control handle.

After arriving at the gate, the flight crew requested that maintenance personnel inspect the nose gear for signs of damage. As no damage was found, the aircraft and occurrence flight crew departed CYTZ for a flight back to CYUL.

During the landing at CYUL, the nosewheel touchdown and power lever movements were the same as on the occurrence flight (Appendix E).

Flight crew

Records indicate that the flight crew was certified and qualified for the flight in accordance with existing regulations. The captain had approximately 4500 hours total time, including 1500 hours on the DHC-8-400 and 400 hours as pilot-in-command on type. He had been employed with the operator for 2 years. The captain had been recently upgraded from first officer on type; he had completed the required training and check ride approximately 5 months prior to the occurrence.

The first officer had accumulated approximately 4100 hours total time, including approximately 1050 hours on the DHC-8-400, and had been employed by the operator for 1.5 years. He had completed the required recurrent training and check rides in July 2014.

At the time of the occurrence, the Sky Regional Airlines flight crew training program included unstable approach training in both initial and upgrade training. However, the training was ground-based and did not include the recognition of unstable approaches in simulator training. Simulator training is not currently required by regulation to include recognition of unstable approaches.

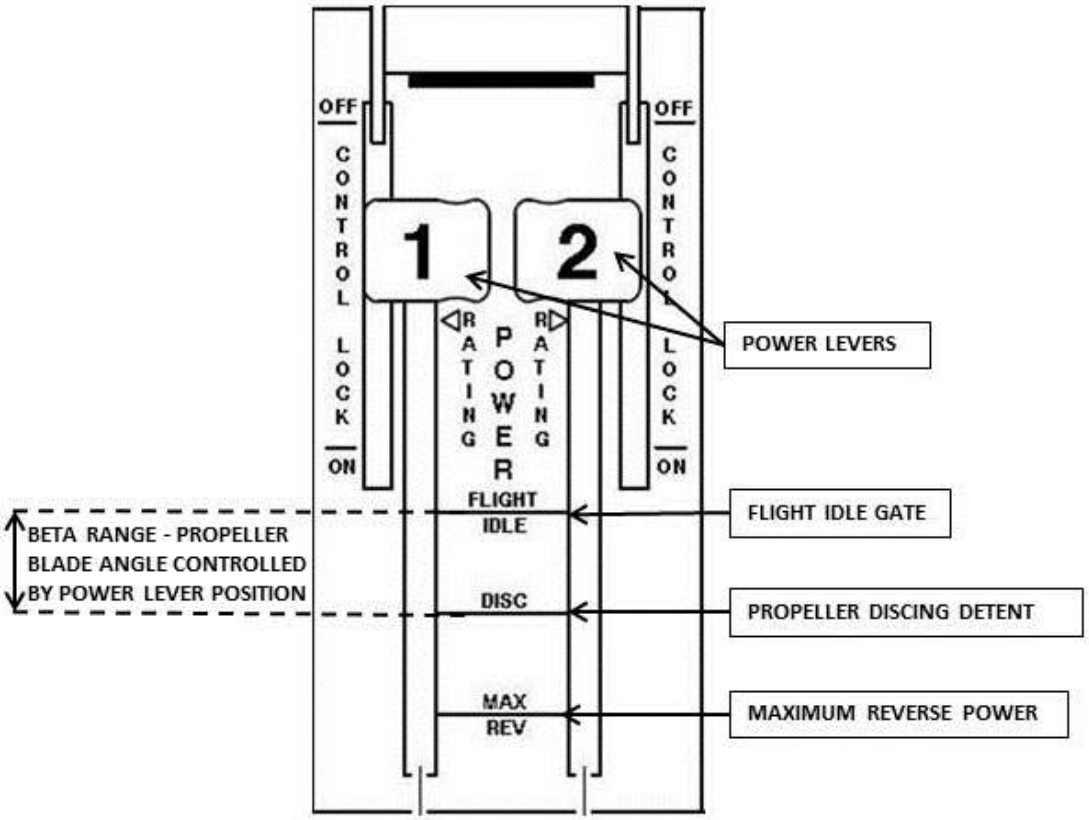
Aircraft systems

Power levers

The aircraft propulsion system consists of 2 engines and 2 propellers, which are mounted on the aircraft wings. Power levers, located on the centre console in the cockpit, are operated by flight crew to control engine power (Figure 1). The Bombardier aeroplane operating

manual[10] (AOM) for this aircraft describes the power levers in detail, some of which is provided below.

Figure 1. DHC-8-400 power levers and console (Source: Bombardier DASH 8-Q400 *Aeroplane Operating Manual*, Volume 4, Chapter 6, page 6.24-11, 31 May 2011, with TSB annotations)



Using the power levers, the flight crew can select the desired engine power for any phase of flight and for ground operations. During flight, the power levers are operated above the FLIGHT IDLE gate to control engine power. Movement of the power levers aft of the FLIGHT IDLE gate is prohibited during flight. However, during ground operations, the power levers can be operated forward and aft of the FLIGHT IDLE gate, depending on the required engine power.

To move the power levers aft of the FLIGHT IDLE gate, the gate-release triggers located below the power lever handgrips must be raised. The power levers can then be retarded to the desired position.

Moving the power levers aft of the FLIGHT IDLE gate will place them in the DISC detent. The DISC detent position has a mechanical slot. When the power levers are placed in the DISC detent, the propeller blade angle is such that it creates significant aerodynamic braking.

---

10 Bombardier Aerospace, *Bombardier Q400 Aeroplane Operating Manual*, Volume 4, Chapter 6, page 6.26-3, 31 May 2011.

When the power levers are moved further aft of the DISC detent, reverse power is selected; full movement aft (to MAX REV) applies maximum reverse power.

Ground proximity warning system

The aircraft is equipped with a GPWS that monitors the flight path of the aircraft between 50 and 2450 feet agl. During an ILS approach, when there is an excessive descent below the glideslope, the GPWS alerts the flight crew with an aural and visual indication. The glideslope feature on the GPWS operates when the following conditions are met:

- An ILS frequency is set
- The landing gear is down
- The AGL altitude is less than 925 ft
- The airplane is below the glidepath
- Glideslope cancel is not set[11]

When the aircraft is operated below the glideslope, the aural alert "GLIDESLOPE" will sound and both of the amber annunciators labelled "BELOW G/S" located on the cockpit glare shield will illuminate. If a "BELOW G/S" annunciator switch is pushed for 1 second or longer, the aural indication is cancelled, and all further GPWS glideslope alerts are cancelled. However, the annunciator stays illuminated to indicate that the mode was intentionally cancelled.[12]

Ground steering

When the aircraft is manoeuvring on the ground, the flight crew members use the rudder pedals and/or steering control handle for directional control. The steering control handle is located on the left-seat side console. According to the AOM, steering with the rudder pedals turns the nosewheel up to 8° either side of centre; using the steering control handle, the nosewheel can be turned up to 70° either side. If the nosewheel angle is greater than 70°, "the nosewheel will revert to a passive shimmy dampened castoring [*sic*] mode."[13]

The steering control handle was designed for low-speed ground directional control only; the steering control handle should not be used during the landing roll until the aircraft has slowed to taxi speed.

---

11 Bombardier Aerospace, *Bombardier Q400 Aeroplane Operating Manual*, Volume 4, Chapter 6, page 6.15-116, 13 April 2012

12 Ibid.

13 Bombardier Aerospace, *Bombardier Q400 Aeroplane Operating Manual*, Volume 4, Chapter 6, page 6.13-33, 28 February 2014

The flight data recorder (FDR) does not record the position of the steering control handle or the nosewheel, so the exact timing and extent of the steering control handle operation could not be determined.

Airport

Sky Regional Airlines was authorized by Transport Canada (TC) to use the *Restricted Canada Air Pilot* (RCAP) chart for the ILS/DME Runway 26 approach at CYTZ (Appendix F). The approach has a 3° LOC offset from the runway centreline and a glideslope path of 4.8° (the standard is 3°). Runway 26 is 3988 feet long and 150 feet wide, with a heading of 262°M. Runway 26 is equipped with a set of 4.8° abbreviated precision approach path indicator (APAPI) lights and a 300 foot overrun area. The waters of Lake Ontario abut the overrun area. The airport elevation is 252 feet asl.

Weather

A CYTZ aerodrome special meteorological report (SPECI) issued 7 minutes after the occurrence indicated the wind was from 170° true (T) at 9 knots, with visibility of 6 statute miles (sm) in light rain, a few clouds at 3300 feet agl, a broken ceiling at 4800 feet, and an overcast cloud layer at 6000 feet.

Due to the light rain, the runway was wet; however, weather was not considered a factor in this occurrence, nor was there any evidence of hydroplaning.

Sky Regional Airlines operating procedures

The SOPs in the Sky Regional Airlines aircraft operations manual for a normal landing are as follows:

> On approach do not fly slower than the approach speed. As the aircraft approaches the threshold, reduce airspeed to achieve Vref at touchdown.
>
> POWER levers to FLIGHT IDLE just prior to touchdown then to DISC after touchdown. Check PROPELLER GROUND RANGE advisory lights come on.
>
> **Note:** To decrease the landing descent rate, when the landing descent rate is higher than desired, power will be required in the landing flare through to touchdown.
>
> ROLL OUTBD and ROLL INBD SPOILER advisory lights - Check illuminated at mainwheel contact. The nose wheel shall be promptly brought into contact with the ground following mainwheel contact.[14]

[14] Sky Regional Airlines, *Skyregional DH8-400 Aircraft Operations Manual*, Volume 1, Chapter 3, page 91, 14 October 2013.

According to the Sky Regional Airlines aircraft operations manual, captains are to use the HGS for all phases of flight.[15]

The Sky Regional Airlines SOPs include arrival instructions for CYTZ which indicate that, under normal conditions, flight crew should use the HGS and a 3.3° flight path angle for all visual approaches.

Sky Regional Airlines stabilized approach policy

Sky Regional Airlines has a stabilized approach policy where the aircraft must be stable during the approach when it passes the 1000 feet height above aerodrome (HAA)[16] point in instrument meteorological conditions (IMC), and 500 feet HAA in VMC. The stabilized approach criteria are as follows:

> 1) Stabilized Approach: Stabilized airspeed, stabilized sink rate and a constant or planned profile
> 2) Maximum Sink Rate: 1000 fpm, unless briefed otherwise for a steeper approach
> 3) Approach Speed:
>
>   Q400 - Vref + 5 kts or Vref + Gust Factor (Max Gust Factor 10 Kts)
>
>   […]
>
>   Deviations of + 10 kts to – 5 kts are acceptable if the airspeed is trending toward approach speed
> 4) Landing flap
> 5) ILS Approaches should be flown within 1 dot of the Localizer and Glide Slope
> 6) VNAV Approaches should be flown 1 dot of the glides [*sic*] path and LNAV Track
> 7) All checklists and briefings have been completed[17]

According to company policy, if the stabilized approach criteria are not met between 1000 feet height above touchdown (HAT)[18] and 500 feet HAA, the PM must call the

---

15 Sky Regional Airlines, *Skyregional DH8-400 Aircraft Operations Manual*, Volume 1, Chapter 1, page 18, 14 October 2013.

16 Height above aerodrome (HAA) is the height in feet of the minimum descent altitude above the published aerodrome elevation. (Source: Transport Canada TP 11958E, *Glossary for Pilots and Air Traffic Services Personnel*, Revision No. 22, August 2013, page 80)

17 Sky Regional Airlines, *Sky Regional Company Operations Manual*, Chapter 3, page 34, Revision 5, 04 October 2013.

18 Height above touchdown (HAT) is another expression for height above touchdown zone elevation. It is the height in feet of the decision height or minimum descent altitude above the

deviation, and the deviation must be corrected or a go-around performed.[19] If the criteria are not met below 500 feet HAA, a go-around must be performed.[20] Due to the lack of cockpit voice recorder (CVR) information, it could not be confirmed whether the deviation calls were made.

In an attempt to enhance safety and reduce the risk of approach-and-landing accidents, Sky Regional Airlines has a discipline-free (no-fault) missed approach policy.[21] The policy is as follows:

> In addition to the requirement to perform a missed approach if an approach is not stabilized, a pilot may conduct a go-around for any reason (i.e. lack of adequate visual references, weather conditions not suitable, conflicting traffic, or loss of contact with ATC) without fear of disciplinary action. A Missed Approach should also be considered if the aircraft fails to land within the touchdown zone of the runway.[22]

Unstable approaches

Research has shown that unstable approaches present a high risk to safe flight operations. As shown in previous investigations by the TSB and agencies in other countries, negative outcomes include tail strikes, runway overruns, and controlled flight into terrain (CFIT). While there are some defences in place to mitigate the risk of unstable approaches, not all defences are employed by all operators. Defences are available to air operators to mitigate the risks associated with unstable approaches and their consequences. These mainly administrative defences include:

- A company stabilized-approach policy, including a no-fault go-around policy;
- Operationalized stable approach criteria and standard operating procedures (SOPs), including crew phraseology;
- Effective crew resource management (CRM), including empowering of first officers to take control in an unsafe situation;
- Use of flight data monitoring (FDM) programs to monitor SOP compliance with stabilized approach criteria;
- Use of line-oriented safety audits (LOSA) or other means, such as proficiency and line checks, to assess CRM practices and identify crew adaptations of SOPs;

---

touchdown zone elevation. (Source: Transport Canada TP 11958E, *Glossary for Pilots and Air Traffic Services Personnel*, Revision No. 22, August 2013, page 80)

19 Sky Regional Airlines, *Sky Regional Company Operations Manual*, Chapter 3, page 34, Revision 5, 04 October 2013.

20 Ibid.

21 Ibid., page 36.

22 Ibid.

- Non-punitive reporting systems (to report occurrences or unsafe practices);
- Use of terrain awareness and warning systems (TAWS).[23]

The Flight Safety Foundation has found[24] that 3.5% to 4% of approaches are unstable. Of these, 97% are continued to a landing, with only 3% resulting in a go-around.

The results of a study of pilots' experiences conducting unstable approaches and go-arounds were reported in the April 2013 issue of *AeroSafety World*. [25] More than 2000 pilots were asked to provide detailed accounts of recent experiences with approaches that were unstable below the stabilized approach height and that either resulted in a go-around or were continued to a landing. The study found that the decision to continue with an unstable approach was associated with lower levels of perceived risk associated with such an approach.

In particular, the study found that pilots were more likely to continue with unstable approaches in VMC and where environmental factors that might increase operational complexity (such as wind shear, turbulence, and contaminated runways) were absent. The authors suggest that these factors increase the pilot's perception that an approach can be salvaged, reducing the perceived risk associated with continuing the approach. The study also found a lower incidence of unstable approaches being continued to landing in cockpit environments that were described as more supportive, less judgmental, and more accepting of challenge, and in which there were more frequent conversations with respect to operational and flight risks.

It has also been found that approaches conducted either high and fast or low and slow were a causal factor in almost two-thirds of approach-and-landing accidents and incidents worldwide between 1984 and 1997.[26] As well, flight handling difficulties (e.g., crew management of airspeed and thrust) were a causal factor in almost half of the studied occurrences, with the improper use of automation cited as a contributing factor.[27]

Other TSB investigations[28] have shown that non-adherence to company SOPs related to stabilized approaches is not unique to Sky Regional Airlines.

---

23 TSB Aviation Investigation Report A11H0002, section 4.2.1, "Unstable approaches."

24 J.M. Smith, D.W. Jamieson, and W.F. Curtis. "Failure to Mitigate." *AeroSafety World*, February 2013. Available at http://flightsafety.org/asw-article/failure-to-mitigate/ (last accessed 5 December 2016).

25 J.M. Smith, D.W. Jamieson, and W.F. Curtis. "Why Do We Forgo the Go-Around?" *AeroSafety World*, April 2013. Available at http://flightsafety.org/aerosafety-world-magazine/apr-2013/why-forgo-go-around (last accessed 2 December 2016).

26 Flight Safety Foundation (2000). FSF ALAR Briefing Note 7.1 Stabilized Approach. *Flight Safety Digest*, August-November 2000.

27 Ibid.

28 TSB aviation investigation reports A07Q0213, A11H0002, A11O0098, A12P0034, A12Q0216, A13O0098, and A14W0127

SOPs, including standard calls and checklists, are critical information resources that provide procedural guidance to pilots for the operation of aircraft. They assist with pilot decision-making and with crew coordination, and provide pilots with pre-determined successful solutions to various operational scenarios during normal operations or an abnormal/emergency situation. Disciplined use of SOPs is a known mitigation for unstable approaches.

Safety management system and flight data monitoring

Sky Regional Airlines became a *Canadian Aviation Regulations* (CARs) Subpart 705 operator in January 2011. According to the TC Canadian Civil Aircraft Register, the company operates 15 Embraer ERJ 170 and 5 Bombardier DHC-8-400 aircraft.

The company has implemented a safety management system (SMS) in accordance with the CARs. The SMS provides the company with the structure to identify hazards, conduct risk assessments, mitigate risks, and continuously improve the program, enabling the development of a proactive and just safety culture.

SMS reports are used by flight crew to reports incidents and hazards. The reports are de-identified and can be accessed by all levels of management, who are required to regularly review them, provide feedback, and monitor the progress of analysis and safety investigations. However, at the time of the occurrence, unstable approaches were not mandatory reportable events in the Sky Regional Airlines SMS, and as a result, pilots were not required to submit an SMS report when one occurred.

In addition to the SMS, flight data monitoring (FDM) is also used by Sky Regional Airlines as part of its safety program. Flight data from regularly scheduled flights is downloaded from the FDR at scheduled intervals. However, at the time of the occurrence, FDR parameters did not provide sufficient information to properly monitor unstable approaches on the Sky Regional Airlines DHC-8-400 fleet.

Flight data recorder and cockpit voice recorder

The FDR and the CVR were not quarantined after the flight. The CVR audio of the occurrence had been overwritten, and these data were not available to the investigation. Due to the missing CVR data, flight crew dialogue pertaining to crew resource management, SOPs and other possible safety issues could not be evaluated.

The TSB obtained the digital FDR download files. The FDR file contained approximately 26.5 hours and 26 flights, including 15 flights after the occurrence flight. If the recorder had continued to run for another 7.6 hours, the occurrence flight would have been overwritten.

The FDR data indicated that the normal landing SOPs regarding the execution of the nosewheel touchdown and movement of the power levers had not been followed during the crew's next landing. As on the occurrence flight, only light braking was initially applied.

Data from other flights, with different flight crews, were examined, and the aircraft handling on those flights was generally in compliance with the SOPs.

TSB Recommendation A14-01

On 20 August 2011, the Boeing 737-210C combi aircraft (registration C-GNWN, serial number 21067), operated by Bradley Air Services Limited under its business name First Air, was being flown as First Air charter flight 6560 from Yellowknife, Northwest Territories, to Resolute Bay, Nunavut. At 1642 Coordinated Universal Time (1142 Central Daylight Time), during the approach to Runway 35T, First Air flight 6560 struck a hill about 1 nm east of the runway. The aircraft was destroyed by impact forces and an ensuing post-crash fire. Eight passengers and all 4 crew members sustained fatal injuries. The remaining 3 passengers sustained serious injuries and were rescued by Canadian military personnel, who were in Resolute Bay as part of a military exercise. The accident occurred during daylight hours.

The TSB concluded its investigation and released TSB Aviation Investigation Report A11H0002 on 25 March 2014.

In the Resolute Bay accident, the aircraft arrived high and fast on final approach, was not configured for landing on a timely basis, had not intercepted the localizer and was diverging to the right. This approach was not considered stabilized in accordance with the company's stabilized approach criteria, and the situation required a go-around. Instead, the approach was continued. When the crew initiated a go-around, it was too late to avoid the impact with terrain.

Unstable approaches continue to be a high risk to safe flight operations in Canada and worldwide. Occurrences in which an unstable approach was a contributing factor demonstrate that the severity of an occurrence can range from no injuries or damage to multiple fatalities and destruction of the aircraft. In Resolute Bay, the continuation of an unstable approach led to a CFIT accident and the loss of 12 lives. Without improvements in compliance with stabilized approach policies, most unstable approaches will continue to a landing, increasing the risk of CFIT and approach-and-landing accidents.

Current defences against continuing unstable approaches have proven less than adequate. In Canada, although many CARs Subpart 705 operators have voluntarily implemented FDM programs, there is no requirement to do so. First Air was not conducting FDM at the time of the Resolute Bay accident. Furthermore, FDM programs must specifically look at why unstable approaches are occurring, how crews handle them, whether crews comply with company stabilized approach criteria and procedures, and why crews continue an unstable approach to a landing. Unless further action is taken to reduce the incidence of unstable approaches that continue to a landing, the risk of approach-and-landing accidents will persist.

Therefore, the Board recommended that:

> Transport Canada require CARs Subpart 705 operators to monitor and reduce the incidence of unstable approaches that continue to a landing.
>
> **TSB Recommendation A14-01**

In its initial response, TC indicated that a Civil Aviation Safety Alert (CASA) had been developed to encourage Subpart 705 operators to use their SMS to identify the incidence of unstable approaches and to develop mitigation measures for the risk they pose.

On 27 June 2014, TC issued CASA 2014-03. The content of the CASA reflected the information proposed in the TC response letter dated 19 June 2014. The CASA also emphasized the value of voluntary FDM programs.

Subsequently, TC

1. published an Aviation Safety Letter (ASL) providing safety awareness information related to the theme of unstabilized approaches;
2. published Internal Process Bulletin (IPB) 2016-01 for targeted inspections to review the implementation of CASA 2014-03 among Subpart 705 operators; specifically, to examine an operator's assessment of unstable approaches using its SMS and, when applicable, review established mitigation strategies and the extent, type, and frequency of interventions related to unstable approaches; and
3. developed a Safety Promotion presentation on unstable approaches to raise industry awareness. The inspection campaign was to be completed by the end of summer 2016.

TC has collected the necessary data for the surveillance activities for all Subpart 705 operators. Subsequent ongoing analysis of the data regarding IPB 2016-01 will allow TC to validate the impact of its CASA 2014-03.

The TSB looks forward to the opportunity to review TC's analysis in order to better understand what measures airlines have implemented, and to assess whether they are effective in addressing the underlying safety deficiency associated with Recommendation A14-01. Additionally, TC's ongoing safety promotion initiatives, related to unstable approaches, will help sustain industry awareness.

Therefore, the response to Recommendation A14-01 was assessed as **Satisfactory in Part**.[29]

---

[29] A **Satisfactory in Part** rating is assigned if the planned action or the action taken will reduce but not substantially reduce or eliminate the deficiency, and meaningful progress has been made since the recommendation was issued. The TSB will follow up with the respondent as to options that could further mitigate the risks associated with the deficiency. The TSB will reassess the deficiency on an annual basis or when otherwise warranted.

TSB Watchlist

The TSB Watchlist is a list of issues posing the greatest risk to Canada's transportation system; the TSB publishes it to focus the attention of industry and regulators on the problems that need addressing today.

Unstable approaches are a 2016 Watchlist issue. As this occurrence demonstrates, accidents involving unstable approaches continue to occur at Canadian airports.

This issue will remain on the TSB Watchlist until

- major airlines track stable approach–policy compliance through their safety management systems, and take action to reduce the number of unstable approaches that are continued to landing; and
- there is a reduction in the number of incidents of unstable approach and in the number of accidents in which approach stability was a causal or contributing factor.

TSB laboratory reports

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

- LP241/2014 – Flight Data Recorder Analysis

Analysis

Records indicate that the flight crew was certified and qualified for the flight in accordance with existing regulations, and nothing was found to indicate that there was any aircraft system failure or malfunction that may have contributed to the occurrence prior to or during the flight. Therefore, the analysis will focus on the sequence of events, flight crew actions, training, standard operating procedures (SOPs), and unstable approaches.

When the aircraft was in the initial stages of the approach, it was on the localizer and glideslope and within the speed requirements indicated in the SOP. The speed of the aircraft was stable and consistent with the aircraft weight and flap configuration and company policy.

The flight crew was cleared for the instrument landing system / distance measuring equipment (ILS/DME) approach, and the aircraft was in visual meteorological conditions (VMC) when established on the glideslope. At 1.9 nm on final, the aircraft began to deviate below the ILS 4.8° glideslope as the flight crew transitioned to the heads-up guidance system for the 3.3° flight path angle. Because the cockpit voice recorder was overwritten, flight crew dialogue regarding this transition and crew resource management skills could not be determined.

The aircraft was well above the desired approach path at the operator's 500-foot stabilization height. In addition, the sink rate was not stable and exceeded the stabilized approach criteria. As a result, the approach was not considered stabilized according to the company's SOPs.

A ground proximity warning system (GPWS) alert occurred, as designed, when the aircraft was approximately 1.5 dots (580 feet) below the glideslope, as the aircraft transitioned from the 4.8° glideslope to the 3.3° flight path angle. However, this is a normal event for this type of approach at CYTZ; the flight crew cancelled the GPWS alert as they were trained, and continued the approach.

Sky Regional Airlines had a stabilized approach policy and criteria, a no-fault go-around policy, and a safety management system (SMS) hazard and occurrence reporting policy. Despite these factors, which encourage flight crews to conduct a go-around when an aircraft is not stabilized for an approach, the unstable approach was continued.

Sky Regional Airlines did not provide flight crews with simulator training on how to recognize an unstable approach leading to a missed approach. As a result, this likely contributed to the occurrence flight crew not recognizing the unstabilized conditions during the approach and continuing the flight to a landing. Training scenarios that involve go-arounds following an unstable approach may increase the likelihood that pilots will carry them out during active flight operations.

Unstable approaches are known to increase the likelihood of a landing incident. If operators do not provide adequate simulator training for flight crews to recognize an unstable

approach, then there is a risk that flight crews will continue an approach when it is unstable, which may lead to a landing incident.

After touchdown, the control column was pulled aft, contrary to the SOPs. This delayed the nosewheel ground contact (7 seconds after the main wheels). In addition, the power levers were not brought to the DISC detent until the nose gear touched the runway. The aft movement of the control column suggests that the nosewheel was intentionally held off the runway. The soft main wheel touchdown, delay in moving the power levers aft, and late nosewheel touchdown suggest that the pilot flying was attempting to perform a smooth landing.

If the flight crew had performed the landing sequence (post-touchdown) in accordance with the SOPs (with regard to executing the nosewheel touchdown, bringing the power levers to the DISC detent, and applying brakes immediately), normal aircraft deceleration likely would have occurred.

When the nose gear touched down, the aircraft was more than halfway down the runway, and at that point, the flight crew did not apply braking. Maximum braking and reverse was not applied until near the end of the runway, with 720 feet remaining. At this point, the flight crew likely realized that a runway overrun was imminent.

According to the aircraft operations manual, the steering control handle should not be used until the aircraft has slowed to taxi speed. However, the investigation revealed that the steering control handle was used during the landing roll. The nosewheel began to caster (i.e., it entered "passive shimmy dampened castoring mode"), which is conceivable given the system design and possible reduced runway friction from the light rain. However, the nosewheel position is not recorded by the flight data recorder (FDR); therefore, its exact position and range of movement could not be determined. Using the steering control handle on the ground at high speeds may cause the aircraft to veer or deviate from the desired direction unexpectedly.

If flight crews operate directional control systems outside the manufacturer's recommendations, then there is a risk that difficulties in directional control may occur.

FDR data indicated there was an increase in lateral acceleration and deviation from the runway centreline during the landing roll, which occurred at the same time as maximum braking and full reverse was applied near the runway end. This suggests that the flight crew operated the steering control handle, applied maximum braking and full reverse when they realized an overrun was possible, and attempted to steer the aircraft off the runway to avoid the excursion.

During the landing roll, the flight crew did not follow the normal landing SOPs (with regard to the timing of the nosewheel de-rotation and the position of the power levers). In addition, only light braking was initially applied, and as a result, the flight crew had difficulty slowing the aircraft in a timely manner and a runway overrun nearly occurred.

The flight crew's light braking technique, and non-compliance with the SOPs with regard to handling of the power levers and nosewheel touchdown, was also evident during their next landing. Flight data from other flights with different flight crews were examined as a comparison with the occurrence flight. In those flights, the aircraft handling was generally in compliance with the SOPs. This suggests that the deviation from SOPs during the occurrence landing was not systemic to the company, but was likely isolated to the occurrence flight crew. It could not be determined how frequently deviation from SOPs occurred.

The Sky Regional Airlines SMS includes mandatory reportable events that, when reported, will help identify and monitor unsafe practices and other safety deficiencies. However, unstable approaches were not a mandatory reportable item in the operator's SMS manual. If an air operator's SMS does not include mandatory reporting of unstable approaches, then there is a risk that the practice will continue without being detected or monitored, which may increase the likelihood of an incident occurring.

The cockpit voice recorder (CVR) audio recording of the occurrence had been overwritten. If cockpit voice recordings are not available to an investigation, the identification and communication of safety deficiencies to advance transportation safety may be precluded.

Findings

Findings as to causes and contributing factors

1. During the landing roll, the flight crew did not adhere to the normal landing standard operating procedures (nosewheel de-rotation, position of power levers). In addition, only light braking was initially applied. As a result, the flight crew had difficulty slowing the aircraft in a timely manner and a runway overrun nearly occurred.

Findings as to risk

1. If operators do not provide adequate simulator training for flight crews to recognize an unstable approach, then there is a risk that flight crews will continue an approach when it is unstable, which may lead to a landing incident.

2. If flight crews operate directional control systems outside the manufacturer's recommendations, then there is a risk that difficulties in directional control may occur.

3. If an air operator's safety management system does not include mandatory reporting of unstable approaches, then there is a risk that the practice will continue without being detected or monitored, which may increase the likelihood of an incident occurring.

4. If cockpit voice recordings are not available to an investigation, the identification and communication of safety deficiencies to advance transportation safety may be precluded.

Safety action

Safety action taken

Sky Regional Airlines conducted an internal safety management system (SMS) investigation into this occurrence, and identified and took steps to mitigate the risks associated with portions of its flight operations. The following corrective actions have been taken:

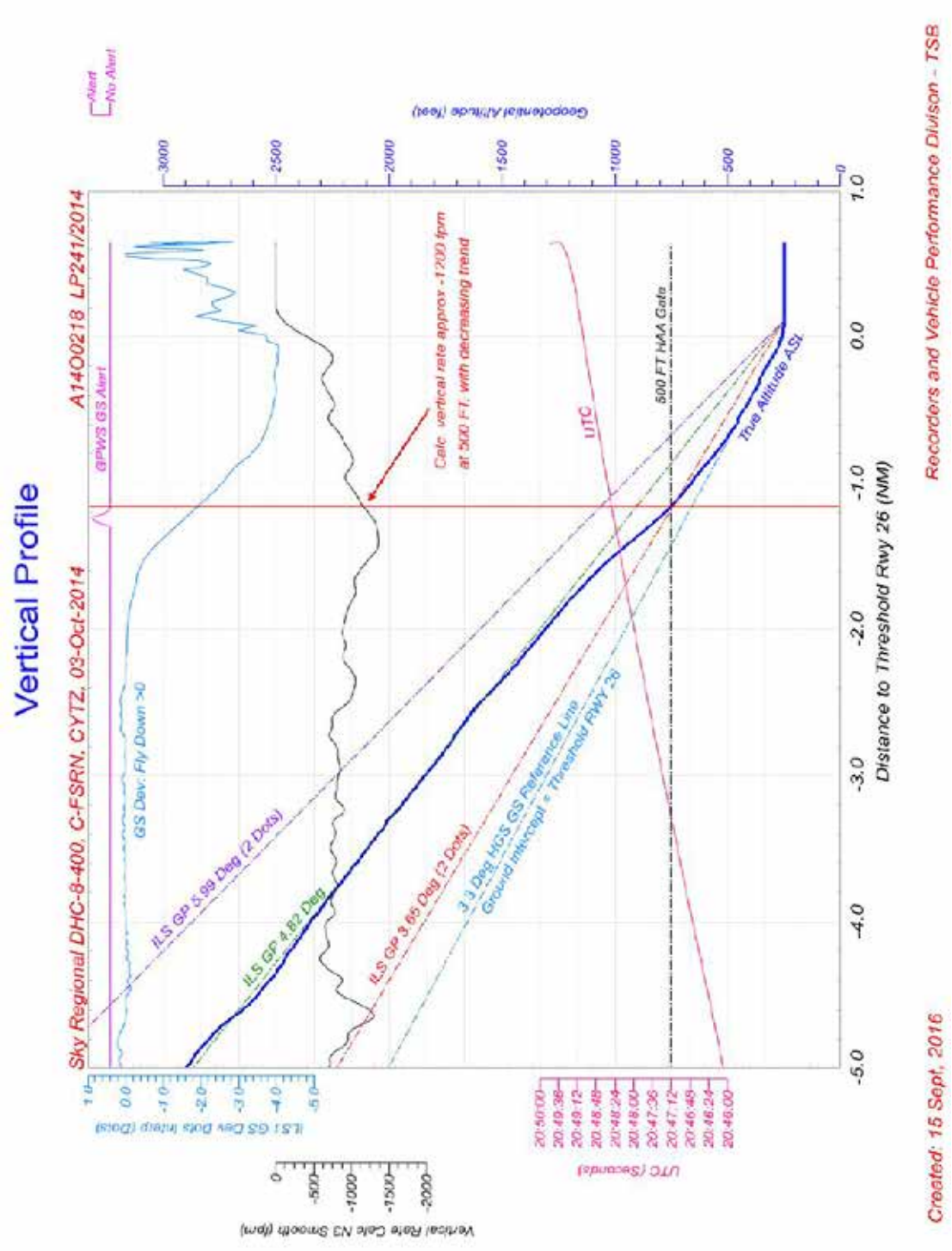
- Provided additional training to the captain, which included simulator training on landing procedures and techniques, and a review of the aircraft operating manual and the company operations manual pertaining to company flight operations.
- Conducted remedial line training and a line check for the captain.
- Revised the aircraft operating manual regarding the parameters for selection of DISC from nosewheel touchdown to main wheel touchdown.
- Updated initial and recurrent training to address landing procedures.
- Equipped the entire Q400 fleet with an enhanced digital quick access recorder that now permits accurate flight data analysis (FDA) of landings at CYTZ.
- Enhanced the training syllabus to specifically train the use of the instrument landing system (ILS) steep approach as a cloud break procedure if visual meteorological conditions (VMC) exist.

This report concludes the Transportation Safety Board's investigation into this occurrence. The Board authorized the release of this report on 23 November 2016. It was officially released on 10 January 2017.

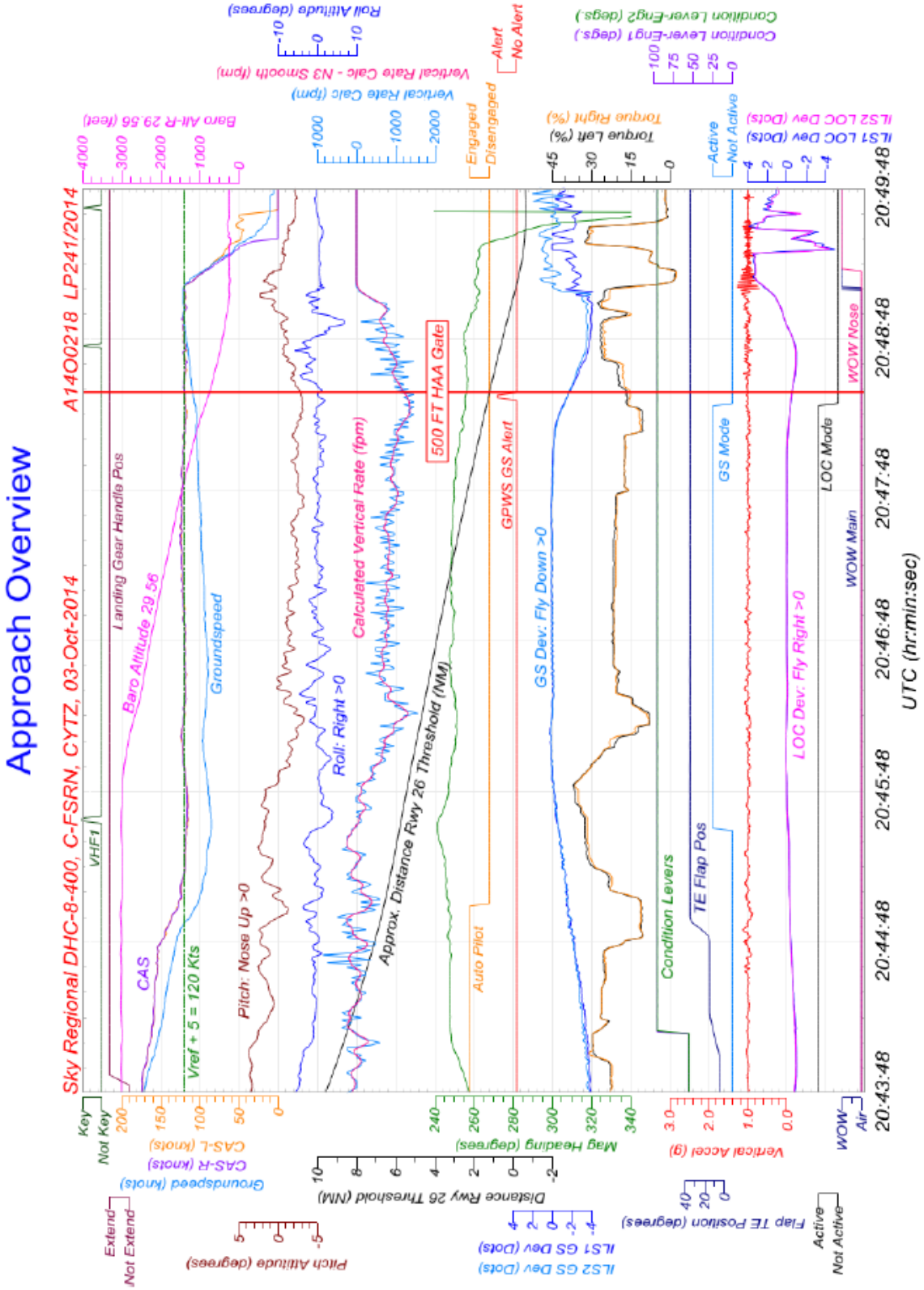
Visit the Transportation Safety Board's website (www.tsb.gc.ca) for information about the TSB and its products and services. You will also find the Watchlist, which identifies the transportation safety issues that pose the greatest risk to Canadians. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.

Appendices

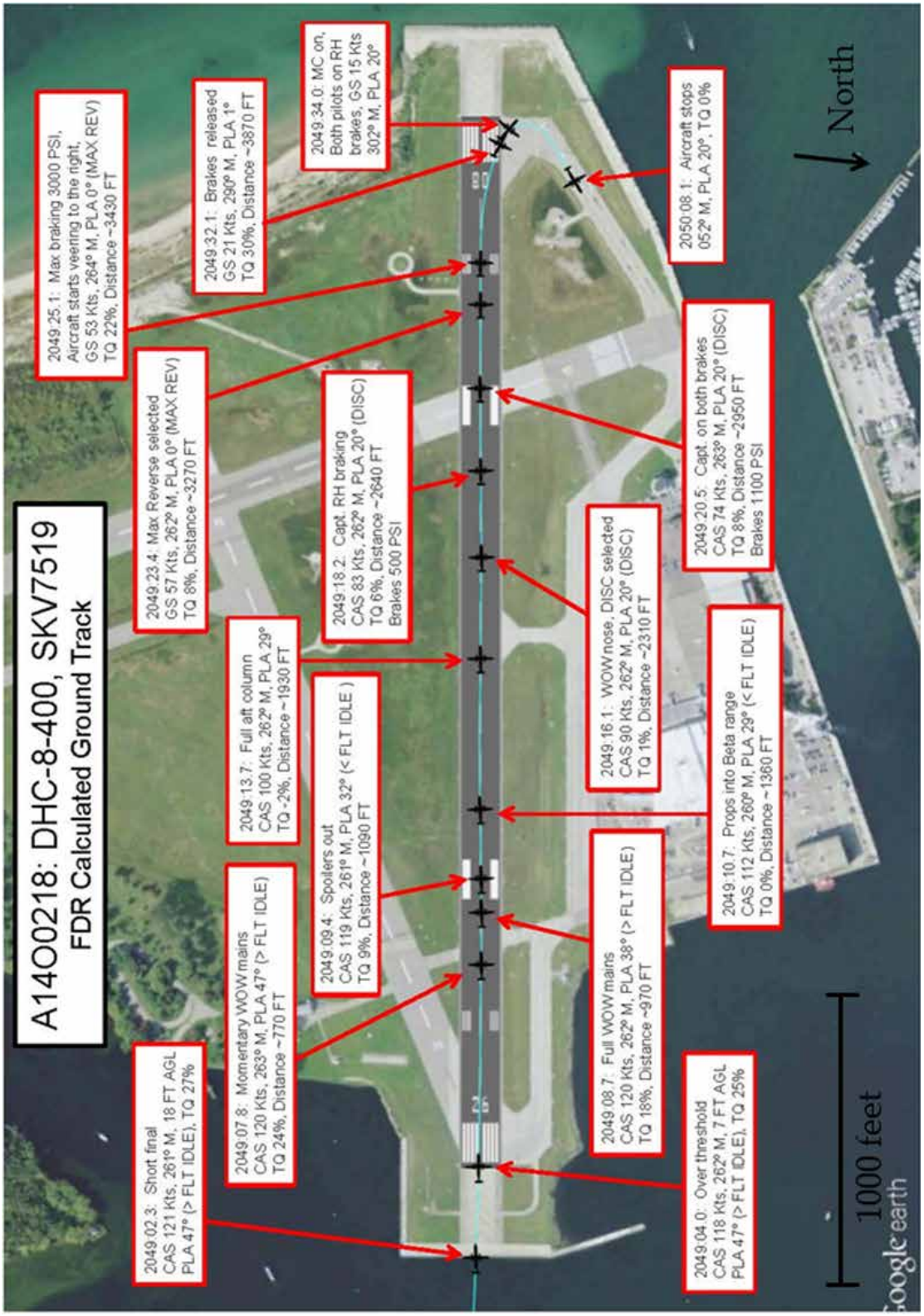
Appendix A – Vertical profile



Appendix B – Approach overview

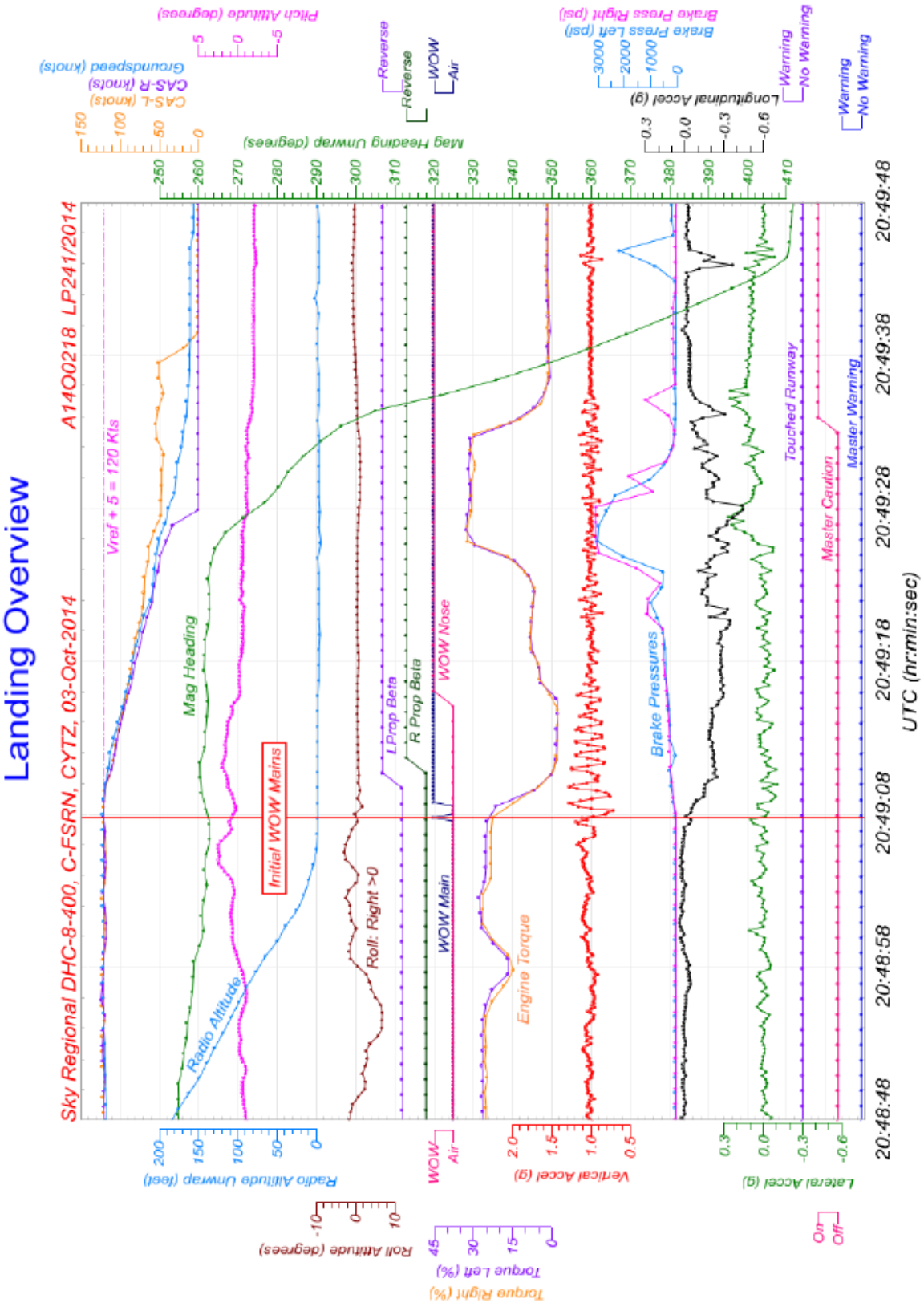


Appendix C – TSB calculated ground track with annotations

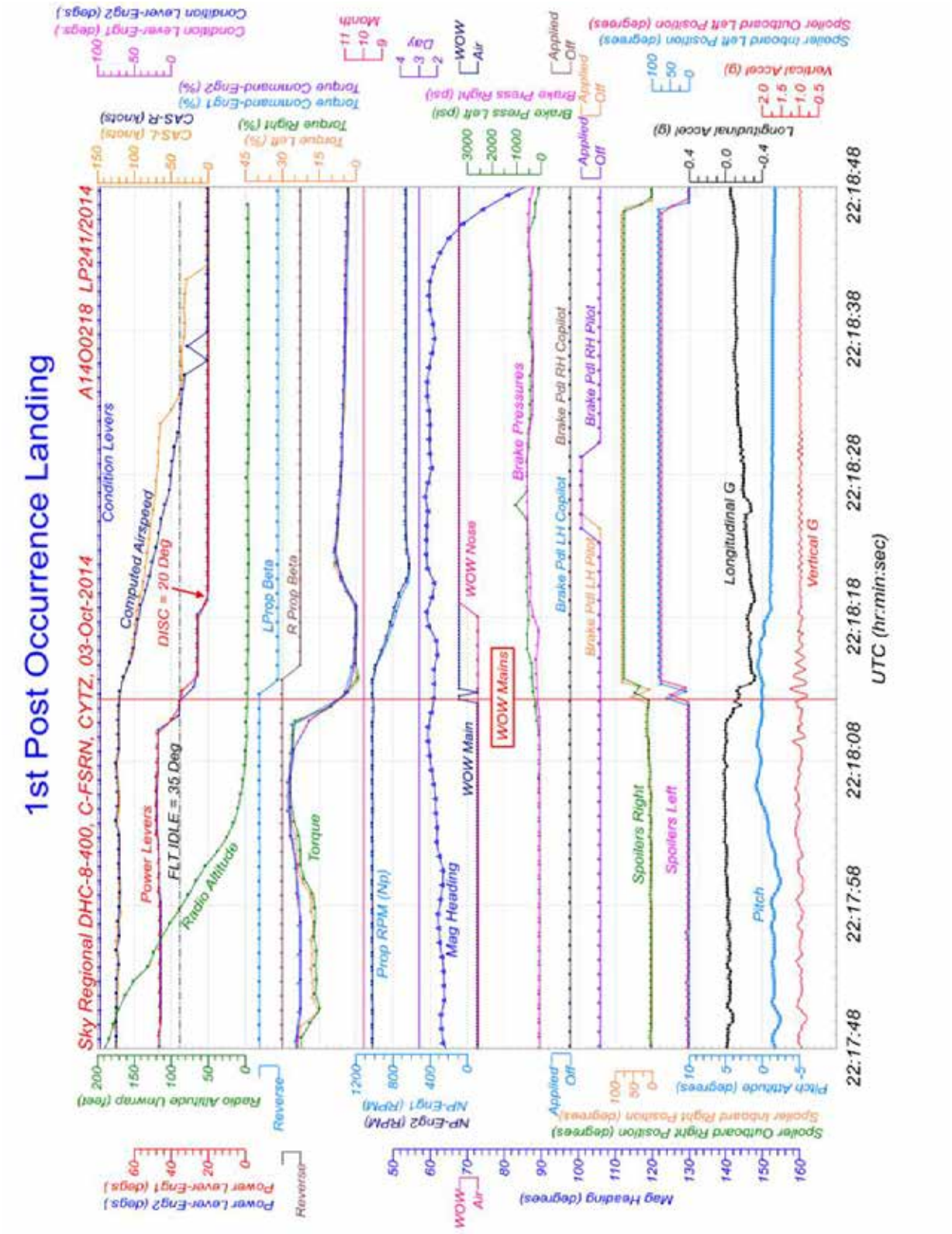


Source: Google Earth, with TSB annotations

Appendix D – Landing overview



Appendix E – First post-occurrence landing



Appendix F – Restricted Canada Air Pilot CYTZ ILS/DME RWY 26